Journal of Agriculture and Environment Vol. 18 No. 1, 2022: 141-156
ISSN: 1595-465X (Print) 2695-236X (Online)

INFLUENCE OF FLOOD LEVELS ON RAINFED RICE (*Oryza sativa*) PRODUCTION IN FLOODPLAIN OF AWE LOCAL GOVERNMENT AREA OF NASARAWA STATE, NIGERIA

J. Usman[1], M. Usman[2], I.J. Tekwa[1], O.J. Ogbu[3] and E.D. Azagaku[4]

[1]Department of Soil Science and Land Resource Management, Federal University Wukari, Taraba State-Nigeria
[2]Department of Agricultural Science Education, Federal College of Education (Technical), Potiskum-Nigeria
[3]Department of Agricultural Education, College of Education, Oju, Benue State-Nigeria
[4]College of Agriculture, Science and Technology, Lafia, Nasarawa State-Nigeria

ABSTRACT

A pedological study was carried out in floodplain of GidanTindi, Awe Local Government Area of Nasarawa State, Nigeria to characterize and evaluate the effect of flood levels on the growth and yield of rain-fed rice during the 2017 and 2018 cropping seasons. The experiment comprised of three flood levels (levees – shallow swamp, lower elevation- lower slope, and toeslope - deep swamp) and four rice varieties (FARO 44, FARO 52 (WITA 4), L-19 (FARO 60) Africa 18 (WITA 9), and FARO 15) laid out in a 3 x 4 factorial arrangement fitted into randomized complete block design (RCBD) and replicated three times giving a total of 12 treatment combinations. Each plot measured 2 × 2 m ($4m^2$) and 1 m alley ways between plots. Soil samples were collected from different horizons of the pits, air dried crushed and sieved (d<2mm) for routine laboratory physical and chemical analyses. Crop growth and yield data were collected and subjected to one-way analysis of variance (ANOVA) at 5% level of significance. Soils of the three flood levels were rated highly suitable ($S_{1)}$ for rice production because of its ability to retain water during the growth period as well as favourable physical and chemical characteristics such as climate, slope, water levels, pH and texture. From the three levels of water used for the test crop, FARO 44 gave the highest yield (6.62 to 6.66 t ha^{-1}) at levee flood levels (shallow) but submerged in medium and toeslope flood levels while L-19 had the least (5.09 and 5.03 t ha^{-1}) under toeslope flood levels.

Keywords: Flood levels; rainfed rice; flood plain; Southern Guinea Savannah

INTRODUCTION

Nasarawa State is an Agrarian State with enormous agricultural potentials. The State is located in the Southern Guinea Savannah vegetation zone which supports virtually all crops. Areas around the eastern part of the State have major rivers like River Bakin Kogi, River Shankodi, River Ankwe and River Wuse (Asu River group). These rivers provide a wide floodplain that is low-lying, stretching from Jangwato GidanTindi where seasonal floods enrich the soils with nutrients as well as water through surface floods and seepage, from the rivers. This area is widely known for rice production. Rice production is one of the major sources of income to farmers in the area. The history of large-scale commercial rice production dates back to the early eighties to nineties by Lower Benue River Basin Development Authority (LBRBDA), and Lafia Agricultural Development programme (LADP). Today, the area is taken over by Nasarawa State University, retired military generals, directors and seasoned commercial farmers who are largely into rice production.

Rice is one of the main staple foods in Nigeria and the world at large. Its demand for domestic consumption and export for foreign exchange return is on the increase despite the low domestic production (Ogbu *et al.,* 2019). This low production could be partly attributed to incessant crop failures in recent times due to erratic and unpredictable rainfall pattern and badly eroded soils of upland currently being experienced throughout the country due to global climate change. The obvious effect of the wetland soils, which may lead to abuse of land use that may lead to decrease in rice yield and soil degradation even in the lowland wetland.

Rice is an aquatic crop and mostly grown under submergence or variable ponding conditions. Variations in water depth due to irregularity of levelling, especially in large size paddy fields, often affect rice growth and yield (Abou *et al.,* 2006). Water depth is an important parameter for the prediction of rice growth and yield. Different varieties of rice respond differently in various water levels. Similarly, their morphological behaviour differs in various water levels, plant height, number of leaves, panicle length of seed, size of seed, number of spikelet and many others (Ogbu *et al.,* 2019).

Morphologically, the rice varieties differ from each other mainly in ligules size, shape, colour of leaves and seeds, tillaring ability, blade area number of leaves, time of maturity, pubescent length of caryopsis, and paddy weight. The determination of the relationship between the effects of various rice varieties and water depth will provide grower management options in dealing with water depth problems that may occur in rice production. However, this research was designed with the objective to characterize and evaluate the effects of three flood levels on optimum rice production and as well, the use of appropriate rice varieties and flood levels in order to mitigate the effects of erratic rainfall in the study area.

Flood plains are relatively flat, largely horizontally bedded alluvial landform occupying a large part of valley bottom, adjacent to river channel, separated by banks which may be leveed, normally underlain by consolidated sediments. They are dynamic systems that are shaped by repeated erosion and deposition of sediment, inundation during rising water levels, and complex groundwater–surface water exchange processes It is important to understand the unique properties of flooded plain soils for better management of fertilizers for rice. This is because rice is predominantly grown under wetland conditions. When a soil is flooded, major chemical and electrochemical changes take place. These changes include: depletion of molecular oxygen; increase in pH of acid soils and decrease in pH of calcareous and sodic soils; increase in specific conductance; reduction of Fe3+to Fe2+ and Mn^{4+} to Mn^2; reduction of NO^{3-} to NO^{2-} and N_2/N_2O; reduction of SO_4^{2-} to SO_3^{2-}; increase in supply and availability of N, P, Si and Mo; decrease in concentrations of water-soluble Zn and Cu; generation of CO_2 and methane and reduction in toxic products such as organic acids and hydrogen sulfide. These reactions usually have profound influences on soil nutrient transformations and availability to rice grown under wetland conditions.

MATERIALS AND METHODS

Study Area

The study area is GidanTindi (latitudes 7^0 45' to 9^0 25' N and longitudes 7^0 32' to 9^0 37' E) which lies within south- eastern block of Nasarawa State and covers a total area of over 22,000 hectares of Fadama along Rivers Shankodi, Wuse and Ankwe (ASU river group). It has two distinct seasons (wet season between April and October and the dry season which starts from November to March). Annual rainfall in the area is between 1143 mm and 1270 mm. The monthly maximum mean air temperature is high (36.4ºC) in the period prior to the onset of rains in March/April and is low (22.9°C) during the period of heaviest rainfall in August. The study area consists of extensive flood plains dissected by rivers Bena and Gbagbok (Jangwa) while Abanbu, Hunki (GidanTindi) drain dendrically into river Katsina-Ala in Benue State. River Wuse forms the major drainage pattern of the area. It rises from the Jos Plateau (River depth) and empties into river Ankwe a tributary of River Benue. The flood plain has an abrupt boundary with the Namu formation and Benue piedmont which is predominantly made of cretaceous shales (Fagbemi and Akamigbo, 1986; Gani *et al.,* 2022).

Experimental Design

The experiment is comprised of three flood levels (levees – shallow swamp (>0cm, 0-50cm, >50cm) lower elevation- lower slope and toeslope - deep swamp) and four rice varieties (V_1- FARO 44, V_{2-} FARO 52 (WITA 4) V_3 – L-19 (FARO 60) Africa 18 (WITA 9) and V_4 – FARO 15) and were laid out in a 3 x 4 factorial arrangement fitted into randomized complete block design (RCBD) and replicated three times giving a total of 12 treatment combinations. Each plot measured 2 × 2 m (4 m^2) and 1 m alley ways between plots.

Field and Laboratory Studies

A reconnaissance survey was carried out in the area. Based on the local relief/drainage, three soil units were mapped out as; toeslope, lowerslope and levee. Two profile pits were sunk in each of the topographic positions, giving a total of 6 profile pits. Each profile pit was described according to the guideline for soil profile description (Soil Survey Staff, 2014) and samples collected from identified soil horizons into polythene bags carefully labelled and taken to the laboratory for physical and chemical analysis. The samples were air dried, crushed and sieved (d<2mm). The samples were analyzed for particle size distribution, pH, organic carbon, cation exchange capacity, exchangeable bases (Ca, Mg, K and Na), total nitrogen and available phosphorus. Particle size distribution was determined by Bouyoucos hydrometer method (Day, 1965). Soil pH was determined by electrometric methods as described by IITA (2015). Walkley- black method as described by Nelson and Summers (1996) was employed for organic matter content. Total nitrogen was determined using the modified macro-kjeldahl method as described by IITA (2015). Bray No.1 method as described by IITA (2015) was used for extractable P.

Agronomic Practices

Sarosate, a non-selective herbicide dissolved in 1500 litres of water was used to clear the land of weeds (grasses, broad leaves) in mid-May at both years. After which the land was ploughed with a tractor and harrowed twice before it was demarcated into plots manually using hoe in the first week of June in both years.

Two seeds were sown per hole as per treatment at a spacing of 20 x 20 cm to give 500,000 plants/ha. NPK 20:10:10 at the rate of 250 kg ha^{-1} was broadcasted basally at two weeks after sowing. This was supplemented with 100 kg of urea as top dressing before booting stage (Panicle initiation) as recommended by Chude *et al.* (2011). Grasses, sedges and broad leaf weeds were controlled with a mixture of 250ml of Nominee gold mixed and 2, 4 – Dimethylamine salt (72% W/V) dissolved in 900 litres of water. Harvesting was done when they attained physiological maturity between 90 – 130 days depending on the variety at moisture content of 12 – 13%. This was followed by threshing and winnowing.

Crop Data Collection and Analysis

Data were collected using a quadrat of one metre square (1 m^2) placed in the middle of each plot to measure the crop growth and yield parameters viz; plant height per plant (cm), days to maturity, days to 50 % flowering, heading height (cm), number of tillers / m^2, number of filled panicles, number of seed per spikelets, 1000 seed weight (g), seed yield (t/ha). One-way Analysis of Variance (ANOVA) was used to analyse the data with the aid of statistical analysis software (SAS, 2009).

RESULTS AND DISCUSSION

Morphological Properties of Soils of the Study Area

The major surface characteristics are gilgai micro-relief and poor drainage as indicated by the presence of mottles at the surface. Soil structures were well developed, and soil texture was generally sandy clay loam to clay loam at surface and clay at subsurface (Table 1). The soils were poorly drained. Soil structure influenced the root development, penetration, seedling emergence, plant growth, adsorption of water and nutrients at surface and subsurface of soil, percolation, infiltration, aeration and water holding capacity (Ali *et al.*, 2022a). The A horizon of all the pedons were characterized by moderate to strong coarse subangular blocky structure. This could be attributed to the relatively high level of organic matter in the surface horizons as well as the high clay content of the soils (Ogbu *et al.*, 2022). The soils of the area were predominantly dark brown (10 YR 3/3, 10 YR 4/3 Moist) in their A and Ap horizons of all the profiles. This could be attributed to the presence of relatively high organic matter which is the main colouring agent on surface soils (Ufot, 2012; Brandy and Ray, 2014).

Physical and Chemical Properties of Soils of the Study Area

The hydraulic conductivity of the study area was moderate to high in the A and Ap horizons and is ideal for cropping due to better soil aggregates resulting to high pore space for agricultural activities (Table 2). Hydraulic conductivity is the flow of water through soil per unit of energy gradient. For practical purposes, it is a measure of the rate at which water moves into and through the soil. It is useful for predicting runoff from rainfall, soil drainage, irrigation rates, leakages from dams and deep drainage that contributes to salinity (Pramod *et al.*, 2009).

The moisture content of the study area decreased with depth due the predominance of clay. The total porosity values ranged between 10.12 and 15.48 %. The total porosity value decreased with depth in all the units. This may be attributed to high compaction and vegetation in the lower soil, leading to lower soil porosity values. Use of heavy equipment on soil reduces pore space by increasing bulk density (Usman, 2021).

Bulk density values ranged between 1.015 and 1.485mgm^{-3}. The bulk density of the study area was moderate to high. It decreased with depth and mid-way high by forming a hard pan layer due to frequent use of tractors in yearly farm operations. After the hard layer, it increased down the profile due to the influence of clay as the dominant mineral. The frequent deposit of harvested residues also increased the bulk density of soils. The moisture content values ranged between 30 and 38 %. Moisture content could be influenced by a number of factors such as drainage, ground water table, elevation and infiltration (Usman, 2015). Sand fraction was the most dominant particle size distribution at surface and subsurface horizons in all the profiles (Table 3). The high sand fraction is a feature of most savannah soils due to eluviation and illuviation processes as well as the effect of erosion and lessivage. Soils with high sand fractions are vulnerable to erosion because they can easily be detached where heavy down pour and running water are frequent. The silt fraction was irregular with depth in most of the units due to the rate of materials brought by flood (flash and river flood). Generally, the soils were relatively high in clay content. The values of the surface horizons ranged from 20.2 to 59.0 %. The relatively high clay content could be due to nature of the underlying geological materials (shales) (Idoga and Ogbu, 2012). Clay is the dominant mineral in shale and therefore tends to accumulate when shale weathers (Idoga and Azagaku, 2005). Alluvium is another geologic material in the area, being an inland depression. The fine materials are deposited here probably because of the reduction in the velocity of flow of rivers due to low slope gradient. The relative differences in clay content among the pedons could be attributed to slight difference in topography and cultivation.

The pH values across the study area generally indicated that the soils were strongly acidic to slightly acidic in reaction (4.01 – 6.54). This pH levels fall within the range of 4.5 – 7.5 which is considered highly suitable for rice production (Maniyunda *et al.*, 2015). The pH values decreased with depth in all the profiles. This decrease with depth may probably be as result of effect of nutrient bio-cycling (Ogunwale *et al.*, 2002; Idoga and Azagaku 2005). The percentage organic carbon content in the study area was low to moderate with values ranging from 0.01 and2.64 % in the research years. The values were higher in the surface horizons in all the Pedons. This may be due to the concentration of plant roots and plant residues on the topsoil. The moderate values may be attributed to the "aquic moisture" conditions of the flood plains which reduce soil temperature and consequently lower the rate of organic matter decomposition (Idoga and Azagaku, 2005; Dengiz, 2010). Total Nitrogen values of the soil ranged from 0.05 to 0.97 %. This is rated low at the surface and high in the subsurface (Lawal *et al.*, 2012). Low nitrogen is attributed to release from plant tissues, gaseous loss, and loss in surface runoffs, leaching, climatic factors, vegetation, human activities and initial soil pH (Usman *et al.*, 2020).

The phosphorus content of the study area was extremely low (1.78 to 4.87 mg/kg). The low values however agreed with the views of Brady and Ray (2014) and Ali *et al.*

(2022b) that the total quantity of phosphorus in most native soil is low with most of it present in the form quite unavailable to plants. The low available phosphorus may be attributed to low amount of organic carbon of the flood plains. The exchangeable bases (Ca, Mg, K and Na) are low in all the profiles. The low exchangeable bases may be attributed to the nature of the underlying materials, intensity of weathering, scorching, low activity clay, very low organic matter content, surface runoff and the lateral translocation of bases. The CEC values ranged between 4.28 and 8.34 cmol/kg^{-1}. The CEC of the soils of the study area was low to medium according to Esu (1991) rating of <6 = low, 6-2 = medium and <12 = high. The low CEC values of the soils could be attributed to the nature of the silicate clay minerals (Kaolinite) believed to be the dominant clay type in depressed soils (Hassan *et al*., 2011). The percentage base saturation values of the soils (63 to 93 %) were rated moderately high to very high. The distribution of base saturation was irregular in all the profiles. This could be attributed to the active plant litter decomposition process which incorporated cations from the litter into the soil surface and also the contribution by harmattan dust known to contain some high fraction of cations especially Ca (Idoga, 2002; Usman *et al.,* 2015).

Table 1: Morphological description of GidanTindi, Awe Local Government Area of Nasarawa State

Horizon	Depth	Munsell colour (moist)	Mottling	Texture	Structure	Boundary	Inclusions	Consistency	Remarks
Profile 1 Toeslope – *VerticEpiaqualfs/StagnicLixisols*									
A	0 – 7	10YR 3/3		SCL	2mcsbk	CW		SSW	
B	07 – 32	10YR ¾		C	3csbk	GS	Many fine roots	VSW	
Bt1	32 – 51	2.5Y 4/2	5YR 3/2clf	C	3csbk	GS	few medium roots	VSW	
Bt2	51 – 72	2.5Y 4/6	7.5YR 3/2	C	3csbk	GS	Few fine roots	VSW	Concretions
Bt3	72– 130	7.5YR 5/6		C	3csbk	GS	Few fine roots	VSW	
Profile 2: Toeslope – *VerticEpiaqualfs/StagnicLixsol*									
Ap	0 – 14	10YR 3/2	7.5YR 4/4flf	SCL	2mbsk	GS	Many coarse roots	SSW	Pores
Ab	14 – 33	10YR 4/4	7.5YR 4/6clf	C	2csbk	GS	Medium fine roots	VSW	Pores
B	33 – 52	2.5Y 4/3	7.5YR 4/6clf	C	3msbk	DS	Few fine roots	VSW	Stones
Bt1	52 – 74	2.5Y 4/4	7.5YR 4/4	C	3csbk	DS	Few fine roots	SW	Concretion
Bt2	74– 110	2.5Y 4/2		C	3csbk	DS	Few fine roots	SW	
Profile 3 lower slope: – *VerticEndoaqualfs/StagnicLixisols*									
Ap	0 – 11	10YR7/2	7.5YR 4/4flf	CL	2msbk	GS	Medium roots	SW	
Ab	11 – 32	10YR 3/2	10YR 4/6clf	C	2msbk	GS	Medium roots	VSW	
Bt1	32 – 54	10YR 6/2	7.5YR 4/2clf	C	3csbk	GS	Common fine roots	VSW	
Bt2	54 – 70	10YR 6/3		C	2csbk	GS	Few fine roots	SW	
Profile 4: lower slope – VerticEpiaqualfs*/stagniclixisols*									
Ap	0 – 12	10YR 3/3	7.5YR 4/3flf	CL	3csbk	CW	Many fine and medium	SW	
Ab	12 – 29	10YR 4/4	10YR 4/6cld	C	3csbk	GS	Few medium roots	VSW	
B	29 – 48	10YR 5/4	10YR 6/8clf	C	3csbk	GS	Few fine roots	VSW	
Bt1	48 – 67	10YR 3/3	2.5Y 4/3	C	2mbk	GS	Few fine roots	SW	
Bt2	67 – 118	10YR 5/6	7.5YR 5/6	C	2mbk	GS	Few fine roots	SW	
Profile 5: Levee – *AericEndoaqualfs/Aericlixisols*									
Ap	0 – 35	10YR 4/2		SCL	2msbk	GS	Many coarse roots	SSW	
Ab	35 – 41	10YR 5/2	5YR 3/2flf	C	3csbk	GS	Many fine roots	SSW	
Bt1	41 – 63	10YR 3/2	5YR 5/4clf	C	3csbk	DS	Few fine roots	VSW	
Bt2	63 – 80	10YR 6/8	2.5Y 5/2cld	C	2msbk	DS	Few fine roots	VSW	
Bc	80 – 155	10YR 8/6	7.5YR 5/8cld	C	2msbk	GS	Fine roots	SW	

: Levee – *AericEndoaqualfs/Aericlixisols*									
Ap	0 – 25	10YR 2/2		SCL	2msbk	GS	Many coarse roots	SSW	
Ab	25 – 44	10YR 4/4	7.5YR 4/4flf	C	3msbk	DS	Many fine roots	VSW	
B	44 – 60	2.5Y 4/3		C	3mbsk	GS	Few fine roots	VSW	
Bt1	60 – 89	2.5Y 4/4	10YR 4/6cld	C	3mbsk	DS	Few fine roots	SW	Water

Mottling Details: FIF = Few fine faint, C2D = Few Common medium distinct, M3P = Many coarse prominent, C3P = Common coarse prominent
Texture: S = Sandy, C = Clay, SL = Sandy Loam, SCL = Sandy Clay Loam, SC = Sandy Clay
Structure: 3CCR = Strong Coarse Crumb, 2CCOr = Moderate Coarse Crumb, 2MCR = Moderate Medium Crumb, 2MSBK = Moderate Medium Subangular blocky, 2MFBK = Moderate Fine Subangular Blocky, 3 CSBK = Strong Coarse Subangular Blocky, 3MSBK = Strong Medium Subangular Blocky
Consistence: SSW = Slightly Sticky Wet, VSW = Very Sticky Wet, VPW = Very Sticky Wet, SW = Stick Wet, NSW = Non-Sticky Wet, NPW = Non-plastic Wet
Inclusion: C2F = Common Medium Faint, M2D = Many Medium Distinct, F1F= Few Fine Faint, C3D = Common Coarse Distinct
Boundary: DS = Diffuse smooth, GS = Gradual Smooth, CS = Clear Smooth, AS = Abrupt Smooth
Colour: DB = Dark Brown, VDGB = Very Dark Grayisn Brown, LB = Light Brown, SB = Strong Brown, RY = Redishn Yellow, BRB = Dark Redish Brown, RG = Redish Green, DYB = Arkn Yellowish Brown, G = Gray, B = Brown

Table 2: Soil physical characteristics in GidanTindi, Awe Local Government Area of Nasarawa State

Location / soil depth (cm)	Hydraulic Conductivity(M/s)		Moisture Content (%)		Bulk density (g/cm^3)		Total porosity (%)	
Toeslope	2017	2018	2017	2018	2017	2018	2017	2018
0 – 7	1.231	1.131	33	34	1.108	1.015	15.48	13.01
7 – 32	0.658	1.105	32	34	1.125	1.108	14.25	12.91
32 – 51	0.458	0.895	31	33	1.256	1.385	12.21	11.16
51 – 72	0.245	0.628	30	31	1.315	1.406	11.26	10.20
72 – 130	0.145	0.458	30	30	1.389	1.520	10.15	10.12
Lower slope								
0 – 11	1.458	1.451	38	37	1.015	1.001	12.01	13.21
11 – 32	0.875	0.871	36	36	1.158	1.121	11.89	12.25
32 – 54	0.645	0.645	34	33	1.485	1.351	10.26	11.51
54 – 70	0.524	0.494	32	32	1.299	1.131	10.15	10.85
70 – 110	0.485	0.481	31	30	1.244	1.121	10.06	10.15
Levee								
0 – 35	2.145	2.141	37	38	1.125	1.121	14.14	13.75
35 – 41	1.125	1.125	36	35	1.214	1.254	13.54	13.25
41 – 63	0.758	0.708	34	33	1.354	1.405	11.25	12.12
63 – 80	0.489	0.418	33	32	1.135	1.419	10.25	10.15

Table 3: Some physical and chemical properties of the inland wetland soils of GidanTindi, Awe Local Government Area of Nasarawa State

Horizon	Depth (cm)	Sand	Silt	Clay	Texture	pH H_2O	Org. C (%)	Total N (%)	Avail. P Mg/kg	Ca	Mg	K	Na	TEB	CEC	BS %	Fe
		Particle Size dist (%)								Exchangeable Bases Cmol kg							
Profile 1: Toeslope–*VerticEpiaqualfs/StagnicLixisols*																	
A	0-7	74.4	5.4	20.2	SCL	6.50	1.64	0.06	3.99	1.97	1.66	0.98	0.64	5.25	5.36	87	1.65
AB	7-32	48.6	5.4	46.0	C	6.50	0.27	0.05	3.68	2..68	2.38	0.64	0.48	6.80	6.29	85	1.75
B	32-51	48.0	8.8	43.2	C	5.55	0.01	0.07	3.84	3.70	2.62	0.72	0.48	7.52	7.53	78	2.08
BC	51-72	49.4	7.6	45.2	C	5.52	1.04	0.05	2.57	3.73	1.08	0.54	0.37	5.72	5.72	74	2.40
C	72-130	48.1	5.4	43.5	C	5.01	1.02	0.06	2.26	1.99	0.84	0.58	0.48	4.17	4.37	53	2.45
Profile 2: Toeslope–*VerticEpiaqualfs/stagniclixisols*																	
Ap	0-14	70.4	6.0	29.6	SCL	5.55	1.65	0.05	3.67	1.69	1.38	0.82	0.79	4.68	4.78	82	1.58
A	14-33	45.0	10.0	44.0	C	5.46	1.55	0.06	3.98	2.47	1.86	0.54	0.46	5.33	5.35	83	1.88
Bt_1	33-52	48.0	6.2	45.8	C	5.35	1.25	0.05	4.89	3.93	2.41	0.54	0.48	7.36	7.47	77	1.95
Bt_2	52-74	46.1	6.3	47.6	C	5.27	1.18	0.04	3.87	2.01	1.76	0.93	0.64	5.34	5.35	71	2.15
Bt_3	74-110	47.4	7.5	45.1	C	5.07	1.12	0.06	2.15	1.38	2.43	0.35	0.29	4.45	4.58	63	2.20
Profile 3 Lower slope–*VerticEndoaqualfs/StagnicLixisols*																	
Ap	0-11	54.2	5.8	40.0	CL	5.55	1.60	0.07	3.52	2.05	2.03	0.84	0.44	5.35	5.38	64	1.55
Ap	11-32	46.4	5.4	43.2	C	5.46	1.05	0.08	3.46	1.93	1.75	0.72	0.54	4.94	4.98	58	1.80
Bt_1	32-54	45.4	6.6	48.0	C	5.35	1.15	0.06	2.65	2.07	2.04	0.75	0.54	5.60	5.73	88	2.00
Bt_2	54-70	45.8	5.0	48.2	C	5.27	1.20	0.97	2.61	2.13	1.84	0.69	0.43	5.09	5.12	88	2.35
Profile 4Lower slope–*VerticEndoaqualfs/StagnicLixisols*																	
Ap	0-12	53.9	5.9	40.2	CL	6.50	2.64	0.06	3.64	2.60	2.34	0.82	0.53	6.29	6.34	63	1.60
A	12-29	47.0	7.8	45.2	C	6.50	1.47	0.21	2.96	1.98	0.96	0.76	0.58	4.28	4.39	54	1.65
AB	29-48	46.2	6.0	47.8	C	5.55	2.11	0.08	3.84	3.36	2.73	0.52	0.64	7.25	7.34	90	1.75
B	48-67	47.1	7.7	45.2	C	5.52	1.01	0.07	2.57	2.69	2.48	0.73	0.64	6.54	6.72	91	1.85
Bt1	67-118	45.2	6.4	48.4	C	5.01	1.02	0.06	2.26	3.38	2.43	0.8	0.55	7.23	7.23	92	1.90
Profile 5Levee – *AericEndoaqualfs/AericLixisols*																	
AP	0-35	62.8	8.0	29.2	SCL	6.54	1.88	0.06	3.74	1.98	1.42	0.82	0.58	4.80	4.85	65	1.78
AB	35-41	34.4	18.4	49.2	C	6.25	1.42	0.25	1.96	1.98	2.64	1.03	0.94	7.59	7.68	91	1.65
B	41-63	31.4	6.6	55.0	C	6.12	1.45	0.03	3.85	2.99	2.32	0.94	0.82	7.07	7.07	76	2.00
Bt1	63-80	30.9	6.6	59.0	C	5.25	2.35	0.02	1.78	1.82	0.98	0.73	0.64	4.17	4.28	67	2.20
Bt2	80-155	30.4	6.2	54.4	C	4.01	1.3	0.01	2.25	3.38	2.41	0.84	0.58	7.21	7.22	90	2.25
Profile 6Levee – *AericEndoaqualfs/AericLixisols*																	
Ap	0-25	61.0	8.2	30.8	SCL	6.52	2.24	0.09	3.46	2.68	2.55	1.86	0.98	8.07	8.19	93	1.85
B	25-44	44.4	9.5	46.1	C	6.20	1.56	0.08	2.98	4.94	1.83	0.87	0.62	8.26	8.28	82	1.90
Bt1	44-60	48.0	6.8	45.2	C	6. 15	1.60	0.06	1.85	3.93	2.34	1.04	0.94	8.25	8.34	80	2.10
Bt2	60-89	41.2	5.4	53.2	C	5.20	1.35	0.05	2.78	3.24	2.38	0.82	0.62	7.06	7.16	78	1.90

Growth and Yield Parameters of Rice Varieties

Plant Height (cm) and Number of Tillers

The result on the main effect of water level and rice variety on plant height (Table 4) indicated that there was significant difference on flood levels and varietal treatments during the study. At toeslope flood level, the highest plant height was obtained in (117.08 cm) in 2017 as against (95.75 cm) in 2018. At lower slope flood level, highest plant height (113.83 cm) was observed in 2017 as against (105 .75 cm) in 2018. At levee flood level the highest plant height (121.58 cm) in 2017 as against (95.33 cm) in 2018. The high growth observed in Levee (shallow) water treatment in 2017 and 2018 farming season may be attributed to rise in water level and deposit of basic soil nutrients such as CEC, exchangeable bases, nitrogen and phosphorus from upper slope (lower water levels) to low slope (high water levels). Rice can grow up to about 1m tall but there are varieties that can elongate up to 5m with rise in water levels (Abou *et al.*, 2006). The values obtained in this study were in agreement with the report of NCRI (2016) that most height of rice varieties is within the range 80 cm to 200 cm. The results also revealed that at maturity, the main effect of variety differed significantly both in 2017 and 2018 cropping seasons.

Table 4: Effect of flood levels on plant height and number of tillers of rice varieties

Flood levels	Varieties	Plant Height		Number of Tillers	
		2017	2018	2017	2018
Toeslope (deep swamp)					
	FARO 44	00.00	00.00	00.00	00.00
	FARO 52	104.00	95.75	378.00^{b}	378.00
	L-19	117.08	94.92	297.75^{c}	364.42
	FARO 15	96.42	92.75	380.34^{b}	360.00
	LSD (0.05)	22.42	5.42	2.36	55.42
Lower slope					
	FARO 44	00.00	00.00	00.00	00.00
	FARO 52	113.83^{a}	99.83	378.00^{b}	378.00^{ab}
	L-19	113.67^{a}	105.75	296.42^{c}	296.75^{c}
	FARO 15	95.42^{b}	102.50	384.22^{b}	348.67^{bc}
	LSD (0.05)	15.74	6.72	7.11	58.65
Levee (shallow)					
	FARO 44	96.75b	96.17	432.82a	431.00a
	FARO 52	121.58^{a}	97.00	384.78^{b}	378.00^{c}
	L-19	108.27^{b}	95.33	296.25^{c}	297.75^{d}
	FARO 15	93.87^{b}	97.50	386.87^{b}	380.33^{b}
	LSD (0.05)	15.87	3.62	13.90	2.33

Table 4 also revealed that there was significant difference ($P > 0.05$) in flood levels on number of tillers. Tillering is a varietal character as the tillering habit is dependent on varieties, spacing, nutrient, water level and cultural conditions. The levee (386.87) flood level had higher tiller per square meter than lower slope (384.22) and toeslope (380.34) in both years. The high tillering is in line with the view of Ogbu *et al.* (2019) that as water rises; deep water varieties of rice usually produce fewer tillers than the non-deep water rice varieties but contrary to the work of David (1992) who reported that tillering increases with water level.

Days to 50% Flowering and Days to Maturity

Results in Table 5 showed that there was significant difference in flood levels and varietal treatments in the research years. At the toeslope, lower slope and levee flood levels, the highest number of days to 50% flowering was 96. It was observed that in 2017 there was higher number of days to 50% flowering compared with that of 2018. Flowering time indicates the onset of seeding. FARO 44 is an early maturing variety and all varieties flowers according to genetic make-up and environmental conditions. FARO 44 took shorter time to flower, hence they are early flowering varieties (WARDA). FARO 52 and L-19 (FARO 60) are medium maturing varieties which takes 5-6 months to mature. It has a longer growth period than L-19 (FARO 60), but not a late maturing variety (Mohammed and Toungo, 2016), this suggests that FARO 52 flowers slower than the remaining varieties studied with exception of FARO 15. Days to 50% flowering can be seen to decrease from the raining season of 2017 to raining season of 2018, this is because the environmental condition for the season of 2018 was favourable to rice flowering production in the research years. Comparing the results of the days to 50 % of 2017 and 2018 in the water media, levee (103.08) and (93.58) had the highest while toeslope had the least values.

Table 5: Effect of flood levels on days to 50% flowering and days to maturity of rice varieties

Flood levels	Varieties	50% Flowering		Days of Maturity	
		2017	2018	2017	2018
Toeslope (deep swamp)					
	FARO 44	00.00	00.00	00.00	00.00
	FARO 52	91.08[b]	82.08[b]	133.33[b]	121.58[b]
	L-19	82.00[c]	79.58[c]	120.42[d]	117.25[b]
	FARO 15	96.42[a]	93.58[a]	140.83[a]	136.50[a]
	LSD (0.05)	3.88	4.71	3.25	8.90
Lower slope					
	FARO 44	00.00	00.00	00.00	00.00
	FARO 52	86.63[b]	82.25[ab]	135.17[b]	120.00[b]
	L 19	81.67[bc]	74.75[b]	123.00[c]	119.42[b]
	FARO 15	100.25[a]	88.92[a]	142.92[a]	133.92[a]
	LSD (0.05)	6.41	10.46	3.57	10.86
Levee (shallow)					
	FARO 44	64.00[c]	64.58[c]	97.92[c]	98.92[c]
	FARO 52	91.50[b]	82.11[b]	137.75[b]	119.75
	L 19	86.58[b]	74.58[c]	119.58[c]	129.67
	FARO 15	103.08[a]	93.58[a]	144.83[a]	133.08
	LSD (0.05)	6.35	4.63	3.62	15.24

Regarding days to maturity, data obtained from the research (Table 5) indicated that there was significant difference on flood levels and varietal treatments. At toeslope flood level, FARO 15 had the highest (140.83 cm) days to maturity in 2017 as against 136.50 cm in 2018. At lower slope flood level, FARO 15 still had the highest (142.92 cm) days to maturity in 2017 as against 133.92 cm in 2018. At levee flood level, it was still FARO 15 FARO 15 that had the highest (144.83 cm) days to maturity in 2017 as against 133.08cm in 2018.The main effect of flood levels and that of variety do not differ significantly. Days to maturity were more in 2017 than in 2018 cropping season. This is because the weather conditions for the raining season of 2017 was more favourable to rice production and tends to delay maturity as it is a common phenomenon with rice. Where there is water shortage it tends to mature faster. FARO 15 is a late maturing variety, a flood resistant variety suitable in iron toxicity areas and waterlogged (commercial production guide series), hence it has the highest days to maturity (130-140 days). FARO 52 and L-19 (FARO 60) are medium maturing variety with about <130 days (Fasina and Adeyanju, 2006) while FARO 44 is an early maturing variety with <120 days to maturity (WARDA).

Heading Height and Number of Filled Panicles

Result obtained (Table 6) indicated that there was no significant difference on flood levels and varietal treatments in both heading height and filled panicles in both years. The heading height trait is an important yield attributes of rice that affects the overall rice yield as it is often used as a guide to assess the performance of a particular rice cultivar. Based on the data collected by Pramod *et al.* (2009) for lowland rice, these values can vary depending on the variety and environmental factors present. Hence, heading height from the result is seen to decrease from the raining season of 2017 to the raining season of 2018.

Table 6: Effect of flood levels on heading height and filled panicles of rice varieties

Flood levels	Varieties	Heading height		Filled panicles	
		2017	2018	2017	2018
Toeslope (deep swamp)					
	FARO 44	00.00	00.00	00.00	00.00
	FARO 52	22.60[b]	20.25	12.17	18.92
	L 19	22.73[b]	20.75	12.43	9.58
	FARO 15	21.93[b]	20.88	10.63	10.67
	LSD (0.05)	3.62	2.56	4.28	4.96
Lower slope					
	FARO 44	00.00	00.00	00.00	00.00
	FARO 52	30.25[a]	20.00	12.92	12.67[a]
	L 19	24.58[b]	20.75	12.27	9.75[b]
	FARO 15	23.60[b]	20.88	10.67	10.38[ab]
	LSD (0.05)	3.01	3.44	3.40	2.45
Levee (shallow)					
	FARO 44	29.93[a]	20.67	13.33[a]	11.00
	FARO 52	27.25[a]	20.38	13.75[a]	10.67
	L 19	22.67[b]	20.38	12.13[ab]	9.67
	FARO 15	22.83[b]	20.65	9.50[b]	10.28
	LSD (0.05)	1.17	1.65	2.91	1.82

1000 Seed Weight (g) and Grain Yield (t/ha)

Data obtained from the two research years indicated that there was significant difference on flood levels and varietal treatments as regards the 1000 seed weight at levee flood level but no in toeslope and lower slope flood levels (Table 7). At toeslope flood level the seed weight was significant in both locations. At lower slopeflood level seed weight was significant in the two years. At levee flood level seed weight was significant in both years. The major components in rice are number of panicles per unit area, number of seeds per spikelet, panicle weight and individual grain weight expressed as 1000 seed weight. Grain yield is controlled and also influenced by many yields contributing component characters. Hence, direct selection is often misleading. Furthermore, establishing the extent of association between yield and its attributes is a very useful tool for successful selection. Therefore, FARO 44 had the highest seed weight because it has short growth and high yield of up to 6 tonnes/ha, it can be harvested three (3) times in a year (Mohammed and Toungo, 2016) and it can withstand lodging (Malini *et al.,* 2006).

Regarding the grain yield (t/ha), the results from Table 7 indicated that there was no significant difference among them. At toeslope flood level, FARO52 had the highest (5.78 and 5.87 t/ha) grain yield in both years. At lower slope flood level, FARO52 also produced the highest (5.83 and 5.62 (t/ha).

Table 7: Effect of flood levels on 1000 seed weight and grain yield of rice varieties

Flood levels	Varieties	1000 Seed weight (g)		Seed Yield (t/ha)	
		2017	2018	2017	2018
Toeslope (deep swamp)					
	FARO 44	00.00	00.00	0.00	0.00
	FARO 52	26.83	25.38	5.78	5.87
	L-19	25.51	24.34	5.14	5.16
	FARO 15	21.73	20.83	5.22	5.33
	LSD (0.05)	3.09	1.25	0.39	0.27
Lower slope					
	FARO 44	00.00	00.00	0.00	0.00
	FARO 52	25.19	25.26	5.83	5.62
	L-19	24.12	25.52	5.02	5.41
	FARO 15	21.56	21.25	5.30	5.13
	LSD (0.05)	1.82	1.66	0.48	0.12
Levee (shallow)					
	FARO 44	30.87[a]	30.42[a]	6.62	6.66
	FARO 52	26.45	25.85[b]	5.13	5.10
	L-19	26.52	24.34[b]	5.09	5.03
	FARO 15	20.59	21.04[a]	5.78	5.12
	LSD (0.05)	1.95	1.93	0.22	0.25

However, at levee flood level, FARO 44 produced the highest (6.62 and 6.66 t/ha) grain yield during the research years. Comparing the results of the grain yield in the water media, levee flood level (6.62 and 6.66 t/ha) had the highest grain yield during the research years while toeslope flood level had the least. Similar results were also obtained by Ogbu *et al.* (2019). The grain yield results were in tandem with the recommendation of 6 tha-^{1} of

NCRI (2018). The variation in yield values among the varieties during the farming seasons may be attributed to their genetic makeup. All rice varieties used for the study perform well in upland, lowland or deep flooded or shallow water except FARO 44 which suited shallow water level.

CONCLUSION

From the four (4) varieties tested, FARO 44 gave higher yields in shallow swamp (levee) but could not survive lower slope and deep swamp (toeslope) flood level, so should be limited to levee/shallow swamp or farmers can be advised to adopt early planting. Meanwhile, FARO 15, FARO 52, L-19 can be grown in the lower slope and deep swamp because of their height above flood level.

REFERENCES

Abou, E.W.H., Zayed, B.A, Kitamura,Y., Shehata, S.M., Zahor, A. and Faridullah, B. (2006). Effect of poor-quality water on rice growth and yield. *Asian Journal of Plant*. 5(2): 287-295.

Ali, A., Usman, M. and Ebele, E. (2022b). Effect of application of root tap on soil properties, growth and yield of cowpea in Makurdi, *Nigeria. Journal of the Science of Agriculture, Food Technology and the Environment*, 2(2): 10-14.

Ali, A., Usman, M. and Inaku, M.O. (2022a). Effect of mulching and soil water trap on the growth and yield of cucumber (*Cucumis sativus* L.) in Makurdi, southern guinea savanna zone of Nigeria. *Nigerian Journal of Soil Science*, 32(1): 37- 43.

Brady, N.C. and Ray, R.W. (2014). *The Nature and Properties of Soils*. 14th Edition. Person Education Inc. Publishers, India. 976 pp.

Chude, V.O., Olayiwola, S.O., Osho, A.O. and Daudu, C.K. (2011). *Fertilizer Use and Management Practice for Crops in Nigeria*. 4th Ed, Federal Fertilizer Department (FFD) Pub. 215pp.

David, C.C. (1992). *Rice in Deep Water*. London: Macmillan Press Ltd, 542pp.

Day, P.R. (1965). Particle fraction and particle size analysis. *In:* C.A. Black (Ed), *Methods of Soil Analysis*, Agron. 9.ASA, Madison, Wisconsin, USA. Pp547-577.

Dengiz, O. (2010). Morphology, Physico-chemical and classification of soils on terraces of the Tigris River in the South–East Anatola region of Turkey. *Journal of Agric. Science*, 16: 205-212.

Esu, I.E. (1991). Detailed soil survey of NIHORT farm Bakaure, Kano State, Nigeria Institute of Agricultural Reseach. ABU Zaria, Nigeria.Pp.126-138.

Fagbemi, A. and Akamigbo, F.O.R. (1986). Soils of Benue State and their capabilities. Proceedings of the 14th Annual Conference of Soil Science Society Nigeria. Held at Makurdi on the 4th -7th November. Pp. 49-52.

Fasina, A.S. and Adeyanju, B.A. (2006). Suitability classification of some granitic soils of humid West Nig. For rainfed maize, cassava and swamp rice production. *Nigerian Journal of Soil Science*, 16: 1-9.

Gani, A.T., Usman, M., Agber, P.I. and Jatau, A. (2022). Assessment of climatic water balance and soil moisture storage in southern guinea savanna zone of Nigeria. *Journal of the Science of Agriculture, Food Technology and the Environment*, 2(2): 1-9.

Hassan, A.M., Raji., D.A., Malgwi, W.B. and Agbanin, J.O. (2011). The basaltic soils of Plateau State, Nigeria: Properties, classification and management practices. *In*: M.K.A. Adebaye, A. Odofin, J. Osunde, A.O. Baba, A. andOjeniyi, S.O. (Eds). *Soil Resources Management, Global Climate Change and Food Security*. Proceedings of the 35th Annual Conference of Soil Science Society of Nigeria, Minna, Nigeria, March 7th to 11th, 2011.

Idoga, S. (2002). Characterization and effect of harmattan dust on the soils of the lower Benue valley, Nigeria. Ph.D. Thesis, University of Agriculture Makurdi, 130 pp.

Idoga, S. and Azagaku, E.D. (2005). Characterization and classification of soils of Janta area of Plateau State, *Nigeria Journal of Soil Science*, 15:116 – 122.

Idoga, S. and Ogbu, O.J. (2012). Agricultural potentials of the Andibillo Plateau State, *Nigeria Journal of Soil Science*, 22(2):53 – 30.

IITA, (2015). Selected Methods for Soil and Plant Analysis. Manual Series N0.3, IITA Ibadan, Nigeria. 126pp.

Lawal, B.A., Odofin, A.J., Adeboye, M. and Ezenwa, M.I.S. (2012). Evaluation of selected Fadama Soils in Katcha Local Government area of Niger State for Arable Cropping. *Nigeria Journal of Soil Science*, 22(2): 104-112.

Malini, N., Sundaram, T., Ramakrishman, S.H. and Saravanan, S. (2006). Prediction of Hybrid vigour for yield attributes among synthesized hybrids in rice (*Oryza sativa* L.) *Research Journal of Agriculture and Biological Science*, 2:166-170.

Maniyunda, L.M., Samndi, A.M., Malgwi, W.B. and Tarfa, B.D.C. (2015). Characterization classification and rice sustainability evaluation of floodplain soils in Savannah Zones of Nigeria. *Nig. Journal of Soil and Environmental Resources*, 13: 43-104.

Mohammed, D. and Toungo, S. (2016). Introduction of Faro – 52 (WITA – 4) rice variety as a measure of solving low yield problem among farmers in Yola-North Local Government Area of Adamawa State, Nigeria. *International Journal of Innovative Agriculture & Biology Research*, 4(2): 1-7.

NCRI (2016). Recommended practices for lowland rice production in Nigeria. National Cereal Research Institute, Badeggi, Niger State, Nigeria. 142pp.

Nelson, D.W. and Summers, L.E. (1996). Total carbon, total organic carbon and organic matter. *In*: Sparks D.I. (Ed). *Methods of Soils Analysis, Part 3, Chemical Methods*. Agronomy Monograph N0. 9, American Society of Agronomy, Medison. Pp9961-1010.

Ogbu O., Idoga, S., Abagyeh, S. O. and Usman, J. (2019). Land suitability evaluation of the wetland soils of Obukiyo, Oju LGA of Benue State, Nigeria for rice (*Oryza sativa*) Production. *Nigeria Journal of Soil Science,* 29 (2): 7-17.

Ogbu, O.J., Usman, M., Usman, J. and Ogbu, G.E. (2022). Land suitability evaluation for yam (*Dioscorea spp*) production among the soils of Andibilla plateau in Oju Local Government Area of Benue State, Nigeria. *Nigerian Journal of Tropical Agriculture.* (25): 1-11.

Ogunwale, J.A., Olaniyan, J.O. and Aduloj, M.O. (2002). Morphological, physic-chemical and clay mineralogical properties of soils overlying basement complex rocks in llorin east, Nigeria. *Moor Journal of Agricultural Research*, 3(2):147-154.

Pramod, T., Abrol, Y.P. and Suman, K. (2009). *Collection and Conservation of Rice Germplasm in India: Biodiversity and its Significance*. I.K. International Group, 128.

Soil Survey Staff (1994). *Soil Survey Manual*. Washington D.C. US Department of Agriculture. Pp. 10-26.

Ufot, U. O. (2012). Soils and the Environment for Colleges and Universities. Shadow Pub. Ltd, Owerri, Nigeria. Pp1635.

Usman, M. (2015). Cow dung, goat and poultry manure and their effects on the average yields and growth parameters of tomato crop. *Journal of Biology, Agriculture and Healthcare*, 5(5), 7-10.

Usman, M. (2021). *Fundamental Principles of Soil Fertility and Plant Nutrition.* Zaria: Ahmadu Bello University Zaria Printing Press. Pp. 2-88.

Usman, M., Ali, A. and Olatunji, O. (2020). Effect of fertilizer application on soil properties and yield of sesame (*Sesamumindicum* L.) varieties in Southern Guinea and Sudan Savanna Agro-Ecological Zone of Nigeria. *African Journal of Agriculture and Food Science*, 4(1): 89-108.

Usman, M., Madu, V.U. and Alkali, G. (2015). The combined use of organic and inorganic fertilizers for improving maize crop productivity in Nigeria. *International Journal of Scientific and Research Publications*, 5(10), 1-7