Characterization of Soils from Potential PD/A CRSP Sites in East Africa

Interim Work Plan, Africa Study 4

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Introduction

The termination of research activities at the Rwasave Fish Culture Station in Rwanda, due to civil war in 1994, led PD/A CRSP/Africa researchers to revise many of the activities of Work Plan 7 and to begin the search for a new PD/A CRSP research site in Africa. Two aquaculture sites in Kenya were evaluated as future CRSP research sites. Pond soil samples were collected and characterized. Study 4 of the Interim Work Plan complemented that activity by providing for the collection and analysis of soil samples from additional sites. The soil characterization data obtained were intended to supplement other information about each site to be used in evaluating and selecting the new prime site for Africa.

Materials and Methods

Soil samples were collected from pond bottoms at five potential research sites in East Africa during country and site evaluation visits conducted on three trips made in 1994 and 1995. In Kenya, samples were collected at Sagana Fish Culture Farm (SFCF), Sagana, at Kibos Fry Production Centre, near Kisumu; and at the Baobab Farm, near Mombasa. Samples were also collected from ponds at the Lake Chivero Fisheries Station, near Harare, Zimbabwe, and at the Bunda College aquaculture facility, near Lilongwe, Malawi.

Sampling methods and sample sizes varied according to constraints faced by the researchers participating on the site evaluation trips. At SFCF, a composite sample was collected from each of three ponds (one each from the B, C, and D pond series, near the center of the farm) as well as from a soybean field on the west side of the farm. At Mombasa, samples were collected at the roadside near the entrance to the facility. Time constraints allowed for the collection of only one composite sample each at the Lake Chivero (Zimbabwe), Kibos (Kenya), and Bunda College (Malawi) sites. Most samples were collected using PVC core samplers inserted into pond bottoms to a depth of 15 cm. At Kibos and Bunda College, however, 15-cm-deep samples were collected using a shovel. There was an abrupt margin between horizons at a depth of 7 cm in the sample collected at Lake Chivero, so this sample was divided into two subsamples for analysis. All samples were air-dried as much as possible in-country before being returned to Oregon State University (OSU).

At OSU, samples were further prepared for analysis by completing air drying as necessary and crushing to pass a No. 10 (2 mm) sieve at the Oak Creek Laboratory, Department of Fisheries and Wildlife. Subsamples were then analyzed for sand, silt, and clay contents of the mineral fraction, organic carbon, pH, acidity, exchangeable bases (Ca, Mg, Na, K), SMP lime requirement, and total nitrogen content. Analyses were completed at the Oak Creek Laboratory and at the Central Analytical Laboratory (Crop and Soil Science) on the main campus. Base saturation, CEC of the clay fraction, and organic matter (OM) contents were estimated from the analytical data obtained.

Results and Discussion

The physical and chemical composition of each soil sample is shown in Tables 1-3. As might be expected, most samples taken from sites with earthen ponds had clay contents of 25% or more (Table 1). A notable exception was the lower (7- to 15-cm) horizon of the sample from Pond 3 at the Lake Chivero (Zimbabwe) site, which had a clay content of only 4.4%. The upper (0- to 7-cm) horizon in this pond had a clay content of 29.1%, which suggests that a blanket of clay may have

Table 1. Composition of soils sampled at African sites in 1994 and 1995.

Source	Sand*	Silt*	Clay*	Textural	Particle-size	O.M.
	(%)	*(%)*	*(%)*	*Class*	*Class*	*(%)***
Sagana (Pond D2)	5.8	12.5	81.7	clay	2:1 Clayey	3.88
Sagana (Soya field)	11.6	17.3	71.1	clay	Mixed Clayey	3.89
Kibos	32.4	29.3	38.2	cl. loam	2:1 Clayey	2.62
Chivero (0 - 7 cm)	51.0	19.9	29.1	s. cl. loam	Fine-loamy	3.90
Chivero (7 - 15 cm)	82.1	13.5	4.4	l. sand	Coarse-loamy	0.25
Bunda College	16.6	15.1	68.4	clay	2:1 Clayey	6.31
Sagana (Pond B2)	30.7	10.2	59.1	clay	Clayey	---
Sagana (Pond C6)	10.9	12.1	77.0	clay	Clayey	---
Mombasa	28.9	21.5	49.7	clay	Clayey	---

* Percentage of the mineral fraction.
** Organic matter, calculated as 1.7 x % organic carbon.

been applied to the pond during or after construction to prevent excessive seepage. It should also be noted that the original Mombasa soil sample contained a high proportion of coral fragments ranging in size from 4 mm to 10 cm in diameter or length, and that the clay content shown in Table 1 (49.7%), is for the fine earth (< 2 mm) fraction of the sample. The actual overall clay percentage of the soil at the Mombasa site was lower, and soils there were clearly too porous to retain water; this was also evidenced by the fact that the fish culture operation there was conducted entirely in concrete tanks. With the exception of these two soil samples, the physical characteristics of the soil at all sites evaluated would have been satisfactory for good water retention. Clay contents in some of the other samples were *very* high; for example, Pond D2 at Sagana was 81.7%.

The soil sample obtained from Kibos, Kenya, was described by station personnel as a "black cotton" soil. That sample, as well as the one from Bunda College, Malawi, did indeed have the appearance and some of the characteristics of this soil type: very dark brown to black colors, high contents of very sticky clay, relatively high pH values and base saturation percentages, and, in the case of the Bunda

Table 3. Exchangeable base contents of soils sampled at African sites in 1994 and 1995.

Source	Ca (meq/100 g)	Mg (meq/100 g)	Na (meq/100 g)	K (meq/100 g)	Sum of Bases (meq/100 g)
Sagana (Pond D2)	20.03	15.87	0.18	0.00	36.08
Sagana (Soya Field)	9.60	8.70	0.02	0.00	18.32
Kibos	20.40	4.75	0.90	0.35	26.40
Chivero (0 - 7 cm)	4.40	1.70	0.51	0.28	6.89
Chivero (7 - 15 cm)	0.65	0.26	0.12	0.05	1.07
Bunda College	30.05	14.65	0.90	0.42	46.02
Sagana (Pond B2)	*	*	*	*	*
Sagana (Pond C6)	*	*	*	*	*
Mombasa	*	*	*	*	*

* Percentage of the mineral fraction.
** Organic matter, calculated as 1.7 x % organic carbon.

Table 2. Chemical characteristics of soils sampled at African sites in 1994 and 1995.

Source	pH	Acidity (meq/100 g)	Sum of Bases (meq/100 g)	Soil CEC (meq/100 g)	Clay CEC** (meq/100 g)	Base Sat. (%)	Organic Carbon (%)	Organic Matter (%)***	SMP Lime Req. (kg/ha)	Total Nitrogen (TN)
Sagana (Pond D2)	5.08	20.83	36.08	47.23	57.81	76.39	2.28	3.88	10898	0.18
Sagana (Soya field)	5.44	15.53	18.32	26.63	37.45	68.79	2.29	3.89	8430	0.19
Kibos	6.55	6.90	26.40	27.70	72.51	95.30	1.54	2.62	1519	0.11
Chivero (0-7 cm)	5.20	7.25	6.89	9.40	n/a	73.34	2.30	3.90	4418	0.21
Chivero (7-15 cm)	5.55	1.50	1.07	1.25	n/a	86.00	0.15	0.25	0	0.00
Bunda College	6.85	11.80	46.02	46.20	67.54	99.61	3.71	6.31	1519	0.23
Sagana (Pond B2)	7.62	*	*	*	*	*	*	*	*	*
Sagana (Pond C6)	7.22	*	*	*	*	*	*	*	*	*
Mombasa	8.01	*	*	*	*	*	*	*	*	*

* Full analyses not carried out on alkaline samples.
** Calculated as Soil CEC/percent Clay*100.
*** Calculated as 1.7 x percent organic carbon.

College sample, a relatively high cation exchange capacity (CEC). The reactions of these soils were nearly neutral, with pH values of 6.55 and 6.85 and base saturation percentages of 95.3 and 99.6, respectively. Their CEC values were 27.7 and 46.2 cmol/kg soil, respectively. SMP lime requirements for these nearly neutral soils were relatively low (1519 kg/ha for both). The estimated CECs of the clay fractions of these soils (72.5 and 67.5 cmol/kg, respectively) suggest that in the absence of high levels of OM, a relatively high content of 2:1-type clay minerals such as smectite exists. This would be expected for "black cotton" soils. Such soils have several potential advantages in aquaculture, including low permeability, relatively high availability of nutrients, relatively low amounts of acidity, and high base saturation percentages, which result in minimal lime requirements.

Samples from the other sites were all quite acidic, with pH values ranging from 5.08 to 5.55. Base saturation percentages, however, were all greater than 68%. CECs from the Lake Chivero samples were quite low, at 1.25 and 9.40 cmol/kg (lower and upper horizons, respectively), but those from the Sagana soya field and Kibos were 26.63 and 27.70 cmol/kg, respectively. These values reflect the clay contents of the soils, and—to some extent—the type of clay present. The pH, CEC, and base saturation percentage relationships of these soils were reflected in their SMP lime requirements, which ranged from a low of 0 kg/ha (lower horizon, Lake Chivero) to a high of 10,898 kg/ha (Pond D2 at Sagana) (Table 2). With the exception of the Bunda College sample, the OM content of all samples was within the normal range expected in aquaculture ponds (Tables 1 and 2). Even the OM content of the Bunda sample (6.31%) was only slightly higher than the usual range of 0-5% observed in ponds (Boyd, 1979). Table 3 shows the proportions of the exchangeable bases (Ca, Mg, Na, and K) of the soils collected.

Anticipated Benefits

The characteristics of soils at different potential new research sites contributed to our overall understanding of the nature of the sites and to the final selection of the Sagana site. Ultimately, however, soil character played a minor role in the selection of a site for continued PD/A CRSP research in Africa. Only the Mombasa site was clearly unacceptable in terms of soil quality. Other site selection criteria, such as the existing physical infrastructure (ponds, lab facilities, communications, etc.), country political stability, potential USAID support, and factors such as the species available for use in the research program clearly outweighed soil character in importance as factors to be considered.

Literature Cited

Boyd, C.E., 1979. Water quality in warmwater fish ponds. Auburn University Agricultural Experiment Station. Auburn, Alabama, USA.