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Yield Enhancement Through Nitrogen Fertilization of Pakchong Napier Grass *(Pennisetum purpureum x P. glaucum)*

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RESEARCH ARTICLE INFORMATION

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ABSTRACT

The study was conducted to evaluate the yield performance of Pakchong and native Napier varieties. Specifically, it aimed to determine the effects of varying levels of nitrogen and constant rate of phosphorus (P) and potassium (K), the interaction effect of Napier varieties over varying levels of nitrogen, and economic benefits. The experiment was laid out in a two-factor Randomized Complete Block Design replicated thrice. The number of tillers, height of the plant, fresh and dry matter yield, crude protein, and herbage yield were gathered and analyzed using the analysis of variance. Nitrogen fertilization of 80 kg N ha-1 increases yield performance on the number of tillers/clumps, plant height, fresh and dry matter yield, and herbage yield in the 30-day cutting intervals (DCI). Native (NT) Napier is comparable to the Pakchong (PK) Napier and has significant effects on varying levels of nitrogen at 45 DCI on other parameters. Pakchong was found better to native at 30 DCI as the grass matured at 45 DCI. Nitrogen fertilization to aging Napier grass can increase crude protein content. Interaction between varieties and levels of nitrogen on the parameters was not observed. Income benefits are favorable for 80-60-0 kg NPK ha -1 of fertilization 30 DCI and 45 DCI. The same study is recommended for the wet season and acceptability trials of ensiled Napier grass to animals.

Keywords: *dry matter yield, fresh matter yield, herbage yield, Napier grass, Native Napier, Pakchong Napier*

Introduction

Ruminants have a valuable role in sustainable agricultural systems and in providing human food. Their role in the conversion of vast renewable resources from rangeland, pasture, and crop residues and/or other by-products into food edible for humans plays a pivotal role (Abubakar et al., 2018). Balanced and economical feeding of livestock is very important for ideal productivity. The low livestock production is mainly due to the scarcity of feeds and unbalanced feeding practices. Effective utilization of available feed resources is the key to economic livestock rearing (Beigh et al., 2017). Ruminant feeds are mainly concentrates and forages and ruminant animals can consume 60% to 80% of forages in their diet. Forage crops are considered an inexpensive feed resource for ruminant animals (Loresco et al., 2019). Due to the wet and dry seasons in the country, success in ruminant production requires an adequate supply of good-quality forage. Animals suffer from malnutrition, decreased body weight, low milk production, and reproduction problems due to the shortage of roughage during the dry season. Common pasture grasses are used for grazing, cutting, and carrying methods of feeding. Forage grasses like guinea grass, Napier grass, para grass, signal grass, and Setaria are some grasses rich in nutrients. Napier grass (*Pennisetum purpureum*) is also widely used in ruminant feed in the tropics, and "silage-making practice" is an optional method of year-round feeding. (Kaewpila et al., 2020).

Furthermore, Pakchong 1 is a special grass developed by Dr. Krailas Kyiothong and his team at the Nakhonratchasima Animal Nutrition Research and Development Center in Thailand. Dr. Kyiothong describes Pakchong 1 as woody, perennial, and cane grass. They confirmed that Pakchong 1 is a sterile, non-GMO, and hybrid with value in tropical and subtropical areas (Sarian, 2018) like the Philippines. It is also known as Super Napier grass, a fast-growing and high-yielding variety that can be cut 7 to 8 times a year. Once planted, it can continuously provide a high yield for 7 to 8 years with a harvest of 180 to 200 metric tons of green succulent grass per acre annually (Wanjiru, 2023).

On the other hand, Pakchong (PK) fodder is comparatively better than BN-3 fodder concerning biomass yields, intake, digestibility, and nutrient utilization in growing bull calves (Sarker et al., 2019). It also contains as high as 14 to 18% crude protein (Mugachia, 2022). Planting Napier grass should be supported since it increases the energy supply and creates jobs while also reducing surface runoff, sediment yield, nitrate load, and CO2 emission. (Nantasaksiri et al., 2021). According to Leite et al. (2021), crude protein, soluble protein, and total digestibility nutrient (TDN) concentration were observed higher when Marandu palisade grass was applied 90 kg of nitrogen per hectare. Crude protein was higher than 12% and NDFwas lower than 60% when 90 kg of nitrogen per hectare was applied to Marandu grass. The increasing level of nitrogen is a promising way to improve Marandu grass production, nutritive value, and animal production (Delevatti et al., 2019). The crude protein yield of pure fertilized grasses was superior to both annual crops in optimized rotations and traditional systems (Solati et al., 2018).

In addition, crude protein is associated with livestock animals' productivity. Dietary crude protein (CP) ranging from 16.3% to 17.4% maintained production in early and mid-early lactation but feeding a higher CP concentration in late lactation had a negative effect on cow performance (Letelier et al., 2022). In another study by Madsen et al. (2023), crude protein is associated with nitrogen and when increasing the dietary CP level, the proportion of N intake excreted in urine increased, whereas the proportion of N intake excreted in feces decreased. Urinary nitrogen (N) excretion increased with increased CP level in the diet and was greatest in older heifers and appeared to be strongly correlated with dietary N intake and seemed to increase with age in dairy heifers (Johansen et al., 2022). The fertilization scheme significantly affected the days to flowering and maturity, vegetative tillers, plant height, number of productive and unproductive tillers, panicle length, herbage and grain yields of adlay, and also the tiller and herbage yield of Napier as well as the land equivalent and area time equivalent ratios (Gorne & Aradilla, 2020).

Thus, rare studies are conducted concerning the local Napier varieties such as the native, which are found commonly by farmers abundant at creeks, drainages, swamps, etc. Hilly uplands have marginal soil and are found to be arable and can be suitable and potential for forage production. The conversion of idle lands is a promising area for pasture development.

The study was conducted to evaluate the effect of varying levels of nitrogen (0, 80, 88, 96 & 104 kg N ha^{-1}) and constant rate of phosphorus (P) and potassium (K) on the yield performance of Pakchong and Native Napier varieties. It also examined the interaction effects between Napier varieties over varying levels of nitrogen, and determined economic benefits.

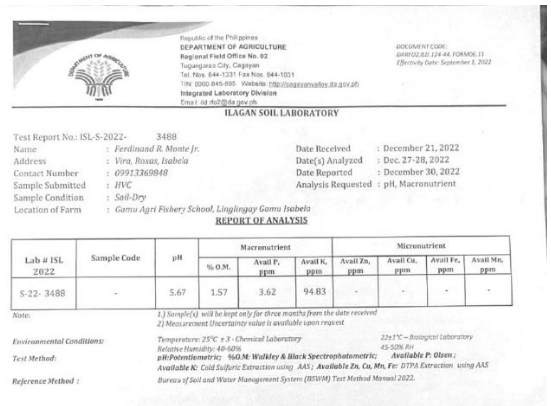
Methods

Procurement of Planting Materials and Fertilizers

The planting materials of Pakchong & Native Napier grasses were secured from Clemente Claro Crossbred Dairy Farm, Masaya Centro, San Agustin, Isabela, and local farms which are naturally grown along creeks in Bantug, Roxas, Isabela. Urea (46-0-0) and Ammonium Phosphate (16-20-0) fertilizer materials used in the study were secured from Abad's Agricultural Supply, Bantug, Roxas, Isabela.

Soil Sampling and Analysis

Soil samples were collected before the land preparation from the experimental area. A composite of 10 sampling points was collected from the experimental area. The soil samples were air-dried, pulverized, and mixed. One kilogram of soil sample was brought to Cagayan Valley Research Soils Laboratory, City of Ilagan, Isabela for analysis. The result of the analysis was the basis for calculating the amount of fertilizer material in terms of NPK.



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Effectivity Date: September 1, 2022

ILAGAN SOIL LABORATORY

Test Report No.: ISL-S-2022- 3488

Name : Ferdinand R. Monte Jr.
Address : Vira, Roxas, Isabela
Contact Number : 09913369848
Sample Submitted : HVC
Sample Condition : Soil-Dry
Location of Farm : Gamu Agri Fishery School, Linglingay Gamu Isabela

Date Received : December 21, 2022
Date(s) Analyzed : Dec. 27-28, 2022
Date Reported : December 30, 2022
Analysis Requested : pH, Macronutrient

REPORT OF ANALYSIS

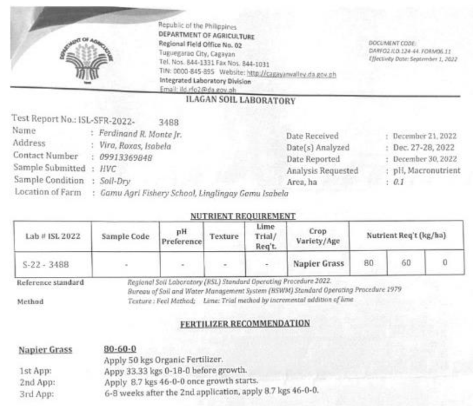
Lab # ISL 2022	Sample Code	pH	Macronutrient			Micronutrient			
			% O.M.	Avail P, ppm	Avail K, ppm	Avail Zn, ppm	Avail Cu, ppm	Avail Fe, ppm	Avail Mn, ppm
S-22- 3488	-	5.67	1.57	3.62	94.83	-	-	-	-

Note: 1.) Sample(s) will be kept only for three months from the date received
2) Measurement Uncertainty value is available upon request

Environmental Conditions: Temperature: 25°C ± 3 - Chemical Laboratory; 22±1°C – Biological Laboratory
Relative Humidity: 40-60%; 45-50% RH

Test Method: pH:Potentiometric; %O.M: Walkley & Black Spectrophotometric; Available P: Olsen; Available K: Cold Sulfuric Extraction using AAS; Available Zn, Cu, Mn, Fe: DTPA Extraction using AAS

Reference Method : Bureau of Soil and Water Management System (BSWM) Test Method Manual 2022.



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Date(s) Analyzed : Dec. 27-28, 2022
Date Reported : December 30, 2022
Analysis Requested : pH, Macronutrient
Area, ha : 0.1

NUTRIENT REQUIREMENT

Lab # ISL 2022	Sample Code	pH Preference	Texture	Lime Trial/ Req't.	Crop Variety/Age	Nutrient Req't (kg/ha)		
S-22 - 3488	-	-	-	-	Napier Grass	80	60	0

Reference standard: Regional Soil Laboratory (RSL) Standard Operating Procedure 2022.
Bureau of Soil and Water Management System (BSWM) Standard Operating Procedure 1979

Method: Texture : Feel Method; Lime: Trial method by incremental addition of lime

FERTILIZER RECOMMENDATION

Napier Grass 80-60-0
Apply 50 kgs Organic Fertilizer.
1st App: Appy 33.33 kgs 0-18-0 before growth.
2nd App: Apply 8.7 kgs 46-0-0 once growth starts.
3rd App: 6-8 weeks after the 2nd application, apply 8.7 kgs 46-0-0.

Figure 1. *Results of Soil Analysis.*

Land Preparation, Experimental Layout, and Design

The study was conducted at Gamu, Agri-Fishery School, Linglingay, Gamu, Isabela. The experimental area was cleared of any form of weeds followed by thorough land preparation. Deep plowing was done for the roots to be able to penetrate deep into the ground. The third plowing and harrowing were done before laying out the experiment. After thorough land preparation, an area of 531.9 square meters was divided into three blocks. Each block measures 5.9 meters by 27 meters and a distance of one meter between blocks. Each block was further subdivided into plots with a dimension of 2.7 meters by 5.0 meters and a half meter between plots. The experiment was laid out following the Randomized Complete Block Design (RCBD) with two factors: the two Napier grass varieties, and five nitrogen levels including control. Factors for the experiment are as follows:

Factor A: Napier Grass Varieties
- A1 = Pakchong
- A2 = Native

Factor B: Levels of Nitrogen Fertilizers
- B1 = Control
- B2 = 80-60-0 NPK ha-1
- B3 = 80-60-0 NPK ha-1 + 10% of the Recommended Rate N ha-1
- B4 = 80-60-0NPK ha-1 + 20% of the Recommended Rate N ha-1
- B5 = 80-60-0NPK ha-1 + 30% of the Recommended Rate N ha-1

Crop Establishment

Two-nodes cutting were used as planting materials. Planting materials were pre-germinated in a seedbed to facilitate uniformity of the plant during planting. Uniform pre-germinated cuttings were placed in the furrows with an angle of 20 degrees from the ground, 32 centimeters between hills, and 50 centimeters between rows. Planting materials were covered with two inches thick of soil. Newly planted Napier grasses were irrigated after planting to facilitate growth (Sarian, 2018).

Fertilization Application

An appropriate amount of fertilizers was applied equally in every plot as specified in the recommended rate and treatments per hectare. The application of the fertilizer treatments was strictly followed in the 30th and 45th days cutting interval (DCI), respectively.

Care and Management

The crop was irrigated as often as necessary because an adequate supply of water was essential for the crop. Weeds were controlled regularly by hand weeding so that nutrients were concentrated in the Napier grass. During the occurrence of pests and diseases, chemical pesticides were used following the manufacturer's recommendation.

Harvesting/Crop Cutting

Harvesting/crop cutting was done by cutting the grass down to the ground level leaving 1-2 nodes. The standardized cutting was done at 60 days after transplanting (DAT) and the 30 and 45-day cutting intervals (DCI) were carried out.

Data Gathered

1. *Number of Tillers.* The number of tillers was counted in every hill or plant for every sampling area.
2. *Height of Plant.* The height was measured from the base of the plant to the tip of the leaves using a meter stick.
3. *Herbage Weight.* Fresh matter and dry matter yield were weighed in 30 DCI and 45 DCI. The herbage weight per sampling area was the basis for calculating the herbage yield per hectare.
4. *Biomass/Herbage Yield.* The total weight of the samples per hill in the sampling area was the basis for calculating the biomass/herbage yield.
5. *Plant Tissue Analysis.* Initial samples of Pakchong and Native Napier grass for the first 60 days were collected for nutrient analysis. The 30 and 45 DCI samples per treatment at every cutting interval were collected and air-dried for nutrient analysis. The samples were brought to Cagayan Valley Integrated Agriculture Laboratory (CVIAL), Department of Agriculture Regional Field Office No. 2, Carig Sur, Tuguegarao City for the plant tissue analysis in terms of crude protein, crude fiber, moisture, and ash.
6. *Herbage Yield per Hectare.* The yield per hectare was computed using this formula:

   Yield per Hectare = ((AW x NH)/PA)*10 000 (Formula derived from Sair et al., 2012)
   where:
   AW – Average weight per hill in a sampling area (kg)
   NH – Number of hills per plot (80)
   SA – Sampling area (m^2)

Cost and Return Analysis

Considering various assumptions, Return on Investment (ROI) was calculated by dividing the total Net Income by the Total Cost of Production multiplied by 100, as in the following formula:

Return on Investment (ROI) = (Total Net Income)/(Total Cost of Production) x 100

Statistical Analysis

The gathered data were organized, tabulated, and interpreted using the Analysis of Variance in a Randomized Complete Block Design (RCBD) in a Statistical Tool for Agricultural Research (STAR) computer software application. The treatments with significant results were compared using the Least Significant Differences (LSD) test.

Ethical Considerations

The authors confirm that ethical research standards were observed in the conduct of the study. Appropriate occupational health and safety protocols in handling fertilizer materials and chemicals were complied with.

Results and Discussion

Observations

Stand and Vigor of the Crop. It was observed that all plants in the different treatments had different heights and sizes during the first 60 days after transplanting (DAT). The plants had uniform growth in the next 30 days cutting interval (DCI) and 45 DCI. The fertilized plants showed more vigor as manifested by greener leaves and taller and healthier stems than plants without fertilization (Control). The plants showed a good response when irrigated.

Occurrence of Insect Pests, Weeds, and Diseases. There were a few plant hoppers (*Nilaparvata lugens*) observed within the 30 DCI and more on the 45 DCI. It was controlled by the application of insecticide following the manufacturer's recommendation doses. There was an observed leaf spot in the lower leaves, but it was gone as the plants grew and matured. There were observed occurrences of weeds, but they could not outgrow the Napier grasses which were taller and had near planting distances. Weeds were controlled by hand weeding.

Climatic Condition During the Conduct of the Study. The climatic conditions during the crop establishment were favorable because of the presence of rain. The rain became rare at 30 DAT until 30 and 45 DCI. Adequate rain was observed one week before the 45 DCI at the experimental area.

Number of Tillers

Nitrogen fertilization and Napier varieties showed significant effects on the number of tillers/clumps (Table 1). It was recorded that the recommended rate (80-60-0 kg NPK ha $^{-1}$) had the highest number of tillers/clump (18.40 pcs.) compared to plants without fertilization (Control) on the 30 DCI. Pakchong (PK) Napier grass had more tillers (17.85 pcs.) than Native (NT) Napier grass (16.29 pcs.). There is a significant difference in the Napier varieties on 30 DCI, but no significant difference at 45 DCI while levels of nitrogen at 30 and 45 DCI were highly significant at 1% and 5%, respectively.

The results in Table 1 agree with the findings of Gorne and Aradilla (2020) that fertilization significantly affects plant tillers (productive and unproductive) in Adlay and Napier, and that increasing nitrogen fertilization rate increases growth (Dokbua et al., 2021). The data shows further that there is a significant difference between fertilized and unfertilized plants. Interactions between Napier grass varieties and nitrogen levels were not observed. However, there were more tillers/clumps at 30 DCI (17.07) than at 45 DCI (6.71) due to younger and more aggressive roots at 30 DCI.

Table 1. Number of Tillers/Clumps of Napier Grasses as Affected by Nitrogen Fertilization

Factor B (Level of Nitrogen)	Factor A (Napier Variety)					
	30 DCI			45 DCI		
	PK	NT	Mean	PK	NT	Mean
Control	14.07	11.87	12.97^{b}	5.73	5.53	5.63^{b}
80-60-0 kg NPK ha $^{-1}$	19.60	17.20	18.40^{a}	8.07	6.97	7.52^{a}
88-60-0 kg NPK ha $^{-1}$	17.73	17.83	17.78^{a}	6.90	7.13	7.02^{a}
96-60-0 kg NPK ha $^{-1}$	19.23	17.17	18.20^{a}	6.77	7.50	7.13^{a}
104-60-0 kg NPK ha $^{-1}$	18.60	17.37	17.98^{a}	6.37	6.43	6.40^{ab}
MEAN	17.85^{a}	16.29^{b}	17.07	6.77	6.71	6.74
Napier Variety (A)		*			ns	
Level of Nitrogen (B)		**			*	
A x B		ns			ns	
C.V. (%)		11.33			15.64	
LSD (A)		1.48			-	
LSD (B)		2.35			1.28	

Note: Means with common letters are not significantly different from each other using the Least Significant Difference (LSD) Test.
ns – not significantly different, ***** - significant at 5% level, ****** - significant at 1% level

Height of the Plant

Napier grass varieties show a significant (5%) difference and is highly significant (1%) in Nitrogen levels at 30 DCI. Pakchong (PK) was observed taller (151.73 cm), bigger, and more vigorous than the Native (NT) (140.74 cm). Plants applied with nitrogen fertilizer showed no significance with each other, but significant effects were observed between plants applied with fertilizer and those without fertilization (Control). The 45 DCI, on the other hand, showed no significant difference in the height of the Napier varieties but there was a high level of significance (1%) between fertilized and the control groups. This is also the same with Napier grass, confirming that nitrogen fertilization improves the morphogenic, production, and chemical characteristics of Guinea grass (Oliveira et al., 2020). Interaction between Napier varieties and levels of nitrogen was not observed.

The plant height had improved from 30 DCI (146.23) to 45 DCI (199.67). It indicates more harvest at 45 DCI than 30 DCI. Liman et al. (2022) reported that nutrient detergent fiber (NDF) was affected by the age of cut and significant results on harvesting age on biomass production, leaf-stem ratio, crude protein content, and NDF content.

Table 2. Height of Napier Grasses as Affected by Nitrogen Fertilization

Factor B (Level of Nitrogen)	Factor A (Napier Variety)					
	30 DCI			45 DCI		
	PK	NT	Mean	PK	NT	Mean
Control	120.60	105.10	112.85[b]	174.90	166.73	170.82[b]
80-60-0 kg NPK ha $^{-1}$	168.07	149.03	158.55[a]	209.17	209.53	209.35[a]
88-60-0 kg NPK ha $^{-1}$	154.27	146.60	150.43[a]	199.53	208.33	203.93[a]
96-60-0 kg NPK ha $^{-1}$	156.67	154.80	155.73[a]	201.77	209.87	205.82[a]
104-60-0 kg NPK ha $^{-1}$	159.03	148.17	153.60[a]	202.03	214.87	208.45[a]
MEAN	151.73[a]	140.74[b]	146.23	197.48	201.87	199.67
Napier Variety (A)		**			ns	
Level of Nitrogen (B)		**			**	
A x B		ns			ns	
C.V. (%)		4.65			7.45	
LSD (A)		5.22				
LSD (B)		8.25			18.04	

Note: Means with common letters are not significantly different from each other using the Least Significant Difference (LSD) Test.
ns – not significantly different, ***** - significant at 5% level, ****** - significant at 1% level

Fresh Matter Yield

As shown in Table 3, highly significant (1%) differences were observed in Napier varieties and levels of nitrogen at 30 DCI. Pakchong is heavier (0.76 kg) than the Native (0.57 kg). Plants applied with fertilizer have better herbage weight compared to the unfertilized. Unfertilized (control) plants (0.289 kg) were significantly lower than the fertilized plants (0.824 -0.722 kg). Plants applied with increasing levels of nitrogen were not significantly different from each other. At 45 DCI, no significant differences in the Napier grass varieties were observed. This means that the Pakchong variety is comparable with the native variety in terms of fresh matter yield and a significant (5%) level was noted in the levels of nitrogen. The recommended rate of 80-60-0 kg NPK ha -1 has the highest mean at 30 DCI (0.82 kg) and 45 DCI (1.40 kg) per sampling plot, which is affected by the number of tillers and height of the plant and size of the stem.

This uncovers that nitrogen fertilization has an impact on fresh matter yield. This coincides with the study of Liman et al. (2022) who reported that the increasing cutting interval increases dry matter, crude fiber, biomass production, and other parameters. There were no significant differences between plants applied with fertilizer, but control groups were significantly (1%) lower. This can be further improved through the addition of higher nitrogen concentration as Nantasaksiri et al. (2021) reported that 500 kg of nitrogen per hectare enhanced benefits on water quality and would benefit farmers and aid in carbon dioxide reduction. Interaction between the Napier varieties and levels of nitrogen was not observed.

Table 3. Fresh Matter Yield of Napier Grasses as Affected by Nitrogen Fertilization

Factor B (Level of Nitrogen)	Factor A (Napier Variety)					
	30 DCI			45 DCI		
	PK	NT	Mean	PK	NT	Mean
Control	0.34	0.24	0.29[b]	0.88	0.60	0.74[b]
80-60-0 kg NPK ha $^{-1}$	0.96	0.69	0.82[a]	1.66	1.15	1.40[a]
88-60-0 kg NPK ha $^{-1}$	0.82	0.62	0.72[a]	1.27	1.20	1.23[a]
96-60-0 kg NPK ha $^{-1}$	0.82	0.66	0.74[a]	1.16	1.11	1.13[a]
104-60-0 kg NPK ha $^{-1}$	0.85	0.64	0.74[a]	1.20	1.15	1.17[a]
MEAN	0.76[a]	0.57[b]	0.66	1.23	1.04	1.14
Napier Variety (A)		**			ns	
Level of Nitrogen (B)		**			*	
A x B		ns			ns	
C.V. (%)		16.75			26.88	
LSD (A)		0.085			-	
LSD (B)		0.135			0.371	

Note: Means with common letters are not significantly different from each other using the Least Significant Difference (LSD) Test.
ns – not significantly different, ***** - significant at 5% level, ****** - significant at 1% level

Dry Matter Yield

The increasing harvesting ages have an impact on the yield, as reflected in Table 4, and this is supported by the study of Bacorro et al. (2018), which found that the dry matter yield of Mulato II and Mombasa grasses was greater at a 45 DCI. The recommended rate (80-60-0 kg NPK ha -1) had the highest dry matter yield (0.12 kg) at 30 DCI and 0.2 kg at 45 DCI. During 30 DCI, Pakchong had greater dry matter yield than the Native, as manifested by their significant differences at 1% level on Napier varieties and levels of nitrogen. Napier varieties become comparable as the age of the grass increases (45 DCI). These findings further support Bacorro et al. (2019) who stated that 5 Pennistum species have a promise of nutrient availability as indicated by high degradability in 30 days of grasses and dry matter degradability of grasses declines with maturity including the native Napier in the Philippines. Even though no interaction was observed between the factors, nitrogen fertilization at 45 DCI increased dry matter significantly (5%). Though 80-60-0 kg NPK ha -1 (B2) has the highest dry matter yield, no significant effect was observed compared to other levels of nitrogen.

Table 4. Dry Matter Yield of Napier Grasses as Affected by Nitrogen Fertilization

Factor B (Level of Nitrogen)	Factor A (Napier Variety)					
	30 DCI			45 DCI		
	PK	NT	Mean	PK	NT	Mean
Control	0.05	0.03	0.04[b]	0.12	0.08	0.10[b]
80-60-0 kg NPK ha $^{-1}$	0.14	0.10	0.12[a]	0.23	0.16	0.20[a]
88-60-0 kg NPK ha $^{-1}$	0.11	0.09	0.10[a]	0.18	0.17	0.18[a]
96-60-0 kg NPK ha $^{-1}$	0.12	0.09	0.11[a]	0.16	0.16	0.16[a]
104-60-0 kg NPK ha $^{-1}$	0.12	0.09	0.11[a]	0.17	0.16	0.17[a]
MEAN	0.11[a]	0.08[b]	0.09	0.17	0.15	0.16
Napier Variety (A)		**			ns	
Level of Nitrogen (B)		**			*	
A x B		ns			ns	
C.V. (%)		17.69			26.45	
LSD (A)		0.0127			-	
LSD (B)		0.0201			0.0517	

Note: Means with common letters are not significantly different from each other using the Least Significant Difference (LSD) Test.
ns – not significantly different, ***** - significant at 5% level, ****** - significant at 1% level

Biomass/Herbage Yield

Table 5 revealed the production potential of Napier grass varieties as affected by various levels of nitrogen. Napier varieties had a difference of 11.09 tons based on the mean at 30 DCI which is significant at a 1% level and 11.39 tons based on the mean at 45 DCI. It illustrates that Pakchong is superior to Native in terms of herbage yield. The highest herbage yield had a difference of 31.72 tons based on the mean at 30 DCI, showing a greater effect between fertilized plants and plants without fertilization (Solati et al., 2018). Although 45 DCI has no significant effects on grass varieties, the plot with the highest herbage yield has a significant difference on plants without fertilization that brings about 39.31 tons difference manifested with the significance at 5% level. Pakchong Napier is considered best in terms of dry matter and nutritive values (Haryani et al., 2018). This coincindes with the study of Delevatti et al. (2019) that increasing the level of nitrogen is a promising way to improve Marandu grass production and nutritive value and this finding is also applicable to Napier grass.

Table 5. Herbage Yield of Napier Grasses as Affected by Nitrogen Fertilization

Factor B (Level of Nitrogen)	Factor A (Napier Variety)					
	30 DCI			45 DCI		
	PK	NT	Mean	PK	NT	Mean
Control	20.19	14.02	17.11^{b}	52.11	35.48	43.79^{b}
80-60-0 kg NPK ha $^{-1}$	56.69	40.97	48.83^{a}	98.33	67.87	83.10^{a}
88-60-0 kg NPK ha $^{-1}$	48.67	36.86	42.77^{a}	75.18	70.95	73.07^{a}
96-60-0 kg NPK ha $^{-1}$	48.79	39.35	44.07^{a}	68.58	65.82	67.20^{a}
104-60-0 kg NPK ha $^{-1}$	50.09	37.81	43.95^{a}	70.99	68.11	69.55^{a}
MEAN	44.89^{a}	33.80^{b}	39.34	73.04	61.65	67.34
Napier Variety (A)		**			ns	
Level of Nitrogen (B)		**			*	
A x B		ns			ns	
C.V. (%)		16.75			26.88	
LSD (A)		5.0561			-	
LSD (B)		7.9944			21.9586	

Note: Means with common letters are not significantly different from each other using the Least Significant Difference (LSD) Test.
ns – not significantly different, * - significant at 5% level, ** - significant at 1% level

Crude Protein Content

Figure 1 illustrates a declining crude protein content of unfertilized plants (Control) from the 60-day standardized crop cutting to 45 DCI based on laboratory analysis. It proves that Napier grass cultivation without fertilization affects its crude protein content. The levels of nitrogen fertilization and Napier varieties have no significant effects or interactions (Table 6). The crude protein content of Napier grass varieties (PK & NT) is comparable at 30 DCI. However, on 45 DCI, levels of nitrogen have significant differences. Moreover, B4 and B5 are significantly different over B2 and B3 over B1 (Control).

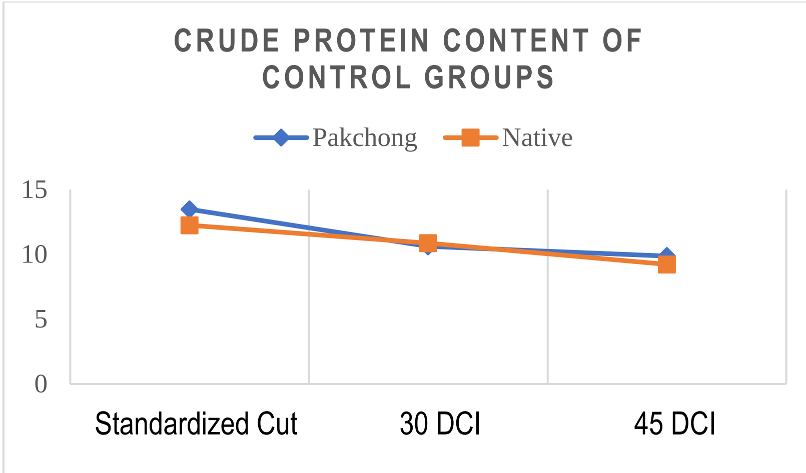

Figure 2. *Crude Protein Content of Napier Grasses in Control Groups.*

Levels of nitrogen show an impact at 45 DCI, wherein 90-60-0 kg NPK ha-1 is the highest (10.59%) and significantly different at 5% level compared to plants without fertilization. The 80-60-0 kg and 88-60-0 kg NPK ha-1 are at average. This supports that the crude protein yield of pure fertilized grasses was superior to both annual crops in optimized rotations and traditional systems (Solati et al., 2018) and Napier grass contains as high as 17% to 18% crude protein (Mugachia, 2022). The application of increasing levels of nitrogen improved the crude protein content of Napier grass at 45 DCI. However, there was no interaction between Napier grass variety and levels of nitrogen observed for 30 and 45 DCI. It manifests that at 45 DCI onward, a decrease in nitrogen from the soil is evident. Crude protein is a chemical analysis for forage that calculates the amount of nitrogen (Anderson, 2021). Furthermore, nitrogen fertilization can increase crude protein in grass (Widodo et al., 2019).

Table 6. Crude Protein Content of Napier Grasses as Affected by Nitrogen Fertilization

Factor B (Level of Nitrogen)	Factor A (Napier Variety)					
	30 DCI			45 DCI		
	PK	NT	Mean	PK	NT	Mean
Control	9.17	8.79	8.98	8.20	8.02	8.11[b]
80-60-0 kg NPK ha $^{-1}$	10.60	10.20	10.40	10.05	9.33	9.69[ab]
88-60-0 kg NPK ha $^{-1}$	10.70	10.93	10.82	9.15	8.93	9.04[ab]
96-60-0 kg NPK ha $^{-1}$	12.16	11.06	11.61	11.66	9.51	10.59[a]
104-60-0 kg NPK ha $^{-1}$	13.48	10.31	11.89	10.29	10.35	10.32[a]
MEAN	10.61	10.86	10.74	9.87	9.23	9.55
Napier Variety (A)		ns			ns	
Level of Nitrogen (B)		ns			*	
A x B		ns			ns	
C.V. (%)		22.91			14.81	
LSD (B)		-			1.7157	

Note: Means with common letters are not significantly different from each other using the Least Significant Difference (LSD) Test.
ns – not significantly different, * - significant at 5% level, ** - significant at 1% level

Cost and Return Analysis

The cost and return for one hectare of Napier grasses production as affected by levels of nitrogen fertilization sold for 5 pesos per kg is presented in Table 7. The return on investment (ROI) of plants without fertilization (Control) at 30 DCI was found to be a net loss. This reveals that nitrogen fertilization is a factor in determining the profitability of Napier grass varieties. The 80-60-0 kg NPK ha -1 applied in the Pakchong variety has the highest ROI that has

108.43%. Plants applied with 80-60-0 kg NPK ha -1 were found 57% higher than the plants applied with 88-60-0 kg NPK ha -1 which obtained the highest ROI than the native variety. Cost and return analysis reveals further that at 45 DCI, ROI goes higher than 30 DCI. Pakchong applied with 80-60-0 kg NPK ha -1 is still the highest in terms of ROI, followed by Pakchong Napier grass applied with 96-60-0 kg NPK ha -1 at 45 DCI. The 80-60-0 kg NPK ha -1 shows favorable weather conditions and soil types. There were no significant differences in Napier varieties and levels of nitrogen and the interaction effects of the factors. However, at 45 DCI, the ROI drastically increased from 30 DCI. This further shows that fertilization of Napier grass can give higher economic returns as the age of the grass increases. Napier farming is found to be economical and has income potential.

Table 7. Return on Investment of Napier Grasses as Affected by Nitrogen Fertilization

Factor B (Level of Nitrogen)	Factor A (Napier Variety)					
	30 DCI			45 DCI		
	PK	NT	Mean	PK	NT	Mean
Control	-22.87	-46.42	-34.64[b]	955	618	787
80-60-0 kg NPK ha $^{-1}$	108.43	50.62	79.53[a]	1,549	1,038	1,294
88-60-0 kg NPK ha $^{-1}$	78.59	35.25	56.92[a]	1,149	1,079	1,114
96-60-0 kg NPK ha $^{-1}$	78.67	44.09	61.38[a]	1,029	984	1,007
104-60-0 kg NPK ha $^{-1}$	83.17	38.18	60.62[a]	1,059	1,011	1,035
MEAN	65.18[a]	24.34[b]	44.76	1,148	946	1,047
Napier Variety (A)		**			ns	
Level of Nitrogen (B)		**			ns	
A x B		ns			ns	
C.V. (%)		54.06			29.96	
LSD (A)		18.5632			-	
LSD (B)		29.3510			-	

Note: Means with common letters are not significantly different from each other using the Least Significant Difference (LSD) Test.
ns – not significantly different, * - significant at 5% level, ** - significant at 1% level

Conclusion and Future Works

Based on the results of the study, nitrogen fertilization of 80 kg N ha-1 increases yield performance on the number of tillers/clumps, plant height, fresh and dry matter yield, and herbage yield in the 30-day cutting intervals. In some parameters, the native Napier is comparable to the Pakchong Napier. There are significant effects of varying levels of nitrogen at 30 DCI. Pakchong was found to be superior to the native at 30 DCI as the grass matured at 45 DCI. Fertilization of nitrogen enhances yield performance; aging Napier grass can increase its crude protein content as one of the primary nutrients needed by ruminant animals. The same study is recommended for the wet season and acceptability trials of ensiled Napier grass to animals.

References

[1] Abubakar, M., Iqbal, A., Kabir, A., & Manzoor, S. (2018). Introductory chapter: Ruminants—The husbandry, economic, and health aspects. In *Ruminants - The husbandry, economic and health aspects*. InTech. https://doi.org/10.5772/intechopen.76064

[2] Bacorro, T. J., Angeles, A. A., Loresco, M. M., & Reyes, P. M. B. (2018). Herbage dry matter yield, nutrient composition and *in vitro* gas production of Mulatto II and Mombasa grasses at 30- and 45-day cutting intervals. *Philippine Journal of Veterinary and Animal Science, 44*(1).

[3] Bacorro, T. J., Cala, C. P., Abes, E. E. C., Victoriano, E. E., Astillero, A. F., & Avante, L. M. (2019). In situ dry matter degradability at 30- and 45-day cutting intervals of five *Pennisetum* species in dairy cattle. *Philippine Journal of Veterinary and Animal Science*, 187–190.

[4] Beigh, Y. A., Ganai, A. M., & Ahmad, H. A. (2017). Prospects of complete feed system in ruminant feeding: A review. *National Library of Medicine*, 424–437.

[5] Delevatti, L. M., Cardoso, A. S., Barbero, R. P., Leite, R. G., Romanzini, E. P., Ruggieri, A. C., & Reis, R. A. (2019). Effect of nitrogen application rate on yield, forage quality, and animal performance in a tropical pasture. *Scientific Reports, 9*(1), 7596. https://doi.org/10.1038/s41598-019-44138-x

[6] Gorne, N., & Aradilla, A. (2020). Adlay (*Coix lacryma-jobi L.*) and Napier grass (*Pennisetum purpureum Schum.*) intercropping and fertilization schemes as climate-smart strategy for food and feed production. *Annals of Tropical Research*, 56–71. https://doi.org/10.32945/atr4215.2020

[7] Haryani, H., Norlindawati, A. P., Norfadzrin, F., Aswanimiyuni, A., & Azman, A. (2018). Yield and nutritive values of six Napier (*Pennisetum purpureum*) cultivars and different cutting age. *Malaysian Journal of Veterinary Research, 9*(2), 6–12. https://www.dvs.gov.my/dvs/resources/user_16/MJVR%20Vol9%20No%202/MJVR-V9N2-p6-12.pdf

[8] Johansen, M., Madsen, P. A., Brask-Pedersen, D. N., & Lund, P. (2022). Effect of age and dietary crude protein level on nitrogen excretion in dairy heifers. *Livestock Science, 264*, 105058. https://doi.org/10.1016/j.livsci.2022.105058

[9] Kaewpila, C., Khota, W., Gunun, P., Kesorn, P., & Cherdthong, A. (2020). Strategic addition of different additives to improve silage fermentation, aerobic stability and *in vitro* digestibility of Napier grasses at late maturity stage. *Agriculture, 10*(7), 262. https://doi.org/10.3390/agriculture10070262

[10] Leite, R. G., Cardoso, A. da S., Fonseca, N. V. B., Silva, M. L. C., Tedeschi, L. O., Delevatti, L. M., Ruggieri, A. C., & Reis, R. A. (2021). Effects of nitrogen fertilization on protein and carbohydrate fractions of Marandu palisadegrass. *Scientific Reports, 11*(1), 14786. https://doi.org/10.1038/s41598-021-94098-4

[11] Letelier, P., Zanton, G. I., & Wattiaux, M. A. (2022). Production performance of Holstein cows at four stages of lactation fed four dietary crude protein concentrations. *Journal of Dairy Science, 105*(12), 9581–9596. https://doi.org/10.3168/jds.2022-22146

[12] Liman, K. W., Erwanto, M., Septianing, C., Asidiq, T., Nur, T., & Adhianto, K. (2022). Productivity and quality of Pakchong-1 hybrid grass (*Pennisetum purpureum* × *Pennisetum americanum*) at different harvesting ages and fertilizer levels. *Pakistan Journal of Biological Sciences, 25*(5), 426–432. https://doi.org/10.3923/pjbs.2022.426.432

[13] Loresco, M. M., Andal, M. J. C., Ty, K. J. S., & Angeles, A. A. (2019). Growth performance of growing dairy heifers fed fresh Mulato II (*Brachiaria ruziziensis* × *B. decumbens* × *B. brizantha*) and Mombasa (*Panicum maximum Jacq. cv. Mombasa*) compared to Napier (*Pennisetum purpureum Schum.*). *Philippine Journal of Veterinary and Animal Sciences, 45*(1).

[14] Madsen, P. A., Lund, P., Brask-Pedersen, D. N., & Johansen, M. (2023). Effect of age and dietary crude protein level on nitrogen excretion in Holstein bull calves. *Livestock Science, 267*, 105139. https://doi.org/10.1016/j.livsci.2022.105139

[15] Mugachia, J. (2022, December 10). Fodder rush should be reason enough to worry farmers. *Nation Media Group*. https://nation.africa/kenya/business/seeds-of-gold/fodder-rush-should-be-reason-enough-to-worry-farmers-4049736

[16] Nantasaksiri, K., Charoen-amornkitt, P., Machimura, T., & Hayashi, K. (2021). Multi-disciplinary assessment of Napier grass plantation on local energetic, environmental and socioeconomic industries: A watershed-scale study in Southern Thailand. *Sustainability, 13*(24), 13520. https://doi.org/10.3390/su132413520

[17] Oliveira, J. K. S. de, Corrêa, D. C. da C., Cunha, A. M. Q., Rêgo, A. C. do, Faturi, C., Silva, W. L. da, & Domingues, F. N. (2020). Effect of nitrogen fertilization on production, chemical composition and morphogenesis of Guinea grass in the humid tropics. *Agronomy, 10*(11), 1840. https://doi.org/10.3390/agronomy10111840

[18] Sair, R. R., Pastor, C. D. A., & Balneg, B. B. (2012). Growth and yield performance of promising Napier grass accessions as affected by the frequency of chicken manure application. *Philippine Journal of Veterinary and Animal Science, 2*(July–December).

[19] Sarian, Z. B. (2018, February 28). Super Napier planting guide. *Agriculture Magazine*. https://www.agriculture.com.ph/2018/02/28/super-napier-planting-guide/

[20] Sarker, N. R., Yeasmin, D., Tabassum, F., Amin, Md. R., & Habib, Md. A. (2019). Comparative study on biomass yield, morphology, silage quality of hybrid Napier and Pakchong and their utilization in bull calves. *Journal of Agricultural Sciences and Technology*, 166–176. https://www.researchgate.net/publication/335870073

[21] Solati, Z., Manevski, K., Jørgensen, U., Labouriau, R., Shahbazi, S., & Lærke, P. E. (2018). Crude protein yield and theoretical extractable true protein of potential biorefinery feedstocks. *Industrial Crops and Products, 115*, 214–226. https://doi.org/10.1016/j.indcrop.2018.02.010

[22] Wanjiru, S. (2023, May 3). Super hybrid Napier grass-Pakchong. *The Organic Farmer*. https://theorganicfarmer.org/super-hybrid-napier-grass-pakchong/

[23] Widodo, S., Suhartanto, B., & Umani, N. (2019). Effect of shading and level of nitrogen fertilizer on nutrient quality of *Pennisetum purpureum cv. Mott* during wet season. *IOP Conference Series: Earth and Environmental Science*.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.