SNRU Journal of Science and Technology

Journal home page: snrujst.snru.ac.th

Prototype Design of Solar Soil Moisture Controller to be used as an Alternative Energy for Agriculture Against the Growth of Vegetables in Khao Kho District, Phetchabun Province.

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Received: 30 September 2020; **Revised**: 9 December 2020; **Accepted**: 15 December 2020; **Available online**: 1 January 2021

Abstract

This research aimed to design two moisture control prototypes. The first prototype humidity control unit is covered with a single layer of transparent plastic sheet all around without a humidity control system. This is different from the second prototype humidity control unit, which is covered with transparent plastic panels all around and covered with side and top mesh filters. Including an exhaust fan, humidity control, and solar cell installation for applying in vegetable cultivation of agriculturist's group at Sado Phong sub-district, Khao Kha district, Phetchabun province in which this area faced the problem in deficient of electricity for farming. The development of these moisture control prototypes with solar energy was for renewable energy in drip irrigation for agriculture. The study compared the appropriate temperature and moisture for vegetable growth. The results of the study found that prototype 1 had average growing rate at 86% which was less than the prototype 2 with average at 92%. The best variable for plant growth was the temperature at 21 – 28 °C and the suitable moisture value was at –17 to –25 centibar which the growth rate of vegetable was able to 93 – 96%. When compared the growth rate of the old methods agriculturalists, the growth rate was at 55 – 72% which was obviously less than planting by these two prototypes which its growth rate was at 74 – 96%. Nevertheless, in applying moisture control prototypes, agriculturists can cultivate their products for 850 kilogram per rai each time, comparing with the old method of farming, agriculturists can cultivate their products for 500 kilogram per rai. From transferring of moisture control technology to agriculturists, the average score of satisfaction was at 4.35 and the standard deviation was 0.66 with the level of opinion was in the high rank.

Keywords: Moisture control prototype; Solar energy; Renewable Energy; Drip Irrigation.

1. Introduction

Currently, some area in Thailand still faces the deficient problem of electricity for both daily life and farming due to the Provincial Electricity Authority cannot access to the whole country. For example, the target group of agriculturists at Sado Phong sub-district, Khao Kha district, Phetchabun province in which located on the Khek River Basin Development Project, the main crops of agriculturists in this area are vegetables such as cauliflower, Chinese mustard green, kale, cabbage, celery, parsley, and strawberry. [1, 2] This area was empty and foothill slope topography with no river or canal for farming irrigation. The area was formerly in charge by the Army and later allocated to inhabitants for living and farming. From interviewing with local people, some of them moved to live here without electricity for 3 – 5 years ago, which in the summer, late rainy season and winter were the agricultural seasons, it caused damage to crops and effected to agricultural products. Presently, people applied the generator with fuel consumption in generating electricity to pump water for their daily lives and farming which it costed highly from fuel, maintenance, additionally, it is not convenient in working.

Consequently, renewable energy is the alternative way for advantageous management, it is now developed to solve the spatial problem in electricity access and solar energy is the renewable energy that will not run out and able to apply in every area [3] with many beneficial sides. To convert solar energy to be electricity can be applied by an equipment called solar cell which is the electricity producing process from sun light. It was clean energy, not cause pollution and able to store electricity for a long period with battery even in the little light place. Also, it can apply with other household electric devices and mostly agricultural equipment. [4]

From the information above, the idea of moisture control prototype was developed to be renewable energy for drip agriculture. The existing method of agriculturists in watering vegetables is using the water pumping machine to supply water along the PVC pipe that connected with rubber tube then watering plant from tube tail. They noticed the moisture on the ground surface without the right humidity control and this caused to both fuel and water waste in pumping water since it had taken a long time in watering vegetable and pumping water. Additionally, the direction of water was not limited to the proper area, it became uneven growth plant since the temperature and the soil moisture was irrelevant. Accordingly, the purpose of this research was to develop the moisture control prototype in farming by drip irrigation with moisture control system which was the efficiently method in watering plants across pipes and gradually supply water through drippers or sprinkles [5] which were set in the root area of plant or set in the moisture control system. The advantage of this method was to save water, time and suit for the foothill region as well as it can control the moisture in the restricted area and also the direction of water as needed. The key advantage from designing and creating the moisture control prototypes was when the cited area cannot cultivate in the insufficient seasons, agriculturists can work with this prototype to control moisture and also can protect plants from insects and other pest.

2. Materials and methods

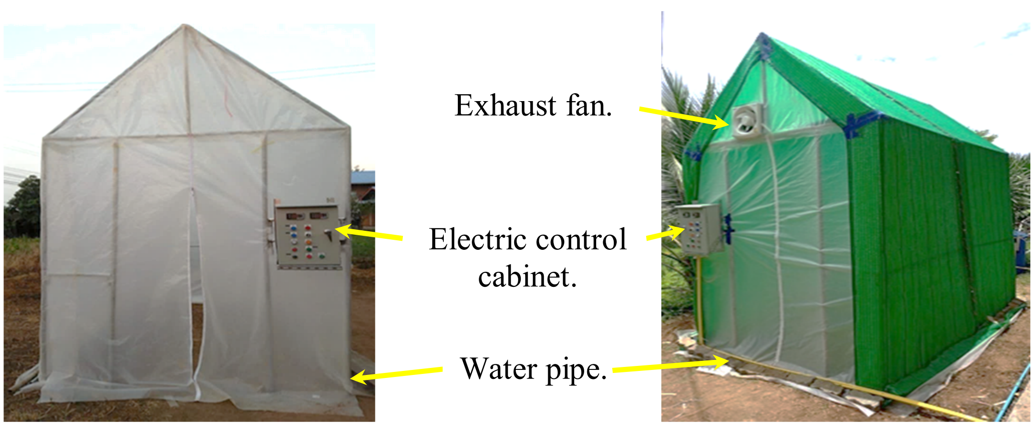
The agriculture in the current time.

Presently, agriculturists plants vegetable by shifting the land surface as a plot of field lengthy around 2 × 20 meter and covering the surface with hay to preserve the soil moisture. This method is the local wisdom [6] as in Fig. 1, its reflection was the heat can be easily access to the open air area and it cannot maintain the soil moisture for a long time since the soil was loamy sand. Besides, the watering method was by water pumping machine through PVC pipes connecting with rubber tube and watering from the tail. With this method, it took 2 – 3 hours per rai per day and the cost on fuel was around 60 – 90 baht per rai per day. When calculated from growing to cultivating vegetables in 35days [2], it costed around 2,100 – 3,150 baht per rai which was the wasteful factor. If agriculturists can reduce the uneconomical cost, they can gain more income per rai. Moreover, the cultivation each time was around 500 kilogram per rai and can sell 25 – 30 baht per kilogram, the total cost was around 12,500 – 15,000 baht per rai [7, 8] which was not yet included 2 – 3 labourer wage per rai, fertilizer, insecticide and other costs.

Fig. 1 Cultivation of folk wisdom

The moisture control prototype.

Two moisture control prototypes was designed for comparing the applicable temperature and moisture in growing plants and vegetables. On the top of prototype was triangle shape to protect crash and reflection [9] and the ground area was rectangle shape to preserve moisture and light. [10, 11] The prototype 1was designed as in Fig. 2A, covering with only one layer plastic without moisture controlling system. The prototype 2 was designed as in Fig. 2B, covering with plastic in every sides, and also covering with light filter net in sides and top area, the ventilating fans were set for moisture control on the two top sides. On the top of the two prototype, the solar cell was installed as 250 watt input, 2 sets per 1 set of humidity control in Fig. 3A and 3B [12] for transmit to FWS 03/06 – 12/24 controller for converting to electricity to the battery. Then the direct current would be loaded to the battery for storing solar energy 24V 45A size. [13] After that, the direct current can use from battery by connecting to electrical box for turning on and off the 30 watt ventilating fans, when the heat or moisture was in the unsuited condition, and also for controlling 300 watt 24V solar cell water pump which transmit signal from inside of the moisture control set with 4tensiometers [14, 15] and 4 thermometers. [16] Inside the controlling system, the water flowing into drip form through the small hole 3mm size, setting in the bottom along the way of vegetable plot, and mist sprayer for small water molecule 0.80 mm was set on the top along the way of vegetable plot.



A. The prototype 1 B. The prototype 2

Fig. 2 Humidity control unit developed as a prototype by solar drip irrigation system

A. Solar panel set 1 B. Solar panel set 2

Fig. 3 Solar cell power

Methodology and variable of the experiment.

This research prepared the soil by using manure mixed with the soil. Approximate ratio 0.50 – 1 kg m^{-2} and compost to accelerate the growth after planting. After that, water and leave it for 1 night. Since the soil moisture value and proper light temperature in farming were the main factors of the growth of vegetable plants, the suitable soil moisture value was regularly at 0 to –40 centibar [5] that showed absorbing water condition and the accurate light temperature for growing plants was 12 – 38 °C. Hence, the experimental variables in moisture control were set into 2 types: the transparency type as in Fig. 2A which can obtain the light and temperature from 20 – 60 °C. [16] and, opacity type as in Fig. 2B which can obtain light and temperature from 12 – 35 °C to compare the temperature and soil moisture from proper watering in plant growing. Including providing a water system for 5 variables, 15 minutes each variable.

3. Results and Discussion

The result of vegetable plant growth from applied moisture control prototype.

15 days 25 days 35 days

A. The growth of vegetables from prototype 1.

Fig. 4 The growth of vegetables from the humidity control developed as a prototype.

15 days 25 days 35 days

B. The growth of vegetables from prototype 2.

Fig. 4 The growth of vegetables from the humidity control developed as a prototype. (cont.)

Fig. 3 showed the vegetable growth from moisture control prototype with drip system that control with solar energy. The growth was recorded at intervals of 15, 25, and 35 days. The data from measuring moisture value and automatically gathering results of moisture control prototype was –11 to –45 centibar. (Table 1) The result in plant growth found that the vegetable grew in the uneven rate, the birth rate was less, the size and length of trunk are extremely different. In Fig. 4A, the average height of trunk was 32 – 48 cm [16] and the average height of leaf stalk of the flower was 1 – 5 cm [17] due to the high temperature and less moisture. From Fig. 4B, the vegetable grew consistency, the growing rate was in the high rank, most size and the length of trunk in the plot was also similar which the average height of trunk was 43 – 50 cm [2, 5] and the average height of leaf stalk of the flower was 3 – 4 cm due to the appropriate temperature and the moisture rate [11].

The results from proper experimental variable in moisture control technology.

This research gathered the data from the first day of farming until the period of cultivation which was totally 35 days and recorded the moisture value and temperature with data locker. Measuring the growth rate of vegetables and comparing the birth rate with cultivating area was done one time per day at 12.00. The experiment in finding the suitable variables for moisture control technology was applied by drip system (Table 1) which started from 07.00 every day because it was the sunlight time and not over 17.00 because after this time the amount of moisture in vegetable plot might be excessive and can cause rotten or fungus in root. [1, 7] From the result of testing the moisture control prototype in drip irrigation for 5 variables, each variable for 15 minute, it was found that drip irrigation with solar energy was the alternative energy which can truthfully apply to solve the problem to the agriculturist's group. When compared with the old method of agriculture which the growth rate was only 55 – 72% of the plot, agriculturists can apply the moisture control technology to gain the growth rate to 74 – 96% from using the two moisture control prototypes.

Table 1 The results of the experiment were to find the suitable parameters of the humidity control technology.

No.	Water supply system 15 minutes each time.	Time period.	The moisture control prototype 1.			The moisture control prototype 2.		
			Temp. (°C)	Moisture. (Centibar)	The growth	Temp. (°C)	Moisture. (Centibar)	The growth
1	4 times per day	07.00 a.m. 10.00 a.m. 01.00 p.m. 04.00 p.m.	24	–22	95%	18	–11	91%
2	3 times per day	07.00 a.m. Time 12.00 05.00 p.m.	28	–26	91%	21	–17	93%
3	2 times per day	07.00 a.m. 05.00 p.m.	33	–30	87%	25	–20	96%
4	1 times per day	07.00 a.m.	36	–39	82%	28	–25	93%
5	2 Day per times	07.00 a.m.	42	–45	74%	35	–36	87%
Average			32.60	–32.40	86%	25.40	–21.80	92%

However, from comparing the appropriate variable of the moisture control prototype, it was found that the prototype 1 had the average growth rate at 86% which less than the average growth rate of prototype 2 which was at 92%. Since the moisture control prototype 2 was opaque and able to keep longer moisture as well as there were ventilators to lower the heat from evaporation of the ground surface. The suitable average temperature of vegetable growing was 25.40 °C [11, 18] and the suitable average moisture of vegetable growing was –21.80 centibar especially, in the watering system 2 times per day which was corresponding to the cultivating data with moisture control prototype 2 that the growth rate was high at 93 – 96%, the suitable temperature was 21 – 28 °C and the suitable moisture was –17 to –25 centibar. The reason that the growth rate of moisture control prototype 1 was not good since the moisture control system was translucent and this caused high temperature rapidly. Besides, it cannot ventilate the water vapor on the ground surface and produced the spontaneous heating that effected to the growing of vegetable and plant [19].

When comparing the use of the prototype humidity control unit. By selecting the best variant of each series, it can be seen that the prototype humidity control unit 1, the variable with the highest growth rate was 95% at 24 °C, and the humidity was –22 centibar. Watering 4 times a day, which affects the energy consumption and may result in a shortened life cycle of the device due to continuous operation. Compared with prototype humidity control unit 1, the highest growth variable was 96% at 25 °C and humidity was –20 centibar, requiring watering twice a day, resulting in less energy consumption. And affect the lifespan of the device for longer as well when finding the breakeven point of old agriculture Farmers can harvest about 500 kg per rai of vegetables at a time or sell it for a total of money 12,500 – 15,000 baht per rai, compared with the two prototype humidity control kits, farmers can harvest vegetables at a time of approximately 850 kg per rai or sell them for a total of money 21,500 – 27,000 baht per rai, and can save fuel costs completely. Save time for watering and agriculture, being able to grow vegetables in any season.

Results from technology transfer of moisture control prototype development.

In transferring technology of moisture control system with solar energy for renewable energy in drip irrigation to agriculturist's group at Khao Kho district, Phetchabun province, 20 participants were attended: 10 females and 10 males who the average age were 23 – 46 years old with working experience related to plant and vegetable growing from 3 to 10 years. From the evaluation of moisture control prototype technology transferring (Table 2), it was found that the average score from the level of satisfaction of participants was 4.35 and the standard deviation was 0.66 and the opinion level was in the high rank. When considering in each aspect, the highest mean was in satisfaction and utilization side which was 4.61, the standard deviation was 0.63, and the level of opinion was in the highest score [1, 2] because the soil moisture control prototype was able to apply in agriculture and obviously increased income to agriculturist.

Table 2 The results of the evaluation of questionnaires from technology transfer of the humidity control unit developed as a model.

Assessment details.	**($\bar{x}$)**	**(S.D.)**	**Conclusion**
The process of knowledge transfer.			
The speakers have sufficient knowledge for the training.	3.28	0.82	Moderate
The trainers have demonstration experience.	4.04	0.71	Good
The speakers have techniques and methods for transferring knowledge that are easy to understand.	4.86	0.60	Very good
Speakers have the ability to explain and answer questions.	3.93	0.74	Good
The media used for knowledge transfer is suitable for the topic of the training.	4.22	0.63	Good
The training period is reasonable.	4.94	0.57	Very good
Average	**4.21**	**0.67**	**Good**
Knowledge and understanding.			
Knowledge before joining the humidity control equipment technology training.	3.63	0.78	Good
Knowledge after joining the humidity control equipment technology training.	4.87	0.60	Very good
Average	**4.25**	**0.69**	**Good**
Satisfaction and utilization.			
He is satisfied with the technology transfer project and project activities.	4.85	0.63	Very good
You can apply the knowledge and technology gained in your daily life.	4.98	0.55	Very good
You can transfer the knowledge and technology that you have trained.	4.01	0.72	Good
Average	**4.61**	**0.63**	**Very good**
Average total.	**4.35**	**0.66**	Good

4. Conclusion

The growth rate of vegetable with the old method was about 55 – 72% which is less value and when comparing the growth rate of vegetable with two moisture control prototypes which gain higher growth rate at 74 – 96% and agriculturists can cultivate the vegetable around 850 kilograms per rai, sell 25 – 30 bath per kilograms, and earn 21,500 – 27,000 baht per rai. Moreover, this method can save fuel cost, save time in watering and can cultivate plants in every season.

From cultivating with the old method, the average height size of trunk was 30 – 47 cm which was less than using with two moisture control prototypes, especially with the prototype 2, the growth rate was consistency and the size of trunk was around 46 – 52 cm. From comparing two moisture control prototypes, the prototype 1 had the average growth rate at 86% which was less than the average growth rate of prototype 2 at 92%. The most appropriate variable for growing vegetable was the temperature at 21 – 28 °C, the suitable moisture at –17 to –25 centibar which produced the growth rate at 93 – 96%.

From moisture control technology transferring to agriculturist's group at Khao Kho district, Phetchabun province, the average satisfaction level was 4.35, the standard deviation was 0.66 and the level of opinion was in the high rank. The highest mean score was satisfaction and utilization aspect at 4.61, the standard deviation was 0.63 and the opinion level was in the highest rank.

5. Acknowledgement

The researcher would like to express my sincere thanks to Research and Development Institution Phetchabun Rajabhat University for supporting the budget of this research project for constructing potential knowledge as well as Industrial Electrical Technology majoring, Industrial Technology department, faculty of Agricultural and Industrial technology for supporting instruments and research tools. Additionally, pleasantly thanks to agriculturist's group at Sado Phong sub-district, Khao Kha district, Phetchabun province for giving information and apply the soil moisture control prototype with solar energy in drip agricultural irrigation. Finally, thanks for every suggestion and support in making this research successful.

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