GROWING CUCUMBERS IN BEVERAGE CANS RESTING IN SHALLOW TANKS OF AERATED AND NON-AERATED NUTRIENT SOLUTION

B.A. Kratky[1], L.A. Peterson[2], M. Yamasaki[1] and A.R. Krueger[2]
[1]University of Hawaii, 461 W. Lanikaula, Hilo, HI 96720
[2]Dept. of Horticulture, University of Wisconsin, 1575 Linden Drive, Madison, WI 53706

Abstract: Yields of Japanese cucumbers grown in 0.35 liter aluminum beverage cans were similar to those grown in 3.8 liter pots but greater than those in rockwool blocks and 160 ml forestry tubes in 2 trials utilizing a non-circulating hydroponic system. No yield advantage was gained by removing and replacing 2 liters of nutrient solution per week in this system. Plants growing in aerated solution produced 12 per cent more salable fresh cucumbers by weight (a non-significant difference at P.05), 41 per cent more root dry weight, used 14 per cent more nutrient solution, took up significantly more K, Mg, Zn and B, and the final nutrient solution was 1.38 pH units lower than the corresponding non-aerated treatment.

KEYWORDS: non-circulating hydroponics, containers, cucumbers, growing medium

INTRODUCTION

Hydroponic cucumbers are typically grown in trough culture (3,8), bag or container culture (1,3,8) and rockwool culture (2,3,8). The amount of growing medium required in these systems typically ranges between 7 and 20 liters per plant. It is usually necessary to discard nutrient solution during the growing period (2); however, recent environmental laws prohibit wholesale dumping of nutrient solutions.

Cost of growing medium is high in Hawaii. Thus, there is a need to develop a simple production system which requires very little growing medium. Reducing or eliminating the need to replace nutrient solution would reduce production costs and minimize nutrient solution disposal problems.

MATERIALS AND METHODS

Cucumbers were grown by a non-circulating, sub-irrigation hydroponic system (5). A nutrient solution level of 5 cm was maintained by at least twice weekly additions.

Trial 1. 'Narukami' Japanese cucumbers were planted in 7.5 x 7.5 x 7.5 cm rockwool blocks resting on 15 x 15 x 7.5 cm blocks. Cucumbers were also planted in 3.8 liter plastic pots and 0.35 liter aluminum beverage cans containing 1 cinder:1 commercial peat-vermiculite potting medium. Containers with plants rested on the bottom of the tank and were spaced 0.6 m apart in 0.6 m wide tanks. Tanks were constructed by placing 2 layers of 0.15-mm-thick polyethylene sheeting over a 9 cm high rectangular lumber frame and they were covered with polyethylene sheeting with openings for the containers. The beverage cans were prepared by cutting the bottom out with a Swing-A-Way can opener which has the gripper gear and the cutting disk synchronized by gears. The hole formed by the pop-tab conveniently becomes an opening at the bottom of the can and two vertical slits were cut in the sides with a sharp screwdriver. There were 6 plants per treatment arranged in a randomized complete block design with 3 replications. The experiment was conducted in a screen-sided, polyethylene-covered rainshelter at an 800 m elevation in Hawaii. Plants were seeded Oct. 26, 1992 and harvested from Dec. 24, 1992 to March 10, 1993. Nutrient solution consisted of 63 g Chem-Gro 4-18-38 plus micronutrients (Hydrogardens), 63 g calcium nitrate, 37 g magnesium sulfate and 21 g potassium nitrate per 100 liters of water.

Trial 2. 'Kaga Early Green' cucumbers were grown in tapered plastic forestry tubes (40 mm top and 218 mm deep which contained 160 ml of medium), 3.8 liter plastic pots and 0.35 liter aluminum beverage cans. Plants were seeded on June 30, 1993 and harvested from Aug 23 to Sept. 29, 1993. Other conditions were the same as in Trial 1.

Trial 3. 'Corona' European cucumbers were grown in 0.35 liter aluminum beverage cans filled with a 1 peat:1 perlite:1 vermiculite medium. Each can rested in a 60 x 60 x 14 cm high polyethylene-lined tank covered with a polyethylene sheet. A nutrient solution level of 5 cm (14 liters/plant) was maintained. A non-aerated control treatment was compared with an aerated (2 bubblers/tank) and also a non-aerated treatment where 2 liters of nutrient solution per tank were removed weekly (for 12 weeks) and replaced with fresh nutrient solution. There were 7 replications arranged in a completely random design. Nutrient solution (pH 6.0) consisted of the following in ppm: N-228, P-31, K-220, Ca-202, Mg-48, Fe-5, B-0.2, Mn-0.16, Zn-0.1, Cu-0.06 and Mo-0.01 from planting time (Oct. 26, 1993) until Dec. 14 when it was reduced to half for the rest of the experiment because the electrical conductivity was becoming too high. An additional 1 g N and 1.1 g K per plant were added on Feb. 1, 1994. Plants were harvested from Dec. 16, 1993 to Feb. 10, 1994. This experiment was conducted in a University of Wisconsin glasshouse at the Arlington Research Farm. High pressure sodium lamps extended the light period to 15 hours, and the minimum and maximum temperatures were 20 and 27C, respectively.

RESULTS AND DISCUSSION

Trial 1. An excellent crop of cucumbers was produced. There were no significant differences between cucumber yields from plants growing in aluminum beverage cans and in 3.8 liter pots. (Fig. 1). Cucumbers growing in beverage cans produced significantly higher yields (10.1 kg/plant) than those growing in rockwool blocks (8.2 kg/plant). Nutrient solution consumption rates for cucumbers growing in beverage cans, rockwool blocks and 3.8 liter pots was 18.2, 19.3 and 19.2 liters/kg of fruit, respectively.

Trial 2. Lower yields were obtained in this trial primarily because cultivar 'Kaga Early Green' was not as well adapted to this environment as cultivar 'Narukami' in the previous trial (Figure 2). Again, yields from plants growing in aluminum beverage cans (4.41 kg/plant) and 3.8 liter pots (4.02 kg/plant) were statistically similar, but both yielded significantly more than plants growing in the plastic forestry tubes (1.38 kg/plant). Nutrient solution consumption rates for cucumbers growing in beverage cans, 3.8 liter pots and forestry tubes were 40.4, 36.0 and 85.3 liters/kg of fruit. When plastic forestry tubes were utilized for lettuce production (6), they were suspended above the tank floor. In this trial, the tubes rested on the tank floor and this may have contributed to their relatively poor performance.

Trial 3. No yield advantage was gained by removing and replacing 2 liters of nutrient solution per week (Figure 3). A possible explanation for this may be that there is a relatively large amount of nutrient solution for each plant (14 liters) compared to other systems such that a toxic buildup of nutrients or exudates is more dilute in this system.

Plants growing in aerated nutrient solution yielded 12 per cent more fruit than the comparable non-aerated treatment, but this was not significantly different from the other treatments. Plants growing in aerated nutrient solution produced 41 per cent more root dry weight, used 14 per cent more nutrient solution and the remaining nutrient solution was 1.38 pH units lower compared to a non-aerated solution (Table 1).

The nutrient solution was analyzed at 4 and 8 weeks after first harvest (Table 2). The 8 week analysis indicated that P was very low, but there were notable accumulations of K, Ca, Mg, S and Fe. Thus, the composition of the nutrient solution should be altered for future trials. Nutrient accumulation was greatly reduced in the treatment where 2 liters of nutrient solution were removed and replaced each week.

Nutrient uptake was determined by subtracting the amount of nutrients in the final solution from the total amount applied. When calculated on the basis of nutrient uptake per kg of fruit, the aerated treatment had a significantly higher uptake of K, Mg, Zn and B than the corresponding non-aerated treatment (Table 3). In fact, the aerated treatment had a higher uptake of all the nutrients excepting for Fe and Cu; however not all of these differences were significant. P (7) and K (4) uptake are in close agreement with previous studies but N, Mg and Ca uptake in this trial are 25, 39 and 50 per cent higher, respectively, than other reported data (4). The minimum range of sensitivity of the Al test was 35 ppm, and this did not allow for a reliable calculation of Al uptake. An analysis of dried cucumber fruit tissue did not reveal Al uptake. Thus, we can conclude that the aluminum beverage can does not contribute greatly to aluminum accumulation in the fruit.

Many roots emerged from the slits on the sides of the cans, but few roots emerged from the tab-hole in the bottom of the can. It is advantageous to cut slits as far up on the cans as is practical since root growth is favored by the moist air immediately above the nutrient solution.

CONCLUSION

Cucumbers were successfully grown in beverage cans containing growing medium by a simple, non-aerated, non-circulating hydroponic system and yield performance compared favorably with an aerated system. This system requires only 0.35 liter of growing medium which is far less than typical medium requirement of between 7 to 20 liters per plant. It was not necessary to drain and replace nutrient solution throughout the growing period.

LITERATURE CITED

1. Bohme, M. 1993. Effect of hydroponics on the development of roots and shoots of cucumber. Proc. Int. Soc. for Soilless Culture 8:73-83.
2. Bohme, M. 1993. Parameters for calculating nutrient solutions for hydroponics. Proc. Int. Soc. for Soilless Culture 8:85-96.
3. Jensen, M.H. and W. L. Collins. 1985. Hydroponic vegetable production. Horticultural Reviews 7:483-558.
4. Knott. J.E. 1957. Handbook for Vegetable Growers. Wiley and Sons. New York.
5. Kratky, B.A. 1990. Design of a capillary, sub-irrigation hydroponic lettuce cultivation system for a remote area. Proc. Nat. Agr. Plastics Cong. 22:141-146.
6. Kratky, B.A. 1993. A capillary, non-circulating hydroponic method for leaf and semi-head lettuce. HortTechnology: (April) 206-207.
7. Pike, L.M. and R.W. Jones. 1989. Cucumbers in D.L. Plucknett and H.B. Sprague. Detecting mineral nutrient deficiencies in tropical and temperate crops. Westview Press. p. 263-274.
8. Resh, H.M. 1989. Hydroponic food production. 4th ed. Woolbridge Press Publishing Co., Santa Barbara, CA 93160.

Table 1. Yield and nutrient solution data for Trial 3.

Parameter	Not Aerated	Not Aerated Nutrient Solution Replaced[z]	Aerated	LSD 5%
Salable fresh weight kg/plant	3.60	3.66	4.02	0.46
Dry weight of roots g/plant	8.44	9.98	11.92	2.29
Remaining solution pH	6.62	6.21	5.28	0.85
Remaining solution EC mS	3.63	2.80	3.95	0.36
Nutrient solution consumed liters/plant	99.18	105.48[z]	113.20	10.90

[z]A total of 24 liters of 'old' nutrient solution per plant were replaced with fresh nutrient solution.

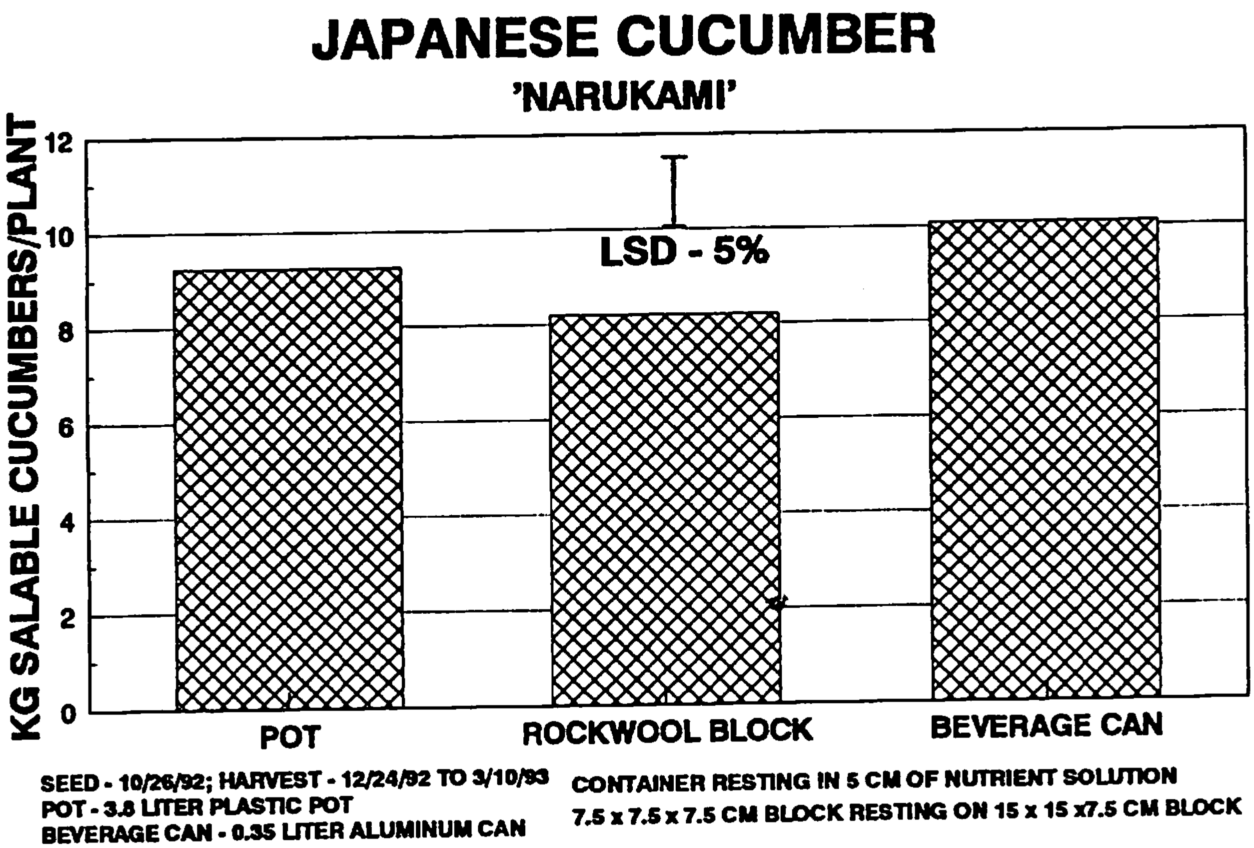

Figure 1. Yields of salable 'Narukami' Japanese cucumbers growing in pots, rockwool blocks and beverage cans in a non-circulating hydroponic system.

Table 2. Nutrient solution composition (in ppm) at 4 and 8 weeks after first harvest in Trial 3.

Element	Fresh Nutrient Solution[z]	Not Aerated		Not Aerated Nutrient Solution Replaced[y]		Aerated		LSD 5%
		4 Wks	8 Wks	4 Wks	8 Wks	4 Wks	8 Wks	
				ppm				
N	114	26	136	37	150	19	142	36
P	16	3	3	2	2	1	1	3
K	110	127	292	48	213	86	253	57
Ca	101	201	374	140	267	222	455	65
Mg	24	75	110	44	67	75	130	17
S	48	264	371	158	208	289	478	55
Zn	0.05	0.03	0.07	0.01	0.05	0.02	0.01	0.04
B	0.10	0.18	0.12	0.09	0.04	0.14	0.09	0.06
Mn	0.08	0.10	0.23	0.12	0.17	0.22	0.31	0.10
Fe	2.50	13.20	17.84	7.86	10.44	13.82	23.83	2.57
Cu	0.03	0.04	0.05	0.03	0.04	0.05	0.08	0.01
Al	0.35	0.35	0.39	0.35	0.37	0.36	0.51	0.09
Na	2.10	12.53	19.41	7.01	13.00	14.15	25.18	2.98

[z]The first 18.0, 24.4 and 19.3 liters of treatments not aerated, not aerated-nutrient solution replaced and aerated, respectively, were applied double strength. All 3 treatments received an additional 0.98 g N and 1.08 g K on Feb. 1, 1994.
[y]A total of 24 liters of 'old' nutrient solution per plant were replaced with fresh nutrient solution.

Table 3. Mg nutrient uptake per kg of fruit production (includes roots, shoots and fruits) for the aerated and non-aerated treatments in Trial 3.

Element	Non-aerated	Aerated	LSD 5%
	mg/kg of fruit[z]		
N	3846	3970	NS
P	578	591	NS
K	3409	3723	231
Ca	2488	2607	NS
Mg	503	539	29
S	487	488	NS
Zn	1.66	1.87	0.12
B	3.40	3.64	0.16
Mn	2.14	2.20	NS
Fe	30.07	26.16	3.07
Cu	0.95	0.92	NS

[z]mg nutrients/kg of fruit = (Total nutrients applied minus nutrients remaining in final nutrient solution)/kg of fruit.

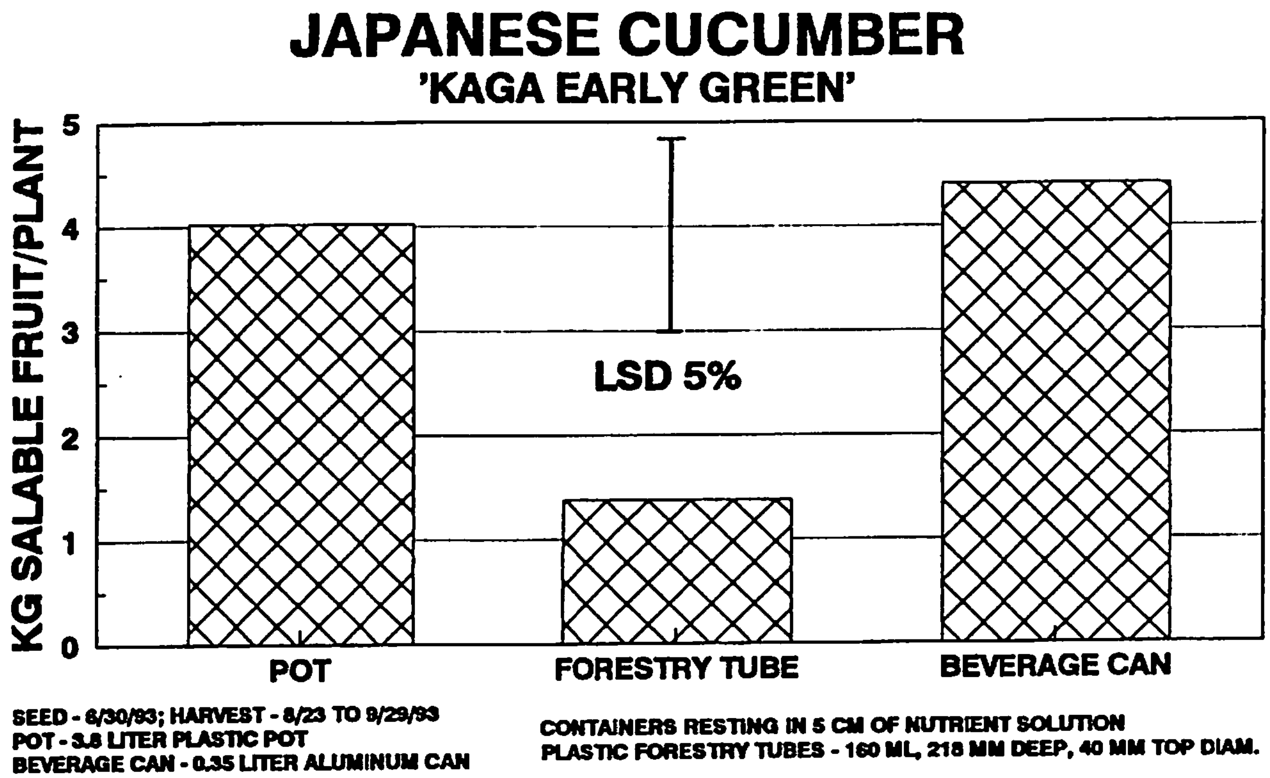

Figure 2. Yields of 'Kaga Early Green' Japanese cucumbers growing in pots, forestry tubes and beverage cans in a non-circulating hydroponic system.

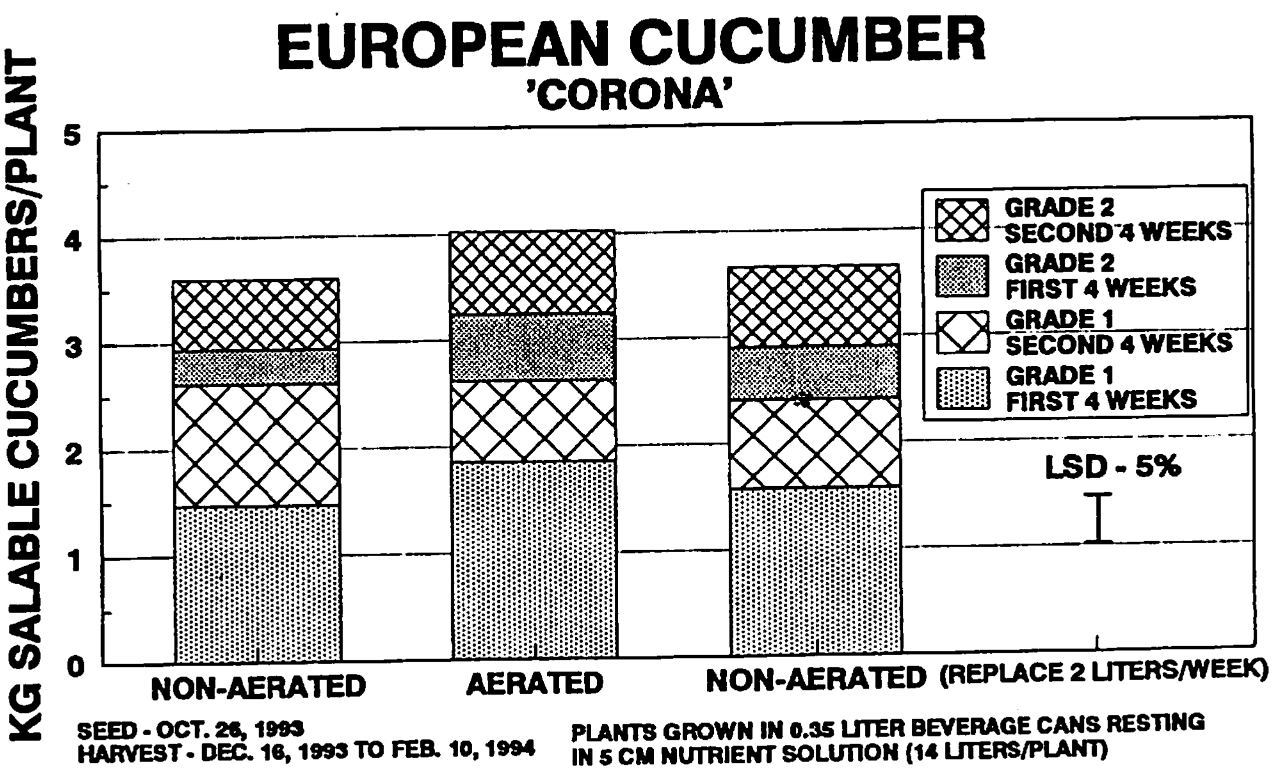

Figure 3. Yields of 'Corona' European cucumbers growing in beverage cans resting in 5 cm of nutrient solution which is aerated, not aerated and not aerated plus 2 liters/plant are replaced each week.