MORPHOLOGICAL RESPONSES OF RICE LANDRACES IN NIGERIA SAVANNA ZONES TO FLASH FLOODING AND DEEP WATER SUBMERGENCE

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Abstract: This study was aimed at investigating the morphological responses of rice landraces in Nigeria savanna zones to flash flooding and deep water submergence. The rice landraces were obtained from local farmers across the savanna region. Submergence tolerant checks were obtained from AfricaRice and served as control. The research was conducted at the Botanical Garden, Department of Botany, Ahmadu Bello University, Zaria, Nigeria. The rice landraces were sown in 1.54 m^2 labelled polythene bags containing 3.5 kg of surface loamy soil. The seedlings were maintained using standard cultural practices. The treatments were laid out in a randomized complete block design with two replicates. Thirty-day old seedlings were submerged in a plastic tanks of 1000 L capacity at a water depth of 100 cm for a period of 14 and 30 days. Growth parameters were recorded following the protocol of the International Rice Research Institute. The result obtained was statistically significant ($p<0.05$). Highest percentage variance under flash flood are: number of panicles(10.50%), number of leaves (30.43%), number of tillers (15.91%), stem elongation (80%), days to maturity (8.15%), leaf length (7.1%), leaf width (4.18%), hundred-seed weight (2.8%) and yield (15.72%). Highest values for agronomic traits obtained under deep water submergence are: elongation (3.0-71.50 cm), number of leaves (35.0), number of tillers (4.0), days to maturity (118 days), hundred-seed weight (2.60 g) and yield (34.74 kg/ha). Landraces Fijo (15.72 kg/ha) and Jamila-Plt (22.08 kg/ha) with high yield could be used by farmers in flood prone areas for increased production. Breeders could also exploit these genotypes as a source of submergence tolerance gene.

Keywords: Deep-water, flash, flood, landraces, morphological, response, submergence

Introduction

Rice landraces are known as the traditional, local or farmers varieties. They are not bred as varieties but adapted to the environmental conditions of the localities where they are cultivated under a natural and certain level of unconscious artificial selection (Sinha and Mishra, 2013). These are composed of heterogeneous mixtures of genotypes in association with each other and with the environmental conditions (Kohli *et al*., 2004). Landrace constitutes a good source of unique genes for stress tolerance, yield stability, adaptability and genetic dynamics (Guei and Traore, 2001).

Importance of rice landraces can never be denied in agricultural system, because improvement in existing varieties depend upon desirable genes which are possibly contained in landraces and wild varieties only (Sinha and Mishra, 2013). Rice landraces are prone to flash flooding and deep water submergence. Although, rice is a crop that requires flooded and irrigated condition for cultivation; most of the rice varieties are susceptible to flooding (Jackson and Ram, 2003). According to Toojinda *et al*. (2003), flooding is a serious constraint to rice plant growth and survival in rainfed lowland and deep-water areas because excess water in their environments will limit the supply of important elements for their survival, such as oxygen, carbon dioxide and light for photosynthesis (Jackson *et al*., 2009; Choi, 2011). Thus, flooding is one of the major abiotic stresses that pose threat on crop distribution and agricultural productivity worldwide as most crop plants are sensitive to submergence (Choi, 2011). Flash flooding can cause complete inundation of the entire plant for several days, often for up to two weeks (Ismail *et al*., 2008; Singh *et al*., 2014). In Nigeria, approximately 70% rainfed lowland rice farms are prone to seasonal flooding (Akinwale *et al.*, 2012). Flash floods are common features in Nigeria during the rainy seasons that destroy several hectares of farmland (Hula and Udoh, 2015). Among the most frequently and severely affected states in Nigeria are Kebbi, Niger, Kogi and Taraba states which together account for over 80% of lowland rice ecology (Erenstein *et al*., 2003; Akinwale *et al*., 2012). Yield losses due to flashfloods range from 10% to total destruction depending on water depth, duration of submergence, temperature and age of the crops (Das *et al*., 2009). In Deep water flooding, the water level stagnates at greater than 100 cm for several months; plants may become completely submerged for short periods in severe floods (Singh *et al*., 2011). When partially or completely submerged, most rice varieties display a moderate capacity to elongate leaves and the portion of stems are trapped under water. This elongation growth leads to a slender plant that easily lodges when floodwaters recede. If the flood is deep, underwater elongation growth can exhaust energy reserves, causing death within a matter of days (Ranawake *et al*., 2014). When the flood is deep and transient, the protection of energy reserves and growth meristems provides advantages for subsequent recovery.

However, in cases of slow-rising floodwater that persists for longer duration, investment of energy into elongation growth is a successful survival strategy. Stagnant flood at later stages of growth could hinder photosynthesis and impair translocation to the developing panicles that may lead to apparent decrease in grain filling percentage with a consequent reduction in yield. Hence, grain yield is associated with decreases in panicle number, grain weight, and grain filling percentage. Under deeper floodwater, a major proportion of photosynthetically active leaves remain underwater, where they receive only diffused light. Besides reducing net photosynthesis, low light intensity probably results in reduced tillering ability (El- hendawy *et al*., 2012). Furthermore, photosynthesis decreases considerably under reduced light conditions and translocation to the developing panicles impaired, thus decreasing filling percentage, grain weight and yield.

Materials and Methods

Study area

Phenotypic screening of the rice landraces subjected to flash flooding and deep water submergence was conducted at the Botanical Garden, Department of Botany, Ahmadu Bello University, Zaria, Nigeria (Lat. 11 º N, Long. 70 º 42´E and Altitude 660 m).

Source of plant materials
Healthy seeds of seventy five (75) rice genotypes were used for the study. They comprised of seventy three (73) rice landraces collected from local farmers across savanna zones (the nineteen (19) northern states of Nigeria) and submergence tolerant lines (L- 19 SUB1 and Futia-12) obtained from AfricaRice Research Institute. The rice landraces consisted of eighteen (18) *Oryza glabberima* and fifteen (15) lowland rice landraces. The traditional names of the landraces were identified by the farmers (Table 1).

Table 1: Rice landraces, states of collection, species and ecosystem

S/n	Rice Landrace	Location	State	Species	Ecosystem
1	Jamila-Yola	Yola	Adamawa	*O. sativa*	Upland
2	Faro- Yl	Yola	Adamawa	*O. sativa*	Upland
3	Bakin Yar China Bau	Bauchi	Bauchi	*O. sativa*	Upland
4	Tasama	Bauchi	Bauchi	*O. glaberrima*	Upland
5	Jamila-Bauchi	Bauchi	Bauchi	*O. sativa*	Upland
6	Mai Madara	Bauchi	Bauchi	*O. sativa*	Upland
7	Lete/Viu	Gboko	Benue	*O. sativa*	Upland
8	Mass/Osi	Vandekya/Zakibien	Benue	*O. sativa*	Upland
9	Miruwa	Akwara/Aledi	Benue	*O. sativa*	Lowland
10	Soppi	Bayango	Benue	*O. sativa*	Lowland
11	Cdi	Vandekya/Zakibien	Benue	*O. sativa*	Upland
12	Dan Koydo	Borno	Borno	*O. glaberrima*	Upland
13	Bakin Iri – Borno	Borno	Borno	*O. glaberrima*	Upland
14	Jan Iri – Borno	Borno	Borno	*O. glaberrima*	Upland
15	Jamila-Gombe	Gombe	Gombe	*O. sativa*	Upland
16	Chaina	Gombe	Gombe	*O. sativa*	Upland
17	Cp Gombe	Gombe	Gombe	*O. sativa*	Lowland
18	Yar Das	Birnin Kudu	Jigawa	*O. glaberrima*	Upland
19	Jamila-Jigawa	Kyawa/Shuwarin	Jigawa	*O. sativa*	Upland
20	Mai Zabuwa/Biro	Zaria	Kaduna	*O. sativa*	Upland
21	Mai Adda/Kilaki	Zaria	Kaduna	*O. sativa*	Lowland
22	Jamila-Zaria	Zaria	Kaduna	*O. sativa*	Upland
23	Mai Allura	Zaria	Kaduna	*O. sativa*	Lowland
24	Yar Nupawa	Zaria	Kaduna	*O. sativa*	Upland
25	Fijo	Zaria	Kaduna	*O. sativa*	Upland
26	Yar Dan Hassan	Zaria	Kaduna	*O. sativa*	Upland
27	Farar Jellof	Zaria	Kaduna	*O. sativa*	Upland
28	Tilaki	Giwa	Kaduna	*O. sativa*	Upland
29	Jamila-Kd	Giwa	Kaduna	*O. sativa*	Upland
30	Frajalam	Giwa	Kaduna	*O. sativa*	Upland
31	Doguwar Carolea	Giwa	Kaduna	*O. sativa*	Upland
32	Mai Zabuwa Giwa	Giwa	Kaduna	*O. sativa*	Upland
33	Yar Dashe	Giwa	Kaduna	*O. glaberrima*	Upland
34	Gajere Carolea	Giwa	Kaduna	*O. sativa*	Upland
35	Yar Telak	Giwa	Kaduna	*O. sativa*	Upland
36	Yar Bijinaye	Giwa	Kaduna	*O. sativa*	Upland
37	Yar Kura	Giwa	Kaduna	*O. sativa*	Upland
38	Doguwar Jamila	Giwa	Kaduna	*O. sativa*	Upland
39	Farar Jana	Wudil	Kano	*O. sativa*	Upland
40	Jap	Jibia	Katsina	*O. sativa*	Upland
41	Santana (Yar Ruwa)	Dutsinma	Katsina	*O. glaberrima*	Lowland
42	Farar Ja	Funtua	Katsina	*O. sativa*	Lowland
43	Jaka	Funtua	Katsina	*O. glaberrima*	Upland
44	Yar Maaji	Funtua	Katsina	*O. sativa*	Upland
45	Shatika	Funtua	Katsina	*O. glaberrima*	Upland
46	Yar Gidan Yarima	Funtua	Katsina	*O. sativa*	Upland
47	Bolaga	Funtua	Katsina	*O. sativa*	Upland
48	Jamila Katsina	Funtua	Katsina	*O. sativa*	Upland
49	Wacot	Funtua	Katsina	*O. sativa*	Upland
50	2bc	Funtua	Katsina	*O. sativa*	Upland
51	Yar Mamman	Birnin Kebbi/Argungu	Kebbi	*O. glaberrima*	Lowland
52	Yar Kalage	Jega	Kebbi	*O. glaberrima*	Upland

53	Jan Iri Kebbi	Birnin Kebbi/Yauri	Kebbi	*O. glaberrima*	Lowland
54	Bakin Iri Kebbi	Birnin Kebbi	Kebbi	*O. glaberrima*	Lowland
55	Bayawure	Argungu/Bunza	Kebbi	*O. glaberrima*	Lowland
56	Yar China Kebbi	Jega/Yauri	Kebbi	*O. sativa*	Upland
57	Iresi Tsarigi	Kwara	Kwara	*O. sativa*	Upland
58	Sipi Nasarawa	Asakto	Nasarawa	*O. sativa*	Upland
59	Water Proof	Awe	Nasarawa	*O. sativa*	Lowland
60	Biruwa	Doma	Nasarawa	*O. sativa*	Lowland
61	Koro-Koro	Iga/Basa	Nasarawa	*O. glaberrima*	Upland
62	Dantudu	Lapai	Niger	*O. glaberrima*	Upland
63	Sipi-Niger	Tufa	Niger	*O. sativa*	Upland
64	Wati	Suleja	Niger	*O. sativa*	Lowland
65	Jamila-Niger	Egabi	Niger	*O. sativa*	Upland
66	Jamila Plt	Plateau	Plateau	*O. sativa*	Upland
67	Ba Ingila	Rabah	Sokoto	*O. sativa*	Upland
68	Yar Zaiti	Rabah	Sokoto	*O. sativa*	Upland
69	Yar Kabori	Wurno	Sokoto	*O. sativa*	Upland
70	O-Tu	Jalingo	Taraba	*O. sativa*	Lowland
71	Jaton Mini	Yobe	Yobe	*O. glaberrima*	Upland
72	Dan Kaushi	Yobe	Yobe	*O. glaberrima*	Upland
73	Yar Dirya	Kaura	Zamfara	*O. sativa*	Upland
74	L-19 Sub1	AfricaRice	AfricaRice	*O. sativa*	Upland
75	Futia-12	AfricaRice	AfricaRice	*O. sativa*	Upland

Bau- Bauchi; Kd- Kaduna; O- Oryza; Yl- Yola; Plt- Plateau

Phenotyping rice landraces to flash flooding and deep water submergence

Surface loamy soil from the Botanical Garden was used for sowing. Five seeds of each rice landrace were sown in a 1.54 m^2 labeled polythene bags containing 3.5 kg of surface loamy soil (Panda *et al*., 2006). The experiment was laid out in a Randomized Complete Block Design (RCBD) with two replicates (Kawano *et al*., 2002).The seedlings were thinned to three seedlings per bag after germination (Kawano *et al.*, 2009) and watered daily, weeds were controlled by hand weeding in the bags (Akinwale *et al*., 2012). Fertilizer was applied at 50 N, 25 P and 25 K mg/kg of soil before the seeds were planted (Wazed, 2014). Six plastic tanks of 1 x 1 x 1 m dimension and 1000 litres capacity each were set up and utilized for submergence stress. Thirty (30) day- old plants were increasingly submerged to a water depth of Hundred (100) cm (IRRI, 2006; NICRA, 2012) according to International Rice Research Institute protocol for submergence. The seedlings were de-submerged after fourteen (14) days. A non-submerged control treatment was also maintained. Seedling height (cm) was measured with meter rule immediately before submergence.

Physicochemical characteristics of the flood water were monitored using portable Hanna instrument during the experiment. Chlorophyll content (CC) of the de-submerged genotypes were measured after de-submergence using SPAD model- 502 chlorophyll meter by positioning at 2/3 distance from the base of the leaf. Plant height (cm), percentage (%) survival after de-submergence, length (cm) and maximum width (cm) of longest leaf of each hill were measured (IRRI, 2013). Number of tillers per plant (NTPP), Days to Maturity (DTM), number of leaves per plant (NLPP), 100- Seed weight (HSWT) and yield per plant (YLPP) were taken according to IRRI protocol (Wazed, 2014; Duttarganvi *et al*., 2016). Data collected were subjected to Analysis of Variance (ANOVA) using SAS 2007 (version 9.0). Where significant, Least Significant Difference (LSD) was used to separate the significant means.

Similar protocol of flash flooding was observed for deep water submergence. However, de-submerged was effected 30 days after submergence (IRRI, 1997).

Results and Discussion

The landraces were significantly ($p<0.05$) affected by flash flood. The mean percentage variance of the agronomic traits in comparison to the non-submerged genotypes are presented in Table 2. The percentage variance (10.50%) in the number of panicles per plant (NPPP) was highest in Bayawure, percentage variance (30.43%) in number of leaves per plant (NLPP) was highest in Jamila- Niger landrace while percentage variance (15.91%) in number of tillers per plant (NTPP) was highest in Bakin iri-Kebbi. Percentage variance (80%) in stem height elongation (PHEL) was highest in Farar jellof, percentage variance (8.15%) in days to maturity (DTM) was highest in Frajalam, similar trends were observed in leaf length (LFLG) and leaf width (LFWD) where high percentage variances in leaf length ((7.1%)) and leaf width (4.18%) were shown by Tilaki and Doguwar carolea, respectively. Percentage variance in hundred-seed weight (HSWT) was highest in Bakin iri- Borno landrace with 2.8% variance. Furthermore, for yield per plant (YLPP), Fijo showed a variance of 15.72% (Table 2). Percentage variance (4.38%) in chlorophyll content with respect to control after de-submergence (CCAD) was highest in CD1 (Table 2).

Table 2: Percentage variance in traits of submerged and non-submerged rice landraces in response to flash flood

S/N	RICE LANDRACE	NPPP (%)	CCAD (%)	NLPP (%)	NTPP (%)	PHEL (%)	DTM (%)	LFLG (%)	LFWD (%)	HSWT (%)	YLPP (%)
1	JAMILA-YOLA	0.60	0.25	20.52	4.80	13.88	0.21	0.46	0.09	0.22	0.57
2	FARO- YL	0.38	0.33	0.85	1.09	3.50	0.35	0.01	0.07	0.22	1.30
3	BAKIN YAR CHINA	1.38	0.95	2.47	1.38	4.00	0.23	0.44	0.11	0.15	0.31
4	TASAMA	1.25	1.78	4.00	8.00	2.15	0.14	0.06	0.09	0.02	0.58
5	JAMILA-BAUCHI	2.14	0.16	14.76	4.28	0.45	0.06	0.18	0.08	0.02	0.27
6	MAI MADARA	0.00	0.59	1.14	2.23	0.20	0.25	0.01	0.10	0.90	4.00
7	LETE/VIU	0.75	0.10	0.68	2.70	1.32	0.18	0.05	0.07	0.06	1.05
8	MASS/OSI	1.67	0.48	0.97	2.00	5.27	0.04	0.30	0.21	0.02	0.32
9	MIRUWA	1.13	0.90	2.95	2.81	0.38	0.23	0.43	0.19	0.03	1.37
10	SOPPI	2.00	0.96	5.96	2.73	0.28	0.11	0.33	0.24	0.18	0.01
11	CDI	1.13	4.38	0.66	5.33	0.39	0.06	0.14	0.22	0.23	0.38
12	DAN KOYDO	4.56	0.66	8.26	5.78	8.67	0.03	1.80	0.92	1.20	4.00
13	BAKIN IRI – BORNO	7.50	0.89	6.75	1.55	1.32	1.90	6.63	1.55	2.80	1.81
14	JAN IRI – BORNO	0.86	0.13	5.80	8.25	0.41	0.03	0.20	0.24	0.25	0.58
15	JAMILA-GOMBE	0.78	0.80	1.03	2.80	0.56	0.18	0.18	0.07	0.08	1.18
16	CHAINA	2.71	1.97	1.21	1.70	0.48	0.32	0.04	0.73	0.09	0.12
17	CP GOMBE	1.11	0.76	0.76	2.45	0.22	0.25	0.31	0.08	0.40	0.19
18	YAR DAS	3.14	0.90	3.30	4.25	0.73	0.24	0.03	0.32	0.28	1.10
19	JAMILA-JIGAWA	1.43	0.83	11.36	10.25	16.50	0.12	0.23	0.35	0.26	0.16
20	MAI ZABUWA/BIRO	2.09	2.60	5.03	2.78	1.80	0.04	0.09	0.27	0.06	0.88
21	MAI ADDA/KILAKI	1.40	2.74	1.91	3.25	2.45	0.07	0.90	0.00	0.05	0.85
22	JAMILA-ZARIA	1.44	0.92	0.58	0.53	14.00	0.17	0.22	0.30	0.30	0.47
23	MAI ALLURA	1.80	1.90	1.83	6.60	0.35	0.16	0.04	0.52	0.02	0.77
24	YAR NUPAWA	0.57	0.08	0.21	0.33	0.83	0.09	0.68	0.08	0.14	0.65
25	FIJO	1.73	0.65	2.02	7.90	0.34	0.17	0.12	0.11	0.01	15.72
26	YAR DAN HASSAN	2.00	1.76	1.91	1.80	13.00	0.25	0.32	0.30	0.71	5.59
27	FARAR JELLOF	3.92	0.39	2.94	12.41	80.00	0.16	0.39	0.27	0.02	0.54
28	TILAKI	6.00	0.66	2.60	1.50	4.94	1.80	7.10	1.30	1.90	4.50
29	JAMILA-KD	1.17	1.63	5.00	4.86	5.29	0.13	0.18	0.17	0.10	0.14
30	FRAJALAM	5.50	1.80	13.50	11.50	23.00	8.15	3.15	1.80	2.15	4.45
31	DOGUWAR CRLEA	3.21	1.54	21.31	2.13	7.44	0.15	1.45	4.18	0.73	0.58
32	M/ZABUWA GIWA	0.00	2.23	2.69	0.11	1.25	0.17	0.39	0.09	0.18	0.41
33	YAR DASHE	0.20	0.04	0.11	0.45	0.02	1.00	0.30	0.17	0.11	0.24
34	GAJERE CAROLEA	2.00	1.35	1.12	2.40	5.00	0.26	1.01	0.87	0.47	0.80
35	YAR TELAK	3.80	0.65	4.31	3.75	0.26	0.46	0.44	0.27	0.20	0.21
36	YAR BIJINAYE	0.86	1.14	1.10	2.00	0.32	0.19	0.12	0.58	0.02	0.01
37	YAR KURA	0.84	2.43	6.55	2.45	0.66	0.11	0.11	0.53	0.02	0.27
38	DOGUWAR JAMLA	1.33	0.78	1.78	1.51	1.60	0.03	0.15	0.40	0.25	1.83
39	FARAR JANA	2.20	0.39	2.88	1.78	0.21	0.06	0.19	0.33	0.24	0.22
40	JAP	1.20	1.08	3.00	3.50	4.33	0.18	0.11	0.50	0.08	0.93
41	SANTANA	0.25	1.19	1.15	0.69	3.31	0.47	0.09	0.88	0.53	0.04
42	FARAR JA	0.22	0.88	0.91	0.12	0.43	0.27	0.31	0.23	0.39	0.65
43	JAKA	2.00	0.89	4.14	3.29	10.33	0.23	0.14	0.01	0.13	2.29
44	YAR MAAJI	6.00	0.92	3.40	5.14	8.75	1.01	3.56	1.70	2.30	6.35
45	SHATIKA	2.67	1.24	3.39	3.11	0.55	0.54	0.42	0.16	0.08	0.50
46	Y/GIDAN YARIMA	0.25	2.24	1.08	0.00	0.80	0.38	0.07	0.07	0.05	0.26
47	BOLAGA	0.67	0.59	1.62	0.67	3.00	0.31	0.02	0.43	0.46	0.79
48	JAMILA KATSINA	0.88	1.53	0.80	1.50	7.33	0.21	0.01	0.08	0.17	0.54
49	WACOT	3.27	0.19	2.36	2.02	3.12	0.10	0.18	0.04	0.19	0.48
50	2BC	1.80	2.04	2.68	2.86	1.57	0.13	0.23	0.04	0.10	0.29
51	YAR MAMMAN	1.00	0.01	2.05	5.00	2.38	0.76	0.16	0.23	0.19	0.79
52	YAR KALAGE	4.18	0.02	13.60	3.55	38.50	0.63	0.59	0.67	2.64	10.87
53	JAN IRI KEBBI	1.93	2.04	14.19	3.02	1.26	0.03	1.32	0.99	1.05	3.50
54	BAKIN IRI KEBBI	1.77	0.48	16.96	15.91	0.46	0.01	0.66	0.07	1.00	3.50
55	BAYAWURE	10.50	4.19	4.35	1.85	14.00	1.99	5.71	1.50	0.95	4.00
56	YAR CHINA KEBBI	0.75	1.67	1.77	2.30	0.05	0.20	0.12	0.18	0.18	0.07
57	IRESI TSARIGI	1.63	1.46	1.03	3.10	0.96	0.13	0.34	0.03	0.52	1.25
58	SIPI NASARAWA	0.71	0.52	3.00	0.55	0.54	0.44	0.22	0.16	0.09	0.60
59	WATER PROOF	0.71	0.41	1.00	0.43	3.09	0.25	0.07	0.07	0.03	0.47
60	BIRUWA	1.83	0.29	1.73	3.17	0.33	0.08	0.37	0.11	0.80	3.50
61	KORO-KORO	0.08	0.83	0.27	1.00	21.67	0.17	0.41	0.10	0.05	1.17
62	DANTUDU	0.88	0.43	2.85	3.17	0.75	0.38	0.14	0.21	1.00	3.50
63	SIPI-NIGER	0.63	1.06	0.96	1.09	2.33	0.10	0.02	0.15	0.26	0.17
64	WATI	0.67	1.18	3.58	4.20	0.15	0.05	0.07	0.06	0.09	0.51
65	JAMILA-NIGER	0.79	2.35	30.43	11.50	1.89	0.02	0.68	0.53	0.35	0.45
66	JAMILA PLT	0.42	0.38	1.90	3.13	0.26	0.45	1.74	0.06	0.75	3.63
67	BA INGILA	0.13	0.45	0.78	0.14	0.48	1.00	0.78	0.50	0.13	0.43
68	YAR ZAITI	1.13	0.49	2.20	3.20	3.30	0.11	0.46	0.19	0.80	0.60
69	YAR KABORI	1.25	0.50	4.00	3.83	9.00	0.42	0.49	0.14	0.52	1.00
70	O-TU	0.92	0.43	1.17	3.43	0.38	0.07	0.08	0.04	2.50	4.45
71	JATON MINI	2.86	0.66	13.24	4.30	0.77	0.39	0.32	0.19	2.00	4.45
72	DAN KAUSHI	0.51	0.48	8.09	0.15	0.44	1.00	0.13	0.12	0.07	0.02
73	YAR DIRYA	1.25	2.02	2.00	1.45	2.87	0.04	0.28	0.24	0.02	0.27
74	L-19 SUB1	0.10	0.12	1.37	1.50	0.37	0.06	0.29	0.31	0.02	0.23
75	FUTIA-12	1.14	0.82	1.63	1.78	2.83	0.12	0.24	0.82	0.14	0.31
Mean		1.78	1.06	4.42	3.33	5.01	0.03	0.51	0.33	0.38	1.42
S. D		0.21	0.10	0.65	0.35	1.25	0.12	0.16	0.07	0.08	0.30
LSD(0.05)		0.369	1.570	4.071	0.396	3.400	5.790	2.801	0.080	0.100	0.640

NPPP- Number of Panicles/Plant, CCAD- Chlorophyll Content after De-submergence, NLPP- Number of Leaves/Plant, NTPP -Number of Tillers/Plant, PHEL- Plant Height Elongation, S.D- Standard deviation, DTM- Days to Maturity, LFLG- Leaf Length, LFWD- Leaf Width, HSWT- Hundred-Seed Weight, YLPP- Yield/Plant, LSD- Least Significant Difference

The landraces were significantly ($p<0.05$) affected by deep water submergence. The number of rice landraces that survived after deep water submergence were 38 with stem height elongation (PHEL) ranging from 3.00 to 71.50 cm. Highest elongation (71.50 cm) was recorded in Yar mamman and Bayawure landraces (Table 3). Highest number of leaves per plant (NLPP) was obtained in Jan iri-Kebbi with 35 leaves (Table 3). Bakin iri-Borno and Jaton mini with 4 tillers/plant had the best tillering ability (Table 3). The observed reduction in number of panicles, number of leaves, number of tillers, stem height, days to maturity, leaf length, leaf widthand chlorophyll content could be as a result of reduction in metabolism and growth of the rice landraces during submergence which affected their physiological processes leading to poor development of morphological parameters. Reduction of panicle number observed in this study could be as a result of reduction in the number of tillers of the rice landraces and also the inherent genetic makeup of the rice landraces for tolerance or susceptibility to flooding. Reduction in paniclenumber of rice due to submergence was reported by several workers (NICRA, 2012; Vergara *et al*., 2014; Aliyu *et al*., 2015).

The mean reduction in the number of leaves, leaf length, leaf width and number of tillers could be attributed to the reduction in metabolism of the rice landraces. The reduction in number of leaves could be as a result of leaf senescence during submergence. Reduction in leaf length and width under submergence could be due to death or decay of living tissues which also reduced the supply of additional carbohydrates through concurrent under-water photosynthesis and is in agreement with the findings of Brathkumar *et al*. (2015) and Aliyu *et al*. (2015) who reported that there was reduction in all morphological parameters of rice genotypes subjected to 14 days of submergence compared to the non-submerged genotypes in their studies. Reduction in tiller number could be responsible for the decrease in yield as a result of reduced number of panicles. Elanchezian *et al*. (2013) and Vergara *et al*. (2014) reported a reduction in tiller number in rice cultivars subjected to 14 days of complete submergence and consequently reduction in grain yield. Phenotypic plasticity in number of tillers was also reported by Bharathkumar *et al*. (2015). Minimum of 15 days delay to maturity observed in submerged landraces could be attributed to the effect of the submergence on the flowering of the landraces as compared to the non-submerged control and is in concomitance with the report that there was significant shift to maturity date due to submergence in susceptible rice genotypes (NICRA, 2012). The study is also in consonance with the findings of Elanchezian *et al*. (2013) who proposed that variation of 2 to 12 days to flowering and maturity was dependent on the genotypic background of the rice cultivars.

Low 100-seed weight observed in this study was due to improper grain filling and uneven filling, therefore, at harvest the grains showed different maturity stages thus lowered seed weight. The low yield of the rice landraces observed was indicative of the varied responses of rice to submergence stress and could be attributed to the reduction in the physiological processes, morphological traits and the influence of the Sub1 gene conferring tolerance in the tolerant genotypes. Reduction in grain yield under submergence conditions could therefore be attributed to the degree of injury experienced by each genotype, depending on the level of tolerance.

The higher the submergence tolerance of rice, the higher the yield. Nugraha *et al*. (2013) reported a difference of 4 fold between rice lines carrying submergence tolerance gene (Sub1) compared to the non-sub1 rice lines. However, Ray *et al*. (2016) reported a reduction in yield and yield attributes of both Sub1 and non-sub1 rice cultivars completely submerged at different reproductive stages. Elanchezian *et al*. (2013) reported that despite submergence stress condition, there is a yield advantage of about 2 tons/ha of the submergence tolerant rice varieties and they attributed it to the alternation of growth and yield attributes.

Table 3: Variation in morphological traits of rice landraces subjected to DW submergence

S/N	Rice Landrace	PHEL (cm)	CCAD	NLPP	NTPP
1	Tasama	4.25^{b}	23.98^{ab}	10.23^{c-i}	2.25^{ab}
2	Lete/VIU	25.00^{ab}	30.48^{ab}	13.02^{c-i}	2.50^{ab}
3	Mass/Osi	0.75^{b}	19.25^{ab}	6.98^{g-i}	1.75^{b}
4	Miruwa	15.75^{ab}	19.95^{ab}	17.73^{a-d}	2.75^{ab}
5	Dan Koydo	37.25^{ab}	20.08^{ab}	17.52^{a-e}	3.25^{ab}
6	Bakin Iri – Borno	68.25^{a}	42.63^{a}	20.25^{a-g}	4.25^{a}
7	Jan Iri – Borno	47.25^{ab}	15.10^{b}	13.27^{c-i}	3.00^{ab}
8	Chaina	3.00^{b}	16.75^{ab}	6.02^{i}	1.50^{b}
9	Yar Das	27.00^{ab}	28.68^{ab}	15.27^{a-g}	2.50^{ab}
10	Jamila-Jigawa	2.25^{b}	18.05^{ab}	11.23^{c-i}	2.50^{ab}
11	Yar Das	34.75^{ab}	30.88^{ab}	15.27^{a-g}	3.50^{ab}
12	Mai Adda/Kilaki	62.00^{a}	35.25^{ab}	10.52^{d-i}	2.25^{ab}
13	Jamila-Zaria	26.50^{ab}	17.93^{ab}	7.77^{f-i}	2.00^{ab}
14	Mai Allura	6.00^{b}	23.38^{ab}	9.48^{d-i}	1.75^{b}
15	Yar Nupawa	19.00^{ab}	27.25^{ab}	14.77^{c-i}	2.25^{ab}
16	Tilaki	31.50^{ab}	23.00^{ab}	18.02^{a-f}	3.25^{ab}
17	Jamila-KD	3.00^{b}	15.35^{b}	13.73^{b-i}	3.25^{ab}
18	Doguwar Carolea	68.25^{a}	24.43^{ab}	14.77^{c-i}	2.50^{ab}
19	Gajere Carolea	19.25^{ab}	22.88^{ab}	14.73^{a-g}	2.25^{ab}
20	Yar Bijiinaye	22.75^{ab}	27.25^{ab}	8.27^{f-i}	1.75^{b}
21	Santana (Yar Ruwa)	31.50^{ab}	23.28^{ab}	14.23^{b-i}	3.00^{ab}
22	Farar JA	63.00^{a}	34.03^{ab}	11.20^{d-i}	2.50^{ab}
23	Jaka	28.25^{ab}	25.75^{ab}	10.02^{d-i}	1.75^{b}
24	2BC	20.25^{ab}	23.25^{ab}	15.23^{a-g}	2.50^{ab}
25	Yar Mamman	71.50^{a}	40.68^{a}	24.25^{a-d}	3.75^{ab}
26	Yar Kalage	56.50^{ab}	26.25^{ab}	14.98^{a-g}	2.75^{ab}
27	Jan Iri Kebbi	45.00^{ab}	29.26^{ab}	35.27^{a}	3.75^{ab}
28	Bayawure	71.50^{a}	35.48^{ab}	17.75^{c-i}	3.00^{ab}
29	Iresi Tsarigi	33.00^{ab}	22.45^{ab}	15.48^{a-g}	3.25^{ab}
30	Sipi Nasarawa	6.75^{b}	16.95^{ab}	13.02^{c-i}	2.25^{ab}
31	Water Proof	30.25^{ab}	27.35^{ab}	11.98^{c-i}	2.25^{ab}
32	Koro-Koro	29.00^{ab}	18.75^{ab}	11.02^{c-i}	2.00^{ab}
33	Dantudu	57.50^{ab}	20.65^{ab}	7.50^{hi}	3.75^{ab}
34	Jamila Plt	35.25^{ab}	28.00^{ab}	19.02^{b-i}	2.75^{ab}
35	Yar Zaiti	31.75^{ab}	27.35^{ab}	15.27^{b-i}	3.25^{ab}
36	Jaton Mini	70.00^{a}	17.43^{ab}	29.00^{ab}	4.25^{a}
37	Yar Dirya	5.50^{b}	19.63^{ab}	9.98^{d-i}	1.75^{b}
38	L-19 Sub1	64.75^{a}	37.50^{ab}	19.00^{a-g}	3.75^{ab}
	S. E. M	0.13	0.07	0.05	0.02
	P value	<0.0001	<0.0001	<0.0001	<0.0001

Means with the same superscript along columns are not significantly different at $p\leq 0.05$

PHEL- Stem Height Elongation, CCAD- Chlorophyll Content after De-submergence, NLPP-Number of Leaves per Plant, NTPP- Number of Tillers per Plant, DW- Deep-water, S. D- Standard deviation

Table 4: Yield and yield- related traits of rice landraces subjected to DW submergence

S/N	Rice Landrace	DTM	HSWT (g)	YLPP (kg/ha)
1	Mass/Osi	139.00 [cd]	1.30[cd]	17.21[cd]
2	Jan Iri – Borno	181.50[ab]	0.63[f]	8.78[fg]
3	Yar Das	118.00[d]	1.40 [c]	11.36[defg]
4	Jamila-Jigawa	149.25[bcd]	1.75[b]	25.94[b]
5	Mai Zabuwa/Biro Zar	126.50 [d]	0.00[g]	0.00[g]
6	Mai Adda/Kilaki	181.50 [ab]	0.00[g]	0.00[g]
7	Yar Nupawa	171.50[abc]	0.00[g]	0.00[g]
8	Tilaki	182.00 [ab]	1.40[c]	13.31[edf]
9	Doguwar Carolea	184.00 [ab]	0.95[e]	6.82[fg]
10	Farar JA	123.25 [d]	1.98 [b]	14.81[ed]
11	Jan Iri Kebbi	192.00[a]	1.10[ed]	10.71[fg]
12	Bayawure	181.50 [ab]	1.05[ed]	13.96[edf]
13	Sipi Nasarawa	135.25 [cd]	0.00[g]	0.00[g]
14	Dantudu	132.00 [d]	1.10[ed]	16.75[cd]
15	Jamila Plt	141.50 [cd]	2.60[a]	22.08[b]
16	Jaton Mini	145.50[bcd]	1.45 [c]	5.84[fg]
17	L-19 Sub1	131.00 [d]	2.45[a]	34.74[a]
	S. E	11.81	0.09	0.28

Means with the same superscript along columns are not significantly different ($p \leq 0.05$)
DTM- Days to Maturity, HSWT- Hundred-Seed Weight, YLPP- Yield per Hectare, DW- Deep-water, S. E. – Standard Error

Days to maturity of rice landraces submerged in deep water are presented in Table 4. The result indicated that only seventeen (17) rice landraces flowered out of the thirty eight landraces that survived deep water submergence. Yar-das landrace had the least days to maturity (118 days in submerged treatment and 85 days in non-submerged control). Hundred-Seed weight (HSWT) and Yield per Plant (YLPP) of rice landraces submerged in deep water are presented in table 4. The result indicated that thirteen (13) rice landraces produced seeds out of the seventeen (17) that flowered. 33% of *Oryza glabberima* and 12% of *Oryza sativa* produced seeds. Jamila-Plt showed the highest Hundred-Seed Weight of 2.60 g in submerged treatment and 2.8 g in non-submerged control. However, L-19 Sub1 variety showed Hundred-Seed Weight of 2.45 g and 2.5 g in submerged and non-submerged treatments respectively. The tolerant variety L-19 Sub1 had the highest yield per plant of 34.74 kg/ha in submerged treatment but a yield of 51.95 kg/ha in the non-submerged control (Table 4).
Stem elongation has been reported in deep-water rice cultivar completely submerged when water depth increase daily was more than 10 cm. The observed reduction in morphological traits such as number of leaves and number of tillers in this study could be due to the fast depletion of energy for utilization in elongation growth. Delays in days to maturity of rice landraces subjected to deep water submergence in this study could be attributed to increase in carbohydrate depletion as a result of elongation growth during submergence and consequently low amount of energy for reproductive growth leading to delay in flowering and maturity of the rice plants. The low yield and grain weight could be attributed to reduced grain filling and panicle infertility leading to improper or even failure of grain development. Kamoshita and Ouk (2015) reported 79% and 81% yield reduction of rice in deep-water areas. Mahapatra (2017) reported variation in submergence tolerance of some local varieties in Orissa, India. He studied morpho-physiological, yield and yield-attributing traits of submerged rice landraces and opined that local landraces adapted to extreme in water availability could be a source of new gene(s). The new genes could be used to improve adaptability and guide breeding of rice to submergence with high yield.

Conclusion
A significant ($p< 0.05$) variation in all agronomic traits evaluated was obtained. Submergence tolerant landraces had the highest yield. The highest yielding landraces were Fijo (15.72 kg/ha) under flash floodand Jamila-Plt (22.08 kg/ha) under deep water submergence.

Conflict of Interest
Authors have declared that there is no conflict of interest reported in this work

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