ASSESSING THE GROWTH PERFORMANCE OF *Hibiscus sabdariffa* UNDER DIFFERENT LIGHT INTENSITY AND FERTILIZATION LEVEL ON BRIS SOIL

by:

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DECLARATION

I declare that this thesis entitled “title of the thesis”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 : Mohammad Aizuddin bin Awang

Date : _____

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Assessing The Growth Performance of *Hibiscus sabdariffa* Under Different Light Intensity and Fertilization Level on BRIS Soil

ABSTRACT

BRIS (Beach Ridges Interspersed with Swale) soil is one type of poor soil that has many problem. Most of the crops planted on BRIS soil did not grow well because of the characteristic of BRIS soil. This study is carried out to improve the fertility of BRIS soil by the application of different light intensity and fertilization level on BRIS soil. A total of 30 roselle seeds were planted in three different treatment of BRIS soil which is BRIS soil only (T1), BRIS soil + 2g of NPK (T2) and BRIS soil + 4g of NPK (T3) under two different light intensity which is 30% and 50% of light penetration. The diameter and height of roselle were recorded every two weeks for 12 weeks. The relative growth rate (RGR) of each plant were calculated at the end of the experiment. The T3 treatment under 50% light intensity is proven the most effective for the growth performance when have the highest average for diameter with the average 0.86cm in week 12th, fresh weight (634.33g), dried weight (128.28g) and fresh weight of roselle's fruits (184.80g) is in this treatment. The T2 treatment in 50% light intensity shows the highest average of height in week 12th with average 78.60cm compared to T3 in 50% light intensity with average 75.20cm. T3 is most effective treatment compared to other treatment (T1 and T2) based on the result. As a conclusion, BRIS soil + 4g NPK fertiliser (T3) plays a vital role as a nutrient supplier for roselle and the 50% light intensity also affect for the growth performance of roselle.

Menilai Prestasi Pertumbuhan *Hibiscus sabdariffa* pada Tanah BRIS di Bawah Keamatan Cahaya dan Kadar Baja Yang Berbeza

ABSTRAK

Tanah BRIS (Beach Ridges Interspersed with Swale) adalah salah satu jenis tanah yang mempunyai banyak masalah. Kebanyakkan tanaman yang ditanam di tanah BRIS tidak membesar dengan baik kerana ciri-ciri tanah BRIS yang mempunyai suhu permukaan yang tinggi yang menyebabkan pengewapan kelembapan dan nitrogen yang tinggi diatas permukaan tanah, keupayaan memegang air yang rendah, kandungan bahan organik yang rendah, kadar penyejatan yang tinggi dan kekurangan nutrient. Kajian ini dilakukan untuk mempertingkatkan kesuburan tanah BRIS dengan menggunakan keamatan dan kadar baja yang berbeza ke atas tanah BRIS. Sebanyak 30 biji benih roselle telah ditanam dalam tiga jenis tanah BRIS dengan rawatan yang berbeza iaitu tanah BRIS sahaja (T1), tanah BRIS + 2g baja NPK (T2) dan tanah BRIS + 4g baja NPK (T3) dibawah dua keamatan cahaya yang berbeza iaitu 30% dan 50%. Diameter dan ketinggian diambil dua minggu sekali selama 12 minggu. Kadar pertumbuhan relative (RGR) setiap pokok dikira pada akhir kajian. Tanah BRIS + 4g baja NPK (T3) dibawah keamatan cahaya 50% memberi kesan yang paling baik pada prestasi pertumbuhan apabila mempunyai purata tertinggi untuk diameter dengan purata 0.86cm pada minggu ke-12, berat bersih (634.33g), berat kering (128.28g) dan berat bersih buah roselle (184.80g). Rawatan T2 dibawah keamatan cahaya 50% menunjukkan purata tertinggi untuk ketinngian pada minggu ke-12 dengan purata 78.60cm berbanding T3 dibawah keamatan cahaya 50% dengan purata 75.20cm. T3 adalah rawatan yang paling berkesan berbanding dengan rawatan T1 dan T2 berdasarkan kepada keputusan. Kesimpulannya, tanah BRIS + 4g baja NPK (T3) memainkan peranan penting sebagai pembekal nutrient kepada roselle dan keamatan cahaya 50% juga memberi kesan kepada pertumbuhan.

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%	-	percentage
°	-	degree
C	-	celcius
>	-	greater than

LIST OF ABBREVIATION

BRIS	-	Beach Ridges Interspersed Soil
CEC	-	cation exchange capacity
CRD	-	Completed Randomized Design
cm	-	centimeter
g	-	gram
ha	-	hectare
km	-	kilometer
ln	-	lorne
NPK	-	Nitrogen, Phosphorus and Potasium
RGR	-	Relative growth rate

CHAPTER 1

INTRODUCTION

1.1 Background Study

BRIS (Beach Ridges Interspersed with Swale) soil is one type of poor soil that has many problem. Most of the crops planted on BRIS soil did not grow well because of the characteristic of BRIS soil which were high surface soil temperature that causes speedy vaporisation of moisture and nitrogen on soil surfaces, low water holding capacity, low organic matter content, high infiltration rate and low nutrient availaibility (Hanafi *et al.* 2010). Due to this characteristic, roselle were planted in BRIS soil in order to measure whether it is suitable to grow in BRIS soil.

Hibiscus sabdariffa known by various name depends on the countries such as rozelle, sorrel, red sorrel and karkade. Other vernacular names include rozelle, jelly okra, lemon bush, and Florida cranberry. Roselle is important subject that react to the light with different intensity to show the growth rate and can grow in BRIS soil with a small amount of water. Roselle physical characteristic is the plant is upright and has branches. It can be grow up to 3.5m with a bit hairy stem, cylindrical in shape with reddish colour and with taproot type. Qi *et al.* (2005) stated that leaves of roselle are dark green to red, glabrous, alternate, serrate margins with long petiole and palmately divided into 3-7 lobed at lower leaves and 3-5 lobed at the upper leaves. For its flower, it present in the leaf axils which can growth up to 12.5 cm wide, yellow with dark centre containing short-peduncles in maroon colour (Mahadevan *et al.* 2009).The size of its fruit around 1.25-2cm long with green colour when immature and dark red colour when matured.Each fruit has five valves and contain 3-4 seed each valve. The seeds has a small size which is 3-5mm with kidney-shaped like, light brown in colour and covered with minute, stout and stellate hairs (Mahadevan *et al*.

2009).

Light intensity is the total amount of light and the degree of brightness that received by plant. The germination and growth of roselle is affected by the amount of light received. The light intensity that received by plant can be different based on a situation such geographic location, distance from the equator and weather. Ismail *et al.* (2008) stated that roselle needs 12 hours of sunlight for growth during the phase one of growth to prevent premature flowering.

1.2 Problem Statement

BRIS soil is a type of poor and problematic soil which contain less nutrients and organic matter. Its also sandy type of soil that contain more than 90% sand and make it has low water holding capacity. Despite of all the problem of BRIS soil, the study about the most suitable light intensity and effect of fertilization on growth performance of roselle must be done. BRIS soil should be utilize by using a suitable methods in order to increase the growth performance and production yield of *Hibiscus sabdariffa* or also known as roselle.

1.3 Objective

The objectives of these study are:-

1. To determine the effect of fertilizer on growth performance of *Hibiscus sabdariffa* in BRIS soil.
2. To compare the different light intensity on the growth performance of *Hibiscus sabdariffa.*

CHAPTER 2

LITERATURE REVIEW

2.1 BRIS Soil

Beach Ridges Interspersed with Swale soils or also known as BRIS soil are the sandy marine deposits, which mainly developed along with a narrow belt ranging from three to 12 km fringing the east coast of Peninsular Malaysia (Hanafi *et al.* 2010).BRIS soil can be found near the beach area around 0.2-8.0km from the sea beach which covers about 155 400 ha Peninsular Malaysia and about 40 000 ha in state of Sabah (Khairi *et al.* 2011).Hazandy *et al.* (2009) stated that in Peninsular Malaysia, BRIS soil covered about 155,400 ha and 40,400 ha in Sabah.

In Peninsular Malaysia, BRIS soil mostly found near the coastal area in Terengganu, Kelantan and Pahang with the total area 67,582.61 ha in Terengganu, 36,017.17 ha in Pahang and 17,806.20 ha in Kelantan (Armanto *et al.* 2013). The Department of Agrilculture of Malaysia stated that there have seven types of BRIS soil that has been identified based on depth, drainage and serial profile which is Rusila, Rhu Tapai, Rompin, Rudua, Baging, Jambu and Merchang. Based on the American Department of Agrilculture, BRIS soil can be divided into two type which is Spodosol and Entisol. Entisol is a young soil that can be found near the sea and has high sand content. Whereas, Spodosol is a acidic soil with a unstructured sandy texture that contain mor humus(acidic humus). Figure 2.1 shows the types and location of BRIS soil.

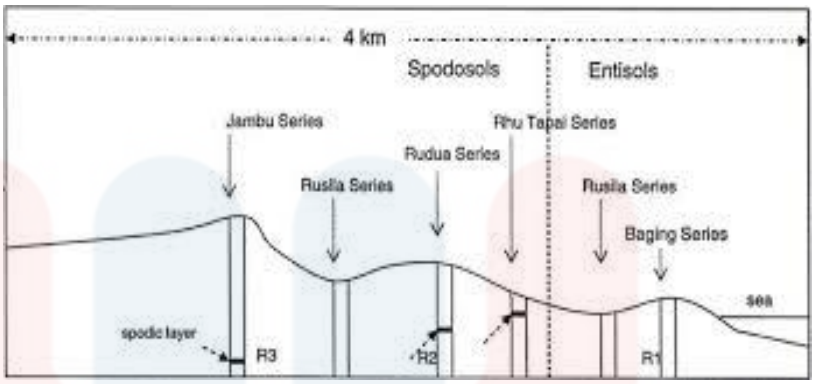

Figure 2.1: The location of BRIS soil's

BRIS soil is the soil that has many problem. Usually the plant that has be planted on BRIS soil will face many problem due to high surface soil temperature, low water retention, low organic matter, high infiltration rate and low nutrients content (Naimah *et al.* 2014). It is too sandy, week soil structured, low content of nutrients and low water retention (Ekhwan *et al*., 2009). Most of the crops planted on BRIS soil did not thrives because of the its characteristic which is high surface soil temperature, low water holding capacity, low organic matter content, high infiltration rate and low nutrients availability (Hanafi *et al.*, 2010).

According to Chen (1985), BRIS soil contain low cation exchange capacity (CEC) which is 9.53 mq/100g with a pH range from 4.3 to 4.4. BRIS soil contain high sandy texture (> 90%), low fertility, low cation exchange capacity, and low water holding capacity (Khairi *et al.* 2011) and cause the infiltration rate become high.Besides, high sandy texture in BRIS soil cause a rapid water drainage (Khairi *et al.* 2011).

2.2 *Hibiscus sabdariffa L.*

Hibiscus sabdariffa also known as roselle is one type of herbaceous shrub belonging to family Malvaceae. Its can be planted in many type of soil including in most problematic soil which is BRIS soil. BRIS soil provide a well-aerated and deep rooting system (Naimah *et al.* 2014). The flowers, calyces, young shoots, leaves and seeds of roselle has many functions to the human. Its leaves and seeds were used in traditional medicine and young shoot are eaten as raw or as cooked vegetables. This plant contain many type of vitamins, proteins, carbohydrates, acids and minerals. Roselle contain red calyx (Mahadevan *et al.* 2009) which contains high concentration of anthocyanin and also vitamin such as C,B1 and B2. Musa *et al.* (2006) stated that the concentration of vitamin C that contain in roselle higher than the concentration of vitamin C in blackcurrant, grapes and citrus. The anthocyanins are very strong antioxidants which can act as anti-oxidative, anti-mutagenic, anti-microbial and anti-carcinogenic agents (Awad *et al.*, 2000). Roselle also had been reported can reduce the chronic disease such as asthma, cancer, cardiovascular disease because of anthocyanins that contain in roselle (Boyer and Liu, 2004) and also have antihypertensive, hepatoprotective, anticancer, antihyperlipidemic and antioxidant properties.

Futhermore, roselle calyces is the most important part in roselle. The calyces were used to make a product such as tea, beverage, jams, syrup and also jellies. Qi *et al.* (2005) stated the calyces possess pectin and produce a firm jelly. Whereas, tea that are produced from the roselle calyces can reduce cough (Morton, 1987) and also act as antidepression. The roselle's seeds that has been sown will take a few days to germinate. Germination of seed usually begins after two to three days after sown (Naturland, 2000). It takes three to four months for the plants to reach maturity

before the flowers can be harvested (Ismail *et al.* 2008).

Figure 2.2: Roselle plant

2.3 Light Intensity

Light intensity is the amount of light and the degree of brightness that can reach or receive by the seed, soil or the plant. It is also described as the degree of brightness that a plant is exposed to (Bareja, 2011). Light is very important for seed and plant in order to germinate and growth. Laboratory experiments and field observations indicate that light is a main controller of seed dormancy in a wide array of species. Without light, seeds will not germinate. Seed that planted in sandy soil will germinate first compared to loam because sandy soil allow higher light transmission than loam.

Each leaves on the plant received a different amount of light. The upper part of the plant receive more light compare to the lower part. Leaves on the upper part tend to shade and reflect light away from reach the lower part. In order to minimize the interplant shading, row planting and proper spacing should be practice with somewhat vertical leaves (erectophyle plant type) allow more downward passage of light and tolerate high population planting than plants with drooping leaves (planophyle type).

The increase of the rate of light intensity will increase the rate of photosynthesis. The lack of light intensity to the plant will reduce plant growth, development and yield. This happen because of low amount of solar energy restrict the rate of photosynthesis. Inadequate or excessive light intensity not only affect the photosynthesis process but also will affect the morphology of the plants (Muslihatinn and Daesusi, 2014). The different amount of light intensity can cause the different temperature receive by plant. The temperature that received by plant will effect the photosynthesis, transpiration rate, respiration and absorption of water and nutrients.

2.4 Growth

Growth can be defined as the changes of the size from a small size to a bigger size over a period of time. Its takes time for growth to occur. Moreover, growth also can be defined as the progressive development of an organism. Usually the growth can be measure in terms of height, weight, length, diameter and others. Plant growth analysis is a measure to study of plant growth and its productivity (Ozalkan *et al.*, 2010).

The factor that can effect the rate of growth can be divide into two which is genetic or environmental factor. Whereas, the environmental factor is the surrounding factor that can effect the plant growth. The example of environmental factor include temperature, moisture supply, soil reaction, biotic factors, supply of mineral nutrients, soil aeration, soil structure and others. The plant is suitable with dry weather and desired the weather for the second months of growth (Mohamed *et al*., 2012).The plant thrives and growth well in hot and dry areas with high humidity and temperature about 25°C to 35°C (Hacket and Carolene, 1982).

CHAPTER 3

MATERIALS AND METHOD

3.1 Study Area

In this experiment, 30 seeds of *H. sabdariffa* will be planted in Agropark, Jeli Campus, Universiti Malaysia Kelantan. Figure 3.1 shows the map location of study area in Jeli, Kelantan. The seeds of *H. sabdariffa* will be obtained from Federal Agricultural and Marketing Authority (FAMA). The seeds will be sown in BRIS soil that taken from Bachok, Kelantan. Figure 3.2 shows the activity of BRIS soil sample collect in Bachok, Kelantan.

Figure 3.1: Map location of study area in UMK Jeli, Kelantan
(source:httpswww.google.commapsplaceUniversiti+Malaysia+Kelantan@5.745836,101.8658718,727mdata)

Figure 3.2: Collect BRIS soil in Bachok,Kelantan

3.2 Materials and Apparatus

Table 3.1 below shows the material and apparatus that used in this experiment:

Table 3.1: List of materials and apparatus that used in this experiment.

Material	Apparatus
Roselle's seeds	Paranet
NPK fertiliser	Watering pot
BRIS soil	1 Meter ruler
Water	Digital caliper
Insectiside	Polybag
	Barbed wire
	Wheelbarrow
	Hoe
	Mulch Plastic Sheet (3 m x 3 m)
	Laboratory oven

3.3 Method

3.3.1 Preparation of Seeds

The seed of *H. sabdariffa* undergoes pre-treatment in order to reduce the seed dormancy. Schmidt (2000) stated that seed dormancy defined as the failure of seed to germinate although there has sufficient factor to germinate such as water, temperature and light. The seed of H. sabdariffa were soaked in distilled water for 24 hours.

After that, *H. sabdariffa* were divided into six different categories whereas 15 seeds were placed under 30% light intensity. The seeds divided into three treatment group which five seeds with BRIS soil without NPK fertilizer (T1), five seeds with BRIS soil+2g NPK fertilizer (T2) and five seeds with BRIS soil+4g NPK fertilizer (T3) and Other 15 seeds were placed under 50% light intensity and also divided into three group treatment to separate the seeds which is five seeds with BRIS soil without NPK fertilizer (T1), five seeds with BRIS soil+2g NPK fertilizer (T2) and five seeds with BRIS soil+4g NPK fertilizer (T3). Table 3.2 below shows the types of category:

Table 3.2: Types of category.

	Without NPK fertilizer	With 2g NPK fertiliser	With 4g NPK fertiliser
30% light intensity	5 seeds	5 seeds	5 seeds
50% light intensity	5 seeds	5 seeds	5 seeds

3.3.2 Mixing and Sieving Process

The soil was dried, mixed and sieved using 1.5mm siever. Then,it filled in 30 of black polybags (18cmx30cm) and ready to be use. Figure 3.3 below show the process of mixing and sieving of BRIS soil:

Figure 3.3: Process of mixing and sieving BRIS soil.

3.3.3 Seed Sowing

One seed of *H. sabdariffa* was placed in each polybag at the average two to three cm depth. Agarwal and Dedhia (2014) stated that, seeds of *H. sabdariffa* that are sown at a depth of two to three cm will have a good germination. The polybag was divided into two and were placed under two different light intensity which is 30% and 50% with 15 polybag each. To differentiate the light intensity that reach the seeds, paranet with the 30% and 50% sunlight penetration were used. Light intensity was determined using light meter to get precise measurement. The light meter was applied under the paranet during the afternoon with direct sunlight without any barriers such as cloud and trees.

NPK fertilizer with ratio 15N:15P_2O_5:15K_2O was applied to the plant in polybag that has been placed in 30% and 50% light intensity with different quantity based on the treatment once a month. Watering schedule were carried out twice daily which is during morning and evening. Hand weeding were done when necessary. Fungicides and insecticide application will applied one month after planting to control pests and disease.

3.3.4 Data Collection

The growth of the seeds was monitoring every two weeks to collect data such as height of plant and diameter of stem. Plant height were measured from the soil level to the shoot using a ruler while stem diameter were measured using digital callipers to nearest 0.1mm 10cm above the soil level. The data collection taken every 2 weeks for 3 month.

A mortality rate analysis were done where all germinated seeds were counted and percentage of seed germinated were calculated.The calculation were done in order to identify the growth performance of *H.sabdariffa* seed in BRIS soil.

$$\% \, GP = \frac{no \; of \; germinated \; seeds}{total \; number \; of \; seeds} x100 \; \% \quad \text{.....(eq. 1)}$$

To calculated the biomass of the *H. sabdariffa,* plant were uprooted, washed and overdried. The plant were divided into four component which is stem, root, leaf and fruit. These component were weighed using electronic scale in wet and dry state. For the wet weight, the component will be weighed immediately after it was removed from the soil to avoid the plant component from lost its actual weight because plants

have high composition of water and they can dying if take a long time to weight them. For the dry state, the plant component were dried using the oven at 70°C for 48hour before recording the dry weight. All the weighing process and drying process was done in laboratory of Universiti Malaysia Kelantan.

Figure 3.4 and 3.5 shows the dried and fresh of roselle were weighted using electronic scale in UMK laboratory.

Figure 3.4: Dried roselle were weighted

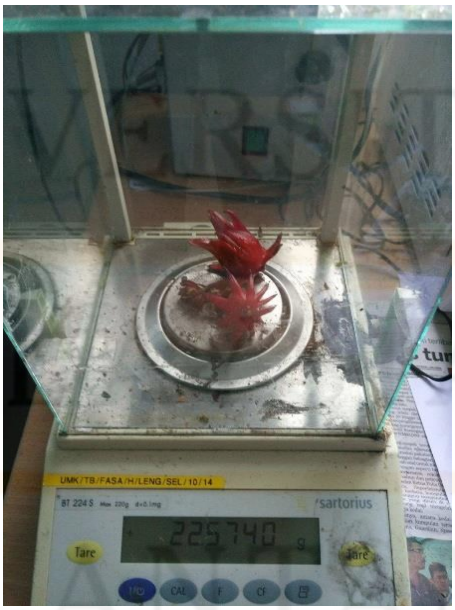

Figure 3.5: Fresh roselle were weighted

Relative Growth Rate (RGR) formula (Zheng et al., 2014) will be use to calculated the average rate of growth of the seedling. The formula RGR as shown in the Equation 2:

$$RGR = \frac{(\ln W_2 - \ln W_1)}{(t_2 - t_1)} \quad \text{.....} \quad \text{(eq. 2)}$$

Where;

ln = natural logarithm

t_1 = time of experiment starts (in day)

t_2 = time of experiment end (in day)

W_1 = initial dry weight of plant at t_1 (in grams)

W_2 = initial dry weight of plant at t_2 (in grams)

3.3.5 Experimental Setup

A 3x2 factorial experiment was carried out. The experiment will be involved of two treatments which is percentage of light intensity and fertilization level. Treatment for percentage of light intensity consist of two different percentage of light intensity and treatment for fertilization level consist of three different quantity of fertilizer. The treatments involve are as shown in the Table 3.3:

Table 3.3: Treatments for the experiment.

No.	Treatments	Descriptions
1.	Percentage of light intensity	30% light intensity 50% light intensity
2.	Fertilization level	BRIS soil only BRIS soil+2g NPK BRIS soil+4g NPK

Experiment was arranged in Completely Randomized Design (CRD). The polybags were labelled according to the Table 3.4:

Table 3.4: Layout design for Completely Randomized Design (CRD)

Percentage of light intensity	Treatments	Labelling
30% light intensity	BRIS soil only	A_{01}, A_{02}, A_{03}, A_{04}, A_{05}
	BRIS soil+2g NPK	A_{06}, A_{07}, A_{08}, A_{09}, A_{10}
	BRIS soil+4g NPK	A_{11}, A_{12}, A_{13}, A_{14}, A_{15}
50% light intensity	BRIS soil only	B_{16}, B_{17}, B_{18}, B_{19}, B_{20}
	BRIS soil+2g NPK	B_{21}, B_{22}, B_{23}, B_{24}, B_{25}
	BRIS soil+4g NPK	B_{26}, B_{27}, B_{28}, B_{9}, B_{30}

The layout for the experiment was arranged according to the Tables of Random Number (Beyer, 1968). The last two digit number from the number in Table of Random Numbers was chosen to represent the number of polybags. The number for layout arrangement was chosen without any repetition or replacement. The number of Random Number Table will start from first number in top row from left as shown in the Figure 3.4. The two last digits that appear with a similar number as labelled at the polybags was chosen. The selection was continued until all the polybags are chosen.

	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
40	14577	62765	35605	81263	39667	47358	56873	56307	61607	49518	89656	20103	77490	18062
	98427	07523	33362	64270	01638	92477	66969	98420	04880	45585	46565	04102	46880	45709
	34914	63976	88720	82765	34476	17032	87589	40836	32427	70002	70663	88863	77775	69348
	70060	28277	39475	46473	23219	53416	94970	25832	69975	94884	19661	72828	00102	66794
	53976	54914	06990	67245	68350	82948	11398	42878	80287	88267	47363	46634	06541	97809
45	76072	29515	40980	07391	58745	25774	22987	80059	39911	96189	41151	14222	60697	59583
	90725	52210	83974	29992	65831	38857	50490	83765	55657	14361	31720	57375	56228	41546
	64364	67412	33339	31926	14883	24413	59744	92351	97473	89286	35931	04110	23726	51900
	08962	00358	31662	25388	61642	34072	81249	35648	56891	69352	48373	45578	78547	81788
	95012	68379	93526	70765	10592	04542	76463	54328	02349	17247	28865	14777	62730	92277
50	15664	10493	20492	38391	91132	21999	59516	81652	27195	48223	46751	22923	32261	85653

Figure 3.6: Tables of Random Number (Beyer, 1968)

Table 3.5 shows the result of the selection from Tables of Random Number. This field layout was applied for the arrangement of polybags in Agropark UMK Jeli.

Table 3.5: Field layout for experimental design (50% light intensity)

A_{11}	A_{10}	A_{14}	A_{07}	A_{09}
A_{13}	A_{02}	A_{08}	A_{03}	A_{15}
A_{04}	A_{12}	A_{05}	A_{01}	A_{06}

Table 3.6: Field layout for experimental design (30% light intensity)

B_{27}	B_{20}	B_{25}	B_{19}	B_{29}
B_{28}	B_{16}	B_{18}	B_{17}	B_{24}
B_{30}	B_{21}	B_{22}	B_{26}	B_{23}

3.3.6 Statistical Analysis

The data was arranged in Complete Randomized Design (CRD) with two different regimes of light intensity: i)30% light intensity(five seeds in BRIS soil without NPK fertilizer, five seeds in BRIS soil with 2g NPK fertilizer and five seed in BRIS soil with 4g NPK fertilizer) and ii)50% light intensity(five seeds in BRIS soil without NPK fertilizer, five seeds in BRIS soil with 2g NPK fertilizer and five seeds in BRIS soil with 4g NPK fertilizer). Then, all the data collected were subjected to Kruskal-Wallis Test and Mann-Whitney Test. Results will be considered significant at 5% probability level.

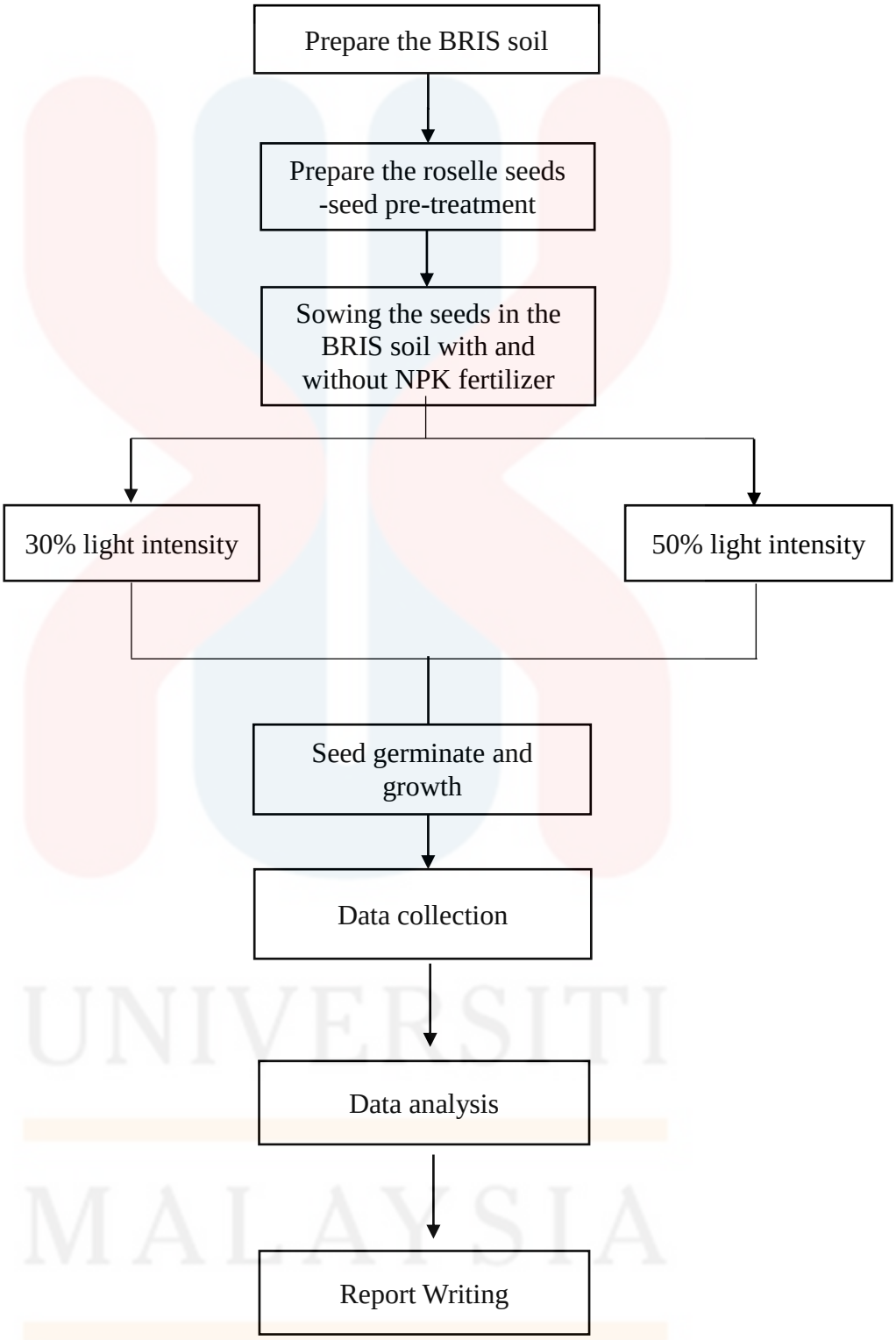

Figure 3.7: Research flow chart

CHAPTER 4
RESULT AND DISCUSSION

4.1 Germination Rate

Mortality rate analysis were done where all germinated seed were counted. The percentage of seed germinated were calculated using the formula below.

$$\% \, GP = \frac{no \, of \, germinated \, seeds}{total \, number \, of \, seeds} x100$$

$$= \frac{63}{90} \text{ x } 100$$

$$= 70\%$$

Figure 4.8 shows the percentage of growth performance of *H.sabdariffa* seed in BRIS soil is 70%. The total of the seed that has been sown in BRIS soil is 90 seeds. 63 of them were germinated and 27 seeds were died and not survive. The effect of a seed pre-treatment on longevity is largely dependent on the quality of the seed at the time of pre-treatment (Hofmann and Steiner, 1994).

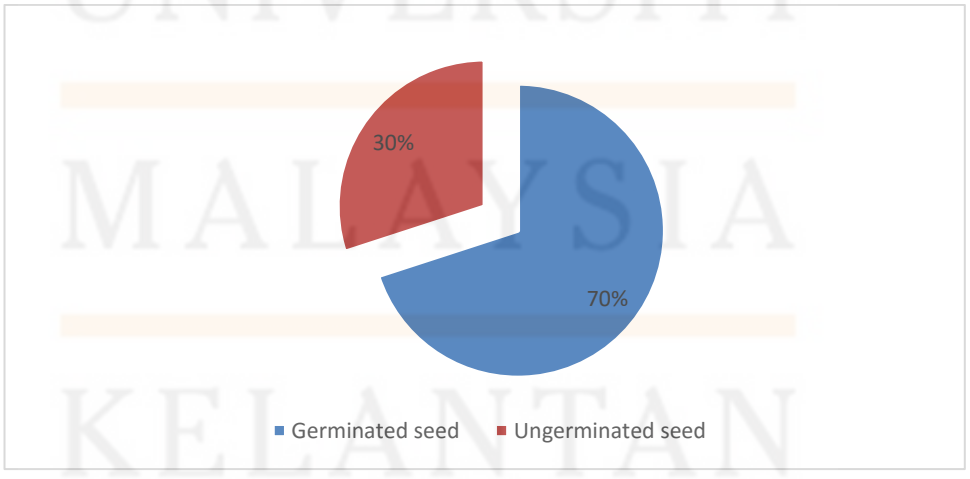

Figure 4.1: Percentage of germinated and ungerminated seed

4.2 Growth Performance of Roselle's Diameter

Figure 4.2 and 4.3 shows the growth performance of diameter in different types of treatment which is BRIS soil only (T1), BRIS soil+2g of NPK (T2) and BRIS soil+4g of NPK (T3) under 30% and 50% light intensity. The diameter growth for all treatment under two different light intensity shows an increasing trend throughout 12 weeks of experimental period. It might be due to maximum branching and vegetative growth facilitated by suitable and enough nutrient supply and also because of positive effect of nutrient content in N, P and K. P requirement of crop is fairly high and additional P application could increase the plant growth (Solaiman, 1991).

Based on figure 4.2, the graph refer to the diameter of roselle in 30% light intensity. The diameter of roselle is taken start from week 4 due to the diameter size of roselle before 4 weeks is too small. From the graph, T1 has the smallest average of diameter growth performance which is 0.26cm per plant in week 12^{th} compared to the other two treatment which is T2 and T3 which is 0.67cm and 0.81cm respectively. The second highest average which is T2, 61.19% higher than average of diameter in T1. The highest average is T3, 67.90% higher than T1 and 17.28% higher than T2. The differences of the average diameter among T1, T2 and T3 treatment is affected by the amount of NPK fertilizer supplied. The lowest average by T1 is because of the lack of nutrient supplied by BRIS soil compared to T2 and T3 that was added with different amount of NPK fertilizer.

Roselle that applied with T1 treatment has slowest diameter growth performance compared to roselle that applied with T2 and T3 treatment. All the roselle under T1 group has a diameter lower than 0.3cm. The biggest diameter of roselle under 30% is the plant that applied with BRIS soil + 4g of NPK (T3) with diameter 0.92cm.

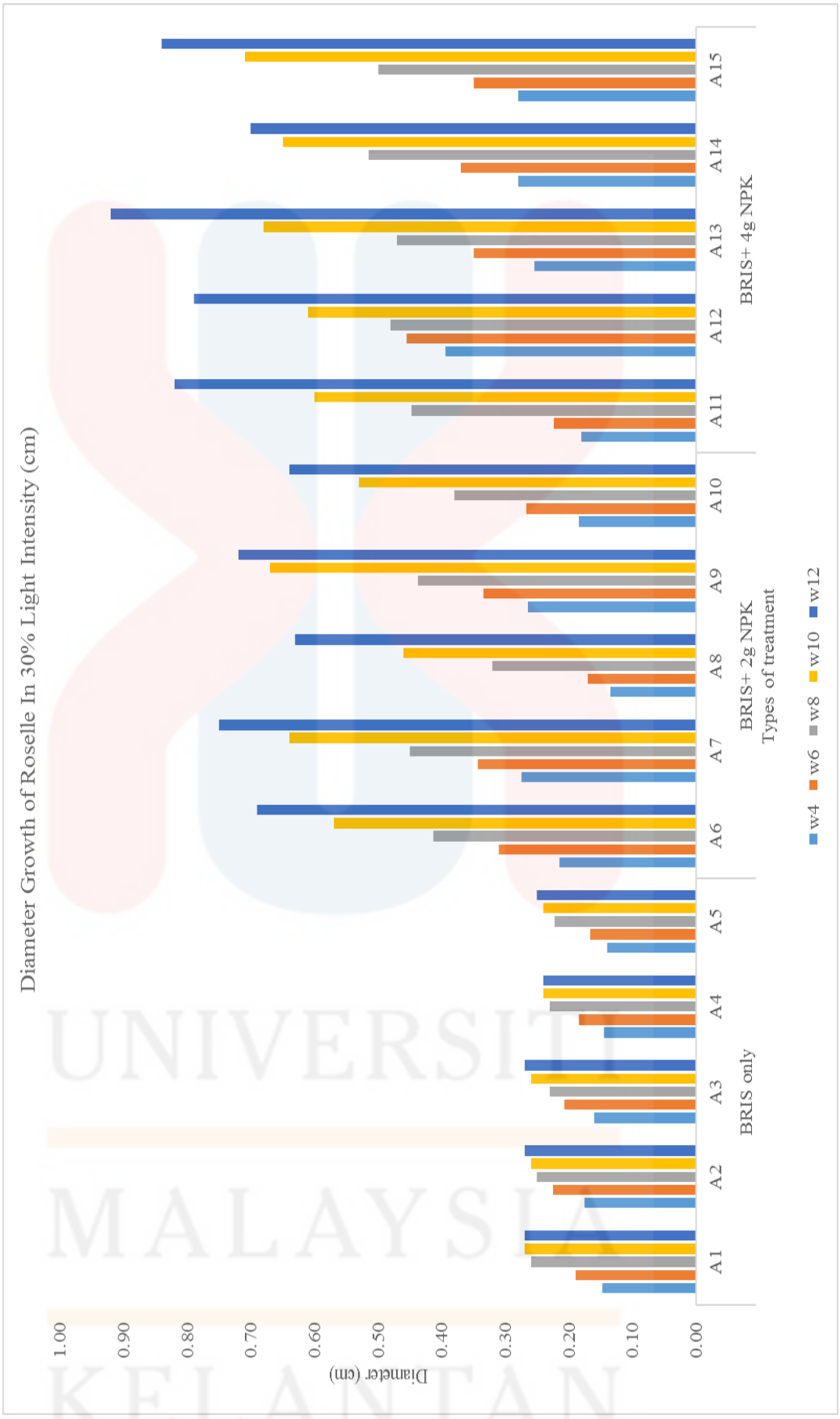

Figure 4.2: Diameter of roselle in 30% light intensity (cm)

Figure 4.3 shows diameter growth of roselle in 50% light intensity. The graph shown an increasing trend. Sample B17, only second roselle plant that applied with T1 under 50% intensity showed the rapid growth started from week 10. From the observation, the root of has penetrate the polybag. This cause the plant growth rapidly compared to other roselle plant. Thus, the plant data is invalid.

The diameter of roselle that applied with T1 showed the passive growth performance among three treatment with average 0.26cm per plant followed by T2 and T3 which is 0.66cm and 0.86cm respectively during week 12th. Other than that, the diameter range for roselle that applied with T2 from week four until week 12 is from 0.23cm to 0.76cm. Majority roselle that applied with T3 has diameter more than 0.9cm when the data is taken at week 12th which has a diameter of 0.91cm,0.90cm and 0.92cm respectively. The different amount of NPK fertilizer in T1, T2 and T3 shown the different effect on the diameter growth under 50% light intensity.

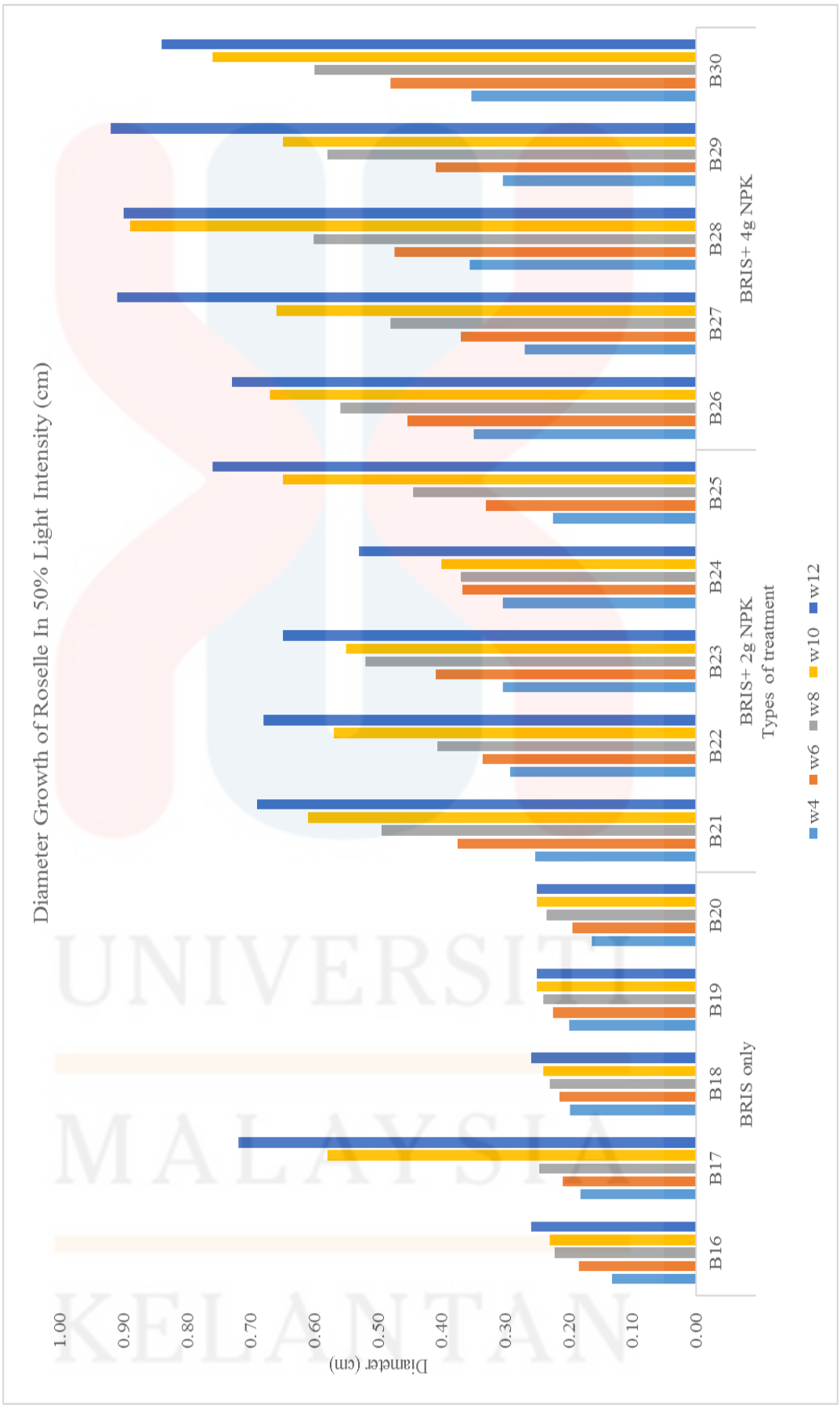

Figure 4.3: Diameter of roselle in 50% light intensity (cm)

Table 4.1 shows the comparison of diameter of *Roselle* stem in three different treatment (BRIS soil only, BRIS soil+2g of NPK and BRIS soil+4g of NPK) and two light intensity (30% and 50%). In Kruskal Wallis test, there have significant with (α=0.006) and (α=0.003) at 0.05 significant level in the three different treatment in 30% and 50% light intensity respectively. In Mann Whitney test showed there was significant different between BRIS soil only and BRIS soil+2g of NPK in 30% light intensity with (α=0.008) and in 50% light intensity with (α=0.074) at 0.05 significant level. For the BRIS soil only and BRIS soil+4g of NPK, there has a significant different between the treatment in 30% light intensity with (α=0.008) and in 50% light intensity with (α=0.009). Next, there also has a significant different between BRIS soil+2g of NPK and BRIS soil+4g of NPK with (α=0.028) in 30% light intensity and (α=0.016) in 50% light intensity.

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

Table 4.1: Comparison of diameter of *Roselle* stem by three different media and two different intensity by using Kruskal Wallis and Mann Whitney U test

Light	Chi-Square	Asymp.Sig	Media	Mean Rank	Asymp.Sig.
30%	11.663	0.006	BRIS soil	3.00	0.008*
			BRIS soil with 2g NPK	8.00	
			BRIS soil	3.00	0.008*
			BRIS soil with 4g NPK	8.00	
			BRIS soil with 2g NPK	3.40	0.028*
			BRIS soil with 4g NPK	7.60	
50%	10.297	0.003	BRIS soil	3.80	0.074
			BRIS soil with 2g NPK	7.20	
			BRIS soil	3.00	0.009*
			BRIS soil with 4g NPK	8.00	
			BRIS soil with 2g NPK	3.20	0.016*
			BRIS soil with 4g NPK	7.80	

Note: *significant value < 0.05

4.3 Growth Performance of Roselle's Height

Figure 4.4 refers to height of roselle plant that applied with T1, T2 and T3 under 30% light intensity. All the plant from all treatment shown increasing trend. Roselle that applied with BRIS soil only which is T1 showed minimum rate of height growth performance compared to T2 and T3. The average for growth of height for 12 weeks is 20.5cm (T1), 69.90cm (T2) and 76.30cm (T3). The average height of roselle in T3 has the higher height compared to T1 and T2 with the different 55.80cm and 6.48cm respectively. Average height of T2 is 9.41% lower than T3 and 79.19% higher than T1. The height growth of T1 has the minimum rate due to the lack of nutrient supplied. The roselle plant in T1 only gain the nutrient from BRIS soil only compared to other two treatment which is T2 and T3 that were added 2g and 4g of NPK fertilizer in BRIS soil respectively.

Figure 4.5 shows the height of roselle in 50% light intensity. In T1, B17 is the highest among the other four roselle in the same treatment with 52.00cm height during week 12th. The average height of roselle in 50% light intensity in week 12th for T1 remains the lowest among the treatment with the mean value 26.70cm followed by T3 and T2 with the average of 75.20cm and 78.60cm respectively. The average height of roselle in T2 and T3 has a slightly different which is 4.33%. Whereas, the average height different between T2 and T1 is 66.03%.

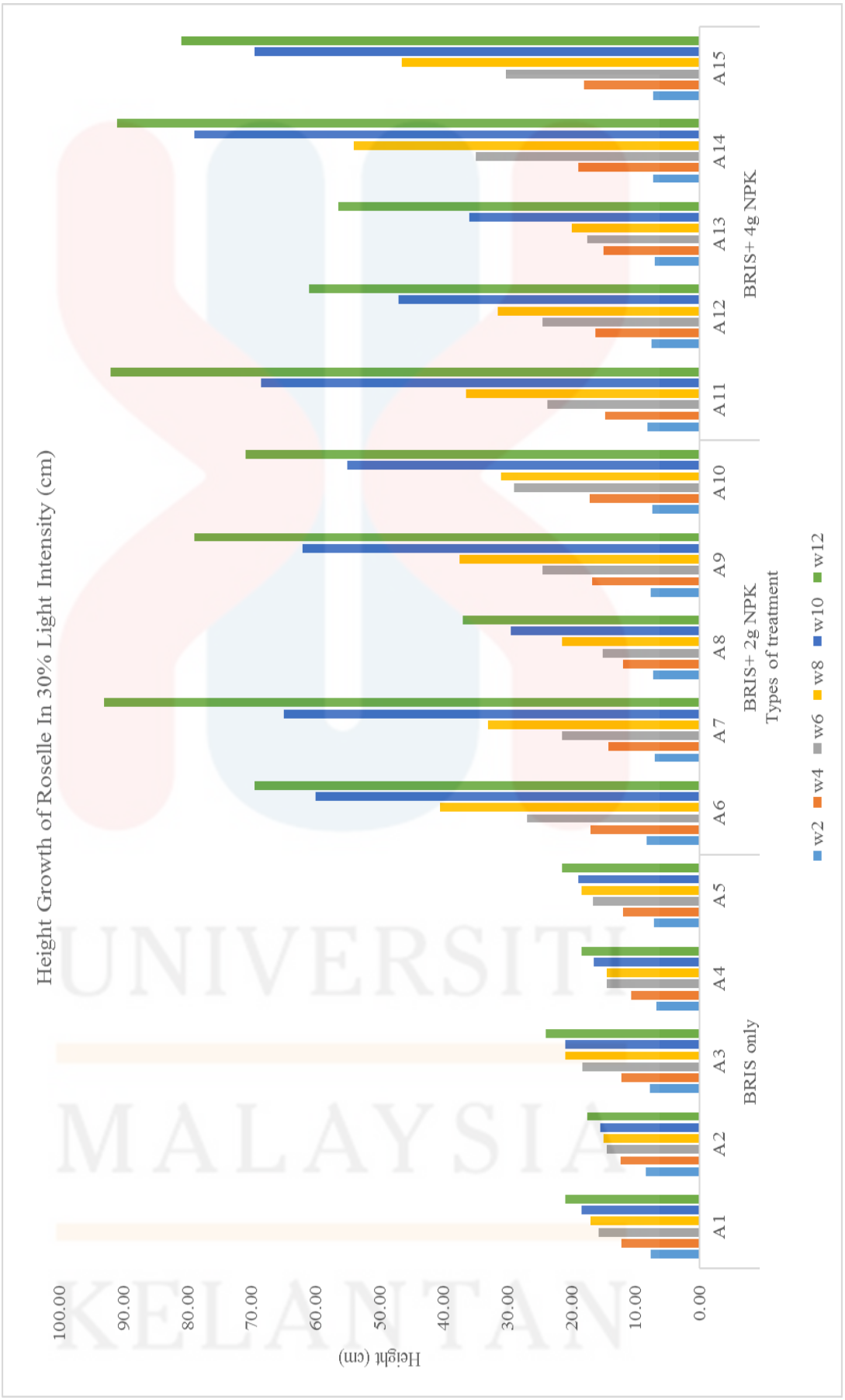

Figure 4.4: Height of roselle in 30% light intensity (cm)

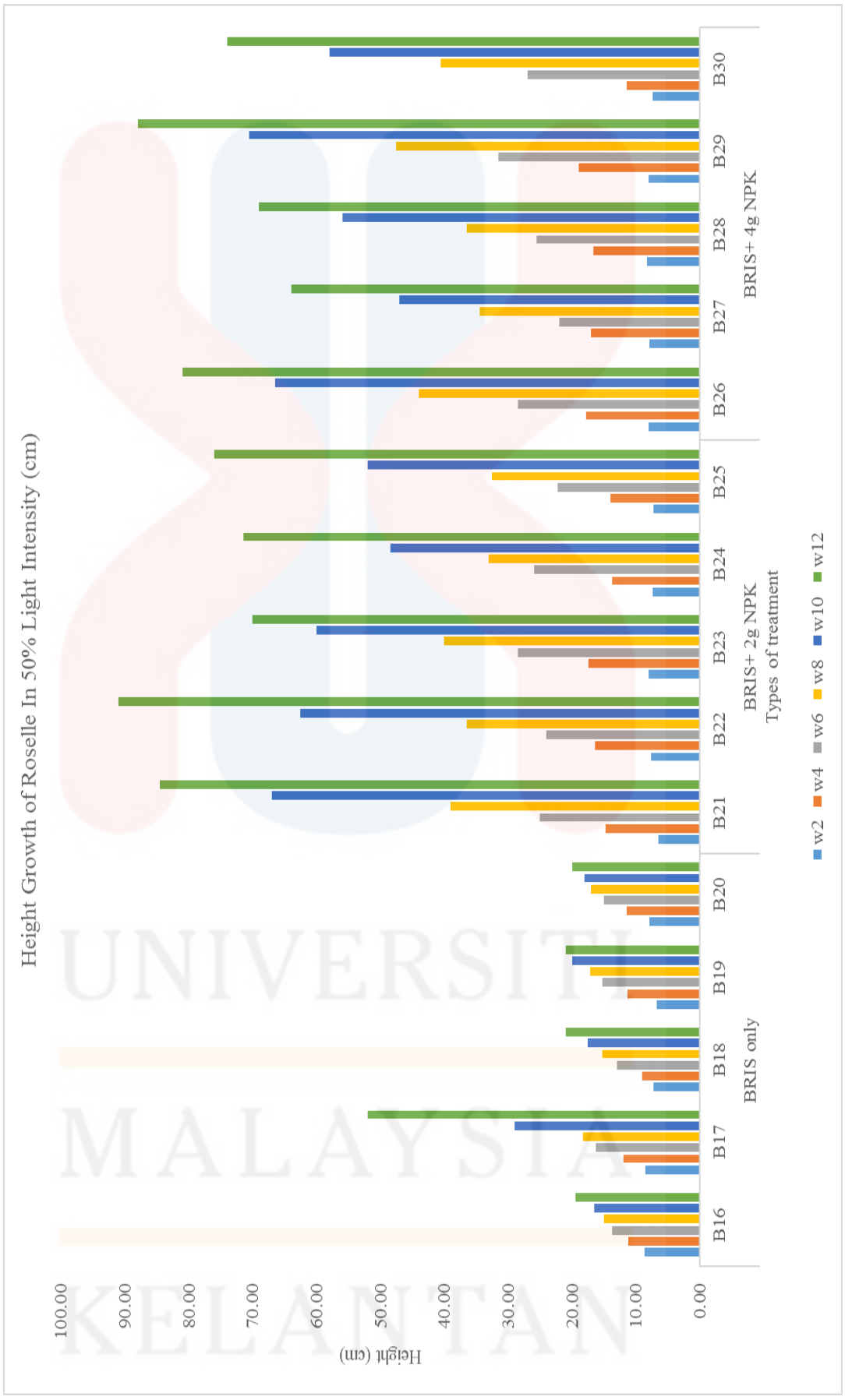

Figure 4.5: Height of roselle in 50% light intensity (cm)

Table 4.2 shows the comparison in height for *Hibiscus sabdariffa.L* (*Roselle)* in three different treatment (BRIS soil only, BRIS soil+2g of NPK and BRIS soil+4g of NPK) and two light intensity (30% and 50%) by using Kruskal Wallis and Mann Whitney U test.

In Kruskal Wallis test, there have significant with (α=0.009) and (α=0.008) at 0.05 significant level in the three different treatment in 30% and 50% light intensity respectively. In Mann Whitney test showed there was significant different between BRIS soil only and BRIS soil+2g of NPK in 30% light intensity with (α=0.009) and in 50% light intensity with (α=0.009) at 0.05 significant level. For the BRIS soil only and BRIS soil+4g of NPK, there has a significant different between the treatment in 30% light intensity with (α=0.008) and in 50% light intensity with (α=0.009) at 0.05 significant level. Next, there has no significant different between BRIS soil+2g of NPK and BRIS soil+4g of NPK with (α=0.754) in 30% light intensity and (α=0.465) in 50% light intensity at 0.05 significant level.

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

Table 4.2: Comparison of height of *Roselle* stems by three different media and two different intensity by using Kruskal Wallis and Mann Whitney U test

Light	Chi-Square	Asymp.Sig	Media	Mean Rank	Asymp.Sig.
30%	9.420	0.009	BRIS soil	3.00	0.009*
			BRIS soil with 2g NPK	8.00	
			BRIS soil	3.00	0.008*
			BRIS soil with 4g NPK	8.00	
			BRIS soil with 2g NPK	5.20	0.754
			BRIS soil with 4g NPK	5.80	
50%	9.637	0.008	BRIS soil	3.00	0.009*
			BRIS soil with 2g NPK	8.00	
			BRIS soil	3.00	0.009*
			BRIS soil with 4g NPK	8.00	
			BRIS soil with 2g NPK	6.20	0.465
			BRIS soil with 4g NPK	4.80	

Note: *significant value < 0.05

4.4 Total Fresh Weight of Roselle

Figure 4.6 refer to the comparison between fresh weight of roselle in 30% and 50% light intensity. The fresh weight under 30% intensity is lower than under 50% in all three treatment which T1, T2 and T3. The weight of roselle in T1 under 30% light intensity is 77.37% lower than under 50% light intensity with the different 76.27g. While, for T2 the weight of roselle under 50% light intensity is 25% higher than under 30% light intensity which is 399.40g for under 50% and 299.36g for under 30% with the diffent value 100.04g. The total fresh weight under 50% light intensity 196.43g or 30.97% higher than fresh weight under 30% light intensity in T3. The fresh weight of roselle under 50% light intensity is higher than fresh weight under 30% light intensity.

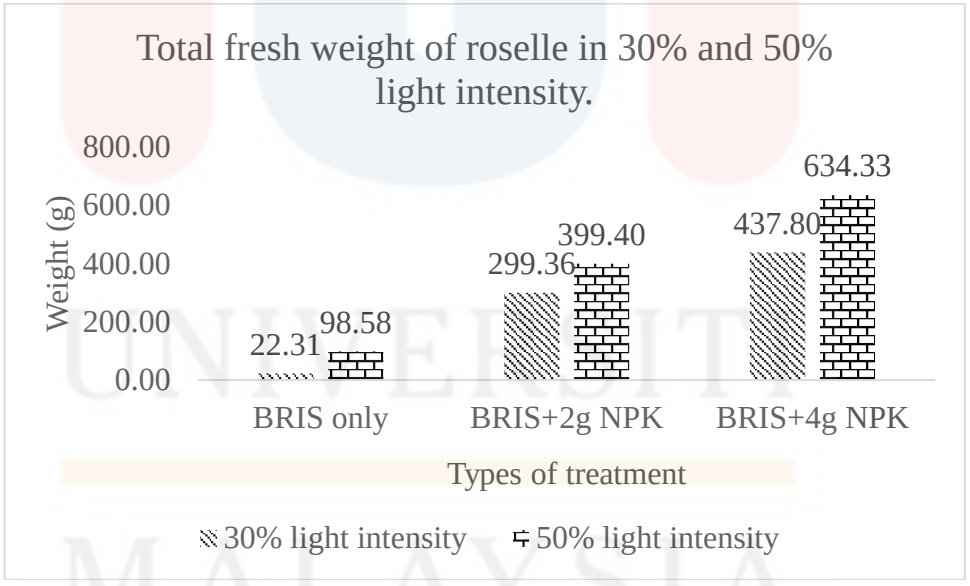

Figure 4.6: Comparison between fresh weight of roselle in 30% and 50% light intensity

Table 4.3 shows the comparison of fresh weight of *Roselle* between three different treatment (BRIS soil only, BRIS soil+2g of NPK and BRIS soil+4g of NPK) and two light intensity (30% and 50%). By using Kruskal Wallis test, in 30% and 50% light intensity, there has significant between three different treatment with (α=0.002) at 0.05 significant level. In Mann Whitney test showed that there has significant between (BRIS soil only and BRIS soil+2g of NPK), (BRIS soil only and BRIS soil+4g of NPK) and (BRIS soil+2g of NPK and BRIS soil+4g of NPK) in 30% light intensity with value (α=0.009). In 50% light intensity, Mann Whitney test showed that there has significant difference between BRIS soil only and BRIS soil+2g of NPK with value (α=0.016). There also has a significant difference between (BRIS soil only and BRIS soil+4g of NPK) and (BRIS soil+2g of NPK and BRIS soil+4g of NPK) with value (α=0.009).

4.3.1 Comparison of fresh weight of *Hibiscus sabdariffa.L (Roselle)*

Table 4.3: Comparison of fresh weight of *Roselle* by three different media and two different intensity by using Kruskal Wallis and Mann Whitney U test

Light	Chi-Square	Asymp.Sig	Media	Mean Rank	Asymp.Sig.
30%	12.500	0.002	BRIS soil	3.00	0.009*
			BRIS soil with 2g NPK	8.00	
			BRIS soil	3.00	0.009*
			BRIS soil with 4g NPK	8.00	
			BRIS soil with 2g NPK	3.00	0.009*
			BRIS soil with 4g NPK	8.00	
50%	12.020	0.002	BRIS soil	3.20	0.016*
			BRIS soil with 2g NPK	7.80	
			BRIS soil	3.00	0.009*
			BRIS soil with 4g NPK	8.00	
			BRIS soil with 2g NPK	3.00	0.009*
			BRIS soil with 4g NPK	8.00	

Note: *significant value < 0.05

4.5 Total Dried Weight of Roselle

Figure 4.7 refer to the comparison between dried weight of roselle in 30% and 50% light intensity. The dried weight under 30% intensity is lower than under 50% in all three treatment which T1, T2 and T3. The weight of roselle in T1 under 30% light intensity is 74.39% lower than under 50% light intensity with the different 13.37g. While, for T2 the weight of roselle under 50% light intensity is 22.62% higher than under 30% light intensity which is 88.02g for under 50% and 60.11g for under 30% with the different value 27.91g. The dried weight of roselle under 50% light intensity is higher than dried weight under 30% light intensity.

The fresh and dried weight of plant under 50% light intensity is higher compared to 30% light intensity. This shows that light intensity is important for plant to growth and produce food besides the fertilization level factor. The higher sunlight a plant receives the better capacity it has to produce food through photosynthesis (Hlatshwayo, 2010).

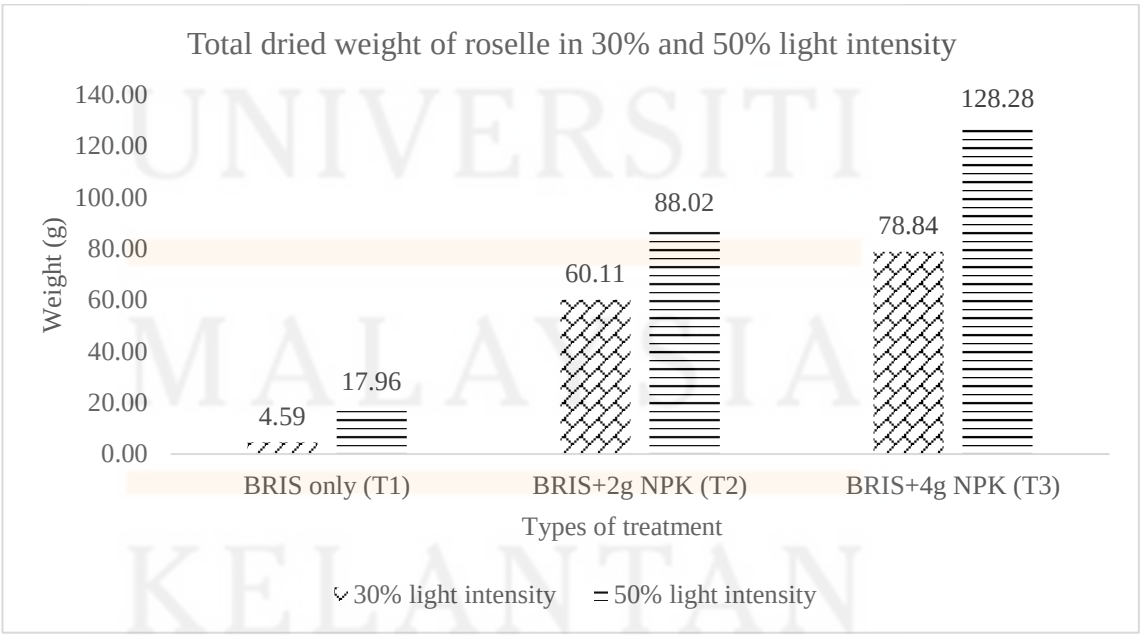

Figure 4.7: Comparison between dried weight of roselle in 30% and 50% light intensity

Table 4.4 shows the comparison of dried weight of roselle between three different treatment (BRIS soil only, BRIS soil+2g of NPK and BRIS soil+4g of NPK) and two light intensity (30% and 50%). By using Kruskal Wallis test, in 30% and 50% light intensity, there has significant between three different treatment with (α=0.004) and (α=0.003) respectively at 0.05 significant level. In Mann Whitney test showed that there has significant between (BRIS soil only and BRIS soil+2g of NPK) and (BRIS soil only and BRIS soil+4g of NPK) with significant (α=0.009). There also has the significant difference between (BRIS soil+2g of NPK and BRIS soil+4g of NPK) in 30% light intensity with value (α=0.047). In 50% light intensity, Mann Whitney test showed that there has significant difference between (BRIS soil only and BRIS soil+2g of NPK) and (BRIS soil+2g of NPK and BRIS soil+4g of NPK) with value (α=0.016). There also has a significant difference between (BRIS soil only and BRIS soil+2g of NPK) with value (α=0.009).

4.3.2 Comparison of dried weight of *Hibiscus sabdariffa.L (Roselle)*

Table 4.4: Comparison of dried weight of *Roselle* by three different media and two different intensity by using Kruskal Wallis and Mann Whitney U test

Light	Chi-Square	Asymp.Sig	Media	Mean Rank	Asymp.Sig.
30%	11.200	0.004	BRIS soil	3.00	0.009*
			BRIS soil with 2g NPK	8.00	
			BRIS soil	3.00	0.009*
			BRIS soil with 4g NPK	8.00	
			BRIS soil with 2g NPK	3.60	0.047*
			BRIS soil with 4g NPK	7.40	
50%	11.520	0.003	BRIS soil	3.20	0.016*
			BRIS soil with 2g NPK	7.80	
			BRIS soil	3.00	0.009*
			BRIS soil with 4g NPK	8.00	
			BRIS soil with 2g NPK	3.20	0.016*
			BRIS soil with 4g NPK	7.80	

Note: *significant value < 0.05

4.6 Total Fresh Weight of Roselle's Fruit

Result of the comparison of fresh weight of roselle's fruit in 30% and 50% light intensity were presented in figure 4.8. Based on the figure 4.7, the fresh weight of fruit in 50% light intensity is higher compared to in 30% light intensity. The fresh weight of roselle's fruit in BRIS soil only (T1) under 30% light intensity is 6.22g lower than under 50% light intensity with fresh weight 7.58g. The roselle plant that applied with BRIS soil+2g of NPK (T2), fresh weight of roselle's fruit under 30% light intensity is 69.30g which is 41.07% lower than the fresh weight of fruit under 50% light intensity with fruit's weight, 117.60g. While, for the T3 the weight of roselle's fruit under 50% light intensity is two times higher than in 30% light intensity. In 50% light intensity, the weight is 184.40g, 54.71% higher than in 30% light intensity. The differences of the weight of roselle's fruit is due to lack of nutrient supply and the lack amount of light intensity.

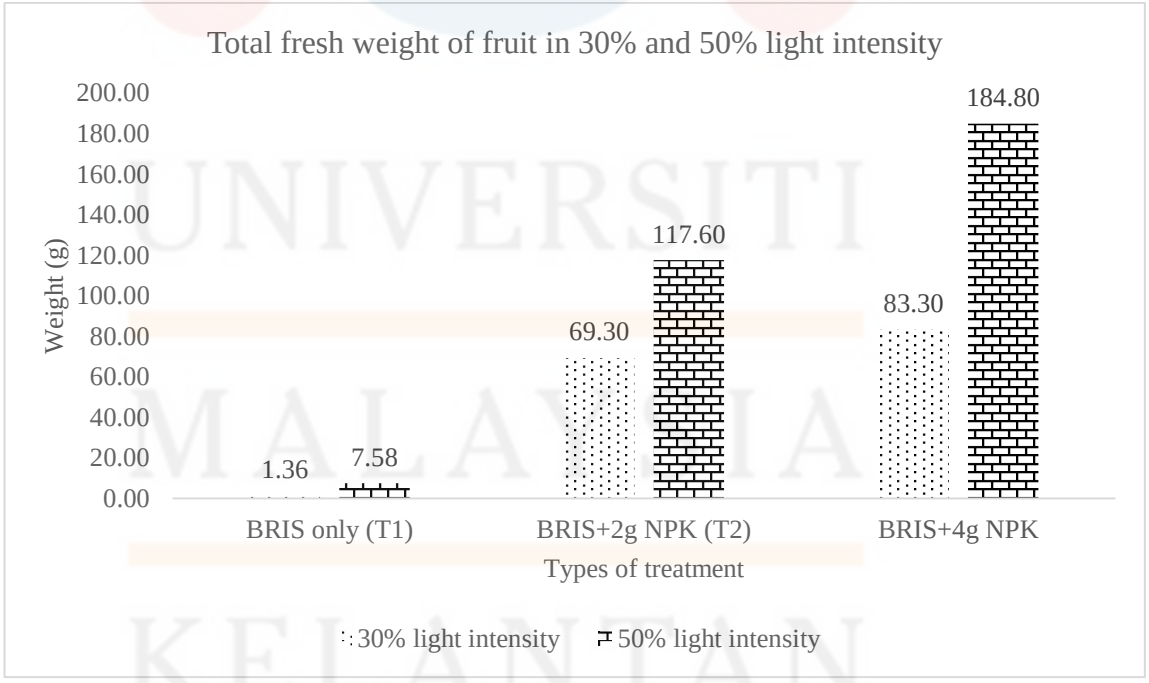

Figure 4.8: Comparison of fresh weight of fruit in 30% and 50% light intensity

Table 4.5 shows the comparison of fresh roselle's fruit between three different treatment (BRIS soil only, BRIS soil+2g of NPK and BRIS soil+4g of NPK) and two light intensity (30% and 50%). By using Kruskal Wallis test, in 30% and 50% light intensity, there has significant between three different treatment with (α=0.008) and (α=0.004) respectively at 0.05 significant level. In Mann Whitney test showed that there has significant between (BRIS soil only and BRIS soil+2g of NPK) and (BRIS soil only and BRIS soil+4g of NPK) under 30% light intensity with significant (α=0.009). But, there has no significant difference between (BRIS soil+2g of NPK and BRIS soil+4g of NPK) in 30% light intensity (α=0.465). In 50% light intensity, Mann Whitney test showed that there has a significant different in all three comparison between treatment which is BRIS soil and BRIS soil+2g of NPK (α=0.016), BRIS soil and BRIS soil+4g of NPK (α=0.009) and BRIS soil+2g of NPK and BRIS soil+4g of NPK (α=0.047).

4.3.3 Comparison of fresh weight of *Hibiscus sabdariffa.L (Roselle)* fruits

Table 4.5: Comparison of fresh weight of *Roselle's* fruit by three different media and two different intensity by using Kruskal Wallis and Mann Whitney U test

Light	Chi-Square	Asymp.Sig	Media	Mean Rank	Asymp.Sig.
30%	9.654	0.008	BRIS soil	3.00	0.009*
			BRIS soil with 2g NPK	8.00	
			BRIS soil	3.00	0.009*
			BRIS soil with 4g NPK	8.00	
			BRIS soil with 2g NPK	4.80	0.465
			BRIS soil with 4g NPK	6.20	
50%	11.180	0.004	BRIS soil	3.20	0.016*
			BRIS soil with 2g NPK	7.80	
			BRIS soil	3.00	0.009*
			BRIS soil with 4g NPK	8.00	
			BRIS soil with 2g NPK	3.60	0.047*
			BRIS soil with 4g NPK	7.40	

Note: *significant value < 0.05

4.7 Relative Growth Rate (RGR)

Figure 4.9 shows the comparison Relative Growth Rate (RGR) of the roselle between 30% and 50% light intensity in different fertilization level. The RGR of the roselle in all treatment which is BRIS soil only (T1), BRIS soil + 2g NPK fertilizer (T2) and BRIS soil + 4g NPK fertilizer (T3) shows RGR in 50% light intensity is higher compared to RGR in 30% light intensity. The highest value of RGR is in T3 under 50% light intensity with value 0.00095. The different RGR among 30% and 50% light intensity is due to lack of light intensity amount for the plant to do photosynthesis and cause the lower biomass. The more sunlight a plant receives the better capacity it has to produce food through photosynthesis (Hlatshwayo, 2010). However, T1 has a lower RGR compared to other treatment. This is most probably due to lack of nutrient supplied by BRIS soil and no additional of NPK fertilizer in this treatment.

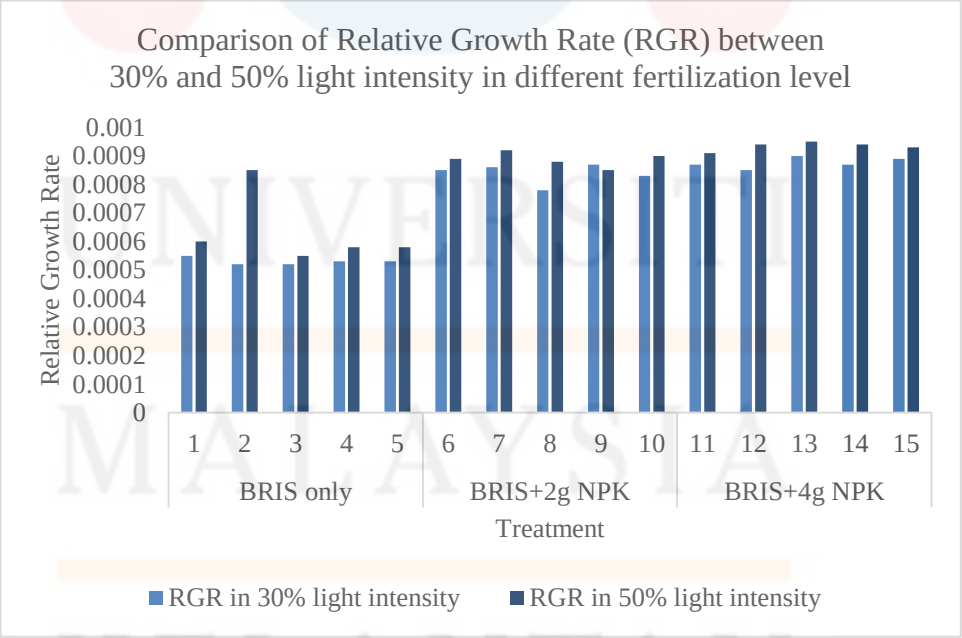

Figure 4.9: Comparison of Relative Growth Rate (RGR) between 30% and 50% light intensity in different fertilization level

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Results of this experiment suggest that application of NPK fertilizer in combination of BRIS soil give the best growth and yield of roselle. The data for the growth performance were collected every two week for 12 weeks of experiment. From the data, the BRIS soil + 4g of NPK fertilizer (T3) shows the effective growth performance compared to BRIS soil + 2g NPK fertilizer (T2) and BRIS soil only (T1). Its can be suggested that the BRIS soil + 4g NPK fertilizer is the best treatment for the growth performance of height and diameter. T1 has passive growth performance due to lack of nutrient in BRIS soil.

The data were analyzed using Kruskal Wallis Test and Mann-Whittney Test. Kruskal Wallis Test shows there has the significant difference among all three treatment (BRIS soil only, BRIS soil+2g of NPK and BRIS soil+4g of NPK) under 30% and 50% light intensity.

From Mann-Whitney Test, there has significant different in growth performance of the diameter, fresh weight and dried weight between the comparison of (BRIS soil and BRIS soil+ 2g of NPK), (BRIS soil and BRIS soil + 4g of NPK) and (BRIS soil + 2g of NPK and BRIS soil + 4g) in 30% and 50% light intensity. The growth performance of height has a significant different when the comparison of (BRIS soil and BRIS soil+ 2g of NPK) and (BRIS soil + 4g of NPK) but there has no significant between the comparison of BRIS soil + 2g of NPK and BRIS soil + 4g in both 30% and 50% light intensity. There also has a significant for the fresh weight of roselle's fruit in all treatment except for comparison of BRIS soil + 2g of NPK and BRIS soil + 4g in 30% light intensity.

In conclusion, the different light intensity and different level of NPK fertilizer effect the growth performance of roselle. BRIS soil + 4g of NPK in 50% light intensity is the most suitable treatment for the growth performance of the diameter, fresh weight, dried weight and fresh weight of roselle's fruit compared to other treatment. The most suitable treatment for the growth performance of height of roselle is BRIS soil + 2g of NPK in 50% light intensity. The positive effect of the NPK fertilizer and light intensity on the growth performance of roselle plants was expressed through an increased of height, diameter, fresh weight and quantity of fruits. The use of NPK fertilizers increased the Relative Growth Rate (RGR) of the crop in the present study.

The recommendation for this study, the amount of water supplied to all plant should be same in order to avoid the plant from get insufficient and excessive of water. So, the study of soil moisture content should be done. Besides, the study also should be done in suitable area without any blocking from anything that can effect the amount of light intensity receive by plant such as the trees around the study area.

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APPENDICES

Appendix A: Result of growth performance of diameter and height in 30% light intensity

Treatment	Plant	Diameter (cm)					Height (cm)				
		W4	W6	W8	W10	W12	W2	W4	W6	W8	W10	W12
BRIS soil only	A1	0.15	0.19	0.26	0.27	0.27	7.60	12.20	15.80	17.00	18.50	21.00
	A2	0.18	0.23	0.25	0.26	0.27	8.40	12.40	14.50	15.00	15.50	17.50
	A3	0.16	0.21	0.23	0.26	0.27	7.80	12.20	18.30	21.00	21.00	24.00
	A4	0.15	0.19	0.23	0.24	0.24	6.70	10.70	14.50	14.50	16.50	18.50
	A5	0.14	0.17	0.22	0.24	0.25	7.10	12.00	16.70	18.50	19.00	21.50
BRIS soil+2g of NPK	A6	0.22	0.31	0.41	0.57	0.69	8.30	17.00	27.00	40.50	60.00	69.50
	A7	0.28	0.34	0.45	0.64	0.75	7.00	14.20	21.50	33.00	65.00	93.00
	A8	0.14	0.17	0.32	0.46	0.63	7.30	12.00	15.20	21.50	29.50	37.00
	A9	0.26	0.34	0.44	0.67	0.72	7.60	16.80	24.50	37.50	62.00	79.00
	A10	0.19	0.27	0.38	0.53	0.64	7.40	17.20	29.00	31.00	55.00	71.00
BRIS soil+4g of NPK	A11	0.18	0.22	0.45	0.60	0.82	8.10	14.70	23.80	36.50	68.50	92.00
	A12	0.39	0.46	0.48	0.61	0.79	7.50	16.30	24.60	31.50	47.00	61.00
	A13	0.25	0.35	0.47	0.68	0.92	7.00	15.00	17.50	20.00	36.00	56.50
	A14	0.28	0.37	0.52	0.65	0.70	7.30	19.00	35.00	54.00	79.00	91.00
	A15	0.28	0.35	0.50	0.71	0.84	7.30	18.00	30.30	46.50	69.50	81.00

Appendix B: Result of roselle's part weight in 30% light intensity

Treatment	Plant	Fresh weight (g)				Dried weight (g)			
		Stem	Leaf	Root	Fruit	Stem	Leaf	Root	Fruit
BRIS soil only	A1	0.90	2.00	1.48	0.40	0.24	0.35	0.37	0.07
	A2	0.65	1.64	1.30	0.18	0.17	0.16	0.37	0.06
	A3	1.20	1.70	1.60	0.18	0.32	0.23	0.45	0.03
	A4	0.80	2.20	1.40	0.30	0.05	0.31	0.48	0.04
	A5	0.90	1.58	1.60	0.30	0.26	0.22	0.37	0.04
BRIS soil+2g of NPK	A6	13.70	26.50	7.10	25.90	3.84	3.07	2.44	3.73
	A7	21.40	28.60	7.70	10.50	6.20	3.78	2.60	1.55
	A8	6.90	13.80	7.20	1.40	2.45	2.25	2.46	0.11
	A9	16.50	22.70	7.60	28.40	4.18	3.32	3.21	4.32
	A10	17.70	26.30	6.16	3.10	4.93	3.20	2.04	0.43
BRIS soil+4g of NPK	A11	28.30	36.00	11.40	7.40	6.50	4.37	3.29	0.88
	A12	24.50	44.60	7.00	5.10	5.68	3.38	2.45	0.61
	A13	26.50	52.00	9.70	4.00	5.33	8.56	3.92	0.73
	A14	20.60	26.00	7.90	29.20	3.30	3.86	2.84	5.26
	A15	19.80	31.00	9.20	37.60	5.08	4.36	2.70	5.74

Appendix C: Result of growth performance of diameter and height in 50% light intensity

Treatment	Plant	Diameter (cm)					Height (cm)				
		W4	W6	W8	W10	W12	W2	W4	W6	W8	W10	W12
BRIS soil only	B16	0.13	0.18	0.22	0.23	0.26	8.60	11.20	13.80	15.00	16.50	19.50
	B17	0.18	0.21	0.25	0.58	0.72	8.50	12.00	16.30	18.30	29.00	52.00
	B18	0.20	0.22	0.23	0.24	0.26	7.20	9.00	13.00	15.30	17.50	21.00
	B19	0.20	0.23	0.24	0.25	0.25	6.80	11.30	15.30	17.20	20.00	21.00
	B20	0.16	0.20	0.24	0.25	0.25	7.90	11.50	15.00	17.00	18.00	20.00
BRIS soil+2g of NPK	B21	0.25	0.38	0.50	0.61	0.69	6.50	14.80	25.00	39.00	67.00	84.50
	B22	0.29	0.34	0.41	0.57	0.68	7.60	16.40	24.00	36.50	62.50	91.00
	B23	0.30	0.41	0.52	0.55	0.65	8.00	17.40	28.50	40.00	60.00	70.00
	B24	0.30	0.37	0.37	0.40	0.53	7.40	13.70	26.00	33.00	48.50	71.50
	B25	0.23	0.33	0.45	0.65	0.76	7.20	14.00	22.30	32.50	52.00	76.00
BRIS soil+4g of NPK	B26	0.35	0.45	0.56	0.67	0.73	8.00	17.80	28.50	44.00	66.50	81.00
	B27	0.27	0.37	0.48	0.66	0.91	7.90	17.00	22.00	34.50	47.00	64.00
	B28	0.36	0.47	0.60	0.89	0.90	8.30	16.70	25.50	36.50	56.00	69.00
	B29	0.30	0.41	0.58	0.65	0.92	8.00	19.00	31.50	47.50	70.50	88.00
	B30	0.35	0.48	0.60	0.76	0.84	7.40	11.50	27.00	40.50	58.00	74.00

Appendix D: Result of roselle's part weight in 50% light intensity

Treatment	Plant	Fresh weight (g)				Dried weight (g)			
		Stem	Leaf	Root	Fruit	Stem	Leaf	Root	Fruit
BRIS soil only	B16	1.10	1.88	1.50	0.57	0.41	0.55	0.48	0.12
	B17	23.20	42.00	6.50	4.40	3.51	6.79	1.84	0.62
	B18	1.22	2.70	1.56	1.94	0.29	0.25	0.42	0.05
	B19	0.90	1.28	2.30	0.00	0.36	0.32	0.62	0.00
	B20	0.97	1.76	2.13	0.67	0.32	0.31	0.58	0.12
BRIS soil+2g of NPK	B21	17.40	27.00	12.40	41.20	4.04	3.82	4.19	5.85
	B22	25.80	37.50	12.40	17.60	8.01	6.68	5.27	2.04
	B23	16.50	27.20	7.70	32.00	4.24	3.80	3.00	5.10
	B24	11.50	15.90	7.60	12.00	3.70	2.48	3.52	2.60
	B25	18.90	39.00	11.00	14.80	6.05	7.01	4.48	2.14
BRIS soil+4g of NPK	B26	40.70	15.80	41.40	4.18	4.22	4.53	7.90	40.70
	B27	54.10	20.30	22.60	8.18	5.65	9.47	2.94	54.10
	B28	51.60	17.40	41.50	4.65	8.24	7.77	8.58	51.60
	B29	24.80	38.30	42.00	5.96	7.92	8.82	4.03	24.80
	B30	41.80	22.00	37.30	8.74	4.22	6.68	5.60	41.80