Journal of Degraded and Mining Lands Management
ISSN: 2339-076X (p); 2502-2458 (e), Volume 8, Number 2 (January 2021): 2595-2600
DOI:10.15243/jdmlm.2021.082.2595

Research Article

Effect of wick application of growick irrigation system on the cultivation of pakcoy in sand tailing media from post-tin mining land

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Received 12 November 2020, Accepted 11 December 2020

Abstract: A large part of post-tin mining land covered by sand tailing which has low water storage capacity, making it vulnerable to drought stress. The innovation of irrigation technology has been developed to overcome this problem such as capillary irrigation system combined with groasis system using a large reservoir with hydroponic wick system called the growick system. This study aimed to determine the best number and type of wick in growick irrigation system to water consumption and also growth and yield of pakcoy cultivated in sand tailing media. The research was conducted from February to June 2020 at Experimental field of Universitas Bangka Belitung, Indonesia. Treatments consisted of the types of wick (flannel and stove wick) and numbers of wick per polybag (1, 2, 3, and 4 wicks). The study used a completely randomized factorial design with 3 replications. Data obtained were analyzed using Analysis of Variance continued with Duncan's Multiple Range Test (DMRT) at 95% significant level. The result showed that usage of flannel wick gave the highest results of growth and yield of pakcoy but it absorbed more water than stove wick. Flannel wick also had lower water usage efficiency than stove wick. The use of single wick gave the highest result of growth and yield of pakcoy than using more wicks. Results of the study showed that single wick treatment gave the highest growth and yield of pakcoy. Flannel wick gave the highest growth and yield of pakcoy, but it was not significantly different from stove wick. Single flannel wick treatment showed no significant difference with single stove wick treatment in growth and yield of pakcoy except for water usage volume parameter. Flannel wick absorbed more water than stove wick, so it has lower water usage efficiency than stove wick. Application growick system using 1 stove wick was the best treatment for cultivating pakcoy in sand tailing media from post-tin mining land.

Keywords: *growick irrigation, pakcoy, post-tin mining land, sand tailing, wick application*

To cite this article: Inonu, I., Hambali, R., Pratama, D. and Lestari, A.W 2021. Effect of wick application of growick irrigation system on the cultivation of pakcoy in sand tailing media from post-tin mining land. J. Degrade. Min. Land Manage. 8(2): 2595-2600, DOI: 10.15243/jdmlm. 2021.082.2595.

Introduction

Tin mining activities in Bangka Belitung islands have left a large area of post-tin mining land. Based on data from BBSDLP (2016), Bangka Belitung Islands have 124,838 ha of post-tin mining land consisting of 79,163 ha in Bangka island and 45,675 ha in Belitung island. As many as 82-92 % of post-tin mining land consist of tailing (Asmarhansyah and Hasan, 2017). The texture of sand tailings dominated by a sand fraction. Because of that, it has high permeability and low water resistance (Pratiwi et al., 2012). High permeability rate causes water to flow faster so it will disappear quickly and not reach plant roots. This condition can cause drought stress for plant cultivation. High permeability is a problem for plant cultivation in post-tin mining land and becomes limitations for crop cultivation, especially horticultural commodities. It is necessary to develop various methods to find a solution from this problem such as application of organic fertilizer (Inonu et al., 2020) and irrigation technology that can drain water continuously (Aini et al., 2020). One of the technological innovations developed for this problem is a micro-irrigation system called growick. This system is a combination of the hydroponic wick system and water box groasis irrigation system. Growick working principle is to use wicks that can drain water from a water reservoir to root surface area by using capillary principle. Amprin and Suryanto (2019) pointed out that the capillary irrigation system can maintain soil moisture and provide available water for plant roots by minimizing evaporation, surface water flow and percolation.

Mustard commodity has the potential to cultivate in post-tin mining land (Yarda et al., 2019). Mustard family such as pakcoy (*Brassica rapa ssp chinensis*) is considered a prospective commodity for cultivation in post-tin mining land. This commodity has a higher price than any other vegetables from the Brassicaceae family. Pakcoy is good for business because it has a high market demand (Wibowo and Asriyanti, 2013). Pakcoy cultivation and wick irrigation system in post-tin mining land have the potential to utilize for innovation in post-tin mining land cultivation method. Application of wick irrigation technology for pakcoy cultivation in post-tin mining land requires initial study to obtain optimal cultivation conditions, such as type and number of wicks that are used for cultivation.

This study aimed to determine the effect of number and type of wicks used for growick irrigation system on sand tailings media on growth and yield of pakcoy, and determine the type and number of wicks that most suitable for the growth of pakcoy.

Material and Methods

The study was conducted from March to September 2020 in the experimental field of the Universitas Bangka Belitung. Pakcoy seed that used in this study was Nauli cultivar. The study used a completely randomized factorial design. The first factor was types of wicks (K) that consisted of stove wick (K_1) and flannel wick (K_2). The second factor was the numbers of wicks (W) that consisted of 1 wick (W_1), 2 wicks (W_2), 3 wicks (W_3) and 4 wicks (W_4). Combination treatments consisted of 8 wick treatments, and beside wick treatment, there was 1 control treatment (conventional irrigation system) as a comparator for wick treatments. There was a total of 9 treatments, and each treatment had 3 replications, so there were 27 experimental units. Each experimental unit consisted of 4 plants, so there were 108 plants in total. The parameters observed consisted of plant height, number of leaves, root length, plant yield, shoot dry weight, root dry weight, total dry weight, root volume, water usage volume, and water usage efficiency. Data were analyzed using analysis of variance at 95% significant level followed by the Duncan Multiple Range Test (DMRT) at 95% significant level.

Installation of growick system irrigation was made by using a plastic container for a water reservoir. A hole was made in the wall of the plastic container about ¾ of container height. Hole in a plastic container was then connected with polybag (planting media) by using ¾ inch PVC (polyvinyl chloride) pipe. Wicks were applied from water container through PVC pipe to plant root zone in a polybag (planting media). Water container was then filled with water. One more hole was made in a plastic container lid then connected with 1.5 inch PVC pipe. That hole was made to control the water level in the reservoir and refill irrigation water (Figure 1).

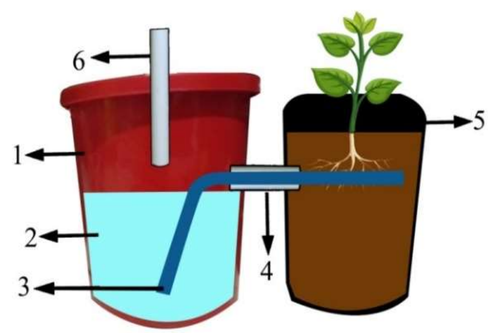

Figure 1. Installation of growick irrigation system, 1) plastic container, 2) irrigation water, 3) wick treatment, 4) ¾ inch PVC pipe, 5) polybag, 6) 1.5 inch PVC pipe.

Results and Discussion

The result from the analysis of variance showed that the type of wick gave significant effect to root length, shoot dry weight, root dry weight, total dry weight, root volume, water usage volume and water usage efficiency. The number of wicks gave significant effect to plant height, plant yield and water usage volume. Interaction between the type of wick and number of wick gave significant effect to water usage volume (Table 1). Different type and the number of wicks affected the water supply to the plant. Different amount of water supply in each treatment affected the water content in cultivation media. In addition, sufficient water supply can optimize soil moisture content.

Anestasia et al. (2013) stated that soil moisture could help to maintain soil temperature make it neither too hot nor too cold. It will maintain the evaporation process in soil and keep the plant save from water loss. Good water absorption by plants can increase the metabolism of the plant and stimulate plant growth (Xue et al., 2017). The root growth of pakcoy with flannel wick treatment was better than stove wick treatment. It proved by observation parameters such as average root length, root volume, and root dry weight of pakcoy with flannel wick treatment have better result and significantly different with stove wick treatment. The shoot growth of pakcoy such as plant height, number of leaves, shoot dry weight with flannel wick treatment also gave a better result than stove wick treatment, although the significantly different parameter from shoot growth was only shoot dry weight (Table 2). Water volume used using flannel wick was ten times higher than that of stove wick. Higher water consumption by flannel wick means that it has less efficient water consumption than stove wick. Water usage efficiency by using flannel wick was 0.14 g/L, that means every 1 L of water consumption gave 0.14 g of the dry weight of pakcoy. That value was lower and significantly different than stove wick of 0.95 g/L of water usage efficiency (Table 2).

The ability of flannel wick transporting water from reservoir to cultivation media was 10 times higher than stove wick in growick irrigation system. That difference has happened possibility because the fibre structure of the flannel wick is more porous than stove wick making flannel wick absorbed more water than stove wick. Higher rate of water absorption was influenced by the size of wick pores. Ardiani et al. (2019) state that the water absorption rate of flannel was 0.086 cm/second and cotton fabrics was 0.070 cm/second. The use of flannel wick treatment tended to have higher water usage volume than stove wick treatment.

Table 1. Analysis of variance of type and number of wick application on growick irrigation system for pakcoy cultivation.

Parameter	**Type of wick**	**Number of wick**	**Interaction**	**CV (%)**
	Pr>f	**Pr>f**	**Pr>f**	
Plant height (cm)	0.1730^{ns}	0.0106*	0.6906^{ns}	7.21
Number of leaves (sheet)	0.8924^{ns}	0.9777^{ns}	0.3434^{ns}	10.06
Root length (cm)	0.0173*	0.0842^{ns}	0.7030^{ns}	18.22
Plant yield (g/plant)	0.5565^{ns}	0.0087*	0.3090^{ns}	22.15
Shoot dry weight (g)	0.0321*	0.2260^{ns}	0.6062^{ns}	22.24
Root dry weight (g)	0.0015*	0.2100^{ns}	0.1090^{ns}	26.15
Total dry weight (g)	0.0190*	0.2016^{ns}	0.5697^{ns}	21.70
Root volume (cm^3)	<.0001*	0.0930^{ns}	0.5736^{ns}	25.32
Water usage volume (L)	<.0001*	<.0001*	<.0001*	4.35
Water usage efficiency (g/L)	<.0001*	0.0520^{ns}	0.5622^{ns}	30.52

Note: Pr>f (probability), * (significant effect), ns (no significant effect), CV (coefficient of variation).

Table 2. Growth and yield of pakcoy with flannel and stove wick treatment.

Parameters	**Type of wick**			
	Stove wick		**Flannel wick**	
Plant height (cm)	18.88	b	23.02	a
Number of leaves (sheet)	4.47	b	7.88	a
Root length (cm)	0.51	b	0.78	a
Plant yield (g/plant)	23.55		24.56	
Shoot dry weight (g)	17.67		17.77	
Root dry weight (g)	5.83	b	7.22	a
Total dry weight (g)	6.34	b	7.99	a
Root volume (cm^3)	123.13	a	130.00	b
Water usage volume (L)	6.80	b	63.93	a
Water usage efficiency (g/L)	0.95	a	0.148	b

Note: Numbers followed with different letters in the same row show significant difference based on the DMRT test with 95% significant level.

High water usage volume was also caused by physical properties of tailings media which tended to be porous. The physical characteristics of tailings media cause low water holding capacity, so percolation is easy to happen especially with flannel wick treatment with high capillary ability makes water flow from wick continues to flow in large quantities due to gravity. Sutono (2012) stated that sand tailing dominated with aeration pores. It makes the exchange of water and air in tailing is very intensive. Water that fills aeration pores was lost easily because it evaporates into the air or infiltrates to deeper parts of soil due to gravity power. Haryati et al. (2019) stated that the imbalance between the number of aeration pores and number of available water pores causes the water in available water pores is easily move to aeration pores to supply the evaporation needs and increases evaporation process. The high amount of water lost affected water usage volume in growick irrigation system. Water usage volume with stove wick treatment was lower than that of flannel wick treatment, it presumably because pores in stove wick ware smaller and tighter making a lot of water retained in wick pores, so the water that reached media was lower. Subagia and Susila (2016) stated that the smaller diameter of the capillary pipe causes greater resistance makes decreasing in the rate of mass flow.

There was a tendency that root growth decreased with the increasing of the number of wicks. That phenomenon was indicated by some parameters such as root length, root volume and root dry weight. However, the average values of those parameters were not significantly affected by numbers of the wick. The decrease of root growth was followed by a decrease in shoot growth. Overall, the more wicks used made plant height, number of leaves, and dry weight of the pakcoy lower. Plant height of pakcoy with 1 wick treatment was higher and significantly different from pakcoy with 3 wicks and 4 wicks treatments (Table 3).

Total dry weight and pakcoy yield decreased with the increasing number of wick on the media. The yield of pakcoy with 1 wick was 156.02 g and significantly different from the yield of pakcoy with 3 wicks and 4 wicks. A contradiction happen with a parameter of water usage volume, the increasing number of wick makes water usage volume was higher. Pakcoy with 4 wicks treatment has the most water consumption and significantly different from that of pakcoy with 1 wick and 2 wicks treatments. High total dry weight and low water consumption made pakcoy with 1 wick treatment was the most efficient treatment for water usage volume compared to pakcoy with more wick treatment (Table 3).

Tabel 3. Growth and yield of pakcoy with a different number of wick treatment.

Parameters	**Number of Wick**							
	1		**2**		**3**		**4**	
Plant height (cm)	22.59		22.72		21.19		17.29	
Number of leaves (sheet)	0.65		0.74		0.67		0.52	
Root length (cm)	7.20		6.7		5.9 0		4.90	
Plant yield (g/plant)	25.66	a	24.93	a	23.60	ab	21.98	b
Shoot dry weight (g)	17.87		17.79		17.75		17.45	
Root dry weight (g)	6.99		6.97		6.72		5.41	
Total dry weight (g)	7.63		7.70		7.39		5.93	
Root volume (cm^3)	156.02	a	137.62	ab	119.50	bc	93.12	c
Water usage volume (L)	19.90	c	32.2	b	43.80	a	45.60	a
Water usage efficiency (g/L)	0.70		0.6		0.50		0.40	

Note: Numbers followed by different letters in the same row show significant difference based on the DMRT test at a 95% significant level.

The various number of wick did not have a significant effect on water usage volume. It was caused by the limited movement of water in the wick. Amprin and Suryanto (2019) stated that water in a capillary pipe could not flow freely in the capillary pipe. The amount of water flow matches with the amount of evaporation, however, this principle is different when using a flannel wick. High water absorption ability in flannel wick causes a large volume of irrigation. A higher number of flannel wicks means a greater volume of irrigation water.

Availability of water in media is important for plant growth and yield. Water has a very important role in plant growth as the main support for plant cells. Availability of water in plants can help maintain cell vigour and makes plants stay fresh. Water has a role as a dissolver for various soil nutrients, transporting photosynthate from source to sink, maintaining cell turgidity including in cell enlargement and opening of stomata (Felania, 2017). Limited water availability will affect the growth and yield of the plant itself. There were tendencies that combination of different type and the number of the wick gave different response for pakcoy growth and yield, although it did not give significant effect for each parameter except water usage volume parameter. The interesting fact from this research is more wick used made growth and yield of pakcoy lower. The increased number of the wick also made water usage volume tended to increase.

High water consumption but low growth and yield caused low water usage efficiency. It means that using more than 1 wick for pakcoy cultivation in sand tailing media is not good considering the low water usage efficiency. Another interesting fact was flannel wick absorb more water than stove wick. Flannel wick absorbed more water but not followed with increasing of growth and yield of pakcoy significantly. It means that using stove wick is better than flannel wick considering the water usage efficiency. From those 2 facts, it can describe that using 1 stove wick is the best treatment for pakcoy cultivation in sand tailing media that other treatment because it gave the best water usage efficiency (Table 4).

In this case of study, 1 wick is enough to support pakcoy growth and yield in sand tailing media. Water and nutrients content in plant tissue can affect plant weight (Manurung et al., 2015). Embarsari et al. (2015) stated that the availability of water and nutrients greatly determine the plant weight. Research from Anjarwati et al. (2017) proved that green mustard plant showed an increase in plant weight due influence of water and nutrients content in cultivation media.

The treatment of 1 wick and 2 wicks of stove wick gave similar effect on water usage efficiency. High water usage efficiency was caused by lower water usage volume by plants. Lower watering volume means higher water usage efficiency by plant root (Anggraini et al., 2015). Increasing water usage efficiency can be done by reducing water demand (Suryanti et al., 2015). High water usage efficiency can increase water usage value, so the water can be used optimally by plants. Water amount that matches with plant needs can prevent percolation and maintain soil humidity in cultivation media (Triana et al., 2018).

Tabel 4. Growth and yield of pakcoy with combination between type and number of wick.

Parameter	**Stove wick**				**Flannel wick**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Plant height (cm)	25.8	24.5	23.1	20.9	25.6	25.4	24.1	23.1
Number of leaves (sheet)	18.8	17.3	17.9	16.6	16.9	18.2	17.6	18.3
Root length (cm)	20.7	19.3	18.9	16.5	24.4	26.1	23.4	18.1
Plant yield (g/plant)	163.8	126.6	126.9	75.2	148.2	148.6	112.1	111.0
Shoot dry weight (g)	6.3	5.6	6.3	5.0	7.6	8.3	7.1	5.8
Root dry weight (g)	0.7	0.5	0.5	0.3	0.6	1.0	0.8	0.7
Total dry weight (g)	7.0	6.1	6.9	5.4	8.3	9.3	7.9	6.5
Root volume (cm^3)	5.7	4.3	4.7	3.1	8.7	9.2	7.1	6.6
Water usage volume (L)	6.7e	5.7e	8.0e	6.9e	33.2d	58.7c	79.5b	84.3a
Water usage efficiency (g/L)	1.0	1.0	0.9	0.7	0.2	0.2	0.1	0.1

Note: Numbers followed with different letters in the same row show significant difference based on the DMRT test with 95% significant level.

Cultivation of seasonal crops in sand tailings media of post-tin mining land has the advantage because it is easier to reach field capacity conditions through the watering process. The weakness from that case is maintaining the field capacity conditions because it requires frequent watering activities (Sutono, 2012). Application of growick system in sand tailing media can help to maintain that condition. The type and number of wick in growick irrigation system that closes to optimal criteria for maintaining water efficiency is 1 stove wick treatment. By using 1 stove wick treatment, Water usage volume was significantly lower, water usage efficiency relatively higher, and also maintaining the yield of pakcoy that cultivated in sand tailing media. Growick irrigation system has several drawbacks in its application such as upfront investment is quite expensive and the distance between water reservoir and plants cannot be too far, but growick irrigation system also has several advantages such as it can be used in the long term application, easy installation, and good for water efficiency.

Conclusion

Application of different type of wick with growick irrigation system gave different result to growth, yield and water absorption of pakcoy that cultivated in sand tailing media of post-tin mining land. Flannel wick absorbed more water than stove wick but gave similar growth, yield and water usage with stove wick. Application of the different number of the wick with growick irrigation system gave an effect to growth, yield and water absorption of pakcoy in sand tailing media of post-tin mining land. Less number of wick gave higher water usage efficiency in pakcoy cultivation. Considering the water usage efficiency, application 1 stove wick with growick irrigation system gave the best result for pakcoy cultivation in sand tailing media of post-tin mining land.

Acknowledgement

The authors are very grateful to the Universitas Bangka Belitung for founding this research trough University Lecturer Research program carried out by the Institute of Research and Community Service (LPPM).

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