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Effect of Inorganic Fertilizers and Farm Yard Manure on Agronomic Characteristics of Upland Rice Straw in Taita Taveta Highlands, Kenya

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Authors' contribution

This work was carried out in collaboration among all authors. Author SW wrote the methodology, did literature search, collected the data, and drafted the discussion. Author JK provided expert technical support during the study and participated in manuscript preparation. Authors AKK, MM, and JG participated in manuscript preparation. Author MM provided technical support in study design, supervised the study, performed the statistical analysis, wrote the first draft of the manuscript and prepared the final copy. All authors read and approved the final manuscript.

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ABSTRACT

The study evaluated upland rice varietal agronomic characteristics and differences due to effects of fertilizer treatment and season at Taita Taveta University, Ngerenyi campus. The experiment was conducted during the short rains of 2018 and long rains of 2019. The experiment was a Randomized Complete Block Design with 3 replications. Individual plots measured 2.5 m by 2 m. Varieties evaluated were 17KH09010093B, WDR73 Hybrid, NERICA 1, NERICA 10 and Komboka. The treatments included were farm yard manure (8 tons ha^{-1}), DAP at 75 kg ha^{-1}, NPK (17:17:17) at 65 kg ha^{-1}, and no fertilizer. Plant height, panicle length, leaf length, number of tillers, fresh weight, and dry weight were assessed. Variety, fertilizer and season had significant effects (P=0.05) on the morphological variables. NERICA 10 was the tallest variety at a mean of 72 cm in

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2018 and a mean height of 61 cm in 2019. DAP treated plants were the tallest in both 2018 and 2019. Varieties were significantly different (P=0.0004) for panicle length. NERICA 10 had the longest panicles. Varietal effect was significant (P<0.001) for leaf length. NERICA 1 had the longest leaves in both seasons. DAP had the greatest effect on leaf length. Varieties differed significantly (P<0.001) in number of tillers per plant. Variety 17KH09010093B had the highest number of tillers per plant of 34.78 obtained in 2018. DAP resulted in the highest number of tillers. Variety and fertilizers interacted significantly (P=0.007) for foliage weight. WDR73 Hybrid out-yielded other varieties (149.31g) in fresh foliage weight. DAP resulted in the highest fresh morphological yield followed by NPK. There were significant differences in dry foliage weight among varieties and between seasons (P<0.001). Variety 17KH09010093B had the highest dry weight. Further studies on the socio–economics of fertilizer use should be conducted to provide reliable recommendations for upland rice production as forage.

Keywords: Rainfed; rice; fertilizer; forage; fresh weight; dry weight.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is an important staple food around the world, and is the second most produced and consumed grain worldwide after wheat [1]. In Kenya rice is mainly produced by small-scale farmers as a commercial and food crop [2]. However, rice products, including straw and bran are also used as livestock feeds to provide roughage and energy. There are two types of forage rice, one is feed rice whose cultivars are harvested as edible rice and only the grain is used to feed domestic fowl and animal as concentrate feed. The other is whole-crop silage (WCS) rice, whose cultivars are harvested at the yellow ripening stage, and the whole rice plant including panicles, leaves, and stems are conditioned into silage to feed cattle [3]. Since forage rice is used to feed livestock, the grain weight and total above ground biomass of feed and WCS rice are larger than those of edible rice. The inorganic fertilizer rates of forage rice cultivars are also higher than those for edible rice [4].

Crop development and performance as well as yield and quality of rice forage are affected by various factors which include temperature, rainfall, relative humidity, solar radiation, soil types and soil nutrient status. Forage rice is grown for its whole crop silage (WCS) as well as dry straw. For good animal production, the straw must be supplemented preferably with N, protein and energy [3]. It's worth noting that, soils that would otherwise be suitable for rice production are declining in fertility in various parts of the world [5,6,7]. In high rice yielding environments where improved varieties are used, the difference between the soil's inherent nutrient supply and crop nutrient demand could be provided in the form of organic and mineral fertilizer. However, studies show that combining inorganic fertilizer application with farm yard manure (FYM) could significantly increase soil organic matter, CEC, N, P and K leading to higher grain and straw yield in rice [8]. This also increases the above-ground biomass components that could be utilized as animal feeds.

In an effort to increase rice production and productivity in the country, the Rice Research Program (RRP) of Kenya introduced New Rice for Africa (NERICA) and other upland rice varieties since 2002. The upland rice varieties were developed purposely for resource-poor farmers in Africa [9]. However, in Taita Taveta hills rice production is strongly inhibited by low temperatures (at times below 18°C), particularly during the grain filling stage. Nonetheless, the hills could potentially be new sites for production of upland rice as a forage. These hills experience rainfall of at least 750mm per annum but the temperature regularly falls below 18°C thus inhibiting grain formation. Production of rice for grain here is, therefore, not feasible until cold tolerant varieties are developed, but rice could be produced to supplement natural grass forage for dairy farmers. The objective of this study, was to evaluate the response of upland rice varieties' morphological characteristics to application of inorganic fertilizers and manure, season effects and to assess varietal differences. This was in order to assess the varieties as possible supplementary forage in the highlands of Taita Taveta County.

2. MATERIALS AND METHODS

2.1 Experimental Sites

This study was conducted at Taita Taveta University, Ngerenyi campus located at latitude 3°25'54"S and longitude 38°20'35"E and 1,591 masl in Taita highlands. The soils at the site are predominantly alfisols with relatively high clay content. They are slightly acidic due to long-term use of soil acidifying fertilizers. Taita hills experience relief rainfall from moisture-laden winds originating from the Indian Ocean. As a result, the area has two rain seasons, long rains occurring from March to June and short rains from November to December. The experiment was conducted during the short rains of 2018 and the long rains of 2019.

2.2 Experimental Layout and Treatments

Five (5) upland rice varieties, 17KH09010093B, WDR73 Hybrid, NERICA 1, NERICA 10 and Komboka were evaluated. These varieties were selected because they were the most vigorous in the seedling nursery. The experiment was set up as a Randomized Complete Block Design (RBCD) with three (3) replications. Individual plots measured 2.5m by 2m. Individual blocks were spaced 1m apart while the plots within the blocks were separated by a 0.5m path. The different basal fertilizer treatments applied were (i) farm yard manure (FYM) at the rate of 8 tons ha^{-1}. (ii) DAP at the rate of 75 kg ha^{-1}, (iii) NPK (17:17:17) at the rate of 65 kg ha^{-1}, and (iv) control where there was no fertilizer application. The control represents common farmer practice. This resulted in twenty treatment combinations per replication. In total, 60 plots were set up. The fertilizers were applied by broadcasting and incorporated in the soil before sowing. These were followed by Calcium Ammonium Nitrate, CAN, (27% N) fertilizer applied at the rate of 65 kg ha^{-1} as top dressing across all treatment combinations in two splits: the first at tiller initiation (i.e. 30 days after planting) and the second application at panicle initiation. Soil nutrient content analysis before experimentations is presented in Table 1. Two seedlings were transplanted per hole at a spacing of 30cm by 20cm giving a plant population of 160 plants per plot (320,000 plants ha^{-1}) on eight rows. The two outer rows along each plot and the outer plants along the width of the plots were border rows and were not considered for data collection. The experiment ran for three months during the short rains season of 2018 (November 2018 to February 2019) and long rains season of 2019 (April 2019 to July 2019).

2.3 Variable Measurement and Data Collection

Data recorded included the number of tillers per plant, leaf length, plant height, and panicle length at 90 days after transplanting. Five plants were harvested at ground level and fresh foliage determined at harvest, 90 days after transplanting. These plants were sampled randomly from the middle six rows, avoiding the border plants. The harvested plants were dried at 70°C for 72 hours and then weighed after attaining constant weight to obtain biomass.

Table 1. Soil and farm yard manure chemical properties before experiment set up

Soil Property	**Short rains season 2018**		**Long rains season 2019**	
	Values	Interpretation	Values	Interpretation
Soil PH	5.12	Strongly acidic	4.90	Very strongly acidic
Total Nitrogen (%)	0.34	Adequate	0.26	Adequate
Total Organic Carbon (%)	3.57	Adequate	3.72	Adequate
Phosphorus (ppm)	50.00	Adequate	40.00	Adequate
Potassium (me %)	0.32	Adequate	1.05	Adequate
Calcium (me %)	0.40	Low	2.60	Adequate
Magnesium (me %)	0.95	Low	1.20	Adequate
Manganese (me %)	0.18	Adequate	40.80	High
Copper (ppm)	1.44	Adequate	1.09	Adequate
Iron (ppm)	71.9	Adequate	77.50	High
Zinc (ppm)	3.18	Low	11.70	Adequate
Sodium (me %)	0.48	Adequate	0.96	Adequate
Farm yard manure				
Total Nitrogen (%)	12.40	High	5.30	Adequate
Total Organic Carbon (%)	250	High	700	Adequate
Phosphorus (ppm)	34.40	High	0.63	Adequate
Calcium (me %)	34.40	High	23.60	Adequate

2.4 Data Analysis

Data were analyzed using the Statistical Tool for Agricultural Research (Version 2.0.1) software. Data were subjected to analysis of variance (ANOVA) at α=0.05, and significant means were separated using the LSD test. Linear correlation and regression analysis, with straw yield as the dependent variable were also done.

3. RESULTS AND DISCUSSION

3.1 Weather Data

The total amount of rainfall received in seasons one and two was 295.7 mm and 939.5mm respectively (Fig. 1). The highest amount of rainfall experienced in a month was 96.8mm in December 2018 during the short rains and 347.7mm in May 2019 during the long rains. The lowest amount in a month was 0mm in October during the 2018 short rains season and 0mm in July during the 2019 long rains season. Higher temperature was experienced during the day than at night in both seasons. The highest temperatures experienced during the 2018 season and the 2019 season were 28.7°C and 31.5°C respectively (Fig. 2). On the other hand, the lowest temperatures in the same seasons were 10.7°C and 13°C respectively.

3.2 Tests of Significance

The three main factors, namely variety, fertilizer, and season, had significant effects (P=0.05) on the morphological variables to different levels (Table 2). Varieties were significantly different for all variables except fresh weight. Fertilizer and varieties interacted significantly to affect only fresh weight and dry weight. Varieties interacted significantly with season for all traits except fresh weight. Season, fertilizer, and variety interactions were significant only for fresh weight and dry weight. When the data were tested for normal distribution, the probability of getting a lesser Shapiro Wilk value than the value of 0.989 obtained was 0.426, hence the assumption of normality was not rejected. Data for the six morphological characteristics are presented in Tables 3, 4, 5 and 6.

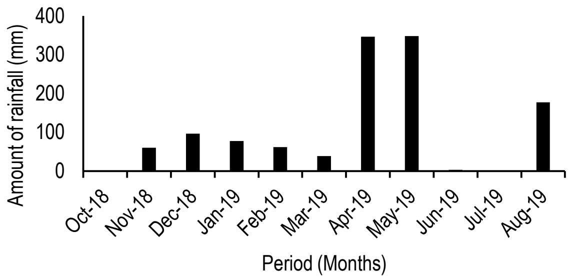

Fig. 1. Rainfall pattern during the two seasons of the experiment

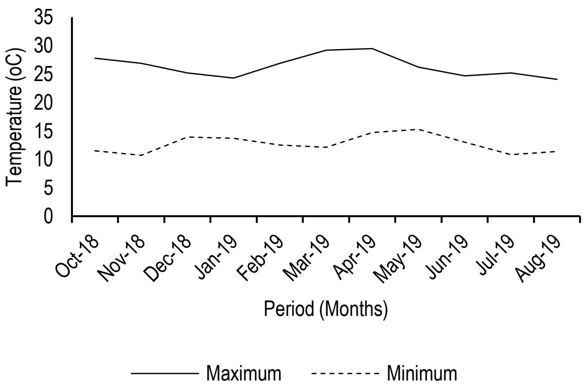

Fig. 2. Temperature pattern during the two seasons of the experiment

Table 2. Analysis of variance

Sources of variations	Degrees of freedom	Mean squares					
		Plant height (cm)	**Panicle length (cm)**	**Leaf length (cm)**	**Number of tillers**	**Fresh weight (g)**	**Dry weight (g)**
Season	1	1754.15***	68.55	84.00	261.67	29688.49***	3999.33***
P value		0.0023	0.1847	0.0648	0.1512	<0.001	<0.001
Replication(Season)	4	37.04	26.76*	13.15	83.40	378.73	45.12
P value		0.1675	0.0201	0.0822	0.1102	0.3702	0.8437
Fertilizer	3	143.95***	7.54	6.25	132.45*	5765.21***	894.15***
P value		0.0006	0.4580	0.3866	0.0316	<0.001	<0.001
Variety	4	1440.55***	49.37***	47.37***	519.15***	257.72	1148.24***
P value		<0.001	<0.001	<0.001	<0.001	0.5689	<0.001
Fertilizer* Variety	12	29.28	10.73	4.72	16.49	884.92**	662.67***
P value		0.2284	0.2688	0.6749	0.9647	0.0073	<0.001
Season* Fertilizer	3	30.90	18.83	8.60	80.31	5803.64***	1620.33***
P value		0.2533	0.0966	0.2467	0.1399	<0.001	<0.001
Season* Variety	4	182.29***	25.50*	43.64***	776.24***	610.02	352.92*
P value		<0.001	0.0250	<0.001	<0.001	0.1485	0.0350
Season* Fertilizer* Variety	12	37.52	7.30	4.57	33.40	674.39*	403.25**
P value		0.0871	0.6019	0.6991	0.6668	0.0434	0.0012
Pooled Error	76	22.28	8.62	6.10	42.70	349.20	129.11
Total	119						

** P=0.05; ** P=0.01; ***P=0.001*

3.3 Plant Height

The variety, season and fertilizer main effects were significant for plant height (Table 2). NERICA 10 was the tallest variety at a mean of 72 cm in 2018 and a mean height of 61 cm in 2019 (Tables 3 and 5). DAP treated varieties were the tallest in both 018 and 2019 seasons with mean heights of 62 cm and 57 cm respectively. These were followed by NPK-treated plants with mean heights of 62cm in 2018 and 54 cm in 2019. The higher plant height due to DAP and NPK application compared to FYM and control is associated with the fact that nutrients in inorganic fertilizer are readily available for plant uptake while FYM releases nutrients slowly [10,11]. Control plots had the shortest plants due to poor soil fertility. Nutrient requirement for newly transplanted rice is met from the soil plus the DAP, NPK and manure applied as basal. The present results are also supported by [12] who reported that moisture and nitrogen fertilizer had significant influences on plant height, total dry matter, number of tillers, days to flowering and days to physiological maturity. On the other hand, [13] reported that plant height was significantly affected by water stress at booting, flowering and grain filling stages.

3.4 Panicle Length

The five varieties tested were significantly different from each other (P=0.0004) in plant panicle length (Tables 2, 3 and 5). NERICA 10 had the longest panicles with a mean of 19.7cm in 2018 and 16.8cm in 2019. No seasonal trends were observed. There was no significant difference in panicle length during 2018 and 2019. Further, fertilizer treatments did not result in significant differences. Another researcher in Ethiopia [14] obtained longer panicles in long rains season and shorter panicles in short rains season compared to another study in Kenya that obtained contrary results [15]. Our study found significant differences in panicle length among the varieties, a result that was also obtained by [16] in Tanzania. The same researcher [16] suggested that panicle length is influenced by both environmental and genetic characteristics of cultivars because those cultivars that have long or many roots have high nutrient use efficiency. We found a significant interaction between season and variety with the second season having longer panicles in our study. Similarly, [17] reported increases in panicle length with increase in soil moisture availability, the same condition that may have influenced the results reported in our study. Fertilizer treatments had no significant effect on panicle length in this study. This is contrary to [16] who obtained different panicle lengths in different fertilizer treatments.

3.5 Leaf Length

Only varietal effect was significant (P<0.001). WDR73 Hybrid had the longest leaves of 34.52cm in 2018 while in 2019 NERICA 1 had the longest leaves at a mean of 29.76cm. DAP treatment had the greatest effect on leaf length in 2018 resulting in an average length of 32.33cm, but in 2019 NPK treated crops were superior resulting in an average length of 30.18cm. This could be due to the fact that in 2019, the amount of Potassium in the soil was three times as much as in 2018. There was a positive association between leaf length and plant height of rice cultivars. This is in agreement with [18] who stated that plants with the longest leaves were the tallest plants. Similar results were obtained by [16] whose data indicated that tall rice varieties had longer leaves and panicle length while short varieties had s ho r t leaves and panicles. All fertilizer treatments increased the leaf length compared to the control but with significant differences among treatments, an observation similar to that of [19].

3.6 Number of Tillers Per Plant

The five varieties tested were significantly different from each other (P<0.001) in the mean number of tillers per plant. This is in agreement with [20] who stated that tillering characteristics, among other factors, are influenced by the genetic characteristics of the cultivars. Variety 17KH09010093B had the highest number of tillers per plant of 34.78 in 2018 while in 2019 NERICA 1 was superior with 25.18 tillers (Tables 4 and 6). The overall mean number of tillers per plant was 25.27 in 2018 season and 22.32 in 2019. Fertilizer treatments had significantly different effects (P=0.032) on the number of tillers per plant. DAP treatment resulted in the highest mean number of tillers per plant of 30.01 in 2018 while NPK had a greater effect in 2019 with a mean of 23.26 tillers. Control treatment produced the least mean number of tillers per plant, 21.41 tillers in 2018 and 21.76 tillers in 2019. The overall effect of fertilizer treatments was to increase the numbers of tillers. Inorganic nitrogenous fertilizers release their nutrient contents faster compared to FYM. This is because nutrients from FYM need to be converted to ammonium during decomposition before being released for plant use. A large number of tillers formed a wide h ill of plants which yielded higher forage quantity.

3.7 Fresh Foliage Weight Per Plant

The five varieties tested were not significantly different from each other (P=0.569) with respect to fresh foliage weight (Table 2). However, the interactions between variety and fertilizer treatment were significant (P=0.007). WDR73 Hybrid had the highest fresh weight of 149.31g in 2018 while Komboka had the highest fresh weight of 115.33 in 2019 (Tables 2, 4 and 6). DAP application resulted in the highest fresh foliage weight of 172.39 g in 2018 while NPK resulted in a mean weight of 113.51 g in 2019. The differences in varietal fresh foliage weight could be attributed to genotypic differences and sources of nutrients supplied. Number of tillers per plant was a major contributor to fresh weight, a result that was also reported by [21] and [22]. According to [23] and [24], with the exception of NERICAs, other rice varieties have been reported to have deep roots. According to [24], NERICAs have been reported to have a greater plasticity in lateral root development under moderate drought conditions. Therefore, it is reasonable to assume that higher above -ground biomass among the five upland rice varieties in our study was associated with the root system. Seasons (P=<0.001) and the interactions among seasons, fertilizer and varieties (P=<0.043) were significant. This is similar to the results obtained by [25] who reported that when both maximum and minimum temperatures were decreased by 4°C and solar radiation was increased by $1 MJm^{-2}day^{1}$, the biomass yield increased by 18% and growth duration increased by 24 days. The total amount of rainfall received in the 2018 was 295.7mm while that received in the 2019 season was 939.5 mm. Despite these rainfall differences, there was more foliage growth in 2018 compared to 2019. Our results show higher maximum temperatures during the 2018 growth season compared to the 2019 growth season, and this could have contributed to more vigorous growth. The significant effect (P<0.001) of DAP and NPK could be attributed to their nitrogen content. DAP contains 18% N and NPK contains17% N, thus contributing to more vigorous foliage growth compared to FYM that contained 1.2% N and the untreated soil (control) that contained 0.34% N. Further, DAP contains 46% P_2O_5 while NPK has 17% P_2O_5 and thus enhanced photosynthetic processes and ultimate growth of the plants that received these treatments. Basal inorganic fertilizer treatments, together with additional Nitrogen from CAN top-dressing and the liming effect of CAN on the acidic soils, significantly increased the growth of rice that was observed in the two seasons. A study by [19] on the effect of fertilizer treatments, although on trees, showed significant increase in the fresh weight and dry weight of the stems and leaves by 72% and 133% respectively compared to the control.

3.8 Dry Foliage Weight Per Plant

Our results showed significant differences in dry weight among the varieties (P<0.001). Seasons had a significant effect (P=0.0007) on dry foliage weight. Variety 17KH09010093B had the highest overall mean dry foliage weight of 121.09 g in the 2018 season and 98.29g in the 2019 season. WDR73 Hybrid produced the least mean dry foliage weight of 94.21g, in 2018 while in 2019 NERICA 10 produced the least mean dry foliage weight of 89.30 g. Also, fertilizer treatments had significant effects (P=0.0003) on dry foliage weight (Tables 4 and 6). Among all treatments, DAP resulted in the highest dry foliage weight with 147.28 g being recorded in 17KH09010093B in 2018 and 109.61g in WDR73 Hybrid in 2019. On average, dry foliage weight was 104.03 g in 2018 and 92.48g in 2019. These phenotypic differences may be associated with genotypic characteristics of varieties [26]. The 2018 season resulted in significantly higher fresh foliage and dry foliage weight compared to the 2019 season. [27] and [28] have suggested that rice is sensitive to low and high temperatures because these temperatures cause embryos to abort and thus inhibit seed setting. The additional dry matter from photosynthesis in such vegetative rice therefore significantly contributes to foliage production. Temperatures that approach 30°C decrease photosynthesis, increase respiration, and shorten the vegetative and biomass forming period. We recorded significantly higher dry matter from FYM compared to control, which could have been due to improved soil structure. [29] reported that after use of FYM as a fertilizer for many years and/or at high rates, a possible improvement of the soil structure, due to organic matter increase, cannot be excluded.

3.9 Relationship Analysis

A correlation analysis suggests that the strongest and most significant positive associations are those between leaf length and plant height (*r* = 0.422**), fresh weight and tiller number (*r* = 0.392**) and fresh weight and plant height (*r* = 0.33**), as presented in Table 7. Contrary to our results, [30] reported a negative relationship between fresh biomass and number of tillers (*r* = -0.1343) and a non-significant positive correlation between biomass and plant height (*r* = 0.2902). We found that taller plants had fewer tillers (*r* = -0.362**), which was similar to the findings of [31] who observed a negative non-significant correlation between the same variables. However, our findings were contrary to those of [32] found a positive and significant correlation (*r* = 0.552**) between plant height and tiller number and [30] who found a direct non-significant relationship (*r* = 0.1598) between the same variables. The other strong indirect relationship in our results was that plants with longer panicles had fewer tillers, (*r* = -0.362**), possibly an indication of the crop's attempt to partition dry matter optimally.

A linear regression model was fitted for the data obtained, with biomass being the dependent variable. Variables selection was attempted using the forward selection, backward elimination and stepwise regression methods. Backward elimination and stepwise regression methods gave an identical final model, which was more conservative but not significantly different from the one generated by the forward selection. The model fitted was:

Fresh weight ~ -106.47 + 1.16(plant height) + 2.54(leaf length) + 1.67(number of tillers) + 0.51(dry weight) + error

Table 3. Means of plant height, panicle length and leaf length for the 2018 short rains season

Parameter	Variety		Fertilizer treatment				
			Control	**DAP**	**FYM**	**NPK**	**Mean**
Plant height (cm)	17KH09010093B		47.20	54.87	50.93	51.33	51.08c
	WDR73 Hybrid		62.80	56.13	55.13	59.07	58.28b
	Komboka		47.13	53.40	54.07	51.13	51.43c
	NERICA 1		65.27	72.53	67.20	78.47	70.87 a
	NERICA 10		72.13	71.40	76.67	67.53	71.93a
	Mean		58.91	61.67	60.80	61.51	
	Overall mean	60.72					
	LSD (P = 0.05)	5.29					
	CV%	10.53					
Panicle length (cm)	17KH09010093B		14.50	15.97	12.83	13.80	14.28b
	WDR73 Hybrid		11.17	18.47	15.67	16.23	15.38b
	Komboka		18.50	18.33	16.67	17.83	17.83a
	NERICA 1		20.50	17.83	18.17	21.67	19.54a
	NERICA 10		19.17	19.17	20.00	20.33	19.67a
	Mean		16.77	17.95	16.67	17.97	
	Overall mean	17.34					
	LSD (P = 0.05)	1.97					
	CV%	13.77					
Leaf length (cm)	17KH09010093B		26.80	29.67	28.93	26.27	27.92c
	WDR73 Hybrid		35.93	33.33	34.00	34.80	34.52a
	Komboka		27.90	31.57	29.47	28.53	29.37bc
	NERICA 1		31.07	35.77	33.37	33.30	33.38a
	NERICA 10		30.73	31.30	29.93	30.90	30.72b
	Mean		30.49	32.33	31.14	30.76	
	Overall mean	31.18					
	LSD (P = 0.05)	2.13					
	CV%	8.27					

**Means within a column followed by the same letter are not significantly different at α = 0.05*

Table 4. Means of tiller number, fresh foliage weight and dry foliage weight for the 2018 short rains season

Parameter	Variety		Fertilizer treatment				
			Control	**DAP**	**FYM**	**NPK**	**Mean**
Number of tillers per plant	17KH09010093B		31.47	41.87	30.40	35.40	34.78 a
	WDR73 Hybrid		25.40	34.00	27.70	32.13	29.81b
	Komboka		27.47	39.27	32.73	33.53	33.25a
	NERICA 1		10.67	15.27	13.13	13.40	13.12 c
	NERICA 10		12.07	19.67	13.93	15.87	15.38c
	Mean		21.41d	30.01a	23.85c	26.07b	
	Overall mean	25.27					
	LSD (P = 0.05)	2.14					
	CV%	11.46					
Fresh foliage weight per plant (g)	17KH09010093B		95.18c	171.75a	140.03b	174.57a	145.38
	WDR73 Hybrid		121.27c	172.61a	147.03b	156.33ab	149.31
	Komboka		97.58c	162.40a	132.74b	148.08ab	135.20
	NERICA 1		84.58c	186.26a	107.15c	161.42b	134.85
	NERICA 10		143.81b	168.94a	137.47b	135.17b	146.35
	Mean		108.48	172.39	132.88	155.11	
	Overall mean	142.22					
	LSD (P = 0.05)	23.32					
	CV%	9.92					
Dry foliage weight per plant (g)	17KH09010093B		65.34c	147.28a	123.51b	148.24a	121.09
	WDR73 Hybrid		95.01a	96.90a	91.23a	93.69a	94.21
	Komboka		91.64a	101.79a	97.78a	101.57a	98.20
	NERICA 1		92.10c	126.16a	97.37bc	106.85b	105.62
	NERICA 10		93.46b	111.51a	96.34b	102.78ab	101.02
	Mean		87.51	116.73	101.25	110.63	
	Overall mean	104.03					
	LSD (P = 0.05)	13.49					
	CV%	7.85					

**Means within a column followed by the same letter are not significantly different at α = 0.05*

Table 5. Means of plant height, panicle length and leaf length for the 2019 long rains season

Parameter	Variety		Fertilizer treatment				
			Control	**DAP**	**FYM**	**NPK**	**Mean**
Plant height (cm)	17KH09010093B		50.53ab	52.30a	51.77ab	48.93b	50.88c
	WDR73 Hybrid		46.50b	52.37a	48.80b	53.30a	50.24c
	Komboka		41.90c	51.53a	45.40b	48.30b	46.78d
	NERICA 1		51.17c	61.83a	56.07b	56.53b	56.40b
	NERICA 10		55.57c	65.50a	59.93b	63.23a	61.06a
	Mean		49.13	56.71	52.39	54.06	
	Overall mean	53.07					
	LSD (P = 0.05)	3.17					
	CV%	3.61					
Panicle length (cm)	17KH09010093B		16.53	16.50	17.70	11.10	15.46
	WDR73 Hybrid		14.40	14.77	18.60	13.93	15.43
	Komboka		14.20	16.93	15.00	16.63	15.69
	NERICA 1		16.10	16.00	16.40	14.63	15.78
	NERICA 10		15.17	16.80	18.27	16.90	16.78

Parameter	Variety		Fertilizer treatment				
			Control	DAP	FYM	NPK	Mean
	Mean		15.28	16.20	17.19	14.64	
	Overall mean	15.83					
	LSD (P = 0.05)	ns					
	CV%	21.46					
Leaf length (cm)	17KH09010093B		27.00	30.03	30.17	31.40	29.65
	WDR73 Hybrid		29.07	29.33	29.83	30.03	29.57
	Komboka		28.77	29.43	30.30	29.17	29.42
	NERICA 1		29.40	28.17	29.77	31.70	29.76
	NERICA 10		30.23	28.97	28.73	28.60	29.13
	Mean		28.89	29.19	29.76	30.18	
	Overall mean	29.51					
	LSD (P = 0.05)	ns					
	CV%	7.99					

Means within a column followed by the same letter are not significantly different at α = 0.05

Table 6. Means of tiller number, fresh foliage weight and dry foliage weight for the 2019 long rains season

Parameter	Variety		Fertilizer treatment				
			Control	DAP	FYM	NPK	Mean
Number of tillers per plant	17KH09010093B		19.73	16.30	26.83	25.97	22.21
	WDR73 Hybrid		23.33	22.57	17.13	24.80	21.96
	Komboka		23.17	24.70	17.90	16.97	20.68
	NERICA 1		23.63	26.20	23.93	26.93	25.18
	NERICA 10		18.93	23.10	22.53	21.63	21.55
	Mean		21.76	22.57	21.67	23.26	
	Overall mean	22.32					
	LSD (P = 0.05)	ns					
	CV%	39.33					
Fresh foliage weight per plant (g)	17KH09010093B		92.87	95.46	111.20	129.59	107.28
	WDR73 Hybrid		123.48	112.08	101.36	102.29	109.80
	Komboka		115.33	118.75	100.11	106.86	115.33
	NERICA 1		106.19	102.84	136.48	119.69	106.19
	NERICA 10		113.31	114.85	103.38	109.13	110.17
	Mean		110.24	108.79	110.51	113.51	
	Overall mean	110.76					
	LSD (P = 0.05)	ns					
	CV%	20.17					
Dry foliage weight per plant (g)	17KH09010093B		91.50	99.50	105.84	96.32	98.29
	WDR73 Hybrid		88.15	84.92	89.31	109.61	93.00
	Komboka		90.19	85.83	101.29	87.91	90.19
	NERICA 1		99.29	94.74	88.22	93.91	99.29
	NERICA 10		102.57	90.26	88.89	75.47	89.30
	Mean		94.34	91.05	94.71	89.82	
	Overall mean	92.48					
	LSD (P = 0.05)	ns					
	CV%	14.97					

Table 7. Correlation coefficient (r) of rice growth characteristics

	Plant height	Panicle length	Leaf length	Number of tillers per plant	Fresh weight per plant	Dry weight per plant
Plant height	1					
Panicle length	0.359**	1				
Leaf length	0.422**	0.193*	1			
Number of tiller per plant	-0.362**	-0.362**	-0.239**	1		
Fresh weight per plant	0.330**	-0.009	0.303**	0.392**	1	
Dry weight plant per plant	0.134	0.031	0.058	0.275**	0.504**	1

** P = 0.05; ** P = 0.01*

Table 8. Statistics for the linear regression model

Variable	Degrees of freedom	Estimate (β)	Standard error of estimate	AIC	t value	Pr(>|t|)
Intercept		-106.47	23.39	738.80	-4.55	≤.001
Panicle length	1	-	-	740.70	-	>.05
Leaf length	1	2.54	0.71	749.60	3.60	≤.001
Dry weight per plant	1	0.51	0.11	756.00	4.48	≤.001
Plant height	1	1.16	0.24	759.50	4.89	≤.001
Tillers per plant	1	1.67	0.24	778.40	6.91	≤.001

Table 8 below presents the regression statistics. The adjusted R^2=0.5299 suggests that the variables included in the model accounted for the majority of the variance in biomass. The rest of the variability could be explained by environmental factors and other variables that were not measured. Holding other variables constant, the number of tillers was the most influential variable, followed by plant height, based on the AIC value. However, number of tillers per plant and plant height were negatively, though not significantly correlated. This relationship suggests that there has to be a balance between selecting for more tillers and selecting for tall varieties.

5. CONCLUSION

Among the five upland rice varieties used in this study NERICA 10 out yielded the other varieties followed by Komboka, and WDR73 Hybrid. Overall, DAP application resulted in the highest morphological yield because it has the highest Nitrogen and Phosphorous content among the fertilizers in the study. DAP was followed by NPK and FYM while the least effective was control treatment. NPK has lower Nitrogen and Phosphorous content compared to DAP while FYM has the least of these nutrients among the three fertilizers. The effect of Potassium in NPK was not evident in foliage yield, possibly because it was already adequate in the soil for foliage growth. There is, therefore, an opportunity for farmers to be encouraged to use inorganic or organic fertilizers at planting in addition to regular top dressing using appropriate nitrogenous fertilizers to boost the performance of upland rice. Nonetheless, an experiment that will include different levels of treatments to further interrogate their effects and profitability is recommended to further provide more reliable information for fertilizer use recommendations. Further, an economic cost-benefit analysis of recommended agronomic practices like the use of inorganic and organic fertilizers and other agronomic methods should be conducted in order to come up with reliable recommendations for production of upland rice as a forage.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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