COMPARISON OF CANE GROWTH PERFORMANCE PLANTED IN PEAT AND MINERAL SOIL

By

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Dedicated to:

My dearest Abah and Mak,

Beloved Brothers and Sister.

Thank you for all the supports given

Always love all of you

ABSTRACT

Growing juice cane on mineral soil has fewer obstacles compare with peat, except mineral land is more preferably used for commercial purposes. The potential of growing juice cane in peat soil as correspond to mineral soil was evaluated in this study. *Madu* variety were planted on mineral soil (MS) and peat soil (PS) with three replicates for each treatment in 18 L of pot. Both treatments were applied with N, P, and K fertilizer at the ratio 15:15:15. At the tillering (60D) and grand growth phase (120D), measurement of agronomic parameters and soil samples were collected for analysis. Agronomic parameters that have been measured were stem diameter and plant height of juice cane. Soil sample was collected to determine the total N and available P in MS and PS. Results from soil analysis and agronomic parameters were statistically test to access the potential use of peat soil in growing *Madu* juice as comparable in mineral soil. Results on plant height (34 - 43 cm), stem diameter (20 – 21 mm), total N (120 – 523 mg kg^{-1}), and available P (460 – 1,220 mg kg^{-1}) between PS and MS treatment were insignificant for both growth phases. In conclusion, succession of juice cane cultivation in peat soil is attainable provided with the initial installation of proper drainage system and efficient nutrient management.

ABSTRAK

Pertumbuhan tebu di tanah mineral mempunyai sedikit halangan dibandingkan dengan tanah gambut, kecuali tanah mineral lebih banyak digunakan untuk tujuan komersial. Varieti Madu ditanam mineral (MS) dan tanah gambut dengan tiga replikasi untuk setiap rawatan di dalam pasu 18 L. Kedua-dua rawatan dibaja dengan baja N, P, K, pada kadar 15:15:15. Semasa fasa percambahan anak pokok (60D) dan fasa tumbesaran (120D), ukuran parameter agronomik dan sample tanah dikumpulkan untuk analisis. Parameter agronomik yang diukur ialah diameter batang dan tinggi tebu. Sampel tanah yang dikumpul dianalisis untuk mengetahui jumlah keseluruhan N dan kedapatan P dalam MS dan PS. Hasil daripada agronomik parameter dan analisis tanah diuji secara statistik untuk mendapatkan potensi menggunakan tanah gambut untuk penanaman tebu Madu dibandingkan dengan tanah mineral. Keputusan terhadap tinggi pokok (34-43cm), diameter batang (20-21mm), keseluruhan N (120-533mg kg-1), dan kedapatan P (460-1220mg kg-1) diantara MS dan PS menunjukkan tidak signifikan untuk kedua-dua fasa pertumbuhan. Secara kesimpulan, kejayaan penanaman tebu Madu di tanah gambut boleh dicapai dengan penyeliaan sistem pengairan yang berkesan dan pengurusan nutrien yang efisyen.

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APPROVAL SHEET

I certify that this research project report entitled "Comparison of Cane Growth Performance Planted in Peat and Mineral Soil" has been examined and approved as a partial fullfillment of the requirement for the degree of Bachelor Science of Bioindustry in the Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Sarawak Campus.

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CHAPTER 1

INTRODUCTION

1.1 Background

In Malaysia sugar industry can be categorized as increasing and fast growing industry. This development is supported by the food processing industry and by a small domestic production. The cultivation of sugarcane in Malaysia is run as a small scale among local farmers and mostly found in the state of Kedah and Perlis. These two states have a distinct dry season which is essential to produce sugarcane at effective cost. Other states that has potential for sugarcane expansion is Johor and Sarawak.

Approximately about 20,000 and 24,000 ha of Malaysia land had already being planted with sugarcane (FAO 1997). However, continuous land development and a shift of interest among farmer for oil palm and rubber had caused a declination of cane cultivation area. Sugar cane yield have increased steadily over year, the increases of yield is contributed from the improving of varieties and the greater input use.

One of ways to increase cane productivity is by expanding total cultivation area by developing potential area in Johor and Sarawak. However, the major problem in these two potential states is the land was mostly covered by the peat soil. Chew and Joseph (1976) reported the total area of peat soil in Malaysia was 23,610 km^2 composed of 8,090 km^2 in Peninsular Malaysia and 14,660 km^2 in Sarawak. Before cane cultivation on peat soil will take place, proper investigation on land suitability and plant growth should be conducted to reduce low productivity as resulted by different soil properties.

As for cane, the crop itself has the ability to growth in the flooded condition due to the present of aeranchyma tissue. The utilization of peat soil for the juice cane cultivation can support the increasing consumption in Malaysia. Through this, problems of sugar and juice can supplies can be solved.

1.2 Objective

To evaluate the potential of growing cane in peat soil as correspond to mineral soil.

CHAPTER 2

LITERATURE REVIEW

2.1 Sugarcane Background

Sugarcane or *Saccharum spp*, is a Gramineae that is a grass family from the Andropogenae tribe (Matsuoka 2012). Sugarcane is a perennial grass that is grows well in tropical and sub-tropical region such in Asian country. Sugarcane consists of six species such as *S. officinarum, S. robustum, S. spontaneum, and S. barberi, S. sinense,* and *S. edule, S. officinarum* is resulted from complex introgression between *S.spontaneum.* Sugarcane is a C4 plant which stores carbohydrates as sucrose. Sugarcane provides the cheapest form of energy food with the lowest unit of land area per unit area of energy produced. Nowadays, commercialization of sugarcane has been recognized as food sweeter and bio-fuel since the crop substantial amount of ethanol (Izursa 2013)

2.1.1 Cane Cultivation

Proper selection of cane varieties for the cultivation in the subtropics is vital because of weather from the successful cultivation in the tropic region. Sugarcane was reported to be able to grow well in an ideal environment especially when irrigation system was provided during the growing season (Begum 2012). During the ripening period, the cane need relatively dry and sunshine hours are plentiful for the whole season. There is a positive correlation between the number of sunshine hours per year and the yield of sugar (Binbol 2006). There were four stages of the growth cycle for the sugarcane:

i. germination stage (21 days)

ii. tillering stage (60 days)

iii. grand growth stage (120 days)

iv. maturity (150 days)

Sugarcane was vegetative propagated through sett, whole stalks or segmented stalk according to the variety or cultivar (Department of Health and Ageing, Australia 2008). The crop also can be propagated by allowing the re-growth of the stem of the stools that remain in the soil after harvesting of the previous cane.

2.1.2 Morphology and Physiology of Cane

Water viability is very important throughout cane growth stages (Zingaretti *et al.* 2011). As water resources become limited, the development of more efficient cultivar for water usage is extremely important. The molecular approaches concerning sugarcane response to stress have been conducted by using techniques based on hybridization and the comparison of sensitive tolerant cultivar. It is well known that gene expression alteration can promote adaptation to water stress. The mechanism involves a complex network of signaling molecule, gene responsive to stress and regulation of sugarcane plant hormone.

Rocha *et al.* (2007), described genes differentially expressed by sugarcane cultivar sensitive to water deficit. Their result indicates that drought elicit changes mostly in the late experimental phase 72h and 120h after the onset of drought. About 88% of drought responsive genes were detected as differentially expressed exclusively after 72h and or 120h of water deprivation. Using macro array technology and water stress tolerant cultivar, verified that plant response starts with stress recognition at a cellular level and activation of signal transduction pathways.

The tolerant and sensitive cultivar of sugarcane were compared, it is possible to conclude that the tolerant to water deficit in sugarcane cultivar may be related to the early perception of stress signal mediated by calcium (Ca) intracellular level. Considering that Ca^{2+} function as second messenger in signal transduction and the transient Ca^{2+} influx into the cell cytoplasm will stimulate stomatal closure and the ion transport pathway. This signal transduction will increase abscisic acid (ABA) content and consequently the induction of transcriptional factors, stomal closure, increasing proline synthesis and the entire cellular response to drought. In sensitive cultivar, they exhibit a late perception stress. There no transient increase of Ca^{2+} influx into the cell cytoplasm so there was any osmo-protection induced (Rocha *et al.* 2007)

2.2 Factors Affecting Cane Cultivation

There were many factors involve in the cane cultivation such as water, temperature and nutrient availability (Nazir 2013). Temperature will also affect the germination of sugarcane. Optimum temperature for cane germination is about 32°C to 38°C (Department of Health and Ageing, Australia 2008). The second stages in the growth phase of cane have correlation with the total rainfall (Binbol 2006). Whereas, excessive rainfall is unsuitable for the young cane plant. Evaporation means have strong positive relationship with sugarcane yield. The internal moisture relation in sugarcane is dominant factor in the synthesis and translocation of sugars. High evaporation is favorable for the sucrose build up process.

Sugarcane requires around 1,100 – 2,000 mm per annual season of water depending on the local climatic factors and crop age. Excess water in soil system may induce leaching of nutrient beyond root zone and may create O_2 stress that able to retard normal plant growth. Sugarcane in general grows well up to soil moisture retention

2.2.1 Pest and Diseases

In sugarcane cultivation there are pests such as plant hoppers (*Perkinsiella saccharicida)*, and vector of diseases that can limit cane yield (Croft *et al.* 2000). Pest can be grouped by feeding habit that is pests that feed on stalks of sugarcane or known as the stalk borers. Soil pest is the pests that feed on the subterranean parts of stools. The other group is the pests that feed on the plant sap and the pests that feed the sugarcane leaves. The major pests for each of group are examined for the controlling of pest by the biology, damage, and distribution. Pest status may vary from region to region according to the group.

In the commercial production of sugarcane there are many serious outbreaks of diseases that have occurred. Reasons why sugarcane is relatively susceptible to outbreaks was because the crop is grown over large, contiguous area (Rott 2013). The disease that normally attack sugarcane are Red rot, Common rust *Puccinia melanocephala* Sydow, Orange rust, smut *Ustilago sctaminea* Sydow and miscellaneous fungal diseases. Selection of varieties is important for the disease resistance.

The cost of controlling the major pest and disease of sugarcane in Australia was estimated to be $111 million in 1996 (McLeod *et al.* 1999). Sugarcane smut has become a serious threat to sugarcane industry in east coast Australia. The net loss from the overall pests and disease are less than 1% which is low compared with other country.

2.2.2 Fertilizer

Nitrogen (N) is applied in small amount 125 kg/ha (DOA Perak 2010) to sugarcane grown on the Histosol because of soil mineralization which will release large amount of N annually. Nitrogen is essential nutrient for sugarcane growth where low N uptakes can

limit leaf photosynthesis and sugar production (Morgan 2012). Accumulation of N ceased before biomass accumulation. Thus, N accumulation in crop reached a maximum at 198 and 151 days after planting (Morgan 2012).

Development of normal cane greatly depends on the presence of PO_4 solubility. Roles of P in the sugarcane development are to stimulate root growth, tillering and altogether with sufficient uptakes of N and P helps to facilitate cane ripening (Morgan 2012). Deficiency of P leads to reduce in number of tiller, delay in canopy closure, and stunted growth.

Potassium was absorbed by plant as K^+, is the most abundant cation accumulating in the cell sap of sugarcane. Among the function is as the enzyme activator in plant metabolism such as in photosynthesis, protein synthesis, starch formation and translocation of protein (Schachtman *et al.* 1998) and sugar. Deficiencies of K in cane will show first in the older leaves where the appearance of chlorosis and necrosis. Serious deficiency eventually will retard cane growth, where stalk and nodes, internodes become shorter. This was due to reduction rate of photosynthesis.

2.3 Cane Cultivation in Mineral

A well-drained loamy soil with neutral soil reaction with pH 6.5 to 7.5 and adequate nutrient and without soil compaction is considered an ideal soil for cane production. The soil should be loose and friable with a minimum depth of 45cm without any harmful salts. Cultivation techniques are largely determined by the physical properties in the soil (Hebsur 2001). In loamy soils with stable and crumb structure, preparation of the land for planning sugarcane cultivation would be relatively easier and limited to normal ploughing and formation of ridges and furrows at the required spacing.

The soil are harden due to clayey structure can be improve with cultivation practice such as the deep ploughing or chiseling would be necessary before formation of furrows. Sugarcane has the potential for deep rooting over 5 meters and crop growing in deep soils have appreciable drought tolerance. The soil should have bulk density below 1.4 mg/m^3 and porosity of about 50% which at field capacity would be occupied by air and water in almost equal proportion. Soil with bulk density more than 1.5 mg/m^3, there would be difficult for the growth and spread of roots (Sugarcane Breeding Inst.2014).

The mass of soil should have surface infiltration rate that are rapidly and free internal drainage. This due to the excess water from the rain and irrigation water can be readily absorbed (Ray 2009). The ground water table should be at not less than 1.5 to 2.0 m depth below the surface. Higher water table can cause to impeded drainage creating anaerobic condition which will negative affect the root system (Tetsushi 2007).

2.4 Peat Soil Characterization

Peat soil can be define as the accumulation of purely one 100 % organic matter and the distinction between soil and vegetative accumulation is not clear (Andriesse 1998). Peat is also referring as organic soil or Histosols. Peat soil contains at least 65% organic matter and less than 35% mineral content (Tie 1979). USDA defines a soil types as organic soils if more than half of the upper 80 cm of the soil is organic or if organic soil material of any thickness rests on rock or on fragmental material having interstices filled with organic material.

2.4.1 Physical Properties

There are four major components which make up the physical properties of the organic soil system, which are the organic material, the mineral material, water and air. The parameters commonly used to describe the physical properties of organic soil are the texture, loss on ignition, bulk density, porosity, wetting and drying process, moisture relationships, and hydrology (Sime Darby Services 1999).

Tie and Kueh (1979) reported very few bulk density determinations have was carried out on organic soils in Sarawak. The few measurements made gives bulk density values ranging from 0.05 g/cm^3 in fibric much undecomposed material, to less than 0.5 g/cm^3 in well decomposed sapric materials. The mean bulk density values reported for Sarawak organic soils were between 0.12g/cm^3 and 0.09 g/cm^3 (Andriesse 1988). The higher bulk density value of 7 to 8% of a mineral soil implies high pore space in organic soil.

Total pore spaces largely determine the water retention (Andriesse1998). In Sarawak, the organic material found in peat soil mostly consisted of raw and woody material. Therefore, soil porosity analysis is greater, 80-90 % and, resulting in high soil permeability. Drainage pore space are as high as 0.8. The drainable porosity is estimated over a three day period of Sarawak organic soils to be between 15 to 40% (Sime Darby Services 1999).

Subsidence is an important characteristic of drained organic soil Initial subsidence is mainly caused by consolidation when natural organic soils are drained. A saturated organic material layer is compressed due to loss of buoyancy after water table is lowered (Tie and Kueh 1979). Subsequently, compaction is followed by rapid decomposition of the exposed organic matter through biochemical oxidation. Subsidence depends to a

large extent on the depth of water table. In reclaimed peat land for agriculture, water table should be kept as high as possible according to the plant needs.

The bearing capacity of organic soil varies considerably with moisture content and generally improves with decreasing moisture content (Sime Darby Services 1999). Bearing capacity of soil is the power of foundation soil to hold forces from superstructure without undergoing failure (Prasad 2010). The bearing capacity is indirectly linked to the water table level in the soil. Other factors affecting bearing capacity are the fibers at the surface and the bulk density. This can be achieved through drainage, which will result in compaction and consolidation after drainage before proceeding with planting for agriculture. The mechanical compaction improves the bearing capacity by increasing the bulk density.

2.4.2 Chemical Properties

Soil acidity of organic soils in Sarawak has been found to be highly correlated with decomposition rate, the higher pH, and the greater the decomposition rate. Almost all organic soils in Sarawak are very low in pH ranging from 3.2 to 4.0 (Sime Darby Services 1999). Variation within this range is caused either by admixtures of mineral soil which generally increase pH or by specific location in the peat swamp (Andriesses 1988).

The mineral and peat component of soil have negatively charged sited on their surface which adsorb and hold cations by electrostatic force. In general terms, soil with large quantities of negative charge are more fertile because they retain more cations. Peat of is naturally acidic soil. As soils become more acidic the cation is replaced by H^+, Al^{3+}, and Mn^{2+}, this will produce CEC values much higher.

Organic carbon content determination in organic soils is important, interpret as C/N ratio. The C/N ratio is also an indication of the degree of humification of the organic material. The values can range from 12 – 60% (Andriesse 1988) organic carbon content commonly found to be higher at the surface than in the subsoil, the values ranging from 58% at the surface and 25% in the subsoil.

2.5 Challenges of Cane Cultivation in Peat Soil

There are many challenges in cane cultivation in peat soil such as oxidation of organic material and drainage. Maintaining a high water stable in peat soil is necessary to reduce organic matter oxidation and irreversible drying. For example, sugarcane grown in Florida on what was a marsh ecosystem drained for agricultural production in the 20th century (Synder 1994). The drained muck Histosols are often more than 85% organic matter (Synder 1994). Because the commercial management objective is usually to maintain the water table at 40 to 95 cm below the soil surface there has been widespread land subsidence. Approximately, 2.5 cm of soil per year were lost from the early 1900s to 1978 (Shih *et al.* 1978). Even with altered cropping systems, subsidence was still occurring at 1.4 cm/year (Shih 1998). Maintaining the soil in a wet, even water-saturated, condition could decrease oxidation and subsidence even further.

Drainage for the peat soil is also another challenge should be taken care. Drainage system is important to prevent the water logging especially during the monsoon season which can cause cane rot which can cause cane rot (Brady and Weil 2008). Drainage is needed during the monsoon season to control the water table and to remove excess surface and subsurface water from the land.

Associated with the subsidence is an increase in bulk density and decrease in porosity and infiltration capacity (Brady and Weil 2008). For an example the soil is compressed or compacted and subsequently the drainage is poorer. Most field operations cause some compaction. Increase in wheel pressures enhances compaction but operations conducted in wet soil co cause the most serious problems. As the soils becomes more complicated at the soil surface, which may in turn cause more compaction.

On fertile soil and with sufficient water supply, was sugarcane able to produce approximately eight tillers per plants. Whereas, on acid sulphate soil or peat soil with little or no fertilizers applied, tillering is reduced greatly, not more than 3 – 5 plant per hill. This will lead the farmer increase the density of planting. Maximum height of sugarcane can be 3.5 – 4 m at the harvesting time. At Hoa an, Mekong delta, 9 months old cane about to be harvested was only 145 to 250 cm high (Nga 1993). Plant also showed a low number of internodes, 18 – 23 per plant and internodes were about 5 to 12 cm long (Nga 1993). These yield components reflect well the nutritional and water supply status of sugarcane.

On peat soil, nutrient management is complicate by the soil is naturally low fertility, high carbon content and very acid pH (Brady and Weil 2008). Poor nutrient management can result in crop failure or make the cost of producing a good crop economically unsustainable. Peat soil is low in soil fertility with the common limiting elements are N, P, K, Ca, Mg, Fe, B, Cu, Mo, Zn and Mn (Brady and Weil 2008). Many of these elements react with other and some interaction can lead to nutrient deficiencies or toxicities. Deficiencies in both macro and micro nutrient are one of the long term problem associated with the production of cane on the peat soil.

CHAPTER 3

MATERIALS AND METHODS

3.1 Site of Study

This study was conducted at the Horticulture and Nursery Unit of University Putra Malaysia Bintulu Sarawak Campus.

3.2 Application of Treatment

There were two soil types used as a treatment in this experimental studies, where MS and PS represent juice cane that planted on different soil type which is mineral (Bekenu Series) and peat soil (Table 3.1) Both of the treatments were fertilized with N, P, K at rate of 15:15:15, as recommended by DOA Perak (2010). Three replications were applied to all treatments planted with Madu variety.

Table 3.1 Type of treatments and mediums applied to examine juice cane growth performance

Treatment	N: P: K (DOA Perak 2010)
MS (mineral soil)	15: 15: 15
PS (peat soil)	15: 15: 15

Experimental Design

Experimental design used in this study was Complete Randomized Design (CRD).

3.3 Field Planting

About 20cm length of cane cutting was collected from the Kuala Tatau area, Bintulu. The sett comprise of three nodes was sow in germination tray on Bekenu Series. After 21 days, only healthy germinated setts were transplant into 18L pot. Fertilizers were applied according to cane growth phase. The watering activities were performed daily according to the cane growth requirement of juice cane. In each cane growth phase, soil sample were collected and analyzed.

3.4 Growth Performance and Soil Analysis

Assessment on Tebu Madu growth performance planted in different soil types was monitored into two ways, agronomic parameter and soil physiochemical properties. The agronomic parameters consist of measurement of plant height and stem diameter. While, determination on soil physio-chemical properties were consisted of soil pH_{H2O}, total N, K, and available P.

3.4.1 Agronomic Parameter

Plant Height

The plant heights were measured from growing point of soil surface up to shoot. The collected data are used for comparing between the growth performance of juice cane grown in mineral soil and peat soil. Related data was collected during tillering and grand growth phase.

Stem Diameter

The stem diameters were measured in the middle part of the plant and collected during tillering and grand growth phase. All collected data on plant height and stem diameter

were used to access soil compatibility (i.e. between peat and mineral soil) to grow cane after standard crop management had been applied (DOA, Perak 2010).

3.4.2 Soil Analysis

pH $_{H2O}$

10 g of air dried soil were weighted in plastic vial. Then 25 ml distilled water were added, stopper and shake by using orbital shaker model 720 at 180 rpm for 15 minute. The soil sample was leaved for 24 hours. pH were measured with pH meter model AB 15 . Read pH in the scale of pH. Rinse electrode with distilled water and place it preferably in the buffer solution of pH 7.0.

Determination of Total Nitrogen

0.5 g soil (sieved to pass 0.5mm) was weighed and put into 50 ml Kjedhal digestion tubes. The soil were wetted with few drops of water and added with 5 ml (96% H_2SO_4). One tablet of Kjedhal catalys were added, shake the samples and allowed them to equilibrate for 30 minutes. The samples were heated in a digestion block at 180°C for 1 hour and then at 320°C for 5 hours until sample become colourless. Then, the samples were allowed to cool down. 30 ml distilled water were added, the sand fraction if any should be left in Kjedhal flask. Make up to volume when the solution is cool.

10 ml of the sample were pipette into distillation apparatus. Add 10 ml of NaOH (40%). Distil and collect distillate in 10 ml of 2% (H_3BO_3) boric acid indicator solution. The colour changed from purple to green during distillation. About 2% boric acid indicator is prepared by weighing 80 g of pure boric acid (H_3BO_3) in a 5 L flask marked to indicate a volume of 4 L. 3500 ml of water were added, heated and swirled

until boric acid dissolve and then allowed it to cool. 80 ml of mixed indicator (0.099g bromocresolgreen + 0.066 g methyl red) were added in 100 ml of ethanol. 0.1 M of NaOH was added until the solution becomes reddish purple with pH 5.0. Make up the solution to 4L with distilled water. 50ml conical flask containing the distillate was removed when twice of the original volume (20 ml) is obtained. Titrate against 0.01M HCl or 0.01 H_2SO_4 until the colour changes from green to purple. Percentage N in soil is calculated as in Equation 2.1.

$$\%N = \left[(V - B) \times M \times R \times \frac{14.01}{wt} \times 1000\right] \times 100 \qquad (2.1)$$

The description for each abbreviation used Equation 2.1 is:

V = volume of 0.01 M HCl or 0.01 M H_2SO_4 titrated for sample (ml)
B = digested blank titration volume (ml)
M = molarity of HCl or H_2SO_4 solution
14.01 = atomic weight of N (g/mol)
R = ratio between total volume of the digest and the digest volume used for distillation
wt = weight of air dry soil (g)

Determination of Phosphorus

5g of soil were weight in a 250 ml Erlenmeyer flask. 50 ml of extracting solution mixture was added and shake mechanically at 180 rpm for 15 minutes. The supernatant was filtered using Whatman (No. 2) into a plastic vial. 2 ml of extract solution were pipette into 50 ml volumetric flask and 8 ml of Reagent B were added made up with distilled water.

1. Reagent A preparation

   12 g of $[(NH4)_6\ Mo7O_24.H_2O]$ Ammonium molybdate dissolve in 250 distilled water. 0.2908 g Potassium antimony tartrate ($KSbO.C_4H_4O_6$), dissolved in 100 ml distilled water. Using 2 L volumetric flask dilute 148 ml concentrated H_2SO_4 in 1 L of distilled water (5.76M of H_2SO_4). Ammonium molybdate solution were added into 5.76 M of H_2SO_4 mix thoroughly and allowed cooling at room temperature approximately in 1 hour. Potassium antimony tartrate were added solution and make up to 2 L with distilled water. Mix thoroughly and leave overnight.

2. Reagent B is prepared fresh

   1.32 g ascorbic acid dissolves in 250 ml of reagent A.

3. Standard P solution

   4.3935 g KH_2PO_4 dissolve in 1 L of distilled water (1000ppm). Pipette 5 ml of KH_2PO_4 solution (1000 ppm) into 1 L volumetric flask and made up to 1 L with distilled water to produce 1L of stock solution with 5ppm.

4. Calibration standard (Fresh on experiment)

   8 ml of reagent B is pipetting into 50 ml volumetric flask containing 0 ml, 1 ml, 2 ml, 3 ml, 4 ml, 5ml, and 6ml of stock solution P. Made up with distilled water and wait for colour development. Analyst the samples prepared by using UVspectrometer. The absorbance should be measured at 820nm.

Determination of Potassium (single dry ashing)

Dried air sample was placed in an oven and dry it at 60°C for 24 hours. Cool the sample in the desiccators. 1 g of this ground and dried sample was place into crucible. Place the sample in a muffle furnace and initially ash at 300°Cfor 1 hour. The temperature was raised to 520°C and continues with the ashing for 4 to 5 hours and allows the sample to cool down before inspection. The sample in the dish should turn white. If not, add few drops of HNO_3, evaporates to dryness and place in furnace and ash it again as described. Few drops of distilled water were added to the sample followed by 2 ml of concentrated HCl. Evaporate the sample to dryness in a fume chamber using a hot plate. 10 ml of 20 % HNO_3 (20% HNO_3= 200 ml HNO_3 in 1 L of distilled water) were added to the sample and place in a water bath for 1 hour. Filter the sample through Whatman filter paper (No 2) into 100 ml volumetric flask and make up to volume. Determine total cation K using AAS.

3.5 Statistical Analysis

Result on plant height, stem diameter, total N, pH, and available P of MS and PS were compared by using T-test analyzing using SAS version 9.1.

CHAPTER 4

RESULTS

4.1 Soil Characterization

Results on the selected soil physicochemical properties between mineral (MS) and peat soil (PS) are shown in Table 4.1. A result on soil pH for MS (5.54) has exhibited that the value was in an acceptable range as recommended by Sugarcane Breeding Institute (2010) for sugarcane cultivation 5.5 to 6.5. Whereas, pH of PS was strongly acidic (3.8), thus may affect nutrients availability and cane growth performance if improper soil management had been applied respectively (Pratseted 1966). As for moisture content, it was observed that PS (78%) contains 26 times greater than MS soil (3.3%). This phenomenon was common since peat has been reported to have high water holding capacity due to the organic matter enrichment (Brady and Weil 2008).

The percentage of the (TOC) between MS and PS was also significantly different. Generally, results on the total percentage of TOC measured in MS and PS were 3.2 x 10^{-3}% and 4.6 x 10^{-2}%, respectively. It has been reported previously that, soil with large amounts of organic carbon will as well contains substantial amounts of N (Mohamed 2002). Similar relationship was observed between TOC in peat and MS soil (Table 4.1). Analysis on soil N has exhibits that PS contains 1.87 g/kg N compare to 0.43 g/kg, which were four folds greater that MS. Theoretically, such concentrations were sufficient enough for crop growth (Mohamed 2002).

Results on available P between MS and PS exhibit that the value were relatively small different (Table 4.1). Available phosphorus in MS was780 mg/kg and 105 mg/kg in PS. Apparently, differences in soil physical and chemical properties between mineral soil (MS) and peat soil (PS) will affect the nutrient availability and influence the growth performance of juice cane (Section 5.2).

Table 4.1 Soil physio-chemical properties of mineral soils (MS) and peat soil (PS) used in this investigation

Soil Characteristics	Soil type	
	Mineral	Peat
pH	5.54	3.80
MC (%)	3.27	77.42
TOC (%)	3.2×10^{-3}	4.6×10^{-2}
Total N (g/kg)	0.43	1.87
Available P (mg/kg)	780	105

4.2 Agronomic Parameter

Figure 4.1 (a) shows the results on stem diameter of T. Madu planted in peat soil (PS) and mineral soil (MS). Results from the T-test analysis shows that the stem diameter and plant height of juice cane planted in the MS and PS have insignificant different in both tillering and grand growth phase ($p = 0.05$). For both growth phases, results on stem diameter obtained by T. Madu were in the range of 13-15 mm and 20mm, respectively. During grand growth phase, there were insignificant different between MS and PS for stem diameter. These indicate that, the cultivation of juice cane on peat soil exhibits similar plant growth effects as planted in mineral soil. The planted cane was able to survive in the flooded conditions. However, at grand growth phase the cane planted in MS exhibit higher mean in compared to PS. This showed that, the efficiency of cane planted on PS was decline with time.

The plant height (Figure 4.1) of T. Madu during tillering and grand growth phase shows insignificant different observed between cane planted on mineral soil (MS) and peat soil (PS). The range of plant height for both MS and PS soils was 18 – 34 cm and 22 – 43 cm, respectively. It can been summarized from the figure, that an application of N:P:K at 15:15:15 on peat soil exhibits similar plant growth in terms of plant height and stem diameter which probably related to soil properties. Effects of fertilization towards soil and juice cane growth performance are further explains in Section 5.1.

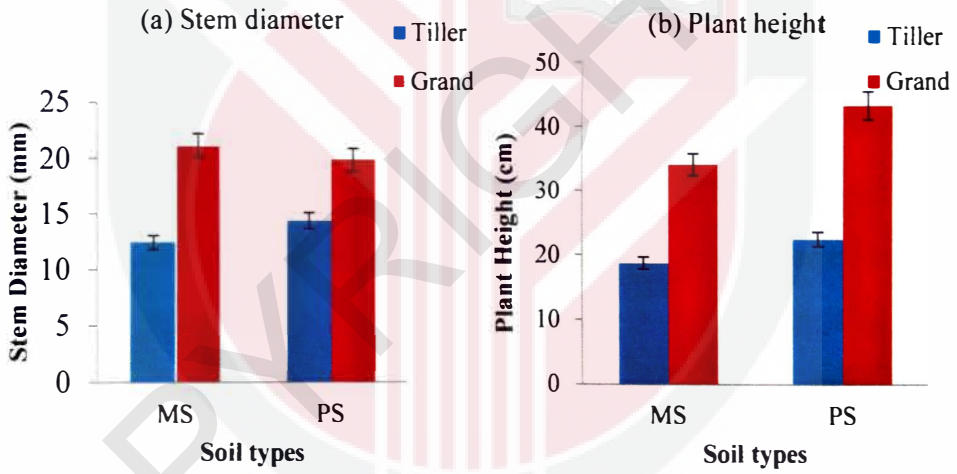

Figure 4.1 Stem diameter (a) and plant height (b) of juice cane planted in mineral soil and peat soil

Table 4.2 shows the number of tillers produced by juice cane in comparing plant growth performance after planted in mineral soil (MS) and peat soil (PS). Both MS and PS treatments indicates insignificant results on the number of tillers produce at

Table 4.2 Number of tillers produced by cane planted in mineral soil and peat soil

Soil types	Number of tiller
Mineral soil	7
Peat soil	6

4.3 Soil Analysis

4.3.1 Available P in Soil

Results from statistical analysis shows that there were significant different for the available P between MS and PS ($p= 0.05$) for both of growth phase (Figure 4.2).Figure 4.2 (a) shows that in tillering phase there was significantly different on $P_{avai.}$ where MS result was 209.93 mg kg^{-1} higher than PS (82.14 mg kg^{-1}). Whereas the results of P_{avai} in MS (1224 mg kg^{-1}) at the grand growth phase exhibits three times higher than PS (469.72 mg kg^{-1}). It was observed that the concentration of P_{avai} was elevated from tillering growth to grand growth phase for both soil types. It was predicted, cane planted in PS at some extent might experience P deficiencies after comparing P availability at both plant phases. Most studied in P uptake by plant stated thatthe uptake was pH dependent (Schachtman *et al.*1998). Highest P uptakes occur at pH between pH 5.0 and 6.

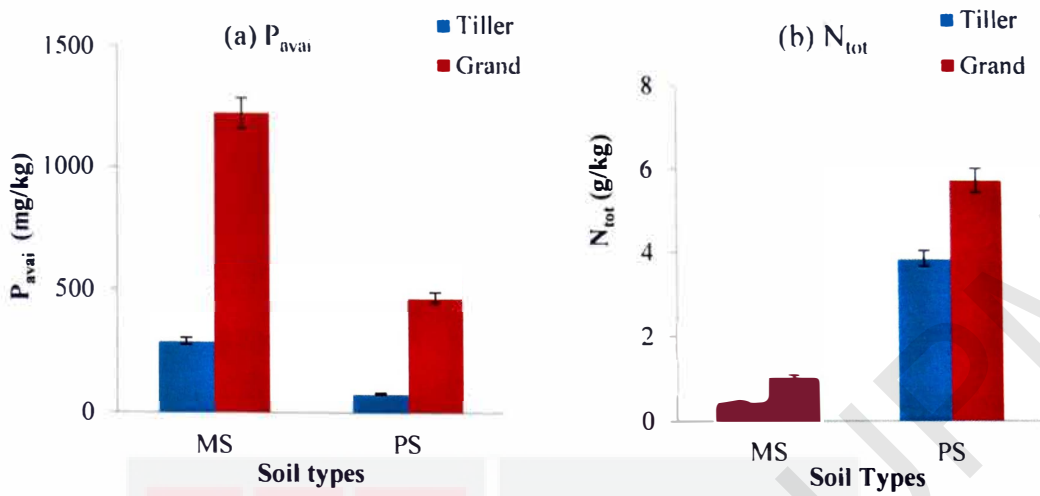

Figure 4.2 Available phosphorus (a) and total nitrogen (b) in mineral soil (MS) and peat soil (PS) planted with Madu variety at different growth phases

4.3.2 Total N

Figure 4.2 (b) shows the total of N in soil used for comparing cultivation of juice cane on mineral soil (MS) and peat soil (PS). Results from T-test shows that total N for the same soil (PS or MS) was insignificantly different between growth phases (tillering and grand growth). However, significant results ($p \leq 0.05$) on N_{tot} had been observed between soil types regardless at plant growth phase; about eight folds higher.

The elevated concentrations of N_{tot} in PS were signified by the large amounts of organic matter which will release N upon decomposition (Mohamed 2002). Indirectly, such conditions had been reported to improve nutrient uptake and accelerate plant growth rate (Morgan 2012). At grand growth phase, about 1.05 g/kg N and 5.69 g/kg N was measured in MS and PS soil which potentially can be absorbed by cane.

4.3.3 pH uzo

Results on soil pH measured between mineral soil (MS) and peat soil (PS) that had been planted with T. Madu was shown by Table 4.3. Only MS soil exhibits compatible pH values (5.6 -6.52) when results at both plant phases were compare to the recommended pH for sugarcane cultivation, pH5 – pH6.5 (Sugarcane Breeding Inst. 2010). Meanwhile for PS treatment, soil pH was found to be strongly acidic throughout plant growth which may affects nutrients availability and plant uptakes. The consequences of soil acidity towards juice cane cultivation are further explained in Section 5.1.

Table 4.3Soil pH based on plant growth phases

Growth phase	Mineral soil	Peat soil
Tillering	6.52	4.61
Grand growth	5.61	4.26

CHAPTER 5

DISCUSSION

5.1 Juice Cane Growth Performance Planted in Mineral and Peat Soil

Application of N: P: K at 15:15:15 for juice cane that being planted on peat soil was sufficient since comparable growth has been exhibited with MS in term of plant height, stem diameter, and number of tillers (Figure 4.1 and Table 4.2). This was resulted by the sufficient amounts of macronutrients (i.e. N, P, and K) that has been absorbed and utilized appropriately according to plant growth (James 2004). Differences on soil properties between MS and PS such as pH, total N, TOC, moisture content, and soil bulk density (Table 4.1 and 4.3, and Figure 4.2) was irrelevant to produce a pronounce undesirable effects towards the overall growth of planted cane.

It was observed that peat soil contains large concentrations of N compare to mineral soil (Figure 4.2b) which related to the enrichment of soil organic matter as shown by Table 4.1 (Mohamed 2002). Decomposition of soil organic matter will eventually release N-NO_3^- thus enable for cane uptake (Brady and Weil 2008). Therefore, only small amounts of N fertilizer were required to fertilizer cane when planted in peat soil (Morgan 2012). The elevation of N in peat was further extended from tillering to grand growth (Figure 4.2) which probably related to N application. Theoretically, application of chemical fertilizer at the appropriate rate (such as urea and triple super phosphate) will lead to absorb of sufficient amount of nutrients to allow any crop being well developed regardless of soil fertility since N (from fertilization) is in the readily forms (Brady and Weil 2008).

Although complexation of P was common in peat soil (Schachtman *et al.* 1998), observation on P deficiency in cane was absent when results on crop growth were compare with mineral soil (Figures 4.1 – 4.2). Apparently, P concentration in peat soil was elevated from 82.14 mg kg^{-1} (tillering stage) to 469.72 mg kg^{-1} (grand growth stage), and such reaction may involves with the decomposition of organic matter (humic and fulvic acid) that eventually releases OM-P (Brady and Weil 2008). The released of OM-P altogether with P fertilization, may substantially have elevated the available P in soil solution for cane uptake, as shown in stem diameter and plant height.

5.2 Prediction of Peat Soil for Juice Cane Cultivation

Successful cultivation of juice cane on peat soil (Figures 4.1 -4.2) was obtained from this experiment regardless of different soil physiochemical properties exists between mineral and peat soil (EASF 2013). Therefore, cane cultivation on peat soil Malaysia especially for small state holder can be introduced thus able to increase their monthly income. Although peat soil was naturally more acidic, have greater water retention, low bulk density, and lack in nutrients especially P. (Table 4.1), such problems can be resolved by following proper crop management practices (EASF 2013; McCray 2008; Nga *et al.* 1993).It was suggested, proper drainage system must be installed over peatland area before any industrial crops can be cultivated (Brady and Weil 2008; Mohamed 2002; Nga et al 1993) to avoid land subsidence and irreversible drying. In order to increase the efficiency of P uptakes, it was recommended for P to be applied using a broadcasting method at the last preparatory tillage and mixed thoroughly with the soil (Das 2006).

Since Malaysian received between 2,000 to 4,000 mm year^{-1} (FAO) rainfalls annually and has a tropical climate, suggestion on planting session has been given DOA Perak (2010). The recommendation was proposed prior to reduce crop damage as resulted by heavy rainfall and unexpected flood in the peat area. According to DOA Perak (2010), the best time for cane cultivation should be after the monsoon season. Hence the best month for cane cultivation in Sarawak should be start at the middle of July till September, where the state is experiencing dry season which allow crop to grow successfully. As for the cane, the crop itself doesn't exhibits substantial problem in terms of pest and diseases, leaning problem, and have higher grow abilities if planted over peat soil area. Thus, farmers should take advantage of this opportunity to grow juice cane in peat soil area either for export purposes or local consumption.

CHAPTER 6

CONCLUSION

Cultivation of juice cane on peat soil as correspond to mineral soil was achievable based on the results from agronomic growth and soil fertility. However, deficiency of phosphorus as well as other nutrients may occur thus limit root development and crop maturation when improper soil management had been applied. These are resulted from the leaching, irreversible drying, decomposition, and volatilization of peat soil as influence by changed in weather. It was suggested with proper drainage installation, a correct method and rate of NPK fertilization and appropriate planting time will increase cane productivity.

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PUBLICATION OF THE PROJECT UNDERTAKING

This is to certify that I have no objection to publish the project entitled "Comparison of Cane Growth Performance Planted in Peat and Mineral Soil" by the supervisor in a joint authorship. However, it has to be evaluated by the Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Sarawak Campus and published in the form approved by the Faculty.

Sabariah Bt Mohd Sharif

Date: