Response of rice yield and yield parameters to timings of nitrogen application in Northern Ethiopia

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***Abstract* - A field experiment was conducted in western Tigray, Northern Ethiopia, during the 2012 main cropping season, to investigate the influence of time of nitrogen application on rice yield and yield components. The experiment consisted of six application timings viz. 50% of the recommended at sowing and the remaining 50% at tillering (T1), 50% of the recommended at tillering and the remaining 50% at early panicle initiation (T2), 50% of the recommended at sowing and the remaining 50% at early panicle initiation (T3), 33% of the recommended dose at sowing, 34% of the recommended dose at tillering and 33% of the recommended dose at early panicle initiation (T4) , 33% of the recommended dose at tillering, 34% of the recommended dose at early panicle initiation and 33% of the recommended dose at late panicle initiation (T5) and 100% of the recommended dose at sowing (T6). The trail was laid out in a randomized complete block design with three replications. Rice yield and yield components were significantly affected by time of nitrogen applications. Highest grain yield, number of productive tillers per plant, plant height and harvest index were recorded with application of 33% of the recommended dose at sowing, 34% of the recommended dose at tillering and 33% of the recommended dose at early panicle initiation. However, rice crop phenology and panicle length were not affected by timings of nitrogen application.**

***Key words* - Nitrogen, application time, Rice, Northern Ethiopia, Grain yield**

I. INTRODUCTION

Rice is the second largest, after wheat, produced cereal in the world. It is vital food crop for a large proportion of the world's population. The crop is the primary food grain consumed by almost half of the world's population (FAO, 2004). Rice crop grows both under irrigated and rainfed conditions worldwide contributing 75% and 25% of the rice production each, respectively (Dowling et al. 1998). Rice is becoming an increasingly popular food crop in Ethiopia. With about 17 million hectares of land suitable to rice production, Ethiopia has tremendous potential to increase the area under rice (EUCRD, 2012). With a relatively fixed amount of land, agricultural intensification practices such as soil fertility improvement and crop management and breeding practice are the most important components of the modern agricultural activity.

Fertilizers are increasingly important to improve crop productivity required to feed the overwhelming world population growth. Applications of organic and inorganic fertilizers replenish the nutrient removed from the soil by harvested crops. Fertilizers are currently responsible for between 40 and 60 percent of the world's food supply (Bruinsma, 2003). Despite African soils present inherent difficulties for agriculture, fertilizer use is one of the factors defining poor agricultural performance and growth in Africa (Morris et al., 2007).

Adequate supplies of nutrient for rice crop play a major role in realizing the yield potential of crops. Moreover, the profitability of intensive rice production depends on fertilizer application (Yoseftabar, 2013). Among the nutrients, nitrogen is required in comparatively greater quantities than other essential elements derived from the soil. Nitrogen plays a vital role in the growth and consequently the yield of crops. Apart from being a part of proteins, N is essential component of chlorophyll, a chemical crucial for life sustaining process, photosynthesis. Qiao-gang et al. (2013) reported that deficiency of soil nitrogen supply is one of the main limiting factors for achieving high rice yields. Hence, constant replenishment through extraneous nitrogen inputs becomes mandatory for optimal yield. An increase in nitrogen supply increased number of grains per panicle and 1000 grain weight, grain yield and number of tillers per hill (Manzoor *et al*., 2006), nutritive quality of straw (Nori et al., 2008) and number of panicle bearing tillers and harvest index (Irshad et al., 2000). However, within soil the applied nitrogen undergoes several complex physical and chemical transformations which either decrease or increase the availability of nitrogen fertilizer to plant roots. The processes or reactions include volatilization, denitrification, nitrification, immobilization, leaching, and plant uptake. Therefore, availability of nitrogen at various plant growth stages is important to reduce nitrogen loss and increase rice production. For good yield, N must be applied at appropriate stages (Saha et al., 1998).

Given that fertilizer is an expensive and precious input, so determination of an appropriate dose and method of application would reduce the cost of production and enhance the productivity, and consequently increase the profits of the grower under given situations (**Manzoor *et al*., 2006)**. The significance of time of nitrogen application on rice growth, yield and nitrogen efficiency was reported by many authors. The key period for nitrogen absorption by rice plants is from tillering to flowering, during this period the absorption of soil nitrogen is at its maximum rate (Qiao-gang et al., 2013). Rice grain yield increased significantly with application of 33% N at sowing, 33% at tillering, and 34% at panicle initiation (Hirzel et al. 2011). This study was, therefore, designed to investigate the effect of time of nitrogen application on rice growth, yield and yield components.

II. MATERIALS AND METHODS

Study area

The field experiment was conducted in Northern Ethiopia, western Tigray regional state, during the 2012 main crop growing season with the objective to determine the effect of timings of nitrogen application on rice yield and yield components. The geographical location of the area is 13° 31' 00" North latitude and 37° 11' 00" East longitude. The area receives 620mm annual rainfall and with mean minimum and maximum temperature of $20C^0$ and $38C^0$ temperature respectively. The soil type of the area is deep chromic Vertisols characterized with hardness when dry and stickiness and loss of trafficability when wet, which permit tillage and seedbed preparation only within a very narrow range of moisture contents.

Experimental design and treatments

The experiment consisted of six nitrogen application timings viz. 50% of the recommended at sowing and the remaining 50% at tillering (T1), 50% of the recommended at tillering and the remaining 50% at early panicle initiation (T2), 50% of the recommended at sowing and the remaining 50% at early panicle initiation (T3), 33% of the recommended dose at sowing, 34 of the recommended dose at tillering and 33% of the recommended dose at early panicle initiation (T4) , 33% of the recommended dose at tillering, 34 of the recommended dose at early panicle initiation and 33% of the recommended dose at late panicle initiation (T5) and 100% of the recommended dose at sowing (T6). The treatments were arranged in randomized complete block design replicated three times keeping 30cm and 5cm inter and intra row spacing, respectively. All plots received identical cultural treatments in terms of plowing, cultivation, seed rate, sowing method and disease and insect pest control.

Data collection

Data on number of days from sowing to emergence, panicle initiation and maturity were recorded for each treatment by counting number of days from sowing till 50% of the plants in each plot emerged, initiated heads, and maturity respectively. Moreover, ten plants were randomly selected for recording plant height at forty days after emergence and maturity (cm), number of productive tillers per plant, panicle length (cm) and number of seeds per panicle. Grain yield per plot (kg) and straw yield per plot (kg) were recorded at harvesting. Harvest index (%) was calculated following the formula given below.

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biomass yield}}$$

Statistical analysis

All the data collected were analyzed using JMP-5 computer statistical software package. Following the analysis of variance procedures, treatments showed significant difference were separated using Tukey HSD mean separation test.

III. RESULT AND DISCUSSION

Crop Phenology

Results of analysis of variance for days to emergence, panicle initiation and days to 50% of heading showed that timings of nitrogen application had no significant effect. This could be due to the fact that only one type of variety was used as planting material.

Plant height at maturity (cm)

Result of analysis of variance (Table 1) revealed that application of nitrogen fertilizer at different times significantly ($P<0.05$) affected rice plant height at forty days after emergence and maturity. Taller plant height (46.0) at forty days after emergence was recorded from plots received 33% of the recommended dose at sowing, 34% at tillering and 33% at early panicle initiation (T4). On the other hand, shorter plan height (34.6 cm) at this growth stage was recorded from plot receiving 100% of the recommended dose at sowing (T6). Similarly, application of nitrogen in split showed significant difference in plant height measured at maturity (Table 2). Maximum plant height (83.2cm) was recorded in treatments in timings application when 33% 34% and 33% of the recommended dose was applied at sowing, tillering and early panicle initiation (T4), respectively, which remained statistically at par with application of 50% of the recommended at tillering and the remaining 50% at early panicle initiation (T2) and 33% of the recommended dose at tillering, 34% at early panicle initiation and 33% at late panicle initiation (T5). However, minimum plant height (66.3cm) was achieved in the control treatment where 100% of the recommended dose was applied at sowing (T6). The positive effect of nitrogen on plant height in general and split application in particular was reported by many researchers. Raj et al. (2014) reported that application of nitrogen in four equal at 5-10, 20- 25, 40-45 and 60-65 days after emergence produced significantly taller plants. The same result was also reported by Anil et al. (2014) where taller plants were recorded in 4 equal splits.

Table 2: Effect of nitrogen timings on crop phenology of rice

Time of N-application	Days to emergence	Days to panicle initiation	Days to 50% heading	Plant height at 40 Days After Emergence
50% of the recommended at sowing and the remaining 50% at tillering (T1)	6	71.8	85	41.7ab
50% of the recommended at tillering and the remaining 50% at early panicle initiation (T2)	6	72.0	85	44.8ab
50% of the recommended at sowing and the remaining 50% at early panicle initiation (T3)	6	71.8	85	43.1ab
33% of the recommended dose at sowing, 34% at tillering and 33% at early panicle initiation (T4)	6	71.8	85	46.0a
33% of the recommended dose at tillering, 34% at early panicle initiation and 33% at late panicle initiation (T5)	6	73.3	85	41.1ab
100% of the recommended dose at sowing (T6)	6	72.7	85	34.6b
SEM (±)	0	0.3	0	1.1
CV	0	2.7	0	15.7

Levels not connected by same letter are significantly different

Number of productive tillers

As depicted in table 2 various nitrogen application timings gave significant ($p<0.05$) difference in production of fertile tillers per plant. Maximum number of fertile tillers per plant was produced from plots treated with 33%, 34% and 33% of the recommended dose at sowing, tillering and early panicle initiation (T4), respectively, which was statistically similar to application timings at 50% of the recommended at sowing and the remaining 50% at tillering (T1) and 50% of the recommended at tillering and the remaining 50% at early panicle initiation (T2). Similar results were also noted by Ehsanullah et al. (2001), Anil et al. (2014) and Manzoor et al. (2006).

Panicle length

Unlike to the other yield parameters, panicle length was not affected by nitrogen appliacation timings.

Grain yield (kg/ha)

Result of analysis of variance in Table 2 portrays significant ($P<0.05$) effect of nitrogen application timing treatments on grain yield. Rice grain yield varied in the range of 2830.7kg/ha and 3419.8kg/ha. The highest grain yield (3419.8 kg/ha) was recorded from plots received with 33% of the recommended dose at sowing, 34% at tillering and 33% at early panicle initiation which was statistically similar with application of timing of 50% of the recommended at sowing and the remaining 50% at tillering (T1), 50% of the recommended at tillering and the remaining 50% at early panicle initiation (T2) and 33% of the recommended dose at tillering, 34% at early panicle initiation and 33% at late panicle initiation (T5). The lowest grain yield (2830.7 kg/ha) was recorded with application of 100% of the recommended rate at sowing. The current result is in conformity with the finding of Fageria (2010) who reported highest grain yield with N timing treatment of 1/3 at sowing + 1/3 at active tillering and 1/3 at panicle initiation growth stage. Similarly, Yoseftabar (2013) reported maximum grain yield of rice with nitrogen applied in three split viz. 1/3 basal, 1/3 mid tillering and 1/3 panicle initiation. Moreover, Hirzel et al. (2011) confirmed highest productivity of flooded rice crop in Chile with application of 33% N at sowing, 33% at tillering, and 34% at panicle initiation, or 50% N at sowing and 50% at panicle initiation. The low grain yield record from the basal application of the entire recommended dose at planting could be due to low available nitrogen from loss by denitrification, leaching and volatilization. Qiao-gang, et al. (2013) reported the highest loss of nitrogen due to ammonia volatilization from basal fertilizer application.

Harvest Index

Harvest index is the ratio of economic yield to total dry weight. The influence of nitrogen application timings in rice harvest index are presented below in table 2. Maximum harvest index was recorded from application timing of 33% of the recommended dose at sowing, 34% at tillering and 33% at early panicle initiation. This application timing was statistically similar with all except with application timings of 100% of the recommended dose at sowing and 50% of the recommended at sowing and the remaining 50% at early panicle initiation. With regard to the timing of nitrogen fertilizer application, Fageria (2010) reported that highest harvest index was recorded from 2/3 N applied at sowing and 1/3 applied at panicle initiation.

Table 2: Main effect of method and time of nitrogen application on yield and yield components of rice

Time of N-application	Ph at harvest	No. productive Tillers	Panicle length	Yield (kg/ha)	Harvest index
50% of the recommended at sowing and the remaining 50% at tillering (T1)	73.2bc	6.0ab	16.55	3091.5ab	0.36a
50% of the recommended at tillering and the remaining 50% at early panicle initiation (T2)	82.2a	5.8ab	17.15	3370.1a	0.36a
50% of the recommended at sowing and the remaining 50% at early panicle initiation (T3)	72.3bc	5.3b	17.65	2945.2b	0.33b
33% of the recommended dose at sowing, 34% at tillering and 33% at early panicle initiation (T4)	83.2a	6.5a	18.6	3419.8a	0.36a
33% of the recommended dose at tillering, 34% at early panicle initiation and 33% at late panicle initiation (T5)	75.9ab	5.2b	17.6	3377.6a	0.35a
100% of the recommended dose at sowing (T6)	66.3c	3.7c	15.55	2830.7b	0.32b
SEM (±)	1.1	0.18	0.35	52.9	0.003
CV	9.1	21.4	12.4	10	5.3

Levels not connected by same letter are significantly different

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