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A Proposal to Demonstrate Production of Salad Crops in the Space Station Mockup Facility with Particular Attention to Space, Energy, and Labor Constraints

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SUMMARY

A desire for fresh vegetables for consumption during long term space missions has been foreseen. To meet this need in a microgravity environment within the limited space and energy available on Space Station requires highly productive vegetable cultivars of short stature to optimize vegetable production per volume available. Special water and nutrient delivery systems must also be utilized. As a first step towards fresh vegetable production in the microgravity of Space Station we have evaluated several soil-less capillary action media for the ability to support growth of two root crops (radish and carrot) which are under consideration for inclusion in a semi-automated system for production of salad vegetables in a microgravity environment (Salad Machine). In addition, we have evaluated productivity of different cultivars of radish as well as the effect of planting density and cultivar on carrot production and size. 'Red Prince' radish was more productive than 'Cherry Belle' and grew best on Jiffy Mix Plus. During greenhouse studies, vermiculite and rock wool supported radish growth to a lesser degree than Jiffy Mix Plus but more than Cellular Rooting Sponge. Comparison of three carrot cultivars ('Planet',

'Short n' Sweet', and 'Goldinhart') and three planting densities revealed that 'Short n' Sweet' planted at 25.6 cm^2/plant had the greatest root fresh weight per pot, the shortest mean top length, and intermediate values of root length and top fresh weight per pot. 'Red Prince' radish and 'Short n' Sweet' carrot showed potential as productive cultivars for use in a "Salad Machine". Results of experiments with solid capillary action media were disapointing. Further research must be done to identify a solid style capillary action media which can productively support growth of root crops such as carrot and radish.

SALAD MACHINE DEMONSTRATION RACK PROGRESS

A double rack has been fitted with 4 fans, a fluorescent light bank, and transparent polycarbonate doors. Two fans are mounted in the bottom of the rack and two fans are mounted in the top of the rack. Ventilation holes have been cut into the rack where the fans are located to allow circulation of room air through the rack. To more effectively remove the heat generated by the light bank room air is circulated through the rack from the bottom of the rack to the top. The ballasts have initially been located on the outside of the rack. After more efficient lighting or better cooling methods are incorporated then all equipment will be placed within the rack. The light bank provides an irradiance of 300-350 umoles/m^{-2}/s^{-1} at a distance of 3 cm from the lamps and 185-250 umoles/m-2/s-1 15 cm from the lamps. The temperature in the rack varies with distance from the light bank and with the location of the shelf within the rack and the shelf's effect on air flow. If the shelf is placed 30 cm from the bottom of the light bank and the 12.7 cm tall nutrient delivery tray placed on the shelf, the temperature is 27 ^{o}C 30 cm from the lamps and 38 ^{o}C 15 cm from the the lamps. Additional fans may be necessary to circulate the air in the rack, particularly in the area of the light banks. Temperatures may also be lower in the rack if ambient temperatures can be lowered. Ambient temperature at the time these measurements were made was 25 ^{o}C.

An acrylic nutrient delivery tray with moveable dividers to allow for variable sized cells has been constructed. Preliminary salad production trials in the Salad Machine Demonstration Rack will begin in the next two weeks.

SUPPORTING RESEARCH AT ALABAMA A&M UNIVERSITY

INTRODUCTION

In the interest of utilizing a simple method for nutrient delivery which would work in a microgravity environment we have decided to use capillary action media for the first version of the Salad Machine Demonstration. The best capillary action media for use in microgravity would be a self-contained material which would not break free. Two examples of these types of media are rock wool cubes and Cellular Rootins Sponge (CRS, Grow-Tech Inc. of California, Freedom, CA). These media are known to work satisfactorily for plants with net-like root systems but have not been used much for the growth of crops which have thickened tap roots such as carrot and radish. To determine if such media would be suitable for root crops we have investigated the ability of radish and carrot to grow on these media.

In addition to the problem of root growth in firm self-contained media carrots present an additional challenge for inclusion in a Salad Machine since the average carrot root is 15 cm long and typical growing instructions indicate that carrot roots need at least a 30 cm growing depth. Carrots also have long shoots of at least 38 cm which would utilize excess volume in a Salad Machine. To locate a highly productive carrot cultivar which would have both short roots and shoots we have conducted a study to determine the effect of cultivar and planting density on carrot production, growth, and size.

MATERIALS AND METHODS

Radish cultivar and rooting media studies

To determine the effect of media and cultivar on radish productivity either 'Cherry Belle' (W. Atlee Burpee & Co., Warminster, PA) or 'Red Prince' (Asgrow Seed Co, Doraville, GA) radish seeds were sown in a 72 cell styrofoam block which contained either Jiffy Mix Plus (JMP), vermiculite, or CRS in the cells. Plants were continuously irradiated with 400 umoles/m^{-2}/s^{-1} of light from a fluorescent-incandescent light bank. Temperature was 23 $\pm$ 1 and humidity was set at 70%. Plants were harvested 21 days after sowing.

Radish cultivar and nutrient solution studies

To determine if increased nutrient concentration could increase radish root growth, 'Cherry Belle' and 'Red Prince' radishes were grown on half strength and full strength Hoaglands nutrient solution. Radish seeds were sown in a 72 cell styrofoam block which contained CRS, rock wool (Agrodynamics Inc., E. Brunswick, NJ), vermiculite, or Jiffy Mix Plus in its cells. The styrofoam block was divided into 6 replicate blocks of 12 cells each, with 3 cells per each growing medium. Plants were grown in the greenhouse under continuous lighting from a fluorescent light bank. Irradiance was 200 umoles/m^{-2}/s^{-1}. Temperature varied from a maximum of 39^{0} C to a minimum of 19^{0} C . Plants were harvested 21 days after planting and fresh weight of shoots and the edible portion of the roots determined.

Carrot cultivar and planting density studies

"Short n' Sweet' (W. Atlee Burpee & Co., Warminster, PA), 'Goldinhart' (W. Atlee Burpee & Co., Warminster, PA), and 'Planet' (Stokes Seed Co., Buffalo NY) carrot cultivars were planted in 5 inch diameter azalea pots with a planting density of 4, 6, or 8 carrots per pot (25.6 cm^2, 17.1 cm^2 or 12.8 cm^2). Seeds were sown in JMP soil-less potting mix and plants watered daily. Two weeks after planting, plants were watered with half strength Hoaglands nutrient solution once weekly in addition to daily watering. To encourage root growth, after the carrots were four weeks of age, the Hoagland's solution was modified by increasing the KH_2PO_4 to 1.03 mM. Irradiance was 200 umole/m^{-2}/s^{-1} at the top of the plants and was provided by continuous lighting with a fluorescent light bank. Day temperatures were 22^0 C $\pm$ 3 degrees and night temperatures were 20^0 C $\pm$ 3 degrees. Plants were harvested twelve weeks after planting and fresh weight data collected.

Study of carrot growth on various media

Seeds of 'Planet' and 'Baby Sweet' (W. Atlee Burpee Seed Co., Warminster, PA) carrot were sown on CRS, rock wool, perlite, vermiculite, perlite:vermiculite 1:1, or peat:perlite:vermiculite 1:1:1. Plants were planted at a density of 1 plant per 17.6 cm^2 and watered daily. After two weeks plants were watered daily with full strength Hoagland's solution. Plants were grown in the greenhouse under natural sunlight from March 7 to June 27. During March and April temperatures remained steady with day temperatures of 22^{o} C ± 3 degrees and night temperatures of 20^{o} C ± 2 degrees. In May and June day temperatures fluctuated greatly, with highs reaching 32^{o} C.

Tomato and sweet pepper cultivar evaluations

'Red Robin' (Stokes Seed Co., Buffalo, NY) minature tomato and Stokes 'Christmas Lights' sweet pepper were sown on rock wool and grown in a growth chamber with a 20/4 day/night photoperiod. Light intensity was 400 umole/m^{-2}/s^{-1} at plant tops and temperature was 25^{o} C ± 2 degrees. Plants were watered daily with half strength Hoaglands nutrient solution for two weeks and then with full strength Hoaglands thereafter. In an effort to use a single common nutrient solution formulation for all species selected by the Salad Machine Working Group (SMWG) it was suggested that all plants be grown on half strength Hoagland's nutrient solution. In our experience, radish had acceptable growth with half strength Hoagland's but 'Red Robin' tomato and 'Christmas Lights' sweet pepper showed clear signs of nutrient defieiency. The nutrient solution was increased to full strength Hoagland's for tomato and sweet pepper and signs of nutrient deficiency disapeared. Fruit were first harvested thirteen weeks after planting and harvested as needed for another five weeks. Plants are still producing fruits and periodic harvesting is continuing.

RESULTS

Radish cultivar and rooting media studies

'Red Prince' radishes which were grown on JMP had the greatest root fresh weight (Table 1). Root fresh weight of the 'Cherry Belle'-JMP combination was only 58% of that of the 'Red Prince'-JMP treatment. Root fresh weight of the 'Red Prince'-vermiculite treatment was also significantly less than the 'Red Prince'-JMP combination. CRS did not promote root growth of either 'Red Prince' or 'Cherry Belle' as compared with the other media. Root fresh weight of 'Cherry Belle' radishes which were grown on CRS was poor with a mean weight of only 2.33 g. Fresh weight of 'Red Prince' radishes which were grown on CRS was somewhat better but was still only 44% of the root weight of 'Red Prince' radishes grown on JMP. Analysis of the root:shoot fresh weight ratio showed that 'Red Prince' radish had a significantly greater proportion of its biomass in root fresh weight relative to 'Cherry Belle'. Even the most productive 'Cherry Belle'-media combination had a lower root:shoot fresh weight ratio than the least productive 'Red Prince'-media combination.

Radish cultivar and nutrient solution studies

Table 1. The effect of cultivar-media combination on radish growth.

Cultivar-media trt	Root fw (g)	Shoot fw (g)	Root:Shoot fw
Red Prince-JMP	14.23 a*†	4.34 c	3.38 a
Red Prince-Verm.	8.61 b	3.56 d	2.61 b
Cherry Belle-JMP	8.21 b	6.79 a	1.47 c
Red Prince-CRS	6.28 c	3.19 d	2.03 d
Cherry Belle-Verm.	5.00 c	5.02 b	1.26 de
Cherry Belle-CRS	2.33 d	3.25 d	0.93 e

* Means within columns followed by different letters are significantly different at the 5 % level as tested by Duncan's Multiple Range Test.

† Means represent an average of 48 samples.

Roots of 'Red Prince' radishes which were watered with half strength Hoagland's nutrient solution and grown on JMP were significantly larger than those grown on vermiculite, rockwool, or CRS (Table 2). Roots of radishes grown on vermiculite or rock wool were 40% and 35% respectively of the fresh weight of those grown on JMP. Radish root growth on CRS was severely retarded, with a mean fresh weight of 0.27 g. Because JMP contains additional nutrients that the other media do not, 'Red Prince' radishes were grown on full strength Hoagland's solution to determine whether increased nutrients could increase radish growth in vermiculite, rock wool, or CRS. Fresh weight of radish roots which were watered with full strength Hoagland's solution and grown on vermiculite was not significantly different from that of JMP, however fresh weight of radish roots grown on rock wool was significantly less than that of JMP (Table 3). CRS again severely inhibited root growth. The mean root fresh weight of radishes grown on CRS was only 7% that of radishes grown on JMP.

'Cherry Belle' radishes which were watered with half strength Hoagland's nutrient solution also grew best on JMP (Table 4). Radishes grown on vermiculite and rock wool had root fresh weights 30% and 17% relative to radishes grown on JMP, while CRS had a root fresh weight 7% of that of radishes which were grown on JMP. Fresh weight of roots of 'Cherry Belle' radishes which were watered with full strength Hoagland's and grown on JMP was significantly greater

Table 2. The Effect of media on growth of 'Red Prince' radishes watered with half strength Hoagland's nutrient solution.

Media	Root fw (g)	Shoot fw (g)	Root fw:Shoot fw
Jiffy Mix Plus	6.81 a* †	5.60 a	1.31 a
Vermiculite	2.76 b	4.21 b	0.66 b
Rock wool	2.39 b	3.08 c	0.83 b
CRS	0.27 c	1.22 d	0.14 c

* Means within columns followed by different letters are significantly different at the 5 % level as tested by Duncan's Multiple Range Test.

† Means represent an average of 18 samples.

Table 3. The effect of media on growth of 'Red Prince' radishes watered with full strength Hoagland's solution.

Media	Root fw (g)	Shoot fw (g)	Root fw:Shoot fw
Jiffy Mix Plus	5.61 a* †	6.54 a	0.93 a
Vermiculite	4.29 ab	5.44 b	0.83 a
Rock wool	3.83 b	4.42 c	0.80 a
CRS	0.38 c	2.16 d	0.14 b

* Means within columns followed by different letters are significantly different from at the 5% level as tested by Duncan's Multiple Range Test.

† Means represent an average of 18 samples.

Table 4. The effect of media on growth of 'Cherry Belle' radishes watered with half strength Hoagland's nutrient solution.

Media	Root fw (g)	Shoot fw (g)	Root fw:Shoot fw
Jiffy Mix Plus	4.74 a* †	7.86 a	0.62 a
Vermiculite	1.43 b	6.11 b	0.24 b
Rock wool	0.79 bc	3.45 c	0.20 b
CRS	0.17 c	2.58 c	0.06 b

* Means within columns followed by different letters are significartly different at the 5 % level as tested by Duncan's Multiple Range Test.

† Means represent an average of 18 samples.

than root fresh weight of radishes grown on the other three media (Table 5). Compared to the mean root fresh weight of radishes grown on JMP root fresh weight of radishes grown on vermiculite, rock wool, and CRS was only 50%, 26% and 7% respectively.

Carrot cultivar and planting density studies

'Short n' Sweet' (8 plants per pot) had the greatest root fresh weight per pot (Table 6). 'Short n' Sweet' with 4 plants per pot had the next greatest root fresh weight per pot. A factorial ANOVA showed that the 'Short n' Sweet' cultivar of carrot had the greatest overall root fresh weight per pot and a density of 4 or 8 plants per pot to be optimum regardless of cultivar (Table 7). This result was interesting since one might expect the density response to be linear. A look at the effect of planting density on individual carrot root fresh weight reveals why the response is not linear. Root fresh weight of carrots grown 4 per pot was significantly greater than that of carrots grown either 6 or 8 per pot, while there was no significant difference in root fresh weight between carrots grown either 6 or 8 to a pot (Table 8). Since the inhibition due to crowding did not inhibit growth of individual carrots grown 8 per pot more than carrots grown 6 per pot, the additional 2 carrots per pot contributed enough to the root fresh weight per pot to equal that of the noncrowded carrots grown 4 per pot. The carrots grown 4 per

Table 5. The effect of media on 'Cherry Belle' radish growth watered with full strength Hoagland's solution.

Media	Root fw (g)	Shoot fw (g)	Root fw:Shoot fw
Jiffy Mix Plus	4.35 a* †	9.29 a	1.57 a
Vermiculite	2.15 b	7.56 ab	0.27 b
Rock wool	1.12 bc	6.31 b	0.16 b
CRS	0.36 c	3.21 c	0.10 b

* Means within columns followed by different letters are significantly different at the 5 % level as tested by Duncan's Multiple Range Test.

† Means represent an average of 18 samples.

Table 6. The effect of cultivar-planting density combination on root growth of carrots.

Cv/Planting Density (plants/pot)	Root fw/pot (g)	Root fw/carrot (g)	$\bar{x}$ root lgh/carrot (mm)
Short n' Sweet, 8	109.11 a*†	13.78 cd ††	38 c ††
Short n' Sweet, 4	97.16 ab	25.57 a	44 b
Goldinhart, 4	83.20 bc	20.80 b	53 a
Short n' Sweet, 6	68.13 cd	11.78 de	37 c
Goldinhart, 8	66.85 cd	8.59 ef	36 c
Planet, 4	66.46 cd	16.62 c	30 d
Goldinhart, 6	55.67 d	9.28 ef	37 c
Planet, 8	59.00 d	7.61 f	24 e
Planet, 6	54.85 d	9.14 ef	26 e

* Means within columns followed by different letters are significantly different at the 5 % level as tested by Duncan's Multiple Range Test.

† Means represent an average of 15 samples.

†† Means represent an average of 60 (4 carrots/pot), 90 (6 carrots/pot) or 120 (8 carrots/pot) samples.

Table 7. Factorial ANOVA of the effect of cultivar and planting density on carrot root fresh weight per pot.

Cultivar	Root fw/pot (g)	Planting Density (plants/pot)	Root fw/pot (g)
Short n' Sweet	90.75 a* †	4	82.64 a †
Goldinhart	68.91 b	8	77.71 a
Planet	60.16 c	6	59.55 b

* Means within columns followed by different letters are significantly different at the 5 % level as tested by Duncan's Multiple Range Test.

† Means represent an average of 45 samples.

Table 8. Factorial ANOVA of the effect of cultivar and planting density on root fresh weight per carrot.

Cultivar	Root fw/carrot (g)	Planting density (plants/pot)	Root fw/carrot (g)
Short n' Sweet	15.97 a* †	4	21.02 a †
Goldinhart	11.71 b	6	10.04 b
Planet	10.33 b	8	9.94 b

* Means within columns followed by different letters are significantly different at the 5 % level as tested by Duncan's Multiple Range Test.

† Means represent an average of 270 samples.

pot were much less crowded and grew to a greater individual size resulting in root fresh weight per pot essentially equal to that of pots which contained 8 carrots.

Root length ranged from 53 to 24 mm (Table 6). Goldinhart (4 plants per pot) had the longest root length and 'Planet' (8 plants per pot) had the shortest. 'Short n' Sweet (8 plants per pot) had an intermediate root length. Factorial ANOVA of cultivars showed 'Goldinhart' to have the longest roots, 'Short n Sweet' an intermediate length, and 'Planet' the shortest (Table 9). Increasing density from 4 plants per pot to 6 plants per pot resulted in decreasing root length (Table 9). However, there was no significant difference in root length between carrots grown 6 to a pot versus 8 per pot.

'Short n' Sweet' (8 plants per pot) had the shortest mean shoot length of all cultivar-density combinations (Table 10). Factorial ANOVA of cultivar also showed that 'Short n' Sweet' and 'Planet' cultivars had significantly shorter shoots than 'Goldinhart' (Table 11). Planting density significantly affected shoot length, with shoots of plants grown 4 per pot significantly longer than those grown either 6 or 8 plants per pot (Table 11). 'Short n' Sweet' (8 and 4 plants per pot) had intermediate shoot fresh weights of 46.63 g and 44.48 g per pot respectively (Table 10). There was no effect of planting density on shoot fresh weight per pot. Overall 'Goldinhart'

Table 9. Factorial ANOVA of the effect of cultivar and planting density on carrot root length.

Cultivar	Root length (mm)	Planting density (plants/pot)	Root length (mm)
Goldinhart	40 a* †	4	43 a †
Short n' Sweet	39 a	6	33 b
Planet	26 b	8	33 b

* Means within columns followed by different letters are significantly different at the 5 % level as tested by Duncan's Multiple Range Test.

† Means represent an average of 270 samples.

Table 10. The effect of cultivar and planting density on shoot growth of carrots.

Cv/Planting Density (plants/pot)		Shoot length (mm)	Shoot fw/pot (mm)
Goldinhart,	4	55.8 a* †	48.34 b †
Goldinhart,	6	53.5 b	50.77 ab
Goldinhart,	8	50.9 c	55.59 a
Planet,	4	49.5 cd	40.27 cd
Short n' Sweet,	4	48.4 d	44.48 cd
Planet,	6	45.7 e	40.24 cd
Planet,	8	44.6 e	39.83 d
Short n' Sweet,	6	43.8 e	44.75 cd
Short n' Sweet,	8	43.4 e	46.63 bc

* Means within columns followed by different letters are significantly different at the 5 % level as tested by Duncan's Multiple Range Test.

† Means represent an average of 60 (4 carrots/pot), 90 (6 carrots/pot) or 120 (8 carrots/pot) samples.

Table 11. Factorial ANOVA of the effect of cultivar and planting density on shoot length.

Cultivar	Shoot length (cm)	Planting density (plants/pot)	Shoot length (cm)
Goldinhart	53.0 a* †	4	51.3 a †
Planet	46.2 b	6	47.7 b
Short n' Sweet	44.8 c	8	46.6 b

* Means within columns followed by different letters are significantly different at the 5 % level as tested by Duncan's Multiple Range Test.

† Means represent an average of 270 samples.

had the greatest shoot fresh weight per pot and 'Planet' the least (Table 12).

Due to the possibility of less irradiance at the borders of the light banks under which the carrots were grown, location under the light bank was a factor in the experimental design. Factorial ANOVA revealed no significant effect of location on either individual root fresh weight or root fresh weight per pot (Table 13). There was , however, a slightly significant effect of location on root length (Table 13), shoot length, individual shoot fresh weight, and fresh weight of shoots per pot (Table 14). There was a trend for root length to be longer in the center 3 rows of pots and shorter in the two outer rows of pots. There was no discernable trend in the effect of location on shoot growth.

Study of carrot growth on various media

Data from this experiment has just been collected and data is awaiting analysis.

Tomato and sweet pepper cultivar evaluations

Data are still being collected for this cultivar evaluation. At the termination of this study results will be tabulated, summarized, and reported.

Table 12. Factorial ANOVA of the effect of cultivar and planting density on shoot fresh weight per pot.

Cultivar	Shoot fw/pot (g)	Planting Density (plants/pot)	Shoot fw/pot (g)
Goldinhart	51.49 a* †	8	47.79 a †
Short n' Sweet	45.20 b	6	45.25 a
Planet	40.13 c	4	44.46 a

* Means within columns followed by different letters are significantly different at the 5 % level as tested by Duncans Multiple Range Test.

† Means represent an average of 45 samples.

Table 13. The effect of pot location on carrot root growth.

Location** (row)	Root fw/pot (g)	Root fw/carrot (g)	Root length (mm)
1	78.10 a *†	13.06 a ††	34 b
2	78.16 a	13.35 a	35 ab
3	71.10 a	14.08 a	36 ab
4	74.28 a	13.96 a	38 a
5	64.94 a	12.24 a	33 b

* Means followed by different lettrers are significantly different at the 5% level as tested by Duncan's Multiple Range Test.
** Locations 1 and 5 represent pots under the edges of the light bank and 3 represents pots in the center of the light bank.
†Data represents a mean of 27 pots.
†† Data represents a mean of 162 samples.

Table 14. The effect of pot location on carrot shoot growth.

Location ** (row)	Shoot fw/pot (g)	Shoot fw/carrot (g)	Shoot length (mm)
1	44.70 ab *†	7.66 ab ††	44.5 c ††
2	41.06 c	7.18 b	47.2 b
3	44.94 bc	7.58 ab	49.0 a
4	46.39 b	8.18 ab	50.4 a
5	51.68 a	8.72 a	49.3 a

* Means followed by different lettrers are significantly different at the 5% level as tested by Duncan's Multiple Range Test.
** Locations 1 and 5 represent pots under the edges of the light bank and 3 represents pots in the center of the light bank.
†Data represents a mean of 27 pots.
†† Data represents a mean of 162 samples.

CONCLUSIONS

'Red Prince' radish shows promise as a highly productive cultivar and illustrates the importance of cultivar selection in optimizing vegetable production for Salad Machine. To put the results with 'Red Prince' radish into perspective for food production in a Salad Machine we can look at some earlier production estimates. It has been estimated that with an average radish root fresh weight of 10.8 g it would require 4 radishes harvested every other day to contribute to a salad every other day for a crew of 6. This would use 1083.9 cm^2 of growing space. If we could produce radishes with a mean root fresh weight of 14.2 g, as in the 'Red Prince-JMP treatment, then only three radishes need be planted every other day for a total of 812.9 cm^2 of space needed. If a mean of only 6.3 g per radish can be produced in 21 days then 72 radishes would be needed per planting cycle and occupy 1858.1 cm^2 of growing area.

Results with the CSR were disapointing and need further study to either increase production or rule out the use of CRS in Salad Machine. Possibly, radish root growth can be increased if the texture of CRS and rock wool can be altered to present less resistance to root growth and yet still retain a self contained form. We will investigate the effect of firmness reduction treatments as well as nutrient concentration on radish growth this fall in the greenhouse when temperatures are conducive to radish growth. We will also conduct a survey of several radish cultivars to determine if productivity can be increased further.

Based on our data, 'Short n' Sweet' carrot cultivar shows promise for use in a Salad Machine. Although root length of 'Short n' Sweet' was not the shortest of the cultivar-density combinations, any length within the observed range of 53-24 mm would be acceptable for our purposes. Fresh weight of shoots per pot was also intermediate for 'Short n' Sweet' (8 plants per pot). Fresh weight of shoots is a less critical parameter at this point in time since the goal of Salad Machine is to provide dietary enhancement, and is not to act as part of a Controlled Ecological Life Support System. Although shoot length of 'Short n' Sweet' (8 plants per pot) was the shortest of all cultivar-density combinations we would like to see a further decrease in shoot length. The light intensity for this experiment was low and could have contributed to the long shoot lengths of all carrot cultivars. Future experiments will be done to attempt to shorten shoot length further. This may be possible to acheive by increasing light intensity and by certain temperature regimes.

FUTURE STUDIES AND WORK PLANNED

As mentioned above we will continue studies to determine the optimum radish and carrot cultivar-media combinations for use in the Salad Machine Demonstration Project. Plant compatibility studies will commence this fall. During the aquisition of materials for construction of the NFT system to conduct these studies the growth chamber became unavailable. The necessary materials are now on hand and the growth chamber will be available this fall. Vegetable crop productivity in the Salad Machine Demonstration Rack will evaluated this fall and modifications to improve yield, increase light intensity, and decrease temperature implemented.