International Journal of Agriculture Innovations and Research
Volume 7, Issue 4, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy):
Received: 18/12/2018 | Accepted on: 27/12/2018 | Published: 16/01/2019

Screening Lowland Rice Genotypes for Ratooning Performance in the Associated Mangrove Swamp of Sierra Leone

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Abstract – **Doubling harvesting systems in rice ratooning may be one practical way to increase productivity per unit land. A study to evaluate 30 lowland rice varieties with good ratooning performance of main crop and relationship of traits with grain yield was conducted at the Mawirr crop site of the Rokupr Agricultural Research Centre. Data collected were subjected to analysis of variance for each of main and ratoon crops. Significant treatment means were separated and compared using Duncan's multiple range test at 5% probability level. Pearson's correlation coefficient was also performed for each of the main and ratoon crops to deter--mine traits association with grain yield. Results revealed significant differences among the 30 rice varieties for both the main and ratoon crops for the traits evaluated. The main crop recorded highest number of hills harvested, number of tillers per hill, plant height, and effective tillers per hill and grain yield than the ratoon crop. NERICA-L-21 produced the highest grain yield, longest days to 50% flowering and maturity of main crop and demonstrated good ratoon performance while Hitomebore had the least grain yield, shortest days to 50% flowering and maturity of main crop and exhibited very poor ratoon performance. Correlation studies revealed that genotypes with taller plant height, late flowering and maturity and with large culm diameter would effectively and ultimately increase grain yield in main crop. Grain yield in ratoon crop is a complement of the main crop, improvement of any trait in the ratoon crop would simultaneously translate into an improvement in the others thereby increasing total grain yield.**

Keywords – **Ratooning Performance, Rice Variety, Grain Yield, Analysis of Variance.**

I. Introduction

Rice (*Oryza sativa* L.) is the main staple food of the vast majority of Sierra Leoneans. It is eaten on a daily basis by almost every household in the country [1]. Rice is grown mainly by small scale farmers on both the upland and diverse lowland ecologies including inland valley swamp, mangrove swamp, boliland and riverine grassland [2]. Seventy-four percent of the land area of the country, covering 5.4 million hectares, is suitable for cultivation. This area comprises 4.3 million hectares of upland and 1.1 million of lowland. Over 90% of the lowland area is arable and suited to rice cultivation. Current total rice production in the country is estimated to be 756, 000 metric tons [3] in an area of 504,000ha. Yields are still very low, estimated at nearly 2 metric tons over the past 10 years with 104 kg per person [4] local consumption demand of rice. However, the total production in the country does not meet the local consumption demand which results in the country importing nearly 40% of the national staple food, rice.

In rainfed lowland ecologies such as inland valley swamps, mangrove swamps, bolilands and riverine grasslands, only one crop per year is generally grown. The moisture left in the field at the end of the wet season is often adequate for a second, short duration crop, especially if the first crop is early maturing and the rainy season lasts about six months. Soil moisture may not be enough to permit high returns on investment in fertilizers and pesticides for another crop. Thus, ratoon crop stands advantageous in this regard with about 50-60% less labour and the crop matures with about 60% less water than the main rice crop [5].

Ratooning is the practice of obtaining a second harvest from tillers originating from the stubble of the previously harvested crop (main-crop) [6]. It requires low input and has potential to increase rice production in the lowland ecologies without expanding land. This improves the resilience of farmers to climate change [7], enables farmers to produce more rice in a limited area, using limited water and at low cost, thereby increasing farmers' incomes and improving their livelihoods.

Ratoon grain yield is nonetheless affected by some factors such as main plant harvesting time, climatic condition, water and fertilizer management in the ratoon [8]; height of crop, leaf area, leaf canopy, which are affected by genetic factor of the plant [9]-[11]; temperature at ratoon reproductive stage, cutting plant crop height and growth regulators [12].

Reference [13] reported that low yields of the ratoon crops are due to improper land cultivation, low quality of the soil, difficulty in controlling weeds, lack of water availability, low potential ratoon cropping, competition among shoots and disturbance. As a result of these, research showed that yields of ratoon cropping decreased by 25.1 6% [14], however, other research showed that the reduction reached 42 - 61% from the first crops [15]. Reference [16] and [17] further suggested that water is the basic requirement for plants to grow, develop, and produce better yields, which requires 1300-1900 mm during land preparation until planting time and starting the filling phase to spikelet filling.

It has been opined that plant crop should be harvested immediately when matured grains are at maximum and their stems are physiologically alive. Reference [8] conducted a field experiment to investigate the effect of harvesting time and main plant residual on grain yield and yield components of rice. His results showed that plant

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height, total tillers, fertile tillers, filled spikelet percentage, and ratoon grain yield were decreased with delaying harvesting time.

Reference [18] reported that the rice crop which was ratooned of 0-5 cm in height resulted the highest yield (2.95 t/ha), decreased of 49% from the first crop. The cutting height of 10-15 cm by considering the pests and diseases, as well as the death rate of the ratoon rice and interval without flooding for 2 days related to water efficient use as the recommended treatment for ratoon rice cropping.

The addition of N to the ratoon crop can delay the maturity of the ratooned rice, which typically requires 90 days of frost-free weather; and the later the main crop is harvested, the less N should be applied [19] and [20].

Another important aspect is stubble management. Research from Texas has shown that reducing stubble height will generally result in higher ratoon rice yields, but it also requires a longer growing period in order to produce a ratoon crop [20]. Reference [21] reported that stubble height was quantified following main crop harvest and there was no significant influence of main crop N rate on stubble height, with cultivar being the only significant factor influencing main crop stubble height.

Rice yield is a complex quantitative trait that is determined by combined effect of various yield determination factors. Correlation is a useful tool for selection of rice lines in breeding programs [22] and explains the relative contribution of different traits on yield determination [23]. It quantifies the degree of association between a response variable and a predictor variable [24]. The existence of correlation is attributed to the presence of genetic effect of genes or environmental effect or in combination of all factors [11]. Utilizing these relationships effectively is critical in rice breeding [25]. Significant association between yield and other traits should be considered to determine a selection criterion for rice [26]. Different morphological traits act differently on rice production [27], [28].

There is the need to increase production and productivity of rice in the rainfed lowland ecologies. However, to our knowledge, based on literature research, no information exists on rice ratooning in Sierra Leone. Doubling harvesting systems in rice ratooning may be one practical way to increase productivity per unit land, particularly on rainfed lowland agro-ecologies in Sierra Leone. This work aimed at identifying high yielding rice varieties with good ratooning ability with a view of enhancing productivity, income and improving the livelihoods of smallholder rice farmers.

II. Materials and Methods

Description of Experimental Site

The experiment was conducted at the Mawirr crop site of the Rokupr Agricultural Research Centre (RARC), Rokupr (8° 40'N and 12° 23'W) at an altitude of 80m above sea level during 2016 wet cropping season. Rokupr is in the Magbema Chiefdom, Kambia District, Northern Province of Sierra Leone. Rokupr had an average rainfall of 0.6mm and temperature of 33^{oc} during the time of experimentation. The crop was grown on an associated mangrove swamp soil with a characteristic of Entisols poorly drained swamps or lagoons that are waterlogged throughout the year.

Experimental materials, Trial design, Crop Management practices and Data collection

Trial consisted of thirty diverse lowland rice varieties including one check obtained from the Crop Improvement Program and Farm Management Unit (Table 1).

Table 1. List of rice varieties and seed source

Entry number	Variety	Source	
1	ARICA 6	CIP	
2	ARICA 9	CIP	
3	CCA	CIP	
4	CK 90-1	CIP	
5	Hitomebore	FMU	
6	NERICA-L-4	CIP	
7	NERICA-L-8	CIP	
8	NERICA-L-16	CIP	
9	NERICA-L-19	CIP	
10	NERICA-L-20	CIP	
11	NERICA-L-21	CIP	
12	NERICA-L-29	CIP	
13	NERICA-L-32	CIP	
14	NERICA-L-34	CIP	
15	NERICA-L-36	CIP	
16	NERICA-L-38	CIP	
17	NERICA-L-43	CIP	
18	NERICA-L-45	CIP	
19	NERICA-L-48	CIP	
20	NERICA-L-49	CIP	
21	NERICA-L-50	CIP	
22	NERICA-L-53	CIP	
23	NERICA-L-60	CIP	
24	OM3242	CIP	
25	ROK 11	CIP	
26	ROK 14	CIP	
27	ROK24	CIP	
28	ROK 30	CIP	
29	ROK34 (Check)	CIP	
30	TGR 19	CIP	

The land was brushed manually and debris was cleared. The land was plough and puddle using a power tiller machine. Long handle native hoes were then used to level the plot in order to facilitate uniform distribution of water.

Seedlings were raised on 1m x 7m dry seed beds prepared on the upland. The rice varieties were sown on drilled rows 20cm apart using short handle drilling hoes. The seeds were covered with soil to prevent damage by birds and rodents. Each variety was sown in five rows, leaving a space of 40 cm between plots to avoid mixtures.

Twenty-one-day old seedlings were transplanted in five rows per plot in 1m x 5m plots at 1 seedling per hill, spaced 20cm within and between rows and 40 cm between plots. Trial was laid out in randomize complete block design with three replications.

NPK 15:15:15 fertilizers were applied at the rate of 67.5 kgha^{-1} at transplanting. This was followed by the application of 55.2 kgha^{-1} N in the form of urea in two

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equal splits at 21 days and 42 days after transplanting for the main crop, while 23 kgha-1 N in the form of urea was used for the ratoon crop at 15 days after harvesting. Hand weeding was done prior to fertilizer application at 21 days and 42 days after transplanting and 15 days after harvesting of main crop.

At physiological maturity, the rice crop in each plot was harvested separately, cutting the tillers at the height of 15 cm above ground level by using a harvesting knife. The following data were collected according to the standard evaluation system for rice [29]:

Tiller Number per Plant:

Average number of tillers per plant was counted and recorded on five individual plants.

Panicle Number per Plant:

Average number of tillers per plant bearing panicles was counted and recorded on five plants.

Days to 50% Heading:

Observation was made on plot basis on the time when 50% of the plants produced heading.

Days to Maturity:

Observation was recorded on plot basis from seeding to the time when 85% of grains on panicle became mature and ripe.

Plant Height:

Average height of five plants on plot basis measured from the soil surface to the tip of the tallest panicle.

Culm Diameter:

The diameter of culm of five plants was measured on plot basis using Vernier caliper.

Grain Yield:

The dried grains obtained from each plot were weighed and moisture content recorded. The grain weight was then adjusted to 14% according to the following formula:

$$\text{Adjusted grain weight} = \frac{\text{Grain weight x (100 – Moisture content)}}{(100 - 14)}$$

Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) for each of main and ratoon crops to determine the effects of varieties for the different traits recorded. Significant treatment means were separated and compared using Duncan's multiple range test (DMRT) at 5% probability level. Pearson's correlation coefficient was also performed for each of the main and ratoon crops to determine traits association with grain yield. The Statistical Tool for Agricultural Research (STAR, 2014), version 2.0.1 was used for the analyses.

III. Results

Analysis of Variance of Traits of Main and Ratoon Crops

Table 2 shows the analysis of variance showing means squares of traits of main crop of 30 rice varieties. Result showed significant (p<0.01) differences among the 30 rice varieties for number of hills, harvested number of tillers per hill, plant height, days to 50% flowering, days to maturity, culm diameter, effective tillers per hill and grain yield.

The analysis of variance showing mean squares of traits of ratoon crop of 30 rice varieties is presented in Table 3. Results revealed that the 30 rice varieties showed signifi--cant (p<0.01) differences for number of hills harvested, tiller numbers per hill, plan.t height, panicle number per hill and grain yield.

Means of traits of Main and Ratoon Crops

Table 4 shows the means of traits of main crop of 30 rice varieties. Results showed that ARICA 9 recorded the highest number of hills harvested while NERICA-L-38 recorded the lowest number of hills harvested. ARICA 6, CK 90 - 1, OM 3242, ROK 11, ROK 30 ; CCA, NERICA - L - 16, NERICA - L - 20, NERICA - L - 43, TGR 19; HITOMEBORE, NERICA - L - 19, NERICA - L - 21, NERICA - L - 29, NERICA - L - 36, NERICA - L - 45, NERICA - L - 50, ROK 14, ROK 24; NERICA-L-32; NERICA - L - 34, NERICA - L - 8; NERICA - L - 4, NERICA - L - 48, ROK 34; produced significantly similar number of hills harvested.

Table 2. Analysis of variance showing mean squares of traits of main crop of 30 rice varieties

Source	DF	Number of hills harvested	Number of tillers per hill	Plant height (cm)	Days to 50% flowering	Days to maturity	Culm diameter	Effective tiller per hill	Grain yield
Rep	2	10.53ns	10.87**	461.78**	12.13ns	3.74ns	0.03**	2.49ns	421800.21ns
Variety	29	245.67**	8.05**	1404.77**	149.87**	132.96**	0.01**	4.54**	950079.67**
Error	58	47.12	2.22	42.87	4.58	6.99	0.00	1.46	224041.99
Total	89								
Mean		116.53	7.84	111.95	100.43	130.29	0.41	5.86	2161.29
CV (%)		5.89	18.99	5.85	2.13	2.03	12.13	20.62	21.90

**= significant at probability level of 0.01; ns = non-significant

Table 3. Analysis of variance showing mean squares of traits of ratoon crop of 30 rice varieties.

Source	DF	Number of hills harvested	Tiller number/hill	Plant height (cm)	Panicle number/hill	Grain yield (kg/ha)
Rep	2	264.04ns	74.90**	773.88**	43.62**	893.48ns
Variety	29	1779.04**	17.44**	410.88**	11.34**	95987.69**
Error	58	510.87	6.15	39.48	4.30	501.14
Total	89					
Mean		59.94	7.14	59.49	5.77	281.44
CV (%)		37.71	34.76	10.56	35.97	7.95

**= significant at probability level of 0.01; ns = non-significant.

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In the number of tillers per hill, Hitomebore showed the highest while OM 3242 indicated the lowest number of tillers per hill. ARICA 6, CK 90 - 1, NERICA-L-20, NERICA-L-48, NERICA-L-60, ROK 11, ROK 24, ROK 30; ARICA 9, NERICA-L-32, NERICA-L-49; NERICA-L-16, NERICA-L-45, NERICA-L-53, NERICA-L-8; NERICA-L-21, NERICA-L-43; NERICA-L-38, NERICA-L-4; ROK 34, TGR 19; produced significantly similar number of hills harvested.

With plant height, CK 90-1 revealed the highest plant height while Hitomebore recorded the lowest plant height, ARICA 6, NERICA-L-32, NERICA-L-38, NERICA-L-43, NERICA-L-45, NERICA-L-48; NERICA-L-16, NERICA-L-60; NERICA-L-4, NERICA-L-53; NERICA-L-49, NERICA-L-50; OM 3242, ROK 34; ROK 11, ROK 24; showed significantly similar plant height.

NERICA-L-21 and ROK 24 showed longer duration to 50 % flowering while Hitomebore showed earliness than all the other varieties to 50 % flowering. ARICA 9, NERICA-L-20, NERICA-L-49, CK 90 - 1, ROK 30; NERICA-L-19, NERICA-L-38; NERICA-L-29, NERICA-L-32, NERICA-L-43, NERICA-L-48; NERICA-L-29, NERICA-L-32, NERICA-L-43, NERICA-L-48, NERICA-L-50; NERICA-L-4, NERICA-L-45, OM 3242; NERICA-L-53, NERICA-L-8; ROK 11, ROK 14; had significantly similar days to 50% flowering.

With number of days to maturity, NERICA-L-21 and CK 90-1 showed late duration to maturity while Hitomebore matured very early. ARICA6, NERICA-L-38, NERICA-L-49; ARICA 9, NERICA-L-20, NERICA-L-29, NERICA-L-32, NERICAL-L-50; NERICA-L-16, NERICA-L-19, NERICA-L-4, NERICA-L-45, NERICA-L-53; NERICA-L-43, OM 3242; showed significant similar days to maturity.

Result also revealed that, ROK 24 showed bigger culm diameter while Hitomebore indicated smallest culm diameter. ARICA 6, NERICA-L-16, NERICA-L-19, NERICA-L-20, NERICA-L-21, NERICA-L-38, NERICA-L-4, NERICA-L-43, NERICA-L-60, ROK 11, ROK 34 and TGR 19; ARICA 9, NERICA-L-48; CCA, NERICA-L-32 and ROK 14; NERICA-L-53 and ROK 30; NERICA-L-34 and ROK 34 revealed significant similar culm diameter.

Effective tillers per hill were recorded highest in Hitomebore and lowest in NERICA-L-19. ARICA 6, CK 90-1, NERICA-L-16, NERICA-L-20, NERICA-L-38, NERICA-L-4, ROK 11, ROK 24, and ROK 30; ARICA 9 and NERICA-L-48; CCA and NERICA-L-29; NERICA-L-20, NERICA-L-49, NERICA-L-49, NERICA-L-49, NERICA-L-53 and NERICA-L-8; NERICA-L-43 and NERICA-L-45; NERICA-L-50 and ROK 34; OM3242 and TGR 19 indicated significant similar effective tillers per hill.

Results further revealed that NERICA-L-21 showed the highest yield while Hitomebore showed the lowest yield. ARICA 6, ARICA 9, NERICA-L-16, NERICA-L-19, NERICA-L-29, NERICA-L-38, NERICA-L-4, NERICA-L-45, ROK 11 and ROK 14; NERICA-L-20, NERICA-L-45 and NERICA-L-53; NERICA-L-36, NERICA-L-48 and NERICA-L-49 produced significantly similar grain yield.

Table 5 shows the means of traits of ratoon crops of 30 rice varieties. Results revealed that, the highest number of hills was harvested from Hitomebore while the lowest number of hills was harvested from ROK 11, ARICA 6 and NERICA-l-29; ARICA 9, CK 90-1, NERICA-L-4, ROK 11, and TGR 19; NERICA-L-21, NERICA-L-36, NERICA-L-45 and NERICA-l-8; NERICA-l-38 and NERICA-L-50; NERICA-L-43 and OM3242; NERICA-L-48 and NERICA-L-60 showed significantly similar number of hills harvested.

The highest number of tillers per hill was recognized in ROK 43 and the least number of tillers was observed in ARICA 6. ARICA 9, NERICA-L-60, OM3242, ROK 11 and ROK 14; CCA and NERICA-L-53; CK 90-1, NERICA-L-16, NERICA-L-29, NERICA-L-, NERICA-L-34, NERICA-L-38 and NERICA-L-48; Hitomebore, NERICA-L-19 and ROK 30; NERICA-L-50 and TGR 19 revealed significantly similar number of tillers per hill.

Results of plant height showed that, NERICA-L-50 had the highest plant height and the shortest in the ratoon was observed in NERICA-L-60. CCA and NERICA-L-19; CK 90-1, NERICA-L-21, NERICA-L-50, ROK 30 and ROK 34; Hitomebore, NERICA-L-34 and ROK 14; NERICA-L-16; NERICA-L-43; NERICA-L-21, NERICA-L-50, ROK 30 and ROK 34; NERICA-L-32, NERICA-L-36 and NERICA-L-4 indicated significant similar number of plant height.

In the number of panicles per hill, ROK 34 showed the highest number of panicles per hill while ARICA 9, NERICA-L-4, and ROK 11 recorded the least number of panicles per hill. ARICA 6, NERICA-L-32, NERICA-L-4, OM3242, ROK 14; ARICA 9, NERICA-L-43, ROK 11; CCA, Hitomebore, NERICA-L-16, NERICA-L-19, NERICA-L-34, NERICA-L-38, NERICA-L-48, NERICA-L-53 and ROK 30; CK 90-1, NERICA-L-36, NERICA-L-49, NERICA-L-50, NERICA-L-60 and TGR 19; NERICA-L-20 and ROK 24; NERICA-L-21 and NERICA-L-45 all showed significantly similar number of panicles per hill.

In addition, the highest grain yield was observed in ROK 24 and least yield was revealed in ROK 14. ARICA 6, ARICA 9, Hitomebore, NERICA-L-34, NERICA-L-36, NERICA-L-4, NERICA-L-48, NERICA-L-60, OM3242 and ROK 30; CK 90-1, NERICA-L-29, NERICA-L-38; NERICA-L-19 and NERICA-L-50; NERICA-L-20, NERICA-L-53 and TGR 19; NERICA-L-32, NERICA-L-43, NERICA-L-49, ROK 11 and ROK 11 produced significantly similar grain yield.

Table 4. Means of traits of main crop of 30 rice varieties.

Variety	Number of hills harvested	Number of tillers per hill	Plant height (cm)	Days to 50% flowering (days)	Days to maturity (days)	Culm diameter	Effective tiller per hill	Grain yield (kg/ha)
ARICA 6	122.67 ab	7.20 e-i	107.73 h-k	102.00 cd	131.67 d-g	0.45 a-f	4.87 e-i	2268 d-i
ARICA 9	129.00 a	8.60 b-f	108.80 g-k	98.33 e-h	128.33 g-j	0.40 c-g	5.67 d-i	2128 d-i

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CCA	121.00 a-c	8.53 b-g	121.07 e-g	91.67 j	123.33 l	0.37 f-h	6.67 b-f	2721 a-e
CK 90-1	122.33 ab	6.73 e-i	161.33 a	111.0 a	141.0 a	0.49 a-d	4.87 e-i	3159 ab
Hitomebore	118.67 a-d	12.60 a	60.87 n	74.67 k	104.67 m	0.21 i	9.27 a	732.7 k
NERICA-L-16	121.33 a-c	8.00 c-g	100.20 j-l	101.33 de	131.33 e-h	0.41 a-f	5.53 e-i	2163 d-i
NERICA-L-19	118.33 a-d	5.40 hi	124.80 d-f	101.67 c-e	131.33 e-h	0.41 a-f	3.87 i	2267 d-i
NERICA-L-20	121.00 a-c	7.20 e-i	110.47 g-j	98.33 e-h	128.33 g-j	0.45 a-f	5.20 e-i	1814.0 f-j
NERICA-L-21	118.33 a-d	7.80 c-h	115.13 f-i	112.0 a	141.667 a	0.42 a-f	6.27 b-g	3279 a
NERICA-L-29	119.67 a-d	9.13 b-e	115.33 f-h	99.67 d-g	129.33 g-j	0.41 b-f	6.67 b-f	2201 d-i
NERICA-L-32	109.67 de	8.93 b-f	106.07 h-k	99.33 d-g	129.33 g-j	0.36 f-h	6.80 b-e	1570 ij
NERICA-L-34	104.67 ef	10.13 a-c	72.33 n	95.00 h-j	126.00 i-l	0.27 hi	7.87 a-c	1256 jk
NERICA-L-36	119.67 a-d	11.00 ab	84.67 m	94.00 ij	124.00 kl	0.31 g-i	8.13 ab	1674 h-j
NERICA-L-38	83.00 g	7.47 d-i	107.93 h-k	101.67 c-e	131.67 d-g	0.41 a-f	5.60 e-i	2267 d-i
NERICA-L-4	115.00 b-e	7.40 d-i	102.13 jk	101.00 d-f	131.00 e-h	0.43 a-f	5.60 e-i	2166 d-i
NERICA-L-43	121.33 a-c	7.87 c-h	103.27 h-k	99.33 d-g	129.67 g-i	0.44 a-f	6.00 c-h	1814 f-j
NERICA-L-45	118.00 a-d	8.00 c-g	105.80 h-k	101.00 d-f	131.00 e-h	0.50 ab	6.00 c-h	2198 d-i
NERICA-L-48	115.67 b-e	6.73 e-i	103.80 h-k	100.00 d-g	130.00 f-i	0.40 c-g	4.53 g-i	1674.3 h-j
NERICA-L-49	110.67 c-e	9.07 b-f	103.00 i-k	98.33 e-h	131.67 d-g	0.39 d-g	6.40 b-g	1639.3 h-j
NERICA-L-50	120.67 a-d	6.53 f-i	136.60 b-d	99.33 d-g	129.33 g-j	0.37 fg	4.80 f-i	2477 b-g
NERICA-L-53	96.67 f	8.40 c-g	102.67 jk	105.00 bc	131.33 e-h	0.48 a-e	6.40 b-g	1849 f-j
NERICA-L-60	117.67 b-d	6.80 e-i	99.80 j-l	96.67 g-i	127.33 h-l	0.44 a-f	5.67 d-i	1954 e-j
NERICA-L-8	106.00 ef	8.07 c-g	98.07 kl	105.00 bc	135.00 c-e	0.38 e-g	6.27 b-g	2372.3 c-h
OM3242	122.00 ab	4.93 i	139.93 bc	100.33 d-f	129.67 g-i	0.49 a-c	4.27 hi	2512 a-f
ROK 11	122.00 ab	7.07 e-i	132.73 c-e	105.67 b	134.00 d-f	0.43 a-f	5.53 e-i	2093 d-i
ROK 14	120.67 a-d	9.87 b-d	89.80 lm	106.00 b	135.67 b-d	0.36 f-h	7.60 a-d	2128 d-i
ROK 24	120.67 a-d	6.87 e-i	130.33 c-e	112.0 a	138.67 a-c	0.51 a	5.27 e-i	3105 a-c
ROK 30	122.67 ab	6.93 e-i	148.07 b	109.67 a	139.33 ab	0.47 a-e	5.13 e-i	2825 a-d
ROK 34	115.67 b-e	6.00 g-i	140.47 bc	95.33 hi	125.33 j-l	0.45 a-f	4.73 f-i	1709.0 g-j
TGR 19	121.33 a-c	6.00 g-i	125.27 d-f	97.67 f-h	127.67 g-k	0.43 a-f	4.2667 hi	2826 a-d

Means with the same letter are not significantly different at 5% probability level using Fisher's least significant difference.

Table 5. Means of traits of ratoon crop of 30 rice varieties.

Variety	Number of hills harvested	Tiller number/hill	Plant height (cm)	Panicle number/hill	Grain yield (kg/ha)
ARICA 6	57.7 d-k	4.00 g	53.80 f-l	3.60 de	189.67 i
ARICA 9	49.67 f-k	4.40 fg	66.73 a-f	2.93 e	189.67 i
CCA	73 a-j	7.00 c-g	69.73 a-c	6.53 b-e	232.0 h
CK 90-1	46.7 f-k	7.93 b-g	76.07 a	5.27 c-e	251.7 gh
Hitomebore	108.33 a	8.00 a-g	44.80 kl	6.53 b-e	162.33 i
NERICA-L-16	87.67a-e	7.13 b-g	53.13 g-l	6.53 b-e	488.0 d
NERICA-L-19	100.67 ab	8.40 a-g	69.87 a-c	6.53 b-e	392.7 e
NERICA-L-20	91.3 a-d	11.80 ab	61.27 b-h	8.20 a-c	352.67 f
NERICA-L-21	82 a-f	11.27 a-c	74.73 a	9.33 ab	542.3 c
NERICA-L-29	56.67 d-k	7.67 b-g	54.73 e-k	6.60 a-e	251.3 gh
NERICA-L-32	33.67 m	4.73 fg	48.40 h-l	4.07 de	123.67 j
NERICA-L-34	65 b-k	7.07 b-g	43.07 kl	5.53 b-e	166.00 i
NERICA-L-36	81.3 a-f	5.93 e-g	49.13 h-l	4.87 c-e	170.00 i
NERICA-L-38	64 c-k	7.27 b-g	60.47 b-i	5.93 b-e	267.00 gh
NERICA-L-4	45.33 f-k	5.20 fg	52.00 h-l	4.13 de	166.33 i
NERICA-L-43	28 m-o	4.13 fg	53.07 g-l	3.13 e	100.33 j
NERICA-L-45	75.67 a-f	10.80 a-d	59.13 c-j	9.33 ab	275.00 g
NERICA-L-48	37 kl	7.47 b-g	47.60 i-l	5.67 b-e	169.0 i
NERICA-L-49	24.67 m-p	5.60 fg	46.07 j-l	4.80 c-e	120.00 j
NERICA-L-50	62.3 c-k	6.33 d-g	78.40 a	4.87 c-e	422.00 e
NERICA-L-53	85 a-k	6.10 c-g	54.00 d-l	5.70 b-e	337.0 f
NERICA-L-53	48 e-k	5.60 b-g	50.40 d-l	5.60 a-e	319.50 f
NERICA-L-60	38.3 kl	5.47 fg	41.47 l	4.87 c-e	166.33 i
NERICA-L-8	79 a-f	8.87 a-f	59.33 c-l	7.47 a-d	581.0 b
OM3242	26.7 m-o	4.20 fg	68.40 a-d	3.87 de	189.67 i
ROK 11	17.67 p	4.27 fg	65.47 a-g	2.93 e	96.67 j
ROK 14	46.3 f-k	5.40 fg	42.00 kl	4.00 de	88.67 j
ROK 24	97.33 a-c	10.47 a-e	73.40 ab	8.13 a-c	852.7 a
ROK 30	42 jk	8.53 a-g	76.33 a	6.27 b-e	189.67 i
ROK 34	74.3 a-j	12.73 a	76.27 a	10.47 a	573.33 bc
TGR 19	45.67 f-k	6.07 d-g	67.13 a-e	4.93 c-e	348.33 f

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Correlation of Traits of Main and Ratoon Crops

Table 6 presents the correlation of eight traits of main crop in 30 genotypes evaluated at Rokupr. In this study, plant height, number of days to 50% flowering, number of days to maturity and culm diameter exerted positive and significant (p≤0.01) correlation with grain yield. However, number of tillers per hill and effective tillers per hill showed negative and significant (p≤0.01) relationship with grain yield. Number of tillers per hill showed positive and significant (p≤0.01) correlation with effective tillers per hill. Plant height, number of days to 50% flowering, and number of days to maturity exerted positive and significant (p≤0.01) correlation with culm diameter. Traits such as plant height and number of days to 50% flowering also showed positive and significant (p≤0.01) correlation with days to maturity. Plant height revealed positive and significant (p≤0.01) relationship with days to 50% flowering. Number of hills harvested showed positive and significant (p≤0.01) correlation with plant height. On the other hand, plant height, number of days to 50% flowering, number of days to maturity and culm diameter revealed negative and significant (p≤0.01) association with effective tillers. Number of tillers per hill showed negative and significant (p≤0.01) correlation with plant height, number of days to 50% flowering, number of days to maturity, and culm diameter.

Table 7 shows the Pearson's correlation of five traits of ratoon crops in 30 genotypes. Results showed number of hills harvested, number of tillers per hill, plant height and number of panicles per hill recorded positive and significant (p≤0.01) correlation with grain yield. Number of hills harvested, number of tillers per hill and plant height exerted positive and significant relationship with number of panicles per hill. Number of hills harvested and number of tillers per hill indicated positive and significant correlation with plant height. Also, number of hills harvested showed positive and significant correlation with number of tillers per hill.

Table 6. Pearson correlation of traits of main crop of 30 rice varieties.

Traits	Number of hills harvested	Number of tillers per hill	Plant height	Days to 50% flowering	Days to maturity	Culm diameter	Effective tiller per hill
Number of tillers per hill	-0.12						
Plant height	0.28**	-0.57**					
Days to 50% flowering	-0.03	-0.41**	0.49**				
Days to maturity	-0.04	-0.40**	0.48**	0.96**			
Culm diameter	0.13	-0.50**	0.59**	0.51**	0.48**		
Effective tiller per hill	-0.21*	0.94**	-0.54**	-0.38**	-0.36**	-0.44**	
Grain yield	0.22*	-0.40**	0.58**	0.60**	0.58**	0.40**	-0.40**

*, ** = significant at probability levels of 5% and 1%, respectively.

Table 7. Pearson's correlation of traits of ratoon crop of 30 rice varieties.

Traits	Number of hills harvested	Tiller number/hill	Plant height	Panicle number/hill
Tiller number/hill	0.55**			
Plant height	0.25**	0.47**		
Panicle number/hill	0.59**	0.95**	0.43**	
Grain yield	0.49**	0.47**	0.46**	0.48**

** = significant at probability levels of 1%.

IV. Discussion

Mean Performance of main and Ratoon Crops

Increasing and sustainable production of rice in associated mangrove swamp is critical where rice ratooning can overcome this limitation. Considering rice ratooning as an important practice will help the rice breeders as well as marginal rice farmers to achieve sustainable rice production in associated mangrove swamp for maximum gains.

There were significant differences observed among the 30 rice varieties for both the main and ratoon crops for number of hills, number of tillers per hill, plant height, days to 50% flowering and maturity, culm diameter, effective tillers per hill and grain yield. The significant genotypic effects observed for all the traits evaluated in both main and ratoon crops suggest the potential inherent genetic diversity of the genotypes. Similar results were observed by [30] and [31]. Reference [32] reported significant differences in grain yield for main and ratoon crops.

The main crop of the 30 lowland rice varieties recorded highest number of hills harvested, number of tillers per hill, plant height, effective tiller per hill and grain yield than the ratoon crop. This is in agreement with earlier studies for number of tillers and productive tillers [11], [31] - [33], grain yield [32] - [34], and plant height [31]. The highest number of tillers and productive tillers recorded in the main crop than the ratoon crop may had possibly contributed to the observed lower grain yield in the ratoon crop compared to the main crop. Tillering ability has been cited as one of the most genetic factors affecting ratoon performance of grasses [11].

In general, 77% of genotypes out-yielded the check genotype (ROK 34) by 5% to 73% for main crop whereas only two genotypes out-yielded the check genotype by 3% and 100% for ratoon crop. Specifically, results revealed

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that NERICA-L-21 produced the highest grain yield, longest days to 50% flowering and maturity of main crop and demonstrated good ratoon performance. ROK 24 and NERICA-L-8 also exhibited higher grain yields, late days to 50% flowering and maturity of main crop and produced very good ratoon performance, with ROK 24 yielded highest in ratoon crop. On the other hand, Hitomebore had the least grain yield, shortest days to 50% flowering and maturity of main crop and exhibited very poor ratoon performance. Genotypes such as NERICA - L - 34, NERICA - L - 60 and ROK 34 produced low grain yields with early days to 50% flowering and maturity. These genotypes demonstrated very poor ratoon performance, except ROK 34 which showed very good ratoon performance. However, ROK 34 which flowered and matured very early with very good ratoon performance is more likely to escape drought stress and could has the potential to benefit local rice farmers in drought prone areas where soil moisture is critical in the production of ratoon crop. It is therefore deduce that, genotypes which flowered and matured very late produced better grain yields of main crop and had good ratoon performance, whereas those with very early days to flowering and maturity expressed low grain yields of main crop and poor ratoon performance.

Characters Association of main and Ratoon Crops

Grain yield, being a quantitative trait is a complex character of any crop that depends on other traits. These yield contributing components are interrelated with each other showing a complex chain of relationship and also highly influenced by the environmental conditions [35]. Information on correlation coefficient has always been helpful as a basis for selection in a breeding programme - breeding strategy in rice mainly depends upon the degree of associated characters as well as its magnitude and nature of variation [35], [36].

A significant and positive correlation of traits showed that these traits could be improved simultaneously. In this study, grain yield showed positive and significant correlation with plant height, days to 50% flowering and maturity, and culm diameter in the main crop. These traits also revealed positive and significant relationships with each other, implying that genotypes with taller plant height, late flowering and maturity, and with large culm diameter would effectively and ultimately increase grain yield. Reference [37] observed positive and highly significant relationship of grain yield per hill with days to flowering and plant height. Reference [30] reported that days to maturity showed positive and highly significant correlation with grain yield per plant. The negative association that existed between grain yield and number of hills harvested, number of tillers per hill and effective tiller per hill in the main crop is not a guarantee that improving these traits would translate into an increase in grain yield, although indirect contribution may be suspected. This result is contrary to the findings of [38] who observed that plants with heavy panicles tend to have high number of fertile grains thereby increasing rice yield. Reference [39] also reported positive and significant association of grain yield with number of fertile tillers per plant and number of tillers per plant. The study also points out that traits such as number of hills harvested, number of tillers per hill and panicle number per hill which exerted negative and significant correlation with grain yield in the main crop revealed positive and significant association with grain yield in the ratoon crop. These traits also showed positive and significant relationship with each other, indicating that improving one of these traits would simultaneously improve the others and hence improve grain yield. This further indicates that grain yield in ratoon crop is a complement of the main crop - improvement of any trait in the ratoon crop would simultaneously translate into an improvement in the others thereby increasing total grain yield.

V. Conclusions

There were significant genetic differences observed among the 30 rice varieties for both the main and ratoon crops for the traits evaluated. The main crop of the 30 lowland rice varieties recorded highest number of hills harvested, number of tillers per hill, plant height, effective tiller per hill and grain yield than the ratoon crop. Most of genotypes evaluated out-yielded the check genotype (ROK 34) by 5% to 73% for main crop and only two genotypes out-yielded it by 3% and 100% for ratoon crop. NERICA-L-21 produced the highest grain yield, longest days to 50% flowering and maturity of main crop and demonstrated good ratoon performance while Hitomebore had the least grain yield, shortest days to 50% flowering and maturity of main crop and exhibited very poor ratoon performance. Correlation studies revealed that genotypes with taller plant height, late flowering and maturity and with large culm diameter would effectively and ultimately increase grain yield in main crop. Grain yield in ratoon crop is a complement of the main crop, improvement of any trait in the ratoon crop would simultaneously translate into an improvement in the others thereby increasing total grain yield.

Recommendations

It is recommended that:

- NERICA-L-21, ROK 24 and NERICA-L-8 which produced better grain yield, flowered and matured very late in main crop and demonstrated good ratoon performance should be advanced on-farm prior to their commercial production as ratoon crop varieties.
- ROK 34 which flowered and matured very early with very good ratoon performance could has the potential to benefit local rice farmers where soil moisture is critical in the production of ratoon crop.

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