

Effect of Nitrogen Fertilizer Timing on Yield of Hybrid Upland Ecosystems Rice (*Oryza sativa* L.) in Main Rainy Season at Kamash Zone of Western Ethiopia

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Abstract: The most important nutrient for rice (*Oryza sativa* L.) production is nitrogen. But it lost from soil in different process. Proper nitrogen (N) management of high yielding rice varieties is crucial for obtaining their potential yield benefit. The area of the study is characterized by long rainy season which predispose for leaching of N to the ground water. A randomized block design with three replications was used to assess the response of upland rice Variety (Nerica 4) to N application intervals. N was investigated at six different levels or points in time. The N timing were: Applying all recommended N rate at planting, applying 50% of the N at planting and the other 50% at mid tillering, applying 50% of the N at planting and the other 50% at panicle initiation, applying 25% of the N at planting and 75% at mid tillering, applying 75% of the N at planting and 25% at panicle initiation, applying 25% of the N at planting, 25% at mid tillering and 25% at panicle initiation. The study shows that applying 50% of N at planting and the other 50% at tillering is best N management practice for the area to maximize rice yield avoiding the excess use of N fertilizer.

Keywords: N Rate Timing, Nerica 4 Rice, Split, Kamashi

1. Introduction

Western Ethiopia is characterised by high rainy fall with long rainy season (from April to November). This affects the fertility of the soil washing the top soil every year. Without applying nitrogen fertilizer expecting yield is impractical. N fertilizer could be lost from the soil through different mechanism. So nitrogen is one among the essential nutrient determine yield of a crop in the area. Nitrogen increases plant height, panicle number, leaf size, spikelet number, and mature spikelet number, all of which affect rice plant output [1]. The number of tillers that develop during the vegetative stage has a significant influence on the amount of panicles produced [2]. The number of spikelets and the number of filled spikelets are determined by the reproductive stage [3].

Rice plants require N during the tillering stage to ensure a sufficient number of panicles. The critical time at active tillering for N application is typically about midway between

14 days after transplanting (DAT) or 21 days after sowing (DAS) and panicle initiation [4].

Researchers have discovered that the response of existing commercial rice types to nitrogen varies from year to year and site to site [5-10], making appropriate nitrogen recommendations for rice harvests a difficult task [11]. Fertilizer recommendations must be updated on a regular basis, especially for rice, because the qualities of rice-growing soils change dramatically over time due to the intensity of cultivation [5]. New rice varieties must also be evaluated for their ability to respond to current nitrogen strategies [12]. For many years, grower preference, supported by some research results, was to apply nitrogen fertilizer as a heavy single dose 5–10 cm below the soil surface to upland rice [5].

This method is still practiced in some rice-growing districts. Depending on the paddock's history, it's

recommended to administer 120–180 kg N/ha to attain a goal nitrogen uptake of 130–150 kg N/ha at panicle start, resulting in a 12 t/ha yield [13].

According to Prasad and De Datta [14], conventional N fertilizer should be provided in two or three splits, with one dose applied at the start of panicle growth. The dry matter produced and grain yield were found to be highly correlated with the average crop N status from panicle initiation to flowering [2, 4, 19], and the number of spikelets per unit area was found to be highly correlated with the increase in total crop weight during this period, indicating the importance of N application at the panicle initiation stage. N management could be crucial in order to obtain the potential yield of the crop.

2. Material and Method

2.1. Site Description

The experiment was conducted for two consecutive years (2014 and 2015) at the Experimental site of Kamashi sub-center located at latitude of 09°31.435' and longitude of 035°53.196'. It is situated in north western Ethiopia of beshangul gumuz regional state at about 657 km from the capital Addis Ababa, and about 200m from the regional city Asosa to the East at an altitude of 1219 meters above sea level (masl). The long term weather data of the annual rainfall varies from 800 to 2000 mm. sowing was done in same day June 24 in both year (2014 and 2015). The average air temperature is 27°C, with a minimum of 20°C in the coldest month (July) and a maximum of 35°C in the hottest month (November). The soil of the experimental area was classified as Netisol. Have with the following chemical properties

2.2. Experimental Treatments and Design

The treatments consisted one variety Nerica 4 upland rice and six time of different rate of recommended. Three recommended Urea at the time of experimentation was 160kg/ha. Urea fertilizer as source of N (100% at sowing, 50% at time of sowing and 50% at mid tillering, 50% at sowing and 50% at panicle initiation, 25% at sowing and 75% at mid tillering, 75% at sowing and 25% at mid tillering, 25% at sowing, 25% at mid tillering, and the other 25% at panicle initiation. The experiment was arranged in a randomized complete block design (RCBD) with three replications and the plot size was 4mx3m.

2.3. Experimental Procedure

The soil was conventionally tilled by disking twice. Rice was sown by hand, drilling seeds in furrows, at seed rate of 80kg/ha. Urea at planting time was drilled in furrow on which seed was sown after covered with hand the soil before sowing seed. Weeds were controlled by hand hoeing. Harvesting had been done manual by hand at 112 days after emergence. When an average of 90% of panicles had grains

with typical mature coloration, plants were cut 0.10m above the soil surface and left in the sun for 10 hours. After that the grains were removed from panicles manual. The following yield parameters were evaluated: number of tillers per hill, number of grain per panicles, biological yield, lodging index, Thousand seed weight, number of grains per panicles, number of unfilled grains per panicles, plant height in cm, panicle length cm and grain yield in t/ha.

2.4. Soil Sampling and Analysis

Using Zigzag soil sampling method random soil samples (0-30 cm depth) from the experimental field were thoroughly mixed to make a composite. The sample was air dried and ground to pass 2 mm sieve and necessary parameters such as soil texture, available P, pH and CEC were determined. For the determination of OC and N 1mm sieve was used. Soil texture was analyzed by Bouyoucos hydrometer method [11]. Available P was extracted with a sodium bicarbonate solution at pH 8.5 following the procedure described by Olsen *et al.* (1954). The pH of the soil was measured potentiometrically in the 1:2.5 soil: water mixture by using a pH meter and organic carbon was determined following Walkely and Black wet oxidation method [13]. Cation Exchange Capacity (CEC) was determined by Ammonium Acetate method [14].

2.5. Data Collection

All phonological, growth and yield and yield component data are collected and were subjected to analysis of variance. The mean separation technique were done using DMRT test at 1%, and the effect of N timing was shown graphically.

3. Results of Discussion

3.1. Physicochemical Properties of the Experimental Soil

The analysis results indicated that the experimental soil of kamashi sub-site of assosa agricultural research center were textured sandy loam. The organic content and organic carbon content (OC) were 0.95 and 0.78% respectively (Table1). Accordance with [20], the soil in locations had low OC, who rated OC between 1.74-2.90% as high. The CEC of the soil were 23.87 cmol kg⁻¹ and 23.87 cmol kg⁻¹ at Dokotsida and Gindogambla kebeles respectively which, could be considered as medium. Because if CEC value ranges between 25 and 40 cmol kg⁻¹ satisfactory response for applied fertilizer [19]. According to [21] P rating (mg kg⁻¹), P content of < 3 is very low, 4 to 7 is low, 8 to 11 is medium, and > 11 is high. Thus experimental sites, available P content were medium in both locations. The pH of the soil were 5.88 and 5.23 on Dokotsida and Gindogambla respectively, which is within the range of 4 to 8 suitable for wheat \ production [20]. Total N of the soil on both locations (0.098% and 0.070%), are low; as rated by [22] who rated total N less than 0.15% as low.

Table 1. Soil physical and chemical properties of the experimental sites before planting.

Soil properties	Results	Rating	Reference Authors
Soil textural class			
Sand (%)	75.00		
Silt (%)	11.00		
Clay (%)	14.00	sandy loam	
Bulk density (g cm ⁻³)	1.30	Moderate	(Miller and Donahue, 1995)
pH (1:2.5 H ₂ O)	5.80	Moderately acidic	(Jones, 2003)
Organic carbon (%)	2.17	Low	(Berhanu, 1980)
Electric conductivity	0.13	Salt free	(FAO, 2008)
Organic matter (%)	3.90	Low to medium	(Tekalign, 1991)
Total N (%)	0.17	Poor	(Landon, 1991)
Available P (mg kg ⁻¹)	15.26	High	(Olson, 1954)
Available K (mg kg ⁻¹)	90.27	Very low	(FAO, 2008)
CEC (cmol (+) kg ⁻¹)	22.60	Moderate	(Hazelton and Murphy, 2007)

CEC=Cation Exchange Capacity, OC=Organic Carbon, Av. P=Available phosphorous.

3.2. Crop Phenology

3.2.1. Plant Height

The impact of fertilizer treatments on plant height was rather obvious and statistically significant. Generally N application in two or three times increased slightly the plant height. In previous experiments, similar results were

explained as a positive effect of N topdressing on increasing panicle length. But the greatest increase of plant height (79.65 cm) for Nerica-4 upland variety was obtained using application of 50% N at planting and the other 50% at mid tillering. Thus, appears clearly the stimulating effect of preplant urea fertilizer application on height increase.

Table 2. Two years combined analysis of variance for selected yield parameters.

Treatment	BY	NGP	GY	PH	PL	NT/hill	TSW	NUG
Applying all recommended N rate at planting	5.13	114.20	10.65	75.93	19.20	8.53	23.33	26.60
Applying 50% of the N at planting and the other 50% at mid tillering	6.66	153.27	10.80	79.67	19.40	9.10	23.33	29.80
Applying 50% of the N at planting and the other 50% at panicle initiation	3.66	127.27	7.69	72.53	18.53	5.07	21.00	32.00
Applying 25% of the N at planting and 75% at mid tillering	5.63	121.07	8.84	74.40	18.20	6.73	23.67	27.87
Applying 75% of the N at planting and 25% at panicle initiation.	3.66	118.80	5.49	70.80	16.67b	6.00	18.67	37.07
Applying 25% of the N at planting, 25% at mid tillering and 25% at panicle initiation	4.67	118.60	9.14	75.93	19.13	5.60	23.67	24.47
LSD	0.89	5.27	1.62	2.82	1.3214	0.57	2.29	4.66
CV	10.01	2.31	10.18	2.07	3.92	4.61	5.66	8.64
P value ≤ 0.05	***	**	***	**	**	**	**	**

Where “***”, “**” highly and strongly significant at 1% probability level respectively, (NT) Number of tillers per hill, (BY) Biological yield (t/ha), (NGP) No of grains per panicles, (NG) Number of grains per panicles, (NUG) Number of unfilled grains per panicles, (PH) Plant height in (cm) and (PL) Panicle length (cm) (GY) Grain yield (t/ha), (TSW) thousand seed weight in (gm).

3.2.2. Tiller Number

Split application of urea significantly influenced on the number of tillers hill⁻¹ (Table 2). The highest number of tillers hill⁻¹ was produced when urea was applied at two equal splits and the lowest number of tillers hill⁻¹ was produced in applying 75% of the N at planting and 25% at panicle initiation. In both of the cases, the highest number of tiller hill⁻¹ obtained from applying 50% of the N at planting and the other 50% at mid tillering. Other researchers [2, 15, 18, 20, 21] reported that the nitrogen application in two splits, gave the highest number of tillers hill⁻¹.

3.2.3. Panicle Number and Length

Panicle number is a major yield determining factor of rice. Nitrogen contributes to rice panicle formation by stimulating cell division in the reproductive stage of crop growth in two split applications, filled grain panicle⁻¹ significantly increased with applying 50% of the N at planting and the other 50% at

mid tillering than it significantly applying 75% of the N at planting and 25% at panicle initiation.

3.2.4. Filled and Unfilled Grain

The increase in the number of filled grain with the appropriate time of application for N indicates that N split application is important for both sources and sinks development. The highest number of unfilled grain panicle⁻¹ applying 75% of the N at planting and 25% at panicle initiation. This may due to the final N application didn't help for sink development (Table 2).

On the other hand, when a single nutrient element increases, the availability of other nutrients and genetic potentiality of the crops become more determining factors for the yield component [22]. Others also [23] reported more production of spikelet and less translocation of photoassimilates from leaves to spikelet with appropriate N timing which explains the increased unfilled grain with higher N at planting than at tillering the study.

3.2.5. Grain Yield

The results showed that rice yield increased with applying 50% of the N at planting and the other 50% at mid tillering. Other scholars [3, 5, 17, 22] reported response of grain yield to N split application for upland rice which supports the result. N application time with grain yield kg/ha was significant (Table 2). For the 100%N rate applied at planting, the line graph study showed it is minimum or lower yield is

obtain but higher in number of grains per panicles, plant height in (cm) and panicle length (cm), (Figure 1). The results confirmed that, by *Applying 50% of the N at planting and the other 50% at mid tillering*, increasing N rates increased the number of panicles per m². This can be attributed to the effect of N to increase the number of rice tillers, as also observed by [3, 7, 22]. When applying 50% of N at sowing and 50% at tillering.

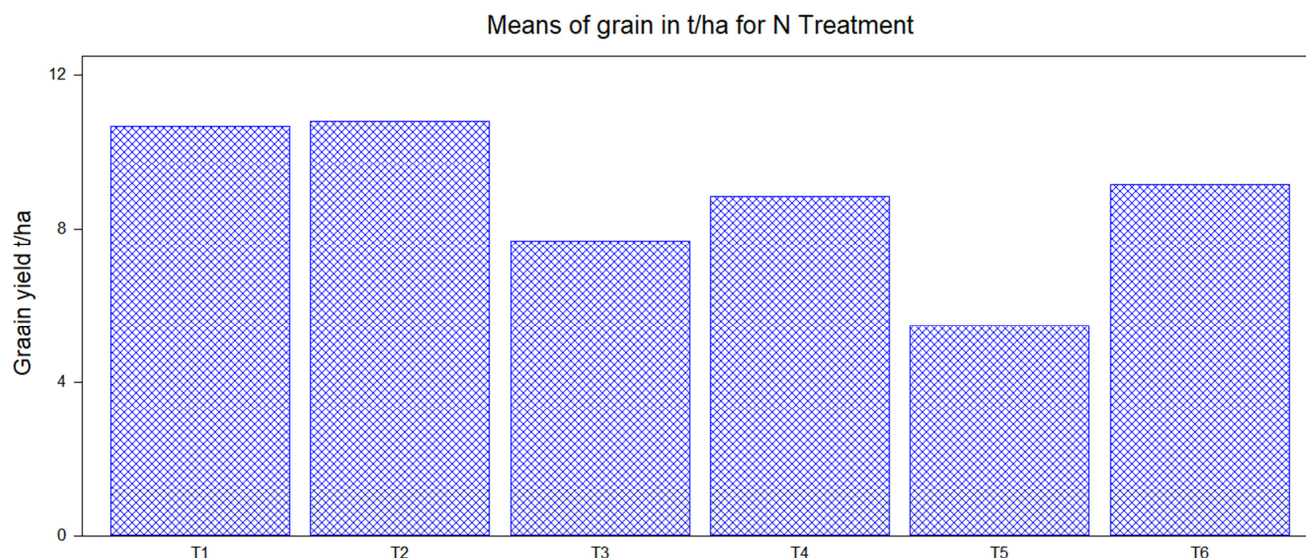


Figure 1. Graphical relationship of yield and N timing at different point.

Where T1, T2, T3, T4, T5, T6 is Applying all recommended N rate at planting, Applying 50% of the N at planting and the other 50% at mid tillering Applying 50% of the N at planting and the other 50% at panicle initiation Applying 25% of the N at planting and 75% at mid tillering, Applying 75% of the N at planting and 25% at panicle initiation, Applying 25% of the N at planting, 25% at mid tillering and 25% at panicle initiation respectively.

4. Conclusion

Split nitrogen application of 50% at planting 50% at mid tillering could result in better yield than nitrogen applied at other stage in upland rice ecosystem (Nerica 4). Good nitrogen management is crucial for achieving high rice yields and profitability. Combined with sowing on time and when good moisture level attained. The correct timing of nitrogen application can lead to consistently high rice grain yields.

References

- [1] S. Youseftabar, A. Fallah, J. Daneshiyan, and Y. R. Club, "Effect of Split Application Of Nitrogen Fertilizer On Growth And Yield Of Hybrid Rice," vol. 6, no. 6, pp. 1–5, 2012.
- [2] Z. Tadesse, T. Tadesse, and D. Ayalew, "Effects of Time of Nitrogen Fertilizer Application on the Growth and Productivity of Rice (*Oryza sativa* L.) in Fogera Plain, North Western Ethiopia," vol. 3, no. 9, pp. 36–44, 2017.
- [3] J. Hildernando, B. Barreto, and I. Soares, "Yield Performance of Upland Rice Cultivars at Different Rates and Times of Nitrogen," no. 1, pp. 475–483.
- [4] Q. Jiang, J. Zhang, X. Xu, G. Liu, and J. Zhu, "Effects of free-air CO₂ enrichment (FACE) and nitrogen (N) supply on N uptake and utilization of indica and japonica cultivars (*Oryza sativa* L.)," 2020.
- [5] R. Subasinghe, T. Dunn, D. Wornes, and K. Bechaz, "Timing of nitrogen applications for rice," no. 177, pp. 34–40, 2007.
- [6] F. Belete, N. Dechassa, A. Molla, and T. Tana, "Effect of split application of different N rates on productivity and nitrogen use efficiency of bread wheat (*Triticum aestivum* L.)," *Agric. Food Secur.*, pp. 1–10, 2018, doi: 10.1186/s40066-018-0242-9.
- [7] W. Zhou, T. Lv, Y. Chen, J. Hu, Q. Zhang, and W. Ren, "Late nitrogen application enhances spikelet number in indica hybrid rice (*Oryza sativa* L.)," no. April, pp. 127–133, 2017.
- [8] M. Semon, H. Tsunematsu, and H. Samejima, "Growing upland rice: a production handbook."
- [9] R. Page, "PLAN OF WORK AND BUDGET 2017 CGIAR RESEARCH PROGRAM ON RICE AGRI-FOOD SYSTEMS Led by IRRI," 2017.
- [10] A. Khalofah *et al.*, "Deep placement of nitrogen fertilizer improves yield, nitrogen use efficiency and economic returns of transplanted fine rice," pp. 1–16, 2021, doi: 10.1371/journal.pone.0247529.
- [11] "Oryza Sativa," 2000.

- [12] G. Gribaldi, N. Nurlaili, N. Dewi, E. Danial, F. Sakalena, and R. A. Suwignyo, "Modified Application of Nitrogen Fertilizer for Increasing Rice Variety Tolerance toward Submergence Stress," vol. 2017, no. Inpara 5, pp. 1–7, 2017.
- [13] J. Zhang, T. Tong, P. M. Potcho, and S. Huang, "Nitrogen Effects on Yield, Quality and Physiological Characteristics of Giant Rice," 2020.
- [14] S. Saravanakumar, "Nitrogen Nutrition to Rice – A Review," pp. 73–74, 2014.
- [15] M. S. Islam, M. Hasanuzzaman, and M. Rokonzaman, "Effect of split application of nitrogen fertilizer on morpho-physiological parameters of rice genotypes," vol. 3, no. January, 2009.
- [16] "INFLUENCE OF TIME AND LEVEL OF NITROGEN APPLICATION ON GROWTH Of the nutrient elements derived from the soil, the rice plant requires nitrogen in the greatest amount 2 a 6 7. Generally, there appears to be at least three stages of growth most suitable," vol. 29, pp. 15–29, 1972.
- [17] S. O. Oghalo, "Effect of Population Density on the Performance of Upland Rice (*Oryza Sativa*) in a Forest-Savanna Transition Zone," vol. 3, no. 2, pp. 44–48, 2011.
- [18] S. Tigray, "Response of bread wheat (*Triticum aestivum* L.) varieties to N and P fertilizer rates in Ofla district," vol. 12, no. 19, pp. 1646–1660, 2017, doi: 10.5897/AJAR2015.10545.
- [19] V. Kumar, "INFLUENCE OF RATE AND TIME OF NITROGEN APPLICATION ON THE PERFORMANCE OF BASMATI RICE (*Oryza sativa* L.)," 2013.
- [20] A. Jahan, A. Islam, I. U. Sarkar, and M. Iqbal, "Nitrogen response of two high yielding rice varieties as influenced by nitrogen levels and growing seasons," *Geol. Ecol. Landscapes*, vol. 00, no. 00, pp. 1–8, 2020, doi: 10.1080/24749508.2020.1742509.
- [21] A. Efreteuei, M. Gooding, E. White, J. Spink, and R. Hackett, "Effect of nitrogen fertilizer application timing on nitrogen use efficiency and grain yield of winter wheat in Ireland," vol. 55, no. 1, pp. 63–73, 2016, doi: 10.1515/ijagr-2016-0006.
- [22] K. Djaman, M. Vc, A. Fy, and K. Koudahe, "Journal of Agricultural Science and Effect of Nitrogen Fertilizer Dose and Application Timing on Yield and Nitrogen Use Efficiency of Irrigated Hybrid Rice under Semi-Arid Conditions," vol. 9, no. 2, 2018.
- [23] E. S. Goulart, L. O. B. Schuch, L. V. M. De Tunes, and J. F. Vieira, "Performance of rice hybrids determined by different planting arrangements," vol. 42, no. 1, pp. 75–83, 2015, doi: 10.4067/S0718-16202015000100008.