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Effect of Split Nitrogen Application on Growth and Yield of Rice (*Oryza sativa* L.) Under Irrigated Condition in the Guinea Savanna Zone of Ghana

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ABSTRACT

Experiment was set up in 2013 at the experimental field of Savannah Agriculture Research Institute to evaluate the effect of split nitrogen application on growth and yield of lowland rice. It was made up of ten treatments laid out in split plot design with three replications. Treatments were made up of two low land rice varieties (Jasmine and Degang) randomly assigned to main plots and five levels of N fertilization (control, 60 kg NPK/ha, 60 kg NPK/ha + 30 kg N/ha, 60 kg NPK/ha + 15 + 15 kg N/ha and 60 kg NPK/ha +10 + 10 + 10 kg N/ha) randomly assigned to sub plots. Fertilizers used were NPK (15-15-15) and Sulfan (24% nitrogen). Variety x split N fertilization had no significant (P>0.05) effect on all parameters measured. Main effect of variety and split N fertilization significantly (P<0.05) affected most parameters measured, especially grain yield. Jasmine proved superior to Degang in grain yield. Application of 60 kg NPK/ha + 30 N/ha optimized rice growth and maximized yield similar to 60 kg NPK/ha + 15 kg N/ha + 15 kg N/ha and 60 kg NPK/ha + 10 kg N/ha + 10 kg N /ha + 10 kg N/ha. Application of 60 kg NPK/ha + 30 N/ha is recommended for increase rice yield and income of farmers, as split application at 15 + 15 kg N/ha and 10 + 10 + 10 kg N/ha attract additional labour cost.

1.Introduction

In Africa, the commodity is increasingly gaining more importance. The continent now consumes far more rice than it produces, a situation that has led to huge imports to the continent (CSIR, 2012). Rice production in Ghana is faced with a number of limitations. Yield maximization is hindered by poor water management, poor soil fertility management, use of low yielding varieties and incorrect fertilizer application [3].

Many researchers have reported the effects of splits application of N with emphasis on increasing the total quantity of N. There is, however, little available information on effects and efficiency of splitting the same quantity of N for different rice varieties. [1] split applied N at 0, 30, 60 and 90 kg ha^{-1}. From their results, yield of rice increased with corresponding increases in the quantities of split-applied N. Since fertilizer is an expensive and precious input, determination of an appropriate dosage of N application that would be both economical and appropriate to enhance productivity under agiven growth condition needs intensive study. This experiment was thus thus set up to evaluate the response of two lowland rive varieties to split N fertilization.

2. Material and Methods

2.1 Description of study area

The experiment was carried out during the 2013 cropping season at the experimental field of Savanna Agriculture Research Institute in Nyankpala. The location lies on an altitude of 183 m above sea level, latitude 09° 25' 41'' North and 0° 58' 42'' West of the equator [10]. The area experiences a relatively uniform temperature distribution, with a monthly mean of 28.3°C, a minimum value of 20.2°C and maximum value of 36.6°C. Relative humidity is highly variable, reaching a peak of 93 % during the rainy season [8]. The experimental site experiences a mono-modal rainfall pattern, which starts from

June and end in December with a total rainfall of about 1030.3 mm and monthly mean of 85 mm [9]. The total average rainfall for 2013 cropping season was 1159 mm, the minimum and maximum temperatures were 26°C and 31°C respectively, whilst the mean temperature was 28°C and relatively humidity was 84% [9].

2.2 Experimental design

It was a 5 x 2 factorial experiment. A total of ten treatments (Table **1**) comprising of five rates of split fertilizer application and two varieties, were laid out in a split plot design with three replications. Varieties and fertilizer application were respectively assigned to the main and sub plots.

Table 1. Experimental treatments

Main plot	Subplot
Jasmine 85	Control
	60 kg NPK/ha
	60 kg NPK/ha + 30 kg N/ha
	60 kg NPK/ha + (15 + 15) kg N/ha
	60 kg NPK/ha + (10 + 10 + 10) kg N/ha
Degang	Control
	60 kg NPK/ha
	60 kg NPK/ha + 30 kg N/ha
	60 kg NPK/ha + (15 + 15) kg N/ha
	60 kg NPK/ha + (10 + 10 + 10) kg N/ha

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2.3Soil sampling and analysis

Soil samples were taken from the experimental sites prior to planting and analyzed at the Soil Science Laboratory of the Savannah Agricultural Research Institute (SARI) to determine the initial fertility status. Samples were taken from the site using the tube auger from 0-20 cm depth of the soil layer with the zig-zag method a day before land preparation. A total of 30 samples were taken from the experimental site and mixed together to obtain composite sample using quartering technique [4].The samples were dried, ground and passed through a 0.2 mm sieve for chemical analysis. The physico-chemical properties such as textural analysis, soil pH, organic carbon, total nitrogen, available phosphorus, available potassium, available sodium and cation exchange capacity (CEC) were determined using standard laboratory procedures.

2.4 Land preparation and planting

After ploughing and harrowing, the experimental field was demarcated into respective plots measuring 5 x 3 m^2. Five seeds were planted to a hill at a spacing of 20 cm x 20 cm and a depth of 3 cm. Sub plots were separated by a 1 m alley, whiles main plots and replication were each separated by a 2 m alley.

2.5 Cultural Practices

Basal application of 60 kg/ha NPK 15-15-15 was done at three weeks after planting. First, second and third split applications of N fertilizer (Sulfan) was done at the fifth, tenth and eleventh weeks after planting, respectively. Weeding was done twice. First and second hand weeding was done at the third and tenth week after planting respectively.

2.6 Data Collection and Analysis

Five plants in each plot were randomly tagged for data collection on:

- Plant height
- Number of tillers
- Number of panicles
- Panicle length and weight
- Number of grains per panicle
- 1000 grain weight
- Biomass yield
- Grain yield

Data collected were subjected to analysis of variance using Genstat statistical package, edition 12^{th}. Means were separated using LSD at 5% significance level.

3. Results and Discussions

3.1 Soil Analysis

Soil was very acidic with a silty loam texture. It had moderate available Phosphorus (P) and exchangeable cations (K, Na, Ca and Mg), with low percentage nitrogen, organic matter and organic carbon (**Error! Reference source not found.**). The soil was characteristically typical of Northern Region [8]. According to him Northern soils were characteristically sandy to sandy loam textured, with low clay and organic matter contents resulting in low cation exchange capacity.

3.2 General observation

Split nitrogen application x Variety interaction did not significantly (P>0.05) affect any of the parameters measured. However, main effect of varietal difference was significant (P<0.05) on all parameters measured except number of panicles, panicle length and weight and 1000 grain weight. Main effect of Split nitrogen application significantly (P<0.05) affected all parameters measured except number of panicles and panicle length.

Table 2. Initial soil physico-chemical analysis.

Properties	Values	Range for rice production
Texture	Silty loam	Clay loams, silt loams and gravel
pH 1:2.5 (H_2O)	4.6	3.10-5.30
Soil organic C (%)	0.74	0.20-21.00
Total N (%)	0.06	0.02-0.10
P (Cmol/kg)	0.03	8.60-83.00
CEC (Cmol/kg)	5.05	2.12-11.39
Avail. C Cmol/kg	2.11	0.85-2.70
Avail. M Cmol/kg	0.78	0.10-0.84
Avail. K Cmol/kg	0.15	0.04-0.23

3.3 Effect of varietal difference

The highest height among the varieties was recorded by Digang (Table 3). Trend of variability among the varieties was similar in number of tillers, grains per panicle, biomass weight and grain yield. In these parameters, Jasmine predominantly recorded the highest values relative to Degang (Table 3). The difference among the varieties is strongly believed to be resulting from the inherent genetic variabilities among the two varieties. This result is consistent with findings of [5] in a study on the characterization of the two varieties.

3.4 Effect of split nitrogen (N) application

3.4.1 Vegetative growth

Basal application of 60 kg NPK/ha plus 30 kg N/ha topdressing recorded the highest plant height. It was however similar to height recorded by basal application of 60 kg NPK/ha plus split 15 kg N/ha + 15 kg N/ha, and basal application of 60 kg NPK/ha plus split 10 kg N/ha + 10 kg N/ha + 10 kg N/ha (Table 4). These were followed by sole application of 60 kg NPK/ha, with the control recording the least height (Table 4). Basal application of 60 kg NPK/ha plus split 15 kg N/ha + 15 kg N/ha produced the highest number of tillers. It was however similar to tillers produced by 60 kg NPK/ha + 30 kg N/ha and sole application of 60 kg NPK/ha, which were in turn similar to 60 kg NPK/ha plus split 10 kg N/ha + 10 kg N/ha + 10 kg N/ha (Table 3). Nitrogen is known to enhance vegetative growth. Hence basal application of NPK plus topdressing with N resulted in the difference in vegetative growth due to the availability of nitrogen during the whole growth period of rice. This is similar to findings of [11].

3.4.2 Yield components

Basal application of 60 kg NPK/ha plus split 10 kg N/ha + 10 kg N/ha + 10 kg is N/ha and application of 60 kg NPK/ha plus split 15 kg N/ha + 15 kg N/ha recorded similar panicle weight. These followed by sole application of 60 kg NPK/ha, whose performance was also similar to 60 kg NPK/ha + 30 kg N/ha (Table 4). Basal application of 60 kg NPK/ha plus split 10 kg N/ha + 10 kg N/ha + 10 kg N/ha produced the highest number of grains per panicle, it was however similar to that produced by 60 kg NPK/ha plus split 15 kg N/ha + 15 kg N/ha and 60 kg NPK/ha + 30 kg N/ha (Table 4). These were followed by sole application of 60 kg NPK/ha, whose performance was similar to the control (Table 4). The highest 1000 grain weight was recorded by basal application of 60 kg NPK/ha plus split 10 kg N/ha + 10 kg N/ha + 10 kg N/ha. It performance was however similar sole 30 kg NPK/ha and 60 kg NPK/ha + 30 kg N/ha, whose performance were in turn similar to 60 kg NPK/ha plus split 15 kg N/ha + 15 kg N/ha (Table 4). Basal and topdressing fertilizer treatments enhanced yield components of rice, probably due to the availability of nitrogen, which is known to promote vegetative growth, in adequate quantities with a resultant increase in yield components. These finding agrees with [2].

Table 3. Effect of varietal difference on vegetative growth, grain per panicle, and biomass and grain yield.

Variety	Plant height (cm)	Grains/ Tiller	panicle	Biomass weight (kg/plot)	Grain yield (tons/ha)
Degang	89.41a	18.00b	79.60b	300.00b	2.89b
Jasmine	78.26b	25.30a	88.10a	376.00a	3.91a
LSD (0.05)	6.09	7.31	11.75	94.30	1.02

Means followed by different alphabet in the same column are significantly different

Table 4. Effect of split N application on vegetative growth, yield components and biomass yield.

Split N	Plant height(cm)	Tiller	Panicle Weight (g)	Grains/Weight (g)	1000 grain Weight (g)	Biomass Yield (kg/plot)
F0	73.63c	14.10c	201.20c	74.50b	17.24c	199c
F1	82.60b	22.80ab	221.7b	77.00b	20.58ab	336b
F2	88.65a	24.20ab	220.50b	87.70a	19.57ab	379ab
F3	87.95a	26.60a	230.10a	88.80a	19.41b	402a
F4	86.30a	20.50b	232.80a	91.10a	20.88a	373ab
LSD (0.05)	3.85	4.62	7.55	7.43	1.40	59.70

Means followed by the same letter(s) in each column are not significantly different

F0= Control, F1= 60 kg NPK/ha, F2= 60 kg NPK/ha + 30 kg N/ha, F3= 60 kg NPK/ha + 15 kg N/ha + 15 kg N/ha, F4= 60 kg NPK/ha + 10 kg N/ha + 10 kg N/ha + 10 kg N/ha

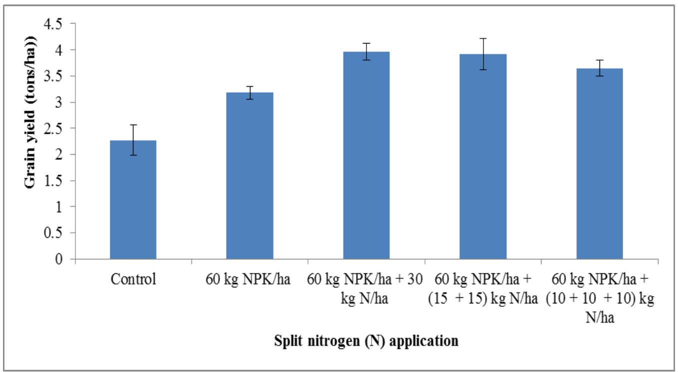

Figure 1. Effect of split N application on grain yield of ric.

3.4.3 Yield

The highest biomass yield was produced by 60 kg NPK/ha plus split 15 kg N/ha + 15 kg N/ha. Its however was similar to 60 kg NPK/ha + 30 kg N/ha and 60 kg NPK/ha plus split 10 kg N/ha + 10 kg N/ha + 10 kg N/ha, whose performance were similar to sole application of 60 kg NPK/ha (Table 4). Basal application of 60 kg NPK/ha + 30 kg N/ha top dressing produced the highest grain yield, it was however similar to yields produced by 60 kg NPK/ha plus split 15 kg N/ha + 15 kg N/ha and 60 kg NPK/ha plus split 10 kg N/ha + 10 kg N/ha + 10 kg N/ha (Figure 1). It was followed by sole basal application of 60 kg NPK/ha, with the control producing the least grain yield (Fig. 1). Yield component studies by [7] indicated a positive correlation between yield components and grain yield. They stated that yield differences in agronomic crops are associated with yield components. Hence, the ability of basal NPK and top dressing treatments to have improved yield components will consequently result in yield increment.

4. Conclusion and recommendation

The two varieties varied in both growth and yield, with Jasmine 85 proving to be superior to Degang in growth, yield components and ultimately grain yield. It was evident that sole basal fertilization was inadequate to improve growth and yield of rice. Hence necessitates top dressing to provide require nutrients during the advanced stage of rice growth and development. Basal application of 60kg NPK plus 30 kg N/ha, split 15 kg N/ha + 15 kg N/ha or 10 kg N/ha + 10 kg N/ha + 10 kg N/ha improved grain yield similar to each other. Hence 60 kg NPK/ha + 30 kg N/ha is recommended for optimum rice growth and yield, as split application at 15 kg N/ha + 15 kg N/ha and 10 kg N/ha + 10 kg N/ha + 10 kg N/ha attract additional labour cost.

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