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EVALUATION OF SOME CONVENTIONAL METHODS FOR ESTIMATING AVAILABLE PHOSPHATE IN MUDS AT MBIABET RICE FARM, AKWA IBOM STATE

W. UBI, M. W. UBI AND A. U. AKPANIDIOK

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ABSTRACTS

A study was carried out in May 2008 using Seven Conventional methods for estimating available soil phosphorus from swamp mud, in acid sulphate soils of Mbiabet, Akwa Ibom State, Nigeria. The Seven extractants were tested to determine which would be suitable for routine use in the water-logged soils. The extractans were Bray and Kurtz's (0.03NNH$_4$F in 0.025N Hcl), Morgan's (10% NaOAC/3%HOAC), Sounder's (0.1NNOOH), Olsens (0.5N NaHCO$_3$ at pH 8.5). Treatment consisted of potassium dihydroxide added in the doses of 0, 50, 100, 150, 200, 250 and 300mg/kg, fitted into Latin square of 36 x 5m. Limestone (Ca CO$_3$) was applied at the rate of 50 kg/ha to reduce the activity of aluminum. The results of the selective tests showed that the Oslen's procedure gave the most reliable estimate of available P. Fractionation of the forms of inorganic phosphorus in the phosphate treated mud showed that the extracting solutions removed chiefly aluminium phosphate. In the absence of facilities for field, the relationship between crop response, concentration of soil phosphorus and available phosphorus as determined by Olsen's procedure gave the most reliable estimate of available P. was estimated for polyethylene bag culture experiment with rice and maize. Response to additions (Rice and Maize) had available P 11 mg/kg with Oslen's method.

INTRODUCTION

An investigation of the most suitable solvent and convenient procedure for determining available nutrients in soils has led to the accumulation of an enormous literature. However, there is little information on soils of the acid sulphate swamp mud type. A number of extraction methods have been proposed for measuring fractions of soils phosphorus (available phosphorus) that could be correlated with field response to crops in tropical soils. Phosphate is one of the chief limiting factors in the production of crops in the tropics (Vivman, 1964; Walts, 1965; Ubi and Osodeke, 2009). Seven conventional methods for estimating available soil phosphorus have been used by several soils scientists (Watts, 1965; Le Mare, 1968; Ubi and Osodeke, 2009). In addition to the acid and alkaline solutions, acid extractants containing chealating agents have been used for tropical soils of which the Bray and Kurtz No 1 and No. 2 solutions (Bray and Kurtz, 1945) have been widely used by soil scientists for measurement of available soil phosphorus.

According to Bray and Kurtz, the extractants remove proportional part of (or) the more readily soluble portion of each form of phosphorus. The use of acid-fluoride extractant for water-logged acid sulphate soils produced unreliable results. Anderson and Mogensen (1962) thus it is necessary to explore other conventional methods for estimating available soil phosphorus in such soils.

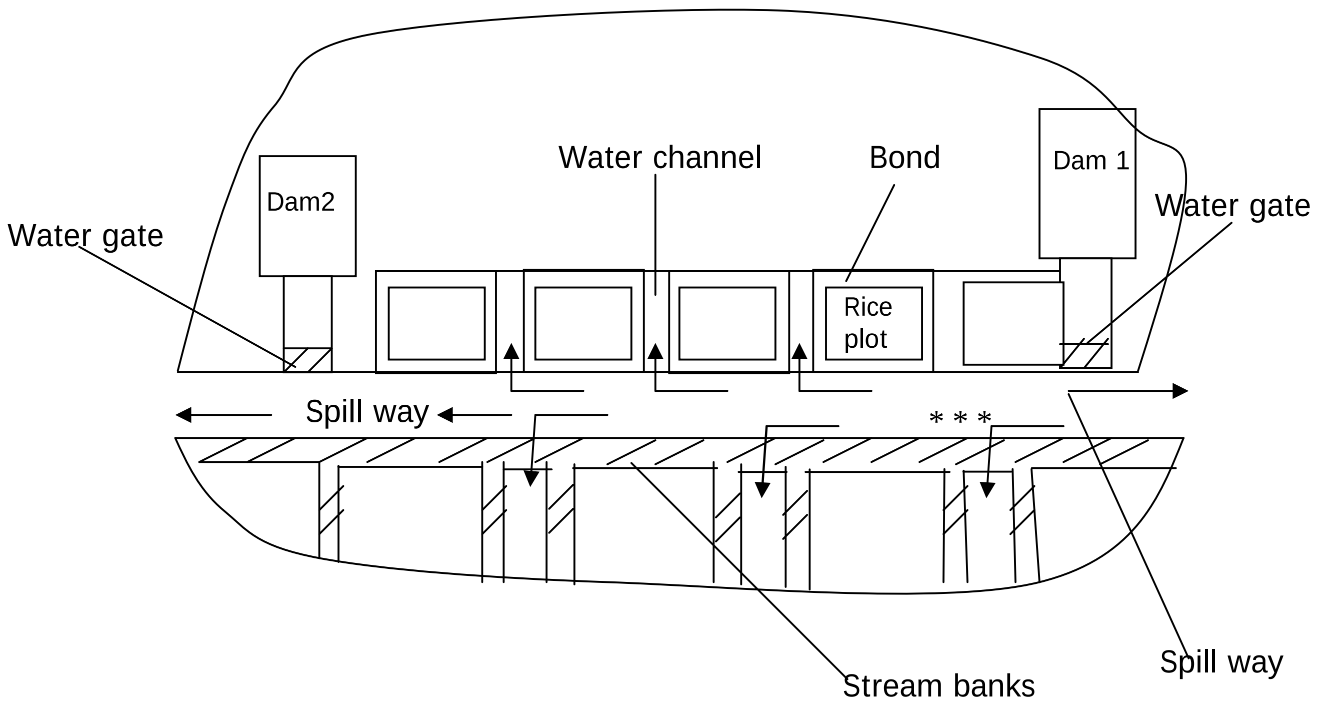
Materials and methods

Location of study area:

The study was conducted in 2008 at Mbiabet (7^{0}34-36'E, 5^{0}29-310N; 125' a SL (Eshett, 1994), Ini Local Government Area of Akwa Ibom State, Nigeria. The area is located within the humid rain forest zone with two distinct seasons; the rainy and dry seasons. The annual precipitation ranges from 2000-3000mm. The fresh swarm mud, used for this study was sandy loam with the following characteristics: P^H 4.86; exchangeable aluminum, 2.50amolkg^{-1}; Nitrogen 0.06%; Avail P 13.00mg, exchangeable calcium, magnesium and potassium were 1.7, 0.65 and 0.46 cmol kg^{-1} respectively.

W. Ubi, Department of Science and Technology, National Open University of Nigeria, Calabar Study Centre, Calabar, Nigeria
M. W. Ubi, Department of Soil Science, University of Calabar, Calabar. Nigeria.
A. U. Akpanidiok, Department of Soil Science, University of Calabar, Calabar. Nigeria.

Sketch of Sampling Area, Mbiabet Rice Farm



The soil samples were mud obtained from the areas

(1) The bottom of the water channel cut through swamp land and used for brining water to the rice field.
(2) From the base of bunds within stream banks
(3) Along the spill way that links the upper water reservoir to the field.

The samples were taken from 0-1, 1-2, 2-5, 5-8, 8-10 and 10-15cm soil depths. The unfertilized swamp mud was taken from the swamp of the Latin square of 36 x 5m swamp mud which received a surface limestone dressing of 50kg/ha to reduce activity of aluminum. In the three samples areas, 30 soils samples were collected, 10 per area. The idea was to obtain a representative sample of the area for analytical work.

Phosphorus was applied as phosphoric acid at the rate of 0, 50, 100, 150, 200, 250, 300 mg $kgha^{-1}$. These were fitted into 36 x 5m Latin Square design, replicated twice.

As a basis for selecting a suitable method for use on the acid sulphate swamp muds, a comparison was made of the amount of phosphorus extracted by seven different methods from phosphorus treated dried mud.

Procedures used in extracting phosphorus from the mud were: 0.1.N NaoH, Olsen, Morgan, Bray-1, Kurtz-2, Truog and Electrodiatysis. Bray and Kurtz's method: 5.7% soil shaken for 1 minute with 40 milli-litters of 0.03N NH4F in 0.025 NHCl. Morgan's method: 10g soil shaken for 30 minutes with 50 millititres of 10% NaOAC and 3% HOAC. 0.1N NaoH: 1g soil shaken for 17 hours with 50ml of 0.1H NaoH. Olsen's Method: 5g soil shaken for 30 minutes with 100 millittres of 0.5N $NaHco_3$ buffered at pH 8.5. The sodium hydroxide extractions were carried out on 1gm sample, using a 1:20 ratio of soil to extractant, and an extraction of 30 minutes. An initial extraction with ammonium chloride was used to saturated the exchange complex (with ammonium) and prevent secondary reactions from removing the phosphorus brought into solution by the sodium hydroxide. An extraction time of 10 minutes, using neutral normal ammonium chloride was found to be satisfactory in preventing reabsorption.

The ammonium phosphate iron phosphate and calcium phosphate were determined by subtracting the difference between the fractionation results on the mud before and after extraction from the total extracted.

P in the extract was determined by measuring the pH, Ca^{++} and total P obtained after equilibrating a series of 5.0g soil of each sample with 50ml of solution of 0.01m Cac12 containing phosphorus concentrations ranging from 1 to 5x 10-5m (White and Beckett, 1964). The equilibrium phosphate potential was then determined by interpolation from the plot of $\pm$ ΔP (representing the net gain or loss of phosphate per grain of soils) against the monocalcium phosphate potential determination at a wave of 660nm.

In the absence of suitable data from field trials, an attempt was made to relate crop response to fertilizer-phosphorus additions and available phosphorus levels by means of culture experiments. Rice and maize were grown in polyethylene bags, filled with fresh swamp mud to which phosphorus as potassium dehydrogen phosphate was added at different rates trail. Preliminary trial has shown that potassium is adequate in these soils (International Institute for tropical; Agriculture IITA 1989; FPDD, 1989).

The crop was harvested at 60 days and plants, which were thinned out to 2 seedlings per bag after germination, were bulked and then weighted. The wet and dried plant materials were weighed and ground for laboratory analysis, for plant phosphorus, and available phosphorus using standard laboratory methods.

The nutrient uptake = Nutrient value x shoot dry weight or Dmy (Irshad et al, 2002). Extracted P was correlated with plant uptake to better reflect the most suitable extractant.

RESULTS AND DISCUSSION

1. Phosphorus recoveries by seven methods commonly employed for estimating available phosphate of swamp mud. Table 1: Values for available phosphorus given by seven methods for varying additions of phosphate to dried swamp mud. Results are in mg/kg oven-dried mud.

P added to mud (mg/kg)		**Phosphorus extracted from mud by the procedures (mg/kg)**						
	0.1N NaoH	**Olsen**	**Morgan**	**Bray & Kurtz**		**Truog**	**Electrdialys**	**LSD (0.05**
0	8	0	0	-	-	0	0	
50	25	16	0	14	23	12	1	4.0
100	58	32	3	27	43	25	4	0.8
150	78	56	5	50	65	46	5	8.9
200	120	80	6	66	76	63	10	10.2
250	158	105	8	86	92	85	27	5.7
300	188	121	9	95	96	91	38	18.4

The sodium hydroxide solution removed the largest amount of phosphorus over the range of concentration used for phosphating the mud (Table 1). The lowest values were given by Morgan's extractant and by electrodialysis method of Purvis and Hanna. Olsen's method gave values which lies between those given by the two Bray and Kurtz (1945) extractants for phosphate additions up to about 150 mg/kg P, but above this concentration the higher values were obtained with Olsen's method.

This apparent fall-off in the recovery of phosphorus shown by the Bray and Kurtz extractants was first thought to be due to reasborption, probably caused by interfering factor. Similar results were reported in Fallows and Chuann (1956), Le Mare (1968) and Ubi and Osodeke (2009).

Truog's method was used for many years by soil scientists before the Bray and Kurtz method largely superseded at as a result of the work of Owen (1953). It could be seen from the results in Table 1 that recoveries were lower with Truog's methods than for the two Bray and Kurtz extractants, but higher than for Morgan's or the electro-dialysis methods. The difficulty of evaluating the results in the presence of possible interference by iron led to the rejection of this and similar methods for estimating available soil phosphorus, as the procedure required to eliminate such interference would make the tests too time-consuming for routine soil testing.

Morgan's reagent was tested as a representative of the type of extractant which employs weak acids, in this case dilute acetic acid of pH 4.6, buffered with sodium acetate. It is apparent from Table 1 that the range of values would be narrow to allow to clear discrimination between soils which respond and those which do not respond to treatment with phosphorus.

There remain only the Olsen's and sodium hydroxide extractants, which of course, provided the widest ranges of values relatively free from interference by iron or aluminum, and showed no abnormal instability of the molybdenum blue colour in their soil extracts.

2. The Soil Phosphorus Fractions Extracted

Watts (1965) and Ubi and Osodeke (2009) found that added phosphorus was rapidly immobilized in the swamp mud, chiefly as aluminum and iron phosphates, so presumanly, the extractants removed these inorganic forms and other soluble phosphorus fractions.

Morgan's and electrolysis methods were omitted from the list of procedures employed, as the amount of phosphorus removed from the mud (at the level used for phosphation) was too low to be detected in the results of the fractionation analysis.

Table 2 represents the amount of each phosphorus fraction extracted by the respective extractant. This was determined from the difference between the fractionation results on the mud before and after extraction.

The amount of iron phosphate removed by Bray and Kurtz No. 1 and 2. Truog and Olsen procedures were the same. However, the largest amount of iron phosphate removed by the Bray and Kurtz 2 and sodium hydroxide extractants were – 23 and 40 percent respective of that found in the fractionation analysis. Only a small amount of calcium phosphate was removed, but then, calcium phosphate formed a relatively small proportion of the total phosphorus in the mud.

Table 2: The phosphorus fraction extractants (p mg/kg oven-dry soil)

Phosphorus fraction	Total P in Mud	Bray and Kurtz		Truog	Oslen	O.I.N Na OH	LSD (0.05)
Aluminum	35	22	27	13	22	35	7.3
Iron	44	2	10	2	2	18	6.6
Calcium	5	1	1	2	1	0	0.6
Others	116	3	4	8	6	4	1.3
Total	200	28	42	25	31	57	-

The amount of aluminum and iron extracted from the phosphate treated dried swamp mud by the extracting solutions, under the conditions of each test are given in Table 3.

Table 3: Aluminum and iron extracted from dried swamp mud by five extractants (P mg/kg oven dry mud)

Extraction solution	pH	A1	$A1p0_4^{-p}$ Theoretical equivalent	Fe extracted	Fe pO_4-P Theoretical equivalent	LSD (0.05)
Bray and Kurtz	3.2	896	1029	56	31	22.8
Bray and Kurtz	1.8	971	1115	112	62	48.4
Troug	3.0	392	449	72	39	31.6
Olsen	8.5	168	193	40	22	17.1
0.1N Na0H	13.0	430	494	70	38	30.5
LSD (0.05)		74.6	85.1	15.9	6.7	

In each case more aluminum was extracted than iron and this was found to be so with the majority of swamp muds so examined. The acid fluoride extractant removed the largest amount of aluminum. The highest concentration of iron appeared in the Bray and Kurtz No: 2 extractant and the lowest was Olsen's.

Reference to Table 2 shows that compounds of aluminum and iron rather than phosphate have been dissolved by the extractants. Apparently, the alkaline extractant dissolved relatively the largest amount of phosphorus for the least amount of aluminum and iron brought into solution. This property is an advantage where, as in the case of local muds, there was a possibility of interference by aluminum and iron during the colorimetric determination of phoshorus in the extracts.

Although Olsen's method was not developed for acid soils, the present soil used for the test has been under rice cultivation for over 50 years. During this period the soil was subjected to yearly liming and fertilization in which the swamp basically depended on the supply reservoirs, north and south of the swamp (see Fig.). Even at this, the performance of soil is not trust worthy due to (1) Microenvironment of the soil which could be atypical (2) Another growing season with different weather pattern may alter the environment (3) the soil condition throughout the area, even though classified, doubtlessly vary, whereas initial estimate has been based on a single soil situation.

Equally, man alters both the physical and chemical properties of the soil as he uses it in such areas as vegetation, topography (may change due to tillage or constructions), fertilizer and lime applications, insecticides, pesticides and herbicides (may change the chemical properties of the soil at any time), as well as the disturbance of water in the soil by irrigation or flood waters.

On this note, research is a continuous approach within the scientific community. Effect of climate and environmental changes at a time may validate contemporary results of some tests, forming part of the learning process in the modern day research. Wambeke (1998) found that the soil is not static system but subject to modification in both physical and chemical properties as a result of environmental and human impact. Olsen's method has been in existence since 1954, about fifty eight (58) years ago and could still be used to make findings and draw conclusions on scientific concepts that were originally in distaste to certain scientific prove. This result could be a new scientific prove for some acid soils that have gone through both physical and chemical management for several years.

4. Relationship between available phosphorus and crop yield response to phosphorus fertilizer.

The results of the comparisons described in the proceeding sections, of this test suggest that Olsen's method is more suitable for routine use with these soils. The sodium hydroxide extractant gave higher recoveries of phosphate, but was less convenient to use because of the longer analytical procedure involved.

Table 4: Average weight and phosphorus content, 60 days after germination of rice and maize plants grown in fresh swamp mud which had received various addition of phosphateAvailable phosphorus (Olsen's) as mg/kg P Oven- dry mud

Phosphorus addition to mud mg/kg	**Weight of plants (g)**			**Plant phosphorus % dry wt (60^{0}C)**			**Wet Wt/Plant P ratio**			**Avial P (mg/kg)**
	Rice	Maize	LSD (0.05)	Rice	Maize	LSD (0.05)	Rice	Maize	LSD (0.05)	
0	1.8	1.8	0.15	0.069	0.208	0.12	26.1	8.6	16.2	0
5	1.9	1.8	0.15	0.274	0.234	0.03	6.9	7.7	0.6	0
10	2.0	2.3	0.20	0.315	0.336	0.02	6.3	6.8	0.4	1
30	2.1	3.3	0.20	0.400	0.446	0.03	5.6	7.6	1.4	7
40	2.4	3.9	1.25	0.431	0.510	0.06	5.6	7.8	2.1	11
50	2.3	4.0	1.41	0.441	0.551	0.03	5.7	7.3	1.4	15
100	2.6	4.4	1.62	0.495	0.762	0.22	5.2	5.8	0.4	29
150	2.5	4.3	1.60	0.580	0.876	0.21	4.3	4.9	0.4	40
200	2.4	4.4	1.61	0.625	1.082	0.44	4.1	4.1	0.2	51
250	2.5	4.3	1.60	0.680	1.143	0.45	3.7	3.8	0.13	62

Table 4 gives the results of the culture experiments which clearly showed that growth was stimulated by addition of phosphorus. This result is in accordance with the generally accepted fact that phosphorus deficiency is distinct and wide spread on acid-sulphate soils (Uchara *et al* 1962; Viviman 1964, IITA, 1989, FPDD, 1989).

The maximum responses to phosphorus in both crops occurred for addition of up to about 100 mg/kg P. The content of plant phosphorus, however, showed a relatively sharp rise for phosphorus addition of about 40mg/kg P, but thereafter dropped consistently. The ratio, wet weight of crop/plant phosphorus indicated that the plants began to take up phosphorus in excess of their immediate requirements (luxury consumption) of 100mg/kg. Using the available data in Table 4, it was possible to relate the available phosphorus values to both crop response and concentration of soil phosphorus.

The relationship may be expressed as follows:

Response To Phosphorus Additions (Rice and Maize)	**Available Phosphorus mg/kg P (Olsen's)**
Response likely	<11
Response probable	11-29
Adequate, response unlikely	>2

Drying the unfertilized swamps muds normally causes a decrease in the available phosphorus level and the magnitude of the fall was in many samples dependent on the drying period (Watts, 1965; Vivman, 1965; Rohrbach *et al* 2003).

Table 5: Correlation between extracted P and plant uptake of uptake of P.

Variety	SDW (g/plant)	P (gkg^{-1})	PUP ($kgha^{-1}$)
Maize	55	0.43	24.56
Rice	51	0.41	22.84

Correlation between extracted P and plant uptake of P (PUP) for maize and rice were highly significant. Thus, Olsen's method could be used for estimating available P in muds at Mbiabet rice farm (Table 5).

CONCLUSION

A satisfactory correlation between fertilizer phosphorus requirements and available phosphorus levels is more likely to be achieved by using the fresh swamp mud rather than the dried mud. In the grain experiment, the ratio (wet weight of crop/plant phosphorus) indicates that the plants began to take up phosphorus in excess of their immediate requirements. This test confirmed that phosphorus deficiency is very distinct in acid-sulphate soils.

Although sodium hydroxide extractant gave higher recoveries of phosphate, the Olsen's method considered not appropriate for acid soil test for P, was more suitable and convenient with this soil probably because this soil has undergone several years of both human and environmental influence coupled with inorganic additions.

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