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Effects of Varied Nitrogen Levels and Plant Density on Growth and Yield of Nerica 1 Rice Variety

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Abstract: *NERICA varieties are fast gaining popularity in Kenya and have shown high potential in both rain fed lowland and rain fed upland ecosystems. Many farmers in Kenya still apply inadequate fertilizers and inappropriate spacing compromising the yields of paddy rice. This research experiment studied the effect of varying nitrogen levels and plant spacing on yield and yield components of NERICA. NERICA 1 rice variety was subjected to three levels of nitrogen (0, 60 and 120kg ha$^{-1)}$ and 3 spacings (30x15cm, 25x15cm and 20x15cm) in a split plot design with 3 replications. Soil was tested and plant nutrient analysed at the onset and at heading times respectively.Plant height, tillers and SPAD were recorded at 21, 32, 42, 55 and 65 DATs while Panicle length, culm length, spikelets/panicle, grain weight, % filled grains and grain yield were determined at 110DAT. The level of Nitrogen significantly influenced all growth and yieldparameters, while spacing was significant for tillers numbers m^{-2}, plant length, culm length, panicle length and % filled grains. There interactive effect of N and spacing was significant on tiller numbers m^{-2}, culm length, panicle m^{-2}, and 1000 grain weight and % number of filled grains. The highest grain yieldwas8.1tons ha^{-1}and 7.64tons ha^{-1} from 25x15cm and 30x15cm respectively, both at120kg N ha^{-1}.These were followed by 7.56 tons ha^{-1} from 20x15cm at 60kg N ha$^{-1.}$ There were no statistically significantdifferences ($P<0.05$) amongst these.There was significant increase in plant height, SPAD and panicle length with increase in nitrogen levels.Panicle m^{-2} and 1000grain weight increased to maximum at 60kgNha^{-1}. Tillers numbers m^{-2}and yield were maximum at 120kg N ha^{-1} but optimum levels were at 60kgN ha^{-1}. The% filled grains significantly reduced with increase in nitrogen levels.The study therefore shows that yield of NERICA can be improved by increasing nitrogen levels to optimum of 60kg ha^{-1} at 20 x15cm Spacing.*

Keywords: *NERICA, Nitrogen, Spacing, Yield, yield components*

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I. Introduction

Nitrogen is one of the most important elements for rice plant and adequate amounts are necessary to achieve high grain yield (WARDA, 1969; Rao, 2014). It has the strongest effect on growth and yield of rice (Ahmed *et al.*, 2005). Application therefore leads to increase in plant height, leaf size, panicles, spikelets and grain yield (Walker *et al.*, 2008). Apart from the effect of Nitrogen, increase in yields has also been due to improved high yielding varieties which are more responsive to N application.Yields are also qualitatively and quantitatively affected by planting densities (Matsubayeri*et al.*,1967). Thus, planting rice closer than normal spacing increases the cost and enhances chances of lodging (De Datta, 1981).

Whereas many famers apply less than recommended quantities of fertilizers or none leading to low yields, nitrogen application to appropriately spaced crop enhances morphological characteristics, reduces lodging and optimizes yield. The grain yield response to increased nitrogen application is reported to be linear but optimum levels need to be confirmed (Kamara*et al.*, 2011). This is especially for newly developed varieties.Many farmers in developing countriesstill do not consider planting density as an important factor in rice growth and development. In Kenya, more than 80% of farmers plant rice at random (NRDS, 2008; Rice MAPP Baseline Survey, 2012).

NERICA varieties are fast gaining popularity in Kenya and have shown high potential in both rain fed lowland and rain fed upland ecosystems (WARDA, 2010). They are becoming more popular in rain fed upland ecosystem, where most farmers currently earn their living (WARDA, 2008).Trials done on N response analysis have focused on different varieties and even more, on land races and improved varieties (Kamara*et al.*, 2011; Kegaand Maingi., 2005; Yoshida, 1972). The relationship between yield components with respect to different levels of N applications and various densities need to be examined.This work therefore focuses on growth response of NERICA1 and grain yield together with its componentson varying levels of applied nitrogen at different spacing. The study will determine appropriate Spacing and Nitrogen levels for NERICA1.

II. Materials and methods

Site Description

The experiment was carried out atMwea Agricultural Development Center(MIAD)in Mwea Irrigation Scheme,in Kirinyaga County at an altitude of 1159 masl. The climate is tropical with equatorial and medium high altitude characteristics andlies within Agro-ecological zones LM3 and LM 4 (Marginal cotton zones).Mwea receives a mean rainfall of about 930mm out of which 510mm is duringlong rainy season and 290 mm in short rainy season,with 66% reliability. The mean temperature is 22^oC with a wide range between minimum of 17^oC and maximum of 28^o C. The soils are predominantly Vertisols (LB 8) imperfectly drained, deep dark grey to black, cracking with calcareous deep sub soil. During the experimental period, average temperatures ranged between 24- 27^oC, with a minimum of 15 ^oC and a maximum of 34 ^oC.There werelow minimum temperatures of up to 15 ^0C which could have prolonged maturation period beyond stipulated 100 days, (WARDA, 2010). The amount of rainfall obtained was 174.6 mm, poorly distributed and far short of 20 mm per week recommended requirement. Supplementary irrigation was hence used to complement the requirement during the dry periods. Soil nutrients for N, P, K, and pH averaged 0.149%, 20 ppm, 0.149% and 6.65 respectively (Appendix 1.0).

Experimental Procedure

NERICA1 variety was grown atthreeNlevels of 0kg Nha^{-1}, 60kg Nha^{-1}and 120kg N ha^{-1})and three different spacing of 30x15cm25x15cmand20x15cm. These were laid out inSplit Plot Designwith three replications. Nitrogen levels were the main plots while spacings sub plots. The plots were separated by a 500 gauge blackpolyethenesheet, to prevent lateral nutrient mobility between plots.Soils were analysed for N, P, K and pH and weather data for the period recorded.

Seed and Seedling Preparation

Selected seeds were soaked for 24 hours in Seed plus-30WS(10% Cabendazim, 10%Metalaxyl and10% Imidacloprid) at 2.5g kg^{-1} seed, to prevent seed borne and earlyfungal and pest infections. The treated seeds were subsequently sprouted by soaking in water for 24 hours followed by incubation for another 48 hours at temperatures of about 30^oC to accelerate germination. Sprouted seeds werethen planted in to a nursery and raised for 21 days before manual transplanting of 1 seedling per hillat 4-5 leaf stage.

Field Preparation and fertilizer application

Prior to planting, land was rotovated 3 days after flooding, followed by leveling and removal of stubbles and weeds.Basal fertilizer equivalent of 50kg P_2O_5 ha^{-1}was applied to all plots.Nitrogen was appliedin two equal splits at 30 DAT and at PI. Potassium was applied at 2nd top dressing stage at the rate of 50 kg ha^{-1}.Weed control was done manually 3 times at 21, 40 and 55 DAT.

III. Data Collection

Growth observation were done and recorded five times at 30DAT, 42 DAT, 55 DAT, 75 DAT and 100 DAT. Plant tissue and nutrient analysis was done at 75 DAT.

Growth parameters

Ten hills per plot were sampled for plant height (cm), tillersm^{-2}and leaf age. Plant height was measured in cm from ground level to the vertical tip of the flag leaf using a ruler while the number of tillers were obtained by physically counting per hill and averaging for 10 hills. Total dry matter weight above ground was also recorded at heading stage (The hills were dried in the oven at 80^oC for 48 hours).Plant tissue was analysed for N content using Kjedahl's method (Kjedahl, 1883), P content by calorimetric method (Barton, 1948) and K content using flame photometry method (Schollenberger *et al.*, 1945). The ratio of the dry grain weight to total biomass (Harvest Index) was also determined at maturity.

Yield and yield components

Yield components were determined from ten hills collected from each plot. Panicle bearing tillers m^{-2}were counted and averaged. Number of spikelet panicle^{-1}; total spikelets per hill were counted and averaged by number of panicles.Percentage of ripened grain (%) was determined by separating filled and filled grains using a salt solution with specific gravity of 1.01. Weight of 1000 grains was determined from filled grains and adjusted to 14% moisture content. Grain yield was determined by partial harvest in an area of 1 m^2 in each plot afterremoving empty grains.

Data Analysis

Data were subjected to analysis of variance using SAS statistical package and means separated using the least significant difference test at p≤0.05.

IV. Results

Effect of N and spacing on plant height

Nitrogentreatments and spacing significantly affected plant height (Table 4.1). Application of either 60 kg or 120 kg N ha^{-1} gave significantly taller plants than non-treatment at 30, 42, 60 and 75 DAT. At 60 DAT, the effects of 120 Kg N ha^{-1} and 60 Kg N ha^{-1} treatmentswere similar. Plant spacing of 30 x15 cm gave significantly taller plants than either 25x15 or 20x15 cm at 21 and 30 DAT. The effect of interaction between N and spacing was not significant on plant height.

Effect of N and spacing on tillers

The effect of nitrogen and spacing significantly affected tiller numbers. Application of 120 kg N ha^{-1} gave significantly more tillers than non-treatment at all times. It was however not significantly different from that of 60 Kg N ha^{-1} at 60 and 75 DAT. Plant spacing of 25x15 gave significantly more tillers than either 30x15 cm or 20x15 cm at all times. There were no significant differences on tiller numbers from either 30x15 cmof 20x15 cm treatments.

Table 4.1: Effect of N and spacing on plant height and tillers

	Plant height					**Tillers**					
Treatment	**21 DAT**	**30 DAT**	**42 DAT**	**60 DAT**	**75 DAT**	**21 DAT**	**30 DAT**	**42 DAT**	**60 DAT**	**75 DAT**	
0 kg N/ha	23.3	36.8	50.4	61.3	75.8	88.4	155.3	333.1	325	289.3	
60 Kg N/ha	25.2	39.5	54.3	66.3	82.5	90.3	176.0	370.9	379.3	359.2	
120 Kg N/ha	24.5	39.7	54.9	69.2	90.3	92.6	188.3	410.1	449.1	414.7	
30 x15 cm	26.4	38.7	53.2	65.6	83.6	90.4	173.9	371	382.5	354.4	
25 x 15 cm	23.9	37.8	52.8	65.1	83.5	79.5	157.5	343.3	373.3	344.9	
20 x 15 cm	22.8	37.3	52.3	64.7	82.9	110.4	202.9	428.5	433.7	394	
Mean	24.3	38.7	53.2	65.6	83.6	90.4	173.9	371	382.5	354.4	
P-value Fertilizer	0.37	0.02	0.03	0.01	0.0001	0.77	0.04	0.0022	0.0001	0.0001	
P -value Spacing	0.05	0.003	0.42	0.6	0.79	0.0001	0.002	0.0002	0.0001	0.0002	
LSD (0.05) Fertilizer	NS	2.0	3.5	5.0	4.2	NS	24.9	38.5	31.7	26.9	
LSD (0.05) Spacing	2.9	2.0	3.5	5.0	NS	12.2	24.9	38.5	31.7	26.9	
Cv (%)		11.2	5.5	5.7	6.7	5.5	10.8	9.1	10.3	8.9	7.9

Effect of N and spacing on neck node

Application of 120 kg N ha^{-1}gave significantly longer neck node than 60 kg ha or non-treatment. Spacing and theinteraction between N and spacing had no significant effect on neck node length.

Effect of N and spacing on spiklets panicle $^{-1}$

The effect of N application significantly increased spikelets panicle $^{-1}$. Nitrogen application at 120 kg ha^{-1} gave significantly more spikelets per panicle compared with 60 kg N ha^{-1} and 0 kg N ha^{-1} treatment. Application of 60 kg N ha^{-1} and non- treatment (0 kg N ha^{-1}) did not result into statistical differences in the number of panicles. The effect of spacing and the interaction effect between N and spacing were not significant on spikelets panicle $^{-1}$.

Effect of N and spacing on grain yield

The effect of N was significant on grain yield, while spacing was not (Table 4.2). Application of 120 Kg N ha^{-1} gave significantly higher grain yield than either 60 Kg N ha^{-1} or non-treatment. The effect of interaction between N and spacing was not significant on grain yield.

Table 4.2: Effect of N and spacing on yield and yield components

Treatment	Leaf age	Panicle Length	Neck node	Spikelets/ panicle	Pan/ m^2	000 grain wt	% grain filling	Yield (t/ha)
0 kg N/ha	10.9	18.7	2.4	85.7	211.3	0.0287	0.909	4.7
60 Kg N/ha	11.0	20.6	2.6	107.3	372.4	0.029	0.59	6.6
120 Kg N/ha	11.0	21.9	2.9	111.1	413.4	0.030	0.574	7.8
30 x15 cm	10.9	20.8	2.7	103.0	306.6	0.0291	0.67	5.9
25 x 15 cm	11	20.5	2.6	103.3	328.3	0.0291	0.69	6.5
20 x 15 cm	11	19.8	2.6	97.8	362.2	0.0293	0.71	6.7

Mean	10.9	20.4	2.6	101.3	332.4	0.0290	0.691	6.4
P-value Fertilizer	0.79	0.0001	0.0001	0.0006	0.0001	0.35	0.0002	0.0002
P -value Spacing	0.77	0.027	0.55	0.055	0.0039	0.962	0.815	0.33
P-value- Fert x Spacing	0.55	0.03	0.32	0.089	0.047	0.0063	0.496	0.2999
LSD (0.05) Fertilizer	0.31	0.76	0.23	12.5	29.7	0.0017	0.146	1.16
LSD (0.05) Spacing	0.31	0.76	0.23	12.5	29.7	0.0017	0.146	1.16
LSD (0.05) Fert x Spacing	2.9	0.9	4.9	8.7	26.7	0.002	0.05	18.2
CV (%)	2.3	4.1	7.1	8.7	10.1	5.0	19.0	19.3

Effect of interaction between N and spacing on panicle length, panicle m^{-2}, grain filling and grain weight.

The effect of interaction between N and spacing was significant on panicle length, panicle m^{-2}, grain filling and grain weight. Application of 120 Kg N ha^{-1} at 30x15cm or 25x15cm spacing gave significantly the longest panicle length.Grain weight was also significantly highest but not different from that of 60 Kg N ha^{-1} x 25x15 cm spacing treatment.Grain filling reduced with increase in N levels and reduction in spacing. Treatment with 120 Kg N ha^{-1} at 20x15 cm spacing gave significantly the least grain filling while 0 Kg N ha^{-1}with 20x15 cm spacing had significantly the highest grain filling.

Table 4.2: Effects of interaction between N and spacing on panicle length, panicles m^{-2}, grain filling and grain weight.

Treatment	Panicle length	pan/ m^2	grain wt	% grain filling
0 kg N/ha * 30x 15 cm	20.1	200.0	0.030	0.82
0 kg N/ha * 25x 15 cm	18.1	177.8	0.028	0.86
0 kg N/ha * 20x 15 cm	17.9	211.1	0.028	0.79
60 kg N/ha * 30x 15 cm	20.1	348.1	0.026	0.71
60 kg N/ha * 25x 15 cm	21.2	426.7	0.026	0.58
60 kg N/ha * 20x 15 cm	20.3	388.9	0.029	0.63
120 kg N/ha * 30x 15 cm	22.3	444.4	0.032	0.58
120 kg N/ha * 25x 15 cm	22.3	346.7	0.031	0.61
120 kg N/ha * 20x 15 cm	21.0	433.3	0.030	0.54
Mean	20.4	330.8	0.029	0.7
P-value- Fert x Spacing	0.030	0.047	0.006	0.496
LSD (0.05) Fert x Spacing	0.9	26.7	0.002	0.1

V. Discussion

The soil N levels of 0.149% were fairly adequate for plant growth, although less than recommended minimum of 0.25 %. The amounts were capable of supplying 41% (equivalent to 35 kg N ha^{-1}) of the requirements. Phosphorus levels of 20 ppm were equivalent to 44 kg P_2O_5 ha^{-1}. This was nearly adequate to supply 73% (about 45 kg of P_2O_5 ha^{-1}) of the requirements. K level of 0.1485 meq was equivalent to 25 kg K_2O ha^{-1} and capable of supplying about 35% of the plant requirements. The pH level of 6.6 was near to neutral and availability of P as a critical nutrient was hence at maximum.

The level of N and spacing significantly affected growth, yield components and yield of NERICA 4 rice variety. However, the effect of N application was more pronounced than the effect of planting densities due to plant characteristics of the test variety. Plant height increased with increase in planting distance and N levels. The tallest plant height attained was 92.3cm followed by 88.3cm both from120 kg N ha^{-1}.Widely spaced plants were taller than closely spaced ones. The tallest plant was from 30 x15 cm spacing followed by 20 x 15 cm spacing.The increase in plant length with increase in N levels may be attributed to the effect of N on growth while taller plants from wider spacing waspartly due to reducedinter-plants competition. Non-significant responseon plant height observed between 120 Kg N ha^{-1} and 60 Kg N ha^{-1}treatments suggests that 60 kg N ha^{-1} applicationis optimum for NERICA variety.Results are consistent with reported findings of Mohammed *et a*l. (2011) that 60 kg N ha^{-1}is optimum for growth response.Plant height influences leaf area, affects photosynthetic assimilates, dry matter and grain yields (Akter*et al*., 2016).

Nitrogen and spacing significantly affected tiller numbers. The number of tillersm^{-2} increased with increase in N levels. The maximum number of tillers m^{-2} attained(463 m^{-2}) was higher than 189-304 plants m^{-2} which is required for maximum yields in rice (Councel, 1987). This suggests that increasing levels of N, increases number of tillers m^{-2}although optimum reproductive tillers may be limited to less than 120 kg N ha^{-1} as shown by a decline in tillers m^{-2} after 60 DAT. This is in conformity with reported findings that increased nitrogen levels increases tillers m^{-2}(Yoshida *et al*., 1972; Walker *et al*., 2005; Mohammed *et al.*, 2011). Tillers are one of the most important components of yield and more reproductive tillers lead to increased yields (Yoshida *et al*., 1972). Plant spacing of 25x15 cm gave significantly more tillers than either 30x15 cm or 20x15 cm spacing at all times. Spacing of 25x15 cm may therefore be the most appropriate for NERICA 1 variety under paddy conditions.

Panicle length increased with increase in nitrogen levels and reduced with closer spacing.Recorded highest and least panicle lengths of 23.5cm and 17.5cm correspond to 24.5cm and 18.5cm obtained from 150 kg

N ha^{-1} treatment by Salahuddin (2009). Nitrogen increases panicle length possibly due to its role in panicle formation and elongation. This is in conformity with reported findings of Salahuddin*et al*. (2009).

The number of panicle m^{-2} generally increased with increasing Nlevels and wider spacing**.**The effect of N increasing panicles per m^2 has previously been reported (Awan *et al.*2005; Ahmed *et al.*, 1998). There were no significant differences amongst 120 kg N ha^{-1} at 30x15 cm, 120 Kg ha^{-1} at 20x15 cm and 60 Kg N ha^{-1} at 25x15 cm. This suggests that application of 60 Kg N ha^{-1} at 25x15 cm spacing is optimum for NERICA 1 rice variety.The highest panicle numbers of 444.4/m^2 attained from high N levels and low density spacing of 30x15cm were higher than 266/m^{2}realised under upland conditions in Kenya (Kega&Maingi, 2005). Thissuggests that there is potential for increasing panicle m^{-2} for NERICA rice variety through higher N levels and wider spacing under paddy conditions.

Panicles m^{-2} increased with increase in levels of N application to 120 Kg N ha^{-1}. A spacing of 25 x 15 cm was advantageous at both 120 kg N ha^{-1} and at 60 kg N ha^{-1}.The increase is in conformity with reportedfindings by Ahmed*et al.*(1998).Grain filling reduced withincreasing levels of Nand reduced spacing.

The effect of N on grain filling may be attributed to enhancement of growth and consequent delay in maturation at the harvesting time of 115DAT.The negative correlation between N levels and maturity of rice has previously been reported (Wani*et al*., 2016). Grain weight increased with increase in N levels and there was lack of differences betweenapplication of 60kgN ha^{-1}at 25x15 cm and 120 Kg N ha^{-1} at 30x15 or 25x15cm. This suggests that 60 Kg N /ha isoptimum requirement. The results are consistent with reported findings of decreased 1000 grain weight with increased nitrogen levels by Tanaka *et a*l., 1969. However, it contradicts findings byAhmed *et al.* (1998), who reported no significant differences in weight with increase in N levels.

Higher nitrogen levels and closer spacing generally gave higher yields. Application of 120 kg N ha^{-1} at 25 x 15 cm gave the highest yield but not significantly different from 120 kg N ha^{-1} at 30 x 15 cm (7.75 t/ha), 60 kg N ha^{-1} at 20 x 15 cm (7.56 t/ha), 120 kg N ha^{-1} at 20 x 15 cm(7.53) or 60 kg N ha^{-1} at 25 x 15 cm (7.3 t/ha).This suggests thatoptimum yields for NERICA can be obtained from N levels lower than 120kg ha^{-1}dependent on inherentsoil fertility. The progressive increase in yield with increase in N levels up to a limit is consistent with reported findings of Ahmed *et al*(1998) and Salahuddin*et al.*(2009).The highest yield attained (8.1 t ha^{-1})was higher than (5 t ha^{-1}) reported under upland conditions (WARDA, 2005; Kega&Maingi, 2005). This suggests that the potential of NERICA under lowland ecological zone is higher than in upland areas.

VI. Conclusions

Nitrogen and spacing significantly affected growth and grainyield of NERICA 1 rice variety.High N levels and wider spacing significantly increased plant height with120kg ha^{-1}at 30x15cm spacing givingthe tallest plants. Although number of tillersm^{-2} increased to maximum at 120kg ha^{-1}, optimum number of reproductive tillers was attained at 60kg ha^{-1} with 30x15cm spacing. Panicle m^{-2} and Spikelets per panicle increased to optimum at 60kg ha^{-1} and 25x15cm spacing. The percentage filled grains however reduced with increase in N levels while 1000 filled grains increased to a maximum at 60kg N ha^{-1}. At 60kg N ha^{-1}and 20x15cm spacing, optimum yields were attained.

VII. Recommendations

Nitrogen level of 60 kg N ha^{-1}at 20x15cm spacing gave optimum yields hence better for NERICA 1 farmers, who normally apply medium levels of fertilizers. Tillers m^{-2}, spikelet panicle^{-1} and 1000grain weight increased to optimum levels at 60kg Nha^{-1}. A possibility of higher optimum levels should be tested at between 100-120kg N ha^{-1}.The delayed effect of nitrogen on maturity could have contributed to the reduction in percentage of filled grains with increased N levels. Harvesting at more than 115DAT can possibly increase % filled grains and the yield. There is need to undertake the trial with 120DAT for verification.

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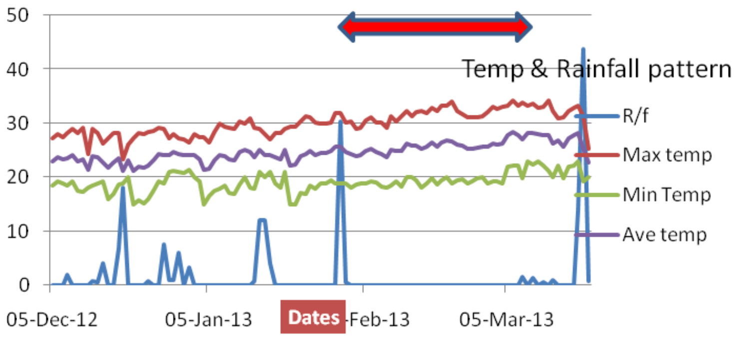
Appendix 1: Soil nutrient levels at the experimental site

	N%	P(ppm)	K(meq%)	PH
	0.189	19.0	0.127	6.58
	0.109	21.0	0.170	6.71
Average	0.149	20	0.1485	6.65

Obtained from Soil analysis Lab, MIAD- Mwea, January 2013

Appendix2: Weather for the period between November 2012 and March 2013



Adapted from MIAD field station during 2012/2013

W.A. Oyange. " Effects Of Varied Nitrogen Levels And Plant Density On Growth And Yield Of Nerica 1 Rice Variety. "IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS) 12.3 (2019): PP- 72-77.