MAURITIUS RESEARCH COUNCIL

DEVELOPMENT OF A HYDROPONIC PRODUCTION SYSTEM FOR INTENSIVE HOME GARDENING

Final Report

March 1999

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AGRICULTURAL RESEARCH AND EXTENSION UNIT

Food and Agricultural Research Council

Development of a Hydroponic production system for intensive home gardening

Project Contract 95/33

End Of Project Report

by

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Table of Contents

Executive Summary

There is a growing interest among local growers and the public in general for soilless culture. Until now very little research has been carried out in this field in Mauritius. The following study was undertaken in order to provide some useful information on this new technology.

The project objectives were:

- To show that hydroponics can be an acceptable alternative to conventional method of vegetable production
- To provide a part-time activity to the housewife
- To provide an opportunity to the public to produce fresh vegetable for self-consumption

The project activities consisted of trials to:

- evaluate the possibility of using locally available substrates as soilless media to investigate two different systems of production, namely the planting bed method, which can be constructed over unproductive land or on house-tops, and the wick method, which can be set up in restricted areas in households

The substrates that were evaluated included sugar-cane by-products, gravel and sawdust with soil as a control. The planting bed method was set up on marginal land at Reduit Crop Research Station where the following crops were grown: lettuce, sweet pepper, bean and cauliflower. The wick method was set up under a covered structure at Wooton Crop Research Station where crops like tomato, strawberry, sweet pepper and bean were grown. Except for bean, which was directly sown, all the other crops were first sown in field and roots of seedlings were washed to remove all soil particles before transplantation. The plants were fertilized using commercially available hydroponics solution.

Results obtained from trials set on both the planting bed and the wick system showed that organic media like flyash and scum, used singly or in combination with bagasse or an inert substrate (like gravel) can be used as rooting media in soilless culture. Substrates differed in such characteristics as water holding capacity and decomposition rate. Organic media like scum and flyash retained moisture for a longer period but had a faster rate of decomposition as compared to gravel. In general scum and flyash gave better yields than gravel but had to be replaced each year because they decomposed more rapidly. Gravel had the advantage of being inert, (did not decompose), was easily available and could be sterilized after each cultivation. The low nutrient retention capacity of gravel could be overcome by a regular application of small quantities of hydroponics nutrient solution.

It can be concluded that the planting bed method is more appropriate for marginal lands owned by small commercial growers or in households, whilst the wick method is more suitable for backyard activity or home gardening.

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(ii) the management of AREU/FARC for their support,

(iii) the Station Managers and staff of Reduit Crop Research Station and Wooton Crop Research Station for their help during implementation

(iv) the Agricultural Chemistry Division of the Ministry of Agriculture, Food Technology and Natural Resources for assistance provided with respect to chemical analysis.

1 INTRODUCTION

1.1 Project description

In Mauritius land shortage is one of the major limiting factors to agricultural development. Greater attention is therefore being given towards maximizing the use of marginal lands and unexploited areas in household unit for vegetable production. In this context, a preliminary study was conducted lo evaluate the possible implementation of soilless culture for the production of vegetables.

Soilless culture or hydroponics is the science of growing plants in a medium, other than soil, using mixtures of the essential plant nutrients elements dissolved in water. Up to now very little research has been carried out in this field in Mauritius. This study was started with certain specific objectives.

1.2 Project objectives

- To show that hydroponics can be an acceptable alternative to conventional method of vegetable production
- To provide a part-time activity to the housewife
- To provide an opportunity to the public to produce fresh vegetable for self-consumption
- To rehabilitate unproductive land, particularly at home level

1.3 Project activities

The study aims at

- evaluating the potential of locally available substrates for use as soilless media (substrates) under two different systems of production, namely: the planting bed method, which can be constructed over unproductive land or on house-tops, and the wick method, which can be set up in restricted areas in households

1.4 Sites

Trials on the planting bed method were set up at Reduit Crop Research Station, where, chinese green, lettuce, sweet pepper, bean and cauliflower were grown.

The wick method was studied at the Wooton Crop Research Station, bean and sweet pepper were grown. Trials were also conducted with tomato and strawberry but could not be followed till completion due to cyclone damage and pest and disease occurrence respectively.

2 MATERIALS AND METHODS

The growing media evaluated were analyzed to determine the pH, EC, total nitrogen, available phosphorus and potassium, organic matter and organic carbon contents, as well as the C/N ratio.

Two different methods were used to raise the seedlings and these were the planting bed method at Reduit and the wick method at Wooton.

2.1 The planting bed method

The planting beds comprised two rows of interlocking concrete blocks raised on the soil surface. This gave rise to a basin to contain the growing medium under test. Each bed was l 0111 long and lm wide with slope crossways towards the center so as to provide a central drainage channel. The bed was lined up with polyethylene plastic sheet so as to isolate the substrate under study from the soil below and from the sides of the bed. One side of the bed was closed with concrete blocks while the lower end was boarded using wooden planks. A PVC tube of length 30-cm was glued to the lower encl to provide a drainage outlet.

Statistical design: Randomized Block design with three replicates

Experimental Treatments: Gravel, Scum, Flyash and Soil (Control)

Crops grown: Lettuce, Sweet pepper, Bean and Cauliflower

2.2 The Wick method

In this method two containers were used. One of the containers (planting pots) was used to hold the growing medium while the nutrient solution was placed in the second container (planting pot / tray) which acted as a reservoir. Holes were drilled in the first planting pot which held the growing medium. The wick was thread through the holes in such a way that three-quarters of the wick was in the rooting substrate and the rest was hanging into the nutrient solution. The plant took up the nutrient by the capillary action of the rooting medium. The substrate was soaked two days prior to planting. Nutrient was added once the reservoir was depleted.

Statistical design: Randomized Block design with three replicates

Experimental Treatments: The substrates were evaluated singly and in different combinations. The details are given in the respective sub• sections.

- Treatments (singly): Bagasse, Scum, Flyash, Sawdust, Gravel and Soil (Control).

Crops grown: Bean, Tomato and Strawberry

Treatments (in different combinations): Bagasse, Flyash, Scum, Bagasse + Flyash, Bagasse + Scum, Flyash + Scum, Bagasse + Flyash + Scum, Sawdust, Gravel and Soil (Control).

Crops grown: Bean and Sweet pepper

2.3 Cultural practices

Fertigation

All the elements needed by the plants to grow and produce fruits were provided by hydroponics nutrient solution available commercially. It was assumed that all the treatments were inert. The composition of this solution is given in Appendix 1.

Weeding

Weed was not a problem in the double pot wick system. However in the planting bed system. manual weed control had to be carried out often to keep the weeds from affecting the crops.

Pest and disease control

All pests and diseases encountered during the trials were controlled as per recommendations given in "le Guide Agricole".

3 RESULTS AND DISCUSSION

3.1 Substrate Analysis

Substrates were sent to the Agricultural Chemistry Division of the Ministry of Agriculture for analysis and the results are given in Tables 1, 2 and 3.

Results of the analyses indicate that the organic substrates like flyash, scum and bagasse did contain higher levels of nitrogen (N), phosphorus (P), potassium (K), organic carbon (C) and organic matter (OM) than soil. The pH of these substrates ranged from 5.7 to 7.2 and was therefore favourable for growing a wide range of crops.

A potential problem associated with these organic substrates is that they have a high C/N ratio, in which case nitrogen should be added so that the plants do not suffer from nitrogen deficiency. Gravel is inert and has an alkaline pH, which can be controlled by

Table 1 :Chemical composition and characteristics of substrates

Treatments Growing media	pH	E.C.25C mhos	Total N •;.	p Ppm	Kme "/0	Org. C %	Org. M%	*CIN* Ratio
Fly ash	6.4	15.67x100	0.58	3365	19.3	8.76	15.23	15.15
Scum	5.7	19.97xl 00	1.28	5661	9.70	11.20	19.51	8.75
Gravel	6.5	-	-	-	-	-	-	-
Soil	7.2	8.13x100	0.61	2411	7.50	4.94	8.60	8.09

Table 2: Results of chemical analysis for substrates (used singly)

Treatments Growing media	pH	E.C.25C mhos	Total N%	p Ppm	K me%	Org. C%	Org. M%	C/N Ratio
Bagasse	6.0	5.0x100	0.45	306		18.5	31.89	4.76
Fly ash	7.5	11.0x100	1.52			12.43	21.27	3.70
Scum	8.0	6.0x 100	0.27			5.00	8.62	6.17
Sawdust	4.3	3.8x l 00	0.14	98	nil	26.95	57.36	33.27
Gravel	7.3							
Soil	4.6	5.5x 100	0.35	165	0.39	5.00	8.62	2.53

Table 3: Results of chemical analysis for treatments (used in combinations)

Treatments Growing media	pH	E.C.25C mhos	Total N%	p Ppm	K me %	Org. C%	Org. M%	C/N Ratio
Bagasse	6.1	21.0x l 00	1.23	2399	21.63	29.36	51.15	23.87
Fly ash	5.4	17.0x!OO	0.61	3819	25.64	8.29	14.44	13.59
Scum	5.5	50.0xl 00	1.58	6944	20.83	12.86	22.40	8.14
Bagasse: Flyash(l: l)	5.4	27.0x l 00	0.61	3283	28.85	10.28	17.91	16.85
Bagasse: Scum(l : l)	5.5	41.0x l 00	1.40	6439	21.63	15.18	26.44	10.84
Bagasse: Flyash: Scum(l: l: l)	5.6	32.0x100	1.58	4419	27.24	12.52	21.81	7.92
Flyash: Scum(!: l)	5.5	l 8.5x 100	0.79	4166	26.44	8.79	15.31	l 1.13
Sawdust	5.1	23.0x100	0.98	1483	18.43	33.42	58.22	34.10
Gravel	7.1		-	-	-	-	-	-
Soil	6.5	12.5x100	0.44	947	5.61	2.32	4.04	5.27

addition of acid. All the elements needed by plants to grow and give a good yield should be provided through nutrient solutions.

3.2 Evaluation of Substrates under the Planting Bed Method

Four trials were conducted at Reduit Research Station. Each trial comprised one crop, respective yields of which are given in Tables 4, 5 and 6.

In the case of lettuce, it was noted that crops grown in scum had higher mean marketable weight and head diameter as compared to crops grown in flyash, soil or gravel. No significant difference was obtained among treatments as far as marketable weight, % dry matter and ash% were concerned though mean head diameter was significantly different. It was equally observed that plants grown in scum, flyash and soil had a faster growth rate than those in gravel. Consequently the harvest of lettuce in gravel was delayed by two weeks.

With sweet pepper, no significant difference was obtained among the treatments. It was observed that plants grow in flyash, scum and soil were more susceptible to disease outbreak as compared to those in gravel. Also plants grow in gravel produced fruits earlier. In general low yields were obtained and this could be attributed to the fact that plants were affected by PVY disease.

As for cauliflower, significant difference in yield among the different treatments was observed. From the t-test, it was noted that plants grown in flyash, scum and soil gave significantly higher yield than plants grown in gravel.

Cauliflower plants grown in gravel had a slower growth and development rate as well as smaller curd production.

Finally in the case of bean, significant difference was observed among treatments. Plants grown in tlyash and scum gave higher yield per plant than those grownin gravel. Disease occurrence in rooting media like scum, flyash and soil was higher than in gravel.

Table 4: Crop yield (g/plant) under planting bed method

Treatment	Lettuce (Marketable yield (g/plant)	Sweet-pepper (g/plant)	Bean (g/plant)	Cauliflower curd weight (g/plant)
Gravel	\35.0	81.3	174.9	235.3
Scum	181.9	72.4	351.1	584.7
Flyash	169.1	83.8	243.0	609.3
Soil	178.2	75.3	240.5	542.3
S.E.D (6 df)	6.98	13.46	47.09	55.87

Table 5: Lettuce yield (g/plant) and characteristics under planting bed method

Treatment	Marketable yield (g/plant)	Total yield (g/plant)	Head diameter (cm)
Gravel	135.0	151.9	20.3
Scum	181.9	207.2	21.4
Flyash	169.1	190.8	20.2
Soil	178.2	200.8	20.9
S.E D (6 df)	6.98	7.75	0.45

Table 6: Cauliflower yield (g/plant) and characteristics under planting bed method

Treatment	Cauliflower (Leaves+curd) (g/plant)	Cauliflower Curd weight (g/plant)
Gravel	619.0	235.3
Scum	1319.7	584.7
Flyash	\ 178.3	609.3
Soil	1145.0	542.3
S.E D (6 dt)	93.22	55.87

3.3 Evaluation of Substrates under the Wick Method

Two trials were conducted and results are given in Tables 7 and 8. Trials on strawberry and tomato could bot be followed till completion due to unfavorable factors mentioned earlier.

It was however observed that strawberry plants grown in bagasse and sawdust developed better and gave fruits earlier compared to those growing in soil and gravel. Plants grown in flyash and scum did not develop at all and finally died. Also due to high infestation with pests especially mites, trials had to be terminated at an earlier stage.

The trial on tomato was damaged during the passage of cyclone Daniella and therefore data was collected for some treatments only, as shown in Table 9. Significantly higher yields were obtained when plants were grown in gravel compared to those grown in soil.

In the case of sweet pepper, yield per plant was calculated for each treatment and the analysis of variance (Anova) worked out. Significant difference was obtained among the treatments. The Duncan Multiple Range Test was equally carried out and results given

Bagasse as a medium gave better yield. When combined with flyash and scum whereas on its own it proved to be a very poor growing medium. The higher N,P,K levels in flyash and scum could be the possible reason for higher yield as compared to soil. As for gravel although it is an inert rooting medium it could be a good rooting medium provided all the necessary plant nutrients are supplied through the nutrient solution.

For bean, yield per plant (g/plant) was calculated and analyzed statistically. Significant difference was obtained among treatments. When used in combination with bagasse, flyash and scum gave better yields. Gravel appeared to be a good growing medium compared to sawdust and bagasse, and equally taking into consideration the acid soil in the region of Wooton.

Table 7: Crop yield (g/plant) under Wick Method

Treatments	Sweet-pepper (g/plant)	Bean (g/plant)
Gravel	900.0'	113.3'°
Scum	400.2'·	95.4'°
Flyash	351. 7'"	112.6'"
Soil	380.9–·	71.400
Bagasse	130.2°	30.1'
Bagasse:Scum	709.0'°	128.6'
Bagasse:Flyash	383.o–·	125.2'"
Bagasse:Scum:Flyash	418.J–·	124.0'°
Scum:Flyash	483.8'0<	73.1 ec
Sawdust	155.0'°	109.7''
S.E.D (18 df)	135.86	

Table 8: Bean yield (g/plant) under Wick Method

Treatments	Yield (g/plant)
Gravel	9.3
Flyash	48.4
Soil	11.2
Bagasse	8.8
S.E.D (6 df)	9.7

Table 9: Tomato yield (g/plant) under Wick Method

Treatments	Yield (g/ plant)
Gravel	6902
Bagasse :Gravel	5622
Bagasse : Flyash	5503
Flyash:Gravel	5130
Bagasse: Flyash:Gravel	3928
Soil	3586
S.E.D (10 df)	727.8

5 CONCLUSION

The results obtained both the planting bed and wick methods showed that organic growing media like flyash and scum used singly or in combination with bagasse or an inert substrate like gravel could be used as rooting medium in soilless culture. No specific fertilization could be formulated for the different media evaluated and so commercial hydroponics solution was supplied in all growing media. The substrates differed in characteristics such as water holding capacity and decomposition rate. Organic growing media like scum and flyash retained moisture for a longer period but had decomposed faster as compared to gravel. In general though growing media like scum and flyash were higher yielding than gravel, they were not easily available, had to be replaced every year and decomposed very quickly. Gravel had the advantage of being inert, did not decompose, was easily available and could be sterilized after each cultivation. The low nutrient retention capacity of gravel could be overcome by applying the nutrient solution more frequently.

Concerning the two production systems evaluated, it seemed that the planting bed method would be more successfully raised on marginal lands and could be adopted by small commercial growers or in households. The wick method however would be more suitable for hobby hydroponics or for very simple self-feeding production systems. Care should however be taken when choosing material to be used as a wick. In the literature, it is normally recommended to use a nylon wick.

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APPENDIX 1

The composition of the commercial available hydroponics nutrient solution is given below:

The hydroponics solution is available in 2 components, namely:-

I IYDROPONIC SDLR-A
HYDROPONIC SDLR-B

For application, the final solution should be prepared by diluting 10ml A + 10ml B in 1 L of water and this solution will contained all the nutrients essential for hydroponics culture:-

Nitrate Nitrogen	200 ppm N
Phosphorus	50 ppm P
Potassium	300 ppm K
Calcium	180 ppm Ca
Magnesium	50 ppm Mg
Sulphur	120 ppm S
Iron	3.0 ppm Fe
Manganese	1.0ppmMn
Boron	0.3 ppm B
Zinc	0.3 ppm Zn
Copper	0.1 ppm Cu
Molybdenum	0.05 ppm Mo
pl-I	5.5-6.5
E.C	±2300 µs