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Response of lowland rice-ratooned rice-fluted pumpkin sequence to fertilizer in rainfed inland valley in derived savannah of Nigeria

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ABSTRACT

Trial was carried out at Federal University of Agriculture, Abeokuta, Nigeria between 2010 and 2012 to determine response of lowland rice-ratooned rice-fluted pumpkin sequence to fertilizer. Experiment was laid out in Randomized Complete Block Design arranged in split-split plot in three replicates. Three rice genotypes constituted the main treatments sown in May and harvested in August. Split fertilizers application constituted sub-plot treatments were 90:45:45 (single dose), 45:22.5:22.5 & 45:22.5:22.5 (1:1), 30:15:15 & 60:30:30 (1:2) and 60:30:30 & 30:15:15 (2:1) NPK ha^{-1} at tillering and heading. N-fertilizer rates were sub-sub plot treatment and applied to ratooned 'NERICA L-42' had the tallest plants compare to others. 'Ofada' had the lowest number of days to 50 % flowering for main and ratooned rice, while 'NERICA L-42' had the highest number of days to 50 % heading. 'NERICA L-41' variety had the highest grain yield in main and ratooned rice. Based on this study, 'NERICA L-41' plus its ratooned rice obtained from single dose NPK and zero N-fertilizer plots produced grain yield of 4.69 t ha^{-1}.

Key words: rice; ratooned; triple cropping sequence; fertilizer; inland valley; Nigeria

IZVLEČEK

ODZIV NIŽINSKEGA KOLOBARJA RATONIRANEGA RIŽA IN KRILATE BUČKE NA GNOJILA V NENAMAKANEM NIŽAVJU ANTROPOGENE SAVANE V NIGERIJI

Poskus je potekal na Federal University of Agriculture, Abeokuta, Nigeria v rastnih sezonah med 2010 in 2012 z namenom ugotoviti odziv kolobarja ratoniranega riža in krilate bučke na gnojenje. Poskus je bil zasnovan kot popoln naključni bločni poskus, na ploskvah s tremi ponovitvami. Glavna obravnavanja so obsegala tri genotipe riža, ki so bili posejani maja in požeti avgusta. Gnojenje z enkratnim odmerkom NPK gnojil 90:45:45 je potekalo na podploskvah, ostala obravnavanja pa v kombinacijah 45:22.5:22.5 & 45:22.5:22.5 (1:1), 30:15:15 & 60:30:30 (1:2) in 60:30:30 & 30:15:15 (2:1) NPK ha^{-1} v fazi bilčenja in latenja riža. Gnojenja z dušikom pri obravnavanjih na podploskvah z ratoniranim rižem 'NERICA L-42' so dala najvišje rastline v primerjavi z drugimi. Sorta Ofada je potrebovala najmanjše število dni do 50 % cvetenja, sejanega in ratoniranega riža, 'NERICA L-42' pa je potrebovala največ dni do 50 % latenja. Sorta NERICA L-41 je imela največji pridelek zrnja pri sejanem in ratoniranem načinu pridelave. V raziskavi je bilo ugotovljeno, da je sorta NERICA L-41 pri običajni setvi in sledečem ratoniranem posevku pri enkratnem dodatku gnojil in brez dodatnega dognojevanja z N dosegla pridelek zrnja 4.69 t ha^{-1}

Ključne besede: riž; ratonirani posevek; trisetveni kolobar; gnojilo; notranje nižine; Nigeria

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1 INTRODUCTION

Rice is a staple food consumed by more than 3.5 billion people of the world based on the fact that it contains more energy (kcal/kg) than wheat (Muthayya et al., 2014). The straw serves as fodder for livestock, while rice bran is a good component in the preparation of poultry feed (FAO, 2003). Globally, rice production ranks third after wheat and maize whereas in Nigeria, it is the sixth major crop following sorghum, millet, cowpea, cassava and yam in terms of land area under cultivation (Akinbile, 2010). Rice represents a symbol of equally cultural identity and global unity, a main source of employment and livelihoods and also an increasingly important cereal crop with world annual production estimated at 738.2 million tonnes in 2015 during which Africa recorded an average of 28.5 million tonnes (FAO, 2003; FAO, 2016).

Rice production in Nigeria in 2006 was estimated at 2.10 million tonnes while consumption was 3.71 million mega grams. The balance of 1.60 million mega grams was obtained by importation (Africa Rice Center, 2008). Nigeria imports one million tonnes of rice, valued at $700 million or about N106 billion, from the Peoples Republic of Thailand every year (Sams, 2010). Currently, Nigeria is the second largest importer of rice (N356 billion per year i.e. approximately N1 billion per day) after Philippines in the World (ATA, 2011).

Ironically, Nigeria has the resource (abundant rainfed upland and inland valley) and management potential to produce enough rice to meet local and as well as for exportation (FAOSTAT, 2008). Lançon and Erenstein (2002) reported that out the total land area of 1.6 million ha devoted to rice cultivation, rainfed upland accounted for 492, 600 ha (30 %), rainfed lowland (wetland i.e. inland valleys and flood plains) for 788, 860 ha (48 %), irrigated lowland for 262, 720 ha (16 %), deep water floating for 82, 100 ha (5 %) and mangrove for 16,420 ha (1.0 %). Whereas World Bank (2006) reported that Nigeria has 3 million ha of inland valleys and flood plain (FADAMA) suitable for rice production. Consequently, with efficient utilization of land resources, there are two options available in order to reduce rice importation via; land intensification and extensification of the naturally abundant fadama.

Adigbo et al. (2007) examine the intensification of inland valley via triple cropping of lowland rice-upland rice-vegetable) within 3 year and reported that it was possible to grow 3 crops without reducing the yield of lowland rice. However, the upland rice component in the sequence decreased the overall benefit/cost ratio of triple cropping rather than increasing it. Hence, Adigbo et al. (2012a) report that ratooned rice was technically feasible technology to fit into the niche between lowland rice and fluted pumpkin. Rice ratooning is the practice of harvesting grain from tillers originating from the stubble of previously harvested crop and it enhances rice grain yield without increasing land area because it provides higher resources use efficiency per unit land area per unit of time (Jason et al., 2005). Ratooned rice crop was reported to be an economically viable technology capable of boosting rice production and consequently increasing the overall productivity of the inland valley in a lowland rice–rice–vegetable cropping sequence (Adigbo et al., 2012b).

The assertion that the continual inflow of nutrients from the adjacent uplands guarantees the inland valley sustainability (Mitsch and Gosselink, 1993) perhaps for one crop per annual but that may not be true for triple crops. Adigbo (2008) was of the opinion that there was the need for additional fertilizer to supplement the geological fertilization from the adjacent uplands. But how much of fertilizer to be applied at the critical growth stages to complement the geological fertilization need to be evaluated. Beside, how much residual fertilizer previously applied to lowland rice was available to ratooned rice. What quantity of N-fertilizer should be added to ratooned rice? Earlier studies reveal that judicious and proper use of fertilizers can markedly increase the yield and improve the quality of rice (Place et al., 1970). The profitability of rice production system depends on yields and inputs quantities (Moya et al., 2004). So, the appropriate fertilizer input that is not only for getting high grain yield but also for attaining maximum profitability. Earlier study by Adigbo et al. (2013) on fertilizer requirement for ratooned rice in lowland rice-ratooned rice-vegetable was in sawah rice based technology. Sawah is leveled, bunded, puddled rice field with inlets and outlets to water control. Simple irrigation is involved and fixation of nitrogen by soil microbes under a submerged sawah systems could reach 20 – 200 kg/ha/year (Kyuma, 2003; Hirose & Wakatsuki, 2002). However, the current study was based solely on rainfall where water is not controlled and without power tiller for puddling. Resource constraint farmers who accounted for 75 % of food production in Nigeria may not be able to afford the cost of power tiller and labour to construct bunds required for sawah. The objectives of the study were to: (1) evaluate the yield and yield component of lowland rice in inland valley (2) evaluate the effects of split fertilizer application on grain yield and yield component of lowland rice (3) effects of the preceding lowland rice, split application of fertilizer and urea fertilizer on ratooned rice.

2 MATERIALS AND METHODS

The experiment was conducted in 2010/2011 and 2011/2012 cropping seasons at the bottom of the inland valley of the Federal University of Agriculture, Abeokuta. The top 20 cm soil layer was taken using soil auger. The pre-planting sampled soil was air dried before determining following: total nitrogen (using Macro-Kjedahl method), available phosphorus (Bray extractable P), exchangeable potassium (extracted with 1 M ammonium acetate and measured using Flame photometry), Organic matter (Walkley–Black method), cation exchange capacity (CEC), pH (1:2, soil/water) and the textural class (Table 1). The soil series of the experimental site was Ikire (Aiboni, 2001). This is equivalent of Aquic Ustifluvents according to Aiboni (2001).

The available long-term climatic data are: precipitation (1148 mm/annum) and mean temperature (28 ^{o}C). At first peak of the bimodal rainfall during the raining season, the water table was above the soil surface. This receded to the soil level but remains saturated in August and became flooded, again at the second peak of rainfall in September. The major part of the experimental soil remains saturated throughout the dry seasons.

The 3 x 4 x 4 experiment was laid out in a Randomized Complete block Design (RCBD) in split split-plot with three replicates on the same site for two years. The size of the main, sub and sub sub-plots were 15 m x 11 m, 11 m x 3 m and 3 m x 2 m, respectively. Three selected varieties of lowland rice; NERICA L-41, NERICA L-42 (NERICA = New Rice for Africa) and Ofada (control variety) constituted the main treatment assigned to main plot. Each of the variety was dry dibbled at the spacing of 20 cm x 20 cm by chipping 4 to 6 seeds into 16 plots of 6 m^{-2} raised beds on 14th and 17th May 2010 and 2011, respectively. They were harvested in 27 and 30th September 2010 and 2011, respectively. After harvesting of the lowland rice, the straws were cut to about 5 to 10 cm above the soil surface with aid of secateurs on 4th and 7th of October 2010 and 2011, respectively.

The sub plot treatments were split fertilizer applications at the ratio of 1:0 (i.e. single dose of 90 kg N, 45 kg P ha^{-1} and 45 kg K^{-1} was applied at 3 three weeks after planting (WAP), 1:1 (45 kg N ha^{-1}, 22.5 kg P ha^{-1}, 22.5 kg K ha^{-1} each applied at 3 and 11 WAP), 1:2 (30 kg N ha^{-1}, 15 kg P ha^{-1} and 15 kg K ha^{-1} was applied at 3 WAP while 60 N kg ha^{-1}, 30 kg P ha^{-1} and 30 kg K ha^{-1} at 11 WAP) and 2:1 (60 N kg ha^{-1}, 30 kg P ha^{-1} and 30 kg K ha^{-1} at 3 WAP while 30 kg N ha^{-1}, 15 kg P ha^{-1} and 15 kg K ha^{-1} 11 WAP in the form of NPK 20:10:10 compound fertilizer). The split applications at 3 and 11 WAP were targeted to enhance tillering (prior to tillering stage) and grain filling (50 % heading stage). The sub sub-plot treatments were N-fertilizer rates applied to ratooned crop (0, 40, 80 and 120 kg N ha^{-1}) in the form of urea applied at 1 week after cutting (WAC) the main rice straw.

During the dry season, pre-germinated fluted pumpkins [(*Telfairia occidentalis* Hook f.) is an important cucurbitaceous leafy vegetable rich in Fe, protein, minerals, vitamins and oil which nourishes the body], was planted at spacing of 1 m x 0.5 m on the entire experimental plots in late December as the third crop in the sequence. The seeds were pre-germinated in moist saw dust to enhance germination given the fact that the soil was wet.

Contact herbicide was sprayed on field on the fifth day after planting rice but prior to lowland rice emergence to keep the field free of weeds. Other supplementary weeding were done at 3, 6 and 9 WAP for main rice crop whereas ratooned crop was weeded at 1 and 4 WAP while vegetable was weeded at 3, 6 and 9 WAP.

2.1 Data collected on rice crops

Chlorophyll content (greenness of rice leave): The leaf chlorophyll content was determined by using chlorophyll meter (model SPAD 502) to measure the average greenness of lower, middle and upper leaves of rice plant. This was done for 5 randomly selected plants.

Number of days to 50 % flowering: The day at which 50 % of the panicles of stands emerged.

Panicles m^{-2}: With the aid of the quadrat of 1 m X 1 m, the total number of panicles enclosed within quadrat was recorded.

Panicle mass (g): Five panicles were randomly selected from each plot and their lenghts were taken with the aid of ruler in the lab which was divided by 5.

Number of grains/panicle: Five panicles were randomly selected from each plot, threshed and grains were counted which was divided by 5.

Grain yield: The brown panicles were harvested with the aid of a harvesting knife. The harvested panicles were sun dried, threshed and weighed. This was converted to t ha^{-1}.

3 RESULTS AND DISCUSSION

3.1 Pre-planting soil chemical analysis of the inland valley in 2010/2011

The soil physico-chemical properties prior to planting in 2010/2011 experiment are shown in Table 1. The total nitrogen, available P, exchangeable K and organic matter of the soil level were below the critical levels according to Enwezor et al. (2002). However, sulphur level of the soil appeared to be adequate enough. The textural class of the soil justified the split fertilizer application as a factor because of its porousness associated with less colloids which will encourage leaching. The soil pH of 6.00 recorded was slightly acidic but could likely be increased by anaerobic condition of the soil. According to Adigbo et al. (2013), the pH of both acid and alkaline of paddy soil tend to converge on a pH of 7 soon after flooding when he reviewed the potentials of inland valley for poverty alleviation in Nigeria. Furthermore, the process of anaerobiosis in paddy soils, iron phosphate tends to be reduced, with a release of some of the P in available forms. Moreover, reduction of iron oxides releases some of the occluded P into the soil. Thus, raising the availability of P in paddy soils (FFTC, 2007).

Table 1: Soil physico-chemical properties before the commencement of the study in 2010/2011 cropping season

Properties	Values
pH	6.00
Sand (g kg^{-1})	788
Silt (g kg^{-1})	116
Clay (g kg^{-1})	97
Textural Class	Sandy loam
Available P mg kg^{-1}	7.89
Exchangeable Na (c mol kg^{-1})	2.23
Exchangeable K (c mol kg^{-1})	0.15
Exchangeable Ca (c mol kg^{-1})	1.09
Exchangeable Mg (c mol kg^{-1})	0.49
Exchangeable H^+ (c mol kg^{-1})	0.11
CEC (c mol kg^{-1})	4.07
Organic matter	0.91
Total nitrogen	0.05
Sulphur mg kg^{-1}	8.49

3.2 Response of lowland rice to split fertilizer application

There was significant difference among the varieties in the all parameter considered except chlorophyll content of the leaves (Table 2). ‘NERICA L-41’ had significantly highest number of panicles m^{-2} while ‘Ofada’ was the lowest. The panicle length observed in ‘NERICA L-41’ and ‘NERICA L-42’ were similar but significantly longer than that of ‘Ofada’ variety in 2010/2011. ‘NERICA L-42’ consistently had significantly the highest number of days to 50 % flowering while ‘OFADA’ had the lowest in both cropping seasons. The biomass obtained from the 3 varieties was similar in 2010/2011 but ‘NERICA L-41’ had 1.60 and 2.25 times higher grain yield than ‘NERICA L-42’ and Ofada’, respectively in 2011/2012. The grain yields of lowland rice ranged between 3.21 and 1.87 t ha^{-1}.

The chlorophyll content of the leaves which is a measure of leaf greenness of the rice plant arising from the nutrient uptake monitored throughout life cycle of the lowland rice was influenced by split fertilizer application at heading stage in both cropping seasons. Plots treated with 30:15:15 at 3 WAP and 60: 30:30 at 11 WAP had significantly greener leaves compared plots that received single dose NPK 90:45:45 at 3 WAP in 2010/2011 whereas plots that received single dose NPK 90:45:45 at 3 WAP application had significantly greener leaves than those plots treated with split application of 60:30:30 at 3 WAP and 30:15:15 11 WAP in 2011/2012. However, the differences in the greenness in the various split fertilizer application did influence rice straw (biomass) in 2010/2011. Split fertilizer application of ratio 1:1 had significantly higher biomass compared to others but this difference could not be translated into higher grain yield. Adigbo et al. (2013) reported similar difference in greenness of rice leaves which did not translate to increase in grain yield.

Table 2: Effects of fertilizer on the chlorophyll content, yield and yield component of lowland rice

Treatments	Chlorophyll content @ heading		Panicles m^{-2}		Panicle length (cm)		Days to flowering	50 %	Grain yield ($t\ ha^{-1}$)	
	2010/2011	2011/2012	2010/2011	2011/2012	2010/2011	2011/2012	2010/2011	2011/2012	*2010/2011	2011/2012
Variety (V)										
NERICA L-41	39.71	35.70	-	164.0	-	24.8	90	86	20.6	3.20
NERICA L-42	40.66	36.60	-	130.8	-	26.2	100	105	22.6	2.61
Ofada	39.91	35.63	-	119.9	-	20.9	80	79	20.1	1.87
LSD	NS	NS	-	25.95	-	2.21	8.5	2.32	NS	0.47
Fertilizer split application (F)										
1:0 (90:0)	38.93	37.22	-	138.9	-	24.4	89	90.1	19.1	2.79
1:1(45:45)	40.26	35.92	-	148.0	-	24.0	91	89.5	23.4	2.94
1:2 (30:60)	41.28	35.79	-	129.1	-	23.9	89	89.8	22.4	2.88
2:1 (60:30)	39.90	34.98	-	136.8	-	23.7	91	90.3	19.5	2.91
LSD	1.63	2.24	-	NS	-	NS	NS	NS	3.58	NS
V x F	NS	NS		NS	-	NS	NS	NS	NS	NS

Data were unavoidably lost, * Biomass and NS Not significant

3.3 Response of ratooned rice to preceding lowland rice, split fertilizer application and N-fertilizer rates

There were no variations in the chlorophyll content among the leaves of ratooned lowland rice varieties obtained from the preceding lowland rice in 2010/2011 and 2011/2012. However, the chlorophyll content of the leaves of ratooned lowland rice in the preceding plot treated with single dose of 90:45:45 fertilizer had significantly greener leaves than the others in 2011/2012. The observed greener leaves in the preceding plots of single dose of fertilizer application may not only imply cost and labour saved but suggests that higher residual fertilizer was available to the succeeding ratooned rice. The ratooned rice obtained from the preceding plots of Ofada and NERICA L-41 varieties had significantly higher panicle length in 2010/2011 and 2011/2012 cropping systems, respectively than the others.

Ratooned rice obtained from preceding plots of Ofada variety significantly flowered earlier than the two improved varieties in both cropping seasons. The earlier attainment of flowering of Ofada ratooned rice compared to the two improved varieties contradicted the report of Africa rice center (2008a) that the improved varieties mature earlier than the local ones. The same trend of observed earliness in flowering in the main rice crop of 'NERICA L-42' > 'NERICA l-41' > 'Ofada' was genetically transferred to their ratooned counterpart. However, the number of days to flowering in the main crop was 3.0 times higher than in the ratooned rice crop for all the three lines. This also agrees with the findings of Oad et al. (2002); Rehman et al. (2007) and Adigbo et al. (2012) who reported that the ratooned crop matures earlier than the main crop. The number of days to 50 % flowering was not influenced by the preceding split fertilizer application but the interaction of variety x split fertilizer application and variety x N-fertilizer were significant in 2011/2012 (Figs. 1 and 2). 'NERICA L-42' consistently had highest number of days to flowering irrespective of the split fertilizer application ratio and N-fertilizer while 'Ofada' also constantly had the lowest number of days to flowering across the split fertilizer ratio. This is a pointer to the fact that the numbers of days to flowering among the three cultivars were genetically inherent and cannot be influenced by fertilizer application.

The grain yield obtained from 'NERICA L-41' was superior to the other varieties in 2011/2012 cropping season (Table 3). However, it is pertinent to note that the preceding plots of split fertilizer application did not influence the overall performances of the ratooned rice. The grain yield of ratooned rice variety ranged between 1.39 and 1.79 t h^{-1} with grand mean of 1.64 t ha^{-1} in 2010/2011 while those of 2011/2012 cropping season was 1.02 and 1.49 t ha^{-1} with grand mean of 1.2 t ha^{-1}. The range of the mean yield obtained in 2010/2011 was not substantially different from the results of Oad et al. (2001) and Adigbo et al. (2013) who reported 1.68-1.83 and 1.39 – 1.62 t ha^{-1}. However, the range of the mean yield got in 2011/2012 was slightly lower than those of Oad et al. (2011) and Adigbo et al. (2013). The lower grain yield obtained in this report compared to the earlier reports of Adigbo et al. (2013) and Oad et al. (2001) could be attributed to water control and other facilities used that had additional cost of operations to the farmers. The grain yield of ratooned rice obtained from the niche in the inland valley was similar to the obtainable yield from one cropping season of the upland ecology according the following researchers IITA (1990), Adigbo et al. (2003) and Africa Rice Center (2008b) who reported 1.5, 1.2 and 1.4 t ha^{-1}, respectively. The ratooned rice of Ofada, NERICA L 41 and NERICA L 42 varieties contributed about 58.3, 46.5 and 39.1 %, respectively to their corresponding grain yield of the lowland rice and indicates that 'Ofada' has better ratoonability than the others. This corroborate the findings of Stansel (1997), Oad et al. (2002) and Adigbo et al. (2012) who reported 30, 50 and 43 % of the total yield. Furthermore, it is pertinent to note that the grand mean grain yield (1.2 t ha^{-1}) obtained from ratooned rice in 2011/2012 was about 59.1, 63.2, 72.7 and 43.6 % of the national average rice paddy yield of Nigeria according to FAO reports of 2011, 2012, 2013 and 2014, respectively (http://faostat3.fao.org/download/Qov/E).

Generally, the non-significant grain yield and yield components observed among the split fertilizer and N-fertilizer application levels could be attributed the loose texture of the soil, lack of water control and nutrients solubility which favoured the free movement of soil nutrient elements along the flow of water occasioned by excess water within and between the plots.

The total grain yield obtained from the main lowland rice varieties and their ratooned rice counterpart were 4.69, 3.63 and 2.96 t $ha^{-1}yr^{-1}$ in 2011/2012 for NERICA L-41, NERICA L-42 and Ofada, respectively.

Table 3: Effects of preceding lowland rice and fertilizer on chlorophyll content, yield and yield components of ratooned rice

Treatments	Chlorophyll content		Panicles m^{-2}		Panicle length (cm)		Days to 50 % flowering		Grain yield ($t\ ha^{-1}$)	
	2010/ 2011	2011/ 2012	2010/ 2011	2011/2012	2010/ 2011	2011/2012	2010/ 2011	2011/ 2012	2010/ 2011	2011/ 2012
Variety (V)										
NERICA L-41	37.73	35.70	133	122	29.9	30.5	30	29	1.73	1.49
NERICA L-42	39.08	36.60	136	124	28.4	23.4	31	34	1.79	1.02
Ofada	37.73	35.63	102	122	33.3	23.2	28	23	1.39	1.09
LSD	NS	NS	NS	NS	3.65	4.59	1.86	4.10	NS	0.30
Fertilizer split application (F)										
1:0 (90:0)	38.23	37.22	121	123	30.72	26.86	30	29	1.65	1.24
1:1(45:45)	36.69	35.92	131	123	30.81	23.75	30	29	1.62	1.09
1:2 (30:60)	38.47	35.79	126	123	29.44	24.06	30	29	1.59	1.14
2:1 (60:30)	39.31	34.98	118	123	31.14	28.14	30	29	1.68	1.32
LSD	NS	2.24	NS	NS	NS	NS	NS	NS	NS	NS
V x F	NS	NS	NS	NS	NS	NS	NS	S	NS	NS
N-fertilizer (N)										
0	37.64	34.98	122	122	31.58	24.81	30	29	1.69	1.16
40	38.31	35.79	132	123	31.25	25.08	29	29	1.67	1.13
80	38.56	35.92	120	124	29.58	26.69	30	28	1.57	1.21
120	38.22	37.22	122	123	29.69	26.22	30	29	1.61	1.30
LSD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS	NS	S	NS	NS
N x F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N x V x F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Not significant

The pumpkin planted in December was adversely affected by anaerobic condition of the soil. The leaves had yellow colorations which were likely to be the symptoms of sulphur, nitrogen and other nutrients interaction as well as the overall effects of anaerobic conditions which resulted in wilting off. This chlorosis, symptom of sulphur and nitrogen deficiency, could not have been associated with lack of these elements in the soil. The pre-planting soil analysis showed that there was sufficient S supply. Although N content was below the critical level, but the residue from the previous application of NPK (90:45:45) and urea (0, 40, 80 and 120 kg N ha^{-1}) to the preceding crops of lowland and ratooned rice, respectively were expected to have corrected the deficiency symptoms if it was not caused by the anaerobic soil conditions. Consequently, the symptoms could be attributed to excess water which reduced nitrate to ammonium and sulphate to sulphid. These reduced forms of S and N in anaerobic soil conditions were not available to fluted pumpkin. This agrees with the opinion of George et al. (1992) that, under anaerobic conditions the N in the form of nitrate are reduced to ammonium (NH_4) and will not be available to upland crop except rice. As the soil becomes even more reductive, sulphate reducers, which are strict anaerobes, produce sulphides; and methanobacteria, also strict anaerobes, produce methane (FFTC, 2007). However, in the opinion of Setter et al. (2009) who reviewed the importance of anaerobiosis and element toxicities associated with different soils in Australia and India with respect to wheat improvement for waterlogging tolerance documented as follows that waterlogging alters the cation exchange capacity of soil particles and valency of nutrient elements (more reduced forms), making them toxic or unavailable for plant uptake. Hypoxia-induced nutrient deficiency/toxicity interferes with a range of shoot physiological processes such as photosynthesis, respiration and growth, causing chlorosis and necrosis and ultimately, plant death (Dodd et al., 2013; Bailey-Serres and Colmer 2014). These explained why pumpkin vegetable could not thrive in saturated inland valley suggesting that another rice crop would be more appropriate to be planted instead of fluted pumpkin.

The successful management of inland valley for triple of rice-rice-vegetable, rice-rice-cowpea have been reported (Adigbo et al., 2007, 2010, 2012a, b and 2013) but this study was a deviation from the previous ones. This observed deviation in inland valley was buttressed by FAO (http://www.fao.org/docrep/003/x6611e/x6611e03a.htm) who are of the opinion that inland valleys varied: internally, where they comprise such different elements as valley bottoms, slopes and crests, as well as externally where they have a characteristically high spatial variability due to differences in parent material, physiography and climate and, as a resultant thereof, hydrology and soils. Inland valleys, therefore, do have very high variability in actual and potential uses. Consequently, the correct use of this particular inland valley should be rice-rice-rice because of its uniqueness in water availability to support three crops of rice in year.

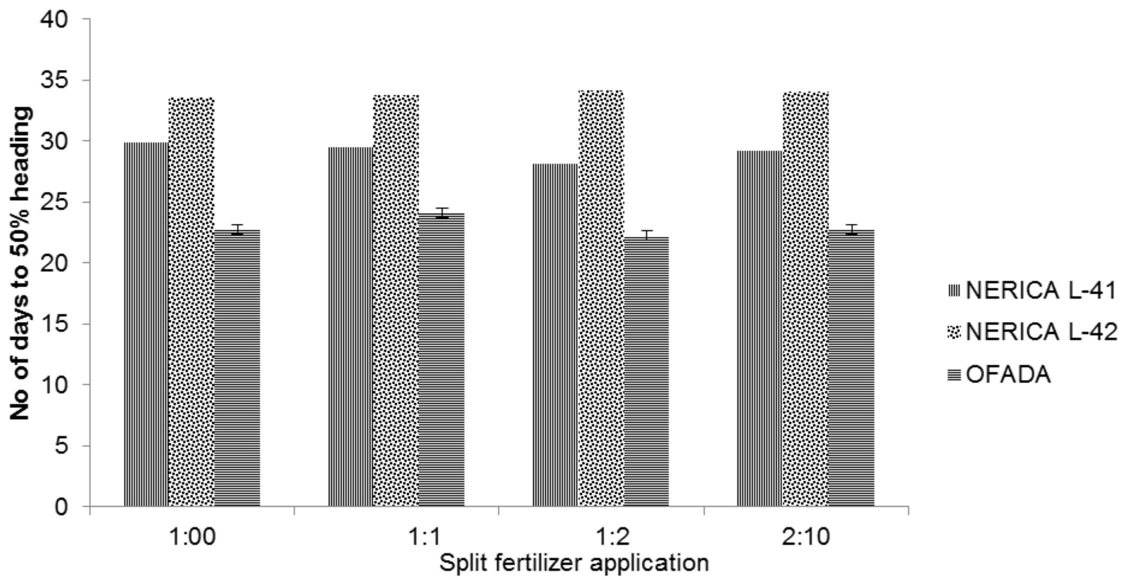

Figure 1: Interaction of variety X split fertilizer application on number of days to 50 % heading

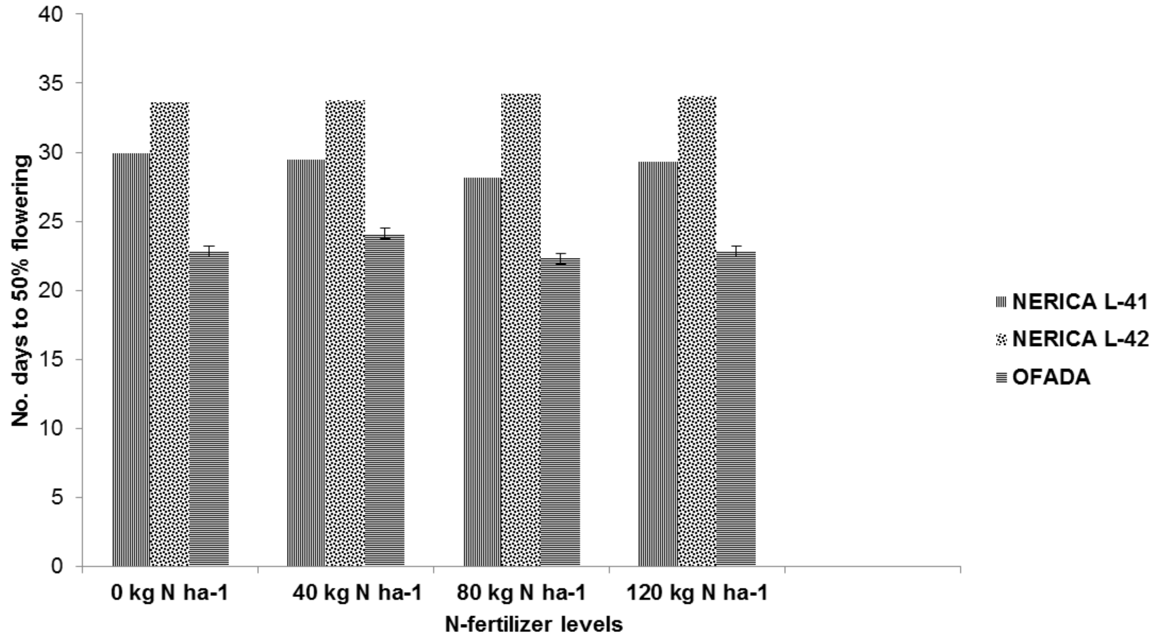

Figure 2: Interaction of variety and N-fertilizer on days to 50 % flowering of ratooned rice

4 CONCLUSION

'NERICA L-42' lowland rice had the highest grain yield. Single dose of NPK 90:45:45 could conveniently be applied to the main lowland rice. The panicle length and grain yield of ratooned rice from 'NERICA L-41' plot were the highest. Consequently, 'NERICA L-41' and its ratooned rice were the best combination. The combination of single dose of NPK (90:45:45) in the form of 20:10:10 and urea were sufficient for the crops of rice. The ratooned rice of 'Ofada', 'NERICA L 41' and 'NERICA L 42' varieties contributed about 58.3, 46.5 and 39.1 %, respectively to their corresponding grain yield of the lowland rice. The total grain yield obtained from the main lowland rice varieties and their ratooned rice counterpart were 4.69, 3.63 and 2.96 t $ha^{-1}yr^{-1}$ for 'NERICA L-41', 'NERICA L-42' and 'Ofada', respectively. The study also showed that this particular inland valley used in this trial should be planted to three crops of rice rather than two rice crops and vegetable or legume.

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