Original Research Article

Fertilizer Effects on Panicle Characteristics, Grain Weight and Yield of Upland Rice in Lowlands of Taita Taveta, Kenya

Abstract

This study was done at Mlughi Agricultural demonstration farm in Bura, Taita Taveta County-Kenya to test upland rice varietal performance and di-ammonium fertilizer effects on panicle characteristics and yield parameter. A randomized complete block design (RCBD) was used with seven upland rice varieties and three fertilizer levels. The treatments were replicated thrice to give a total of 63 treatment combinations or plots. The experiment was carried out for two seasons (short rains from October to December 2018 and long rains from March to May 2019). The upland rice varieties included 17KH09010014B, 17KH09010093B, AT 058, China Hybrid, NERICA 1, NERICA 4, and NERICA 10. The fertilizer treatments were di-ammonium phosphate fertilizer (DAP), farm yard manure (FYM), and a control of no fertilizer. Topdressing was done at the flowering stage with NPK fertilizer. Data collected included plant height, number of leaves, tiller number, panicle length, spikelets count per panicle, grain yield ha^{-1} and weight of 1000 grains. The data were subjected to multivariate analysis of variance (MANOVA) using R version 3.6.1 program and Tukey's HSD test, $p \leq 0.05$ was used to separate the significant means. The results showed that there was significant influence ($p = 0.0001$) of overall seasonal, treatment and variety on the yield of rice grains in tonnes per hectare. The 2018 season had the lowest tonnage compared to the 2019 season. Crops under the control treatment yielded the least tonnage per hectare while the DAP treated fields yielded the highest in both seasons. NERICA 4 was the highest yielding variety while AT 058 was the least yielding among the treatments in both seasons. It was therefore concluded that the application of DAP and FYM significantly increased rice productivity. Farmers are therefore encouraged to carry out soil fertility testing occasionally and to plant NERICA varieties.

Keywords: Fertilizer; season; upland rice; manure; yield

1. INTRODUCTION

The origin of rice (*Oryza sativa*) was identified as India, Korea and Japan and it spread to the rest of Asia and other continents as a wild grass (Fuller, 2011, Singh *et al.*, 2018). *Oryza sativa* species is cultivated globally in all rice growing areas while *Oryza glaberrima* is confined to West Africa along the flooded plains (Yang *et al*., 2018). In Kenya, 95% of the rice is grown under flooded conditions while 5% is rain-fed (Muhunyu, 2015). The potential capacity for rain-fed upland rice was projected to be 2,600,000 ha which corresponds to 4.6% of the entire land space and is found in the western counties around Lake Victoria, South Eastern coast and the central part of the country (Saito *et al.*, 2016). The potential for irrigated rice is conversely limited by inadequate irrigation water while the environment and infrastructure play a key role (Uphoff *et al.*, 2015). Nevertheless, there is potential to grow rice under rain-fed conditions thus offering the possibility of producing rice in new areas as a means of increasing domestic output and therefore increasing household incomes, food and nutrition security. Rice is cultivated on a wide range of soils from sandy loam to heavy clay soils. The crop thrives under a wide range of soils, including saline or sodic soils, with pH range of 5.5 - 6.5 in upland rice cultivation and a pH of between 7.0 - 7.2 under flooded conditions (Uphoff *et al.*, 2015). Under rain-fed conditions, rice crop grows best when it receives an average rainfall of 800 – 2000 mm per annum and an altitude of 0 – 1700 meters above sea level (masl). The ideal temperature range is 25^0C to 31^0C at tillering, 30^0C to 35^0C at flowering and 20^0C to 29^0C at ripening (Deng *et al.*, 2015).

Low productivity in rice could be associated with lack of suitable varieties for these areas, use of traditional agronomic practices and limited water supply (Kimani *et al.*, 2011). This could be as a result of inadequate interest in coming up with innovations for developing upland rice (Nasuda *et al.*, 2014). Drought is one of the major constraints in the production of upland rice in Kenya (Kimani *et al.*, 2011). In order to achieve optimum yields, it is imperative to plant rice varieties that are tolerant to water stress. Rice responds well to both organic and inorganic fertilizer applications. The use of fertilizers was noted to increase rice productivity based on the ecological zones and has a strong correlation with yield and yield components under diverse soil nutrient environments (Jewel *et al.*, 2019). Studies on N, P, and K fertilizers, showed that grain yield was enhanced by increased levels of N and P up to the point of diminishing returns (Mulugeta and Heluf, 2014). Kajonphol *et al.*, (2018) also found out that nitrogen application promotes tillering and panicle growth, which may have resulted in more productive tillers and grains (Chawana *et al.*, 2021). Notwithstanding, most smallholder upland rice farmers rarely use inorganic fertilizers and/or manure despite the fact that application of fertilizer, especially nitrogen (Matsunami *et al.*, 2009, Salman *et al.*, 2012) enhances rice yields. Otsuka and Kalirajan (2006) reported that farmers in Sub-Sahara Africa use fertilizer inadequately despite studies showing that both organic fertilizers like cow dung and chicken manure (Kajiru, 2006) and inorganic fertilizers resulted in significant increase in yield. Inadequate use could be attributed to limited availability of fertilizers, high cost of fertilizers, inadequate quantities of good organic fertilizer, the bulky nature of most organic fertilizers which increases transport costs, and in some cases, the attitude of farmers on the importance of fertilizers (Kimani *et al.*, 2011). So far, few experiments to evaluate the performance of different rice varieties under rain-fed and different fertilizer conditions in Kenya have been done. The overall objective of this study was, therefore, to test the performance of selected upland rice varieties under different fertilizer levels in the lowland Bura valley ecosystem of Taita Taveta County.

2. MATERIALS AND METHODS

2.1 Experimental Site

This study was carried out in Taita Taveta County, Mlughi Agricultural demonstration farm in the South Eastern lowlands of Kenya. The experimental site was at a valley bottom which lies on GPS coordinates S03.49023° and E038.31244° and at an altitude of 949 meters above sea level. The area receives rain in a bimodal pattern, long rains which fall between March and May and short rains (October to December), with an average rainfall of 500mm per annum. The soils are mostly fluvisols with moderate to high fertility levels.

2.2 Planting Materials and Study Design

The study was carried out in October to December 2018, during the short rains, and was repeated in March to May 2019, during the long rains. Seven upland rice varieties, which consisted of four experimental lines from the Kenya Agricultural and Livestock Research Organization (KALRO) and three released NERICA varieties from the Kenya Seed Company were assessed in this study. They included 17KH09010014B, 17KH09010093B, AT058, China Hybrid, NERICA 1, NERICA 4, and NERICA 10. The experiment was laid out as a Randomized Complete Block Design (RCBD) with the two fertilizer levels and a control as the main block (plot) and the seven upland rice varieties as the subplots. The fertilizer treatments were (i) Di-ammonium phosphate (DAP, 18:46:0) at the rate of 13.5kg N ha^{-1} and 34.5kg P_2O_5 ha^{-1} and (ii) Farm Yard Manure (FYM) at the rate of 992kg N ha^{-1} in 2018 and 424kg N ha^{-1} in 2019, which was based on the soil test results and N concentration in the FYM. The control treatment had no fertilizer. The treatment combinations were replicated three times to give a total of 63 plots measuring 2m by 2.5m each. The distance between plots and between blocks was 0.5 meters. All the plots were topdressed with NPK (17:17:17) fertilizer at the rate of 11.05kg P_2O_5 ha^{-1} and 11.05kg K_2O ha^{-1} to promote tillering and seeding as described by Kajiru (2006). DAP and FYM were applied at planting while NPK fertilizer was applied at tillering stage. A seedling spacing of 20cm within the rows and 30 cm between the rows was adopted. Two seedlings were transplanted per hole within furrows, resulting in a plant population of 83 plants per plot or 166,000 plants per hectare. Thinning was carried out once the plants were established to obtain one seedling per hole. Good agronomic practices were carried our as commonly practiced by farmers in the experimental site.

2.3 Data Collection

Soil sampling was done at the beginning of the season before land preparation to determine adequacy of soil nutrients. Surface organic materials were removed, and soil samples randomly collected from 6 single cores within topsoil (0 - 30 cm depth), which is the root zone of upland rice. The samples were mixed thoroughly to make a 1.0 kg composite sample. Samples were packed in sterile 500 g containers and transported at room temperature to Crop Nutrition Laboratory Services Ltd for physicochemical analysis. The pH was measured using the Potentiometric method (Okalebo *et al.*, 2002) while nitrogen was analysed using Kjeldahl acid digestion (Wi, 2005) and organic carbon using the wet oxidation method (Anderson and Ingram, 1993). Total phosphorous was determined through the Olsen method (Okalebo *et al.*, 2002) while potassium, calcium and sodium were determined using the Mehlich 3 method (Mehlich, 1984). The crop parameters that were assessed included: the number of branches per panicle, number of grains per panicle, weight of 1000 grains, and grain yield per hectare. Six plants within one m^2 area at the centre of the plot were selected randomly for each plot and tagged at 14 days after transplanting (Yasmin *et al.*, 2018). Guard row plants were excluded from data collection. The six plants were used for collecting pre-harvest data. The final yield was determined from the $1m^2$ quadrant in the middle of each plot.

2.4 Data Analysis

All data was subjected to multivariate analysis of variance (MANOVA) using R version 3.6.1 program (R Development, 2019). The R packages used for this analysis were '*lattice*', '*asbio*', '*ffmanova*' and '*multicomp*'. Single parameter analysis of variance was used to evaluate the statistical significance where the MANOVA indicated significant interaction. If the means of the samples differed significantly, they were separated using Tukey's HSD test, $P \leq 0.05$. Analytical procedures followed methods described by Steel and Torrie (1980). Data in the tables are presented as means with standard deviation (±).

3. RESULTS AND DISCUSSION

3.1 Soil Chemical Properties

The soil type was fluvisols with a pH of 6.72 (slightly acidic) during the 2018 planting season and 7.08 (neutral) during the 2019 planting season. The pH for the FYM was 8.47 (slightly alkaline). The total nitrogen of the soil was 0.18% during the short rains, and 0.19% during the long rains. These values were low compared to the total nitrogen in farmyard manure which was high at 1.22% (Mulugeta and Heluf, 2014). Phosphorus was adequate for the soils in both seasons but low in the farmyard manure (**Table 1**). In addition, potassium levels were satisfactory in the two soil samples and medium in FYM (Wopereis *et al*., 2009).

Table 1: Analysis of soil and farm yard manure chemical properties status

Parameter	**Optimum values**	**Soil (2018)**	**Soil (2019)**	**Farmyard manure**
pH	5.0-6.5	6.72	7.08	8.47
Total Nitrogen (%)	>0.2	0.18	0.19	1.22
Total Organic Carbon (%)	2.0-3.5	3.10	3.89	11
Phosphorus (ppm)	30-100	36.20	28.40	0.23
Potassium (ppm)	>120	499	355	299
Calcium (ppm)	1060-1700	1200	1260	1170
Sodium (ppm)	30.1<140	96.4	99.20	80

3.2 Analysis of Variance

Analysis of variance showed that varieties and fertilizer treatments were significantly different for all four variables. Seasons had a significant effect on 1,000 grain weight and yield per hectare **(Table 2).** There was significant influence of overall treatment (P = 0.0006) and variety (P = 0.0001) and their interaction (P = 0.0100) on the number of branches per panicle. The results in this study showed that there was significant fertilizer main effect (P = 0.0001) and variety main effect (P = 0.0001) on the number of grains per panicle. In this research, there were significant differences (P = 0.0001) between seasons, among fertilizers and among varieties with respect to the weight of 1000 rice grains. There were significant differences (*P* = 0.0001) between seasons, among fertilizers and among varieties with respect to the yield of rice grains in tonnes per hectare.

Table 2: Overall seasonal and nutrient sources effects (*P* values) on yield and yield components

Source of variation	**Branches per**	**Grains per**	**1000-grain**	**Yield (ton ha^{-}**

	panicle	Panicle	weight	^{1})
Variety	0.0006	0.0001	0.0001	0.0001
Season	0.9669	0.9820	0.0001	0.0001
Fertilizer	0.0001	0.0001	0.0001	0.0001
Variety*Season	1.0000	1.0000	1.0000	1.0000
Variety*Fertilizer	0.0100	0.1556	0.3634	0.3488
Season*Fertilizer	0.6462	0.7002	0.3493	0.4232
Variety*Season* Fertilizer	0.9339	1.0000	0.7814	0.6627

3.3 Branches Per Panicle

The DAP fertilizer had a significant influence ($P \leq 0.05$) on number of branches in varieties 17KH09010093B and AT 058 in the 2018 season while in the 2019 season, DAP had a significant effect ($P \leq 0.05$) on 17KH09010014B, China Hybrid and NERICA 4 (**Table 3**). Farm Yard Manure had a significant influence on the branching ability of 17KH09010093B in the 2018 season, while in the 2019 season it influenced China Hybrid and NERICA 4 rice varieties. On average, DAP application resulted in the highest number of branches per plant in both seasons. However, when the varieties were treated with DAP, NERICA 1 and NERICA 10 differed significantly ($P \leq 0.05$) from other varieties. NERICA 1 differed significantly from NERICA 4. The number of branches per panicle is important in that it determines the spaces that are available for grain attachment on the panicle and therefore the yield. Consequently, the number of spikelets per panicle and the number of panicles per unit area influence the ultimate rice yield. Kato *et al.,* (2008), also made similar observations that in upland conditions where drought occurs sporadically, the number of spikelets per unit area contributes to yield to a very large extent. The difference in yield among the varieties could be due to pre-flowering abortions due to water stress or cold weather among other factors. Under moisture stress conditions, there is a considerable reduction of rachis branches which initiate spikelets thus limiting the number of spikelets per panicle during early reproductive stages (Kato *et al*., 2008).

Table 3: Number of branches per panicle of the seven upland rice varieties subjected to three fertilizer treatments in 2018 and 2019 seasons

Variety	**Fertilizer treatment**					
	2018			**2019**		
	Control	**DAP**	**FYM**	**Control**	**DAP**	**FYM**
17KH09010014B	9.9 ± 1.6^{Aa}	13.2 ± 2^{Ac}	10.7 ± 2.4^{Aa}	8.3 ± 1.4^{Aa}	13.8 ± 0.8^{Ba}	9.9 ± 1.3^{Aa}
17KH09010093B	8.5 ± 1.2^{Aa}	11.7 ± 2.3^{Bc}	11.3 ± 1.8^{Ba}	9.3 ± 1.1^{Aa}	11.5 ± 1.2^{Aa}	9.8 ± 1.4^{Aa}
AT 058	8.9 ± 1.1^{Aa}	12 ± 1.7^{Bc}	9.8 ± 1.6^{Aa}	8.1 ± 1.2^{Aa}	9.1 ± 1.3^{Aa}	9.3 ± 1.3^{Aa}
CHINA HYBRID	10.1 ± 1.6^{Aa}	12.1 ± 1.4^{Ac}	11.4 ± 1.3^{Aa}	8.8 ± 0.9^{Aa}	10.3 ± 1.2^{Ba}	12.6 ± 1.1^{Ba}
NERICA 1	9.3 ± 1.7^{Aa}	9.2 ± 1.1^{Aab}	8.6 ± 1^{Aa}	9.9 ± 1.3^{Aa}	10.9 ± 1.2^{Aa}	9.9 ± 1^{Aa}
NERICA 10	8.3 ± 1.3^{Aa}	8 ± 1^{Aa}	9.6 ± 1.4^{Aa}	8.1 ± 1.1^{Aa}	8.6 ± 0.6^{Aa}	9.1 ± 1.1^{Aa}
NERICA 4	7.8 ± 1^{Aa}	11.2 ± 1.4^{Abc}	10.7 ± 3.2^{Aa}	8.6 ± 1^{Aa}	13.8 ± 0.8^{Ba}	13.3 ± 1^{Ba}

The values in the table are Means ± Standard deviation, where n = 6. Different capital letters show significant differences ($P \leq 0.05$) among treatments per variety while small letters indicate significant differences ($P \leq 0.05$) among varieties per treatment

3.4 Number of Grains Per Panicle

The DAP fertilizer significantly influenced ($P \leq 0.05$) the NERICA varieties while FYM influenced the number of grains per panicle per plant in NERICA 10 and NERICA 4 during the 2018 season (**Table 4**). In the 2019 season, DAP had a significant effect on all varieties except 17KH09010014B whereas FYM had a significant effect on 17KH09010014B, NERICA 4 and NERICA 10 when compared to the control. Varieties differed under the control treatment in both seasons while in the 2019 season they differed under FYM where China Hybrid had the lowest number of grains per panicle (**Table 4**). Generally, FYM resulted in the highest number of grains per panicle in both seasons. The number of grains per panicle contributes to the yield output (Kato *et al*., 2008). This study identified a significant influence by the fertilizer main effect ($P = 0.0001$) and variety main effect ($P = 0.0001$) on the number of rice grains per panicle. The DAP fertilizer and FYM significantly affected the number of rice grains per panicle in ($P \leq 0.05$) in NERICA varieties during the 2018 season. The results from this study agree with the findings of Yosef, (2012) who noted that NERICA varieties can produce up to 400 grains compared to other upland varieties which can only produce 75 to 100 grains and also noted that the application of fertilizer (DAP) increased the number of grains per panicle in NERICA varieties compared to control plants.

Table 4: Number of grains per panicle per plant of the seven upland rice varieties subjected to three fertilizer treatments in 2018 and 2019 seasons

Variety	Treatment					
	2018			2019		
	Control	DAP	FYM	Control	DAP	FYM
17KH09010014B	72.8 ± 5.1^{Aab}	121.1 ± 8.8^{Aa}	124.8 ± 15.4^{Aa}	73.6 ± 5.2^{Aab}	122.8 ± 7.4^{Aa}	112.4 ± 26.7^{Abc}
17KH09010093B	94.1 ± 11.2^{Ab}	111 ± 5.4^{Aa}	113.9 ± 16.2^{Aa}	90.8 ± 7.4^{Ab}	115.9 ± 5.8^{Ba}	111.6 ± 12.6^{Bbc}
AT 058	90.8 ± 8^{Ab}	101.9 ± 14.2^{Aa}	100.5 ± 10.5^{Aa}	91.2 ± 7.7^{Ab}	108.7 ± 5.5^{Ba}	99.9 ± 8.7^{ABb}
CHINA HYBRID	58 ± 10.5^{Aa}	96.4 ± 24^{Aa}	99.9 ± 32^{Aa}	60.1 ± 10.1^{Aa}	97.6 ± 18.3^{Ba}	79 ± 7.3^{ABa}
NERICA 1	108.2 ± 9.8^{Ab}	123.2 ± 6.7^{Ba}	117.3 ± 8.7^{ABa}	105.9 ± 9.4^{Ab}	124.6 ± 5.5^{Ba}	118.2 ± 6.5^{Bbc}
NERICA 10	96.6 ± 6^{Ab}	114.9 ± 12.9^{Ba}	124.9 ± 10^{Ba}	95 ± 5.1^{Ab}	120.8 ± 5.4^{Ba}	118.9 ± 6.8^{Bc}
NERICA 4	84.1 ± 10.3^{Aab}	117.5 ± 15^{Ba}	116.7 ± 6.7^{Ba}	87.8 ± 11.4^{Aab}	121.3 ± 10.6^{Ba}	116.9 ± 5.9^{Bbc}

The values in the table are Means ± Standard deviation, where n = 6. Different capital letters show significant differences ($P \leq 0.05$) among treatments per variety while small letters indicate significant differences ($P \leq 0.05$) among varieties per treatment.

3.5 One Thousand (1000) Grain Weight

The 1000-grain weight is an indication of how dense the grains are. The 2019 season produced denser grains when compared to the 2018 season (**Table 5**). In both seasons, DAP resulted in significantly heavier grains ($P \leq 0.05$) compared to FYM or control treatments. This could be ascribed to the nutritional significance of P in seed formation which is higher in DAP than FYM. NERICA 4 and NERICA 10 produced the densest grains compared to other varieties. Grain weight is mainly determined by the supply of assimilates during the grain filling period and the capacity of the developing grains to accumulate the translocated assimilates (Koutroubas *et al*., 2008). Grain weight is also influenced by the intensity of moisture. Grain yield loss could therefore be attributed to moisture stress which could have led to a decrease in the number of filled grains per panicle. Yao *et al*., (2000) acknowledged the importance of sink size in enhancing rice grain yield. In this context, yield sink was defined as the product of number of filled panicles per unit area and the number of spikelets per panicle. One thousand (1000) grain weight is important in rice production because it helps the producer to project the expected yield and therefore make a decision on the profitability of taking up the enterprise. The increase in available N and P increases rice yield (Yadav, 2003). However, the research findings of Khorshidi *et al*., (2011), indicated that fertilizer application did not have a significant effect on the weight of 1000 grains and showed that weight is a varietal characteristic. In addition, a study by Liu *et al*., (2013) found out that both grain weight and number of panicles per plant influence total grain yield to differing degrees depending on the variety.

Table 5: Weight of 1000 grains per variety per treatment of the seven upland rice varieties subjected to three fertilizer treatments in 2018 and 2019 planting seasons.

Variety	**Treatment**					
	2018			**2019**		
	Control	**DAP**	**FYM**	**Control**	**DAP**	**FYM**
17KH09010014B	22.8 ± 2.4^{Aa}	27.4 ± 3.2^{Ba}	25.4 ± 2.4^{Bab}	24.2 ± 1.7^{Aab}	29.2 ± 2^{Cab}	26.6 ± 2^{Ba}
17KH09010093B	23.3 ± 2.4^{Aa}	26.1 ± 3.5^{Ba}	24.5 ± 3.4^{ABa}	25.3 ± 1.9^{Aac}	28.6 ± 2.4^{Bab}	27.3 ± 2^{Ba}
AT 058	23 ± 2.7^{Aa}	25.7 ± 3.6^{Aa}	25.8 ± 3.6^{Aab}	24 ± 2.5^{Aa}	27.5 ± 2.6^{Ba}	26.4 ± 3.4^{Ba}
CHINA HYBRID	23.3 ± 2.3^{Aa}	27.6 ± 1.6^{Ca}	26.2 ± 2.6^{Bac}	25.2 ± 1.7^{Aac}	28.1 ± 1.8^{Bab}	26.9 ± 2.4^{ABa}
NERICA 1	24.6 ± 3.2^{Aa}	25.6 ± 2.9^{Aa}	26.4 ± 3.4^{Abc}	26.2 ± 2.5^{Abc}	30.3 ± 1.4^{Bb}	27.3 ± 3.3^{Aa}
NERICA 10	24 ± 2.6^{Aa}	27.7 ± 2.7^{Ba}	26.1 ± 2.7^{ABac}	25.9 ± 1.3^{Aac}	29.7 ± 1.4^{Bab}	28.9 ± 1.6^{Ba}
NERICA 4	25.4 ± 2.9^{Aa}	28.9 ± 3.2^{Ba}	27.8 ± 3.1^{Bc}	26.3 ± 2.2^{Ac}	33.1 ± 1.6^{Cc}	28.6 ± 1.6^{Ba}

The values in the table are Means ± Standard deviation, where n = 6. Different capital letters show significant differences ($P \leq 0.05$) among treatments per variety while small letters indicate significant differences ($P \leq 0.05$) among varieties per treatment.

3.6 Yield Tonnes Per Hectare

Generally, the 2018 season had less grain yield tonnage compared to the 2019 season (**Table 6**). In addition, the DAP treated plots yielded the most while the control treatment yielded the least tonnage per hectare in both seasons. When comparing varieties within the treatments, NERICA 4 was the highest yielding variety while AT 058 was the lowest yielding variety in both seasons. NERICA 4 and NERICA 10 produced considerably high yields. This conformed with the results of Liu *et al.,* (2013) whose findings described the NERICA varieties to be superior to other upland varieties and the results of Menge *et al*., (2016) who explained the high yields of NERICAs due to adaptable root systems. The 2018 season had the least tonnage compared to the 2019 season, which could be attributed to weather-related parameters during the two seasons since higher rainfall was recorded in the 2019 season. The results of this experiment were in accord with the conclusion by Liu *et al.,* (2013) who noted a positive correlation between addition of soil nutrients, yield and yield components. The use of plant nutrients such as nitrogen led to an increase in photosynthetic rate and therefore an increase in the rate of the actual filling of the grains due to the separation of assimilates towards the rice grain which was the sink. A previous study found that the supply of nitrogen and phosphorus can possibly increase the density of the grains and therefore increase the yield (Yosef, 2012). On the other hand, Khorshidi *et al*., (2011) distinguished that grain weight, which is a major yield component is a genetic factor that is not solely a result of the soil organic matter or inorganic fertilizer effect.

Table 6: Yields in tonnes per hectare per variety per treatment of the seven upland rice varieties subjected to three fertilizer treatments in 2018 and 2019 seasons.

Variety	**Treatment**					
	2018			**2019**		
	Control	**DAP**	**FYM**	**Control**	**DAP**	**FYM**
17KH09010014B	4.10 ± 0.31^{Aa}	4.41 ± 0.17^{Ba}	4.12 ± 0.09^{Bab}	4.28 ± 0.26^{Aab}	4.75 ± 0.15^{Cab}	4.35 ± 0.07^{Ba}
17KH09010093B	4.01 ± 0.10^{Aa}	4.30 ± 0.04^{Ba}	3.99 ± 0.08^{ABa}	4.43 ± 0.19^{Aab}	4.73 ± 0.05^{Bab}	4.34 ± 0.20^{Ba}
AT 058	3.96 ± 0.10^{Aa}	4.29 ± 0.05^{Aa}	4.18 ± 0.13^{Aab}	4.19 ± 0.18^{Aa}	4.51 ± 0.06^{Ba}	4.39 ± 0.03^{Ba}
CHINA HYBRID	4.15 ± 0.26^{Aa}	4.53 ± 0.07^{Ca}	4.27 ± 0.10^{Bac}	4.36 ± 0.16^{Aab}	4.65 ± 0.05^{Bab}	4.37 ± 0.11^{ABa}
NERICA 1	4.21 ± 0.11^{Aa}	4.21 ± 0.05^{Aa}	4.35 ± 0.07^{Abc}	4.59 ± 0.26^{Ab}	4.86 ± 0.20^{Bb}	4.53 ± 0.06^{Aa}
NERICA 10	4.15 ± 0.19^{Aa}	4.53 ± 0.10^{Ba}	4.31 ± 0.07^{ABac}	4.50 ± 0.20^{Aab}	4.94 ± 0.03^{Bab}	4.64 ± 0.17^{Ba}
NERICA 4	4.44 ± 0.21^{Aa}	4.77 ± 0.04^{Ba}	4.55 ± 0.11^{Bc}	4.72 ± 0.35^{Ab}	5.29 ± 0.22^{Cc}	4.79 ± 0.01^{Ba}

The values in the table are Means ± Standard deviation, where n = 6. Different capital letters show significant differences ($P \leq 0.05$) among treatments per variety while small letters indicate significant differences ($P \leq 0.05$) among varieties per treatment.

4. CONCLUSIONS AND RECOMMENDATIONS

The results from this study suggest that NERICA varieties are superior yielding upland rice varieties. In addition, the DAP fertilizer had a better effect compared to other treatments, which could be attributed to the readily available P in DAP that enhanced good rooting. The 2019 long rain season also resulted in higher yields compared to the 2018 short rains. This could be accredited to more moisture retention in the 2019 long rain season as opposed to the 2018 short rain season. Further studies involving the NERICAs and different levels of DAP fertilizers could yield even more suitable combinations of varieties and fertilizers. Although significant differences in season effect were observed, further confirmatory inter-season comparisons are recommended.

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