Nigerian J. Anim, Sci. 2025, 27 (2): 170 - 179

Preliminary Study on Yield and Nuritional Potential of Newly Introduced Juncao Grass *(Pennisetum purpureum)* in Shika, Nigeria

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Abstract

Juncao grass, a multifunctional crop developed through innovative agricultural technology, has gained significant attention for its agronomic potential in addressing food security, enhancing environmental sustainability, and rural development. The grass is utilized for mushroom cultivation, livestock feed, soil conservation, and bioenergy production. The high nutritive value, adaptability, and ecological benefits of Juncao grass make it a promising crop for sustainable agriculture. A study was conducted at the Introduction Plot of the feeds and nutrition research programme, National Animal Production Research Institute, Shika, Zaria, to explore a preliminary investigation on the nutritive potential of Juncao grass (Pennisetum purpureum). The grass was planted in a Randomized Complete Block Design with stage of harvest as treatment and three replicates in 5m x 5m plots. Planting was done through stem cuts with 2 to 3 nodes at an angle 450 into the ground. Data on plant height, leaf length, leaf width, tiller number, stem diameter, and dry matter yield were taken from each plot before the first and second harvest. Also, data on moisture, dry matter, crude protein, ether extract, crude fibre, nitrogen-free extract, and metabolizable energy were determined. Data collected were analyzed using SAS, package and means were compared using Duncan Multiple Range Test. The plant height was significantly (P<0.05) higher (332.5cm) in second harvest. Similar trend was observed for stem diameter (7.03cm) and total dry matter yield of 12.21t/ha. The leaf length (113.3cm), leaf width (5.43cm), number of leaves (25) and tillers (23) were significantly higher (P<0.05) during the first harvest. The percentage crude protein, ether extract, moisture, and metabolizable energy are significantly (P<0.05) highly concentrated in the leaves 7.40%, 2.89%, 62.65%, and 1,205 kcal/kg respectively. The percentage dry matter (46.61%), crude fibre (22.03%), ash (12.82%), and nitrogen-free extract (12.18%) is highly concentrated in the stems of Juncao grass than in leaves. The nutritive values obtained for Juncao grass in Shika are necessary for the improvement of livestock feed. The silage produced exhibits acceptable fermentation quality (pH, aroma) and nutritional value (CP, NFE). It is therefore, necessary to explore the potential yields and nutrient of Juncao grass as feed for ruminant. It could be recommended to cultivate Juncao grass on large scale to address feed shortage in Nigeria.

Keywords: Agronomic yield, Nutritive value, Juncao grass, Silage, Shika

Description of Problem

Juncao technology, developed by Professor Lin Zhanxi of Fujian Agriculture and Forestry University (FAFU), China. The term "Juncao" translates to "mushroom grass," highlighting its dual-purpose application in fungal cultivation and as a forage crop for livestock feeding. Juncao grasses are used as fodder for cattle, goats, and sheep, improving animal health and productivity. The high protein and fiber content of Juncao grass enhances milk production and weight gain in livestock (Lin *et al.*, 2022). In line with the proposal by the presidential committee on the implementation of livestock reforms proposed that a combination of ranching and open grazing could offer the most viable solution to Nigeria's farmers- herder crises. In the quest to take proactiveness to resolve this crisis. The National Animal Production Research Institute, Shika, received a sample of Juncao grass in May, 2024 from Federal Ministry of Agriculture and Food Security (FMAFS), Department of Animal Husbandry Services, Abuja. The grass is mainly used as feed for livestock in form of cut and carry feeding systems. It has the ability to withstand repeated cutting and will rapidly regenerate, producing palatable leafy shoots (Negawo *et al.*, 2017). It is a multipurpose forage crop that can be grazed directly, or made into silage or hay and as substrate for mushroom production. The varied uses provide an indication of the diversity of roles that Juncao grass could contribute to the reduction of poverty and nutrition. In Rwanda, Lin (2022) reported that Juncao project created job for poor people and have trained more than 20,000 people, directly supported 50 cooperatives and companies. In Fuzhou, Jin L., (2012) reported nutritional features of artificially cultivated Juncao grass (*Pennisetum purpureum* Schumach cv Huanan Xijing) with a forage height of 1.4m, protein content of about 10.46% on air dried basis. The objective of this study was to explore preliminary investigation on the yield and nutritive quality of the newly introduced Juncao grass and optimizing nitrogen fertilization to improve crude protein content and yield.

Description of the experimental site

The study was conducted during the rainy season in 2024 at the experimental farm of Feeds and Nutrition Research Programme, National Animal Production Research Institute (NAPRI), Shika, Zaria. Shika is located on Latitude 11° 12'W. Longitude 07° 33'E and altitude 660m above sea level, 22km North-West of Zaria in the Northern Guinea Savannah zone of Nigeria. The climate of the study area is characterized by a defined wet and dry season. Wet season starts from April to early May and ends in late September to early October while the dry season from October to April ranges from 1110 to 1160mm with a maximum temperature of 39°C in May and minimum temperature of 10.5°C recorded in December/January and relative humidity of approximately 75% (IAR, 2024).

Soil sampling and Analyses

Soil samples was collected from the experimental site with the aid of soil auger at 4 corners and centers of the plots at 0-15 depth and make a composite sample for soil analysis before the commencement of the experiment. The soil samples were

analyzed for physical and chemical properties as described by (AES, 1998), to determine texture, particle size, total nitrogen, total carbon, phosphorus, soil pH and Cations Exchange Capacity (CEC). The analysis was done at the Department of Soil Science, Faculty of Agriculture, Ahmadu Bello University, Zaria. The soil texture was sandy loam (73.95% sand, 16.20% clay, 9.85% silt), with a pH of 5.20 and total nitrogen of 0.12% (Table 1).

Planting and Management

The Juncao grass was planted through cuttings having double to triple nodes horizontally placed in the soil at 45° and covered with soil. The area of each plot is 5m x 5m and plant spacing, inter and intra rows are 0.5m x 1m respectively. The chemical fertilizer used in the experiment was N-P-K = 20:10:10, the application quantity was 250 kg/ha. The 60% fertilizer was used as a base fertilizer, 20% fertilizer was applied in tillering stage and 20% fertilizer was used during elongation stage. Weeding was done manually with hoes at 4 and 8 weeks after sowing. The experiment was laid in a Randomized Complete Block Design with stage of harvest as treatment in three replicates. Data was collected from five (5) plants randomly sampled per plot and tagged for the measurements of various agronomic parameters using the Standard Procedure of Tarawali *et al.* (1995). Number of tillers was estimated by counting the number of tillers within 5 randomly selected Juncao grass stand at each harvesting period using a 0.5mx 0.5m quadrat. The plant height of Juncao was determined by measuring from the base of the plant to the flag leave with the aid of a tape rule on 5 randomly selected stands per plot. Leaf length of Juncao grass was estimated by measuring from the tip of the leaf to the base of the ligule with the aid of tape rule from 5 randomly selected plant stands per plot. The leaf width was determined by measuring the width at midpoint of the leaf on 5 randomly selected plants stands per plot. The first harvest was done on the 10th November, 2024 while the second harvest was done on the 5th of January, 2025. The Kjeldahl method (AOAC, 2005) was used to measure the total nitrogen from Juncao samples collected from the two harvests.

Preparation of Juncao Silage

Juncao grass was harvested at 100 days chopped to 2 cm with a forage chopper. The chopped forage material was ensiled in bottle silos containing 1kg of the chopped Juncao and properly compressed to eliminate any trace of air in the bottle and then sealed with cover lid to ensure anaerobic fermentation. After 22 days Juncao silage was opened three samples were collected from the bottom, middle and top of each silage bottle. Samples collected were examined for physical properties (colour, aroma and texture) by visual examination and rated by independent scorers as described by Ishiaku *et al*. (2020). The pH of the silage was measured with pH meter. Composite sample (450g) was obtained by selecting materials (150g) then bulk immediately and mix thoroughly before it is being stored in the refrigerator at (-5°C) until required for proximate analysis.

Data Collection and Analysis

Agronomic parameters (plant height, leaf length, leaf width, tiller number, stem

diameter, and dry matter yield) were measured at the first (November 10, 2024) and second (January 5, 2025) harvests. Nutritional composition (crude protein, ether extract, crude fibre, ash, nitrogen-free extract, and metabolizable energy) was analyzed using standard methods (AOAC, 2005). Data were analyzed using SAS (2005), with means compared using Duncan's Multiple Range Test (Duncan, 1955).

Results and Discussion

Agronomic performance

The mean plant height at first harvest was 313.8 cm, which was significantly lower ($P<0.05$) compared to the mean height of 332.5 cm at second. This indicates that Juncao grass continues to grow taller with extended harvest periods. The mean leaf length at first harvest was 113.3 cm, significantly higher than the 108.8 cm observed at second harvest. Conversely, the mean leaf width was slightly higher at first harvest (5.43 cm) compared to second harvest (4.88 cm). These differences suggest that leaf growth may stabilize or decrease slightly as the plant matures. The mean stem diameter increased from 6.28 cm at first harvest to 7.03 cm at second harvest, indicating that the stems thicken as the plant ages. The mean tiller number decreased from 23 tillers at first harvest to 13 tillers at second harvest. This reduction could be due to the plant allocating more resources to height and stem growth rather than producing new tillers (Islam *et. al.*, 2023). The dry matter yield significantly increased from 8.69 t/ha at first harvest to 12.21 t/ha at second harvest. This suggests that Juncao grass accumulates more biomass over time, making it a valuable crop for biomass production. The variation in plant height may be associated with soil fertility or nutrient absorption rate by individual crop. There was slight decrease in leave width compared to a study conducted in china. (Lin *et al.* 2022) which suggested that leave width may vary with environment condition. Juncao grass tends to produce more tillers at earlier age than when fully matured and tend to allocated more resources to height and stem growth. Mengistu *et al.*, (2024) reported yields tend to be higher in tropical environment than in cooler climates. The dry matter yield in this study aligns with findings by Mwendia *et al.* (2017), who reported yields of 10–40 t/ha depending on management and environmental conditions.

Nutritional composition

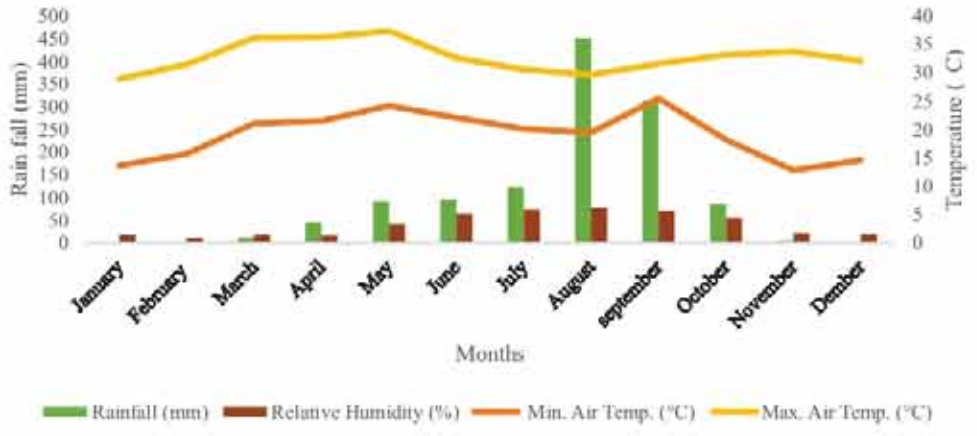
The percentage crude protein, ether extract, moisture and metabolizable energy are significantly ($P<0.05$) highly concentrated in the leaves 7.40%, 2.89%, 62.65% and 1,205 kcal/kg respectively than those found in the stems of the Juncao grass. Its high crude protein (8 to 12% CP) makes it valuable component of ruminant feed. The percentage Dry matter (46.61%), Crude fibre (22.03%), Ash (12.82%) and Nitrogen Free Extract (12.18%) are highly concentrated in stems of Juncao grass. Juncao grass is highly nutritious, making it an excellent substrate for mushroom cultivation and a valuable forage crop for livestock feeding (Lin 2022). The nutritive composition of Juncao grass in this study is up to 7.40% CP depending growth stage. The crude protein content was lower than the 11.33–17.74% reported for giant Juncao in China (Lin, 2022), possibly due

to differences in soil fertility or climate. Nitrogen is one of the key factors affecting the quality and yield of Juncao grass (Zhu *et al*., 2022). In another study, Lin, (2022) reported that crude protein in first and second harvest are 5.58 and 25.4 respectively and crude fiber of 40.6 to 56.6% higher than the values obtained in this study was sufficient for ruminant production. The Crude fibre content in stem was 24% which supports growth and provides roughage for livestock. The metabolizable energy was comparable to the report of 10.8MJ/Kg DM, (Islam *et al*., 2023).

The recorded temperature of 18.33°C falls within the typical range for well-preserved silage. Proper fermentation usually occurs at temperatures below 30°C, as higher temperatures may indicate undesirable microbial activity (McDonald *et al*., 2011). The moderate temperature here suggests effective fermentation. A pH of 5.30 is slightly higher than the ideal range (3.8–4.2) for high-quality silage, which is critical for inhibiting clostridial and enterobacterial growth (Kung et al., 2018). However, it is still within an acceptable range for silage preservation, indicating partial lactic acid fermentation. A sweet aroma is indicative of successful fermentation, likely due to the presence of lactic acid and other volatile organic compounds (VOCs) produced by lactic acid bacteria (Li *et al*., 2020). This is a positive sensory attribute for silage quality.

The yellowish-green color suggests minimal oxidation and good preservation of chlorophyll, which aligns with proper anaerobic conditions during ensiling (Weinberg and Muck, 1996). Discoloration (brown or black) would indicate spoilage. The coarse texture may reflect the inherent fibrous nature of Juncao grass. While finer textures are often preferred for palatability, coarseness can still be suitable for ruminants, depending on the species (Van Soest, 1994). The DM content of a typical silage ranges from 30–50% Ishiaku *et al*., (2024). The CP content is moderate, comparable to other grass silages (Napier grass: 8–12%) (Ogunade *et al*., 2016). This level is

Figure 1. Weather observations at Shika and environs during the experimental period in 2024



adequate for livestock nutrition, though higher protein silages (e.g., legume-based) may be preferable for high-performance animals. The high CF content reflects the lignocellulosic nature of Juncao grass, which is typical for tropical grasses. While this provides rumen fill, excessive fiber may reduce digestibility (Van Soest, 1994). The low EE value indicates minimal lipid content, which is expected for grasses. Higher EE could improve energy density but may also risk rancidity (Buxton and O'Kiely, 2003). NFE represents soluble carbohydrates and starches. The high value suggests good fermentable substrate availability, which is essential for lactic acid production during ensiling (McDonald et al., 2011). The ash content reflects mineral residues. This value is within the typical range for grass silages (8–12%) and indicates no excessive soil contamination (Kung *et al.*, 2018).

The key observations (Figure 1) showed that the highest temperature was observed in May, 37.4°C typical of pre-rainy season heat and lowest temperature 12.8°C was in November attributed to harmattan influence. rainfall was peak in august (452.3 mm), consistent with the monsoon core. The total annual rainfall of 1,123.8 mm recorded align with long-term averages (IAR, 2024). The relative humidity was highest in August (77.1%) due to heavy rains and lowest in February (10.8%) during dry harmattan winds.

Table 1: Physical and Chemical Characteristics of Silage produced from Juncao grass

Physical characteristics		Chemical characteristics	
T^{0}C	18.33	DM	35.0
pH	5.30	CP	10.06
Aroma	Sweet	CF	27.96
Color	Yellowish green	EE	0.28
Texture	Coarse	NFE	50.91
		Ash	10.56

Table 2: Physical and Chemical Properties of Soil collected at the experimental site.

	Soil depth (0-15cm)	
Physical properties	2023	2024
Particle size (%)		
Clay	16.20	17.50
Silt	9.85	7.50
Sand	73.95	75.0
pH ($CaCl_2$)	5.20	5.10
Chemical properties		
Total Nitrogen (%)	0.12	0.20
Organic carbon (%)	0.90	0.75
Zn (ppm)	3.82	3.60
P (ppm)	96.4	92.4
Exchangeable cation (meg/100g of soil)		
Ca^{2+}	2.25	2.41
Mg^{2+}	0.82	0.73
K^{+}	0.22	0.30
Na^{+}	0.17	0.22

Table 3: Growth parameters and forage yield of Juncao grass (cm) in Shika

Harvest	replication	Plant height	Leave length	Leave width	Leave number	Stem diameter	Tiller number	Dry matter yield (t/ha)
	1	306.6	115	5.88	23	6.46	24	8.04
First	2	321.0	111.60	4.98	27	6.10	22	9.34
	mean	313.8^{b}	113.3^{a}	5.43^{a}	25^{a}	6.28^{b}	23^{a}	8.69^{b}
	1	292.0	104.6	4.58	19	6.8	14	11.67
Second	2	373.0	113.0	5.18	22	7.26	12	12.75
	mean	332.5^{a}	108.8^{b}	4.88^{b}	21^{b}	7.03^{a}	13^{b}	12.21^{a}
	SEM	21..66	2.73	0.32	1.87	0.46	0.07	1.70
	LOS	*	*	*	*	*	*	*

Means*[ab] with different alphabets are significantly (P< 0.05) different, SEM=standard error of mean, LOS= level of significance.

Table 4: Percentage nutrient composition of Juncao grass in Shika (on wet basis)

Juncao grass	No of Samples	CP	EE	Moisture	DM	CF	ASH	NFE	ME (kcal/Kg)
		8.01	2.96	63.75	36.25	13.09	4.33	7.86	1233.237
		7.75	3.12	63.15	36.85	13.09	4.32	8.57	1237.06
Leaves	4	6.90	2.73	61.87	38.13	14.43	5.50	8.57	1173.59
		6.92	2.76	61.81	38.19	14.40	5.50	8.61	1176.81
	mean	7.40^{a}	2.89^{a}	62.65^{a}	37.36^{b}	13.75^{b}	4.91^{b}	8.40^{b}	1205.17^{a}
		3.63	1.65	52.00	48.00	20.20	11.50	11.02	964.38
		3.67	1.40	52.55	47.45	20.30	11.64	10.44	945.04
Stems	4	3.45	0.98	54.50	45.50	23.60	14.14	13.33	902.06
		3.45	0.10	54.51	45.49	24.00	14.00	13.94	828.51
	mean	3.55^{b}	1.04^{b}	53.39^{b}	46.61^{a}	22.03^{a}	12.82^{a}	12.18^{a}	910.10^{b}
	SEM	0.41	0.50	1.15	1.15	1.55	1.13	1.24	49.15
	LOS	*	*	*	*	*	*	*	*

Means*[ab] with different alphabets are significantly (P< 0.05) different, SEM=standard error of mean, LOS= level of significance. CP=Crude protein, EE= Ether extract DM= Dry matter CF=Crude fibre, NFE= Nitrogen free extract, ME= Metabolizable energy

Conclusion and Recommendation

Juncao grass is a highly versatile and valuable plant species with numerous agronomic, environmental, and economic benefits. Its rapid growth, high biomass production, and adaptability to marginal soils make it an excellent candidate for sustainable agriculture and environmental conservation. From the result of this investigation one can take the advantage of exploring the full potential of Juncao grass, with the aim of optimizing its cultivation and expanding its applications in various sectors. The yield obtained was very encouraging in the second harvest 12.21t/ha and plant height of 332.5cm. Mass production of Juncao grass (*Pennisetum sp.*) will enhance animal feed availability in both dry and wet seasons. The nutritive values up to 8.02 %CP and 1233.23Kcal/kg of energy obtained in leaves for Juncao grass in Shika are critical and necessary for improvement of livestock feed. The silage exhibits acceptable fermentation quality (pH, aroma) and nutritional value (CP, NFE).

There is a serious concern to explore the potential yields and nutrient of Juncao grass as feed for ruminants in Nigeria. It could therefore be recommended that:

1. Large-scale cultivation of Juncao grass to address feed shortages, improve livelihood and income
2. Further research on optimizing nitrogen fertilization to improve crude protein content.
3. Integration of Juncao technology into National Livestock Development Programs.
4. Further research could optimize Juncao grass ensiling by using additives (inoculants) to improve fermentation.

Acknowledgement

The authors acknowledge the Chinese Government for organizing International Study Tour on Juncao Technology in Fuzhuo, China and Federal Ministry of Livestock Development, Department of Livestock Husbandry Services for Introducing Juncao Technology in Nigeria.

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