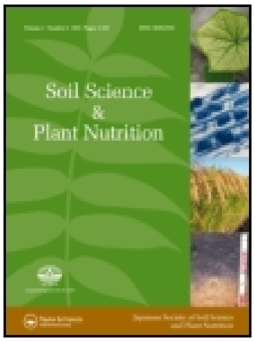

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Extent and Management of Low pH Soils in Ghana

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A review of soil acidity problems with regards to causes, extent and management in Ghana shows that the extent of soil acidity has changed within a period of 2–3 decades. In the 1970s' soil acidity was a major problem in the Western region and the lowlands. Oxisols and Ultisols are common soils found in this area. However, anthropogenic causes have augmented natural causes resulting in more low pH soils. Soil acidity has therefore become a serious problem throughout the country. Anthropogenic causes identified include general agronomic practices such as tillage, use of mineral fertilizers and continuous cultivation. Rates of 1–2 t ha^{-1} lime on ultisols and oxisols in Ghana are more than adequate to meet the calcium demands and sufficient to neutralize residual acidity of any nitrogen fertilizer. Addition of organic amendments on low pH soils was also found to be beneficial and resulted in increased yields. The adoption of the "sawah" technology for lowland rice production has also resulted in improved water management, increased nutrient availability and significant increases in rice yields.

Key Words: **causes, extent, Ghana, management, soil acidity.**

Intensive rainfall coupled with favourable temperature in the humid tropical world expose soils to severe weathering and excessive leaching. These are contributory factors to the low inherent fertility and acidic nature of these soils. In these soils, the levels of available nutrients are low; generally containing little or no primary minerals and hence no appreciable levels of Ca, Mg and K. Sustained production of crops requires the addition of soil amendments. In Ghana, soils with low pH no longer occur within the western part of the country alone, but extensively across the country particularly the lowlands which cover over one million hectares.

In order to improve the food production capacity of the country's small-scale farmer, there is the need to evolve soil management systems that are not only acceptable but also affordable. One method in alleviating soil constraints to crop production is to modify or supplement soils to remove deficiencies or toxicities. Most crops are grown on these low pH soils. The purpose of this study is to determine the causes and extent of soil acidity problems and methods adopted in ameliorating its effects in order to improve soil productivity and crop yields in Ghana.

MATERIALS AND METHODS

A review of works was done on the causes, extent and methods adopted in ameliorating soil acidity problems across the country. The review-covered Annual Reports of Soil Research Institute (SRI) of Ghana, Soil Survey Reports and Technical Reports (including reports on field experiments conducted at various sites throughout the country).

The causes of low soil pH were evaluated based on rainfall regimes, soil types (Fig. 1 and Table 1) and agronomic practices at selected areas. Soil pH values before 1980 and after, within similar areas, were compared and formed the bases for estimation of extent of soil acidity problems. Request from Non-Governmental Organizations (NGOs), Governmental Organizations and commercial farmers for fertilizer recommendations or management of their problem soils facilitated to provide more basic information in the estimation of the extent of the problem.

RESULTS AND DISCUSSION

Causes and extent

Figure 1 shows major soils and political regions of Ghana. Oxisols are commonly found in the Western region where annual rainfall is generally higher (over 1,800 mm) than in other parts of the country. These highly weathered and leached soils have very low pH values due to natural causes. Places within Western region where soil acidity problems have been reported include Aiyinase, Chorichori, Bosomoiso, Akwadum, Asawinso and some parts of the Juabeso-Bea, Aowin-Suraman and Wassa districts.

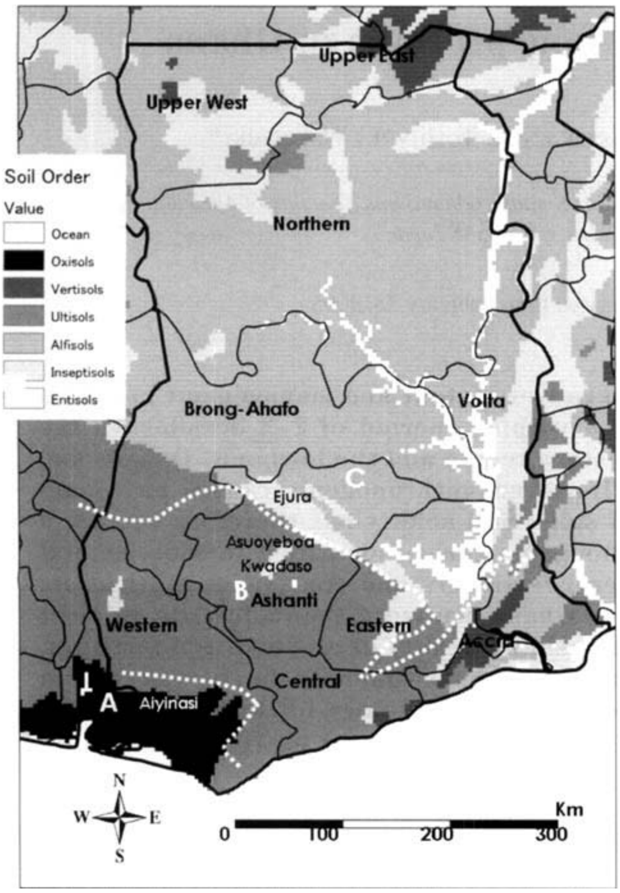

Fig. 1. Map of Ghana showing dominant soils and political regions.

Serious soil acidity problems have been reported from many places including Kwadaso and Manga research stations, Nakpanduri (Gambaga), Ejura Farms and Asuoyeboa (formerly occupied by the then Ghana Seed Company). These areas have been under continuous cultivation with the use of various kinds of mineral fertilizers. These problems are directly due to human influence. Comparison of topsoil pH values of similar areas before 1980 and after clearly shows that more areas are showing soils with low pH (Table 2).

In addition to high temperatures and abundant rainfall, bushfires and overgrazing are some of the natural causes. Anthropogenic causes include various agronomic practices, e.g. fertilization (particularly use of acid forming fertilizers such as ammonium sulphate), continuous cultivation and various tillage practices. Human influence have augmented natural causes to produce more low pH soils, resulting in soil acidity becoming a more serious problem throughout the country. Areas under intensive cultivation particularly in the Upper East, Upper West and Greater Accra regions (where land for agriculture has become very scarce and limited) are experiencing problems related to soil acidity.

Management of uplands

Several authors have reported on various options for

Table 1. Rainfall regime and soil type distribution in Ghana.

Rainfall regime (mm per annum)	Major soils (USDA)
<1,200	Plinthustalf, Alfisols, Leptosols, Fluvents, Aquents, Aquepts, Alfisols, Entisols
1,200–1,400	Alfisols, Plinthustalf, Fluvents, Inceptisols, Entisols, Alfisols, Psamments
1,400–1,800	Ultisols, Plinthustalf, Fluvents, Aquents, Aquepts, Psamments, Inceptisols
>1,800	Oxisols, Psamments, Plinthustalf, Aquents, Aquepts, Alfisols, Fluvents, Inceptisols
750–1,000	Vertisols, Psamments, Salorthids, Alfisols, Fluvents, Aquents, Aquepts

Table 2. Comparison of soil pH values for selected areas across Ghana.

Site	Soil pH value	
	Before 1980	After 1980
Manga	5.5 (Adu et al. 1973)	4.9 (Anane-Sekye 1997)
Navrongo	6.0 (Adu et al. 1973)	5.5 (Anane-Sekye 1997)
Nyankpala	6.0 (SRI Annu. Rep. 1974/75)	5.4 (SRI Annu. Rep. 1995)
Wenchi	6.2 (SRI Annu. Rep. 1974/75)	5.5 (Issaka et al. 2001)
Ejura	6.3 (SRI Annu. Rep. 1974/75)	5.4 (Buri et al. 2001)
Kwadaso	5.4 (Lathwell 1979)	4.7 (Buri et al, 2001)
Aiyinasi	4.5 (Lathwell 1979)	4.1 (SRI Annu. Rep. 1992)
Afram Basin	6.2 (SRI Annu. Rep. 1974/75)	6.0 (Tetteh et al. 2003)

Table 3a. Influence of liming on yield of maize and total dry matter on a Kumasi series (Paleaudult).

Lime applied ($t\ ha^{-1}$)	Soil pH	Ex. cations Ca+Mg	Maize grain yield	Dry matter yield
			Major season ($kg\ ha^{-1}$)	Minor season ($kg\ ha^{-1}$)
0.0	5.6	5.86	4,990	5,120
0.5	5.9	9.97	4,470	5,650
1.0	6.1	7.32	5,220	5,670
2.0	6.1	7.16	5,450	5,580
4.0	6.6	10.82	4,900	5,310

Lathwell 1979. Cornell International Agricultural Bulletin 35. Major season starts from April and ends in August; minor season starts from September and ends in December.

Table 3b. Residual effect of various lime levels on grain yields of two soybean varieties on a dark red latosol (Haplustox).

Lime applied First year ($t\ ha^{-1}$)	Al saturation			
	First year (%)	Fourth year (%)	Soybean variety (fourth year)	
			Vicoja	IAC-2
0	85	70	1,095	1,060
1	61	49	1,900	1,870
2	56	29	2,135	1,920
4	34	20	2,140	2,295
6	12	7	2,695	2,405
8	3	4	2,730	2,260

Cornell International Agricultural Bulletin 35.

Table 4a. Influence of various combinations of lime and P on maize grain yield (kg ha^{-1}) grown on Asuansi series I (Ultisol) at Kwadaso.

P_2O_5 (kg ha^{-1})	Lime rate (t ha^{-1}) 0	1	2	4	Mean
0	1,040	1,860	2,550	2,370	1,955
25	2,110	2,270	2,560	2,780	2,430
50	2,150	2,820	2,780	3,350	2,775
75	2,350	2,910	3,160	3,240	2,915
100	3,190	2,760	2,970	3,460	3,095
Mean	2,165	2,525	2,805	3,080	

Cornell International Agricultural Bulletin 33. Asuansi series. Depth: 0–15 cm; pH(water)=5.4; Ca+Mg=1.83; Al=0.09.

Table 4b. Influence of various combinations of lime and phosphorus on maize grain yield (kg ha^{-1}) grown on Basachia series (Oxisol) at Aiyinasi.

P_2O_5 (kg ha^{-1})	Lime rate (t ha^{-1}) 0	1	2	4	Mean
0	715	910	1,525	1,635	1,195
25	1,515	1,965	1,735	1,610	1,705
50	1,550	1,915	1,880	2,555	1,975
75	2,160	1,415	1,855	2,740	2,045
100	1,430	1,780	2,165	2,330	1,845
Mean	1,340	1,600	1,830	2,175	

Brachia series. Depth: 0–15 cm; pH(water)=4.2; Ca+Mg=0.98; Al=0.41.

Table 5. Effect of various lime rates on dry matter yield of maize.

Treatments	Non-fertilized Yield (kg ha^{-1})	% Increase over control	Fertilized Yield (kg ha^{-1})	% Increase over control	% Increase over non-fertilized	% Increase over un-fertilized
Control	1,670	—	1,960	17	290	17
0.5 t ha^{-1} lime	2,900	73	3,460	107	560	34
1.0 t ha^{-1} lime	1,260	−24	2,790	67	1,530	91
200 kg P_2O_5 ha^{-1}	1,940	16	1,860	11	−80	−5
1.0 t organic matter ha^{-1}	1,800	7	2,380	42	580	35

Fertilized plots were given mineral fertilizer of 200 kg ha^{-1} 15-15-15 (NPK) at 2 weeks after planting and 100 kg ha^{-1} ammonium sulphate at 5 weeks after planting.

improving conditions of low pH soils for better crop performance: Ofori (1971), Lathwell (1979), Dennis and Issaka (1986), Anane-Sekye (1997). Broadly the authors evaluated the use of lime, various sources of organic matter, phosphorus and legume-fallows in an attempt to ameliorate the effect of soil acidity on crop performance.

Several experiments conducted to improve the fertility of soils in Ghana, showed that pH and Ca+Mg contents increased upon liming (Table 3a). Yield increased with a reduction in Al saturation after lime was applied the previous year (Table 3b). Similar experiments conducted at Kwadaso showed that liming at 1.0 t ha^{-1} (1,460 kg ha^{-1}) and 2 t ha^{-1} (1,248 kg ha^{-1}) gave 72% and 48% increases in yield respectively over no lime treatments (850 kg ha^{-1}). It was generally recommended that acid soils should be limed in order to increase yields especially where acidifying fertilizers were used.

Field experiments on lime-phosphorus combinations (Table 4a and b) showed that maize grain yield was increased by both lime and phosphorus at both Aiyinasi (Oxisol) and at Kwadaso (Ultisol). Working on a forest Ultisol in Kumasi with a pH range of 4.7 to 5.5, Dennis and Issaka (1986) observed that liming at 0.5 t ha^{-1} gave highly significant yields over other treatments with a 73% increase in yield over the control (Table 5). According to them organic matter helps in increasing the moisture regime of the soil. The authors observed that fertilizer interacted with lime and organic matter to give significantly higher yields over non-fertilized treatments. The authors observed a general increase in soil pH for treatments without mineral fertilizer, emphasizing the acidifying effect of some mineral fertilizers (e.g. ammonium sulphate). Triple super phosphates, green gram and organic matter slightly improved pH with time.

Results of long term experiments (SRI, 1984) involving N, P, K, lime and mulching initiated in 1949 on a Kumasi soil also show that crop yields could be maintained at fairly reasonable levels for several years. Consistent significant effects of applied P, lime and mulch on groundnut kernels and maize grain yields were observed from these experiments. Continuous application (27 yrs) of ammonium sulphate even at moderate rates markedly lowered soil pH while liming considerably raised its value.

Table 6a. Comparison of mean rice paddy grain yields between the traditional and "sawah" systems of rice production in selected inland valleys in Ghana.

Location	Paddy grain yields (t ha^{-1})		
	2001	2002	2003
Adugyama under "sawah" system	4.0	4.7	4.6
Biemso No. 1 under "sawah" system	4.4	5.3	4.5
Biemso No. 2 under "sawah" system	4.9	5.5	4.0
Fedeyeya under "sawah" system	3.7	4.3	3.5
"Sawah" mean	4.4	5.3	4.3
Traditional (non-"sawah")	1.1	1.1	0.8

JICA/CSIR Project Report 2000, SRI "Sawah" Project Report 2001–2003.

Table 6b. Effect of rice environment on rice grain yield (paddy) in two inland valleys in the forest agro-ecology of Ghana.

Rice environment	Paddy grain yield (t ha^{-1})	
	Potrikrom	Biemso No. 1
"Sawah" with mineral fertilizer (ponded conditions)	6.23d	6.82b
"Sawah" without mineral fertilizer (ponded conditions)	4.58bc	6.03b
Farmers practice with mineral fertilizer	5.20cd	5.56ab
Farmers practice without mineral fertilizer	3.62ab	3.74a
Minimum levelling with mineral fertilizer	5.32cd	4.93ab
Minimum levelling without mineral fertilizer	4.25abc	5.46ab
No levelling with mineral fertilizer	4.53bc	4.25ab
No levelling without mineral fertilizer	3.17a	2.50a

Issaka et al. 2001. Depth (0–15 cm); pH(water)=5.5; OM=2.38%; TN=0.016%; P=2.88 mg kg^{-1}.

Table 6c. Effect of organic and inorganic fertilizers on rice grain yield under the "sawah" system in three inland valleys in the forest agro-ecology of Ghana.

Treatment	Paddy grain yield (t ha^{-1})		
	Potrikrom	Biemso 1	Biemso 2
Control	1.68	3.59	1.50
NPK 120-90-90 kg ha^{-1}	6.77	8.37	4.03
NPK 90-60-60 kg ha^{-1}	6.57	7.09	3.90
Poultry manure (PM)-7.0 t ha^{-1}	5.96	6.36	3.82
PM (3.5 t ha^{-1})+ NPK 45-30-30 kg ha^{-1}	6.25	7.30	4.15
Cattle manure (CM)-7.0 t ha^{-1}	4.54	6.25	3.05
CM (3.5 t ha^{-1})+ NPK 45-30-30 kg ha^{-1}	4.86	6.49	3.72
LSD (0.05)	0.99	2.14	0.84
Mean (site)	5.23	6.09	3.58
LSD (0.05)		0.52	

Buri et al. 2001. Depth (0–15 cm); pH(water)=5.5; OM=2.38%; TN=0.016%; P=2.88 mg kg^{-1}.

Management of lowlands

Most inland valleys and floodplains in West Africa have soils with low pH values (Issaka et al. 1996; Buri et al. 1998). In Ghana, it is estimated that over one million hectares of lowlands (basically low pH soils) are available for cultivation particularly rice production (Wakatsuki et al. 2003). The introduction of the "sawah" technology (bunding, puddling and levelling of rice fields) has not only proved very beneficial but also timely. Average rice yields have risen from below 1.5 t ha^{-1} under the traditional system to over 4.5 t ha^{-1} under the "sawah" system (Table 6a).

In evaluating different environments for sustainable rice production, Issaka et al. (2001), noted that higher and similar grain yields were obtained irrespective of fertilizer treatment in areas where ponding occurred for most part of the growing season (Table 6b). Under similar conditions, Buri et al. (2001) observed that, rice grain yields were significantly affected by available and affordable farm manures such as poultry manure, cow dung and rice husk either solely or in combination with lower rates of mineral fertilizers (Table 6c). Based on availability, affordability and suitability, the authors recommended the use of farm organic manure as a suitable and alternative fertilizer sources for rice production within these inland valleys for poor resource farmers. In both cases, Issaka et al. and Buri et al. noted that soil pH was improved and nutrient availability enhanced under the "sawah" system.

CONCLUSION

Soil acidity problems are caused by both natural and human influences. The problem of soil acidity is now nation-wide and increasing mostly due to human influence. Intensive cultivation and the use of acid forming fertilizers are the major contributing factors enhancing the spread of soil acidity in the country. Liming, organic matter and the use of rock phosphate have a positive effect on soil acidity. The "sawah" technology for lowland rice production in particularly is a very useful tool for obtaining higher grain yields in Ghana's low pH inland valley soils. More work is, however, required to refine existing information on effective management of these problem soils.

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REFERENCES

Adu SV, Mensah JA, and Acguah GW 1978: Soils of Navrongo-Bawku area. Upper East Region. Ghana. Soil Research Institute Annual Report

Anane-Sakye C 1997: The effect of cow dung and mineral fertilizer on yield of early millet/sorghum intercrop in the north-east savannah zone of Ghana. CSIR-SRI Annual Report 1997, 35–38

Buri MM, Ishida F, Kubota D, Masunaga T, and Wakatsuki T

1998: Soils of flood plains of West Africa: General fertility status. *Soil Sci. Plant Nutr.*, **45**, 37–50

Buri MM, Wakatsuki T, Issaka RN, Otoo E, and Kubota D 2001: The effect of organic and inorganic fertilizers on rice growth and yield under "sawah" within the forest agro-ecology of Ghana. Proceedings of the International Workshop on "Integrated Watershed Management of Inland Valleys—Ecotechnology Approach" held in Novotel, Accra, Ghana. February 6–8, 2001

Dennis EA and Issaka RN 1986: Management of low pH soils: Results of a preliminary study. Paper presented at the 6th Maize and Cowpea workshop at Kumasi Technical Institute, Kumasi, Ghana. February 4–6, 1986

Issaka RN, Masunaga T, Kosaki T, and Wakatsuki T 1996: Soils of inland valleys of West Africa: General fertility parameters. *Soil Sci. Plant Nutr.*, **42**, 71–80

Issaka RN, Wakatsuki T, Buri MM, Otoo E, and Kubota D 2001: Evaluation of four rice environments for sustainable rice production. Proceedings of the International Workshop on "Integrated Watershed Management of Inland Valleys—Ecotechnology Approach," held in Novotel, Accra, Ghana. February 6–8, 2001

Lathwell DJ 1979: Crop response to liming of Ultisols and Oxisols. New York College of Agriculture and Life Sciences, Cornell International Agricultural Bulletin 35

Ofori CS 1971: Effect of lime application on maize yields on a forest Ochrosol. SRI Annual Report 1970–71

SRI Annual Report 1974–75. Extracts of Soil Survey Reports. CSIR-Soil Research Institute Annual Report 1974–75

SRI Annual Report 1984: Research Findings of the CSIR-Soil Research Institute. Special Report, February 1984

SRI Annual Report 1992: CSIR-Soil Research Institute, Kumasi, Ghana

SRI Annual Report 1995: CSIR-Soil Research Institute, Kumasi, Ghana

Tetteh FM, Issaka RN, and Buri MM 2003. Annual Report on Fertilizer Update and Recommendation under the Soil Fertility Initiative Programme of AgSSP, Ghana

Wakatsuki T, Buri MM, and Fashola OO, 2003. Restoration of degraded inland valley watersheds in West Africa by sustainable "Sawah" development. Paper presented at the International Conference on "Managing Soils for Food Security, Human Health and the Environment: Emerging Strategies for Poverty Alleviation," GIMPA-Accra, Ghana, July 28–August 2, 2003