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Growth and Yield Response of Signal Grass (*Brachiaria decumbens* Stapf) Applied with Different Rates of Nitrogen Fertilizer

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Abstract

Application of fertilizers is essential to sustain the yield of forage crops, hence, this study was conducted to: 1) evaluate the effect of different nitrogen fertilization rates on the growth and yield of signal grass and 2) determine the appropriate nitrogen fertilization rate for optimum production of signal grass. It was laid out in a Randomized Complete Block Design (RCBD) with three replications and five treatments (T_0 – Unfertilized, T_1 – 30 kg N ha^{-1}; T_2 – 60 kg N ha^{-1}; T_3 – 90 kg N ha^{-1} and T_4 – 120 kg N ha^{-1}). The plant height, number of tillers hill^{-1}, fresh herbage yield and dry matter yield of signal grass were significantly affected by the different rates of nitrogen fertilizer. Increasing the levels of N fertilization correspondingly improved its overall performance with plants applied with 120 kg N ha^{-1} having the tallest, most number of tillers and heaviest fresh herbage and dry matter yields among fertilized plants. However, the appropriate fertilization rate for optimum production was 90 kg N ha^{-1} as the aforementioned parameters were comparable to that of the higher rate yet of lower amount of N fertilizer needed resulting in lower production cost and higher income.

Key words: Application, Dry matter, Herbage, Forage crop, Inorganic fertilizer

1. Introduction

Signal grass (*Brachiaria decumbens* Stapf) is a vigorous, rhizomatous and stoloniferous, medium-lived perennial grass (Heuzé et al., 2017). Although, it is a native of tropical Africa (Uganda), it has been introduced and distributed to other tropical countries (Fukumoto and Lee, 2003) being high yielding and adapted to a wide range of soils in the humid tropics (Heuze et al., 2017). It can be grazed or cut to be fed fresh or made into hay as it is palatable to all classes of livestock and withstands heavy grazing (Cook et al., 2005). It is also used as a cover crop to prevent erosion and to control weeds and insects (Mollot et al., 2012; Cook et al., 2005).

Forage production needs continuous replenishment of nutrients due to crop removal and other losses. Of all the essential plant nutrients, nitrogen (N) is the most commonly deficient nutrient in soil and generally has the greatest impact on forage production. It is the nutrient most important in cell division and growth being the building block of proteins and a major component of chlorophyll. The effectiveness of N fertilizer on forage grasses is strongly influenced by rates, sources, times and methods of N application (Malhi et al., 2004). Timing of N fertilization depends on the N source and soil and climatic conditions which influence how quickly N becomes available from soil organic matter (Rutz and Jones, 2018).

In most situations, granular fertilizers are used for forage production. Urea is the dominant granular N fertilizer, as it has higher N content and is therefore less bulky and costs less per unit of N than other granular fertilizers. According to Malhi et al. (2004), urea and ammonium nitrate were equally efficient at increasing dry matter yield of hay type grasses but urea appeared to be a better source of N for pasture-type grasses.

Plants respond differently to N fertilization such that there is a need to investigate the response of signal grass to said fertilization. Moreover, addition of N fertilizer influences the chemical composition of the plant as well as the fertility status of soils. However, information on its fertilizer response is limited, hence, this study was conducted to evaluate the effect of different nitrogen fertilization rates on the growth and yield of signal grass and determine the appropriate nitrogen fertilization rate for its optimum production.

2. Material and Methods

Soil samples were randomly collected from the soil surface to a depth of 30 cm in the experimental area which were composited, mixed thoroughly, processed and a kilogram soil was submitted for laboratory analysis of soil pH (potentiometer method at 1:2.5 soil-water ratio), % organic matter (Walkley-Black method), total N (Kjeldhal method) and extractable P (Bray No. 2). Right after the final harvest, soil sampling was done by collecting five samples from each treatment plot. The said samples were composited per treatment, mixed thoroughly, processed and analyzed for the same aforementioned soil parameters.

The experimental area was laid-out in a Randomized Complete Block Design (RCBD) replicated three times with five treatments (T_0 – Unfertilized, T_1 – 30 kg N ha^{-1}, T_2 – 60 kg N ha^{-1}, T_3 – 90 kg N ha^{-1} and T_4 – 120 kg N ha^{-1}). Each treatment plot had a dimension of 3 m x 3 m separated by 1 m alleyways.

Half of the required amount of nitrogen for each fertilized treatments together with the full amount of 30 kg P_2O_5 K_2O ha^{-1} were applied basally using urea (46–0–0), solophos (0–20–0) and muriate of potash (0–0–60), respectively. Right after the first harvest at 60 days after planting, the remaining amounts of nitrogen were applied.

The setts were planted 50 cm x 50 cm apart on the ridges and appropriate cultural management practices were employed until harvesting. All the plants within the harvestable area were harvested at 60 and 105 days after planting by cutting the tillers 10 cm from the ground using a sharp sickle.

The data gathered were plant height, number of tillers per hill, fresh herbage yield and dry matter yield as well as meteorological data such as weekly total rainfall and temperature that occurred during the conduct of the study.

3. Results and Discussion

3.1. Agroclimatic conditions

As presented in Table 1, the initial soil analysis revealed that the experimental area had a pH of 5.870, 0.897% organic matter, 0.150% total nitrogen and 8.400 mg kg^{-1} available phosphorous. These results indicate that the soil was moderately acidic with very low organic matter and low total nitrogen and available phosphorus based on the soil chemical interpretation of Landon (1991).

Final soil analysis showed an increase in pH and a decrease in % total nitrogen. On the other hand, % organic matter increased only in plots applied with 30 kg ha^{-1} N while available phosphorous increased in plots applied with 120 kg N ha^{-1} and 60 kg N ha^{-1}. Such available phosphorous values were still lower than the 10.5 ppm considered by Suradej (2010) as extremely low for high yields of signal grass. However, Pastures Australia (2008) reported that signal grass tolerates low soil pH and adapted to soils of low fertility but is very responsive to applied N and P.

Table 1. Soil pH, organic matter, total N and available P of the experimental area before planting and after harvest of signal grass applied with different rates of nitrogen fertilizer.

	Soil pH (1:2:5)	OM (%)	Total N (%)	Available P (mg kg^{-1})
Initial Analysis	5.870	0.897	0.150	8.400
Final Analysis				
T_0 – Unfertilized	6.660	0.819	0.127	8.127
T_1 – 30 kg N ha^{-1}	6.480	0.936	0.121	7.951
T_2 – 60 kg N ha^{-1}	6.370	0.858	0.115	10.225
T_3 – 90 kg N ha^{-1}	6.520	0.858	0.124	8.330
T_4 – 120 kg N ha^{-1}	6.410	0.897	0.122	9.011
Mean	6.488	0.874	0.122	8.729

The total weekly rainfall that occurred throughout the conduct of the study ranged from 0 to 567.40 mm (Figure 1). Such wide range of rainfall could probably be one of the consequences of climate change. Thus, supplemental application of water was done on weeks with limited moisture. The total amount of rainfall of 851.40 mm in 105 days growth period could have been adequate for the growth and development of signal grass if these were well distributed as best production of said grass in tropical coastal areas require rainfall >1,500 mm year^{-1} (Pastures Australia, 2008) or rainfall ranging from 1000 to >3000 mm year^{-1} (Cook et al., 2005).

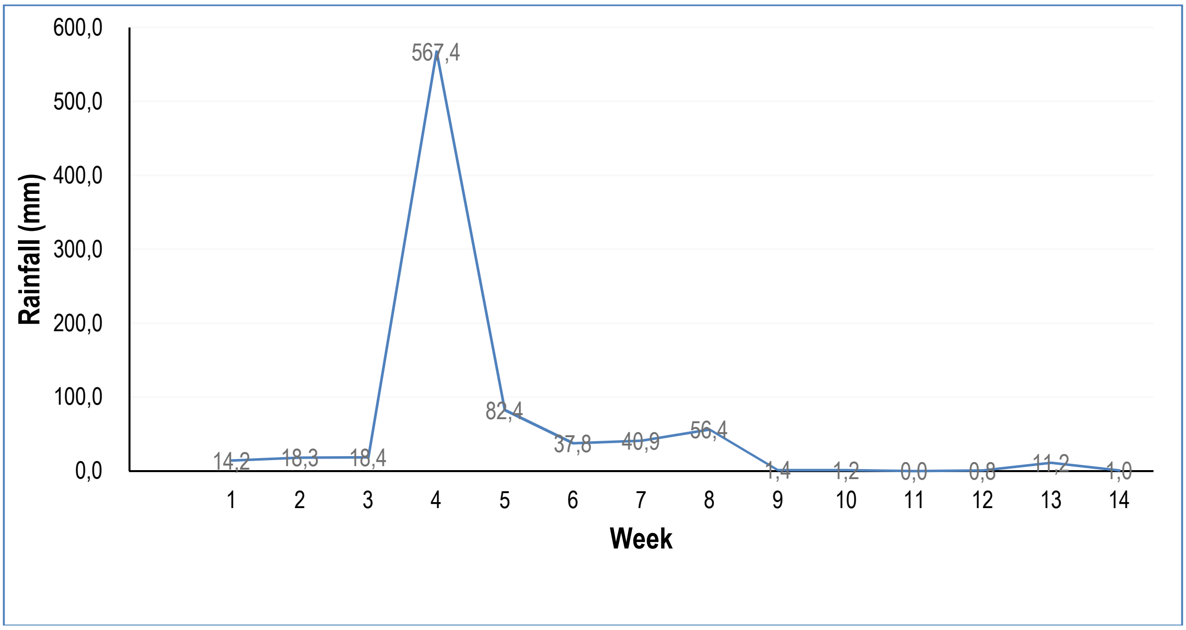

Figure 1. Rainfall (mm) that occurred during the conduct of the study.

On the other hand, the average daily minimum and maximum temperatures ranged from 21.05 - 24.92 ºC and 27.73 - 33.04 ºC, respectively (Figure 2). Said values closely conformed to the temperature requirements for optimal growth of signal grass which ranged from 30 – 35 ºC (FAO, 2016).

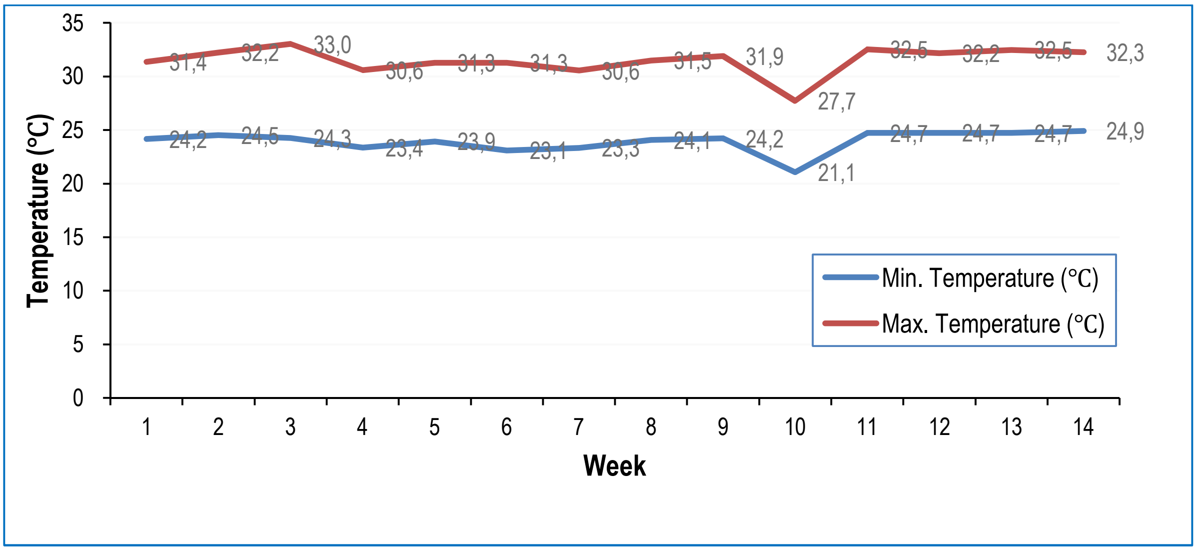

Figure 2. Minimum and maximum temperatures (°C) that occurred during the conduct of the study.

3.2. Agronomic characteristics

Table 2 shows the agronomic characteristics of signal grass as affected by different levels of nitrogen fertilizer at first and second harvests. The plant height and number of tillers per hill were significantly influenced by nitrogen fertilization.

Plants applied with 120 kg N ha^{-1} were the tallest at 112.10 cm and 91.73 cm during the first and second harvests, respectively among fertilized plants except those plants applied with 90 kg N ha^{-1}. The untreated plants were the shortest during the first harvest but were comparable to those plants applied with 30 and 60 kg N ha^{-1} during the second harvest. Application of higher rates of nitrogen fertilizer significantly increased the overall growth performance of the plants since it is an essential component of DNA and protein, which are necessary for all plant processes. These findings confirmed the linear increase in plant height of signal grass with nitrogen fertilization reported by Souza et al. (2016).

The application of nitrogen fertilizer significantly increased the number of tillers per hill at first and second harvests. Higher number of tillers were observed on plants applied with 90 and 120 kg N ha^{-1} and fewer to those unfertilized plants. The results imply that as the rate of N fertilization increases, the number of tillers will likewise increase. These corroborated the results of Silva et al. (2013) who reported an increase in the number of vegetative tillers of marandu grass with N fertilization due to its positive effect on leaf elongation and tillering rate promoting greater capacity in the formation of axiliary buds, which may potentially originate new tillers. Likewise, Canto et al. (2020) reported significant increase in reproductive tiller density of signal grass at harvest for the first and second crops with N fertilization.

Table 2. Plant height (cm) and number of tillers per hill of signal grass as influenced by different rates of nitrogen fertilizer at 1st and 2nd harvests.

Treatment	Plant height (cm)		No. of tillers per hill	
	1st harvest	2nd harvest	1st harvest	2nd harvest
T_0 – Unfertilized	82.18^{c}	65.20^{c}	19.60^{c}	48.43^{c}
T_1 – 30 kg N ha^{-1}	96.05^{b}	73.10^{bc}	37.60^{b}	80.73^{b}
T_2 – 60 kg N ha^{-1}	99.42^{b}	73.13^{bc}	40.27^{b}	80.57^{b}
T_3 – 90 kg N ha^{-1}	105.75^{ab}	85.23^{ab}	45.50^{ab}	99.97^{a}
T_4 – 120 kg N ha^{-1}	112.10^{a}	91.73^{a}	49.73^{a}	108.13^{a}
C.V. (%)	6.67	12.01	12.75	11.40

Treatment means within a column with the same letter are not significantly different at 5% level of significance based on Tukey's HSD test.

3.3. Fresh herbage and dry matter yields

Table 3 presents the effect of the different levels of nitrogen fertilizer on fresh herbage and dry matter yields of signal grass. Application of different rates of nitrogen significantly influenced the fresh herbage and dry matter yields of the plant.

Plants applied with 60, 90 and 120 kg N ha^{-1} had heavier total fresh herbage and total dry matter yields compared to the unfertilized plants and those plants applied with 30 kg N ha^{-1}. This is attributed to the increase in plant height and tiller number with increasing rates of nitrogen. According to Silva et al. (2013), tiller density increases with increasing nitrogen fertilization which linearly increases forage mass (Souza et al., 2016).

In terms of dry matter yield at first harvest, plants applied with 120 kg N ha^{-1} had the heaviest dry matter yield than the rest of the plants applied with the other treatments. However, the plants applied with 60 and 90 kg N ha^{-1} were of comparable yields to the former at second harvest and in terms of total yield. Lighter dry matter yields were obtained from the unfertilized plants and those applied with 30 kg N ha^{-1}. The result is in conformity with the reported increase in plant biomass of signal grass (Canto et al., 2020) and dry matter yield of palisade grass (Dupas et al., 2016) with N fertilization.

Table 3. Fresh herbage and dry matter yields of signal grass as influenced by different rates of nitrogen fertilizer.

Treatment	Fresh herbage yield (t ha^{-1})			Dry matter yield (t ha^{-1})		
	1st harvest	2nd harvest	Total	1st harvest	2nd harvest	Total
T_0 – Unfertilized	2.66^b	6.38^d	9.04^b	0.75^c	1.13^c	1.88^c
T_1 – 30 kg N ha^{-1}	4.50^b	8.75^c	13.25^b	1.11^c	1.68^{bc}	2.79^c
T_2 – 60 kg N ha^{-1}	5.17^{ab}	9.88^{bc}	15.05^{ab}	1.88^b	2.32^{ab}	4.20^{ab}
T_3 – 90 kg N ha^{-1}	7.88^a	11.54^{ab}	19.42^{ab}	1.73^b	2.60^a	4.33^{ab}
T_4 – 120 kg N ha^{-1}	8.23^a	12.50^a	20.73^a	2.91^a	2.86^a	5.77^a
C.V. (%)	29.84	9.99	19.92	19.66	17.42	18.54

Treatment means within a column with the same letter are not significantly different at 5% level of significance based on Tukey's HSD test.

3.4. Cost and return analysis

As indicated in Table 4, the highest net income of PhP5,804.44 ha^{-1} was derived from signal grass applied with 90 kg N ha^{-1} followed by those applied with 120 kg N ha^{-1} with PhP5,655.50 ha^{-1}. The unfertilized plants and those applied with 30 kg N ha^{-1} incurred net loss of PhP1,680.00 ha^{-1} and PhP1,066.50 ha^{-1}, respectively. The lesser income and net loss incurred was attributed to the low price of PhP1.75 per kilogram of herbage which did not offset the production cost incurred.

Table 4. Cost and return analysis of signal grass production as affected by different rates of nitrogen application.

Treatments	Total Fresh Herbage Yield (t ha^{-1})	Gross Income^a (PhP ha^{-1})	Production Cost (PhP ha^{-1})	Net Loss/Net Income (PhP ha^{-1})
T_0 – Unfertilized	9.04^b	15,820.00	17,500.00	-1,680.00
T_1 – 30 kg N ha^{-1}	13.25^b	23,187.50	24,254.00	-1,066.50
T_2 – 60 kg N ha^{-1}	15.05^{ab}	26,337.50	26,221.20	116.30
T_3 – 90 kg N ha^{-1}	19.42^{ab}	33,985.00	28,180.56	5,804.44
T_4 – 120 kg N ha^{-1}	20.73^a	36,277.50	30,622.00	5,655.50

[a]Calculated by multiplying the fresh herbage yield with the price at PhP1.75 kg^{-1}.

4. Conclusion

Application of nitrogen fertilizer significantly increased the plant height, number of tillers, fresh herbage and dry matter yields of signal grass. Except for the lowest N rate, the rest of the N fertilizer treatments significantly increased the aforesaid growth and yield parameters over the unfertilized treatment. Among these treatments, the appropriate rate of N application for optimum signal grass production was 90 kg N ha^{-1} for having a yield closer to that of 120 kg N ha^{-1} but of lower production cost resulting in higher income.

Conflicts of Interests

Authors declare that there is no conflict of interests

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