THE EFFECT OF COMPOST AND GREEN MANURE ON GROWTH PERFORMANCE OF *Hibiscus sabdariffa.L (Roselle)* AND GROWN ON BRIS SOIL

by

NURUL FARIHAH BINTI ZAKARIA

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DECLARATION

I declare that this thesis entitled "The Effect of Compost and Green Manure on Growth Performance of *Hibiscus sabdariffa.L (Roselle)* and 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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Sincerely,

Nurul Farihah bt Zakaria

The Effect of Compost and Green Manure on Growth Performance of *Hibiscus sabdariffa.L (Roselle)* and Grown on BRIS Soil

ABSTRACT

Fertility of BRIS soil was evaluated for growth performance of *Hibiscus sabdariffa.L (Roselle)* and to discover on the potential of *Sesbania grandiflora* as green manure for improvement of BRIS soil fertility. Growth performance of *Hibiscus sabdariffa.L (Roselle)* was determined by using three different media; BRIS soil, BRIS soil with compost and BRIS soil with green manure under two different light conditions (30% and 50%). The growth performance analysis of *Roselle* was carried out in the study to determine the effects on height of stem, number of leaves, stem diameter and biomass production (fresh and dry weight) of *Roselle* plants. The result showed that, the highest performance of stem height of *Roselle* was in BRIS soil with compost under 30% light intensity, while the best performance in term of number of leaves was BRIS soil with compost under 50% light intensity. In term of stem diameter, the highest value was in BRIS soil with compost under 50% light intensity. The highest performance of biomass production (fresh and dry weight) of roots, stems and fruit was treatment BRIS soil with compost under 50% light intensity. Based on statistical analysis using non-parametric method, the result indicated that there was significant different in the comparison of media BRIS soil and BRIS soil with compost under two different light conditions (30% and 50%). However, there was no significant different in comparison of media BRIS soil and BRIS soil with green manure. BRIS soil with compost showed the highest potential for growth performance of *Roselle*. In conclusion, compost is the best treatment that suitable for BRIS soil as it improves the fertility and structure of BRIS soil. Similarly, the light condition of 50% was better than 30% as sufficient amount of light is important for photosynthesis process and for growth and yield of plants.

Kesan daripada Baja Organik dan Baja Hijau bagi Prestasi Pertumbuhan *Hibiscus sabdariffa.L (Roselle)* dan ditanam pada Tanah BRIS

ABSTRAK

Kesuburan tanah BRIS dinilai untuk prestasi pertumbuhan *Hibiscus sabdariffa.L (Roselle)* dan untuk menemui potensi *Sesbania grandiflora* sebagai baja hijau untuk peningkatan kesuburan tanah BRIS. Prestasi pertumbuhan *Hibiscus sabdariffa.L (Roselle)* ditentukan dengan menggunakan tiga media yang berbeza; tanah BRIS, tanah BRIS dengan baja organik dan tanah BRIS dengan baja hijau di bawah dua keadaan yang berbeza cahaya (30% dan 50%). Analisis prestasi pertumbuhan *Roselle* telah dijalankan dalam kajian ini untuk menentukan kesan pada ketinggian batang, jumlah daun, ukur lilit batang dan biomas pengeluaran (berat basah dan kering) tumbuhan *Roselle*. Hasilnya menunjukkan bahawa, prestasi tertinggi ketinggian batang *Roselle* adalah tanah BRIS dengan baja organik di bawah keamatan cahaya 30%, manakala prestasi yang terbaik dalam bilangan daun adalah tanah BRIS dengan baja organik di bawah keamatan cahaya 50%. Dalam jangka ukur lilit batang, nilai tertinggi adalah pada tanah BRIS dengan baja organik di bawah keamatan cahaya 50%. Prestasi tertinggi pengeluaran biomass (berat basah dan kering) daripada akar, batang dan buah adalah rawatan pada tanah BRIS dengan baja organik di bawah keamatan cahaya 50%. Berdasarkan analisis statistik menggunakan kaedah bukan parametrik, hasilnya menunjukkan bahawa terdapat perbezaan yang signifikan dalam perbandingan media tanah BRIS dan tanah BRIS dengan baja organik di bawah dua keadaan cahaya yang berbeza (30% dan 50%). Walaubagaimanapun, tidak ada perbezaan yang signifikan dalam perbandingan media tanah BRIS dan tanah BRIS dengan baja hijau. Tanah BRIS dengan baja organik menunjukkan potensi yang paling tinggi bagi prestasi pertumbuhan *Roselle*. Kesimpulannya, baja organik adalah rawatan yang terbaik yang sesuai untuk tanah BRIS kerana ia meningkatkan kesuburan dan struktur tanah BRIS. Begitu juga, keadaan cahaya 50% adalah lebih baik daripada 30% jumlah yang mencukupi cahaya adalah penting untuk proses fotosintesis dan untuk pertumbuhan dan hasil tanaman.

TABLE OF CONTENTS

	PAGE
DECLARATION	**i**
ACKNOWLEDGEMENTS	**ii**
ABSTRACT	**iii**
ABSTRAK	**iv**
TABLE OF CONTENTS	**v-vii**
LIST OF TABLES	**viii**
LIST OF FIGURES	**ix-x**
LIST OF EQUATIONS	**xi**
LIST OF ABBREVIATIONS	**xii**
LIST OF SYMBOLS	**xiii**
CHAPTER 1 INTRODUCTION:	
1.1 Background of study	1-3
1.2 Problem statements	3-4
1.3 Objectives	4
1.4 Significant of study	5
1.5 Limitation of study	5
CHAPTER 2 LITERATURE REVIEW:	
2.1 BRIS soil	
2.1.1 General	6-7
2.1.2 Properties	7-8
2.1.3 Characteristics	8-10
2.1.4 Physical Characteristics	10-11
2.1.5 Soil Taxonomy	11-12
2.2 *Sesbania grandiflora*	
2.2.1 General	12
2.2.2 Characteristics	13
2.2.3 Taxonomy	13-14

2.3 *Roselle*
2.3.1 General 14-15
2.3.2 Physical and chemical properties of *Roselle* 15
2.3.3 Botanical crop 16
2.4 Light intensity 16-17
2.5 Effect of watering 17
2.6 Biomass production 18-19

CHAPTER 3 MATERIALS AND METHODS:
3.1 Material
3.1.1 Materials 20
3.1.2 Apparatus 20-21
3.2 Site preparation 21-22
3.3 Preparation of Sample 22-25
3.4 Planting of trees 25-26
3.5 Determination of measuring and collecting data
3.5.1 Growth performance of *Roselle* 26-27
3.5.2 Fresh and Dry biomass weight 27-28
3.6 Experimental Design 29
3.7 Site layout 30-31
3.8 Data Analysis 31
3.9 Flow chart 31-32

CHAPTER 4 RESULT AND DISCUSSION:
4.1 Growth performance of *Hibiscus sabdariffa.L* 33-34
4.1.1 Growth percentage of seed germination 34
4.1.2 Identification of height of stem *Hibiscus sabdariffa.L (Roselle)* 35
4.1.2.1 Comparison of height of stem of *Roselle* 36-37
4.1.3 Identification of number of leaves *Hibiscus sabdariffa.L* 37-38
4.1.3.1 Comparison of number of leaves *Roselle* 38-40
4.1.4 Identification of diameter of stem *Hibiscus sabdariffa.L* 40-41
4.1.4.1 Comparison of diameter of stem *Roselle* 41-42
4.2 Biomass production (fresh and weight) of *Hibiscus sabdariffa.L* 42

(Roselle) in terms of stem, roots and fruit.

4.2.1 Mean of fresh biomass production of roots, stem and fruit. 43-44

4.2.2 Mean of dry biomass production of roots, stem and fruit. 44-45

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS:

5.1 Conclusion 46

5.2 Recommendation 47

REFERENCES 48-52

APPENDIX A 53

APPENDIX B 54

APPENDIX C 55

APPENDIX D 56-57

LIST OF TABLES

NO.	TITLE	PAGE
3.1	Arrangement based on Complete Randomized Design (CRD)	31
4.1	Comparison of height of *Roselle* stems by three different media and two different intensities by using Kruskal Wallis and Mann Whitney U test	36
4.2	Comparison of number of leave by three different media and two different intensities by using Kruskal Wallis and Mann Whitney U test	38
4.3	Comparison of diameter of *Roselle* stem by three different media and two different intensities by using Kruskal Wallis and Mann Whitney U test	41

LIST OF FIGURES

NO.	TITLE	PAGE
2.1	Map BRIS soil in Peninsular Malaysia	6
2.2	Map of countries where the species has been planted. Since some tree species are invasive (*Hibiscus sabdriffa Malvaceae L.)* .	14
3.1	BRIS soil was taken in UMK Bachok	20
3.2	Site clearing activities in Agro Park, UMK Jeli	21
3.3	Installed net and plastic mulching sheet	22
3.4	Soaked *Roselle* seeds about 1 day	22
3.5	Soil were be mixed and filtered to remove other matters	23
3.6	Open drying *Sesbania grandiflora* about 3 days	23
3.7	Weighting of BRIS soil, compost and green manure	24
3.8	The BRIS soil is mixed with compost	24
3.9	Reading of soil moisture and soil pH by using soil tester	25
3.10	*Roselle* plant was transferred into polybags	25
3.11	Measuring diameter of stem by using Vernier caliper	27
3.12	Used oven to drying stems, roots, and fruit about 48hours in 65^{o}C	28
3.13	Split Plot Design	29
3.14	Layout planting site	30
3.15	Flow chart	32
4.1	Mean height of stem *Roselle* comparison between different media and different light intensity	35
4.2	Mean number of leaves *Roselle* comparison between different media and different light intensity	37
4.3	pests harmful to plants *Roselle*	39-4
4.4	Mean diameter of stem *Roselle* comparison between different media and different light intensity	40
4.5	Mean of fresh weigh biomass production from roots,	43

stem and fruit *Hibiscus sabdariffa.L (Roselle)*

4.6 Mean of dry weight of biomass production from roots, stem and fruit *Hibiscus sabdariffa.L (Roselle)* 44

LIST OF EQUATIONS

NO.	TITLE	PAGE
3.1	Growth percentage (%)	23

LIST OF ABBREVIATIONS

cm	centimeter
g	gram
GP	Growth Percentage
h	depth that the soil corer is pushed into the soil (5 cm)
kg	kilogram
L.	Refer to *Hibiscus sabdariffa Linn.*
l	*liter*
ln	natural logarithm
m	meter
ml	milliliter
mm	millimeter
r	radius of soil corer (1.25 cm)
µm	micrometer

LIST OF SYMBOLS

^{o}C	Celsius
%	Percentage
π	the constant 3.1415
±	plus minus

CHAPTER 1

INTRODUCTION

1.1 Background of Study

BRIS soil is stand for Beach Ridges Interspersed with Swales. BRIS soil is the sandy soil usually has at the beach areas. BRIS soil is a problematic soil and has poorly drained or excessively drained land. According to Hanafiah *et al.,* *(*2004), BRIS soil is compost mainly of quartz with minor amounts of heavy minerals. The free-draining soil is contains weather able minerals that soil are sufficiently fertile to grow a range of crops where these minerals have all been lost by leaching because the soil has low fertility and not used. The poorly drained soil have low fertility and frequently not used for agriculture (Panton, 1958). The BRIS soil weakness is that it cannot store water for long periods. BRIS soil has a high percentage of sand and this hinders the growth of plants. The lack of plants growing on the BRIS soil in turn causes the temperature of the soil to remain high.

Roselle or the scientific name *Hibiscus sabdariffa L*. is an important crop in tropical and sub-tropical regions. *Roselle* is dicotyledonous and autogamous plant cultivated. *Roselle* thrives in mineral soil and when planting in BRIS soil good watering and fertilizing is needed for high growth and yield. *Roselle* suitable for planting in any area as long as it getting enough sun and good water supply. *Roselle* is a shrub plant. The plants can be planted with a wide range of soil conditions. A relatively infertile soil is sufficient for it to grow for domestic cultivation. At the same time, the soil needs to be rich in organic, materials and nutrients for commercial cultivation. Moreover, the *Roselle* is not suitable to be planted in the rainy season (monsoon) because the risk of facing the problem of fungal diseases on leaves, stems and fruit. However, *Roselle* is suitable to be grown due warm and humid climate because will help cultivation of the *Roselle* crop. The economical part of the plant is the fleshy calyx (sepals) surrounding the fruit (capsules).

Sesbania grandiflora was chosen as cover plants and green manure because is well adapted to hot, and humid environments. The trees that can survive in lack of sources situation. *Sesbania grandiflora* is known as hardy plant because lowland species that is lacking tolerance for cool temperature. It is also plants that can grow rapidly during the wet seasons a small, erect, fast-growing, and usually sparsely branched tree that reaches about 10 m in height (Orwa *et al*., 2009). *Sesbania grandiflora* is able to tolerate waterlogging, alkaline, and saline soil and is therefore ideally suited to environments that are seasonally waterlogged or flooded. *Sesbania grandiflora* are also used for reforestation projects to help stabilize eroded disturbed in environments, however, it is shallow roots and vulnerable to wind throw (Anon, 1924; Whyte *et al.*, 1953). The plant is easy to propagate from seed or stem cuttings capable of N-fixing. *Sesbania grandiflora* has also excellent roots nodulation and hence fixed of nitrogen, although the ability may be suppressed by nematodes or high acidity of the soil (Orwa *et al*., 2009). The fruit, falling leaflets and flowers can make excellent green manure and help to improve soil fertility.

Therefore, the identification and improvement of fertility in BRIS soil towards particular plants are very importance in soil conservation and synchronise soil productivity with and without enhancement, with crop requirements for high sustainable growth and yields in addition to encouraging the use of BRIS land for cultivation. This study may also increase the level of confidence, especially to entrepreneurs are involve in agriculture farming that want to develop the poor soil as quality soil.

1.2 Problem Statement

BRIS soil is the soil which is lacking in many aspects such as too sandy, weakly structured, nutrient deficient, having low water retention capacity, and limited ability to support plant growth and have a relatively high soil temperature (Gasim *et al*., 2010). The current problem issues that have to be considered in this research were identified. Firstly, BRIS soil lack of plant require in farming activities. As the result, BRIS land is not being used for farming activities in order to avoid risks in crop yield. The second issue is the materials and products from crop plants for example, timber and rubber is decreasing and hard to get because of the growth may take long time, about three to five years. *Roselle* is the fast growth plants because it can take about five until six months to grow and get the yield besides encourage people to plant *Roselle* and generate products from the crop plants. The third issues is the optimum uses of land BRIS from human because of the disadvantage in the soil get big potential of causing wastage factor and abandonment to land BRIS.

Therefore, this study was conducted to obtain a better understanding of the fertility of BRIS soil to assess the level performance growth of *Roselle.* Moreover, the further studies on *Sesbania grandiflora* as a subject in green manure BRIS soil also need to be conducted to provide information related with it potential of fertility of BRIS soil toward growth performance of tree. This study are relevant to helping reducing unanswerable related to questions especially on BRIS soil fertility as follow:

1. What is the level of growth performance of *Hibiscus sabdariffa.L* by using three different medium; (BRIS soil, BRIS soil with compost and green manure BRIS soil) under two different lighting treatment (50% and 30%).

1.3 Objectives

The main focus of this study is to evaluate the fertility of BRIS soil towards growth performance of *Roselle* and to discover on the potential of *Sesbania grandiflora* as green manure in term of silviculture treatment and fertility of BRIS soil. The specific objectives of this study are:

1. To determine the growth performance and biomass production of *Hibiscus sabdariffa.L* in three different medium; (BRIS soil , BRIS soil with compost and green manure BRIS soil).
2. To determine the growth performance and biomass production of *Hibiscus sabdariffa.L* under two different light intensities (50% and 30%).

1.4 Significance of Study

There are many benefits from studying this research for human activities, especially for agricultural activity. The research can give evidence of performance growing plant when using BRIS soil. Throughout this experiment, the fertility of BRIS soil were identified from seeing growth performance of *Roselle* in three difference media. This study is a good initiative to prevent activities terraced hill to get land for agricultural activities, at the same time be able to preserve and conserve the existing soil BRIS.

This research project were observed and identify the quality nutrient in *Roselle and Sesbania grandiflora* as green manure fertilizer. This study also may contribute to the country and society through information on fertility of BRIS soil and obtained from the analytical data of crop yields such as crop growth performance, the height and diameter of stem, number of leaves. The results obtained can be used as examples and references to future generations.

1.5 Limitation of Study

There was have some limitation during progression this experiment. Firstly, the limitation of this study is temperature and weather that uncontrollable. In September until January is the rainy season for Malaysia. The unpredictable weather will affect the growth of trees. The rainy season causes excessive irrigation water and soil becomes wet and compact. Finally it impact to stunted of tree growth. Then, the planting area should be cleared of bushes that could potentially cause the plant pest attend. The pests will affect the growth of *Roselle* and finally, the result samples of *Roselle.*

CHAPTER 2

LITERATURE REVIEW

2.1 BRIS soil

2.1.1 General

BRIS soil is available usually along the east coast region of Peninsular Malaysia, from Kelantan (17,806.20 hectares), Terengganu (67,582.61 hectares) Pahang (36,017.17 hectares) right down along the coast to the west coast of Johor (Shamsuddin, 1990) as shown in Figure 2.1. BRIS soil is sand particles that are large and irregularly shaped bits. In sandy soil, water drain very quickly into the soil because the large air spaces between the sand particles. The high nutrient from soil will drain away probably undertake process of evaporation, may cause plants could not absorb that nutrient. For this reason, sandy soil are usually nutrient-poor.

Figure 2.1: Map BRIS soil in Peninsular Malaysia

BRIS soil contain abundant air that make easy microbes consume organic matter very quickly. The BRIS soil not have much of a crumb structure and usually contain very little clay or organic matter. The soil particles do not have stick together, even when they wet. The BRIS soil has high percentage that can conducts the growth of plants. This is reason when the agriculture activity that use BRIS soil require more water resources for adapt and growth. According to the Department of Agriculture (1995), the sand content percentage of BRIS soil depends on depth, drainage and profile development of the BRIS soil. Malaysian soil has highly heterogeneous inherent soil nutrient status (Goh and Chew, 1995). BRIS soil is inclined as a problematic soil and sandy soil which does not support plant growth. Therefore, BRIS soil was the object of research and study initiated by the Ministry of Agriculture as regards its suitability for agriculture. According to Shamsuddin (1979) said that when applied BRIS soil with modern techniques, which earlier had a reputation of being useless has change in functional diversity increased which has enabled it adapted to all types of plants. Indirectly, this will rising the fertility of sandy soil in the near future.

2.1.2 Properties

From the results of done study have found that BRIS soil has low pH (less than 5) indicated that level it is acidic. This study shown the existence of a strong bonding between soil pH and base saturation percentage in the soil (Abdullah, 1988). In addition, the sandy and loose of grains allow an active leaching process of the soil, especially when heavy rainfalls disappeared of nutrients which act as soil pH binders washed away. In general, the percentages of sand, silt and clay in BRIS soil for different land uses that not much show variation.

In the BRIS soil composition is always higher than silt or clay. In all the plots under study, which encompassed all four categories of land use, were found a high sand percentage in the soil in comparison to percentages of the other components of the soil. Focusing in aspect of soil plasticity, BRIS soil mostly low of plasticity. The reason in physically, the soil cannot be solid and easily to crumbles on attempts to mould it with high content of sand. BRIS soil have plasticity presence of high organic substances mixture that found in waterlogged or swamp areas, silt and clay in the soil. Nevertheless, in agricultural areas soil too show plasticity and it could be the addition soil and fertiliser to the BRIS soil to reduce leaching and reclaim the land compatible with agriculture. The plasticity of the soil that have in BRIS soil is depends on the mineral content of the soil from the soil itself (Abdullah, 1988). Based on study done by Shamsuddin (1990), the chemical properties of the main nutrients in BRIS soil is low include of nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg) and calcium (Ca). This is because of the soil structure that causes of rapid leaching of nutrients in soil.

2.1.3 Characteristics

According to the identification and recommended by Department of Agriculture of Malaysia (1995), there are hyave seven types of BRIS soil based on depth, drainage and serial profile. Ordinarily *Casuarinas equisetifolia* and *Zoysia matrala* species found growing side by side along the ridges and beaches soil. As a result of low in nutrients support of these plants which might be the source of organic materials in the soil that can be responsible for the emission of acidity, which lead to the development of acidic humus and forming moor humus at the soil surface (Roslan *et al.*, 2010). Existent agriculture on cleared land no longer has the advantages of this layer. The positions of these horizons relate to leaching processes and water table levels, past and present. They are used to characterise the various soil formed on the beach ridges. Evidence was seen from Anon (1977), these horizons are not fixed and may be improved by construction of deep drains in the area. The excessive flood force corrugated is not economically beneficial for agricultural output with use BRIS soil. Besides that, BRIS soil is marine origin, contain of the seaward flanks of these flats, whose landward portion are commonly under freshwater swamp in which are deposited, sometime peat layers develop in these clays (Hanafiah *et al.*, 2004).

Based on the measurement of moisture, temperature conducted in-situ at the time plotting works were carried out and it was found that the average temperature of BRIS soil commonly was 31.2°C (Abdul Wahab, 1982). The maximum temperature was at 36^{o}C and the minimum at 24^{o}C. High temperature of soil causes the speedy vaporisation of moisture and nitrogen in soil surfaces. It is for this reason that BRIS soil have a low moisture content for the high sand content not allow the soil to permenant water for any length of time (Mohd Ekhwan *et al*., 2009).

According to Abdussalam *et al.*, (2013), BRIS soil in the coastal region of Malay Peninsular which is known as successful in growing Tobacco, in combination of waste products such as chicken manures and palm oil extracts and also can improve with the generate of the soil quality. The soil is sandy and moisture that very difficult to hold, to treatment heavier topsoil can be added. Organic matter were valuable in this situation to improves the water-holding capacity of the sandy soil. In the other hand, the BRIS soil have a low moisture content since the high sand content does not allow the soil to retain water for any length of time. Therefore, the study of soil is suitable for human activities in addition to solve the waste problem on land. Regardless of the removal (excavation) from topsoil by the local farmer for the reason best known to them during the field work (Lim, 1989). It is further believed that the dredging was due to construction purpose to level the soil for agricultural activities. This is why the farmers remove the topsoil in order to reach the Bhs horizon where more nutrients are present and nutrient retention are higher than the horizon above or below it (Roslan *et al.*, 2010).

2.1.4 Physical characteristics

According to Hanafiah *et al.*,(2004), the study of physical characteristics on the BRIS soil categorize the land to the land use policies vary, the solution, swamp, industry and agriculture. Referring to statistical analysis (2000), there are have ten colour of BRIS soil that is brownish yellow, brownish grey, blackish brown, yellowish dark-brown, brown, pale brown, pale grey, grey, light grey and yellow brown. Series of BRIS soil at near a beach was almost 90% sand. It is different from the other series because of the presence of spodic horizons at depth of 50 to 100 cm, a complex layer of organic matter bonded together with chemical elements resulting from the leaching process of organic matter from the soil surface (Shamsuddin, 1979). The BRIS soil in Malaysia is not well utilized for crop production due to their poor fertility inherent. The only feasible and profitable crop in the soil over the years was tobacco. However, the government of Malaysia wants to replace tobacco with other eco-friendly crops, such as kenaf plant.

2.1.5 Soil taxonomy

The taxonomy classification system of the American Department of Agriculture divides BRIS soil into two orders, namely Entisol and Spodosol. Entisol is a young soil without a podogenetic horizon and it found near the sea and has a high sand content. Spodosol is acidic soil with a sandy texture but unstructured with acidic humus content. According to Lim (1989), the Malay Peninsular is found to be tectonically stable as much of high Spodosol and Entisol could be identified. Soil series are occurs side by side which relate the coexistence of beach ridges running parallel in different elevation to the seashore. In addition, in underlying soil layer the deposition at the horizon below 100cm is strongly bleached in plant nutrients, colloid, soluble salts and mineral particles leached out of an overlying soil layer below the horizon that make it very difficult for plant and to benefit from the nutrients. In addition, the constant leaching process reduces the moisture content of the soil. Soil texture can significantly stimulus our management decisions. For example, in loamy soil to sandy loam soil such as at Lintang series, the high percolation, low nutrient and water holding capacity, need more numerous manure and mulching to improve crop productivity and reduce environmental pollution. Instead, plant cultivation need to avoid on heavy soil to prevent soil compaction which degrades the soil and reduce crop productivity. This way is well to give benefit in improving the standard of crop production in Malaysia, therefore in order to upgrade, sustain and increase agricultural production in soil that is need for a specific soil management.

2.2 *Sesbania grandiflora*

2.2.1 General

Regarding to Journal from Agroforestry Database 4.0 (Orwa *et al*., 2009), *Sesbania grandiflora* is well adapted to hot temperature and humid environments besides have ability to tolerate waterlogging and is very suitable to seasonally flooded environments. *Sesbania grandiflora* can protects their stem and roots when flooded. It seems to prefer growing rapidly during the wet season and a bimodal rainfall distribution, but capable of with standing prolonged dry seasons of up to 9 months. It is commonly seen growing on rice bunds, along roadsides, in home gardens and in mixed croplands. *Sesbania grandiflora* is usually grown in India as a bio fertilizer. Based on *National Academy of Sciences* (Anon, 1986) studied the type of soil, it can be grown on a wide range of soil including those that are poor and waterlogged. *Sesbania grandiflora* can tolerate saline and alkaline soil and has some tolerate to acidic soil down to water pH 4.5. Salinity is the major threat to crop production in these regions (Dhanapackiam and Muhammad Ilyas 2010a, 2010b). It is commonly found in disturbed and agricultural environments including along roadsides, on dikes between rice paddies, and in backyard vegetable gardens. It is frost-sensitive (Duke and James A.,1983).

2.2.2 Characteristics

From Orwa *et al*., (2009), the characteristics of *Sesbania grandiflora* is a small and loosely branching tree that grows up to 8-15m tall and 25-30cm in diameter, stems tomentose, unarmed roots normally heavily nodulated with large nodules cause the tree can develop floating roots. Leaves alternate and compound, pinnate, 15-30 cm long with 12-20 pairs of oblong, rounded leaflets, 3-4 cm long and about 1cm wide; leaves borne only on terminal ends of branches which leaves turn bright yellow before shedding. The bark of this species is light gray, corky and deeply furrowed and the wood is soft and white. All *Sesbania* species have innately compound leaves where each leaf is divided into multiple leaflets. *Sesbania* leaves can be up to 30 cm long with 5-15 paired leaflets that are oblong to elliptic in shape and about 3 cm in length. Two varieties of *Sesbania grandiflora* are recognized including which has rose pink or red flowers. The flowers are similar in shape and arrangement to pea flowers with five petals that are differentiated into a standard, wing, and keel petals. The beneficial of *Sesbania grandiflora* is extensively grown for fuel wood and food in Southeast Asia and Indonesia as it is a very fast-growing plant that vigorously following harvesting. The standard petal is usually upright, the wing petals spread out on either side of the flower, and the keel is boat-shaped and in this species is curved down and away from the flower. The fruit is a thin pod which can be up to 60 cm long and contains from 15-50 seeds (Staples *et al*., 2005).

2.2.3 Taxonomy

Plant taxonomy of *Sesbania grandiflora* is from kingdom plantae. The rank of taxonomic is species then the division of taxonomy is *Tracheophyta* (vascular plants and *tracheophytes*) and the subdivision is in *Spermatogames* (*Spermatophytes*, seed plants and *phanerogames*), classes is in *Magnoliopsida*, superorder is *Rosanae*, order is from Fabales, family from *Fabaceae* and lastly, genus and species is from *Sesbania grandiflora* Pers. (Vegetable hummingbird).

2.3 *Roselle*

2.3.1 General

Roselle is commonly called Jamaica sorrel, India sorrel or red sorrel, is a dicotyledous and autogamous plant cultivated in tropical and subtropical regions (as shown in Figure 2.2) for it fleshy calyces, seeds, leaves and stem.

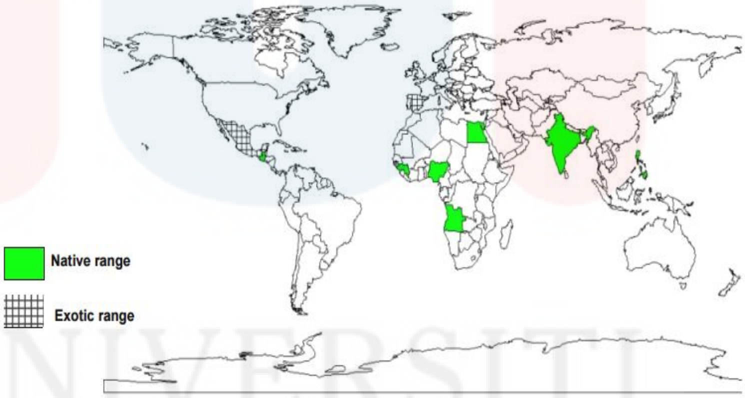


Figure 2.2: The map above shows countries where the species has been planted. Since some tree species are invasive (*Hibiscus sabdriffa Malvaceae L.*)
Source: (Orwa *et al.*, 2009)

According to El-Saidy (1992), *Roselle* is probably a native of West Africa and is now widely cultivated throughout the tropics and subtropics for example in Sudan, China, Thailand, Egypt, Mexico and the West India. *Roselle* (*Hibiscus sabdariffa L.)* is an annual fibre crop and is considered to be a potential source of raw material for manufacturing paperboard products, and may also be a substitute for fibreglass and other synthetic fibres. As a fibrous crop, kenaf appears to have massive potential to become valuable biomass crop for the future (Alexopoulou *et al.,* 2000). It is also has high potential to be used as a raw material for boards with low density panels, suitable for both sound absorption and thermal resistance (Sellers *et al*., 1993). It has also used as a raw material alternative to wood in pulp production and the paper industries (Ardente *et al.*, 2008). The inner part of the plant (core) is appropriate as an adsorbent animal bedding material (Lips, 2009). Since the plant is fast-growing, kenaf also has a good ability to isolate carbon and can produce large quantity of biomass. Given it is high adaptability to all kinds of soil, kenaf has the potential to be planted on problem soil that have characteristically low productivity, and are poor in water-holding capacity and nutrient availability (Roslan *et al.*, 2010). There are important need to identify and adopt irrigation management strategies to improve the *Roselle* yield, growth and quality performance throughout the high importance use of water in agriculture especially focus on *Roselle* industry.

2.3.2 Physical and chemical properties

Roselle has same of physical and chemical properties as jute in term of it is softness and color. According to Rao and P.U., (1996), *Roselle* is grown in some regions for fiber and pulp obtained from the stems. Apart from that, stated that well prepared *Roselle* fiber can be woven into bed clothing, table linen and for other articles where cotton was used. It has acid amino and mineral salts. *Roselle* water extract is characterized by a brilliants red and good acid taste (Siti Nur Sarah, 2012).

2.3.3 Botanical crop

Regarding to botanical journal (Siti Nur Sarah, 2012) decribed that *Roselle* is an annual plant with shrub-sized tree and can grow to a height of 205 centimetres (cm). The life span of the economy is 6 to 10 months and during that time some would branch out from the main stem. The stem is dark red and the tree will usually lodge at maturity unless the crop is made. Green leaves and during the early stages, the leaves are oval and turned into a form of three fingers. *Roselle* fruit is dark red and will mature at the age of 35 days after the flower. Each piece will contain five calyx and merge together at the bottom of the flower. *Roselle* cultivation in soil BRIS require the use of organic fertilizer such as chicken manure and NPK compound fertilizer.

2.4 Light intensity

There are numerous photoreceptors in plants, including chlorophylls, phtyo-chromes, crypto chromes, phototropism, and ones that react to green light (Siti Nur Sarah, 2012). Light, along with other environmental signal that enables plants adapt to environmental conditions. Efforts to influence plant morphology and physiology using photo discriminating filters have been ongoing for periods, especially in greenhouse environments (Rajapakse *et al.*, 1992). More recently, colour shade netting designed specifically for controlling and dependency of plant development and growth to be. These nets can be used outdoors as well as in greenhouses. They can provide physical protection (birds, hail, insects, exces-sive radiation), affect environmental variation (humidity, shade, temperature) (Pérez *et al.*, 2006), and increase the relative proportion of diffuse (scattered) light as well as absorb various spectral bands, thereby affecting light quality.

These effects can influence crops as well as the organisms associated with them. Referring to the journal of Wersal and Madsen (2012) said that the 50% lighting is better to plants as compared with 30% as the plant acquires enough light for photosynthesis. In other hand, total biomass was greater when plants were grown under 30% compared with total biomass in the 50% that was reduced shade treatment. Results of the journal indicated that optimal growth occurred at intermediate light intensities, particularly 30% of shading.

2.5 Effect of watering to *Roselle*

There are some effects of irrigation on quality and postharvest performance of *Roselle* calyx, and to determine the exact quantity of irrigation water to be applied on *Roselle* plant grown on BRIS soil. The research on the effect of irrigation mainly water deficit technique on quality of *Roselle* and the growth performance is infrequent. Water deficit techniques such as regulated deficit irrigation (RDI), with holding irrigation (WHI) and partial roots zone drying (PRD) widely implemented to improve water use efficiency and growth performance of various crops. *Roselle* is suitable planting on BRIS soil because it can provides a well aerated and deep rooting zone. The characteristics of *Roselle* with a strong tap roots and high moisture stress tolerance allowed it to fit efficiently in areas with limited water. Besides that, the well aerated soil may increase the efficiency of roots in water uptake under water stress condition (Babatunde and Mofoke, 2006). The effects of moisture content and locality of harvest on some physical properties of *Roselle* seeds range of 13 to 25% (Sánchez-Mendoza *et al*., 2008).

2.6 Biomass Production

This Standard Operating Procedure (SOP) described the method for determining biomass of herbaceous plant tissues. This analysis along with other plant physiological and toxicological techniques was used to assess the impact of impurities on primary productivity. This method can be used to normalize analytical data, such as contaminant, protein, or nutrient content. The tissue concentrations must be given on per unit of dry weight basis for valid comparisons. In order to compare the concentration of a specific component in a sample with the concentration of that same component in another sample, a common basis for the comparison must be provided. For instance, if the sample weight is the same for both samples a comparison on this basis might be valid in some situations. However, if one sample is half water and the other is dry, then a calculation would have to be made to account for this difference. The amount of the component in question is therefore often expressed per unit of the dry weight of the sample because dry weight is a substantially uniform standard. This is called "normalizing" for the tested component. Included below are procedures for obtaining representative samples, quality assurance or quality control measures, and proper documentation of sampling activities.

To obtain the dry weight, the weighted fruits, leaves, stems and roots were cut and distributed separately in paper bags. The bags were put into an oven with forced air circulation at a temperature of 60°C ± 5°C and dried until a constant weight was achieved (this usually takes 24-48 hours in a forced-air drying oven) (Ramos, 2012). According to Gower et al., (1997) said that plant biomass is the weight of living plant material contained above and below a unit surface area of ground at a given point in time. Individual and combined variance analysis was completed for each measurement. A Tukey test was applied at 5% probability to compare the means, and to compare each treatment with the control. At test was used for comparison of the contrasts. Analysis of contrasts was performed to separate specific treatments, and the trends and stability of these contrasts were also evaluated. All statistical analysis was completed using SPSS software. In many agricultural countries, large quantities of food products are dried to improve shelf life, reduce packaging costs, lower weights, enhance appearance, retain original flavour and maintain nutritional value (Baysal *et al*., 2003; Demir *et al.*, 2007; Simal *et al*., 2000; Sokhansanj and Jayas, 1987). However, consumption of high amount of energy in drying industry, makes drying one of the most energy intensive processes with great industrial significance (Carsky, 2008).

CHAPTER 3

MATERIALS AND METHODS

3.1 Material

3.1.1 Materials

The BRIS soil was taken in UMK Bachok Kelantan as shown in Figure 3.1. Then, *Roselle* seeds compost fertilizer was purchased in area of Kelantan supplier (refer to Appendix A). *Sesbania grandiflora* were taken in Pasir Mas, Kelantan area. The *Sesbania grandiflora* leaves were mixed with BRIS soil to be green manure. Compost also were purchased in area of Kelantan supplier. Source of water to watering trees from the drainage water can be found in Agro Park. Besides that, the net were used as cover the shading trees as light intensity and polybags (12cm x 23 cm).

Figure 3.1: BRIS soil was taken in areas UMK Bachok

3.1.2 Apparatus

The necessary equipment has been used for planting such as cutter, hoe, sand scoop, gloves and watering can. For measuring the diameter of stem sizes of leaves and plant height must used a ruler, and digital vernier caliper (Naimah *et al.*,2014). Light intensity under 50% and 30% were measured by using light meter. Soil moisture and pH were measured by using soil moisture tester . Electronic balance and drying oven were used to weighing and drying biomass of *Roselle*.

3.2 Site preparation

A small area measure 5m x 5m adjacent to fish ponds in Agro Park UMK Jeli is cleared as shown in Figure 3.2.

Figure 3.2: Site clearing activities in Agro Park, UMK Jeli

Plastic mulching sheet is installed along the project site to avoid the grass grow. The area was plotted 5m x 5m. The basic Split-Plot Design involves assigning the levels of factor (A - lighting) to main plots arranged in a Complete Random Design, and then assigning the levels of a second factor (B - Media) to subplots within each main plot with 5 replication . In each plot there were 3 rows of 5 m length. The polybags arranged in accordance with lighting plot intensity of 50% and 30%.The lighting were measured by using light meter and be divide into 50% of lighting and 30% of lighting in the plot by using net as shown in Figure 3.3 below. The nets supported by poles from PVC rod.

Figure 3.3: Installed net and plastic mulching sheet

3.3 Preparation of Sample

Roselle seeds were soaked until germinate before sown in polybags as shown in Figure 3.4 above. Then, formula of growth percentage from Eq. (3.1) are used to determine the growth percentage of seed.

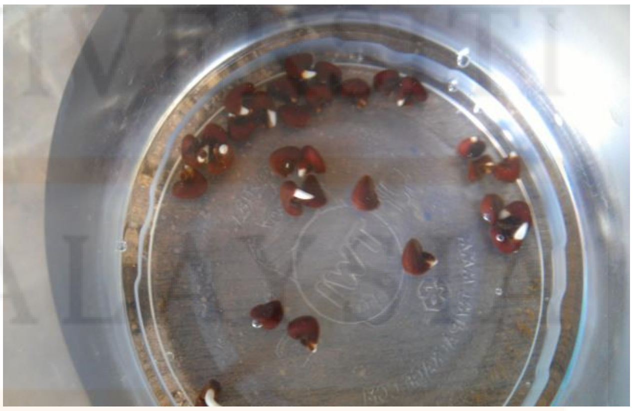


Figure 3.4: Soaked *Roselle* seeds about 1 day

Formula :

Growth percentage

$$\% \text{ GP} = \frac{\text{seed germinated}}{\text{Total seed}} \times 100 \qquad \textbf{Equation 3.1}$$

BRIS soil was taken at UMK Bachok. Before the BRIS put into polybag accordance ratio and media, the BRIS soil must be isolated other matters that are not needed by using plastic filter (as shown in Figure 3.5).

Figure 3.5: Soil were be mixed and filtered to remove other matters

BRIS soil was converted into three media, namely BRIS soil in ratio 1:0, BRIS soil mixed compost in ratio 1:2 and green manure BRIS soil in ratio 1:2. (Md. Sarwar *et al.*, 2014). *Sesbania* leaves dried under sun for 72 hours (3 days) to remove the water in the leaves as shown in Figure 3.6 below.

Figure 3.6: Open drying *Sesbania grandiflora* about 3 days

Compost that used is from vegetable waste. After mixed the BRIS soil with different media (BRIS soil, BRIS soil mixed compost and BRIS soil mixed green manure), the different media treatment were filled into polybag accordance the quantity of the same weight to each polybag as shown in Figure 3.7 and Figure 3.8.

Figure 3.7: weighting of BRIS soil, compost and green manure

Figure 3.8: the BRIS soil is mixed with compost

The soil that contain of media treatment watered to get readings of initial soil moisture and pH by using soil tester as shown in Figure 3.9.

Figure 3.9: Reading of soil moisture and soil pH by using soil tester

3.4 Planting of trees

For survival of sapling growth experiment,treatments of the experiment are conducted in Complete Randomized design with 5 replications. 50 of *Roselle* seeds was soaked in water for one day and sown into the trial tray. Readings of seed germination were taken from the seeds soaked and successfully to be saplings. Then, 30 of *Roselle* seedlings were sown into 30 polybags (12 cm x 23 cm) as shown in Figure 3.10 below.

Figure 3.10: *Roselle* plant was transferred into polybags

Each treatment consist of 30 polybags seedlings of *Roselle* in three different of BRIS soil. *Sesbania grandiflora* were mixed thoroughly with the soil BRIS as green manure fertilizer. Every 5 trees of polybags is under two different lighting treatment and three different soil such as 5 trees under 50% lighting treatment in BRIS soil (1:0) and 5 trees under 30% lighting treatment in BRIS soil (1:0) while 5 trees of polybags under 50% lighting treatment in BRIS soil with compost (1:2) and 5 trees under 30% lighting treatment in BRIS soil with compost (1:2) and the other 5 trees polybags using 50% of lighting treatment in green manure BRIS soil (1:2) and other 5 trees polybags using 30% of lighting treatment in green manure BRIS soil (1:2) by followed (Md. Sarwar *et al.*, 2014). The suggestion suitable quantity of water is 4 litres (Naimah *et al.*, 2014). The trees were watered twice daily to ensure adequate water in trees and soil.

3.5 Determination of measuring and collecting data

3.5.1 Growth performance of *Hibiscus sabdariffa.L (Roselle)*

All of observation on survival of cutting were recorded at the time of roots initiation and growth parameter at the time of transplanting for all of 30 trees for survival percentage. The data on survival percentage of growing was recorded according to growth ability (height of stem, number of leaves, diameter of stem and biomass production). Plant height were recorded by measure from polybags top soil surface upto the highest of leaf tip by straghtening the stem. Diameter of stems was recorded by using digital vernier caliper as shown in Figure 3.11 below. Plant growth performance was recorded along progresses time and transplanting at the end. Plant height and stem diameter were expressed in cm and mm.

Figure 3.11: Measuring diameter of stem by using Vernier caliper

3.5.2 Fresh and Dry biomass weight *Hibiscus sabdariffa.L (Roselle)*

The roots length are measure by destructive method of uprooting the plants and taking measurement by standard method. At the last, fresh and dry weight of the plant (fresh weight of stem, roots and fruits) was recorded before and after 48 hours reduction of moisture from the *Roselle*.

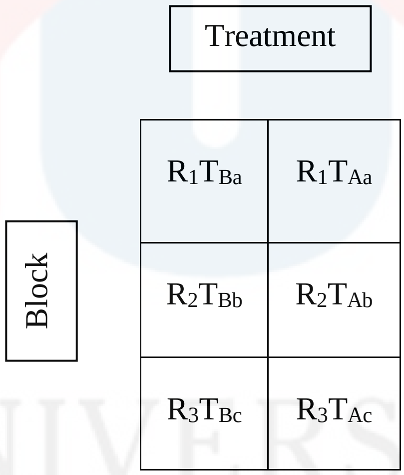
The samples should be washed through two sieves (1.41 mm and 600 µm diameter pore size) to remove any excess soil from the roots and placed into pre-weighed glass dishes. In laboratory session, plants will be placed in resealable plastic bags, kept cool, weighed as soon as possible, and dried following the weighing. If the plants cannot be weighed for fresh weight in the field, they must be transported to the lab or other appropriate facility in plastic bags on wet ice and weighed within 48 hours. Then, the fresh weight was recorded and dried at 60°C for 24-48 hours in oven as shown in Figure 3.12 below. After drying, the samples need to be reweighed to record the dry weight of samples.

Figure 3.12: Used oven to drying stems, roots, and fruit about 48 hours in 65°C

The process of drying *Roselle* plants were conducted in constant temperature that is four temperatures (35, 45, 55, and 65°C) for 48 hours in oven. Drying air temperature was found to be the main factor affecting the drying kinetics of *Roselle*; rising the drying temperature from 35°C to 65°C intensely reduced the drying times (I.E. Saeed *et al.*, 2008). The weighted fresh and dry of fruit, stem and roots were conducted to determine the weight of biomass initial and after of *Roselle* as (refer to Appendix B).

3.6 Experimental Design

Experimental design is comprise of different factors (A and B) in Split Plot Design as shown in Figure 3.13. Factor A is the main plot factor with 2 levels (A and B) while factor B is subplot factor with 3 levels (a, b and c). T_{Ba} represent of BRIS soil with ratio (1:0) in lighting 50%, T_{Aa} represent of BRIS soil with ratio (1:0) in lighting 30%, T_{Bb} represent of BRIS soil with compost (1:2) in lighting 50%, T_{Ab} represent of BRIS soil with compost (1:2) in lighting 30%, T_{Bc} is represent of green manure BRIS soil (1:2) in lighting 50%, T_{Ac} is represent of green manure BRIS soil (1:2) in lighting 30%. While R represents the number of plants replicate in a plot. There are 3 replications per main plot.



Main plot: Lighting (50% and 30%)

Subplot: BRIS soil medium

Figure 3.13: Split Plot Design

Treatment Ba – BRIS soil (1:0) in lighting 50%

Treatment Aa - BRIS soil (1:0) in lighting 30%

Treatment Bb – BRIS soil with compost (1:2) in lighting 50%

Treatment Ab - BRIS soil with compost (1:2) in lighting 30%

Treatment Bc – Green manure BRIS soil (1:2) in lighting 50%

Treatment Ac – Green manure BRIS soil (1:2) in lighting 30%

3.7 Site layout

Referring to random table from Washington State University (2000), Complete Randomized Design (CRD) layout arrangement subject were used to this study for simplest of all designs. A group of experimental subjects is considered a single independent experimental unit. There are 2 (A-B) treatments with 5 replications each as shown in Figure 3.14.

Split Plot Design

	Aa_{11}	Ac_{07}	Ab_{02}	Ab_{15}	Aa_{05}
30 % (L_1)	Ac_{30}	Aa_{27}	Ab_{09}	Aa_{29}	Ac_{04}
A	Ab_{17}	Ab_{21}	Aa_{10}	Ac_{13}	Ac_{08}
	Ba_{16}	Ba_{25}	Bb_{20}	Bc_{01}	Bb_{22}
50% (L_2)	Bc_{14}	Bb_{03}	Ba_{18}	Bb_{06}	Bc_{26}
B	Bb_{19}	Bc_{28}	Bc_{12}	Ba_{24}	Ba_{23}

Figure 3.14: Layout planting site
(Source: William, 1968)

Before setting the planting site, the Split Plot Design layout was plotted by referring to table of random number (William, 1968) (refer to Appendix C) and then was arranged based on Completed Randomized Design (CRD) as shown in Table 3.1.

Table 3.1: Arrangement based on Complete Randomized Design (CRD)

	BRIS soil	Aa_{11}, Aa_{27}, Aa_{10}, Aa_{29}, Aa_{05}
30 % (L_1) A	BRIS soil with compost	Ab_{17}, Ab_{21}, Ab_{09}, Ab_{02}, Ab_{15}
	Green manure BRIS soil	Ac_{30}, Ac_{07}, Ac_{04}, Ac_{08}, Ac_{13}
	BRIS soil	Ba_{16}, Ba_{25}, Ba_{18}, Ba_{24}, Ba_{23}
50% (L_2) B	BRIS soil with compost	Bb_{19}, Bb_{03}, Bb_{20}, Bb_{06}, Bb_{22}
	Green manure BRIS soil	Bc_{14}, Bc_{28}, Bc_{12}, Bc_{01}, Bc_{26}

(Source: William, 1968)

3.8 Data Analysis

The analyse were subjected to using descriptive analysis, Kruskal Wallis test and Mann Whitney U test in SPSS software.

3.9 Flow chart

According to Figure 3.15 below shown the flow chart of activities in this project research. The gantt chart and milestone (refer to Appendix D) is the proggression of framework along this project research.

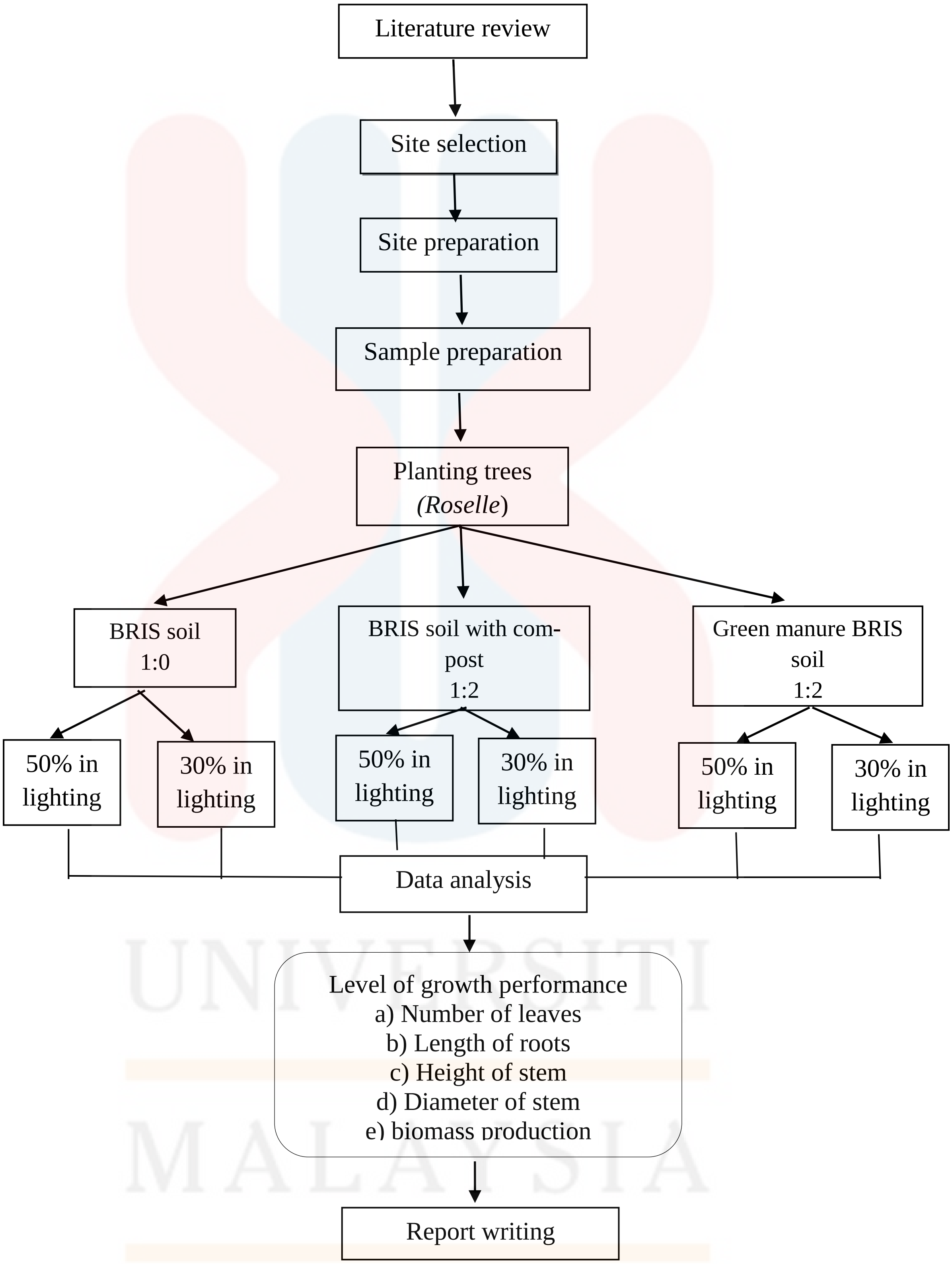


Figure 3.15: Flow chart

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Growth performance of *Hibiscus sabdariffa.L (Roselle)*

This study is to determine the level of growth performance and biomass production of *Hibiscus sabdariffa.L* by using three different medium; (BRIS soil, BRIS soil with compost and green manure BRIS soil) and to determine the growth performance and biomass production of *Hibiscus sabdariffa.L* under two different light intensities (50% and 30%). The growth performance analysis of *Roselle* were carried out in this study are height of stem, number of leaves, diameter of stem and biomass production.

There are separation sections according to the specific objectives of research that is, (i) identification of height of *Roselle*, (ii) identification of number of leaves, (iii) identification of diameter of stem, (iv) comparison of height of *Hibiscus sabdariffa.L (Roselle)* between three media and two light intensities, (v) comparison of number of leaves *Hibiscus sabdariffa.L (Roselle)* between three media and two light intensities, (vi) comparison of diameter of stem *Hibiscus sabdariffa.L (Roselle)* between three media and two light intensities, (vii) comparison of biomass production of *Hibiscus sabdariffa.L (Roselle)* between three media and two light intensities.

This data statistical was interpreted by using the non-parametric statistical, which are descriptive, Kruskal Wallis test, and Mann Whitney U test. The reasons of using are the data have small sample size and it have not normal data.

4.1.1 Growth percentage of seed germination

Seed germination percentage indicate the good quality and performance growth of *Roselle* seed. Trial of experiment, seed is tested. The calculation of seed germination shown as below:

$$\% \text{ GP} = \frac{\text{seed germinated}}{\text{Total seed}} \times 100$$

$$= \frac{41 \text{ seeds}}{50 \text{ seeds}} \times 100$$

$$= 82\ \% \text{ growth percentage}$$

The result indicates the percentage of seed growth was 41 seeds from 50 seeds of *Roselle* which is 82% of growth percentage.

4.1.2 Identification of height of *Hibiscus sabdariffa.L (Roselle)*

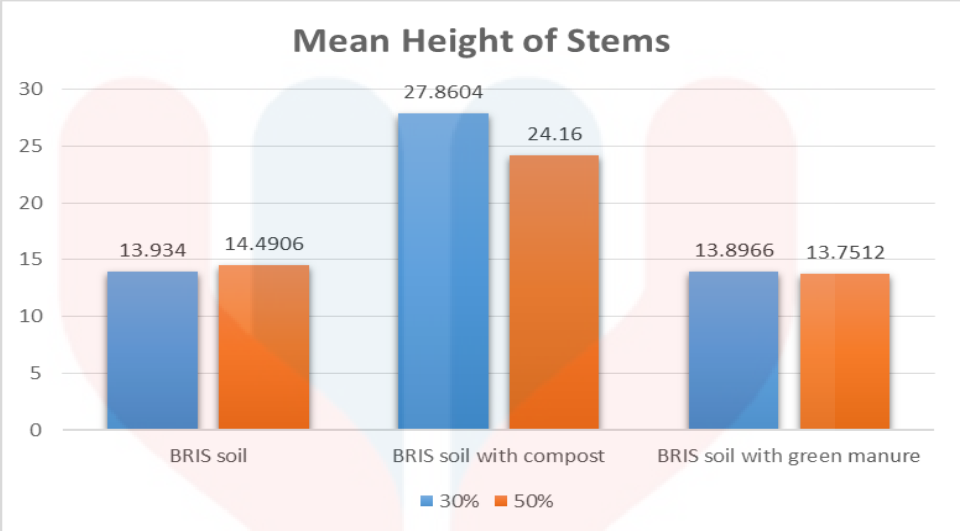


Figure 4.1: Mean height of *Roselle* comparison between different media and different light intensity

Figure 4.1 shows the mean height of stem comparison of three different media; BRIS soil, BRIS soil with compost and BRIS soil with green manure under two different light intensities (30% and 50%). The mean of height performance of stem *Roselle* at BRIS soil under 30% lighting was 13.93 while under 50% lighting was 14.49. The mean of height of stem *Roselle* at BRIS soil with compost under 30% light intensity was 27.86 compare to 50% light intensity was 24.16. Then, the mean of height of stem *Roselle* at BRIS soil with green manure have differ slightly under 30% of light intensity was 13.90 and under 50% light intensity was 13.75. According to the Figure 4.1, the most impressive achievement of the height performance of stem *Roselle* was on BRIS soil with compost under 30% of light intensity with (27.86).

4.1.2.1 Comparison in height of *Hibiscus sabdariffa.L* (*Roselle)*

Table 4.1: Comparison of height of *Roselle* stems by three different media and two different intensities by using Kruskal Wallis and Mann Whitney U test

Light	Chi-Square	Asymp. Sig.	Media	Mean Rank	Asymp. Sig.
30%	34.000	0.000	BRIS soil	35.88	0.000
			BRIS soil with compost	65.12	
			BRIS soil	54.58	0.160
			BRIS soil with green manure	46.42	
			BRIS soil compost	64.78	0.000
			BRIS soil with green manure	36.22	
50%	17.853	0.000	BRIS soil	40.03	0.000
			BRIS soil with compost	60.97	
			BRIS soil	53.34	0.328
			BRIS soil with green manure	47.66	
			BRIS soil compost	60.97	0.000
			BRIS soil with green manure	40.03	

Note: Mean rank and chi-square followed by Kruskal Wallis test, contrasts significant and no significant, respectively, at ($p \leq 0.05$).

Table 4.1 above shown that the comparison in height of stem for *Hibiscus sabdariffa.L* (*Roselle)* by using Kruskal Wallis and Mann Whitney U test. In Kruskal Wallis test shown that there have significantly different at three different media of BRIS soil, BRIS soil with compost and BRIS soil with green manure under lighting (30% and 50%) with (α=0.000) at 0.05 significant level. However in Mann Whitney test shown it was not significant different at comparison between media BRIS soil and BRIS soil with green manure under 30% lighting with (α=0.160) at 0.05 significant level. Result also shown that it was not significant different comparison of BRIS soil and BRIS soil with green manure under 50% lighting with (α=0.328) at 0.05 significant level.

From this study, the highest mean rank of height of *Roselle* stems was at BRIS soil with compost under 30% light intensity (65.12). In observation, *Ro-*

selle shown good performance growth of height at media BRIS soil with compost in lighting 30%. The low light-induced absence reduced photosynthetic supply effect. In the absence of such effects, an injected plant might be expected to achieve the same size and shape as an uninfected plant under greater light intensities (Sultan.H *et al*, 2002). The common fungal disease also that attacks *Roselle* roots and stem is *Coniella rnusaiaensis var*.*Hibisci* and *Phoina spp*.

4.1.3 Identification of number of leaves *Hibiscus sabdariffa.L (Roselle)*

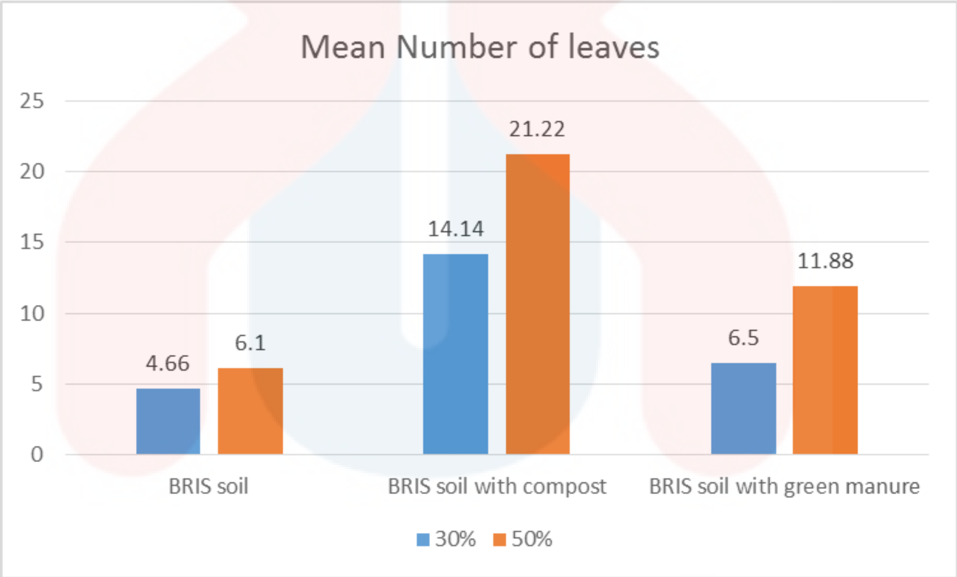


Figure 4.2: Mean number of leaves *Roselle* comparison between different media and different light intensity

Figure 4.2 above represent of mean number of leaves comparison of three different media; BRIS soil, BRIS soil with compost and BRIS soil with green manure under two different light intensities (30% and 50%). The mean of number of leaves of *Roselle* at BRIS soil under 30% lighting was 4.66 while under 50% lighting was 6.1. The mean of number of leaves of *Roselle* at BRIS soil with compost under 30% light intensity was 14.14 but under 50% light intensity was 21.22. Then, the mean of number of leaves *Roselle* at BRIS soil with green manure under 30% light intensity was only 6.5 and under 50% light intensity was 11.88. So that, this study shown the highest performance of leaves was at BRIS soil with compost under 50% light intensity (21.22). This result prove that there are have compatibility of treatment media BRIS soil with compost under 50% light intensity for performance growth of number of leaves. It shown that, the light appropriate affected and give influence in the growth of stem and number of leaves. This result also shown the same statement with Sultan.H *et al.*, (2002), proves that when light intensity adequate to plant help to growth ability of plant. The light dependent to performance growth and photosynthesis process of plant.

4.1.3.1 Comparison of number of leaves *Hibiscus sabdariffa.L (Roselle)*

Table 4.2: Comparison of number of leave by three different media and two different intensities by using Kruskal Wallis and Mann Whitney U test

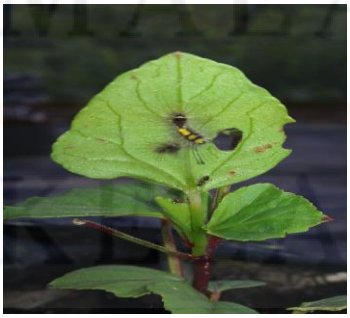
Light	Chi-Square	Asymp. Sig.	Media	Mean Rank	Asymp. Sig.
30%	48.673	0.000	BRIS soil	31.09	0.000
			BRIS soil with compost	69.91	
			BRIS soil	48.23	0.426
			BRIS soil with green manure	52.77	
			BRIS soil compost	65.43	0.000
			BRIS soil with green manure	35.57	
50%	29.404	0.000	BRIS soil	34.18	0.000
			BRIS soil with compost	66.82	
			BRIS soil	45.56	0.087
			BRIS soil with green manure	55.44	
			BRIS soil compost	59.39	0.002
			BRIS soil with green manure	41.61	

Note: Mean rank and chi-square followed by Kruskal Wallis test, contrasts significant and no significant, respectively, at (p≤ 0.05).

Table 4.2 above shown that the comparison of number of *Roselle* leaves between three different media; (BRIS soil, BRIS soil with compost and BRIS soil with green manure) and two light intensities (30% and 50%).

From Kruskal Wallis test show that it have significant of the three different media of BRIS soil, BRIS soil with compost and BRIS soil with green manure in light intensity of (30% and 50%) with (α=0.000) at 0.05 significant level. In Mann Whitney test shown, there were not significant different comparison between media BRIS soil and BRIS soil with green manure at 30% lighting with (α=0.426) while it was also were not significantly different comparison between media BRIS soil and BRIS soil with green manure under 50% lighting with (α=0.087) at 0.05 significant level.

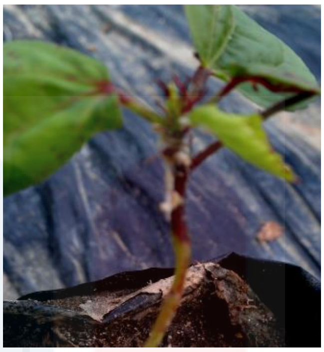
Table 4.2 shown that the highest of mean rank of number of leave was from media BRIS soil with compost under 30% light intensity that was (69.91). In observation of study, the factor of light intensity and compost give effect to growth number leaves of *Roselle*. The factor of effect number of leaves decrease is disruption of insect pests such as snails, caterpillar, grasshoppers (*Valanga nigricornis),* black citrus aphid and white moth as shown in Figure 4.3 (i-iv) below.



(i) Larva (Caterpillar)

(ii) *Toxoptera aurantii* (black citrus aphid)

(iii) *Helix pomatia* (Snail)



(iv) *Lawana conspersa* (White moth)

Figure 4.3: Pests harmful to *Roselle* plants

4.1.4 Identification of diameter of stem *Hibiscus sabdariffa.L (Roselle)*

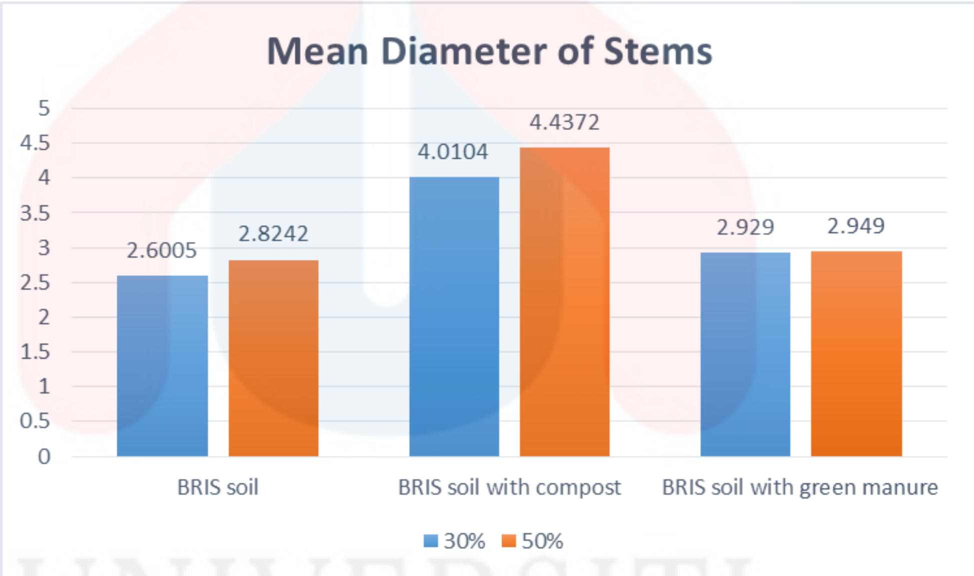


Figure 4.4: Mean diameter of stem *Roselle* comparison between different media and different light intensity

Figure 4.4 above represent of mean diameter of *Roselle* stem comparison of three different media; BRIS soil, BRIS soil with compost and BRIS soil with green manure under two different light intensities (30% and 50%). The mean of diameter of stem of *Roselle* at BRIS soil under 30% lighting was 2.60 while under 50% lighting was 2.82. The mean of diameter of stem of *Roselle* at BRIS soil with compost under 30% light intensity was 4.01 but 50% light intensity was 4.44. Then, the mean of diameter of stem *Roselle* at BRIS soil with green manure was only differ in 20 that was under 30% of light intensity was 2.93 and under 50% light intensity was 2.95. The Figure 4.4 shown that the mean diameter of stem was higher at 50% light intensity in media BRIS soil with compost (4.44).

4.1.4.1 Comparison of diameter of stem *Hibiscus sabdariffa.L (Roselle)*

Table 4.3: Comparison of diameter of *Roselle* stem by three different media and two different intensities by using Kruskal Wallis and Mann Whitney U test

Light	Chi-Square	Asymp. Sig.	Media	Mean Rank	Asymp. Sig.
30%	27.911	0.000	BRIS soil	35.59	0.000
			BRIS soil with compost	65.41	
			BRIS soil	47.70	0.334
			BRIS soil with green manure	53.30	
			BRIS soil compost	61.52	0.000
			BRIS soil with green manure	39.48	
50%	18.582	0.000	BRIS soil	38.74	0.000
			BRIS soil with compost	62.26	
			BRIS soil	49.51	0.733
			BRIS soil with green manure	51.49	
			BRIS soil compost	60.24	0.001
			BRIS soil with green manure	40.76	

Note: Mean rank and chi-square followed by Kruskal Wallis test, contrasts significant and no significant, respectively, at ($p \leq 0.05$).

Table 4.3 above shown the comparison of diameter of *Roselle* stem between three different media; (BRIS soil, BRIS soil with compost and BRIS soil with green manure) and two light intensities (30% and 50%). In Kruskal Wallis test, there have significant with (α=0.000) at 0.05 significant level in the three different media under two lighting (30% and 50%), but in Mann Whitney test shown there was not significantly different of media BRIS soil and BRIS soil with green manure in lighting 30% with (α=0.334) at 0.05 significant level. It is also have no significant different of media BRIS soil and BRIS soil with green manure in lighting 50% with (α=0.733) at 0.05 significant level.

The Table 4.3 above shown that the highest of mean rank of diameter of *Roselle* stem was at BRIS soil with compost in lighting 30% at (65.41). The shading of place impact on soil moisture besides maintains sufficient nutrients to the plants. Regarding to Sultan.H *et al*, (2002), the shading under 75% changes in structure and moisture of soil, suggesting that these effects are strictly due to light intensity and not related to photosynthetic availability. From this study prove that compost be able to help giving nutrient and repair structure of soil in order to improve stem growth from get enough water because rising of soil moisture (US Composting Council, 2008).

4.2 Biomass production (fresh and weight) of *Hibiscus sabdariffa.L (Roselle)* in terms of stem, roots and fruit.

The focus of this study is to determine the biomass production of *Hibiscus sabdariffa.L* (fresh and dry). This experiment was conducted to determine the fresh and dry weight biomass of *Hibiscus sabdariffa.L* interaction with the three media treatment; BRIS soil, BRIS soil with compost and BRIS soil with green manure and two different light intensities (30% and 50%). The analysis of *Roselle* biomass production were carried out in the study for measured the fresh weight (initial) and dry weight of *Roselle* stem, roots and fruits after drying.

4.2.1 Mean of fresh biomass production of roots, stem and fruit.

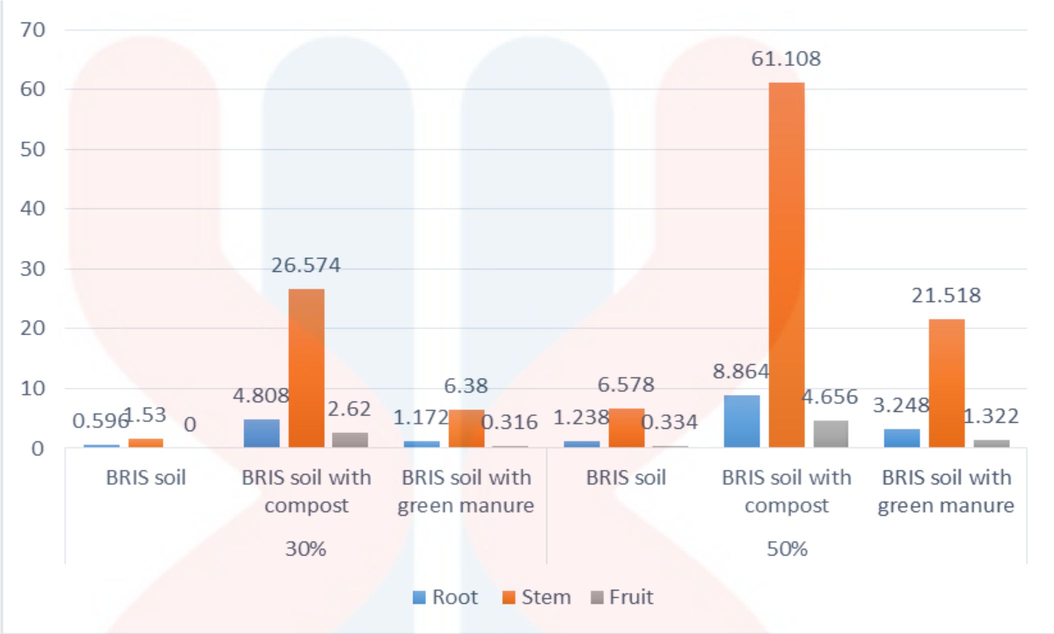


Figure 4.5: Mean of fresh weigh biomass production from roots, stem and fruit *Hibiscus sabdariffa.L (Roselle)*

Figure 4.5 shows the mean of fresh biomass production in term of roots, stem and fruit *Hibiscus sabdariffa.L (Roselle).* The highest mean of roots in fresh weight was at BRIS soil with compost under 50% lighting with (8.86g) while the lowest mean roots was at BRIS soil under 30% lighting with (0.59g). The highest mean of stem was at BRIS soil with compost under 50% light intensity with (61.11g) while the lowest mean of stem was at BRIS soil under 30% light intensity with (0.53g). The highest mean of fruit in fresh weigh was at BRIS soil with compost under 50% lighting with (4.66g) while the lowest mean of fruit was at BRIS soil under 30% light intensity with zero weight.

The highest performance of fresh weight biomass production was at BRIS soil with compost under 50% light intensity which roots (8.86g), stem (61.11g) and fruit (4.66g).

In observation, the better performance of fresh weight biomass production in roots, stem, and fruits was at BRIS soil under 50% lighting because the *Roselle* received adequate sun and the BRIS soil received nutrient and mineral from compost. This study proved that adequate lighting can help the process of photosynthesis and biomass production of stem, roots and fruit of *Roselle.*

4.2.2 Mean of dry biomass production of roots, stem and fruit.

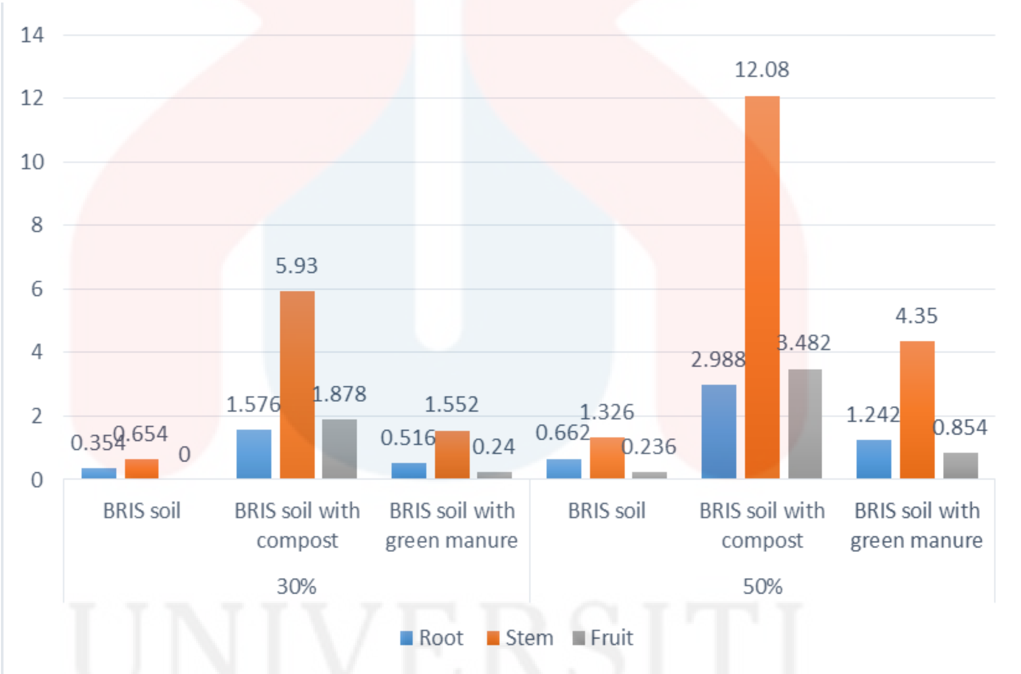


Figure 4.6: Mean of dry weight biomass production from roots, stem and fruit *Hibiscus sabdariffa.L (Roselle)*

Figure 4.6 shows the mean of dry biomass production from roots, stem and fruit *Hibiscus sabdariffa.L (Roselle).* The highest mean of roots was at BRIS soil with compost under 50% lighting with (2.99g) while the lowest mean roots was at BRIS soil under 30% lighting with (0.35g). The highest mean of stem was at BRIS soil with compost under 50% lighting with (12.08g) while the lowest mean of stem was at BRIS soil under 30% light intensity with (0.65g). The highest mean of fruit was at BRIS soil with compost under 50% lighting with (3.48g) while the lowest mean of fruit was at BRIS soil under 30% light intensity with zero weight.

In observation, the highest of biomass performance is because factor of lighting which the adequate sun can help in plant photosynthesis and growing. However, the lowest performance of biomass production was at BRIS soil under 30% lighting because the *Roselle* cannot receive more sun lighting to support the above and below *Roselle* trees. The low lighting also can because fungus infected to *Roselle* trees and reduced performance of height, number of leaves and diameter of stem.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on this study, there is significant different between three different media and two different light intensities (30% and 50%). The successful result from growth performance of *Roselle* height was in BRIS soil with compost under 30% of light intensity, while the best performance number of leaves was at BRIS soil with compost under 50% lighting intensity. In term diameter of stem growth performance, the highest was at BRIS soil with compost under 50% light intensity. The better performance of biomass production (fresh and dry weight) was at BRIS soil with compost under 50% light intensity. The result of fresh and dry weight biomass are better to improve growth performance of plants highlighted at treatment media BRIS soil with compost that is suitable to increasing fertility of BRIS soil because it improves water holding capacity, thus reducing water loss and leaching in sandy soil. The suggestion accordingly from this study, the best media treatment was BRIS soil with compost; however the light intensity is depends on the growth parameters. The light condition 50% was better than 30% because light is the one important treatment for photosynthesis process and required for growth and yield of plants.

5.2 Recommendation

According to this study of fertility BRIS soil for growth performance of *Roselle,* the technical improvement for future experiment is related to limitation of this study such as lengthening the time of the study, conducting experiment such as not in rainy season (monsoon) to avoid inappropriate weather factor and excessive water that will affect the crop performance. Moreover, the surrounding area at the planting site should be suitable pesticide treated with care order to avoid pests attacked on plants.

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APPENDIX A

Figure A.1: *Hibiscus sabdariffa.L (Roselle)* seeds
(Source: made in Thailand)

Figure A.2: Compost fertilizer

APPENDIX B

Figure B.1: Fresh and dried biomass of *Roselle* fruit (gram)

Figure B.2: Fresh and dried biomass of roots (gram)

Figure B.3: Fresh and dried biomass of stems (gram)

APPENDIX C

Table C.1: Random Numbers Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	10480	15011	01536	02011	81647	91646	69179	14194	62590	36207	20969	99570	91291	90700
	22368	46573	25595	85393	30995	89198	27982	53402	93965	34095	52666	19174	39615	99505
	24130	48360	22527	97265	76393	64809	15179	24830	49340	32081	30680	19655	63348	58629
	42167	93093	06243	61680	07856	16376	39440	53537	71341	57004	00849	74917	97758	16379
5	37570	39975	81837	16656	06121	91782	60468	81305	49684	60672	14110	06927	01263	54613
	77921	06907	11008	42751	27756	53498	18602	70659	90655	15053	21916	81825	44394	42880
	99562	72905	56420	69994	98872	31016	71194	18738	44013	48840	63213	21069	10634	12952
	96301	91977	05463	07972	18876	20922	94595	56869	69014	60045	18425	84903	42508	32307
	89579	14342	63661	10281	17453	18103	57740	84378	25331	12566	58678	44947	05585	56941
10	85475	36857	53342	53988	53060	59533	38867	62300	08158	17983	16439	11458	18593	64952
	28918	69578	88231	33276	70997	79936	56865	05859	90106	31595	01547	85590	91610	78188
	63553	40961	48235	03427	49626	69445	18663	72695	52180	20847	12234	90511	33703	90322
	09429	93969	52636	92737	88974	33488	36320	17617	30015	08272	84115	27156	30613	74952
	10365	61129	87529	85689	48237	52267	67689	93394	01511	26358	85104	20285	29975	89868
15	07119	97336	71048	08178	77233	13916	47564	81056	97735	85977	29372	74461	28551	90707
	51085	12765	51821	51259	77452	16308	60756	92144	49442	53900	70960	63990	75601	40719
	02368	21382	52404	60268	89368	19885	55322	44819	01188	65255	64835	44919	05944	55157
	01011	54092	33362	94904	31273	04146	18594	29852	71585	85030	51132	01915	92747	64951
	52162	53916	46369	58586	23216	14513	83149	98736	23495	64350	94738	17752	35156	35749
20	07056	97628	33787	09998	42698	06691	76988	13602	51851	46104	88916	19509	25625	58104
	48663	91245	85828	14346	09172	30168	90229	04734	59193	22178	30421	61666	99904	32812
	54164	58492	22421	74103	47070	25306	76468	26384	58151	06646	21524	15227	96909	44592
	32639	32363	05597	24200	13363	38005	94342	28728	35806	06912	17012	64161	18296	22851
	29334	27001	87637	87308	58731	00256	45834	15398	46557	41135	10367	07684	36188	18510
25	02488	33062	28834	07351	19731	92420	60952	61280	50001	67658	32586	86679	50720	94953
	81525	72295	04839	96423	24878	82651	66566	14778	76797	14780	13300	87074	79666	95725
	29676	20591	68086	26432	46901	20849	89768	81536	86645	12659	92259	57102	80428	25280
	00742	57392	39064	66432	84673	40027	32832	61362	98947	96067	64760	64584	96096	98253
	05366	04213	25669	26422	44407	44048	37937	63904	45766	66134	75470	66520	34693	90449
30	91921	26418	64117	94305	26766	25940	39972	22209	71500	64568	91402	42416	07844	69618
	00582	04711	87917	77341	42206	35126	74087	99547	81817	42607	43808	76655	62028	76630
	00725	69884	62797	56170	86324	88072	76222	36086	84637	93161	76038	65855	77919	88006
	69011	65795	95876	55293	18988	27354	26575	08625	40801	59920	29841	80150	12777	48501
	25976	57948	29888	88604	67917	48708	18912	82271	65424	69774	33611	54262	85963	03547
35	09763	83473	73577	12908	30883	18317	28290	35797	05998	41688	34952	37888	38917	88050
	91567	42595	27958	30134	04024	86385	29880	99730	55536	84855	29080	09250	79656	73211
	17955	56349	90999	49127	20044	59931	06115	20542	18059	02008	73708	83517	36103	42791
	46503	18584	18845	49618	02304	51038	20655	58727	28168	15475	56942	53389	20562	87338
	92157	89634	94824	78171	84610	82834	09922	25417	44137	48413	25555	21246	35509	20468

(Source: William, 1968)

APPENDIX D

Table D.1: Gantt chart

No.	Activities	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan
1	Selection of research project title													
2	Literature review													
3	Writing research proposal													
4	Submission of research proposal report for evaluation													
5	Proposal defend													
6	Preparation of sample													
7	Conducting site preparation													
8	Carried out sample planting and collection data													
9	Data analysis and interpretation (Result, discussion and conclusion)													
10	Research project presentation (VIVA)													
11	Submission of thesis													

Table D.2: Milestone

Description	Duration date	
	Start	End
Preparation of sample	1/5/2016	13/8/2016
Conducting site preparation	1/5/2016	13/8/2016
Carried out sample planting	4/8/2016	17/10/2016
Data analysis and interpretation (Result, discussion and conclusion)	14/8/2016	30/11/2016
Research project presentation (VIVA)	14/12/2016	15/12/2016
Submission of thesis	1/1/ 2017	8/1/ 2017