Comparative study between laser beam transmitter, canopy temperature and soil moisture content under automate drip irrigation for cucumber in greenhouse

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Abstract: Automate drip irrigation in greenhouse was conducted at Elhssen Agriculture Authriuts, Giza governorate, Egypt. The aim of this research was to determine the sensible technique suitable for operate the automate drip irrigation system in greenhouse. Three instruments were used, 1) laser beam transmit (LBT) build in laser leaf control unit (LLCU); 2) infrared thermometer (IRT) used to measure canopy temperature around plant leaf (Tc) and air temperature (Ta) to estimate the different temperature between the canopy temperature and the air temperature different temperature (dt) °C; 3) soil moisture meter (SMM) to measure soil moisture content (SMC). The result exhibited that there is a relationship between the LBT, dt and SMC, The values of LBT ranged from 65 to 90 mV, while the values of dt ranged from -2.5°C to 4.3°C, with the values of SMC ranged from 12% to 16%.

Keywords: LASER, sensor, water, leaves, automate, irrigation, wavelength, cucumber

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1 Introduction

Using high technology of Laser with Automate drip irrigation. The leaser control unit (LCU) depends on leaf plant content and leaf plant stress. The high frequency of automate drip irrigation will often maintain in low soil moisture suction (high moisture contents) in a portion of the effective root zone. Mansour et al. (2015) reported that the frequency of automation control drip irrigation system involves that the infiltration process prevails, relative to other irrigation systems, over the soil water extra lines phase of the irrigation system. Purnima et al. (2012) mentioned that in past few years, automatic irrigation system has seen a rapid growth in terms of technology. At present cost-saving technology, labor-saving are the addressing key issues in irrigation. Luciana et al. (2013) stated that in the field of agriculture temperature sensor and moisture sensor are used to measure the soil and weather conditions of the field. The temperature and moisture values from the sensors are sensed to the microcontroller and thus the current temperature and moisture are compared with predefined values. According to the temperature and moisture values, required amount of water is supplied to the crops. Mahendra and Bharathy (2013) reviewed that the greenhouse based modern agriculture industries is the recent requirement in every part of agriculture. In this technology, the humidity and temperature of plants are precisely controlled. Due to the variable atmospheric circumstances these conditions sometimes may vary from place to place in large farmhouse, which makes very difficult to maintain the uniformity at all the places in the farmhouse manually. Therefore there is an intense need to

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develop such microcontroller based embedded system, which could maintain the physical parameters uniform and also could keep the records for analytical studies. They present in this paper, to the best of our knowledge for the first time an auto-control network for agriculture industry, which could give the facilities of maintaining uniform environmental conditions. Dag et al. (2015) studied the use of thermal remote sensing to detect irrigation-system malfunctions in olive orchards and table grape vineyards. The accuracy of leak detection by thermal remote sensing was 75%-90% and the reliability values of leak and clog detection were 90% and 70%, respectively. Thermal remote sensing seems to be a useful tool for detecting drip irrigation malfunctions, thereby enhancing water-use efficiency and saving on labor. Saito (2005) studied that developed three different the LASER- induced fluorescence (LIF) measurement systems according to applications. The basic configuration of LIF system consists of a laser, a spectroscopic device, a detector and a personal computer (PC). Saito et al. (2006) stated that broad LIF spectrum 400 to 800 nm gave information about pigments inside the leaves. Plant leaves can emit fluorescence in response to laser irradiation which is called LIF. The LIF spectrum varies its shape depending on molecule species and concentration containing in the leaves. Therefore, LIF will be a good indicator to monitor plant status. LIF spectrum of a poplar’s green leaf representative LIF spectrum with two peaks at 685 and 740 nm and small ones at 460 and 530 nm are observed. Hartz (1999) novel device was shown by long- and short-term measurements. The changes in leaf water content during drought stress induced dehydration as well as during the course of rapid re-hydration after re-watering vividly highlight the tremendous potential of this novel technique and its high reliability. The findings presented here provide the basis for THz-based in vivo determination of changes in the leaf water content under field conditions. Created the relationship between the optical properties and moisture content of the leaf using light emanation diode (LED)’s in infrared region between 1300 to 1500 nm since this range of wavelength falls in the water absorption band. Percentage moisture content; at every stage of drying of the leaves and their transmittance and reflectance properties were analyzed. The conclusions presented could lead to the development of portable instruments for leaf water content estimation and other biological parameters rapidly and non-destructively. Schuerger et al. (2003) summarized that healthy and stressed plants were measured with two hyperspectral imagers, laser-induced fluorescence spectroscopy (LIFS), and laser-induced fluorescence imaging (LIFI) systems in order to determine if the four handheld remote sensing instruments were equally capable of detecting plant stress and measuring canopy chlorophyll levels in bahia grass. However unique capabilities of “LIFS” and “LIFI” instruments continue to argue for the development of laser-induced fluorescence remote sensing technologies. Mobasheri and Fatemi (2013) investigated the relationship between leaf equivalent water thickness (EWT) and reflectance in wavelength. The results showed that band combinations such as ratio and normalized difference had higher regressions with leaf water content. In addition, the findings of this study showed that some parts of the near infrared (NIR) and short wave infrared (SWIR) of the spectrum provided higher accuracies in EWT assessment and correlations of more than 90% were achieved. The design of embedded system for the automation of drip irrigation consists of a microcontroller. The system gives the real time for feedback control and monitoring and controlling all the activities of drip irrigation system. Irrigation system controls valves by using automated controller to turn ON & OFF. This allows the farmer to apply the right amount of water at the right time, regardless of the availability of the labor to turn valves. It improves crop performance and help in time saving in all aspects (Prathyusha and Suman, 2012). Hade and Sengupta (2014) reviewed different monitoring systems and proposed an automatic monitoring system model using wireless sensor network (WSN) which helps the farmer to improve the yield.

The objective of this study is to determine the best ways to control the amount of water irrigation and the time of irrigation.

2 Material and methods

Experiments were carried out in greenhouse under automated drip irrigation system for cucumber crop in

Elhssen Agriculture Authriuts, Giza governorate, Egypt at 2014 to 2015 seasons to compare and evaluate the performance of three instruments to determine the optimum irrigation time.

The designed device (Figure 1) was laser leaf control unit (LLCU), has a cylindrical shape (1), made from polyethylene (PE), with 90 mm length, and 60 mm diameter. It had a horizontal hole with diameter of 10 mm. A part with 69, 20 and 60 mm length width and depth was deducted longitudinally from cylinder body along vertical axis (2). Two horizontal tubes were passing through in cylinder body holes (3), with diameter of 10 mm. Laser source (green light) was fixed inside one of them, and photodiode sensor was fixed inside the other. Diode laser was used in the present work as light source. Laser source for 532 nm was recommended as stable to absorption and transmittance for plant leaf, more over it was safe for use in this case. On the other hand, the distance between laser source and photodiode sensor was adjustable as a plant leaf thickness; so, reflection of laser beam will be neglected.

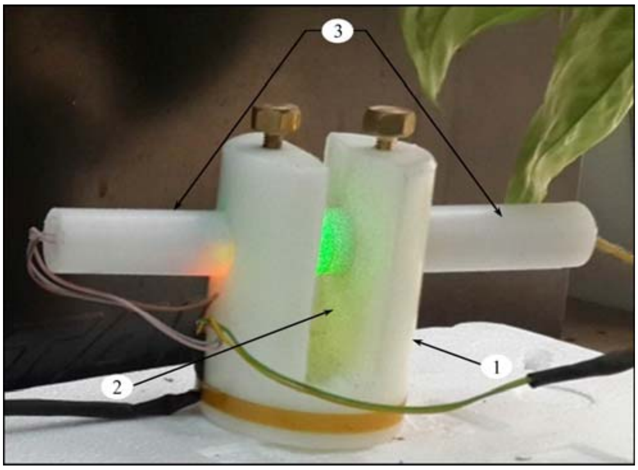

Figure 1 Laser leaf control unit "LLCU"

Infrared thermometer (IRT), with laser pointer model 42535A was used for measuring the canopy temperature around plant leaf. The IRT ranged from –20ºC to 400ºC ± 3ºC. Accuracy specified for ambient temperature (23ºC ± 5ºC).

Soil moisture meter was used to measure soil moisture content under plant before and after irrigation. Measurement range of 0% to 50% moisture content on soil and has accuracy of ± (5%+5 d) F.S. @ 23±5º, F.S.: full scale.

2.1 Greenhouse

Arc shape, polyethylene–greenhouse models, and fully covered were constructed, and oriented to face east-west direction. These models were made of iron galvanized pipes of 25 mm diameter. The ventilation system was a natural. A single layer of transparent polyethylene was treated against ultraviolet radiation effect (200 µm, thickness, and 0.96 g cm^{-3}, density).

2.2 Soil

In experiments the sandy soil was used. It has coarse sand about 55.9%, fine sand about 37.9% and silt + clay about 6.2%.

2.3 Plants

Cucumber (*Cucumis sativus*) sunhems-variety which product after 40 days under green house. Cucumber seedlings were transplanted when the second true leaf stage was into treatment location.

2.4 Experimental procedures

Three instruments were used; 1) laser beam transmit (LBT) build in LLCU; 2) IRT used to measure canopy temperature around plant leaf and air temperature to estimate the difference between the canopy temperature and air temperature (dt); 3) soil moisture meter (SMM) to measure soil moisture content (SMC). Data were measured for six days in the week. Just after two hours from irrigation daily and each two hours for LBT and four hours for dt and SMC.

2.5 Measurements

2.5.1 Photovoltaic

According to the conservation law of energy equations as seen below, the absorption, transmission and reflection laser beam in vegetable leaves through plant developments were calculated according to Ahn and Moore (1992)

$$I = T + A + R \tag{1}$$

where, I is the incident beam, mV; T is laser beam transmitted (LBT), mV; A is absorbance, mV; R is reflectance, mV.

2.5.2 Leaf water contents (LWC)

To calculate leaf water content W^i, Equation (3) according to Gente et al. (2013) was used:

$$W\ i = \frac{W_i - W_{dry}}{W_i} \times 100 \tag{2}$$

where, W^i: is average of the gravimetric water content for ten at each plant step; W_i: is the moist weight measured at each step; W_{dry}: is the dry weight measured at each step.

2.5.3 IRT measurements

To estimate the different between the canopy temperature and air temperature (*dt*) according to Lobo et al. (2004)

$$dt = (Tc - Ta) \quad (3)$$

where, *dt* = different between *Tc* and *Ta*, ºC; *Tc* = canopy temperature measurement by IRT, ºC, and *Ta* = air temperature, ºC.

2.6 Statistical analysis

The experiment was conducted as a factorial experiment in randomized complex blocky design (RCBD), having two vegetable plant (cucumber and squash), and three field capacity (100%, 85% and 70%). Results were analyzed by analysis of variation, a statistical method (ANOVA) using STATISTIX 8 Analytical Software (2010).

3 Result and discussion

The data in Figures (2, 3 and 4) presented the LBT, dt and SMC with time for cucumber. From these figures it was clear that LBT gradually increased with time after irrigation. Dealing with time during day after irrigation the increase of LBT was about 1: 5 mV every 2 hours. It was clear that the highest value of LBT appeared just before irrigation at 12 pm for the same day reaching 90 mV. Meanwhile the lowest value of LBT, 65 mV was recorded after 2 hours from irrigation at 2 pm. This is mainly due to the evaporation of water from the leaves indicating that the leaves water content decreased with

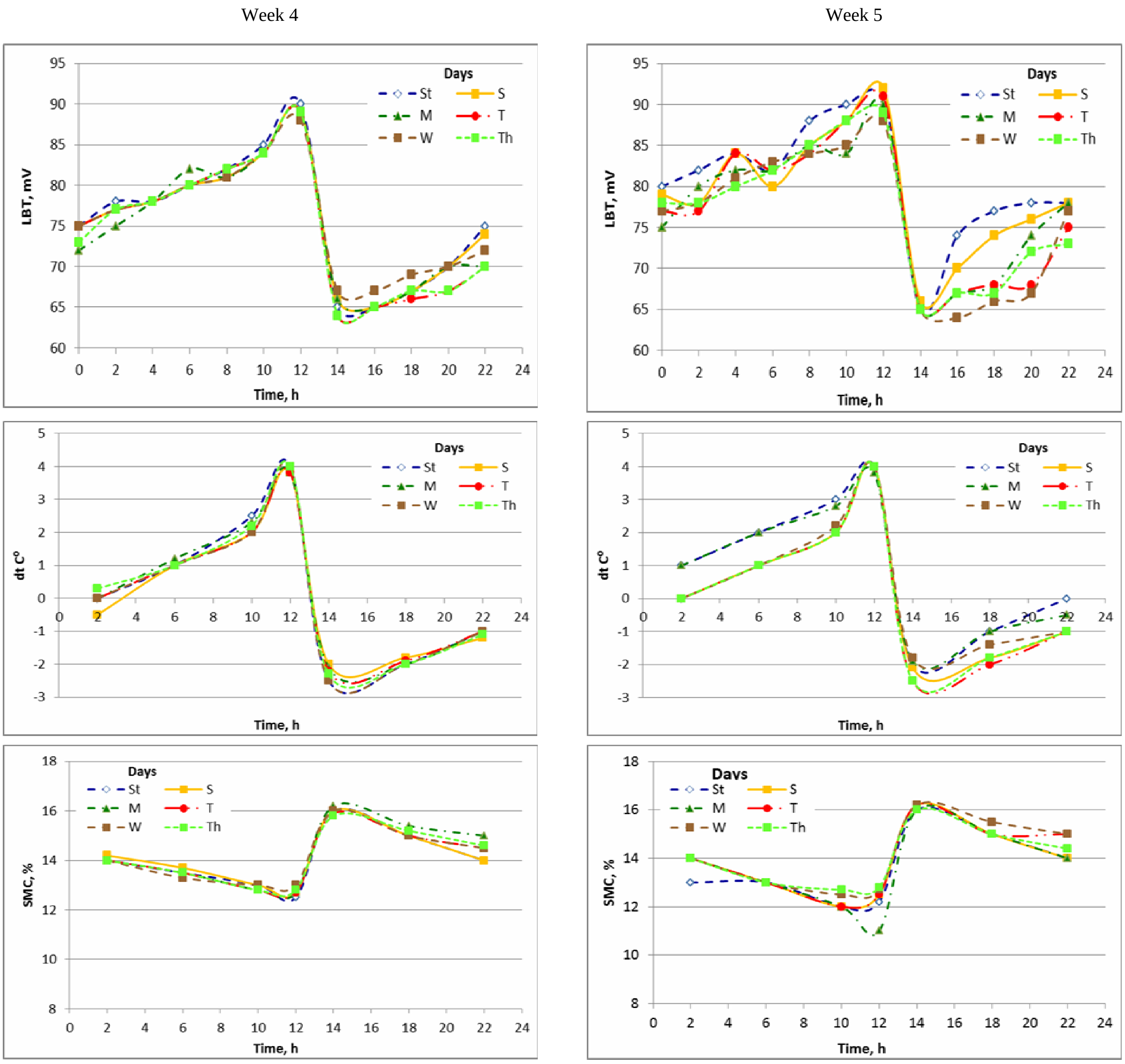

Figure 2 Comparative study of (LBT), different temperature (dt) and (SMC) for weeks 4th and 5th for cucumber plants under greenhouses. (St, S, M, T, W, Th) are the days of the week.

time after irrigation. Dealing with the days through the 4th week the recorded the LBT values after two hours from the irrigation were, were 65, 66, 66, 64, 67 and 64 mV for Sat, Sun, Mon, Tue, Wed and Thu respectively. While the LBT just before two hours from irrigation were 90, 89, 89, 89, 89 and 88 mV for Sat, Sun, Mon, Tue, Wed and Thu days respectively. It was clear from the figure that the curves representing the relationship between LBT and time during the days after and before irrigation took almost the same trend. However there are small differences in the LBT value ranging from 1: 3 mV in the same time of the days. This indicated that the laser beam had high absorption rate in water, so the laser beam transmitted from the leaves of plants depended on the leaves water content.

The values of SMC gradually decreased with time from 16.7% to 15%, 14.2%, 14%, 13.7%, 13% and 12.7% two hours after irrigation, and once every 4 hours, respectively, during the 24 hours a day.

The values of dt in week 6th took the same trend; meanwhile the values of dt increased for ±1ºC From the data recorded and the figures it can be concluded that there were relationship between LBT, dt and SMC meanwhile the values of LBT and dt increased with time after irrigation while the values of SMC decreased with time after irrigation.

Finally it can be concluded that, the values of LBT 65 mV represented of dt −2.5°C and SMC 16%. Meanwhile the value of LBT 90 mV represented of dt 4°C and SMC 12.7%.

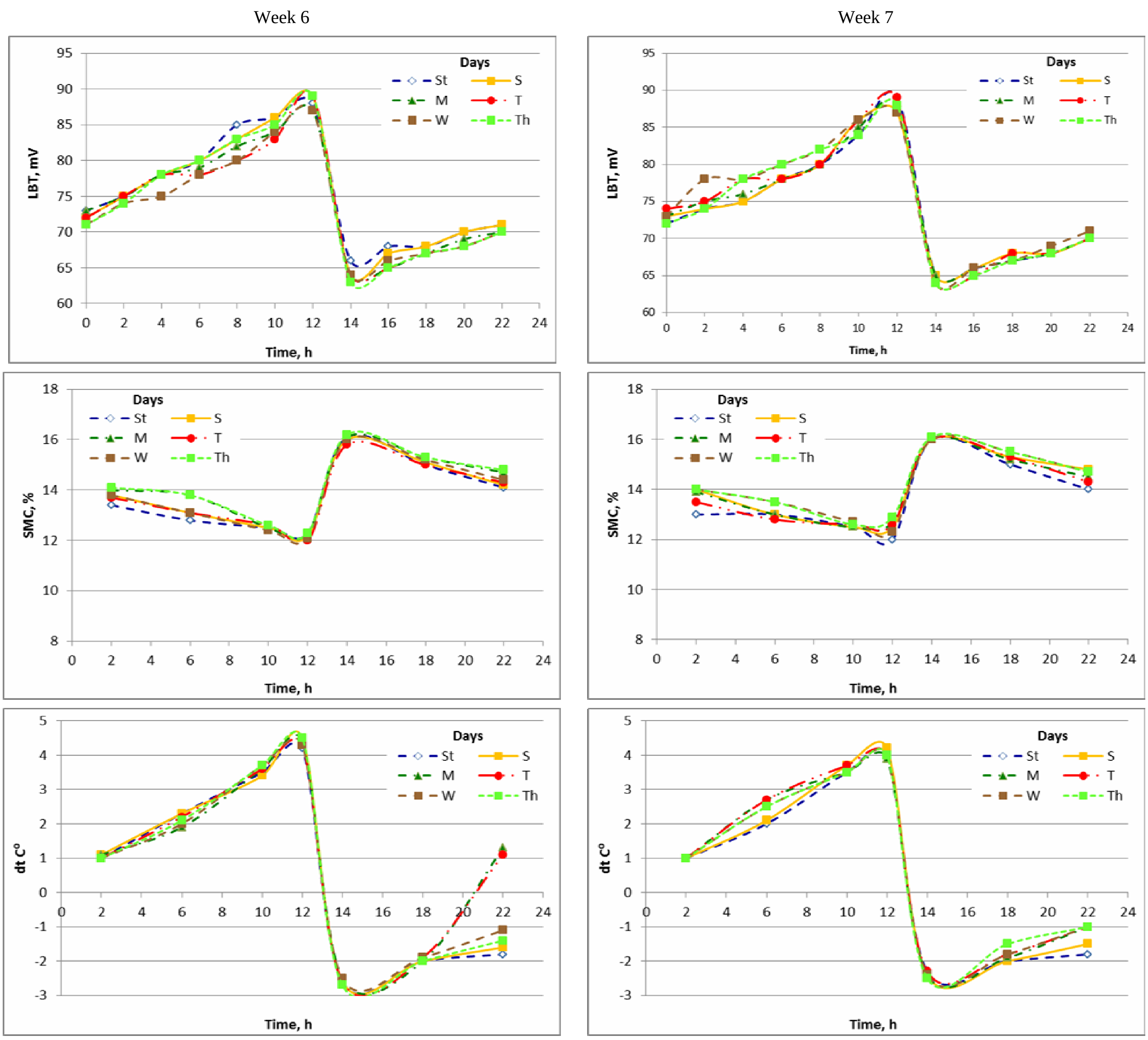

Figure 3 Comparative study of (LBT), different temperature (dt) and (SMC) for weeks 6th and 7th for cucumber plants under greenhouses. (St, S, M, T, W, Th) are the days of the week.

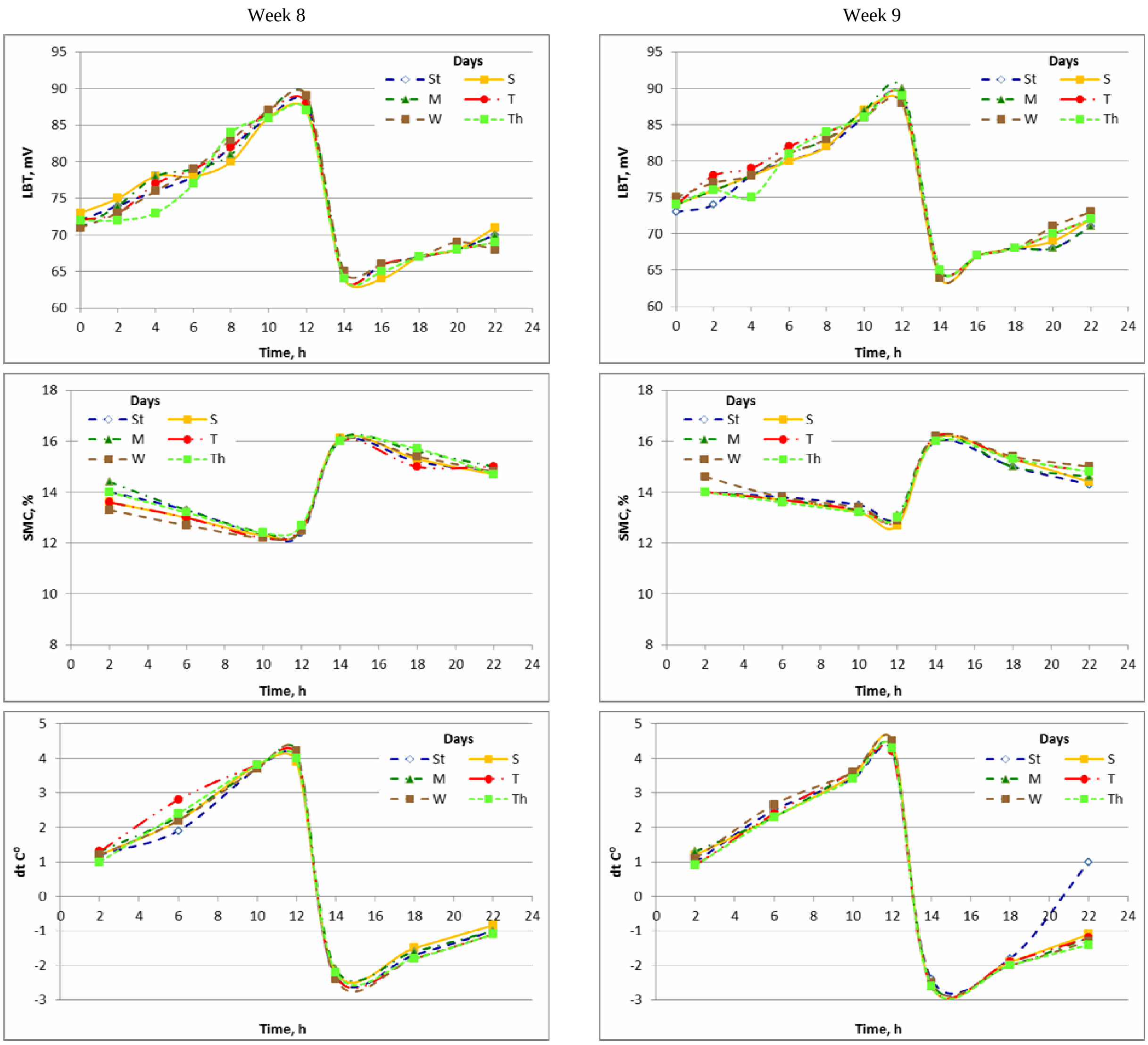

Figure 4 Comparative study of (LBT), different temperature (dt) and (SMC) for weeks 8th and 9th for cucumber plants under greenhouses. (St, S, M, T, W, Th) are the days of the week.

4 Conclusion

LLCU is designed depending on optical properties of laser beam transmittance through plant leaf, to estimate plant leaf water content. The results obtained from lab, experiment show that, leaf water content values have an important impact in SMC, and have high correlation with LBT and SMC, deducting high correlation between LBT and SMC. So LLCU has the ability to predict the LWC which used to estimate the SMC. Finally the LLCU can be used for operate the automat drip irrigation system, through knowing the SMC values or best time to start irrigation.

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