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Effect of water depth on eight varieties of rice in Obukiyo, Oju lga of Benue state, Nigeria

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ABSTRACT

Water depth has been described as one of the most important environmental factors determining the growth and yield of rice. Different rice varieties respond differently to various water levels. Three (3) naturally existing water levels (5cm, 10cm and 15cm) at Obukyo Oju Local Government Area of Benue State were studied to evaluate their impact on eight varieties of rice (FARO 15, 37, 44, 52, 57, 60, 61 and 62). The data collected showed significant different ($P< 0.05$) in plant height, blade area, panicle length and dry seed weight, while the number of leaves and tillers were not significantly affected by the various water levels. Generally, the rice performed better in high water levels (15cm) than the medium (10cm) and low water depth (5cm). FARO 57 (9.86t/ha), FARO 61(9.86t/ha), FARO15 (8.78t/ha) and FARO 52 (8.28t/ha) were significantly higher while FARO 44 (5.24t/ha) the dwarf variety and FARO 37 (5 54t/ha) the lodging and low drought resistance variety yielded very poor in high and medium water levels but encouragingly high in low water depth. FARO 57 (5.75t/ha) and FARO 60 (5.65t/ha) were the lowest in low water levels. FARO 15, 52, 57, 60, 61 and 62 were recommended for high water levels while FARO 15, 52, 57, 60, 61 and 62 were recommended for medium water levels. FARO15, 37, 44, 52, 61 and 62 are recommended for low water level. FARO 15, 52, 61 and 62 had encouraging yield in all water levels and are recommended as such.

1.0 Introduction

In recognition of the current global food crises and poor economic situation, Nigeria currently pursues a policy of expanding the land area under cultivation as well as intensifying crop production by continuous cropping system of which rice (*oryza sativa L*) is included.

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. 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 invariable may lead to abuse and the consequence of which may lead to reduced 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 leveling, especially in large size paddy fields, often affect rice growth and yield (Anbumozhi et al., 1998) 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. They had different plant height, number of leaves, panicle length of seed, size of seed, spikelet number and many other rice parameter differ significantly from each other (Ogbu 2019)

Different opinions on the effect of water depth on the growth and yield of rice have been documented. Lingle et al. (2003) viewed that rice performed better with respect to seedling establishment and grain yield in shallow water (< 10cm) than in deep water (>10cm). With the increase of water depth to reduction in fertile tiller number and increase in salinity, they suggested that water depth should be lowered during the initiation and growth of productive tiller. However, the practice of lowering water depth must be incorporated with appropriate field management such as the increase of irrigation frequently, precision leveling and effective weed control method. At the other hand, Talpur et al (2013) observed that increase in water depth (<10cm) is found suitably for maximum growth and yield of rice. Similar result was observed by Anbumozhi et al., (1998). That grain loss due to the excessive ponding was more than that of the deficient ponding. This indicates that rice plants have the ability to survive better at shallow water depth than deeper ponding water depths. Contrary to the above opinions Tarpur et al., (2013) observed that increase in water depth (<10cm) was found suitable for maximum yield of rice.

Rice can be grown over a wide range of climate, soil and water conditions from wet tropical to region of semi-arid, warm-temperature climate in heavy clays or poor sandy soils, on dry land or in swamp/fadama land, in water that may be 15-20f deep, in fresh or brackish water. The thousands of rive varieties that exist account for the cosmopolitan nature. A variety may be found suitable to any condition provided that the plant is subjected to abundant sunshine and given water sufficient for the growth and yield requirement of the particular variety. The fundamental environmental factor that differentiate rice cultural type that are not upland or irrigated is the depth, duration of flooding and water management factor.

Morphologically, the rice varieties differs from each other mainly in ligules size, shape, colour of leaves and seeds, tillaring ability, blade area number of leaves, time of maturity, pubescent awned or aweless, 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 occur in rice production. The objective of this study were to determine the interactive effect of depth 5cm, 10cm and 15cm on the growth and yield of eight (8) varieties of rice (FARO 15, 25, 37, 44, 57, 60, 61 and 62)

2.0 Materials and Methods

2.1 Study Area

Obukiyo lies about 2 km South East of Oju Local Government Headquarter with an average height of about 65m above mean sea level. The area lies between latitude 06.52'N and 06.56'N and longtitude 07.37' and 07.45'E. The study site covers about 600 hectares of land. The area falls within the humid tropical climate. The rainy seasons start from April and last till October while the dry season covers the month of November to March. The mean annual rainfall is about 1100mm falling between April and October. The mean monthly maximum temperature is 34^{0}c. The area was named after river Obukiyo which rises from Andibilla Plateau. The soil consists predominantly of sedimentary rocks of sandstones and shale. The sediment were transported from the upland, Andibilla Plateau by water and deposited on the lowland. The soils of the area are sandy clay loam and clay loam at the surface. Soils of the low water level (unit 1) and medium water level (units III and IV) are characterized by gentle slope while that of high water level (unit II) are nearly level plain. The lowest spots are characterized by gilgai micro-relief, a feature of hydromorphism. The soils host a complex web of organisms which influence soil evolution and specific soil physical and chemical properties. For instance earthworms and crabs activities increase infiltration rate, aeration, permeability, porosity, erosion and many others. The vegetation of the area is dominated by vast grassland with few scattered trees or patches of forest trees and shrubs.

2.2 Soil Data Collection

Before the commencement of the experiment, soil samples were collected from three replicates of each of the treatments and taken to laboratory for physic-chemical analysis. The air dried, crushed and sieved (d<2mm) samples were analyzed for particle size distribution, pH, organic carbon, CEC, EB, TN, available P, ECEC and base saturation (table 1and 2) following the procedures described in IITA (2015).

2.3 Experimental Methods

The factorial combinations of water levels and 8 rice varieties were laid out in Randomized Complete Block Design (RCBD) and replicated three times (3x). In all there were 24 treatments combinations. Each plot measured 2 m x 2 m (4 m^2) and 1m alley ways between the plots. The total land area per water levels was 25 m x 10 m (250 m^2).

2.4 Land Preparation and Planting

The inland wetland was chemically cleared using a non selective herbicide, glyphosate, manually ploughed and designed into experimental blocks and plots. Two seeds/ hole from each of the eight rice varieties were randomly drilled after cultivation at a spacing of 20 cm x 20 cm to give 500,000 plants/ha. The seed rate was 70 kg/ha in line with the standard recommendation of the Benue State Agricultural and Rural Development Authority (BNARDA) and Federal Ministry of Agriculture and Rural Development (FMARD). 100kg N/ha, 50kg P_2O_5/ha and 50kg K_2O/ha (5 bags of NPK 20:10:10) was basally broadcasted at 8 DAP and top dressing was done with 2 bags of Urea (45% N) at 6WAP (panicle initiation stage, Chude *et al.,* 2011). A selective pre and post emergence herbicide, 2, 4-Dimethylamine salt (72% W/V) was mixed with SPADA 60WG (a.i, propanil) and sprayed to control grasses, broad leaf weeds and sedge at 2 Weeks After Planting (WAP) and the second weeding was done manually at 8WAP. The mature rice paddies were harvested at 20WAP, 21WAP and 22WAP (varied per variety), dried, threshed, winnowed, bagged, weighed and recorded for analysis. The experiment was carried out for two years (2017 and 2018).

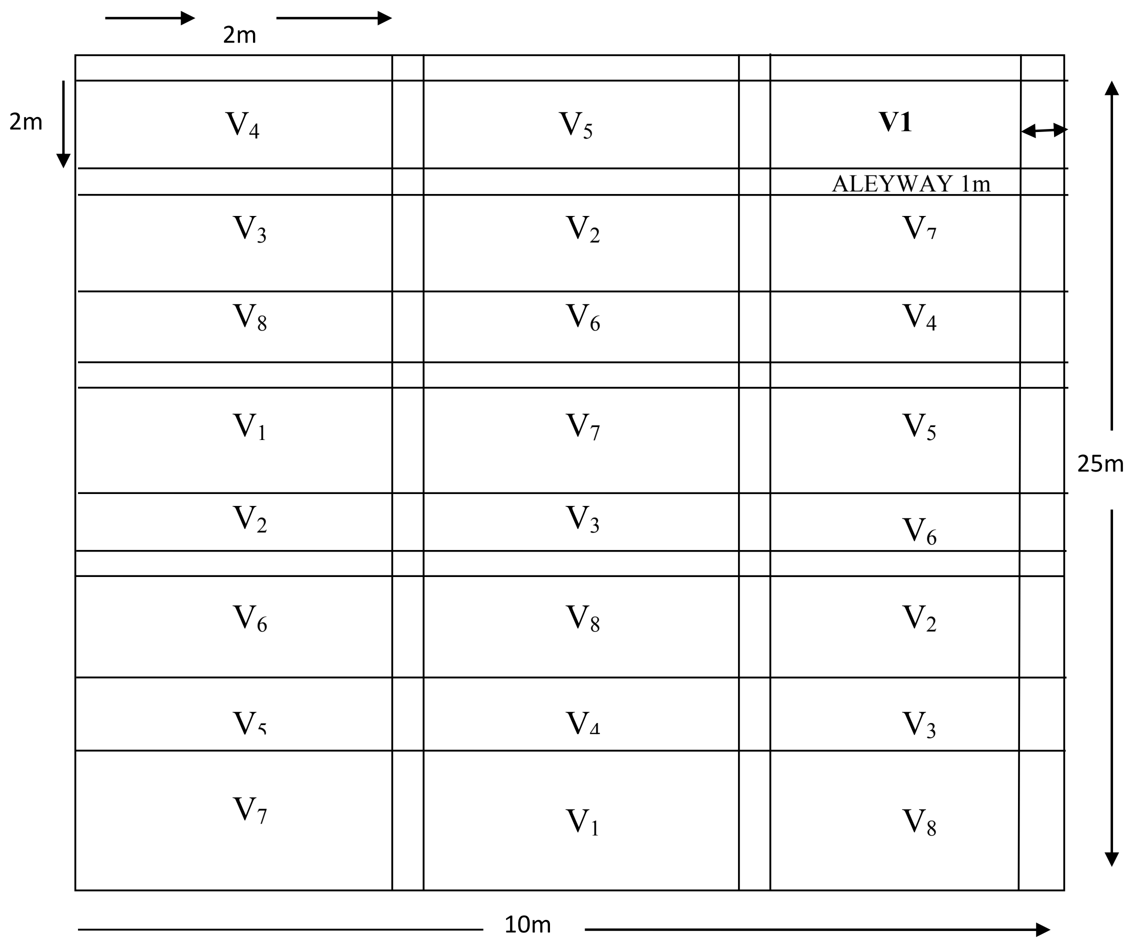

Figure 1; Layout of Treatments in the field

Note: the soil and water levels selected for this study are natural factors that were not randomized along with the rice varieties. The layout showed separate varietal randomization per water depth, low (unit 1), medium (units III and IV) and high (unit II).

2.5 Crop Data Collection

Ten plants were randomly tagged per plot to monitor the following growth and yield parameters; plant height (cm), number of leaves, blade area (cm^2), number of tillers, panicle length (cm) and matured/dry seed or paddy weight at 2WAP, 4WAP, 6WAP, 8WAP and 10WAP representing seedling establishment, vegetative growth, flowering, panicle initiation and maturity stage respectively..The crop data collected were subjected to one way Analysis of Variance (ANOVA) Techniques test using Statistical Analysis Software (SAS, 2009) at 5% level of significance and the treatment means were separated with Duncan Multiple Range Test (DMRT:P>0.05). The mean yield of each variety at the two farming seasons (2017 and 2018) was compared and recommendation was made for the best variety (ies) of rice to be cultivated in each water levels. Spearmans rank correlation was used to establish the relationship between evaluation classes and rice yield for the two cropping seasons. The regression relationship between the rice yield parameters (dependent) and the water levels (independent) and soil chemical characteristics (independent) and the yield parameters (dependent) were calculated using a simple liner regression method.

3.0 Result and Discussiion

3.1 Morphological and Physico-chemical Properties of Soils of the Study Area

Exception of the soils of unit I (low water level) which were well drained, the soils was poorly drained with the presence of mottles and cracks at the surface horizons, indicating that the soils are seasonally waterlogged (table 1). They were mostly sandy clay loam and clay loam in the surface horizons and sandy loam and clay loam in their subsurface horizons (table 2). The common soil structures identified in the study area were, strong medium subangular blocky, strong coarse subangular blocky and strong coarse crumbs characterizing the A and Ap horizons. The soils had high sand fraction (47.40%--74.40%), silt (15.84%-36.56%), and clay fraction (19.76%- 58.26%). The high sand and silt fraction is a characteristic of most savannah soils and is mainly due to the nature of the parent materials, constant weathering of rocks and the downward movement of clay through the soil mass (Ogbu, 2011, Yau *et al*., 2015, Yakubu, 2006)). The relatively high clay content could be due to the nature of the underlying soil geological materials (shales). The Agwu shale is presumed to have constituted the underlying geology of the area. These pH levels falls within the range (4.5-7.5) considered highly suitable for rice production (Maniyunda *et al*., 2015). The organic carbon content (0.30%-2.25%), TN (0.01%-0.42%), p (1.213mg/kg-6.515mg/kg), CEC (3.75cmol/kd-8.34cmol/kg) and the exchangeable bases were low while the base saturation(53%- 93%) were moderately high (Idoga, 2002, Brady and Ray 2014). The high B.S is probably associated with the presence of weathered minerals in the soils profile which release nutrients into the soil, their alluvial nature and inadequate leaching caused by several dry months as well as seasonal high water table.

Table 1; Morphological Description of the Soils of Obukiyo, Oju Local Government Area

Horizon	Depth (cm)	Munsel Colour (Moist)	Mottling	Mottling deails	Texture	Structure	Consistence	Inclusion	Boundary
		Unit I Profile 1: Arenic Paleustalfs/Aeric Lixisols							
A	0-40	7.5YR4/3DB	-		Sandy clay loam	3MSBK	SSW	Few Medium Roots	cs
B	40-60	7.5YR6/4LB	-		Sandy loam	2MSBK	SSW	Few Fine Roots	ds
BC	60-110	5YR6/6RY	-		Sandy loam	2MSBK	SSW	Few Fine Roots	ds
C	110-120	5YR7/6RY	-		Sandy clay loam	2MSBK	SSW	Few Fine Roots/hard coherent rock at 170cm	-
		Unit I Profile 2: Arenic Paleustalfs/Aeric Lixisols							
Ap	0-28	10YR5/3B	-		Sandy clay loam	3CSBK	SSW	Medium Common Roots	ds
A	28-76	10YR4/2DGB	-		Sandy clay loam	3CSBK	SSW	Few fine roots	cs
AB	76-105	10YR4/6DYD	-		Sandy loam	2MSBK	SSW	Few fine roots	gs
B	105-115	7.5YR6/4LB	-		Sandy Clay loam	2MSBK	SSW	Few fine roots	ds
Bt_1	115-130	5YR 5/4RB	-		Sandy Clay loan	2MSBK	VSW	Few Fine roots/ hard coherent rock at 180cm	-
		Unit II Profile 3: Aeric Endoaqualfs/Endogleyic Gleysols							
Ap	0-20	10YR5/6YB	2.5YR5/6 RB	F3P	sandy clay loam	3CCR	SSW	Many coarse roots	cs
Bt_1	20-80	2.5YR5/2GB	10R5/6 YB	M2P	Clay loam	2MSBK	VSW	Many coarse roots	ds
Bt_2	80-110	2.5YR4/3RB	10YR7/6 Y	F2D	Clay loam	2MSBK	VSW	Common medium roots	ds
Bt_3	110-180	2.5YR5/4RB	10YR5/2 GB	F2D	Clay loam	2MSBK	VSW	Few medium roots	-
		Unit II Profile 4: Aeric Endoaqualfs/Endogleyic Gleysols							
Ap	0-24	10YR8/6Y	10YR3/2VDGB	C2D	Clay loam	3CCR	VSW	Many coarse roots	ds
Bt_1	24-86	5YR5/3RB	10YR3/3 DB	F2P	Sandy clay loam	2MSBK	VSW	Few fine roots	ds
Bt_2	86-118	2.5Y4/3OB	5YR4/3 RB	M2P	Clay loam	2MSBK	VSW	Few fine roots	ds
Bt_3	118-190	2.5Y5/6LOB	5YR7/1 LG	M3P	Sandy clay loam	2MSBK	VSW	Few fine roots	-
		Unit III Profile 5: Ustic Epiaquerts/Epiclayic Vertisols							
Ap	0-30	10YR5/6YR	10YR5/2 GB	FIF	Sandy clay	3CSBK	SSW	Many medium roots	cs
AB	30-60	10YR5/8YB	10YR5/2 RG	E2D	Sandy clay	3MSBK	VSW	Common fine roots	cs
B	60-75	10YR6/4LYB	2.5Y7/6 Y	C2P	Sandy clay	2MSBK	VSW	Few fine roots	Ds
Bt_1	75-115	7.5YR5/4B	5YR5/ RB	C2D	Sandy clay	2MSBK	VSW	Few fine roots	Ds
Bt_2	115-150	7.5YR7/4P	5YR7/1 LG	C2P	Sandy clay	2MSBK	VSW	Few fine roots	Ds
Btn	150-180	7.5YR5/6SB	2.5Y7/2 LG	C2D	Sandy clay	2MSBK	VSW	-	-
		Unit III Profile 6: Ustic Epiaquerts/Epiclayic Vertisols							
Ap	0-20	10YR5/4YB	10YR6/8 BY	C2P	Sandy clay	3CSBK	SSW	Many fine ro	Cs
B	20-50	2.5Y4/4OB	7.5YR6/3LB	F1D	Clay	3MSBK	VSW	Common fine roots	Ds
Bt_1	50-100	2.5Y5/6LOB	5YR5/4RB	C2D	Clay	2MSBK	VSW	Few fine roots	Ds
Bt_2	100-160	2.5Y5/4LOB	7.5YR7/1LG	M3P	Clay	2MSBK	VSW	Few fine roots	Ds
Btn	160-180	2.5Y6/0G	10YR4/2 DGB	M3P	Clay	2MSBK	VSW	Few medium concretions	-
		Unit IV Profile 7: Ustic Epiaquerts/Epiclayic Vertisols							
Ap	0-34	10YR3/3DB	10YR5/6 YB	F1D	Sandy clay	3CSBK	SW	Many coarse roots	Cs
B	34-74	10YR4/3DB	10YR6/6 BY	F1D	Sandy clay	3CSBK	VSW	Many coarse roots	Ds
Bt_1	74-98	7.5YR5/4B	10YR5/4YB	F2D	Sandy clay	2MSBK	VSW	Few coarse roots	Ds
Bt_2	98-133	5YR6/3LRB	10YR4/2 BGB	M2P	Sandy clay	2MSBK	SPW	Few fine roots	Ds
Bt_3	133-180	2.5Y5/2GB	5YR4/DRG	M3P	Sandy clay	2MSBK	SPW	Few fine roots	-
		Unit IV Profile 8: Ustic Epiaquerts/Epiclayic Vertisols							
Ap	0-56	10YR3/4DYB	5YR3/2 DRB	F1D	Sandy clay	3CCR	VSW	Many medium roots	Cs
Bt_1	56-96	10YR4/4DYB	2.5YR6/2 PR	F1D	Sandy clay	3CSBK	VSW	Common medium roots	Cs
Bt_2	96-126	7.5YR5/0G	5YR5/2 RG	C2P	Sandy clay	3CSBK	SPW	Few fine roots	Ds
Bt_3	126-160	5YR4/8YR	5YR5/2 RG	C2D	Sandy clay	2MSBK	PW	Few fine roots	-

Mottling Details:
F1F=Few fine faint, C2D= 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, 2CCR = Moderate coarse crumb, 2MCR = Moderate medium crumb, 2MSBK = Moderate medium subangular blocky, 2FSBK = Moderate fine subangular blocky, 3CSBK = Strong coarse subangular blocky, 3MSBK = Strong medium subangular blocky

Consistence
SSW = Slightly sticky wet, VSW = Very sticky wet, VPW = Very sticky wet, SW = Sticky 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= Darkn Yellowish Brown, G=Gray, B= Brown

Table 2: Physical and Chemical Properties of the Inland Wetland Soils of Obukiyo, Oju Local Government Area

Horizon	**Depth (cm)**	**Particle size dist.**			**Texture**	**pH H2O**	**Org. C**	**Total N**	**Avail. P**	**Exchangeable Bases**				**TEB**	**CEC**	**BS**
		Sand	Silt	Clay						Ca	Mg	K	Na			
		(%)					(%)		Mg/kg					Cmol kg^{-1}		(%)
Unit I Profile 1: Arenic Paleustalfs/Aeric Lixisols																
A	0-40	70.40	7.84	21.76	SCL	7.2	1.30	0.05	3.36	1.97	1.66	0.98	0.64	5.25	5.36	87
B	40-60	72.40	7.84	19.76	SL	6.8	0.30	0.06	1.62	2.68	2.38	0.64	0.48	6.80	6.29	85
BC	60-110	79.76	0.00	20.24	SL	6.8	0.60	0.05	3.52	3.70	2.62	0.72	0.48	7.52	7.53	78
C	110-120	71.12	5.54	23.04	SCL	6.0	0.71	0.06	3.56	3.73	1.08	0.54	0.37	5.72	5.72	74
Unit I Profile 2: Arenic Paleustalfs/Aeric Lixisols																
Ap	0-28	74.40	4.56	21.04	SCL	6.1	1.19	0.05	3.27	1.69	1.38	0.82	0.79	4.68	4.78	82
A	28-76	70.40	6.84	22.76	SCL	6.5	0.32	0.06	1.56	2.47	1.86	0.54	0.46	5.33	5.35	83
AB	76-105	72.40	8.54	19.06	SL	5.6	1.54	0.05	2.46	3.93	2.41	0.54	0.48	7.36	7.47	77
B	105-115	69.12	4.84	26.04	SCL	5.7	1.30	0.08	4.67	2.01	1.76	0.64	0.93	5.34	5.35	71
Bt_1	115-180	62.40	5.56	32.04	SCL	5.6	0.40	0.42	4.47	1.38	2.43	0.35	0.29	4.45	4.58	63
Unit II Profile 3: Aeric Endoaqualfs/Endogleyic Gleysols																
Ap	0-20	50.40	28.56	21.04	SCL	4.8	2.00	0.05	3.41	2.05	2.03	0.84	0.44	5.35	5.38	64
Bt_1	20-80	43.12	27.84	29.04	CL	4.4	1.52	0.05	3.13	1.93	1.75	0.72	0.54	4.94	4.98	58
Bt_2	80-110	43.12	27.84	29.04	CL	5.6	1.50	0.04	1.45	2.07	2.04	0.75	0.54	5.60	5.73	88
Bt_3	110-180	42.42	24.54	33.04	CL	5.1	1.26	0.04	2.77	2.13	1.84	0.69	0.43	5.09	5.12	88
Unit II Profile 4: Aeric Endoaqualf/Endogleyic Gleyols																
Ap	0-24	42.40	24.56	33.04	CL	4.1	2.00	0.05	2.10	2.60	2.34	0.82	0.53	6.29	6.34	63
Bt_1	24-86	48.40	20.56	31.04	SCL	4.6	1.42	0.05	1.93	1.98	0.96	0.76	0.58	4.28	4.39	54
Bt_2	86-118	40.40	24.56	35.04	CL	5.0	2.13	0.06	3.73	3.36	2.73	0.52	0.64	7.25	7.34	90
Bt_3	118-190	39.40	21.56	39.04	CL	5.0	0.40	0.08	2.84	2.69	2.48	0.73	0.64	6.54	6.72	91
Unit III Profile 5: Ustic Epiaquerts/Epiclayic Vertisols																
Ap	0-30	58.40	3.54	38.06	SC	5.7	1.38	0.06	1.42	1.99	0.84	0.76	0.58	4.17	4.37	53
AB	30-60	60.24	0.44	39.32	SC	7.5	0.88	0.11	1.52	1.98	1.42	0.82	0.58	4.80	4.85	65
B	60-75	53.04	6.36	40.60	SC	6.7	0.74	0.05	1.44	1.98	2.64	1.03	0.94	7.59	7.68	91
Bt_1	75-115	51.68	7.20	41.12	SC	7.0	0.97	0.06	1.26	2.99	2.32	0.94	0.82	7.07	7.07	76
Bt_2	115-150	56.40	1.50	42.10	SC	6.0	1.97	0.06	1.21	1.82	0.98	0.73	0.64	4.17	4.28	67
Btn	150-180	55.68	0.78	43.54	SC	6.3	1.56	0.04	1.26	3.38	2.41	0.84	0.58	7.21	7.22	90
Unit III Profile 6: Ustic Epiaquerts/Epiclayic Vertisols																
Ap	0-20	56.40	2.62	40.98	SC	7.8	1.74	0.09	1.41	2.68	2.55	1.86	0.98	8.07	8.19	93
B	20-50	43.12	2.59	54.29	C	5.4	0.86	0.07	1.82	4.94	1.83	0.87	0.62	8.26	8.28	82
Bt_1	50-100	42.12	3.22	54.66	C	6.0	0.74	0.07	1.33	3.93	2.34	1.04	0.94	8.25	8.34	80
Bt_2	100-160	40.40	2.89	56.71	C	5.6	1.26	0.14	2.19	3.24	2.38	0.82	0.62	7.06	7.16	78
Btn	160-180	39.12	2.62	58.26	C	7.7	0.78	0.01	1.50	2.98	1.87	0.98	0.96	6.52	6.58	91
Unit IV Profile 7: Ustic Epiaquerts/Epiclayic Vertisols																
Ap	0-34	58.40	2.60	39.00	SC	5.4	2.25	0.05	3.36	1.82	1.34	0.86	0.77	4.79	4.89	72
B	34-74	59.68	0.32	40.00	SC	6.5	1.02	0.05	1.57	2.94	1.86	0.93	0.56	6.29	6.29	78
Bt_1	74-98	61.12	1.65	37.23	SC	6.2	0.36	0.04	2.14	3.67	2.48	0.89	0.03	7.97	7.98	91
Bt_2	98-133	59.70	1.14	39.70	SC	5.8	1.59	0.06	6.51	2.47	1.65	0.42	0.84	5.38	5.49	72
Bt_3	133-180	35.12	7.45	39.43	SC	5.7	1.73	0.06	1.97	1.64	1.34	0.64	0.53	4.15	4.26	65
Unit IV Profile 8: Ustic Epiaquerts/Epiclayic Vertisols																
Ap	0-56	57.40	2.40	40.20	SC	5.5	1.45	0.07	2.33	2.34	1.86	0.95	0.82	5.97	5.98	73
Bt_1	56-96	53.12	2.34	44.59	SC	4.9	1.45	0.06	1.66	2.78	2.02	0.41	0.36	5.55	5.67	65
Bt_2	96-126	53.40	0.61	45.99	SC	6.1	0.48	0.04	1.94	3.37	2.62	0.82	0.72	7.53	7.33	91
Bt_3	126-160	52.12	2.62	45.26	SC	5.8	0.46	0.06	2.48	3.43	2.14	1.58	0.42	7.57	7.69	77

Table 3: Effect of Water Level and Variety on Growth and Yield Parameters of Rice in 2017 and 2018 Cropping Seasons

Treatment	Plant Height (cm)		Number of Leaves		Number of Tillers		Blade Area (cm^3)		Length of Panicle (cm)		Plant Yield (t/ha)	
Water Level (W)	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
High	109.66a	94.60a	6.72b	4.67b	41.46	24.73a	76.99a	66.90a	31.61a	26.74a	5.61	9.18a
Medium	102.35a	77.76b	7.28a	5.84a	38.48	18.73b	74.05b	55.10b	27.79b	26.33a	5.45	7.59b
Low	91.30b	73.33b	6.76b	4.59b	41.06	20.22ab	68.25c	49.42b	26.86b	23.59b	5.39	6.47b
P-value	<0.0001	<0.0001	0.0013	0.1272	0.1499	0.0102	<0.0001	0.0002	<0.0001	<0.0001	0.9561Ns	0.0109*
Variety (V)												
V1 (FARO 15)	97.67bc	85.38a	6.88bcd	5.04ab	35.34c	17.91bc	75.79ab	73.70a	29.36bc	28.36a	5.45	8.54a
V2 (FARO37)	102.93ab	84.82a	6.46d	4.80b	40.74abc	23.68ab	72.58bc	56.17bc	27.26bc	25.91b	5.32	7.39a
V3 (FARO44)	83.67d	69.00b	6.54cd	4.77b	43.24ab	17.91bc	60.72d	45.14c	26.91bc	23.09c	5.16	6.14b
V4 (FARO52)	93.53c	82.27a	6.87bcd	5.26ab	43.22ab	23.08ab	77.20a	51.96bc	28.40bc	25.94b	5.36	7.68a
V5 (FARO57)	106.93a	89.01a	7.29ab	5.42a	40.76abc	25.07a	77.27a	56.59bc	31.80a	26.16b	6.92	9.31a
V6 (FARO60)	97.60bc	86.20a	7.09abc	5.02ab	36.69c	20.04abc	77.12a	58.41bc	27.96bc	24.40bc	5.63	7.22a
V7 (FARO61)	92.98c	82.42a	6.71bcd	4.97ab	38.22bc	25.02a	69.29c	60.66b	28.73bc	25.29b	5.98	8.93a
V8 (FARO 62)	106.84a	81.09a	7.53a	4.97ab	44.42a	20.86abc	74.80ab	54.51bc	29.60ab	25.27b	5.65	7.14ab
P-value	<0.0001	0.0183	0.0020	<0.0001	0.0093	0.0484	<0.0001	0.0073	0.0020	<0.0001	0.8923Ns	<0.0001
Interactions (W × V)												
P-value	0.0001**	0.1621 Ns	0.7156 Ns	0.4377NS	0.1979 Ns	0.7988NS	<0.0001**	0.4769 Ns	0.3088 Ns	0.5892 Ns	0.9697Ns	0.0093*

Means (±SEM) with the same lowercase alphabet in a column are not significantly different from each other (DNMRT: P> 0.05); ** = P < 0.01; * = P < 0.05; Ns = Not significant; WAP = Weeks after planting; P-value = probability value

Table 4: Interaction Effect of Water Level and Variety on Growth and yield Parameters in 2017 and 2018 Cropping Seasons

Treatments		Plant Height (cm)		Number of Leaves		Number of Tillers		Blade Area (cm^3)		Panicle Length (cm)		Dry Seed Weight (t/ha)	
Water Level	Variety	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
												5.89	8.58a
High	V1 (FARO 15)	102.03a	103.00	5.85	4.86	26.63	19.80	77.53a	81.93	32.33	28.53	5.18	8.10ab
	V2 (FARO37)	97.93a	95.20	5.10	4.53	36.76	26.53	65.68b	54.13	30.86	26.73	5.17	5.24c
	V3 (FARO44)	86.16ab	80.26	5.03	3.93	28.86	19.20	59.65bc	55.13	29.60	23.20	5.50	8.43a
	V4 (FARO52)	90.03ab	82.60	6.03	5.00	36.86	23.40	72.31ab	56.83	31.06	28.63	6.84	9.86a
	V5 (FARO57)	107.51a	106.50	6.03	5.33	36.96	26.33	73.70ab	70.03	35.06	27.66	5.83	8.08ab
	V6 (FARO60)	105.70a	104.93	5.60	4.73	29.53	21.53	75.88ab	67.33	29.86	25.66	6.44	9.42a
	V7 (FARO61)	99.80a	98.73	5.16	4.00	34.03	28.06	79.61a	82.83	31.73	27.53	5.33	7.74b
	V8 (FARO 62)	97.86a	96.60	5.86	4.10	32.90	23.00	71.18ab	67.00	32.33	27.13		
												5.95	8.50a
Medium	V1 (FARO 15)	97.46a	88.00	6.56	5.86	24.68	14.20	82.43a	79.80	30.06	28.46	5.23	6.48c
	V2 (FARO37)	94.00a	73.93	6.35	5.73	31.11	22.86	61.35bc	51.20	26.36	27.86	5.19	5.68c
	V3 (FARO44)	75.80b	70.66	6.18	5.40	30.76	18.80	53.06c	43.50	27.26	24.40	5.83	8.28ab
	V4 (FARO52)	84.73ab	81.33	6.56	6.13	29.23	18.73	63.46bc	54.66	27.86	27.13	5.68	7.54b
	V5 (FARO57)	99.46a	81.20	6.80	6.00	27.23	16.60	68.86b	55.86	29.33	26.73	5.73	7.93b
	V6 (FARO60)	86.13ab	81.53	6.53	5.66	27.00	18.53	66.05b	58.86	27.93	25.53	5.39	7.83b
	V7 (FARO61)	86.06ab	71.60	6.50	6.00	28.76	22.86	61.78bc	49.06	27.46	24.86	5.68	7.43b
	V8 (FARO 62)	96.76a	73.80	7.00	5.93	30.03	17.26	59.58bc	47.06	26.00	25.60		
												5.39	6.75bc
Low	V1 (FARO 15)	83.10ab	68.13	7.28	4.40	18.93	19.73	66.25b	59.36	32.33	28.06	5.74	7.50b
	V2 (FARO37)	93.00a	85.33	6.86	4.83	25.56	21.66	70.20ab	63.16	30.86	23.13	6.33	7.86b
	V3 (FARO44)	74.06b	56.06	7.93	6.60	21.76	15.73	50.48c	36.80	24.60	21.66	5.25	6.33bc
	V4 (FARO52)	89.16ab	81.86	7.10	4.66	27.50	27.13	66.08b	44.36	31.06	23.26	5.25	5.75c
	V5 (FARO57)	88.43ab	73.33	5.36	4.93	23.46	11.00	60.61bc	43.86	35.06	24.06	5.25	5.65c
	V6 (FARO60)	89.30ab	72.13	5.26	6.66	21.10	20.06	66.73b	49.03	29.86	22.00	5.25	7.08bc
	V7 (FARO61)	88.90a	76.93	6.43	4.53	22.26	24.13	62.86bc	49.33	31.73	23.46	5.73	6.25bc
	V8 (FARO 62)	86.00ab	72.86	5.73	4.40	23.60	22.33	62.41bc	49.46	32.33	23.06	0.96	0.00
P-Value		0.0001 **	0.1621 Ns	0.7156 Ns	0.4377NS	0.1979 Ns	0.7988NS	<0.0001**	0.4769 Ns	0.3088 Ns	0.5892 Ns	97 Ns	93*

Means (±SEM) with the same alphabet in a column are not significantly different from each other (DNMRT: P> 0.05); ** = P < 0.01; * = P < 0.05; Ns = Not significant; WAP = Weeks after planting; P-value = probability value

Table 5: Variations in Data Collected in the Two Cropping Seasons

Parameters	2017	2018	t-statistics	P-value
Plant height (cm) at 4 WAP	54.42	47.3	11.53	<0.0001
Number of leaves at 4 WAP	4.59	4.61	Ns	0.9122
Number of tillers at 4 WAP	8.17	5.39	15.16	<0.0001
Blade area (cm^2) at 4 WAP	29.42	22.76	8.01	<0.0001
Plant height (cm) at 6 WAP	70.13	65.88	3.73	0.0004
Number of leaves at 6 WAP	5.84	5.02	6.88	<0.0001
Number of tillers at 6 WAP	13.76	9.57	10.83	<0.0001
Blade area (cm^2) at 6 WAP	48.78	47.46	Ns	0.6134
Plant height (cm) at 8 WAP	97.77	81.90	8.24	<0.0001
Number of leaves at 8 WAP	6.90	8.42	NS	0.0704
Number of tillers at 8 WAP	30.46	25.68	3.47	<0.0001
Blade area (cm^2) at 8 WAP	73.09	57.14	9.15	<0.0001
Panicle length (cm)	28.75	25.55	7.62	<0.0001
Dry Seed Weight (ton/ha)	5.52	7.41	8.85	<0.0001

Ns = Not significant; WAP = Weeks after planting; P-value = probability values

Table 6: Regression of Yield Parameters (Dependent) with Water Level (Independent)

Dependent Variables	a (constant)	b (coefficient)	P-Value
Dry Seed weight (kg)	7.658	0.956	<0.01
Length of Pinacle	4.320	-0.067	<0.01

Significant at 99% CL (p<0.05)

Table 7: Matrix of Correlation Coefficient between Yield Parameters and Water Levels

	Dry Seed weight (kg)	Length of Pinacle	Water Level
Dry Seed weight (kg)	-		
Length of Pinacle	-0.24**	-	
Water Level	0.17*	0.23**	-

**indicates statistical significance at 99% CL; *indicates statistical significance at 95% CL

Table 8: Regression of Soil Chemical Characteristics (Independent) with Dry Seed Weight (Dependent)

Independent Variable	b (coefficient)	P-Value
Sand	-0.003	0.65
Silt	-0.002	0.74
Clay	0.586	0.28
pH (water)	-0.003	0.93
Organic Carbon	-0.017	0.75
Total Nitrogen	-0.004	0.65
Available Phosphorus	-0.017	0.48
Calcium	-0.087	0.41
Magnesium	-0.267	0.08
Potassium	-0.142	0.37
Sodium	-0.265	0.12
TEB	-0.027	0.91
CEC	0.144	0.53
BS	0.002	0.45

Constant a = 2.222; ns = not significant

Table 9: Regression of Soil Chemical Characteristics (Independent) with Length of Panicle (Dependent)

Independent Variable	b (coefficient)	P-Value
Sand	0.005	0.97
Silt	0.078	0.61
Clay	-0.152	0.33
pH (water)	-0.437	0.60
Organic Carbon	-1.001	0.30
Total Nitrogen	14.94	0.12
Available Phosphorus	0.069	0.87
Calcium	1.13	0.53
Magnesium	0.81	0.75
Potassium	1.46	0.59
Sodium	3.72	0.20
TEB	-3.52	0.41
CEC	2.94	0.46
BS	0.019	0.72

Constant a = 30.40; ns = not significant

Table 10: Correlation of Soil Chemical Properties with Yield

Soil Chemical Properties	Yield Parameters	
	Panicle Length	Dry Seed Weight
Sand	0.226	-0.063
Silt	0.377*	-0.053
Clay	-0.498**	0.066
pH (water)	-0.168	-0.043
Organic Carbon	-0.101	-0.150
Total Nitrogen	0.281	0.125
Available Phosphorus	0.349*	-0.100
Calcium	-0.118	-0.060
Magnesium	0.183	-0.323
Potassium	-0.154	-0.169
Sodium	-0.130	-0.370*
TEB	-0.56	-0.240
\CEC	-0.05	-0.236
BS	0.003	-0.150

**indicates statistical significance at 99% CL; *indicates statistical significance at 95% CL

Crop growth and yield parameters

The differences in growth and yield indices observed between the rice varieties are attributed to inherent differences in behavior of the varieties in each water level.

Plant height (cm)

The result on the main effect of water level and rice variety on plant height (Table 3) indicated that there were significant differences in water level and varietal treatment. The high growth observed in high water treatment (109.66cm) and (94.60 cm) as against low growth in low water treatment (91.30 cm) and (73.33 cm) in 2017 and 2018 farming season may be attributed to the rise in water level and deposit of basic soil nutrients such as soil organic matter content, CEC, exchangeable bases, N and P from the upper slope (low water environment) to the lower slope soils (high water level). Rice can grow to about 1m tall but certain deep water varieties can elongate up to 5m with rise in water levels (Thomson, 2006; Abou *et al.*, 2006). Table 3 also reviewed that at maturity, the main effect of variety differed significantly both in 2017 and 2018 cropping seasons. The interaction effect of water level and variety on plant height statistically differed significantly. The high plant height of 107.51 cm (FARO 57), 105.70 cm (FARO 60), 102.03 cm (FARO 15) in 2017 and 106.50 cm, (FARO 57 104.93cm (FARO 60) and 103.00 cm (FARO 15) in 2018 from high water level and variety interaction (Table 4) may be attributed to the genetic nature of the rice varieties and rises in water level. This is in agreement with the view of Gupta (2009) that plant height and numbers of leaves are governed by genetic make-up of the plant and environmental factors. Rice growth was favoured as the water got deeper. Rice produced stem which elongated as water rose keeping the terminal leaves above the water for photosynthetic activities and further growth and development. From Tables 3 and 4 above, the more the water level the greater the height of rice. This is in agreement with the work of David (1992) and Chandrasekaran *et al.* (2007). It may also be attributed to the fact that N and some other plant nutrients increase along with flood, as such improve the soil water fertility that encourage rice growth in the high water environment as compared to the medium and low water level. FARO 44 is a dwarf variety and it's the shorter in all the water levels. Although it increased in height along with water level as other varieties (Table 4) but more preferable for low water cropping or upland. The values of plant growth (70 cm-110 cm) obtained in this work were in agreement with the report of NCRI (2016) that the heights of most common rice varieties are within the range of 80 to 200cm. N and P fertilizer promotes rice growth (height) but excess or lack of it reduces plant height and optimum yield (Ogbu and Iji, 2017). The difference in plant height among the varieties could be attributed to the genetic makeup of the rice varieties as well as the water level/environmental factor. Plant height is predominant factor determining the N response of rice plant. It determines the lodging behaviour thus deciding yield.

Number of leaves

The main effect of water level and that of variety differed significantly in leaves number (Table 3) but the interaction effect of water level and variety did not cause any statistical change on number of leaves (Table 4). However they were relatively lesser in high water than medium and low water environment. This is in agreement with the views of Thomson (2006) and Khairi (2016). They opined that number of rice leaf decreases with rise in water level and differ within varieties. The similarity in number of leaves among the varieties is in line with the work of David (1992), who remarked that the numbers of rice leaves per culm are remarkably consistent throughout the growth period and between the cultivars. It usually varies from 3 - 4 leaves/culm, with an absolute minimum of 2 and maximum of 6 or 7. Also the electron microscopy studies by Willkins and Culter (1988) revealed that the leaves of lowland and deep water rice are morphologically similar as indicated in this result. Number of plant leave is one of the most important characteristic as it has direct effect on seed yield. Plants with more number of leaves have higher photosynthetic rate with invariably more crop food production and positively higher yield.

Number of tillers

Data obtained from the study (Table 3) suggest that the water treatment had significant effect on number of tillers only in 2018 cropping season. The high water level had higher tiller (24.73) than low (20.22) and medium (18.73) in 2018 cropping season. The main effect of variety differed significantly in both farming seasons. FARO 62 (44.42) and FARO 57 (25.07) in 2017 and 2018 respectively recorded the highest number of tillers while FARO 15 (35.34) in 2017 and FARO 44 which had the same tiller value of 17.91 with FARO 15 in 2018 were least in number of tillers. The data agreed with the work of Thomson (2006) who worked on the quality of water on the growth and yield of rice and discovered that tillering increase with the depth of water ponding (0-3 cm), (3-6 cm) and (6-9 cm). Tillering is a varietal character. That is tillering habit is dependent on varieties, spacing, manuring, water level and cultural conditions. The high tillering ability obtained from high water level is in line with the view of David (1992) that tillering increase with water level. Nodal tillers are produced from the bud of the node as water rises. Nonetheless, it is divergent with the opinion of Grist, 1986 who reported that deep water rice varieties usually have fewer tiller than the non-deep water rice. If flood intervened before the plant is well established, development of basal tiller is inhibited and that complete submergence for about 14 days kills tillers and reduces yield.

Blade area (cm^2)

Data in Table 3 reviewed that the water level and the varietal treatment had significant effect on the wideness of the leaves in 2017 and 2018 cropping seasons at maturity while the interaction of water level and variety were only significant in 2017 farming season. Comparing the results of the blade area of 2017 and 2018 in the water media, high water (78.99 cm^2) and (66.90 cm^2) had the widest blade area while low water level recorded the narrowest blade area. FARO 57 (77.27 cm^2), FARO 52 (77.20cm^2), FARO 60 (77.12 cm^2) and FARO 15 (75.79cm^2) in 2017 and FARO 57 (74.59 cm^2), FARO 15 (73.70 cm^2) and FARO 61(60.66cm^2) in 2018 cropping seasons were wider while FARO 44 (60.72 cm^2), FARO 61 (69.29cm^2) in 2017 and FARO 44 (45.14 cm^2), FARO 52 (51.96 cm^2) and FARO 62 (54.51 cm^2) in 2018 were the narrowest varieties (Table 3). All the varieties were wider in high water level than medium and low water level. The values decreased as water receded. This is in agreement with the statement of Yosheda (1981). He remarked that rice leaves are broader in deep water than non-flooded fields. It can also be attributed to the fertility nature of the soil and the flooding pattern. During flooding, large part of N and P are taken up by plant for its growth and development. Also blue green algae fixed N_2 in flooded field along with dry season pulse and N in rainwater. These favourable nutrient conditions along with the added urea influence the wideness of leaves in high water than medium and low water level. FARO 37 had narrower leaf blade than all other varieties as a result of its genetic nature. The shrinking behaviour (narrow blade area) of the varieties in low water level may be attributed to the effect of drought which occurred in August (August break). This climatic variation and very low nutrient status of the low water environment (upper slope) were strongly responsible for the narrow leaf size. This means that blade area depend directly on water availability and the fertility level of the soil. High nutrient level and water availability as in high water level (lower slope) encourage rice leaves wideness.

Panicle length (cm)

The water level and the varietal treatments had significant ($P<0.05$) effect on the panicle length with high water level having longer panicle (5.61 cm) and (9.18 cm) than medium (5.45 cm) and (7.59 cm) while the panicle lengths were shorter in low water level (5.39 cm) and (6.47 cm) . FARO 57 which was the tallest rice variety recorded the longest panicle lengths (31.80 cm) and (28. 63 cm) while the dwarf variety FARO 44 which was the shortest plant had shorter panicle lengths (26.91 cm) and (23.09 cm). The interactions effect of water level and variety had no significant affect on panicle lengths in both years. FARO 57 (31.80 cm) in 2017 and FARO 15 (28.36 cm) in 2018 had significantly longer panicle length than FARO 44 (26.91 cm) and (23.09 cm) which were the shortest as a result of their growth condition and genetic traits (Iji, 2013). That is the variation in the length of panicle was due to their genetic makeup and depth of water. From table 3 above, the length of panicle increased with the depth of water. They were longer in high water level than medium and low water environment. Based on this experiment, one can say that the deeper the water depth, the taller the rice variety, the wider the blade area and the longer its panicle length.

Grain yield (t/ha)

Grain seed yields were significantly ($P<0.05$) affected across the main water treatments, variety and their interactions in 2018 cropping season while the water level, variety and interaction did not statistically differ in 2017 (Table 4). This implies that the varieties equally performed well in high water level (soil unit II), medium (soil units III and IV) and low (soil unit I) water level in 2017 cropping season. The variety had better yield in high water level (9.18 t/ha) but yielded poorly in low water level (6.47 t/ha) in 2018 cropping season. FARO 57 had greater and encouraging yield (9.31 t/ha) while FARO 44 had the least yield (6.14 t/ha). Among the varieties, FARO 57 (9.31 t/ha) gave the highest yield while FARO 44 recorded the lowest yield value. The highest yield value above was orderly followed by FARO 61 (8.93 t/ha), FARO 15 (8.54 t/ha) and FARO 52 (7.68 t/ha) while the lowest was followed by FARO 62 (7.14 t/ha) and FARO 37 (7.39 t/ha). The variation in yield values among the varieties in 2018 farming season may be attributed to their genetic makeup. FARO 15, 37, 52, 57, 69 and 61 were statistically the same in yield value (Table 4).

The interaction effect of water level and variety on rice yield in 2018 showed that high water x FARO 57 interaction (9.86 t/ha) gave the highest grain yield while high water x FARO 44 interaction was the least in grain yield (5.24 t/ha). The best yielded variety was orderly followed by high water x FARO 61 (9.42 t/ha), high x FARO 15 (8.78 t/ha), medium x FARO 15 (8.50 t/ha), high water x FARO 52 (8.08 t/ha) and medium x FARO 52 (8.28 t/ha) while poor yielded variety FARO 44 in high water environment (soil unit II) above was followed by high water x FARO 37 (5.54 t/ha), low water x FARO (5.65 t/ha) and low water x FARO 57 (5.65 t/ha). FARO 15, 52, 57 and 61 in high water level were statistically ($P<0.05$) the same in yield values with the best yielded variety FARO 57 (Table 4). That is, they equally performed well in high water level. Similar yield were obtained by Mustapha *et al*., (2017), National Cereal Research Institute, NCRI, (2018) and FADAMA II Rice Project, (2018). The grain yield results above were encouragingly better than the recommended rice yield of 6tons (6000kg) per ha by NCRI and FADAMA II. Double yield of rice is possible under favourable climatic and environmental conditions and careful/good management ability by the farmer.

The superior grain yield of FARO 15, FARO 52, FARO 57,, FARO 60 ,FARO 61 and FARO 62 in high water level may be attributed to the fertility nature of the soil, favourable water habitat, climatic factors, time of planting, genetic makeup and many other factors. Compared to medium water and low water level, the rate of N and P uptake is rapid in the preflood period, and this influences the better yield obtained above. The poor performance of FARO 44 in high water level may be due to the long period of flash flood which submerged the dwarf rice at panicle initiation and maturity stage and reduce its yield. It is an early yielding variety, hence affected by the heavy rainfall toward the end of the year. Depending on management factors, all rice varieties can do well either in upland or lowland or deep water or shallow water but FARO 44 is better suited for low water level or upland environment. This was indicated by it highest grain yield of 7.50 t/ha in low water level (Table 4). The yield result also showed an increasing trend in grain yield as water rises, exception of FARO 44 and FARO 37. The poor yield of FARO 37 (5.54 t/ha) in high water level may be attributed to it lodging ability and lease resistance to drought. It has a poor kneeling capacity, as such lodged into the heavy flood.

Variation in Data Collected in the Two Cropping Seasons

The data in Table 5 showed that exception of number of leaves, all the parameters collected differed significantly between the two cropping seasons at maturity. Plant height, blade area and panicle length were significantly higher in 2017 than 2018 cropping season while number of leaves and grain yield were greater in 2018 than 2017. The variation in the growth and yield parameters collected per year may be attributed to yearly climatic variation (climatic change) and fluctuation in soil nutrient status. Leaf is a plant organ which is responsible for photosynthesis and gas exchange. It regulates carbon dioxide, oxygen and water vapour exchange with atmosphere (Anyanwu *et al*., 2003). Leaf is one of the most important organ of the plant as it supplies photosynthesis mainly to the panicle, hence increase yield. Similar results were obtained by Victoriano (2016). Climatic factors such as rainfall, temperature, solar radiation and relative humidity influence plant growth, development and seed yield. The early rainfall in 2017 actually contributed to the higher plant height, longer panicle length and wider area but the early end of the rain resulted in less weight of the paddy while in 2018 the late rainfall may be attributed to the dwarf growth but the long period of the flash flood toward panicle initiation favoured the weight of the paddy. Rice is a water loving crop and its yield depends greatly on the availability of water throughout the growing period and other soil properties such as; soil texture, depth and nutrient availability (Idoga, 2005). Higher number of leaves in 2018 implies greater rate of photosynthesis per time which invariably resulted in greater and encouraging yield in 2018 as compared to 2017 cropping season.

Regression of yield parameters (dependent) with water level (independent)

Table 6 indicated a simple regression relationship between the yield parameters (dependent variable) and the water level (independent variable). This illustrates the dependence of the yield parameters (panicle length and dry seed weight) on the water level. The grain yield had a strong positive regressional relationship (0.926) with the change in water regime and this relationship was statistically significant ($p<0.05$). The grain yield was observed to increase when the water level tended to increase. The constant a (7.658 kg) explained the least value of the dry seed weight expected to be retained irrespective of the variations in the water level. The regression result is in line with the yield data collected (Tables 3 and 4). The data showed that rice yield increased along with water depth (low—medium---high). It is also in agreement with the the views of Idoga (2005) who opined that water is one of the most important factor for rice growth and yield. Similar results were recorded by Iji (2013) who worked on two varieties of rice (FARO 44 and 52) in four different geographical areas (Makurdi, Adi, Buruku and Abinsi) and observed that rice yield increased along with water depth.

The length of panicle however had a negative weak relationship (-0.067) with the changes in water level. The length of panicle was recorded to be decreasing with increase in water level with constant a (4.32cm). This relationship was statistically significant ($p<0.05$) (Table 17). This may be attributed to the differences in the genetic make up of each rice variety. The present findings are in conformity with the findings of Jarnardhen and Murty (1990) and Mashooque (2013) who worked differently and observed that, excessive water hampers rooting and decreases growth, tillering and panicle length of rice. The result is also in accordance with the findings of Parden and Adak (1980). They observed that N leaching reduces leave size, growth and panicle length of rice. .

Matrix of correlation coefficient between yield parameters and water levels

Table 7 is a correlation matrix of the relationship between the yield parameters and water levels. Pearson correlation was used for analyzing this relationship. A weak negative coefficient ($r=-0.24$) was established in the relationship between length of panicle and dry seed weight. This relationship was statistically significant ($p<0.05$). Grain yield however correlated positively with dry seed weight. Although the relationship was weak, it was however statistically significant ($p>0.05$). In a similar vein, the length of panicle was recorded to have a weak positive relationship ($r= 0.23$) with water level which was statistically significant ($p<0.05$). The perfect positive correlation between the grain yield and the water level implies that the grain yield increase as the water rises. The result is in line with the yield data collected (table 15). Similar reports were rcorded by Mustapha *et al*. (2017) and Ethan (2006).

Regression of soil chemical characteristics (independent) with dry seed weight (dependent)

Table 8 presents the result of the regression relationship between the dry seed weight as a yield parameter and the soil chemical properties. Apart from clay fraction ($r=0.586$), CEC ($r=0.144$) and BS ($r=0.002$) that had positive relationship with the dry seed weight, the other soil chemical characteristics had negative relationship with the dry seed weight. The relationship was not significant ($p<0.05$) with all the nutrient elements.

Regression of soil chemical characteristics (independent) with length of panicle (dependent)

The result of the regression relationship between the length of panicle and the soil chemical characteristics is presented in Table 10. There was no statistical significance between length of panicle and any of the soil chemical properties ($p>0.05$). Total nitrogen showed a very high positive regression coefficient ($b = 14.94$). Also, sand ($b = 0.005$); silt ($b= 0.078$); available phosphorus ($b=0.069$); Potassium ($b= 1.46$); Na ($b= 3.72$), CEC ($b= 2.94$) and BS (0.019) also had positive relationship with length of panicle, although weak. Clay ($b= -0.152$); pH ($b = -0.43$); organic carbon ($b= -1.001$) and TEB (-3.52) however had negative relationship with the length of panicle. That is they decreased in values as the panicle length increased or vice versa. This called for careful and scientifically controlled management practice to amend the soil nutrient status in order to increase panicle length with nutrient level.

Correlation of soil chemical properties with yield

The correlation between the soil chemical properties and the yield parameters is presented in Table 10. Sand (0.226), silt (0.377), total nitrogen (0.281), available phosphorus (0.349), magnesium (0.183) and BS (0.003) correlated positively with panicle length, although they were all weak. The rest of the nutrient elements were negatively correlated with panicle length. Only the relationship between the panicle length and silt, clay and available phosphorus were statistically significant ($p<0.05$).

The grain yield correlated negatively with all the soil chemical properties except clay (0.066) and total nitrogen (0.125). Also, only the correlation with Na that varied significantly ($p<0.05$). the results (Table 10) showed that soil Na negatively and significantly ($p< 0.05$) correlated with yield. The negative correlation implies that as the soil Na nutrient element increases rice grain yield decreases. Generally, the results showed that, rice yield increase with possible increase in soil total N, CEC, Organic Carbon, available P, BS, TEB and the physical properties with a decrease in the soil Na and other elements that correlated negatively with yield. Therefore any agricultural practice(s) that may help improve availability of these essential nutrient elements which are environmentally friendly and socially acceptable should be encouraged in our cropping systems.

4.0 Conclusion and Recommendation

The results of the study conducted showed that rice growth and yield increased along with water depth but varied within variety. Rice yielded far better in high water level (unit II) than medium water level (units III and IV) and relatively poor in low water level, (unit I). FARO 57 (6.84 t/ha) and (9.86 t/ha), FARO 61 (6.44 t/ha) and (9.42 t/ha), FARO 15 (5.89 t/ha) and (8.78 t/ha) and FARO 52 (5.50 t/ha) and (8.43 t/ha) had encouraging yield in high water level and can be grouped as deep water rice varieties while FARO 44 (5.25 t/ha)/(6.33 t/ha) and FARO 37 (5.74 t/ha)/(7.30 t/ha) with high yield in low water level can be placed under low water or upland rice. FARO 57 did well in all water levels but better in high water area (soil unit II). Other varieties that equally performed well in high water level include; FARO 15, 37, 52, 60, and 61. In medium water level (units III and IV) FARO 15 had the best yield. FARO 52, 57, 60, 61 and 62 equally did well in medium water regime while FARO 44, 37 and 61 had the best yield in low water level (unit I). Although with good genetic, time management and environmental factors (climatic, biotic, edaphic and anthropic/ human factors) all rice varieties can yield well in all ecological zones. Organic fertilizer application, liming, weeding and irrigation is recommended for low water level (unit I) while planting time management, water channel control is recommended for medium (units III and IV) and high water level (unit II).

Recommendations

From the test crop, FARO 15, FARO 52, FARO 57, FARO 60, FARO 61 and FARO 62 which were statistically the same in yield values and yielded better in high water and medium water level, hence recommended for the heavy (flooding environment) or moderate water environment while FARO 44, the dwarf variety and FARO 37, the high lodge variety can be cultivated in low water level as they will submerge or lodge into the heavy and moderate water environment. Further study is needed on the effect of iron toxicity on rice yield and growth in the study area.

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