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The Response of GRDB 15 to Increasing Levels of Slow-Release and Conventional Nitrogen Fertilizer Application

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Abstract: ***A field experiment was undertaken during the first crop of 2018 at the Rice Research Station located at Burma, Mahaicony latitude 6.49^o and longitude -57.76^o to look at the response of GRDB 15 to different sources and levels of nitrogen on growth, yield, nutrient uptake and soil chemical residue. The soil type was Litchfield clay having 197, 27 and 299 kg ha^{-1} of N, P and K with pH of 4.9 and soluble salts 270 ppm. The experiment was carried out in a randomized complete block design with three replications using variety GRDB 15. Treatments applied were 50, 75 and 100 kg N ha^{-1} in the form of urea and control release nitrogen fertilizer with 0 kg N ha^{-1}as control. Results obtained showed that regular urea recorded higher growth, grain yield. Grain yield increased with increasing levels of nitrogen from both sources. For obtaining equivalent grain yield, 25 kg N ha^{-1} more of control release fertilizer needed to be added. Nitrogen uptake in both straw and grain increased with increasing levels of nitrogen for both sources of fertilizer. Control release nitrogen fertilizer had more residual soil nitrogen as compared to urea and it increased with increasing levels of nitrogen. At similar nitrogen levels, urea applications realized higher net returns as compared to control released nitrogen fertilizer. This is mainly due to higher grain yield for urea treatments and lower cost of fertilizer. The current GRDB recommendation for nitrogen application (75 to 100 kg N ha^{-1}) in the form of urea still holds.***

Keywords: Control release fertilizer, nitrogen, grain yield

1. Introduction

Rice is one of the most important and fastest growing staple foods among the Caribbean countries. This crop can be cultivated on a wide variety of soils under irrigated submerged conditions for maximum growth and control of weeds. Nitrogen (N) is one of the most important macro nutrient which is required in large quantities by rice plants since most in soils, applied in largest quantities and has the greatest potential for losses (Linquist *et al*., 2013). Urea is a nitrogenous fertilizer consisting of 46% of N that is commonly used country wide by rice farmers. This fertilizer is usually applied in 2-3 different stages during the cultivation of a crop to sustain the amount required which depends on the field conditions (GRDB, 2008). According to GRDB, urea is applied to rice crop using three-split application at 18-21, 42 and 60 days after sowing at a total rate of 225 kg ha^{-1}.

The N within urea becomes readily available once applied which creates a higher chance of this nutrient to be lost by leaching and volatilization. In lowland irrigated rice, losses from 60 to 70% of applied nitrogen has been recorded. Additionally, the consecutive application of the urea fertilizer throughout the cropping period of rice could be costly especially in terms of labour and fertilizer costs. A new technology called slow release nitrogen fertilizer (SRNF) is slightly soluble in solution. The nitrogen release rater depends on microbial activity and hydrolysis. It reduces the rate of ammonification and ultimately nitrate release in the soil solution thereby reducing leaching, volatilization and denitrification. Rate of release depends on coating size and materials used, micro pores and cracks. Thus, an introduction to a controlled release of N fertilizer (coated urea) is being used in this research to conduct an evaluation and comparison between the two which is expected to facilitate the N to be released in very small portions thus controlling N loss as well as reducing the labour and fertilizers costs in production.

Objectives

- To determine the growth responses, yield attributes and grain yield of GRDB 15 when N is applied at three rates using conventional and slow release urea fertilizers.
- To determine the amount of nutrients (NPK) removed by the crop as influenced by different source and quantity of nitrogen applied.
- To determine the effects of different sources and quantities of nitrogen on soil chemical residue.
- To determine the economic benefit

2. Methodology

This experiment was conducted during the first crop of 2018 at the Rice Research Station located at Burma, Mahaicony latitude 6.49^o and longitude -57.76^o to look at the response of GRDB 15 to different sources and levels of nitrogen on growth, yield, nutrient uptake and soil chemical residue. The soil type was Litchfield clay having 197, 27 and 299 kg ha^{-1} of N, P and K with pH of 4.9 and soluble salts 270 ppm. The experiment was carried out in a randomized complete block design with three replications using variety GRDB 15. Treatments applied were 50, 75 and 100 kg N ha^{-1} in the form of urea and control release nitrogen fertilizer with 0 kg N ha^{-1}as control. The experiment was laid out in a randomized complete block design using three replications. These treatments were laid out on a plot size of 20 m^2 (5m × 4m). Treatment $_1$, T_2 and T_3 were applied at a three-split application at a dosage rate of ¼, ½ and ¼ of the total amounts given above at 18, 42 and 60 days after sowing respectively.

3. Results and Discussion

Table 1: Effect of nitrogen rates and sources on the growth parameters

Treatment (N kg/ha)	Plant height (cm)	Number of tillers m^{-2}	Panicles m^{-2}	Panicle length (cm)
50 kg N ha^{-1} as Urea	89.8 ^{ab}	493.9 ^{a}	486.6	20.8 ^{ab}
75 kg N ha^{-1} as Urea	90.8 ^{ab}	517.7 ^{a}	498.2	21.9 ^{a}
100 kg N ha^{-1} as Urea	92.8 ^{a}	531.0 ^{a}	500.0	21.9 ^{a}
50 kg N ha^{-1} as SRNF	85.9 ^{c}	486.9 ^{a}	453.7	19.1 ^{c}
75 kg N ha^{-1} as SRNF	87.6 ^{bc}	521.7 ^{a}	510.6	19.9 ^{bc}
100 kg N ha^{-1} as SRNF	89.0 ^{bc}	529.8 ^{a}	484.8	21.0 ^{ab}
0 kg N ha^{-1}	78.7 ^{d}	409.2 ^{b}	408.8	20.1 ^{bc}
Grand Mean	**87.79**	**498.6**	**477.5**	**20.7**
Sem ±	**1.86**	**30.3**	**0.6**	**0.64**
LSD (p=0.05)	**3.78**	**61.4**	**NS**	**1,29**
CV (%)	**10.11**	**12.9**	**12.7**	**6.6**

SRNF = Slow Release Nitrogen Fertilizer

Effect on growth parameters with respect to N levels and sources

The treatment with an N rate of 100 kg ha^{-1} with the source being conventional urea (CU) recorded the highest plant height of 92.8 cm while the treatment with no application of N recorded the lowest plant height (78.7 cm). Mean plant height for all treatments was 87.79 cm. Hashim *et al* (2017) reported higher plant height with SRNF. When plants absorb sufficient amount of N, protein will be available at an optimum level to accomplish metabolic processes, which in turn will improve the vegetative and reproductive growth of the plant, as well as improve the yield (Lawlor, 2002).

The highest number of tillers per square meter (531.0), was also recorded by the treatment with an N rate of 100 kg ha^{-1} with the source being conventional urea (CU) while the lowest number of tillers per square meter (409.2), was recorded by the treatment with no application of N fertilizer as well. Mean number of tillers per square meter for all treatments was 498.6.

Highest panicle length (21.9 cm) was recorded by two rates of CU (75 and 100 kg ha^{-1}) while lowest panicle length (19.1 cm) was recorded by the treatment with an N rate of 50 kg ha^{-1} from a source of slow release nitrogen fertilizer (SRNF). Mean panicle length for all treatments was 20.7 cm. There was no statistical difference among treatments for panicles per square meter. Mean number of panicles per square meter for all treatments was 480.4.

Table 2: Effects of the rice varieties, N levels and sources of the yield parameters measured

Treatment	Grains per panicle		1000-grain weight (g)	Grain yield (kg ha^{-1})	Harvest index
	Filled	**Unfilled**			
50 kg N ha^{-1} as Urea	91.3 ^{abc}	18.2 ^{ab}	28.6 ^{abc}	6805 ^{bcd}	0.45
75 kg N ha^{-1} as Urea	98.3 ^{a}	22.3 ^{a}	28.5 ^{bc}	7239 ^{ab}	0.44
100 kg N ha^{-1} as Urea	96.2 ^{ab}	23.1 ^{a}	28.2 ^{bc}	7554 ^{a}	0.43
50 kg N ha^{-1} as SRNF	76.8 ^{cd}	13.4 ^{bc}	28.5 ^{bc}	6352 ^{d}	0.43
75 kg N ha^{-1} as SRNF	82.1 ^{bcd}	13.0 ^{bc}	29.5 ^{a}	6682 ^{cd}	0.42
100 kg N ha^{-1} as SRNF	84.3 ^{abcd}	11.5 ^{c}	29.0 ^{ab}	6946 ^{bc}	0.42
0 kg N ha^{-1}	72.3 ^{d}		27.9 ^{c}	4741 ^{e}	0.37
Grand Mean	**85.9**	**16.9**	**28.6**	**6617**	**0.42**
SEM±	**7.4**	**6.0**	**0.5**	**230**	**0.02**
LSD (p=0.05)	**15.1**	**70.8**	**1.0**	**467**	**0.04**
CV (%)	**30.6**		**6.7**	**10.1**	**10.1**

Effect on yield parameters with respect to N levels and sources

With respect to the number of grains per panicle, the treatment with a rate of 75 kg of conventional urea (CU) per hectare recorded the highest number of filled grains per panicle (98.3) while the treatment with no N fertilizer application recorded the lowest number of filled grains per panicle (72.3). Highest number of unfilled grains per panicle (23.1) was recorded by the treatment with an N rate of 100 kg CU per hectare while the treatment with an N rate of 100 kg CU per hectare recorded the lowest number of unfilled grains per panicle (11.5). Mean number of filled and unfilled grains per panicle for all treatments were 85.9 and 16.9 respectively.

For 1000-grain weight, the treatment with an N rate of 75 kg of slow release nitrogen fertilizer (SRNF) per hectare recorded the highest weight (29.5 g) while the treatment with no application of N fertilizer recorded the lowest weight (27.9 g). Mean 1000-grain weight for all treatments was 28.6 g.

Highest grain yield (7554 kg ha^{-1}) was recorded by the treatment with a rate of 100 kg of CU per hectare while the treatment with a no application of N fertilizer recorded the lowest grain yield (4741 kg ha^{-1}). Mean grain yield for all treatments was 6617 kg ha^{-1}.Carvalhoc*et al.* (2016) found similar results where coated urea did not provide increases in rice grain yield in relation to common urea.Highest harvest index (HI) of 45% was recorded by the treatment with a rate of 50 kg of CU fertilizer while lowest HI (37%) was recorded by the treatment with no application of N fertilizer. Hashim *et al* (2017) also found higher HI with application of SRNF.

Grain yield with respect to the interaction of varieties versus N levels and sources

With respect to the level of N fertilizer and source, the treatment with an N rate of 100 CU per hectare recorded the highest mean grain yield (7554 kg ha^{-1}) while the treatment with no N fertilizer application recorded the lowest mean grain yield (4741 kg ha^{-1}).

Table 3: Nutrient uptake from straw and grain

Treatment	Nutrient uptake in straw (kg ha^{-1})			Nutrient uptake in grain (kg ha^{-1})		
	N	P	K	N	P	K
50 kg N ha^{-1} as Urea	58.1 ^{b}	20.4 ^{b}	27.9 ^{bcd}	47.2 ^{bc}	8.6 ^{ab}	127.4
75 kg N ha^{-1} as Urea	78.5 ^{a}	22.2 ^{ab}	34.5 ^{abc}	63.6 ^{a}	9.5 ^{a}	160.3
100 kg N ha^{-1} as Urea	82.1 ^{a}	28.3 ^{a}	42.4 ^{a}	64.1 ^{a}	8.7 ^{a}	152.2
50 kg N ha^{-1} as SRNF	59.7 ^{b}	20.3 ^{b}	27.2 ^{cd}	53.8 ^{ab}	9.7 ^{a}	134.6
75 kg N ha^{-1} as SRNF	74.9 ^{a}	27.7 ^{a}	35.8 ^{ab}	51.9 ^{abc}	9.4 ^{a}	148.8
100 kg N ha^{-1} as SRNF	86.2 ^{a}	27.6 ^{a}	35.9 ^{ab}	47.2 ^{bc}	9.5 ^{a}	159.0
0 kg N ha^{-1}	44.4 ^{c}	17.0 ^{b}	20.1 ^{d}	39.6 ^{c}	7.3 ^{b}	109.5
MEAN	**69.2**	**23.4**	**32.0**	**52.5**	**9.0**	**141.7**
Sem ±	**5.9**	**3.2**	**4.0**	**7.0**	**0.7**	**10.1**
LSD (p=0.05)	**12.0**	**6.5**	**8.2**	**14.2**	**1.4**	**20.4**
CV (%)	**18.1**	**29.1**	**26.8**	**28.2**	**16.8**	**15.1**

Nutrient uptake from by straw and grain

With respect to the uptake of nutrients in the straws, highest amount of N (86.2 kg ha^{-1}) was found in the treatment with a rate of 100 kg slow release nitrogen fertilizer (SRNF) per hectare, highest amount of P (28.3 kg ha^{-1}) was found in the treatment with a rate of 100 kg conventional urea (CU) fertilizer per hectare and highest amount of K (42.4 kg ha^{-1}) was also found in the treatment with a rate of 100 kg CU fertilizer per hectare. Lowest amounts of N (44.4 kg ha^{-1}), P (17.0 kg ha^{-1}) and K (20.1 kg ha^{-1}) were all found in the treatment with no N fertilizer application. For the uptake of N, P and K in grains, it was found that the treatment with a rate of 100 kg CU fertilizer per hectare recorded the highest amount of N (64.1 kg ha^{-1}), the treatment with a rate of 50 kg SRNF per hectare recorded the highest amount of P (9.7 kg ha^{-1}) and the treatment with a rate of 70 kg CU fertilizer per hectare recorded the highest amount of K (160.3 kg ha^{-1}). Lowest amounts of N (39.6 kg ha^{-1}), P (7.3 kg ha^{-1}) and K (109.5 kg ha^{-1}) were all found in the treatment with no N fertilizer application. Linquist *et al* (2013) found that SRNF can increase grin yield and nitrogen uptake but it can be modest.

Table 4: Soil Residue analysis

Treatment	Soil residual nutrients (kg ha^{-1})		
	Nitrogen	Phosphorus	Potassium
50 kg N ha^{-1} as Urea	69.3 ^{b}	11.8 ^{bc}	124.6 ^{bc}
75 kg N ha^{-1} as Urea	74.4 ^{b}	13.4 ^{a}	162.6 ^{a}
100 kg N ha^{-1} as Urea	82.7 ^{ab}	13.9 ^{a}	142.8 ^{ab}
50 kg N ha^{-1} as SRNF	83.5 ^{ab}	13.9 ^{a}	157.4 ^{a}
75 kg N ha^{-1} as SRNF	90.4 ^{a}	13.2 ^{ab}	164.3 ^{a}
100 kg N ha^{-1} as SRNF	91.7 ^{a}	12.9 ^{ab}	147.1 ^{ab}
0 kg N ha^{-1}	76.3 ^{ab}	10.9 ^{c}	116.3 ^{c}
Mean	**81.2**	**12.9**	**145.0**
SEM±	**7.9**	**0.7**	**12.2**
LSD (p=0.05)	**15.9**	**1.5**	**24.8**
CV (%)	**20.5**	**11.9**	**17.9**

Soil residual nutrient analysis

For the various levels of N fertilizer and the different sources, it was found that the treatment with an N rate of 100 kg of SRNF per hectare recorded the highest amount of soil residual N (91.7 kg ha^{-1}) while the treatment with an N rate of 50 kg of CU per hectare recorded the lowest soil residual N (69.3 kg ha^{-1}). Fazlina *et al*. (2014) observed that CRNFs application on rice end up having less residual N in soil which is opposite to our finding where SRNF showed higher residual nitrogen.

Two treatments with N rates of 100 kg of CU and 50 kg of SRNF per hectare both recorded the highest amount of soil residual P (13.9 kg ha^{-1}) while the treatment with no N fertilizer application recorded the lowest amount of soil residual P (10.9 kg ha^{-1}). When fertilizer application precisely matched with crop needs, less residual N were traced in soil (Andraski *et al*. 2000), especially when the rate of application was equal. This trend is also similar to the study by Fazlina*et al*. (2014).

Highest amount of soil residual K (164.3 kg ha^{-1}) was found in the treatment with an N rate of 75 kg of SRNF per hectare while the treatment with no N fertilizer application recorded the lowest amount of soil residual K (116.3 kg ha^{-1}).

Table 5: Costs benefit analysis (Guyana dollars) between the two fertilizers used in the study.

Treatments	N Source	Fertilizer Cost ($)	Grain Yield (Kg ha^{-1})	Value of Paddy sold at Mills ($)	Gross Profit Margin ($)	Differences between N source ($)
0 Kg N ha^{-1}	-----	0	4,741	218,086	218,086	-----
50 Kg N ha^{-1}	CU	9,592	6,805	313,030	303,438	23,273
	SRNF	12,027	6,352	292,192	280,165	
75 Kg N ha^{-1}	CU	14,344	7,239	332,994	318,650	29,263
	SRNF	17,985	6,682	307,372	289,387	
100 Kg N ha^{-1}	CU	19,096	7,554	347,484	328,388	32,866
	SRNF	23,944	6,946	319,516	295,522	

1US $ = 200 Guy $

Cost benefit analysis

With respect to cost of N fertilizer rate and source, it was observed that SRNF at a rate of 100 kg ha^{-1} had the highest cost ($23,944 ha^{-1}) while it was obvious that there was no cost attached to the treatment with no N fertilizer application. Highest profit margin ($328,388) was realized by the treatment with an N rate of 100 kg CU per hectare while the lowest amount ($218,086) was realized by the treatment with no N fertilizer application. With respect to the comparison between the different N levels and source, it was observed that the 100 kg ha^{-1} rate recorded the highest margin ($32,866).

4. Conclusions

Conventional urea (at 100 kg ha^{-1}) performed better than slow release nitrogen fertilizer (SRNF) with respect to plant height, number of tillers per square meter and panicle length. Conventional urea (at 100 kg ha^{-1}) recorded highest grain yield. Highest amount of N in straw was found in the treatment with 100 kg of SRNF per hectare while both highest P and K were found in the treatment with 100 kg CU per hectare. Grain analysis showed that highest N was recorded in the treatment with 100 kg CU per hectare while highest P in grain was found in the treatment with 50 kg SRNF per hectare and highest K in grains was found in the treatment with 75 kg CU per hectare. Soil residual analysis showed that highest residual N was found in the treatment with 100 kg SRNF per hectare, highest residual P was found in the treatment with 100 kg CU per hectare and highest residual K was found in the treatment with 75 kg SRNF per hectare. Highest profit margin was realized from the treatment with 100 kg of CU per hectare. The lowest rate of CU realized greater profit than the highest rate of SRNF.

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