

EFFECT OF SALINITY ON THE PHYSIOLOGICAL GROWTH AND
PROXIMATE MINERAL CONTENT OF PURSLANE
(*Portulaca oleracea* L.)

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DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF BACHELOR OF
AGRICULTURAL SCIENCE WITH HONOURS

PERPUSTAKAAN
UNIVERSITI MALAYSIA SABAH

CROP PRODUCTION PROGRAMME
FACULTY OF SUSTAINABLE AGRICULTURE
UNIVERSITI MALAYSIA SABAH
2016



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JUDUL: EFFECT OF SALINITY ON THE PHYSIOLOGICAL GROWTH & PROXIMATE MINERAL CONTENT OF PURSLANE PLANT (Portulaca oleracea L)

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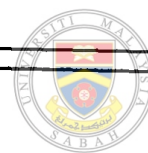

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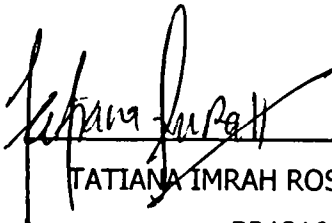
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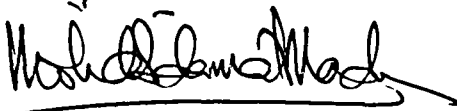
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APPRECIATION

All praises is to Allah and to Him alone. He guided me, showed me what to do, removed all obstacles from and lighted my path, inspired me, eased the tedious task of writing, and gave me surplus energy, He bestowed on me to enable me to alhamdulillah (praise be to Him) successfully finish this thesis.

First and foremost, I would like to extend my sincerest thanks and appreciation to those patient souls who helped me accomplish this study. I have to thank my research supervisors Dr. Md. Kamal Uddin and co-supervisor Dr. Mohammed Selamat, without their assistance and dedicated involvement in every step throughout the process, this paper would have never been accomplished.

I would also like to thank Professor Dr. Wan Mohamad Wan Othman the Dean of the Faculty of Sustainable Agriculture, UMS for his support and encouragement.

Thanks are also extended to all my friends, this is a special group of people that I consider members of my extended family. A special thanks also goes to Nur Farah Atiqah, we grumbled and laughed together from the beginning until we had complete our Final Year Project course. I must thank to Nuratika Abdul Karim, Nur Hafizah Roslan and Sylvia Taiming for their kindness and patient with my knowledge gaps in this area.

Most importantly, none of this could have happened without my family. To my mother Yushiana Mansor for her undivided attention, raised and taught me. Every time I was ready to quit, you did not let me and I am forever grateful. This dissertation stands as a testament to your unconditional love and encouragement.

ABSTRACT

The demand for salinity-tolerant plant is increasing due to augmented use of effluent or low-quality water irrigation and the growing Purslane in coastal areas. Purslane (*Portulaca oleracea*) is a drought and salt tolerant annual plant which contains high amounts of beneficial antioxidant vitamins and minerals. This study is to determine the effects of different concentrations of sea water application on the physiological growth and proximate mineral contents on this succulent weeds. The experiment was conducted in pots filled with a mixture of top soil in the rain shelter at the Faculty of Sustainable Agriculture, UMS (Sandakan Campus). The planting medium is top soil and the weeds were subjected to six different sea water treatments. The electrical conductivity (EC) of collected sea water was 45.3dSm^{-1} then diluted according to a different level of salinity which is 0.0 (tap water), 4.53, 9.06, 13.59, 18.12 and 22.65dSm^{-1} . Each treatment was replicated five times using Completely Randomized Design (CRD) and the treatment means were compared by Least Significance Differences (LSD) at 5% probability level. The physiological changes were evaluated to indicate the current condition of Purslane plant every week (for three weeks) after initial sea water application, and at the end of the evaluation week the whole plants were harvested. The result obtained showed Purslane response varied to different levels of salinity, and the growth of Purslane was more suppressed under 50% of salinity level (22.65dSm^{-1}). The physiological changes were also evaluated to indicate the current condition of Purslane plant every week (for three weeks) after initial sea water application and at the end of the evaluation week the whole plants were harvested. The morphological traits suppressed highest at 50% of salinity level, stem diameter reduction was (79.7%); leaf width reduction was (66.1%); leaf length reduction was (54.5%). The highest mineral residue content was found in leaves and the mineral composition was also affected by the salinity level. Nitrogen and crude protein content reduced with the increasing of salinity treatment. At 50% of salinity level (22.65dSm^{-1}) the nitrogen content was (1.05%) and showed the highest reduction (35.1%) compared to other treatments. At the same salinity treatment crude protein content showed the lowest value (6.62%) and at the same time it showed the highest total reduction (34.7%) compared to other treatment. The findings suggested that Purslane can be utilized at salt-affected soil and helps reduce the salt element in soil. This plant can become an alternative for a healthy lifestyle due to its good antioxidant and Omega-3 content. In addition, Purslane has the potential to become a key vegetable crop, especially for functional food and nutraceutical applications. The antioxidant content and nutritional value of purslane are important for human consumption and the potential use of this herb for the future is very promising.

**Kesan Kemasinan Ke Atas Pertumbuhan Fisiologi Serta Kandungan
Proksimat Nutrisi Terhadap Tumbuhan Purslane
(*Portulaca oleracea*)**

ABSTRAK

*Permintaan terhadap tumbuhan yang mempunyai daya toleransi terhadap unsur kemasinan semakin meningkat kerana semakin banyak kawasan di dunia ini mengalami masalah kemasinan pada tanah. Masalah kemasinan ini dipengaruhi oleh kualiti air yang rendah pada sistem pertanian. Purslane (*Portulaca oleracea*) adalah tumbuhan yang hidup secara tahunan yang mempunyai ketahanan terhadap situasi kemarau dan kemasinan, tumbuhan ini mengandungi tinggi unsur antioksidan, vitamin dan mineral. Kajian ini adalah untuk melihat kesan perbezaan kepekatan unsur kemasinan terhadap pertumbuhan fisiologi dan kandungan proksimat mineral terhadap rumpai Purslane. Kajian ini telah dijalankan menggunakan pasu yang diisi dengan tanah lapisan atas di bawah rumah perlindungan hujan yang bertempat di Fakulti Pertanian Lestari, UMS (Kampus Sandakan). Subjek kajian iaitu Purslane diberikan dengan enam jenis rawatan kemasinan yang berbeza. Bacaan kekonduksian elektrik bagi sumber kemasinan iaitu air laut yang diambil adalah 45.3dSm-1 dan dicairkan mengikut tahap kemasinan yang berbeza iaitu 0.0 (air paip), 4.53, 9.06, 13.59, 18.12 dan 22.65 DSM-1. Setiap rawatan diulang lima kali menggunakan Rekabentuk Rambang Lengkap (CRD) dan cara-cara rawatan dibandingkan dengan Perbezaan Kepentingan yang paling kurang (LSD) pada tahap kebarangkalian 5%. Setelah rawatan kemasinan diberikan, perubahan fisiologi pada tumbuhan Purslane akan dinilai setiap minggu selama tiga minggu dan pada minggu terakhir keseluruhan pokok Purslane akan dituai untuk dibawa ke makmal. Melalui keputusan kajian, Purslane mempunyai pelbagai tindak balas terhadap rawatan kajian yang telah diberikan namun Purslane telah menunjukkan perubahan yang ketara pada rawatan 50% nilai kemasinan (22.65 dSm-1), pada rawatan tersebut nilai pengurangan pada diameter pokok adalah (79.7%); nilai pengurangan pada lebar daun adalah (66.1%); nilai pengurangan pada panjang daun adalah (54.5%) dan sekali lagi pada rawatan 50% nilai kemasinan menunjukkan pengurangan paling tinggi untuk kelembapan dalam batang pokok iaitu (89.6%). Bahagian daun mempunyai kandungan mineral yang paling tinggi, kandungan mineral ini turut dipengaruhi oleh unsur kemasinan. Pada tahap rawatan kemasinan yang sama iaitu 50% nilai kemasinan (22.65 dSm-1) kadar protein mentah yang paling rendah adalah (6.62%) dan pada masa yang sama ia menunjukkan nilai perubahan yang paling tinggi iaitu (34.7%). Tumbuhan Purslane sesuai ditanam pada kawasan tanah yang mempunyai masalah kemasinan dan ia dapat membantu mengurangkan masalah kemasinan pada tanah tersebut. Tumbuhan ini juga sesuai dijadikan sebagai alternatif untuk gaya pemakanan yang sihat kerana kandungan antioksidan dan Omega-3nya. Tumbuhan Purslane boleh dijadikan sebagai sayur yang berfungsi sebagai sumber makanan dan sebagai tumbuhan yang mempunyai nilai nilai perbuatan. Kandungan antioksidan pada tumbuhan ini adalah penting untuk tubuh badan manusia tumbuhan ini juga mempunyai potensi yang cerah sebagai tumbuhan herba di masa akan datang.*

TABLE OF CONTENT

Contents	Pages
DECLARATION	ii
VERIFICATION	iii
APPRECIATION	iv
ABSTRACT	v
ABSTRAK	vi
TABLE OF CONTENT	vii
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF SYMBOLS, UNITS AND ABBREVIATIONS	xii
LIST OF FORMULA	xiii
CHAPTER 1 INTRODUCTION	
1.1 Introduction	1
1.2 Justification	3
1.3 Objective	4
1.4 Hypothesis	4
CHAPTER 2 LITERATURE REVIEW	
2.1 History of Purslane	5
2.2 Purslane Morphology	6
2.3 Purslane variety available in Malaysia	9
2.3.1 Green Purslane	10
2.3.2 Golden Purslane	11
2.3.3 Scarlet Purslane	12
2.3.4 Sea Purslane	13
2.4 Propagation of Purslane plant	14
2.5 The use of Purslane	16
2.6 Composition Nutrient in Purslane	17
2.6.1 Omega 3-fatty acid in Purslane	17
2.7 General aspect of salinity problems in Purslane	18
2.7.1 Effect salinity on Purslane physiology	19
2.8 Effect salinity on growth and development of Purslane	20
2.8.1 Salinity effect on plant height	20
2.8.2 Salinity effect on leaf length	21
2.8.3 Salinity effect on root growth	22
2.8.4 Salinity effect on shoot growth	22
2.8.5 Salinity effect on fresh & dry weight content	23
CHAPTER 3 MATERIALS & METHODS	
3.1 Location of the study	24
3.2 Duration of the study	24
3.3 Materials	24
3.4 Methods	24
3.5 Rain Shelter Cleaning	25
3.6 Pot Preparation	25
3.7 Soil Preparation	26
3.8 Transplanting	26
3.9 Parameters	26



3.10	Sample Preparation	27
3.11	Seawater Collection	27
3.12	Seawater Analysis	27
3.13	Physiological Growth Analysis	28
	3.13.1 Determination of leaf length (cm)	28
	3.13.2 Determination of leaf width (cm)	28
3.14	Biomass Analysis	28
	3.14.1 Determination of relative water content	28
	3.14.2 Determination of nitrogen content and crude protein	29
	3.14.3 Determination of shoot fresh weight and shoot dry weight	29
3.15	Experimental Design	29
3.16	Statistical Analysis	29
CHAPTER 4 RESULTS		
4.1	Effects of Different Salt Water Concentration on the Height (cm) of Purslane	30
4.2	Effects of Different Salt Water Concentrations on Stem Diameter (cm) of Purslane	31
4.3	Effects of Different Salt Water Concentrations on Leaf Width (cm) of Purslane	32
4.4	Effects of Different Salt Water Concentrations on Leaf Length (cm) of Purslane	33
4.5	Effects of Different Salt Water Concentrations of on Shoot Fresh Weight (g) of Purslane	34
4.6	Effects of Different of Salt Water Concentration on Shoot Dry Weight (g) of Purslane	35
4.7	Effects of Different of Salt Water Concentration on Shoot Moisture Content (%) of Purslane	36
4.8	Effects of Different of Salt Water Concentration on Nitrogen Content of Purslane	37
4.9	Effects of Different Salt Water Concentration of on Crude Protein Content of Purslane	38
CHAPTER 5 DISCUSSION		
	Discussion	39
CHAPTER 6 CONCLUSION		
	Conclusion	44
REFERENCES		46
APPENDIXES		51

LIST OF TABLES

Table		Page
4.1	Effects of Different Salt Water Concentration on the Plant Height (cm) of Purslane	30
4.2	Effects of Different Salt Water Concentrations on Stem Diameter (mm) of Purslane	31
4.3	Effects of Different Salt Water Concentrations on Leaf Width (cm) of Purslane	32
4.4	Effects of Different Salt Water Concentrations on Leaf Length (cm) of Purslane	33
4.5	Effects of Different Salt Water Concentrations of on Shoot Fresh Weight (g) of Purslane	34
4.6	Effects of Different of Salt Water Concentration on Shoot Dry Weight (g) of Purslane	35
4.7	Effects of Different of Salt Water Concentration on Shoot Moisture Content (%) of Purslane	36
4.8	Effects of Different of Salt Water Concentration on Nitrogen Content (%) of Purslane	37
4.9	Effects of Different Salt Water Concentration of on Crude Protein Content (%) of Purslane	38

LIST OF FIGURES

Figure		Page
2.2.1	Picture of reddish Purslane stem	7
2.2.2	Picture of Purslane leaves	7
2.2.3	Picture of Purslane tap and fibrous lateral root	8
2.2.4	Picture of Purslane seed and the seeded capsule	8
2.2.5	Picture of Purslane flower	9
2.3.1	Picture of Green Purslane or <i>Portulaca oleracea</i> L	10
2.3.2	Picture of <i>Portulaca oleracea</i> var <i>sativa</i>	12
2.3.3	Picture of Scarlet Purslane	13
2.3.4	Picture of Sea Purslane flower	13
2.4.1	Picture shows location of cuttings on stem for Purslane vegetative reproduction	15
2.5.1	Picture shows Purslane use in salad	17
2.5.2	Picture shows Purslane use as chicken feed	17

LIST OF SYMBOLS, UNITS AND ABBREVIATIONS

ALA	α -linolenic acid
ANOVA	Analysis of Variance
$^{\circ}\text{C}$	Degree Celsius
CAM	Crassulacean acid metabolism
CHN	Carbon, Hydrogen, Nitrogen
Cl^{-}	Chloride
Cm	Centimetre
CRD	Completely Randomized Design
dSm^{-1}	Decimetre
'E	Earth
EC	Electrical Conductivity
FSA	Faculty of Sustainable Agriculture
FW	Fresh Weight
G	Gram
Kg	Kilogram
LSD	Least Significant Differences
Mm	Milimetre
'N	North
Na^{+}	Sodium
RWC	Relative Water Content
Spp	Species
UMS	Universiti Malaysia Sabah
WHO	World Health Organization
%	Percentage

LIST OF FORMULAE

Formula		Page
3.14.1	Relative Water Content (RWC)	28
	$\text{RWC} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fully turgid weight} - \text{Dry weight}} \times 100\%$	
3.14.1	Crude Protein Content (CPC)	29
	$\text{CPC} = \% \text{ Protein} = \% \text{ Nitrogen} \times 6.25$	

CHAPTER 1

INTRODUCTION

1.1 Introduction

There are more than 2,000 unexplored herbal plants in Malaysia (Anonymous, 2012) and up until now, there are 70 species of edible herbs in Malaysia or domestically known as 'ulam' (Chu *et al.*, 2002). Ulam is a traditional medicine because some of these herbs have medicinal properties that can heal some diseases. However, in Malaysia one edible herb, called Purslane is very well known as wild weed that grown on field crop areas has received less attention in terms of its potential for human consumption. Besides Malaysia, this *Portulaca oleracea* can be found in Europe, Africa, North America, and Australia (Liu *et al.*, 2000)

Portulaca oleracea, is a herbaceous annual plant that belong to Portulaca family and their genus is Portulaca L. The botanical name of this plant is pusley or deckweed and many other names that vary according to region and places.

This plant can reproduce by seed and the seed can stay viable for 40 years in the soil (Helen, 2014). Normally, the leaves are oval shaped, smooth surfaced and a little bit shiny and after 20-30 days of emergence this plant start to flower, blooming at the end of the stem. The flower is small, for wild species the colour would be yellow while the ornamental types grow different colour of flower (Galinato *et al.*, 1999).

The 'weed' purslane is gaining special attention by agriculturist and nutritionists. This 'weed' is grown in turf grass area and field crops (Uddin *et al.*, 2012). This



plant had the largest level of Omega-3 fatty acid compared to any other green plant (Ezekwe *et al.*, 1999).

Before the conduct of scientific research, the U.S Department of Agriculture had classified Purslane as a 'noxious plant' because *Portulaca oleracea* can sprout from the sidewalk cracks (Vozzella, 2015). However, after being subjected to several scientific research, the Purslane is now listed in the World Health Organization (WHO) as one of the most used medicinal plants and it has been given the term 'Global Panacea' (Samy *et al.*, 2004).

The common Purslane which is largely consumed in the Mediterranean basin has the richest source of a-linolenic acid (ALA) among green leafy vegetables and a rich source of antioxidants (Alam *et al.*, 2014). Purslane is an excellent source of vitamin A which is a known powerful natural antioxidant source. It has high antioxidant properties that comes from high phenolic compound, a biosynthesis product when this plant is exposed to various stress environments (Yazici *et al.*, 2007).

Soil salinity is a major threat to global food security, and up to 20% of the world's irrigated land which produces one third of the world's food, is salt affected (Abogadallah, 2010). Soil salinization is caused by several factors and the main contributing factor is the low quality of irrigation waters, excessive fertilization, salty raining water that is close to coastal areas and lastly is due to contamination from the parental rocks, and the oceanic salts (Mahajan *et al.*, 2005). As mentioned earlier, soil salinity is a major threat in agriculture field which will lead to salt stress that causes adverse effect in plants. Soil salinity affects plant growth and crop productivity by changing the plant morphological, physiological, biochemical and anatomical (Tester and Davenport, 2003).

Salinity causes osmotic stress where it reduces the soil water potential by limiting the water uptake and it causes excessive uptake of ions, particularly Na^+ and Cl^- resulting into nutritional imbalance which then interferes at various metabolic processes (Munns *et al.*, 2008). Salinity impacts both vegetative and reproductive development, and it has the ability to delay emergence if the stress is severe enough. Plant shoot has higher sensitivity to salinity, and the impact of salinity can be seen

when the total leaf area keeps reducing and consequently reducing the number of photosynthetic leaf area.

Purslane is a salt tolerant crop that can be used as an approach to solve salt stress problem in agriculture industry. According to the current situation of salinity problem, it is necessary to grow some salt tolerant plant which can stand the increasing salt stress and can substitute the existing crop economically (Alam *et al.*, 2014).

Purslane has many medicinal potential and it has good adaptability to survive in saline condition. This project was designed to study the effect of different salt level on the Purslane physiological growth and proximate mineral content of purslane.

1.2 Justification

This study is important because it can help to raise the awareness of Malaysians on advantage of this plant. Majority of the population is only cultivating the plant as an ornamental plant. This plant is an excellent alternative to chemical herbicide in weed control. Besides that, it works very well for human health because it contains high Omega-3 fatty acid that is higher compared to cod fish. The human body cannot produce Omega-3, thus it has to be taken from outside sources such as from plants or animals (Anonymous, 2015).

In addition to containing Omega-3, Purslane is capable of acting as an antioxidant, this plant has been around since the days of Chinese civilization. During that time, these plants are used as medicines to help reduce the problem of clogged blood vessels that can cause heart disease (Boulos and El-Hadidi, 1984).

Second, this study investigated the effect of different levels of salinity on Purslane physiological growth. Typically, the soil containing high salinity values will negatively affect plant growth. The effect can be seen when the rate of tree growth decreases and eventually the plant will die. This situation occurs because the salt will provide an osmotic pressure while limiting the intake of water in trees. In addition, it also resulted in the recruitment Na^+ and Cl^- ions in excess and lead to nutrient imbalances, which in turn have an impact on tree growth. Purslane is a plant that is

resistant to salt element and can survive in arid climates. The analysis on the impact of different percentages of salinity on purslane growth may provide very useful information for the grower and suggest new method to encounter salinity problem which might reduce the nutrient content in the plant.

1.3 Objectives

The objectives of this study were:

1. To determine the effect of salinity on the physiological growth of *P. oleracea*.
2. To determine the effect of salinity on the proximate mineral content of *P. oleracea*.

1.4 Hypothesis

H₀: High application rate of salinity affect the physiological growth and proximate mineral content of Purslane plant.

H₁: High application rate of salinity did not affect the physiological growth and proximate mineral content Purslane plant.

CHAPTER 2

LITERATURE REVIEW

2.1 History of Purslane

Purslane is a member of the *Portulaca* family with more than 120 different species found in the family. The Asia region is a native for Purslane plant, but now it's widely spread through tropical and temperate land of earth (Kutschera, 1960). In the Mediterranean region and central Europe, this plant was known since the ancient time.

This plant was imported from southern Europe to United States, European Purslane is a very famous herb and appreciated in ancient times for thousands of years. However, the use of *Portulaca oleracea* somewhat died out in the 1900's.

The origin of this plant is uncertain, but *P. oleracea* has been reported as native to South America, North Africa, and Western Asia, and also Europe (Holmet *et al.*, 1977). Although it had reached at North America by the pre-Columbian, the seed and pollen of Purslane have been found in the sediment of Crawford Lake, Ontario from AD 1350 and seed from Illinois and Kentucky dated from 1000 BC to AD 750 (Watson, 1969).

In Malaysia, the 'weed' Purslane receives less attention among the citizen. It is very well-known as wild weed that grown on field crop areas while in some countries, Purslane is used as ornamental plants in the garden.



Every region has different types of climate which altered the Purslane's growth biologically, anatomically and physically. The impact of this alteration is many new varieties of Purslane produce with different physical characteristic.

2.2 Purslane Morphology

Purslane or its scientific name *Portulaca oleracea* L., is a member of *Portulaca* family and one of 25 genera of succulent herbs and shrub in *Portulaca* family, and the genus includes 40 species of warm and tropical climate species (Mitich, 1997).

According to Kutschera (1960), Purslane is a typical plant in the plant associated with *Galinsoga* (*Galinsoga spp*) and *Amaranthus spp*, it can survive under high climate area and famous as drought resistant plant. This plant (*oleraceae*) ranked as the eight most common plants in the world, it is widespread as a weed, fast growing, self-compatible and have an amazing ability to reproduce seed even on death's doorsteps (Liu *et al.*, 2000).

Purslane grows fast, even if it receives less care from its grower. This plant can survive at various types of soil such as acid, alkaline and neutral soil. This plant grows fertile when receives good moisture content of the soil, however it requires full sunlight and *P. oleracea* cannot survive in shade area.

Portulaca oleracea is an annual plant that can reproduce by stem cutting and seed. The plant can be differentiated into 4 groups which is cool temperate, warm temperate to wet dry sub-tropic; humid sub-tropic to tropic; and cultivated (Proctor, 2013).

The stem structure is reddish in colour, glabrous and branches radially from central axis which thick form, soft and able to grow up to 60 cm in diameter (Proctor, 2013). During young the stem is erect and becoming prostrate within age.



Figure 2.2.1: Picture of reddish Purslane stem

(Source: Anonymous, 2010)

The leaf is thick and succulent which means that it is able to absorb and store water. This makes this plant easily stand to excessive cold and hot climate. Purslane leaves are alternate, subopposite or opposite and have smooth margin. Both of the leaves and stem have watery sap and the average size of Purslane plant is 4-28mm long and 2-13mm broad.



Figure 2.2.2: Picture of Purslane leaves

(Source: Anonymous, 2003)

Purslane has long thick tap root surrounded by many fibrous lateral root, which has good ability to go deep in the soil just for absorbing nutrient and water activity, this ability makes this plant have excellent resistance to drought season. Some naturalist considers this plant as a pioneer plant whose root may open up soil crop root, so as an impact root crop can go deeper into the ground to gain more water and nutrient (Cocannouer, 1950).



Figure 2.2.3: Picture of Purslane tap and fibrous lateral root

(Source: Manitoba, t.t)

A single Purslane plant produces 240,000 numbers of seeds which can stay viable for 40 years in the soil and the seed can be found in a fruit or seeded capsule of Purslane plant. Due to its short growing season and continuous seed production makes this plant very persistent troublesome annual broad leaf weed.

The seed is oval shaped and the size is around 0.5-0.6 mm in diameter with flat, yellowish with scar and has a small concave at the small end part. It was developed at the main branches then followed at the secondary branches throughout the growing season (Egley, 1974).

Purslane seed can be spread by wind, animal digestive system and water. The seed grows easily and is able to survive at unfavourable condition. Seed dormancy in Purslane plant happens very rarely, (Egley, 1974) seed dormancy was related to water content and the seed age.



Figure 2.2.4: Picture of Purslane seed and the seeded capsule

(Source: Wikipedia, 2010)

Common Purslane starts to produce flowers in 20-30 days after emergence and it is only open during sunny morning. Purslane is a self-pollinating plant and insects play zero role in Purslane pollination. The size of the flower is small about 3-10mm broad, including 5 yellow petals, and has many seeded capsule. The flower exists in sessile solitary in the leaf axils or several together in the led cluster that is located at the end of the branches.

At the flower area is a calyx, a lower portion that combines with the ovary, and the upper part has two petals sized around 3-4 mm long, petal and the 6-12 stamens appear to be inserted on the calyx (Spielman, 1972).



Figure 2.2.5: Picture of Purslane flower
(Anonymous, t.t)

2.3 Purslane variety available in Malaysia

Every plant in this world grows with several types of varieties. In agriculture, the word variety refers to the changing or differences that exist between a species. So, variety is when a plant grows with different characteristics from their species and normally the difference is due to the changes in the physical plant characteristics. For example, changes in the colour of the leaf, colour of the fruit, and the shape of the leaf.

The changes in the plant character are an impact from the living factors such as water, light, and soil. Difference in climate and environment forces the plant to alter their life cycle processes in order to adapt to the surrounding conditions.

Climate change impacts plant physiological and induces a higher order response. For example, rising in temperature reduces freezing and chill stress incidence, but warming will increase metabolic rates and high extremes will lead to heat-shock responses.

2.3.1 Green Purslane

Several types of Purslane grow in Malaysia, with different colour of flower that can beautify gardens, but still this plant is categorized as unwanted plant that grows in crop fields. The most popular Purslane variety that grow in Malaysia is Green Purslane, scientifically known as *Portulaca oleracea L.* The common name for this green purslane is little Hogweed, this variety is easily found at their habitat like fields, waste ground, and roadside areas.

Green Purslane is an annual plant, their flower is hermaphrodite, have frost tender, self-fertile, and can grow up to 0.3m height. The best soil that can be used to grow this plant is loam, sandy, good drainage and a little bit moist. Normally, Green purslane cannot grow in the shades and this variety prefers full sunlight area.

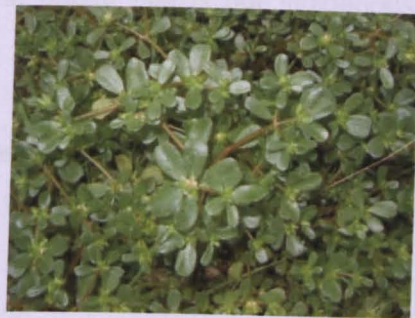


Figure 2.3.1: Picture of Green Purslane or *PortulacaoleraceaL*

(Source: Roberts, 2013)

The origin of this variety is India, it is an edible plant, producing flowers with varied colours such as pink, orange, and yellow, and it does not open on cloudy or rainy days. This variety can grow tall up to 4-8 inches and spread around 15 inches wide (Alamet *et al.*, 2014).

The leaves of this variety are a rich source of Omega-3 fatty acids, which is important to prevent heart attack and strengthen the body immune system. Besides Omega-3 fatty acids, green purslane leaves have protein, carbohydrate, fibre, calcium, and many more nutritional content. So this plant is good for human consumption and has also a good potential to be used as animal feed.

2.3.2 Golden Purslane

The second variety of Purslane found in Malaysia is 'Golden Purslane' or its scientific name is *Portulaca oleracea var sativa*, the origin of this variety is India. According to Grieve (1971) 'Golden Purslane' are herbaceous annual plants native of many parts of Europe. 'Golden Purslane' also can be found in West and East Indies, China and Ascension Island, and though found also in the British Isle is not indigenous there (Grieve, 1971).

Golden purslane has yellow leaves and less hardy compared to Green purslane. It can grow until 1ft, and this variety produces flowers from June-July and their seed ripen from August to September.

This purslane variety has yellowish leaf, size around 1½ inch, round shaped, succulent and thick. A Golden purslane produces flower that have female and male organ, thus this species is under classified under hermaphrodite group. Like other plant, purslane can be pollinated by itself or by insects.

After 35 days of planting this plant is ready to be harvested, and the best technique to harvest this plant is cut bite-sized leafy stem tips with whorls of tiny leaves. Normally, the plant is cut within 2 inches of the base and it will regrow fast after harvest.

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