Thigmomorphogenesis of Root-Crop Growth Due to Drip and Mist Irrigation

Murtiningrum Murtiningrum[1,*] Wilda Monicha Mukti[1] Tiana Nur Annisa[1] Yubelia Agasa[1] Ngadisih Ngadisih[1]

[1] *Department of Agricultural and Biosystems Engineering, Universitas Gadjah Mada, Indonesia*
[*] *Corresponding author. Email: tiningm@ugm.ac.id*

ABSTRACT
Thigmomorphogenesis is a plant growth response caused by mechanical stimuli from outside of the plant body. The mechanical stimulations used in this study was irrigation methods, namely drip and mist. The objectives of this study were to determine the morphology of tubers, to compare the growth rates, as well as to determine the most suitable irrigation for respected crops. The parameters observed in this study were leaves number, root depth, plant volume, root and crown weight, number of tubers, and the ratio of crown and tuber dry weight. Considering the parameters, the different sweet potato, jicama, and onion responded differently to each irrigation method. Finally, drip irrigation was recommended for sweet potato while mist irrigation was recommended for jicama and onion.

Keywords: *Thigmomorphogenesis, drip irrigation, mist irrigation, tubers.*

1. INTRODUCTION

Water is a very important factor for life, including for agriculture. The importance of water in plant growth is to form an environmental factor that affect plant growth in the internal physiological processes of plants [1]. Crop water requirements fulfilled by rainfall and irrigation to supply. Irrigation is an effort to add water to the soil layer to supply water shortage or water deficit due the process of evapotranspiration [2].

Horticultures, especially tuber are needed by the people to get carbohydrates, vitamins and minerals for a healthy body. Current research only studied the top because root growth is difficult to examine. Roots are the most important part in plant growth function to support, absorb water, nutrients, and respiration. If the root's condition disturbed it can affect the growth of the top of the plant. Different irrigation methods will have different thigmomorphogenesis effects in plant roots. Thigmomorphogenesis is a plant response to touch, stimulation or mechanical pressure from outside the plant which affects the growth and development of plants [3]. Based on description, this research aimed to determine the morphology of tubers, to compare the growth rates, as well as to determine the most suitable irrigation for tubber crops, especially jicama, onion, and sweet potato.

2. MATERIAL AND METHOD

The research was conducted at a screen house located in the Nanggulan area, Depok, Sleman, Yogyakarta Special Region and the Laboratory of Land and Water Resources Engineering Department of Agricultural and Biosystems Engineering, Faculty of Agricultural Technology UGM. The stages in this research include the arrangement of the screen house, preparation of the root window, preparation of planting media, irrigation installation, seeding, data collection, and data analysis. Parameters observed were leaves number, root depth, plant volume, root and crown weight, number of tubers, and the ratio of crown and tuber dry weight. The materials used were jicama (*Pachyrhizus erosus* L.), onion (*Allium ascalonicum* L.), and sweet potato (*Ipomoea batatas* L.). Observation of plant roots using root window media and measurement of growth parameters using a ruler, scales, and oven. Data were analyzed using graphically and statistically.

A UV plastic shading was set to protect the experiment plot from rainfall. Under the shading, the root window was prepared to observe the growth of plant roots. The type of root window used in this

A. D. Saputro et al. (Eds.): ICOSEAT 2022, ABSR 26, pp. 401–405, 2023.
https://doi.org/10.2991/978-94-6463-086-2_53

research was a rhizobox-type made of plastic containers. The root window had dimensions of 46 cm x 34 cm x 25.6 cm as shown in Figure 1. The type of root window used in this research is a rhizobox made of plastic containers. The layout of crops and irrigation treatments is shown in Figure 2.

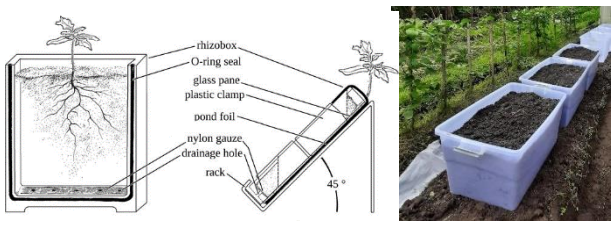

Figure 1 Rhizobox root windows

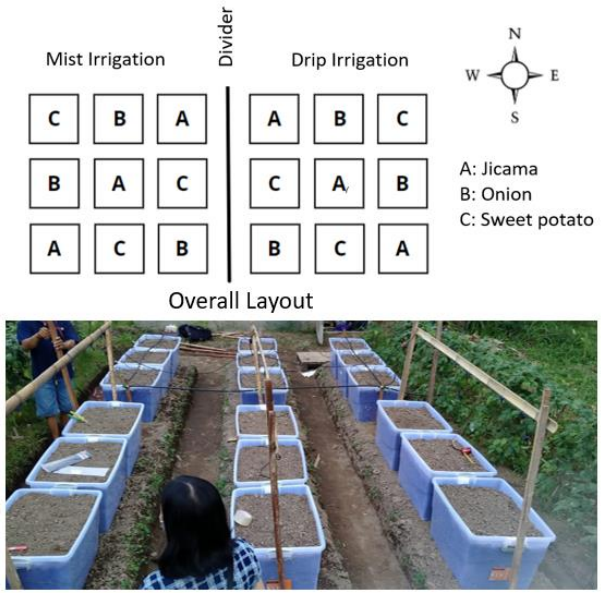

Figure 2 Layout of root windows

The next stage was the installation of irrigation in each treatment, namely drip irrigation and mist irrigation. Layout of irrigation treatment is shown in Figure 3. After all irrigation components were installed, parameters of discharge and uniformities were measured. The pressure of the system was set constant for all treatments.

The irrigation systems were calibrated by measuring the discharge and uniformity. The discharge measurement was carried out by collecting water that falls on the top surface of the root window. Uniformity was determined by Christiansen uniformity. The discharge of each irrigation type was important to determine irrigation duration to make sure that equal volume of water supplied to each root window. Irrigation duration was set to supply 7 mm/day water.

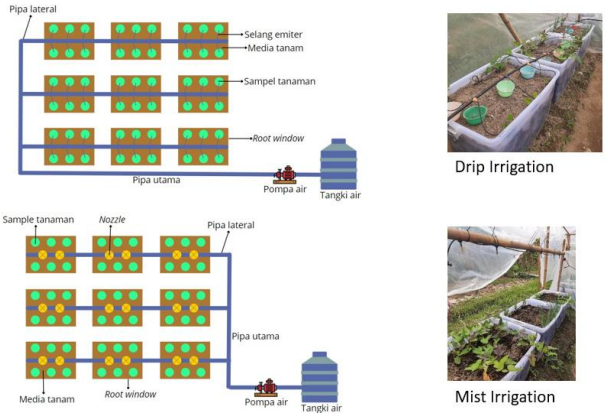

Figure 3 Layout of irrigation system setting

The parameters observed during crop growth in this study were leaves number and root depth, which were measured every two days. The crop parameter collected at the harvesting period were plant volume, root and crown weight, number of tubers, and the ratio of crown and tuber dry weight. The biomass of each crop was weighed right after harvested to obtain biomass weight. Consecutively, root and tubbers were removed and the crown part of vegetable was weighed to obtain crown weight.

3. RESULT AND DISCUSSION

3.1. Irrigation Calibration

The calibration of drip and mist irrigation observed included discharge and irrigation time to determine the characteristics of each type of irrigation. The test of uniformity coefficient value (CU) was carried out to determine the percentage of uniformity of water distribution in drip and mist irrigation treatments. The calibration results of drip and mist irrigation are shown in Table 1.

Table 1. Irrigation calibration and performance,

Irrigation type	Discharge (ml/sec)	Duration (min, sec)	Uniformity Coefficient (%)
Drip	36.46	9’ 40”	90.46
Mist	46.35	7’ 45”	87.75

Table 1 showed that discharges received by each root windows were 36.46 ml/sec and 46.35 ml/sec for drip and mist irrigation respectively. The nozzle was set fixed therefore to make sure water received by all root windows were the same, duration was determined. To supply 7 mm/day water, the irrigation durations were 9 minutes 40 seconds and 7 minutes 45 seconds for drip and mist irrigations respectively. The water supplied to each root window was excessive compared to crop water requirement of the tree crops to make sure that crops were not sufferring from stress of water shortage. The excessive water would be drained through base holes of root windows. This treatment was set so soil

was always on field capacity and all of the crops received adequate water. The parameters measured were only the result of the irrigation method.

Table 1 showed that coefficient uniformities were 90.46% and 87.75% for drip and mist irrigation, respectively. The uniformity of mist irrigation was generally lower than that of drip irrigation because water droplet direction of mist irrigation was affected by wind. The coefficient uniformity was considered good so the setting can be applied as treatment.

3.2. Root and Leaf Growth

Root depths of the crops were measured in the transparent wall of root windows every two days. The average root depth of each crop and each irrigation treatment is shown in Figure 4.

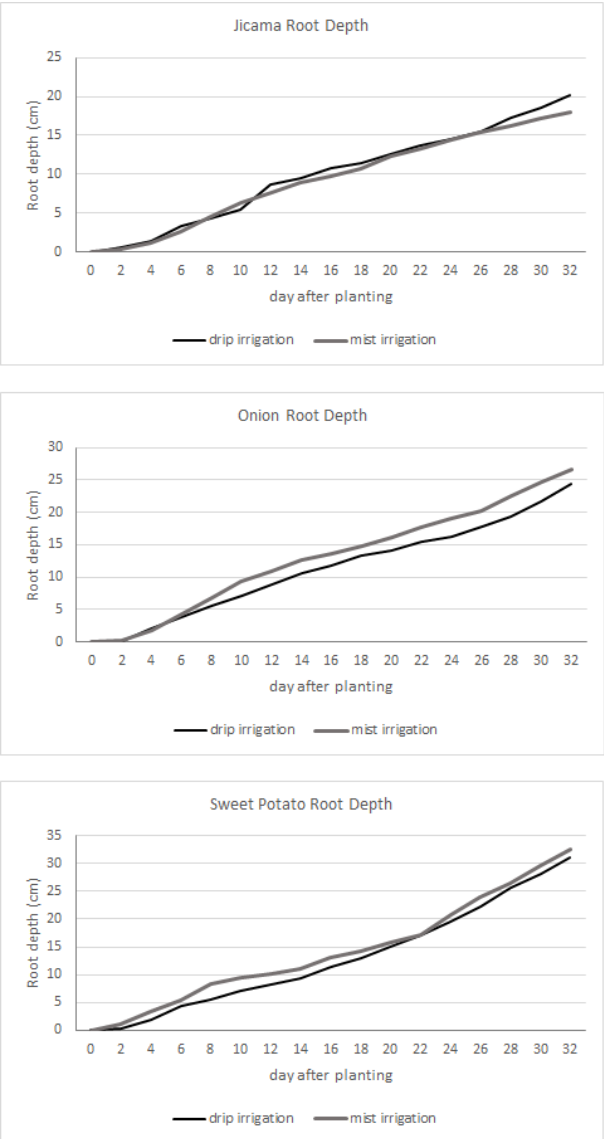

Figure 4 Graph of root depth measured in root windows

Figure 4 shows the growth of root from the planting day to the day when the root reached the base of root windows. The roots have continued growing into deeper soil but it is not measurable because in is deeper than the transparent wall of root windows.

Figure 4 showed that the root grew almost linearly for all samples. For jicama, roots grew at the similar rate between crop with drip and mist irrigations. For the onion and sweet potato, root with mist irrigation grew faster than that with drip irrigation. Mist irrigation spreads water over the entire land surface while drip irrigation provides water to a single point near the roots. Therefore, roots with mist irrigation tends to chase water all over the soil. On the other hand, root with drip irrigation received water easily without moving to water source.

The leaf number was counted every two days from when a leaf appeared to harvesting time. The average leaf number from day to day is displayed in Figure 5.

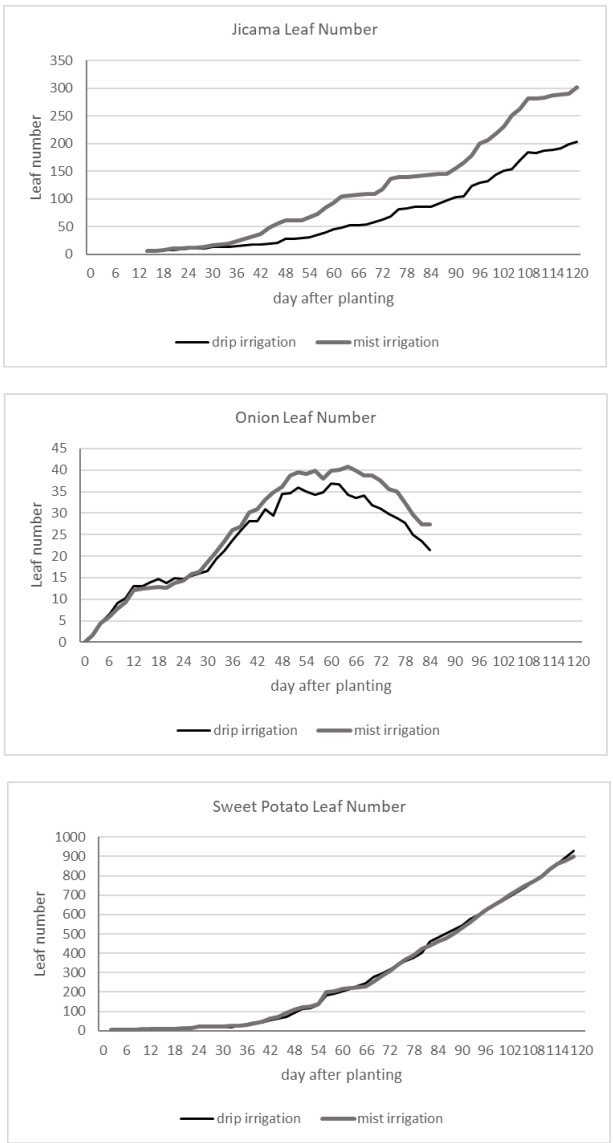

Figure 5 Graph of leaf number growth

Figure 5 exposed different responses of leaf number growth type. Jicama leaves grow after transplanting

from nursery to harvesting with almost constant rate. Onion leaves grow slowly at the beginning, then grow faster during day 30 to 48. From day 48 to 66 the onion leaves and after day 66, the onion leaves withered starting from the outer leaves. Therefore, onion leaf numbers tended to decrease. The sweet potato leaves grow slowly at the beginning but the rate is getting faster after day 50.

The response of leaf number to irrigation type is also shown in Figure 5. The leaves of sweet potato show the same responds to drip and mist irrigation. The leaves of jicama and onion shown better response to mist irrigation than that of drip irrigation. The droplets of mist irrigation gave stimulus to growing point similar to beaten that hindered the leaves growth of jicama and onion but they stimulated the tendril of the crops to spread longer and produce more biomass. The tendrils of jicama were easily elongated and produced new roots and leaves when they got droplets from mist irrigation.

3.3. Harvesting Parameters

The parameters determined in the harvesting include final number of leaves, number of tubbers, as well as wet and dry weight of crown and root. The results of those parameters were presented in Table 2.

The treatment of drip irrigation and mist irrigation given to jicama samples resulted in different morphological and physiological responses of plant growth. In the mist irrigation treatment, the parameters of wet weight and dry weight of the crown, root dry weight, wet weight and dry weight of tubers, root volume, tuber volume, number of tubers, and dry weight ratio of root crown and tuber were higher than those of drip irrigation treatment. In general, the jicama showed better responses to drip irrigation.

The treatment of drip irrigation and mist gave different morphological appearance of onion samples. The mist irrigation treatment was able to produce onion with higher plant height and diameter of bulbs, a greater number of leaves and bulbs, and higher weight of shoots, roots, and bulbs than the drip irrigation treatment. The dry weight ratio of shoots to roots and tubers with mist irrigation treatment was smaller than that of drip irrigation, which means that plant growth focuses more on tubers and roots.

In this study, mist irrigation gave a better impact on onion. So the recommended type of irrigation for onion cultivation is using mist irrigation.

Thigmomorphogenesis of sweet potato growth produced different results for each irrigation treatment. Based on the morphological parameters of sweet potato in the form of root depth and number of leaves resulted in different morphological responses of plant growth. The drip irrigation treatment resulted in better root wet weight, root dry weight, root volume, and root crown dry weight ratio. However, the condition of weeds that grow on the root window is more common in the mist irrigation treatment so that routine maintenance is needed.

Based on the growth parameters, sweet potato had a better thigmomorphogenesis response to drip irrigation treatment, which was indicated by the condition of the root crown ratio. In this study, sweet potatoes did not produce tubers, so this condition only described vegetative growth in the form of leaf and root growth. Drip irrigation has the advantage of being able to adapt to the original conditions of the plant. It cannot be concluded which type of irrigation was more suitable for sweet potato cultivation.

4. CONCLUSION

The treatment of mist irrigation for jicama resulted in better parameters of crown weight and tuber weight. The treatment of drip irrigation for jicama resulted in higher root weight. For onions, mist irrigation resulted in better performance of crown weight, root weight, and

Table 2. Harvesting parameters

Parameters	Jicama		Onion		Sweet Potato	
	drip	mist	drip	mist	drip	mist
Crown wet weight (g)	240.59	269.52	27.53	41.01	210.62	233.64
Crown dry weight (g)	48.66	57.24	2.88	3.56	99.91	117.67
Root wet weight (g)	20.49	14.80	2.70	4.27	64.19	50.13
Root dry weight (g)	3.69	3.88	0.30	0.37	17.28	10.99
Tuber wet weight (g)	63.74	209.62	48.37	74.87	na	Na
Tuber dry weight (g)	15.23	31.38	9.86	12.67	na	na
Root length (cm)	73.4	71.65	9.62	8.73	137	130
Crown-root ratio	10.6	3.20	0.38	0.27	9.24	11.87
Tubber number	1	1	9	17	0	0
Leaf number	211	208	22	27	131	133

bulb weight. Therefore, mist irrigation was considered most suitable for jicama and onion cultivation. On the contrary, sweet potato showed better responses to mist irrigation and drip irrigation for crown and root respectively. Hence, the drip irrigation was considered more suitable for sweet potato cultivation.

AUTHORS' CONTRIBUTIONS

In this research, Murtiningrum presented the ideas, provided the method related to irrigation, wrote the introduction and conclusion, and submitted the manuscript. Ngadisih provided the method related to root windows, shading, and soils as well as wrote the discussion of this paper. Wilda Monicha Mukti, Tiana Nur Annisa, and Yubelia Agasa conducted the research in the field and laboratory as well as data analysis for jicama, onion, and sweet potato, respectively.

ACKNOWLEDGMENTS

The authors would like to express appreciation for Universitas Gadjah Mada for providing research funds through Rekognisi Tugas Akhir (RTA) program.

REFERENCES

[1] M. Mawardi, Rekayasa Konservasi Tanah dan Air, Yogyakarta: Bursa Ilmu, 2016.

[2] M. Mawardi, Tanah-Air-Tanaman: Asas Irigasi dan Konservasi Air, Yogyakarta: Bursa Ilmu, 2011.

[3] I. W. Wiraatmaja, Bahan Ajar Gerak Pada Tumbuhan, Agroteknologi Fakultas Pertanian Universitas Udayana, 2017.

[4] A. Tusi and B. Lanya, Rancangan Irigasi Curah Portable Tanaman Pakcoy, Jurnal Irigasi, vol. 11(1), 2016, pp. 43–54.