Vegetable Production Using Energy-Saving Hydroponics Systems in Northeast Thailand

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Receibed September 29, 2000

Abstract

Energy-saving hydroponics system could be improved using soilless culture media made of local plant materials in Northeast Thailand. This hydroponics system was developed as a kind of capillary hydroponics system at the Okinawa Subtropical Station of JIRCAS in 1997. Several types of soilless culture media were examined to reduce the production cost of the hydroponics system in this study. Local materials used instead of polyester fibers as soilless culture media were as follows; fresh rice hulls, charred rice hulls, sugarcane bagasses, decomposed roselle stem residues, coconut coirs, coconut fibers and their mixture. The use of the medium consisting of a mixture of coconut coirs and charred rice hulls led to a high yield of tomato and enhanced the growth of melon. Melon produced fruits on coconut coir medium.

Key words: capillary hydroponics system, charred rice hull, coconut coir, soilless culture medium

Introduction

Hydroponics is one of the advanced cultural methods for high production of vegetables. However, current hydroponics systems require a large quantity of electricity and are difficult to operate. Sakuma (1997)[3] developed a capillary hydroponics system reffered to as "*Energy-saving hydroponics*" that does not require electricity for pumping the nutrient solution or oxygen into the system, which is achieved by gravity and capillary action. The capillary hydroponics systems which is simpler than the current hydroponics system enables to produce high-quality vegetables[1-2,4]. The hydroponics system using polyvinyl alcohol chips as soilless culture medium led to a high production of tomato, sweet potato, melon and Chinese mustard in Ishigaki Island, Okinawa Prefecture under subtropical climatic conditions[3]. Since our previous trial had been conducted within Ishigaki Island, all the necessary materials for the system could be easily prepared. However, it was difficult to introduce this system into the tropics due to the lack of availability of materials or their cost. Especially soilless culture medium made from polyvinyl alcohol chips is very expensive. Although we used polyester fibers instead of polyvinyl alcohol chips, the costs remained high.

In this study, we tried to cultivate vegetables with the energy-saving hydroponics systems using local plant materials available in Northeast Thailand as culture media. The soilless culture medium plays a role in the support of the root systems of plants. Since aeration and the supply of a nutrient solution by capillary action are necessary, chips or materials with a fiber shape should be used. Rice husks, sugarcane baggasses and roselle fibers can be easily obtained as by-products of crop production in Northeast Thailand. Coconut coirs and coconut fibers are also wastes from the coconut industry. These materials are cheap and commonly available in the tropics especially in this region. We examined the possibility of using such local materials as culture media instead of polyester fibers, which were used for the energy-saving hydroponics system in Japan.

Materials and Methods

The system was constructed in a net house in the experimental field of Khon Kaen Field Crops Research Center. The roof of the net house was covered with a transparent polyethylene sheet to avoid rain and also with a black nylon net to decrease the radiation level to 25%.

The system consisted of a culture bed, 200 liter solution tank, and adjusting tank as described in the previous paper[3]. The hydroponics system used in this experiment consisted of six culture beds and the size of one bed was 5.10-meter long $\times$ 0.6 wide $\times$ 0.15 deep. Liquid-absorbing sheet (Toyobo Co. Ltd., Osaka, Japan) and root barrier sheet (Toyobo Co. Ltd., Osaka, Japan) were brought from Japan. Both sheets are made of polyester. Other materials for the hydroponics system were obtained in local markets in Thailand.

The soilless culture medium was poured at a depth of about 10 - 15 cm on the root barrier sheet in the culture bed. Polyester fibers (Germbreaker, Toyobo Co. Ltd., Osaka, Japan) were used as a control medium. The materials for the media which were collected in Thailand were as follows; fresh rice hulls (FRH), charred rice hulls (CRH), sugarcane bagasses (SCB), decomposed roselle stem residues (DRS), coconut coirs (CC) and coconut fibers (CF). SCB and DRS were used after decomposition for six months. CC and CF were made from a coconut shell, CC is the inner side and CF is the outer side of a coconut shell. The CC fibers are finer than those of CF.

One bed was divided into three parts. Soilless culture media tested in this experiment were prepared from the above-mentioned media and their combinations (Table 2). The pH value and electrical conductivity (EC) of the individual materials were measured for substrates after soaking in distilled water at the ratio of 1:2.5 (substrate: water) by a simple method (Table 1).

Two chemical liquid fertilizers were used as culture solution; solution No. 1 (Otsuka House No. 1, Otsuka Chemicals Co. Ltd., Osaka, Japan) containing N: 10%, P_2O_5: 8%, K_2O: 27%, MgO: 4%, MnO: 0.10%, B_2O_3: 0.10%, Fe: 0.18%, Cu: 0.002%, Zn: 0.006% and Mo: 0.002% and solution No. 2 (Otsuka

Table1. pHEC and moisture content of the materials used as soilless culuture media for hydroponics system

Materials	pH	EC (mS/cm)	Moisture (% fresh weight/dry weight) 0cm on surface	5cm in depth	10cm in depth
Polyester fibers	5.9	0.012	129	618	469
Decomposed roselle stems	8.3	1.041	17	282	1000
Fresh rice hulls	7.1	0.483	15	76	143
Sugar cane bagasses	6.2	0.112	13	356	214
Coconut coirs	6.8	0.734	76	488	607
Charred rice hulls	7.2	0.064	406	403	769

Table2. Yield and components of tomato, melon and Chinese mustard in relation to the use of different soilless culture media

		Tomato		Melon		Chinese mustard
Bed number	Medium	Height (cm)	Fruit fresh weight (g)/ plant	Height (cm)	Fruit fresh weight (g)	Fresh weight (g)/ plant
1	Polyester fibers	76	1303	65	0	50
	FRH	27	0	48	0	0
	FRH+SCB	33	261	105	0	0
2	Polyester fibers	61	662	98	0	31.8
	CC	18	171	80	1230	0
	CC+CRH	46	616	137	0	0
3	Polyester fibers	63	26	145	0	4.1
	DRS	0	0	59	0	0
	DRS+SCB	18	0	82	0	0
4	Polyester fibers	61	445	81	0	12
	SCB	19	150	114	0	0
	CC+FRH	39	393	45	0	0
5	Polyester fibers	54	600	127	0	24.3
	SCB+CF	23	108	115	0	0
	CC+CF	33	238	90	0	0
6	Polyester fibers	53	397	105	0	23.7
	CRH	55	477	128	0	0
	CRH+FRH	53	238	25	0	0

Remarks; CC: cocount coirs, CF: coconut fibers, CRH: charred rice hulls, DRS: decomposed roselle stem residues, FRH: fresh rice hulls, SCB: sugarcane bagasses. Plant height of tomato and melon was measured 45 days after planting. Chinese mustard wass harvested 45days after sowing.

House No. 2, Otsuka Chemicals Co. Ltd., Osaka, Japan) containing N: 11% and CaO: 23%. Three kg of solution No. 1 and 2 kg of solution No. 2 were diluted with 20 liter of water, respectively. One liter of solution No. 1 and one liter of solution No. 2 were diluted with water to prepare a 200 liter culture solution in the culture solution tank.

Four plants from the tomato cultivars, 'Valentine' (Thai variety), 'Sekaiichi', 'Kyouryokubeiju', 'Yellowpair' (Japanese varieties), and one plant of muskmelon (cv. 'Arlesdarling', Japanese variety), were transplanted in various culture media. Some seeds of Chinese mustard were directly sown on the soilless culture medium. The vegetables were cultivated from October 1999 to January 2000.

Results and Discussion

When polyester fibers were used as soilless culture medium in this system, tomato and melon grew well (Fig. 1, Table 2). Among the local materials, tomato showed a similar growth when CRH, CC+CRH and CRH+FRH were used. The highest yield and growth of tomato (17 fruits and 616 g per plant) were observed in a combination of CC+CRH (Table 2). In the case of melon, SCB, FRH+SCB, SCB+CF, CC+CRH led to a similar growth to that of polyester fibers. Only one melon plant growing on coconut coir could produce a fruit weighing 1,230 g with a Brix value of 13 for the sugar content (Fig. 2). However, other melon plants were infected with powdery mildew and did not produce mature fruits. The growth of Chinese mustard on the local materials was very poor compared with the use of polyester fibers. The yield of Chinese mustard cultured on polyester fibers which were used for the

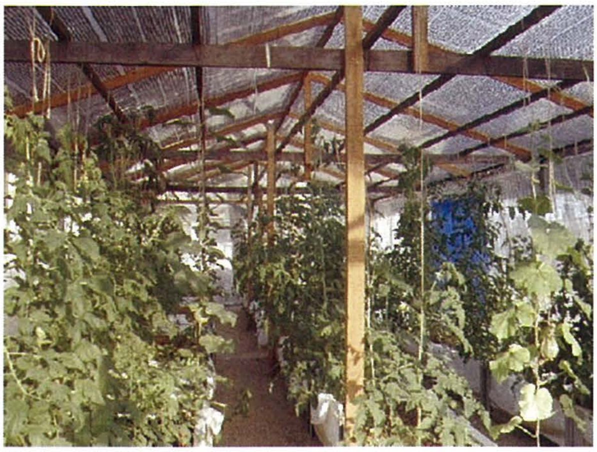

Fig.1. Vegetable production using energy-saving hydroponics systems in Northeast Thailand.

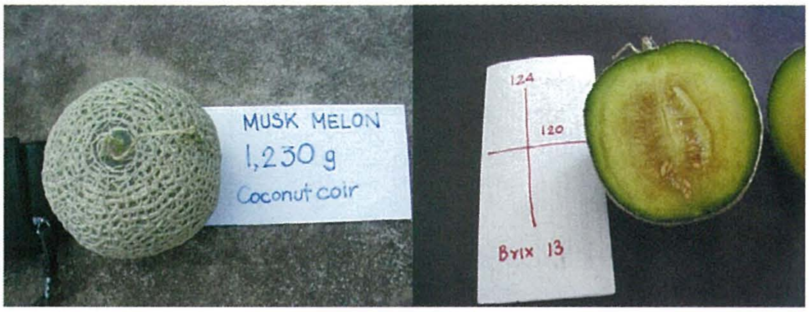

Fig.2. Melon fruit produced on coconut coir medium for energy-saving hydroponics systems.

bed of DRS and DRS+SCB was very low. The pH of the solution in the adjusting tank exceeded 7. The bottom of the soilless culture medium in DRS was very wet. Since decomposed roselle stem residues affected the pH of the culture solution in the canal and the solution in the adjusting tank, this material was not suitable as soilless culture medium.

The energy-saving hydroponics systems with polyester fibers was could be used for vegetable production in the tropics. Since the polyester fibers are fine, good aeration occurred through the fibrous materials and the solution was transferred by capillary action. It is necessary to keep a moderate level of moisture for a soilless culture medium for the aeration and absorption of the solution. However there were some shortcomings in the cultivation of crops when local plant materials were used. For example, Chinese mustard could not grow well on the local materials, since seeds of Chinese mustard were sowed directly on the surface of the medium. The surface of DRS, FRH, and SCB was too dry for the seedlings to grow normally. The leaf color changed to yellow in the case of CRH, presumably due to the high pH value.

The use of a CC+CRH medium led to a good yield of tomato and adequate melon growth. A melon fruit could be harvested in CC. Teo and Hoe (1993)[5] reported that cocopeat, either singly or in a mixture with charcoal dust, could be used for growing tomatoes. In our experiment, the plant growth was also better in the CC+CRH mixture than on CC. The CC medium showed a high EC, when the CRH content was low. The moisture level of the surface in CRH was higher than that in polyester fibers, while CC showed a lower moisture content than polyester fibers. It is assumed that the combination of these materials provided better conditions for the cultivation of tomato and melon. The mixture ratio of these materials should be further examined and improved to provide good growth conditions for achieving high yield.

The results of the experiment show that the most promising local materials available in Northeast Thailand were coconut coirs and charred rice husks. Coconut coir is a commonly available and cheap material in the region, since it is a waste product from the processing of coconut seeds. Rice husks can also be obtained easily. The pH value of CRH was slightly higher for vegetable cultivation, though rinsing with water before use, the pH could be decreased. The system would be suitable for farmers engaged in vegetable production in Northeast Thailand, if the production cost could be markedly reduced by the use of local plant materials as soilless culture media. The system could be introduced to tropical areas with a long dry season and problem soils, since water can be used efficiently.

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東北タイにおける省エネルギー型養液栽培装置利用による野菜生産

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摘　要

熱帯地域の東北タイにおいて、JIRCAS 沖縄支所で開発した省エネルギー型養液栽培装置を組み立て、トマト、メロン、チンゲンサイの栽培を行った。栽培装置組み立てには、防根透水シート、不織布（吸水シート）は日本製のものを、その他の資材は現地で調達したタイ製のものを用いた。日本製のポリエステル繊維を栽培培地に用いた場合の野菜の生育は良好であった。システム製造のコストダウンをはかるため、現地で安くて入手が簡単な、籾殻、籾殻燻炭、サトウキビバガス、ケナフ茎、ココナッツコイア、ココナッツ繊維やその混成物などを培地として検討した。ココナッツコイア、ココナッツコイアと籾殻燻炭の混成物を培地にしたときトマト・メロンの生育は良好であったが、その他のものでは不良であった。ココナッツコイアの培地ではメロンの果実を収穫した。ココナッツコイアは培地として通気性にすぐれ、籾殻燻炭を加えることで保水性が増加し、養液栽培培地として適当であると考えられた。

キーワード：ココナッツコイア、毛管水耕、養液栽培培地、籾殻燻炭