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Application of Automatic Timer for Irrigation System in *Dioscorea hispida* Dennst. Propagation

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Abstract This paper will discuss on the irrigation system that will be applied for Dioscorea hispida Dennst. species. The methodology part will be explained with the image of automatic timer and pump, that will be used according to the proper manner. The automatic timer will be attached to the power supply, while the pump will be controlled by timer according to the time which had been setup as, 1) once every day (T1); 2) once every three days (T2); 3) once every four days (T3); 4) once every five days (T4). The control treatment for the frequency of water supply is 5) once every two days (C). The data for the volume of water to be applied in this experiment were referred to the local climatological information and calculated by the formula which will be discussed further in the materials and methods section.

Keywords Automatic Timer, Irrigation System, *Dioscorea Hispida* Dennst

1. Introduction

Water is one of the natural resources and it is the main factor of plant development and root system development. Experimental irrigation of tree plantations has shown that growth can be increased with proper irrigation[1]. Global decline in fresh water resources did not only cause development of irrigation technologies, but also innovated the water-saving irrigation strategies that save a substantial amount of water compared to traditional irrigation that is now believed as a luxury use of water[2]. Therefore, irrigation technologies are very important for cultivation of commercial plant because the relative amount of water available to agriculture is declining worldwide, due to the rapid population growth and the greater incidence of drought in recent years as caused by climate change and different human activities. Lately, the agricultural field is being im-proved worldwide and the water usage increase every year. Continued successful management of the limited amount of water available for agricultural usage depends upon better agronomic practices and enhanced understandings of water productivity, defined as the crop productivity output per unit of water consumed[3]. There are two main methods developed to schedule irrigation: 1) by replacing crop evapotranspiration (ETC) fractions according to a soil-water balance, or (2) by triggering irrigation according to water content status of the soil and allowable depletion levels. But both of these methods had been less effective; for the first method it requires local crop coefficients, and these vary according to crop varieties, plant densities, row configurations and planting dates; and the second method will be affected by the sensor reading and highly dependent on types of soil, climate, plant root zone depth, soil salinity and soil temperature[4]. Previous work[5] also stated that weather broadcast can be an indicator to schedule irrigation frequency due to the lack of crop (potato) evapotranspiration. Therefore, the schedule of irrigation that is based on rainfall data is easier to control because the data is available from the World Meteorology Organization website such as for Kuala Terengganu area. This is also because, according to[6], randomly *Dioscorea* sp. is well adapted to most tropical climates with temperatures of 30–34 ^{o}C and annual rainfall of 1500 mm. While, the *Dioscorea hispida* species is known to be well adapted to the local climate of Kuala Terengganu; which has the annual average precipitation (rainfall) of 2709 mm/year[7] and average number of rainy days in a year is approximately 132 days[8].

Irrigation frequency is one of the most important factors in drip irrigation scheduling. Due to the differences in soil moisture and wetting pattern, crop yields may be different when the same quantity of water is applied under different irrigation frequencies. Typically, the higher the irrigation frequency the smaller the wetted soil volume and the higher mean soil water content can be maintained in the wetted soil volume during a period when the total irrigation water is equal. High irrigation frequency might provide desirable conditions for water movement in soil and for uptake by roots[5]. The objective of this research will be to determine the effect of irrigation on growth parameters and also the concentration of toxic compound within *D. hispida*. This research is important because *Dioscorea* sp. is the third most

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important tropical root and tuber crop after cassava and sweet potato[9].

2. Objectives

The objectives of this study are:

1) To measure aerial agro-morphological parameters
2) To measure underground agronomic parameters
3) To determine the colour of tubers according with irrigation treatments
4) To determine the quantity of phytochemicals
5) To observe the relationships between tuber's colour and phytochemicals

3. Literature Review

Dioscorea hispida is one of the *Dioscorea* (Yam) species, and it belongs to the family Dioscoreaceae within the genus *Dioscorea*[9]. It has botanical characteristics of a climbing plant with glabrous leaves and twining stems, which helix readily around other trees, and is classified as a wild creeping and climbing plant which can grow up to 20 meters in height[10]. The majority of species of the genus *Dioscorea* are perennial herbaceous climbers, that form rhizomes and tubers as storage organs and are distributed in tropical regions of Africa, America and Asia. The leaves and stems of *Dioscorea dregeana* are shown to have antibacterial properties[11]. These tubers are found to be rich in essential dietary nutrients[12]. World's estimated yam production in 2003 was 39 643 170 tonnes[13]. Malaysia does not yet becomes yam crop producers, although the yams are very much in demand in the world.

Many wild *Dioscorea* sp., especially from tropical areas, are a very important source of secondary metabolites, and used in pharmaceutical industry and medicine[14]. However, certain tubers of wild yams like *D. hispida* are known to be toxic to mammals. Behavioural studies have shown that the toxic components cause dizziness, nausea, vomiting, and later sleepiness in humans. Toxic components of this plant exhibit insecticidal and anti-feedant activities in various species of insects. Several toxic components were isolated from this plant and one of them was identified as dioscorine [1R-(1a,4a,5a)]-2,48-dimethyl-spiro-[2-azabicyclo(2.2.2)octane-5,28-(2H)-pyran]-68-(38H)-one (8–10)[15].

Although toxic, Malay community and Aborigines have found ways to lose the poison. *Gadong* tubers will be soaked in flowing water, dioscorine content in it will be dissolved by water gradually, then this tuber will be free from dioscorine. For that purpose, maybe irrigation also can be the way to decrease the toxic level in *D. hispida* either through proper irrigation system or rainfall. Although their watering activity has not been investigated yet but randomly, *D. hispida* is known to adapt at Kuala Terengganu area which has annual average rainfall of 2709 mm/years[7] and average number of rainy days of about 132 days in a year[8]. These climate data were based on monthly averages for the 30-year period of 1971-2000.

The toxic content may also has a relationship with the colour of tubers, but this has not been investigated yet. There are two kinds of colour which was reported by the local people of Terengganu state of Malaysia, which are yellow and white. Most of the villagers claimed that yellow flesh has better taste then the white flesh. This is because the yellow one tastes starchier. They also call the yellow tubers as *Gadung Pulut* and the white tubers as *Gadung Jemah*[16]. This discoloration phenomenon has long been studied in fresh yam tubers and has mainly been associated with enzymatic browning due to the action of polyphenoloxidase and the quantity of chemical content (dioscorine) will differ due to cultural and climatic factors under which yam is cultivated, its maturity stage at harvest and the method and duration of storage[17]. The colour of tubers is one characteristic of a plant's phenotype and it depends on both the genotype and the environmental effects[18].

4. Materials and Methods

4.1. Side Plant Lot

The work will take place at Universiti Sultan Zainal Abidin, Gong Badak Campus, Kuala Terengganu, Terengganu, Malaysia. The annual average precipitation (rainfall) in Kuala Terengganu is 2709 mm/years[7]. The experimental plot is designed with waterproof roof which covers approximately 19.67 m^2 area. The tubers weighed approximately 6-62 g and propagated until all tubers have active bud prior to experiment.

4.2. Experimental Design

A Randomized Complete Block Design (RCBD) with irrigation method treatments as main plots and irrigation frequency as random treatments within all blocks will be established. There are six trees for every block and the drip systems will be applied at each block. The irrigation will be supplied to individual trees with pipe connection and will be controlled by timer setup for each block. The irrigation timers will be setup for five conditions; in which once every two days is applied for control and there are four types of frequency treatments to be applied, 1) once every day (T1); 2) once every three days (T2); 3) once every four days (T3); 4) once every five days (T4), this schedule had been modified from experimental design of [5] and the control frequency had been estimated according to well grown *Dioscorea rotundata* Poir. by[13] in which the plants were watered once every two days. The dripper had a discharge rate of 2 L/h under an operation pressure of one atm. The rainfall data in Kuala Terengganu was obtained from World Meteorology[8] (Table 1). The amount of water per day was calculated from the average rainfall data available by using the following equation: DDIR = (RAW/FX) and Volume (kL) = depth (mm) × Area (m2) ÷ 1000[19]. Previous researchers[5] also stated that weather broadcast can be an indicator to schedule irrigation due to the lack of crop evapotranspiration. Each block will be separated at about two meters from each other and will be planted with three trees in each row for two rows in a block plot. The automatic timer that will be used is as shown in Figure 1[20]. While the automatic timer be attached to a water pump, and its function is to control the on and off of the pump, the pump will suck water and provide enough pressure to make sure all plants get similar volume of water. The image of this pump is as shown in Figure 2[21].

Table 1. The climatology information.

Month	Mean Temperature °C		Mean Total Rainfall (mm)	Mean Number of Rainy Days
	Daily Minimum	Daily Maximum		
Jan	22.8	29.3	79.9	8
Feb	22.9	30.2	53.9	5
Mar	23.3	31.3	117.9	6
Apr	24.0	32.6	89.9	6
May	24.4	32.9	103.8	8
Jun	24.0	32.6	114.0	9
Jul	23.7	32.2	157.8	11
Aug	23.6	32.0	171.2	13
Sep	23.4	31.7	189.9	14
Oct	23.5	31.2	256.4	15
Nov	23.4	29.6	690.3	20
Dec	23.3	28.9	580.1	17

*Climatological information is based on monthly averages for the 30-year period 1971-2000.
*Mean number of rainy days = Mean number of days with at least 1 mm of rain.

Figure 1. Automatic timer.

4.3. Shoot

This parameter will be measured from first day of planting until the day of harvesting. The height of the tree will also be recorded after nine months of growth before the trees are harvested.

4.4. Leaf

The number of leaf in different treatments will be observed when most of these trees already attained maximum growth in all trees. Five matured leaves will be taken per plant randomly and be measured at different stages of plant growth by using the Leaf Area Meter or graph paper.

The length will be multiplied with width and then multiplied the factor of graph paper. Total leaf area will be calculated by taking average leaf area and multiplying with the number of leaves.

Figure 2. Water Pump image and blueprint.

4.5. Stem

The data for the main stem thickness will be collected prior to harvest. This measurement will be carried out by using dial micrometer, by placing it on every main stem produced from tuber, expressed it in centimetres and calculated their averages. The number of main stems will be calculated by counting the stem produced from tuber- producing tree. Total stem thickness will be calculated by taking the average of main stem thickness then multiply it by the number of main stem produced by the tuber- producing tree.

4.6. Root

Number and length of roots which are produced from tuber-producing tree will be measured. Total root length took account of both the elongation and branching processes and helps visualize the root distribution spatial dimensions of root system components in tubers of *D. hispida*. Total root length (TRL) will then be calculated by using the following equation: $TRL = n_1 \times (L_1 + n_2 \times (L_2 + n_3 \times L_3))$, where n_x = number of roots of the xth order on the (x − 1)th branching order root, and L_x = length of xth order root[13].

4.7. Colour of Tuber

The colour of tubers for all trees will be evaluated by using Chromameter as provided by the Faculty of Agriculture and Biotechnology, UniSZA. The tubers of each plant will be further extracted for their dioscorine content.

4.8. Dioscorine Content

After the rhizome was peeled, they will be chopped into two portions. Each portion will be weighed at 50 g. They will be sliced. Each sample will be blended with 200 mL of 0.5 N HCl by using an electric blender. For HCl preparation, 42 mL of HCl will be dissolved with distilled water. The mixtures of sample will be placed into conical flask and covered with parafilm. They will be left at room temperature for two days. After that, the samples will be filtered by using the sheet filter followed by Whatman filter paper Cat. No. 1001 150. The pH of the samples will be checked by using a pH meter.

The mixture will be made alkaline (pH 10-11) by adding K_2CO_3 and extracted with three portions (600-200 mL x 3) of ether by using the separatory funnel. All the extracts will be combined and dried overnight with Na_2SO_4. Dried extract will be filtered and concentrated under reduced pressure to a final volume of approximately 5 mL. The concentrated extract will be spotted on a 20 x 20 cm TLC plate (Silica gel G, 60 F_{254}, 0.5 mm thickness, Merck). The compounds will be separated by an ascending method with a solvent mixture of chloroform:ethanol:ammonia (100:10:0.5). The plates will be air-dried and sprayed with Dragendorff reagent. The calculated R_f value will be compared with the literature's R_f value. The compound having R_f value of 0.3 will be isolated and further subjected to MS and NMR analysis. Field desorption (FD) mass spectra will be detected with a JEOL JMS-SX102A Mass Spectrometer, and the ^{13}C-NMR spectra will be observed with a Brucker AMX-500 instrument by using chloroform-*d* as a solvent[12].

4.9. Statistical Analysis

All data collections will be evaluated for analysis of variance (ANOVA) by using the Excel Windows XP[22] or SPSS or SAS softwares.

5. Conclusions

Dioscorea hispida is the most famous yam in Malaysia and is distributed more in Terengganu where it is well adapted to its environmental condition. Therefore, to commercialize this species, the proper irrigation condition must be established. Then, this research is proposed to optimize the use of irrigation water for *D. Hispida* because innovation of water-saving irrigation strategies can save a substantial amount of water resources compared to traditional irrigation that is now practiced based on a luxury use of water Kang and Zhang, 2004 Sh. Kang and J. Zhang, Controlled alternate partial root-zone irrigation: its physiological consequences and impact on water use efficiency, Journal of Experimental Botany 55 (2004), pp. 2437–2446. Full Text via CrossRef |View Record in Scopus | Cited By in Scopus (61)262219.

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