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RESPONSE OF SOME IMPROVED UPLAND RICE VARIETIES TO DIFFERENT SOURCES AND RATES OF NITROGEN FERTILIZER IN A HUMID RAIN FOREST REGION

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ABSTRACT

Nitrogen (N) is a major lacking nutrient element for the growth and yield of cereal crops Calabar, it is necessary to determine the response different sources and rates of N in four varieties of upland rice. Treatments comprised factorial combinations of the four rice varieties (NERICA 1, NERICA 2, FARO 45, FARO 48), three straight inorganic N sources (urea, Calcium ammonium nitrate, ammonium sulphate) and four levels of N (0, 30, 60, 90 kg N ha^{-1}) laid in randomized complete block design. The N was split applied twice; one-third at the beginning of tillering and the remainder at panicle initiation. The results showed that the source of fertilizer N did not affect significantly the growth and yield of the rice crop (p=0.05). Considering that soils in Calabar are acid sands it will not be advisable to consistently apply such acidifying fertilizers as ammonium sulphate or urea except with soil liming which will undoubtedly increase the cost of production and probably make it unprofitable to cultivate rice in the area. The fertilized crop grew taller and produced more biomass compared with the control. It also produced significantly more tillers hill^{-1}, panicles m^{-2}, grains panicle^{-1}, weight of 1,000 grains and grain yield. However, whereas NERICA 1, NERICA 2 and FARO 45 were more responsive to lower N levels, the grain yield of FARO 48 was significantly higher when the crop received 90 kg N ha^{-1} compared with other varieties, probably because of its longer growth duration in the field. The responsiveness of these varieties to low N application was the result of their higher grain yield resulting from enhanced N use efficiency. Genotypes that were most responsive to low N input levels were early maturing with high N-use efficiencies. On the basis of grain yield, it is recommended that for high yield in the humid region of Cross River State, N should be applied at the rate of 60 kg ha^{-1} for early- and 90 kg ha^{-1} or above for the medium-maturing upland rice varieties.

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INTRODUCTION

Rice (*Oryza sativa* L.) is one of the world's most important cereal food crops. It is a staple food for more than half of the world's population, and about 1 billion households in Asia and Africa (Esang, 2015) and the Americas depend on rice cultivation for employment and their main esource of livelihood (Shimamura, 2005). Rice is extremely important food and cash crop in Nigeria. Rice is rapidly the preferred staple food in urban areas where annual consumption epartrroolexceeds 47 Kg per capita (Esang, 2015) with a total annual rice production of about 2 million tonnes (WARDA 2006. It is the fourth largest cereal crop grown in the country behind sorghum, millet and maize (WARDA 2006). However, Nigeria also imports about 2.5 – 3 million metric tonnes of rice as, total national consumption exceeds 5 million tonnes per year, or more than 30kg per capita per annum. Farmers sell about 80% of the rice they produce, making it a very important source of income for smallholder producers, complementing other agricultural production. Considering that total sales of rice exceeds $5 billion per year, $3 billion of which are from imports, there is a significant rice market in Nigeria (USAID, 2009).

Africa is a major player in the international rice market, importing about 9 million tonnes (32% of global imports) in 2006. The continent's emergence as a big rice importer could be explained by the fact that rice has become the most rapidly growing food source in sub-Saharan Africa (SSA) over the past few decades (Sohl, 2005). Indeed, due to rapid population growth (4% per annum), rising incomes and a shift in consumer preferences in favour of rice, especially in the numerous urban areas (Balasubramanian et al., 2007), the relative growth in demand for rice is faster in this region than anywhere else in the world (Africa Rice Center, 2007). Rice yields in upland systems are however generally low and average about 1 tonne per hectare. In Nigeria upland rice growing environment, drought, weed competition and a short growing season together with low soil fertility and rice blast disease are the major constraints to productivity. Upland rainfed systems are associated with higher production risk factors due to the unpredictable nature of rainfall. This has a great impact on the farmers' cropping system and production risk factors. This causes fluctuation in both yield and area under cultivation from year to year (WARDA, 2008). Modest inputs of organic and/or inorganic fertilizers or soil amendments such as rock phosphate, or the use of fallow legumes may counter soil fertility decline in the upland environments and improve yields. Studies on soil characterization show that in the upland production systems, the magnitude of nitrogen (N) deficiency increases from the humid forest to the semiarid zone, whereas phosphorus (P) deficiency is highest in the humid forest but low in the semiarid (Oikeh et al, 2006). On soils developed from sandstones, all three macronutrients N, P and K, are deficient. Therefore, to optimize rice production in these soils will require the application of fertilizers. Chemical fertilizer use has contributed significantly to increased global food output in the past half century, especially in climatically favourable regions of the world. It is now widely adopted in rainfed and irrigated agriculture. As elsewhere, fertilizer use is underpinned by concerns about biological and economic efficiency. Fertilizer use efficiency is therefore central to the current concept of fertilizer best management practices, which embraces right source, right timing and Aright application methods. Thus, improving nutrient use efficiency should be given top research priority.

Fertilizer use efficiency is also influenced by soil test values and agronomic factors that influence crop yields such as sowing date and varietal differences. Rational fertilizer application rates are guided by calibration-response trials. The response of improved rice varieties (which are usually short-statured and high-tillering) to applied inorganic fertilizer is in general superior to the local cultivars. Furthermore, fertilizer recommendations often apply only to the soil type the trial was executed on. Continuous research efforts, taking into account local conditions, fertilizer and product prices are needed to establish optimal fertilizer rate(s) for different cultivars and production systems. The extremely low usage of inorganic fertilizer in Nigeria is associated with the high cost of fertilizer. Also, inappropriate fertilizers are used in many areas because there is a lack of soil testing, thus uneconomic blanket applications of expensive and scarce fertilizers are used. In addition, environmental concerns and increasing human population have led to research on permanent and intensive cropping on the land. One strategy to facilitate cultivation of the same piece of upland rice field without high input of human and fossil energy, nutrients and chemicals is the use of low – input rice varieties. This is a major challenge for research because upland rice often needs a higher level of fertilization than does lowland rice. Nitrogen is most often the limiting nutrient and is required in the greatest quantity for rice production as N deficiency effect is manifested quickly on plant growth and ultimately on crop yield. Hence, the fertility status of a soil depends to a great extent on the N status of the soil (Sinha and Prasad, 1980). African rice varieties are generally well adapted to the major stresses found in upland areas. When grown under non–intensive management, these tend to produce moderately higher yields in farmers' fields than introduced Asian varieties. The New Rice for Africa (NERICA) varieties developed by the West Africa Rice Development Association (WARDA, now Africa Rice

Centre) are reputed to give high yields under low – input management conditions (WARDA, 2008). It is important to examine the relationships between yield and nitrogen utilization and the economics of production. The goal of this research work was to achieve food self-sufficiency by increasing the productivity of upland rice in the rainforest region of Cross River State. The research objectives were to: Assess the productivity of some improved upland rice varieties as influenced by different N sources and levels. Determine Nitrogen-use efficiencies (NUE) of the rice cultivars

MATERIALS AND METHODS

Experimental site

A two - year field experiment was conducted at the Teaching and Research Farm of the University of Calabar, Calabar from May to August of 2010 and 2011. Calabar is located in the humid rainforest agro - ecological zone of Nigeria. It is co-ordinated by latitude $05^{0}3^{'}$ and $04^{0}27^{'}$ North and longitude $07^{0}15^{'}$ and $09^{0}28^{'}$East. Rainfall is bi-modal with peaks in June and September, with a short dry spell in August. Annual rainfall ranges from 2500mm-3500mm, combined with a high relative humidity (75-85%) typical of a humid rainforest as well as high ambient temperatures (27^{0}C to 35^{0}C) (CRBDA, 1995).

A piece of farmland measuring 291 × 21 m was cleared with machete, the cut vegetation raked and the land tilled with hoe and spade. The field was then divided into 3 blocks, each consisting of twelve plots of 3 m × 3 m, separated by 3 m-wide boundaries in order to minimize drift of applied nitrogen to adjoining plots and avoid unintended effects. The land had previously been cultivated to cassava (*Manihot esculentus*) and pumkin (*Telfaria occidentalis*), in rotation for several seasons. Whereas cassava had been fertilized with NPK, pumkin received poultry droppings and low levels of urea. The predominant weeds observed at the site were *Paspalum scrobiculatum*, *Chromoleana odorata*, *Tridax procumbens*, *Euphorbia heterophylla* and *Cyperus* species.

Composite soil samples were randomly collected with a soil auger from a depth of 0 -30 cm prior to tilling and after crop harvest. The soil samples were thereafter air-dried, sieved with a 2 mm sieve and analyzed for physical and chemical properties. The soil particle size was done by the hydrometer method (Bouyoucos, 1951); soil textural class determined with a soil triangle; soil pH was determined in a 1:2.5 soil: water suspension using a glass electrode pH meter (corning p H meter portal 7); organic carbon was determined on 2gm soil samples by wet oxidation with dichromate as outlined by Anderson and Ingram (1996); total nitrogen was determined on soil sample (sieve through 2mm mesh) by the micro kjeldhal procedure (IITA, 1979), using mercuric sulphate and selenium dioxide catalysts. Available P was extracted by the Bray no.1 solution and estimated by the molybdenum blue technique as described by IITA (1979); exchangeable cation were determined on extracts obtained after leaching samples with 1N neutral ammonium acetate (1N NH_4OAc:pH 7.0) solution. Sodium and potassium were determined with an EEL flame photometer, while calcium and magnesium were determined by the vernasate (0.1m EDTA) titration method. Effective acidity (H^++ Al^{3+}) was extracted with 1N KCl and estimated in the extract by titration (Jackson, 1969). The results of physico – chemical analysis of the soil are presented in Table I. Treatments comprised factorial combinations of 4 upland rice varieties {FARO 45, NERICA 1 (FARO55), NERICA 2 (FARO 56), and FARO 48}, 3 inorganic nitrogen sources (urea, calcium ammonium nitrate, and ammonium sulphate), and 4 rates of inorganic nitrogen application (0, 30, 60, and 90 kgha^{-1}) laid in a randomized complete block design, replicated thrice. FARO 45, NERICA 1 and NERICA 2 are early maturing varieties (90 – 100 days), while FARO 48 is medium maturing (100 – 120 days). Nitrogen was split applied twice; one third at tillering and the remainder at panicle initiation The rice varieties were obtained from the National Cereals Research Institute, Badeggi, Niger State while fertilizer was procured from the Cross River State Agricultural Project’s fertilizer depot at Ikot Effanga, Calabar.

Rice seeds were primed by hardening (Binang *et al,* 2012b) before sowing at the rate of 50kgha^{-1}. Five rice seeds were dibbled per hole on May 5, 2010 and May 3, 2011. The planting distance was 20 cm × 20 cm while thinning/supplying to two seedlings per stand was at three weeks after sowing. The sowing depth was 2 – 4 cm. Each plot received 13kg P, 25kg K and 20kg Zn per hectare at sowing time. The P was applied as single superphosphate (SSP), K as Potassium chloride (MOP) and Zn as zinc sulphate. Weed control was done manually using hoe and machete; thrice at 3, 6 and 9 weeks after sowing (WAS). Insect pests such as stem borers and leafhoppers were controlled by the use of Lamdacyhalothrin at the rate of 25g a.i. ha^{-1}, at 6 and 10 WAS, while birds were controlled by a combination of trapping with fishing nets and scarring by hired labour. The following parameters on plant growth and yield were collected for analysis; Plant height (cm) was taken from a net plot of 1 m^2 at plant maturity. It was done by measuring the plant with metre rule from ground level to the tip of the tallest stem measured at the ring of hairs below the panicle (junction of culm and peduncle) (Grist, 1983). Number of total tillers per m^{-2} taken as the average of all tillers from a square metre of each plot. Number of panicles per m^{-2} taken as the mean of all panicles from a 1 m^2 sample plot at plant maturity. Number of grains per panicle was taken as the mean number of grains obtained from panicles in (c) above. The 1000-grain weight was the average weight of 1000 randomly selected grains per plot, taken at plant maturity. Weighing of grains was with a sensitive Mettler weighing scale. Grain yield was determined based on a 1 m^2 net plot and expressed on a hectare basis. Significant differences among treatments were determined using a three-factor analysis of variance (ANOVA) model. Comparison of treatment means was done using the least significant difference (LSD) test as described by Gomez and Gomez (1984). The GENSTAT 5.0 release, Discovery edition 1 (2003) package was used for all the statistical analysis.

RESULTS

The results of soil analysis indicated a pre planting average soil pH of 4.30 and 4.50 in 2010 and 2011 (Table 1). These values indicated that the soil was acidic. The percentage total N was low (Table 1). The soil was predominately sandy soil. Therefore, the soil requires application of fertilizer in order to improve its fertility. The meteorological data of Calabar during the period of study is presented in Table 2. In both years, rainfall was bi-modal with peak rainfall occurring in the months of June and September in 2010, and June and August the following year. The mean rainfall during the months of May to August when the crop was in the field was 350.7mm and 478.5mm in 2010 and 2011, respectively. The corresponding mean atmospheric temperature, relative humidity and number of sunshine hours received was respectively, 29.6 ^{0}C, 88.5%, 2.8 hours (2010) and 25.4 ^{0}C, 84.0 %, 4.3 hours (2011). Although the incident solar radiation, particularly in 2010 might have been insufficient to allow high yields and optimize nitrogen fertilization (Schalbroeck, 2001), the general climatic conditions of Calabar during the period of study were suited for the cultivation of upland rice (Gupta and O'Toole, 1986). The effects of rice variety, source and rates of N on plant height at maturity are presented in Tables 2. Across all treatment combinations, average plant height increased from 58.6 to 122.6 cm in 2010 and 70.3 to 125.5 cm in 2011. In both years, FARO 48 was the tallest, followed by FARO 45, but the difference between NERICA 1 and NERICA 2 was not significant. Plants that received nitrogen fertilizer were taller than the unfertilized ones, irrespective of the rice variety but the source of N made no significant difference. Plant height increased progressively with increasing N rate, although the difference betwen 60kg N and 90kg N ha^{-1} was not significant in the NERICA 1 and NERICA 2 varieties, applying 90kg N ha^{-1} gave FARO plants that were significantly taller than those that received 60kg N ha^{-1}. The ability of low rates of N fertilizer to increase plant height was more pronounced with the NERICA varieties. Compared with FARO 45 which is also early maturing, the two NERICA varieties responded better to the lower rate of 60kg N ha^{-1}. Overall, the higher N rates of CAN tended to produce the tallest plants.

The number of rice tillers per m^{-2} pooled across all N sources and rates averaged 226.09, 226.56, 227.57 and 229.50 (2010), and 267.95, 264.41, 264.45 and 265.72 (2011), for NERICA 1, NERICA 2, FARO 45 and FARO 48, respectively (Table 3). In both years of study, varietal differences did not affect tiller production significantly. However, source of N significantly influenced tillering in 2011 only, with plants that received CAN or ammonium sulphate fertilizers bearing more tillers than others. Irrespective of the rice variety cultivated and source of N, tillering was enhanced by N fertilization, the number of tillers increasing linearly with N rate. Increasing the rate of N application from zero to 90kg ha $^{-1}$ increased total tiller number up to but, not beyond 60kg ha^{-1} in all the varieties. The NERICA varieties tended to bear fewer tillers as the application rate exceeded 60kg ha^{-1}. CAN at the rate of 60kg ha^{-1} applied to NERICA 1 followed by FARO 48 that received 90kg ha^{-1} Ammonium Sulphate produced the highest number of tillers per m^{-2} (300.6 and 296.0, respectively).

All fertilized plants had a significantly higher number of panicle-bearing plants than others (Table 4). In 2010, average panicles obtained per m^{2} was 180.2, 192.6, 205.9 and 223.4 for the unfertilized control, 30, 60 and 90 kg N ha^{-1}, respectively. This increased the following season to 233.52, 241.67, 255.30 and 265 54, respectively. Pooled across both seasons of study, the differences in panicle gain due to N fertilization between the rates of 60 and 90kg N ha^{-1}was significant only in FARO 48, but there was no significant difference between 30 and 60 kg N ha^{-1} when applied to NERICA 1, NERICA 2 and FARO 45. (P=0.05) Although N source did not show significance, the interaction comparison revealed that panicle m^{-2} increased significantly with increasing N rate, particularly in FARO 45 and FARO 48. The beneficial effects of high N rate were less pronounced in the NERICA varieties in which the number of panicles obtained by applying 60kg N ha^{-1} was similar to those from the higher dose of 90kg N ha^{-1}. The effect of the various treatment combinations on the number of grains per panicle is presented in Table 5. The number of grains borne per panicle averaged 165.34, 164.51, 161.36 and 162.98 for NERICA 1, NERICA 2, FARO 45 and FARO 48, respectively in 2010, and 173.47, 167.10, 164.06 and 169.61 in 2011. The effect of rice variety on grains per panicle was not significant. However, fertilizer N application significantly increased the number of grains borne per panicle, compared with the zero fertilizer treatment. Pooled across all varieties, plants that received 30, 60 and 90 kg N ha^{-1} produced panicles with 9.7, 24.9, and 34.4 % more grains per panicle than the no-fertilizer treatment in 2010, and by 9.2, 20.9 and 28.2 % the following year. The number of grains per panicle was invariably higher under high than low N levels, particularly in FARO 48 in which the difference between 60 and 90 kg N ha^{-1} was significant.

The number of spikelet per panicle averaged 13.3, 13.3, 12.3 and 12.4 in NERICA 1, NERICA 2, FARO 45 and FARO 48, respectively (2010), and 14.7, 14.8, 14.4 and 14.9, respectively in 2011 (Table 6). Neither the rice variety, N source, N rate nor the interaction effect was significant in both years of study.

Table 7 shows the response of the weight of 1000 grains to the different treatments studied. The average weight of 1000 grains pooled over both seasons was 27.9, 26.49, 24.09 and 25.03g respectively for NERICA 1, NERICA 2, FARO 45 and FARO 48. Grain weight was not dependent on source of N applied (P = 0.05), but the effect of variety was significant in 2011 only, in which NERICA 1 had grains that weighed significantly more than others. Grain weight increased with rate of N applied in FARO 45 and FARO 48, but not beyond 60 kg ha^{-1}.

Average over all varieties and sources of N, rice grain yield was approximately 1.36, 2.27 2.72 and 2.95 t ha^{-1} (2010) for the unfertilized control and N applied at the rates of 30, 60 and 90 kg ha^{-1}, respectively (Table 8). The corresponding yield values in 2011 were 1.49, 2.56, 3.33 and 3.49 t ha^{-1}, respectively. Grain yield was significantly influenced by the combination of rice variety and rate of N fertilization. Grain yield of the four varieties studied increased with N rate but, whereas the response was not beyond the 60 kg ha^{-1} rate in NERICA 1, NERICA 2 and FARO 45, the highest rate of 90 kg ha^{-1} gave significantly more yield than other treatments (Tables 8). NERICA 1 out yielded NERICA 2, FARO 45 and FARO 48, respectively by 2.9, 29.8, and 5.9 % in 2010, and by 9.3, 19.4 and 10.3 % the following year.

The source and rate of N did not affect the duration to maturity of the rice varieties cultivated (P = 0.05). In 2010, NERICA 1, NERICA 2, FARO 45 and FARO 48 matured in approximately 94, 95, 97 and 127 days, respectively while the corresponding maturation duration was 97, 95, 94 and 129 days in 2011.

DISCUSSION

The soil was acidic in reaction and was more fertile in 2011 than in the preceding year. According to Sinha and Prasad (1980), the fertility status of a soil depends to a great extent on its N status of which the organic matter content constitutes a major source of nutrients, especially N in low-input rice cultivation systems. Even in the case of high yields of rice, N derived from the soil has been shown by Ponnampenuma (1984) to make up about 76 to 80 percent of the total N uptake of single-cropped rice. Tropical humid forest soils containing less than 0.15% N are considered to be low in the nutrient (Enwezor *et al.* 1989). In addition, there was a higher precipitation and incident solar radiation in 2011 which might have favoured the optimization of nitrogen fertilization and accounted for the better crop performance recorded in 2011.

The rice grain yield was relatively low, and ranged from 1.02t/ha to 4.43t/ha. Under farmer's field conditions, NERICA 1 and NERICA 2 produces average yields of 4.5t/ha and 4.0t/ha, respectively, (WARDA, 2010), while the average yield of FARO 45 and FARO 48 is 4.3t/ha and 5.4t/ha, respectively. The NERICA varieties yielded better probably because of their resistance to insect pests and leaf blast which were prevalent during the study, as well as their resistance to lodging. The mean daily number of sunshine hours during the crop growing months (May, June, July, August) was 4.4, 3.2, 1.8, 1.8, respectively in 2010, and 5.6, 3.7, 1.8, 6.2, respectively in 2011. Cloudy weather prevailed during both vegetative and reproductive crop growth stages thereby reducing the crop's capacity to absorb and optimally utilize the applied inorganic N. In addition, unfavourable conditions of the upland environment may limit recovery of applied N, which reduces rice growth and yield. In areas with high rainfall such as Calabar, substantial N leaches from the soil might be expected. Study conducted in Onne in Rivers State, Nigeria, revealed that leaching losses on maize and upland rice varied from 28 percent to 53 percent depending upon N application method (Arora and Juo, 1993).

The N effect was manifested quickly on plant growth and subsequently yields. Growth and yield response of upland rice varieties to inorganic N fertilization depended to a great extent on genotype and growth duration. The NERICA varieties performed well under low soil fertility, but also responded to moderate levels of fertilizer N and given that they recorded a relatively high Harvest Index meant that they are generally more efficient in nutrient use, a conclusion that is in agreement with findings of Inthapanya *et al*., (2000). FARO 45 and FARO 48 responded generally to higher N levels, and in the case of FARO 48 might have responded to even higher rates than those tested in this study. Genotypic differences in the response of cereals have also been reported in rice (Sta Cruz and Wada, 1994), corn (Chevalier and Schrader, 1977), sorghum (Maranville *et al,* 1980). and wheat (Cox *et al*, 1985). In studies conducted by De Datta and Broadbent (1990), genotypic variation in N content was significant under conditions of low soil fertility, as was the case in this study.

The source of N did not in general, affect the growth and yield of upland rice in Calabar, even though nitrogen-use efficiency was highest with calcium ammonium nitrate. The source of N reportedly did not influence the growth and yield of mangrove rice in the same area (Binang and Okpara, 2011). Given that the NUE was low, measures that would increase fertilizer recovery should be explored. Fertilizer –N recovery equal to 50 to 70 percent of what is applied can be achieved when N is applied in the proper amount, in the proper form, and at the proper time (Peng and Cassman, 1998). The relatively poor response of rice as a result of using urea and ammonium sulphate suggests that with ammoniacal fertilizer, more N is lost as ammonia. Moreover, under upland conditions, most N is taken up as nitrate. Therefore, ammoniacal fertilizers such as urea and ammonium sulphate would have to be quickly converted into nitrate before they can be taken up and utilized by the plants, whereas calcium ammonium nitrate would not need to undergo such a transformation. Furthermore, ammonium sulphate and to a lesser extent urea are acid-forming fertilizers. Their continuous usage without liming in an acid soil would worsen the acidity of the soil, making it unsuitable as farmland.

Grain yield is a good measure of nutrient use efficiency especially as related to N (Barraclough *et al*, 2010). Nutrient use efficiency is the product of both uptake and utilization efficiencies (Sta Cruz *et al*, 1994, Hawkesford, 2010). Although uptake efficiency was not measured in this study, it is known that small improvements or even negative trends in nutrient acquisition or uptake may be hidden by gains in utilization efficiency (Hawkesford, 2010). Thus, observed performance differences in this study could be attributed, at least in part to differences in utilization efficiencies among the various genotypes. Similar differences have also been reported in such cereals as wheat, corn and sorghum (Cox *et al.* 1985, Chevalier and Schrader, 1977, Maranville *et al.* 1980).

The higher grain yield of rice varieties recorded under different N rates was mainly attributed to a greater leaf surface, more panicles per plant and to the number of grains per panicle. According to Takeda (1984), the number of spikelets per unit land area, or sink size, is the primary determinant of grain yield in cereal crops. The number of spikelets per unit land area can be increased by increasing the number of panicles, or the number of spikelets per panicle. In this study, even though the number of spikelets per panicle was not significantly influenced by N source and rate, both the number of panicles per m^2 and number of grains per panicle were affected by the application of all the N fertilizers, especially CAN at low levels (for early maturing varieties e.g. NERICA 1, NERICA 2 and FARO 45) and higher levels (for the medium maturing variety e.g. FARO 48). The differential growth and yield responses of early- and medium- maturing upland rice varieties to different levels of N may perhaps be due to their distinct growth and phenological characteristics, as well as the fact that the NERICA varieties are better adapted to the varied stresses associated with the upland ecology in the humid tropics (WARDA,2010).

An early maturing rice crop has a relatively short period for panicle growth before heading, and spikelet number is positively correlated with crop growth rate during the period from panicle initiation to flowering. A shorter duration for panicle growth is often accompanied by decrease grain yield (Yoshida, 1972). However, the NERICA varieties responded to lower N rates probably because, given that they matured earlier, they might have grown initially faster and covered the field with little or no fertilizer N addition. At higher N levels, faster growth rates in the early growth stages might have resulted in mutual shading during the middle and late growth stages, thereby reducing uptake of N because of a decrease in net photosynthesis. By contrast, the later maturing FARO 48 which grew more slowly in early growth, and thus avoided mutual shading responded better to higher N rates. In this regard, and by comparison, the two NERICA varieties may be considered ideal for the upland ecology since they not only performed well under low soil fertility, but also responded to applied fertilizer N.

Table 1: Soil Properties

Physical composition	2010		2011	
Particle size (%)	**Before**	**After**	**Before**	**After**
Sand	**79.30**	**79.50**	**74.6**	**74.9**
Silt	**14.70**	**14.0**	**12.8**	**12.8**
Clay	**6.0**	**6.50**	**12.6**	**12.3**
Textural class	**Sandy loam**	**Sandy loam**	**Sandy loam**	**Sandy loam**
Chemical composition				
pH	**4.30**	**4.50**	**4.50**	**5.43**
Organic carbon (%)	**1.12**	**1.09**	**1.25**	**1.20**
Total N (%)	**0.12**	**0.17**	**0.25**	**0.27**
Available P (mg kg^{-1})	**16.12**	**15.66**	**14.37**	**15.03**
Na (cmol kg^{-1})	**0.10**	**0.10**	**0.08**	**0.11**
K (cmol kg^{-1})	**0.10**	**0.15**	**0.14**	**0.31**
Ca (cmol kg^{-1})	**3.50**	**3.39**	**5.0**	**4.02**
Mg (cmol kg^{-1})	**1.23**	**1.20**	**0.40**	**0.37**

ECEC (cmol kg^{-1})	**6.92**	**5.58**	**4.09**	**4.16**
Base saturation (%)	**93.0**	**90.10**	**85.0**	**85.10**
Al^{3+} (cmol kg^{-1})	**0.35**	**0.33**	**0.28**	**0.24**
H^{+} (cmol kg^{-1})	**0.20**	**0.22**	**0.24**	**0.27**

Table 2: Effects of N sources and rates on plant height (cm) at maturity of different upland rice varieties in Calabar in 2010 and 2011

Treatment (kg Nha^{-1})	Variety				Mean	Variety				Mean
	NERICA 1	**NERICA 2**	**FARO 45**	**FARO 48**		**NERICA 1**	**NERICA 2**	**FARO 45**	**FARO 48**	
Urea										
0	58.6	61.9	63.0	59.4	**60.73**	78.9	76.5	79.5	84.8	**79.9**
30	76.4	75.8	79.6	77.3	**77.27**	88.5	84.0	99.5	102.0	**93.5**
60	81.0	78.9	83.8	93.4	**84.28**	100.4	96.7	101.7	102.8	**100.4**
90	88.9	93.0	100.4	116.4	**99.68**	108.8	100.6	113.6	118.6	**110.4**
Mean	**76.23**	**77.4**	**81.7**	**86.63**	**80.49**	**94.2**	**89.5**	**98.6**	**102.1**	**96.1**
CAN										
0	60.4	65.0	65.7	63.5	**63.65**	84.3	85.1	83.7	88.6	**85.4**
30	87.3	89.0	87.6	85.9	**87.45**	90.0	96.3	100.1	101.6	**97.0**
60	95.2	98.1	98.4	106.4	**99.53**	109.0	100.3	100.9	105.7	**104.0**
90	103.0	107.4	111.8	122.6	**111.2**	114.3	106.6	119.5	125.5	**116.5**
Mean	**86.48**	**89.88**	**90.88**	**94.60**	**90.46**	**99.4**	**97.1**	**101.1**	**105.4**	**100.7**
$(NH_4)_2SO_4$										
0	59.3	60.8	65.5	63.3	**62.23**	70.3	72.5	79.6	86.3	**77.2**
30	74.7	85.6	73.2	71.6	**68.78**	80.9	89.7	92.0	100.5	**90.8**
60	82.8	89.4	85.0	96.8	**86.0**	98.9	96.7	100.2	104.4	**100.1**
90	88.8	93.8	100.9	110.7	**101.05**	100.7	96.9	108.9	114.8	**105.3**
Mean	**76.4**	**74.9**	**81.15**	**85.6**	**79.52**	**87.7**	**89.0**	**95.2**	**101.5**	**93.4**
Main effect of variety	**79.70**	**80.73**	**84.58**	**88.94**		**93.8**	**91.87**	**98.3**	**103.0**	
Interaction between V & NR										
0	59.43	62.57	64.73	62.07	**62.20**	77.83	78.03	80.93	86.57	**80.84**
30	79.47	83.47	80.13	78.27	**80.34**	86.17	90.00	97.20	101.39	**93.69**

60	86.33	90.27	89.07	98.87	**91.14**	102.77	97.90	100.93	104.93	**101.48**
90	93.57	98.07	104.37	116.57	**103.15**	107.94	109.37	114.00	119.63	**110.74**
LSD (0.05) between treatment means for:										
Variety (V)	**3.55**					**4.01**				
N Source (NS)	**NS**					**NS**				
N Rate (NR)	**8.9**					**8.9**				
V X NS	**NS**					**NS**				
V X NR	**15.08**					**10.64**				
NS X NR	**NS**					**NS**				
V X NS X NR	**44.27**					**36.7**				

Table 3: Effects of N sources and rates on number of upland rice tillers m^{-2} of different upland rice varieties in Calabar in 2010 and 2011

Treatment (kg Nha^{-1})		Variety			Mean	Variety				Mean
	NERICA 1	**NERICA 2**	**FARO 45**	**FARO 48**		**NERICA 1**	**NERICA 2**	**FARO 45**	**FARO 48**	
Urea										
0	216.0	220.9	219.2	224.7	**220.2**	244.7	247.2	243.0	246.6	**245.38**
30	222.6	220.0	226.9	228.3	**224.45**	256.9	248.6	250.5	242.1	**249.53**
60	228.0	233.6	230.6	228.0	**230.05**	283.0	265.7	277.5	278.4	**276.15**
90	235.2	241.9	238.0	237.4	**238.13**	289.4	277.7	279.3	270.1	**279.13**
Mean CAN	**225.45**	**229.1**	**228.3**	**229.6**	**228.21**	**268.50**	**259.80**	**262.58**	**259.30**	**262.55**
0	218.6	209.1	213.0	219.9	**215.15**	250.6	245.0	245.8	252.2	**248.40**
30	226.3	224.0	220.7	228.4	**224.85**	265.1	260.5	270.8	266.2	**265.65**
60	236.8	240.5	236.0	233.7	**236.75**	300.6	285.7	278.0	279.3	**285.90**
90	243.5	240.9	244.3	249.8	**244.63**	289.7	280.4	274.6	282.6	**281.83**
Mean	**231.3**	**228.63**	**228.50**	**232.95**	**230.35**	**276.50**	**267.9**	**267.3**	**270.08**	**270.45**
$(NH_4)_2SO_4$										
0	212.7	215.3	215.0	211.9	**213.73**	240.8	243.4	237.7	243.1	**241.25**
30	220.8	220.0	225.5	224.8	**222.78**	248.0	266.9	237.0	243.7	**248.90**

60	223.6	226.2	229.8	230.3	**227.48**	283.1	279.6	285.6	288.3	**284.15**
90	229.0	226.3	233.3	236.8	**231.35**	263.5	272.2	293.6	296.0	**281.33**
Mean	**221.53**	**221.95**	**225.90**	**225.95**	**223.84**	**258.85**	**265.53**	**263.48**	**267.78**	**263.91**
Main effect of variety	**226.09**	**226.56**	**227.57**	**229.50**		**267.95**	**264.41**	**264.45**	**265.72**	
Interaction between V & NR										
0	215.77	215.10	215.73	218.83	**216.36**	245.37	245.20	242.17	247.30	**245.01**
30	223.23	221.33	224.37	227.17	**224.03**	256.67	258.67	252.77	250.67	**254.69**
60	229.47	233.43	232.13	230.67	**231.43**	288.97	277.00	280.37	282.00	**282.09**
90	235.90	236.37	238.53	214.33	**238.03**	280.87	276.77	282.50	282.90	**280.76**
LSD (0.05) between treatment means for:										
Variety (V)	**NS**					**NS**				
N Source (NS) N Rate (NR) V X NS	**NS** **8.63** **NS**					**4.47** **6.30** **NS**				
V X NR	**13.08**					**12.11**				
NS X NR	**NS**					**NS**				
V X NS X NR	**20.67**					**20.73**				

Table 4: Effects of N sources and rates on number of panicles per m^2 of different upland rice varieties in Calabar in 2010 and 2011

Treatment (kg Nha^{-1})		Variety			Mean	Variety				Mean
	NERICA 1	**NERICA 2**	**FARO 45**	**FARO 48**		**NERICA 1**	**NERICA 2**	**FARO 45**	**FARO 48**	
Urea 0	171.9	177.4	180.8	180.2	**177.58**	231.0	233.6	236.9	240.0	**235.38**
30	183.6	188.3	174.7	187.0	**183.40**	241.4	239.5	238.0	244.6	**240.88**
60	191.4	197.2	207.1	201.9	**199.40**	252.0	248.8	263.3	260.0	**256.03**
90	201.6	211.1	219.0	246.7	**219.60**	257.2	254.6	269.4	276.4	**264.4**

Mean	**187.13**	**193.50**	**195.40**	**203.95**	**195.00**	**245.4**	**244.13**	**251.9**	**255.25**	**249.17**
CAN										
0	181.5	184.9	180.3	176.6	**180.83**	236.4	231.9	225.4	232.0	**231.43**
30	196.8	190.2	203.7	200.4	**197.78**	249.8	245.1	239.2	243.1	**244.30**
60	205.0	205.8	213.4	220.9	**211.28**	255.6	250.1	267.4	272.0	**261.28**
90	217.5	222.0	227.8	238.2	**226.38**	269.5	258.3	277.0	296.8	**275.40**
Mean	**200.20**	**200.73**	**206.30**	**209.03**	**204.07**	**252.83**	**246.35**	**252.25**	**260.98**	**253.10**
$(NH_4)_2SO_4$										
0	184.0	180.8	177.9	185.5	**182.05**	230.1	228.6	230.3	246.0	**233.75**
30	187.6	200.3	200.7	198.4	**196.75**	238.4	240.9	240.0	240.0	**239.83**
60	205.6	205.9	210.6	206.3	**207.10**	246.5	246.9	242.2	258.7	**248.58**
90	212.3	219.7	221.2	243.8	**224.25**	253.0	252.7	254.7	266.9	**256.83**
Mean	**197.38**	**201.68**	**202.60**	**208.50**	**202.54**	**242.0**	**242.28**	**241.80**	**252.90**	**244.75**
Main effect of variety	**194.90**	**198.64**	**201.43**	**207.16**		**246.74**	**244.25**	**248.25**	**248.65**	**256.38**
Interaction between V & NR										
0	179.13	181.03	179.67	180.77	**180.15**	232.5	231.37	230.87	239.33	**233.52**
30	189.33	192.93	193.03	195.27	**192.64**	243.2	241.83	239.07	242.57	**241.67**
60	200.67	202.97	207.03	209.70	**205.09**	251.37	248.6	257.63	263.57	**255.29**
90	203.80	217.60	222.67	242.90	**221.74**	259.9	255.2	267.03	280.03	**265.54**
LSD (0.05) between treatment means for:										
Variety (V)	**NS**					NS				
N Source (NS)	**NS**					**NS**				
N Rate (NR)	**13.97**					**7.32**				
V X NS	**NS**					**NS**				
V X NR	**8.75**					**8.07**				
NS X NR	**NS**					**NS**				
V X NS X NR	**22.04**					**32.09**				

Table 5: Effects of N sources and rates on number of grains per panicle of different upland rice varieties in Calabar in 2010 and 2011

Treatment (kg Nha^{-1})		Variety			Mean	Variety				Mean
	NERICA 1	**NERICA 2**	**FARO 45**	**FARO 48**		**NERICA 1**	**NERICA 2**	**FARO 45**	**FARO 48**	
Urea										
0	135.3	144.3	139.6	142.0	**140.30**	146.3	149.6	144.4	151.2	**147.88**
30	155.9	151.8	150.4	152.6	**152.68**	165.9	158.4	162.0	159.5	**161.45**
60	176.2	173.6	168.3	173.0	**172.78**	183.5	180.1	176.2	178.1	**179.48**
90	188.9	178.3	170.4	182.0	**179.90**	192.4	183.8	184.6	197.6	**189.60**
Mean	**164.08**	**162.00**	**157.18**	**162.40**	**161.42**	**172.03**	**167.98**	**166.80**	**171.60**	**169.60**
CAN										
0	144.8	140.8	140.2	136.5	**140.58**	149.0	153.0	146.9	146.0	**148.73**
30	167.3	159.6	149.6	153.0	**157.38**	177.2	171.6	165.8	163.8	**169.60**
60	179.6	174.0	178.6	187.0	**179.80**	213.9	179.7	183.4	190.4	**191.85**
90	199.3	183.8	198.3	209.2	**197.65**	198.7	194.0	199.7	205.2	**199.40**
Mean	**172.75**	**164.55**	**166.68**	**171.43**	**168.85**	**184.70**	**174.58**	**173.95**	**176.35**	**177.40**
$(NH_4)_2SO_4$										
0	138.4	141.1	141.5	129.5	**137.63**	147.8	143.5	136.7	151.0	**144.75**
30	147.9	153.6	148.4	145.2	**148.88**	152.6	149.7	144.7	157.0	**151.0**
60	166.0	181.2	166.0	168.0	**170.30**	168.5	166.9	153.5	160.2	**162.28**
90	184.5	192.0	185.0	177.7	**184.80**	185.8	174.8	170.8	175.3	**176.68**
Mean	**159.20**	**166.98**	**160.23**	**155.10**	**160.38**	**163.67**	**158.73**	**151.43**	**160.88**	**158.68**
Main effect of variety	**165.34**	**165.51**	**161.36**	**163.98**		**173.47**	**167.10**	**164.06**	**169.61**	
Interaction between V & NR										
0	139.50	142.07	140.43	136.00	**139.50**	147.70	148.70	142.67	149.40	**147.12**
30	157.03	155.00	149.47	150.27	**152.94**	165.23	159.90	157.50	160.01	**160.68**
60	173.93	176.27	170.97	176.00	**174.29**	188.63	175.57	171.03	176.23	**177.87**
90	190.90	184.70	184.57	189.63	**187.45**	192.30	184.20	185.03	192.70	**188.56**
LSD (0.05) between treatment means for:										
Variety (V)	**NS**					**5.22**				

N Source (NS)	**NS**				**NS**				
N Rate (NR)	**8.14**				**13.42**				
V X NS	**NS**				**NS**				
V X NR	**3.85**				**6.67**				
NS X NR	**NS**				**NS**				
V X NS X NR	**18.11**				**23.06**				

Table 6: Effects of N sources and rates on number of spikelet per panicle of different upland rice varieties in Calabar in 2010 and 2011

Treatment (kg Nha^{-1})		Variety			Mean	Variety				Mean
	NERICA 1	**NERICA 2**	**FARO 45**	**FARO 48**		**NERICA 1**	**NERICA 2**	**FARO 45**	**FARO 48**	
Urea										
0	14.1	11.8	9.7	15.4	**12.75**	13.3	12.8	10.4	12.5	**12.25**
30	13.2	14.4	10.4	12.6	**12.65**	15.7	15.3	14.2	15.3	**15.13**
60	13.1	10.5	14.6	10.6	**12.20**	15.0	15.9	15.4	15.3	**15.40**
90	13.5	12.0	13.9	11.2	**12.65**	14.7	15.3	16.0	14.5	**15.13**
Mean	**13.48**	**12.18**	**12.15**	**12.45**	**12.56**	**14.68**	**14.83**	**14.0**	**14.40**	**14.48**
CAN										
0	12.4	13.2	13.4	10.9	**12.48**	14.4	15.9	12.1	15.3	**14.43**
30	13.8	13.6	13.0	11.8	**13.05**	15.0	13.6	14.6	15.1	**14.58**
60	13.3	14.8	13.3	12.2	**13.40**	13.7	16.3	14.4	15.9	**15.08**
90	15.1	13.8	13.7	14.4	**14.25**	15.5	14.8	16.3	15.1	**15.43**
Mean	**13.65**	**13.85**	**13.35**	**12.33**	**13.30**	**14.65**	**15.15**	**14.35**	**15.35**	**14.88**
$(NH_4)_2SO_4$										
0	10.7	14.3	10.6	10.4	**11.50**	14.9	11.4	14.8	15.0	**14.03**
30	12.3	13.7	10.2	14.8	**12.75**	16.1	15.3	14.8	14.9	**15.28**
60	15.2	13.2	12.8	10.7	**12.98**	13.7	14.1	14.6	14.6	**14.25**
90	13.3	13.9	11.5	13.3	**13.0**	14.8	16.5	15.0	14.8	**15.28**
Mean	**12.88**	**13.78**	**11.28**	**12.30**	**12.56**	**14.88**	**14.33**	**14.80**	**14.83**	**14.71**
Main effect of variety	**13.34**	**13.27**	**12.26**	**12.36**		**14.74**	**14.77**	**14.38**	**14.86**	
Interaction										

between V & NR										
0	12.40	13.10	11.23	12.23	**12.24**	14.20	13.37	12.43	14.27	**13.57**
30	13.10	13.90	11.20	13.07	**12.82**	15.60	14.73	14.53	15.10	**14.99**
60	13.87	12.83	13.57	11.17	**12.86**	14.13	15.43	14.80	15.70	**14.91**
90	13.97	13.23	13.03	12.97	**13.30**	15.00	15.53	15.77	14.80	**15.28**
LSD (0.05) between treatment means for:										
Variety (V)	NS					NS				
N Source (NS)	**NS**					**NS**				
N Rate (NR)	**NS**					**NS**				
V X NS	**NS**					**NS**				
V X NR	**NS**					**NS**				
NS X NR	**NS**					**NS**				
V X NS X NR	**NS**					**NS**				

Table 7: Effects of N sources and rates on weight of 1000 grains (g) of different upland rice varieties in Calabar in 2010 and 2011

Treatment (kg Nha^{-1})		Variety			Mean	Variety				Mean
	NERICA 1	**NERICA 2**	**FARO 45**	**FARO 48**		**NERICA 1**	**NERICA 2**	**FARO 45**	**FARO 48**	
Urea 0	26.5	26.7	21.7	22.6	**24.38**	28.0	25.7	20.4	21.9	**24.0**
30	27.0	26.2	23.3	24.7	**25.30**	27.4	26.4	21.0	25.7	**25.13**
60	27.3	27.3	23.9	27.9	**26.60**	29.0	26.3	24.5	28.0	**26.95**
90 Mean	28.1 **27.23**	25.8 **26.50**	24.1 **23.25**	27.2 **25.60**	**26.30** **25.65**	28.9 **28.33**	26.0 **26.10**	27.8 **23.43**	28.5 **26.03**	**27.80** **25.95**
CAN										
0	25.8	25.3	20.8	21.6	**23.38**	29.30	26.3	21.3	20.3	**24.30**
30 60	28.0 24.6	27.1 23.1	22.3 26.5	21.3 27.2	**24.68** **25.35**	29.0 29.6	26.3 26.7	23.2 25.5	23.6 25.8	**25.53** **26.90**
90	27.3	27.5	28.2	27.9	**27.73**	29.1	25.8	27.5	29.3	**27.93**

Mean	**26.43**	**25.75**	**24.45**	**24.50**	**25.29**	**29.25**	**26.23**	**24.38**	**24.75**	**26.15**
$(NH_4)_2SO_4$										
0	27.3	26.8	21.9	22.5	**24.63**	27.9	28.3	20.0	20.5	**24.18**
30	27.4	28.2	20.5	20.9	**24.25**	28.5	26.0	21.8	22.2	**24.63**
60	27.1	28.6	27.3	28.3	**27.83**	29.3	25.6	25.7	26.9	**26.88**
90	28.4	27.5	26.9	27.8	**27.65**	28.6	26.4	27.9	28.0	**27.73**
Mean	**27.55**	**27.78**	**24.15**	**24.88**	**26.09**	**28.58**	**26.58**	**23.85**	**24.40**	**25.85**
Main effect of variety	**32.04**	**26.28**	**23.95**	**24.99**		**28.72**	**26.30**	**23.89**	**25.06**	
Interaction between V & NR										
0	26.53	26.27	21.47	22.23	**24.13**	26.73	26.77	20.57	20.90	**23.74**
30	27.47	27.17	22.03	22.22	**24.72**	28.30	26.23	22.00	23.83	**25.09**
60	26.33	26.33	25.90	27.80	**26.59**	29.30	26.20	25.23	26.90	**26.91**
90	27.93	26.93	26.40	27.63	**27.22**	28.87	26.07	27.73	28.60	**27.82**
LSD (0.05) between treatment means for:										
Variety (V) N Source (NS)	**1.43** **NS**					**2.02** **NS**				
N Rate (NR)	**0.93**					**0.59**				
V X NS	**NS**					**NS**				
V X NR	**2.07**					**2.01**				
NS X NR V X NS X NR	**NS** **3.09**					**NS** **2.29**				

Table 8: Effects of N sources and rates on rice grain yield (kg ha^{-1}) of different upland rice varieties in Calabar in 2010 and 2011

Treatment (kg Nha^{-1})		Variety			Mean	Variety				Mean
	NERIC A 1	**NERIC A 2**	**FARO 45**	**FARO 48**		**NERIC A 1**	**NERIC A 2**	**FARO 45**	**FARO 48**	
Urea										

0	1696.01	1689.90	1052.83	1003.53	**1360.57**	1893.33	1935.29	1101.89	1072.15	**1500.67**
30	2976.50	2835.77	1989.07	1766.83	**2392.04**	3237.01	3010.61	2012.45	2024.90	**2571.24**
60	3249.11	3198.60	2515.02	2831.64	**2948.59**	3677.25	3160.48	3168.44	3985.44	**3497.90**
90	3336.19	3209.95	2639.78	3256.80	**3110.68**	3811.96	3222.64	3222.07	4439.52	**3674.05**
Mean	**2814.45**	**2733.56**	**2049.18**	**2214.70**	**2452.97**	**3154.89**	**2832.26**	**2376.21**	**2880.50**	**2810.97**
CAN										
0	1684.59	1760.44	986.79	1063.48	**1373.83**	1950.23	1808.02	1062.00	1025.22	**1461.37**
30	2881.63	2605.58	1875.21	1929.80	**2323.06**	3061.05	2947.16	2755.06	2119.50	**2720.69**
60	3046.08	2907.86	2306.63	2518.19	**2694.69**	3522.11	3360.04	3300.54	3844.02	**3506.68**
90	3101.95	3029.53	2510.44	2868.20	**2877.53**	3590.08	3340.55	3283.73	4033.84	**3562.05**
Mean	**2678.56**	**2575.83**	**1919.77**	**2094.92**	2317.28	**3030.86**	**2863.94**	**2600.33**	**2755.65**	2812.70
$(NH_4)_2SO_4$										
0	1670.25	1708.37	1001.49	1000.70	**1345.20**	1933.09	1869.05	1114.71	1094.69	**1502.89**
30	2797.02	2459.30	1576.84	1587.11	**2105.07**	2955.00	2277.52	2276.94	2007.47	**2379.23**
60	2999.86	2980.54	1980.53	2106.14	**2516.77**	3139.21	2839.22	2838.90	3130.98	**2987.08**
90	3004.17	3115.75	2346.17	2991.46	**2864.39**	3364.86	2996.89	2999.05	3618.32	**3244.78**
Mean	**2617.83**	**2565.99**	**1726.26**	**1921.35**	2207.86	**2848.04**	**2495.67**	**2307.40**	**2462.87**	2528.50
Main effect of variety	**2703.6**	**2625.13**	**1898.40**	**2076.99**		**3011.26**	**2730.62**	**2427.90**	**2699.67**	
Interaction between V & NR										
0	1683.6	1719.57	1013.70	1022.57	**1359.86**	1925.55	1870.79	1092.87	1064.02	**1488.30**

30	2885.05	2633.55	1813.71	1761.25	**2273.39**	3084.35	2745.10	2348.15	2050.62	**2557.06**
60	3098.35	3029.0	2267.39	2485.32	**2720.02**	3446.19	3119.91	3102.63	3653.48	**3330.55**
90	3147.44	3118.41	2498.80	3038.82	**2950.87**	3588.97	3186.69	3168.28	4030.56	**3493.63**
LSD (0.05) between treatment means for:										
Variety (V)	**63.19**					**229.71**				
N Source (NS)	**NS**					**NS**				
N Rate (NR)	**247.03**					**186.03**				
V X NS V X NR	**NS** **123.47**					**NS** **168.55**				
NS X NR	**NS**					**NS**				
V X NS X NR	**141.38**					**184.09**				

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