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Abstract

Soil infertility is a major constraint to food production in the communal areas of Zimbabwe. Smallholders in the region recognize the problems of low soil fertility and have devised ways of coping with them. This study describes the use of farmers' taxonomies of themselves and their soils to identify and understand the options they have, and the constraints they face in managing poor soil fertility in Chihota, a sub-humid communal area of north central Zimbabwe. It is part of an effort by a group of agricultural researchers and extensionists working on improved soil fertility technologies, to better integrate their work with farmers in order to expose the latter to promising technologies, get feedback on the technologies merits and feasibility, and help farmers experiment with them. The results show that these farmers have relatively sophisticated taxonomies, which provide a good picture of the resources, constraints, and concerns they have about soil infertility and ways to manage it. The taxonomies are an important framework for integration of technical interventions with farmers' requirements, systems, and circumstances.

Key words: participatory methods, soil fertility, local taxonomies, smallholders, Zimbabwe

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Introduction

Soil infertility is a major constraint to food production in Southern Africa (see Kumwenda et al. 1996). Soils can be very poor, and inorganic fertilizers have become expensive. Furthermore, the low fertility of the soils diminishes the effectiveness of these inputs. The development and adoption of new technologies to enhance soil fertility are important components of improving food security in the region, particularly among smallholders.

Smallholders in the region recognize the problems of low soil fertility and have devised ways of coping with them (for Zimbabwe see Huchu and Sithole 1993; Carter and Murwira 1995; Scoones et al. 1996). The new technologies would either improve on those practices or substitute them. Therefore, it is important to understand what those practices are and what are their advantages and disadvantages in order to assess the appropriateness of these new technologies, their adoptability, and, if necessary, to modify them to better suit farmers' needs. Farmers' current practices do not exist in a vacuum. Associated with them is a knowledge system that provides a framework for their application and evaluation. Furthermore, farmers' socioeconomic conditions also heavily influence the use of these practices.

An important contribution of farmer participatory research has been the recognition of the value of farmers' knowledge systems in general, and in particular, their potential role in the development, evaluation, and diffusion of new agricultural technologies (Ashby et al. 1995; Bentley 1994). Farmers' taxonomies are a well-documented part of their knowledge systems. The taxonomies include soils and productive environments (Bellon and Taylor 1993; Carter and Murwira 1995; Sandor and Furbee 1996), insects and pests (Bentley et al. 1994), crops and crop varieties (Richards 1986), and soil and water management practices (Lamers and Feil 1995).

This study describes the use of farmers' taxonomies of themselves and their soils to identify and understand the options available to them and the constraints they face in managing poor soil fertility in Chihota, a sub-humid (650-800 mm rainfall, Natural Region IIb) communal area in northern Zimbabwe. Soil infertility is the major biophysical constraint to agricultural production in this area.

The Soil Fertility Network and Soil Fertility Technologies

The Soil Fertility Network for Maize-Based Cropping Systems in Malawi and Zimbabwe (Soil Fert Net) began in 1994 with funding from the Rockefeller Foundation. It is a grouping of agricultural researchers and extensionists from government research institutions and universities in Malawi and Zimbabwe, together with their colleagues in international research institutes. It is coordinated from CIMMYT-Zimbabwe. The Network aims to help smallholder farmers in Malawi and Zimbabwe produce higher, more sustainable, and profitable yields from their dominant maize-based cropping systems through improved soil fertility technology and better management of scarce organic and inorganic fertilizer inputs. In recent years, Network members have become more confident that some of the technologies they are working on will provide benefits to smallholder farmers. The Network is now moving toward fully integrating farmers through initiatives that expose many farmers to promising soil fertility technologies. In addition, this move toward integrating farmers allows researchers to get feedback on the merits and feasibility of the various technologies and to help farmers experiment with them. Network members decided to establish one such major initiative in Chihota during 1998. The participatory work described in this paper was the first step in that initiative and was aimed at learning more about farmers' current knowledge, concerns and opportunities with soil fertility in that communal area.

Field Site and Methods

Chihota communal area is located in Marondera district, Mashonaland East Province, Zimbabwe. It has nine wards, each with five to six villages. Chihota is relatively close (50-80 km) to Harare, and therefore farmers have important farm and off-farm opportunities. Maize continues to be the most important crop in the region, however, the production of vegetables in gardens, off-farm labor, and migration are important sources of income. From a strategic perspective, these conditions make this area an interesting place to conduct research because it is an area where soil fertility problems and their management options interact with the nonagricultural sector of the economy. If we assume that in the future more farmers in Zimbabwe will have access to these opportunities as the economy develops, our results will illuminate the potentials and constraints of these technologies under changing conditions.

Most of the soils in this area are sands of granite origin and many show a catenary[1] association. Under the US Soil Taxonomy system, upper and midslopes are classified as Arenic or Plinthic Paleustalfs or Typic Kandiustalfs and lower slopes as Aquic or Typic Ustipsamments (Anderson et al. 1993). They vary in texture from sands to sandy loams on upper and midslopes to sandy clay loams in the lowest dambo or vlei areas. Soil depth ranges from moderately shallow (>50 cm) to moderately deep. Average crop yields in the area are well below the potential. Low pH is an important constraint in these soils (Dhliwayo et al. 1998:217). Furthermore, considerable research on soil improvement methods including liming, use of inorganic NPK, legume rotations, and green manures has been carried out in the area (Waddington et al. 1998a) .

Four wards were selected based on whether or not soil fertility research work had been conducted there, two and two, respectively. In each of the wards, 14 to 23 farmers took part in group discussions; in all, 69 farmers participated, 46% of which were female. Discussions took place during the dry season during a two-week period in September 1998. In an effort to

[1] A catena is defined as a sequence of soils from similar parent material and of similar age in areas of similar climates, but whose characteristics differ because of variations in relief and drainage.

capture the different views of gender groups, the participating farmers in each ward were divided into three groups: male, female, and mixed. The farmers were invited to participate in this exercise by a local officer from the Department of Agricultural, Technical and Extension Services (Agritex). Members of the Department of Research and Specialist Services (DR&SS) and CIMMYT also participated. The discussions were led and recorded by members of Agritex and DR&SS.

Group discussions were used to elicit three types of farmers' taxonomies: (1) of farmers, (2) of soils, and (3) of climate. In this paper, we report only on farmers and soils. With those taxonomies as a framework, a discussion followed on management practices to improve soil fertility. The aim was to use farmers' knowledge and perceptions in an open but systematic way to illuminate the problems and opportunities they have with improving soil fertility.

Under farmer taxonomy, participating farmers came up with a list of farmer categories, category descriptions, and category strengths and weaknesses. On soil taxonomy, various soil types were listed and described. Strengths and weaknesses of each soil type were explored. Farmers then suggested how each soil type could be improved and discussed their constraints regarding such improvements.

Following each group discussion, a short questionnaire was administered to all participants. It solicited information on personal characteristics of the respondent, such as age, education, marital status, as well as household characteristics, which included identifying the head of the household, family size, landholdings, crops grown and area planted to each for the previous season (1997/98), ownership of livestock, and agricultural implements.

Participants were asked to rate six different sources of income in terms of their importance to the household during the past five years (e.g., very important, regular importance, not important): cited sources were (1) maize production, (2) production of other crops, (3) animal production, (4) off-farm labor in agricultural activities, (5) off-farm labor in nonagricultural activities, and (6) remittances. Farmers were also asked about their use of six soil fertility improvement practices during the previous season: (1) application of manure, (2) application of chemical fertilizers, (3) application of lime, (4) planting of a leguminous crop in rotation with maize, (5) intercropping of a leguminous crop with maize, (6) planting of green manures. Finally, they were asked whether they had previously worked with the Agritex extension worker in their area or with DR&SS.

The Participants

Knowing who your participants are is a central issue in any type of participatory research. The content and quality of the information elicited and the joint outputs obtained depend on with whom one works. In this exercise, farmers were invited to participate by their ward's Agritex extension worker. As is often the case in participatory research, this was clearly a self-selected and therefore biased sample (involving principally farmers that work in groups with Agritex). Nevertheless, it is important to identify the characteristics of the farmers we work with, and the extent of their similarities and differences. We were able to achieve this through the short questionnaire.

To assess the degree of heterogeneity among the informants, we applied a two-stage modified location model (Franco et al. 1998) to generate groups or clusters of farmers that share the same socioeconomic characteristics. The information used to form those clusters included only part of the data set that we had collected, specifically, family size, landholdings, area planted, number of livestock (oxen, cattle and goats) owned, ratings of six sources of income, and ownership and use of agricultural implements.

Table 1. Characteristics of the groups of farmers formed by the application of clustering method: variables used to form these groups

Group		A	B	C	D	E	Total
N		14	12	25	13	5	69
Family size							
(persons)	Mean	9.6	8.0	6.7	6.2	6.4	7.5
Std. Error		0.8	0.7	0.5	0.8	0.8	0.4
Landholding							
(ha)	Mean	2.0	1.8	1.7	0.8	0.6	1.5
Std. Error		0.3	0.3	0.3	0.1	0.2	0.2
Area planted							
(ha)	Mean	1.0	0.6	0.8	0.4	0.4	0.7
Std. Error		0.1	0.1	0.1	0.01	0.1	0.1
Number							
of oxen	Mean	3.4	2.5	2.1	0.2	0.0	1.9
Std. Error		0.6	0.5	0.5	0.2	0.0	0.3
Number of							
cattle	Mean	11.6	10.4	3.8	1.0	0.4	5.8
Std. Error		2.8	2.2	0.6	0.6	0.4	0.9
Number of							
goats	Mean	1.9	1.1	1.8	1.0	0.6	1.5
Std. Error		0.4	0.5	0.4	0.5	0.6	0.2
Farmers who rated as very important sources of income (%):							
Maize		57.1	91.7	88.0	92.3	40.0	79.7
Other crops		7.1	66.7	28.0	15.4	0.0	26.1
Animal production		71.4	91.7	80.0	76.92	0.0	73.9
Off farm agricultural labor		7.1	25.0	12.0	30.8	60.0	20.3
Off farm non agricultural labor		21.4	66.7	4.0	38.5	60.0	29.0
Remittances		0.0	66.7	20.0	61.5	0.0	30.4
Ownership and use of implements (%)							
Plough	own	100.0	91.7	16.0	0.0	0.0	42.0
	rent	0.0	0.0	48.0	69.2	60.0	34.8
Cultivator	own	92.9	100.0	36.0	15.4	0.0	52.1
	rent	7.1	0.0	48.0	84.6	80.0	40.6
Cart	own	92.9	100.0	36.0	15.4	0.0	52.2
	rent	7.1	0.0	48.0	84.6	80.0	40.6
Tractor	rent	14.3	16.7	12.0	15.4	0.0	13.0
	do not use	85.7	83.3	88.0	84.6	100.0	87.0

The results of applying the clustering method are shown in Table 1. Five groups of farmers emerged. The group characteristics suggest a gradient of wealth and access to resources. Group A appears to be the wealthiest. Its members have the largest average landholdings, area planted, and number of oxen and cattle. As a source of income, animal production was viewed by the highest percentage of farmers as being "very important," remittances by the lowest percentage, and off-farm agricultural labor by the next to lowest percentage. All of the members of this group own a plough, and most own a cultivator and a cart. This group also has the highest average family size, and therefore the highest potential for family labor availability.

Group B appears to be the second wealthiest, in terms of average landholdings and number of oxen and cattle. A high proportion of its members rated maize and animal production as "very important," followed by remittances and nonagricultural off-farm labor. This group seems to have the most diversified sources of income. Most own a plough, and all own a cultivator and a cart. They also have the second largest average family size.

Group C appears to be the third wealthiest, following the patterns of the previous two in terms of assets, but with a substantially smaller average number of cattle. The two sources of income that received a high proportion of the "very important" rating are maize and animal production. In contrast to group B, other sources of income received substantially fewer votes for "very important," which suggests a higher degree of specialization in agriculture. In this group, the ownership of ploughs, cultivators, and carts decreases substantially, and farmers depend more on either renting these implements or simply do not use them at all.

Group D ranks fourth, with less than half the average landholdings and area planted of Group A. Few farmers in this group own oxen, as the average for the group is one head of cattle per farmer. As with groups C and B, the two sources of income that received a high proportion of the "very important" rating are maize and animal production; remittances, however, also got a relatively high proportion. No one in this group owned a plough, and only a few own a cultivator or a cart. Most of the Group D farmers either rent these implements or do not use them.

Group E, apparently those with the least wealth, was the smallest group with only five members. On average, its members have the fewest agricultural assets of all groups, in terms of landholdings, oxen, cattle, and implements. Maize and other agricultural activities were rated as a "very important" source of income by the lowest proportion of group members. On the other hand, off-farm labor, both agricultural and nonagricultural, seem to be important income sources among its members. This group could be viewed as the poorest. Alternatively, given off-farm sources of income, this group may simply be the least involved in agriculture. However, considering that agricultural off-farm labor is usually poorly paid and that ownership of animals is a good indicator of wealth and savings in Shona rural society, it is likely that indeed this group may be the poorest.

Table 2 presents other characteristics of these farmer groups that were not taken into consideration in their formation. Female-headed households were found in all groups, except group A; and although their proportional representation varied, they are not necessarily associated with the groups classified as poorer. Not surprisingly, most of the farmers have worked with Agritex or DR&SS in the past; of the groups, Group D had the lowest percentage of farmers who had such contacts.

Table 2 also presents the extent of adoption of practices to enhance soil fertility. The application of manure and chemical fertilizer is by far the most commonly adopted practice, both overall and within the groups. The use of legumes in rotation or intercropping with maize shows intermediate levels of adoption, except for group A, in which adoption is high. Finally, lime and green manure are the least commonly adopted practices.

In general, the adoption patterns are similar among the groups, however, a few groups display some unique and interesting characteristics. For instance, Group A shows the highest adoption of all the practices, except for legume intercropping. For lime and green manure, adoption is as high as 25% and 20% of its members, respectively. Group D has the lowest proportion of adoption of manure and fertilizer, though this does not hold for the other practices. Group E has a high proportion of members using manure, which is surprising given that few group members have animals. This suggests that they are purchasing this input, probably with part of the income derived from off-farm labor.

Although this is a biased sample, the information presented above indicates variation among the participants. There is a gradient of assets and sources of income among them, however even the "best-off" farmers in our groups could be considered resource poor by most measures, as average landholdings and number of cattle are not very large. The composition of Group A-better-off male farmers, who have adopted some practices at higher rates than the other groups-suggests that this group is made up of "master farmers," i.e., farmers who have completed a comprehensive training course managed by Agritex and who afterwards agree to undertake "good" farming practices.

Table 2. Additional farmers' characteristics and degree of adoption of soil fertility improvement practice by group

Group		A	B	C	D	E	Total
N		14	12	25	13	5	69
Male headed households (%)		100.0	58.3	70.8	58.3	80.0	73.1
Have worked with:	Agritex	100.0	100.0	92.0	69.2	100.0	91.3
	DR&SS	28.6	41.7	28.0	30.8	0.0	29.0
Farmers who said they applied input/practice last season (%):							
manure		100.0	100.0	92.0	76.9	100.0	92.8
fertilizer		100.0	100.0	84.0	76.9	80.0	88.4
lime		28.6	8.3	20.0	15.4	0.0	17.4
green manure		21.4	16.7	8.0	15.4	0.0	13.0
legume:							
in rotation with maize		92.9	50.0	60.0	53.9	40.0	62.3
intercrop with maize		50.0	50.0	60.0	61.5	40.0	55.1

Farmers' Taxonomies of Themselves

The farmers in these groups classified themselves in many ways. The classifications are based on the presence or absence of an attribute, and therefore are dichotomous. Some of these attributes refer to personal characteristics, such as age and sex, though most involve the ownership or lack of an asset, such as cattle, or access to income or knowledge. Not surprisingly, inherent in most of these classifications are common socioeconomic categories such as age, gender, wealth, and access to inputs and knowledge. However, some of the attributes associated with these "types" include value judgments such as laziness and industriousness.

The different types of farmers identified by the groups are presented in Table 3. Recognizing that the participants' classification of farmer types reflect common socioeconomic categories, we grouped them by age, gender, ownership of assets, labor allocation and organization, access to cash, knowledge, linkages to the market, and synthetic, (i.e., a type that incorporates attributes from several other types).

Age is associated with the ownership of assets, access to family labor, and knowledge. In general, younger farmers are considered worse off than older farmers. Gender is associated with control over labor, assets, and income. Male farmers are in control and, not surprisingly, there seems to be tension between male and female farmers. For example, females believe that they are not rewarded for their labor and that their fields are prepared last.

The ownership of assets in general is linked with the timing of farming operations, the ease of performing them, and the crop yield achieved. It is thought that owners perform operations on time and easily, and therefore get higher yields than nonowners. A particularly important asset is the ownership of gardens. Six different groups mentioned gardens in very positive terms. Gardens provide a stable income and are less subject

Table 3. Farmers' taxonomy of themselves and their characteristics

Socioeconomic category	Farmer type	Groups who mention it
Age	Young	3
	Old	3
Gender	Male	3
	Female	3
Ownership of assets/access inputs	draught to animals	3
	cattle	3
	manure	1
	implements	4
	garden	6
	dry lands	6
	large fields	1
	small fields	1
	own fields	1
	fenced fields	1
Labor allocation	work outside the area	1
	work in groups	2
	work individually	2
	industrious	4
	lazy	4
Access to cash/wealth	adequate cash for farming	3
	rich	2
	poor	2
Knowledge	with knowledge	5
	with Master Farmer certificate	1
Linkage to market	sell their produce	1
	subsistence	1
Synthetic (combine different categories)	perform operations timely	2
	attain high yields	1
	plan operations	1

to drought than dry lands, on which income is more seasonal, less stable, and production is more vulnerable to drought. The size of a landholding is another interesting variable. Survey participants thought that farmers owning larger fields tended to spread inputs thinly, while those with smaller fields concentrated them. Agritex advocates farming smaller areas and concentrating inputs in them, even if one has a larger landholding. The authors do not understand why farmers with larger landholdings do not concentrate inputs in smaller areas. On the other hand, maximization of the area under cultivation has been observed in marginal environments in Africa and it may, in fact, be a risk management strategy (Carter and Murwira 1995:82).

Labor allocation refers to the ability of farmers working outside the area to hire local labor. This is a process by which those with skills to work elsewhere substitute their own labor with hired local labor, indicating an increased integration of these farmers into the market economy. Another dynamic in these circumstances is labor organization, whereby farmers working in a group cooperate by sharing labor, knowledge and the purchase of inputs. Working in a group may be more common among farmers who work closely with extension, because extension officers promote such group arrangements. One particularly puzzling taxonomy is based on classifying farmers as lazy or industrious. It is not clear whether lazy farmers are actually lazy or rather, poor or sick. The farmer participants recognized such “lazy” farmers as a good source of labor. But, if these farmers are indeed lazy, why are they working for others?

Access to cash was associated with the timely performance of farm operations, and the ability to purchase inputs and hire labor. Not surprisingly, those with access to cash were considered to be in a better position that those without it.

Farmers who possess knowledge are viewed very positively. The groups provided a long list of advantages for those who have knowledge and a long list of disadvantages for those who do not. Knowledge was associated with timely operations, high yield, and crop rotations. The emphasis on knowledge may also be related to the fact that almost all participants work with Agritex, and therefore value access to knowledge-they have been exposed to the message that knowledge is important. One group of farmers also classified farmers into those with and without a Master Farmer Certificate, which, in effect, recognizes the technical training that Agritex provides.

Linkage to the market captures the differences between those who sell their produce and those who are subsistence farmers. However, this distinction may not be so rigid, because most likely many farmers are both.

Finally, three farmer types recurrently appear, frequently together, as attributes in the other taxonomies: timely performance of farming operations, high crop yields, and planning of operations. These attributes are highly correlated. In the view of farmers, ownership of assets, access to cash, and possession of knowledge lead to good planning and timely operations, which in turn lead to high yields.

Farmers' Soil Taxonomies

Farmers in Chihota have a broad and sophisticated soil taxonomy. They recognize ten different soil classes, although not all classes were described by all groups (Table 4). The most widely recognized soil classes with an agricultural use are Shapa, Jecha, Rukangarahwe, and Churu. Rebani (also known as Doro) and Rondo (also known as Chidakha) were mentioned by less than half of the groups, Mhukutu (also known as Bukutu) by two groups and Chinamwe by only one. Two soil classes without agricultural uses were also mentioned: Gokoro and Chibandati.

As Table 4 shows, the male groups mentioned slightly more soil classes than the female groups. The mixed groups reported the largest number of soil classes, in many cases twice as many as those reported by the other two groups.

Table 5 presents a description of the soil classes and their respective advantages and disadvantages according to the farmers. The descriptions and assessments given by the different groups were very similar. These descriptions are based on texture (i.e., particle size), fertility status, and color (the latter is used to distinguish subclasses). The advantages / disadvantages mentioned by the farmers refer particularly to the water holding capacity of the soil class, the ease of working it, inherent fertility, response to fertilizers and manure, proneness to waterlogging, particular uses (e.g., use in gardens and appropriateness as a building material).

The soil classes described by these farmers can be segregated into two classes based on their texture:

- Lighter texture soils with high sand content, found in areas where dryland agriculture is practiced and maize is the primary crop.
- Heavier texture soils, with high clay content, found where gardens are located, near the bottom of the catena, and usually close to water sources.

Based on local perceptions, the two most important soil classes for maize production are the lighter texture soils Jecha and Shapa. Jecha is a sandy soil of low fertility and poor water-holding capacity. It can be easily waterlogged, is easy to work, and is good for building. Shapa is a sandy loam soil, with low to average fertility (yields may be low unless additional inputs are applied), but better water-holding capacity than Jecha. It can also be waterlogged and is easy to work, but it is not good for growing groundnut. The subclasses of Shapa depend

Table 4. Farmers' soil classes and number of groups who identified them by type of group

	Groups			
Soil class	Male	Female	Mixed	Total
Shapa	3	2	4	9
Jecha	3	2	4	9
Rukangarahwe	1	2	4	7
Rebani/Doro	1		3	4
Mhukutu/Bukutu	1		1	2
Rechuru/Churu	1	2	4	7
Chinamwe		1		1
Rondo/Chidhaka	1		3	4

Table 5. Farmers' soil taxonomy: characterization of their soil classes

Soil class	Groups who mention it	Sub-classes	Description	Advantages	Disadvantages
Jecha	9	white blackish grayish	sandy soil, coarse grained, low fertility, use for building	• responds to manure application • can get good yields even with inadequate rains • easy to work • good for building	• low fertility • low water holding capacity • easy to erode • waterlogged easily • can get very hot • difficult to farm because a need to put more inputs
Shapa	9	black (dema) white (nhuke)	sandy-loam soil, easy to cultivate, low fertility	• produces good yields even with inadequate rains • average water holding capacity • can hold water for long periods • one can grow any crop • responds well to manure and fertilizers • easy to work • can be worked by hand	• low to average fertility • no yields unless inputs are added • gets waterlog under heavy rains • crop failure if little rain • maize wilts easy when hot • not good for growing groundnuts •
Rukanga- rahwe	7	reddish whitish	gravel, mixture of fine and coarse grained sands	• resist erosion • good yields if good rains • does not waterlogged • good for road construction • good for fruit tree production •	• infertile • makes farming implements blunt • difficult to work (plowing and weeding) • poor water holding capacity • crops wilt with reduced moisture • difficult to deep plough • needs too much water • many plants are cut during cultivation • harbors termites
Churu/ Rechuru	7	makura: upland soil type of termite moundbani: fley soil type of termite mound	termite mound soil, heavy texture, sticks when wet and cracks when dry	• can be used to improve soil • high fertility • good yield if good rains • used for molding & plastering • use as graveyards •	• hard to dig • crops wilt with slight moisture stress • requires a lot of water to support plant growth • difficult to plough
Rebani/ Doro	4	blackish whitish	clay soil, heavy texture, sticky, requires a lot of water, found in gardens/wet areas	• can grow crops all year • high fertility • can be cultivate without adding fertilizer • retains moisture • good for pot making	• easily waterlogged • hard crust formed when hot • sticky in wet conditions
Mhukutu/ Bukutu	2	reddish	sandy, clay and loam soil, heavier texture, needs a lot of water	• high fertility • good water holding capacity • yields with adequate rains • produces few weeds • used for plastering	• cracks with little moisture • needs harrowing after plowing • sticky, difficult to use implements
Chinam-we	1	fine grained coarse grained	heavy clay soil, very heavy texture, found in	• good fertility • good yields with average rains	• difficult to cultivate when wet • slippery when wet • sticks to farming implements
Rondo/ Chidhaka	4	blackish	Clay soil, heavy texture, high fertility, good water retention capacity, very hard when dry, also used in pottery	• high fertility • good waterholding capacity • can be used for rice and vegetable production • can be cultivated all year	• can get waterlogged • difficult to plough • cracks when dry • difficult to work when too wet

on the position of the soil in the toposequence; they include

- the darker soil, which is considered more fertile, located at the lower areas close to the dambo (vlei) areas;
- the whitish soil, located in the intermediate areas, in the margins of dambo areas;
- and the grayish soil, the least fertile, located at the top of the toposequence.

The soil taxonomy elicited from the farmer groups is consistent with findings from other studies in local soil taxonomies. As in other parts of the world, soil texture and color are the most important characteristics recognized by the smallholder farmers. Other characteristics that farmers refer to and that have also been found by others include appropriateness for agricultural use, ease of cultivation, water-holding capacity, and fertility (e.g., Bellon and Taylor 1993:772 for Mexico; Sandor and Furbee 1996:1507 for the Andes). Farmers' distinction between upland and riverbank soils has also been reported for Zambia (Edwards 1987:7) and Zimbabwe (Carter and Murwira 1995:78).

Farmers' Management of Soil Fertility

Table 6 presents a list of the practices that farmer groups identified as improving soil fertility and the number of farmer groups that cited each practice. These practices may or may not actually be used by farmers, but, nevertheless, are recognized by them. The most common practices include the addition of termite mound soil, cattle manure, and inorganic fertilizer to the soil. Lime was also widely mentioned, however, this may be because the farmers have been exposed to this knowledge through past work with extension, and so it may not be an indicator of widespread use. As Table 2 shows, the adoption of lime is relatively low.

Table 6. Farmers' practices to improve soil fertility and number of farmer groups who mentioned them by soil type

Soil type	Jecha	Shapa	Rukanga-rahwe	Churu/ Rehuru*	Rebani/ Doro	Rondo/ Chidhaka	Mhukutu/ Bukutu	Chinamwe
Number of groups mentioning specific soil type	9	9	7	7	4	4	2	1
Soil improvement practice								
add termite mound soil	7	9	4	0	3	2	0	1
add manure	6	8	5	4	3	2	1	1
add fertilizer	4	6	5	3	2	2	0	1
add lime	4	7	2	1	1	0	1	0
add compost	2	2	0	0	0	0	0	0
rotation	1	1	0	0	0	0	0	0
fallowing land	3	1	0	0	0	0	0	0
early planting	3	4	0	0	0	0	0	0
dry planting	0	0	0	0	0	1	2	0
early plowing	1	1	1	0	1	0	0	0
deep plowing	0	0	2	0	0	0	0	0
soil analysis to add correct fertilizers	0	1	0	0	0	0	0	0
conservation works (contours)	1	3	0	0	0	2	0	0
drain excess water with cultivator	1	0	0	0	0	1	0	0
raised beds	0	0	0	0	2	2	0	0
timeliness of operations	0	0	0	0	0	1	0	0

* The churu or termite mound soil can be used to improve other soils, but also can be planted. Therefore there are a few specialized practices for this soil type, which includes: potholing to trap water, add sand, plow when moist.

Only one group mentioned the rotation of maize with a leguminous crop as a soil improvement practice. Most of the groups did not recognize it as a soil improvement practice, even though rotations are widely practiced by the participating farmers (Table 2). This may be because of the dominance of the maize cereal crop and the low fertility of the soils where rotations take place, which restrict the production of legume biomass and N fixation, and therefore their beneficial effect on the soils.

Similarly, no farmers identified intercropping of maize and a leguminous crop as a soil improvement practice, although it is widely used. Clearly, farmers do not perceive a benefit to soil fertility associated with the use of legumes. This indicates a knowledge gap that must be addressed if research and extension want to promote the use of leguminous crops for soil improvement. It also indicates that this gap may be because current rotations have little effect over the soil fertility in local conditions.

Several of the practices the farmers referred to could not be considered as enhancing soil fertility per se, such as early or dry planting, early or deep plowing, draining excess water, raising beds, or timeliness of operations. These practices may be perceived as improving soil fertility because they can interact with more conventional practices, such as the addition of fertilizers or manure, and thereby enhance their effectiveness. For example, early planting may lead to a larger production of crop biomass, particularly if cattle manure or fertilizers are added, which, if incorporated back into the soil will improve soil fertility. The identification by the farmers of practices such as soil analysis and conservation works may result from interactions these farmers have had with extension workers, who in the past promoted, or at least referred to, these practices.

There does not appear to be a clear association between the soil improvement practices cited by the farmers and the soil types they recognize, as most they would prescribe most of the practices for all of the soils (or at least Jecha and Shapa, the most important ones). However, there were a few exceptions, specifically the use of deep plowing for Rukangarahwe, raised beds for Rebani / Doro (heavier soils in gardens), and fallow, mostly associated with Jecha. Overall, this would seem to suggest that we should not be overly concerned with trying to tailor practices to farmers' soil classes, at least when dealing with dryland farming. However, such an assumption may be premature because new practices or technologies may not respond equally well to the various soil types and / or the lack of specificity exhibited by the farmers may result from a lack of knowledge. Whether matching soil improvement technologies, current or future, to farmers' soil classes generates additional net benefits, and therefore is merited, requires further thought and research.

Constraints to Farmers' Soil Fertility Management

When farmers were queried about the soil fertility management practices we've been discussing, they were also asked to provide constraints to their use. Table 7 lists these constraints together with their associated practice(s), and notes the number of groups that mentioned it.

The constraints reflect a number of underlying themes or issues. The two most common themes are

- scarcity of and access to inputs-both local, such as manure and termite mound soil, and purchased, such as fertilizers and lime; and
- labor scarcity for the application of inputs, due to the labor intensiveness of the operations or simply the lack of available labor or cash to hire it.

A similar theme that emerged was that of priorities given to alternative uses for the input; for instance, the preference for applying manure to gardens rather than field plots, or the low priority given to improving some classes of soil (in this case, Rukangarahwe). The lack of implements and power were also cited as limitations, although these relate to the specific practices of deep plowing and the application of termite mound soil. Also mentioned was lack of land, which limits the frequency and duration of fallows. Several farmer groups mentioned lack of knowledge about application rates for fertilizer and the use of lime as

Table 7. Farmers' constraints to soil improvement practices and number of farmer groups who mentioned them by soil type

	Soil type	Jecha	Shapa	Rukanga-rahwe	Rebani/ Doro	Mhukutu/ Bukutu	Churu/ Rechuru	Chinamwe	Rondo/ Chidaka
Constraint	**Improvement practices:**								
lack of cash to purchase inputs	* fertilizer * lime	6	7	2	0	1	1	0	2
lack of cattle	* manure	1	0	0	2	0	1	1	0
shortage of termite mounds	* termite mound soil	0	2	0	1	0	1	0	0
shortage of labor to dig and move mound	* termite mound soil	2	3	1	0	0	1	1	1
lack of cash to hire labor	* early planting * inputs	1	1	1	0	0	0	0	1
labor intensive	* termite mound soil	2	0	0	1	0	0	0	0
labor intensive to raise beds	* raised beds	0	0	0	2	0	0	0	0
lack of cart to move termite mound	* termite mound soil	1	2	1	0	0	0	0	2
shortage of draft power	* manure * early plowing * deep plowing	1	1	0	0	0	0	0	0
lack of knowledge	* use of lime * rates of application of fertilizer	2	4	2	0	1	0	0	0
shortage of arable land	* fallowing land	2	0	0	0	0	0	0	0
priority of manure for garden	* manure	1	1	1	0	0	0	0	1
low priority for the soil class	* termite mound soil	0	0	3	0	0	0	0	0
digging mound causes erosion	* termite mound soil	0	1	0	0	0	0	0	0

constraints. This was surprising given that, in general, these farmers work closely with extension agents. This suggests that there may be a need for better communication between them. Finally, one group also mentioned soil erosion as a constraint.

The overriding theme regarding constraints to employing better soil fertility practices center on the scarcity of the factors of production-labor and capital, and to a much lesser extent land, and also knowledge. Although the sample may include better-off farmers, they are still resource poor. If anything, these constraints may be even more acute in the rest of the farming population.

The list of elicited constraints can be incorporated into a scheme for the assessment of new soil fertility improvement technologies. Farmers and researchers would want to assess how a new soil fertility management technology performs with respect to

- access to the inputs;
- labor intensity, including timing of the labor used;
- additional knowledge required to successfully apply the new technology;
- requirements for the effective use of implements, in terms of the types of implements, access to them, and timing of their use;
- assessments of the new technology as it relates to farmers' current priorities and resource allocation.

This assessment involves not only the technology per se, but the infrastructure and institutional setting in which it may be deployed, as well as the changes that would be required for increasing its possibility of adoption.

Discussion

The analysis of the farmers' taxonomies shows that the systems are consistent and logical. There are no glaring contradictions, and the surprises can be explained; for example, the fact that nearly all groups failed to consider crop rotation to be a soil improvement practice. The information contained within these taxonomies provides a framework for understanding the farmers' soil fertility practices.

There is great consistency between the themes that emerged from the taxonomy of farmers and the constraints they face in applying soil fertility improvement practices. The ownership of assets (such as cattle and draught power), access to cash to pay for labor and inputs, and possession of knowledge are important categories in the taxonomies of farmers. Indeed, these factors allow or constrain the use of most of the soil fertility improvement practices recognized by farmers. Those with cattle, draught power, and financial resources, i.e., wealthier farmers, should be better able to use soil fertility improvement technologies than those without them, i.e., poorer farmers. Young or female farmers, considered to have less access than others to these resources, are probably in a poorer position to apply these practices. Not surprisingly, the cluster of participants found in Group A, which could be considered the wealthiest, reported the highest rate of adoption of all soil fertility practices. Although this should not be interpreted as definitive evidence, it certainly is consistent.

The most recurrent theme cited by the participants is the timing of farm operations, typically a major concern for farmers in areas characterized by unimodal rainfall area. Delays imply decreased productivity. Ignorance of the correct scheduling of fertilizer and / or lime applications was mentioned as a constraint to using these inputs. Delays are also associated with a lack of assets and access to resources, consequently, such delays should be a greater issue for poorer farmers. Undoubtedly, the factor of timing in the use of soil fertility improvement practices, and the potential for conflict and complementarity between the practices and other farm activities, must be an important consideration in their improvement, design, and assessment.

Many of the practices, relationships, and themes identified here have been reported in previous studies, which used different methodologies, in the communal areas of Zimbabwe. Carter and Murwira (1995:78) observed most of the same soil fertility management practices and crops for the Mutoko communal area in northeast Zimbabwe. They also found that gardens are very important for farmers. Huchu and Sithole (1993:45-48) also reported many of the same soil fertility practices for communal areas in other natural regions of Zimbabwe. Crop management and productivity levels among smallholders in the adjacent areas of Mangwende and Mutoko were found to be closely related to cattle ownership (Shumba et al. 1989:446; Carter and Murwira 1995:77). In Mangwende, ownership of cattle was used to identify target groups for potential technologies (Shumba et al. 1989:444). It was found that farmers with cattle had larger arable landholdings. In addition, they applied manure, had better and more timely seedbed preparation, more timely weed control, winter-ploughed and consequently planted earlier, achieved larger crop yields, and earned higher incomes. Another study showed that for maize and groundnut, increased quantities and earlier application of inputs increased grain or seed yield and economic return (Shumba et al. 1990:112). Another study in the same agroecological region showed that late planting of maize is a major contributor to low yields (Waddington et al. 1991:28). Because our results are consistent with other studies in the region and with what “common sense” would tell us, we are comfortable generalizing our results, despite the fact that they are based on a self-selected sample of farmers.

Given these results, what is the way forward? Many of the factors that constrain the use of soil fertility improvement practices cannot be eliminated through the efforts of Agritex or the Soil Fert Net, for example, those practices that require greater access to draught animals or farming implements. Nevertheless, these constraints should be taken into account in the identification, design, assessment, and promotion of “best bet” soil fertility technologies (Huchu and Sithole 1993: 49; Waddington et al. 1998b: 246). The technologies must be compatible with farmer circumstances and interests and where possible should improve the efficiency of resource use. One constraint that Agritex and Soil Fert Net can greatly impact is the knowledge gap. By providing better information on the time of application, quantity, and long-term management of lime and fertilizers, Agritex and Soil Fert Net can help farmers glean the full benefits offered by these inputs.

One practice that deserves special attention in future research efforts is the application of termite mound soil. It is one of the most widely mentioned practices, but it carries with it many constraints. Farmers seem to appreciate this practice, despite its high cost in terms of labor, implements, and management. In conversations among farmers, experiments with termite mound soil are frequently mentioned. Clearly, the practice is a very important option for farmers, and they appear willing to invest resources in it. Supply, however, is limited. This suggests the need for further research in the use and management of termite mound soil, particularly in conjunction with farmers, who are already experimenting with it. Furthermore, the application of termite mound soil could be a useful basis for comparison in the assessment of new soil fertility improvement technologies.

Conclusions

The farmers in our study area have relatively sophisticated taxonomies, which provide a good picture of the resources, constraints, concerns, and opportunities they have regarding soil infertility and ways to manage it. The farmers' taxonomy of themselves provides a good picture of their socioeconomic environment, while the farmers' soil taxonomies provide important insights into the fertility and management of their soils. The taxonomies provide an important framework for the integration of technical interventions with farmers' requirements, systems, and circumstances. They also provide valuable feedback to researchers on gaps and opportunities for new participatory research on soil fertility technologies.

Soil infertility and practices to reduce it are very prominent issues in the minds of farmers. Effectively addressing the issue will require a partnership that brings the best that outside research and extension have to offer together with the time-proven knowledge and practices of the local farmers.

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