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Effect of water depth on four varieties of rice in Jangwa flood plains, Awe Local Government Area of Nassarawa State, Nigeria

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ABSTRACT

A pedological study was carried out on some low-lying land area referred to as Jangwa flood plains with a view to characterized and evaluate the effect of three (3) flood levels namely: toeslope, medium and levee flood levels on growth and yield of four (4) varieties of rice (Faro 44 maturing, FARO 52 and L-19 (FARO 60), medium maturing and late FARO 15 maturing) grown in the area.Field trialsand crop trials were carried out for 2015 and 2016 cropping season. Profile pits were sunk, giving a total of 6 profile pits. Soil samples were collected from different horizons, air dried crushed and sieved (d<2mm) for laboratory physical and chemical analyses. The soils were deep (101cm – 170cm) and well drained. poorly to very poorly drained. The soils were fine textured and strongly to moderately acidic and slightly alkaline in reaction (PH 5.10 – 7.15). The percentage sand fraction ranged from 44.8% to 83.1%; silt 5.4% to 9.4% and clay 9.4% to 46.7%. They had low to moderate organic carbon (0.41% to 3.52%); total N (0.04% to 0.11%); available P (1.64mglkg^{-1} to 3.72mg/kg^{-1}), total exchangeable bases (2.85cmol/kg^{-1} to 7.97cmol/kg^{-1}), CEC (4.10cmol/kg^{-1} to 7.98cmol/kg^{-1}), base saturation (65% to 97.5%) and Fe^{2+} (1.10 to 2.11). Soils of the three flood levels (toeslope or deep swamp, medium or lower slope, levee or shallow swamp) were rated highly to suitable ($S_{1)}$ because of the soils ability to retain water during the growth period with the favourable physical and chemical characteristics such as climate, slope, water levels, PH and texture. From the three levels of water used for the test crops, FARO 44 gave the highest yield (6.19 to 6.66tlha) at leveeflood levels (shallow) but submerged in medium and toeslope flood levels. FARO 52, FARO 15, L-19 (FARO 60) grows best under medium and toeslope flood levels with yield (4.96 -5.91) which is within the expected range.

1.0 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 Gidan Tindi 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 is one of the major sources of income to farmers who are engaged in small land areas of about 0.4 hectares on the average. The history of large scale commercial rice production dates back to the early eighties to nineties by Lower Benue River Basin Development Authority (LBRBDA), andLafia Agricultural Development programme (LADP).Today, the area is taken over by Nasarawa State University, retired generals, directors and seasoned commercial farmers who are largely into rice production.

In the late 1920s, retired generals, directors seasoned commercial farmers after few years of farming, some withdrew due to low output caused by flood and drought despite the seemingly excellent environmental conditions for rice production.

The eastern part of the state has the major landmass suitable for rice production but are faced with challenges of low yield due to uneven and erratic distribution of rainfall and erosion that is causing havoc in the country globally. In some years the amount of rainfall is higher than normal resulting into flooding with subsequent submergence of rice and zero yield. In years of inadequate rainfall, soil moisture is insufficient for rice growth and consequently very poor yield.

Generally, farmers need adequate information on soil physical, chemical and biological properties and desired management. For rice production, edaphic factors (soil) and climatic factors like rainfall and temperature are critical for farmers to obtain maximum yield on their farms. The inability of farmers to correctly forecast years of high, normal or insufficient rainfall has exposed them to frustrating rice yields. The fluctuating rice yields have defiled solutions over the years because of the fluctuating weather conditions. Azagaku and Idoga(2005) had recommended the construction of a dyke to store excess water in years of above- normal rainfall for supplemental irrigation in years of inadequate rainfall. This recommendation as laudable as it is has not received any attention from Government as it is surely beyond the financial power of the individual farmers. This research work seeks to approach the issue from cultural practices- hence use of varieties and time of panting to further minimize the effects of floods or escape the floods.

For optimum production and enhanced productivity, adequate information on soil properties will give the desired approach to averting or ameliorating soil physical and chemical limitations. This research is designed to characterizeand evaluate the effect of three (3) flood levels and proffer solutions to the fluctuating rice yields through the use of appropriate rice varieties and flood levels in order to mitigate the effects of erratic rainfall.

2.0 Materials and Methods

2.1 Study Area

The study area is south- eastern block of Nasarawa State stretching from Jangwa in the North East to Gidan Tindiin the South. The land area is geomorphologically referred to as Jangwa flood Plains. It lies between latitude 7° 45[1] and 9° 25[1] N and longitude 7°32[1]and 9° 37E and covers a total area of over 22,000 hectares of Fadama along Rivers Shankodi, Wuse and Ankwe (ASU river group).Two principal air masses influence the climate of the area.The south west maritime wind which originates from the Atlantic Ocean blows across Lafia between April and October and is associated with the wet season while the dry season which starts from November to March is brought about by the north eastern wind locally called harmattan. Wet or rainy season is fairly long and well distributed lasting for about seven months in the year.

Nassarawa State experiences two rainfall peaks, July andSeptember, separated by moderate decrease in August known as August break (Hill,1979). Annual rainfall in the area is between 1143mm and 1270mm. The monthly maximum mean air temperature was highest (36.4°C) in the period prior to the onset of rains in March/April and lowest (22.9°C) during the period of heaviest rainfall in August

Jangwa flood plains is drained by Asu group of rivers and its tributaries. The river which runs north –south forms a dendritic drainage system with its tributaries. The slope of the area is about 0 to 2% and the elevation above mean sea level is about 93m (Hill, 1979). The study area consists of extensive flood plains dissected by rivers, Bena, Gbagbok rivers, (Jangwa) while Abanbu, Hunki(Gidan Tindi) which 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 extensive flood plain is bordered to the north by the escarpment of the Jos plateau. The plain continues south wards to River Benue, westwards to the rolling plains of Lafia and eastward to River Maiburugu. There are few isolated lateritic mesas in the area. The Jangwa flood plain has an abrupt boundary with the Namu formation and Benue piedmont which is predominantly made of cretaceous shales (Fagbemi and Akamigbo, 1986).

2.2 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 soils on Levee, soils of the lower slope from the surrounding upland and the soils over toeslope between the lowerslope andthe levee correspondingto shallow swamp (>0cm),medium swamp (lower slope) (0-50cm), and deep swamp(>50cm).Auger point investigation were carried out across the slope according to the topographic positions mentioned above. Two profile pits were sunk in eachof 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, CEC, exchangeable bases (Ca, Mg, K and Na), total nitrogen and available P. PSD 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 Sommers (1982) 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. For exchangeable

2.3 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 physico-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).

2.4 Agronomic/Management/Practices

(i) **Land Preparation**: A non-selective herbicide with market name sarosate (sarosate, 360g/L of sarosate – Isopropylamine salt) was used in mid-May at both years to clear the land. 1,500ml of sarosate 41% W/W SL/ha mixed with 2 drums of 200 litre capacity was used per hectare (75mls of sarosate/20L knapsack sprayer) blanket spray on the tip of weeds (grasses, broad leaves) and allowed for over 2 weeks to dry.

(ii) **Cultivation**: The land was ploughed with a tractor and harrowed twice before it was demarcated into plots and sub plots using small hoe in the first week of June.

(iii) **Planting**: Two (2) seeds/hole from each of the four rice varieties randomly distributed within the plots were manually drilled after the second harrowing at a spacing of 20cm x 20cm to give 500,000 plants/ha (200 plants/4m^2) in line with recommendations of Nasarawa State Agricultural Development Project (NADP) and Federal Ministry of Agriculture and Rural Development (FMARD 2012) at recommended seed rate of 60 – 70kg/ha.

(iv) **Fertilizer application**: Five (5) bags of NPK 20:10:10 (100kg N/ha, 50kg P_2O_5/ha and 50kg K_2O/ha) was broadcasted basally at two (2) weeks after planting to avoid leaching and washing away of nutrient by heavy rainfall in July – August. Two (2) bags of urea (45%N) was used as top dressing before booting stage (Panicle initiation) Chude *et al.,* 2011) for levee flood levels as moderate and deep swamp flood levels had water at the base.

(v) **Weeding**: 250ml of Nominee gold mixed with 2,4 – Dimethylamine salt (72% W/V) was mixed with 900L of water and sprayed to control grasses, sedges and broad leaf weeds.

(vi) **Pest and diseases control**; prior to panicle initiation, karate was sprayed to allow for full panicles.

(vii) **Harvesting**: This was done when they attained physiological maturity (90 – 130 days) depending on the variety as their maturity period varies. It was harvested at a moisture content of 12 – 13% threshed, winnowed, weighed and recorded for analysis. The research was conducted for two (2) years (2015 and 2016)

2.5 Experimental Sites Field trials/ Rice varietal trials

(i) **Treatments** – the treatments comprised of three flood levels levees – shallow swamp (>0cm,0-50cm,>50cm) lower elevation- lower slope, toeslope-deep swamp andfour rice varieties. The rice varieties were V1- FARO 44, V_{2-} FARO 52 (WITA 4) V3 – L-19 (FARO 60) Africa 18 (WITA 9) and V4 – FARO 15. The rice varieties were obtained from Nasarawa Agricultural Development Project (NADP), National Cereal Research Institute (NCRI) badegi Niger state. They were chosen basically on their social, economic and adaptability to the wetland (Fadama) ecology of the study area.

(ii) **Experimental layout**: The factorial combination of flood levels and rice varieties were laid out in a randomized complete block design (RCBD) and replicated three times (3x) giving in all 12 treatments combinations. Each plot measured 2m X 2m (4m^2) and 1m alley ways between plots. The varieties are described as follows- FARO 44-V_1 early maturing, grown in shallow swamp or upland. 90 – 100 days, high yielding and grain size of 3mm – 5.5mm moderate starch, high quality malting, high germination capacity and can be grown two (2) times a year. It has outstanding milling property, low breakage and moderate water absorption. Moderate rupturing and affected by diseases such as *Meloidogyne incognite*and attainable yield of 7 – 10t/ha (WARDA, 1999).

FARO 52-V_2 (WITA 4) – medium maturing and grown in moderate or shallow swamp, maturity is 100 – 120 days. It is a parent to FARO – 66 and has the ability to withstand lodging and grows above one (1m) meter tall (Malini *et al.,* 2006) WARDA.

L – 19, Africa 18, (WITA 9), NERICA – Medium maturing, Cote divoire origin and rainfed lowland rice, high yielding and resistant lowland stresses. Tolerant lowland variety with improved plant height. Resistant to insect's diseases. It was evaluated across 20 African countries-east, west, central with

	REP 1	REP 2	REP 3
Toeslope	V3	V1	V2
	V4	V2	V3
	V2	V4	V1
	V1	V3	V4
Lower slope	V3	V1	V2
	V4	V2	V3
	V2	V4	V1
	V1	V3	V4
Levee	V3	V1	V2
	V4	V2	V3
	V2	V4	V1
	V1	V3	V4

Figure 1: Layout of Treatment in the field

a yield of 6 – 7t/ha (Africa rice centre, WARDA).

FARO – 15 – Late duration > 120 days (deep swamp), grown in flood prone areas or water logged area, suitable for iron toxic areas WARDA.

2.6 Crop Data Collection

Growth and yield parameters: Data was collected using a quadrat of one metre square (1m^2) placed in the middle of each plot to measure the following parameters; Plant height per plant (cm). Days to Maturity, Day to 50 % flowering, Heading height, Number of tillers / m^2, Number of filled Panicles, Number of seed per spikelets, 1000 seed weight, seed yield.

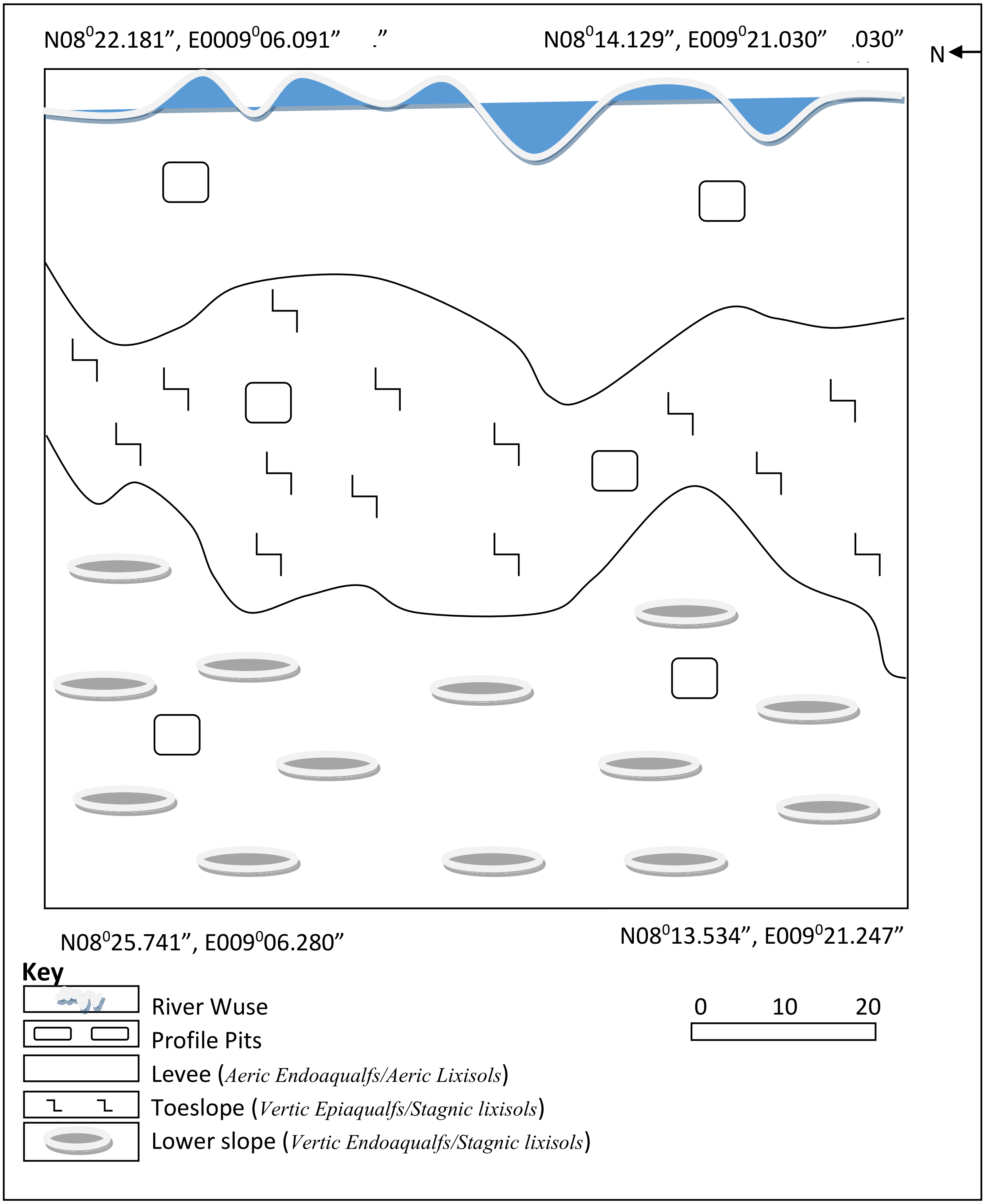

Figure 2: Soil map of the study areas

3.0 Results and Discussions

3.1 Morphological and Physico-chemical 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 structure is well developed and soil texture is generally sandy clay loam to clay loam at surface and clay at subsurface. The surface soil is moderate- fine subangular blocky to strong subangular blocky at the subsurface. Soils in unit 2 (lower slope flood level) were generally low-lying and nearly flat and covers about 35% of the study area. The texture is generally to clay loam to loamy sand to sandy loam at the surface and clay loam to clay at subsurface. In the case of unit 3 (Levee flood level), it is located by the river bank and relatively more elevated and nearly flat. The soils in both locations are somewhat poorly drained. Soil texture is sandy clay loam at surface and clay at subsurface. Soil structure is well developed being medium subangular blocky at the surface and at subsurface is strong coarse subangular blocky.

Generally, the soils are relatively high in clay content. The values of the surface horizons ranged from 8.6% to 34.6%. The relatively high clay content could be due to nature of the underlying geological materials (shales). The Awgu shales are presumed to have constituted the underlying geology of the area (Idoga, 2005). 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 due to slight difference in topography and cultivation.Sand fraction was most the dominant particle size at surface and subsurface horizons in all the mapping units. The high sand fraction is a feature of most savannah soils due to eluviations 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). The PH values generally across the study area indicates that the soils were moderately acidic to slightly alkaline in reaction (5.10 – 7.15). These pH levels fall within the range (4.5 – 7.5) considered highly suitable for rice production (Maniyunda *et al.,* 2015). The pH values decreased with depth from surface to subsurface in both locations. This decrease with depth may probably be due to the effect of nutrient biocycling (Ogunwale *et al.,* 2002; Idoga and Azagaku 2005). The percentage organic carbon content in the study area was low to moderate, it ranged from 0.41 to 3.62 in both years (2015 and 2016). The values decreased with depth in all the Pedons due to the concentration of plant roots and plant residues on the topsoil. The high 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 0.11%. 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, loss in surface runoffs, leaching, climatic factors, vegetation, human activities and initial soil/pH. The phosphorus content of the study area was extremely low with values ranging from 1.64 to 3.72mg/kg. The low values however agree with the views of (Brady and Ray 2014) 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

Table 1Morphological Description of the study area(2015 and 2016)

Depth	Munsell colour (moist)	Mottling	Texture	Structure	Boundary	Inclusions	Consistency	Remarks
Profile 1: Toeslope – Vertic Epiaqualfs/stagnic lixisols								
0 – 32	10YR 2/2		SCL	2msbk	CS	Common fine roots	SSW	
32 – 57	10YR 3/2	10YR 3/1fif	C	2msbk	GS	Common fine roots	VSW	
57 – 96	2.5Y5/2	10YR 5/8cif	C	2msbk	GS	Common fine roots	VSW	
96 – 120	2.5Y 5/3	10YR 6/4cif	C	2msbk	GS	Fine roots	VSW	
120 – 170	10YR 4/4	7.5YR 4/6cid	C	2msbk	GS	Fine roots	SW	
Profile 2: Toeslope – Vertic Epiaqualfs/stagnic lixisols								
0 – 35	10YR 2/2		CL	2msbk	CS	Many fine and medium roots	SSW	
35 – 61	10YR 3/3	7.5YR 4/4fif	C	2msbk	GS	Common fine and medium fine roots	VSW	
61 – 94	2.5Y 5/6	7.5YR 6/4cif	C	2msbk	GS	Fine roots	VSW	
94 – 122	2.5Y 5/2	10YR 5/8cid	C	2msbk	GS	Few fine roots	VSW	
122 – 170	2.5Y 5/6	10YR 5/8cid	C	2msbk	GS	Few fine roots	VSW	
Profile 3: lower slope – Vertic endoqualfs/stagnic lixisols								
0 – 10	10YR 5/4		LS	2msbk	CS	Common fine root	SSW	
10 – 22	7.5YR 4/4		LS	2msbk	GS	Few fine roots	VSW	
22 – 89	7.5YR 5/6		SL	2msbk	DS	Few fine roots	VSW	
89 – 101	7.5YR 4/6		SCL	2msbk			SW	

Table 1 Continue								
profile 4: lower slope – Vertic endoqualfs/stagnic Lixisols								
Depth	Munsell colour (moist)	Mottling	Texture	Struc-ture	Bounda-ry	Inclusions	Con-sistency	Remarks
0 – 14	10YR 4/2		SL	3csbk	GS	Common fine roots	SSW	
14 – 25	10YR 5/6		SL	3csbk	GS	Common fine roots	VSW	
25 – 78	7.5YR 4/6		SL	3csbk	GS	Common fine roots	VSW	
78 – 110	10YR 5/8		SL	2msbk	GS	Few fine roots	VSW	
110 – 150	7.5YR 6/4		SCL	2msbk	GS	Few fine roots	VSW	
Profile 5: Levee – Aeric Endoaqualfs/Aeric Lixisols								
0 – 22	10YR 4/2		SCL	3csbk	CS	Many fine and medium roots	VSW	
22 – 57	10YR 5/6		SCL	2msbk	DS	Common fine roots	VSW	
57 – 89	10YR 4/3		SCL	2msbk	DS	Common fine roots	VSW	
89 – 101	2.5Y 5/1	10YR 6/3	SCL	2msbk	DS	Few fine roots	VSW	
101 – 150	5YR 3/2		LS	2msbk	DS	Nodules	VSW	
Profile 6: Levee – Aeric Endoaqusalfs/Aeric Lixisols								
0 – 22	10YR 2/2		CL	3csbk	CS	Many fine and medium roots	SW	
22 – 53	10YR 5/6	7.5YR4/6	CL	2msbk	CS	Common fine roots	VSW	
53 – 92	10YR 5/6	2.5Y5/6	CL	2msbk	DS	Fine roots	VSW	
92 – 115	10YR 5/2		CL	2msbk	DS	Fine roots	VSW	

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

and Na) are low in both locations of the research. 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 4.10 and 7.98cmol/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 (65 to 97.5%) were rated moderately high to very high. The distribution of base saturation is irregular in all the units. 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).

Table 2: Some Physical and chemical properties of the inland wetland soils of Jangwa, Awe Local Government Area

Hori-zon	Depth (cm)	Particle Size dist Sand	Silt (%)	Clay	Texture	pH H2O	Org. C	Total N %	Avail. P Mg/kg	Exchangeable Bases Ca	Mg	K	Na	TEB Coml kg	CEC	BS %	Fe
Profile 1: Toeslope Vertic Epiaqualfs/stagnic lix-isols																	
Ap	0-32	62.0	7.4	30.6	SCL	7.10	3.62	0.06	3.35	1.82	1.34	0.86	0.77	4.79	4.89	72	1.25
B	32-57	48.0	7.6	44.4	C	6.99	1.6	0.07	3.26	2.94	1.86	0.93	0.56	6.29	6.29	78	1.10
Bt_1	57-96	47.0	6.4	46.6	C	6.98	2.54	0.08	2.21	3.67	2.48	0.89	0.03	7.97	7.98	91	1.46
Bt_2	96-120	49.0	7.4	43.6	C	5.86	0.72	0.06	2.42	2.47	1.65	0.42	0.84	5.38	5.49	72	1.45
Bt_3	120-170	47.0	5.4	47.6	C	5.53	2.10	0.04	1.67	1.64	1.34	0.64	0.53	4.15	4.26	65	1.50
Profile 2: Toeslope -Vertic Epiaqualfs/stagnic lix-isols																	
Ap	0-35	52.1	8.0	30.9	CL	7.15	2.65	0.05	3.56	2.34	1.86	0.95	0.82	5.97	5.98	73	1.60
B	35-61	50.0	7.1	42.7	C	6.58	2.88	0.08	2.25	2.78	2.02	0.41	0.36	5.55	5.67	65	1.76
Bt_1	61-94	44.8	8.4	46.8	C	6.24	1.54	0.06	3.51	3.37	2.62	0.82	0.72	7.53	7.33	91	1.72
Bt_2	94-122	48.0	7.3	44.7	C	5.25	2.72	0.05	2.62	3.43	2.14	1.58	0.42	7.57	7.69	77	1.98
Bt_3	122-170	48.0	6.6	43.4	C	5.14	1.25	0.04	2.42	2.34	2.31	0.32	0.64	4.45	4.74	81	2.01
Profile 3: Lower slope-Vertic endoqaualfs/stagnic lixisols																	
A	0-19	86.0	5.4	8.6	LS	6.89	1.65	0.04	3.29	3.68	1.42	0.46	0.55	5.06	7.26	69.9	1.43
AB	10-22	79.0	7.4	13.6	LS	6.85	0.61	0.08	3.61	3.66	2.41	0.35	0.37	6.33	6.98	91.0	1.39
B	22-89	75.0	6.5	18.5	SL	6.75	1.59	0.06	3.72	3.65	1.36	0.36	0.18	5.59	6.57	83.3	1.28
BC	89-101	61.0	8.2	30.8	SCL	6.13	2.52	0.05	2.55	3.15	1.20	0.30	0.24	4.91	6.38	77.2	1.56

Hori-zon	**Depth (cm)**	**Particle Size dist Sand**	**Silt (%)**	**Clay**	**Tex-ture**	**pH H2O**	**Org. C**	**Total N %**	**Avail. P Mg/kg**	**Exchangeable Bases Ca**	**Mg**	**K**	**Na**	**TEB Coml kg**	**CEC**	**BS %**	**Fe**
Profile 4: Lower slope–*Vertic endoaqualfs/Stagnic Lixisols*																	
Ap	0-14	83.1	7.2	9.7	SL	6.80	2.72	0.05	3.36	3.68	2.34	0.41	0.62	7.05	7.23	97.5	1.48
A	14-25	80.3	7.0	12.7	SL	6.72	2.61	0.08	2.28	3.67	0.95	0.39	0.37	5.38	6.94	77.5	1.52
AB	25-78	76.0	9.2	14.8	SL	6.70	1.59	0.07	3.21	3.05	1.68	0.38	0.16	5.27	6.67	79.0	1.76
	78-110	77.0	10.2	12.8	SL	6.30	0.72	0.11	2.75	3.15	1.25	0.32	0.11	4.83	6.36	75.9	1.98
Bt_3	110-130	70.4	8.2	21.4	SCL	5.26	1.42	0.06	2.68	1.35	1.32	0.28	0.17	3.21	4.10	78.2	2.11
Profile 5: Levee -*Aeric Endoaqualfs/Aeric Lix-isols*																	
Ap	0-22	60	6.4	33.6	SCL	5.43	2.06	0.05	3.12	1.87	0.56	0.37	0.60	3.40	5.02	84.5	1.58
Bt_1	22-57	58	9.4	32.6	SCL	5.35	1.56	0.07	2.98	2.56	0.53	0.35	0.38	4.02	4.93	81.5	1.69
Bt_2	57-89	62	7.4	30.6	SCL	5.14	1.52	0.08	3.26	2.14	1.34	0.31	0.34	4.13	4.34	95.1	1.90
Bt_3	89-101	60	8.5	31.6	SCL	5.10	0.41	0.06	1.87	2.11	1.20	0.30	0.21	3.82	4.22	90.5	2.06
Bt_3	110-130	82.6	8.2	9.4	LS	5.25	1.42	0.05	2.36	2.15	1.12	0.28	0.22	3.77	4.10	91.9	2.11
Profile 6: Levee –*Aeric Endoaqualfs/Aeric Lix-isols*																	
Ap	0-22	59.0	6.4	34.6	CL	5.40	1.53	0.07	3.27	2.67	1.40	0.37	0.25	4.69	5.62	93.4	1.36
Bt_1	22-53	54.0	9.2	36.8	CL	5.35	1.53	0.08	2.50	1.56	0.68	0.35	0.38	2.97	5.22	90.3	1.48
Bt_2	53-92	58.0	7.4	34.6	CL	5.14	1.44	0.05	2.15	2.14	1.06	0.30	0.31	3.81	4.33	87.9	1.64
Bt_3	92-115	53.2	8.6	38.2	CL	5.12	1.34	0.04	1.64	2.13	0.23	0.29	0.20	2.85	4.15	68.6	1.92

Table 3: Effect of flood levels on plant height and number of tillers of rice varieties at the study site in 2015 and 2016 Cropping Season

Flood levels	Varieties	Plant Height		Number of Tillers	
		2015	2016	2015	2016
Toeslope (deep swamp)					
	FARO 44	00.00	00.00	00.00	00.00
	FARO 52	117.83[a]	96.67	377[b]	380.78
	L-19	109.08[ab]	93.67	295[c]	367.76
	FARO 15	109.08[ab]	99.08	368[b]	368.22
	LSD (0.05)	11.90	8.74	6.02	106.68
Lower slope					
	FARO 44	00.00	00.00	00.00	00.00
	FARO 52	122.67[a]	94.42[b]	370.56[b]	362.11
	L-19	110.92[b]	96.83[b]	302.89[d]	330.45
	FARO 15	92.92[c]	97.50[ab]	363.78[c]	370.22
	LSD (0.05)	10.79	11.20	5.07	107.34
Levee (shallow)	FARO 44	87.75c	95.67	418.25a	417.75a
	FARO 52	124.67[a]	96.25	377.22[b]	377.44[b]
	L-19	100.67[b]	101.08	288.11[a]	295.47[c]
	FARO 15	99.25[b]	95.92	375.33[b]	368.22[b]
	LSD (0.05)	10.54	13.62	6.54	12.34

Table 4: Effect of flood levels on days to 50% flowering and days to maturity of rice varieties at the study area in 2015 and 2016 Cropping Season

Flood levels	Varieties	50% Flowering		Days of Maturity	
		2015	2016	2015	2016
Toeslope (deep swamp)					
	FARO 44	00.00	00.00	00.00	00.00
	FARO 52	91.25[b]	83.75[b]	130.67[b]	120.08[b]
	L-19	77.33[c]	74.92[c]	120.50[c]	121.25[b]
	FARO 15	96.00[a]	93.92[a]	144.83[a]	133.75[a]
	LSD(0.05)	1.96	3.82	7.00	10.70
Lower slope					
	FARO 44	00.00	00.00	00.00	00.00
	FARO 52	90.25[b]	83.75[b]	135.08[b]	122.33[b]
	L 19	78.50[c]	73.33[c]	123.08[c]	118.33[b]
	FARO 15	96.58[a]	93.92[a]	139.67[a]	136.50[a]
	LSD(0.05)	4.87	3.93	3.58	9.00
Levee (shallow)	FARO 44	65.33[c]	64.92[c]	94.50[c]	98.12[c]
	FARO 52	92.18[b]	83.52[b]	131.86[b]	120.25[b]
	L 19	76.58[c]	74.92[c]	125.75[b]	122.00[ab]
	FARO 15	96.17[a]	93.92[a]	144.92[a]	132.92[a]
	LSD(0.05)	2.88	3.94	7.45	11.97

Table 5: Effect of flood levels on heading height and filled panicles of rice varieties at the study area in 2015 and 2016 Cropping Season

Flood levels	Varieties	heading height		filled panicles	
		2015	2016	2015	2016
Toeslope (deep swamp)					
	FARO 44	00.00	00.00	00.00	00.00
	FARO 52	21.92	21.82	12.98	10.33
	L 19	21.83	21.63	12.20	9.75
	FARO 15	22.67	20.57	11.40	11.17
	LSD(0.05)	7.50	7.30	2.90	2.68
Lower slope					
	FARO 44	00.00	00.00	00.00	00.00
	FARO 52	20.08	20.01	12.79[a]	12.67
	L 19	20.75	20.00	12.87[a]	10.83
	FARO 15	20.08	19.80	11.56[b]	11.25
	LSD(0.05)	2.14	1.82	1.18	2.64
Levee (shalow)	FARO 44	20.65	20.15	15.10	11.00
	FARO 52	20.42	20.13	14.37	10.67
	L 19	20.33	20.03	12.93	9.75
	FARO 15	21.00	21.03	12.29	10.28
	LSD(0.05)	1.11	1.18	3.17	1.87

Table 6: Effect of flood levels on 1000 seed weight (g) of rice varieties in the study area in 2015 and 2016 Cropping Season

Flood levels	Varieties	1000 seed weight (g)	
		2015	2016
Toeslope (deep swamp)			
	FARO 44	00,00	00.00
	FARO 52	25.65	25.71
	L-19	24.21	24.43
	FARO 15	21.42	20.78
	LSD(0.05)	1.65	1.55
Lower slope			
	FARO 44	00.00	00.00
	FARO 52	24.13	25.38
	L-19	24.19	24.65
	FARO 15	20.64	20.76
	LSD(0.05)	3.50	1.98
Levee (shallow)	FARO 44	30.59[a]	30.04[a]
	FARO 52	24.27	25.24
	L-19	24.52	24.79
	FARO 15	21.87	20.42
	LSD(0.05)	0.89	1.94

Table 7: Effect of flood levels on seed yield of rice varieties at the study area in 2015 and 2016 Cropping Season

Flood levels	Varieties	Jangwa	
		2015	2016
Toeslope (deep swamp)			
	FARO 44	0.00	0.00
	FARO 52	5.91	5.81
	L-19	5.03	5.03
	FARO 15	5.47	4.7
	LSD(0.05)	0.24	0.24
Lower slope			
	FARO 44	0.00	0.00
	FARO 52	5.68	5.58
	L-19	5.42	5.12
	FARO 15	5.62	5.21
	LSD(0.05)	0.25	0.25
Levee (shallow)	FARO 44	6.31	6.19
	FARO 52	5.21	5.19
	L-19	4.96	5.09
	FARO 15	5.23	5.06
	LSD(0.05)	0.44	0.21

3.2 Growth and Yield parameters of Rice Varieties

Plant Height (cm)

Data obtained from (Table 3) 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 (104.00 cm, 117.00 cm and 109.08cm, 117.08cm) in 2015 as against (95.75 cm, 94.92cm and 96.67cm, 93.67cm) in 2016. At lower slopeflood level, highest plant height (113.83cm, 113.67cm and 122.67cm, 110.92cm) was observed in 2015 as against (99.83cm, 105 .75cm and 94.42cm, 96.83cm) in 2016. At levee flood level the highest plant height (121.58cm, 108.27cm and 124.67cm, 100.67cm) in 2015 as against (97.00cm, 95.33cm and 96.25cm, 101.08cm) in 2016. Plant height (cm) were 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 (Thomson, 2006, Abou *et al.,* 2006).

The interaction effect of flood level and plant height on areas of toeslope, lower slopeand levee flood levels differed statistically in both locations and this may be attributed to the genetic nature of the rice varieties and rise in water level. This is in agreement with the view of Gupta, (2009) that plant height and number of leaves was monitored by genetic make-up of plants and environmental factors. The values obtained in this study were in agreement with the report of NCRI, (2016) that most height of rice varieties are within the range 80cm to 200cm.

Number of Tillers

The results indicated that there was significant difference on flood levels and varietal treatments in both locations of study (Table 3). At toeslope flood level the highest plant height was obtained in (104.00 cm, 117.00 cm and 109.08cm, 117.08cm) in 2015 as against (95.75 cm, 94.92cm and 96.67cm, 93.67cm) in 2016 at both locations. At lower slopeflood level, highest plant height (113.83cm, 113.67cm and 122.67cm, 110.92cm) was observed in 2015 as against (99.83cm, 105 .75cm and 94.42cm, 96.83cm) in 2016. At levee flood level the highest plant height (121.58cm, 108.27cm and 124.67cm, 100.67cm) in 2015 as against (97.00cm, 95.33cm and 96.25cm, 101.08cm) in 2016.

Tillering is a varietal character as the tillering habit is dependent on varieties, spacing, nutrient, water level and cultural conditions. The levee and medium flood level had higher tiller per square meter in both years. In all the varieties, there was significant difference (P> 0.05) on number of tillers per square meter. The high tillering obtained from high water level agrees with the view of David (1992) that tillering increase with water level. As water rises, Nodal Gris (1986) reported the opposite, deep water varieties of rice usually have fewer tillers than the non-deep water rice varieties.

Days to 50% flowering

The resultsshowed that there was significant difference on flood levels and varietal treatments in the research years (Table 4). At the toeslope, lower slope and levee flood levels, the highest number of days to 50% flowering was between 90 to 105 for FARO 15. FARO 52 ranged between 82 to 93 and L-19 ranged between 73 to 87 at both locations. It was observed that in 2015 there was higher number of days to 50% flowering compared to 2016. 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, 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 2015 to raining season of 2016, this is because the environmental condition for the season of 2016 was favourable to rice flowering production in both locations.

Days to Maturity

Data obtained from the research (Table 4) indicated that there was significant difference on flood levels and varietal treatments. At toeslope flood level, the highest days to maturity of FARO 15 and FARO 52 was 140.83 cm,144.83 cm and 133.33cm ,130.67cm in 2015 as against 136.50 cm,133.75cm and 121.58cm, 133.75cm in 2016. At lower slopeflood level, highest days to maturity for FARO 15 and FARO 52 was 142.92cm, 139.67cm and 135.17cm, 135.08cm was observed in 2015 as against 133.92 cm, 136.50cm and 120.00cm, 122.33cm in 2016. At levee flood level the highest days to maturity for FARO 15 and FARO 52 was 144.83cm, 144.92cm and 137.75cm, 131.86cm in 2015 as against 133.08cm, 132.92cm and 119.75cm, 120.25cm in 2016.

The main effect of flood levels and that of variety do not differ significantly. Days to maturity was more in 2015 compared to 2016. This is because the weather conditions for the raining season of 2015 was favourable to rice production and tends to delay maturity as it is a common phenomenon with rice. Where there is adequate, water shortage it tends to mature faster. FARO 15 is a late maturing variety, a flood resistant variety suitable in iron toxicity areas and water logged (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 (USAID and ICS) while FARO 44 is an early maturing variety with <120 days to maturity (WARDA).

Heading Height

Data obtained (Table 5) indicated that there was no significant difference on flood levels and varietal treatments in heading height in both years.

The heading height trait is an important yield attributes of rice. This trait 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.*, (2000) for lowland rice, these values can vary depending on the variety and environmental factors present. Hence heading height can be seen to decrease from the raining season of 2015 to the raining season of 2016.

Number of filled panicles

The results in Table 5 indicated that there was no significant difference on flood levels and varietal treatments at levee flood level.At lower slopeflood level filled panicles was significant in 2015. At levee flood level filled panicle was not significant in both years.

FARO 52 ranged between 13.75 to 14.37 in 2015 and 10.67 in 2016.L-19 ranged between 12.98 to 12.79 in 2015 and 12.67 in both locations in 2016.Data on filled panicles was significant as FARO 52had the highest number of filled panicles throughout the 2 years. This is because the major yield components in rice are number of spikelets per unit area, number of grains per spikelet, panicles weight and individual grain weight expressed as 1000 grain weight (Mohammed, 2016).

1000 Seed Weight

Data obtained from the two research years indicated that there was significant difference on flood levels and varietal treatments (Table 6). 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 yield 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 2016) and it can withstand lodging (Malini, *et al.,* 2006).

Grain Yield (tlha)

The results from Table 7 indicated that there was significant difference on flood levels and varietal treatments. At toeslope flood level the seed yield was 6.19t/ha for FARO44, 5.10-5.19 for FARO52, 4.69-5.09 for L-19 and 5.06-5.23 for FARO15. At lower slopeflood level seed yield was 5.58-5.83 for FARO52, 5.02-5.42 for L-19 and 5.13-5.61 for FARO15. At levee flood level seed yield was 5.19-5.87 for FARO52, 4.96-5.16 for L-19and 5.06-5.33 for FARO15. FARO 44 had the highest yield (6.19- 6.98t/ha),while the three varieties fall between (4.96 to 5.98t/ha).

In both locations, the four varieties used performed well in all the water levels. similar results were obtained by (Mustapha et al., 2017). The grain yield results were in tandem with the recommendation of 6tlha of NCRI.

The desired grain yield by the four varieties (FARO 44, FARO 52, FARO 15 and L – 19(FARO 60), may be attributed to fertile nature of soils, climatic factors, timely planting, water habitat favourable, genetic makeup and other factors.

Allrice varieties used for the study perform well in either upland, lowland or deep flooded or shallow water except FARO 44 which suites low water level or upland.

4.0 Conclusion and Recommendation

The study areahas limitation that can easily be overcome by farmers to obtain substantial yield. All the three flood levels (toeslope, lower slope and Levee) were highly suitable for the crop in question, if followed logically based on past experience or knowledge of yearly cropping. All the Pedons experienced flash flooding and river flooding between the months of August and September. However, incidences of deep flooding usually take place occasionally, especially when there is heavy down pour from the upper region. From the four (4) varieties tested, FARO 44 is the suitable variety for levee flood level or upland. FARO 52, L- 19(FARO 60), FARO 15 are suitable for lower slope and toeslope flood levels.

Based on the forgoing, FARO 44 was high yielding 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 51, L-19 can be grown in the lower slope and deep swamp because of their height above flood level.

Timeliness of operation/planting(date of planting may be researched into to establish the possibility of flood escape by FARO 44 in the lower slopeand toeslope flood level.

Crop residue (rice stalk) should be left on soil surface after harvest to increase organic matter(OM) content instead of burning or being grazed by livestock so as to bring up the low organic matter content of the soil. This can also improve the soil N and P which were equally low among the soils because they occur in fixed ratios with organic carbon.

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