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Land Use Planning for Vegetable Farming in Benue State of Nigeria

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Abstract - Management of soil organic matter is the key to successful organic farming with regards to soil productivity. Vegetable production is most successful in soils rich in organic matter and also with adequate soil moisture. This paper examines two broad groups of soils in Benue State (the upland and the wetland soils) with respect to their suitability for organic vegetable farming. In 2008/2009 and 2009/2010 cropping seasons, a soil characterization study for field assessment of vegetable crop yields in the upland and wetland soils of Benue state was conducted. The wetland soils were found to be richer in organic carbon (2.28%) than the upland soils (0.87%). This singular difference had multiplier effects as wetland soils had higher total N (0.31%) and available P (9.8 mg kg-1), higher pH (6.7) and total exchangeable bases (12.8 mol kg-1) and by implication higher water holding capacity. Among the wetland soils, okra yields averaged 5.92mt ha-1 (wetland) as against 2.75 mt ha-1 (upland) and garden egg yields were 6.00mt ha-1 (wetland) and 4.50mt ha-1 (upland). These results indicated that wetland soils had greater advantage for organic farming than the upland soils. Since land use planning is all about allocation of land to optimize yields and minimize damage to soil resources, the wetland soils are therefore recommended for organic vegetable farming in Benue State.

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LAND USE PLANNING FOR VEGETABLE FARMING IN BENUE STATE OF NIGERIA

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Idoga, S.[α] & O. M. Egbe[σ]

Abstract - Management of soil organic matter is the key to successful organic farming with regards to soil productivity. Vegetable production is most successful in soils rich in organic matter and also with adequate soil moisture. This paper examines two broad groups of soils in Benue State (the upland and the wetland soils) with respect to their suitability for organic vegetable farming. In 2008/2009 and 2009/2010 cropping seasons, a soil characterization study for field assessment of vegetable crop yields in the upland and wetland soils of Benue state was conducted. The wetland soils were found to be richer in organic carbon (2.28%) than the upland soils (0.87%). This singular difference had multiplier effects as wetland soils had higher total N (0.31%) and available P (9.8 mg kg-1), higher pH (6.7) and total exchangeable bases (12.8 mol kg-1) and by implication higher water holding capacity. Among the wetland soils, okra yields averaged 5.92mt ha-1 (wetland) as against 2.75 mt ha-1 (upland) and garden egg yields were 6.00mt ha-1 (wetland) and 4.50mt ha-1 (upland). These results indicated that wetland soils had greater advantage for organic farming than the upland soils. Since land use planning is all about allocation of land to optimize yields and minimize damage to soil resources, the wetland soils are therefore recommended for organic vegetable farming in Benue State.

Keywords : Land use planning, organic matter, organic vegetable farming.

I. Introduction

Organic farming involves the use of renewable resources and cycling (returning to the soil the nutrients found in waste products). Organic farming respects the environment's own systems for raising crops without use of chemical fertilizers (ICAR, 2006). In Nigeria, before the oil boom era of the late 70s, soil fertility management for agricultural use depended solely on natural soil fertility regeneration through soil organic matter build up. This practice called shifting cultivation was based on the principle that continuous cultivation depletes the soil of its nutrients, mainly as a result of depletion in soil organic matter. Time was therefore needed for soil organic matter to build up, ranging from 5 to 10 years depending on climate and vegetation (Brady, 1990).Over the years, accumulated knowledge about soils point to soil organic matter as the key factor in soil productivity sustenance (Greenland, 1994). Soils with high organic matter normally produce very high yields. As organic matter content declines, yield equally declines.

Consequent upon this finding and the fact that shifting cultivation is no longer feasible due to increasing population, other systems have been developed to either improve or maintain soil organic matter or to sustain soil productivity. Some of these systems include fallow system, crop rotation and use of farmyard manure, agroforestry and of course inorganic farming (the use of chemical elements to maintain and improve soil fertility). Of these systems, inorganic farming has been the most popular, bringing about more than 100% increases in crop yield in the past few decades (Adediran et al., 1999). But the scarcity and consequent high prices of chemical fertilizers due to very poor distribution channels have pushed the commodities out of reach of the resource-poor farmers (who produce most of the food crops) (Oyinlola and Wujat, 2007).The ill effects of unbalanced and unscientific use of chemical fertilizers, especially nitrogen in developing countries (Nigeria inclusive), have necessitated the development of organic agriculture because of safety and local availability.

Current land use patterns in Benue state show that a wide range of food crops (yam, cassava, maize, rice and sorghum, etc.), cash crops (soybean, beniseed,etc.), tree crops (orange, mango, cashew,etc.) and a variety of vegetables (tomatoes, pepper, leafy vegetables, garden egg, onion,etc.) are grown. These crops, including vegetables, are mainly cultivated under rain-fed conditions in the upland. The starch-based diets of the people consider vegetables as secondary in terms of hectarage and attention, despite their importance in the supply of minerals and vitamins as well as proteins (Denton et al., 1988). Like the food and cash crops, vegetables are commonly cultivated on the well-drained upland soils with little or no attention given to weeding, fertilizer application and watering (in times of dry spell). Under these conditions, vegetable yields are low and there is a break in supply in the dry season leading to soaring prices. This is because wetlands are scarcely cultivated in the dry season and vegetables are secondary to cassava during that season. Despite favorable physical and chemical properties as well as soil moisture conditions of the wetlands, they are marginally utilized in the dry season. The objective of this work was therefore to identify (employing land use planning techniques) suitable soil types for organic vegetable farming in Benue State and to characterize and classify such soils for research extrapolation.

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II. Materials and Method

a) Field Work

In 2008/2009 and 2009/2010 cropping seasons, field assessment of vegetable crop yields by a multi stage sampling technique using structured questionnaires administered through field enumerators was carried out in Benue State[Latitude 06^0 $30^/$ - 08^0 $10^/$ N, Longitude 08^0 10^0 – 10^0 E]. The state was stratified into local government areas (LGA) (23№) and the LGA was stratified into wards with 5 wards picked from each LGA. Four respondents were then sampled from each selected ward using the table of random numbers. In all, 460 respondents were involved in the study.

Soil characterization studies were then carried out from selected fields of the respondents. The studies were on two broad soil types – the well-drained soil of the upland (upland soils) and the poorly drained soils of the lowland (wetland soils). Composite surface soil samples were taken from 10 fields each of the upland and wetland soils. Two typical representative profile pits were sunk in each of the soil types to characterize and classify the soils for research extrapolation. The pits were described using the procedures of Soil Survey Staff (1998). Soil samples were collected from identified natural horizons and were carefully labeled and kept for laboratory analysis.

b) Laboratory Work

Both the composite and profile soil samples were air-dried for 5 days, ground and sieved to obtain the fine earth fraction (<2mm). Routine laboratory analyses such as particle size distribution, soil pH, organic carbon, total nitrogen, available phosphorous, exchangeable bases and cation exchange capacity (CEC) were carried out using the methods of IITA (1979). Base saturation was calculated using the total bases and cation exchange capacity.

III. Results and Discussion

Table 1 presents the vegetable crop yields in wet and upland ecologies for the two cropping seasons of 2008/2009 and 2009/2010. Generally, crop yields were higher in the wetland soils than in the upland, but this was only significant in 2008/2009 cropping season. Of the six vegetables, onion and Amaranthus did not show any significant difference in yield between the two soil types in both cropping seasons. However the yields of okra, tomatoes, pepper and garden egg were significantly higher in the wetland than in the upland soils. The reasons for this difference may be found in Table 2. The physical and chemical properties of the soils showed that the wetland soils were by far more favorable for crop yield than the upland soils. The wetland soils had higher organic carbon (2.28%) than the upland soils (0.87%). This singular difference had multiplier effects as wetland soils had higher total N (0.31%) and available P (9.8 mg kg-1), higher pH (6.7) and total exchangeable bases (12.8mol kg-1) as shown in Tables 3-6. The textural class of the wetland soils was sandy clay loam while that of the upland soil was sandy loam. The implications are that soil structural development, CEC (i.e., the ability of the soil to retain plant nutrients and water) are higher among the wetland soils than the upland soils. Available soil moisture content is very critical in crop production. One of the reasons for the declining productivity of the upland soils is erratic rainfall in recent times coupled with the rapid run-off from the upland (Idoga, 2005).

Table 1: Vegetable crop yields (t/ha) in wet and upland environments in 2008/2009 and 2009/2010 cropping seasons in Benue State.

Crop	2008/2009 cropping season			2009/2010 cropping season		
	Wetland	Upland	Mean	Wetland	Upland	Mean
Onion	6.11	6.11	6.11	6.26	6.10	6.18
Okra	5.92	1.76	3.84	5.96	2.14	4.05
Tomato	5.69	2.75	4.22	5.70	3.20	4.45
Pepper	2.97	1.84	2.41	3.11	2.33	2.72
Garden egg	6.00	4.60	5.30	6.82	6.11	6.47
Amaranthus	8.81	8.20	8.26	8.99	9.36	9.18
Mean	5.83	4.20	5.02	6.13	4.87	5.50
SED	0.48	0.04	-	0.006	0.003	-
Paired t-test (0.05)						
Wetland vs Upland (2008/2009)	-2.43*					
Wetland vs Upland (2009/2010)	-1.97ns					

**: significant at 5% probability level; ns: not significant*

Soil PH, organic carbon, total nitrogen, available phosphorous, exchangeable bases, CEC and percentage base saturation were higher in the wetland soils than in the upland. It is important to note that most of these soil properties are dependent to some degree on the quantity and quality of organic matter. Tel and Hagarty (1984) had listed these properties to include, reserves of exchangeable bases, capacity to supply N and P, stability of soil structure, adequacy of soil aeration and CEC which influences the absorption and retention of water and plant nutrients. Kekong et al. (2008) also indicated that lowering of soil bulk density and increased porosity are some other benefits of soil organic matter.

Table 2 : Physico–Chemical properties of upland and wetland soils.

Soil Characteristics	Upland Soil	Wetland Soil
Sand (%)	76	55.6
Silt (%)	14	9.2
Clay (%)	10	35.2
Textural class	Sandy loam	Sandy clay loam
pH(H2O)	5.5	6.5
Organic C (%)	0.87	2.28
Total N (mg kg^{-1})	0.10	0.31
Available P (mg Kg-1)	6.80	9.80
Exchangeable Ca (Cmol Kg-1)	1.10	6.40
Exchangeable Mg (Cmol Kg-1)	0.89	7.80
Exchangeable K (Cmo lKg-1)	0.12	0.10
Exchangeable Na (Cmo lKg-1)	0.11	0.09
CEC (Cmol Kg-1)	3.05	15.36
B.S. (%)	76	94

Since both the upland and wetland soils of Benue state fall within the same vegetation zone and climatic conditions, the differences in their organic matter content could only result from differences in their topographic positions and relative wetness. Fagbami and Akamigbo (1986) observed that topography and parent materials are the major factors that influence soil characteristics in Benue state. Tables 3-6 which show the morphological, physical and chemical properties of two typical representative profiles each of the upland and wetland soils of Benue state are clear illustrations of the influence of topography on the soils. The morphological properties of the upland soils show that they were well drained with dominant colour hues of 7.5YR in the A horizons to 5YR in the B horizons. The A horizons of the upland soils were thin (<10cm) with the texture of loamy sand. On the other hand, the wetland soil profiles had very thick A horizons (>30cm) that were poorly to very poorly drained. The soil color hues were 10YR on the surface and 2.5Y and 5Y in the lower horizons. In the wetland soils of both locations, water table stood at less than 100cm of soil surface keeping the surface horizons moist even in February. This implies that crop production can be carried out in the dry season without irrigation in the wetland soils. Tables 3-6 show that the wetland soils were classified as Aeric Kandiaqualfs /Gleyic Luvsols, meaning that aquic soil moisture regime or gleyic soil conditions are the major attributes of the soils. These soils are saturated with water for most part of the year. Such soils are known to occupy over 300,000 hectares in Benue State (Idoga 2005) and can therefore supply more vegetable than the needs of the people, leaving excess for the market. The chemical properties of the soils are tied to their organic matter content. The organic matter content of the wetland soils is not only higher than that of the upland soils, but also remains relatively stable over the years because of slow decomposition and the effect of cumulization from the surrounding upland, especially of organic particles. These two processes (slow decomposition and cumulization) continually maintain the organic matter content of depressional soils (wetland) and their attendant high nutrient content. These soil conditions help to reduce the negative impact of high temperature and bulkiness in organic materials on organic farming in the tropics. From the fore going discussions, organic vegetable production is recommended for the wetland soils of Benue state especially in the dry season.

Table 3 : Morphological properties of upland and wetland soils of Makurdi LGA.

Horizon	Depth (cm)	Munsell colour (moist)	Mottling	Texture	Structure	Boundary	Remark
Ap	0 – 9	7.5YR3/3	-	LS	1fcr	gs	Many fine roots.
BC	9 – 27	7.5YR5/6	-	SL	2msbk	gs	Common fine roots.
C	27 – 58	5YR4/6	-	Gr.SL	2msbk	-	Many medium Fe concretion.
Ap	0 – 35	10YR2/3	7.5YR5/6fif	SL	2msbk	gs	Many fine roots.
B	35 – 50	2.5Y3/2	10YR5/8fif	SC	3csbk	ds	Few fine roots.
Bt_1	50 – 65	2.5Y3/3	10YR5/8cif	C	3csbk	ds	Few fine roots.
Bt_2	65 - 96	5Y5/6	10YR5/6c2d	C	3csbk	-	Water table at 96cm.

Key: Mottling: fif : few fine faint
Cif: common fine faint
Textures: LS= few fine filth
SL= sandy loam
SC= sandy clay
C= clay
Gr.SL = granalitic sandy loam

Structure: 1fcr= weak fine crumb
2msbk= moderate medium sub angular blocky
3csbk = strong coarse sub angular blocky
Boundary: gs =gradual smooth
ds = diffuse smooth

Table 4 : Physical and Chemical Properties of the upland and wetland soils of Makurdi LGA.

		PSD (%)							Exch. Bases (cmolKg^{-1})					
Horizon	Depth (cm)	Sand	Silt	Clay	pH (H_2O)	Org. C (%)	Total N(%)	Avail. P(mgKg^{-1})	Ca	Mg	K	Na	CEC (cmolKg^{-1})	B.S (%)
Upland Soil														
Soil Name: OxicUstropept/ EutricCambisol														
Ap	0 – 9	78	14	8	5.6	0.78	0.09	6.2	1.2	1.0	0.12	0.11	3.15	77
BC	9–27	76	14	10	5.2	0.42	0.05	3.2	0.92	0.94	0.13	0.11	2.84	75
C	27–58	74	16	10	5.0	0.30	0.03	3.0	0.96	0.68	0.12	0.08	2.80	66
Wetland Soil														
Soil Name: AericKandiaqualf/GleyicLuvisol														
Ap	0 – 35	60	23	17	6.9	2.40	0.35	12.0	6.18	2.40	0.10	0.09	9.56	92
B	35– 50	48	15	37	6.6	1.35	0.15	8.12	5.40	1.89	0.12	0.10	8.36	89
Bt_1	50–65	40	12	48	6.4	0.60	0.05	7.10	4.00	1.90	0.14	0.11	7.36	84
Bt_2	65-96	42	13	45	6.4	0.36	0.04	8.00	3.80	2.44	0.10	0.11	7.40	87

Table 5 : Morphological Properties of Selected Upland and Wetland Soils of Gboko LGA

Horizon	Depth (cm)	Munsell colour (moist)	Mottling	Texture	Structure	Boundary	Remark
Upland: TypicPaleustalf/EutricLuvisol							
Ap	0 – 8	7.5YR3/4	–	SL	1fcr	gs	Many fine roots.
B	8 – 25	7.5YR4/6	–	SL	2msbk	gs	Common fine roots.
Bt_1	25 – 68	5YR4/6	–	SCL	3msbk	gs	Few fine roots.
Bt_2	68 – 90	5YR4/8	–	SCL	3msbk	gs	Few fine roots.
BC	90 – 135	2.5Y4/8	–	SCL	3msbk	–	–
Wetland: UmbricKandiaqualf/GleyicLuvisol							
Ap	0 – 32	10YR2/2	7.5YR 4/6 fif	SCL	2msbk	gs	Many fine roots.
B	32 – 56	2.5Y2/2	10YR5/8 fif	SCL	3msbk	ds	Common fine roots.
Bt	56 – 81	5Y6/6	–	C	3msbk	–	Water table at 81cm.

Key: Textures : SCL = sandy clay loam
Structures: 3msbk = strong medium sub angular blocky
Boundary: gs = gradual smooth
ds = diffuse smooth

Table 6 : Physical and Chemical Properties of Selected Upland and Wetland Soils of Gboko LGA.

		PSD (%)							Exch. Bases (cmolKg^{-1})					
Horizon	Depth (cm)	Sand	Silth	Clay	pH (H_2O)	Org. C (%)	Total N(%)	Avail. P(mg Kg^{-1})	Ca	Mg	K	Na	CEC (cmol Kg^{-1})	B.S (%)
Upland: Typic Paleustalf/ Eutric Luvisol														
Ap	0 – 8	75	13	12	5.8	0.81	0.09	6.50	1.30	1.00	0.14	0.10	3.50	73
B	8–25	73	10	17	5.6	0.50	0.06	4.60	1.20	1.10	0.11	0.11	3.80	66
Bt_1	25–68	70	8	22	5.6	0.50	0.03	5.00	1.40	1.60	0.10	0.09	4.23	75
Bt_2	68 – 90	65	10	25	5.4	0.30	0.03	4.80	1.45	1.60	0.11	0.09	4.36	75
Bc	90 – 135	68	10	22	5.2	0.30	0.03	4.60	1.30	1.20	0.11	0.10	4.20	65
Wetland: Umbric Kandiaqualf/Gleyic Luvisol														
Ap	0 – 32	60	18	22	6.8	2.51	0.35	12.80	6.28	2.28	0.21	0.12	10.00	89
B	32– 56	58	18	24	6.6	1.20	0.15	11.00	4.60	2.16	0.12	0.10	8.52	82
Bt	56–81	48	14	38	6.9	0.80	0.10	11.50	4.00	2.86	0.14	0.09	8.86	80

IV. Conclusion

Yields of vegetable crops were higher when planted in wetland soils than in upland environment in the absence of synthetic fertilizers, implying suitability of wetland soils for organic agriculture in Benue State of Nigeria.

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