THE NATURE, DISTRIBUTION AND MANAGEMENT OF SOME PROBLEM SOILS IN THE PHILIPPINES

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Introduction

Most if not all of the soils that are used pose certain constraints creating problems for production of economic crops. When the other environmental factors are also unfavorable, these soil constraints are magnified and both contribute to greatly depressed productivity. The solutions to such problems are rendered difficult if not impossible under such conditions. Fortunately, nature and science often provide some opportunities to correct certain problems so that improved production can still be achieved.

It is known from common experience that there are soils presenting less difficulties in management while others pose very serious problems requiring critical handling in order to obtain production at reasonable levels. Understandably soils vary in the degree to which problems are manifested in terms of their nature and properties dictating the manner of manipulation for their use. All these assume that the problems in a given soil are identified and known. Often however, the first area of concern is the matter of identifying what the problem is all about.

Over the years, the term problem soils has been regarded to mean special problem soils such as those represented by saline and alkaline (sodic) soils, acid sulfate soils, peat soils, and certain very acid soil systems. On the other hand, this term has also included the general area of soils having certain production problems and being relatively extensive in distribution even if the nature of the inherent problems is not as serious and critical as that known and typified by special problem soils. Considering the demographic problem of a spiralling increase in population placing irresistible pressures on the cultivated and remaining cultivable lands coupled with continuously increasing cost of farm chemicals, availability of economic as well as convenient solutions to overcome such problems is crucial to the small and resource-poor farmers.

Status of survey and classification of soils of the Philippines

An overview of a countrywide occurrence of problem soils may or may not be included in a soil survey and classification map of a given country. If the extent of the soils in question is not large enough such will be inclusions to the more recognizable and extensive soil bodies represented as mapping units of a given soil map. Thus, the scale of the map as set by the details of their survey sets the conditions for inclusions of such soils whether or not they pose important considerations for agriculture.

In the case of the Philippines, Raymundo (1977) observed that only reconnaissance soil surveys have been done for the country although a few semi-detailed and detailed surveys were conducted for some emergency and high priority projects. This was confirmed by Alcasid and Santos (1978) of the Bureau of Soils, the agency whose mandate is to undertake surveys and classification of Philippine soils. From such reconnaissance surveys, soil maps were prepared and suitability ratings recommended supposedly based on the existing concepts of the United States Department of Agriculture (USDA). On the other hand, both these authors recognized the limitations of such surveys and classification of Philippine soils and cited the need to refine the series concept adopted, and a recast of methodologies used both to be attuned to the demanding require-

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ments of development programs and to the needs of individual farmers that are more exacting. It has been the hope and goal of this agency to adopt Soil Taxonomy as the tool to achieve the desired quality for identification, characterization and classification of soils.

In an earlier attempt to communicate findings of soil surveys to the international community, Mariano and Valmidiano (1972) presented what can be considered as the first approximation of soils of the Philippines using the Great Soil Group category with an attempt to follow Soil Taxonomy (1975). Six major soil orders were included wherein eleven Great Soil Groups were recognized excluding the group of soils of mountainous regions. Although the coverage was nationwide, descriptions of the pedons representing the groupings were confined mostly to the Central Plains of Luzon (6 pedons), Bicol area (2 pedons), and one from the Manila area.

The basis for establishing these dominant Great Soil Groups over the country was not clarified in this study nor were the choices of the location where the description of the pedons was made to represent the mapping units. Accordingly, the question of whether such pedons are typical of the corresponding recognized Great Group can be raised with good reasons as well as the problem of providing accurate delineation for each mapping unit. Nevertheless, this work constituted the initial intention to apply the concepts of Soil Taxonomy (1975) to the problem of classifying Philippine soils. But the absence of the necessary correlation and the matter of uncertain delineations among the Great Soil Groups identified are critical points to permit such details so that only the existence and distribution of soil orders can be attempted. A more critical classification is yet to be conducted, one attempt of which was provided by FAO-UNDP (1972) for some rice soils of Eastern Central Luzon where nine subgroups were recognized when the common soil series existing in the area were evaluated.

For the dominant soil series known to be cultivated to wetland rice, Raymundo (1977) considered that these soils can be classified under four soil orders namely, Entisols, Inceptisols, Alfisols, and Vertisols. The absence or unavailability of more field and analytical date prevents any further detailed classification of these soils. On the other hand, some Ultisols of Southern Luzon and Mindanao have been and are cultivated to lowland rice.

1 Some soils and associated problems

The internal environment that brings about the formation of soils and their properties constitute factors related to the potential productivity of such soils as well as cause constraints to production. Such constraints according to Cline (1977) can be recognized from taxonomic names or in soil descriptions or inferred from information given about the soil. The utility depends on the degree to which they accurately represent the geographic distribution of soil conditions that may be critical for use and management. For this reason, Van Wambeke (1976) considered it important to amplify the combinations of soil characteristics associated with the names of soil classes.

The universe of soils was conceived to illustrate the evolution of soils under conditions of free drainage with two kinds of parent materials like weathering regolith and volcanic ash. These in general are obtained under Philippine conditions, for instance, basic igneous rock such as basalts and andesites are commonly found as cores of the major islands and according to Andal and Yambao (1966) volcanic influences in the form of basic ejecta are observed in Central Luzon, Southern Luzon, Bicol Peninsula, Negros Occidental and extensive areas in Central Mindanao.

Three groups of differentiating properties were used to construct the particular 3-dimensional domain of soils at the highest category. The x-axis permitted divisions with respect to stages of weathering from one to three, the latter representing the extreme condition. These stages are roughly represented by CEC of 40, 40 – 16, and less than 16 meq/100 gr clay. The horizontal y-axis indicates whether or not the soil contains argillic horizon, while the vertical z-axis considers the leaching factor that increases in intensity separating two conditions at 35% base saturation.

Ultisols in this model is the domain characterized by the presence of an argillic horizon, generally leached to less than 35% base saturation but include any of the stages of weathering. Inceptisols lack the argillic horizon, at any leaching condition but are confined to the first weathering stage. Dystrandepts however have lost part of their bases due to high rainfall conditions and thus occupy that part of the Inceptisols having less than 35% base saturation. Alfisols fall in either the second or third weathering stage having an argillic horizon and not yet subjected to intense leaching, thus base saturation is greater than 35%.

A first estimate of the extent of each soil order in the Philippines from a collection of identified Great Soil Groups modified from Mariano and Valmidiano (1972) is presented in Table 1. Although Pelluderts and Chromuderts and their corresponding drier counterparts as well as Eutropepts and Tropudalfs are more important because such soils are used for rice cultivation, the most extensive soils of the country appear to be those under the order Ultisols. These are mostly soils of the uplands and hilly lands which Mariano and Valmidiano (1972) classified as Tropudults. It has been observed however in certain areas that other Ultisols exist as well such as Trophumults, Palehumults and Paleudults at least in Southern Luzon, Bicol Peninsula and some parts of Mindanao.

These soils have an acidic condition as part of the chemical environment and as such present problems associated with such systems. Dystrandepts occurring in the country are included within the boundary of what is classified as Eutrandepts in this Great Group classification. Soils classified under this group have long been known to present severe problems in nutrition that seriously depress productivity. The remaining soils of the country particularly those classified as Fluvaquents, Tropaquents, Tropopsamments, and Tropaquents sometimes include the special problem soils with extreme acidity, salinity-alkalinity and other adverse soil conditions that bring about limited or very low productivity. Ponnamperuma and associates (1974, 1975, 1977, 1980) have extensively studied these special problem soils particularly in relation to the nature of amendments for their amelioration. It was estimated that the Philippines has the following areas of problem soils for rice:

Saline soils	400,000 (ha)
Acid sulfate soils	20,000
Peat soils..................	15,000
Alkali soils	5,000

Table 1 Planimetric estimate of aerial extent of various soil orders of the Philippines

Orders	Area (hectares)
Ultisols	11,311,230
Inceptisols	3,945,580
Alfisols	2,765,487
Vertisols	1,015,724
Entisols	658,536
Mountainous areas	8,289,008

2 Predictive connotation of soil class name

Classification of soils as a major function of soil survey serves as a basis for the application of technology, transfer of experience and other interpretation as delineated on soil maps. But Beinroth (1978) citing Kellog (1961) stressed that the precision and detail of prediction about the capability and limitations of soils from interpretation depend on the knowledge of interactions involved between soil characteristics, crop requirements and management practices, and the degree of generalization and homogeneity of the mapping units. Thus, when areas are broadly classified in the higher categories as the one available for the Philippines, the soils are necessarily associations and interpretation can only be general compared to a classification at high intensity involving either soil families or series within families. The family level has been defined in Soil Taxonomy in terms of properties and characteristics important to plant growth.

While specificity of requirements for production can not be provided by soil classes in the higher categories, still important inferences on their utility as well as limitations can be extracted from soil class names. Eswaran (1977) attempted to list the limitations of soils at all levels of categorization except the soil family, a type of prediction earlier presented by Dudal (1976) and Van Wambeke (1976) for soils classified at the order level. However, Uehara (1978) stressed that the technical data used to differentiate families can be useful only if applied in relation to the higher categories. One implication of this reminder is that soils possessing similar properties of particle-size, mineralogy, and temperature regime, three most common criteria used for soil family classification, may still differ in management requirement when they belong to different classes in the higher categories.

The significance of classification in the higher categories is that soils are separated on the basis of properties that serve as marks of the causes of soil behavior. Such marks, as Uehara explained, in combination with the soil family criteria may provide the user an estimate of soil response to manipulation.

On the basis of extensive experience and exposure to soil properties and behavior, Johnson (1980) provided prediction of what he considered as the most common and important soils that are classified under the family level. Actual experimentation on a network of a number of soil families in the tropics generated the Benchmark Soils Project to verify and confirm the utility of soil family classes and provide a more comprehensive and precise prediction of potentials and problems for the soil families under study. Such is anticipated to hold and apply anywhere in the world where the same soil exists (Benchmark Soils Project Report, 1979). Earlier results of this project provided the basis for Briones and Cagauan (1976) to state that the soil family can be used for extension of agrotechnology in hilly lands. This largely follows from the contention that soils classified in one family should have nearly the same potential for crop production and management requirement wherever they exist (Beinroth, 1978). Table 2 capsulizes the inferred and implied limitations leading to management problems of the dominant Great Soil Groups in the Philippines. Because of the extensive distribution of Ultisols, an implication of certain properties and characteristics of some of these soils is considered essential to the objective of this paper.

Ultisols are known to be deficient in nitrogen and phosphorus, which poses limitations for crop production. Swindale (1980) considered this as part of the obvious constraints for which methodologies for improvement are well understood. Dudal (1978, 1980) associated other mineral stresses in these soils due to acidity, depletion of bases with possible toxicity of aluminum, iron and manganese. These soils are also characterized by relatively low cation exchange capacity and base saturation as indicated in Table 3 which shows other properties for some soils classified under this order in the Philippines. The subsurface clay accumulation giving rise to an argillic layer can decrease hydraulic conductivity leading to a constraint related to erodibility, but properly managed as in certain sugar cane plantations in Hawaii, the presence of the argillic horizon can also favor moisture retention. Kaolin (1:1 lattice clays) dominates the clay fraction of the exceeding 60% of the particle-size distribution. Such amount and mineralogy are associated with low negative charge of clays often coated with oxides bringing about moderate to strong fixation of phosphates.

Table 2 General limitations and constraints of some major Great Soil Groups of the Philippines

Great Soil Group	Inferred Constraints
Tropudults	Low mineral contents, aluminum and manganese toxicities probable, P fixation possible.
Paleudults	High aluminum, low mineral contents, N deficiency and low CEC, moderate P fixation.
Tropaquepts	Higher redox, aeration problems.
Dystradepts	High P fixation, low N release, nutrient imbalances, and water stress.
Tropudalfs	Slow water movement, erosive at high rainfall intensities, some tillage problems moisture stress for drier counterparts.
Pellusterts	Narrow tillage range, moisture stress, very slow water movement.
Chromusterts	Same as Pellusterts but may have high contents of carbonates, P availability lower.
Tropaquents	Higher redox, drainage problem.
Fluvaquents	High redox, drainage problem, iron toxicity possible.

Table 3 Some physical and chemical properties of certain soil series under the order Ultisols in the Philippines (source: Bureau of Soils, Ministry of Agriculture)

Location (Province)	Depth (cm)	% Clay	CEC meq/100g	% Base Saturation	pH (Water)
Sorsogon	0–32	66	29.9	17.0	4.9
	32–76	81	21.9	13.7	4.9
	76–128	75	38.3	43.8	4.7
	128–150	66	28.9	30.0	4.7
Camarines Norte	0–32	66	23.1	28.9	4.9
	32–65	60	26.6	19.8	4.7
	65–100	62	26.6	21.0	4.9
	100–150	48	19.1	23.0	5.1
Camarines Sur	0–25	69	24.6	48.8	5.2
	25–80	92	17.1	56.1	5.0
	80+	78	5.0	57.3	5.6
Mindoro	0–25	51	21.1	50.4	5.5
	25–80	60	15.4	10.0	5.4
	80+	51	12.4	11.5	5.1
Quezon	0.25	36	26.0	14.5	4.7
	25–80	35	24.6	29.8	5.1
	80+	38	27.6	49.4	5.0

Trials in management of some Ultisols of the Philippines

As stated previously, Ultisols occur in upland and hilly areas and are rarely irrigated. If they are not under forest or coconuts, indigenous grasses such as *cogon* (*Imperata cylindrica*) and *talahib (Saccharum spontaneum)* are common. In many areas, shifting cultivation is practiced particularly in places abandoned after logging operations. They are planted to upland rice and corn and sometimes to cassava. Unless fertilized and limed, yields are low and these areas are thus abandoned very quickly. The limited infrastructure, combined with erratic and uncontrolled water availability seriously hamper the exploitation of these wide areas for agriculture. Serious attention to the development and use of such areas is urgently needed as it is being done for rice soils, since these areas offer the one remaining opportunity for agricultural expansion to relieve the increasing pressures on the lowlands.

Over the last decade or so, increasing effort has been made to study the properties and behavior of some Ultisols and their response to fertilization and liming. Singlachar (1969) observed highly significant increase in yields of rice when adequate supply of N was applied under unflooded condition of a Luisiana soil which is classified as Tropudult. The poor performance of rice in this soil was attributed to iron and aluminum toxicity so that liming combined with phosphate addition resulted in greatly improved production. These observations were essentially confirmed by Layese (1970) in a soil test study of 14 soils that included Luisiana soils which again showed increases in yield of rice when P was added to the soil in the presence of adequate N and K.

Recurrent catastrophic floods and droughts that occurred in the past have convinced planners and policy shapers to implement immediate reforestation measures of deforested and denuded areas. Ipil-ipil (*Leucaena leucocephala*) has gained widespread popularity but difficulties have been encountered to establish the plants in these areas. Studies conducted by Dacayo (1976) positively indicated the importance of adding both phosphorus and lime in order to ensure normal growth of these plants.

The soaring costs of fertilizers have forced almost all developing countries to adopt economy measures to decelerate importation and use of these chemicals not only by the government but also by individual farmers. As a means of supplementing national requirements for P fertilizers, attention was directed to the possibility of intensifying the proper use of indigenous phosphate deposits consisting mostly of guano and rock phosphates. Briones (1980) compared the effectivity of rock phosphate with that of superphosphate in P-deficient and Luisiana soil and observed significant response due to P fertilization which increases as the rate increases. Fig. 1 shows that while dry matter yields are always higher for superphosphate than those of equivalent rates of either partially acidulated apatite and raw apatite, the differences are not that significant. In the case of P-deficient Ultisols in hilly areas, the presence of deposits of phosphates becomes more meaningful because of nearness and the substantial increase in yields due to a simple application of ground apatite.

In testing the hypothesis on transferability of agrotechnology among soil families, the Philippines through the Philippine Council for Agriculture and Resources Research (PCARR) cooperated with the University of Hawaii in a Benchmark Soils Project that includes a family of Typic Paleudult. The results of the first cropping of corn (*Zea mays* L.) in one of the three sites selected in Bicol Peninsula are presented in Fig. 2. The data further confirm the necessity of adding both P and N to obtain high yields in corn. With very little phosphorus added (about 10 kg P/ha) even with more than 180 kg N/ha, yields barely increased from the control plots although this level of production which is about 50 cavans of shelled corn/ha (about 2.5 ton/ha) approximates the national average. Statistical tests of the data yielded individual significance of both P and N application and indicated as well an interaction of both nutrients on the yield of corn. The predictive equation for yield as a function of P and N is given as,

$$Y = 1.366 + 0.0182P + 0.0046N + 0.000097PN$$

The optimum yield appears to be associated with inputs of about 100 kg N and 80 kg P/ha. Economic analysis of these data will await the results of more seasons of cropping.

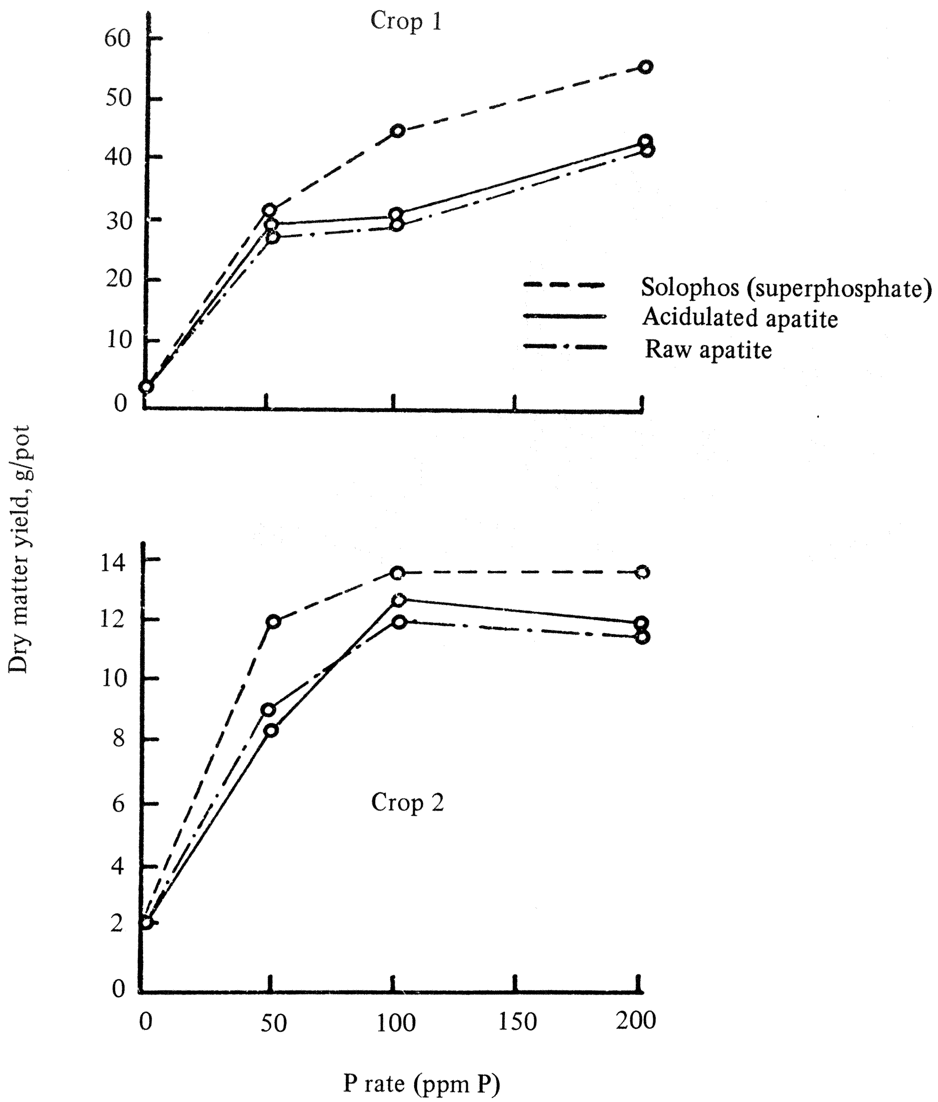

Fig. 1 Comparative effects of varying amounts of P from indigenous phosphates and superphosphate on dry matter yields in a Luisiana soil. (Source: Briones, 1980).

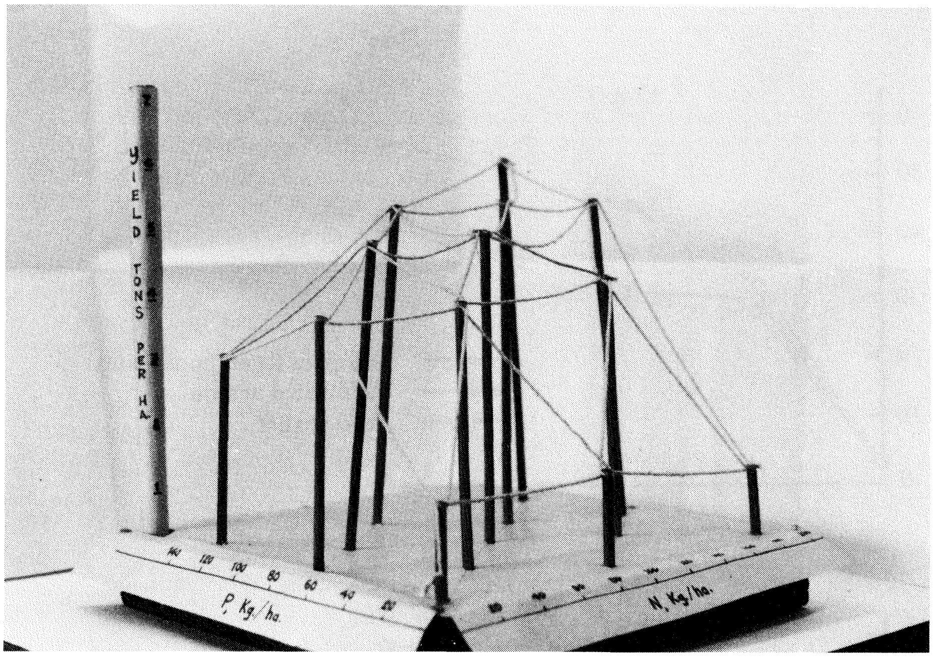

Fig. 2 Response surface of corn from application of nitrogen and phosphorus on a Typic Paleudult. (Source: Benchmark Soils Project, 1981).

One of the principal problems related to the use of these soils, considering the favorable effects of fertilization, remains the unpredictable water supply. This was corrected in the Benchmark Soils Project experiment through irrigation resulting in relatively higher yields of the control plots. Due to the high investment associated with the practice of artificial irrigation that many developing nations can hardly afford, such recommendation while desirable is not yet realistic at the present time. On the other hand, research using drought resistant economic crops in relation to soil water conditions with the intention of obtaining better use of available moisture including determination of cropping patterns is an activity whose results can redound to the benefit of individual resource-poor farmers.

Because of location specificity, it would be necessary to determine the boundary or the extent to which experimental data can be transferred to other locations. If the soil family as the medium of agroproduction transfer is finally proven to be valid not only for one family but to other common soil families, then mapping of soils which will include Ultisols shall then have to be considered a serious priority. Even if the soil family classification is not immediately applicable everywhere, the data generated in producing such maps can prove useful in many aspects of soil use interpretations, leading to more detailed classification such as phases of the soil family or soil series. This may prove more desirable in the long run for the requirements of farmers which tend to involve increasingly more specific conditions of locality to obtain yield levels achieved at experiment stations.

Summary and conclusion

Soils are viewed as systems that present constraints in their use for agriculture. They however differ in the nature as well as degree of the problems to tackle. While special problem soils such as saline-alkaline, acid sulfate, and other soils with adverse conditions exist in the Philippines, their combined area is still very much smaller than the soils under the order Ultisols that is estimated to have an extent of more than 33% of the total land area of the Philippines.

Most soils of this order have been known to pose problems associated with mineral stresses. In addition, these soils are mostly upland systems whose main source of water supply is obtained from rainfall. The combination of nutrient deficiencies, moisture stresses and limited access to other infrastructure contributes to low or very low productivity and slow development of agriculture in these areas. But the soils remain available for exploitation to relieve the increasing pressures on the traditional farming areas of the basins or lowland locations.

Most studies involving some soil series of this order in the Philippines confirm the need for applying moderate to high amounts of phosphorus, nitrogen and lime in order to obtain desirable yields of rice, corn and to establish watershed cover such as ipil-ipil.

To provide a base from which to plan an intensive and realistic program on use of these soils, the matter of determining accurate boundaries of soils in the lower categories such as subgroups or what is better, soil families or series needs serious attention. A project involving survey and classification of Philippine soils will provide the opportunity to include such objectives and is expected to require external source of funds as well as include intensive development of manpower that will become conversant in such work.

While research studies have generally identified the needs of these soils to improve productivity, more efforts are still needed to determine the degree of transferability of such experiences to other soils of the same order. Since not all of these soils can be provided with irrigation, studies on how best to use the water available from rainfall coupled with water and soil conservation practices wherever applicable should provide the needed data and management for the required combination of water control and fertilizaton to improve production of economic crops in these areas.

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