Annals of Tropical Research 27(2):18-30

Evaluation of a simple re-circulating hydroponic system for sweet pepper (*Capsicum annum* L.) and pechay (*Brassica napus* L.)

Misael T. Diputado, Jr.[1], Manolo B. Loreto, Jr.[2] and Jonathan I. Mangmang[1]

[1]Dept. of Horticulture, Leyte State University, Baybay, Leyte, Philippines, [2]Dept. of Ag. Engineering and Science Research Assistant, Leyte State University, Baybay, Leyte, Philippines

ABSTRACT

Diputado, M. T. Jr., M. B. Loreto Jr., and J. I. Mangmang.2005. Evaluation of a simple re-circulating hydroponic system for sweet Pepper (*Capsicum annum* L.) and pechay (*Brassica napus* L.)*Ann. Trop. Res.* 27 (2):18-30

This study assessed the growth, yield and profitability of sweet pepper and pechay grown in a simple, locally designed re-circulating hydroponics system (RHS) provided with coarse river sand and coco-coir dust as aggregates at different ratios. The system consisted of 6 pans (40-cm wide, 2.2 m long, 10 cm deep) made of galvanized iron (G.I.) sheets. The nutrient solution is delivered from a plastic drum by gravity to the aggregates through a system of polyvinyl chloride (PVC) pipes provided with small holes. Each end of the pan is provided with a hole where excess solution drains into a collecting container, which is then re-circulated back into the drum. The performance of the crops under this system was compared to those grown under the conventional (soil-grown), and Simple Nutrient Addition Program (SNAP) hydroponics system.

Pechay plants grown in the RHS were taller, produced more leaves, had faster growth and development and had higher yield compared to those grown in SNAP hydroponics and conventional system. Sweet pepper plants grown in the RHS also had better growth and higher yield compared to the SNAP hydroponics and conventional production systems. The ratio of coarse sand and coco-coir dust as aggregate for the RHS did not significantly affect growth and yield of the two crops. A projected cost and return analysis considering a pechay-pechay-sweet pepper-pechay-pechay-sweet pepper 1-year crop rotation scheme revealed that the use of RHS had higher profitability compared to the other two production systems.

Keywords: sweet pepper, pechay, hydroponics, coco-coir dust

*Correspondence:*M. T. Diputado. *Present Address:* Dept. of Horticulture, Leyte State University, Baybay, Leyte, Philippines 6521-A. *Tel. No.*(053)335-2628.

INTRODUCTION

There are many problems associated with the conventional way of growing vegetables in the soil. The soil may be acidic, contain exceptionally low amount of nutrients, or harbor pests or disease inoculum that would greatly reduce the chance of profitable crop production (Resh, 1989). Also, in urban areas, the area for conventional crop production may be limiting. An alternative way of growing vegetables that would overcome many of these constraints is hydroponics. Hydroponics is a technique for crop production using no soil. In this method, crops are grown in nutrient solution or on a proper medium where crops are planted and nutrient solution is applied. Although this method is costly when it comes to preparing the growing systems, such work as inter-tillage and weeding and almost all of the management works on fertilizing and watering are eliminated, thus saving on labor cost. The additional advantages of this system are the very efficient use of water and fertilizers (Gericke, 1999) and higher density planting leading to increased yields of crop per unit area (Jefferson, 1999; Jensen, 1994; Imai, 2000; Mohyuddin and Younus, 1999)

Most re-circulating hydroponics systems, however, are rather sophisticated and costly to establish and utilize aggregates such as pumice, vermiculite, perlite or rockwool, which are also expensive and difficult to obtain locally. The challenge therefore is to design a hydroponics system, which is not only efficient but also less costly and easily obtainable locally in order to bring the technology to ordinary farmers. The choice of the medium is also determined by its cost, availability, quality and the type of hydroponics structure to be used (Resh, 1993). Some of the aggregates that can potentially replace the more expensive ones are coir or coir pith (Martinez, *et al.*, 1997) and coconut fiber wastes (Norguera, *et al.,* 1996).

This study evaluated the cost-effectiveness of a locally designed, simple re-circulating hydroponics system using locally available materials like large plastic drum to store the nutrient solution, galvanized iron sheets lined with plastic for the pan to hold the aggregates composed of coarse river sand and coconut coir dust. The effectiveness of such system was compared to the conventional system of growing plants in the soil, and to that of the recent technology called, the SNAP (Simple Nutrient Addition Program) hydroponics system which has also shown good potential for use because of its simplicity

(Santos and Ocampo, 2002).

This study used sweet pepper and pechay as test crops because they have relatively simple cultural management requirements and have short maturity period, aside from the fact that they are among the most nutritious and popular vegetables in the country.

MATERIALS AND METHODS

Test crops

Pechay (*Brassica napus* L.) variety "Black Behi" and sweet pepper (*Capsicum annum* L.) var. Hybrid Bless were used as the test crops in the study. Only one cropping of both crops was done with pechay as the first and sweet pepper as the second crop.

Seedling production

Seeds of pechay or sweet pepper were sown in seed boxes filled with heat sterilized mixture of garden soil, compost and sand at 1:1:1 ratio. The seed boxes were placed under a structure of plastic roofing to protect the seedlings from rain and direct sunlight. The seedlings were pricked by transferring healthy individual seedling into propagation cells upon reaching the true-leaf stage. A starter solution of one tablespoon urea (45-0-0) dissolved in one gallon of water was applied to the seedlings 3 days after germination. The seedlings were hardened 5 days before transplanting. This was done by gradual exposure of the seedlings to sunlight and withdrawal of water until they show signs of temporary wilting.

Experimental design and treatment

The experiment was laid out in a simple Randomized Complete Block Design (RCBD) with three replications. The following were the treatments:

M_1 = Conventional (soil culture in pots for pechay and soil culture for sweet pepper)
M_2 = SNAP hydroponics
M_3 = Re-circulating hydroponics system (RHS) with 1:1

ratio of coarse sand + Coco Coir Dust (CCD)
M_4 = RHS with 1:3 ratio of coarse sand + CCD
M_5 = RHS with 3:1 ratio of coarse sand + CCD

The study on pechay and sweet pepper were treated as two separate experiments.

Re-circulating hydroponics system

Six pans (40 cm wide, 2.2 m long, 10 cm deep) made of G.I. sheets were constructed. These were lined with plastic sheet then filled with the medium based on the treatment. Each pan was divided into three sections to correspond to the three media treatments.

A large plastic drum served as reservoir of the nutrient solution. The solution was made to flow into the pans by gravity through a system of pipes provided with tiny holes so that solution is released to the medium in trickle. A hole was provided at the end of each pan so that excess solution is drained into a collecting container, which is then re-circulated back into the drum (Figure 1).

Nutrient source

The following sources of nutrients were used:

Material	Amount (g/100 L)
Peters Hydrosol	96.00 g
Magnesium Sulfate (MgSO4)	10.00 g
Ferrous Sulfate	2.00 g
Peters Calcium Nitrate	96.00 g

These nutrient sources result to an electrical conductivity of 2.14 millimhos/ cm and the following elemental nutrient concentrations:

Nutrient	*Concentration (ppm)*
Nitrogen	200.00
Phosphorus	8.00

Potassium	210.00
Calcium	193.00
Magnesium	40.00
Sodium	3.60
Sulfur	53.50
Boron	0.50
Chloride	0.40
Copper	0.15
Iron	5.00
Manganese	0.50
Molybdenum	0.10
Zinc	0.15

Set-up of SNAP hydroponics system (Santos and Ocampo, 2002)

Empty styropor fruit boxes (30 cm x 40 cm)were used to hold approximately 7 liters of nutrient solution. These were lined with .005-mm polyethylene plastic. Holes (2-3 cm diameter) were provided in the cover of styropor box in order to have ventilation. Additional holes were made to hold the syropor cups where the vegetable seedlings were grown.

The styropor cups (6 oz - capacity) were used to contain the vegetable seedling. Holes were provided at the bottom of the cups and a screen net was placed to cover the holes. The styropor cups were then half-filled with coco coir dust. The bottom of the cups was always immersed in the solution especially if the roots have not developed extensively yet. Upon development of the roots, the solution was maintained 2-4 cm between the bottom of the cup and top of the solution. The setup is shown in Fig.2. The same nutrient solution used in re-circulating hydroponic solution was also used as source of macro and micronutrients until flowering. About 9 liters of the solution were prepared then poured into the styropor fruit boxes. Replenishment of four liters solution was done every two weeks. Solution pH was monitored every week.

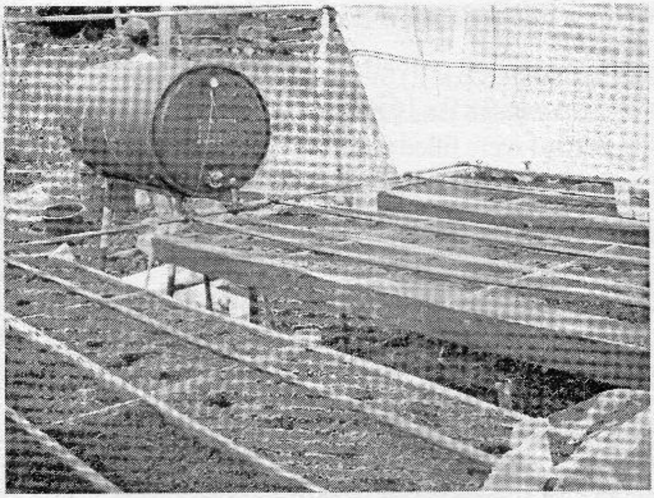

Figure 1. The re-circulating hydroponics structure

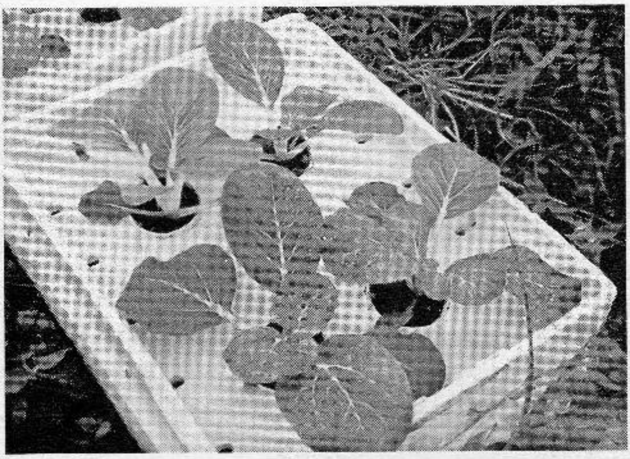

Figure 2. The SNAP hydroponics setup

Conventional cultivation system

The dimension of polyethylene plastic containers used under conventional system was 9 x 9 x 16 inches. There were two plants per container. The polyethylene bags were filled with garden soil medium up to 3.5 cm below the mouth. Equal volume of medium was placed per bag per crop. The fertilizer rates applied for the crop was 120-60-6 kg N, P_2O_5, K_2O/ha. The amount of fertilizer that was applied per pot was based on the amount that each plant is supposed to receive in the field given the recommended fertilizer rate and the population density per hectare. All fertilizer materials were mixed with the soil before planting.

Transplanting

The seedlings were transplanted to the pans, the styropor box or in polyethylene plastic container depending upon the treatments. There were 8 and 4 pechay and sweet pepper plants, respectively, per treatment per replicate.

Harvesting

Pechay was harvested 21 days after transplanting. Harvesting was done by cutting the base of the plants with a sharp knife. These were sorted and classified into marketable and non-marketable plants. Marketable plants were those that were free of diseases and mechanical damage.

RESULTS AND DISCUSSION

Plant height and number of leaves of pechay

Table 1 shows the average plant height and number of leaves of pechay grown under conventional system, in SNAP hydroponics and re-circulating hydroponics (RHS) with various amount of coco coir dust. As early as the 1st week from transplanting, differences in plant height and number of leaves were already evident. Pechay grown on RHS were taller and had more leaves than those grown in container with soil and SNAP hydroponics. The differences

Table 1. Plant height (cm) and number of leaves of pechay grown under hydroponics and conventional production system

Treatment	Weeks after transplanting					
	Plant height (cm)			Number of leaves		
	1	2	3	1	2	3
M_1 - Conventional system	12.54bc	23.65b	26.09b	3.73b	5.80b	9.20c
M_2 - SNAP hydroponics	11.62c	20.22c	23.64b	3.47b	5.60b	10.33b
M_3 - 1:1 (sand &CCD*)	16.15a	28.55a	32.38a	5.47a	7.60a	11.20ab
M_4 - 1:3 (sand &CCD*)	14.66ab	27.45a	31.75a	5.00a	7.20a	11.67a
M_5 - 3:1 (sand & CCD*)	15.90a	28.43a	32.67a	5.60a	7.80a	11.80a
CV (%)	9.85	6.36	6.42	13.24	9.71	5.02

Means within a column having the same letter(s) are not significantly different at 5% level of significance on DMRT

CCD - coco coir dust

* - under re-circulating hydroponics

persisted through the 2nd and 3rd week. Pechay grown in SNAP hydroponics were the shortest but had comparable number of leaves with those under the conventional system.

Marketable yield of pechay

Table 2 shows that pechay plants grown under the RHS regardless of medium used were heavier compared to the conventional and SNAP hydroponics system. Plants under the latter two production systems had comparable yields. The proportion of coarse sand and coco coir dust as aggregates did not significantly affect marketable yield of the crop. This shows that the two media mixed at any ratio can be suitable aggregates for the RHS. However, for practical purposes, the mixture with more coarse sand than coco coir dust would be a better aggregate since this is expected to be more stable. Sand, unlike coco coir dust, is inert and not subject to decomposition.

Plant height of sweet pepper

Table 3 shows the plant height of sweet pepper planted after pechay.

Table 2. Yield of pechay grown under hydroponics and conventional production system

Treatment	Weight of marketable plant (g/plant)
M_1 - Conventional system	53.33b
M_2 - SNAP hydroponics	56.957b
M_3 - 1:1 (sand &CCD*)	156.95a
M_4 - 1:3 (sand &CCD*)	142.50a
M_5 - 3:1 (sand & CCD*)	155.00a
CV (%)	14.69

Means within a column having the same letter(s) are not significantly different at 5% level of significance on DMRT

CCD - coco coir dust

* - under re-circulating hydroponics

Plant height did not vary too much in plants grown under the three production systems, especially during the 5th week or at the peak vegetative stage of the crop. On the first week after transplanting, plants under the SNAP hydroponics were the shortest although not significantly different from those under RHS with 1:1 ratio of sand and coco coir dust. On the third week, soil-grown plants were the shortest although just comparable with those under the SNAP hydroponics system and those under RHS with 1:1 ratio of coarse sand and coco coir dust.

Yield and yield components of sweet pepper

Plants under the RHS produced more and heavier marketable and non-marketable fruits compared to the SNAP hydroponics and conventional system (Table 4). Under the RHS, plants grown on different ratio of sand and coco coir dust as aggregates had comparable number and weight of marketable and non marketable fruits. The conventional and SNAP hydroponics system had comparable number and weight of marketable and non marketable fruits. Fruit size, in terms of fruit diameter, were bigger in plants under the RHS than in the other two production systems. Herbage weight was not significantly

Table 3. Average plant height (cm) of sweet pepper grown under hydroponics and conventional production system

Treatment	Weeks after transplanting		
	1st	3rd	5th
M_1 - Conventional system	36.74a	50.72c	74.00
M_2 - SNAP hydroponics	31.80c	54.85b	76.87
M_3 - 1:1 (sand &CCD*)	36.63bc	56.47bc	68.62
M_4 - 1:3 (sand &CCD*)	36.41c	58.02ab	73.09
M_5 - 3:1 (sand & CCD*)	38.26a	63.36a	77.80
CV (%)	4.25	5.89	11.22

Means within a column having the same letter(s) are not significantly different at 5% level of significance on DMRT

CCD - coco coir dust

* - under re-circulating hydroponics

Table 4. Yield and yield components of sweet pepper grown under hydroponics system and soil culture

Treatment	No. of mrktble fruits /plt	Wt. of mrktble fruits (g/plt)	No.of non-mrktble fruits /plt	Wt. of non-mrktble fruit (g/plt)	Fruit size (cm) Length	Dia-meter	Herbage wt. (g)
-Conventional	14.33bc	183.75b	7.75bc	70.25c	7.27	2.96c	784.00
-SNAP	9.33c	107.00b	6.16c	60.33c	6.60	2.99bc	316.00
-1:1 (sand &CCD)	22.83ab	98.58a	14.08a	136.83ab	8.106	3.48abc	574.33
-1:3 (sand &CCD)	24.33ab	296.25a	12.00ab	100.92bc	8.194	3.53ab	580.00
-3:1 (sand & CCD)	28.50a	354.25a	13.83a	147.42a	8.41	3.87a	659.67
CV (%)	23.25	18.35	25.74	21.42	12.06	8.36	659.67

Means within a column having the same letter(s) are not significantly different at 5% level of significance on DMRT

CCD - coco coir dust

M3 – M5 are under re-circulating hydroponics affected by the production system.

Results thus indicate that the RHS system favored not only the growth and development of both pechay and sweet pepper but also their yield and, in the case of sweet pepper, its yield components.

Cost and return analysis

The projected cost and return analysis considers a one-year *pechay-pechay-sweet pepper–pechay–pechay–sweet pepper* crop rotation scheme utilizing ten (10) units of re-circulating hydroponics structure. This means growing 1,440 pechay and 720 sweet pepper plants per cropping. Table 5 shows that the production cost under the RH system was higher because of the cost of the structure, although its field labor requirement was lower compared to the conventional system. The cost for the structure and other long lasting materials was estimated based on straight-line depreciation cost.

Based on the projected cost and return analysis (Table 6), the use of RH results in higher net income than the SNAP hydroponics and conventional systems.

It should be noted, however, that under the conventional system pechay was grown in container which may not be as cost-effective as when grown directly in the soil.

Under the RH system the use of 3:1 sand to CCD mixture as aggregate had the highest net income because of slightly higher yield and least cost.

CONCLUSIONS AND RECOMMENDATIONS

The use of a simple, locally designed re-circulating hydroponics system promoted faster growth and higher yield and profitability in pechay and sweet pepper than did SNAP hydroponics and conventional production systems. It is recommended that high value vegetables like lettuce, cauliflower, broccoli, and others be tested. Also, other readily available aggregates like crushed pebbles, and rice hull should be tried.

Table 5. Production cost of pechay and sweet pepper following a pechay-pechay-sweet pepper-pechay-pechay-sweet pepper crop rotation scheme under hydroponic andconventional production systems

ITEM	Crop Production Cost Per 10 RH Units/Year (PhP)* Treatment				
	M_1	M_2	M_3	M_4	M_5
Supplies and materials					
Fertilizer	2,760	9,120	12,120	12,120	12,120
Coco-coir dust	–	200	2,400	3,600	1,800
Seeds	2,000	2,000	2,000	2,000	2,000
PE bags**	360	--	--	--	--
Styropor box***	--	1,000	--	--	--
RH unit****	--	--	12,000	16,770	16,770
Field Labor	21,600	12,000	12,000	12,000	12,000
Total Cost	26,720	24,320	45,290	46,490	44,690

Table 6. Analysis of the projected cost and returns of P-P-SP-P-P-SP crop rotation scheme for one year under different produciton systems per 10 units of re-circulating hydroponics structure

Treatment	Total Cost* (PhP)	Gross Income** (PhP)	Net Income (Php)
M_1 - Conventional	26720	27996	1276
M_2 - SNAP	24320	24766	446
M_3 - 1:1 (sand &CCD)	45290	58915	13625
M_4 - 1:3 (sand &CCD)	46490	45612	9122
M_5 - 3:1 (sand & CCD)	44690	64454	19764

*Includes material and field labor cost; 4 and 2 croppings pf pechay and sweet pepper per year, respectively

** based on 1440 pechay and 720 sweet pepper plants which are th enumber that can be accommodated in 10 untis hydroponics structure; based on market price of pechay and sweet pepper which are PhP30/kg and Php80/kg, respectively

REFERENCES

GERICKE, W.F. 1999. A Complete Guide to Soilless Gardening. Prentice Hall, New York.

IMAI, H. 2000. AVRDC Non-circulating Hydroponic System. www.hydropfarm.com.au/back_issue.html.

JEFFERSON, E. 1999. Thriving on a Survival Garden, Growing Edge. New Moon Publishing, Corvallis, *OR* **10**(6):44-45.

JENSEN, M.H. 1990. Hydroponic Culture for the Tropics: Opportunities and Alternatives. International Seminar on Hydroponic Culture of High Value Crops in the tropics. 25-27 Nov. 1990. PPPL, UPM, Serdang Selangor, Malaysia

MARTINEZ, F.X., N. SEPO, and J. VALERIO. 1997. Physical and physiochemical properties of peat-coir mixture and the effects of clay-material addition. Proceedings of the International Symposium on Growing Media and Plant Nutrition in Horticulture. *Acta Hort.* **450**:39-46.

MOHYUDDIN, M. and M. YOUNUS. 1999. Overvirew of the Greenhouse Vegetable Industry in Alberta. Canada. Proceedings of the International Symposium on Growing Media and Hydroponics. Ed. A.P. Papadopoulos. *Acta Hort.* **481**.

NORGUERA, P., M. ABAD, R. PUCHADES, V. NORGUERA, A. MAQUIFERA and J. MARTINEZ. 1997. Physical and chemical properties of coir waste and their relation to plant growth. Proceedings of the International Symposium on Growing Media and Plant Nutrition in Horticulture. *Acta Hort.* **450**:365-373.

RESH, H.M. 1989. Hydroponics Food Production. A Definite Guidebook of Soilless Food Growing Methods. Woodbridge Press Publishing Co. 426.pp.

SANTOS P.J.A. AND E.T.M. OCAMPO. 2002. SNAP Hydroponics (A leaflet). Institute of Plant Breeding, College of Agriculture, U.P. Los Baños, College, Laguna