advances in Technology

*Adv. Technol.* **2024**, *4(1)*, 1-9

## Full Paper

# Study of Nutritional Characteristics of Silages from CO3, CO5, Red Napier (BH18), and Super Napier among Small Holder Dairy Farms in Kilinochchi District, Sri Lanka

S. Thanusan[a,*], H.M. Chamara Pushpakumara[b], and S. Piratheepan[b]

[a]Department of Biosystems Technology, Faculty of Technology, University of Jaffna, Sri Lanka
[b]Department of Animal Science, Faculty of Agriculture, University of Jaffna, Sri Lanka

Corresponding Author: sthanuagri@gmail.com

Received: 02 January 2023; Revised: 12 May 2023; Accepted: 06 March 2024; Published: 25 September 2024

**Abstract**

A study was conducted to examine the nutritive values of the silages made from major grasses available in the Kilinochchi District. Inadequate quality forage and the lower availability of forage crops are considered as a limiting factor for livestock production. Introducing different silage grasses helps to overcome these problems all over the dry zone. In the dry zone of Sri Lanka, insufficient fodder production is one of the main factors restricting dairy production. Silage is a feed that has been preserved by acidification as a result of fermentation in the absence of oxygen. “Ensiled forage” or “silage,” can remain intact for up to three years when stored properly. The lack of high-quality forages and their accessibility may be a factor in Sri Lanka for the lower dairy productivity of livestock. In the dry zone of Sri Lanka, insufficient fodder production is one of the main factors restricting dairy production. The main objective of this study is to find out the nutritional characteristics of silage made from different grasses (Indian red Napier, CO5 grass, and other Napier grasses, CO3 and super Napier) grown in the Northern part of Sri Lanka. Properly matured grasses were harvested and four silage samples (T1, T2, T3, and T4) were prepared according to the standard procedure. The proximate composition of different types of silage made from different grasses was significantly different ($p<0.05$). Among the silages, CO5 had the highest percentage of crude protein (CP) (16.07 %) and moisture (75.04 %) meanwhile super Napier had the highest percentage of fiber (31.43%), lowest percentage of ash content (2.5%) and lowest percentage of fat content (1.16%). Based on the above results, we can conclude that the super Napier silage has a higher nutrient value compared with other silages. Therefore, silage made from super Napier can be suggested for the Kilinochchi district farmers to provide better yield and growth performances.

**Keywords:** CO3, CO5, ensiling, forage, red Napier, silage, super Napier

## Introduction

Sri Lanka’s low productivity of dairy cows may be attributed to poor quality and insufficient fodder supply. Still, some problems need to be addressed concerning the feed for livestock in Sri Lanka [15].

Especially, the availability of forage crop fields amongst all other agricultural fields as farmers are so concerned about the cultivation of cereals and industrial crops [16]. A high-quality green fodder diet is crucial for maximizing milk production. Consequently, a variety of high-yielding forages, such as Napier hybrids have lately been introduced.

Silage is an important way to preserve the nutrients of forage, which is a lactic fermentation process driven by epiphytic lactic acid bacteria (LAB). Once LAB ferments water-soluble carbohydrates (WSC) into sufficient lactic acid in an anaerobic silo, low pH is achieved, the activity of undesired microbes is restrained and the nutrients are well preserved. The activity of the epiphytic microbe is responsive to temperature during ensiling [17] [18] and [19] have reported that roughage ensiled at 30 °C showed a weak lactic fermentation which did not inhibit butyric fermentation and protein loss, while lactic fermentation was more dominant with low nutritive losses when silage was ensiled at 20 °C. The alpha-tocopherol and beta-carotene of forage are antioxidants [20] [21], and play important roles in the immune system of ruminants [22]. Silage containing high contents of alpha-tocopherol and beta-carotene increases the nutritive value of [23]. The alpha-tocopherol and beta-carotene are destroyed by oxidation, which is enhanced by heat [24]. During the initial period of ensiling, air is still present between the plant particles and the temperature can increase to 40 °C or higher because of continuing plant respiration and aerobic microbial activity, and silage may be subjected to high temperatures for a long time in summer [25].

Through a natural "pickling" process, forage that has been cultivated while still green and nutritious can be preserved. When bacteria ferment the sugars in the forage plants in an airless, sealed container called a "silo," lactic acid is created.

At present, the Sri Lankan dairy industry predominantly depends on forage materials from natural pasture fields and fodder collected from the roadside, mountain slopes, tank banks, and uncultivated public and private lands. Lack of availability, accessibility of quality improved pasture, fodder, and availability of cultivable lands for pasture and fodder are some of the major constraints prevailing in dairy production in Sri Lanka.

The Department of Animal Production and Health, Veterinary Research Institute, Gannoruwa, and Department of Animal Science, Faculty of Agriculture, University of Peradeniya have launched research and development activities under field situation to investigate the potentials and limitations under on-farm conditions and popularize the grass among smallholders.

Low output from Sri Lanka's national dairy herd is a result of a lack of good-quality green forages. Growing fodder specifically for the production system in question is an effective and affordable solution to this issue. A high-yielding perennial fodder grass called Hybrid Napier var. CO3 was created by the Tamil Nadu Agricultural University in Coimbatore, India, in 1997. This fodder crop was introduced to Sri Lanka in 1999 by the Livestock Breeding Project [1].

These anaerobic microorganisms ferment plant-soluble carbohydrates or sugar into lactic acid and acetic acid. A higher amount of lactic acid and a lesser amount of acetic acid production reduces the pH of silage which inhibits the growth and activity of spoilage microorganisms [26]. Silage production preserves feed with minimum nutrient losses while maintaining a stable composition of feed for longer periods and routing feed supplements increases the productivity of the animal (National Dairy Development Board, 2012). If not followed basic principles of silage preparation and ensiling, it results in poor quality, unpalatable, and off-flavor silage [27].

One of the solutions to overcome seasonal fodder deficiency is the conservation of surplus fodder during the peak fodder growth period. Silage production is not a common practice among live-stock farmers generally in tropical countries but it is becoming popular in recent times to bridge the dry season gap. In 2013, the government introduced a dairy project to promote medium- and large-scale dairy farms that have state-of-the-art technology, allowing them to achieve the maximum potential from dairy cows. Therefore, production of silage becomes an essential need in the country. There are different kinds of crops used for silage making. Crops that provide adequate levels of moisture, soluble carbohydrates (SCHO), and other nutrients [28] are facilitating to preparation of good quality silage for ruminant feeding. Forage crops such as hybrid Napier (*Pennisetum purpureum Schumach* × *Pennisetum americarnum*) varieties CO3 and CO4 (*P. purpureum Schumach* × *Pennisetum glaucum*) have recently become popular and are grown by the farmers in various locations.

Research has shown that leaf meals can be preserved as briquettes/blocks to reduce the bulkiness, increase keeping quality, and facilitate easy transport and storage [29], [14] stated that leaf-meal blocks mixed with other concentrate feed ingredients provide quality feed for ruminant livestock improving the feed digestibility.

Producing high-quality forage as silage, while avoiding DM losses as much as possible, is a challenge. The silage-making process is commonly divided into 4 phases: (1) the initial aerobic phase in the silo immediately after harvest, (2) the fermentation phase, (3) the stable storage phase in the silo, and (4) the feed-out phase when the silo feed face is open and the material is exposed to air immediately before, during, and after its removal from the silo [30]. Napier CO (BN) 5 is a 100% eco-friendly fodder crop with high levels of crude protein, broader soft lsh green leaves, greater palatability, optimal levels of dry matter and crude fiber, and a year-round supply of forage despite its good nutritional properties [31].

## Materials and Methods

### *Location of the Study*

Livestock & Poultry Farm, Department of Animal Science, Faculty of Agriculture, University of Jaffna, Sri Lanka. This area lies in the dry zone of Sri Lanka and the latitudinal and the longitude coordinates of the field location are 9031’40” N and 80039’82” E respectively. The soil type is red-yellow latosol.

***Materials***

CO3, CO5, super Napier, and red Napier samples were collected in *Akkarayan Kulam*, Kilinochchi.

***Methods***

***Preparation of Four Varieties of Silages***

Figure 1 shows the preparation of four varieties of silages collected from dairy farms in Kilinochchi District. Immediately after harvesting the fresh weight of forage, was taken using a spring balance. Harvested fresh forage (2 kg of the sample) from each plot were allowed to be air-dried for 24 hours. Then the air-dried samples were allowed to be oven-dried at 75 °C for 72 hours to obtain a constant dry matter weight. Added a fermentable substrate for ensiled as chopped the forage into short lengths (1-3 cm) before ensiled. Forage was compacted as tightly and silage bag was sealed air tightly. Bag was kept under proper environment. Four silage samples were prepared according to the above procedure (T1, T2, T3, and T4) as T1- CO3 Silage, T2- CO5 Silage, T3- Red Napier silage, and T4- Super Napier Silage.

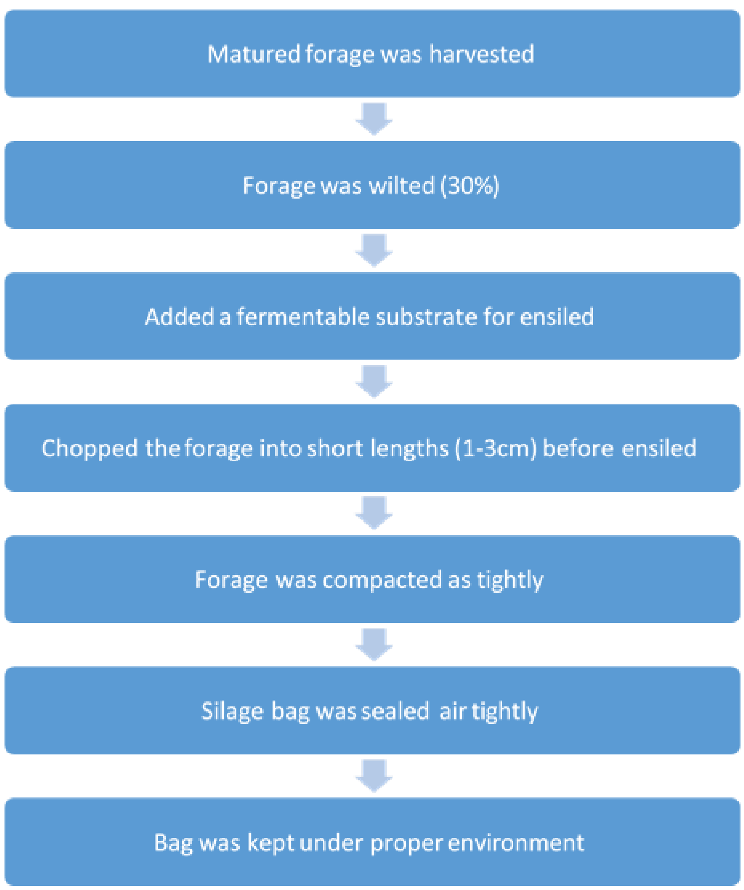


**Figure 1.** Flowchart for preparation of four varieties of silages

***Statistical Analysis***

Proximate analysis and physicochemical properties were determined by using two factor completely randomized design (CRD) using statistical analysis system (SAS) version 6.0.1.0. Duncan's multiple range test was used to compare the treatment means at $p<0.05$.

**Results and Discussion**

Analysis of the newly cultivated Indian Red Napier and CO5 grass in Northern part of Sri Lanka and other Napier grass (CO3 and Super Napier). It was observed that both grass silages (CO3and super Napier var) had wet and leafy texture, which was more typical for tropical grasses. Both grass silages have olive green color, falling within the normal color range for grass silages. Both had little fruity smell, which may be associated with lower fermentation especially from crops with low sugar content. Plant height, number of shoots, tillering capacity, leaf/stem ratio and yielding potential are some of the most important factors that influence the choice of variety to be grown, since they have a direct influence on total forage yield as tall forage cultivars yield more than short cultivars due to the strong positive relationship between plant height and yield. Most forage contains some nitrate which is not particularly toxic to cattle but excess consumption can cause adverse effects. Also, it has been shown that soluble oxalate has adverse effects on cattle [33]. Therefore, when selecting fodder varieties, we have to pay attention not only to the nutrients, to anti-nutrient factors as well.

Plant height as a growth parameter is a result of the elongation of the stem internodes, which is influenced by the environment as suggested [32]. In the current study, taller plants were observed with narrow spacing, which is in agreement with reports in the literature that narrower spacing will give taller plants as a result of competition for sunlight [34]. Taller plants led to narrower stem diameters as well. Leaf development has been described extensively for fodders, as growth is mostly reflected in a large increase in leaf length as plants grow to maturity, accompanied by a relatively small increase in width and thickness [35]. Large leave lengths are also important for the survival of individual plants within a sward [36]. Significant reduction in dry matter yield with increasing plant spacing may be due to decreasing plant density with increasing spacing. Good silage usually preserves the original color of the pasture or any forage [37].

Chopping of original grass before ensiling is highly recommended not only for making better quality silage but also for making better use of silo capacity. Proper preparation of silage minimizes the loss of nutrients during the fermentation process and increases voluntary intake, which results in higher TDN intake. Protein percentage represents total nitrogen in silage which enhances the nutrition level of ruminants to their activities of maintenance, lactation, growth, and reproduction [5]. Significantly ($p<0.05$) higher protein percentage was observed in T2 CO5.

Fiber percentage is one of the crucial parameters of silage due to high fiber% enhances the ability of palatability and amount of metabolic energy intake by animals while low fiber % indicates deterioration of silage [5]. T3 Red Napier significantly (p<0.05) differs from the other three. Ash (%) Ash is the parameter that indicates mineral content in silage. A high ash percentage is observed due to poor fermentation of silage [5]. The results of tested parameters of ash indicated that T3– Red Napier was significantly (p<0.05) higher (4.3). Reduction of moisture and increment of dry matter gives more energy and protein to silage due to moisture having no energy or protein values [5]. Significantly low dry matter limits the intake of animals [5]. MC% was significantly (p<0.05) higher in T2 – CO5 & lower in T4 – Super Napier.

Good silage usually preserves the original color of the pasture or any forage [38]. The temperature range appears to be the operating temperature for normal silage fermentation, good quality silage should be cooled at opening and at feed out phase having a normal room temperature [17] [39] reported that any excessive heat production can result in Maillard or browning reaction which can reduce the digestibility of protein and fiber components. The useful proteins form complexes with carbohydrates thereby making them less digestible. Temperature is one of the essential factors affecting silage color. The lower the temperature the better the silage, and the less the color change. If the temperature obtained for the present silages was above 30 °C the grass silage would have become dark yellow or brown due to caramelization of sugars in the forage [17]. However, the temperature (20 °C) obtained in this study indicates well-made silage. The texture of the silages was firm which was expected to be the best texture of good silage [40]. Slimy texture or mold or fungi growth indicates spoilage in the silage. The pH value of the silages was within the range of 3.5-5.5 classified to be pH for good silage [41]. Generally, pH is one of the simplest and quickest ways of evaluating silage quality. However, pH may be influenced by the moisture content and the buffering capacity of the original materials. Silage that has been properly fermented will have a much lower pH (be more acidic) than the original forage. The pH value of 4.3 obtained in this study was in agreement with 4.2-5.0 reported by Babayemi (2009) and 4.3-4.7 by [40] but lower than 4.5-5.5 reported by [41].

### *Proximate Composition of Four Types of Silages*

**Table 1.** The proximate composition of the silage samples

| Parameter | T1 - C03 | T2 - CO5 | T3 - Red Napier | T4 - Super Napier |
|---|---|---|---|---|
| Moisture | $70.05 \pm 0.05^{a}$ | $75.04 \pm 0.03^{b}$ | $74.10 \pm 0.03^{c}$ | $65.07 \pm 0.05^{d}$ |
| Ash | $2.6 \pm 0.15^{a}$ | $3.1 \pm 0.10^{b}$ | $4.3 \pm 0.20^{c}$ | $2.5 \pm 0.20^{a}$ |
| Fat | $1.81 \pm 0.04^{a}$ | $2.44 \pm 0.39^{b}$ | $2.55 \pm 0.09^{b}$ | $1.16 \pm 0.07^{a}$ |
| Protein | $15.08 \pm 0.04^{b}$ | $16.07 \pm 0.03^{a}$ | $15.50 \pm 0.10^{ab}$ | $14.89 \pm 0.12^{b}$ |
| Fiber | $29.13 \pm 2.51^{a}$ | $27.75 \pm 4.65^{a}$ | $19.95 \pm 1.96^{b}$ | $31.43 \pm 5.22^{a}$ |

Values are expressed as mean ± SD. Mean values with different superscript letters ($^{a,b}$) in a row are significantly different (p<0.05).

## Conclusion

The outcome of this study revealed that the CO5 grass have a high moisture content Dry matter content and pH compared with other silages. The highest fiber and protein content and low moister content was recorded for super Napier grass silage. So, it is considered the best silage recommended for Kilinochchi district dairy farmers.

**Acknowledgements**

The authors gratefully acknowledge the infrastructure and laboratory support extended by Livestock and Poultry Farm, Department of Animal Science, Faculty of Agriculture, University of Jaffna to carry out this study.

**References**

[1] Seresinhe T.,Weerasinghe P.,Sanjeewa J.,Harindrika H.,Manawadu A.,Mahipla K. and Iben C. (2020) Evaluation of silages of hybrids of napier grass and sorghum in the low country wet zone of Sri Lanka. Die Bodenkultur: Journal of Land Management, Food and Environment, Vol.71 (Issue 1), pp. 11-18.

[2] Bandara, P.G.G., Premalal, G.G.C. and W.A.D. Nay-ananjalie (2016): Comparison of yield, nutritive value and silage quality of fodder sorghum (Sorghum bicolor) and maize (Zea mays) with hybrid napier variety CO-3. Rajarata University Journal 4, 26–31.

[3] Reiber,C., Schutze-Kraft, R., Peters, M. and V. Hoffmann (2009): Potential and constraints of little bag silage for small holders – Results and experience from Honduras. Experimental Agriculture 45, 209–220.

[4] Weerasinghe, W.M.P.B. (2019): Livestock feeds and feeding practices in Sri Lanka. In: Samanta, K., Bokhtiar, S.M. and M.Y. Ali (Eds.): Livestock feeding and feeding practices in South Asia. SAARC Agriculture Center, Dhaka, Bangladesh, pp. 181–206.

[5] Hunter, A., Murphy, K., Grealish, A., Casey, D. and Keady, J., 2011. Navigating the grounded theory terrain. Part 2. *Nurse researcher*, *19*(1). [6] Rahman, M. M., T. Nakagawa., M. Niimi, K. Fukuyama and O. Kawamura. 2011. Effects of calcium fertilization on oxalate of napier grass and mineral concentrations in blood of sheep. Asian-Australian Journal of Animal Science 24: 1706-1710.

[7] Chamara, M.W.S., S. Premaratne, and G.G.C. Premalal, (2003) On-farm management and persistence of hybrid Napier (Pennisetum perpureum x P. americanum var.

[8] Samarawickrama, L. L. et al. 2018. Yield, Nutritive Value and Fermentation Characteristics of Pakchong-1 (Pennisetum Purpureum × Pennisetum Glaucum) in Sri Lanka. Sljap, 10(September 2020)

[9] Sarmini, M. and Premaratne, S. 2017. Yield and nutritional quality potential of three fodder grasses in the Northern region of Sri Lanka. Tropical Agricultural Research, 28(2), p. 175. doi: 10.4038/tar.v28i2.8194.

[10] Pathmasiri, P.G.R.P., Premalal, G.C.C. and Nayananjalie, W.A;D. (2014). Accumulation of oxalate and nitrate in hybrid napier var co-3 (Penisetum perpureum x P.americanum) and wild guinea grass (Panicum maximum). Rajarat a University Journal, 91, 62-180.

[11] Han, L., Zhou, H. 2013. Effects of ensiling processes and antioxidants on fatty acid concentrations and compositions in corn silages. J. Anim. Sci. Biotechnol. 4, 48-55.

[12] Senanayake, S.R.H.L.K., Kodithuwakku, K.A.H.T. and Wickramasinghe, H.K.J.P., 2016. Effect of polythene film on grass silage quality as investigated under ambient conditions.

[13] Falola, O.O., Alasa, M.C. and Babayemi, O.J., 2013. Assessment of silage quality and forage acceptability of vetiver grass (Chrysopogon zizanioides L. Roberty) ensiled with cassava peels by WAD goat. *Pakistan Journal of Nutrition*, *12*(6), p.529.

[14] S. Premaratne and Premalal, G.G.C., Hybrid Napier (Pennisetum perpureum X Pennisetum americarnum) VAR. CO-3: a resourceful fodder grass for dairy development in Sri Lanka. *Journal of Agricultural Sciences – Sri Lanka*, **2006**. *2(1)*,22-33.DOI: 10.4038/jas.v2i1.8110.

[15] Pushparajah, S. and Sinniah, J., 2018. Evaluation of dry matter yield and nutritive value of Sugar graze and Jumbo plus at different spacing in the yala season in the dry zone of Sri Lanka. Agriculture & food security, 7, pp.1-6.

[16] Gnanagobal, H. and Sinniah, J., 2018. Evaluation of growth parameters and forage yield of Sugar Graze and Jumbo Plus sorghum hybrids under three different spacings during the maha season in the dry zone of Sri Lanka. Tropical Grasslands-Forrajes Tropicales, 6(1), pp.34-41.

[17] McDonald, P., Henderson, A.R. and Heron, S.J.E., 1991. *The biochemistry of silage*. Chalcombe publications.

[18] Liu, L., Li, Y., Li, S., Hu, N., He, Y., Pong, R., Lin, D., Lu, L. and Law, M., 2012. Comparison of next-generation sequencing systems. *J Biomed Biotechnol*, *2012*(251364), p.251364.

[19] Zhang, X. and Shu, C.W., 2010. On positivity-preserving high order discontinuous Galerkin schemes for compressible Euler equations on rectangular meshes. *Journal of Computational Physics*, *229*(23), pp.8918-8934.

[20] Granelli-Piperno, Angela, Elena Delgado, Victoria Finkel, William Paxton, and Ralph M. Steinman. "Immature dendritic cells selectively replicate macrophagetropic (M-tropic) human immunodeficiency virus type 1, while mature cells efficiently transmit both M-and T-tropic virus to T cells." *Journal of virology* 72, no. 4 (1998): 2733-2737.

[21] Calderon, C., Chong, A. and Stein, E., 2007. Trade intensity and business cycle synchronization: Are developing countries any different?. *Journal of international Economics*, *71*(1), pp.2-21.

[22] Allison, R. D., and R. A. Laven. "Effect of vitamin E supplementation on the health and fertility of dairy cows: a review." *Veterinary Record* 147, no. 25 (2000): 703-708.

[23] Palmquist, D.L., Lock, A.L., Shingfield, K.J. and Bauman, D.E., 2005. Biosynthesis of conjugated linoleic acid in ruminants and humans. *Advances in food and nutrition research*, *50*, pp.179-217.

[24] Seshan, P.A. and Sen, K.C., 1942. Studies on carotene in relation to animal nutrition: Part II. The development and distribution of carotene in the plant and the carotene content of some common feeding stuffs. *The Journal of Agricultural Science*, *32*(2), pp.202-216.

[25] Weinberg, N.Z., Rahdert, E., Colliver, J.D. and Glantz, M.D., 1998. Adolescent substance abuse: A review of the past 10 years. *Journal of the American Academy of Child & Adolescent Psychiatry*, *37*(3), pp.252-261.

[26] Geneva, S. and Salle, X.V., 2004. Food and Agriculture Organization. *Rome, Italy*.

[27] Moran, P., 2005. Structural vs. relational embeddedness: Social capital and managerial performance. Strategic management journal, 26(12), pp.1129-1151.

[28] Cullison, W.E., 1975. An employment pressure index as an alternative measure of labor market conditions. The Review of Economics and Statistics, pp.115-121.

[29] Somasiri, S.C., Premaratne, S., Gunathilake, H.A.J., Abeysoma, H.A., Dematawewa, C.M.B. and Satsara, J.H.M.N., 2010. Effect of Gliricidia (Gliricidia sepium) leaf meal blocks on intake, live weight gain and milk yield of dairy cows.

[30] Davies, R.S., Dean, D.L. and Ball, N., 2013. Flipping the classroom and instructional technology integration in a college-level information systems spreadsheet course. *Educational Technology Research and Development*, *61*, pp.563-580.

[31] Ernawati, A., Abdullah, L., Permana, I.G. and Karti, P.D.M.H., 2023. Morphological responses, biomass production and nutrient of Pennisetum purpureum cv. Pakchong under different planting patterns and harvesting ages. *Biodiversitas Journal of Biological Diversity*, *24*(6).

[32] Hozumi, T., Kageyama, T., Ohta, S., Fukuda, J. and Ito, T., 2018. Injectable hydrogel with slow degradability composed of gelatin and hyaluronic acid cross-linked by Schiff's base formation. *Biomacromolecules*, *19*(2), pp.288-297.

[33] Khan, S.B., Faisal, M., Rahman, M.M. and Jamal, A., 2011. Exploration of CeO2 nanoparticles as a chemi-sensor and photo-catalyst for environmental applications. *Science of the total Environment*, *409*(15), pp.2987-2992.

[34] Sathees, D. and Sivajanani, S., 2022. Evaluation of growth and yield performances of Napier grass cultivar pakchong-1 under different spacial patterns in the Kilinochchi district, Sri Lanka.

[35] Skinner, R.H. and Nelson, C.J., 1994. Role of leaf appearance rate and the coleoptile tiller in regulating production. Crop Science, 34(1), pp.71-75.

[36] Burger, J.A., Tedeschi, A., Barr, P.M., Robak, T., Owen, C., Ghia, P., Bairey, O., Hillmen, P., Bartlett, N.L., Li, J. and Simpson, D., 2015. Ibrutinib as initial therapy for patients with chronic lymphocytic leukemia. *New England Journal of Medicine*, *373*(25), pp.2425-2437.

[37] Mannetje, A.T., Kogevinas, M., Luce, D., Demers, P.A., Bégin, D., Bolm-Audorff, U., Comba, P., Gérin, M., Hardell, L., Hayes, R.B. and Leclerc, A., 1999. Sinonasal cancer, occupation, and tobacco smoking in European women and men. *American journal of industrial medicine*, *36*(1), pp.101-107.

[38] Mannetje, A.T., Kogevinas, M., Luce, D., Demers, P.A., Bégin, D., Bolm-Audorff, U., Comba, P., Gérin, M., Hardell, L., Hayes, R.B. and Leclerc, A., 1999. Sinonasal cancer, occupation, and tobacco smoking in European women and men. *American journal of industrial medicine*, *36*(1), pp.101-107.

[39] Bolsen, K.K., Ashbell, G. and Weinberg, Z.G., 1996. Silage fermentation and silage additives-Review. *Asian-Australasian journal of animal sciences*, *9*(5), pp.483-493.

[40] Kung Jr, L., Shaver, R.D., Grant, R.J. and Schmidt, R.J., 2018. Silage review: Interpretation of chemical, microbial, and organoleptic components of silages. Journal of dairy Science, 101(5), pp.4020-4033.

[41] Menesses, M.D., Megias, J., Madrid, A., Martinez-Teruel, F., Oduguwa, B.O., Jolaosho, A.O. and Ayankoso, M.T., 2007. J. Hemandez and J. Oliva, 2007. Evaluation of the phytosanitary, fermentative and nutritive characteristics of the silage made from crude artichoke (Cynarascolymus L.) by-products feeding for ruminants. *Small Ruminant Res*, *70*, pp.292-296.