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Interactive Effect of Nitrogen Fertilizer and Plant Density on Yield of Nerica 4 Upland Rice using Dibbling Method

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***Abstract*— *The experiment was conducted at the JICA-Tsukuba International Center Experiment Field during the April –October 2015 cropping season. The objective of this experiment was to evaluate the influence of Nitrogen fertilizer and plant density on growth and yield of NERICA 4 upland rice.* In this *study, a split-plot experimental design was used with three replications. The treatments comprised of Nitrogen fertilizer at 0 and 60 Kg N/ha; while planting was done using the dibbling method at spacings of 30cm x 30cm, 30cm x 15cm, and 20cm x 15cm which resulted into plant densities of 11.1 hills/m^2, 22.2 hills/m^2 and 33.3 hills/m^2 respectively. Results showed that Nitrogen application increased tiller number, plant length, leaf area index and SPAD Value at both maximum tillering and heading stages. The analyzed data on yield and yield components at (HSD 5%) showed no significant difference in panicle number/m^2, spikelet number/panicle, percentage of ripened grains, 1000 grains weight and paddy yield between plant densities at both 0, and 60 kg N/ha. However, plant density of 22.2 hills/m^2 resulted in the highest paddy yield of 2.79 t/ha and 3.77 t/ha at both Nitrogen levels 0, and 60 kg N/ha respectively. Plant density S_2 (22.2 hills/m^2) was the optimum for NERICA 4 upland rice for increased growth and yield*

***Keywords*— Nitrogen, Fertilizer, Plant density, Yield.**

I. INTRODUCTION

Rice (*Oryza sp.*) is increasingly becoming a crop of high demand both in Uganda and Zambia. Due to the rise in consumption levels of the commodity in these countries, there have been great efforts by respective governments through responsible ministries to double the efforts in its production. Despite these efforts, however, there have been many challenges that have kept production levels at its lowest. In Zambia, lack of knowledge among farmers and extension staff on rice production techniques and related agronomic practices such as planting methods, seed production, variety selection, fertilizer application and timing, have brought about the poor yields (www.iapri.org.zm, 2016). The fertility of Uganda soils is on the whole, declining. This is due to poor farming practices characterized by low inputs use, among other factors, and a generally poor farmers' response to soil conservation practices. The decline in native fertility is worsened by soil erosion and deforestation on top of low input continuous cultivation (Semalulu and Butegwa, 2000).

Plant response to Nitrogen is generally lower in dry than in wet soils because water deficits prevent plants from making full use of Nitrogen. Almost all upland rice soils have low Nitrogen (Aragon and De Datta, 1982; Mahapatra and Shrivastava, 1983). Local production is low and efforts to increase production are hindered by high input costs, and low yields, especially in the uplands. Cultural practices especially plant density (spacing) influence upland rice response to Nitrogen fertilizer (Chaturvedi, 2005). He further advises that judicial use of fertilisers can incredibly increase both the quantity and quality of harvested rice. The objective of this experiment was to evaluate the influence of Nitrogen fertilizer and plant density on growth and yield of NERICA 4 upland rice

II. MATERIALS AND METHODS

The experiment was conducted at the JICA Tsukuba International Center Experiment field, during the April-October 2016 cropping season. The upland rice variety NERICA 4 was used and sown at a seed rate of 30-40 kg ha^{-1}. The experiment was laid out in split plot design with three replications. The plot size was 3.6 m x 3.0m. Nitrogen fertilizer was applied at two levels of 0, and 60 Kg N ha^{-1} ; and plant spacing of 30cm x 30 cm, 30cm x 15 cm, and 20cm x 15 cm, planted using the dibble method with 6 seeds per hill. Data was collected on heading dates, plant height, tiller number, Leaf area index, panicle number, panicle length and 1000 grain weight.

TREATMENTS

N_0 and N_{60} denote fertilizer levels 0, and 60 Kg N ha^{-1} respectively.

S_1: Spacing of 30 x 30 cm (11.1 hills/m^2)

S_2: Spacing of 30 x 15 cm (22.2 hills/m^2)

S_3: Spacing of 20 x 15 cm (33.3 hills/m^2)

The experimental soil was slightly acidic, with optimum amount of nitrogen and carbon to nitrogen ratio.

Table 1Chemical property of experimental soils.

Properties	Values
pH (H_2O)	5.6
Total Carbon (%)	3.47
Total Nitrogen (%)	0.29
C/N	11.96
Available P_2O_5 (mgkg^{-1})	73.59

Meteorological data at JICA-Tsukuba 2016

Fig. 1 below shows the weather condition of rice during the experiment. The weather pattern indicated that month of July and August experienced below normal rainfall and extreme temperatures.

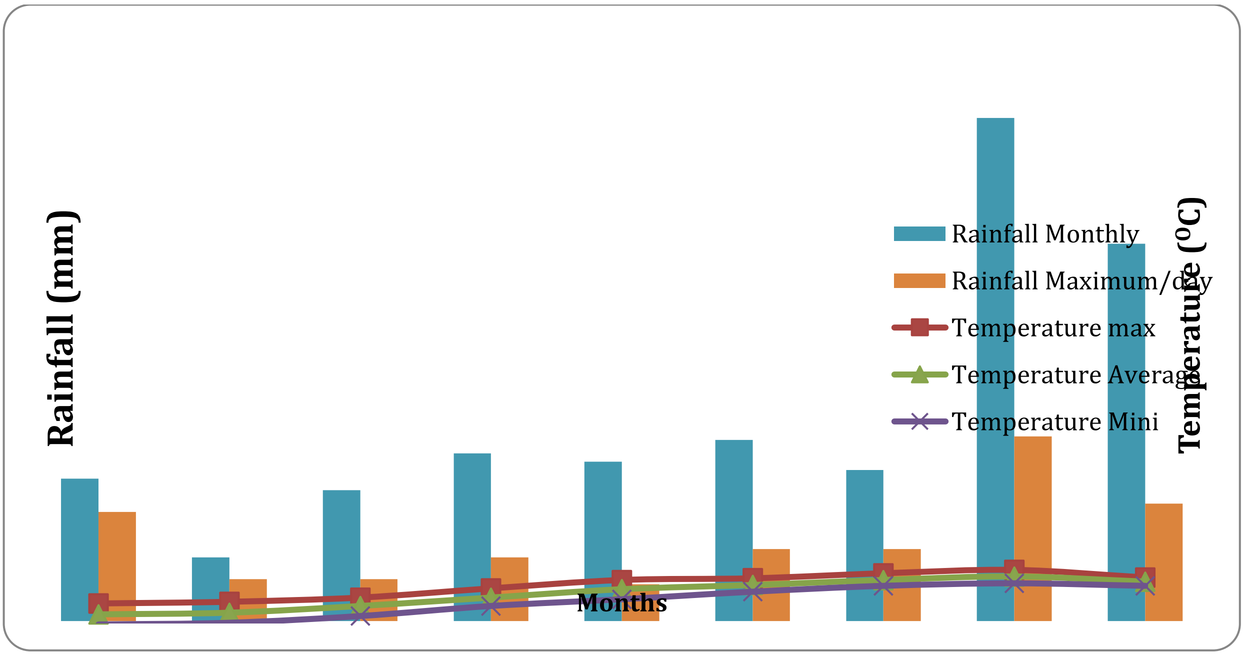

Fig. 1 Temperature and precipitation of the experimental season and normal year (Source: Weather report of the Metrological Agency).

Seed Preparation and sowing

Seeds were selected using 1.06 specific gravity salt solutions, disinfected by Benlate-T (Thiaruam 20%, Benomyl 20%) as fungicides for 24 hours, then dry for 24 hours. After drying seeds were coated with KIHIGENT (TMTD80%) as bird repellent. Seed rate of 30-40kg/ha was used.

Weed Control, GO-GO SAN the herbicides which contains 30% of Pendimethalin was applied 1 day after sowing and 2 times manual weeding was done.

Fertilizer Application

Fertilizers were applied as basal at sowing time and as top dressing about 20 Days before heading (DBH) as shown in Table 2.

Table 2 Fertilizer application regime.

Nutrient Type	Basal Dressing (Kg/ha)	Top Dressing (Kg/ha)	Total (Kg/ha)
1. N_0	0	0	0
2. Nitrogen	40	20	60
3. P (P_2O_5)	100	-	100
4. K (K_2O)	80	20	100

NOTE: N; Ammonium Sulphate (21% N), P_2O_5; Super phosphate (17.5% P); K_2O, Potassium Chloride (61% K).

Agronomic Observation

Agronomic parameters such as seedling establishment rate, SPAD value (chlorophyll content), dry weight/m^2, plant length, tiller number/m^2, leaf area index, culm length, panicle length and heading dates were recorded and evaluated. The panicle number/m^2, spikelet per panicle, percentage of ripened grains and 1000 grain weights were investigated as yield components at maturity stage. For data collection, 100cm rows were marked.

Data Analysis

Excel 2007 was used for data arrangement and the statistical analyses (ANOVA) of data were conducted using Statistics. 9. Mean separation was made according to HSD significance difference with Turkeys test at 5% significant levels.

III. RESULTS

YIELD AND YIELD COMPONENTS

The analyzed data on yield and yield components at (HSD 5%) showed no significant difference in panicle number/m^2, spikelet number/panicle, percentage of ripened grains, 1000 grains weight and paddy yield between plant densities at both 0 Kg and 60 kg of Nitrogen per hectare. However, plant density S2 (22.2 hills/m^2) showed the highest paddy yield at both Nitrogen levels of N_0 2.79 t/ha and N_{60} 3.77 t/ha respectively.

Table 3 Yield and yield components

Nitrogen Level, NL (Kg/ha)	Plant Density, PD (hills/m^2)	Panicle Number/m^2	Spikelet Number/panicle	Percentage of Ripened Grains (%)	1000 grains Weight (g)	Paddy Yield (t/ha)
N_0	S_1	140.30 a	89.10 a	63.85 a	27.42 a	2.34 a
	S_2	150.93 a	134.57 a	54.70 a	27.91 a	2.79 a
	S_3	172.90 a	76.30 a	64.05 a	26.76 a	2.18 a
N_{60}	S_1	129.63 a	121.70 a	59.00 a	28.11 a	2.69 a
	S_2	192.60 a	128.23 a	55.00 a	28.77 a	3.77 a
	S_3	183.33 a	73.37 a	78.30 a	27.95 a	2.95 a
NL X PD		ns	ns	ns	ns	ns

In each column, common letters indicate non-significant difference by Tukeys Honestly Significant Difference (HSD) at 5% level; ns not significant

CORRELATIONS

The analyzed results showed a high positive correlation (r=0.73) between number of panicles/m^2 and paddy yield as shown in Figure 2.

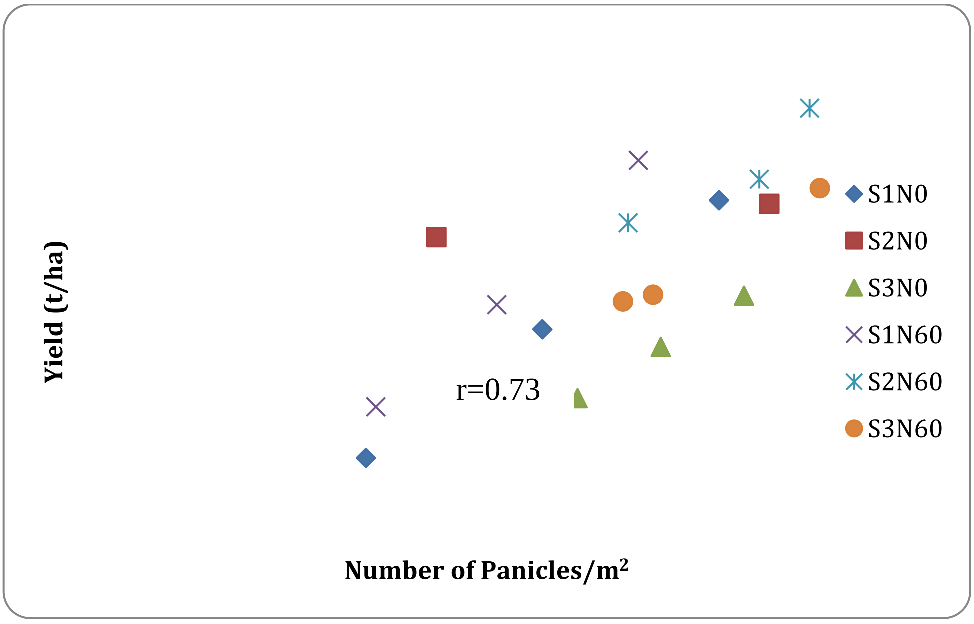

Fig. 2 Correlation between Number of Panicles/m^2 and Paddy Yield.

From the results, there was correlation (r=0.44) between number of Spikelets/panicle and paddy yield as shown in Figure 3.

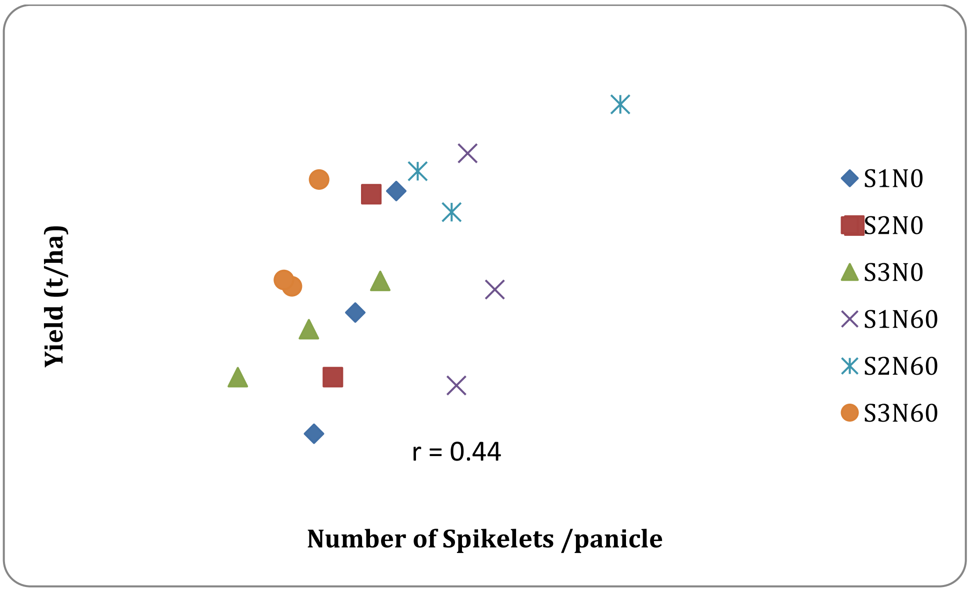

Fig. 3 Correlation between Number of Spikelets/ Panicles and Paddy Yield.

Nitrogen accumulation

The results showed no significant differences in Nitrogen accumulation between Nitrogen levels and planting densities throughout the three growth stages. At both maximum tillering and heading stages, planting density S_3 showed the highest Nitrogen accumulation at Nitrogen level 0 kg/ha. But at maturity stage S_2 planting density S_2 (22.2 hills/m^2) had the highest amount of accumulated Nitrogen.

However, at Nitrogen 60 kg/ha throughout all the three growth stages, S_2 (22.2 hills/m^2) showed the highest nitrogen accumulation as shown in the Table 2 below.

Table 4 Nitrogen Accumulation.

Applied Nitrogen (Kg/ha)	Plant Density (hills/m^2)	Nitrogen Accummulation (%)						
		Maximum tillering	Heading Stage			Maturity Stage		
			Culm	Panicle	Total	Culm	Panicle	Total
N_0	S_1	1.60 a	1.77 a	0.83 a	2.6 a	2.63 a	2.63 a	5.3 a
	S_2	1.93 a	2.98 a	1.28 a	4.3 a	3.24 a	3.24 a	6.5 a
	S_3	2.05 a	3.18 a	1.59 a	4.8 a	2.88 a	2.88 a	5.8 a
N_{60}	S_1	1.90 a	2.99 a	1.92 a	4.9 a	3.89 a	3.89 a	7.8 a
	S_2	3.77 a	5.19 a	3.86 a	9.1 a	5.69 a	5.69 a	11.4 a
	S_3	2.83 a	2.88 a	4.48 a	7.4 a	3.01 a	3.01 a	6.0 a

Means in a column with the same letter are not significantly different at 5% level by Tukey's HSD

TILLER NUMBER

Fig. 6 and Fig. 7 show no significant differences between Nitrogen levels and plant densities on tiller number for S_1 (11.1 hills/m^2) and S_3 (33.3 hills/m^2) at both Maximum tillering and heading stages. Nitrogen levels had no statistical influence on tiller number. However, at both stages of growth, Nitrogen levels increased tiller number at planting densities S_2 (22.2 hills/m^2).

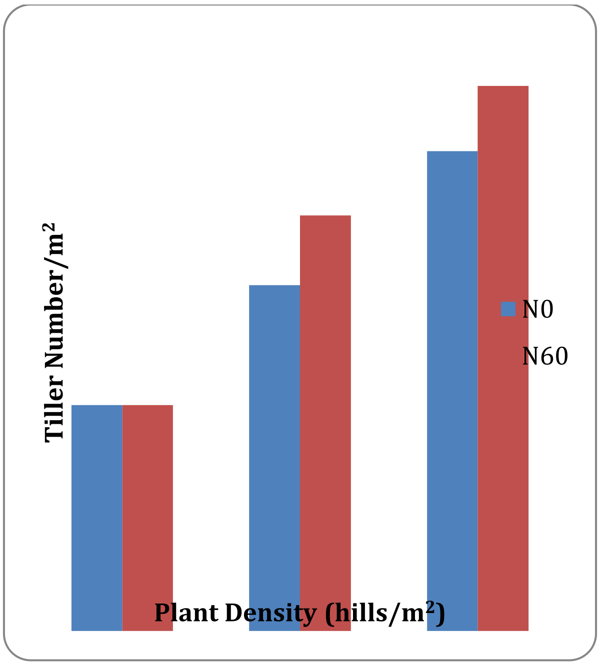

Fig. 6 Effect of Nitrogen fertilizer and plant density on plant length at maximum tillering stage.

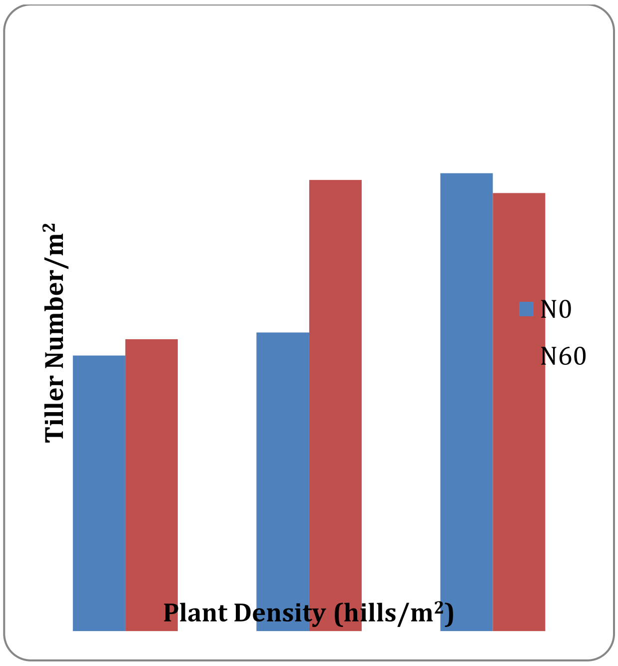

Fig. 7 Effect of Nitrogen fertilizer and plant density on plant length at headingstage.

There were no significant differences between Nitrogen levels and Plant densities on plant length at both maximum tillering (65 DAS) and heading stage (93 DAS). The study showed that Nitrogen levels influenced plant length at both planting densities with S^2 (22.2 hills/m^2) showing the longest plant length (Fig. 8, Fig. 9).

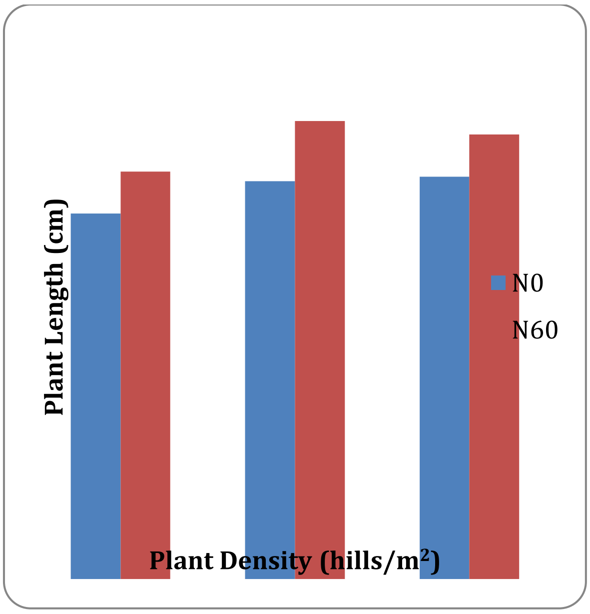

Fig. 8 Effect of Nitrogen fertilizer and plant density on plant length at maximum tillering stage.

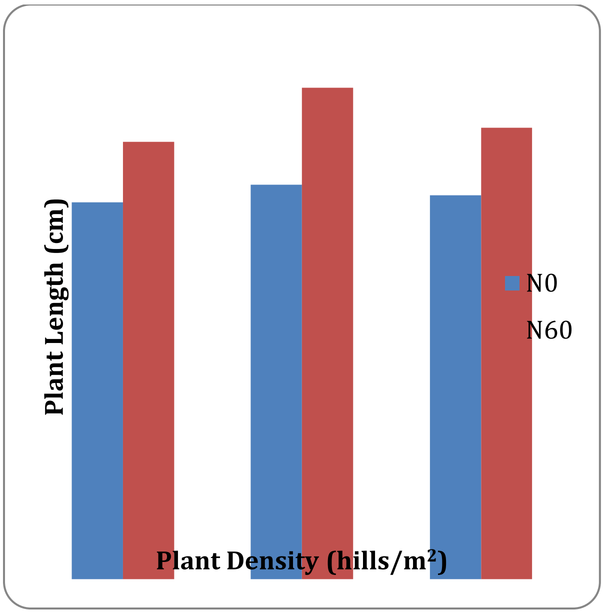

Fig. 9 Effect of Nitrogen fertilizer and plant density on plant length at heading stage.

SPAD VALUE

The observed results showed that S1 and S_2 had the highest SPAD values at maximum tillering (65 DAS), showing distinct influence of Nitrogen and plant density interaction on SPAD value. But S_3 did not show any responsiveness to Nitrogen levels and planting densities on SPAD Value. However, at heading stage (93 DAS), S_3 (33.3 hills/m^2) showed the highest SPAD value followed by S_2 and the least was S_1. There were significant increases in SPAD Value with N application. SPAD Value increased with Nitrogen application (Fig. 10, Fig. 11).

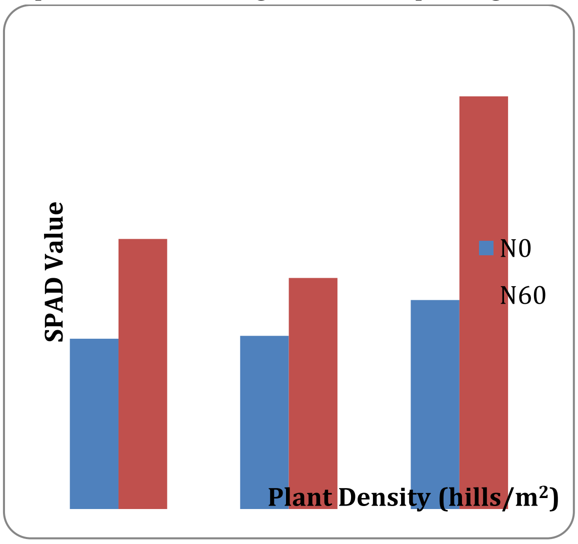

Fig. 10 Nitrogen level and plant density on SPAD value.

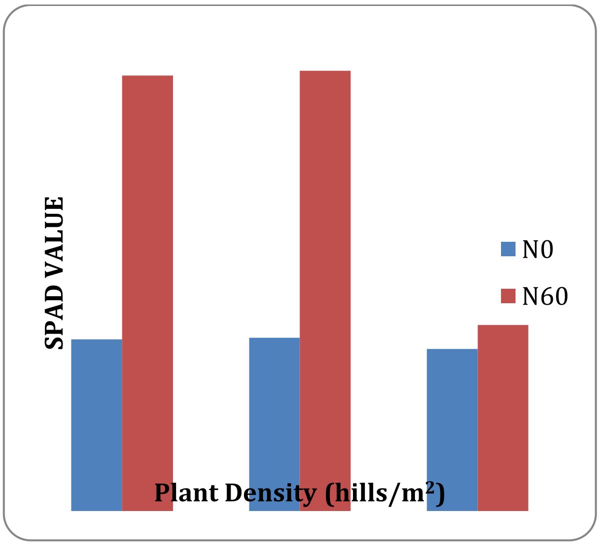

Fig. 11 Nitrogen level and plant density on SPAD value.

LEAF AREA INDEX

From the ANOVA, there were no significant differences between Nitrogen levels and Plant density on leaf area index at both maximum tillering (65 DAS) and heading stages (93 DAS). However, in both stages of growth, S_2 showed the highest LAI at N_{60} (Fig. 12, Fig. 13).

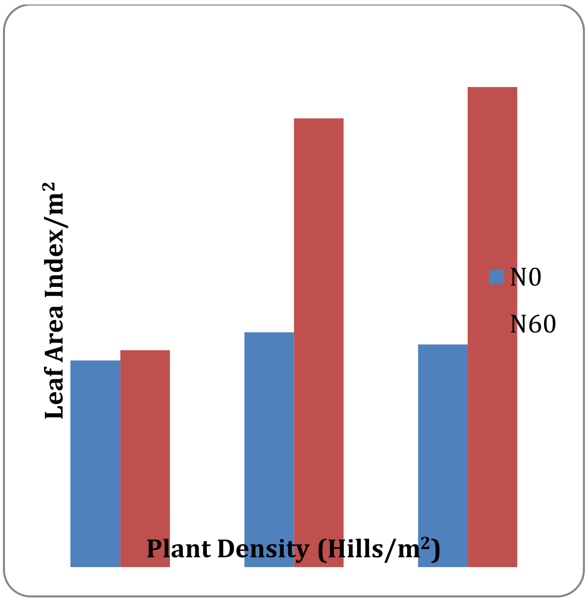

Fig. 12 Nitrogen and plant density on LAI.

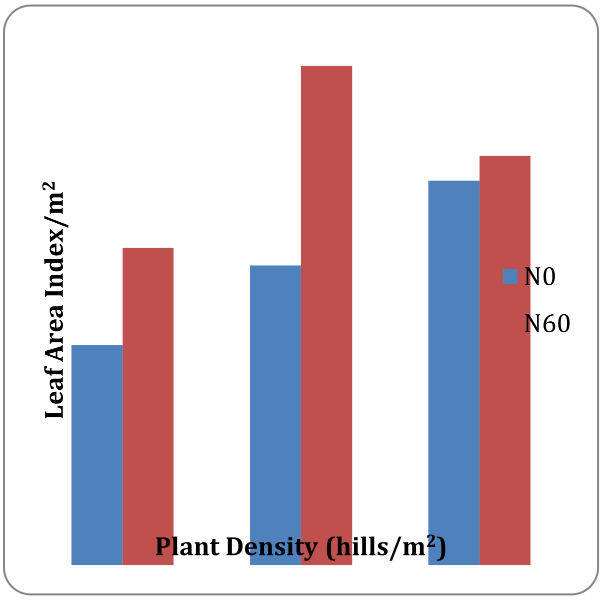

Fig. 13 Nitrogen and plant density on LAI.

IV. DISCUSSION

From the ANOVA, S_2 (22.2 hills/m^2) showed the highest paddy yield for both N_{60} (3.77 t/ha) and N_0 (2.79 t/ha). This can be attributed to the Panicle number/m^2 and spikelet number/panicle which was highest among the three planting densities at both Nitrogen levels. However, this was not the case for S_1 (11.1 hills/m^2) and S_3 (33.3 hills/m^2) which showed lowest paddy yields at both levels of Nitrogen. This is because S_2 was highly responsive to Nitrogen, resulting in less competition for nutrients and light amongst plants per unit area. These findings were confirmed by Fageria and Baligar (2001) who reported that grain yield in rice is a function of panicles per unit area, number of spikelets per panicle, 1000-grain weight and spikelet sterility. Further studies by Kamara and others (2001) reported similar findings that number of grains per panicle increased with increment in nitrogen rates. This was confirmed by the strong positive correlation (r=0.73) between number of panicles/m^2 and paddy yield. And a positive correlation (r=0.44) between number of spikelets per panicle and paddy yield. It is therefore, important to understand the management practices that influence yield components and consequently grain yield

No significant differences were observed in dry matter and Nitrogen Content accumulation in all the three stages of growth between nitrogen levels and Plant densities. But S_2 (22.2 hills/m^2) showed the highest dry matter and Nitrogen content at N_{60}. The dry matter content was higher in treatments with Nitrogen, the highest being at S_2 (22.2 hills/m^2) and N_{60} in all growth stages. This was due to less competition for nutrients and high responsiveness to Nitrogen fertilizer application.

It was further observed that Nitrogen levels and plant densities increased tiller number, plant length and leaf area index at all the three stages of growth. Amanullah *et al.*, (2008) reported similar findings that the increase in leaf area index increases light interception and hence photosynthetic activities are higher. This is due to high responsiveness to Nitrogen.

ANOVA results showed that SPAD value increased with fertilizer application in both S_1 (11.1 hills/m^2) and S_2 (22.2 hills/m^2) due to high photosynthetic activities and access to light. This caused a decrease in chlorophyll accumulation due to shading effect and competition for nutrients was low in S_3 (33.3 hills/m^2) which resulted in low SPAD Value

In conclusion, Nitrogen application increased tiller number, plant length, leaf area index and SPAD Value at both maximum tillering and heading stages. Plant density S_2 (22.2 hills/m^2) is the optimum for NERICA 4 upland rice for increased growth and yield. The recommendation is that a similar study must be conducted in both Uganda and Zambia to ascertain the optimum nitrogen level and plant density combination.

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