EFFECT OF THE WATER REQUIREMENTS ON *SOLANUM LYCOPERSICUM* L. DURING RAINING SEASON

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Abstract

This experiment was conducted to evaluate the effect of amount of water on the vegetative and reproductive growth of tomato and to assess the suitable irrigation to improve the economic efficiency of tomato production. Present investigation was carried out during April to July, 2019 at Oakshitpin Village, Padaung Township, Bago Region to observe the effects of variable water of tomato crop. The four treatments of water requirements were used. This experiment was treated with T_1 (0.05-0.27 L), T_2 (0.21 - 2.07 L), T_3 (0.36 - 2.22 L) and T_4 (0.50-2.37 L). Each treatment had five replications set up in Randomized Completely Block Design (RCRD). Tomato was evaluated in farmer's field with farmer's participation under plastic house condition for yield potential and other yield characters using the effect of amount of water during rainy season. The germination rate of *Solanum lycopersicum* L. was 75.60 %. Vegetative growth such as plant height (17.21 cm), number of leaves per plant (17.97), leaf length (12.22 cm) and single leaf area (78.95 cm^2) were the best in T_2 (0.21 - 2.07 L). Reproductive growth as earliest first flowering days (36 DAT), number of clusters per plant (7), number of fruits per cluster (6.9), single fruit diameter (5.01 cm), fruits weight per plant (282.10 g) and fruits yield (4798.74 kg ha^{-1}) were highest in T_2 (0.21 - 2.07 L). T_2 (0.21 - 2.07 L) could be recommended for commercial production under plastic house condition during rainy season.

Keywords: water requirements, tomato, RCBD

Introduction

Tomato is originated from Western South America and it was introduced into European gardens in the early sixteenth century. Tomato is a member of the Solanaceae family or night shade family (Wien, 1997). Growing tomatoes in greenhouses allows producers to grow plants at a time when it would be impossible to grow outside because of the weather. Tomatoes prefer well drained soil because they are sensitive to water logging. Water should be given in proper amount and accurate time application. Therefore, water management is a key to avoid plant moisture stress during the crop growth stages (Priyanka *et al*., 2015).

Tomato seedling of 7.5 to 10 cm in height is ready for transplanting or 4-5 weeks old or when it has attained 5-6 leaves and irrigates well before and during transplanting. Growth of all plants can be divided into three stages with regard to watering practice: vegetative, flowering, and fruiting (Hansen *et al.*, 1982).

In general, most of the crops show that timely irrigations (watering) are more important than total number of irrigations (Allen *et al.*, 1998). In the growing period of tomato, daily mean air temperature varied between 18.5 and 27.7°C with overall mean air temperature was 22.8°C and the daily minimum and maximum temperatures were 8.5 and 33.3°C, respectively. During the study period, a meager 3.6 mm rainfall was received (Kumar *et al*., 2015). Tomato can be produced both as rainy season crops in the highlands and as cool season vegetables in lowland areas (Yu Yu Tun and Aung Phyo, 2019).

Tomato can be consumed as raw or as an ingredient in many dishes, sauces, salads, and drinks. Factors influencing the considerable increase in tomato consumption include consumer awareness of benefits such as preventing cancer and chronic diseases. This beneficial effect is due

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to the action of antioxidant compounds, which reduce oxidative damage in the body. Tomatoes are not as sweet due to its lower sugar content then other edible fruits. Tomatoes are low in calories and a good source of vitamins A and C, the flavor and texture (Ray *et al*., 2016).

The sustainable use of water in agriculture has become a major concern. The adoption of strategies for saving irrigation water and maintaining acceptable yields may contribute to the preservation of this ever more restricted resource. Irrigation water quality can affect soil fertility and irrigation system performance as well as crop yield and soil physical conditions. Therefore, knowledge of irrigation water quality is critical in understanding the management changes that are necessary for long-term productivity. Tomato is one of the most important vegetable crops and is one of the most demanding in terms of water use (Mahmud *et al*., 2012). Insufficient water at any growth stage will reduce yield and fruit quality. Tomato grows well in moist but not soggy soil, and well-timed furrow or drip irrigation is effective (Ramathani *et al*., 2018).

The aims of the study were to introduce fruit production of tomato in rainy season and the objectives were to study the growing of tomato in the plastic house, to record the water requirements of amount, accurate time application on growth stages and to evaluate growth and yield of tomato under different water supply conditions.

Materials and Methods

Experimental Site

The experiment of water requirements for *Solanum lycopersicum* L. was conducted Oakshitpin Village, Padaung Township, Bago Region, during April to July, 2019.

Planting material used

Tomato seeds were used as planting material for this research. These tomato seeds (var: kyar chay) were purchased from the Marlarmyaing Agricultural shop.

Germination test

The seeds of tomato, *Solanum lycopersicum* L. (Kyar Chay), were germinated in the prepared soil (2 soil: 1 sand). The numbers of germinating seeds were daily recorded. The germination rate was calculated using the method of Soupe (2009).

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

Analysis of soil sample

The soil samples were collected from the experimental field in the depth of 30 cm. The collected soil samples were analyzed in the soil laboratory, Land Use Division, Department of Agriculture, Yangon Region.

Soil Preparation

Firstly the soil of the experimental area was cleaned the wastes. Then the soil from the field was mixed with paddy rice char in the ratio of 5:1. The prepared soil was sprayed water with thoroughly mix. The soil mix was covered with plastic sheet for one week. Twenty four kilogram of soil mix was put into a polyethylene bag; it was contained nine parts of soil and one part of cow dung which was the basal fertilizer treatment.

Cultural management practices

Five weeks after germination, the seedlings with the high or 5-7 cm containing 2-3 leaves were transplanted into the prepared soil medium of polyethylene bag. After transplanting the individual tomato plant was watered with the same amount of water to protect from the transplanting shock. The inorganic compound fertilizer (NPK 15-15-15) was applied at the vegetative growth stages (1WAT) and at early developmental stages (6 WAT). Water treatment was started one week after transplanting. In the treatment T_1 (0.05 – 0.27 L), T_2 (0.21 - 2.07 L), T_3 (0.36 - 2.22 L) and T_4 (0.50 – 2.37 L) were given per day to the assigned plants. The control plants were watered as the amount of water used by (0.05 – 0.27 L) the local farmers. The spraying of tawnid pesticide and weeding were carried out when necessary (Table 1).

Table 1 Weekly water treatments on growing of *Solanum lycopersicum* L. in the plastic house

Treatments	Weekly water treatment (Liter)							
	Vegetative stage				Early developmental stage			Late developmental stage
	1 WAT	2 WAT	3 WAT	4 WAT	5 WAT	6 WAT	7 WAT	8-10 WAT
T_1	0.05	0.08	0.10	0.13	0.15	0.20	0.24	0.27
T_2	0.21	0.36	0.47	0.62	0.83	1.33	1.86	2.07
T_3	0.36	0.50	0.62	0.77	0.98	1.48	2.01	2.22
T_4	0.50	0.65	0.77	0.92	1.12	1.63	2.16	2.37

WAT = weeks after transplanting, Lewis, 2014

Experimental layout

There were four treatments, each with five replications were out in Randomized Complete Block Design (RCBD) which was inside the plastic house. L x W x H (65268000 cm^3) the spacing between the plants and row were 60 cm x 60 cm. The total experimental area was 683100 cm^2 (Figure 1).

Meteorological data

The meteorological data such as temperature, rainfall and humidity were recorded from Meteorological Department, Pyay Township, Bago Region.

Data collection

The vegetative growth such as plant height, petiole length, number of leaves per plant, single leaf width, single leaf length and single leaf area in this experiment and reproductive growth such as first flowering days, fruits per cluster, clusters per plant, single fruit diameter, fruits weight per plant and fruit yield were collected in this experiment using IRRISTAT software.

Single leaf area

The single leaf area (cm^2) was calculated at flowering using leaf length and leaf width measurements following the formulae as follows;

$$\text{Leaf area} = K \times L \times W,$$

K = constant coefficient, L = leaf length, W = leaf width (Bertin, 1993)

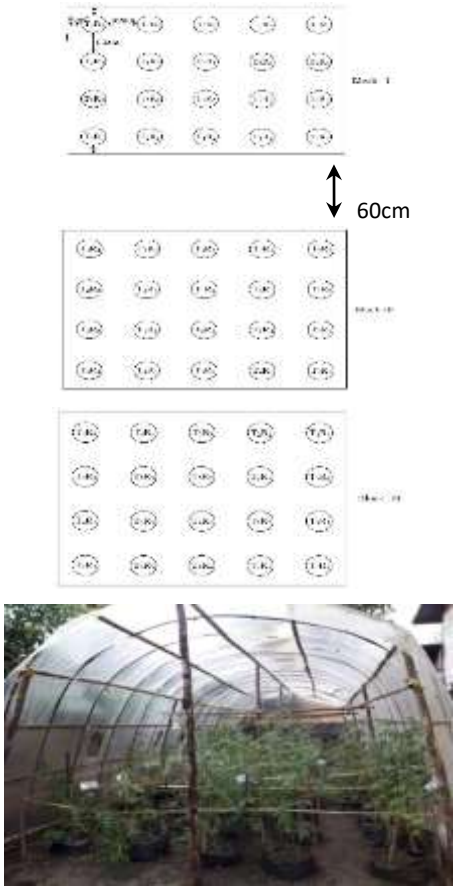

Figure 1 Growing of tomato in RCBD with four treatments and five replications

Results

Soil analysis

The pre planting results of soil laboratory test indicated that the soil in the study site is Oakshitpin Village, Padaung Township, Bago Region, texturally sandy loam, low in nitrogen content. The sample analysis further indicated that the experimental soils have high in potassium and K_2O, very high in phosphorus and neutral in pH (Table 2).

Table 2 Physical and chemical characteristics of experimental area

Parameters	Analyzed results	Rating
pH (soil : water, 1:2.5)	6.59	Neutral
Total N %	0.16	Low
Exchangable K (meq/100 gm)	0.47	High
Available Nutrients, P, ppm (Bray)	50.71	Very high
Available Nutrients, K_2O (mg/100gm)	21.91	High
Moisture (%)	1.39	-
Texture	Sandy loam	-
Sand (%)	67.12	-
Silt (%)	17.00	-
Clay (%)	15.88	-

meq = milliequilivalent, ppm = parts per million, Bray = Bray method

Measurement of temperature, rainfall and humidity

Everyday weather data was recorded from Department of Meteorology and Hydrology, Pyay Township, Bago Region (Table 3).

Table 3 Temperature and rainfall data of Pyay Township in May, June, July 2019

Date	Mean temp (°C)	Mean Rain fall	Mean humidity
May, 2019	31.92	2.00	65.43
June, 2019	29.56	8.73	80.30
July, 2019	29.91	9.10	85.19
Total	30.46	6.61	230.92

Germination test of *Solanum lycopersicon* L.

Two hundred tomato seeds cv. kyar chay were tested in the tray. Among 40 seeds in each plot, plot 1 had 31 germinated plants; plot 2 had numbers of germinated plant 30, plot 3, 33 germinated plant and plot 4, 27 germinated plants, respectively. Therefore germination rate is 75.63 % and the result showed that the germination rate was 75.63 % and thus tomato seeds cv. kyar chay were chosen as planting materials (Table 4).

Table 4 Germination rate of *Solanum lycopersicum* L.

Plot	No. of sown seeds	Germinated	Germination %
1	40	31	77.50
2	40	30	75.00
3	40	32	80.00
4	40	28	70.00
Total	160	121	**75.63**

Vegetative Growth

Plant height

The result of the plant height response to different watering levels on growth stages showed that T_2 (0.21 L – 2.07 L) had the longest height 17.21 cm followed by T_4 (0.50 L – 2.37 L) 17.07 cm, T_1 (0.05 L- 0.27 L) had 16.32 cm and T_3 (0.36 L – 2.22 L) 16.17 cm respectively (Table 5 and Figure 2).

Petiole length

The result of the petiole length response to different watering levels on growth stages showed that T_3 (0.36 L – 2.22 L) had the longest length 5.30 cm followed by T_2 (0.21 L – 2.07 L) 5.06 cm, T_4 (0.50 L – 2.37 L) 4.90 cm and T_1 (0.05 L- 0.27 L) had 4.80 cm respectively (Table 5 and Figure 2).

Number of leaves per plant

The results of the number of leaves per plant response to different watering levels on growth stages revealed that T_2 (0.21 L – 2.07 L) had the most numbers of leaves 17.97. The second and third highest leaf number were observed in T_1 (0.05 L- 0.27 L) 17.24 and T_3 (0.36 L – 2.22 L) 16.42 and the fourth was T_4 (0.50 L – 2.37 L) 15.92 (Table 5).

Leaf length

The results of the leaf length among the treatments showed that T_2 (0.21 L – 2.07 L) had highest leaf length 12.22 cm. It was followed by T_1 (0.05 L- 0.27 L) 10.93 cm, T_3 (0.36 L – 2.22 L) 10.91 cm and T_4 (0.50 L – 2.37 L) had least leaf length of 9.97 cm respectively (Table 5 and Figure 2).

Leaf width

Single leaf width among the treatments gave that T_4 (0.50 L – 2.37 L) was highest leaf width 9.62 cm. It was followed by T_3 (0.36 L – 2.22 L) 8.99 cm, T_1 (0.05 L- 0.27 L) 8.89 cm and T_2 (0.21 L – 2.07 L) had least leaf width of 8.80 cm respectively (Table 5 and Figure 2).

Single leaf area

The single leaf area among the treatments showed that T_2 (0.21 L – 2.07 L) had the highest single leaf area 78.95 cm^2. It was followed by T_3 (0.36 L – 2.22 L) 73.53 cm^2, then T_4 (0.50 L – 2.37 L) 71.76 cm^2 respectively. T_1 (0.05 L- 0.27 L) was the least result 71.53 cm^2 among treatments (Table 5).

The summarized results of vegetative growth expressed the effect of different watering levels on growth stages that the highest plant height was 17.21 cm, T_2 (0.21 L – 2.07 L), the longest petiole length, 5.30 cm, T_3 (0.36 L – 2.22 L), the most number of leaves per plant 17.97, T_2 (0.21 L – 2.07 L), the maximum leaf length 12.22 cm, T_2 (0.21 L – 2.07 L), the broadest leaf width 9.62 cm T_4 (0.50 L – 2.37 L) and the largest single leaf area 78.95 cm^2 T_2 (0.21 L – 2.07 L) respectively (Table 5).

Table 5 Summarized data of vegetative growth of *Solanum lycopersicum* L. responsed to different water treatments

Water treatments	Plant height (cm)	Petiole length (cm)	Number of leaves per plant	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)
T_1 (0.05 L- 0.27 L)	16.32	4.80	17.24	10.93	8.89	71.53
T_2 (0.21 L – 2.07 L)	**17.21**	5.06	**17.97**	**12.22**	8.80	**78.95**
T_3 (0.36 L – 2.22 L)	16.17	**5.30**	16.42	10.91	8.99	73.53
T_4 (0.50 L – 2.37	17.07	4.90	15.92	9.97	9.62	71.76

(a) Plant height (b) Petiole length (c) Leaf length (d) Leaf width

Figure 2 Vegetative growth of *Solanum lycopersicum* L.

Reproductive Growth

First flowering days

The mean number of the earliest first flowering days is 36 (DAT) days after transplanting in T_2 (0.21 L – 2.07 L) followed by T_3 (0.36 L – 2.22 L) and T_4 (0.50 L – 2.37 L) 39 DAT and then 40 DAT in T_1 (0.05 L- 0.27 L) respectively. The statistical results of these experiments were significant (Table 6 and Figure 3).

Table 6 First flowering days of *Solanum lycopersicum* L. responsed to different water treatments

Water treatments	First flowering days (DAT)
T_1 (0.05 L- 0.27 L)	40
T_2 (0.21 L – 2.07 L)	**36**
T_3 (0.36 L – 2.22 L)	39
T_4 (0.50 L – 2.37 L)	39
F test	*
CV%	0.36
5%LSD	1.6

Number of clusters per plant

Compared the mean value of number of clusters per plant among the treatments showed that T_2 (0.21 L – 2.07 L) had the highest number 7, followed by T_3 (0.36 L – 2.22 L) 5.2, T_4 (0.50 L – 2.37 L) 5 and finally T_1 (0.05 L- 0.27 L) 4.5 respectively. The statistical results of these numbers of clusters per plant were significant (Table 7).

Table 7 Number of clusters per plant of *Solanum lycopersicum L.* responsed to different water treatments

Water treatments	Number of clusters plant^{-1}
T_1 (0.05 L- 0.27 L)	4.5
T_2 (0.21 L – 2.07 L)	7
T_3 (0.36 L – 2.22 L)	5.2
T_4 (0.50 L – 2.37 L)	5
F test	*
CV%	2.0
5%LSD	0.70

Number of fruits per cluster

The fruits per cluster of tomato plant had the highest 6.9 T_2 (0.21 L – 2.07 L) followed by 5.4 (T_3 0.36 L– 2.22 L), 5 T_4 (0.50 L – 2.37 L) and 3.5 T_1 (0.05 L- 0.27 L) respectively. According to the statistical analysis showed that all data were significant (Table 8).

Table 8 Number of fruits per cluster of *Solanum lycopersicum L.* responsed to different water treatments

Water treatments	Number of fruits cluster^{-1}
T_1 (0.05 L- 0.27 L)	3.5
T_2 (0.21 L – 2.07 L)	6.9
T_3 (0.36 L – 2.22 L)	5.4
T_4 (0.50 L – 2.37 L)	5
F test	*
CV%	2.5
5%LSD	0.20

Single fruit diameter and Fruits weight per plant

The results of the single fruit diameter response to different watering levels on growth stages showed that largest single fruit diameter had T_2 (0.21 L – 2.07 L) 5.01cm, followed by T_3 (0.36 L – 2.22 L) 4.56 cm and then T_1 (0.05 L- 0.27 L) 4.21 cm. The least diameter was T_4 (0.50 L – 2.37 L) 4.10 cm. According to statistical analysis, all recorded data of single fruit diameter were significant (Table 9 and Figure 3).

The result of the fruits weight per plant among treatment observed that T_2 (0.21 L – 2.07 L) had the largest weight 282.10 g, followed by T_3 (0.36 L – 2.22 L) 213.3 g, then T_4 (0.50 L – 2.37 L) 203.6 g and the least weight was 151.40 g in T_1 (0.05 L- 0.27 L) respectively. According to the statistical analysis, four treatments were significant (Table 9 and Figure 3).

Table 9 Single fruit diameter per plant and Fruits weight per plant of *Solanum lycopersicum L.* responsed to different water treatments

Water treatments	Single fruit diameter	Fruits weight plant^{-1} (g)
T_1 (0.05 L- 0.27 L)	4.21	151.40
T_2 (0.21 L – 2.07 L)	5.01	282.10
T_3 (0.36 L – 2.22 L)	4.56	213.3
T_4 (0.50 L – 2.37 L)	4.10	203.6
F test	*	*
CV%	3.6	14.70
5%LSD	0.28	3.22

Fruits yield

The fruits yield of T_2 (0.21 L – 2.07 L) had the highest 4798.74 kg ha^{-1} and T_3 (0.36 L – 2.22 L) 3628.40 kg ha^{-1}, followed by T_4 (0.50 L – 2.37 L) 3463.40 kg ha^{-1} and then, T_1 (0.05 L- 0.27 L) 2575.43 kg ha^{-1} respectively. The statistical analysis showed that the four treatments were significant (Table 10)

The summarized results of reproductive growth stated the effects of different watering levels on growth stages that the earliest first flowering days 36 DAT, the maximum number of cluster per plant 7, the highest number of fruits per cluster 6.9, the largest single fruit diameter 5.01 cm, the biggest fruits weight per plant 282.10 g and the fruits yield 4798.74 kg ha^{-1} respectively were observed in T_2 (0.21 L – 2.07 L) (Table 11 and Figure 3).

Table 10 Fruits yield of *Solanum lycopersicum* L. responsed to different water treatments

Water treatments	Fruits yield (kg ha^{-1})
T_1 (0.05 L- 0.27 L)	2575.43
T_2 (0.21 L – 2.07 L)	4798.74
T_3 (0.36 L – 2.22 L)	3628.40
T_4 (0.50 L – 2.37 L)	3463.40
F test	*
CV%	0.46
5%LSD	11.7

Table 11 Summarized data of reproductive growth of *Solanum lycopersicum* L. responsed to different water treatments

Treatments	First flowering days (DAT)	Number of clusters plant^{-1}	Number of fruits cluster^{-1}	Single fruit diameter (cm)	Fruits weight per plant (g)	Fruits yield (kg ha^{-1})
T_1 (0.05 L- 0.27 L)	40	4.5	3.5	4.21	151.40	2575.43
T_2 (0.21 L – 2.07 L)	36	7	6.9	5.01	282.10	4798.74
T_3 (0.36 L – 2.22 L)	39	5.2	5.4	4.56	213.3	3628.40
T_4 (0.50 L – 2.37 L)	39	5	5.0	4.10	203.6	3463.40
F test	*	*	*	*	*	
CV %	0.36	2.0	2.5	3.6	14.70	
5 % LSD	1.6	0.70	0.20	0.28	3.22	

(a) Flower with tomato plant (b) Single fruit diameter (c) Fruits weight per plant

Figure 3 Reproductive growth of *Solanum lycopersicum* L.

Table 12 Evaluation on different water treatments and yield in the experiment

Treatments	Growth stages water treatment (Liter)			Total amount of water	Total amount of water per hectare	Fruits yield per plant (g)	Fruits Yield (kg ha^{-1})
	Vegetative stage	Early developmental stage	Late developmental stage				
	1-4 WAT	5-7 WAT	8-10 WAT				
T_1 (0.05 L- 0.27	2.52	4.13	5.67	12.32	1746.44	151.4	2575.4
T_2 (0.21 L – 2.07	11.62	28.14	43.47	83.23	11798.4	282.1	4798.7
T_3 (0.36 L – 2.22	15.75	31.29	46.62	93.66	13276.9	213.3	3628.4
T_4 (0.50 L – 2.37	19.88	34.37	49.77	104.02	14745.5	203.6	3463.4

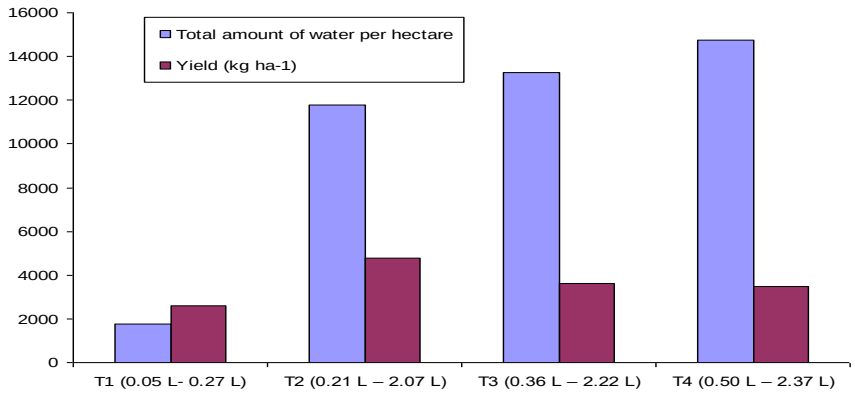

Figure 3 Evaluation of water requirements and yield

Discussion and Conclusion

This research was conducted during April-July, 2019 at Oakshitpin Village, Padaung Township, Bago Region. The growing of *Solanum lycopersicum* L. (kyar chay) using different watering levels on plant growth stages was studied. Properties of the soil prior to experimentation are shown in Table (1). The soil was sandy loam in texture, low in N %, and high in exchangeable K, very high in available P exchangeable Ca and the exchangeable K and high in available nutrients K_2O. The present investigation used NPK fertilizer (15-15-15) for the increasing yield of tomato. Edossa *et al*. (2013) reported that it is well documented that application of N promotes vegetative growth and fruit yield of tomato, and later application in the growing stages favors fruit development. Similarly, application of phosphorus is an important nutrient for tomato plant growth and development, a deficiency of P leads to reduced growth and reduced yields. Tomatoes have the greatest demand for phosphorus at the early stages of development. According to climatic data at experiments site, temperature data was 28-33°C during vegetative growth, 26-33°C during reproductive growth and average temperature 29.05°C, total rainfall 556 mm and mean humidity 62.59, in the whole growing season (Table 3). Yu Yu Tun and Aung Phyo (2019) observed that in Myanmar, while lowland tomatoes can be easily produced in the winter, yields are much lower in the summer and in the rainy season. Relatively cool temperatures and drier conditions in Southern Shan State are very favorable for tomato production throughout the year. In Southern Shan State, highland tomatoes are mainly grown on and around Inle Lake. The main production areas for lowland tomatoes are Pyinmana (Nay Pyi Taw Region), Magway Region (several areas), Monywa (Sagaing Region), Dike Oo and Binnar (Bago East Region) and Watpoke (Bago West Region). Harel *et al*. (2014) mentioned that the relationship between mean daily temperatures and the reproductive stage of tomato plants, found that at daily mean temperatures of 29°C, fruit number, and percentage fruit set and fruit weight per plant decreases in comparison with those at 25°C. Optimum relative humidity in glasshouse crops range from 60-80%. In this research paper, the seedlings transplanted into the field cultivation (polyethylene bags) during 5-7 cm and 2-3 leaves (5 WAS, weeks after sowing). Then these transplanted plants were watered on different rates at one week after transplanting. Shankara *et al*. (2005) reported that the seedlings transplant to the field 3 to 6 weeks after sowing. A week before transplanting, seedlings should be hardened by reducing the application of water, but 12-14 hours before they are taken out of the seedbed they should be thoroughly watered again to avoid excessive damage to the roots. Seedlings of 15-25 cm tall with 3-5 true leaves are most suitable for transplanting. In this experiment, germination and early growth with initial leaves (35 DAS), vegetative stage (28 days, 1-4 WAT), early developmental stage (21 days, 5-7 WAT) and late developmental stage (21 days, 8-10 WAT) were observed. Shamshiri *et al*. (2018) revealed that the five growth stages of tomato as germination and early growth with initial leaves (between 25 and 35 days), vegetative period (20 to 25 days), and flowering (20 to 30 days), early fruiting (20 to 30 days), and mature fruiting (15 to 20 days). In this paper, tomato-vegetative growth as petiole length was the best results in T_3 (0.36 L – 2.22 L) and leaf width, T_4 (0.50 L – 2.37 L). Moreover, plant height, number of leaves per plant, single leaf length and leaf area investigated in T_2 (0.21 L – 2.07 L) (Table 5). This research paper investigated that the differences among the treatments on days to first flowering from transplanting, number of clusters plant^{-1}, and number of fruits cluster^{-1}, single fruit diameter, single fruit weight, and fruits weight plant^{-1} and fruits yield was significant. T_2 (0.21 L – 2.07 L) was the best number of cluster, The highest number of fruits per cluster, the biggest single fruit diameter, the largest fruits weight per plant and the best fruits yield (Table 11). Tomato is grown in the plastic house during rainy season. T_2 (0.21 L – 2.07 L) was the more resultant yield than other treatments. Shova *et al*. (2018) reported that deficient watering may require for tomato crop production in rainy season in this experiment. The low cost plastic tunnels can be used to protect the crops from excessive rainfall and provide the favorable environment for the production of better quality crops over the period of time. This paper observed that the water requirements of vegetative stage

(28 days, 1-4 WAT) was T_1 (0.05 L- 0.27 L) 2.52 L, T_2 (0.21 L – 2.07 L) 11.62 L, T_3 (0.36 L – 2.22 L) 15.75 L and T_4 (0.50 L – 2.37 L) 19.88 L. The water requirements of early developmental stage supplied T_1 (0.05 L- 0.27 L) 4.13 L, T_2 (0.21 L – 2.07 L) 28.14 L, T_3 (0.36 L – 2.22 L) 93.66 L and T_4 (0.50 L – 2.37 L) 34.37 L. The water requirements of late developmental stage supplied T_1 (0.05 L- 0.27 L) 5.67 L, T_2 (0.21 L – 2.07 L) 43.47 L, T_3 (0.36 L – 2.22 L) 46.62 L and T_4 (0.50 L – 2.37 L) 49.77 L. Total water requirements growing on tomato was T_1 (0.05 L- 0.27 L) 12.32 L (1746.44 L ha^{-1}), T_2 (0.21 L – 2.07 L) 83.23 L (11798.40 L ha^{-1}), T_3 (0.36 L – 2.22 L) 83.66 L (13276.92 L ha^{-1}) and T_4 (0.50 L – 2.37 L) 104.02 L (14745.51 L ha^{-1}). Then Tomato yield investigated that T_1 (0.05 L- 0.27 L) was 2575.43 kg ha^{-1}, T_2 (0.21 L – 2.07 L) 4798.74 kg ha^{-1}, T3 (0.36 L – 2.22 L) 3628.40 kg ha^{-1} and T_4 (0.50 L – 2.37 L) 3463.40 kg ha^{-1}. T_2 (0.21 L – 2.07 L) among them was the best yield. These results studied that T_1 (0.05 L- 0.27 L) using local farmer watering was the lowest yield and T_2 (0.21 L – 2.07 L), the best yield (Table 12). The volume of water requirement is length x breadth x height. The volume of 1 m^3 converts 1000 liters. The volume of water 1 mm converts to 0.001 m^3 (or) 1liter (https:// www. Mackillopgroup. com.au/wp-content/uploads/ 2019/03/Irrigation-Glove-Box- Guides.pdf). Yang *et al*. (2017) revealed that the whole growing season was divided into three stages:, the watering applied 3.567 mm (3.567 L) in stage one, vegetative stage, 11.195 mm (11.195 L) in stage two, and 6.139 mm (6.139 L) stage three, flowering and fruit development stage with interval three days (except rainy day) and the whole season 25.501 mm (25.501 L). Moreover, the maximum fruit per plant was 1056.0 g $plant^{-1}$. Water requirements of tomato plant are 10,000 m^3 ha^{-1} (10,000 L ha^{-1}) in greenhouses. Tomato plants are fairly resistant to moderate drought. However, proper management is essential to assure high yield and quality. Water requirements will differ at various growth stages. The requirement increases from germination until beginning of fruit setting, reaching a peak during fruit development and then decreasing during ripening (https://www.haifa roup.com/files/Guides/ tomato/ Tomato.pdf). These results show clearly that the crop water requirement varies from region to region. The results indicated that daily irrigated treatments resulted in better crop growth characteristics and the best yield. The maximum watering treatment gave the highest yield while the minimum treatments gave the least. Tomato yield varied from 4.44 kg m^{-2} (44400.00 kg ha^{-1}) to 3.26 kg m^{-2} (32599.10 kg ha^{-1}) for daily irrigated treatments (Luvai *et al*., 2014). In this paper, tomato grew inside the plastic tunnel (L 840 cm x W 300 cm x H 259 cm) because this plant grew during offseason (rainy season). Tomato production during rainy season in open field condition is very difficult mainly due to serious disease attack. Rainy season tomato production under low cost plastic shelter by avoiding direct contact of rain with tomato foliage avoids favorable condition for disease development. This practice is therefore helpful to produce tomatoes without the use of fungicides contributing towards ensuring continuous production and constant supply of fresh tomatoes throughout the year. Furthermore by improving the microclimatic condition such as raising the temperature under the shelter, favorable environment for the production of high tomato yield with superior quality will be created (Getahun, 2019). It can be concluded that tomato production inside the plastic house during rainy season has become very profitable where there is market access. Adoption of plastic house technology can improve yield and productivity of tomato crop in off season cultivation. Since tomato is very expensive during rainy season, farmers could fetch good price besides its high initial investment cost. For that reason the farmer can know and get the appropriate amount of water during offseason (rainy season) and extend this method to the other growers for dissemination for boosting the national economy.

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