EFFECT OF WATER TREATMENT ON VEGETATIVE GROWTH OF *PLUKENETIA VOLUBILIS* L.

Lae Lae Aung[1], Thanda Aye[2]

Abstract

The effect of days interval water treatment on growth of Sacha inchi (*Plukenetia volubilis* L.) was studied in this experiment. The field experiment was conducted in the field of Department of Agricultural Research Oil Crops, Research center in Magway Region (May2019-2020). This experiment with four replications in a completely randomized block design, T_1 3days interval T_2, 6days interval, T_3 9days interval and T_4 daily water treatments. The collected data such as plant height, number of branch, number of node, number of leaves, leaf area. The result of different days interval water treatment showed that the tallest plant height (90.97 cm), the maximum-number of branch (1.86), the maximum number of node (21.94), the maximum number of leaf (15.86), the largest number of leaf area (590.95 cm^2) were obtained from daily water treatment in this study.

Keywords: water treatment**,** 3days (T1) 6days (T2) 9days (T3) Daily (T4).

Introduction

Water supply is a major limitation for crop production in many areas of the world since it not only reduces cell growth rate, but also limits the crop's reproductive process. A major challenge in food production is to achieve the goal of increasing both food production and resource mainly (water and nitrogen) use efficiency. To maintain sustainable production and efficient use of the limited water resources, various type of water-saving irrigation techniques have been widely introduced, many of them taking advantage of the fact that changes in hydraulic and chemical signals induced by root zone, drying caused partial closure of stomata and inhibition of leaf expansion.

It has been identified that regulated deficit irrigation can save irrigated water up to 20%-30% and increase water–use efficiency greatly with a subtle or even positive impact on the grow, yield and quality of some grain and fruit crops, especially in arid and semiarid regions. Exposure of crops to warmer and drier environments will increase leaf-air water vapor pressure deficit, resulting in increased drought susceptibility and reduced productivity, not only in arid region but also in tropical monsoon regions with seasonal dry periods.

It still remains debatable if the water saving techniques could achieve the goal of increasing crop yield and saving water, especially for the sparsely planted woody crops. *Plukenetia volubilis* L, a tropical evergreen liana native to South America, is a promising new oilseed crop species belonging to the family Euphorbiaceae. *Plukenetia volubilis* plants grow continuously throughout the year. *Plukenetia volubilis* are highly variable and depend on environmental conditions and agricultural management practices. Irrigation in the dry season is necessary for increasing the potential because *Plukenetia volubilis* plants grown under natural drought conditions have lower numbers of female flowers and higher fruit abortion compared to the well-watered plants. (http//www researchgate.net.2017). Therefore the experiments for this study were conducted to investigate the effects of water supply on the growth of *Plukenetia volubilis* in Magway Township.

[1] Lecturer, Department of Botany, University of Magway
[2] Dr, Professor, Department of Botany, University of Yangon

Materials and Methods

Experimental site

The field experiment was conducted in the field of Department of Agricultural Research Oil Crops, Research Center in Magway Region from May 2019 to March 2020.

Soil for growing of *Sacha inchi*

Preparation of Soil for growing of *Plukenetia volubilis* L. (Sacha inchi). In the study area, the wild grasses were cut and land was ploughed to clear root stock and to clean up the land one week before the experimentation.

Soil Analysis

The soil samples at the depth of 1 feet (30.48cm) were randomly collected from 10 different places of the growing area. Then the collected soil samples were thoroughly mixed and analyzed in laboratory of Land Use Division, Myanmar Agricultural Service (MAS), Insein Township, Yangon Region.

Experimental design

Forty-five days old seedling were transferred experimental field. The field was laid out using Randomized Complete Block Design (RCBD), using four replicates of each treatment. Sacha inchi plants were planted 300cm x 105cm apart in each row with uniform plant height. The rows were 300cm apart. Ten liters of water added to each plant, four water treatments were carried out at 3days (T_1), 6days (T_2), 9days (T_3), daily (T_4) interval, respectively. Total experimental area was 2700,000 cm^2 and total sown plants were 64.

Germination of *Plukenetia volubilis* L.

At first, the seeds of Sacha inchi were immersed about 24 hours in water. After immersed in water, 10 seeds were placed on the prepared tissue paper in each plastic box, total 80 seeds were used in this germinations. Plastic boxes were placed at room temperature and nature condition. Each box was regularly water with 10ml once a day.

Germination rate was completed in 15 days after sowing and germination percentage was calculated using the method of Soup (2009).

$$\text{Germination rate (\%)} = \frac{\text{Total number of germinated seeds}}{\text{Total number of swon seeds}} \text{ x } 100$$

At 15 days all seeds were sprouting. They were transplanted into polyethylene bags containing the 1:1:1 volume of soil, rice husk ash and sand were placed under semi shadow to protect the bags from strong sun light. After 45days, all plants height became 20cm were selected to grow in the field.

Cultural management practices

During the growing period of Sacha inchi plants, crop management practice such as watering about 10 liter for each plant, organic pesticide (Neem) was soil drenched in every week. Weed control were done whenever it was necessary. (Basal fertilization 40g of NPK) was drenched to each plant.

Data collection and statistical analysis

Starting from the 14^{th} Day after sowing (DAS) the plants were collected at intervals of two weeks. Data were collected at two weeks intervals the vegetative growth such as the plant height,

the number of leaves, number of branches, number of nodes, leaf areas, were collected in this study. The data are analyzed using CROPSTATS software.

Results

Figure 1 *Plukenetia volubilis* L

Scientific Name	:	***Plukenetia volubilis* L.**
English Name	:	Sacha Inchi, Mountain peanut
Myanmar	:	Kyal-pe
Family	:	Euphorbiaceae

Morphological characters of *Plukenetia volubilis* L.

Habit: Sacha Inchi plant is perennial woody climbing shrub. Leaves: Simple, alternate, exstipulate with long petiole. Limina brodly ovate or ovate-cordate, serrate along the margin, acute at the apex, cordate at the base. Inflorescences: axillary, spike-like racemose, about 30 staminte flowers clustered at the top, 2 pistillate flowers at the base. Staminate flowers: minute, perianth, 4-5, apotepalous, tepal yellowish green, alternate at the ovary lobe, superior. Androecium: stamen, apostemnous, exerted attached on the convex receptacle, filament filiform, anther dithecous, oblongoid, longitudinal dehiscence, dorsifixed. Gynoecium: carpel (4), syncarpous, tetralocular, style long, stigma 4 lobed, ovary superior. Fruit: capsule 4-7 lobed, green in juvenile, dark brown in mature. Seed: 4-7 seeds per fruit.

Soil analysis

Physical and chemical properties of cultivated soil. The result of the analyzed soil from growing area showed loamy sand in soil texture which contained 94.9% sand, silt 9.9% and 3.9% clay. The cultivated soil had low in total nitrogen content (0.12%). The pH of the soil was 6.79% (nearly neutral) and the moisture content was 1.26%. The contents of exchangeable cat-ions, medium content of potassium 0.34% and very high phosphorous content 31.51%. The soil is loamy soil with very low organic carbon content was resulted from analysis (Table 1).

Table 1 Physical and chemical properties of soil samples

Parameter	Results	Remarks
Moisture (%)	**1.26**	**Nearly Neutral**
PH (soil : water) 1:2.5	**6.79**	
Soil Texture		
Sand (%)	**84.9**	
Silt (%)	**9.9**	
Clay (%)	**3.9**	
Total (%)	**98.7**	**Loamy sand**
Organic Carbon (%)	**0.82**	**Very low**
Humus (%)	**1.42**	
Total N_2 (%)	**0.12**	**Low**
Exchangeable Cations		
K^+	**0.34**	**Medium**
Available Nutrients		
P (ppm) (Olsen)	**31.51**	**Very High**
K_2O (mg 100gm)	**15.8**	**Medium**

Weather condition

The maximum temperature (41.7ºC) was obtained on May and the minimum temperature (10.2ºC) in November 2017. The maximum temperature (42.4ºC) was obtained on April and the minimum temperature (10.3ºC) in June 2018. The maximum rainfall (11.73 inch) was obtained in August and the minimum rainfall (0.08 inch) in December 2017. The maximum rainfall (6.42 inch) was obtained in May and the minimum rainfall (zero inch) on Feb, March, April in 2018 (Table 2). The average temperature during the cultivation period was 26.7 ºC and the average rainfall was 5.3 inches (Table 2).

Table 2. Monthly meteorological data of Magway area during growing of Sacha inchi

Meteorological Parameters	2019						
	May	Jun	Jul	Aug	Sep	Oct	Mean
Mean Temperature (˚C)	31.25	29.35	30.00	29.30	36.90	16.90	28.95
Mean Rainfall (mm)	163.06	390.65	77.97	192.27	8.63	163.06	165.94
Mean Relative Humidity	90.50	79.50	78.00	82.00	75.00	81.00	81.00

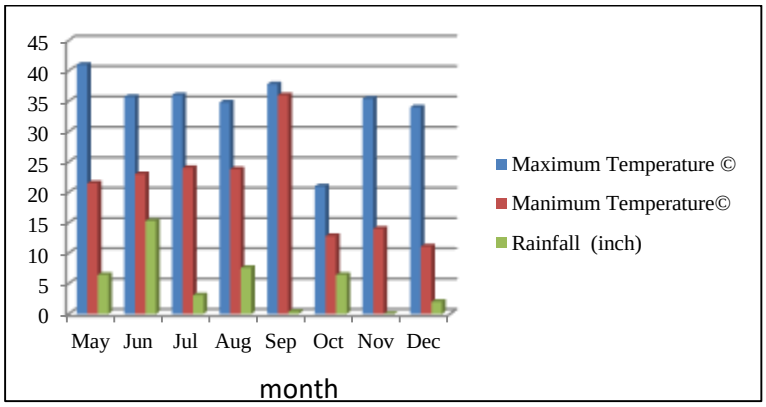

Figure 2 Monthly meteorological data of Magway area during growing of Sacha inchi

Table 3 Effect of days interval water treatment on plant height of Sacha inchi.

Treatment	Plant Height								
	15Days	30Days	45Days	60Days	75Days	90Days	105Days	120Days	mean
T1 (3 days interval)	36.75	39.25	48.5	67.75	91.38	109.88	116.38	120	78.74
T2 (6 days interval)	35	38.75	41.88	60.25	81.88	107.25	115.63	120	75.08
T3 (9 days interval)	37.13	42	46.25	60.88	74.13	91.13	102.38	120	71.74
T4 Daily	55.63	61.75	67.88	81.88	103.88	116.75	120	120	90.97
f-test	*	**	*	**	**	**	**	ns	
5%LSD	12.97	12.02	16.17	8.43	7.31	6.8	4.86	0	
cv%	19.7	16.5	19.8	7.8	5.2	4	2.7	0	

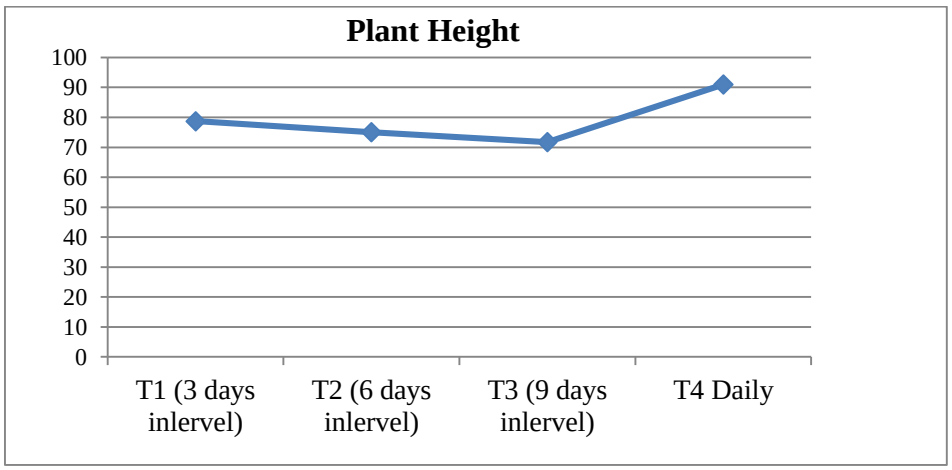

Figure 3 Effect of Days Interval Water Treatment on Plant Height

Plant Height

The growth of plant height were gradually increased in all treatments during 120 days of growing period. The differences in plant height were significant in Sacha inchi plant among treatment up to 15 days to 105 days. In 120 days is non significant. In different days interval water treatment, the tallest plant height (90.97cm) was obtained from daily water supply. The shortest plant height. (71.74cm) was obtained from 9days interval water treatment.

Table 4 Effect of Days interval water Treatment on Branch of Sacha inchi

Treatment	Number of Branch								
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	120 DAS	Mean
T1 3days interval	0	0	1.88	2	2.38	2.5	3.38	4.88	2.13
T2 6days interval	0	0	1.63	1.88	2.38	2.5	3.13	3.8	1.92
T3 9days interval	0	0	1.25	1.63	2	2	2.5	3.5	1.61
T4 (Daily)	0	0	1.88	2.8	2.8	2.88	4.5	6.38	1.86
F-test	ns	ns	**	**	**	**	**	**	
5%LSD	0	0	0.27	0.48	0.26	0.19	0.53	0.65	
cv%	0	0	10.4	14.6	7	9.9	9.9	8.8	

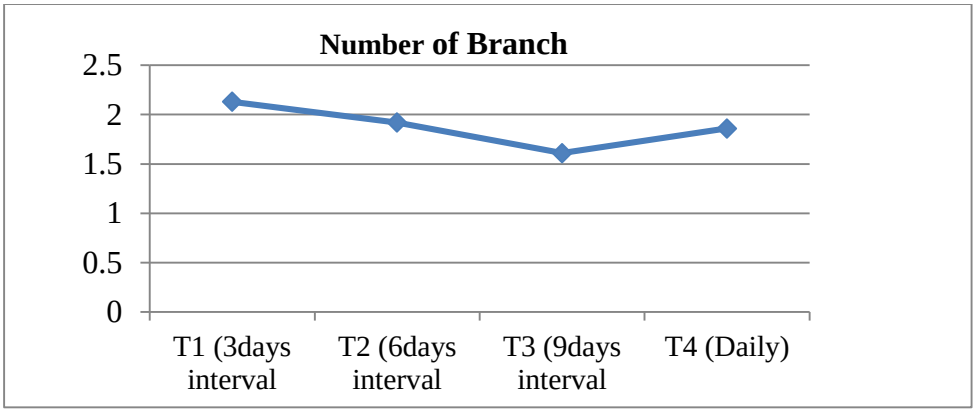

Figure 4 Effect of Days interval water Treatment on Number of Branch

Number of Branch

In all treatment, the statistical result showed that, the highest number of branches was obtained (2.13) from 3 days intervals. The lowest number of branches (1.61) was obtained from 9 days intervals.15 days and 30 days were non-significant.

Table 5 Effect of Days interval water Treatment on Number of node of Sacha inchi

Treatment	Number of Node								
	15 Days	30 Days	45 Days	60 Days	75 Days	90 Days	105 Days	120 Days	Mean
T1(3Daysinterval)	10.88	13	15.13	20.13	24.63	27.5	27.75	28.38	20.92
T2(6Daysinterval)	10.75	12.75	14.75	18.63	22.13	23.75	24.13	25.5	19.05
T3(9Daysinterval)	8.75	10.88	12.5	16.75	21.13	24.5	25	25.63	18.14
T4(Daily)	10.5	12.5	15.75	23.5	27.63	27.63	29	29	21.94
f-test	ns	ns	ns	ns	*	*	**	ns	
5 %LSD	3.29	3.25	3.05	5.54	4.34	2.95	2.48	3.47	
cv%	20.2	16.6	13.1	17.5	11.4	7.2	5.9	8	

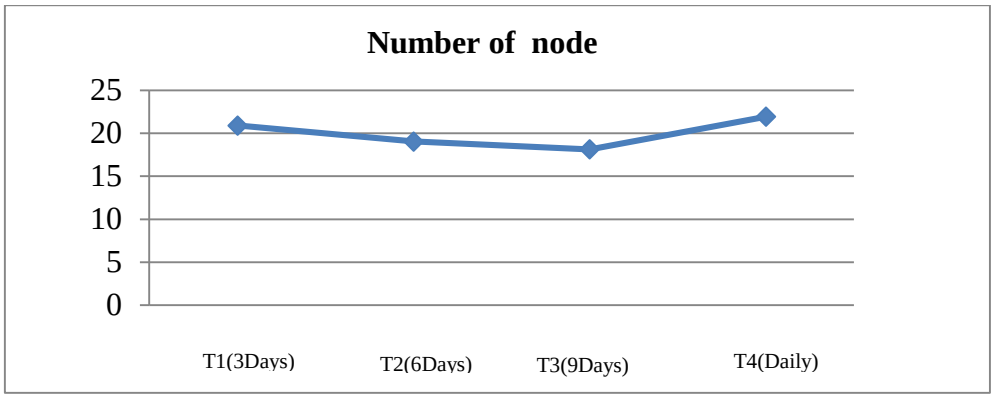

Figure 5 Effect of Days interval water Treatment on Number of Node

Number of Node

The statistical result showed that the days interval water treatments, the number of note (21.94) were obtained from water daily supply, (20.92) 3 days interval water supply, (19.05) from 6 days interval water supply, and number of node (18.14) were obtained from 9 days interval water supply. 75, 90 days are significant and 105 days is highly significant.

Table 6 Effect of days interval water treatment on number of leaves of Sacha inchi

Treatment	Number of Leaves								
	15Days	30Days	45Days	60Days	75Days	90Days	105Days	120Days	Mean
T1 (3Daysinterval)	6.5	9	10.63	15.25	17.75	19.5	17.5	15.38	13.93
T2 (6Daysinterval)	6.38	7.75	9.5	12.75	15.75	18.38	16.88	15.75	12.89
T3 (9Daysinterval)	5.75	6.38	7.63	13.25	14.25	17.13	17.88	16	12.28
T4(Daily)	7.75	10.38	12.13	16.75	18.63	20.25	20.5	20.5	15.86
f- test	ns	*	*	ns	*	ns	ns	**	
5% LSD	1.73	2.44	2.89	3.91	3.14	3.65	3.8	3.12	
cv%	16.5	18.2	18.2	16.9	11.9	12.2	13.1	11.6	

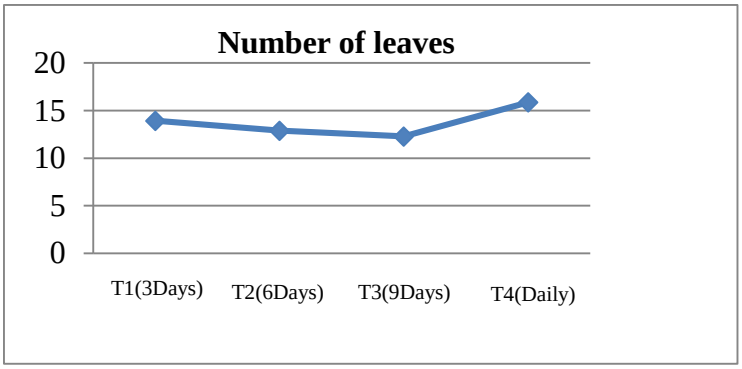

Figure 6 Effect of days interval water treatment on number of leaves

Number of Leaves

The statistical results showed that the number of leaves of all treatments are increased days by days. In different days interval water treatments, the largest number of leaves on main stem was obtained (15.86) from daily water supply. The smallest number of leaves (12.28) was obtained from 9 days interval water treatment. 30, 45, 75days are significant and 120 days is highly significant.

Table 7 Effect of Days interval water Treatment on Leaf Area of Sacha inchi

Treatment	Leaf Area (cm^2)								
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	120 DAS	Mean
T1 (3days interval)	**231.88**	**245.66**	**258.88**	**487.18**	**624.36**	**763.45**	**866.37**	**921.83**	**549.95**
T2 (6days interval)	**231.91**	**241.65**	**252.4**	**483.68**	**598.54**	**743.42**	**842.53**	**897.39**	**536.44**
T3 (9days interval)	**207.45**	**231.47**	**218.83**	**496.58**	**585.82**	**670.76**	**738.2**	**825.21**	**494.54**
T4 (Daily)	**287.92**	**301.35**	**317.24**	**492.07**	**683.99**	**791.87**	**878.6**	**974.52**	**590.95**
F-test	*	**	**	ns	ns	ns	ns	*	
5%LSD	**41.87**	**39.4**	**43.53**	**74.46**	**130.28**	**152.29**	**139.91**	**98.45**	
cv%	**10.9**	**9.8**	**10.4**	**9.6**	**13.1**	**12.8**	**10.5**	**6.8**	

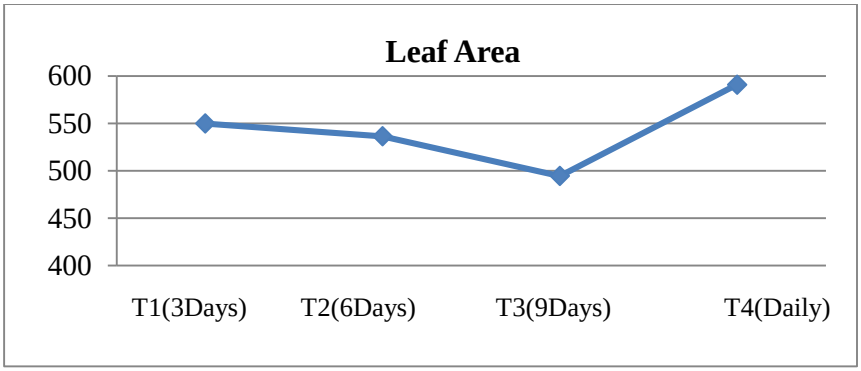

Figure 7 Effect of Days interval water Treatment on Leaf Area

Leaf Area (cm^2)

The statistical results showed that the leaf areas of all treatments 15,30,45,120 days were significant. In days interval water treatment, the largest leaf areas (590.95cm^2) was obtained from daily water supply. The second largest leaf areas (549.95cm^2) was obtained from 3days interval water supply and the smallest leaf areas (494.54cm^2) was obtained from 9days interval water supply.

Discussion and Conclusion

The result of the analyzed soil from growing area showed Loamy sand in soil texture which contained 84.9% sand, silt 9.9% and 3.9% clay. It had low in total nitrogen content (0.12%). The pH of the soil was 6.79 (nearly neutral) and the moisture content was 1.26%. The contents of exchangeable cations, from this experiment showed that the potassium content was 0.34% and phosphorous contents 31.51% very high. Sacha Inchi plant tolerate the acidic soil with a pH as low as 4.5 that contains aluminum (http://www.tandfonline.com). The maximum temperature (36.9)°C was obtained in September 2019 while the minimum temperature of (16.9)°C in October. The maximum rainfall (390.65) mm was obtained in June and there no rainfall in November. Sacha Inchi plants prefer to grow in tropical climates at 5577 feet (1, 700m) above sea level and the best annual rain fall is within 850-1000 mm. Irrigation is important during dry months at the temperature of 36°C. (www.nature.com/ scientificreports, 2018). It is difficult to match the detailed morphological characteristics of Sacha Inchi with any other references because there was no study on this plant. However, most of the characters of this plant could match with the characters mentioned for Euphorbiaceae by Lawrence (1964), Brandi (1906) and (www.nature.com/ scientificreports, 2018). The results of water treatment showed that the tallest plant height (90.97cm) the highest number of branches (2.13) and the maximum number of node (31.94) were obtained from daily water treatment.

This observation agreed with Zareian (2004) who revealed that Sacha Inchi plant requires daily watering for its optimum growth. The height of plants under adequate water supply is higher than that of moderate water stress. These agree with Zareian(2004). In many species, the vegetative growth is more likely to be retarded by soil water deficiency than the period of the reproductive growth. Deficiency of water during stem elongation or shooting period with notation of a marked retarding effect upon the height of plant (Zareian, 2004). Kramer (1983) also stated that vegetative growth, in general and leaf expansion, in particular are several inhibited by relatively moderate water stress. Moreover, the largest number of leaves on main stem was (15.86), the largest leaf area (590.95cm^2) were obtained from the control, daily water treatment. The numbers of leaves of water stress are generally less than that of under well water plants. This observation were in accordance with Marc and Palmer (1976); Yegappan *et al.*, (1980). The area of leaf of well watered

plants were greater than that of moderated water stress plants. This finding is in agreement with the finding of Zhang *et al*., (2016) mentioned that the leaf area of well watered plants were greater than that of stressed plants and it was increased with time.

This study agreed with Zhang *et al*., (2016). The decreased a single leaf area of Sacha Inchi plants are important to maintain leaf function and allow to conserve water under the drought conditions (Jiao *et al*., 2012). Although water stress induced abscisic acid accumulation is generally regarded as an inhibitor of shoot growth (Zhang *et al*., 2016). Leaves and plant growth of Sacha Inchi plants were generally influenced by deficit irrigation (www.nature.com/ scientificreports, 2018). In this study, the vegetative growth of Sacha Inchi plants were well developed from daily water treatment. Zhang *et al*., (2016) reported that even natural drought conditions decreased the plant growth. In Sacha Inchi plant, along other managements practices such as concentrating irrigation on the developmental stages is the most sensitive factor for plant growth (Zhang *et al*., 2016 and http://dx.doi.j.indcrop. 2017.09.002). In many dry regions irrigation is an important way in which water is supplied to crop plants Bernard S. Meyer, (1963).

It is therefore concluded that the experimental results showed that water has an influence on the plant growth. The plants grown under sufficient water supply condition produced highest plant height, larger leaf area than the plants grown under water deficit plants.

Acknowledgements

I would like to express my heartfelt thanks of my Professor Dr. Aye Pye, Head of Botany Department, Yangon University, for allowed me to conduct this research for my phD degree. I wish to express my deepest gratitude to my supervisor, Dr. Thanda Aye, Professor Departments of Botany, University of Yangon, for her invaluable advices, supervisions, guidance and supports for the experiment.

I would to my gratitude to Daw Hla Hmwe Kyu, Assistant research officer, Magway Central farm Oil Seed Crop Research Center in Magway Regions, for her kind helps during my research work.

References

Bernard, S. Meyer & Donald B. Anderson. (1963). **Plant Physiology**. Affiliated East-West Press, AEW (Canada) LTD.

Brandi, D.K.C.I.E. (1906). **Indian Trees, an account of trees, shrubs, woody, climbers, bamboos and plant indigenous or commonly cultivated in the British Indian Empire.**

Jiao, D.Y., M.H. Xiang, W.G & Z.Q. Cai. (2012). **Dry-season irrigation and fertilization affect the growth, reproduction, and seed traits of Plukenetia volubilis L. plants** in a tropical region. J. Hort. Sci. Biotechnol. 87, 311-316.

Kramer, P. J. (1983). **Water Relations of plants.** Academic press, INC (Landon) LTD. PP 57-83.

Lawrence. G.H.H. (1964). **Taxonomy of Vascular Plants.** The Macmillan Company, New York, London.

Marc and Palmer. (1976). **Soil-plant-water relations, growth and nutrient uptake patterns of field-grown soybeans under moisture stress.** M.V.K. Sivakumar, Iowa State University, Thesis Disscertation, 5846.

Soup, S.G. (2009). **Germination rates and Percentages.** Plant Physio. Biology 327-320. 363-2782.

Zareian, J. (2004). **Effects of drought on the different stages of growth and growth traits varieties of winter canola,** MSc Thesis Agronomy, Faculty of Agriculture, Islamic Azad University of Khorasgan.

Zhang. (2006). **Effects of deficit irrigation and plant density on the growth and yield of *Plukenetia volubilis* L. plants independently.**

Website

1. www.nature.com/scientificreports,2018
2. hhttp://www.tandfonline.com
3. http://dx.doi.j.indcrop.2017.09.022
4. http//www.researchgate.net.2017