The Effect of Green Manure (Leaves of *Gliricidia maculata* and *Mimosa pigra)* on the Growth of Roselle (*Hibiscus sabdariffa*) Grown on BRIS Soil

By,

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DECLARATION

I declare that this thesis entitled "The Effect of Green Manure (Leaves of *Gliricidia maculata* and *Mimosa pigra)* on the Growth of Roselle (*Hibiscus sabdariffa*) Grown on BRIS Soil" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ________________________________

Name : ________________________________

Date : ________________________________

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LIST OF ABBREVIATIONS

BRIS	Beaches Ridges Interspersed with Swales
ANOVA	analysis of variance
RGR	Relative Growth Rate
GP	Germination percentage
CRD	Complete Randomized Design
Cm	Centimeter
g	gram
Kg	Kilogram

LIST OF SYMBOLS

%	Percentage
℃	degree Celsius

LIST OF EQUATIONS

Effect of Green Manure (Leaves of *Gliricidia maculata* and *Mimosa pigra)* on the Growth of Roselle (*Hibiscus sabdariffa*) Grown on BRIS Soil

ABSTRACT

Beach Ridges Interspersed with Swales (BRIS) soil has a physical characteristic as sandy soil which limits the growth performance. It was considered among problematic soil in Malaysia since it has a lower water retention and deficiency nutrient. This study was expected to improve the soil fertility of BRIS soil so that it can be developed for agriculture production. The objective of this research was to evaluate the effect of *Mimosa pigra* and *Gliricidia maculata* to amount of soil and to determine the effectiveness between *Mimosa pigra* and *Gliricidia maculata* on the growth of *Hibiscus sabdariffa*. The growth parameters that are being analyze for 8 weeks is the plant's height, the number of plant's leaf and the Relative Growth Rate (RGR). This experiment was carried out as a factorial experiment based on a complete randomized design with four replications. The results show that all growth parameters showed significance different on quantity of BRIS soil at ($p \leq 0.05$) while the type of green manure shows that it has a significance difference on RGR with p=0.018. *G.maculata* showed it effectiveness on RGR with mean of 0.0243 compared to *M.pigra*. Green manure showed beneficial effect based on the growth performance of *Hibiscus sabdariffa* which showed that plants provided green manure tend to grow healthy. Therefore, the use of green manure for cultivation of *H.sabdariffa* is recommended in order to reduce the use of chemical fertilizer which is harmful to environment.

Kesan Baja Hijau (Daun *Gliricidia maculata* dan *Mimosa pigra)* Kepada Pertumbuhan Pokok Roselle (*Hibiscus sabdariffa*) Ditanam di Tanah BRIS

ABSTRAK

Tanah permatang pantai berselang dengan tanah swales (BRIS) mempunyai ciri-ciri fizikal tanah berpasir yang menghadkan prestasi pertumbuhan. Tanah ini dikategorikan sebagai tanah yang bermasalah di Malaysia disebabkan ia mempunyai pengekalan air yang rendah dan kekurangan nutrien. Kajian ini dijangka akan meningkatkan kesuburan tanah BRIS supaya ia berpotensi berkembang menjadi pengeluaran pertanian. Objektif kajian ini adalah untuk menilai kesan baja hijau kepada kuantiti tanah Bris dan untuk menentukan keberkesanan di antara daun *Gliricidia maculata* dan *Mimosa pigra* kepada pertumbuhan *Hibiscus sabdariffa*. Kadar pertumbuhan yang dianalisa selama 8 minggu adalah ketinggian pokok, bilangan daun tumbuhan dan kadar pertumbuhan relative (RGR). Eksperimen ini dijalankan sebagai uji kaji faktorial berdasarkan reka bentuk rawak yang lengkap dengan empat ulangan. Hasil kajian menunjukkan bahawa semua parameter tumbuhan mempunyai kadar yang berbeza pada quantity tanah pada ($p \leq 0.05$) manakala jenis baja hijau menunjukkan ia mempunyai perbezaan yang signifikan pada RGR pada p= 0.018. G.maculata menunjukkan keberkesanan kepada RGR pada 0.0243 berbanding *M.pigra*. Baja hijau memberikan manfaat kepada pertumbuhan pokok berdasarkan kadar pertumbuhan *Hibiscus sabdariffa* yang menunjukkan tumbuhan yand dicampur baja hijau cenderung untuk membesar dengan sihat. Oleh itu, penggunaan baja hijau dalam bidang pertanian adalah disyorkan untuk mengurangkan penggunaan baja kimia yang boleh membahayakan alam sekitar.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

As the years passed, the land in our earth is decreasing. The lands that are previously filled with forest and plant are now developed into a grown city. This is due to the increasing in human population and density that contribute to this change. The increasing of human population urges the action of clearing land for agriculture to suppress human necessity.

In order to develop agriculture, a suitable soil is needed in plantation of any crop. The soil in our earth is not an entirely suitable for crop plantation since there are some type of soil that are known as problematic soils. In Malaysia there are four types of soils that are called as problematic soil which is BRIS soil, highly weathered soil, acid sulphate soil and peat soil. They were called as problematic soil because these soils have a natural characteristic which limiting the crop growth and need special management technique or practices for crop production (Lah *et al.*, 2011) .

BRIS which is stand for Beach ridges interspersed with swales is a type of soil that is mostly found in the coastal area in Peninsular Malaysia which is Terengganu, Pahang, and Kelantan with 155 400 hectares. It can also founded in Sabah but the area covered is only 40 000 hectares (Lah *et al*., 2011) .The most wide area that have this type of soil located in Terengganu. The sand from the sea formed from the erosion of layers of steep cliffs which has a coarse sand component during the monsoon seasons contributed in the formation of BRIS soil. (Nossin, 1964, Lah et al., 2011)

BRIS soil is not suitable for plantation, therefore there already have many attempted that have been made in order to improve the BRIS soil fertility to utilize all the soil that was left unused because of its inability to produce. Some of the attempted is the addition of organic and inorganic fertilizer, addition of compost and green manure (Hadi *et al*., 2013).

The most outstanding problem that make BRIS soil only suitable for certain plant is the physical characteristic which limited the plantation. BRIS soil which have a sandy soil have a difficulties in keeping the soil in a moisture state(Ishaq *et al*., 2014). Besides, without the moisture in the soil any microorganism cannot withstand in the soil which will not provide any nutrient. The addition of compost or green manure in the BRIS soil to help in improving the soil is good in making the soil more compact. This will allow the improvement in the soil fertility. Any sandy soils that have been improved can be a lot more productive.

The use of green manure have been considered as an ecofriendly practices since there will be no chemical involve (Talgre *et al.*, 2009). Nowadays, the use of fertilizers has been spread out which increase the agriculture pollution. Green manure will utilize the leaves of the tree that are easily found alongside the road.

Bris soil is not commercially exploited for plantation crops but the present land use grown annual crops like tobacco, groundnuts, watermelons, sweet potato and vegetables. Over the years, coastal region in Peninsular Malaysia used BRIS soil to plant the Tobacco, which used to be a profitable crop (Hadi *et al.*, 2014). Tobacco is the main role that contributed in rural economies but it is not an edible plant.

Nowadays, this plantation is being changed into some plants that are more eco-friendly such as Roselle *(Hibiscus sabdariffa)* and Kenaf *(Hibiscus cannabis)* as requested from government of Malaysia. *(Hadi et al*., 2014) There are limited data on the plantation of Roselle compared to Kenaf (*Hibiscus cannabis*)since there are already many research on Kenaf (*Hibiscus cannabis*) made by MARDI (Malisa *et al*., 2011). Kenaf (*Hibiscus cannabis*) is an important industrial crop since it can produced raw material for fiber based industries and paper production. This will decrease the issues on deforestation. Meanwhile, Roselle is known as an important cash crop especially in Terengganu since it promote large plantation of Roselle.

In Malaysia, the productions of Roselle have increased after it was being promoted as a multi-used plant (Mohamed *et al.*, 2012). There are many farmers that are interested in planting the Roselle since it gives a highly income.

1.2 Problem Statement

BRIS soil is known for its problematic soil due to only a few crops that can survive in this type of soil. Previous studies showed us that BRIS soil is weakly structured, having low water retention capacity, deficiency nutrient and having a high soil temperature. A good management practices are needed in order to grow a crop successfully. BRIS soil can develop into a potentially agriculture, a good watering schedule and green manure should be optimally used. In order to optimize the soil improvement, a good watering schedule and the addition of green manure is the best solution.

1.2 Objective

The objectives in this study are:

1) To evaluate the effect of *Gliricidia maculata* and *Mimosa pigra* to the amount of soil media on the growth of *Hibiscus sabdarifa.*
2) To determine the effectiveness of *Gliricidia maculata* and *Mimosa pigra* leaves as green manure.

CHAPTER 2

LITERATURE REVIEW

2.1 BRIS soil

BRIS soil can be found about 0.2 – 8.0 km from the beach. There are many soil series in BRIS soil such as Baging, Rhu Tapai, Rudua and Jambu series which is defined by their profile morphology and chemical properties. Rhu Tapai, Rudua and Jambu series are classified as spodosol since they have a spodic layer at depths of 0 – 50, 50 – 100 and 100 – 150 cm respectively. (Roslan *et al*., 2011) BRIS soil contain 82-99% sand particles mainly quartz, low cation exchange capacity of 9.53meq/100g with pH 4.3-4.4.

In order to grow a plant healthily, a good soil is needed. Air and water play an important role in the soil pore. The soil pore is necessary for the soil aeration, water movement, availability of plant nutrient and microbiological activities. However, BRIS soil is considered as unsuitable soil for plantation in their natural state.

BRIS soils have low nutrient retention and have few nutrients of their own (Hossain *et al*., 2011). This soil lack a particle that is responsible for holding the nutrient like other soil. Even when fertilizers are added, they wash away soon after application, leaving plants hungry. Because they naturally lack nutrients and cannot store nutrients provided by fertilizers, plants growing in BRIS soil cannot survive and even its survive, it will show nutrient deficiency symptoms like stunting, yellow leaves and sparse flowering or poor fruit production.

Other than that, BRIS soil lack of microorganisms because this soils have low moisture content and nutrients for these microorganisms survive (Hossain *et al.*, 2011). The plants that are planted on this type of soil will not get the benefit that the microorganisms provide such as the nutrient and mineral supply. Healthy soils which have many microscopic life forms will help plants grow by cycling nutrients in the soil. These microorganisms need the same conditions plants to provide a benefit which is consistent moisture and nutrients.

2.1.1 Soil moisture of BRIS soil

BRIS soils have a high temperature due to lack of plant growing in it and constant leaching process which reduces the moisture content. Based on the measurement of moisture content conducted *in situ*, it was found that the average temperature most of the BRIS soil is 31.2℃. 36℃ is the maximum temperature while 24℃ is the minimum (Ekhwan *et al*., 2009). This proved that BRIS soil have a low moisture content since the water is not stored for too long because of the speedily of vaporization of moisture to the surface.

Besides, BRIS soils have are large and coarse, with lots of air space between them. This allows water to enter the soil quickly, but also to drain away just as quickly, leaving plants high and dry just a few days after a good rainfall. Plants need consistent moisture to grow healthily, however this BRIS soil cannot store water because of its physical.

Soil moisture content play an important role in biophysical process such as seed germination, plant growth, and plant nutrition (Bittelli, 2011). The space between mineral and organic in soil is filled with water and air. If this space is filled with water without air then the soil is called saturated. When the space is filled with water and air again it is described as being in field capacity as the soil particles only holds a certain quantity.

Soil moisture deficit happen when the soil surface evaporates and the crop is consuming the water will make the water is less than the field capacity. The soil will meet wilting point when the water is decrease and is not enough for the plant to extract for its growth.

With the measurement of soil moisture content, the works in agriculture become easy with the optimization of irrigation volumes and schedule as well as plant nutrition. This also will keep the soil water deficit within the field capacity.

(Roslan *et al*., 2011) have studied how to improve the soil fertility in BRIS soil for the plantation of Kenaf (*Hibiscus cannabis*). This study lead them to a conclusion where in order to retain the water and plant nutrient, the soil should have been covered with different types of organic material such as rice straw. Then, the soil should have been irrigated during the dry time. This is because during the dry time, crop may suffer water stress that will stunt its growth.

2.2 Green manure

Green manure which is also called as the fertility building crops is a type of crops that are grown to improve soil fertility (Talgre et al., 2009). This is a practice where humus is being put into the soil. Green manure is divided into two group legumes and non- legumes.

Green manures are an ideal method of sustaining soil fertility in the tropics. The use of green manure will increase the organic matters; improve the richness of soil and helping in increasing crop yields (Talgre et al., 2009). However, green manure is not the only practices that can be done in order to improve the soil fertility. Other practices should also be utilize such as crop rotation, prioritizing soil moisture content and have a proper tillage.

Furthermore, green manure gives a big influence in the soil. With the addition of green manure, the soil moisture will be in a good condition since the soil that already compact with the humus will hold the water. This will decrease the soil rapid drying out from the process of evaporation. Besides that, green manure will lessen the extreme temperature in the soil. Other than that, green manure will improve the aeration in the soil by restrict the entrance of air.

Farmers have practices green manure using crop since long ago. Before the invention of fertilizer using chemical, farmers use paddy straws and mulching it on the plantation. Other than improving the soil fertility, it also preventing any pest from intervene the plantation. It was proved by the student of Faculty of Agricultural at the University Jaffna (Vakeesan *et al.*, 2008). There already have many farmers that have choose to use green manure but it was not fully practices by all farmers. In order to promote the benefit of green manure, more research should be done.

Using green manure in soil is considered as an ecofriendly practices. This is because green manure does not use any chemical. With the decreasing of using inorganic fertilizers and pesticide, the soil and water quality status have been improved. (Vakeesan *et al*.,2008) Nowadays, agriculture also contributes in pollution such as water pollution and soil pollution. The main reason is the addition of chemical fertilizer in plantation. When the fertilizer being sprayed, some of it will seep into the soil which will disrupt the soil nutrient then when there is a rainfall or irrigation, the chemical will flow into the stream. This is what contributing in agriculture pollution.

In Malaysia, the used of green manure using legumes have already begun since long ago. Farmers use cover crop in palm plantation and rubber plantation by planting this crop between each tree. The mostly used of green manure is the *Mucuna bracteata* which provide more biomass to the plantation. Other than that it prevent young palm from invasion of weeds and pests.

Gliricidia maculata and *Mimosa pigra* were used in this research to improve the soil fertility and soil structure.

2.2.1 *Gliricidia maculata*

Figure 2.1 *Gliricidia maculata*
Sources:http://www.tropicalforages.info/key/Forages/Media/Html/Gliricidia.html

Gliricidia maculata is an exotic plant from Central America and Mexico but it have been cultivated and spread widely in tropical America, the Caribbean, Africa and Asia. And now this plant become an endemic in Malaysia (Mohd Helmy Ibrahim *et al*; 2014). This plant is a fast-growing and it grows best in tropical which have a season of dry climate.

This tree which belongs to family Fabaceae is a medium sized leguminious tree that can grow up to 10-12 m high. It has a flower that colored in bright pink to lilac color which located at the end of the branches which have no leaves. The tree’s fruit is a pod which is green when unripe and becomes yellow-brown when it reaches maturity.

G.maculata is multipurpose plants that are second most useful after *Leucaena leucocephala.* This plant is widely used as a shade plantation crops and now it have many other purpose such as fodder, firewood, green manure, intercropping and rat poison and many more. These plants are really useful since it can fix nitrogen in the soil and can live on low soil fertility. Other than that, its leaves can be used a fodder for cattle, sheep and goats.

G.maculata is a potential green leaf manuring crop since this leaf have a nutrients addition that can improved the soil fertility. There are 21 kg N, 2.5 kg P and 18 kg K in the 1 t ha^{-1} leaf manures (Srinivasa R. *et al*., 2011)

2.2.2 *Mimosa pigra*

Figure 2.2 *Mimosa pigra*

Figure 2.2 above show *M. pigra* which is a leguminous prickly shrub. The name of '*mimosa*' is come from the Greek which mean to imitate or mimic. This is because some species of the genus seem to imitate animals by moving and folding up the sensitive leaflets when touched.

This plant is regarded as one of the worst alien invasive weeds of wetlands of tropical Africa, Asia and Australia. In Malaysia it was first noted in 1980 at peninsular state of Kelantan by farmers, who claimed that it had been introduced from Thailand to cure snake bites (Anwar, 2001).

This plant can grow up to 6 m which will be woody when it reached maturity. It has broad-based prickles which is 7mm long around the stem. The flowers have pink in colour which produces a cluster of seedpods. These seedpods will break into segment contained seed when matured. The ripe seed have a light brown or olive green in colour.

M. pigra germinate mostly in the start and end of wet season. It prefers a wet, tropical climate. It is mostly found in moist condition such as river banks. It has a fast growing seedling and after 4 to 12 month it will produce flower. After five weeks then the seed will ripe.

M. pigra can be used on the steep banks of water reservoirs as an erosion-control measure. Other than that, it has been used as a green manure and cover crop in Thailand since the 1960s.

2.3 *Hibiscus sabdariffa*

Figure 2.3: *Hibiscus sabdariffa*

Hibiscus sabdariffa as shown in Figure 2.3 which is also known as Roselle was introduced in Malaysia and being promoted by the department of agriculture of Terengganu to commercial planting it in the early 1990. Roselle is among 300 species of hibiscus in the world that belongs to the Malvaceae family. This plant is an herbal shrub plant.

This plant was believed to come from the west of Africa and have been carried away to the New World by slaves as a source of plant. There are many names given for this plant based on the countries such as *Sorrel* in Africa, *Karkade* in North Africa, *Krajeab* in Thailand and so on. Meanwhile, in Malaysia it was called as *Asam Susur, Asam Paya* or *Asam kumbang.*

Mahadevan *et al*.,(2009) has explained that Roselle's seed have a color shaped; light brown in color, 3-5mm long and the seed is covered with minute, stout and stellate hairs. When planted Roselle can grow up to 3.5m tall. The fruit from this plant is a velvety capsule about 1.25-2 cm long, which is green when immature then turn brown when it already matured.

In Malaysia, Roselle is mostly planted on sandy soil such as BRIS soil. Most of the crops grown on BRIS soil did not perform well however Roselle is suitable to be planted on this soil because it provides a well-aerated and deep rooting zone (Naimah *et al*., 2014 , Musa *et al*., 2006).

Roselle can tolerate a warm and humid tropical climate. Based on (Ismail *et al., 2008)* these plants require rain-fall of 1500-2000 mm/year and 12 hours of sunlight during the first one of growth due to prevent premature flowering. Germination of seed usually begins after 2-3 days after sown and it takes 3-4 months for the plants to reach maturity before the flowers can be harvested.

2.4 Seed germination

The process in which seed develop into a new plant is called germination. The seed need soil, water, oxygen and temperature in order to germinate. Water played an important role where it will provide special protein called enzymes to the seed. The seed will undergo a few steps in order to grow. Firstly, the seed will grow a root to get access of water in the soil. Then, it will grow the shoots where the leaves appear to harvest energy from the sun. (Anand *et al*., 2012)

Water is used during absorption and subsequent stages of growth, whereas oxygen is used for respiration and temperatures adequate for metabolism and growth of the plants. (Hartmann *et al*., 2002)

The depth of the seed being buried is also among a factor that hindering the germination of seed. These phenomena happen when a seed is being buried deep in the soil it cannot provide its own food by searching the light. After the stem breaks through the surface of the soil, the leaves open up to the sun and roots take in water, the plant can begin to make its own food.

CHAPTER 3

MATERIAL AND METHOD

3.1 Area of study

This study was conducted in Agro Park, UMK Jeli at the provided area from the Agro Park Department as shown in Figure 3.1 below.

Figure 3.1 Area provided for conducting study

3.2 Materials

The materials and apparatus that were used throughout the experiment listed in the Table 3.1.

Table3.1: List of material and apparatus.

Apparatus	**Materials**
Polybag (8cm x 20cm) 2kg	BRIS soil (20kg)
Wheelbarrow	Seed of Roselle
Laboratory oven	Water (15 liters)
Mini watering pot	NPK green fertilizer (100 g)
Shovel	*Gliricidia* leaves
Barbed wire (20m)	*M.pigra* leaves
Mulch plastic sheet (3m x 3m)	Insecticides (50 ml)
Netting black	Molluscide (50 g)
Ruler	
Soil moisture meter	
Measuring cylinder	

Materials that needed in this study is the seed of Roselle that were purchased from Federal Agricultural and Marketing Authority (FAMA) while the BRIS soils were bought from Bachok, Kelantan. Both *Gliricidia* and *M.pigra* were taken from the roadside in UMK Jeli area.

3.3 Methods

This experiment included 3 treatments which are the two different type of leaves of green manure, three different ratio of soil mixed with green manure using soil moisture level of 80% using 2x3x1 factorial experiment design. It is well explained using a table shown on Table 3.2.

Table 3.2: Factor that involves in the experiment's treatment

No	Treatment	Description
1.	Green manure	*Gliricidia*
		Mimosa pigra
2.	Germination media	Ratio 1:0
		(1 BRIS soil : 0 *Gliricidia*)
		(1 BRIS soil : 0 *M.pigra*)
		Ratio 1:1
		(1 BRIS soil : 1 *Gliricidia*)
		(1 BRIS soil : 1 *M.pigra*)
		Ratio 1:3
		(3 BRIS soil : 1 *Gliricidia*)
		(3 BRIS soil : 1 *M.pigra*)
3.	Soil moisture	80% field capacity

3.3.1 Soil structure test

BRIS soils were cleaned from any residue such as the root, leaves and living organism in the soil. Then inserted into the tall measuring cylinder then water were poured into it. After that, spatula was used to mix the BRIS soil with the water. Then it were leave for 2 days, each of the layer were marked and calculated.

3.3.2 Soil treatment

The leaves of *Gliricidia* and *M.pigra* were being clean and separated from its stem. Then the leaves of green manure were cut evenly using a knife separately. After that it will be mixed with BRIS soil using a variation of ratio needed into the black polybag. The (volume/volume) ratios that were used were 1:0 (1 Kg BRIS soil: 0 green manure), 1:1 (500 g BRIS soil: 500 g green manure), and 3:1 (750 g BRIS soil: 250 g of green manure). There will be 24 polybags altogether where 12 polybags are for BRIS soil mixed *G.maculata* and the other 12 polybags are for BRIS soil mixed *M.pigra*.

3.3.3 Determining soil moisture

Suitable time for watering schedule can be determined by testing the soil moisture. Water were poured into the polybag until the soil is saturated then it will be leave dry for 1 day. Then a soil moisture measurement is used to determine the moisture until it reached the soil moisture level that is 80%.

3.3.4 Seed pretreatment

Seed pre-treatment need to be done to reduce the seed dormancy. Roselle seed were treated using scarification method. This will allow the water and air to enter the seed to speed the germination. One pack of Roselle seed were cleaned and measured. 150 totals of Roselle seed out of one pack was the same size. All the seed was soaked in a container using distilled water for 24 hours. After that it will be leave on the wet towel for 7 days to get the seed germination percentage. A seed is considered germinated as soon as the cotyledon is above the media. All the germinated seeds were counted and the percentages of germinations were calculated using the equation 3.1 below.

$$\%\ GP = \frac{seed\ geminate}{total\ seed} \times 100\ \% \quad \text{.. (eq 3.1)}$$

Where:

GP = Germination Percentage

3.3.5 Seed sowing

24 plant of Roselle of the same height from the seed germination was sown about 1cm in the soil inside the polybag. The plants were irrigated once a day based on the determination of soil moisture. Weeding, fungicides and insecticides applications will be made when necessary.

3.3.6 Layout model of Complete Randomized Design (CRD)

All of the polybag were labelled from T1R1 until T6R4 based on 6 treatments with 4 replications is summarized in Table 3.3. These label was put on the outside of the polybag where T will represent as Treatment while R representing as Replication.

Table 3.3: Layout model treatment

Treatment	**Label**
(1 BRIS soil : 0 *G.maculata*)	T1R1,T1R2,T1R3,T1R4
(1 BRIS soil : 1 *G.maculata*)	T2R1,T2R2,T2R3,T2R4
(3 BRIS soil : 1 *G.maculata*)	T3R1,T3R2,T3R3,T3R4
(1 BRIS soil : 0 *M.pigra*)	T4R1,T4R2,T4R3,T4R4
(1 BRIS soil : 1 *M.pigra*)	T5R1,T5R2,T5R3,T5R4
(3 BRIS soil : 1 *M.pigra*)	T6R1,T6R2,T6R3,T6R4

After each of this polybag labeled, an arrangement of the placement is made randomly using the random number table as shown in Figure 3.2. The layout arrangement of the polybag will be made from picking the number based on the random number tables. The first two numbers from the vertical random digit was selected and marked in the box horizontally. All of the polybag were arranged based on the CRD layout design shown on Figure 3.3.

TABLE 1 - RANDOM DIGITS

11164	36318	75061	37674	26320	75100	10431	20418	19228	91792
21215	91791	76831	58678	87054	31687	93205	43685	19732	08468
10438	44482	66558	37649	08882	90870	12462	41810	01806	02977
36792	26236	33266	66583	60881	97395	20461	36742	02852	50564
73944	04773	12032	51414	82384	38370	00249	80709	72605	67497
49563	12872	14063	93104	78483	72717	68714	18048	25005	04151
64208	48237	41701	73117	33242	42314	83049	21933	92813	04763
51486	72875	38605	29341	80749	80151	33835	52602	79147	08868
99756	26360	64516	17971	48478	09610	04638	17141	09227	10606
71325	55217	13015	72907	00431	45117	33827	92873	02953	85474
65285	97198	12138	53010	94601	15838	16805	61004	43516	17020
17264	57327	38224	29301	31381	38109	34976	65692	98566	29550
95639	99754	31199	92558	68368	04985	51092	37780	40261	14479
61555	76404	86210	11808	12841	45147	97438	60022	12645	62000
78137	98768	04689	87130	79225	08153	84967	64539	79493	74917
62490	99215	84987	28759	19177	14733	24550	28067	68894	38490
24216	63444	21283	07044	92729	37284	13211	37485	10415	36457
16975	95428	33226	55903	31605	43817	22250	03918	46999	98501
59138	39542	71168	57609	91510	77904	74244	50940	31553	62562
29478	59652	50414	31966	87912	87154	12944	49862	96566	48825
96155	95009	27429	72918	08457	78134	48407	26061	58754	05326
29621	66583	62966	12468	20245	14015	04014	35713	03980	03024
12639	75291	71020	17265	41598	64074	64629	63293	53307	48766
14544	37134	54714	02401	63228	26831	19386	15457	17999	18306
83403	88827	09834	11333	68431	31706	26652	04711	34593	22561
67642	05204	30697	44806	96989	68403	85621	45556	35434	09532
64041	99011	14610	40273	09482	62864	01573	82274	81446	32477
17048	94523	97444	59904	16936	39384	97551	09620	63932	03091
93039	89416	52795	10631	09728	68202	20963	02477	55494	39563
82244	34392	96607	17220	51984	10753	76272	50985	97593	34320
96990	55244	70693	25255	40029	23289	48819	07159	60172	81697
09119	74803	97303	88701	51380	73143	98251	78635	27556	20712
57666	41204	47589	78364	38266	94393	70713	53388	79865	92069
46492	61594	26729	58272	81754	14648	77210	12923	53712	87771
08433	19172	08320	20839	13715	10597	17234	39355	74816	03363
10011	75004	86054	41190	10061	19660	03500	68412	57812	57929
92420	65431	16530	05547	10683	88102	30176	84750	10115	69220
35542	55865	07304	47010	43233	57022	52161	82976	47981	46588
86595	26247	18552	29491	33712	32285	64844	69395	41387	87195
72115	34985	58036	99137	47482	06204	24138	24272	16196	04393

Figure 3.2: Random number table

Source: http://www.rand.org/pubs/monograph_reports/randomdigit

T1R1	T2R1	T6R4	T5R1	T6R1	T4R2
T2R2	T6R2	T4R4	T3R3	T5R2	T5R4
T1R4	T2R4	T6R3	T1R3	T2R3	T3R2
T4R1	T1R2	T3R4	T3R1	T4R3	T5R3

Figure 3.3: Layout arrangements using complete randomized design

3.3.8 Data collection

Data on height growth were measured and the number of leaves was calculated weekly for 8 weeks. Height were measured from soil level to the highest shoot using a ruler while, the number of leaves were counted by calculating the fully open leaves.

At the end of the experiment, all of the plant were uprooted then washed to know the dry biomass. The plant was divided into two part that is top and bottom. The bottom part is the part from the collar of stem under the soil to the end of the root while the top part is the part from the collar of the stem on the soil to the tip of the plant. After that, the plant was weight before and after entering the oven to know the dry weight. Relative growth rate was calculated using the equation 3.2 below.

$$RGR = \frac{(\ln w_2 - ln\, w_1)}{(t_2 - t_1)} \quad \text{...(eq3. 2)}$$

Where:

w_2 = final weight

w_1 = initial weight

t_2 = final time taken

t_1 = initial time taken

RGR = relative growth rate

3.3.9 Statistical analysis

All the data collected were subjected to Analysis of variance (ANOVA) using Minitab 17 software statistical package (Minitab Inc. USA). After that, Tukey's Multiple Range Test was run to find the means that are significantly different to each other. Results will be considered significant at 5% probability level.

CHAPTER 4

RESULTS AND DISSCUSSION

4.1 Symbol of Treatments

Plant's height, total plant's leaf and relative growth rate for the whole plant which give a continuous data indicate the growth of *Hibiscus sabdariffa*. In this context, figures and tables provided to summarize the result. In order to help the reader, Table 4.1 below provides the symbols and their respective meaning, which are used in the discussion.

Table 4.1: Symbol in figure and table

No	Symbol	Explanation
1.	M1	Media 1 which consist of 1 Kg of BRIS soil
2.	M2	Media 2 which consist of 500 g of BRIS soil
3.	M3	Media 3 which consist of 750 g of BRIS soil
4.	T1	1 BRIS soil : 0 *Gliricidia maculate*
5.	T2	1 BRIS soil : 1 *Gliricidia maculate*
6.	T3	3 BRIS soil : 1 *Gliricidia maculate*
7.	T4	1 BRIS soil : 0 *Mimosa pigra*
8.	T5	1 BRIS soil : 1 *Mimosa pigra*
9.	T6	3 BRIS soil : 1 *Mimosa pigra*

4.2 Soil texture analysis

A soil texture analysis was conducted on the BRIS soil. This soil analysis determines the soil texture of the BRIS soil with exact percentage of particles size. The results are listed in table 4.2.

Table 4.2: soil texture analysis

Texture classes	Thickness of soil (cm)	Percentage (%)
Sand	2.772	92.40
Silt	0.144	4.80
Clay	0.084	2.80
Total	3.0	100

Based on the Figure 4.2 of soil texture triangle charts, the blue line indicates the percentage of the result in the analysis of texture. The intersection of the three lines which is corresponding to the three texture classes is in the region of sandy loam. By knowing these physical properties, the nature of the bris soil can be determined. The water holding capacity, nutrient, leaching rate, fertility and productivity of soil are able to be identified.

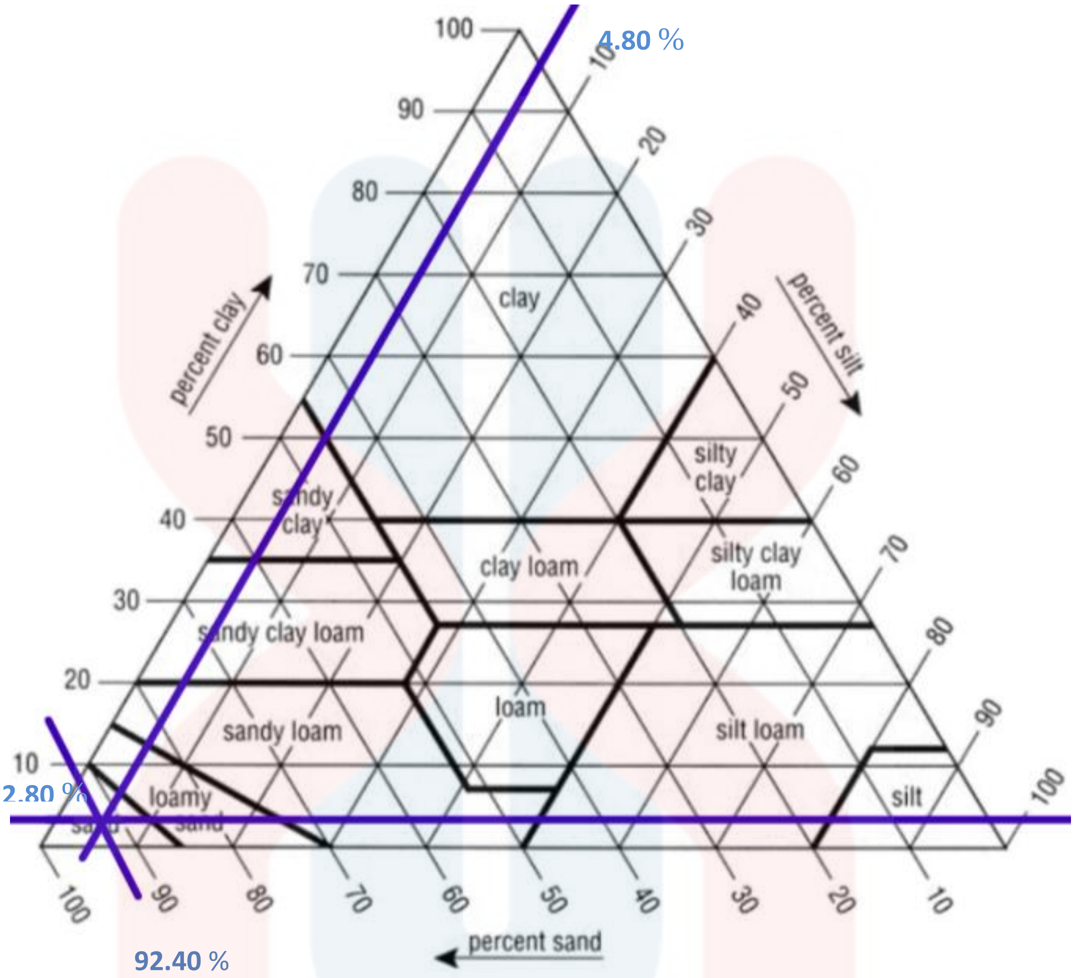

Figure 4.1 soil texture triangle charts
http://www.had2know.com/garden/classify-soil-texture-triangle-chart.html

Sandy soil has a high content of sand which makes it have a gritty feel. This type of soil is unable to retain water in the soil in over a long time. Previous studies conducted by Toriman et al. (2009) reported that due to the sandy structure of the soil frequent irrigation is recommended.

4.3 Seed germination

Figure 4.2: seed germination on the damp towel

Table 4.3: Total seed germination

Total seed	150
Total seed germinate	70

The result from the seed germination test is shown in figure 4.2 and table 4.3. Out of 150 seeds of Roselle only 47% are able to germinate.

4.4 Growth performance assessment

4.4.1 Plant's height

Figure 4.3 below showed the mean of plant's height from the first week until week 8. The graph showed continues increasing of height. The plant on week 1 until week 4 has grown with equal height. Starting week 5, all the plant in different treatment showed a rapid change. This is because the plant has started to exploit nutrients from the soil to meet their needs. At the end of the week treatment 3 showed the highest plant compared to the other 5 treatments. Meanwhile, treatment 1 and treatment 4 have showed more or less equal of height growth. The absence of the green manure in treatment 1 and treatment 4 make the plant stunted. The BRIS soil does not have enough nutrients to give to the plant that caused depressed plant growth (Jahan et al., 2014)

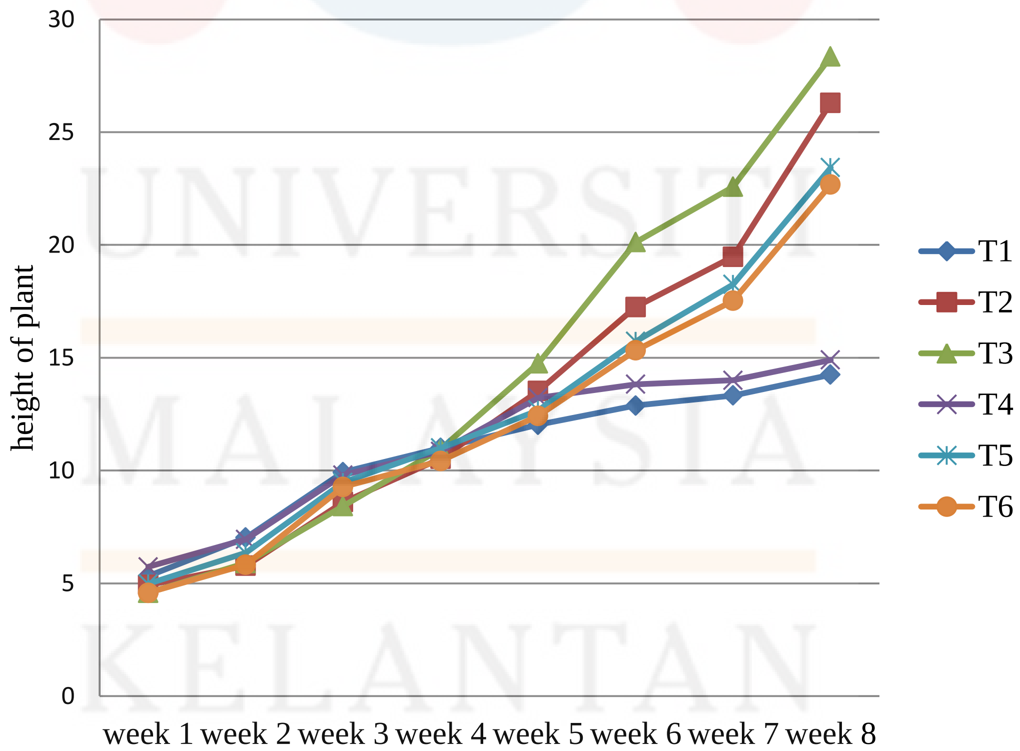

Figure 4.3: Changes in *Hibiscus Sabdariffa* plant's height during 8 weeks

4.4.2 Statistical analysis on plant's height

Table 4.4 below show the summary of ANOVA analysis on plant's height on week 1, week 4 and week 8 to show the growth of plant in 3 phases that is early growth, intermediate and final growth. In the first week, two-way ANOVA analysis showed that media significantly affect the plant height at ($p \leq 0.045$). The green manure showed that it was not significant at ($p = 1.000$). Both of the factor media and the green manure in the media were not significantly affect the plant height for fourth week. The analysis from week eighth indicated that the height of Roselle is highly affected by media ($p \leq 0.001$). However, the green manure type in the media still does not showed any significance influence on height growth and there was no interaction effect between soil media and green manure in three week.

Table 4.4: ANOVA analysis on week 1, week 4 and week 8

Sources	Week 1		Week 4		Week 8	
	f-value	p-value	f-value	p-value	f-value	p-value
Media	3.71	0.045 *	0.05	0.954 n.s	25.38	0.000 **
Green manure	0.33	1.000n.s	0.01	0.935 n.s	3.51	0.077 n.s
Media*green manure	0.49	0.620n.s	0.20	0.818 n.s	1.69	0.212 n.s

Note: * indicates significance difference at $p \leq 0.005$, ** indicates significance difference at $p \leq 0.001$, n.s indicates not significance difference at $p \leq 0.005$

Based on the ANOVA summary it showed that only week 1 and week 8 which have a significant value. Tukey's multiple range is run to test the means that are significantly different in media week 1 and week 8. The mean comparison based on Tukey's test between the media is summarized on Figure 4.5. On the early growth, Media 1 have the highest mean (5.525), meanwhile in the final growth the mean of plant's height in media 3 become the highest (25.5125). Media 2 in week 1 is not significantly different to both of media 1 and media 2. Both of media 2 and media 3 is significantly different to media 1 in week 8.

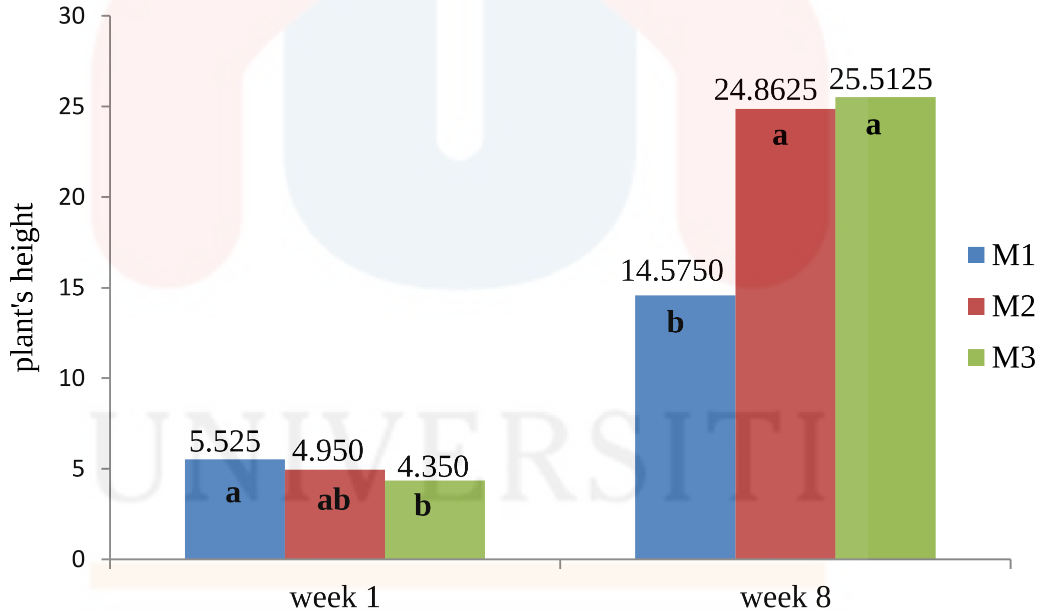

Figure 4.4 Mean comparisons between media in week 1 and week 8 on plant's height

4.5.3 Total plant's leaves

Figure 4.5 below is the summary of the changes of total leaf number for 8 weeks. The graph showed an increasing trend in leaf number. The total number of leaf on week 1 is 2 for all the plant and on week 3 all the plants have a total of 4 for the entire plant. The figure showed that treatment 3 which have 3:1 ratio have the highest number of leaves. Edogawata *et al.*, (2011) in the previous study have mentioned that frequent application of green manure is the key in higher productivity. Meanwhile, treatment 1 and treatment 4 have the lowest number of leaves. This is because since treatment 1 and treatment 4 are absence of green manure it is undergoing internal nutrient cycling process where the leaf will senescence itself so that it will give the soil nutrient for the plants growth. Besides, the lack of green manure which supplied nitrogen seemed have worsen the situation.

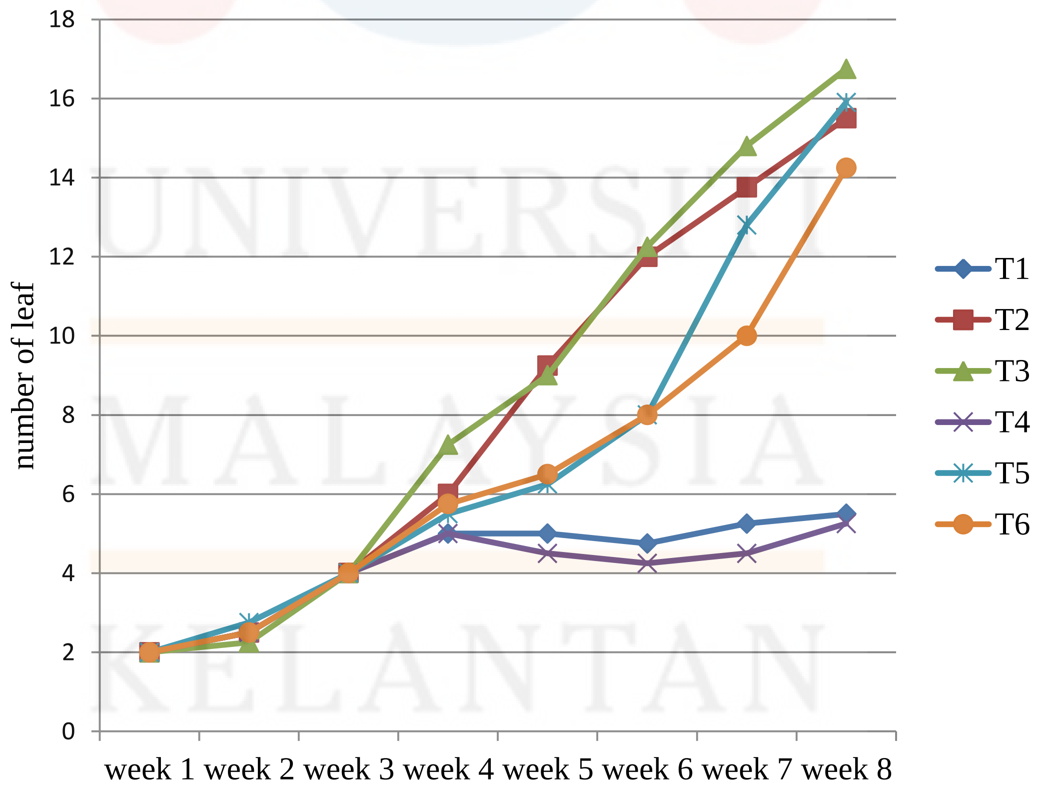

Figure 4.5: Changes in *Hibiscus sabdariffa* number of leaf during 8 weeks

4.4.4 Statistical analysis of total plant's leaf

The comparison of ANOVA was made on week 2, week 4 and week 8. No difference in leaf number for all treatment was observed at week 1 hence ANOVA analysis cannot run. The summary of ANOVA analysis is shown in table 4.5. On the second week which represent early growth, none of the factor had affected the number of leaves since all p value is higher than 0.05. The media is significantly affected the total number of leaves on p = 0.013 at intermediate growth while green manure and the interaction of green manure and media showed no significances. At final growth, ANOVA analysis indicated that soil media has a high significance effect on leaf number (p=0.000) while green manure and the interaction of green manure and media showed no significances.

Table 4.5: ANOVA analysis on week 2, week 4 and week 8

Sources	Week 2		Week 4		Week 8	
	f-value	p-value	f-value	p-value	f-value	p-value
Media	0.41	0.670 n.s	5.59	0.013 **	63.05	0.000**
Green manure	0.55	0.470 n.s	3.31	0.086n.s	1.50	0.236n.s
Media*green manure	0.14	0.873n.s	1.45	0.261n.s	0.65	0.534n.s

Note: * indicates significance difference at p ≤ 0.005, ** indicates significance difference at p ≤ 0.001, n.s indicates not significance difference at p ≤ 0.005

Based on the analysis of variance on total of plant's leaves, only soil media have significant effect on leaf number at week 4 and week 8. Figure 4.6 below showed the mean comparison between the media in week 4 and week 8. In the intermediate growth, the second media which have the same content of BRIS soil and green manure is not significantly different to Media 1 and Media 3. Meanwhile, in final growth Media 2 and Media 3 both are significantly different to Media 1. Both week showed that media 3 have the highest number of mean.

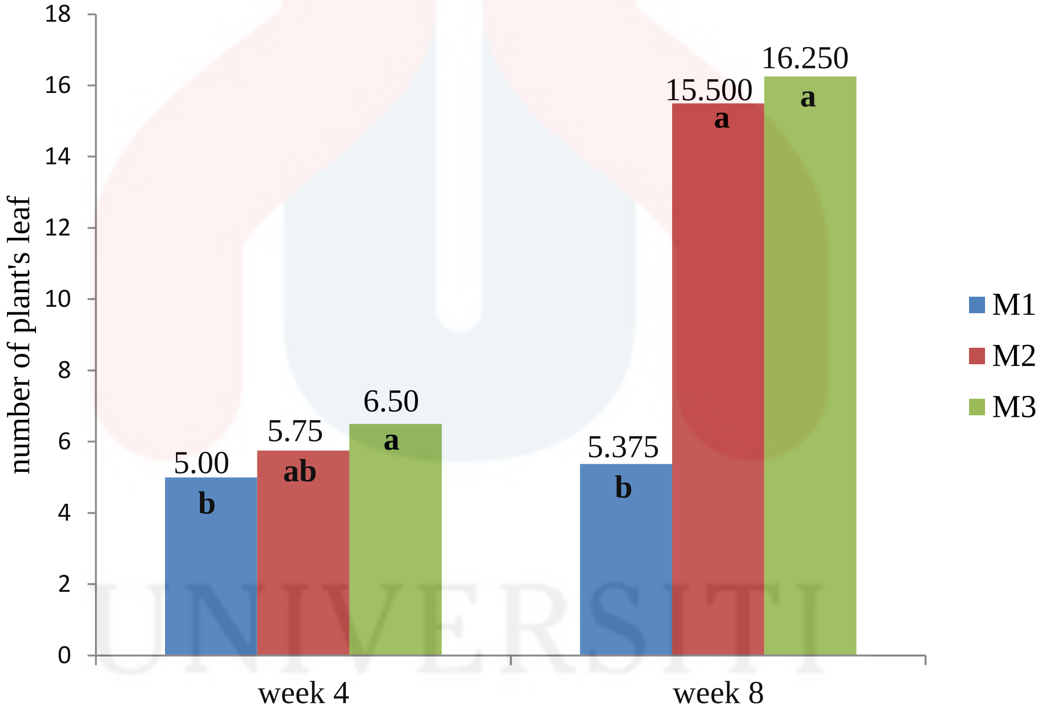

Figure 4.6 Mean comparisons between media in week 4 and week 8 on the number of leaf

4.4.7 Relative Growth Rate

Relative Growth Rate (RGR) is used to measure the speed growth of plant. The dry weight (biomass) of Roselle at the end of week 8 is used to calculate RGR. Figure 4.7 below showed the result of the mean comparison of RGR between 6 treatments. Webber and Bledsoe (2002) who study on Kenaf found that biomass increased along with the increase in plant height. It is showed in treatment 3 which is the highest plant among the treatments have the highest value of RGR. Green manure in treatment 3 helps in aiding the increasing of biomass. In the term of growth rate (RGR), the treatments can be arranged in order of: treatment 3 > treatment 2 > treatment 5 > treatment 6 > treatment 1 > treatment 4. Treatment 4 which does not contain any green manure showed the lowest RGR value.

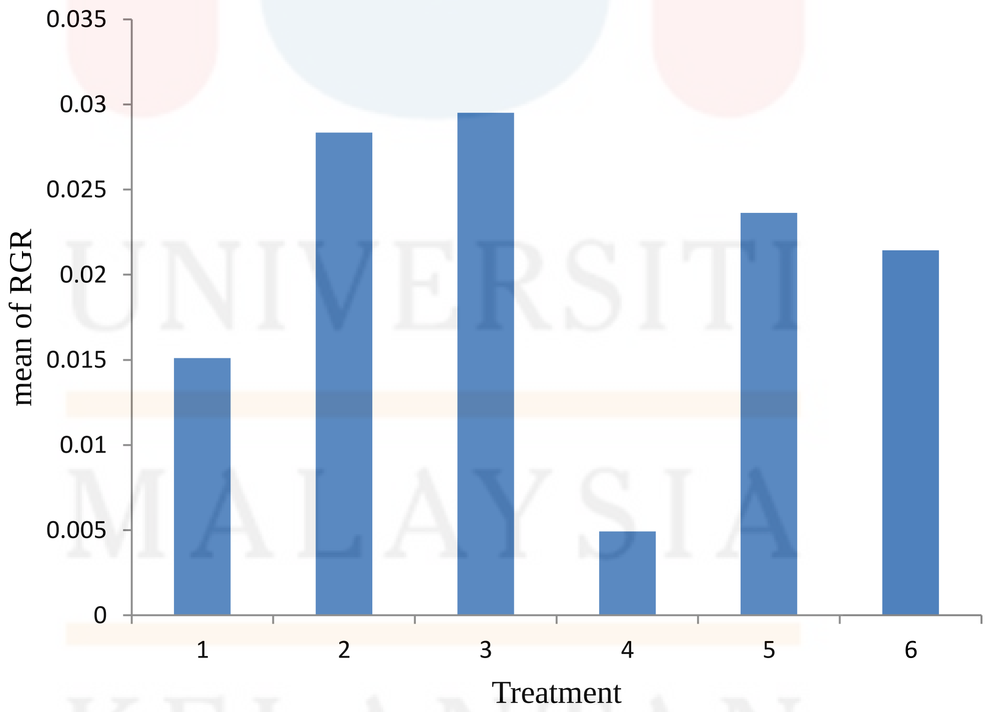

Figure 4.7 Mean of Relative Growth Rate between 6 treatments.

4.4.6 Statistical analysis of Relative Growth Rate

Table 4.6 is the summary of ANOVA of Relative Growth Rate for the plant. It showed that Relative Growth Rate (RGR) is highly affected by the soil media which resulted in a very high significance different value at ($p = 0.000$). The green manure type also showed significance effect on RGR ($p = 0.018$). However, there was no interaction effect between soil media and green manure type ($p = 0.752$).

Table 4.6 Analysis of variance on Relative Growth Rate

Source	Degree of Freedom	Sum of Square	Mean square	F- Value	P-value
Media	2	0.001318	0.000659	12.63	0.000***
green manure	1	0.000352	0.000352	6.75	0.018**
Media*green manure	2	0.000030	0.000015	0.29	0.752 n.s
Error	18	0.000939	0.000052		
Total	23	0.002639			

Note: * indicates significance difference at $p \leq 0.005$, n.s indicates not significance difference at $p \leq 0.005$

The analysis of variance clearly showed that Media and Green manure have a significant effect on growth rate of Roselle. Figure 4.7 below portrayed the mean comparison of soil media, where both Media 2 and Media 3 are significantly different to Media 1. Both of the green manure types which are *Gliricidia maculata* and *Mimosa pigra* are significantly different to each other (p=0.018).

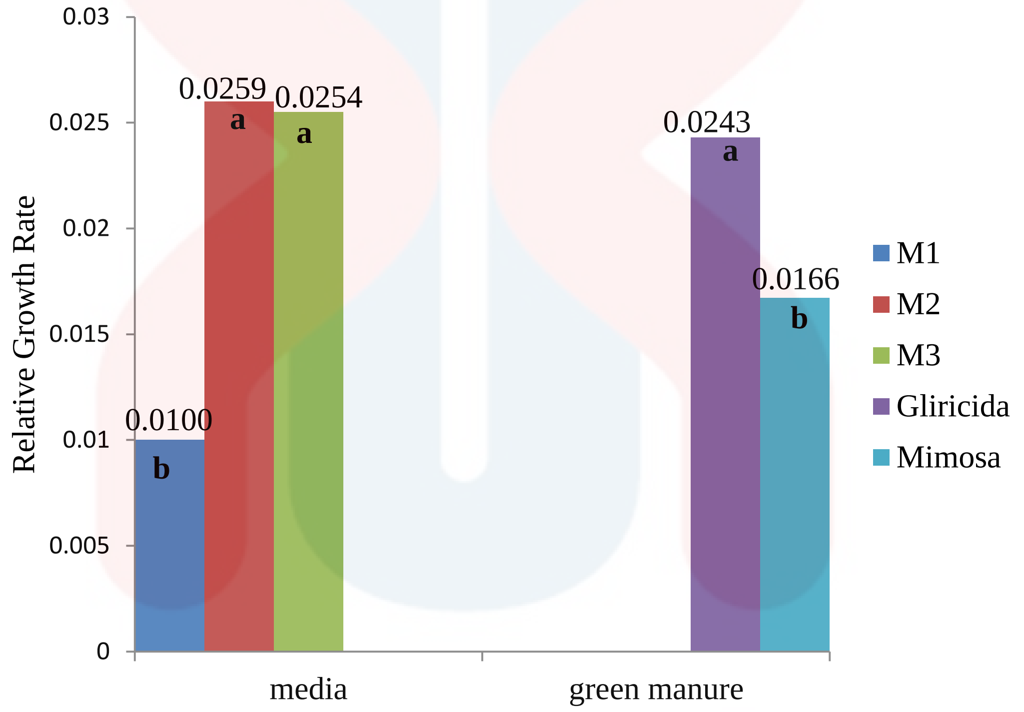

Figure 4.8 Mean comparisons in media and green manure

CHAPTER 5

CONCLUSION AND RECOMENDATIONS

Based on the result, studies found that the growth performance is highly affected type of soil media treatment. Plant growth pattern on Figure 4.3 and Figure 4.5 in chapter 4 showed that treatment 3 had the highest plant growth performance in terms of height, number of leaves and Relative Growth Rate.

The data of growth performance of Roselle were analysed using analysis of variance (ANOVA) to determine whether there are any effects of soil media treatment and green manure types. The analysis showed that all growth performance had the significance difference with the media. There were no significance differences in green manure for the growth performance except for the RGR.

As a conclusion, the variation of growth of different soil media showed that organic matter is very important for a healthy growth of Roselle on BRIS soil. Both *Gliricidia maculata* and *Mimosa pigra* gave provide benefit to the plant but the result of the present study showed no significant different between these two types of green manure. Perhaps the results would be different if greater amount of green manure is applied over a longer period of observation.

In terms of large scale agriculture, further study should be done in order to determine the optimum amount of green manure needed for BRIS soil. The use of green manure should be widened as it is an eco-friendly fertilizer. The use of chemical fertilizer can be reduced substantially and replaced with green manure in view of reducing the harmful effect of chemical fertilizer to the environment. For suggestion of the future study, it is best to have several different ratio of green manure to soil in order to know which ratio is the best.

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LIST OF APPENDICES

APPENDIX A: EXPERIMENTAL LOG

Figure A 1: Methodology of *Hibiscus sabdariffa* planted

Figure A 2: *Hibiscus sabdariffa* after being oven dried

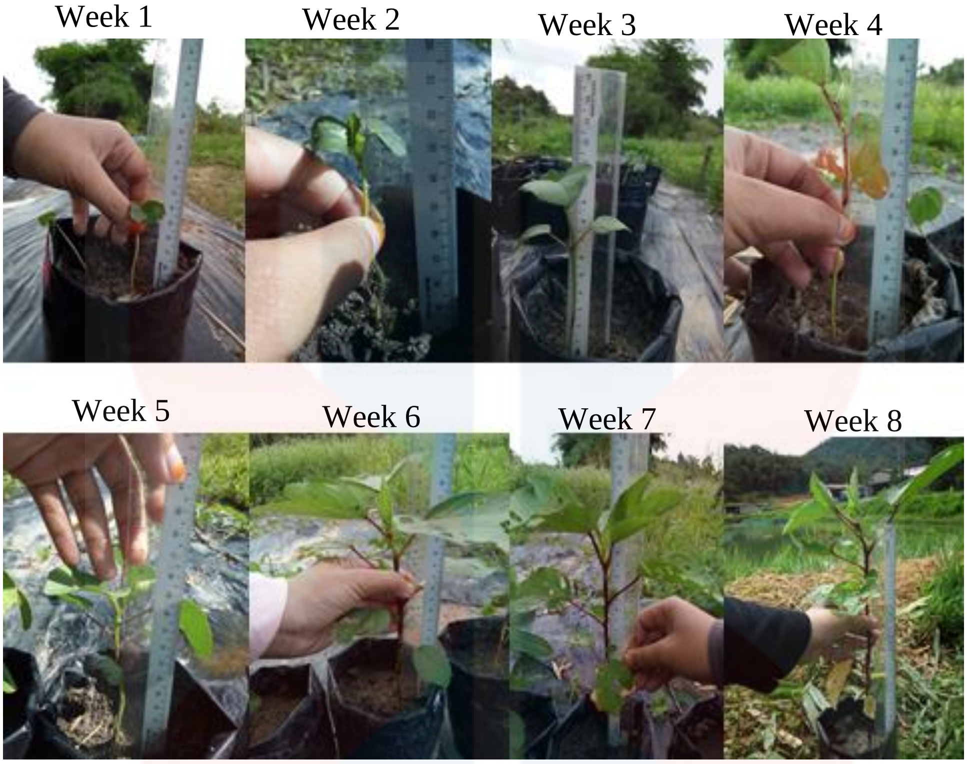

Figure A 3: The growth performances from week 1 until week 8

Figure A 4: Comparison between the highest and the lowest plant

APPENDIX B: SUMMARY OF STATISTICAL ANALYSIS

Table B1: mean of plant's height during 8 week

Ratio	Means of plant height (cm)							
	Week							
	1	2	3	4	5	6	7	8
1B:0G	5.325	7.025	9.925	11.000	12.025	12.875	13.325	14.250
1B:1G	4.925	5.775	8.600	10.525	13.525	17.250	19.475	26.300
3B:1G	4.575	5.900	8.425	10.950	14.750	20.125	22.575	28.350
1B:0M	5.725	6.950	9.800	10.850	13.825	13.225	14.000	14.900
1B:1M	4.975	6.350	9.475	11.000	12.675	15.725	18.250	23.425
3B:1M	4.575	5.825	9.275	10.425	12.425	15.325	17.525	22.675

Table B2 (a): Analysis of Variance for week 1 on plant height

Source	Degree of Freedom	Sum of Square	Mean Square	F-Value	P-Value
Media	2	5.5233	2.7617	3.71	0.045 *
Green manure	1	0.0000	0.0000	0.33	1.000 n.s
Media*green manure	2	0.7300	0.3650	0.49	0.620n.s
Error	18	13.4050	0.7447		
Total	23	19.6583			

Table B2 (b): Analysis of Variance for week 4 on plant height

Source	Degree of Freedom	Sum of Square	Mean Square	F-Value	P-Value
Media	2	0.2358	0.1179	0.05	0.954 n.s
Green manure	1	0.0267	0.0267	0.01	0.935 n.s
Media*green manure	2	1.0208	0.5104	0.20	0.818 n.s
Error	18	45.0950	2.5053		
Total	23	46.3783			

Table B2 (c): Analysis of Variance for week 8 on plant height

Source	Degree of Freedom	Sum of Square	Mean Square	F-Value	P-Value
Media	2	602.36	301.18	25.38	0.000 **
Green manure	1	41.61	41.61	3.51	0.077 n.s
Media*green manure	2	40.18	20.09	1.69	0.212 n.s
Error	18	213.58	11.87		
Total	23	897.72			

Tukey Pairwise Comparisons: Response = h (w1), Term = media

Media	N	Mean	Grouping
M1	8	5.525	A
M2	8	4.950	AB
M3	8	4.350	B

Tukey Pairwise Comparisons: Response = h (w8), Term = media

Media	N	Mean	Grouping
M3	8	25.5125	A
M2	8	24.8625	A
M1	8	14.5750	B

Table B3: mean of total number of leaves during 8 week

Ratio	Number of leaves							
	Week							
	1	2	3	4	5	6	7	8
1B:0G	2	2.50	4	5.00	5.00	4.75	5.25	5.50
1B:1G	2	2.50	4	6.00	9.25	12.00	13.75	16.50
3B:1G	2	2.25	4	7.25	9.00	12.25	13.00	16.75
1B:0M	2	2.50	4	5.00	4.50	4.25	4.50	5.25
1B:1M	2	2.75	4	5.50	6.25	8.00	13.25	16.00
3B:1M	2	2.50	4	5.75	6.50	8.00	10.00	14.25

Table B4 (a): Analysis of Variance for week 2 on total of plant's leaf

Source	Degree of Freedom	Sum of Square	Mean Square	F-Value	P-Value
Media	2	0.2500	0.12500	0.41	0.670 n.s
Green manure	1	0.1667	0.16667	0.55	0.470 n.s
Media*green manure	2	0.0833	0.0417	0.14	0.873n.s
Error	18	5.5000	0.30556		
Total	23	6.0000			

Table B4 (b): Analysis of Variance for week 4 on total of plant's leaf

Source	Degree of Freedom	Sum of Square	Mean Square	F-Value	P-Value
Media	2	9.000	4.5000	5.59	0.013 **
Green manure	1	2.667	2.6667	3.31	0.086n.s
Media*green manure	2	2.333	1.1667	1.45	0.261n.s
Error	18	14.500	0.8056		
Total	23	28.500			

Table B4 (c): Analysis of Variance for week 8 on total of plant's leaf

Source	Degree of Freedom	Sum of Square	Mean Square	F-Value	P-Value
Media	2	590.25	295.125	63.05	0.000**
Green manure	1	7.042	7.042	1.50	0.236n.s
Media*green manure	2	6.083	3.042	0.65	0.534n.s
Error	18	84.25	4.681		
Total	23	687.62			

Tukey Pairwise Comparisons: Response = l (w4), Term = media

Media	N	Mean	Grouping
M3	8	6.50	A
M2	8	5.75	AB
M1	8	5.00	B

Tukey Pairwise Comparisons: Response = l (w8), Term = media

Media	N	Mean	Grouping
M3	8	16.250	A
M2	8	15.500	A
M1	8	5.375	B

Table B5: mean of Relative Growth Rate

Ratio	RGR
1Bris soil : 0 gliricidia	0.0151
1Bris soil : 0 gliricidia	0.02835
1Bris soil : 0 gliricidia	0.0295
1Bris soil : 0 mimosa	0.004925
1Bris soil : 0 mimosa	0.023625
1Bris soil : 0 mimosa	0.021425

Tukey Pairwise Comparisons: Response = rgr, Term = media

Media	N	Mean	Grouping
M2	8	0.0259875	A
M3	8	0.0254625	A
M1	8	0.0100125	B

Tukey Pairwise Comparisons: Response = rgr, Term = green manure

Green manure	N	Mean	Grouping
G	12	0.0243167	A
M	12	0.0166583	B