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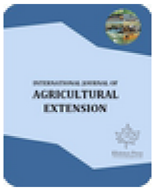

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RESPONSE OF RICE TO NITROGEN RATE AND INTER-ROW SPACING AT GURAFERDA AND GOJEB SOUTHWESTERN ETHIOPIA

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ABSTRACT

Rice is a major cereal crop in Gojeb and Guraferda areas. However, the crop yield is low due to lack of site-specific recommendations on Nitrogen rate and inter-row spacing. Accordingly, a field experiment was conducted at Gojeb and Guraferda, southern Ethiopia, in 2019 to evaluate the response of rice to Nitrogen rate (0,32, 64, and 96kg) and inter-row spacing (20cm, 25cm and 30cm) during the rainy season. The treatments laid out on Randomized complete block design with three replications. The phenological and yield related parameters were recorded. Analysis of variance done by using SAS version 9.3 and mean separation for significant treatments were done by least significant difference. Results of the study indicated that both Nitrogen fertilizer rate and inter-row spacing had a significant effect on growth and yield parameters. As a result, total number of tillers and grain yield were highly significantly ($p<0.01$) affected by main effects of Nitrogen fertilizer rate and inter-row spacing. However, days to maturity and plant height were significantly ($p<0.01$) affected by Nitrogen fertilizer rate. Generally, 96kg of Nitrogen fertilizer was found to be suitable for production of the highest grain yield (4090.5 kg ha^{-1}). Inter-row spacing at 25 cm and 30 cm inter-row spacing had given the highest yield. Therefore, the outcome of this study revealed that the Nitrogen fertilizer rate of 96kg ha-1and inter-row spacing of 25 cm could be feasible and can be recommended for the study area with the assistance of extension field staff.

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INTRODUCTION

In Ethiopia, rice is cultivated on 0.454 million hectares in 2015/2016 and its productivity is 2.7 tons per hectare (Central Statistical Agency, 2016). Optimum spacing ensures better plant growth through efficient utilization of solar radiation and nutrients (Khan *et al.*, 2005). Nitrogen (N) is an essential nutrient and is often the most yield-limiting nutrient in rice production around the world (Samonte *et al.*, 2006). It plays a key role in rice production as it is required in huge amount. According to Manzoor *et al.* (2006) rice grain yield was significantly increased with increasing nitrogen fertilizer application rate.

In addition, grain yield of rice is responsive to N supply because N nutrition increase leaf area index (Anwar *et al.*, 2011). Thus, both vegetative and reproductive phases of growth are highly dependent on adequate N supply. The best dose of mineral fertilizer is the one which gives maximum economic return at minimum cost (Ananthi *et al.*, 2010). The rate of nitrogen is critical in terms of their impacts on yield contributing parameters as nitrogen increases plant height, leaf size, the number of panicles, the number of spikelets and filled spikelets per panicle (Shakouri *et al.*, 2012).

Many workers reported that the nitrogen level and the degree of spacing determine the growth of cereal crops and modify their characters, that is plant height, heading time, tiller number, panicle number, panicle length, panicle weight, and yield. Various research findings indicate that rice responses vary with rate of nitrogen at various locations. According to Sewenet (2005) application of 23kgN/ha recommended at the Fogera plains Vertisols for profitable grain yield of rice had significantly improved grain yield (3992 kgha^{-1}). Similarly, Bekele (2016) recommended at 46 kg N to improve the grain yield and yield component of rice on nitosols at kamashi zone under rainfed conditions. Nesgea *et al.* (2012) reported that 92kgNha^{-1} increased grain yield of rain-fed rice from 3540 to 5900kgha-1in Gambella. There are several reports showing the yield increase of rice crop grown in different rice ecologies due to applied nitrogen fertilizer (De-Datta and Patrick, 1986; Sewenet, 2005). Even though rice is one of the main foods for most of Kaffa and Bench Maji zone but, production is not satisfactory due to the use of blanket recommendation of inter-row spacing and N level in the area without considering specific soil types and agro-ecological characteristics of the area. Hence this study was initiated to determine the optimum level of nitrogen, inter-row spacing and to identify interaction effects of nitrogen and inter-row spacing for yield and yield components of rice.

MATERIALS AND METHODS

Description of the study area: The experiment was conducted on a farmer's field during the main rainy season at Guraferda and Gojeb from June 2019 to November 2019. Guraferda is situated at 06° 50' 368" N latitude and 035° 17' 16" E longitude with an altitude of 1138 m.a.s.l. The annual average temperatures range from 25 to 39°C. Similarly, Gojeb is suited 07° 15' 30" N and 036° 0' 0" E with an altitude of 1235 m.a.s.l.

Treatments and experimental design

The treatments consisted of complete factorial combinations of four N fertilizer rates (0 kg ha^{-1}, 32 kg ha^{-1}, 64 kg ha^{-1} and 96 kg ha^{-1} kg N) and three inter-row spacing (20, 25, and 30cm). Split application (50% of the treatment at sowing and the remaining 50% at tillering) was used. These treatments were laid out in a Randomized Complete Block Design (RCBD) with three replications. The gross plot size of each treatment was 2 m × 3 m (6 m^2). The central rows were used for data collection and measurement. The distance between the plots and replications was kept at 0.5 m and 1 m apart, respectively. Rice seeds were sown by drilling in rows at the recommended rate of 80 kg ha^{-1} in June in both locations. At each location, all the rice plots were supplied with NPS fertilizer at a recommended rate of 100 kg ha^{-1}. Similarly, the N was applied in the form of urea (as per the treatment) at planting time and at the tillering stage, splits were applied by side dressing. Plots were kept free of weeds by hand weeding. Harvesting was done manually using hand sickle in late November.

Data Collection

Major phenological parameters were recorded in the field on a plot basis. Accordingly, days to heading as estimated as several days from sowing to 50% plant bear heading, days to flowering, number of days from sowing to 50% of the plants flowered, days to maturity from the date of sowing to 90% of plants physiologically matured. Growth and yield parameters like plant height was measured from ten randomly selected plants for each unit plot, Number of tillers was recorded through counting tillers number using 0.5m^2 quadrant, panicle length was measured from ten randomly selected plants by using ruler, weight of 1000 grain was measured from taking samples of each unit plot and grain yield (kg ha^{-1}) was determined from the harvested net plot area and was adjusted to 14% moisture contents.

Data Analysis

The data were subjected to Analysis of variance (ANOVA) using statistical analysis Software (SAS version 9.3) with the general linear model procedure. The mean separation was done using Fisher's Least Significant Difference (LSD) test at a 5% probability level.

RESULTS AND DISCUSSION

Phonological parameters

The main effect of Nitrogen fertilizer rate, inter-row spacing, and the interaction of the two factors didn't show a significant difference ($p>0.05$) on days to 50% heading and days to flowering (Table 1). On the other hand, Nitrogen fertilizer rate significantly ($p<0.01$) affects days to 90% maturity. However, inter-row spacing and its interaction effects with Nitrogen rate did not show a significant variation on days to maturity (Table 1). Concerning to Nitrogen fertilizer rate, the crop reached maturity earlier (101.4days) at 0 kg ha^{-1} N (control), while the delayed maturity of 105.7 and 104.7 days was obtained from treatment of 96 kg ha^{-1} N and 64 kg ha^{-1} N, respectively. It was observed that when nitrogen levels increased from 0 to 96kg ha^{-1} days to maturity also increased. The higher nitrogenous fertilizer delays the senescence of leaves and increased succulence of plants; therefore, physiological maturity was increased with increment in N level (Jiban, 2013).

Tanaka *et al.* (1995) found that when N is applied in excess to rice, the sugar concentration in leaves reduces during early ripening stage and hence, inhibition occurs in the translocation of assimilated products to spikelets. The findings of Marschner (1995) who reported that plants treated with adequate nutrients and enough space remained green for longer duration.

Table 1. Effect of Nitrogen rate and inter-row spacing on crop phenology of rice.

Treatment	No of days to heading	No of days to flowering	No of days to maturity
		N rate (kg ha^{-1})	
0	75.6	75.8	101.4[c]
32	77.4	77	103.2[b]
64	77.8	77.9	104.7[a]
96	79.2	79	105.7[a]
LSD (0.05)	NS	NS	1.47
		Inter-Row spacing(cm)	
20	77.3	77.41	103.7
25	77.25	77.36	103.8
30	77.2	77.5	103.7
LSD (0.05)	NS	NS	NS
CV (%)	10	9.1	2.1

LSD (5%)= Least significant difference at P= 0.05, CV(%)= coefficient of variation in percent , NS= non-significant

Means with the same letter(s) with in a column are nor significantly different at 5% level of significance.

Growth and yield parameters

Nitrogen fertilizer showed a significant ($p<0.01$) difference in plant height, despite the main effect of inter-row spacing and the interactions of the two factors were not significant (Table 2). Maximum plant height (93.7cm) was recorded from 96 kg ha^{-1} N which was statistically similar to 80.2cm obtained from 64 kg ha^{-1} N. Generally, the increase of N fertilizer from 0 to 96 kg ha^{-1} increased the mean plant height from 73.3cm to 93.7 cm. The increase in plant height in response to the application of N fertilizers is probably due to enhanced availability of nitrogen, which enhanced more leaf area resulting in higher photo assimilates and thereby resulted in more dry matter accumulation (Chaturvedi, 2005). The analysis of variance revealed a significant number of tiller differences among N fertilizer and inter-row spacing. However, N fertilizer and inter-row spacing did not significantly interact to influence the number of tillers. The higher (178.8) number of tillers was obtained from 96kg ha^{-1} N, which was in parity with the tiller 175.7 obtained from 64kg ha^{-1} N fertilizer. The increased number of tillers in an increased rate of N fertilizer might be due to the more availability of nitrogen that played a vital role in cell division.

Concerning inter-row spacing, the maximum (177.2 and 166.5) tillers were obtained from 30cm and 25cm inter-row spaced, respectively, while the minimum (152.4) was from 20cm. This might be due to more radiation interception, favorable soil and air temperature in the crop canopy during the growing cycle of the crop. The amount of nitrogen applied, inter-row spacing, and interaction of two did not show any significant difference on the one thousand grain weight at $P>0.05$ (Table 2)

The analysis of variance indicated that the grain yield was significantly affected by Nitrogen fertilizer rate and inter-raw spacing. However, Nitrogen fertilizer rate and inter-row spacing did not significantly interact to influence the grain yield. The maximum grain yield (4090.5kg) was obtained from the application 96kg nitrogen, while the minimum (2737.3kg) was from control (0kg N). The increase in nitrogen rate increases the grain yield. This might be associated with the maximum number of tillers obtained from the high rate of N (96kg). According to Kandil *et al.* (2010), the increase of nitrogen levels involved directly or indirectly in the enlargement and division of new cells and production of tissues, which in turn were responsible for the increase in growth characteristics, particularly increase in plant height and tiller numbers, finally determining the yield. This study also showed that the grain yield increased with increasing inter-row spacing. Maximum grain yield was obtained from 30cm inter-row spaced plants, which were statistically similar with the yield obtained from 25cm inter-row spacing, while the minimum was from 20cm inter-row spaced plants. The decrease in grain yield under closer inter-row conditions might be due to more competition for nutrients, space light, and air. As result plants become weaker and thinner, and consequently, grain yield was reduced.

Table 2. Effect of Nitrogen rate and inter-row spacing on growth and yield parameters of rice

Treatment	Plant height(cm)	Panicle length(cm)	No of tillers/m2	1000 seed weight(g)	Yield(kg)
N rate (kg ha^{-1})					
0	73.3^{c}	19.2	145.7^{c}	27.9	2737.3^{c}
32	78b	19.8	161.2^{bc}	29.3	3225^{b}
64	80.2^{ab}	19.3	175.7^{ab}	27.1	3409.6^{b}
96	93.7^{a}	19.4	178.8^{a}	28.5	4090.5^{a}
LSD (0.05)	3.6	NS	16.8	NS	490.5
Inter-Row spacing(cm)					
20	77.5	19.3	152.4^{b}	27.9	2971.0^{b}
25	78.7	19.4	166.5^{a}	28.2	3430.7^{a}
30	80.2	19.6	177.2^{a}	28.4	3695.1^{a}
LSD (0.05)	NS	NS	13.3	NS	331.24
CV (%)	6.75	8.9	13.9	10.4	16.9

LSD (5%) = Least significant difference at P= 0.05, CV (%) = coefficient of variation in percent, NS= non-significant Means with the same letter(s) with in a column are nor significantly different at 5% level of significance.

Table 3. Partial budget analysis.

	Treatments (N rate)			
	0	32 kg	64 kg	96 kg
Average yield	2737.3	3225	3409	4090.5
Adjusted yield	2463.57	2902.5	3068.1	3681.45
Gross benefit	19708.6	23220	24544.8	29451.6
Total variable cost	-	1120	2240	3360
Net benefit	19708.56	22100	22304.8	26091.6
Marginal rate of return	213.57%	18.28%	338.1%	

The partial budget analysis revealed that all N fertilizer rates gave higher net benefit over non fertilized check. Furthermore, the highest net benefit of Ethiopian Birr 26091.6 Birr per hectare was recorded at application rate of 96 kg ha^{-1} (Table 3). The marginal rate of return was 213.57, 18.28 and 338.1% at application rates of 32, 64 and 96 kg ha^{-1}, respectively. In economic analysis, it is assumed that farmers require a minimal rate of return of 100%, representing an increase in net return of at least 1 Birr for every 1Birr invested. For this crop application of 96 kg N ha^{-1} showed better returns over the lower rates.

CONCLUSION AND RECOMMENDATION

Improved agronomic management practices is the most i mportant strategy to feed the rapidly growing population. Among those practice nitrogen fertilizer and inter-row spacing greatly affected plant growth and yield of rice. Especially, nitrogen has more advantages in yield and yield components of rice because optimum rate significantly improves yield components like panicle number, thousand grain weight, reduced grain sterility, and grain yield. The experiment was conducted to determine optimum n itrogen fertilizer and inter row spacing. Among nitrogen fertilizer rate used in the study, 96kg Nha^{-1} gave better total tiller numbers and grain yield. Nitrogen fertilizer and inter-row spacing greatly affected plant growth and yield of rice.

Nitrogen has more advantages in yield and yield compon ents of rice because optimum rate significantly improves yield components like panicle number, thousand-grain weight, reduced grain sterility, and grain yield. The results also indicated grain yield was increased at optimum inter-row spacing. Optimum Inter-row spacing ensures the plants grow in aerial and underground parts through efficient utilization of water, nutrient, and solar radiation. Among inter-row spacing's 25 cm, and 30cm inter-row spacing was better in a total number of tillers and produced higher grain yield which was statistically in parity. Although 25cm and 30cm intra-row spacing equally gave a maximum number of tillers and grain yield, 25 cm spacing is to be favoured for the study area because of efficiently to use the land. Therefore, most attractive rate for farmers of the study area with low cost of production and higher net benefit was 96 kg ha-1 N and 25 cm inter-row spacing can be recommended to obtain maximum yield of rice under the main rain-fed condition study area.

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