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Effects of Time of Nitrogen Fertilizer Application on the Growth and Productivity of Rice (*Oryza Sativa L)* in Fogera Plain, North Western Ethiopia

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Abstract: *An experiment consisting of a fertilizer rate of 69/23 kg N/P_2O_5 ha^{-1} and seven nitrogen application times was conducted on Vertisols of Fogera plain during 2016/2007 cropping season. The N application times were 1/2 at sowing + 1/2 at tillering (control), 1/3 at sowing + 2/3 at tillering, 1/3 at 15 days after sowing + 2/3 at panicle initiation, 1/3 at 25 days after sowing + 2/3 at panicle initiation, 1/3 at sowing + 1/3 at mid tillering + 1/3 at panicle initiation, 1/3 at 15 days after sowing +1/3 at panicle initiation +1/3 at heading and 1/3 at 25 days after sowing + 1/3 at panicle initiation +1/3 at heading. RCB Design with three replications was used. The objective of the experiment was to identify the best time of N fertilizer application for maximum rice yield in Fogera plain. Results showed significant difference in grain yield in response to time of N application. The highest mean grain yield (3.5 ton/ha) was recorded when N was applied 1/3 at 25 days after sowing and 2/3 at panicle initiation. The Agronomic Nitrogen Use Efficiency was higher when 1/3 of N was applied at 25 days after sowing + 2/3 at panicle initiation. Therefore, it can be concluded that nitrogen applied 1/3 at 25 days after sowing plus 2/3 at panicle initiation is the appropriate time for rice production in Fogera plain.*

Keywords: *Vertisol, Low land rice, grain yield, Panicle initiation, agronomic NUE.*

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food security crop for about half of the world's population (Brohi *et al*., 1998) and ranks third in area after wheat and maize and second both in production and productivity after maize worldwide (FAOSTAT, 2012). The total world rice production has risen steadily from about 200 million tons (1960) to over 678 million tons (2009) (USDA, 2012). In the 2010/2011 and 2011/2012, the world paddy productions were estimated at 691.3 and 713.8 million tons, respectively. Globally, 158.9 million hectare of rice was harvested during the 2011/2012 (USDA, 2012). Rice represents 29% of the total output of grain crops worldwide (Xu *et. al*., 2003).These yields are compared with the world average of about 3.8 tones/ha; it is evident that there is a lot of potential to improve rice yields worldwide. Over 90% of the world's total rice crop is produced in South and East Asia. In area and production, China is the leading country in the world (EUCORD, 2012).

Rice is becoming an increasingly popular food in Africa because it is easy to store and cook; it is tasty and can be used for a large variety of dishes. It is grown in more than 75% of African countries, with a combined population of close to 800 million people. While it is already the main staple food crop in ten African countries, per capita consumption in others is rising at such a rapid pace that this figure will more than double in the coming years (Seck *et al*., 2012).

Rice production is increasing year after year in Ethiopia. According to the National Rice Research and Development Strategy of Ethiopia, the trend in the number of rice producing farmers, area allocated and production showed high increase especially since 2006 (NRRDSE, 2009). Area rose from 6,000 hectares in 2005 to nearly 222,000 hectares in 2010 and paddy production from 15,460 tons to

887,400 tons, at the same time, the number of rice farmers increased from 18,000 to more than 565,000 (MoARD, 2010).

Rice can produce grain yield as high as 10-18 t ha-^{1} in countries advanced in its cultivation (Yuan, 2002). However, its productivity in Ethiopia in particular (2.31 t ha-^{1} of paddy rice) and in Africa at large is much below its world average (4.35 t ha-^{1} of paddy rice) due to improper crop management practices. Fertilizer type, level and time of application are among the prioritized rice production input constraints set in Ethiopia (MoARD, 2010). Recommendations on different period of nitrogen fertilizer application were given for various production systems. According to the optimum time of nitrogen fertilizer application could be affected by several factors like rice variety, total amount of nitrogen to be applied, soil type, climate and crop rotation(James and Stribbling, 1995; Dobermann and Fairhurst, 2000).

Concerning the time of application in Fogera area, all the recommended P_2O_5 and half of the recommended nitrogen should be applied at planting and half of the remaining nitrogen at tillering stage of the crop (Tilahun *et al.*, 2007). Inadequate fertilizer applied through improper application technique is one of the factors responsible for low yield of rice (Aamer *et al.*, 2000). Availability of plant nutrients, particularly nitrogen at various plant growth stages is of crucial importance in rice production. Increasing the fertilizer use efficiency is very important, particularly in developing countries where the cost of fertilizer is rather very high and increasing. The judicious use of fertilizers contributes a lot towards improving the yield and quality of grain (Aamer *et al.*, 2000).

Nitrogen is the most essential nutrient for rice production. Nitrogen contributes about 20% of the rice yields out of total application of Nitrogen, Phosphorous and Potassium fertilizers. Most of the nitrogen applied through fertilizer is lost from soil by leaching, volatilization, surface runoff, and de-nitrification. Leaching loss of N occurs in the form of NO_3 and NH_4 from rice fields and the extent of loss by NO_3-N is more than 90% (Sahu and Samant, 2006). Application of N fertilizers at higher doses cause higher leaching loss. Leaching losses can be minimized by split application of nitrogenous simple fertilizer, application of complex/compound fertilizers in granular form, keeping the rice field’s alternate wetting and drying, addition of organic matter to soil. Looking to the various types of losses of nitrogen, the nitrogen use efficiency of rice soil can be increased through right choice of source, right dose, right time and right method of application of N fertilizers along with proper water management practices (Sahu and Samant, 2006). However, the right time of split application of N fertilizer for maximum yield is not studied well in the study area. This research was therefore conducted to determine the appropriate nitrogen fertilizer application timing for better rice production in Fogera plain.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The Field experiment was conducted in Fogera plain, Ethiopia in 2016/17 Cropping season. The experimental location, is situated at 11°46' to 11°59' latitude North and 37°33’ to 37°52’ longitude East at an altitude of 1815 meters above sea level (masl) (Tilahun *et al.*, 2012). The mean annual rainfall of the area is 1216mm. Farmers depend on long rainy season (June to September) for crop production. The dominant soil type on the Fogera plains is black clay soil (ferric Vertisols) (Tilahun *et al.*, 2012). The experimental soil was clayey in texture with a pH of 6.05.

2.2. Experimental Design and Procedures

Recommended fertilizer rate of 69/23 kg N/P_2O_5 ha^{-1}was used in the experiment (Tilahun *et al.*, 2007). The Nitrogen was applied in seven different splits of nitrogen fertilizer application times. (T1) 1/2 at sowing + 1/2 at tillering representing the control, (T2) 1/3 at sowing + 2/3 at tillering, (T3) 1/3 at 15 days after sowing + 2/3 at panicle initiation, (T4) 1/3 at 25 days after sowing + 2/3 at panicle initiation, (T5) 1/3 at sowing + 1/3 at mid tillering + 1/3 at panicle initiation, (T6) 1/3 at 15 days after sowing +1/3 at panicle initiation +1/3 at heading and (T7) 1/3 at 25 days after sowing + 1/3 at panicle initiation +1/3 at heading. The treatments were arranged in RCBD with three replications.

The gross and net plot sizes were 4 m x 3 m (12 m^2) and 3 m x 2 m (6 m^2), respectively. To control mixing of treatments, experimental plots were bunded manually. For each treatment equal amount of phosphorous (23 kg P_2O_5 ha^{-1}) was applied during planting uniformly. The N- fertilizer was side dressed with 5 cm distance from the plant to reduce the burning effect according to the time of nitrogen application. Furthermore, during the different growth stages of the crop, all necessary agronomic practices were carried out equally and properly. Variety X-Jigna was drilled manually at the seed rate of 80 kg ha^{-1} in rows 20 cm apart. Data on Plant height, total numbers of tillers, number of effective tillers, panicle length, numbers of filled spikelets per panicle, number of un- filled spikelet's per panicle, biomass, straw and grain yield were collected from the net plot. The data were subjected to analysis using Statistical Analysis System (SAS) Version 9.2 (SAS Inc., 2002). Agronomic Nitrogen Use Efficiency (ANUE) was calculated as extra kilogram of grain per extra kilogram of N applied (Mushayi *et al.*, 1999; Hatfield and Prueger, 2004).

3. RESULTS AND DISCUSSION

The result of the analysis of Variance indicated that split application of nitrogen fertilizer at different times significantly affected rice plant height ($p<0.01$) (Table 1). The tallest plant height (78.4 cm) was recorded in T4, with 1/3rd of N 25 days after sowing and 2/3rd of N at Panicle initiation followed by T6 and T7 and which was statistically similar (Table 1). On the other hand, the shortest plant height (68.8 cm) was obtained from T2, and followed by T5 and T1 (71.3 and 71.7 cm, respectively) and which were statistically similar (Table 1). The result indicated that split application of nitrogen fertilizer (T4) was found more effective in increasing plant height than that of the other treatments. This result was supported by (Reddy *et al.*, 1987; Akanda *et al.*, 1986) where taller plants were recorded in these treatments. The increase in plant height in response to application of N fertilizer was probably due to enhanced availability of N which resulted in more leaf area (Mandal *et al*., 1992) that in turn enhanced photo assimilates and thereby resulted in more dry matter accumulation (Rupp and Hubner, 1995).

Highly significant difference in total number of tillers at maturity per row meter length was observed due to split application of N fertilizer (Table 1). The highest number of total tillers per row meter length (1962.0 and 1686.0) were produced when nitrogen fertilizer was applied in (T4) two split of N; 1/3 at 25 days after sowing and 2/3 at panicle initiation and (T6) three splits of N; 1/3 at 15 days after sowing and 1/3 at panicle initiation and 1/3 at heading, respectively (Table 1). The lowest number of total tillers (1002.0 and 1020.0) was produced when time of nitrogen fertilizer was applied in T1 and T2 with split application of Nitrogen 1/2 at sowing and 1/2 at tillering representing the control and 1/3 at sowing and 2/3 at tillering, respectively and statistically similar (Table 1) . This result might be due to nitrogen promotes formation of the different organs in the rice plant as well as other physiological processes. N is the major component for the development of tillers, leaves and grains and promotes protein and carbohydrate synthesis. This is supported by Vennila *et al.*, (2007) who reported that productive tillers were effectively increased with fertilizer N application. More number of tillers per row meter length in experiment might be due to the more availability of nitrogen that played a vital role in cell division (Rajput *et al.*, 1988). According to Yoshida *et al.* (1972) as the amount of nitrogen absorbed by the crop increases, there is an increase in the number of tillers per square meter.

The effect of split application of N fertilizer on number of effective tillers per meter row length appeared to be considerable at T4. The highest number of effective tillers 1782.0 and 1506.0 were recorded from (T4) and (T6), respectively (Table 1). The lowest and statistically similar number of effective tillers was recorded from T1 and T2 which is (804.0) and (918.0) respectively (Table1). This result might be due to nitrogen promotes formation of the different organs in the rice plant as well as other physiological processes. It is the major component for the development of effective tillers. This result was in line with (BRRI, 1990), split application of nitrogen has a positive influence on the production of effective tillers per plant, yield and yield attributes.

Rice panicle length was significantly ($P<0.01$) responding to time of nitrogen application (Table 2). Maximum panicle length (17.3 cm) was observed at (T4) with spilt application of 1/3rd of N 25 days after sowing and 2/3rd at Panicle initiation. The minimum panicle length of 14.7cm was obtained with T2; spilt application of 1/3 at sowing + 2/3 at tillering and followed by T1(Table 2). The longer panicle length due to T4 nitrogen application appeared because of the fact that nitrogen takes part in panicle formation as well as panicle elongation and for this reason, panicle length increased with the increase of N fertilization and time of split application of N at panicle initiation stage. The longest panicle length at T4 might again be due to sufficient availability of nitrogen at panicle emergence stage. The result was in line with Kaushal *et al*., (2010); Bahmanyar & Soodaei Mashaee, (2010); Asif *et al*., (2000) who reported that greater panicle length in N application of 1/3 at transplanting+1/3 at early tillering+ 1/3 at panicle initiation. Vennila *et al.,* (2007) had also reported that panicle length was effectively increased with fertilizer N application.

Time of nitrogen fertilizer application significantly affected number of filled spikelet's per panicles ($P<0.05$) (Table 2). Filed spikelet per panicle was the most importance yield component which affect rice yield (Fallah, 2012). Maximum filled spikelet per panicle (141.2) was observed in T4; N application of 1/3 at 25 days after sowing and 2/3 at panicle initiation, while minimum number of spikelets per panicle (101.8) and (107.8) was observed in T1and T2 respectively (Table 2). This result is in agreement with Fallah, (2012) and Ehsanullah *et al*., (2001) who reported that nitrogen promotes rapid growth and increased spikelet number per each panicle. The findings of Witt *et al*., (2007) indicated that N absorbed at sowing, tillering and panicle initiation stage in rice plant ensured a sufficient number of panicles with increased number of spikelet (flower) per panicle that developed in to increased grain number per panicle.

Number of unfilled spicklets per panicle was significantly ($P<0.05$) affected by time of nitrogen fertilizer application (Table 2). Maximum spicklets sterility (34.7) was observed from T1, 1/2 at sowing and 1/2 at tillering representing the control. Minimum number of sterile spicklets per panicle (20.3) was obtained from T4, 1/3 at 25 days after sowing and 2/3 at panicle initiation (Table 2). This result showed that split application of nitrogen fertilizer at panicle initiation growth stage decreases number of un- filled spikelet's per panicle as compared to the control treatment. This result is in agreement with findings of many authors (Mohapatra *et al*., 1993; Yang *et al*., 2006).

Time of nitrogen fertilizer application statistically influenced total dry biomass (P<0.**001**) (Table 2). The highest total above ground dry biomass (14.1 ton/ha) was recorded at (T4). Moreover, T6 also gave the highest dry bio mass yield (13.0 ton/ha) as compared to the rest treatments. However, the lowest above ground dry biomass yield (9.7.and 10.0.ton/ha) were recorded fromT1 and T2, respectively and statistically similar (Table 2). This could be due to appropriate time of nitrogen fertilizer application increases vegetative growth of plants as well as number of tillers, plant height, and panicle length and also increase grain yield. This experiment confirms the observation made by Dobermann and Fairhurst (2000) that N uptake at mid tillering and panicle initiation stage tends to increase the biomass of plants' leaves, stems and panicles. Sathiya and Ramesh, (2009) also reported that spilt doses of nitrogen to different crop growth stage is more important to produce the dry matter production, as higher nitrogen to plant leading to its higher uptake and translocation from vegetative parts. Sallam, (2005) and Abd El-Maksoud, (2008) found splitting nitrogen provided the rice plants with N throughout the vegetative growth period. This may explain the favorable effect of splitting N fertilizer on yield attributing traits. These effects led the grain yield and aboveground biomass to be affected positively by splitting the N fertilizer to 3 or 4 doses.

The rice straw yield was significantly affected by time of nitrogen fertilizer application ($P<0.001$) (Table 2). Significantly higher straw yield (10.5 ton /ha) was obtained with from T4, applying 1/3 of N 25 days after sowing and 2/3 at panicle initiation followed by T6 (9.7 ton/ha). The lowest straw yields were recorded from T1 (7.09 ton/ha) applying half of the N at planting and the other half at mid tillering and T2 (7.3 ton/ha) 1/3 at sowing + 2/3 at tillering which were statistically similar with T1 (Table 2). This might be due to the application of nitrogen in splits according to crop requirement caused not only reduction in loss of nitrogen but also increased the nitrogen absorption, consequently better utilization of applied nitrogen leads to higher yield attributes and finally resulted in higher grain and straw yields. Moreover higher leaf area index, number of tillers per row meter length and significantly more panicle length might have contributed to increase in straw yield. This is in agreement with Maragatham, *et al.* (2010) who stated better straw yield could be explained as higher capability of rice to utilize more N through the expression of better growth by accumulating more plant dry biomass.

Grain yield of the rice exhibited significant response to time of nitrogen fertilizer application ($P<0.001$) (Table 2). The highest grain yield (3.57 ton /ha) was obtained at (T4), applying 1/3rd of N 25 days after sowing and 2/3rd at panicle initiation and followed by T6 (3.22 ton./ha), applying 1/3rd of N 15 days after sowing, 1/3rd at Panicle initiation and 1/3rd at heading (Table 2). The result indicated that relatively the lowest N was required at earlier stages and highest amount of nitrogen should be applied and used by the crop at panicle initiation stage as compared to other nitrogen split application time treatments so as to produce the maximum number of grains and subsequently higher grain yield. This could mainly be attributed to the increase in panicles length, total number of filled grains per panicle and seeds weight. Behera, (1998) also reported findings indicating improvements in grain yields attributed to increments in yield components. Increases in yield components are associated with better nutrition, plant growth and increased nutrient uptake (Kumar and Rao, 1992; Thakur, 1993). The lowest grain yield was recorded at T1 and T2 (2.63 and 2.67 ton./ha) which were statistically similar (Table 4.3). Reinke *et al*, (1994) noted that where the grain yield response is negative, yield reduction is primarily caused by a reduction in the proportion of the number of filled grains per panicle. The present result is in line with a number of reports (Bacon, 1980; Inthavongra *et al*., 1985). The most appropriate time of N application to rice is panicle initiation, which produced maximum plant height, number of spikelets (grains) per panicle and grain yield**.** In agreement to the present finding Marqueses *et al.* (1988) reported that band application of 1/3 N at 20 days after seeding + 2/3 N at 5-7 days before panicle initiation gave significantly higher grain yield (8.5 t/ha). George, (1980) indicated two splits application of nitrogen given at maximum tillering and panicle initiation stages was found to be giving better grain yield for the rain-fed lowland rice production of Thailand. Viraktamath, (2006) reported increase in rice grain yield due to the increased yield attributing characters like panicle number, panicle length, 1000-grain weight and low sterility percentage.

Low Nitrogen Use Efficiency (NUE) continues to be a problem in wetland rice situation as nitrogen (N) is subjected to several transformation losses in the rice ecosystem (Hussain *et al*., 2009). The optimum use of N can be achieved by matching supply with crop demand (Hussain *et al.*, 2009). Nitrogen use efficiency of crops can be improved by adopting adequate management practices. Use of N fertilizers in adequate amount, form, time and methods of application are important management strategies of this element. The highest agronomic Nitrogen Use Efficiency (51.8) was recorded when nitrogen was applied 1/3 at 25 days after sowing + 2/3 at panicle initiation stage (T4) of the rice crop as compared to the other treatments. The lowest ANUE was observed in T1 (38.1) when nitrogen was applied in split application of half at planting and the other half at tillering representing the control (Table 3). The specified treatment (T4) gave 51.8% ANUE for the rates of 69 kg/ha N compared to the control treatment (38.1), where 1/2 of N at planting and the remaining 1/2 of N at tillering. Application of one-third of N at 25 days after sowing + two third at panicle initiation stage gave 14% ANUE advantage over the control. James and Stribbling, (1995) reported that split application of nitrogen increased nitrogen uptake and use efficiency and reduction in nitrogen loss by volatilization, leaching and de-nitrification which in turn resulted in better growth development and yield.

Table1. *Effects of Time of Nitrogen Fertilizer Application on Vegetative Growth of Rice*

Time of Nitrogen Fertilizer applications	**Mean value of**			
	NTT	NET	NNET	PH
T1	1002.0 ^{d}	804.0 ^{d}	468.0	71.7 ^{bc}
T2	1020.0 ^{d}	918.0 ^{d}	246.0	68.8 ^{c}
T3	1536.0 ^{bc}	1332.0 ^{bc}	528.0	72.3 ^{bc}
T4	1962.0 ^{a}	1782.0 ^{a}	438.0	78.4 ^{a}
T5	1164.0 ^{bc}	1014.0 ^{dc}	348.0	71.3 ^{bc}
T6	1686.0 ^{ba}	1506.0 ^{ba}	444.0	75.4 ^{ba}
T7	1452.0 ^{bc}	1296.0 ^{bc}	384.0	74.4 ^{ba}
Significance difference	***	***	NS	**
SE±	231.8	208.5	202.84	2.45
CV (%)	16.5	17.1	50.0	3.34

Means in the column with the same letter are not significant different at 1%, 0.1 and 5% probability level. CV= Coefficient variance; LSD=Least significant difference; SE=Standard error; NTT=Number of total tillers per net plot ; NET=Number of effective tillers per net plot ; NNET=Number of non effective tillers per net plot ; PH=Plant height (cm); T1=1/2 at sowing + 1/2 at tillering ,representing the control T2=1/3 at sowing + 2/3 at tillering,T3=1/3 at 15 days after sowing + 2/3 at panicle initiation,T4= 1/3 at 25 days after sowing + 2/3 at panicle initiation,T5= 1/3 at sowing + 1/3 at mid tillering + 1/3 at panicle initiation, T6= 1/3 at 15 days after sowing +1/3 at panicle initiation +1/3 at heading and T7=1/3 at 25 days after sowing + 1/3 at panicle initiation +1/3 at heading

Table2. *Effects of Time of Nitrogen Fertilizer Application on Yield and Attributes of Rice*

Time Of N Fertilizer Application		Mean Value Of							
		TBY (T/Ha)	GY (T/Ha)	SY (T/Ha)	PL(Cm)	NFSPP	NUSSP	TSW (G)	HI (%)
T1		9.7^{e}	2.6^{d}	7.0^{d}	14.8^{bc}	101.8^{c}	34.7^{a}	24.6	27.1
T2		10.0^{de}	2.6^{d}	7.3^{d}	14.7^{d}	107.8^{bc}	24.8^{b}	24.6	26.7
T3		10.8^{dc}	2.7^{dc}	8.1^{dc}	15.5^{bdc}	120.5^{bac}	23.3^{b}	25.6	25.3
T4		14.1^{a}	3.5^{a}	10.5^{a}	17.3^{a}	141.2^{a}	20.3^{b}	26.1	25.2
T5		10.6^{d}	2.7^{dc}	7.9^{dc}	$15.^{1bdc}$	116.6^{bc}	25.1^{b}	24.8	25.7
T6		13.0^{b}	3.2^{b}	9.7^{ba}	16.3^{ba}	130.3^{ba}	22.6^{b}	26.0	24.8
T7		11.6^{c}	2.8^{c}	8.8^{bc}	16.2^{bac}	123.2^{bac}	24.7^{b}	25.8	24.5
Sig. diff.		***	***	***	**	*	**	NS	NS
SE±		0.55	0.10	0.61	0.79	13.04	3.83	1.10	1.85
CV (%)		4.9	3.83	7.4	5.0	10.6	12.6	4.20	7.59

Means in the column with the same letter are not significant different at 1%, 0.1% and 5% probability level. CV= Coefficient variance; LSD=Least significant difference; SE=Standard error; TBYT /HA=Total above ground biomass yield ton per hectare; GYT/HA=Grain yield ton per hectare ; SYT/HA=Straw yield ton per hectare; PL=Panicle length(cm);NFSPP=Number of filled spicklets per panicle; NUSPP=Number of un-filled spicklets per panicle; TGW=Thousand grain weight in gram and HI%=Harvest Index in percent; T1=1/2 at sowing + 1/2 at tillering ,representing the control T2=1/3 at sowing + 2/3 at tillering,T3=1/3 at 15 days after sowing + 2/3 at panicle initiation,T4= 1/3 at 25 days after sowing + 2/3 at panicle initiation,T5= 1/3 at sowing + 1/3 at mid tillering + 1/3 at panicle initiation, T6= 1/3 at 15 days after sowing +1/3 at panicle initiation +1/3 at heading and T7=1/3 at 25 days after sowing + 1/3 at panicle initiation +1/3 at heading.

Table3. *Effects of Split application of Nitrogen Fertilizer on Agronomic Nitrogen Use Efficiency of Rice*

Time of Nitrogen Application	**ANUE at 69 kg of N**
T1 =1/2 at sowing + 1/2 at tillering ,(control)	38.1
T2 =1/3 at sowing + 2/3 at tillering,	38. 7
T3 =1/3 at 15 days after sowing + 2/3 at panicle initiation	39.5
T4 = 1/3 at 25 days after sowing + 2/3 at panicle initiation,	51.8
T5 = 1/3 at sowing + 1/3 at mid tillering + 1/3 at panicle initiation,	39.9
T6 = 1/3 at 15 days after sowing +1/3 at panicle initiation +1/3 at heading	48.7
T7 =1/3 at 25 days after sowing + 1/3 at panicle initiation +1/3 at heading	41.4

4. CONCLUSIONS

Nitrogen is the most important nutrient needed throughout the growth stages of the rice plant, from seedling up to maturity, for vegetative growth as well as for yield production. Time of nitrogen application was found to be one of the major rice yield limiting factors in Fogera plain where rice is grown year after year as mono-cropping. From the findings of the present experiment, it can be recommended that split application of nitrogen one third at twenty five days after sowing plus two third at panicle initiation stage of rice crop was found to be the best appropriate time of nitrogen fertilizer application for rained lowland rice production in Fogera plain. However, to come with concrete recommendation, this research has to be repeated under similar condition.

REFERENCES

[1] Aamer, I., G. Abbas and A. Khaliq. 2000. Effect of different Nitrogen application Techniques on the Yield and Yield Components of Fine Rice. International Journal of Agriculture and Biology 2(3):239–241.

[2] Abd El-Maksoud M.F. 2008. Effect of Levels and Splitting of N-fertilization on Growth, Yield Components, Yield and Grain Quality of Some Rice Cultivars Res. J. Agric. and Biol. Sci. 4(5), 392-398.

[3] Akanda, M.R.U., Eunus, M., Islam, M.A., Ali, M.I. 1986.Nitrogen application timing and performance of BR4 transplant aman rice. Bangladesh J. Agric. 11 (1), 39-43.

[4] Asif m, Aslan M, Jabar A, Rafique k, Babar MR, Ehsanullah 2000, Panicle structure, kernel quality and yield of fine rice as influenced by NPK rates and split nitrogen application. International journal of agricultural & biology.1560-8530/2000/02-4-306-308.

[5] Bacon PE. 1980. Nitrogen application strategies for rice. Proc. Aust, Agron conf., Lawes, Australia. (Field Crop Abst., 36:4406, 1983). Bangladesh Rice Res. Inst., Joydebpur, Gazipur. P: 95

[6] Bahmanyar MA, Soodaei Mashaee S. 2010. Influences of nitrogen and potassium top dressing on yield and yield components as well as their accumulation in rice (Oryza sativa) African Journal of Biotechnology Vol9 (18):2648-2653.

[7] Behera AK, 1998. Response of scented rice (Oriza sativa) to nitrogen under transplanted condition. Indian Journal of Agronomy. 43(1):64-67.

[8] Brohi, A.R., Karaman, M.R., Aktas, A. and Savasli, E.1998.Effect of nitrogen and phosphorus fertilization on the yield and nutrient status of rice crop grown on artificial siltation soil from the Kelkit River. Turkish Journal of Agriculture and Forestry 22: 585-592.

[9] BRRI (Bangladesh Rice Research Institute), 1990. Nitrogen response of promising variety. Annual Rep. Bangladesh Rice Res. Inst., Joydebpur, Gazipur. P: 95. systems. Adv Agron 45:1–59.

[10] Dobermann, A. and Fairhurst, T. 2000. Rice Nutrient Disorders and Nutrient Management p. 84–86. Singapore: Phosphorus and Potash Institute and International Rice Research Institute.

[11] Ehsanullah M, Attaullah M, Cheema MS, Usman M. 2001.Rice BASMATI-385 response to single and split application of nitrogen at different growth stages. Pak.J.Agri.Sci. vol38 (1-2):84-86.

[12] EUCORD (European Cooperative for Rural Development) 2012.Rice sector development in East Africa A Desk Study Prepared for common Fund for Commodities. Brusseles.

[13] Fallah A. 2012.Interactive effects of nitrogen and irrigation methods on the growth and yield of rice in amole area. International journal of agriculture 3(4):111-113.

[14] FAOSTAT (Food and Agriculture Organization Statistical Databases, United Nations). 2012. World food and agriculture. Food and Agriculture of the United Nations, Rome, Italy.

[15] George I. (1980).Effects of level, time, and splitting of urea on the yield of irrigated directseeded rice. Plant and Soil56(2):209-215.

[16] Hatfield JL, Prueger JH. 2004. Nitrogen Over-use, Under-use, and Efficiency. "New directions for a diverse planet". Proceedings of the 4th International Crop Science Congress, 26 Sep – 1 Oct 2004, Brisbane, Australia. pp 21-29.

[17] Hussain, M Z, S.A Khan, T.M Thiyagarajan. 2009. Increasing Nitrogen Use Efficiency in Rice (Oryza sativa L.) with Chlorophyll Meter and Leaf Color Chart. The IUP Journal of Soil and Water Sciences 12:233-253.

[18] Inthavongra K, Yasve T, Moruwaki T, Watabe T, Imai K. 1985. Studies on the formation of yield and yield components in Indica rice. I. Response to nitrogen application in a local and improved varieties. Japanese J. Tropical Agri. 29 (3): 131-139.

[19] James,E. and Leigh Stribling. 1995. Fertilizer management to protect water quality: In: Agricultural and Natural Resources water quality controlling. Alabama A&M and Auburan Universities.

[20] Kaushal AK, Rana NS, Singh A, Neeray S, Strivastav A. 2010. Response of levels and split application of nitrogen is green manure wetland rice (Oryza sativa L.). Asian Journal of Agricultural sciences. Vol2 (2): 42-46.

[21] Kumar K and Rao K V P, 1992.Nitrogen and phosphorus requirement of upland rice in Manipur. Oryza. 29:306–309.leachate of a paddy plot during the rice cultivation period in southern Korea. Comm. Soil Sci. Plant Anal 37:1957–72.

[22] Mandal NN, Chaudhry PP, Sinha D.1992. Nitrogen, Phosphorus and Potash uptake of wheat (var. Sonalika). Env. Eco. 10, 297 (Field Crop Abst. 46(1), 30.

[23] Maragatham M, Martin GJ,Poongodi T. 2010. Effect of Nitrogen sources on aerobic rice production under various rice soil ecosystems.19th World Congress of Soil Sci. Soil Solutions for a Changing World, 1-6 August 2010, Brisbane, Australia.

[24] Marqueses, E.P. H.F. Schnier, M. Dingkuhn, J.E. Faronilo, C.B. Javellana, J.E. Wijangco, and S.K. De Datta. 1988. Effects of timing and method of nitrogen application on grain yield, agronomic efficiency, plant nitrogen and dry matter yield in transplanted and direct seeded lowland rice [Philippines]. Philippine Journal of Crop Sci. 13:12-16.

[25] MoARD.(Ministry of Agriculture and Rural Development) 2010.National Rice Research and Development Strategy of Ethiopia. Addis Ababa, Ethiopia.

[26] Mohapatra PK, Patel R, Sahu SK. 1993.Time of flowering affects grain quality and spikelet partitioning within the rice panicle, Australian Journal of Plant Physiology , 1993, vol. 20 (pg. 231-242).

[27] Mushayi, P.T., S.R. Waddington and C. Chiduza..1999. Low efficiency of nitrogen use by maize on small holder farms in sub-humid Zimbabwe. In: Maize production technology for the future: Challenges and opportunities, Proceedings of the sixth Eastern and Southern Africa Regional Maize Conference, Addis Ababa, Ethiopia: CIMMYT and Ethiopian Agricultural Research Organization. Pp. 278-81.

[28] NRRDSE, (2009) *National Rice Research and Development Strategy of Ethiopia*; Ministry

[29] Of Agriculture and Rural Development, Addis Ababa, Ethiopia.

[30] Rajput M.K.K., Ansari, A.H., Mehdi, S., and. Hussain, A.M., 1988 Effect of N and P fertilizers alone and in combination with OM on the growth and yield of rice. Toria. Sarhad J. Agri. Res., 4: 3–6.

[31] Reddy, T.M.M., Rangulh, A.V., Ramaiah, N.V., Reddy, G.V., 1987 Effect of methods of planting and nitrogen levels on growth, yield attributes and yield of rice under late condition. J. Res. Andhra Pradesh Agril. Univ. 15 (1), 56-58.

[32] Reinke RF, Lewin LG and Williams RL.1994 Effect of sowing time and nitrogen on rice cultivars of differing growth duration in New South Wales I Yield and yield components Australian Journal of Experimental Agriculture 34(7):933–938.

[33] Rupp D, Hubner H. 1995. Influence of Nitrogen fertilization on the mineral content of apple leaves. Erwerbsobstbau, 37, 29-31.

[34] Sahu, S. K. and Samant, P.K. 2006. Nitrogen Loss from Rice Soils in Orissa http://www. msu.ac.zw/ elearning/ material/1209997439soil%20fertility%20nitrogen%20loses. pdf . Retrieved on April 25/2017.

[35] Sallam STM. 2005. Studies on yield potentiality of Giza 177 and Sakha 101 rice cultivars under the effect of bio fertilization and splitting of nitrogen. PhD. Thesis Fac. Agric. Zagazig Univ., Egypt.

[36] SAS Institute. 2002. SAS Version 9. 1.2 © 2002-2003. SAS Institute, Inc., Cary, NC.

[37] Sathiya K, Ramesh T. 2009. Effect of split application of nitrogen on growth and yield aerobic rice. Asian J,Exp. SCI. Vol (23) , No (1) :303-306.

[38] Seck, P. A., Diagne, A., Mohanty, S., and Wopereis, M. C. S, 2012.Crops that feed the world 7: rice. Food Security4 (1), 7-24.

[39] Thakur RB, 1993.Performance of summer rice (Oryza sativa) to varying levels of nitrogen. Indian Journal of Agronomy 38(2):187–190.

[40] Tilahun Gebey, Berhe, K., Hoekstra, D. and Alemu, B. 2012.Rice value chain development in Fogera woreda based on the IPMS experience. Nairobi, Kenya: ILRI.

[41] Tilahun Tadesse, Minale Liben, Alemayehu Assefa, Belesti Yeshalem and Tesfaye Wossen, 2007. Effect of nitrogen and phosphorus fertilizers on the yield of rice in Fogera and Metema areas. In: Ermiase A., Akalu T., Alemayehu A., Melaku W., Tadesse D., and Tilahun T. (eds.). Proceedings of the 1st Annual Regional Conference on Completed Crop Research Activities, 14- 17 August 2006. Amhara Regional Agricultural Research Institute, Bahir -Dar, Ethiopia.

[42] USDA (United States Department of Agriculture). 2012. World agricultural production. Foreign Agricultural Service, Circular Series WAP 06-12.

[43] Vennila C, Jayanthi C, Nalini k. 2007.Nitrogen management in wet seeded rice. Agric, Rev.28 (4):270-276.

[44] Viraktamath BC. 2006. Evaluation of system of rice Intensification (SRI) under all India coordinated rice improvement project. In: Abstracts of National Symposium on System of Rice Intensification (SRI)–Present status and future prospects, November 17-18, India.

[45] Witt C, Buresh RJ, Peng S, Balasubramanian V, Dobermann A. 2007.Nutrient management. p 1-45. In: T. H. Fairhurst, C. Witt, R. Buresh and A. Dobermann, eds. Rice: A practical guide to nutrient management Los Baños (Philippines) and Singapore: International Rice Research Institute (IRRI), International Plant Nutrition Institute (IPNI), and International Potash Institute (IPI).

[46] Xu Kuangdi and Shen Guofang. 2003. Promoting Chinese Rice Production through Innovative Science and Technology. In: Mew T.W. et al (ed.) Proceedings of the International Rice Research Conference, 16-19 September 2002, Beijing, China, pp 11-18.

[47] Yang J, Zhang J, Wang Z, Liu K, Wang P. 2006. Post-anthesis development of inferior and superior spikelets in rice in relation to abscisic acid and ethylene, Journal of Experimental Botany, vol. 57 (pg. 149-160).

[48] Yoshida S., Cock J.H., Parao F.T. (1972). Physiological aspects of high yield. Int. Rice Res. Inst. Rice breeding , pp. 455-469.

[49] Yuan, L.P. 2002. A scientist's perspective on experience with SRI in China for raising the yield of super hybrid rice. Cornell Institute for Food, Agriculture, and Development: http://ciifad.cornell.edu/sri; 23-25 (Acces- sed on 13/04/2017).

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