EVALUATION OF NAPIER GRASS (*Pennisetum purpureum*) VARIETIES ON MINERAL COMPOSITION BY ATOMIC ABSORPTION SPECTROPHOTOMETER

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DECLARATION

I hereby declare that the work embodied in this report is the result of the original research and has not been submitted for a higher degree to any universities or institutions.

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Student

Name:

Date:

I certify that the report of this final year project entitled "Evaluation of Napier Grass (*Pennisetum purpureum*) Varieties on Mineral Composition by Atomic Absorption Spectrophotometer" by Nurul Eizaty Syahfieqa binti Md Shapei, matric number F15A0184 has been examined and all the correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Animal Husbandry Science) with Honours, Faculty of Agro Based Industry, Universiti Malaysia Kelantan.

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LIST OF ABBREVIATIONS

cmol	Centimole
g	Gram
kg	Kilogram
m	Metre
mg	Milligram
mS	Millisiemens

Evaluation of Napier Grass (*Pennisetum purpureum*) Varieties on Mineral Composition by Atomic Absorption Spectrophotometer

ABSTRACT

There are various types of Napier grass that can be found in Malaysia. Each variety of Napier grass has different morphology, potential yield, and nutritive value. Pakchong Napier (hybrid type), Taiwan Napier and Indian Napier are famous among farmers as they were believed it has the best features of Napier grass, especially in nutritive value. However, there is limited information on mineral composition in various types of Napier grass. Therefore, the objective of this study was to investigate the mineral composition of various types of Napier grass. Seven types of Napier grass were planted in Agro Techno Park, Universiti Malaysia Kelantan and harvested after two months of maturity for mineral analysis by using Atomic Absorption Spectrophotometer (AAS). The composition of minerals found in seven types of Napier grass was assessed and recorded. Zanzibar Napier showed the highest concentration of calcium, potassium and sodium, while Purple Napier showed the lowest concentration of calcium, magnesium and sodium. No differences were observed on phosphorus concentration among Napier grass varieties. On the other hand, Dwarf Napier showed the highest concentration of zinc, manganese and iron, while the lowest concentration was in Pakchong Napier. The importance of this study is to suggest the best type of Napier grass with the optimum minerals concentration as the main forage that effects on animal production positively. Macro and micro minerals concentration were significantly affected by the different varieties of Napier grass. The results suggest that Zanzibar Napier could provide an adequate amount of macro minerals which were calcium, potassium and sodium. Furthermore, for micro minerals, Dwarf Napier obtained a sufficient amount of zinc, manganese and iron required in the ruminant diet.

Keywords: Napier grass, nutritive value, minerals composition, calcium, sodium

Penilaian Pelbagai Jenis Rumput Napier (*Pennisetum purpureum*) Terhadap Komposisi Mineral oleh Spektrofotometer Serapan Atom

ABSTRAK

Terdapat pelbagai jenis rumput Napier yang boleh didapati di Malaysia. Setiap jenis Napier mempunyai morfologi, potensi hasil tanaman dan nilai nutrisi yang berbeza. Napier Pakchong (baka hibrid), Napier Taiwan dan Napier India terkenal dalam kalangan penternak kerana dipercayai mempunyai ciri-ciri terbaik terutamanya dalam nilai nutrisi. Walau bagaimanapun, maklumat berkaitan komposisi mineral dalam pelbagai jenis rumput Napier adalah terhad. Oleh itu, objektif kajian ini adalah untuk menyiasat komposisi mineral terhadap pelbagai jenis rumput Napier. Tujuh jenis rumput Napier ditanam di Agro Techno Park, Universiti Malaysia Kelantan dan dituai selepas dua bulan tempoh matang bagi menganalisa mineral dengan menggunakan Spektrofotometer Serapan Atom (SSA). Komposisi mineral yang terdapat dalam tujuh jenis rumput Napier dinilai dan direkodkan. Napier Zanzibar menunjukkan kepekatan kalsium, kalium dan natrium yang tertinggi manakala Napier Ungu menunjukkan kepekatan kalsium, magnesium dan natrium yang terendah. Tiada perbezaan dalam kalangan pelbagai jenis rumput Napier bagi kepekatan fosforus. Sebaliknya, Napier Dwarf menunjukkan kepekatan zink, mangan dan zat besi yang tertinggi, manakala bagi kepekatan yang terendah menunjukkan Napier Pakchong. Kajian ini penting untuk mencadangkan jenis rumput Napier yang terbaik dengan kepekatan mineral yang optimum, sebagai makanan ternakan utama yang memberi kesan kepada pengeluaran haiwan secara positif. Terdapat perbezaan terhadap kepekatan mineral makro dan mikro yang dipengaruhi oleh pelbagai jenis rumput Napier. Hasil kajian mencadangkan Napier Zanzibar dapat membekalkan mineral makro yang secukupnya, iaitu kalsium, kalium dan natrium. Tambahan pula, bagi mineral mikro, Napier Dwarf memperoleh zink, mangan dan zat besi yang mencukupi bagi diet ruminan.

Kata kunci: Rumput Napier, nilai nutrisi, komposisi mineral, kalsium, natrium

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Minerals are very important for maintaining livestock health, gaining optimal growth and reproduction. Mineral nutrition is classified as macro minerals and micro minerals. The macro minerals include calcium (Ca), sodium (Na), potassium (K), phosphorus (P), magnesium (Mg), chlorine (Cl) and sulphur (S). Calcium is very important in bone and teeth formation, and milk production for lactating animals. For instance, a superior milking cow like Holstein Friesian breed requires three times more Ca than a non-lactating cow (Saha, 2010).

Then, the shortage of Ca in the blood and less able to replace blood Ca quickly cause hypocalcaemia (Saha, 2010). The right amount of Ca is needed for the nervous and muscular to function properly. Besides the amount of each mineral fed, proper utilisation of Ca and P are also affected by the Ca: P ratio (Saha, 2010. Calcium and phosphorus also play important roles in other bodily functions. Phosphorus deficiency cause delay in heifer's puberty and also can delay in beef maturity (Saha, 2010).

Furthermore, Na and Cl help to regulate body pH and the amount of water reserved in the body. Sodium and chloride are present in soft tissues and fluids and there is only very little storage. Deficiency of both elements causes loss of appetite and body weight. For efficient carbohydrate metabolism, Mg is required in the animal diet. A serious and sometimes cause fatal to the livestock is grass tetany disorder due to Mg deficiency (Saha, 2010).

The other mineral essential to the livestock is K that function is in acid-base balance, osmotic pressure and the amount of water reserved in the body. Besides, sulphur is a part of the essential amino acids such as methionine and cystine. The micro minerals are required for livestock including iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), selenium (Se), cobalt (Co) and iodine (I).

Cobalt functions as a component of vitamin B12 which is synthesised by rumen microbes. The Co deficiency can cause appetite loss and reduced growth. Copper is important for normal growth and development and acts as a component in many enzyme systems. The deficiency can reduce fertility, depressed immunity and reduced pigmentation of hair and skin. Iodine is required for thyroid hormone function that regulates energy metabolism. Goitre in newborn calves can occur as the first sign of iodine deficiency (Saha, 2010).

Anaemia happens in livestock when Fe is lacking in the body to produce haemoglobin. For gain normal reproduction as well as faetal and udder development, Mn is essential in the animal diet. Then, to prevent white muscle disease in newborn calves as an example of Se deficiency, Se must be provided adequately to the livestock. The deficiency also can cause weak to calves at birth, increase the rate of retained placentas and poor reproductive performances in cows (Saha, 2010).

Ruminants obtained their required minerals from either concentrate and/or roughage sources. It is better to get a sufficient amount of minerals from roughage sources because the price of roughage is comparatively cheaper than concentrate. For example, alfalfa contains a sufficient amount of minerals as required by animals. On the other hand, different species of grasses have different capacity to absorb minerals from the soil. Napier grass is one of the tropical forage grasses, which is gaining popularity due to high biomass yield and ease of propagation.

This Napier grass has various varieties such as Zanzibar, Indian, Kobe, Taiwan etc. It is hypothesised that mineral concentrations may differ among Napier grass varieties. However, there is limited information on mineral composition in various Napier grass varieties. We need to provide all the essential minerals in the dietary feeding sufficiently that suit to the recommended level because of the minerals importance to the overall livestock health, reproductive efficiency and performance.

Besides, Napier grass is one of the most widely used forage species in Malaysia and a very large portion in cattle and goat diet, therefore the aim of this proposed study is to evaluate the mineral composition in various types of Napier grass (*Pennisetum purpureum*) used as ruminant feed. Also, another objective of this study is to suggest the best variety of Napier grass in terms of minerals composition as a recommendation to the farmers.

1.2 Problem Statement

The quality of forage is the main factor affecting ruminant productivity as forages supply most nutrients in the ruminant diet (Fales, 2007). The productivity of livestock is high when the quality of feed is high. The morphology, chemical composition, adaptation to local climate and soils affect the production of quality forage particularly to produce forage that meets the nutritional needs of livestock as uniformly as possible over time (Fales, 2007).

There are various types of Napier grass used as the ruminant feed that can be found in Malaysia. For this study, the different types of Napier grass that varies in morphology and chemical composition can be the factor to the content of minerals. However, there is limited information on minerals composition of different varieties of Napier grass. Findings of this study can be helpful for farmers to choose the best type of Napier grass with the optimum minerals concentration as animal feed.

1.3 Hypothesis

H_0: The different types of Napier grass may have different nutritive values in term of mineral composition.

H_1: The different types of Napier grass have different nutritive values in term of mineral composition.

1.4 Objectives

1) To evaluate the composition of the minerals in various types of Napier grass.
2) To assess the minerals analysis of soil (before planting and after harvest).
3) To suggest the best type of Napier grass with the optimum minerals concentration as animal feed.

1.5 Scope of Study

Various types of Napier grass were planted in Agro Techno Park, Universiti Malaysia Kelantan (UMK). The assessments of minerals composition (before planting and after harvest) and each variety of Napier grass were carried out in the Animal Science Laboratory, UMK.

1.6 Significance of Study

The mineral content in the forage species varies. Therefore, the composition of the minerals in each type of forage should be known to determine the total amount of minerals consumed as well as meet the daily requirements. Thus, the Napier grass used as feed was evaluated. This study will help to provide information especially to farmers on minerals composition in different types of Napier grass. Then, to choose which the best type of Napier grass with the optimum minerals concentration as the main forage for ruminant livestock production.

1.7 Limitation of Study

The reference sources are limited due to the lack of documented information such as journals and books on various types of Napier grass in Malaysia. Then, there is a limitation to get suppliers who were provided with the various types of Napier seeds and to obtain the accurate Napier grass species with different varieties due to the different local name of Napier grass among the farmers or locations.

CHAPTER 2

LITERATURE REVIEW

2.1 Napier Grass (*Pennisetum purpureum*)

Napier grass is also known as elephant grass introduced as a forage crop that belongs to the order Cyperales, family Poaceae, genus Pennisetum and species *Pennisetum purpureum* (FAO, 2013). Napier grass is a robust, rhizomatous bunchgrass. They are able to produce more DM per unit of time than most other grasses and legumes. This C4 grass is widely naturalised in tropical and subtropical countries of the world (Randall, 2012). Also, it is an invasive species and a fast-growing perennial grass (FAO, 2013). Napier grass (*Pennisetum purpureum*) was first introduced in Malaysia in the 1920s which originated in tropical Africa and particularly in East Africa (Woodard & Prine, 1991), while some other cultivars have been introduced since 1950s.

Besides, this forage species is well adapted to hot and dry condition and humid weather. They are able to re-sprout easily from small rhizomes left after disturbance. The deep root system allows it to survive longer during drought periods. It also can adapt to high daytime temperature (30-35°C), intense sunlight and nitrogen and/or carbon dioxide limitations (Gibson, 2009). Napier grass grows best in well-drained soils but they are also well adapted to grow on various types of soil from poorly drained clay soils to excessively drained sandy soils with pH, 4.5 to 8.2 (Tropical Forages, 2013). The optimum temperature for this forage to grow is from 25°C to 40°C (FAO, 2013).

Breeding of Napier grass has been applied to improve cultivars and hybrids for forage and silage (Tropical Forages, 2013). Napier grass can grow up to 7m in height and produce many tillers, whereas the type of Dwarf Napier grows with maximum growth, 1.6m in height that produces very leafy and high-quality forage. Cultivars categorised as tall types such as Common Napier, Purple Napier, Taiwan Napier and cultivars are categorised as short types such as Australian Dwarf, Dwarf Napier and Dwarf "Mott" (Halim, Shampazurini & Idris, 2013). Typically, they are cut for hay and silage is made by fermentation methods to feed livestock especially cattle (FAO, 2013).

2.2 Napier Grass as Animal Feed

Napier grass (*Pennisetum purpureum*) is well known as the main forage for dairy and feedlot production systems. It is also one of the protein sources for ruminant feed particularly cattle and goat farming in Malaysia. There are various types of Napier grass that are used by farmers as feed. Usually, the cut and carry method is applied to feed the livestock. A proper nutrient is very important to meet the needs of livestock by maintaining adequate quality forage. Besides, supplemental nutrients should obtain economically optimize growth as well as animal productivity. Maximising the use of forage because it's economical and reducing the supplemental feed inputs is the best measure of nutritional management by selecting the best of forage species that is closest to the nutritional needs (Monty, 2007). Different types of Napier grass may have different nutritive values. In this study, the nutritive value in term of mineral composition in various types of Napier grass is the main focus to be evaluated.

2.3 Factors Affecting Forage Quality

A critical factor affecting ruminant productivity is forage quality because it supplies the majority of nutrients in the diet. Thus, increasing in forage quality will improve production and potential economic return. A variation in forage plant species is under genetic control like anatomy, morphology, chemical composition that are producing a large effect on forage quality (Fales, 2007). The quality of forage varies among species that are associated with the climate and soils of a particular region. The productivity of livestock can be improved if the forage quality is improved by breeding or managing forage to have a higher leaf to stem ratio (Moore et al., 1991). However, the forage quality can decrease when both processes of tissues ageing and morphological development occur.

Plant cells consist of cell walls and cytoplasmic contents. The chemical composition contains in cytoplasms such as proteins, lipids, sugars, starch, pectins, water-soluble vitamins and minerals. The factors affect the chemical composition are light, temperature and moisture. Also, those factors can affect the growth rates and morphological development (Fales, 2007). Stress can occur in forage plants caused by soil moisture deficiency. Water deficiency more often limits forage yield compared to the other factors while fertilization or irrigation can modify the environment. Fertilization based on soil tests can repair the imbalance minerals that affect both plant growth and animal health as well (Buxton & Fales, 1994).

Soil samples should be collected at the same depth and time to access soil pH and fertility. Favourable soil pH is crucial for high forage production because it affects the availability of other nutrients and also promotes the growth of desirable microorganisms (Marvin, 2007). A standard recommendation for nitrogen is 30g N/m^2/year and lime is 60g/m^2/year used in soil preparation. Lime is used to repair the soil acidity and reduced soluble aluminium and manganese levels. Lime also promote microbial activity and supply calcium and magnesium based on the liming material used. Furthermore, the used or loss of nutrients in soil such as nitrogen, phosphorus and potassium can be replaced by using manure or fertiliser (Clifford, 2007). Selection of the best forage species according to the suitability of soil type and the forage use will provide the most effective land use.

The climate-dependent factors, forage species, type of livestock and farmer management skills are the important strategies for both grazed and conserved forages. Young plants have higher nutritional value than mature plants because its cells are biochemically active while older plant cells are low in biochemical activity (Huston & Pinchak, 1991). The suitable nutritive value of forage for younger, growing animals or for lactating females is essential to meet the needs of animals. The development and utilisation of a forage system should be a priority goal for all livestock farmers to minimise risk and improve potential profitability of their livestock production systems (Redmon & Larry, 2007). The important factors to be considered when assessing the quality of forage are the nutrient content and the quantity require to be consumed by the animals.

2.4 Minerals Nutrient

Minerals are inorganic compounds which act as an essential element in animal nutrition. Minerals are divided into two types, macro minerals and micro minerals. Macro minerals consist of Calcium (Ca), Phosphorus (P), Sodium (Na), Chloride (Cl), Potassium (K), Magnesium (Mg) and Sulphur (S). For micro minerals are Cobalt (Co), Copper (Cu), Iodine (I), Iron (Fe), Manganese (Mn), Selenium (Se), Zinc (Zn) and Chromium (Cr). Macro minerals are required in relatively large quantities while micro minerals in relatively small quantities. An excessive mineral can impair or improve the absorption of another mineral due to the potential for interaction. Mineral nutrition is crucial and supplements are usually needed to maximise animal productivity because macro minerals can be deficient in many types of forage especially sodium and chloride (Monty, 2007).

Forages are commonly rich in calcium and phosphorus. Phosphorus content in forages can be variant and is affected by soil fertility. Phosphorus can be sufficient to meet the needs of an animal's phosphorus requirement if soil fertility is sufficient and the quality of forage is high (Monty, 2007). In the new-growth forage, magnesium is often deficient, which is worse by soil nutrient imbalance. Micro minerals such as zinc, copper and selenium have been shown to be deficient in forages as well as cobalt, manganese and iodine that usually supplemented to the livestock (Monty, 2007). The minerals composition in each forage needs to be known to determine the amount of minerals consumed so can meet the minerals requirements. Therefore, Napier grass as the main forage needs to be evaluated.

2.5 Macro Minerals

Calcium is the most abundant mineral in the body that are deposited on teeth and bones. Calcium is important for muscle contraction, blood clotting, nerve function and acid-base balance. Sufficient calcium in the body depends on the presence of phosphorus and vitamin D. Lack of calcium, phosphorus and vitamin D results in the poor bone formation, osteoporosis, reduced milk production for lactating animals, nervous symptoms and retarded growth. Excess calcium in the body will disrupt phosphorus utilization and increase the requirement of zinc and vitamin K in the body (David, 2006).

Phosphorus is necessary for the formation of teeth, bones, cell membranes and most enzymes. Also, it is important in maintaining the acid-base balance and osmotic balance. Sufficient phosphorus in the body is supported by the presence of calcium and vitamin K. The high level of calcium above the requirement will affect the absorption of phosphorus. The lack of phosphorus will retard growth, interfere with feed efficiency, reduce milk production and osteoporosis. Excess of phosphorus in diet can cause changes in blood composition and urinary calculi (David, 2006).

Sodium as a main inorganic cation of extracellular fluids that maintain the acid-base balance in the body. Sodium also plays a role in the heart and nerves function. Kidneys are able to conserve sodium during less intake and able to remove the excess sodium. Sodium can be found in the ruminant saliva during fermentation. Sodium pumps are found in all body cells that carry sugars and amino acids from interstitial fluid and intestinal rumen into the cell cytoplasm.

Sodium deficiency in animals can be identified when the animals are drinking urine, licking and chewing the soil or objects. However, the act is not accurate evidence of sodium deficiency in livestock. Other symptoms due to lack of sodium are weight loss, rough hair coat and incoordination. Signs of excess sodium in the body are nervousness, staggering, paralysis and death. Drink good quality water adequately can remove the excess sodium from the body (David, 2006).

Potassium is involved in neuromuscular function, many enzyme systems and energy production. Furthermore, it is also involved in acid-base regulation and osmotic balance which important for normal function of nervous, muscle, kidney and cardiac tissues. Potassium can only be stored minimally in the body due to the limit of storage. Potassium deficiency results in anorexia, inactive and reduced heart function. The high of potassium in the body is usually related to metabolic problems in the dairy industry (David, 2006).

Magnesium is a cofactor in most enzyme systems and requires for normal bone formation. Adequate magnesium is essential in performing parathyroid hormone function while maintaining the optimal blood calcium. Magnesium is also important for normal nerve and muscle function. Symptoms of magnesium deficiency such as stunted growth, nervous and muscular problems, weakness, loss of balance and tetany that can lead to death. Tetany is pain caused by continuous muscle contraction. Symptoms of tetanus are poorly identified and occur due to the low of magnesium in the blood (hypomagnesemia). The high of magnesium in the body can be removed through kidneys (David, 2006).

2.6 Micro Minerals

Copper is a component of most enzyme systems including to produce hair and skin pigment melanin, the formation of connective tissues, immune system functions and synthesize haemoglobin. Copper insufficiency can cause retarded growth, impaired pigmentation, anaemia, reproductive failure, bone fragility and immune failure. Sheep are sensitive to copper deficiency and also copper toxicity. Deficiency results in neonatal ataxia or "swayback" to young lambs. Infected young lambs are weakened as soon as they are born and can die due to breastfeeding failure (David, 2006).

Iron is a component of haemoglobin in red blood cells and required in most enzyme systems. Anaemia occurs due to a shortage of iron that produces red blood cells.

Furthermore, the shortage of iron deactivated the immune function. The excess of iron inhibits the absorption of dietary copper and zinc (David, 2016). Manganese is a component in most enzyme systems and also needed for proper bone development. Stunted growth, increase in fat deposition, skeletal abnormalities and reproductive failure are signs of manganese deficiency while an excess of manganese in the body slows the growth rate (David, 2006).

Zinc is involved in the production of insulin hormones, milk synthesis, tissue repair, sperm production and immune function. Zinc is also associated with carbohydrate, protein and lipid metabolism. Parakeratosis is a sign of zinc deficiency which causes a thick, rough, scaly skin and sometimes hair loss. Zinc deficiency also causes stunted growth and disturbs the reproductive function and development in males and females. The presence of phytate in plants inhibits the zinc absorption. The requirement of zinc will increase when the calcium level is excessive. The high amount of zinc in body inhibits the absorption and metabolism of copper and caused anaemia, arthritis and digestive problems (David, 2006).

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Area

This study was conducted at Agro Techno Park, Universiti Malaysia Kelantan (N5°44'45.79", E101°52'31"; average altitude 62 m above sea level). Samples were analysed in the Animal Science Laboratory, Universiti Malaysia Kelantan. Table 3.1 shows the recorded temperature and monthly rainfall during the experimental period. The average minimum and maximum temperatures at Jeli area were 24°C and 33°C, respectively.

Table 3.1: Temperature and rainfall recorded at Jeli during the experimental period July – September 2018 (Source: AccuWeather.com, 2018).

Month	**Temperature (°C)**	**Rainfall (mm)**
July	29	115
August	29	142
September	28	174

A soil testing was conducted by taking the soil sample in range of 0 – 20 cm depth to determine the soil acidity or alkalinity levels and the chemical composition contained in the soil before planting as described by Tan (2003). The area selected for planting Napier grass was cleared and ploughed with a tractor to get a good tilth. Napier grass was harvested at 2 months of plant maturity (1 cutting). Thus, the total cutting of Napier grass is 6 for a year. Lime and fertiliser treatments were applied to repair soil pH imbalance, while goat manure was used to nourish the soil at a rate of 1.36 kg/m²/year. As a recommendation, the nitrogen (N) and lime [$Ca(OH)_2$] were applied at a rate of 30 g N/m²/year and 60 g calcium (Ca)/m²/year, respectively. A basal fertiliser 15:15:15 (Nitrogen, N: Phosphorus, P: Potassium, K) required was 63 g/m²/year in the land preparation. However, this study was conducted only for 1 cutting. Thus, the lime [$Ca(OH)_2$] and basal fertiliser (NPK) were used at a rate of 5 g $Ca(OH)_2$/m²/cutting and 33.33 g NPK/m²/cutting, respectively.

Table 3.2: The physical and chemical properties of representative soil before planting.

Parameter	**Soil**
Clay, %	> 20
Electrical conductivity, mS/m	25
Nitrogen, g/kg	22.60
Organic matter, %	4.64
Organic carbon, %	2.69
pH	5.31

3.2 Experimental Design

The availability of various Napier grasses was identified among farmers in Malaysia. Seven types of Napier seeds such as Taiwan, Zanzibar, Kobe, Pakchong, Purple, Indian and Dwarf were bought and manually planted at the prepared area. All Napier grass varieties were planted in experimental plots using completely randomized design (CRD) and each variety was planted in 3 plots as replication. A plot area was 2 m by 2 m (15 seeds) and each plot separated by 1 m space from another plot. Therefore, a total of 45 Napier seeds were required for 3 plots.

The total number of plots, 21 were prepared for planting all types of Napier seeds within the total area, 196 m^2. All plots were irrigated manually with the hose pipe and watering can, twice a day during 2 months of the experiment. Weeding was completed by hand for every time during weed growth. The Napier grass was harvested at 60 days of maturity after plantation. The samples were collected randomly from the top, both sides and three distributions around the plot and combined. Then, the samples were analysed in the laboratory to determine the composition of the minerals contained in each of the Napier types.

3.3 Determination of Dry Matter (DM)

The selected empty container to hold the fresh sample was weighted and recorded (W1). After tare, approximately 100 g of the fresh sample was placed in the container and weighed (W2). The fresh sample was put in the forced air oven at 70 °C until it was completely dried (Tan, 2003). The dried sample with container was weighted and recorded immediately after drying (W3). The dried sample was ground by using a grinder and the sample was kept in the zipper bag. The weight of the dry sample (W3 – W1) was divided by the weight of the fresh sample (W2) and multiplied by 100 to get a percentage of DM. The formula used for dry matter determination,

$$DM\ (\%) = [(W3 - W1) / W2] \times 100$$

where W1 – Weight of empty container (g), W2 – Weight of fresh sample (g), W3- Weight of container and dried sample (g).

3.4 Determination of Ash

The empty crucible (W1) and approximately 1 g of ground and dried sample (W2) were weighed. The sample was incinerated in a muffle furnace at 520 ˚C for 6 hours (Tan, 2003). The sample was allowed to cool in a desiccator to room temperature. The final weight (W3) was recorded. The formula used for ash determination,

$$Ash\ (\%) = [(W3 - W1) / W2] \times 100$$

where W1 – Weight of empty crucible (g), W2 – Weight of sample (g), W3- Weight of crucible and ash (g).

3.5 Extraction of Ash (Plant Tissues and Goat Manure)

After ashing, a few drops of distilled water was added to the sample followed by 2 ml of concentrated HCl. The sample was evaporated to dryness in a fume chamber using a hot plate. After the hot plate was turned off, 10 ml of 20% HNO_3 was added to the sample and allowed it to stand on the warm hot plate until cool. The sample was filtered to pass filter paper into a 100 ml volumetric flask and the volume was make up to 100 ml. The sample was diluted to 10, 100 and 1000 times dilution (if necessary) (Tan, 2003).

The total cations were determined such as potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), manganese (Mn), iron (Fe), zinc (Zn) and copper (Cu) by using 900F Atomic Absorption Spectrometer (AAS). Phosphorus (P) was determined by using GENESYS 20 Visible Spectrophotometer after blue colour development. According to Tan (2003), the formula used to obtain the mineral concentration in a sample solution;

Concentration (ppm) = Absorbance reading × (volume of volumetric flask / weigh of sample) × dilution factor (if any)

3.6 Extraction of Soil for Minerals Determination

According to Tan (2003), an extractant with a mixture of 0.05 M HCl and 0.025 M H_2SO_4 was prepared. Then, 5 g of soil was weighed in a 250 ml beaker. Therefore, 20 ml of double acid extractant was added and shake it mechanically at 180 rpm for 10 minutes. The supernatant was filtered by filter paper into another beaker. Thus, the samples were analysed by using 900F Atomic Absorption Spectrometer (AAS). The formula used to obtain the mineral concentration in a sample solution;

Concentration (ppm) = Absorbance reading × (volume of volumetric flask weigh of sample) × dilution factor (if any)

3.7 Colour Development for Phosphorus Determination

For the preparation of reagent A, 12 g of ammonium molybdate was dissolved in 250 ml of distilled water. Next, 0.2908 g of potassium antimonyl tartrate was dissolved in 100 ml of distilled water followed by 148 ml of concentrated H_2SO_4 was dissolved in 1 L of distilled water to make 5.76 M H_2SO_4. Ammonium molybdate solution was added into 5.76 M H_2SO_4. The solution was mixed thoroughly and allow to cool at room temperature for an hour. Then, potassium antimonyl tartrate solution was added and make up to 2 L with distilled water. Again, the solution is mixed thoroughly and left overnight as described by Tan (2003).

As preparation of reagent B, 1.32 g of ascorbic acid was added into 250 ml of reagent A. For Phosphorus determination, 8 ml of reagent B and 2 ml of sample extract was pipetted into a volumetric flask and was make up to 50 ml with distilled water. After the blue colour developed, the solution was pipetted into a cuvette (Tan, 2003). The samples were analysed by using GENESYS 20 Visible Spectrophotometer at 882 nm wavelength. The formula used to obtain the mineral concentration in a sample solution;

Concentration (ppm) = Absorbance reading × (volume of volumetric flask / weigh of sample) × dilution factor (if any)

3.8 Data Analysis

The data were analysed on mineral composition in the seven types of Napier grass by using one-way analysis of variance (ANOVA), whereas the Duncan's Multiple Range Test (DMRT) was used to distinguish the treatment means at the 95% confidence level (P <0.05). The data were obtained as mean ± standard deviation (SD).

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Results

There were seven types of Napier grass (Taiwan, Zanzibar, Kobe, Pakchong, Purple, Indian and Dwarf) used to determine their minerals composition in this study. After two months of maturity, the effect of different Napier grass varieties on macro minerals (g/kg of DM) concentration was analysed as shown in Table 4.1. Furthermore, the micro minerals (mg/kg of DM) concentration in different Napier grass varieties had determined as shown in Table 4.2.

Table 4.1: Effect of different Napier grass varieties on macro minerals (g/kg of DM) concentration, which was harvested after two months of plantation.

Parameter	Napier Variety (Mean ± Standard Deviation)							Level of Significance
	Taiwan	Zanzibar	Kobe	Pakchong	Purple	Indian	Dwarf	
Ca	3.58 ± 1.64^{ab}	6.50 ± 1.28^{c}	4.50 ± 1.08^{abc}	2.96 ± 0.48^{a}	2.54 ± 0.20^{a}	2.88 ± 0.73^{a}	5.64 ± 1.60^{abc}	*
Mg	1.36 ± 0.15^{abc}	1.39 ± 0.08^{abc}	1.15 ± 0.21^{ab}	1.26 ± 0.21^{abc}	1.04 ± 0.35^{a}	1.54 ± 0.22^{bc}	1.59 ± 0.19^{c}	*
K	33.02 ± 5.69^{bc}	40.35 ± 5.93^{c}	36.39 ± 6.10^{bc}	20.20 ± 7.17^{a}	26.18 ± 7.40^{ab}	28.84 ± 2.25^{ab}	36.34 ± 1.81^{bc}	*
Na	0.64 ± 0.79^{a}	2.21 ± 0.39^{b}	1.01 ± 1.32^{ab}	0.30 ± 0.13^{a}	0.19 ± 0.02^{a}	0.31 ± 0.16^{a}	0.57 ± 0.86^{a}	*
P	5.63 ± 0.73	5.14 ± 2.08	5.41 ± 0.54	4.05 ± 1.37	4.43 ± 0.98	4.05 ± 1.23	4.68 ± 0.38	NS

*, *P* <0.05; NS, non-significant (*P* >0.05).

^{abc} Means in a same row with different superscripts differ significantly at *P* <0.05.

Ca: calcium, Mg: magnesium, K: potassium, Na: sodium, P: phosphorus

Table 4.2: Effect of different Napier grass varieties on micro minerals (mg/kg of DM) concentration, which was harvested after two months of plantation.

Parameter	**Napier Variety (Mean ± Standard Deviation)**							**Level of significance**
	Taiwan	**Zanzibar**	**Kobe**	**Pakchong**	**Purple**	**Indian**	**Dwarf**	
Zn	25.38 ± 1.40^{ab}	23.06 ± 2.01^{ab}	23.55 ± 3.07^{ab}	21.51 ± 3.13^{a}	21.69 ± 5.66^{a}	26.44 ± 1.90^{ab}	28.81 ± 4.72^{b}	*
Cu	8.17 ± 0.54^{a}	11.26 ± 1.07^{bc}	12.19 ± 0.34^{c}	8.49 ± 0.62^{a}	9.12 ± 1.04^{a}	8.90 ± 1.37^{a}	10.02 ± 1.37^{ab}	*
Mn	76.69 ± 7.36^{a}	79.57 ± 12.96^{a}	93.09 ± 9.99^{a}	71.18 ± 6.02^{a}	81.76 ± 3.95^{a}	77.99 ± 29.83^{a}	157.35 ± 41.76^{b}	*
Fe	113.92 ± 12.06^{a}	116.38 ± 3.29^{a}	138.76 ± 27.45^{a}	86.63 ± 11.33^{a}	120.23 ± 7.85^{a}	134.19 ± 24.48^{a}	240.75 ± 87.32^{b}	*

*, P <0.05.
^{abc} Means in a same row with different superscripts differ significantly at P <0.05.
Zn: zinc, Cu: copper, Mn: manganese, Fe: iron

The average of macro minerals and micro minerals concentration in Napier grass after two months of maturity were referred in Table 4.3.

Table 4.3: Macro and micro minerals concentration in Napier grass (irrespective of Napier grass varieties).

Parameter	**Mean ± Standard Deviation**
Macro mineral (g/kg of DM)	
Calcium	4.09 ± 1.72
Magnesium	1.33 ± 0.26
Potassium	31.62 ± 8.10
Sodium	0.75 ± 0.88
Phosphorus	4.77 ± 1.15
Micro mineral (mg/kg of DM)	
Zinc	24.35 ± 3.84
Copper	9.74 ± 1.65
Manganese	91.09 ± 33.31
Iron	135.84 ± 55.80

4.2 Macro minerals

Based on Table 4.1, the different Napier grass varieties had a significant effect (P <0.05) on Ca, Mg, K, and Na concentration (g/kg of DM) in plants. However, no significant effects (P >0.05) were observed for P concentration (g/kg of DM) among Napier grass varieties.

4.2.1 Calcium

There was no significant effect (P >0.05) on Ca concentration in Pakchong Napier (2.96 g/kg of DM), Purple Napier (2.54 g/kg of DM) and Indian Napier (2.88 g/kg of DM) but they had a significant effect (P <0.05) with Zanzibar Napier as presented in Table 4.1. Zanzibar Napier obtained the highest concentration of Ca (6.50 g/kg of DM) while Purple Napier contained the lowest concentration of Ca (2.54 g/kg of DM).

According to Khan *et al*. (2006), the sufficient Ca concentration in Napier grass range from 1.2 to 2.6 g/kg of DM required for maintenance, growth and lactation particularly in sheep. Zanzibar Napier obtained the slightly high of Ca concentration (6.50 g/kg of DM). However, most of the Napier grass varieties were achieved the Ca concentration based on the range mentioned by Khan *et al*. (2006). Calcium is very important in bone and teeth formation, as well as milk production for lactating animals. Furthermore, the shortage of Ca concentration in blood can cause hypocalcaemia to the animals (Saha, 2010).

4.2.2 Magnesium

Purple Napier and Dwarf Napier had a significant effect (P <0.05) on Mg concentration. The lowest concentration of Mg (1.04 g/kg of DM) was found in Purple

Napier while Dwarf Napier was contained the highest of Mg concentration (1.59 g/kg of DM) as mentioned in Table 4.1.

Even though Dwarf Napier was the highest in Mg concentration among the Napier grass varieties but it still inadequate for grazing animals according to the average which 2 g/kg of DM of Napier grass (Gill *et al*., 2004). Symptoms of tetanus due to low magnesium in the blood (hypomagnesemia) are poorly identified when happening in animals and sometimes can cause fatal to the livestock (Saha, 2010).

4.2.3 Potassium

There was a significant effect (P >0.05) observed on K concentration in Pakchong Napier and Zanzibar Napier as presented in Table 4.1. The highest concentration of K available in Zanzibar Napier (40.35 g/kg of DM) while the lowest concentration of K was found in Pakchong Napier (20.20 g/kg of DM).

The K concentration in Napier grass up to 8 g/kg of DM was stated for grazing animals and 10 g/kg of DM for high-producing cows (Mirzaei, 2012). However, all varieties of Napier grass in this study gained excessively above the stated range. A cow under stress condition like heat stress required more amount of potassium in a diet to maintain the cow's health and production yield (Mirzaei, 2012).

4.2.4 Sodium

Based on Table 4.1, there was no significant effect (P >0.05) on Na concentration between Kobe Napier (1.01 g/kg of DM) and Zanzibar Napier (2.21 g/kg of DM), but Zanzibar Napier had a significant effect (P <0.05) with other Napier grass varieties. Zanzibar Napier gained the highest concentration of Na, while Purple Napier (0.19 g/kg of DM) gained the lowest concentration of Na.

In this study, all varieties of Napier grass had the low concentration of Na, which below than average range, 1 to 4 g/kg of DM of Napier grass for growing and finishing ruminants (Gill *et al*., 2004) except Zanzibar Napier and Kobe Napier. According to Areghoere (2002), many regions of the world have challenged the shortage of Na in natural forages. Sodium associate with chloride helps to regulate body pH and retain the amount of water reserved in the body. However, the lack of both elements can cause loss of appetite as well as body weight of the animals (Saha, 2010).

4.2.5 Phosphorus

For P concentration, there was no significant effect (P >0.05) observed among the Napier grass varieties (Table 4.1) and the overall mean was 4.77 g/kg of DM (Table 4.3). The highest concentration of P was in Taiwan Napier (5.63 g/kg of DM) and the lowest was found in Indian Napier (4.05 g/kg of DM). Furthermore, P concentration in Napier grass also can decrease with maturity determined by Suttle (2010).

However, in this study, the P concentration found in all varieties of Napier grass was above than the critical value (1.9 g/kg of DM) for growing and finishing beef cattle (Gill *et al*., 2004) which harvested at two months of maturity. Phosphorus deficiency cause delay in heifer’s puberty and also in beef maturity (Saha, 2010). Adequate phosphorus in the body is assisted with the presence of calcium and vitamin K (David, 2006).

4.3 Micro minerals

The different Napier grass varieties had a significant effect (P <0.05) on Zn, Mn, Cu, and Fe concentrations (mg/kg of DM) in plants based on Table 4.2.

4.3.1 Zinc

There was no significant effect (P >0.05) on Zn concentration between Pakchong Napier (21.51 mg/kg of DM) and Purple Napier (21.69 mg/kg of DM) but the both of Napier grass varieties had a significant effect (P <0.05) with Dwarf Napier (28.81 mg/kg of DM) as presented in Table 4.2. Dwarf Napier obtained the highest concentration of Zn, while Pakchong Napier (21.51 mg/kg of DM) was the lowest concentration of Zn among the Napier grass varieties.

For growing ruminants, adequate Zn should within the range of 12 to 20 mg/kg of DM according to Gill *et al*. (2004). In this study, Dwarf Napier gained the slightly high of Zn concentration from the range mentioned above, but Pak Chong Napier was still within the optimal range even though low of Zn concentration in the plant. Zinc is a component in most enzyme systems and involved in the production of insulin hormones in the body. Zinc is also involved in milk synthesis, tissue repair, sperm production and immune function (David, 2006).

4.3.2 Copper

For Cu concentration, there was no significant effect (P >0.05) among Taiwan Napier (8.17 mg/kg of DM), Pakchong Napier (8.49 mg/kg of DM), Indian (8.90 mg/kg of DM) and Purple Napier (9.12 mg/kg of DM), but they had a significant effect (P <0.05) with Kobe Napier (12.19 mg/kg of DM) as mentioned in Table 4.2. The Cu concentration was the highest in Kobe Napier and the lowest of Cu concentration was found in Taiwan Napier.

The nutritional requirements of ruminants for the Cu concentration range from 8 to 14 mg/kg of DM. The Cu concentration can decrease with maturity as referred Khan *et al*. (2006). However, all varieties of the Napier grass in this study had enough of Cu concentration within the range that was harvested at two months of maturity. Shortage of copper in animal diet can lead to infertility, depressed immunity and reduce pigmentation of hair and skin (Saha, 2010).

4.3.3 Manganese

Dwarf Napier had a significant effect (P <0.05) on Mn concentration (157.35 mg/kg of DM) to all of Napier grass varieties (Table 4.2). Dwarf Napier gained as the highest concentration of Mn, while Pakchong Napier was the lowest in Mn (71.18 mg/kg of DM) among the Napier grass varieties.

According to Gill *et al*. (2004), 20 mg/kg of Mn required for growing and finishing cattle as well as only 40 mg/kg is needed as the critical level of Mn in a diet.

However, in this study, the Mn sufficiency was exceeded the average levels as mentioned above for all varieties of Napier grass. Furthermore, manganese is important in the animal diet for normal reproduction and development of foetus and udder (Saha, 2010).

4.3.4 Iron

Dwarf Napier had a significant effect (P <0.05) on Fe concentration (240.75 mg/kg of DM) towards all of Napier grass varieties (Table 4.2). The highest concentration of Fe was observed in Dwarf Napier, while Pakchong Napier was the lowest in Fe concentration (86.63 mg/kg of DM) among the Napier grass varieties.

Furthermore, Khan *et al*. (2005) determined that Fe concentration in Napier grass above the level of 50 mg/kg of DM was suggested as acceptable for grazing animals. In this study, Fe concentration analysed in all varieties of Napier grass has exceeded the level. Anaemia happens in livestock when the iron is deficient in the body to produce haemoglobin (Saha, 2010). Besides, the excessive of iron can inhibit the absorption of copper and zinc in the animal body (David, 2016).

4.4 Factor Affecting Minerals Composition in Napier Grass

As presented in Table 4.4, the composition of minerals in soil at Agro Techno Park, UMK was analysed before planting and after harvest.

Table 4.4: The minerals composition of soil sample.

Parameter	(Mean ± Standard Deviation)	
	Before Planting	**After Harvest**
Calcium $_{exchangeable}$, cmol/kg	11.45 ± 0.04	4.25 ± 0.34
Magnesium $_{exchangeable}$, cmol/kg	12.38 ± 0.02	3.66 ± 2.92
Potassium $_{exchangeable}$, cmol/kg	5.00 ± 0.01	1.33 ± 0.26
Sodium $_{exchangeable}$, cmol/kg	2.23 ± 0.02	0.90 ± 0.20
Phosphorus, mg/kg	10.81 ± 4.71	7.02 ± 0.50
Copper, mg/kg	2.38 ± 0.02	2.96 ± 0.06
Zinc, mg/kg	6.15 ± 0.04	4.31 ± 0.10
Manganese, mg/kg	55.35 ± 0.01	44.97 ± 18.00
Iron, mg/kg	8.02 ± 0.03	9.42 ± 2.81

The mineral composition of goat manure that used to nourish and repair the minerals imbalance in soil is shown in Table 4.5.

Table 4.5: Minerals composition of goat manure used.

Parameter	**Composition (Mean ± Standard Deviation)**
Calcium, g/kg	25.08 ± 1.49
Magnesium, g/kg	3.57 ± 0.12
Phosphorus, g/kg	13.37 ± 0.33
Potassium, g/kg	2.56 ± 0.40
Sodium, g/kg	1.05 ± 0.12
Copper, mg/kg	18.42 ± 0.74
Zinc, mg/kg	72.53 ± 0.15
Manganese, mg/kg	289.00 ± 6.18
Iron, mg/kg	150.42 ± 6.40

In this study, the availability of minerals concentration was different among each Napier grass varieties. According to Fales (2007), the different species of grasses may have different ability to absorb minerals from the soil. Besides, the adaptation to local climate and soil can affect the production of forage quality. Ekemini (2013) reported that the average value of mineral concentration in soil before planting, which were Ca (3.53 cmol/kg), Mg (5.36 cmol/kg), K (0.59 cmol/kg), P (41.2 mg/kg), Cu (2.58 mg/kg), Mn (129 mg/kg) and Zn (14.08 mg/kg).

Based on Table 4.4, there were decreased in concentration of P (10.81 mg/kg), Cu (2.38 mg/kg), Zn (6.15 mg/kg), Mn (55.35 mg/kg) and Fe (8.02 mg/kg) in soil while, the concentration of Ca (11.45 cmol/kg), Mg (12.38 cmol/kg), K (5.00 cmol/kg) and Na (2.23 cmol/kg) in the soil were higher in this study compared to the data found in earlier study Ekemini (2013). Most of the minerals concentration in the soil after harvest were decreased in this study possibly due to the minerals uptake by the Napier grass, except Cu (2.96 mg/kg).

This result may due to the excess of Cu concentration in goat manure applied. However, all of the Napier grass varieties contained sufficient amount of mineral concentration within the average range, except for Mg and Na concentration which were still had a deficiency in the Napier grass. The minerals composition of goat manure was observed in this study to determine the possibility of goat manure in encouraging and repairing the minerals imbalance in soil (Table 4.5).

The average concentration of macro minerals in goat manure as reported by Omisore *et al.* (2018) were P (8.70 g/kg), K (8.90 g/kg), Ca (24.20 g/kg), Mg (12.50 g/kg), Na (1.30 g/kg), while for micro minerals were Cu (23.80 mg/kg), Zn (38.60 mg/kg), Mn (257 mg/kg) and Fe (576 mg/kg). The mineral concentration analysed were high in K, Mg and Fe but slightly high in Na and Cu concentration compared to the results obtained in this study (Table 4.5). Furthermore, the composition of minerals in animal manure is depended on the diet and animal species (Schoenian, 2012).

The basal fertiliser (NPK) and lime [$Ca(OH)_2$] were applied during the land preparation in order to complete the minerals requirement in the soil which might be contributed to the minerals concentration in Napier grass. Furthermore, the quality of Napier grass in terms of minerals concentration also can be varied among varieties due to genetic control such as morphology and chemical composition. Factors affecting forage quality are important particularly to produce forage that meets the nutritional needs of livestock. The quality of forage is the main factor affecting ruminant productivity as forages supply most nutrients in the ruminant diet (Fales, 2007). However, there is limited data on minerals composition in different Napier grass varieties.

CHAPTER 5

CONCLUSION

5.1 Conclusion

Macro and micro minerals concentration were significantly affected by the different varieties of Napier grass. The results suggest that Zanzibar Napier could provide an adequate amount of macro minerals which were Ca, K and Na. Besides, Dwarf Napier could provide an adequate amount of micro minerals such as Zn, Mn and Fe. Thus, it can be utilised by the smallholder of livestock farmers. However, the amount of minerals concentration in Napier grass may not be sufficient like Mg for optimum ruminant respective mineral requirement. Minerals concentration in soil was adequate after fertilisation for optimum plant growth.

5.2 Recommendation

The different varieties of Napier grass were planted at Agro Techno Park, UMK Jeli and analysed in laboratory due to the little information obtained on the minerals composition. Also, a new standard of data was provided for the further study. Furthermore, the data found was very useful especially for the farmers to choose the variety of Napier grass based on the ruminant diet requirement and able to plan for a better forage management that can affect the Napier grass quality. It is recommended to use the other type of organic manure and fertiliser or planted in different type of soil to determine the minerals uptake in the different varieties of Napier grass. Then, the number of cutting can be increased to gain more information.

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APPENDIX A

Figure 1: Site selection.

Figure 2: Land preparation.

Figure 3: Napier grass cultivation.

Figure 4: After two months of maturity.

Figure 5: Preparation for harvesting.

Figure 6: Cutting of Napier grass.

Figure 7: Dry matter samples.

Figure 8: Extraction of plant tissues after ash determination.

Figure 9: Filtration of extraction.

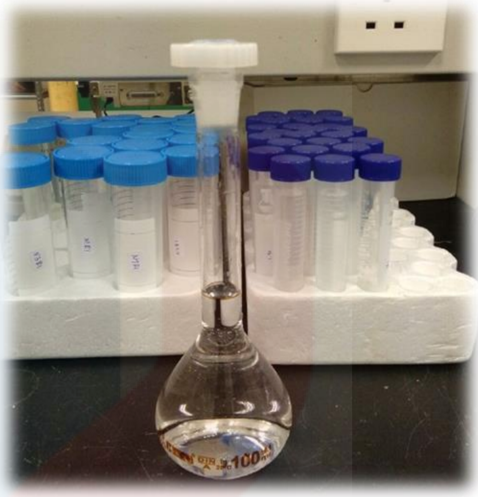

Figure 10: Dilution of stock solution.

Figure 11: Development of blue colour.

Figure 12: Determination of phosphorus.

Figure 13: Dilution of stock solution.

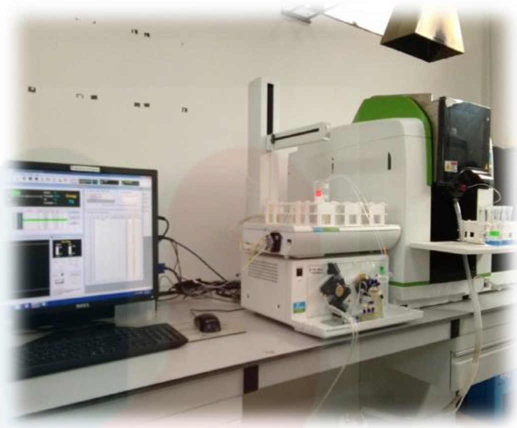

Figure 14: Mineral analysis by 900F Atomic Absorption Spectrometer (AAS).

APPENDIX B

Table of descriptive statistics of Napier grass varieties.

	Treatment	Mean	Std. Deviation	N
Ca	Taiwan	3.584467	1.6394242	3
	Zanzibar	6.503300	1.2773816	3
	Kobe	4.496067	1.0794439	3
	Pakchong	2.963100	0.4803455	3
	Purple	2.544267	0.1968556	3
	Indian	2.876333	0.7261176	3
	Dwarf	5.640267	1.5990616	3
	Total	4.086829	1.7177953	21
Mg	Taiwan	1.364300	0.1502191	3
	Zanzibar	1.387600	0.0798487	3
	Kobe	1.152400	0.2072552	3
	Pakchong	1.257833	0.2087908	3
	Purple	1.044900	0.3517401	3
	Indian	1.536567	0.2224764	3
	Dwarf	1.586800	0.1879160	3
	Total	1.332914	0.2589678	21
K	Taiwan	33.024433	5.6926356	3
	Zanzibar	40.351433	5.9291911	3
	Kobe	36.385500	6.0952629	3
	Pakchong	20.202167	7.1671270	3
	Purple	26.181000	7.3999715	3
	Indian	28.835733	2.2453893	3
	Dwarf	36.341867	1.8104324	3
	Total	31.617448	8.0965272	21
Na	Taiwan	0.639967	0.7910346	3
	Zanzibar	2.213933	0.3943260	3
	Kobe	1.014867	1.3151398	3
	Pakchong	0.301467	0.1275629	3
	Purple	0.193867	0.0229927	3
	Indian	0.310700	0.1627337	3
	Dwarf	0.572167	0.8620780	3
	Total	0.749567	0.8796555	21
P	Taiwan	5.629300	0.7346290	3
	Zanzibar	5.139633	2.0759743	3
	Kobe	5.411167	0.5370983	3
	Pakchong	4.048333	1.3733737	3
	Purple	4.433533	0.9821534	3
	Indian	4.046700	1.2280833	3
	Dwarf	4.683400	0.3768305	3

	Total	4.770295	1.1539058	21
Zn	Taiwan	25.382867	1.4004271	3
	Zanzibar	23.059600	2.0140411	3
	Kobe	23.547567	3.0738745	3
	Pakchong	21.506033	3.1279542	3
	Purple	21.690667	5.6627607	3
	Indian	26.435900	1.8959027	3
	Dwarf	28.813667	4.7160874	3
	Total	24.348043	3.8388816	21
Cu	Taiwan	8.165367	0.5447019	3
	Zanzibar	11.260333	1.0712500	3
	Kobe	12.193000	0.3441237	3
	Pakchong	8.494967	0.6227536	3
	Purple	9.123367	1.0411623	3
	Indian	8.902433	1.3739003	3
	Dwarf	10.022667	1.3727330	3
	Total	9.737448	1.6457901	21
Mn	Taiwan	76.689767	7.3568394	3
	Zanzibar	79.567467	12.9612482	3
	Kobe	93.092000	9.9898061	3
	Pakchong	71.175767	6.0216069	3
	Purple	81.755300	3.9454365	3
	Indian	77.991333	29.8266598	3
	Dwarf	157.353333	41.7587460	3
	Total	91.089281	33.3054858	21
Fe	Taiwan	113.923667	12.0570024	3
	Zanzibar	116.379233	3.2938609	3
	Kobe	138.757767	27.4468324	3
	Pakchong	86.626233	11.3257052	3
	Purple	120.231233	7.8539477	3
	Indian	134.194167	24.4846520	3
	Dwarf	240.746400	87.3211141	3
	Total	135.836957	55.7995127	21

Table of homogenous subsets of minerals composition in Napier grass varieties.

Ca

Duncan

Treatment	N	Subset		
		1	2	3
Purple	3	2.544267		
Indian	3	2.876333		
Pakchong	3	2.963100		
Taiwan	3	3.584467	3.584467	
Kobe	3	4.496067	4.496067	4.496067
Dwarf	3		5.640267	5.640267
Zanzibar	3			6.503300
Sig.		0.073	0.051	0.056

Mg

Duncan

Treatment	N	Subset		
		1	2	3
Purple	3	1.044900		
Kobe	3	1.152400	1.152400	
Pakchong	3	1.257833	1.257833	1.257833
Taian	3	1.364300	1.364300	1.364300
Zanzibar	3	1.387600	1.387600	1.387600
Indian	3		1.536567	1.536567
Dwarf	3			1.586800
Sig.		0.098	0.066	0.111

K

Duncan

Treatment	N	Subset		
		1	2	3
Pakchong	3	20.202167		
Purple	3	26.181000	26.181000	
Indian	3	28.835733	28.835733	
Taiwan	3		33.024433	33.024433
Dwarf	3		36.341867	36.341867
Kobe	3		36.385500	36.385500
Zanzibar	3			40.351433
Sig.		0.093	0.061	0.160

Na

Duncan

Treatment	N	Subset	
		1	2
Purple	3	0.193867	
Pakchong	3	0.301467	
Indian	3	0.310700	
Dwarf	3	0.572167	
Taiwan	3	0.639967	
Kobe	3	1.014867	1.014867
Zanzibar	3		2.213933
Sig.		0.209	0.050

P

Duncan

Treatment	N	Subset
		1
Indian	3	4.046700
Pakchong	3	4.048333
Purple	3	4.433533
Dwarf	3	4.683400
Zanzibar	3	5.139633
Kobe	3	5.411167
Taiwan	3	5.629300
Sig.		0.162

Zn

Duncan

Treatment	N	Subset	
		1	2
Pakchong	3	21.506033	
Purple	3	21.690667	
Zanzibar	3	23.059600	23.059600
Kobe	3	23.547567	23.547567
Taiwan	3	25.382867	25.382867
Indian	3	26.435900	26.435900
Dwarf	3		28.813667
Sig.		0.138	0.084

Cu

Duncan

Treatment	N	Subset		
		1	2	3

Taiwan	3	8.165367		
Pakchong	3	8.494967		
Indian	3	8.902433		
Purple	3	9.123367		
Dwarf	3	10.022667	10.022667	
Zanzibar	3		11.260333	11.260333
Kobe	3			12.193000
Sig.		0.054	0.147	0.266

Mn

Duncan

Treatment	**N**	**Subset**	
		1	**2**
Pakchong	3	71.175767	
Taiwan	3	76.689767	
Indian	3	77.991333	
Zanzibar	3	79.567467	
Purple	3	81.755300	
Kobe	3	93.092000	
Dwarf	3		157.353333
Sig.		0.263	1.000

Fe

Duncan

Treatment	**N**	**Subset**	
		1	**2**
Pakchong	3	86.626233	
Taiwan	3	113.923667	
Zanzibar	3	116.379233	
Purple	3	120.231233	
Indian	3	134.194167	
Kobe	3	138.757767	
Dwarf	3		240.746400
Sig.		0.138	1.000

Table of descriptive statistic of soil and goat manure.

	Treatment	Mean	Std. Deviation	N
Ca	Manure	25.084200	1.4886012	2
	Soil (before)	11.449450	0.0357089	2
	Soil (after)	4.252800	0.3360171	2
	Total	13.595483	9.4878208	6
Mg	Manure	3.570000	0.1197839	2
	Soil (before)	12.377950	0.0178898	2
	Soil (after)	3.657450	2.9153305	2
	Total	6.535133	4.7103500	6
K	Manure	2.559500	0.4012124	2
	Soil (before)	5.000000	0.0055154	2
	Soil (after)	1.327250	0.2605688	2
	Total	2.962250	1.6855037	6
Na	Manure	1.049550	0.1190061	2
	Soil (before)	2.228350	0.0217082	2
	Soil (after)	0.904950	0.1959393	2
	Total	1.394283	0.6574096	6
P	Manure	13.373650	0.3349565	2
	Soil (before)	10.808050	4.7140688	2
	Soil (after)	7.020200	0.4999245	2
	Total	10.400633	3.5622705	6
Zn	Manure	72.526350	0.1488460	2
	Soil (before)	6.146450	0.0357089	2
	Soil (after)	4.313100	0.0999849	2
	Total	27.661967	34.7615687	6
Cu	Manure	18.421050	0.7443713	2
	Soil (before)	2.378750	0.0214253	2
	Soil (after)	2.959600	0.0571342	2
	Total	7.919800	8.1452312	6
Mn	Manure	289.000000	6.1778505	2
	Soil (before)	55.348450	0.0071418	2
	Soil (after)	44.979800	17.9991203	2
	Total	129.776083	123.7145182	6
Fe	Manure	150.421050	6.4012256	2
	Soil (before)	8.024750	0.0335876	2
	Soil (after)	9.415650	2.8119515	2
	Total	55.953817	73.2434202	6