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Full Length Research Paper

Land suitability classification of Southeastern Nigeria wetlands for azolla

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A qualitative land suitability classification of wetlands of southeastern Nigeria, for azolla, a bio-N fertilizer was carried out. The results showed that soils associations represented by Itu Bridge, Oron, Atani, Igbo Beach and Umumbo-Adani are moderately suitable (S2) because of poor drainage, pH (H_2O) of 4.88 - 5.8 and >0.2 cmol (+) kg^{-1} K. However, Atani, Igbo Beach and Umumbo-Adani soil associations require the application of phosphorus (P) fertilizers to boost their potentialities. Bonny-Brass and Opobo-Degema soil associations are marginally suitable (S3). They are prone to tidal waves, intermittent stratification and have pH of 4 - 4.6. Obiokpo-Orsu soil association is unsuitable (N) because of its sandiness, excessive drainage and deficiency in nitrogen (N) and potassium (K). It is concluded that biofertilization of wetlands of southeastern Nigeria with azolla is currently not feasible in Obiokpo-Orsu soil association.

Key words: Land evaluation, azolla, wetland, Southeastern Nigeria.

INTRODUCTION

Wetlands constitute an important ecology in Nigeria agriculture. They are most commonly used for rice production in the southeastern Nigeria. Wetlands are flooded during most parts of the year or part of rice-growing period. Flood culture has been reported by Watanabe and Liu (1992) to control soil erosion, reduce soil acidification and sustain nitrogen fertility of the soil better than under dryland conditions. The Introduction of mineral fertilizers probably influenced farmers to abandon traditional soil fertility management systems in Nigeria. This is because they are more convenient to handle and apply, little quantities are required and they increase crop yields significantly due to their high solubility and nutrient content (Venture and Watanabe, 1992).

Unfortunately, mineral fertilizers are scarce and costly. The resource-poor Nigeria farmers cannot sustain rice production with the use of mineral fertilizers. Attempts to enhance the Presidential initiative on rice production stimulated interest in bio-fertilizers, especially, azolla as a substitute for or supplements to mineral fertilizers.

FAO (1988) defined biofertilizers as those organisms and their symbiotic systems which continue to grow and improve the institute fertility of the ecosystems in which they grow. Azolla is a free floating, aquatic farm found in ponds, flooded rice fields and other still fresh waters. Azolla is used as a N-biofertilizer for wetland at rice because of its ability to fix atmospheric N in symbiosis with N_2-fixing blue green alga *Anabaena azollae*. Other advantages of azolla as a biofertilizer include reduction in NH_4-N loss by volatilization (Chu and Bo-qi, 1988). Azolla is also enriched by trace k from irrigation water which the rice cannot utilize. The azolla – k may be released for rice plant uptake with efficiency equivalent to that of fertilizer – k (FAO, 1988). Azolla controls weeds (Oso and Ayodele, 1984). Report from different countries in Asia confirmed that azolla can fix atmospheric N and increase gain yield of rice. Based on the report of the Regional Expert Consolation of the Asia Network on Biological and Organic Fertilizers (FAO, 1988) azolla replaced ½ - ¾ of the mineral – N fertilizer recommended for rice in Sri Lanka and fixed 25 – 40 kg N/ha/crop in Bangladesh when azolla population was maintained at 75% under shade. The environmental requirement of azolla discussed by several authors is summarized in Table 1.

Azolla is relatively unknown in Nigeria. The initiation of research on azolla by the West African Research Development Association in 1980 in Senegal, stimulated similar research later at the National Cereals Research Institute, Badeggi, Nigeria. Oso and Ayodele (1994) reported that *Azolla pinnata* var *pinnata* has been identi-

Table 1. Environmental requirements of azolla.

Parameter Author	pH -(H_20)	Availability P (mg/kg)	Temperature (°C)	Relative humidity (%)
Boonkerd et al. (1990) (Thailand)	4.5 – 6.0	0.35 – 15	na	na
Kannaiyan et al. (1998) (India)	na	Na	15 – 25	na
Leyese and Tilo (1970)	na	10 (Olsen P)	na	na
Sam Valentine (1986)	na	18	na	na
Chu and Bo-gi (1991)	na	Na	25 – 30	80 – 90
FAO (1988)	8 (ideal) India	4 – 8kg P_20_5/ha India	India 20–30 (Optimum) Sri Lanka18–25 (Optimum) Pakistan For *A. pinnata* 35 (not suitable)	

na = Data not available.

Table 2. Major Soil Associations of wetlands of Southeastern Nigeria.

Pedon n.	Soil Association	Parent Material	State Located	Vegetation
1	Umubo-Adani	Shale	Enugu	Derived Savanna
2	Igbo Beach	Shale	Cross River	Derived Savanna
3	Obiokpo-Orsu	Subrecent Alluvium	Imo	Rainforest
4	Itu Bridge	Recent Alluvium	Akwa Ibom	Rain-forest
5	Atani	Recent Alluvium	Anambra	Derived Savanna
6	Oron	Coastal Plain Sands	Akwa Ibom	Rain-forest
7	Bonny-Brass	Beach Sands	Rivers/Bayelsa	Mangroove Swamp
8	Opobo-Degema	Mangroove Swamp Deposits	Rivers/Bayelsa	Mangroove Swamp

tified in Ibadan, Ihiala, and Bedeggi in Oyo, Anambra and Niger States of Nigeria. Ihiala soils belong to soil mapp-ng unit 431 which is outside the delineated wetlands of Southeastern Nigeria (FDALR, 1985). The natural habitat of azolla is wetland ecology. Information is not available on the suitability of wetlands of Southeastern Nigeria for azolla.

This paper presents the results of soil characterization and suitability evaluation of wetlands of southeastern Nigeria for azolla.

METHODOLOGY

Site

Southeastern Nigeria is located on latitude 4° 15[1] and 7°N and longitude 5°50[1] and 9°30[1]E. It is made up of Abia, Akwa Ibom, Anambra, Cross River, Enugu, Imo and Rivers States. The extent of the area is about 7581126 ha. The underlying geology consists of heterogeneous materials, namely Basement Complex, Beach Sands, Coastal Plain Sands, Mangrove Swamp Deposits, Sand-tone, Shale, Somberirio Warri Deltaic Deposit, Recent and Sub-recent Alluvium (FDALR, 1990). The mean minimum and maximum temperatures ranged from 21 – 30°C in the coast (Calabar and Port Harcourt). In the interior (Abakaliki and Enugu), it ranged from 29 – 33°C. Rainfall is bimodal and decreases from over 3000 mm in Calabar to 1,700 mm in Abakaliki. The vegetation stretches from mangrove swamp in the coast through rainforest to derived savanna in the interior.

Field and laboratory work

The soil map of southeastern Nigeria (FDALR, 1990) served as the base maps for the study. The study centered on 8 major Soil Associations covering the delineated soil mapping units described as wetlands (FDALR, 1985) (Table 2). On each Soil Association, 2 pedons were located on typical soils giving a total of 16. They were dug, sampled and described as outlined in Soil Conservation Service (1984) and FAO-UNESCO (1988). Soil samples were processed and analysed following the procedures of Soil Survey Laboratory Staff (1992). Based on the similarities of the pedons from each Soil Association, data from 8 representative pedons are presented and discussed. From Table 1 soil chemical properties are the pedological criteria that influence azolla growth. Emphasis is, therefore, laid on soil chemical properties land suitability evaluation followed and FAO guidelines (FAO, 1976). They were rated highly suitable (S1), moderately suitable (S2), marginally suitable (S2) and Unsuitable (N), depending on the degree of limitation they prese for suitable azolla growth and production.

The suitability class is determined by the lowest or least favour-able rating for any diagnostic criterion. A combination of two or more deficiencies may effect a downgrading in the suitability classi-

Table 3. Some properties of the soils

Parameters	Pedon							
	1	2	3	4	5	6	7	8
pH (H_20)	4.88*	5.13	5.04	5.80	5.40	5.50	4.65	4.00
pH (KCl)	4.16	3.19	4.02	4.85	4.33	4.30	4.33	3.33
Total N (%)	0.04	0.14	0.04	0.11	0.06	0.12	0.02	0.68
Organic Matter (%)	2.19	0.41	1.69	4.13	1.22	3.11	0.69	1.40
Available P (mg kg^{-1})	4.80	2.75	15.6	8.80	6.00	30.7	3.00	15.8
½ Ca^{2+} cmol (+) kg^{-1}	3.76	1.10	0.97	2.74	1.85	0.92	0.18	0.55
½ Mg^{2+} cmol (+)kg^{-1}	1.98	1.73	0.43	0.89	1.15	0.38	0.03	0.35
K^+ cmol (+) kg^{-1}	0.34	0.33	0.05	0.30	0.25	0.43	0.01	0.10
Na^+ cmol (+) kg^{-1}	0.20	0.12	0.03	0.28	0.23	0.10	trace	0.08
EA cmol(+) kg^{-1}	6.00	7.80	1.96	1.14	3.75	2.28	11.5	24.4
CEC cmol (+) kg^{-1}	13.5	9.50	4.38	6.49	8.33	3.15	2.03	24.8
Base Saturation (%)	46.5	34.5	33.8	64.9	41.8	58.1	10.6	4.33
Sand	20	28	89	83	58.4	775	91	77
Silt	42	18	1	5	19.4	6	3	6
Clay	38	54	10	12	22.2	16.5	6	17
Textural class	CL	C	LS	LS	SCL	SL	S	SL

Mean Values, L = Clay loam, C= Clay, LS = loamy sand, SCL = Sandy Clay loam, CL = Clay loam, S = Sand, EA = exchangeable acidity, CEC = Cation exchange capacity. Pedons 1 – 8 are defined in Table 2.

fication of Soil Association. In practice the minima cannot be established for all conditions and interpretive judgment has to be exercised to maintain a balance between the varying criteria. For instance, the self-liming potential of seasonally flooded soils in increasing P availability (Ragland and Craig, 1985) is recognized. Thus, those non-coastal soils that are imperfectly or poorly drained and deficient in P (< 15 mg/kg) could not be assigned N (non-suitability class).

RESULTS AND DISCUSSION

Chemical properties

The chemical properties of the soils are shown in Table 3. The soils are generally acidic. The pH (H_20) is > 5 in pedons 2 – 6 but less than 5 in pedons 1, 7 and 8. Delta pH (pH H_20-pH KCl) was positive in all the pedons. Cation exchange capacity (CEC) was less than 16 cmol (+)/kg in pedons 1 - 7 but above 20 cmol (+)/kg in pedon 8. Organic matter contents were over 4% in pedons 4. 6 and 8 respectively, but low in pedons 1 – 3 and 5 – 7, respectively. Pedons 1, 2, 5 and 7 suffer multi-nutrient deficiencies particularly N and P.

Low pH values (< 5) could be due to Al saturation in soil solution (Soil Survey Staff, 2003). The positive data pH is evidence of predominant net negative charge in all the pedons except pedon 8. This confirmed similar report by Sutton and Loganathan (1986) on Rivers State soils. The low CEC values suggest that the soils have low activity clays (Uehara, 1978). Soils in the derived savanna are prone to frequent bush burning. Marcroporo-ity are usually associated with coarse sandy soils and are likely to favour quicker oxidation of organic matter. All these account for the low percentage organic matter in pedons 1, 2, 3, 5 and 7 respectively. Medium to high available P recorded in pedons 3, 4, 6 and 8 could be attributed to the remains of marine intrusion that covered the area the past (Asseez, 1975) since the mineralization of organic P is considered insignificant in hydromorphic soils (Udo, 1985).

Suitability classification

Table 4 shows the overall land suitability in relation to azolla for each of the Soil Associations. Each of the Soil Associations was allocated a suitability class as defined below. Class S2: Moderately Suitable – land having limitations which are moderately severe for sustained

Table 4. Land suitable classification for azolla

Land Quality	Soil Association							
	Umumba Adani	**Igbo Beach**	**Obiokpo Orsu**	**Itu Bridge**	**Atani**	**Oron**	**Bonny Brass**	**Opobo Degema**
Relief	S1	S1	S1	S1	S1	S1	S1	S1
Hydrology	S1	S1	N	S1	S1	S1	S2	S2
pH (H_20)	S2	S2	S2	S2	S2	S2	S2	S3
Available P (mg/kg)	S2	S2	S1	S2	S2	S1	S3	S1
Liability to Flooding and Stratification	S1	S1	S1	S2	S2	S2	S3	S3
Overall	S2	S2	N	S2	S2	S2	S3	S3

S1 = highly suitable; S2 = moderately suitable; S3 = marginally suitable; N = Not suitable.

productivity of azolla. Class S3: Marginally suitable – land having severe limitations which are severe for sustained productivity of azolla. Class N: Non-suitable: Land having very severe limitation that will inhibit successful growth of azolla. None of the Soil Associations was found highly suitable. Umumbo-Adani, Igbo Beach, tu Bridge, Atani and Oron Soil Associations are moderately suitable; Opobo-Degema and Bonny-Brass Soil Associations are marginally suitable while Obiokpo-Orsu Soil Association is unsuitable because it is excessively well-drained. Frequent intermittent flooding and satisfaction of Bonny-Brass and Opobo-Degema in addition to their multi-nutrient deficiency reduced their suitability ratings.

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