Annual Report

to the

National Aeronautics and Space Administration

Historically Black Colleges and Universities

Research Centers Program

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Submitted by the

Tuskegee University

Center for Food Production, Processing and

Waste Management in Controlled Ecological

Life-Support Systems

Tuskegee University

Tuskegee, AL 36088

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EXECUTIVE SUMMARY

Goals and Objectives

The overall goal of the Tuskegee University Center for Food Production, Processing and Waste Management in Controlled Ecological Life Support Systems (CELSS) is to provide tested information and technologies applicable to bioregenerative food production systems for life support on long-term manned space missions. Specifically, the center is developing information, computer simulated models, methodologies and technology for sweetpotato and peanut biomass production and processing, inclusive of waste management and recycling of these crops selected by NASA for CELSS. The Center is organized into interdisciplinary teams of life scientists and engineers that work together on specific objectives and long-term goals. Integral to the goal of the Center is the development of both basic and applied research information and the training of young scientists and engineers, especially underrepresented minorities that will increase the professional pool in these disciplines and contribute to the advancement of space sciences and exploration.

The Tuskegee University Center was designated by NASA in January 1992 and received initial funding in April 1992. The Center serves as a focal point for integrating research on subsurface crops within the CELSS program. The research of the Center falls under one of four subsystems: **biomass production** which includes environmental control and computer modeling of plant growth in CELSS conditions conditions; sweetpotato and peanut **germplasm development** for CELSS conditions; **nutrition and processing**, which includes nutrient analysis and preparation of a variety of foods from these crops and **management and recycling of waste** from biomass production and processing. The Center is composed of six functional working groups that interface on a continuous basis. The targeted goals of each working group within the Center are summarized below:

Growing Systems and Environmental Factors (GRO): to ascertain the best systems and environmental conditions for growing sweetpotato and peanut hydroponically for space missions.

Microgravity Applications and Controls Group (MAC): to adapt efficient crop producing hydroponic systems for use under microgravity conditions and to design and build automated environmental control systems for crop growing and waste management systems.

Plant Modeling Group (PAM): to establish a database from existing information, recommend and design experiments for retrieving needed information and, based on these data, produce models that effectively predict growth and yield of sweetpotatoes and peanuts in CELSS.

Nutrition and Food Processing Group (NAF): to analyze the nutrient composition of the edible parts (greens and roots/nuts) of plants grown under controlled environmental conditions and to process these parts into a variety of nutritious and palatable foods.

Germplasm Development Group (GED): to examine the germplasm available for peanut and sweetpotato; to select and breed the best lines for growing in CELSS and to further improve them through biotechnology.

Waste Management and Recycling Group (WAM): to ascertain quantities of inedible plant biomass available from sweetpotato and peanut in CELSS, to analyze the biomass for chemical composition and to establish how all organic and inorganic waste resources from hydroponic culture of these crops will be recovered and recycled in CELSS.

The Center's longer term goal is to test prototype systems in microgravity, in collaboration with NASA partners, using ground-based flight and eventually space station facilities and lunar and Mars bases.

Scientific and Technical Accomplishments in 1992

Biomass production and environmental factors. Variation in sweetpotato growth and biomass production in nine different growth chambers was determined with the same light intensity, photoperiod, temperature, nutrient solution, cultivar and relative humidity in each chamber. Results from this study will assist in designing future experiments. Removal of peanut foliage at 2, 4 and 6 wk intervals from 'Georgia Red' did not result in decreased nut yield or % mature nuts. Biweekly topping of 'TI-155' sweetpotato shoot tips resulted in lower storage root yields than for controls. Greenhouse studies of pH level effects were completed and three different NFT systems were evaluated for peanut growth.

Microgravity systems and controls. A study of the initial stainless steel membrane nutrient delivery system indicated that the pore size was not uniform throughout and that flow along the length of the membrane was irregular. A survey of the literature to identify candidate membrane materials focused on titanium and ceramic membranes that can offer better corrosion resistance than stainless steel. Four growing channels were designed, constructed and tested—one with a titanium membrane, one with a ceramic membrane and two with stainless steel membranes—with and without a porous medium. A control system was designed and is being used to control water flux through the membrane. A prototype system is presently being used to grow sweetpotatoes in the greenhouse and its performance is being assessed. A system to monitor and control CO_2 levels in the environmental growth chambers are being developed.

Plant modeling. A candidate with computer systems/mathematics background who has experience with sweetpotato research has been offered a position with the Center. Funds from USDA have been obtained to hire a Ph.D. level biometrician for the Center to provide expertise in modeling and in experimental design and analysis. Potato (*Solanum*) models have been obtained for study of their adaptability to sweetpotatoes. The Center served as a catalyst to tie the campus into the Alabama Supercomputing Authority with a T1 line. A two-day workshop sponsored by the Center offered campus-wide INTERNET training by three specialists from the MUSPIN office at Goddard Space Flight Center.

Germplasm development. Field evaluation of 10 sweetpotato breeding lines from replicated trials resulted in yields ranging from 8.4 to 37.2 t/ha and dry matter ranging from 28.8 to 40.9%. Observational trials of 182 breeding lines found yields of 28 to 2495 g/plant and %dry matter of 16.0 to 43.0%. Five leading peanut breeding lines have been obtained from the University of Florida and two of them have been planted in the greenhouse for study in NFT. Eight sweetpotato genotypes were compared for adaptability to NFT under greenhouse conditions. Sweetpotato storage root fresh weight and % dry matter of up to 620 g/plant and 30.2%, respectively, were obtained for the genotypes. Use of modified growth media showed significant enhancement of sweetpotato regeneration in tissue culture using small pieces of petiole in as few as 10 days. Initial studies that incorporated the *asp*-1 gene into peanut—cultivars 'Georgia Red' and 'Early Bunch 495-5'—using *Agrobacterium* were completed.

Nutrition and food processing. Nutritive composition of 'TI-155' foliage tips and roots from biweekly harvests were determined for sweetpotato grown in NFT by the GRO group. Nutrient levels in storage roots were not affected by harvest date. For foliage tips, nutrient levels changed depending on the day of harvest. The % dry matter of tips was lower at 83 than at 42 days after planting (DAP), and the fat content of tips increased from 0.3% at 42 DAP, to 0.5% at 111 DAP. The beta-carotene levels of tips were not significantly different throughout the growing period ranging from 4.7 to 6.6 mg/100g. Ascorbic acid levels varied from 0.9 to 3.6 mg/100g. Noodles that were prepared with up to 20% sweetpotato green tip flour were highly acceptable by taste panelists. Nutritive analysis of 'Georgia Red' peanut greens harvested biweekly from the field were completed.

Management and recycling of waste. The proportion of edible to inedible sweetpotato biomass of 'TI-155' was determined to be 54:46 on a fresh weight basis by analyzing data previously collected by the GRO Group. The non-tip portion of the foliage and fibrous root mat represented more than half of the nonedible biomass. Chemical analysis of sweetpotato biomass grown in NFT showed that the fibrous root mat and foliage stems contained higher percentages of cellulose, hemi-cellulose and lignin than other plant parts. Indigenous microorganisms with lignocellulolytic, proteolytic and amylolytic activity were isolated from sweetpotato field sites. Experiments are ongoing to assess the rate of degradation of senescent sweetpotato leaves which were inoculated with indigenous microorganisms having the capacity to degrade cellulose. These microorganisms are being characterized and the nature of the gaseous phase is being analyzed as biodegradation occurs. A profile of microbial flora grown in either NFT or deep water culture showed high population counts in the sweetpotato nutrient solution. Fungal counts were highest in deep water culture and actinomycete counts were highest in NFT.

During 1992, Center staff completed 42 journal articles, books, book chapters, proceedings, abstracts and presentations.

Staff, Student and Academic Program Enhancement and Delay

One of the main accomplishments of the Tuskegee CELSS project has been to strengthen interdisciplinary work among Center scientists and engineers and enhance research productivity. As a result, during the past year several Center staff won honors for their research including the following: Faculty Outstanding Research Award (Tuskegee University), Graduate Student 2nd Place Research Award (Association of Research Directors), three promotions from Associate Professor to Professor, two promotions from Research Associate to Research Assistant Professor, and selection as a *Fellow*, American Society of Agronomy. The Center staff were featured in the *New Explorers* television series produced by Bill Kurtis. The program was aired nationwide on public television during 1992; the series is packaged for school systems as a means of attracting young people into scientific careers.

The Center has made available released-time for faculty in engineering to better focus their efforts on the project. With one full-time waste management engineer position written into the 1993 budget, this will permit further acceleration of both research and academic program development in the environmental science and engineering areas. A full-time engineer in the controls area was written into the 1994 funding cycle of the original proposal. Given the rapid development of the Microgravity Applications and Control Group it is essential that filling this position should occur in the upcoming 1993 cycle along with the waste management engineer position.

The Center has already had a profound effect on the Master of Science degree programs in electrical and mechanical engineering, plant and soil sciences, environmental sciences, biology and food and nutritional sciences, by creating exciting M.S. thesis opportunities that have attracted very bright students. As a result, many new applications and requests to work on the project by outstanding students have been received by the Center. Guided by NASA-MUREP priorities the Center already has 21 African-American engineering and life sciences students—undergraduates and graduates—directly involved in research projects and is requesting supplemental funding to involve additional underrepresented minority students.

Center staff co-authored a paper with colleagues at Kennedy Space Center on environmental factors that impact sweetpotato growth in CELSS. The Center was assisted by Goddard Space Flight Center (GSC) in catalyzing the campus-wide hook-up with INTERNET. After a series of preparatory visits, three GSC/MUSPIN personnel presented a series of lecture-demonstrations on the use of INTERNET to about 50 key faculty and staff from the Office of Computer Services, College of Arts and Sciences, School of Agriculture and Home Economics, School of Engineering and Architecture and School of Veterinary Medicine. In preparation for the November 22 to December 2, 1992 visit of several Center staff to Japan, Johnson Space Center sent to the Tuskegee Center staff select food samples and photographs of foods like those used in previous space missions. These items were used as display materials at the very successful *Symposium on Sweetpotatoes in Space* held both in Kagoshima and Kawagoe. Additional cooperator enhancing Center resources and productivity in 1992 included Kraft Foods, American Cyanamid, North Carolina A & T State University, Pennsylvania State University, Rutgers University, USDA and USAID.

Equipment purchased by the Center has enhanced undergraduate and graduate student laboratory experience in molecular genetics, electrical engineering, mechanical engineering, plant breeding, food science and human nutrition. Given the progress in 1992 there is an urgent need to supplement funding requested in the original approved proposal for facilities development to enhance the Microgravity Applications and Controls Laboratory, the Waste Management and Growth Chamber Facility and fiber optic connections to Milbank and Armstrong Halls (for INTERNET). These requests are modest but essential for effectively carrying out project goals.

Some of the Center's progress was impeded due to several factors: funding for the Center was not received until April 1992 which delayed the initiation of the project; renovations of the current facilities to provide additional laboratory space and growth rooms have been delayed due to insufficient funds allocated in the original budget; and qualified candidates for the postdoctoral plant modeling and biotechnology positions were not identified early enough to be hired in this fiscal year.

DOCUMENTATION OF RESEARCH PROJECTS

Working Group Reports

The Tuskegee University Center was designated by NASA in January 1992 and received initial funding in April 1992. The Center serves as a focal point for integrating research on subsurface crops within the CELSS program. The research of the Center falls under one of four subsystems: biomass production which includes environmental control and computer modeling of plant growth in CELSS conditions; sweetpotato and peanut germplasm development for CELSS conditions; nutrition and processing, which includes nutrient analysis and preparation of a variety of foods from these crops; and management and recycling of waste from biomass production and processing. The Center is composed of six functional working groups that interface on a continuous basis. The targeted goals of each working group within the Center are summarized below:

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The research results obtained by these Center working groups are presented in this section of the report.

Growing Systems and Environmental Factors

Summary

Variation in sweetpotato growth and biomass production in nine different growth chambers was determined with the same light intensity, photoperiod, temperature, nutrient solution, cultivar and relative humidity in each chamber. Results from this study will assist in designing future experiments. Removal of peanut foliage at 2, 4 and 6 wk intervals from 'Georgia Red' peanut did not result in decreased nut yield or % mature nuts. Biweekly topping of 'TI-155' sweetpotato shoot tips resulted in lower storage root yields than for the control but root disease may have affected the results. Greenhouse studies of pH level effects were completed and follow-up growth chamber studies have been planned. Three different NFT systems were evaluated for peanut growth. Five additional systems are presently being evaluated.

First Year Objectives (1992)

(1) To establish a range of variablility that may be encountered with sweetpotato in growth chambers of ranging sizes.
(2) To evaluate the effect of frequency of removing peanut foliage as a green vegetable on peanut growth and yield.
(3) To determine the effect of periodically adjusting nutrient solution pH on sweetpotato growth and yield.
(4) The evaluate peanut growth in a grid system for separation of rooting and gynophone zones when grown in NFT.

Research Activities

Growth Chamber Studies

Variability of Sweetpotato in Growth Chanbers.

'TI-155' vine cuttings of uniform size, length (15 cm) and number of nodes (7) were planted at similar depths in the TU NFT growth channels in chambers of varying sizes with and without a light barrier. The Experimental design was a randomized complete block design with two, three, and four replications depending on the number of each chamber type. All chambers were set at similar environmental conditions—temperature of 28°/22°C day/night, 18/6 h photoperiod, irradiance of 400 μmol $m^{-2}s^{-1}$, and RH of 70%. All environmental conditions were manually measured weekly by use of a thermometer, LI-COR 185B Quantum/Radiometer/Photometer, and a Psychrometer. All plants were grown using a modified half-Hoagland solution with a 1:2.4 N:K ratio. Solutions were changed every two weeks or were topped when the volume fell to 8L or less. Plants were harvested after 120 days and all data were analyzed by analysis of variance.

Table 1 shows that the variance of treatment means was highest for all parameters measured in the two Conviron (CON) chambers, followed by the four Percivals (PC) and the three EGC's, respectively. This suggests that it would take a doubling effect of these variance components to produce a difference in any of these parameters in the Conviron Chambers. For example, it would take a difference of 196.5 g/plant storage root fresh weight to produce a difference due to treatments (e.g. light). With the Percivals, only chamber #1 showed notable differences in storage root fresh and dry weights from the other Percival chambers. Similarly for the EGC's, only chamber #1 produced different results from the other two chambers in storage root fresh and dry weights as well as foliage fresh and dry weights.

The cause of the variance among treatment means in Percival #1 and EGC #1 is not ascribable to environmental factors because these were generally similar among chambers. Variance among treatment means in these two reach-in sets of chambers may have been due to plant-to-plant variation as well as chamber effects. For example, plant-to-plant variation accounted for 31% while chamber effects accounted for 68% of the variance in storage root fresh and dry weights in Percival #1. In EGC #1 plant-to-plant variance contributed 77% for storage root fresh and dry weights while <5% of variation were due to chamber effects. These two main variance contributors—plant to plant and chamber effect—will be accounted for future growth chamber studies, by switching chambers for each treatment as each experiment is repeated.

Table 1. Mean values of sweetpotato growth parameters in three different size growth chambers.

Chamber		Storage root		Foliage	
	No.	Fresh wt.	Dry wt.	Fresh wt.	Dry wt.
		------------------------------(g/plant)------------------------------			
PC1	3.2	458.3	76.3	482.9	60.3
PC2	1.8	576.7	90.0	474.2	63.2
PC3	3.1	608.6	99.6	461.9	63.9
PC4	2.1	635.3	110.0	488.3	61.4
Var. Comp.	0.6	58	10	146	3.4
CON1	5.9	793.8	149.1	606.4	76.3
CON2	5.4	960.8	181.1	616.8	80.1
Var. Comp.	2.1	98.2	46	187	25
EGC1	4.6	630.0	97.8	449.8	48.6
EGC2	4.7	806.2	130.1	562.7	61.0
EGC3	4.1	837.8	139.1	516.9	59.2
Var. Comp.	0.9	62	12	50	5.5

Sweetpotato yields are quite variable and although uniform cuttings were used, there were still large plant-to-plant variances. Variability due to chamber effect was directly related to chamber size with variance decreasing respective for Conviron, EGC and Percivals chambers. It should be noted that the variance of a treatment mean can be lowered if the numbers of plants, channels, or chambers are increased. The results of this study will help in designing future growth chamber experiments.

Field Study

Biweekly Foliage Topping of Peanut.

'Georgia Red' peanut cultivar was planted in the field in May, 1992 in a randomized complete block design with four replications. There were four treatments comprising three harvest times of 2, 4, and 6 weeks and an untreated check. Seeds were sown 20 cm apart in two-plot rows spaced 61 cm apart. Treatments were initiated 6 weeks after planting. At each foliage harvest, the first and fifth fully opened leaves (including petioles) were removed from each branch of 10 plants. Plants were harvested 120 days after planting and foliage was removed, weighed fresh and then dried, while nuts (nuts and pods) were weighed fresh. Table 2 shows means of four variables. Both foliage fresh and dry weights as well as nut/pod yield declined with intervals of foliage removal from 6 weeks to 2 weeks. Foliage dry weight declined 22.6% and 28% for 4 and 2 weeks harvests, respectively, compared to the 6 week harvests. Similarly, nut/pod yield declined 23.8% and 27.9% for 4 and 2 weeks compared to the 6 week harvest. It appears that plants with foliage harvested at 2 and 4 weeks produce similar results. This also holds true for the check and 6 week harvested plants. Total sound mature kernels (TSMK%) seemed not to have been influenced by the interval of foliage removal.

Table 2. Effect of foliage removal on selected peanut growth components.

Harvest	Foliage		Nut	%TSMK
intervals	Fresh wt.	Dry wt.	Fresh wt.	
(weeks)	----------------------g/10 plants)------------------------			
Check	1508.5	396.7	767.5	86.5
2	1023.9	249.9	496.6	84.2
4	1077.7	269.5	524.6	83.0
6	1281.6	348.0	688.6	85.9

1. Biweekly topping of Sweetpotato Shoots.

It is generally accepted that sweetpotato is grown for its storage roots but studies have shown that foliage tips are also used as a vegetable green as a good source of vitamins and minerals. Use of the greens also minimizes requirements for waste recycling. If foliage tips are to be used as a green vegetable, they will have to be removed at an optimum time during the growing period.

The experiment was set up as a complete randomized design with 4 replications. Starting 42 days after planting, foliage tips, 10 cm long were harvested every 2 weeks and compared to plants without harvested tips. Storage roots were harvested 120 days after planting. Harvested tips, storage roots and foliage were analyzed for Ca, Mg, K, Fe, Zn and protein contents. Data were subjected to analysis of variance with mean separation by DMRT or LSD (5%).

Storage root and foliage fresh and dry weights were all reduced in response to bi-weekly foliage tip removal compared to the untreated control (Table 3). The number of foliage tips at each harvest period increased but not significantly (Table 4). Fresh weight of tips was greatest at midseason with dry weights decreasing toward the end of the growing season. Protein levels followed a similar trend except at 70 days after planting when there was a slight decrease in protein content of foliage tips. Nutrient analysis of foliage tips (Table 5) showed highest Ca levels at 70 and 84 days after planting while K accumulation was highest in tips at 70 days. While Zn levels were highest in tips harvested toward the end of the growing season, Fe levels were highest at 70 days after planting. Although the substantial quantities of foliage tips removed (Table 4) reduced storage root and foliage fresh and dry weights, this removal did not affect Mg, K, Fe, or protein levels of the storage roots (Table 6). However, protein, Ca, K, and Zn levels were higher in whole plant foliage of harvested plants than untreated plants (Table 7). Magnesium levels were twice the values in untreated plants as they were in harvested plants. The low yields obtained from plants in which foliage tips were removed may have been due to severe root disease problems which resulted in severe wilting of bi-weekly topped plants for several days early in the growing season. This experiment will be reported.

Table 3. Effect of foliage tip removal on sweetpotato storage root and foliage yields in NFT.

Harvest	Storage root				Foliage	
interval	No.	Fresh wt.	Dry wt.	%DM	Fresh wt.	Dry wt
		---------(g/plant)------			---------g/plant---------	
Bi-weekly	2.3a	201.9a	23.6a	11.3a	162.9	17.5a
Control	2.5a	414.5b	55.5b	13.6b	256.9	29.9b

Means in column followed by the same letter are not significantly different by DMRT (5%).

Table 4. Yield of foliage tips at five harvest dates.

Days	Foliage tip			Protein
after	No.	Fresh wt.	%DM	
planting		(g/plant)		(%)
56	29.0a	157.0a	11.3c	24.1a
70	27.5a	213.6b	10.6b	21.3a
84	30.1a	188.5ab	10.8bc	24.4a
98	35.5a	201.0ab	9.2a	26.1a
102	31.8a	189.2ab	7.8a	26.5a
LSD.05	9.9	55.2	0.2	6.2

Table 5. Elemental content of foliage tips at five harvest dates.

Days after	Ca	K	Fe	Zn
planting	---------------------(mg/100 g dry weight)--------------------------			
56	6.0c	11.6a	2.1d	0.6d
70	14.5a	25.9b	4.9a	0.8c
84	13.9a	23.1b	2.4cd	0.9b
98	13.0ab	25.5b	4.2b	1.0a
102	10.7b	26.1b	2.9c	1.0a
LSD.05	2.6	3.2	0.6	0.7

Table 6. Effects of foliage tip removal on elemental and protein content of sweetpotato storage roots.

Harvest interval	Ca	Mg	K	Fe	Zn	Protein
	------------------------(mg/100 g dry wt.)-------------------					(%)
Bi-weekly	4.9a	153.0a	16.6aa	2.2a	--	8.15a
Control	3.3b	167.0a	12.7a	1.9a	--	8.14a
LSD.05	1.17	59.2	4.08	0.35		2.4

Table 7. Effects of foliage tip removal on elemental and protein content of sweetpotato foliage.

Harvest interval	Ca	Mg	K	Fe	Zn	Protein
	------------------------(mg/100 g dry wt.)-------------------					(%)
Bi-weekly	20.9a	1096b	31.0a	14.8a	0.9a	19.27a
Control	18.4b	2842a	27.4b	8.0a	0.7a	15.43a
LSD.05	1.96	233	2.59	8.56	0.66	4.62

2. Nutrient Solution pH Studies

Nutrient solution pH in any hydroponic system plays a major role in nutrient availability for plant uptake. Changes in pH occur very rapidly in solution culture thus pH must be regulated with a narrow range.

'TI-155' vine cuttings were grown in TU NFT channels. Plants were subjected to three pH treatments. Two pH levels—4 and 6, held constant throughout the growing season by use of a pH controller and dilute NaOH or HCl, were compared to a control in which the pH of the solution was allowed to fluctuate but was periodically adjusted to 6 at bi-weekly nutrient solution changes or when solutions were topped. Harvest data were subjected to analysis of variance and mean separation by DMRT (5%).

Neither number of storage roots/plant nor foliage fresh and dry weights were affected by the pH treatments (Table 8). Storage root fresh and dry weights and percent dry matter were significantly higher for plants maintained at constant pH 4 than either constant or periodic 6. Plants grown in solution with the pH maintained at 6 showed a similar response to those grown in solution with pH periodically adjusted to 6. Results obtained from this study suggest that sweetpotato growth may be enhanced at low solution pH. Since K ions play an integral role in loading of assimilates into phloem cells, it is possible that at low pH K uptake was enhanced; hence greater transport of assimilates may have occurred in sweetpotato storage roots.

Table 8. Effect of constant vs periodic pH adjustment on storage root and foliage yield of sweetpotatoes in NFT.

Harvest	Storage root				Foliage	
interval	No.	Fresh wt.	Dry wt.	%DM	Fresh wt.	Dry wt.
		---------(g/plant)------			---------g/plant---------	
Constant 4	3.4a	476.4a	73.3a	15.3a	373.2a	39.6a
Constant 6	3.4a	339.9ab	47.9b	13.7b	377.6a	39.4a
Periodic 6	2.7a	246.2b	36.2b	14.4ab	359.9a	37.0a

3. Development of NFT Systems for Efficient Production of Peanuts

New Improved Spanish' peanuts were grown for 152 days in NFT utilizing three treatments: (1) standard TU NFT channels fitted with a perforated PVC grid 10 cm above the bottom of the channel; (2) a standard TU NFT channel without a grid; and (3) a wide channel (45 cm) fitted with a perforated PVC grid 10 cm above the bottom of the channel. Seeds were germinated at room temperature in blotting paper soaked in sterile deionized water. Seedlings were selected based on uniformity and planted in growing channels 12 days after germinating. Plants were supplied a modified Evan's plant nutrient solution that was changed at 14-day intervals for the duration of the study. A population density of 6 to 8 plants per square meter was maintained. At harvest, plants were separated into shoots, roots and pods, weighed and dried in a forced air oven at 60C. All data were subjected to analysis of variance with mean separation by LSD (5%).

Differences in peanut pods and shoots were not significantly different for the growing systems (Table 9). Pod and shoot weights tended to be highest in the narrow channel without grid and wide channel with grid, respectively. Presence of the grid in the narrow channel tended to restrict peanut biomass production resulting in 86% fewer pods. The pods germinated in the nutrient solution prior to harvest. This problem is being addressed in a current study that is evaluating five treatments which will allow close observation of developing gynophores to determine when pods actually start germinating.

Table 9. Weight and number of peanut pods and shoot biomass developed in prototype NFT hydroponic systems.

Growing system	Peanut pod			Peanut shoot	
	No.	Fresh wt.	Dry wt.	Fresh wt.	Dry wt.
	(m^{-2})	($kg\ m^{-2}$)			
Narr. - Grid	325	0.121	0.033	3.09	0.67
Wide + Grid	122	0.084	0.041	14.17	0.63
Narr. - Grid	43	0.020	0.014	2.39	0.37
LSD.05	NS	NS	NS	NS	NS

Microgravity Applications and Controls System

Summary

A study of the initial stainless steel membrane nutrient delivery system indicated that the pore size was not uniform throughout and that flow along the length of the membrane was irregular. A survey of the literature to identify candidate membrane materials focused on titanium and ceramic membranes that can offer better corrosion resistance than stainless steel. Four growing channels were designed, constructed and tested—one with a titanium membrane, one with a ceramic membrane and two with stainless steel membranes—one with and one without a porous medium. A control system was designed and used to control water flux through the membrane. A prototype system is presently being used to grow sweetpotatoes in the greenhouse and its performance is being assessed. A system to monitor CO_2 levels in the environmental growth chambers was developed. A schematic for computer control of CO_2 levels in these chambers has been completed and hardware and software development for the CO_2 control system are underway.

First Year Objectives (1992)

(1) To characterize the existing stainless steel membrane nutrient delivery system.
(2) To select candidate membrane materials that can offer better corrosion resistance than stainless steel.
(3) To design and construct better membrane systems and incorporate them into growing channels.
(4) To design control systems for use with the above systems and for control of other parameters.

Research Activities

The use of porous membranes for crop growth in microgravity was initially proposed by Wright (1984) at Kennedy Space Center. Wright et al. (1988) constructed several plate-type porous membranes in a closed circuit system with no free water, to simulate the in-service conditions required in microgravity applications. Later Koontz et al. (1990) reported acceptable lettuce (mature) growth on a stainless steel plate, using a nutrient recirculating system. All of these flat plate systems operate at "ambient" pressure depending on the pore size of the membrane.

Dreschel and Sager (1989) outlined the porous tube membrane as a potential system for crop growth in the microgravity of space. It is based on the same concept proposed by Wright of controlling the nutrient solution delivered to the roots by capillary action. Plant species such as wheat (Deschel et al. 1987a; 1987b; Bubenheim et al. 1987), rice, and lettuce have been grown with varying degrees of success (Dreschel et al. 1988) in porous tube membranes. However, potatoes showed a ten-fold reduction in size in a porous tube membrane system compared to those harvested in peat-vermiculite medium (Dreschel et al. 1988) although they had the same harvest index. Negative pressure relative to the atmosphere is required to contain the solution within the tube. This can restrict the water flow through the thickness of the tube causing water stress on the plants (Dreschel et al. 1987b).

In microgravity applications, all of the membrane configurations examined may operate at or near atmospheric pressure without leakage; however, some shapes cannot operate without leakage. The effect of membrane characteristics such as membrane shape, geometry, pore size, materials and fabrication techniques on the system's delivery performance are not presently available. Although the response of these systems to microgravity cannot be easily predicted from their response in earth gravity fields, a thorough understanding of their performance-related characteristics is needed to obtained baseline data at zero growth conditions. The need to develop a sensoring and companion controller system to monitor the nutrient delivery process is equally important. This includes sensors to measure the moisture and temperature around the roots and leaves, solution pH, electrical conductivity, ambient pressure, etc. Computer software will be developed to monitor and control the nutrient solution.

In the present work the development of a nutrient delivery system utilizing a porous plate membrane has been undertaken. This includes material selection, channel geometry, fluid flow arrangement, long-term performance and control. The following sections detail the research activities of the MAC group during the project's first year.

System Characterization

1. Existing Stainless Steel Membrane System

The research work was initiated with an 0.5 mm porous membrane unit provided by NASA, originally designed by H.W. Scheld (Phytoresource Research, College Station, TX). This system had been used in the past with gravity feed using a stand pipe as shown in Figure 1. Since the long-term objective of the system design is for its use in microgravity, a closed loop arrangement was considered, as shown in Figure 2.

The membrane unit was connected to a reservoir and a variable speed pump unit to provide a closed loop positive head nutrient delivery system. The following experiments and procedures were conducted in order to fully characterize this system.

2. Pump Characteristics

A Cole-Parmer miniature pump was used to circulate the nutrient solution through the system. Initially the flow rate of the pump was determined at various pump speeds by holding the discharge pipe at the same height as the entrance into the plate membrane. The pump was started and water was collected into a measuring cylinder for a certain period of time. The tests were repeated three times at each pump speed. The average results of these tests are shown in Figure 3.

These experiments were conducted in order to establish the actual characteristics of the pump, i.e. flow rate versus speed at the specific elevation of the plate. This was also done to compare the results with similar tests conducted with the porous membrane attached to the pump and to obtain information on the global fluid flow resistance of the porous plate and tray channel.

3. Flow Through the Plate Membrane

The main purpose of this experiment was to determine the flow through the porous membrane at different pump speeds. Sheets of an absorbent pad with a surface area large enough to cover the plate membrane were cut and accurately weighed. Prior to the experiment, water was pumped into the plate membrane and the excess that seeped through the plate was wiped off. The absorbent was then packed on the plate membrane and the timer and the pump started simultaneously. After a certain period of time, the pump and the timer were stopped and the absorbent material was carefully lifted up from the top of the plate membrane and weighed. The difference in the weight of the soaked absorbent and the dry absorbent was obtained and taken as the flow through the plate membrane (Q_m). This was repeated three times at each speed and it was made sure that the absorbent did not become over-saturated. Figure 4 shows the relationship between the rate of water flux through the porous membrane and the pump speed. This total overall water flux is important because this will be the amount of water available at any particular pump speed, to offset the plants' demands. Thus, this provides a direct correlation between pump speed and nutrient solution availability.

In addition to the overall rate of flux, the flux distribution along the membrane was studied. To achieve this, strips of absorbent pads of the same length as the width of the membrane 15 cm and 5 cm wide were cut and individually weighed. These were carefully packed in the plate membrane and the experiment was performed as documented above. Graphical representation of these results is shown in Figure 5. As can be seen in the figure, the rate of flux is not uniform along the 1.2 m length of the porous stainless steel membrane. Several factors may contribute to this problem. These factors mainly are:

-air entrapment and non-uniform water distribution due to inadequate system design
-blockage of the micropores by algae, debris from prior plant growth and precipitates from the nutrient solution
-plate corrosion

Since the success of the design of future systems depends on a better understanding of these parameters, three areas must be closely examined. These are examination of the design from the geometrical dimension viewpoint, fluid flow pattern and microscopic examination of the porous plate after each plant growth cycle. These areas will be studied in the development of future systems.

Microscopic examination was performed on the existing stainless steel plate to establish whether pore blockage, corrosion, algae, etc. could have contributed to the non-uniform flux of water through the membrane. This will be considered in the next section.

4. Microscopic Inspection of the Stainless Steel Membrane

Visual observation of the stainless steel plate after three sweetpotato growth cycles revealed brownish stains and corrosion spots in various places particularly along the weld seams where the plate was joined in the middle. The porous plate was microscopically examined for the following:

-variation of pore sizes
-corrosion of the plate membrane, which might have led to either opening up of pores or their blockage
-pores that might have been blocked by chemical compounds, algae and other impurities.

For the purpose of microscopic inspection, the stainless steel plate was taken from its chamber. A 1" X 1" grid system was created on transparent paper and placed on the top of the plate while it was microscopically examined. This allowed for the mapping of the surface of the plate and any irregularities in the pore size, defects, corrosion spots to be marked on the transparent grid. Many scratches were observed from handling and prior plant growth cycles. Isolated spots of large pores were also noticed. In addition, corroded spots of a brown color were observed. It should be mentioned that the focus of the microscopic analysis was to globally inspect the plate; therefore, only 120X magnification was used. At this magnification no foreign materials such as plant roots or algae could be identified in the pores. Very high magnification examination such as by SEM on specific areas was not feasible during this phase of the investigation since it involves destruction of the plate to obtain samples. However, SEM examination could be done at a later date.

The microscopic examination led to the consideration of titanium and ceramic plates as porous membranes, since they are known to be more resistant to corrosion than stainless steel. The design, construction and utilization of a microporous titanium membrane nutrient delivery unit is presented in the next section.

New Membrane System

1. Titanium Membrane System Design

Part of the flow problems described above were thought to have been caused by inadequate design of the membrane unit. A new membrane unit was designed using a titanium plate with pore size of 0.5 mm. The overall dimensions are 20 cm X 20 cm. The depth of the channel (flow passage beneath the plate) is 6.4 cm. Schematic diagrams of the titanium nutrient delivery system are shown in Figures 6 and 7. The unit was built with transparent plexiglass at the bottom through which the flow pattern, in an initial test without plants, could be observed. It was connected to the pump and reservoir system in the configuration resembling the one that was previously described, i.e. the pump was mounted between the reservoir and the membrane unit. The pump system was composed of a manual control unit—a Cole-Parmer T-2630-25 manual power supply speed controller that rectifies 115V AC to 12V DC. This unit controls a T7012 - 20 gear pump which has pump speed settings ranging from 1 to 10 with 10 being full speed.

a. Fluid Flow Pattern

It was noticed that the plate membrane unit could not be made to flow full channel without flooding the plate and, once the plate was flooded, it was difficult to dry by reducing the pump speed. This behavior led to the conclusion that the pressure required to push water to the other end of the channel was larger than the pressure required to push water through the micropores; hence, water seeps through the micropores before reaching the other end of the channel.

To achieve a better flow control, the pump was placed after the membrane unit so that it was used as a booster pump, (Figure 8). Flow control was improved under this arrangement. The height of water in the reservoir was kept constant throughout the test.

b. Flow Through the Plate Membrane

The flow measurement was achieved by using an absorbent pad as previously described. The results of pump discharge under various speeds and the flow through the plate membrane are given in Table 10.

The total flow rate leaving the reservoir for this particular arrangement is denoted as Q_t, the flow rate through the membrane as Q_m and the flow rate returning to the reservoir is Q_r. Thus, $Q_t = Q_r + Q_m$. It is Q_m that will affect the plants' demands for nutrient delivery solution and Q_m must be varied by the pump speed with the age of the plant.

Table 10. Relationship between pump speed and various flow rates.

Pump Dial Setting	Total flow rate leaving reservoir, Q_t (mL/s)	Return flow rate to reservoir, Q_r (mL/s)	Flow through the membrane, Q_m. (mL/s)
5	9.582	9.57	0.012
4	7.958	7.91	0.048
3	5.3 +	5.3	plate flooded

c. Plant Growth on a Titanium Membrane

The titanium system as described above is now planted with the sweetpotato cultivar 'TU-155' and the plant is in its fifth week of growth. Crop water demand is supplied through the manual control of the pump speed in such a way that water flow through the plate membrane meets the daily crop water requirements of the plants. The consumption was approximated from data obtained from previous experiments performed in growth chambers at Tuskegee University's Agricultural Experiment Station as shown in Figure 9.

2. New Stainless Steel Membrane Units

The experience gained from characterization of the existing stainless steel membrane has been used to construct two new stainless steel systems. Various modifications have been made in both the design and fluid flow arrangement. These systems, fabricated and tested in the laboratory without plants, are described as follows.

a. Unpacked Channel

An open channel system with 0.2 mm pore size was designed. This system is shown in Figure 10. The overall dimensions of the channel are 1.02 m X 0.22 m. The thickness of the plate is 1.0 mm and the unpacked channel depth is 64 mm, similar to the titanium system.

The new features of this system are as follows.

-Its pore size is 2.5 times smaller than the two previous systems, i.e. existing stainless steel and titanium. This is in order to test the behavior of a smaller pore size (0.2 mm) and compare it with other systems with 0.5 mm pores. Moreover, a small pore size which offers a higher resistance to the flux though the membrane could give a larger margin of control.
-The nutrient solution is being delivered and discharged from the sides instead of the ends of the channel as shown in Figure 10. Laboratory tests revealed that a uniform flux pattern was obtained with this flow arrangement. When the inlet pipe is placed in the middle and two exiting pipes of the same diameter as the inlet, are located at the ends, a uniform flux distribution over the entire length of the plate was obtained. This type of flow arrangement will therefore be adopted in future units.
-It is mechanically fastened with gaskets and stainless steel bolts rather than rubber cement adhesive. This type of fastening is critical for quick assembly and disassembly of the system. In addition, it allows for cleaning the system by flushing it with air or inert gases.

b. Porous Medium Packed Channel

This system is similar to the unpacked unit except the flow channel is filled by a stainless steel porous medium with 100 mm pores. Also the pore size of the top stainless steel plate is 0.5 mm, instead of 0.2 mm in the unpacked system. Detailed drawings of the packed system are shown in Figure 11. This system, currently being tested, is believed to further improve the uniformity of the water flux though the membrane by minimizing the air entrapment. Moreover, it provides a better control than an unpacked unit with the same stainless steel membrane pore size distribution; this is due to the resistance added by the porous medium.

3. Ceramic Unit

Although ceramic membrane tubes have been used in plant growth by Dreschel et al., as far as is known, a ceramic plate has not been utilized. In this system, a porous ceramic membrane plate with pores of 0.5 mm and about 30% porosity was used. The dimensions of the plate are 22 cm wide X 61 cm long and 6.4 mm thick. The channel depth is 6.4 mm. The channel geometry is identical to that of the unpacked stainless steel unit shown in Figure 10. This system is currently being assembled to be tested for water flux uniformity and water flux control. This system will have the advantages of being non-corrosive, electrically non-conductive and chemically inert.

Control System Development

1. System Design and Description

A control system is under development to regulate the delivery of nutrient solution through a porous membrane to the roots of sweetpotatoes and peanuts. The system is designed to regulate the speed of the pump using a data acquisition system which is to be attached to a moisture sensor circuit that provides a feedback. The system is to have the features of providing a flow of nutrient solution to the plant as required by a plant consumption master curve (open loop). A feedback (control loop system) can be incorporated from moisture, humidity, and temperature sensors.

The work to date has focused on the construction and testing of an open loop control system, i.e. no sensors for feedback. The hardware required to operate the control system was set up. The software was configured to correspond with the open loop conditions. A test was performed to send a signal to vary the motor speed by a PC keyboard. A potentiometer has temporarily been introduced to simulate any future sensors which are to be developed or acquired. The hardware and software developed and assembled so far are listed below.

2. Hardware

Power Supply (LAMBDA regulated power supply, Model LR602 FM)
Post-Amplifier
Personal Computer (Power Flex ALR)
Motor Speed Controller (Modified Cole Parmer Supply)
Potentiometer 20k
Pump
Porous membrane nutrient delivery channel
MOSFET Switch
Data Acquisition Card

Schematic diagrams and detailed descriptions of the major components of the electronic control system are given in Figures 12-16.

3. Software

Sigscrn (A program written in GW Basic which simulates the feedback control signal. The value is entered via a PC Keyboard to simulate the feed back control signal.)

Consys2 (A program also written in GW Basic which controls the speed of the motor according to an analog voltage from the potentiometer which represents the sensor output.)

4. Calibration

A control system was tested for consistent operation by setting various voltages from the PC and potentiometer to activate the motor. The time required to saturate the membrane was measured as a function of control voltage. Successful control of the pump via the PC to deliver nutrient solution was achieved.

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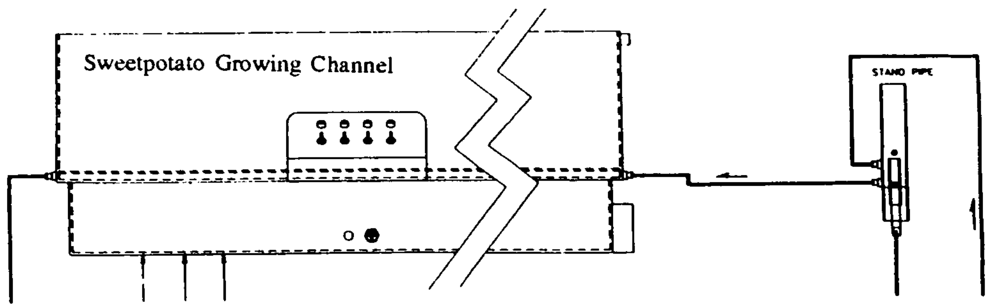


Fig. 1 Gravity fed Phytoresource Research Co. stainless steel nutrient delivery system (6 in. wide x 48 in. long) using a stand pipe.

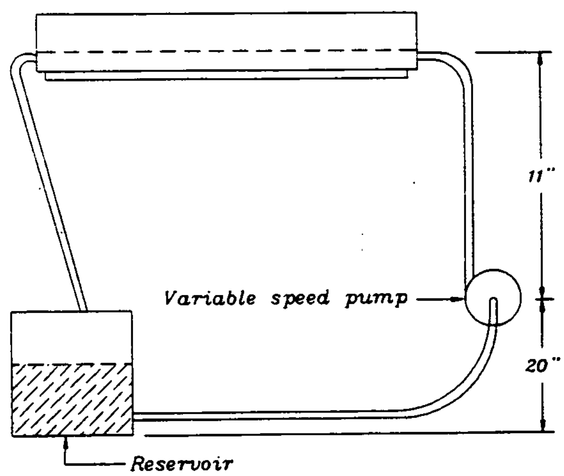


Fig. 2 Closed loop arrangement of the Phytoresource Research Co. stainless steel nutrient delivery system.

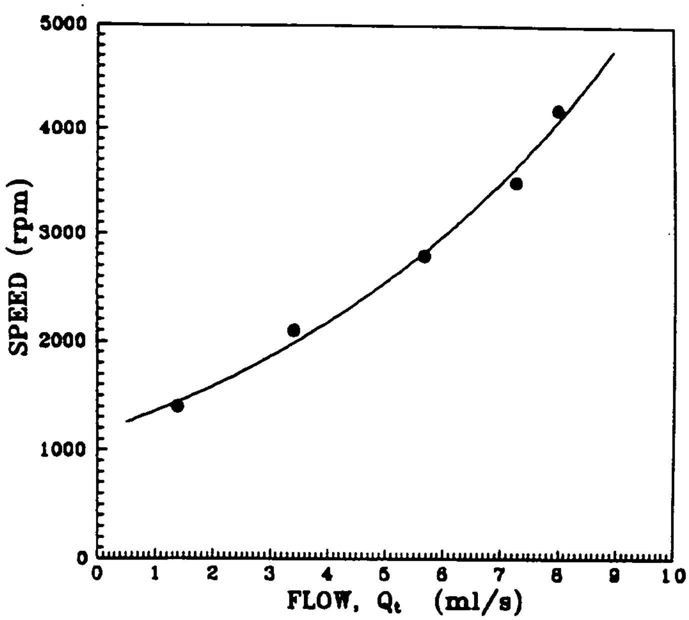


Fig. 3 Pump speed versus flow rate, Q_t

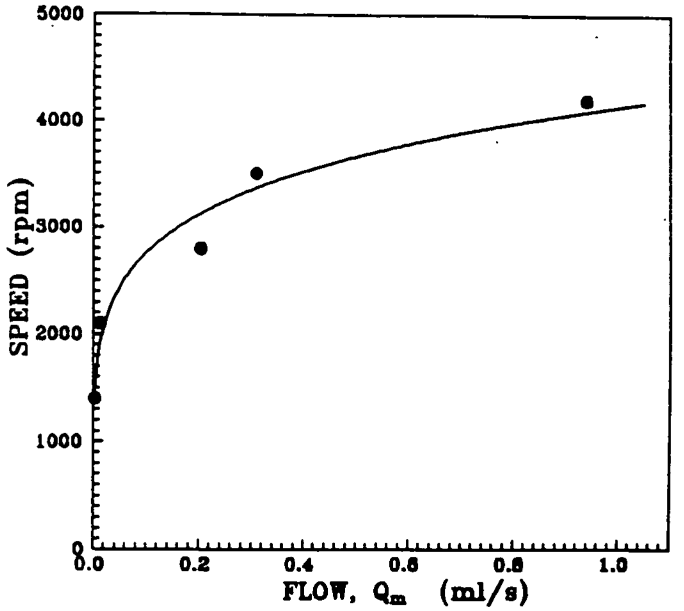


Fig.4 Pump speed versus rate of water flux through the membrane, Q_m

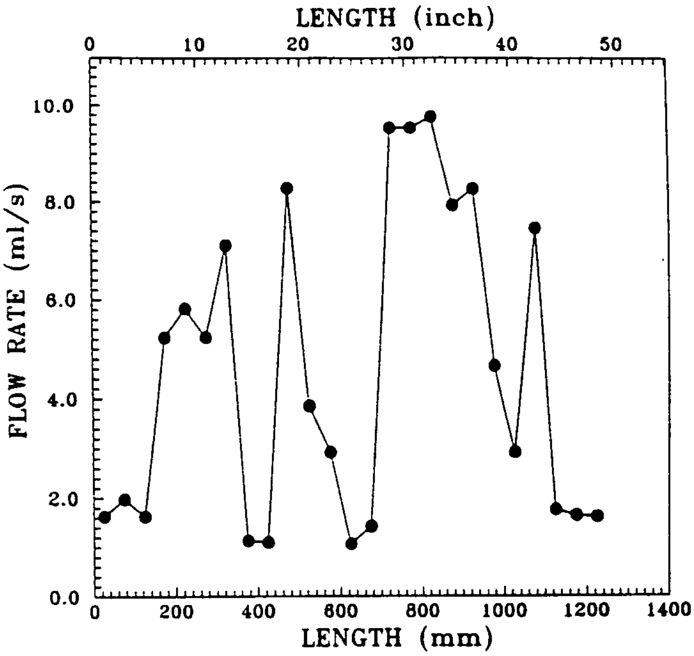


Fig. 5 Rate of water flux through the membrane, Q_m, versus the length of the existing stainless steel membrane.

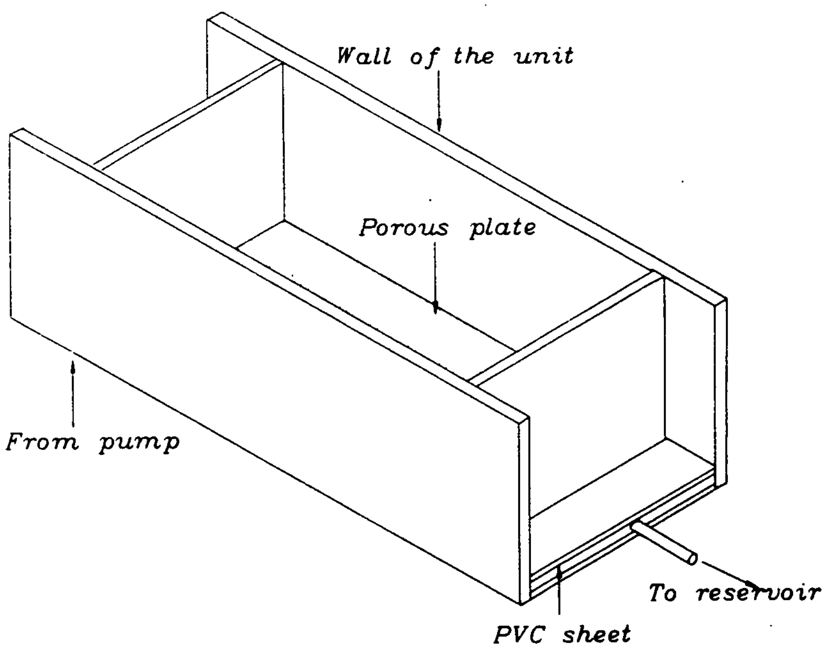


Fig. 6 Schematic of the titanium porous plate Nutrient Delivery System.

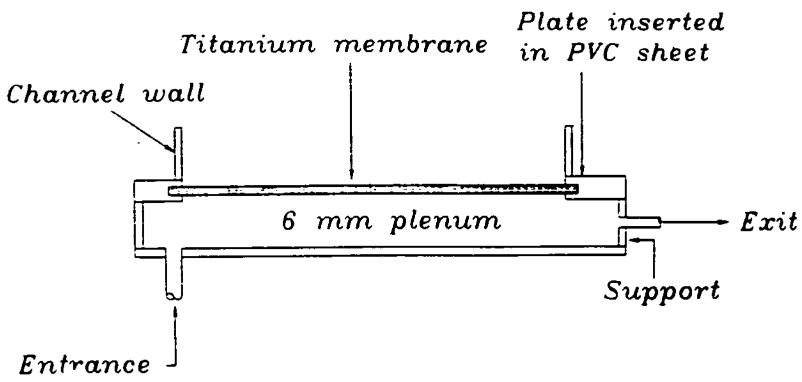


Fig. 7 Sectional view of the titanium unit of Fig. 6

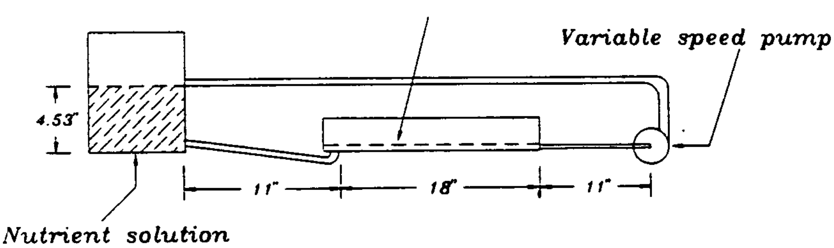


Fig. 8 Schematic diagram of the revised system arrangement for the titanium unit

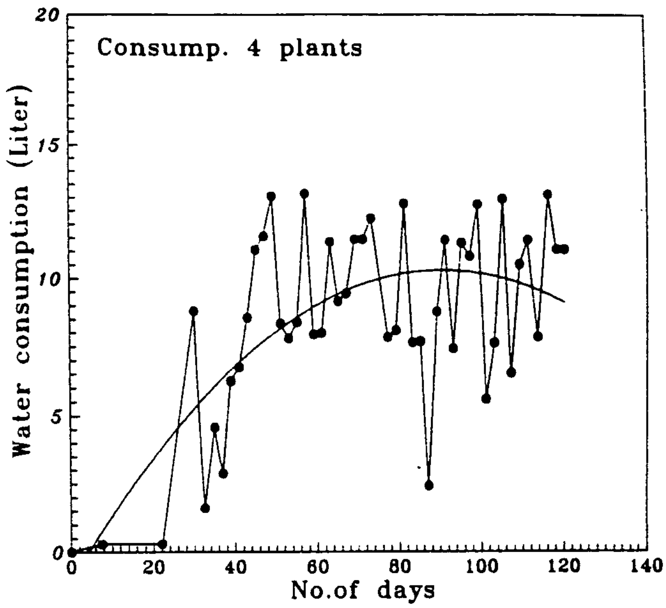


Fig. 9 Water consumption versus plant age for TU-155 sweetpotatoes (Four plants)

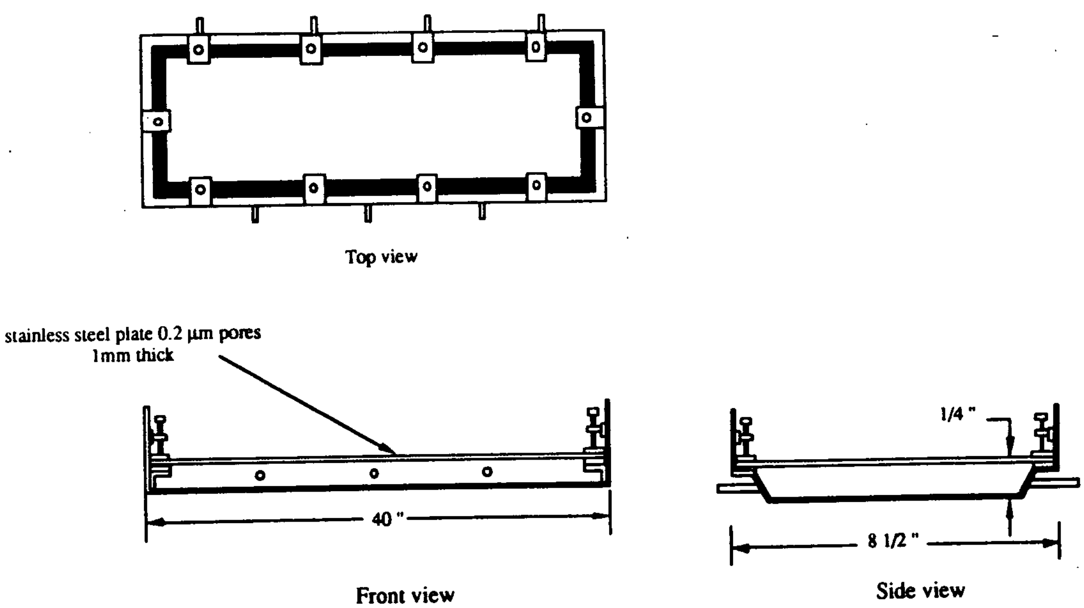


Fig. 10 Microporous stainless steel system with unpacked channel

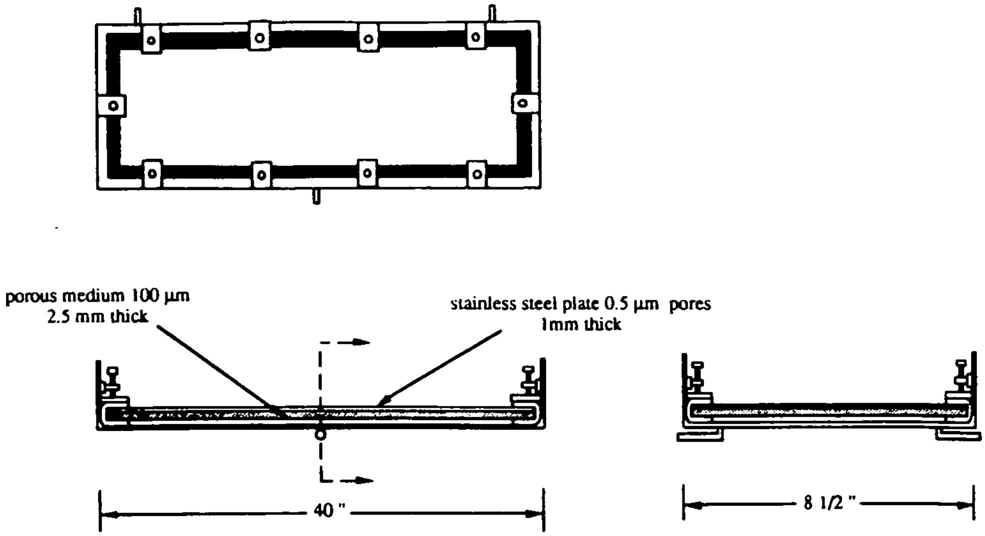
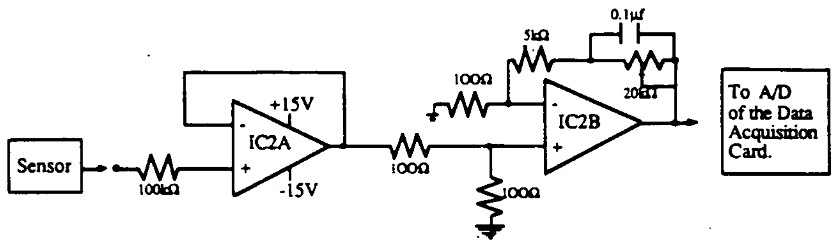


Fig. 11 Microporous stainless steel system with packed channel of porous stainles steel medium



IC2 = 747

Figure 12. Post Amplifier

<u>Description of Post Amplifier</u>

This circuit amplifies the signal from the sensor panel and sends the signal to the Data Acquisition Card in the micro-controller.

Op-Amp IC2A serves as a buffer to provide high input impedance to the sensor as well as low output impedance for the following variable gain amplifier.

Op-Amp IC2B is connected as a variable voltage gain amplifier. The overall Post Amplifier gain is adjusted by the 20k potentiometer. The maximum and minimum gain is:

Max Gain 125.5
Min Gain 25.5

A 0.1mf capacitor is connected across the 20k feedback potentiometer to provide attenuation of any high frequency noise that could be picked up by the sensor. Once the signal is sent to the computer, the command to operate the motor speed is activated.

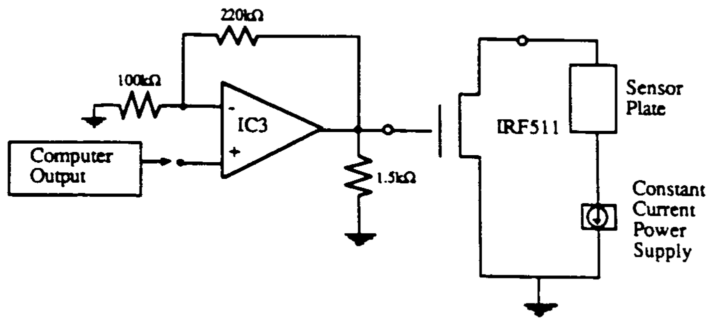


Figure 13. Digital level shift.

Description of the Digital Level Shift

The function of the digital level shift is to interface the digital signal from the computer to the MOSFET IR511 in order to control the constant current supply to the pourous sensor membrane. IC3 provides a gain of 3.2.

This gain boosts the control signal from the personal computer to a level sufficient to ensure on/off switching of the MOSFET (IRF511). The current flow into the sensor panel is turned on for a short duration in order to reduce the average current in the sensor panel to a low value.

MOTOR REGULATOR

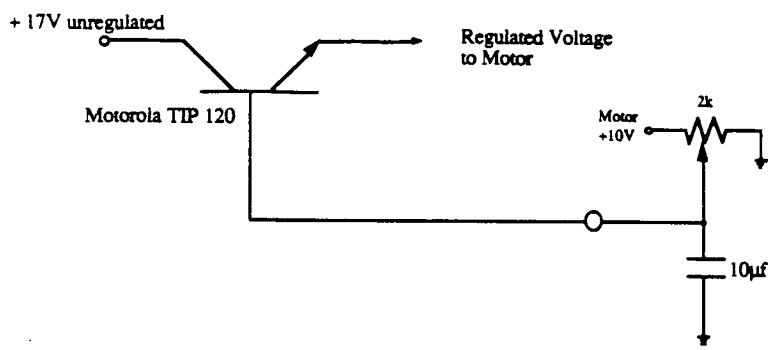


Figure 14. Voltage regulation circuit

Description of Motor Voltage Regulation Circuit

A TIP 120 NPN power transistor is used to regulate 17V DC to feed the pump motor. A 2k potentiometer allows adjustment of the voltage from 0 and 9.3 volts.

The 10mf capacitor prevents noise pick-up.

MOTOR SPEED CONTROL

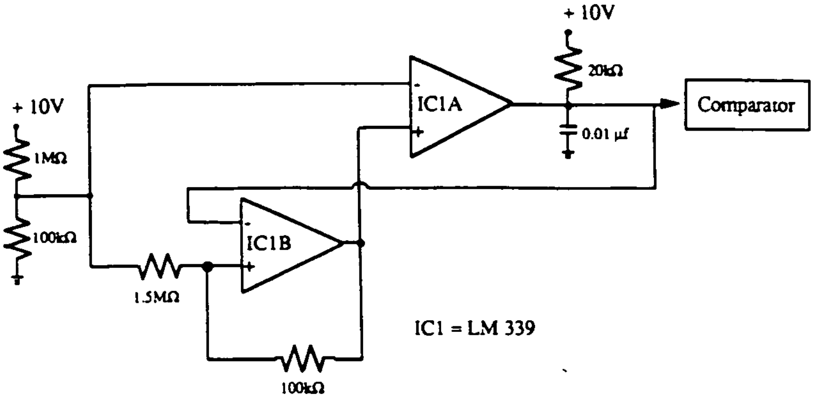


Figure 15a. Multivibrator circuit.

Description of Motor Speed Control

The IC1A and IC1B comparators along with the resistors and capacitor form a multivibrator which purpose provides a sawtooth voltage.

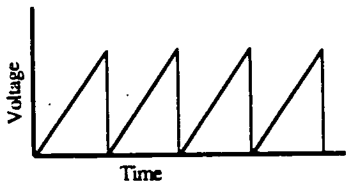


Figure 15b. Output of the multivibrator.

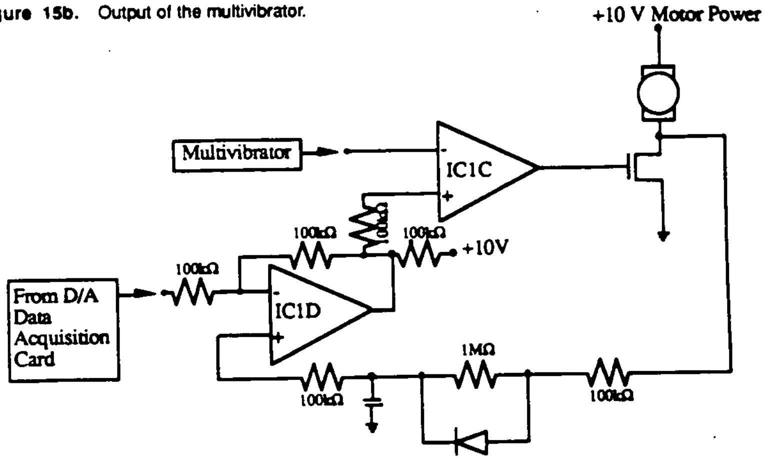


Figure 16. The comparator circuit.

Description of The Comparator Circuit

LM339 is a comparator with an open collector NPN Transistor output.

The IC1D compares the voltage from the computer to the back emf of the motor. The motor speed is determined by the average value of the pulse waveform from . An RC filter is used to average the waveform and provide feedback to IC1D which compares the computer value (set point) to the feedback voltage.

Plant Modeling

Summary

No postdoctoral fellow has applied for the advertised position with PAM so a candidate with computer systems/mathematics background who has experience with sweetpotato research has been offered a position with the Center. Funds from USDA have been obtained to hire a Ph.D. level biometrician for the Center to provide expertise in modeling and in experimental design and analysis. Potato (*Solanum*) models have been ordered for study of their adaptability to sweetpotatoes. The Center served as a catalyst to tie the campus into the Alabama Supercomputing Authority with a T-1 line. A two-day workshop sponsored by the Center offered campus-wide INTERNET training by three specialists from the MU-SPIN office at Goddard Space Flight Center.

First Year Objectives (1992)

1. To select a postdoctoral research associate with a background in plant breeding/biotechnology.
2. To obtain potato models which can be adapted to sweetpotato.
3. To help develop national networking capability (INTERNET) for the campus.

Research Activities

The postdoctoral position for plant modeling was advertised. Efforts are being made to fill the position by January 1993. However in the meantime, a candidate with an M.S. and a Computer System/Mathematics background and experience with sweetpotato hydroponics research, is expected to start in January 1993.

A sweetpotato plant growth model developed in Australia will be tested for adaptability to greenhouse and growth chamber conditions. A literature search is being conducted for the development of the physiological model.

Several potato models have been received and will be examined for modification and adaptability to use for sweetpotato.

Networking on campus has been enhanced with the assistance of the NASA Minority University Space Interdisciplinary Network (MU-SPIN) Program at Goddard Space Flight Center. In May, a MU-SPIN representative visited the campus to assess our needs and in September, a two-day Networking Training Workshop was offered in Tuskegee by three MU-SPIN staff. The workshop served as training sessions for over 50 Tuskegee University scientists including most of the Center staff. The three sessions offered were:

Design and Implementation of Low Cost Local Area Networks
Campus Network Services and Management
Resources on Internet

The interaction with MU-SPIN also served as a catalyst in expanding the Tuskegee University networking capability. Tuskegee University is now connected by a T-1 circuit to the Alabama Supercomputing Authority. Ethernet cable has also been run throughout the Campbell Building. Either high speed or low speed cables connect individual workstations by Ethernet cable and optical fiber to the Office of Computer Services where the T-1 to the campus is being made. Individual personal computers have already been implemented with hardware and licences software to allow use of INTERNET in early 1993.

Germplasm Development

Summary

Field evaluation of 10 sweetpotato breeding lines from replicated trials resulted in yields ranging from 8.4 to 37.2 t/ha and dry matter ranging from 28.8 to 40.9%. Observational trials of 182 breeding lines found yields of 28 to 2495 g/plant and %dry matter of 16.0 to 43.0%. Five leading peanut breeding lines have been obtained from the University of Florida and two of them have been planted in the greenhouse for study in NFT. Eight sweetpotato genotypes were compared for adaptability to NFT under greenhouse conditions. Sweetpotato storage root fresh weight and % dry matter of up to 620 g/plant and 30.2%, respectively, were obtained for the genotypes. Use of modified growth media showed significant enhancement of sweetpotato regeneration in tissue culture using small pieces of petiole in as few as 10 days. Initial studies that incorporated the *asp*-1 gene into peanut—cultivars 'Georgia Red' and 'Early Bunch 495-5'—using *Agrobacterium* were completed.

First Year Objectives (1992)

1. To evaluate sweetpotato and peanut breeding lines in the field.
2. To evaluate selected germplasm in the greenhouse and growth chambers for adaptability to NFT.
3. To introduct the *asp-1* gene into the sweetpotato and peanut through biotechnological approaches.

Research Activities

Field Evaluations

1. Evaluation of Sweetpotato Breeding Lines

The objective of this aspect of germplasm development is to evaluate sweetpotato germplasm in the field for high dry matter content, yield and compact foliage. Lines selected from these trials will be further evaluated in the greenhouse for their adaptability to the TU-NFT and other growing systems. Replicated as well as observational trials were conducted. A dry matter content of 25% or more was the minimum accumulated for selection. For the replicated trials, ten breeding lines of several accessions were selected the previous summer based on the above criteria as well as the availability of planting material. These were planted in replicated field plots. A completely randomized design was used with 4 replications. Sweetpotato vine cuttings were planted 18 cm apart on 75m rows, 1m apart. Standard recommended field practices for sweetpotato production in Alabama were followed. Plants were harvested 120 days after planting. The storage roots were graded and weighed. Yield was calculated based on tons/ha. The observational trials were divided into two trials. The first trial consisted of lines selected from the previous year's accessions which had been grown from true seeds. Twenty plants per breeding line were used. The second observational trial consisted of cuttings of several accessions from true seeds. Each seed constituted a breeding line. Five plants per breeding line were used. Similar field practices were followed as in the replicated trials.

Table 11 shows results of the replicated trial. Breeding lines J6.5, J6.23, Biomass PX.2, AC87.7.7, AC87.8.15 and AC87.8.16 produced significantly higher storage root numbers per plant than the other breeding lines with Biomass PX.2 and AC87.8.16 producing the highest average number of 4 storage roots per plant. Total yield for all the breeding lines ranged from 8.4-37.2 tons/ha with AC87.8.16 producing the highest yield of 37.2 tons/ha. The highest yield of jumbos were produced by AC85.42.10—an indication that this might be an early maturing cultivar. J8.17 produced the highest US#1 yields.

Dry matter content of the breeding lines showed a range of 28.8-40.9%. The highest dry matter contents were obtained from J8.17, Biomass PX.2, AC 87.8.16 and AC 87.7.7. All of these lines had significantly higher dry matter content than those of J6.5, K-123.20 and J6.23. K-123.20 had the lowest dry matter content. From the above data, all the lines except K-123.20 will be further evaluated for their adaptability in hydroponic systems. K-123.20 was excluded because of its very poor yield.

In the first observational trial (Table 12) total yields ranged from 200-1875 g/plant. Again, breeding lines from the K-123 accession showed the lowest yields with AC 81.6.10 having the highest yield. The dry matter content ranged from 23.8 to 43.0% with the highest dry matter obtained from AC 87.7.10, AC 85.42.12 and AC 87.8.3, all were over 40%. Breeding lines from the I13 accessions had the lowest dry matter content. Several of the most promising lines will be selected for replicated trials in the following year. In the second observational trials, (Table 13) storage root yield per plant ranged between 28 to 2495g and the % dry matter (%DM) ranged between 16 to 42.8. The highest storage root yields were obtained from breeding lines derived from the J8 accession whereas the highest %DM was obtained from the Biomass PX accession. Breeding lines with good storage root yield and %DM greater than 25% will be planted in a twenty plant observational trial next year.

Table 11. Yield of ten sweetpotato breeding lines in a replicated trial.

Breeding Line	Total Yield		Jumbo		U. S. #1		Canner		%DM
	*#/plant	wt tons/ha (kg)	*#/plant	wt tons/ha (kg)	*#/plant	wt tons/ha (kg)	*#/plant	wt tons/ha (kg)	
J6.5	3.1abc	8.4bc	0.08b	2.1b	1.1abc^{z}	9.3b	1.2b	4.3ab	30.5d
J8.17	2.5bc	20.5abc	0b	0b	1.0bc	13.5ab	0.9b	4.7ab	40.9a
J6.23	3.4ab	14.0bc	0.02b	0.4b	1.2ab	8.4b	1.2b	3.6b	35.5c
Biomass PX.2	4.4a	18.3bc	0.03b	0.6b	1.2ab	9.6b	2.2a	6.5a	39.8ab
AC 87.7.16	2.6bc	16.5bc	0.09b	2.0b	0.9bc	8.8b	1.0b	3.5b	39.0abc
K-123.20	2.3c	6.4c	0b	0b	0.3c	1.9b	0.9b	2.6b	28.8d
AC 85.42.10	2.7bc	28.9ab	0.40a	13.5a	1.0bc	10.9b	0.6b	2.2b	36.6bc
AC 87.7.7	3.4abc	19.9bc	0.07b	1.6b	1.3ab	12.4b	1.3b	3.8ab	39.2ab
AC 87.8.15	2.8abc	13.8bc	0.02b	0.5b	0.8bc	7.0b	1.1b	3.7b	36.5bc
AC 87.8.16	4.0ab	37.2a	0.15b	4.9b	1.9a	2.5a	1.3b	4.3ab	39.8ab

* Yield data represents the mean of 4 replicates.

z Means with the same superscript within columns are not significantly different according to the DMRT ($P < .05$).

Table 12. Response of eighteen sweetpotato breeding lines in observational trials.

Breeding Line	Storage Roots		%DM
	#/plant	wt g/plant	
J8.14	3.5	833	25.4
AC 87.8.7	6.5	1920	42.4
J6.19	5.5	1320	30.0
Biomass Px.14	3.8	747	39.2
AC 81.6.10	3.69	863	33.4
J8.18	5.83	1133	28.4
AC 81.6.3	6.30	1040	24.1
AC 85.42.12	3.0	1092	42.8
J8.9	2.50	488	32.0
I13.18	5.53	1360	23.6
J6.19	5.20	680	29.2
K-123.5	3.75	200	35.0
I13.14	4.44	556	23.8
AC 87.8.3	1.33	328	40.6
Biomass Px.11	2.2	360	41.8
AC 85.42.15	2.75	1875	32.5
AC 87.7.10	1.48	345	43.0
I13.15	3.0	457	30.8

Table 13. Response of sweetpotato breeding lines in observational trials.

Breeding line	Fr. Wt g/plant	%DM	Breeding line	Fr. Wt g/plant	%DM
J8.6	472	32.6	I13.1	704	29.2
J8.3	1134	38.6	I13.41	453	26.8
J8.1	963	28.8	I13.26	680	20.8
J8.17	793	20.5	I13.3	454	28.8
J8.4	567	28.6	I13.42	57	29.8
J8.34	982	24.2	I13.27	623	25.2
J8.36	440	26.3	I13.28	453	25.7
J8.11	756	26.3	I13.29	907	17.6
J8.33	510	24.2	I13.30	963	26.6
J8.37	2495	26.3	I13.43	226	29.1
J8.5	113	21.1	I13.44	567	23.1
J8.2	623	24.2	I13.45	963	26.6
J8.7	794	27.5	I13.8	396	27.4
J8.8	567	25.0	I13.46	567	25.9
J8.9	226	26.3	I13.31	623	24.6
J8.24	642	29.0	I13.47	704	23.5
J8.21	869	25.9	I13.48	113	31.6
J8.12	793	27.5	I13.49	693	33.5
J8.13	869	28.0			
J8.10	737	25.3	Biomass Px.23	567	39.4
J8.23	631	21.5	Px.14	1077	35.6
J8.15	453	29.4	Px.18	694	37.0
J8.18	529	24.1	Px.24	1191	36.5
J8.7	453	16.8	Px.16	454	42.2
J8.22	518	20.8	Px.5	680	34.1
			Px.25	1530	42.2
AC83.3.1	28	36.6	Px.26	680	42.3
AC83.3.50	170	25.8	Px.22	227	42.8
AC83.3.7	430	33.0	Px.17	614	34.6
AC83.3.12	202	27.9	Px.27	28	36.4
AC83.3.9	340	31.3	Px.19	831	39.5
AC83.3.3	605	34.1	Px.12	567	37.7
AC83.3.13	208	32.5	Px.20	963	37.2
AC83.3.51	972	38.2	Px.9	57	31.9
AC83.3.10	499	34.9	Px.13	624	43.2
AC83.3.8	476	31.0	Px.8	1134	38.3
AC83.3.2	510	32.6	Px.11	680	32.8
AC83.3.11	907	36.7	Px.16	454	34.6
AC83.3.44	680	34.6	Px.28	831	25.8
AC83.3.43	510	32.2	Px.29	614	41.9
			Px.30	680	40.8
I13.7	567	26.2	Px.7	340	38.2
I13.2	935	24.5	Px.31	57	43.6
I13.5	793	22.4	Px.32	963	32.0
I13.6	170	22.9	Px.4	1360	42.6
I13.40	680	20.8	Px.33	878	33.1
I13.4	510	22.3	Px.34	992	31.8

Table 13. continued

Breeding line	Fr. Wt g/plant	%DM	Breeding line	Fr. Wt g/plant	%DM
Px.15	226	40.0	J6.22	491	26.3
Px.16	567	48.4	J6.12	510	22.6
			J6.45	567	18.7
J6.14	272	26.4	J6.46	396	31.4
J6.1	1360	30.1	J6.17	982	27.8
J6.8	963	25.3	J6.25	812	20.2
J6.9	623	31.0	J6.47	113	29.0
J6.10	340	30.4	J6.34	680	22.1
J6.15	453	30.5	J6.48	170	34.0
J6.20	472	32.4	J6.49	1152	18.4
J6.3	482	23.9	J6.13	113	32.8
J6.5	29	34.5	J6.23	1035	27.1
J6.18	982	24.5	J6.2	680	27.3
J6.11	567	23.7	J6.6	680	29.0
J6.7	529	30.2	J6.24	1190	25.6
J6.19	529	21.9	J6.27	567	32.4
J6.42	680	30.2	J6.50	652	29.4
J6.74	1058	28.4	J6.51	283	24.8
J6.75	851	39.9	J6.52	680	31.2
J6.74A	1058	35.5	J6.21	1360	21.7
J6.76	963	24.7	J6.32	481	21.4
J6.77	743	33.2	J6.26	907	26.2
J6.78	945	29.1	J6.53	794	21.8
J6.13	921	26.3	J6.54	454	20.5
J6.79	481	18.8	J6.55	491	22.8
J6.80	567	27.0	J6.56	1020	26.5
J6.81	793	26.8	J6.4	907	38.0
J6.82	680	26.5	J6.58	567	26.0
J6.36	694	29.0	J6.59	793	27.5
J6.28	831	22.4	J6.60	1278	19.6
J6.34	453	21.6	J6.61	28	32.0
J6.7	851	24.6	J6.62	680	30
J6.83	708	32.8	J6.63	794	22.0
J6.84	926	34.4	J6.10	709	28.8
J6.85	822	19.5	J6.64	453	34.8
J6.86	1077	25.8	J6.65	1247	31.7
J6.16	893	25.4	J6.66	822	30.4
J6.87	1043	22.3	J6.30	1043	22.2
J6.33	680	24.2	J6.67	793	31.7
J6.28	340	34.9	J6.68	851	19.9
J6.88	963	31.7	J6.29	765	20.0
J6.4	510	34.2	J6.69	964	28.3
J6.40	680	24.8	J6.71	695	35.0
J6.41	454	25.2	J6.73	481	28.0
J6.43	396	25.7	J6.90	567	34.0
J6.44	340	27.5	J6.91	680	30.6

2. Evaluation of Peanut Breeding Lines

No field evaluations were conducted in 1991. However, five breeding lines—which have been shown to be highly regenerable in tissue culture were obtained from the University of Florida, and two common cultivars adaptable to Alabama conditions have been planted in the greenhouse for seed production.

NFT Studies

Evaluation of Selected Sweetpotato Germplasm for Adaptability to NFT

Eight genotypes were evaluated for adaptability to NFT. These genotypes were selected from our general sweetpotato breeding program based on field performance—yield, disease resistance, nutritive content and percent dry matter.

J6/5	This line has long trailing vines and internodes and leaves that are entire. Two different skin and flesh color types were observed with this line, (a) red skin/white flesh (b) orange skin and flesh. Because both variants produced good yields, they were both evaluated.
I13/11	Semi-compact bushy growth, broad lobed leaves, long internodes, flowers moderately, white fleshed.
AC87.6/16	Very long trailing vines and internodes, entire leaves.
J6/19	Flowers, entire leaves, short internodes, orange fleshed.
TUJ1	Semi-compact growth, medium internode length, entire leaves, white fleshed.
J8/14	Flowers, short internodes, entire leaves, semi-compact growth, orange fleshed.
I13/13	Bushy growth, long internodes, flowers, lobed (3 or 4) leaves, orange fleshed.
I13/18	Flowers, short internodes, semi-compact growth, lobed (3) leaves, orange fleshed.

The above eight genotypes were grown in a replicated trial in the greenhouse in a completely randomized design with two replications. Four 15 cm long vine cuttings from each line were planted into standard TU NFT growth channels and grown in a modified half-Hoagland nutrient solution with a 1:2.4 N:K ratio. Plants were harvested 150 days after planting and harvest data subjected to analysis of variance with mean separation by DMRT (5%).

Results in Table 14 show that J8/14 produced significantly higher numbers of storage roots/plant than the other genotypes, except for I13/11. Highest storage root fresh and dry weights were produced by J8/14, TUJ1, and J6/5, respectively, while storage root % DM was highest for TUJ1 (30.2%) and J6/5 (25.1%). Fibrous root dry weight was highest for I13/13 compared to the other lines. The fibrous roots apparently served as a "sink" for photosynthates since storage root fresh and dry weights were low in this line.

There were very little differences among lines in the production of foliage fresh and dry weights. Based on the results of this trial, two lines, TUJ1 and J6/5 exhibiting the highest storage root fresh weight and %DM, will be evaluated in controlled environments.

Table 14. Response of eight sweetpotato genotypes to growth in NFT.

GP	No.	Storage roots Fr wt	Storage roots Dr wt	DM	Fibrous roots Dr wt	Foliage Fr wt	Foliage Dr wt
		(g/plant)		(%)	(g/plant)	(g/plant)	
J8/14	5.9a	504.9ab	93.5b	18.1bc	13.5cd	455ab	42b
I13/11	4.5ab	291.5c	71.6bc	24.3ab	15.6c	523ab	61ab
J6/19	3.9bc	349.1bc	82.6b	23.6ab	13.2cd	600ab	69ab
TUJ1	3.6bc	517.4ab	162.3a	30.2a	21.5b	594ab	86ab
J6/5	3.4bc	619.8a	164.4a	25.1ab	10.3d	628ab	85ab
AC 87.8/16	2.5cd	288.4c	69.2bc	21.7b	20.6b	650a	104a
I13/18	0.9d	72.7d	10.8d	6.4d	11.3cd	297b	48b
I13/13	0.6d	174.9cd	24.1cd	12.5cd	30.2a	575ab	95a

Means in columns with same letter are not significantly different (DMRT 5%).

Biotechnology Studies

The primary goal of the genetic engineering study is to introduce the nutritional gene *asp-1* that encodes for high essential amino acids into sweetpotato and peanut cultivars selected for hydroponic cultivation, confirm the presence and expression of the *asp-1* gene, and develop strategies to achieve enhanced expression of this protein in the edible parts of sweetpotato and peanut.

The *asp-1* is a synthetic gene that encodes for essential amino acids such as leucine, isoleucine, threonine, and methionine. The gene is under the control of enhanced CaMV promoter (for increased expression of the protein) and also has a signal sequence to target the protein to vacuoles. The *asp-1* protein has been designed to be very stable in the plants and yet easily digested when consumed. Because successful gene transfer and development of transgenic plants require a method to regenerate plants in tissue culture, our initial research was focused on ways to adventitiously regenerate shoots *in vitro*.

1. Introduction of asp-1 gene into sweetpotato

Our research prior to the initiation of this project focused on developing optimum methods for the introduction of foreign genes into sweetpotato using *Agrobacterium* vector and particle bombardment approaches. We were able to achieve a very high degree of transformation by improving the *Agrobacterium* cocultivation variables such as the choice of construct, plant genotype, explant type, cocultivation duration, media additives such as acetosyringone for *vir* gene induction and physical variables such as darkness during cocultivation. While the frequency of transformation was increased to very high levels (some times 100% of the explants showed transformation), the regeneration frequency of transgenic plants was still low. This was because of the relative recalcitrance of sweetpotato explants to adventitiously regenerate *in vitro*. Thus during the past six months our efforts were focused primarily on developing appropriate techniques to regenerate sweetpotato shoots by identifying critical parameters.

The following conclusions were drawn from our studies and many factors were identified as significant in enhancing the regeneration of sweetpotato:

1. Use of a two-step media approach which involves culture of explants on 2,4-D (0.2mg/L) medium for the first three days followed by a transfer to a medium with zeatin riboside (0.2 to 0.8 mg/L).

2. Isolation of aseptic explants from *in vitro*-grown shoots which reduces the contamination and increases the regeneration compared to greenhouse-grown plants.

3. Use of completed leaf (with an intact petiole) as an explant rather than leaf lamina. The leaf is placed with the base of the petiole sticking into the media.

4. More than thirty accessions of sweetpotato (obtained from USDA Plant Introduction Center, Griffin, GA) were screened repeatedly and six cultivars with high potential for adventitious regeneration have been identified: USDA PI# 318846-3, 508507, 531143; and cvs HiDry, Regal and Rojo Blanco. Certain cultivars which are highly intransigent to regeneration (e.g. PI 530193) have also been identified and will be useful as negative controls for future studies). Results of a study involving 15 genotypes is presented in Table 15.

While the methods described above increased the regeneration frequency from less than 1% to nearly 80%, the time taken for initial shoot appearance was still 30 to 60 days. Thus, a series of further studies was performed to further improve the efficiency of regeneration.

5. Sweetpotato accession PI 318846-3 was identified as the most regenerative plant variety and thus was used in subsequent studies (Table 5).

6. When thidiazuron (TDZ), a new synthetic chemical (an aromatic derivative of urea) was substituted for zeatin during the second stage, dramatic improvements in regeneration were observed. Here, instead of a complete leaf (with intact petiole), only small petiole pieces (5 to 8 mm) were used as explants (which is ideal for transformation). Sweetpotato petiole explants showed very high and rapid regeneration (as early as ten days) when subjected to this treatment. In a factorial study involving increasing concentrations, TDZ at 0.2 mg/L produced the most rapid (8 days) and highest regeneration (71% of explants showing regeneration) (Table 16).

7. Developmental stage of the leaf and its phyllotaxy position on the stem are critical factors in determining the competency of the explant for regeneration. We have consistently observed that leaf positions 2 to 4 (from the tip) give excellent regeneration compared to those isolated from the base of the shoot.

Current studies are focused on the use of plasmids containing the *asp-1* gene in both *Agrobacterium* and particle bombardment approaches as vectors to introduce the protein gene into those sweetpotato cultivars found to be highly regenerable. Parallel studies aimed at isolation of developmentally regulated promoters of sweetpotato to enable targeted expression of the *asp-1* protein in storage roots and young leaves are in progress. We have isolated the total RNA from various organs of sweetpotato and mRNA has been separated from this total RNA. We are now in the process of making a cDNA library from various mRNA groups and this will enable subtractive hybridization to isolate organ specific cDNAs.

Table 15. Regeneration frequencies in fifteen genotypes of sweetpotato. The media consisted of MS with 2, 4-D (0.2 mg/L) for the first three days followed by a transfer to a medium containing zeatin riboside (0.2 to 0.8 mg/L).

Genotype	Percent Explants Showing Shoots
HiDry	93
Rojo Blanco	80
Regal	62
PI 508521	55
PI 508507	60*
508511	33
508510	22
531093	0
508518	0
Caromex	0
Southern Delight	15
PI 538344	23
PI 318846-3	94
PI 53143	-
PI 508514	10

Note: *PI 508507 explants developed multiple shoots

Table 16. Effect of thidiazuron on regeneration of sweetpotato shoots and roots from petiole explants.

Concentration of TDZ	Percent Explants Developing Roots	Percent Explants Developing Shoots
0.0	100	41*
0.02	93	21
0.04	90	40
0.06	92	42
0.08	75	56
0.1	66	50
0.2	92	71
0.3	100	63
0.4	30	0
0.5	19	0.06
0.7	12.5	0.06
0.9	0	0

*The control developed shoot primordia only, which did not develop into complete shoots.

2. Transformation of Peanut

The research on transformation of peanut with foreign genes has been very limited. However, we have conducted initial studies on *Agrobacterium* transformation of peanut with very encouraging results. The highest transformability was achieved by the use of hypocotyl explants of cultivars 'Georgia Red' or 'Early Bunch 495-5', and the inclusion of sodium hypochlorite treatment. We have achieved a very high level of transformation (100%) as evidenced by GUS histochemical assay. The current work is focussed on developing an efficient and reliable regeneration system for peanut. To achieve this, we have collected an extensive literature on peanut tissue culture and attempted to reproduce a few protocols that claim to result in high adventitious regeneration. We have also assembled five accessions that have been reported to be highly regenerable by Dr. Alexis McKentley (EPCOT Center, Florida). These lines are now being grown in the greenhouse for seed multiplication.

Summary

Nutritive composition of 'TI-155' foliage tips and roots from biweekly harvests were determined for sweetpotato grown in NFT by the GRO group. Nutrient levels in storage roots were not affected by harvest date. For foliage tips, nutrient levels changed depending on the day of harvest. The % dry matter of tips was lower at 83 than at 42 days after planting (DAP), and the fat content of tips increased from 0.3% at 42 DAP, to 0.5% at 111 DAP. The beta-carotene levels of tips were not significantly different throughout the growing period ranging from 4.7 to 6.6 mg/100g. Ascorbic acid levels varied from 0.9 to 3.6 mg/100g. Noodles that were prepared with up to 20% sweetpotato green tip flour were highly acceptable by taste panelists. Nutritive analysis of 'Georgia Red' peanut greens harvested biweekly from the field showed that % dry matter and vitamins B_1 and B_2 increased with time.

First Year Objectives (1992)

(1) to analyze the nutritive composition of 'TI-155' sweetpotato biweekly shoot tip harvests;
(2) to carry out a nutritive composition analysis of 'Georgia Red' peanut foliage harvested biweekly; and
(3) to study processing food from sweetpotatoes for use in space starting with sweetpotato flour.

Research Activities

1. Nutritive Composition of Sweetpotato Greens

Analysis of nutritive composition of Sweetpotato green tips harvested at 2 wk intervals from plants grown in the NFT was undertaken working along with the GRO Group. The results are summarized and shown in Table 17. The results showed that dry matter (DM) was constant up to 83 DAP and then continuously declined. Fat ranged from 0.3-0.5%.

Carotene was practically the same throughout the harvest period. Ascorbic acid fluctuated from 0.9 to 3.6 mg/100 g. Except for ascorbic acid, it appears that nutrient concentrations in the tips are not affected by the 2 wk interval harvest. The amount of DM, fat and carotene are in the same range as other leafy vegetables.

Table 17. Composition of TI-155 sweetpotato tips harvested from plants grown in the Tuskegee nutrient film technique system (fresh weight basis)[1]

Days after	Dry Matter	Fat	Carotene		Asc. Acid
Planting	%	%	mg/100g	IU/100g	mg/100g
41	10.5±0.3	0.3±0	5.6±0.7	9360 ± 1110	1.6±0.3
55	10.1±0.2	0.4±0	5.5±0.4	9170 ± 640	1.1±0.2
69	10.6±0.3	0.4±0	5.7±0.7	9490 ± 1110	0.9±0.1
83	10.7±0.2	0.4±0	6.6±0.4	10990 ± 740	2.5±0.2
97	9.2±0.2	0.4±0	5.3±0.4	8880 ± 640	1.1±0.1
111	8.0±0.1	0.5±0	4.7±0.6	8520 ± 720	3.6±0.2

[1]Mean ± Standard deviation of mean. Number of replicates = 4 for 41 DAP and for fat at all DAP; 8 for others.

2. Nutritive composition of peanut greens

The purpose of this study was to determine the nutritive and food value of peanut greens and the difference in nutritive composition due to harvesting time and position of leaf from the top—the second position (younger leaf) and the fifth position (older leaf). The peanut plants (Georgia Red) were planted on May 22, and the first sampling began on July 17, with sampling continuing every 2 wks until September 28. The results are summarized and shown in Table 18. The means and ranges were: for DM 25% and 22-29%, for vitamin C 73mg/100g and 52-94 mg, for beta-carotene 36.5 and 27 to 50 mg/100 g, for thiamin 4.5 and 2.8-7.2 mg/100 g, for riboflavin 19 and 11.8-28.9μg/100g, for phosphate 1.17 and 0.4 to 2.44 mg/100 g, and for protein,10.3 and 3.14-21.42%.

Table 18. Nutrient composition of peanut greens ('Ga Red' Variety)[z]

Harvest time (DAP)[y]	Leaf position	DM %	Vit.C mg/100g	Carotene mg/100g	B1 mg/100g	B2 ug/100g	P mg/100g	Protein %
56	2	22.44	94.75	47.68	4.08	11.80	1.48	21.42
	5	21.73	91.21	41.03	4.98	19.68	1.79	21.16
70	2	24.85	67.73	47.43	5.19	13.65	1.82	17.75
	5	24.14	74.89	48.22	5.92	17.35	2.17	13.47
84	2	23.14	66.34	40.81	4.65	15.50	1.29	8.45
	5	25.28	76.80	41.46	4.26	18.58	0.69	11.41
98	2	25.71	64.24	18.57	2.93	15.74	0.51	7.30
	5	25.28	61.50	22.91	2.82	24.59	0.73	6.95
112	2	27.14	54.48	27.27	6.51	27.78	0.40	5.99
	5	29.00	52.99	30.87	7.20	28.91	0.73	5.24

[z]Dry weight basis
[y]DAP - days after planting

The general trend was that DM, vitamin C, beta carotene, thiamin, phosphorous and protein decreased while riboflavin increased with planting time. The difference in the position of leaf showed that, generally, the fifth position (older leaf) leaves were higher in DM, thiamin, riboflavin, phosphorous than the second position leaves (younger leaf). The second position appeared tender and more suitable for consumption. Dietary fiber composition of peanut greens are in progress. At this time, no information is available on nutrient composition of peanut greens. Our results showed that peanut greens are highly nutritious especially as a rich source of vitamin C and protein.

3. Development of Sweetpotato Products

During this period, sweetpotato noodles were prepared using sweetpotato flour (SPF). The sweetpotatoes were peeled, sliced, blanched, then dehydrated at 600°C till crispy. The dried chips were ground into flour by a ball mill to 60 mesh or less. The flour thus prepared was incorporated into wheat flour at 5, 10, 15 and 20%. A Takka pasta maker was used to make noodles using specific size dice. The purpose of this experiment was to determine how much sweetpotato flour can be added to wheat flour to make noodles.

The product was evaluated by a group of sensory panelists consisting mainly of faculty, staff and students on the campus. The results are summarized in Table 19. Based on a 5-point scale, the results showed the products were highly acceptable. SPF can be added up to 20%. Experiments will be continued to refine the product and study the shelf life.

Table 19. Sensory scores for sweetpotato noodles.

%SP flour added	Scores
0	2.88 ± 0.95
5	3.77 ± 0.90
10	3.96 ± 0.65
15	3.80 ± 0.85
20	4.08 ± 0.80

5-pt. scale: 5-like extremely, 3-acceptable, 1-dislike extremely
MEAN ± S.D.

Waste Management and Recycling

Summary

The proportion of edible to inedible sweetpotato biomass of 'TI-155' was determined to be 54:46 on a fresh weight basis by analyzing data previously collected by the GRO Group. The non-tip portion of the foliage and the fibrous root mat represented more than half of the nonedible biomass. Chemical analysis of sweetpotato biomass grown in NFT showed that the fibrous root mat and foliage stems contained higher percentages of cellulose, hemi-cellulose and lignin than other plant parts. Indigenous microorganisms with lignocellulolytic, proteolytic and amylolytic activity were isolated from sweetpotato field sites. Experiments are ongoing to assess the rate of degradation of senescent sweetpotato leaves which were inoculated with indigenous microorganisms having the capacity to degrade cellulose. These isolates are being characterized. Determination of the nature of the gaseous phase as biodegradation occurs is on-going. A profile of microbial flora grown in either NFT or deep water culture showed high population counts in the sweetpotato nutrient solution. Fungal counts were highest in deep water culture, and actinomycete counts were highest in NFT.

First Year Objectives (1992)

(1) To determine the quantity of non-edible sweetpotato biomass.
(2) To examine the composition of non-edible sweetpotato biomass.
(3) To study the profile of nutrient uptake over the growing season by hydroponically grown sweetpotato (cv. 'TU-82-155').
(4) To study the profile of microbial flora in the plant nutrient solution reservoir over the growing season for hydroponically grown sweetpotato (cv. 'TU-82-155').
(5) To determine native microorganisms with cellulose and starch degradative properties.

Research Activities

The development of a viable, efficient system to deal with non-edible plant matter arising from the production and processing of sweetpotato and peanut crops demands that the nature and quantity of the waste be determined. The microbiological load of the nutrient solution has to be determined under hydroponic cultural conditions since high microbial levels will have an influence on the methodology used to treat spent nutrient solution. The size of the microbial population can influence use of membranes for sweetpotato culture since there is the possibility of clogging pores. Additionally, examination of the natural ecosystem for production of these crops may result in the selection and isolation of microorganisms possessing specific biodegradative capacity for the crops being investigated. Therefore, the first year objectives were developed with the intent of compiling an information base from data on waste arising particularly from sweetpotato growth and food processing systems at Tuskegee University.

Sweetpotato biomass data for at least three years for two cultivars ('TU-82-155' and 'Georgia Jet') are readily available from hydroponic crop production in Percival and Conviron growth chambers and greenhouse experiments. These data (Table 20) are useful in forming a basis for preliminary comparisons of edible to non-edible plant material. The storage root and shoot biomass each represent approximately 40% of the biomass produced for either cultivar. Within the shoot biomass the non-edible percentage will vary depending on it's use (as a green vegetable or incorporated in flour). The fibrous root formed the single, largest, non-edible fraction of the biomass represented in this table (16-19%). But neither the root nor the foliage could be accurately separated into edible and non-edible fractions (Tables 20 and 21a and b). There was no apparent effect of sweetpotato cultivar on weight or plant part percentage of either shoot or root biomass for the components measured (Tables 21a and 21b). The total biomass data collected from earlier experiments (1989-1992) were compared with that obtained from six NFT growth channels ('TU-82-155') harvested in June, 1992 (Table 22). The total biomass from harvest data spanning three years was 60% higher than that obtained in a greenhouse harvest of June, 1992. This variation may be accounted for by the higher yields generally obtained from experiments conducted in the Convirons. Plant material collected in the June harvest (Table 22) was used in determination of the edible/non-edible ratio (Table 22) as well as for a comparative composition of the biomass components (Table 23). The non-edible portion (non-harvested foliage, stem, fibrous root, string root and storage root peel) comprised approximately 46% (fwb) of the total biomass. The largest components of the non-edible fraction were the non-tip foliage and the fibrous root, 21 and 14%, respectively (Table 22). Of particular interest to waste management is the high cellulose, hemicellulose and lignin contents of the stem and fibrous root (Table 23). The older green leaves may be used in flour production thereby reducing the non-edible fraction to be treated. The high carbohydrate content of the string roots may give string roots a potential for use as edible material. It is evident from the results that the fraction of the sweetpotato currently considered non-edible may be reduced when non-traditional uses are made of these components.

The profile of nutrient usage was obtained for hydroponically grown sweetpotato ('TU-82-155') during the duration of growth from solution samples collected at two-day intervals. Nutrient usage was characterized based on three growth phases (Table 24). The first phase is characterized by plant establishment and early root differentiation, followed in the second phase by increased root enlargement and rapid translocation. In the third phase, there is bulking of the storage roots and senescing of the shoot. In the first phase spanning the first 42 days, the NO_3^- ion was taken up in the largest amount (2994.4μg.mL^{-1}) followed by K^+ (1623μg.mL^{-1}), SO_4^{2-} (1401.5 μg.mL^{-1}), PO_4^{2-} (917.9 μg.mL^{-1}), NH_4^+ (225.6 μg.mL^{-1}) and Ca^{2+} (112.9 μg.mL^{-1}). In the second phase, covering days 42 to 84, there was increased uptake of each ion except the divalent cations (Table 24). During the final phase, days 86 to 120, the uptake of all the measured ions decreased except for the K^+ ion. Uptake of the K^+ ion increased throughout the growing season of the crop. The K^+ nutrient uptake profile is in agreement with previous studies for soil-grown sweetpotato (Sharfuddin and Voican, 1984; Scott and Bouwkamp, 1974). The specific data obtained in this study (Table 25) will be utilized in a protocol for the utilization of the plant nutrient solution (PNS) throughout the 120-day duration of the sweetpotato crop without discarding it at 14 day intervals, as currently practised.

Microbial population profiling will indicate whether it is necessary to consider microorganisms as a waste to be pretreated as nutrient solution is recycled. The microbial population profile in the PNS contained in individual reservoirs was followed throughout the growth of two greenhouse experiments during 1992. In one experiment, the nutrient solution was supplied using NFT. In another experiment, the nutrient solution was supplied using a deep water technique. A new batch of nutrient solution was placed in the appropriate reservoir/growth channel at 14-day intervals and both the old and new solutions were sampled for microbial population counts. Each experiment was conducted twice. The experiments examined the effect of split root application of nutrients in combinations of: air/modified half hoagland (MHH) solution; deionized water/MHH; MHH/MHH; divalent cations + micronutrients/monovalent cations. There were two replications of each treatment combination. Solution samples were collected from each reservoir at 7-day intervals and serially diluted in 9.0-mL sterile water blanks. Plating of appropriate dilutions was followed by incubation at room temperature (24-28^{o}C). Counts were begun 5 days after plating and plates were discarded when a final count was made at 21 days after incubation. Data tabulated represent the mean of two replications for each experiment. Population counts indicate that the composition of the plant nutrient solution influenced the size of the microbial population for NFT-grown sweetpotato (Table 26). Generally, at 7 and 14 days, "Old" counts were higher than when solution (New) was placed into the reservoir. There was a trend for higher microbial counts in reservoirs with the divalent cation treatment. When a similar microbial culture assay was conducted on nutrient samples from deep water culture of sweetpotato with a similar split root system for nutrient uptake, solution composition influenced population size. The nutrient solution with only monovalent cations had fewer bacteria than the MHH or the divalent or the deionized water treatments (Table 27). The fungal count was higher in the deep water system than in NFT. Also, in NFT, the actinomycete population was higher than for the deep water culture and may be attributed to a lower oxygen tension prevailing in the deep water system. The relatively high counts for these experiments indicate that when membrane systems are being designed for culture of sweetpotato, consideration should be given to installing a conjugate filter system. In this way clogging will be eliminated. Additionally, the large microbial population size indicates that harvesting of the microbial biomass would be necessary in any recirculating system in which the same PNS will be used for the duration of the crop.

Composite soil samples were collected from two field sites on the G.W. Carver Agricultural Experiment Station, Tuskegee University. The rationale was: if sweetpotato research had been on-going on these sites for at least the past 50 years, there would probably be indigenous microorganisms with the intrinsic ability to degrade postharvest remnants of sweetpotato. Two sites were targeted. The first site was well-drained, and it was hypothesized that within the population would be microbial flora capable of aerobic biodegradative activity. The second site was generally water-logged and from there microbial flora capable of anaerobic biodegradative activity was expected to be recovered. Triplicate 1-gram soil samples from each location was added to 9.0-mL of cellulose medium containing a 1-cm strip of filter paper as the sole carbon source. Simultaneously, strips of senesced sweetpotato leaves were treated similarly and provided as the sole carbon source for microbial metabolism. The inoculated test tubes containing cellulose medium were incubated at room temperature under both aerobic and anaerobic conditions. For anaerobic incubation, oxygen in test tubes was displaced by nitrogen gas then covered with septum stoppers prior to incubation. Over the period of the experiment, microorganisms capable of cellulose degradation were collected. These indigenous microorganisms have been utilized in further experiments to determine the nature of the gaseous phase during anaerobic degradation of cellulose. Secondarily, an experiment was set up to investigate the influence of particle size and temperature of incubation on the rate of degradation of senescent sweetpotato leaves. These experiments are ongoing. Additionally, from these field sites indigenous microorganisms capable of proteolysis and amylolysis have been isolated. Physiological characterization of these isolates is in progress.

Table 20. Shoot biomass per sweetpotato (cvs. 'TU-82-155' and 'Georgia Jet') plant and plant part percentage when grown in the Tuskegee University NFT system.

'TU-82-155'[1]			'Georgia Jet'[2]		
Total Biomass (g)	Foliage (g)	Foliage (%)	Total Biomass (g)	Foliage (g)	Foliage (%)
Fresh Weight					
1147.7 ± 72.6	420.3± 30.8	37.2 ± 1.6	1082.8 ± 65.3	393.3 ± 31.6	36.0 ± 2.0

[1] Data were collected from 100 TU-NFT growth channels and are presented as mean ± standard error for harvest conducted from June, 1989 through May, 1992.

[2] Data were collected from 55 TU-NFT growth channels and are presented as mean ± standard error for harvest conducted from June, 1989 through May, 1992.

Table 21a. Root biomass (g) per sweetpotato (cv. 'TU-82-155') plant and plant part percent when grown in the Tuskegee University NFT system.[1]

Total Biomass	Storage Roots		String Roots		Fibrous roots	
(g)	(g)	(%)	(g)	(%)	(g)	(%)
Fresh Weight						
1147.7 ± 72.6	518.2 ± 44.3	43.3±1.7	32.6±2.6	3.0±0.2	176.6±13.4	16.4±1.1
Dry Weight						
153.9 ±11.7	87.3±8.4	54.3±1.8	4.3±0.3	3.2±0.3	8.8±0.9	6.5±0.8

[1] Data were collected from 100 TU-NFT growth channels and are presented as mean ± standard error for harvests conducted from June, 1989 through May, 1992.

Table 21b. Root biomass (g) per sweetpotato (cv. 'Georgia Jet') plant and plant part percent when grown in the Tuskegee University NFT system.[1]

Total Biomass	Storage Roots		String Roots		Fibrous-roots	
(g)	(g)	(%)	(g)	(%)	(g)	(%)
Fresh Weight						
1082.8 ± 65.3	455.7±36.9	42.1±2.5	33.6±2.7	3.2±0.3	200.3±15.1	18.7±1.2
Dry Weight						
150.1±10.2	80.7±7.1	53.0±2.8	4.4±0.3	3.2±0.3	13.1±2.1	8.7±1.5

[1] Data were collected from 55 TU-NFT growth channels and are presented as mean ± standard error for harvests conducted from June, 1989 through May, 1992.

Table 22. Weight (g) per plant and plant part percent of the edible and non-edible sweetpotato biomass (cv. 'TU-82-155') at harvest[1].

Plant Part	Fresh Weight Basis		Dry Weight Basis	
	Weight (g)	Percent	Weight (g)	Percent
Total Biomass	682.6±62.6	100.0	89.9±5.4	100.0
Edible Biomass Total	365.1±47.3	53.6±4.5	55.2±6.9	60.8±0.6
Shoot Tip	65.0±5.0	9.8±0.8	7.3±0.7	8.2±0.6
Storage Root (Pulp)	300.3±45.0	43.5±4.4	47.8±6.4	52.5±5.1
Non-edible Biomass Shoot				
Foliage Minus Tip	150.9±27.9	21.4±3.2	34.0±4.8	38.4±5.6
Stem	3.8±0.2	0.6±0.1	18.4±3.4	20.6±3.9
Root Fibrous Root	90.3±7.7	13.7±1.5	5.4±0.6	6.2±0.9
String Root	39.8±6.2	5.9±0.8	5.2±0.8	5.9±0.9
Storage Root (Peel)	32.6±3.8	4.8±0.2	4.4±0.4	4.9±0.4

[1] Data were collected from 6 TU-NFT growth channels harvested in June, 1992 and are presented as mean ± standard error.

Table 23. Biomass composition (% fresh weight basis) of sweetpotato cultivar 'TU-82-155' grown in the TU nutrient film technique system.[1]

Plant Part	Dry Matter	Ash	Water Solubles	Cellulose	Hemi-cellulose	Lignin
Shoot	12.18±0.64	0.41±0.04	1.82±0.03	1.56±0.05	0.62±0.03	1.20±0.05
Tip	11.25±0.63	1.10±0.13	2.29±0.03	1.06±0.05	1.08±0.06	0.81±0.02
Stem	17.16±0.92	0.47±0.00	1.00±0.02	1.64±0.03	0.57±0.01	0.58±0.00
Root						
Storage Root	16.23±1.10	0.29±0.02	1.54±0.06	0.27±0.01	0.02±0.02	0.10±0.01
Raw Peel	13.72±0.69	0.75±0.04	1.84±0.05	0.64±0.06	0.05±0.01	0.57±0.00
Cooked Peel	16.40±0.92	0.43±0.03	2.19±0.03	0.63±0.00	0.18±0.02	0.33±0.00
String Root	13.12±1.02	0.54±0.06	1.85±0.04	0.93±0.07	0.20±0.08	0.50±0.02
Fibrous Root	5.97±0.30	2.06±0.09	2.49±0.07	3.30±0.11	2.52±0.05	3.65±0.11

[1] Mean + standard error of mean. Materials obtained from 6 growth channels harvested in June, 1992. Number of replicates = 12 except for stem, raw and cooked peel that varied from 4 to 8 depending on availability of material.

Table 24. Mean nutrient usage, as determined by ion chromatography, within each growth phase for sweetpotato plants (cv. 'TU-82-155') cultured in the Tuskegee University NFT system. Samples were collected at two-day intervals.

Growth Phase	Plant Life (days)	NH_3^+ ug.mL^{-1}	K^+ ug.mL^{-1}	Mg^{2+} ug.mL^{-1}	Ca^{2+} ug.mL^{-1}	NO_3^- ug.mL^{-1}	PO_4^{2-} ug.mL^{-1}	SO_4^{2-} ug.mL^{-1}
Initial Phase 1	Up to 42 days after planting	225.6	1623.0	34.0	112.9	2994.4	917.9	1401.5
Phase 2	42-84 days after planting	324.2	3158.6	27.6	71.5	5873.0	2059.7	1815.8
Phase 3	86-120 days after planting	291.5	3777.3	23.8	44.7	3295.4	930.4	Not determined

Table 25. Nutrient usage, as determined by ion chromatography, throughout the growth of sweetpotato plants (cv. 'TU-82-155') cultured in the Tuskegee University NFT system. Samples were collected at two-day intervals.

SOLN	Plant Life	NH_3^+ ug.mL^{-1}	K^+ ug.mL^{-1}	Mg^{2+} ug.mL^{-1}	Ca^{2+} ug.mL^{-1}	NO_3^- ug.mL^{-1}	PO_4^{2-} ug.mL^{-1}	SO_4^{2-} ug.mL^{-1}
	(in days)	Amt Used						
III	28	273.4	1462.5	48.7	196.3	2107.4	774.5	1673.6
IV	30	ND	1364.4	64.0	292.4	1016.3	677.0	1977.5
V	32	222.2	1236.7	34.0	71.0	1231.2	1536.0	2218.5
VI	34	213.7	1336.5	24.2	48.8	991.4	216.8	381.2
VII	36	187.1	1113.3	25.8	81.2	2350.1	495.1	1221.0
VIII	38	305.2	2163.8	15.7	66.0	3474.0	359.7	743.8
IX	40	185.4	2166.7	28.0	76.0	6002.3	289.4	583.3
X	42	192.1	2139.9	31.2	71.5	6782.2	2994.7	2412.9
XI	44	189.4	2459.9	28.3	73.0	5782.7	785.1	1159.1
XII	46	345.0	2566.2	28.0	73.6	6916.3	4205.2	6870.4
XIII	48	369.7	2819.4	29.9	76.7	7243.4	3835.8	1883.0
XIV	50	315.2	2923.8	32.6	74.1	7185.6	3614.9	2686.7
XV	52	397.5	2363.0	25.7	67.0	5278.6	1159.4	1281.4
XVI	54	369.7	3504.6	44.1	118.1	6747.9	3881.7	2241.0
XVII	56	283.6	2977.6	15.2	37.6	4278.2	762.1	626.3
XVIII	58	ND	ND	ND	ND	ND	ND	ND
XIX	60	240.5	3232.9	29.0	82.0	5031.2	697.4	479.0
XX	62	196.1	3259.4	33.1	83.6	5996.1	2331.6	2329.0
XXI	64	359.0	3512.8	27.7	61.0	5638.6	928.5	-29.0
XXII	66	403.1	3607.5	33.1	87.8	5751.4	792.2	26.7
XXIII	68	302.2	3114.8	22.8	69.2	5952.0	2447.4	1856.6
XXIV	70	247.4	3290.5	17.8	50.8	6474.9	2855.9	2426.9
XXV	72	333.8	3349.5	29.1	78.3	6191.6	2506.3	2268.0
XXVI	74	304.6	3300.4	25.7	56.2	5753.2	2234.1	1992.6
XXVII	76	397.9	2613.2	27.0	83.0	5724.6	664.4	-521.0
XXVIII	78	400.4	3616.9	28.5	68.4	6198.2	2098.9	2008.0
XXIX	80	371.8	3449.7	20.5	67.9	5997.9	2358.7	1890.0
XXX	82	230.7	3427.4	22.0	45.8	5882.4	2326.6	3026
XXXI	84	427.1	3782.1	32.8	75.3	3434.3	708.0	
XXXII	86	449.9	3411.5	24.8	51.0	3142.4	440.8	
XXXIII	88	338.6	3220.5	20.6	74.0	3430.0	408.4	
XXXIV	90	353.8	3617.6	17.6	1.0	3480.8	653.1	
XXXV	92	561.5	3933.2	22.6	19.7	3248.2	612.4	
XXXVI	94	202.5	4019.5	33.3	77.8	2974.9	1025.4	
XXXVII	98	218.3	4017.9			2936.0	1043.0	
XXXVIII	100	211.6	3907.0			2857.6	764.5	
XXXIX	102	206.7	3861.4			3141.8	1180.3	
IL	104	183.6	3835.7			2429.9	433.8	
ILI	106	188.8	3949.0			3357.1	1342.2	
ILII						3747.4	1208.2	
ILIII						3963.2	1203.5	
ILIV						3286.2	1431.8	
ILV						3462.0	1386.2	
ILVI						3270.7	1447.3	
I DAY LATER (At HARVEST)						3998.2	304.9	

Table 26a. The population profile (log $cfu.mL^{-1}$) of fungi, bacteria and actinomycetes enumerated in a split root NFT study conducted in the greenhouse at Tuskegee University when sampled at 7-day intervals.[1]

Solution Composition	Plant Life (Days)	Bacteria	Fungi	Actinomycetes
MHH	0	5.11	None Detected (ND)	(ND)
MONOVALENT		5.53	(ND)	(ND)
DIVALENT		5.67	(ND)	(ND)
DEIONIED WATER		5.52	(ND)	(ND)
MHH	7	5.76	(ND)	(ND)
MONOVALENT		5.55	(ND)	4.12
DIVALENT		5.82	(ND)	4.43
DEIONIZED WATER		5.74	(ND)	(ND)
MHH	14 Old	6.25	(ND)	5.20
MONOVALENT		6.38	(ND)	4.30
DIVALENT		6.50	5.54	(ND)
DEIONIZED WATER		6.14	4.60	(ND)
MHH	14 New	5.34	5.88	5.10
MONOVALENT		4.12	(ND)	(ND)
DIVALENT		5.80	4.60	(ND)
DEIONIZED WATER		5.11	(ND)	(ND)
MHH	21	6.10	4.12	4.60
MONOVALENT		5.40	(ND)	(ND)
DIVALENT		6.56	4.43	(ND)
DEIONIZED WATER		5.86	(ND)	4.43
MHH	28 Old	6.27	(ND)	(ND)
MONOVALENT		5.38	(ND)	(ND)
DIVALENT		6.66	4.12	(ND)
DEIONIZED WATER		5.94	(ND)	(ND)

Each data point represents the mean of two experiments (Mar. 12 - Jun. 8 and Jun. 29 - Sept. 28, 1992), with each sample being enumerated using triplicate counts.

[1] Lowest level of detection is log 4.00 $cfu.mL^{-1}$.

Table 26b. The population profile (log cfu.mL^{-1}) of bacteria, fungi and actinomycetes enumerated in a split root NFT study conducted in the greenhouse at Tuskegee University when sampled at 7-day intervals.[1]

Solution Composition	Plant Life (Days)	Bacteria	Fungi	Actinomycetes
MHH		5.89	(ND)	4.33
MONOVALENT	28 New	5.02	4.45	(ND)
DIVALENT		5.97	(ND)	5.20
DEIONIZED WATER		5.12	5.15	(ND)
MHH	35	6.01	(ND)	4.23
MONOVALENT		5.59	(ND)	4.15
DIVALENT		5.86	(ND)	4.48
DEIONIZED WATER		5.79	(ND)	(ND)
MHH	42 Old	6.34	(ND)	5.26
MONOVALENT		6.15	(ND)	5.00
DIVALENT		7.04	5.22	(ND)
DEIONIZED WATER		6.24	4.80	(ND)
MHH	42 New	5.58	(ND)	5.00
MONOVALENT		5.38	4.33	(ND)
DIVALENT		6.60	(ND)	4.80
DEIONIZED WATER		5.02	(ND)	(ND)
MHH	49	6.11	4.20	4.58
MONOVALENT		5.44	(ND)	(ND)
DIVALENT		6.87	5.04	(ND)
DEIONIZED WATER		6.00	(ND)	4.53
MHH	56 Old	6.32	(ND)	5.60
MONOVALENT		6.79	(ND)	4.56
DIVALENT		7.48	6.40	(ND)
DEIONIZED WATER		6.20	5.02	(ND)

Each data point represents the mean of two experiments (Mar. 12 - Jun. 8 and Jun. 29 - Sept. 28, 1992), with each sample being enumerated using triplicate counts.

[1] Lowest level of detection is log 4.00 cfu.mL^{-1}.

Table 26c. Population profile (log cfu.mL^{-1}) of fungi, bacteria and actinomycetes enumerated in a split root NFT greenhouse study at Tuskegee University when sampled at 7-day intervals.[1]

Solution Composition	Plant Life (Days)	Bacteria	Fungi	Actinomycetes
MHH	56 New	5.44	6.01	(ND)
MONOVALENT		4.20	(ND)	(ND)
DIVALENT		5.92	4.62	(ND)
DEIONIZED WATER		5.21	(ND)	(ND)
MHH	63	6.21	5.20	4.78
MONOVALENT		5.44	(ND)	(ND)
DIVALENT		6.67	5.53	(ND)
DEIONIZED WATER		6.42	(ND)	5.53
MHH	70 Old	6.34	(ND)	5.36
MONOVALENT		6.63	(ND)	4.35
DIVALENT		7.49	5.62	(ND)
DEIONIZED WATER		6.02	4.69	(ND)
MHH	70 New	5.63	5.90	5.70
MONOVALENT		5.12	(ND)	(ND)
DIVALENT		6.50	5.00	(ND)
DEIONIZED WATER		5.69	(ND)	(ND)
MHH	77	5.80	(ND)	4.50
MONOVALENT		5.86	(ND)	4.53
DIVALENT		6.12	(ND)	4.92
DEIONIZED WATER		6.00	(ND)	(ND)
MHH	84 Old	6.52	(ND)	5.80
MONOVALENT		6.60	(ND)	4.25
DIVALENT		7.40	5.00	(ND)
DEIONIZED WATER		6.28	4.80	(ND)

Each data point represents the mean of two experiments (Mar. 12 - Jun. 8 and Jun. 29 - Sept. 28, 1992) with each sample being enumerated using triplicate counts.

[1] Lowest level of detection is log 4.00 cfu.mL^{-1}.

Table 26d. The population profile (log $cfu.mL^{-1}$) of fungi, bacteria and actinomycetes enumerated in a split root NFT greenhouse study at Tuskegee University, when sampled at 7-day intervals.[1]

Solution Composition	Plant Life (Days)	Bacteria	Fungi	Actinomycetes
MHH	84 New	4.49	5.87	(ND)
MONOVALENT		4.26	(ND)	(ND)
DIVALENT		4.60	4.83	(ND)
DEIONIZED WATER		4.39	(ND)	(ND)
MHH	91	6.38	4.20	4.76
MONOVALENT		5.22	(ND)	(ND)
DIVALENT		6.72	4.55	(ND)
DEIONIZED WATER		5.87	(ND)	(ND)
MHH	98 Old	6.63	(ND)	(ND)
MONOVALENT		5.82	(ND)	(ND)
DIVALENT		6.91	5.02	(ND)
DEIONIZED WATER		6.00	5.21	(ND)
MHH	98 New	5.32	4.53	4.20
MONOVALENT		5.08	4.82	(ND)
DIVALENT		5.72	4.64	5.70
DEIONIZED WATER		5.28	4.08	(ND)
MHH	105	5.69	5.90	4.38
MONOVALENT		6.31	(ND)	5.30
DIVALENT		6.85	4.68	(ND)
DEIONIZED WATER		6.00	(ND)	(ND)
MHH	112 Old	6.54	4.53	5.36
MONOVALENT		6.92	5.97	4.68
DIVALENT		7.26	5.89	5.53
DEIONIZED WATER		6.28	4.90	(ND)

Each data point represents the mean of two experiments (Mar. 12 - Jun. 8 and Jun. 29 - Sept. 28, 1992), with each sample being enumerated using triplicate counts.

[1] Lowest level of detection is log 4.00 $cfu.mL^{-1}$.

Table 26e. The population profile (log $cfu.mL^{-1}$) of fungi, bacteria and actinomycetes enumerated in a split root NFT greenhouse study at Tuskegee University when sampled at 7-day intervals.[1]

Solution Composition	Plant Life (Days)	Bacteria	Fungi	Actinomycetes
MHH	112 New	5.68	(ND)	(ND)
MONOVALENT		5.73	(ND)	4.32
DIVALENT		6.00	(ND)	5.20
DEIONIZED WATER		5.43	(ND)	5.06
MHH	119	5.90	(ND)	4.32
MONOVALENT		4.38	(ND)	4.05
DIVALENT		6.16	(ND)	4.40
DEIONIZED WATER		5.94	(ND)	(ND)

Each data point represents the mean of two experiments (Mar. 12 - Jun. 8 and Jun. 29 - Sept. 28, 1992), with each sample being enumerated using triplicate counts.

[1] Lowest level of dectection is log 4.00 $cfu.mL^{-1}$.

Table 27a. The population profile (log $cfu.mL^{-1}$) of fungi, bacteria and actinomycetes enumerated in a split root deep-water study conducted in the greenhouse at Tuskegee University when sampled at 7-day intervals.[1]

Solution Composition	Plant Life (Days)	Bacteria	Fungi	Actinomycetes
MHH	0	6.47	5.12	None Detected (ND)
MONOVALENT		6.21	5.00	(ND)
DIVALENT		6.68	5.62	(ND)
DEIONIZED WATER		6.61	(ND)	5.60
MHH	7	6.80	4.30	(ND)
MONOVALENT		6.42	(ND)	(ND)
DIVALENT		6.60	5.20	5.84
DEIONIZED WATER		6.46	5.80	(ND)
MHH	14 Old	6.84	5.00	(ND)
MONOVALENT		6.80	(ND)	(ND)
DIVALENT		7.45	4.36	(ND)
DEIONIZED WATER		6.85	5.89	(ND)
MHH	14 New	5.87	(ND)	(ND)
MONOVALENT		5.88	(ND)	(ND)
DIVALENT		6.84	(ND)	(ND)
DEIONIZED WATER		5.43	(ND)	(ND)
MHH	21	6.87	(ND)	(ND)
MONOVALENT		6.63	(ND)	(ND)
DIVALENT		6.96	5.00	(ND)
DEIONIZED WATER		6.44	5.06	(ND)
MHH	28 Old	6.28	5.97	(ND)
MONOVALENT		6.59	6.60	(ND)
DIVALENT		6.72	6.33	6.62
DEIONIZED WATER		6.30	5.90	(ND)

Each data point represents the mean of two experiments (Mar. 13 - Jun. 9 and Jul. 1 - Sept. 30, 1992) with each sample being enumerated using triplicate counts.

[1] Lowest level of detection is log 4.00 $cfu.mL^{-1}$.

Table 27b. Population profile (log cfu.mL^{-1}) of fungi, bacteria and actinomycetes enumerated in a split root deep-water greenhouse study at Tuskegee University when sampled at 7-day intervals.[1]

Solution Composition	Plant Life (Days)	Bacteria	Fungi	Actinomycetes
MHH		5.43	(ND)	(ND)
MONOVALENT	28 New	5.41	(ND)	(ND)
DIVALENT		5.77	(ND)	(ND)
DEIONIZED WATER		5.45	(ND)	(ND)
MHH	35	6.58	5.04	(ND)
MONOVALENT		6.64	5.43	(ND)
DIVALENT		6.87	4.72	(ND)
DEIONIZED WATER		6.59	5.38	(ND)
MHH	42 Old	6.18	(ND)	(ND)
MONOVALENT		5.46	(ND)	(ND)
DIVALENT		7.04	4.12	(ND)
DEIONIZED WATER		6.81	(ND)	4.90
MHH	42 New	5.09	(ND)	(ND)
MONOVALENT		6.52	(ND)	(ND)
DIVALENT		6.82	(ND)	4.60
DEIONIZED WATER		6.12	(ND)	(ND)
MHH	49	5.43	(ND)	(ND)
MONOVALENT		5.46	(ND)	(ND)
DIVALENT		5.60	(ND)	(ND)
DEIONIZED WATER		5.32	(ND)	(ND)
MHH	56 Old	5.04	(ND)	3.12
MONOVALENT		4.94	(ND)	(ND)
DIVALENT		6.80	(ND)	(ND)
DEIONIZED WATER		5.60	(ND)	(ND)

Each data point represents the mean of two experiments (Mar. 13 - Jun. 9 and Jul. 1 - Sept. 30, 1992), with each sample being enumerated using triplicate counts.

[1] Lowest level of detection is log 4.00 log cfu.mL^{-1}.

Table 27c. Population profile (log cfu.mL^{-1}) of fungi, bacteria and actinomycetes enumerated in a split root deep-water greenhouse study at Tuskegee University when sampled at 7-day intervals.[1]

Solution Composition	Plant Life (Days)	Bacteria	Fungi	Actinomycetes
MHH	56 New	4.11	(ND)	3.12
MONOVALENT		4.45	3.82	(ND)
DIVALENT		4.48	(ND)	(ND)
DEIONIZED WATER		4.27	(ND)	(ND)
MHH	63	4.94	(ND)	(ND)
MONOVALENT		4.82	(ND)	(ND)
DIVALENT		6.01	(ND)	(ND)
DEIONIZED WATER		5.08	5.53	(ND)
MHH	70 Old	6.60	6.06	(ND)
MONOVALENT		6.58	5.40	(ND)
DIVALENT		6.75	6.45	(ND)
DEIONIZED WATER		6.00	5.38	(ND)
MHH	70 New	6.00	(ND)	(ND)
MONOVALENT		5.58	(ND)	(ND)
DIVALENT		6.27	(ND)	(ND)
DEIONIZED WATER		5.38	(ND)	(ND)
MHH	77	5.95	(ND)	(ND)
MONOVALENT		5.86	(ND)	(ND)
DIVALENT		6.74	(ND)	(ND)
DEIONIZED WATER		6.28	(ND)	(ND)
MHH	84 Old	6.89	6.09	(ND)
MONOVALENT		6.79	5.98	(ND)
DIVALENT		6.98	6.47	(ND)
DEIONIZED WATER		6.28	5.82	(ND)

Each data point represents the mean of two experiments (Mar. 13 - Jun. 9 and Jul. 1 - Sept. 30, 1992), with each sample being enumerated using triplicate counts.

[1] Lowest level of detection is log 4.00 cfu.mL^{-1}.

Table 27d. Population profile (log cfu.mL^{-1}) of fungi, bacteria and actinomycetes enumerated in a split root deep-water greenhouse study at Tuskegee University when sampled at 7-day intervals.[1]

Solution Composition	Plant Life (Days)	Bacteria	Fungi	Actinomycetes
MHH	84 New	5.38	(ND)	(ND)
MONOVALENT		5.78	(ND)	(ND)
DIVALENT		5.80	(ND)	(ND)
DEIONIZED WATER		5.50	(ND)	(ND)
MHH	91	6.02	(ND)	(ND)
MONOVALENT		6.12	(ND)	(ND)
DIVALENT		6.89	(ND)	(ND)
DEIONIZED WATER		6.20	(ND)	(ND)
MHH	98 Old	6.88	6.01	(ND)
MONOVALENT		6.69	6.58	(ND)
DIVALENT		6.90	6.43	(ND)
DEIONIZED WATER		6.87	5.48	(ND)
MHH	98 New	6.40	(ND)	(ND)
MONOVALENT		6.43	(ND)	(ND)
DIVALENT		6.88	(ND)	(ND)
DEIONIZED WATER		6.45	(ND)	(ND)
MHH	105	4.74	(ND)	(ND)
MONOVALENT		4.52	(ND)	(ND)
DIVALENT		5.74	(ND)	(ND)
DEIONIZED WATER		5.28	(ND)	(ND)

Each data point represents the mean of two experiments (Mar. 13 - Jun. 9 and Jul. 1 - Sept. 30, 1992), with each sample being enumerated using triplicate counts.

[1] Lowest level of detection is log 4.00 cfu.mL^{-1}.

Table 27e. Population profile (log cfu.mL^{-1}) of fungi, bacteria and actinomycetes enumerated in a split root deep-water greenouse study at Tuskegee University when sampled at 7-day intervals.[1]

Solution Composition	Plant Life (Days)	Bacteria	Fungi	Actinomycetes
MHH	112 Old	6.54	(ND)	(ND)
MONOVALENT		6.08	5.92	4.16
DIVALENT		7.20	4.23	(ND)
DEIONIZED WATER		6.81	5.69	(ND)
MHH	112 New	5.45	(ND)	(ND)
MONOVALENT		5.50	(ND)	(ND)
DIVALENT		5.60	(ND)	(ND)
DEIONIZED WATER		5.12	(ND)	(ND)
MHH	119	6.08	5.66	(ND)
MONOVALENT		5.93	4.73	(ND)
DIVALENT		6.26	6.17	(ND)
DEIONIZED WATER		6.06	(ND)	(ND)

Each data point represents the mean of two experiments (Mar. 13 - Jun. 9 and Jul. 1 - Sept. 30, 1992), with each sample being enumerated using triplicate counts.

[1] Lowest level of detection is 4.00 cfu.mL^{-1}.

Publications Submitted or In Preparation *(Select copies included in Appendix 1)*

Almazan, A. M., D. Mortley and P. Grant. 1992. Sugar beet greens- A potential vegetable for a Controlled Ecological Life Support System. Submitted to Journal of Horticultural Science.

Almazan, A. M., S. O. Adeyeye, X. H. Zhou, W. A. Hill, C. K. Bonsi, J. Y. Lu and P. A. Loretan. 1992. Changes in sucrose and starch syntheses in sweetpotato phytomodels during storage root formation and maturation. Submitted to Plant Physiology.

Almazan, A. M., S. O. Adeyeye, X. H. Zhou, W. A. Hill, C. K. Bonsi, J. Y. Lu and P. A. Loretan. 1992. Changes in sucrose and starch synthesis in hydroponic sweetpotato during storage root formation and maturation. Submitted as a communication to Plant Physiology.

Bonsi, C. K., P. A. Loretan, W. A. Hill and D. G. Mortley. 1992. Response of sweetpotatoes to continuous light. HortScience 27(5):471.

Grant, P. J., J. Y. Lu, D. G. Mortley, P. A. Loretan, C. K. Bonsi and W. A. Hill. 1992. Nutrient composition of hydroponically grown sweetpotato storage roots as affected by frequency of nutrient solution change. (Accepted for publication in HortScience)

Hill, W. A., C. K. Bonsi and P. A. Loretan (editors). 1992. Sweetpotato Technology for the 21st Century, Tuskegee University, Tuskegee, AL. (In preparation)

Titles of papers by Center staff appearing in this book are:

- Optimizing Gene Transfer Systems for Sweetpotato
  Prakash, C. and U. Varadarajan
- Evolutionary Biology of the Sweetpotato: Current Knowledge and Future Directions of Research
  Varadarajan, G.S. and C.S. Prakash.
- Analysis of Genomic Variation in Sweetpotato through DNA Fingerprinting
  Varadarajan, G.S., N.K. Sinha and C.S. Prakash.
- Systems for Growing Sweetpotatoes for Space Missions
  Bonsi, C., W. Hill, D. Mortley, P. Loretan, C. Morris and E. Carlisle.
- Effect of Flow Rate on Hydroponically-grown 'Georgia Jet' Sweetpotatoes
  E.R. Carlisle, D.G. Mortley, P.A. Loretan, C.K. Bonsi, W.A. Hill, C.E. Morris and A.A. Trotman
- Effect of Constant pH vs. Periodic pH Adjustment of Nutrient Solution on Yield of Sweetpotato Using NFT
  E.R. Martinez, C.K. Bonsi, P.P. David, D.G. Mortley, W.A. Hill, P.A. Loretan, C.E. Morris
- Effects of Relative Humidity on Sweetpotato Growth in an NFT System
  D.Mortley, C. Bonsi, P. Loretan, W. Hill, E. Carlisle, C.E. Morris
- Starch and Sucrose Synthesis in Sweetpotato Phytomodels (Check titles)
  A. Almazan, S. Adeyeye, X. Zhou, J. Lu, D. Mortley, C. Bonsi, W. Hill, P. Loretan
- Growth and Yield of Sweetpotato under Different Carbon Dioxide Concentrations
  N.C. Bhattacharya, P.P. Ghosh, D. R. Hileman, M. Alemayehu, G. Huluka and P. K. Biswas
- Nutritive Composition of Sweetpotatoes Grown in NFT with Different Nutrient Solution Application Protocols
  P. Grant, J. Lu, D. Mortley, P. Loretan, C. Bonsi, W. Hill and C. Morris
- Sensory Profiles of Three Sweetpotato Cultivars Grown Using the Nutrient Film Technique
  Dana M. Greene, John Y. Lu, and Karen Crippen
- New Technologies and Conventional Breeding of Sweetpotato
  M. Hall, D. LaBonte, and C. Bonsi

Hill, W. A., D. G. Mortley, C. L. Mackowiak, P. A. Loretan, T. W. Tibbitts, R. M. Wheeler, C. K. Bonsi and C. E. Morris. 1992. Growing root, tuber and nut crops hydroponically for CELSS. Adv. Space Res. 12(5):125-131.

Kanyand, M., A. Porobo-Dessai and C. S. Prakash. 1992. Peanut transformation with *Agrobacterium tumefaciens.* (In preparation)

Loretan, P. A., C. K. Bonsi, D. G. Mortley, R. M. Wheeler, C. L. Mackowiak, W. A. Hill, C. E. Morris, A. A. Trotman and P. P. David. 1992. Effect of several environmental factors on sweetpotato growth. Adv. Space Res. (In press)

Mortley, D. G., C. K. Bonsi, W. A. Hill, P. A. Loretan, C. E. Morris, A. A. Trotman and P. P. David. 1992. Response of sweetpotato grown in NFT to different photoperiods. HortScience 27(6):177 (Abstract).

Mortley, D. G., C. K. Bonsi, W. A.Hill, P. A. Loretan and C. E. Morris. 1992. Sweetpotato growth and yield in nutrient film technique in response to irradiance and nitrogen to potassium ratio. Crop Science (In review).

Porobo-Dessai, A., E. T. Blay, C. S. Prakash and K. Nakamura. 1992. Expression of *gus*A gene with an intron in sweet potato and garden egg plant. *In Vitro* Cellular and Developmental Biology 28: 123A

Prakash, C. S. and U. Varadarajan. 1992. Genetic transformation of sweetpotato by particle bombardment. Plant Cell Reports 11:53-57

Prakash, C. S., A. Porobo-Dessai, E. Blay, G. Ramanamurthy, and K. Dumenyo. 1992. *Agrobacterium* mediated gene transfer and regeneration of transgenic sweetpotato. (In preparation)

Ramanamurthy, G., A. Porobo-Dessai, E. Blay, K. Dumenyo, L. Shen and C. S. Prakash. 1992. Adventitious regeneration of sweetpotato shoots *in vitro*. (In preparation)

Presentations at Professional Conferences

Presented at the Fifty-second Annual Meeting of the Southern Region of the American Society for Horticultural Science. Lexington, KY, Feb. 1-5, 1992.

David, P. P., A. Almazan, C. K. Bonsi, D. G. Mortley and A. A. Trotman. 1992. Effects of biweekly topping on nutrient content of shoot tips and storage root yield of sweetpotato grown in an NFT system.

Gill, Brendalyn. 1992. Growth of sweetpotato in aeroponics compared to nutrient film technique.

Trotman, A. A., D. G. Mortley and P. P. David. 1992. Effect of inoculation with *Azospirillum brasilense* on foliage and storage root yield of sweetpotato grown hydroponically in an NFT system.

Trotman, A. A., D. G. Mortley and P. P. David. 1992. Influence of horizontal versus vertical growth pattern on yield of sweetpotato grown in a nutrient film technique (NFT) system.

Blay, E. T., Porobo-Dessai, A., C. S. Prakash. 1992. Effect of *vir* gene inducers on genetic transformation frequencies of sweet potato and garden egg plant. 89th Annual Meeting of the American Soc. of Hort. Science. Honolulu, HI (August 1-6, 1992) (HortScience 27: 172. #641).

Loretan, P. A., C. K. Bonsi, D. G. Mortley, R. M. Wheeler, C. L. Mackowiak, W. A. Hill, C. E. Morris, A. A. Trotman and P. P. David. 1992. Effect of several environmental factors on sweetpotato growth. Paper 4.3-M.1.06. World Space Congress-1992, Washington, D.C. Aug. 31-Sept. 4, 1992. Adv. Space Res. (In press)

Prakash, C. S. and U. Varadarajan. 1992. Foreign gene delivery into sweet potato and its potential applications in agriculture. Miami Winter Bio/Technology Symposium. January 19-24, 1992.

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Almazan, A. M., P. Grant and D. Mortley. 1992. Sugar beet greens - a potential vegetable for the space station.

Aviki, F., S. Adeyeye, P. Loretan and D. Mortley. 1992. Growing sweetpotatoes hydroponically using a stainless-steel membrane.

David, P. P., C. K. Bonsi, A. Almazan, D. G. Mortley and A. A. Trotman. 1992. Effects of biweekly topping on nutrient content of shoot tips and storage root yields of sweetpotato grown in an NFT system.

David, P., E. Martinez, C. Bonsi, D. Mortley, W. Hill, P. Loretan and C. Morris. 1992. Effect of constant pH vs periodic pH adjustment of nutrient solution on yield of sweetpotato using the nutrient film technique.

Gill, Brendalyn K. 1992. A comparative study of sweetpotato in two hydroponic systems.

Mortley, D. G., P. Loretan, W. Hill, A. Trotman, P. David, C. Bonsi and C. Morris. 1992. Frequency of nutrient solution change affects yield and nutrient uptake of sweetpotato grown by use of nutrient film technique.

Mortley, D., C. Bonsi, P. Loretan, W. Hill, C. Morris, A. Trotman and P. David. 1992. Sweetpotato growth in nutrient film technique in response to varying photoperiods.

Prakash, C. S., A. Porobo-Dessai, and E. Blay. 1992. Potential for improvement of sweetpotato productivity through genetic engineering.

Trotman, A. A., C. E. Morris, D. G. Mortley and P. P. David. 1992. A new method for growing peanut hydroponically in an NFT system.

Trotman, A. A., D. G. Mortley and P. P. David. 1992. Effect of inoculation with *Azospirillum brasilense* on nutrient uptake, foliage and storage root yield of sweetpotato grown hydroponically in an NFT system.

To be presented at Fifty-second Annual Meeting of the Southern Region, American Society of Horticultural Science. Tulsa, OK, Feb. 1-3, 1993.

Burrell, S., D. Mortley, P. Loretan, A. Trotman, P. David and L. Garner. 1993. Photoperiod/light intensity interactions on growth of two sweetpotato cultivars in NFT.

Garner, L., D. Mortley, P. Loretan, A. Trotman and P. David. 1993. Effect of types of cutting and depth inserted in the nutrient solution on growth responses of sweetpotato in NFT.

Morris, C. and A. Trotman. 1993. A comparative study of hydroponic systems for growing peanuts.

Mortley, D., J. Lu and P. Grant. 1993. Effect of foliage removal on growth and yield of 'Georgia Red' peanuts.

Trotman, A A., W. A. Hill,D. G. Mortley, and P.P David. 1993. Response of hydroponically grown sweetpotato to inoculation with *Azospirillum spp*.

Patent Information

An "Amendment After Decision by Board of Appeals' was filed on Oct. 22, 1992 with respect to U. S. Patent 8,860,490, C. E. Morris, P. A. Loretan, C. K. Bonsi, W. A. Hill, Movable root contact - pressure plate assembly for hydroponic system.

DOCUMENTATION OF CENTER PROGRAM ACTIVITIES

Publicity of Center

A video produced jointly by Kurtis Productions and the Public Broadcasting System (PBS) for the 1992 "New Explorers" Series on PBS, highlights the work of the Center based on the tradition of the work of George Washington Carver on the sweetpotato brought to the present with research needed for it to be a food for space missions. This series also targets public school systems for classroom use and, for one, was purchased by the Chicago School System. The January 23, 1992 issue of the *Tuskegee Gram* (circulation:3000) announced the Center grant to Tuskegee University and also served as a "news release" to outside print and video media concerning it. In addition, the Spring/Summer 1992 issue of *Tuskegee Horizons* (circulation:7000) (Appendix 2) carried the announcement. The December 10, 1992 issue of the *Tuskegee Gram* (Appendix 2) reported on the Center and the NASA-Goddard joint workshop at Tuskegee University on use of INTERNET. The Center's activities were widely publicized in Japanese newspapers and television prior to, during and after two symposia on "Sweetpotatoes for Space", held in Kawagoe and Kagoshima, Japan. A color brochure (25,000 copies) (Appendix 3) titled "Space Agriculture," produced by Tuskegee University also announced the fact that the university was designated a Center for this work. Flyers and applications (Appendix 4) were also distributed on campus and sent to other HBCU's introducing TUNACC and hoping to attract prospective students to the Center.

Organization and Staffing of Center

As illustrated in Figure 17 the Center reports through the On-Campus Advisory Committee and the Provost to the President, and through the President to the Board of Trustees. The On-Campus Advisory Board is chaired by the Provost and includes the Deans of all Schools and Colleges with participating faculty and staff. This approach keeps all critical administrative heads informed and in a policy-influencing position relative to the Center's activities. As a result of this structure, the Center has been able to function effectively in the university system. During 1992, the Center had active response and support from the Board of Trustees, President, Provost, the various vice presidents, and deans.

Each member of the Center staff is part of one or more of the six functional working groups. Each working group—GRO, PAM, GED, MAC, NAF and WAM—is responsible for carrying out specific objectives in the original proposal. Each group has a Group Leader who is a member of the Leadership Team, along with the Project Director and two Co-Directors. The latter three persons comprise the Administrative Team. The Leadership Team reports to the On-Campus Advisory Committee that is chaired by the Provost and includes the deans of the participating Schools as members. The Provost reports on the activities of the Center to the President, who in turn keeps the Board of Trustees informed of the Center's activities. Additionally, the Project Director communicates regularly on the Center's activities with the Provost who is in constant contact with the President.

The Working Groups meet formally on a weekly or bi-weekly basis to ensure quality control, but actually work together on day-by day basis. The Leadership Team—Group Leaders, Project Director and Co-Directors—meet bi-weekly to discuss issues that impact all groups, to make collective decisions about priorities and deadlines and to facilitate interdisciplinary and cross-group research and interactions. The Administrative Team meets on an as-need basis (that can range from several times per day to once a week, depending on need) in order to handle financial, personnel and other matters necessary to properly support each Working Group. The entire Center staff meets monthly for a seminar series that includes both Working Group presentations and guest speakers on topics related to Center goals. The On-Campus Advisory Committee has two scheduled meetings per year and additional call meetings on an as-need basis as determined by the Provost.

Description of Student Tracking Method

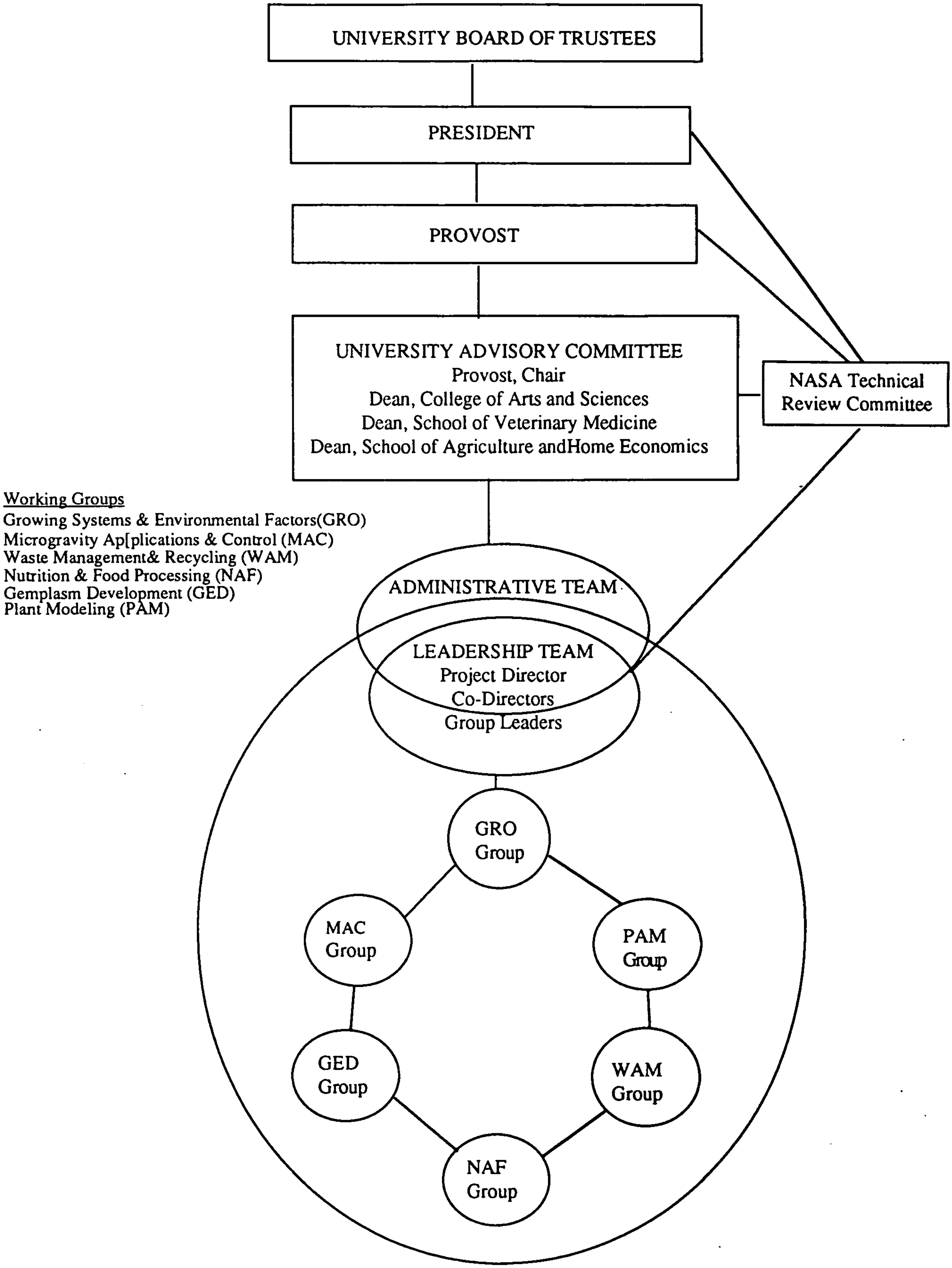
The School of Engineering has had an effective method for tracking its students over the years. The Center is adopting that system for all student participants. The Tuskegee University NASA Tracking Form (Appendix 5), is filled out by all students so that a permanent address (address of a relative who would always know their whereabouts) is on record for them. They are also encouraged to update their record with the Center as they leave the University by having two stamped envelopes addressed to the Center enclosed with blank tracking forms. It should be easy to stay in contact.

Specific Strategies for Inclusion of Underrepresented Minority Faculty and Students

In seeking new faculty and staff for the Center, position announcements have been sent to HBCUs in addition to major historically white institutions, professional societies and agency newsletters. Also we have made special efforts to keep track of our own graduates who have pursued graduate training at other institutions.

First priority for all student positions with the project is underrepresented minorities. After reviewing applications and interviews, students are recommended by the Group Leaders to the Administrative Team. These recommendations are carefully scrutinized for adherence to the priority for underrepresented minorities. Announcements about student positions with the Center are posted throughout the campus with information on application blanks (see Appendix 3 for copies of flyers and application blanks). Also announcements about the Center, associated scholarships and research assistantships and application blanks are sent to other HBCU's. Additionally, Walter Hill (life sciences) and Shaik Jeelani (engineering) seek out talented students and encourage them to apply for participation in Center activities; Hill and Jeelani meet periodically to ensure coordination and balance of life sciences and engineering students in the Center's activities. The On-Campus Advisory Committee is periodically updated on underrepresented minority faculty and students involved in the Center and their recommendations sought to make sure that our selections are in line with University policy. The NASA Technical Review Committee and NASA Headquarters are also kept informed on underrepresented faculty and student involvement to ensure adherence to NASA and MUREP policies.

Figure 17. Organization Chart
TUSKEGEE UNIVERSITY
CENTER FOR FOOD PRODUCTION, PROCESSING AND WASTE MANAGEMENT



Pre-college recruitment programs. During the summer of 1992 pre-college engineering and science programs at Tuskegee University attracted over 400 high school students—the largest number ever. These programs included the following: Freshman Accelerated Start-up and Training for Retention in Engineering Curricula-high school graduates; Research Apprenticeship for Disadvantaged High Schoolers-11th grade; Minority Introduction to Engineering-10th and 11th grades; Pre-Engineering Program (II)-10th grade; Pre-Engineering Program (I)-9th grade; Southeastern Consortium for Minorities in Engineering-6th thru 12th grades; Research Education Apprenticeship in Career Health Occupations for University Training-11th & 12th grades; Educational Nurturing of Highly Motivated Candidates for Excellence in Sciences-12th grade; and Minority Apprenticeship Program-10th thru 12th grade. These programs were supported by funds from 19 corporations, the U.S. Air Force, U.S. Navy, NASA (Space Grant), DOE, USDA, NIH and NSF. All of these programs are focused on the recruitment of undergraduate minority students. Past and present data indicate that 80% of the participants pursue college careers in engineering and the sciences.

Interactions with NASA Field Installations

Tuskegee University has enjoyed an excellent working relationship with staff of the CELSS program at Kennedy Space Center (KSC) for five years prior to establishment of the Center. During the past year this collaboration continued. The Center took the lead in the development of a joint publication with KSC scientists on the effect of CO_2 and environmental conditions on sweetpotato growth and production. This paper has been accepted for publication in *Advances in Space Research.* The Center supplied sweetpotato planting materials and protocols for experiments carried out during the year at KSC. Several of the newer Center scientists visited KSC during April 9-12, 1992 as part of the annual Hydroponics Society of America Meeting.

Goddard Space Flight Center (GSC)-Minority University Space Interdisciplinary Network (MUSPIN) has played an excellent role in catalyzing the campus-wide hook-up with INTERNET. After a series of preparatory visits three MUSPIN specialists presented a series of lecture-demonstrations on the use of INTERNET to about 50 key faculty and staff from the Office of Computer Services, College of Arts and Sciences, School of Agriculture and Home Economics, School of Engineering and Architecture and School of Veterinary Medicine. Most of the Center scientists participated in all of the lecture-demonstrations. This was an excellent and very helpful contribution by NASA to strengthening the research core capability of Tuskegee University. In order to ensure effective utilization of INTERNET by Center staff and the campus community, a follow-up workshop on more specific applications is required when the T1 line is in place to ensure rapid application by Center staff.

In preparation for the November 22-December 2, 1992 visit of several Center scientists to Japan, Johnson Space Center sent Tuskegee Center staff select food samples and photographs of foods like those used in previous space missions. These items were used as display materials at the *Symposium for Sweetpotatoes in Space*, sponsored by Kagoshima Prefecture and University and the 1992 *Sweetpotato Festival* sponsored by the *Kawagoe Friends of Sweetpotato.*

Affiliations with Industry

American Cyanamid has contributed laboratory equipment to Center scientists in support of their research and teaching activities. Since chemistry undergirds life and agricultural sciences and engineering, at the request of Center Staff, American Cyanamid assisted with chemistry faculty development by providing a visiting scientist experience for a faculty member at its research facility in New Jersey. As a follow-up Cyanamid is presently assisting a joint effort by the Departments of Chemistry and Agricultural Sciences in the development of a proposal to be submitted to USDA in January, 1993 that will strengthen the undergraduate chemistry teaching program. Procter and Gamble sponsored a week-long intensive training program in Total Quality Management for engineering and business faculty and campus-wide administrators from Tuskegee University and the University of Wisconsin. Walter Hill, Fred Aviki and Heshmat Aglan were participants from the Center's staff.

Amoco and Waste Management, Inc. were sponsors of the *New Explorers* television series produced by Bill Kurtis that featured the Tuskegee University NASA-funded sweetpotato research program. The program was aired nation-wide on public television during 1992. Kraft Foods invited Walter and Jill Hill to present joint seminars to both corporate staff and research staff in Glenview, Illinois. The response was very positive and agreement was made to follow-up with exchange visits of key scientists and engineers, with a focus on processing and preparation of foods for space missions. An exchange of information between the Center and Food and Agrosystems, Inc. has resulted in the inclusion of sweetpotatoes in their proposed diets for future space missions. Food and Agrosystems, Inc. are under contract by NASA as a small business to develop food processing equipment that will function in microgravity. Continued communication between the TU/NASA Center and Food and Agrosystems will ensure that appropriate systems for processing sweetpotatoes and peanuts are developed.

Affiliations with HBCU's and other Universities

North Carolina A&T State University and Tuskegee University jointly wrote and were funded by USDA to develop faculty expertise in the use of CD-ROM, video and satellite communications technology in classroom teaching. Four modules will be developed at Tuskegee University including a module on the Center's activities. Center staff will become familiar with these modern methods of communications. North Carolina A&T State University and Tuskegee University will jointly sponsor training sessions over the next two years and have issued invitations to 14 other HBCU's to participate. Cooperative research of Center staff with several other universities continues to be mutually supportive. During the past year we received two grants from USDA to enhance our sweetpotato modeling research in joint efforts with Rutgers University and North Carolina State University. We continue our linkage with Louisiana State University in the use of gene constructs to improve protein quality in sweetpotato. Our Cooperative Space Grant effort with Georgia Tech has been very effective during the year in reaching out to high school youth in Alabama and Georgia and motivating them to pursue careers in science and engineering. A Georgia Tech controls specialist consulted with the MAC group on control systems. Based upon our ongoing work in food processing and human nutrition studies of sweetpotato we were funded by USAID in a joint effort with Pennsylvania State University to develop infant and weaning foods in Kenya from sweetpotatoes and other crops. Grants were also funded by USAID for cooperative research on sweetpotato biotechnology that involved scientists from the University of Ghana and Sokoine University, Tanzania. We have recently initiated contact with scientists at Colorado State University to jointly pursue studies with them and Johnson Space Center on the use of zeolites as a medium for growing sweetpotatoes and peanuts.

Report of Equipment Purchased

1. Two EGC Model GCW-15 Plant Growth Chambers - to be delivered January 15, 1993 - To be used to study the effects of elevated CO_2 on sweetpotatoes (GRO group) - to be located in lab 1 at greenhouse.

2. Electrical wiring for new GCW-15 chambers in Item 1 (GRO) - out on bids - to be located in lab 1 at greenhouse.

3. Chest Size Shaker Bath Incubator - out on bids - to be used in microorganism studies (WAM group) to be located in Milbank Hall.

4. Wrist Action Shaker - requisition sent following bid returns—to be used in biochemical studies and food science analyses (NAF). To be be located in the Food Science Laboratory, Campbell Hall.

5. Ohaus Electronic Topload Balance - requisition sent following bid returns - to be used for weighing in Food Science (NAF). To be located in the Food Science Laboratory in Campbell Hall.

6. HP Laserjet III printer with toner - used with item 7 and one of item 8 for control of membrane delivery system (MAC). Located in the Engineering Building with MAC group.

7. Data acquisition board with control software - used with item 6 (MAC). Located in Engineering Building with MAC group.

8. Two PC compatible computers with Dot Matrix printer - one used with item 6 and 7 and other in Lab 1 and greenhouse for CO_2 control (MAC). Located in Lab 1 at greenhouse.

9. Sonitrol National Security System - Fire-safety security system for greenhouse office and growth chamber area (ADM) - located in both greenhouse office area and growth chamber area.

10. KEI Portable Filtered Fume Exhauster - used for exhausting fumes from welding PVC-1 growing channels (ADC). Located in machine shop at Vocational Bldg.

11. Four Kenmore air conditioner units - used to cool environmental growth chamber rooms (GRO) - located in Labs 1-4 at greenhouse.

12. LDC HPLC System repair, conditioning and calibration - used for cartenoids, proteins, etc. (NAF) Located in Food Science Lab in Campbell Hall.

13. Bio Rad Model 1706 Programmable UV-visible monitor and organic acid analysis kit. Used for analysis of sugars and organic acids (NAF). Located in Food Science Lab in Campbell Hall.

Proposals Submitted by Principal Investigators for Funding through External Sources

Grants Impacting NASA

Agency	Title	Amount
NASA Training Grant NGT-40013	Georgia Institute of Technology NASA Space Grant Consortium	$55,000
USDA/SE Capacity Building Grants Program	Improving Capacity for AG*SAT Related Telecommunication and Distant Learning	$202,500
USDA/SE Capacity Building Grants Program	Gene Transfer to Sweetpotato for Disease Resistance	$140,041
USDA/CSRS Capacity Building Grants Program	National Sweetpotato Information Center	$157,500
DOE	Effects of Enriched Carbon Dioxide Water and Nutrient Stress on Growth, Yield, Physiology and Phizophere Biochemistry on Sweetpotato	$180,000
USAID/DNA	Fingerprinting of Sweetpotato Genetic Resources	$100,000
DOE	Interactive Effects of Carbon Dioxide Enrichment, Mineral Nutrition and Water Stress on Physiology and Morphology of Sweetpotato and Peanut: Toward a Sweetpotato Simulation Model	$66,000
USDA/CSRS	Sweetpotato Research Program	$103,106
Egyptian Cultural and Educational Bureau	Peace Fellowship Program. M. A. Sherif, Applicant	$5,592
USDA/SE Capacity Building Grants Program	Development of Sweetpotato Growth and Biomass Simulation Model for Varied Environment	$223,509
N. C. State Univ.	Use of Organic Nitrogen Sources For Sweetpotatoes: Potential and Economic Feasibility	$49,369

Forums, Symposia Sponsored or Attended

Four members attended the Fifty-second Annual Meeting of the Southern Region of the American Society of Horticultural Science in Lexington, KY on Feb. 1-5, 1992.

Seven members attended the Hydroponics Society of America Meeting, Orlando, Florida with tours of Kennedy Space Center CELSS Project and Epcot Center Land Exhibit, April 9-12, 1992.

Two members attended the Institute of Food Technologists meeting in New Orleans, LA, June 20-26, 1992.

Three members attended the 89th Annual Meeting of the American Society for Horticultural Science, Honolulu, Hawaii, July 30-August 6, 1992.

One member attended the Space Station Freedom Utilization Conference, Huntsville, AL August 4-5, 1992.

One member attended the World Space Congress - Cospar '92 Meeting, Washington, D. C., August 31-September 4, 1992.

Eight members attended the Association of Research Directors Ninth Biennial Symposium, Atlanta, GA, October 4-8, 1992.

One member attended the conference on "Biotechnology for Crop Improvement in Latin America," Caracas, Venezuela Nov. 1-7, 1992.

Four members participated in a panel discussion and one gave the key address at both the "Space Agriculture and Sweetpotato" Symposium at Kagoshima University, Kagoshima, Japan and the "Sweetpotato in Space" Symposium and Festival at Kawagoe Japan, November 25-December 2, 1992.

One member attend the symposium in Tropical Root Crops, Kampala, Ugandu, Nov. 23-30, 1992.

Strategies for Technology Transfer

The strategy for technology transfer has not been thoroughly planned but the state of Alabama has a mechanism which can assist in this. When Tuskegee University received a patent for a "Movable root contact-pressure plate assembly for hydroponic system", the Alabama Office for the Advancement of Developing Industries (Birmingham, AL) contacted us to promulgate that information in their brochure entitled: *Quantum-Highlighting Commercial Applications of Alabama's Scientific Achievements* (Copy included in

Appendix 6). This comes out quarterly and is used to assist with technology transfer by communicating the technology to interested parties around the country. This would be one valuable means of transfer for the Center.

Advisory Committees

On-Campus Advisory Committees

William L. Lester, Provost (Chair), Tuskegee University
Ollie Williamson, Dean, College of Arts and Sciences
James Ferguson, Dean, School of Veterinary Medicine
Shaik Jeelani, Acting Dean, School of Engineering and Architecture
Walter Hill, Dean, School of Agriculture and Home Economics - Ex Officiol

Technical Review Committee

Raymond Wheeler, Kennedy Space Center
Richard Young, NASA Headquarters
Gerald Soffen, Goddard Space Flight Center
Donald Henninger, Johnson Space Center
Kumar Krishen, Johnson Space Center

Agenda and Minutes of Advisory Committee Meetings

On-Campus Advisory Committee met on September 11, 1992 and the agenda and minutes for that meeting are included in Appendix 7

Technical Review Committee met on November 20, 1992 but a report for that meeting has not yet arrived (Agenda included in Appendix 7).

DOCUMENTATION OF FACULTY AND STAFF PARTICIPATION

Principal Investigators' Names, Titles, Departments, Ethnic Backgrounds, Group Leaders

TU/NASA CELSS Research Center Staff

Name	*Title*	*Discipline/Department*	*Male*	*Female*	*Underrep Minority*	*U. S. Citizen*	*Perm Resid*
H. A. Aglan*	Assoc Prof	Materials/Mechanical Engineering	X			X	
A. M. Almazan	Res Asst Prof	Food Biochemistry/Home Economics		X			
F. S. Aviki	Asst Prof	Agricultural/Mechanical Engineering	X				X
P. K. Biswas	Prof	Plant Physiology/Agricultural Sciences	X			X	
C. K. Bonsi* +	Prof	Plant Pathology/Agricultural Sciences	X		X		X
J. Carlisle	Specialist	Plant Science/Experiment Station		X	X		
W. Clayton	Prof	Control Systems/Electrical Engineering	X		X	X	
P. David	Res Asst Prof	Horticulture/Agricultural Sciences		X	X		
L. Garner	Specialist	Biology/Experiment Station		X		X	
P. Grant	Specialist	Food Science/Experiment Station		X	X		
T. Habtemarian	Prof	Modeling/Biomedical Info Mgt Systems	X		X	X	
D. Hileman	Assoc Prof	Plant Ecology/Biology	X			X	
J. H. Hill	Consultant	Computer Systems/Experiment Station		X	X	X	
W. A. Hill+	Prof	Agronomy/Agricultural Sciences	X		X	X	
S. Jeelani	Prof	Materials Science/Mechanical Engineering	X			X	
D. Kamau	Asst Prof	Food Science/Home Economics	X		X		
P. A. Loretan+	Prof	Engineering/Agricultural Sciences	X			X	
J. Y. Lu*	Prof	Food Technology/Home Economics	X			X	
C. E. Morris	Assoc Prof	Materials Specialist/Voc & Exten. Educ.	X		X	X	
D. G. Mortley*	Res Asst Prof	Plant Physiology/Agricultural Sciences	X		X		
C. N. Obiozor	Asst Prof	Control Systems/Electrical Engineering	X		X		X
R. D. Pace	Prof	Human Nutrition/Home Economics		X	X	X	
C. S. Prakash	Asst Prof	Molecular Genetics/Agricultural Sciences	X				X
A. A. Trotman*	Res Asst Prof	Microbiology/Agricultural Sciences		X	X		X
Position Offered	Res Assoc	Mol Genetics/ Experiment Station		(X)	(X)		(X)
Position Offered	Research Assoc	Plant Modeling/Experiment Station		(X)	(X)	(X)	
Totals	24(26)		16	8(10)	14(16)	13(14)	5(6)

*Working Group Leader +Project Director/Co-Directors ( )=position offered

DOCUMENTATION OF STUDENT PARTICIPATION

Procedures for Selecting Student Participants

First priority for all student positions with the project is underrepresented minorities. After reviewing applications and interviews, students are recommended by the Group Leaders to the Administrative Team. These recommendations are carefully scrutinized for adherence to the priority for underrepresented minorities (see list of student participants on next page). Announcements about student positions with the Center are posted throughout the campus. Also announcements about the Center and associated scholarships and research assistantships are sent to other HBCU's. Additionally, Walter Hill (life sciences) and Shaik Jeelani (engineering) seek out talented students and encourage them to apply for participation in Center activities; Hill and Jeelani meet periodically to ensure coordination and balance of life sciences and engineering students in the Center's activities. The On-Campus Advisory Committee is periodically updated on underrepresented minority faculty and students involved in the Center and their recommendations sought to make sure that our selections are in line with University policy. The NASA Technical Review Committee and NASA Headquarters are also kept informed on underrepresented faculty and student involvement to ensure adherence to NASA and MUREP policies.

Student Participants, Nature of Participation

Team Student Participants, 1992

Group	*Student Name*	*Major*	*Classification*	*Gender*	*Citizenship*	*Underrep Minority*	*GPA*	*Graduation Date*	*Student SSN*	*Major Professor /Supervisor*	*Topic*
GRO	Stephanie Burrell	PLSCI	Grad	F	USA	Y	2.6	1994	437-55-7444	Mortley/Trotman	Photoperiod-light intensity studies on sweetpotato
	Brendalyn Gill+	PLSCI	SR	F	USA	Y	2.5	1992	254-53-9727	Mortley/Garner	Aeroponics-general maintenance
	Victor Crocker+	PLSCI	SO	M	USA	Y	2.8	1995	255-43-8976	Mortley/Loretan	Pre-rooting cuttings Study #1
	Beverly Smith	BIOL	SR	F	USA	Y	2.7	1993	254-55-9350	Mortley/Garner	Pre-rooting cuttings Study #2
	Derrick King	PLSCI	FR	M	USA	Y	3.1	1996	423-17-6901	W. Hill	Concentrating on course work
MAC	Johnnifer Brown**	ME	SR	F	USA	Y	2.8	1993	418-23-5742	Aglan	Membranes
	Rudzoni Tshitahe	ME	Grad	M	RSA	Y	4.0	1994	190-72-9048	Aglan	Growing with membrane system
	Emory Carter***	EE	Grad	M	USA	Y	3.5	1993	473-92-0221	Aglan	Closed loop membrane control
	Vichelle Taylor	EE	Grad	F	USA	Y	3.5	1992	497-84-0613	Aglan	Open loop membrane control
	Michelle Douglas	EE	Grad	F	USA	Y	3.0	1993	350-62-5182	Obiozor/Loretan	CO_2 control of chambers
	Vernachele Walton	EE	Grad	F	USA	Y	2.7	1993	424-17-6419	Obiozor/Loretan	CO_2 control of chambers
NAF	Wil Ofori	FDSCI	Grad	M	Perm Res	Y	3.6	1993	416-11-1080	Kamau/Lu	Nutritive quality of sweetpotatao & peanut greens
	Ava Bozeman+	FDSCI	SO	F	USA	Y	3.1	1995	255-61-3695	Lu	Sweetpotato product preparation
	Felicia Coles	FDSCI	JR	F	USA	Y	2.6	1994	310-72-7515	Lu	Sweetpotato noodle preparation
PAM	David Johnson	CS	SR	M	USA	Y	3.1	1992	589-10-8478	J. Hill	Sensors w/datalogger
	Vincent Varner*	CE	SO	M	USA	Y	3.4	1995	254-33-1170	J. Hill	Co-op assignment
GED	Dionne Wells	BIOL	SR	F	USA	Y	3.4	1993	580-15-5840	Prakash	Peanut transformation
	P. Young-Curtis	BIOL	SR	F	USA	Y	2.5	1993	417-19-9269	David/Bonsi	General plant maintenance
	R. Gosukonda	PLSCI	Grad	M	India	N	3.8	1993	422-37-4887	Prakash	Sweetpotato gene transfer
WAM	Deloris Alexander	ENSCI	Grad	F	USA	Y	3.0	1995	421-29-1877	Trotman	Comparative study of ATCC & soil isolates at biochem & genetic level
	Xiao Zhou	FDSCI	Grad	F	China	N	3.9	1992	422-35-0965	Almazan	Composition of sweetpotato biomass
	Robert L. Kemp	EE	Grad	M	USA	Y	3.2	1994	564-41-3253	Aviki	Monitoring & control of pH for CELSS
	Samantha Jenkins	CE	SR	F	USA	Y	2.8	1992	417-84-3988	Trotman/Almazan	Determination of organic acid composition of plant nutrient solution
	Paul Drummond	ANSCI	SR	M	Jamaica	Y	3.7	1993	416-37-2688	Trotman	Analysis of gas phase of lignin degradation

*Coop Student - Fall 1992
+Supported by NASA Space Grant
**NSF Scholarship
***GEM Scholarship

DOCUMENTATION OF CENTER PROGRAM IMPACT

Strategies for Recruitment, Retention and Tracking Underrepresented Minority Students in the Targeted Disciplines

Pre-college recruitment programs. During the summer of 1992 pre-college engineering and science programs at Tuskegee University attracted over 400 high school students—the largest number ever. These programs included the following: Freshman Accelerated Start-up and Training for Retention in Engineering Curricula-high school graduates; Research Apprenticeship for Disadvantaged High Schoolers-11th grade; Minority Introduction to Engineering-10th and 11th grades; Pre-Engineering Program (II)-10th grade; Pre-Engineering Program (I)-9th grade; Southeastern Consortium for Minorities in Engineering-6th thru 12th grades; Research Education Apprenticeship in Career Health Occupations for University Training-11th & 12th grades; Educational Nurturing of Highly Motivated Candidates for Excellence in Sciences-12th grade; and Minority Apprenticeship Program-10th thru 12th grade. These programs were supported by funds from 19 corporations, the U.S. Air Force, U.S. Navy, NASA (Space Grant), DOE, USDA, NIH and NSF. All of these programs are focused on the recruitment of undergraduate minority students. Past and present data indicate that 80% of the participants pursue college careers in engineering and the sciences.

Recruitment, retention and tracking. Fliers announcing scholarships and research assistantships by the Center were distributed and posted throughout the campus. Announcements were also sent to HBCU's. The tuition and research assistant opportunities offered through the Center are enabling many students showing promise in the sciences and engineering to concentrate their efforts on their studies and research projects. This alone serves as a powerful retention tool and, when coupled with the seminar series, opportunities to present their research findings at professional meetings and visits to NASA and other partner institutions essentially assures student retention. Additionally, a campus-wide retention program was initiated during the year by the Provost. An early warning system, faculty advisor workshops and campus-wide linkage of advisors to the ISIS registration and course assessment system were instituted in the winter term of 1992 to facilitate communication between faculty advisors and students. The School of Engineering has developed the best system for tracking its students over the years. The Center is adopting that system for all student participants. All applications require a home or permanent address (e.g., parents address) to facilitate locating the student after graduation (see form used for tracking).

Current Enrollment of Underrepresented Minority Undergraduate and Graduate Students in Targeted Disciplines

Enrollment Data (1987-1992)

	1987-88		1988-89		1989-90		1990-91		1991-92		1992-93	
	M	F	M	F	M	F	M	F	M	F	M	F
Agricultural Sciences	78	82	75	86	76	85	92	94	100	103	101	108
Home Economics	17	44	15	41	23	53	25	61	22	56	14	36
Biology	67	119	82	121	75	131	86	152	98	174	98	173
Mechanical Engineering	108	43	143	50	151	48	151	58	155	60	172	60
Chemical Engineering	48	39	47	32	50	35	47	37	52	42	69	55
Electrical Engineering	253	112	267	120	256	115	252	113	261	117	250	112
Veterinary Medicine	110	109	101	100	105	103	112	110	116	110	118	111

Percentage of students* according to ethnic origin are as follows:

African-American 88.5%	Asian 1.1%
Caucasian 3.4%	Others 3.8%
Hispanic 3.0%	

*U. S. Citizens 96.3%

Enrollment Projections in the Targeted Disciplines for the Next Five-Year Period

Projected Enrollments (1992-1997)

	Early 1990's	Late 1990's
Agriculture & Home Economics	300	375
Arts & Sciences	875	1,000
Engineering and Architecture	1,100	1,275
Veterinary Medicine	250	250

Full-time Teaching and Research Staff in Each of the Targeted Disciplines Including Staff Added

TU/NASA CELSS Research Center Staff

Name	*Title*	*Discipline/Department*	*Male*	*Female*	*Underrep Minority*	*U. S. Citizen*	*Perm Resid*
H. A. Aglan*	Assoc Prof	Materials/Mechanical Engineering.	X			X	
A. M. Almazan	Res Asst Prof	Food Biochemistry/Home Economics		X			
F. S. Aviki	Asst Prof	Agricultural/Mechanical Engineering.	X				X
P. K. Biswas	Prof	Plant Physiology/Agricultural Sciences	X			X	
C. K. Bonsi* +	Prof	Plant Pathology/Agricultural Sciences	X		X		X
J. Carlisle	Specialist	Plant Science/Experiment Station		X	X		
W. Clayton	Prof	Control Systems/Electrical Engineering	X		X	X	
° **P. David**	**Res Asst Prof**	**Horticulture/Agricultural Sciences**		**X**	**X**		
° **L. Garner**	**Specialist**	**Biology/Experiment Station**		**X**		**X**	
° **P. Grant**	**Specialist**	**Food Science/Experiment Station**		**X**	**X**		
T. Habtemarian	Prof	Modeling/Biomedical Info Mgt Systems	X		X	X	
D. Hileman	Assoc Prof	Plant Ecology/Biology	X			X	
J. H. Hill	Consultant	Computer Systems/Experiment Station		X	X	X	
W. A. Hill+	Prof	Agronomy/Agricultural Sciences	X		X	X	
S. Jeelani	Prof	Materials Science/Mechanical Engineering	X			X	
D. Kamau	Asst Prof	Food Science/Home Economics	X		X		
P. A. Loretan+	Prof	Engineering/Agricultural Sciences	X			X	
J. Y. Lu*	Prof	Food Technology/Home Economics	X			X	
C. E. Morris	Assoc Prof	Materials Specialist/Voc & Exten. Educ.	X		X	X	
D. G. Mortley*	Res Asst Prof	Plant Physiology/Agricultural Sciences	X		X		
C. N. Obiozor	Asst Prof	Control Systems/Electrical Engineering	X		X		X
R. D. Pace	Prof	Human Nutrition/Home Economics		X	X	X	
C. S. Prakash	Asst Prof	Molecular Genetics/Agricultural Sciences	X				X
° **A. Trotman***	**Res Asst Prof**	**Microbiology/Agri Sciences**		**X**	**X**		**X**
° **Pos. Offered**	**Res. Assoc**	**Mol Genetics/ Expt Station**		**(X)**	**(X)**		**(X)**
° **Pos. Offered**	**Res. Assoc**	**Plant Modeling/Expt Station**		**(X)**	**(X)**	**(X)**	
Totals	24(26)		16	8(10)	14(16)	13(14)	5(6)

*Working Group Leader   +Project Director/Co-Directors   ( )=position offered   Prof=professor
°**Full Time individual added to target discipline**

Utilization of Postdoctoral Research Assistants

The two postdoctoral positions in biotechnology and plant growth computer modeling were advertised. Several applications were received for the Biotechnology position. Three candidates were interviewed and the position was offered to the highest ranked candidate. She however turned down the offer for a more permanent faculty position at another institution. The selection committee is now in the process of interviewing and selecting another candidate for the position. It is anticipated that this position will be filled by January 1993. It is anticipated that the computer modeling position will be filled by Spring of 1993. Also, two postdoctoral researchers associated with the project were promoted to faculty status. This was done to better reflect their roles on the project. One of them is the group leader for the 'WAM' group and the other is in charge of cultivar development.

Status of New Courses and Curricula that Evolved as a Result of Center Activities

Administrative team and GED Group members joined with other key faculty and administrators from the College of Arts and Sciences, School of Agriculture and Home Economics and School of Veterinary Medicine to discuss collective faculty strength in molecular and cell biology. As a result, a first draft position paper was developed for eventual discussion with the Provost. During their November 20, 1992 review, the NASA Technical Review Team encouraged development of this potential Ph.D. program based upon their assessment of the research progress and facilities of the GED Group.

The Center's activities have also influenced campus-wide thinking on the development of an Environmental Science and Engineering Curriculum. During the past year two committees—one made up of chemistry, agricultural sciences and biology faculty and one made up of engineering faculty—initiated discussions on how to strengthen existing courses and curricula in environmental sciences. A preliminary revised curriculum in Environmental Sciences has been completed. The engineering and science faculty recently agreed to a joint meeting to coordinate future planning.

Enhancements to the Existing Programs

One of the main accomplishments of the Tuskegee CELSS project has been to enhance research productivity and strengthen interdisciplinary work among Center scientists and engineers. As a result, during the past year several Center staff won honors for their research including the following: Faculty Outstanding Research Award (Tuskegee University), Graduate Student 2nd Place Research Award (Association of Research Directors), three promotions from Associate Professor to Professor, two promotions from Research Associate to Research Assistant Professor, and selection as a *Fellow*, American Society of Agronomy.

Equipment purchased has enhanced both undergraduate and graduate teaching in molecular genetics, electrical engineering, mechanical engineering, plant breeding, food science and human nutrition. As a result of the project, enhancement of the Microgravity Applications and Controls Laboratory in the Engineering Building has made it a more effective laboratory for demonstrations associated with mechanical engineering and electrical engineering courses. There is a need to further develop this laboratory given its strategic role in the development and training of students in automated growing and environmental monitoring and control systems for CELSS.

The Center has already had a profound effect on the Master of Science degree programs in electrical and mechanical engineering, plant and soil sciences, environmental sciences, biology and food and nutritional sciences, by creating exciting M.S. thesis opportunities that have attracted very bright students. As a result, many applications and requests to work on the project by more outstanding students have been received by the Center for the past few months. We need to exploit this great opportunity and increase the number of scholarships and research assistantships to provide an opportunity for these motivated African-American students to pursue graduate studies at Tuskegee University.

The Center has made available released-time for key faculty in engineering to better focus their efforts on the project. With one full-time waste management engineer position written into the 1993 budget, this will permit further acceleration of both research and academic program development in the environmental science and engineering areas. A full-time engineer in the controls area was written into the 1994 funding cycle of the original proposal. Given the rapid development of the Microgravity Applications and Control Group it is essential that filling this position should occur in the upcoming 1993 cycle along with the Waste Management Engineer position.

Goddard Space Flight Center (GSC) has played an excellent role in catalyzing the campus-wide hook-up with INTERNET. After a series of preparatory visits, three GSC staff presented a series of lecture-demonstrations on the use of INTERNET to about 50 key faculty and staff from the Office of Computer Services, College of Arts and Sciences, School of Agriculture and Home Economics, School of Engineering and Architecture and School of Veterinary Medicine. Most of the Center scientists participated in all of the lecture-demonstrations.

American Cyanamid responded to a direct request by the Center staff to assist in strengthening undergraduate chemistry instruction, so vital to all life and agricultural and engineering majors. As a result, Cyanamid assisted in the development of a proposal by the Departments of Chemistry and Agricultural Sciences to be submitted to USDA in January, 1993 that will strengthen the undergraduate instructional program in chemistry.

FINANCIAL REPORT

Amount of Expenditures and Encumbrances by Budget Category

	Original Budget	Revised Budget	Total Spent 11/9/92	Encumbrances 11/10-12/31/92	Total Spent/Enc 12/31/92	Balance 12/31/92
Salaries	209,557.00	164,557.00	92,362.06	69,104.19	161,466.25	3,090.75
Student Wages	42,000.00	37,000.00	20,077.52	10,772.84	30,850.36	6,149.64
Medicare Tax	3,039.00	2,039.00	423.76	1,002.01	1,425.77	613.23
Social Security	12,993.00	8,993.00	4,123.18	4,284.46	8,407.64	585.36
Retirement	10,478.00	4,478.00	2,183.27	1,424.38	3,607.65	870.35
Unemployment Comp.	524.00	524.00	225.87	298.13	524.00	-0-
Health Insurance	4,191.00	3,191.00	1,212.35	300.00	1,512.35	1,678.65
Disability	2,096.00	2,096.00	329.79	110.00	439.79	1,656.21
Life Insurance	1,256.00	1,256.00	107.89	40.00	147.89	1,108.11
Consultant	20,000.00	25,000.00	9,784.98	15,000.00	24,784.98	215.02
Supplies	50,000.00	80,000.00	41,132.57	38,867.43	80,000.00	-0-
Travel	10,000.00	37,000.00	23,259.82	13,570.00	36,829.82	170.18
Equipment	93,000.00	93,000.00	25,221.93	65,895.90	91,117.83	1,882.17
Renovation	45,000.00	45,000.00	-0-	-0-	-0-	45,000.00
Tuition	56,000.00	56,000.00	35,976.00	-0-	35,976.00	20,024.00
Indirect Cost	123,753.00	123,753.00	-0-	118,298.82	118,298.82	5,454.18
Total	683,887.00	683,887.00	256,420.99	338,968.16	595,389.15	88,497.85

Explanation of Variances

Several budget adjustments were made during the year to reflect actual expenditures. The previous table shows the projected budget and actual expenditures including encumbrances in Year 1.

Budget Adjustments made during Year 1.

1. Salaries - Budget was decreased by $45,000. Funds were available but time constraints and availability precluded Center from hiring postdoctoral research associates for Year 1.

2. Student Wages - Budget was decreased by $5,000. Center in reality started in late spring so students could not be identified and hired at the start of the program. Almost all students started in Fall Semester.

3. Fringe Benefits - Budget was decreased by $12,000. The funds were available in the fringe benefit categories because some employees do not pay into all of the fringes offered by Tuskegee University - Retirement, Health Insurance. The fringe costs for the postdoctoral research associates who could not be hired were also available.

4. Supplies - Budget was increased by $30,000. The supplies and the cost of these supplies were underestimated in the proposed budget. Two of the functional working groups were starting with no supplies and thus required more supplies than were anticipated.

5. Travel - Budget was increased by $27,000. This was due to the fact that the number of trips and costs were underestimated, travel for consultants used in Year I were paid from the travel line but were not included in the proposed budget and the costs for international travel increased more than anticipated in the proposed budget.

6. Consultant - Budget was increased by $5,000. This was due to the fact that other consultants, whose expertise was valuable to the project but not listed in the proposed budget, were used.

7. About 50% of the carry over funds is due to funds budgeted for renovations which could not be used. Cost estimates for renovations have been developed but they are higher than anticipated and thus renovation plans could not move that quickly.

Total Amount Billed by University to NASA

To date, the total amount billed by the University to NASA is $277,779.86, invoice no. 1, dated 10/12/92.

Appendices

Appendix 1 - Select Publications

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GROWING ROOT, TUBER AND NUT CROPS HYDROPONICALLY FOR CELSS

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ABSTRACT

Among the crops selected by the National Aeronautics and Space Administration for growth in controlled ecological life support systems are four that have subsurface edible parts -- potatoes, sweet potatoes, sugar beets and peanuts. These crops have been produced in open and closed (recirculating), solid media and liquid, hydroponic systems. Fluorescent, fluorescent plus incandescent and high pressure sodium plus metal halide lamps have proven to be effective light sources. Continuous light with 16°C and 28/22°C (day/night) temperatures have produced highest yields for potato and sweet potato, respectively. Dry weight yields of up to 4685, 2541, 1151 and 207 g m^{-2} for potatoes, sweet potatoes, sugar beets and peanuts, respectively, have been produced in controlled environment hydroponic systems.

INTRODUCTION

Four crops that traditionally grow edible parts below ground have been selected by NASA /1/ for initial study for Controlled Ecological Life Support Systems (CELSS). These crops include potatoes, sugar beets, peanuts and sweet potatoes. In an earlier study Milov and Balakireva /2/ chose potato, sugar beet and sweet potato in the carbohydrate accumulator group. Unlike above ground crops, root, tuber and peanut crops require specialized, below-surface growing systems to accommodate growth of subsurface edible parts. This paper reviews research on root/tuber/nut production in controlled environments for CELSS.

In the broadest use of the term, hydroponic systems include open and closed (recirculating), solid media and liquid systems. Gericke /3/, who coined the word "hydroponics", used it to describe various technologies for growing plants in nutrient solutions with or without the physical support of an inert medium rather than in soil. He excluded soil-derived aggregates. Collins and Jensen /4/ defined hydroponics to include use of organic aggregates such as peat-vermiculite or other mixes. In this paper the term hydroponics is used in the broad sense of the term and thus includes solid-media aggregates, which are watered with a nutrient solution.

POTENTIAL AND ACTUAL YIELDS

On a fresh and dry weight basis, yields per plant of hydroponically grown potatoes and sweet potatoes have been comparable to or higher than field-grown plants (Table 1). Dry weights of potatoes produced in open aggregate, closed aggregate and closed NFT systems were 27, 32 and 15 g $m^{-2}d^{-1}$, respectively. Sweet potato dry weights produced with open aggregate, closed water culture and closed NFT systems were 12, 25 and 19 g $m^{-2}d^{-1}$, respectively. These values correspond to 3950, 4685, and 1665 g m^{-2} for potato and 1458, 3280 and 2541 g m^{-2} for sweet potato.

The harvest index (HI) for hydroponically grown potatoes and sweet potatoes has been as high as 90% but varies depending on cultivar and growing conditions. Hydroponic studies

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of sugar beets and peanuts have been limited but have produced 476 g m^{-2} for sugar beet (Table 1) and 207 g m^{-2} for peanuts in the first reported studies of that crop in NFT /15/.

Table 1 Yield of Potatoes, Sweet Potatoes, Sugar Beets and Peanuts in Hydroponic Systems for CELSS

Crop	Variety	Root/Tuber/Nut Fresh Wt. (g/plant)	Root/Tuber/Nut Dry Wt. (g/plant)	Root/Tuber/Nut Dry Wt. (g/m^2)	Root/Tuber/Nut Dry Wt. (g/m^2d^1)	Foliage Dry Wt. (g/m^2)	Stolons & Fibrous Roots Dry Wt. (g/m^2)	Total Biomass Dry Wt. (g/m^2)	Harvest[1] Index (%)	Ref
Potato	Norland	--	579	2585	23.1	532	--	3117	--	/5/
Potato	Norland	--	436	2180	20.8	1820	70	4070	54	/6/
Potato	Norland	--	324	1620	15.4	710	30	2360	69	/6/
Potato	Norland	4320	791	3950	26.7	870	30	4855	81	/7/
Potato	Norland	3411	572	2860	19.3	650	10	3520	81	/7/
Potato	Norland	--	937	4685	31.9	1020	--	5705	--	/8/
Potato	Norland	--	617	3085	20.9	715	--	3800	--	/8/
Potato	Denali	2849	666	1665	14.9	385	33	2083	80	/9/
Potato	Denali	1417	318	1590	14.2	353	38	1981	80	/9/
Potato	Denali	2078	314	910	8.1	260	15	1185	76	/9/
Potato	Norland	1300	229	1145	10.2	318	20	1483	77	/9/
Sweet Potato	TI-155	1493	331	2541	19.3	--	--	--	--	/10/
Sweet Potato	Ga Jet	949	190	1439	13.7	848	110	2397	60	/11/
Sweet Potato	TI-155	1126	217	1644	13.7	493	75	2212	74	This Report
Sweet Potato	TI-155	1686	233	1765	14.7	2462	120	4347	41	This Report
Sweet Potato	Ga Jet	748	175	1458	12.1	167	40	1665	88	/11/
Sweet Potato	Hua-bey 350	--	--	1357	9.0	--	--	4500	--	/12/
Sweet Potato	Tucker	1020	306*	3280*	25.2*	1158*	79*	4527*	72*	/13/
Sugar Beet	--	640	160*	1151*	5.5*	--	--	--	--	/14/
Sugar Beet	Great Western	270	43	476	6.0	392	33	901	53	This Report
Peanut	Sunrunner	--	12	207	1.8	900	145	1252	17	/15/
Peanut	Pronto	--	9	106	0.9	586	109	801	13	/15/

* Estimate

[1] Ratio of dry edible biomass to dry total biomass

Tibbitts and Wheeler /8/ listed expected controlled-environment yields (based on field yields) for eight crops designated for CELSS. For potato, sweet potato, sugar beet and peanut the proposed values were 5492, 2186, 6440 and 360 g m^{-2}, respectively. To date, the yields as a per cent of proposed values obtained for hydroponically grown potato, sweet potato, sugar beet and peanut are 85%, 125%, 18% and 58%, respectively. The latter two results were based on preliminary experiments. The potential for increasing actual yields is promising because only a few cultivars (Table 1) and growing systems (Table 2) have been tested.

Units used to express crop yields for CELSS have emphasized dry weights of unprocessed root, tuber or seed (grain or nut) per unit area or unit area/unit time. Several issues can be raised in this regard. First, though dry weights permit comparison of yields and energy produced for different crops, some crops raised in CELSS will be processed as fresh plant material. For example, crops such as sweet potato and potato may be baked, fried or boiled. Thus, fresh and dry weights along with protein, carbohydrates, fat, vitamin and mineral contents will be required for nutritionists and dietitians who will plan preparation and composition of meals. For example, a 300 gram (fresh weight) sweet potato -- CELSS or conventional -- is about 70 to 80% moisture. When baked, the sweet potato has approximately 64% moisture /18/. Food scientists reporting nutritive value on this sweet potato would use a wet basis in reporting on its protein, beta carotene, ascorbic acid, etc. /19/.

Second, CELSS scientists ought to report on foliage when edible. Recent work by Ogbuehi et al. /20/ has shown that biweekly harvesting of sweet potato tips did not decrease storage root yields. Sweet potato foliage tips are commonly eaten in Asia and Africa. Recent studies in the United States indicate that foliage tips are an acceptable green vegetable /21/. Sugar beet and peanut foliage are also edible but limited data is available on their foliage in hydroponic systems. Finally, given the mass of fibrous roots, stolons, unused peelings, shells and non-edible foliage in CELSS crops, harvest index should always be used to express crop production efficiency. In summary, there is a need for interdisciplinary CELSS teams, including dietitians and nutritionists, to explore more complete expressions of food yields.

GROWING SYSTEMS

Growing systems used to produce CELSS plants with subsurface edible parts are shown in Table 2. High potato yields have been produced with aggregates (peat/vermiculite), partial aggregate (a thin layer of arcillite), and NFT. The question of whether an aggregate (rockwool) would make a difference in potato growth when compared to an aggregateless (aeroponic) system was recently addressed by Boersig /17/. He found that tuber yield tended to be higher in the system with rockwool. Sweet potatoes have produced higher yields with some subsurface contact/pressure on the roots. These high sweet potato yields have been obtained both with aggregates (e.g. sand and perlite) and NFT with a "movable plate system" /16/. Sugar beet apparently grows well with or without an aggregate. Bone et al. /14/ found yields equivalent to field-grown sugar beets with an NFT system and an aggregate (gravel) system. Sugar beets were successfully grown in NFT with a movable plate system /16/. A first attempt to grow peanuts in a subsurface growing container that separated nuts from feeder roots did not enhance seed yield /15/.

Table 2 Hydroponic Growing Systems for Potatoes, Sweet Potatoes, Sugar Beets and Peanuts.

Crop	Container	Dimensions	Subsurface Contact	Circulation	Foliage Support	Source
Potato	Pot	20 L	50:50 peat-vermiculite (v/v)	open	wire mesh cage	/7/
Potato	Tray	.83 x .54 x .11m (rectangle)	thin layer of arcillite	closed-NFT	wire mesh cage	/5/
Potato	Tray	.84 x .41 x .18 x .05m (trapezoid)	none	closed-NFT	twine fence	/9/
Potato	Channel	2.4 x .76 x .76m (rectangle)	plastic egg crate	closed-aeroponics	--	/16/
Sweet Potato	Pot	4 L	sand and perlite	open	string, foliage looped	/11/
Sweet Potato	Tray	1.2 x .15 x .15m (rectangle)	flat plate pressure contact	closed	string, foliage looped	/17/
Sweet Potato	Channel	.4 x .7 x .32m (rectangle)	first 20 days - sand after 20 days - none	closed-solution culture	--	/13/
Sugar Beet	Channel	1.2 x .15 x .15m (rectangle)	flat plate pressure contact	closed	none	This report
Sugar Beet	Channel	.50 x .6 x .3m (rectangle)	polyethylene sheet or gravel	closed-NFT	none	/14/
Peanut	Tray	.84 x .41 x .18 x .05m (trapezoid)	none	closed-NFT	twine fence	/15/

For potato either wire mesh or twine fences have been necessary for foliage support and restriction to a specified growth area. Sweet potato foliage has been trained on string supports to restrict growth area and volume. Restricting twine has also been used with "running" peanut types. The low foliage growth habit of sugar beet did not require foliage restricting mechanisms.

ENVIRONMENTAL CONDITIONS

High potato yields have been produced in growth chambers, as shown in Table 3, with both fluorescent (244-400 umol $m^{-2}s^{-1}$) and high pressure sodium plus metal halide lamps (600 umol $m^{-2}s^{-1}$). Sweet potato yields were highest with 960 umol $m^{-2}s^{-1}$ using a mix of fluorescent and incandescent lamps. Continuous light produced higher yields of potato than a 12 hour day/night photoperiod. A continuous 16°C temperature for potato and a 28/22°C day/night temperature regime for sweet potato have produced highest yields. A relative humidity of 70 to 85% and a pH of 5.8 to 6 has been optimal for both potato and sweet potato. Up to 2541 g m^{-2} of sweet potato storage roots have been obtained by changing a modified half Hoagland (MHH) nutrient solution at two week intervals without

Table 3 Environmental Conditions* for Growing Potatoes, Sweet Potatoes, Sugar Beets and Peanuts in Closed Systems.

Crop	Lamp Type+	Irradiance ($\mu mol/m^2s^1$)	PPD Regime (d/n) (h)	Temp Regime (d/n) (°C)	Days	%RH	pH	CO_2 Level	Nutr Sol	Root/Tub/Nut Dry Wt. ($g\ m^{-2}$)	Source
Potato-Norland	f	400	24/0	16/16	148	70	5.8	ambient	MHH	3950	/7/
Potato-Norland	f	400	12/12	16/16	148	70	5.8	ambient	MHH	2860	/7/
Potato-Norland	f	400	24	16/16	147	70	5.8	ambient	MHH	4685	/8/
Potato-Norland	f	400	12/12	16/16	147	70	5.8	ambient	MHH	3085	/8/
Potato-Norland	hps&mh	600	12/12	22/16	112	70	5.8	ambient	MHH	2585	/5/
Potato-	f	244	24/0	17/17	0-28	67	5.8	ambient	MHH		/9/
Denali			12/12	20/16	29-56					1665	
Norland			24/0	18/18	57-112					1145	
Sweet Potato	f&i	960	14/10	28/22	120	70	4-6	ambient	MHH	1644	/11/
Peanut	hps&mh	0	--	23/23	1-5	70	5.8	ambient	MHH		/15/
		30	20/4	23/23	6-13						
		300-500	20/4	23/23	14-118					207	

* %RH: 67-70; CO_2: ambient.
+ f-fluorescent, hps-high pressure sodium, mh-metal halide and i-incandescent.

recharging nutrients or adjusting pH prior to the change-out. Controlling pH to 6 rather than allowing it to drift did not enhance yield /22/. However, nutrient solution change-out every two days using a modified half Hoagland solution at a pH of 6 resulted in the highest yield reported for sweet potato roots grown in NFT to date -- 2816 g fresh weight or 25 g m^{-2} d^{-1} on a dry weight basis (unpublished data).

NUTRITION

Select nutritional information on field and hydroponically grown potatoes, sweet potatoes, sugar beets and peanuts is shown in Table 4. Sugar beet, high in total root yield, contains 14.5% sugar on the average. Potato tubers and sweet potato roots produce

Table 4 Nutritional Value (Wet Basis) of Potato, Sweet Potato and Sugar Beet per 100g.

Crop	Part+	Cultivar	Carbo-hydrate (g)	Crude Protein (g)	Crude Fat (g)	Crude Fiber (g)	Ash (g)	Beta-Carotene (mg)	Vitamin C (mg)	Source	System
Potato*	Tuber	Norland	16.0	1.8	.1	.3	1.2	--	--	/9/	Hydp
Potato*	Tuber	Norland	15.2	2.3	.1	.4	1.4	--	--	/9/	Hydp
Potato*	Tuber	Norland	16.6	1.1	.1	--	--	--	--	/5/	Hydp
Potato*	Tuber	Norland/Denali	16.3	2.1	.1	.3	--	--	--	/23/	Hydp
Potato	Tuber	--	17.1	2.1	.1	.5	.9	Trace	20.0	/18/	Field
Sweet Potato	Root	--	26.3	1.7	.4	.7	1.0	5.3	21.0	/18/	Field
Sweet Potato	Root	Ga Jet	17.7	1.1	.2	--	.6	11.3	13.0	/10/	Field
Sweet Potato	Root	Ga Jet	12.9	1.0	--	--	--	7.5	28.0	/10/	Hydp
Sugar Beet	Root	--	14.5	--	--	--	--	--	--	/14/	Hydp
Sugar Beet	Root	Mono-Hy TX 9	14.5	--	--	--	--	--	--	/24/	Field
Sweet Potato**	Leaf Tips°	Jewel/Ga Jet	--	5.1	.8	2.0	1.0	6.7	--	/25/	Field
Sweet Potato	Leaf Tips°	--	--	2.7	--	2.0	1.7	5.6	41.0	/26/	Field

+ raw unless otherwise stated
* calculated using 79.8% moisture content
** calculated using 83.0% moisture content
° blanched

nutrition comparable to field grown roots. Proximate analysis of field grown and hydroponically grown sweet potato foliage tips were comparable (Table 4). Sweet potato foliage tips have the potential to supply essential proteins, fiber, beta-carotene and minerals to human diets. Nutritional data available for sugar beet or peanut foliage is limited.

PLANTING MATERIAL

Successful propagation and production of hydroponically grown potato, sweet potato and sugar beet have resulted from several sources of planting material (Table 5). The planting material includes vine cuttings, sprouts from roots and plantlets from nodal (stem) cuttings and meristem cuttings. Shoots initiated from seeds have been successfully used for sugar beets and peanuts. Considerable variation in sweet potato root yield has been observed among individual plants propagated from vine cuttings and grown in the same growing system and with similar environmental conditions. More consistent yields may be obtained from sprouts (cut from roots) or tissue culture-derived plantlets.

Table 5 Source of Planting Material for Potato, Sweet Potato, Sugar Beet and Peanut for Hydroponic Systems.

Plant Crop	Plant Part	Pre-plant Treatment	Size	Post-plant Treatment	Source
Potato	Nodule Cutting	Grown in sterile culture tubes for 28d	8-10 cm	Covered 72h with glass beaker to mitigate transplant shock	/7/, /9/
Potato	Meristem	Grown in sterile culture tubes for 25d	—	Covered 48h with glass beaker to mitigate transplant shock	/6/
Sweet Potato	Vine Cutting	Dipped in mild detergent and rinsed with water	15 cm	None	/28/
Sweet Potato	Meristem	Grown in sterile culture for 35d	10 cm	None	/28/
Sugar Beet	Whole Plant	Seeds were germinated and grown in potting soil for 22d; plants were washed and rinsed.	15 cm	None	/28/
Peanut	Whole Plant	Seeds were germinated in sterile media for 14d.	3 cm	Covered 48h with glass beaker for acclimatization	/15/

RESEARCH GAPS

A major research gap for potato, sweet potato, sugar beet and peanut is the limited work on screening of cultivars for hydroponic systems. Only four potato cultivars /6/ have been seriously considered. The limited work done on screening sweet potatoes /27/ has shown considerable variation among cultivars in adaptability to hydroponic and controlled environmental systems.

Many controlled environment studies have used peat-vermiculite or aggregates that may not be available on a lunar or Mars based mission. More study is needed with pure hydroponic systems and with systems using simulated crushed lunar surface material or other pertinent aggregates.

Recent work on sweet potato has shown that nutritional requirements at different stages of growth are not fully understood. The need exists to tailor the frequency of nutrient solution replenishment to each crop and variety.

Preliminary sugar beet and peanut growth in NFT is less than field production and needs to be improved. Proximate analysis of foliage for each crop needs to be done. Until an acceptable volume of the subsurface growing space allocated for edible plant parts is consistently filled with nutritious, edible food that requires minimal processing, we have not optimized the growing system-cultivar-environment interaction. Interdisciplinary teams of food scientists, plant scientists and engineers are needed to accomplish this goal.

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NOTES

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Response of Sweetpotatoes to Continuous Light

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Additional index words. photoperiod, *Ipomoea batatas*

Sweetpotato [*Ipomoea batatas* (L.) Lam.] is one of the four root crops with subsurface edible parts that have been selected as potentially important crops for the Controlled Ecological Life Support Systems (CELSS). Among other environmental variables in CELSS, the amount and duration of light available for plant growth is critical, since it will help determine the range and maximum response of various crop species.

No published data are available on the response of sweetpotatoes to continuous light. Studies of continuous light effects on five potato (*Solanum tuberosum* L.) cultivars showed differences in sensitivity among cultivars (Wheeler and Tibbitts, 1986b). Wheeler and Tibbitts (1986a) showed varietal differences in response of potatoes to photoperiod. When Cao and Tibbitts (1991) subjected four potato cultivars to continuous light, it significantly promoted tuber initiation but slowed tuber enlargement in all cultivars as compared with 6- or 12-h photoperiods, respectively.

Long days promote vine growth, and short days induce root enlargement and flowering of sweetpotatoes (McDavid and Alamu, 1980). Yield of storage roots under 11.5- to 12.5-h days was higher than under shorter (8 h) or longer (18 h) days when vine cuttings were used for propagation, but daylength had no effect on yield when rooted leaves were the propagules. Biswas et al. (1989) showed that 16 h of light stimulated vine length and weight while storage root count and yield and total biomass production were promoted by 9 h of light.

If sweetpotatoes are to be used in CELSS for space missions (Hill et al., 1989; Tibbitts and Alford, 1982), they will have to be grown under controlled-environment conditions. This study examines the growth and yield responses of three sweetpotato cultivars grown under continuous light compared to a 12-h photoperiod.

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Vine cuttings (15 cm long) of 'TI-155', 'GA 120', and 'Georgia Jet', were transplanted to 4-liter pots filled with a mixture of 1 sterilized sand : 1 soil (v/v) (Norfolk sandy loam; Typic Paleudult). Four controlled-environment reach-in chambers were used. Plants were exposed to continuous light (24 h) in two of the chambers and 12 h light/12 h dark in the other two. Irradiance at canopy level ranged between 360 and 400 $\mu mol \cdot m^{-2} \cdot s^{-1}$. The light source was a mixture of cool-white fluorescent and incandescent lights. The relative humidity in each chamber was maintained at 70% ± 5%. A cycle of 28C (light) and 22C (dark) was maintained in the 12-h light treatment. Under continuous light, the temperature was maintained at 28 and 22C for 12 h each. Ten plants of each cultivar were positioned in each chamber at a spacing of 30 cm between plants. Plants were checked daily, watered as needed, and fertilized with (ppm) 683N–300P–567K of Peter's soluble fertilizer (20N–20P–20K) (W.R. Grace, Fogelsville, Pa.) twice weekly. Plants were harvested 112 days after planting. Harvested foliage and fibrous roots were oven-dried for 72 h at 70C for dry weights.

Table 1. Harvest data for 'GA Jet', 'TI-155', and 'GA 120' sweetpotatoes grown under continuous light and 12-h photoperiod for 112 days. Values are means of 10 replications.

Light duration (h)	Storage roots No.	Storage roots Fresh wt (g/plant)	Fibrous roots dry wt (g/plant)	Foliage dry wt (g/plant)
		GA Jet		
12	1.0	11.0	4.3	25.8
24	5.3	202.8	7.5	31.6
LSD 5%	2.3	86.0	1.7	4.8
		TI-155		
12	0.3	7.5	2.6	14.2
24	2.6	132.6	7.0	24.6
LSD 5%	1.3	97.0	1.7	4.3
		GA-120		
12	0.3	4.0	3.0	17.0
24	2.6	116.0	10.3	47.3
LSD 5%	1.1	56.5	2.9	7.9

To minimize potential chamber effects, the experiments were repeated in the same environmental chambers but with the light treatments interchanged. The results of the two experiments were pooled for data analysis.

Plants of all three cultivars exposed to continuous light produced more storage roots and higher fresh weights, fibrous root dry weights, and foliage dry weights than those kept under the 12-h photoperiod (Table 1). We observed that plants under the 12-h photoperiod had large, well-expanded leaves, while under continuous light, the leaves were smaller but more numerous. Sweetpotatoes are normally grown under a daylength >12 h. This study did not consider photoperiods other than 12 and 24 h light. The results indicate that continuous light did not inhibit successful storage root initiation and enlargement in the cultivars used.

Plants under continuous light received twice the quantity of photosynthetic photons each day as plants under 12-h light duration, and this doubling of photons may have accounted for the increased yields, irrespective of daylength effects.

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EFFECTS OF SEVERAL ENVIRONMENTAL FACTORS ON SWEETPOTATO GROWTH

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ABSTRACT

Effects of relative humidity, light intensity and photoperiod on growth of 'Ga Jet' and 'TI-155' sweetpotato cultivars, using the nutrient film technique (NFT), have been reported. In this study, the effect of ambient temperature regimes (constant 28°C and diurnal 28:22°C day:night) and different CO_2 levels (ambient, 400, 1 000, and 10 000 µL/L - 400, 1 000 and 10 000 ppm) on growth of one or both of these cultivars in NFT are reported. For a 24-h photoperiod, no storage roots were produced for either cultivar in NFT when sweetpotato plants were grown at a constant temperature of 28°C. For the same photoperiod, when a 28:22°C diurnal temperature variation was used, there were still no storage roots for 'TI-155' but the cv. 'Ga Jet' produced 537 g/plant of storage roots. For both a 12-h and 24-h photoperiod, 'Ga Jet' storage root fresh and dry weight tended to be higher with a 28:22°C diurnal temperature variation than with a constant 28°C temperature regime. Preliminary results with both 'Ga Jet' and 'TI-155' cultivars indicate a distinctive diurnal stomatal response for sweetpotato grown in NFT under an ambient CO_2 level. The stomatal conductance values observed for 'Ga Jet' at elevated CO_2 levels indicated that the difference between the light- and dark-period conductance rates persisted at 400, 1 000, and 10 000 µL/L.

INTRODUCTION

Studies considering the effects of environmental factors on crop growth must be conducted in order to determine optimum conditions for growth of plants in Controlled Ecological Life Support Systems (CELSS). Two factors that can significantly affect the growth and yield of sweetpotatoes are temperature and CO_2 levels. Kim /1/ reported that sweetpotato plants grown in sand culture at 29°C (16-h light period) and 20°C (dark) produced higher storage root weights and numbers than plants grown at a constant temperature of 29°C (same photoperiod). Spence and Humphries /2/, working with rooted single leaves of sweetpotatoes, obtained optimum storage root formation and development when the soil temperature was 25°C, whereas soil temperatures of 15 and 35°C were inhibitory to storage root formation. Kays /3/ suggested that thermoperiodism is critical to allocation of carbon within the sweetpotato plant. Cao and Tibbitts /4/ indicated that thermoperiodism also enhances growth and tuberization in potatoes. Sweetpotato storage root yields have also been reported to increase when they have been grown at elevated CO_2 concentrations /5,6/. The elevated CO_2 possibly caused a shift in the partitioning of the photosynthate from the leaves to the storage roots, thus improving yield.

This paper reports effects of both temperature and elevated CO_2 levels on growth and yield of sweetpotato using nutrient film technique (NFT).

MATERIALS AND METHODS

Fifteen cm long vine cuttings of 'Ga Jet' and 'TI-155' sweetpotatoes were planted with 25 cm spacing in separate rectangular growing channels (0.15 by 0.15 by 1.2 m) in a nutrient film technique (NFT) as described by Hill et al. /7/. One channel of each cultivar was placed in each of four environmental growth chambers. Two of the chambers had a 12-h photoperiod and the other two, a 24-h photoperiod (continuous light). The experimental treatments consisted of two temperature regimes—a 28°C constant temperature regime and a 28/22°C (12/12h) diurnal temperature variation. The plants were subjected to each treatment for a 120-day growing period at each of the two designated photoperiods. The photosynthetic photon flux (PPF) at 20 cm from the lamps (a mixture of incandescent and cool white fluorescent lamps) averaged 400 µmol $m^{-2}s^{-1}$ during the growing period. The relative humidity was 70 ± 5% and CO_2 was ambient (approximately 350 µL/L). The nutrient solution supplied to the plants was a modified half-Hoagland nutrient solution. At harvest, yield of fresh and dry weights of foliage and storage roots and dry weight of fibrous roots were measured. The experiments were repeated and data were subjected to Analysis of Variance. Means were separated at the 5% significant level using the Least Significant Difference (LSD).

The diurnal stomatal response of leaves from cvs. 'Ga Jet' and 'TI-155' was measured at the tenth week of growth in the environmental chamber with the diurnal temperature (28/22°C) treatment and the 12-h photoperiod. Using a Steady State Porometer (LI-COR, Lincoln, NE), measurements were made on the fourth fully-expanded leaf at one hour before and after the light period, at the beginning and end of the light period, and at 4-hour intervals during the light period. The above experiments were carried out at Tuskegee University. Additional measurements of the diurnal stomatal response of 'Ga Jet' sweetpotatoes grown at elevated CO_2 levels were made in environmental chambers at Kennedy Space Center. The cultural conditions for the plants (described by Wheeler et al. /8/) were similar to those at Tuskegee University except that plastic trapezoidal-shaped trays with two plants per tray were used instead of rectangular channels. Environmental conditions for these studies included a 12-h

TABLE 1 Effect of Constant and Diurnal Temperature Regimes on Growth of Two Sweetpotato Cultivars Using a 12-h Photoperiod

Temp (°C)	Cultivar		Storage Root No.	Storage Root Fresh Wt. (g/plant)	Dry Wt. (g/plant)	Foliage Fresh Wt. (g/plant)
28*	'Ga Jet'		1.3	188	34.4	406
	'TI-155'		1.1	162	28.3	323
		LSD (0.05)	NS	NS	NS	NS
28/22+	'Ga Jet'		4.5	460	78.4	538
	'TI-155'		1.8	310	52.5	557
		LSD (0.05)	1.7	NS	NS	NS

*No. of samples of each cultivar is 12.
+No. of samples of each cultivar is 8.

TABLE 2 Effect of Temperature Regime on Growth of Two Sweetpotato Cultivars Using a 12-h Photoperiod

Cultivar	Temp. (°C)		Storage Root No.	Storage Root Fresh Wt. (g/plant)	Dry Wt. (g/plant)	Foliage Fresh Wt. (g/plant)
'Ga Jet'	28*		1.3	188	34.4	406
	28/22+		4.5	460	78.4	538
		LSD (0.05)	1.5	196	39.3	NS
'TI-155'	28+		1.1	162	28.3	323
	28/22+		1.8	309	52.5	557
		LSD (0.05)	NS	NS	NS	NS

*No. of samples is 12.
+No. of samples is 8.

photoperiod, 300 μmol $m^{-2}s^{-1}$ PPF and a 26:22°C thermoperiod, while the CO_2 level inside the chamber was maintained at 1 000 ppm. Stomatal conductance measurements were made as described above for plants that were five and seven weeks old. The CO_2 level in the chamber was then altered to either 10 000 or 400 ppm for 12 to 24 hours. The stomatal conductance of the leaves at those levels was measured at two times: the middle of the light period and the middle of the dark period.

RESULTS AND DISCUSSION

Results from the temperature studies indicate that there were no differences in yield between cvs. 'Ga Jet' and 'TI-155' grown in NFT with the 12-h photoperiod for either a constant 28°C or a 28/22°C diurnal temperature variation (Tables 1 and 2). However, storage root number of 'Ga Jet' was greater than 'TI-155' with a 28/22°C temperature variation (Table 1). A comparison of temperature treatments for the 12-h photoperiod indicates that yields were higher when the plants were grown under the diurnal temperature variation in comparison to a constant 28°C, with the differences being significant in the case of cv. 'Ga Jet'. Comparison of plant growth under a 24-h photoperiod is presented in Tables 3 and 4. The results indicate that growth of both cultivars was adversely affected by continuous light but, if a diurnal temperature variation was utilized, the 'Ga Jet' cultivar produced yields comparable to those for the 12-h photoperiod. Fresh storage root yield ranged from zero with the constant 28°C regime to 537 g/plant with the 28/22°C regime. It is evident that the effects are cultivar specific and, at least for 'Ga Jet' sweetpotatoes, thermoperiodism is important for yield. These results agree with work by Cao and Tibbitts /4/ on potato (Solanum tuberosum). The fact that sweetpotato storage root fresh and dry yields under the diurnal temperature variation were greater than those at the constant temperature in NFT supports findings by Kim /1/ using sweetpotatoes grown in sand culture.

The diurnal stomatal response of sweetpotato showed a distinctive pattern entrained to the photoperiod. The pattern was observed regardless of whether measurements were made under ambient or elevated CO_2 levels (Figures 1, 2a and 2b). The pattern showed that elevated stomatal conductance readings during the light period decreased during the dark period. The magnitude of the conductance values were approximately the same as those found by Allen et al. /6/. Figures 2a and 2b show that decreasing the CO_2 from 1 000 to 400 μL/L increased the conductance. Conductance also increased when the CO_2 level was elevated to 10 000 μL/L. In both cases, a difference between light- and dark-period conductance rates persisted, suggesting that changes in CO_2 concentration did not eliminate stomatal diurnal rhythms. In addition, the increased conductance at 10 000 μL/L was unexpected but agrees with recent findings reported for soybean and potato (Wheeler et al. /9/).

TABLE 3 Effect of Constant and Diurnal Temperature Regimes on Growth of Two Sweetpotato Cultivars Using a 24-h Photoperiod

Temp. (°C)	Cultivar		Storage Root No.	Fresh Wt. (g/plant)	Dry Wt. (g/plant)	Foliage Fresh Wt. (g/plant)
28*	'Ga Jet'		0	0	0	87
	'TI-155'		0	0	0	54
		LSD (0.05)	NS	NS	NS	NS
28/22+	'Ga Jet'		5.6	537	98.7	398
	'TI-155'		0	0	0	57
		LSD (0.05)	2.1	161	31.8	226

*No. of samples of each cultivar is 8.
+No. of samples of each cultivar is 12.

TABLE 4. Effect of Temperature Regime on Growth of Two Sweetpotato Cultivars Using a 24h Photoperiod

Cultivar	Temp. (°C)		Storage Root No.	Fresh Wt. (g/plant)	Dry Wt. (g/plant)	Foliage Fresh Wt. (g/plant)
'Ga Jet'	28*		0	0	0	87
	28/22+		5.6	537	98.7	398
		LSD (0.05)	2.3	178	35.2	245
'TI-155'	28*		0	0	0	54
	28/22+		0	0	0	57
		LSD (0.05)	NS	NS	NS	NS

*No. of samples is 12.
+No. of samples is 8.

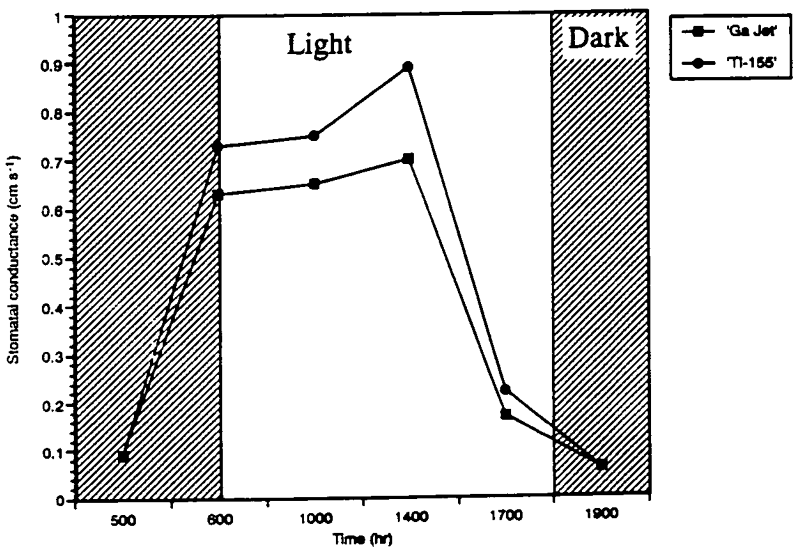

Fig. 1. Diurnal stomatal response of sweetpotato grown in NFT with ambient CO_2 ten weeks after transplanting.

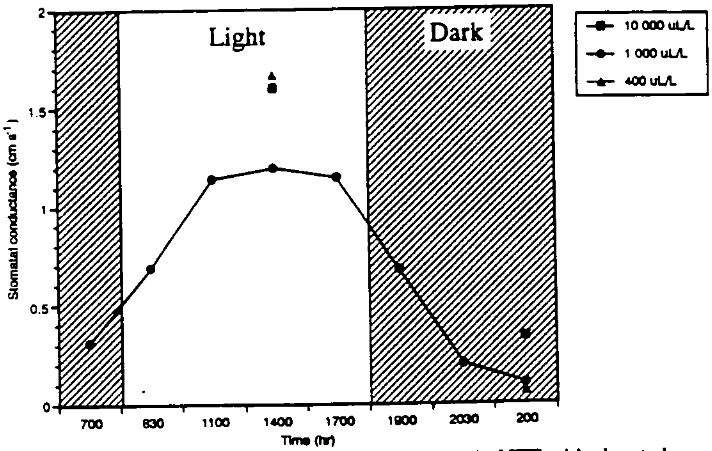

Fig 2a. Diurnal stomatal response of sweetpotato grown in NFT with elevated CO_2 levels five weeks after transplanting.

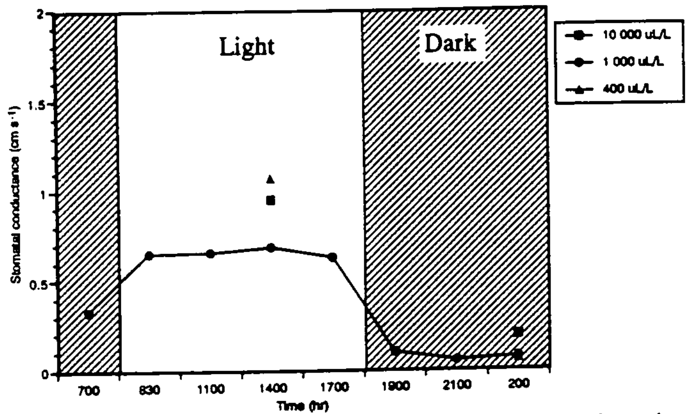

Fig 2b. Diurnal stomatal response of sweetpotato grown in NFT with elevated CO_2 levels seven weeks after transplanting.

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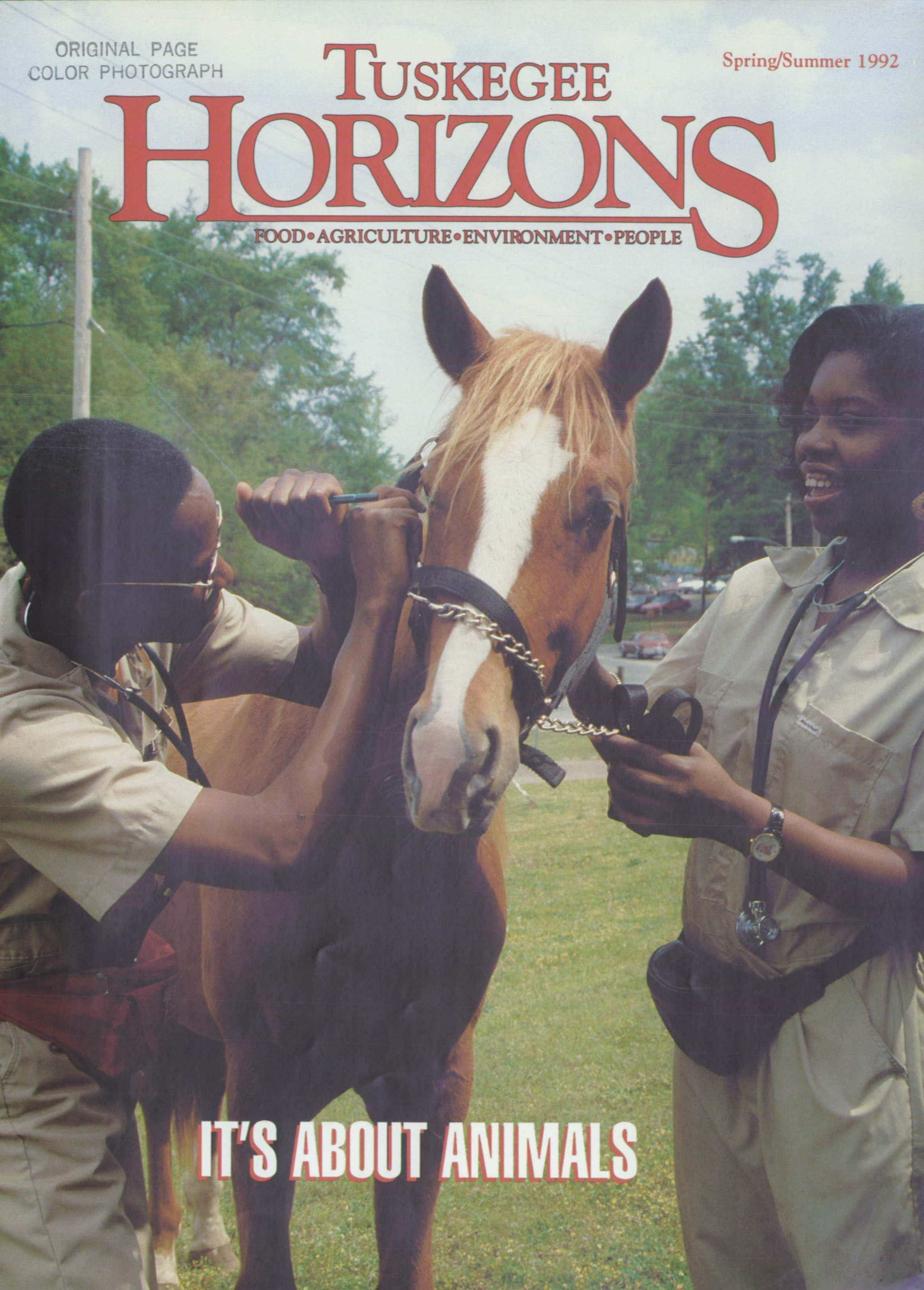
Appendix 2 - Select Publicity

TUSKEGEE HORIZONS

Spring/Summer 1992

FOOD•AGRICULTURE•ENVIRONMENT•PEOPLE



IT'S ABOUT ANIMALS

TUSKEGEE
HORIZONS
FOOD•AGRICULTURE•ENVIRONMENT•PEOPLE

Spring/Summer 1992
VOL. 3, NO. 1

Tuskegee Horizons is published semi-annual by the School of Agriculture and Home Econom ics, the George Washington Carver Agricultur Experiment Station, and the Tuskegee Unive sity Cooperative Extension Program for our c entele, colleagues, students, alumni and friend

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COVERS: (Front) Keith Earle and Tiffin Brabham completed the animal science pro gram in the School of Agriculture and Home Economics at Tuskegee University and are now fourth year students in the School o Veterinary Medicine. Photo by Susanne Loomis. (Back) The Albert Perry family poses at the Perry "home house" near Union Springs Alabama, where Albert was raised.

CAPITAL CAMPAIGN GETS WHITE HOUSE EXPOSURE

Mrs. Bush graciously hosts a reception for Tuskegee University.

It was a grand affair. Special guests: Tuskegee University. The hostess: Mrs. Barbara Bush, wife of President George Bush. The White House reception, like the one in November at the St. Regis Hotel in New York City, is one of several planned to help draw national attention to the University's $150 million capital campaign. "It's the first time that an historically black college or university has ever attempted a fund-raising campaign of this magnitude," Tuskegee President Benjamin F. Payton told the group. President Bush said of the university during his remarks at the occasion: "We know excellence when we see it." The President received an honorary doctorate degree from Tuskegee in 1981.


WALTER SCOTT

Shown with Scholarship Convocation speaker Dr. Bernard Watson (center), president of the William Penn Foundation in Philadelphia, are Eminent Scholars for 1991-92: (l to r) senior Royce T. Reddix of Mobile, AL; sophomore William C. Walton of Omaha, GA; freshman Marc S. Hulin of Washington, NJ; and sophomore Nigel Eames of Los Angeles. All are electrical engineering majors except Hulin who is enrolled in the School of Veterinary Medicine. A student must achieve straight A's to be named an Eminent Scholar.

Nine reunion classes gave their alma mater $103,360 during Founder's Day weekend—with $25,020 coming from the class of 1927. The University also received $11,000 from the Columbus-Phenix City Alumni Club, $2,500 from the Gary (Ind.) Club, $1,825 from the Tallahassee Club, and $2,000 from the Tuskegee Alumni Club. The Tuskegee Club also presented a check for $10,842 to support the restoration of Huntington Memorial Hall.

President Payton has been named to the Board of Directors of Sonat Inc., a worldwide energy corporation involved in natural gas transmission and marketing, oil and gas exploration, production, and services.

New courses and new teaching methods could result from Tuskegee University's participation in a Total Quality Management (TQM) program this spring. Tuskegee University is being sponsored in the program by The Procter & Gamble Company. The TQM program will require 30 engineering and business professors and administrators to spend a week in the classroom in Cincinnati at Procter and Gamble. The program is designed to accelerate the teaching and integration of total quality into the curricula and administrative practices of the business and engineering schools. President Payton noted that P&G and Tuskegee University have been partners in educational efforts for many years. More than 50 engineering and business graduates are employees of Procter and Gamble.

The campus facility formerly housing the University's nursing program has been named the Lillian Holland Harvey Hall, a tribute to the retired dean of the School of Nursing. Harvey was dean for almost 30 years, and it was under her administration that Alabama's first baccalaureate program in nursing was established at Tuskegee University. Lillian Holland Harvey Hall is expected to become the hub of extensive nursing and related continuing education programs.

According to the chairperson of the computer science department, "Tuskegee University has taken another step forward in computer capabilities." Hira Narang was referring to equipment purchased with a $36,000 National Science Foundation grant that enables faculty and students to electronically communicate with their colleagues around the world.

J. J. Johnson III

NEW CENTER FUNDED

The National Aeronautics and Space Administration chose Tuskegee University as one of seven colleges to conduct major research in support of future long-term, manned space missions.

The Core Research Center here will focus on food production, processing and waste recycling for Controlled Ecological Life Support Systems (CELSS).

Selections were based on a competitive merit review by a team of industry, government and academic evaluators and subsequent site visits. Tuskegee was awarded $4.3 million over the five-year support period.

Initially, the Tuskegee center will focus on systems for producing sweetpotatoes and peanuts to determine optimum environmental conditions for their growth in CELSS. Through plant breeding and genetic engineering, the center will develop germplasm for both crops adaptable to CELSS. It will also develop and process food products suitable for consumption in space.

Computer modeling of plant growth and recycling of inedible plant parts are other essential components of the research.

The center team will bring together scientists and engineers from a number of disciplines including faculty from the Schools of Agriculture and Home Economics, Engineering and Architecture, Education, Veterinary Medicine, and the College of Arts and Sciences.

The team will collaborate with NASA's ongoing CELSS and related research efforts at Kennedy, Johnson, and Goddard Space Centers and Ames Research Center and with private industry engaged in NASA research.

Tuskegee University has been conducting sweetpotato research for NASA since 1986. The team is being highlighted on the "New Explorers" series being shown this year on public television throughout the country. In left photo, the crew takes footage of team member and plant breeder Conrad Bonsi who is also associate director of the experiment station. Bonsi was awarded the prestigious Tuskegee University Faculty Achievement Award for 1992.

Series originator Bill Kurtis, who doubles as a TV anchorman in Chicago, presents today's scientists as the "new explorers" of our times. Kurtis has a particular interest in developing materials usable in schools for motivating young people to set high goals.

Team members demonstrated Tuskegee's system for growing sweetpotatoes hydroponically for several thousand visitors at Atlanta's flower show this March. Above, graduate student Pat Grant takes her turn at answering questions.

EXPERIENTIAL LEARNING

It is an important part of the agriculture and home economics curriculum. Whether it's animal science students taking part in a regional goat show or hospitality management students working at Disney World, there is nothing like on-the-job experience and exposure to institutions which daily apply the theories students are taught in class.

At least three off-campus trips were taken recently: Environmental science students went to Oak Ridge, Tennessee for a professional training program on using radioisotopes as research tracers; animal science students went to Purdue University for a symposium on veterinary careers; and agricultural economics students visited the Federal Reserve Bank of Atlanta (right).

ROBERT ZABAWA

CITIZEN TEACHERS

Tuskegee University nutritionists and food scientists are continuing to inform rural black Alabamians about cardiovascular disease through a series of community workshops on how proper nutrition prevents heart disease. Ralphenia Pace (above, standing), who heads the new Tuskegee University Center for Research on Diet, Lifestyle and Cardiovascular Disease, says that community education is an important part of the center's program.

Workshop teachers not only include the center director and her colleagues, Beatrice Phillips and Flora Gailliard, but also community people who participated in a clinical study and who received instruction preparing them for nutritional advocacy in their communities. Together they will explain and demonstrate how tasty meals can be prepared using lowfat foods.

Social scientists Robert Zabawa and Gladys Lyles are also assisting in the workshops. Their function is to encourage open discussion on the relationship between eating habits and health and factors involved in changing to healthier eating habits.

The project is funded by a USDA capacity-building grant.

SENIOR SHOWCASE

Five fashion merchandising seniors presented their designs this spring, a requirement for graduation: Angela Childers (left), Alyssa Ridley, Gladys Marie Sheats, Lorraine Stone (right) and Bayyinah Williams. Marie wants to go into marketing and Bayyinah wants to be a fashion designer. The others aspire to become fashion buyers. Angela hopes one day to own her store.

BETTYE TODD

VERY BRIEFLY...

Congratulations to Beatrice Phillips (top right), nutrition educator and head of the General Dietetics program here, who recently became the first African-American to be President-Elect of the Alabama Dietetics Association by election of her peers. ....and to B.D. Mayberry who received the Carver Public Service Award at the 49th Professional Agricultural Workers Conference. ....and to Louise Herron who was honored as Outstanding Staff Member by both Tuskegee University and the Tuskegee chapter of Sigma Xi. Faculty awards for the year: Teaching—Maurice Maloney and Janette Newhouse; Research—John Lu and Errol Rhoden; Service—Philip Loretan and Beatrice Phillips. ....Retiring after 40 years ' service is Velma Jerido (right), administrative assistant to Ralphenia Pace, department head. Again, congratulations! ....New in the Tuskegee University Cooperative Extension Program are youth specialist Rebecca Jackson, water quality specialist William Hodge and video production specialist Sherelle Williams. Sibyl Caldwell, former production manager for *Tuskegee Horizons*, has joined Annie King and Edna Williams to develop the USDA-funded National Sweetpotato Information Center. New on the experiment station office staff is Beverly Green. ....New USDA liaison officer Clifford Jones has placed 30 students in Summer Intern jobs. ....TU district agent Eunice Bonsi and 38 other interns in the National Extension Leadership Development Program had a week's exposure this spring to Alabama's Black Belt—its people, history, issues and problems. Helping Bonsi coordinate all this: Rick Vaughnes and George Paris. ....Contributing to biotech research here on sweetpotato are visiting scientists Essie Blay of the University of Ghana, and Anant Porobo-Dessai of the University of Agricultural Sciences in Bangalore, India. Mohammed Sherif of Minia University in Egypt is doing split root research on hydroponically-grown sweetpotatoes.

SIBYL CALDWELL

COMING EVENTS

June 17-19 June 20	Youth Leadership Conference Alumni Scholarship Banquet	Milbank Hall Student Union
July 19-25	Scholars in Residence Program	Milbank Hall
Sept. 13	Fall Convocation	Chapel
Oct. 7-9 Oct. 23-25	Youth-in-Crisis Conference Parents Weekend	Montgomery, AL
Nov. 7	Homecoming	
Dec. 6-8	50th Professional Agricultural Workers Conference	

ANIMALS IN THEIR FUTURES

Students of animal science are prepared for a variety of careers, but many aim to become veterinarians. It is a matter of record that Tuskegee University has trained more than 70% of the nation's black veterinarians.

Tuskegee offers a dual degree program leading to a bachelor's degree in animal science and the professional degree of Doctor of Veterinary Medicine. Drs. Joy Anderson '91 (left) and Robert Davis '89 (right) are graduates of this program. Joy just completed an internship in anatomical pathology here; "Bert" works with the Smithsonian Institute at the National Zoo

Not only has enrollment in Tuskegee University's animal science program been up in the last few years, but an interesting trend is observed. The majority of students now come from urban areas. For many, love of animals is a motivating factor. This trend along with pressing current issues relating to animals have had an impact on the program.

The program in the last few decades has consisted of a basic set of courses enabling students to apply various scientific principles to the care and improvement of animals. Today the program must also give students the necessary experience with various livestock species while exposing them to such issues as animal/environment interactions, food safety and quality and the use of new technologies.

According to Maurice Maloney, coordinator of animal sciences, this is the challenge: "We have to prepare students so they'll be able to adapt to an ever-changing world and the role of animals in it.

"They say the great majority of graduates by the end of the decade will be working in a job that doesn't even exist today. This applies to animal science too. We have to give students a strong foundation in the basic sciences and train them in the very important skill of being able to apply what they know to various circumstances."

All animal science students take elective courses throughout their four-year curriculum. They include the traditional liberal arts subjects —philosophy, history, fine arts, social science, mathematics, communication skills. They take students another step in the lifelong process of becoming thoughtful, well-rounded citizens—so needed by any society.

In addition, as freshmen, animal science students begin a strong concentration in the sciences—biology, chemistry, physics—which continues into their sophomore year with introductory plant, soil, animal and poultry sciences. In their junior year students begin advanced animal science courses and must choose among the business option—for those pursuing agribusiness, commodity merchandising, international development or extension work; the science option—for those intending to go into teaching or research and have graduate school in mind; and pre-veterinary medicine—for those wanting to become veterinarians.

A bachelor's degree would qualify graduates for jobs in food regulation and marketing with USDA or state agencies. This is often the choice of students who take the science option.

Tuskegee also offers a master's degree program, and students are encouraged to consider a higher degree. A need exists for African-American, Hispanic and native American Ph.D's in the animal sciences—in nutrition, physiology, molecular genetics, in all areas.

The majority of students now come from urban areas. For many, love of animals is a motivating factor.

Many graduates are now among the nimal scientists and veterinarians in developing countries. Suchet Louis, director f International Programs, notes human esource development for improved livestock production is an important priority or many of these countries.

But, according to P.K. Biswas, head of he Department of Agricultural Sciences, For many of our undergraduate students n animal science, they want to get into our et school to get their DVM." That's the rofessional degree of Doctor of Veteriary Medicine which can be earned in even years along with the undergraduate egree in animal science. In this dual deree program, students must complete all he required courses in animal science durng their first three years.

Maloney says, "Those students who pply themselves are generally able to get nto the vet school without any problem. The important thing is to maintain a good ndergraduate academic record.

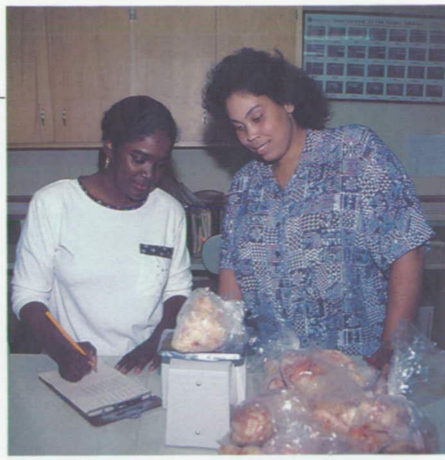
"It is not easy to get in. There is a lot f competition, but the vet school offers pecial assistance in a summer program to elp students with potential and determiation.

"I always encourage students to stay vith their goals, to keep trying until they nake it. I had a student complete a Ph.D. nd then get in. A recent graduate in nimal science is working at a South Caroina zoo right now. He still hopes to get in. He is being considered for fall entry."

Tiffini Brabham, now a fourth year tudent in the School of Veterinary Medicine, says this about her undergraduate najor in animal science, "The first thing you learn is academic excellence. Our professors gave us 100% concern and honesty. We were a very close, unified department. We traveled together to meetings and hows, and we gave several seminars together. It is an aggressive department."

As a livestock producer himself, Maloney blends well the practical and the heoretical in his animal science courses. He also teaches poultry science. He says his first job when he came in 1966 was to construct a modern poultry facility.

But he credits Connally Briles, who etired not long ago after 21 years at Tuskegee University, as being the major contributor to the development of the present poultry program. Briles developed and maintained special genetic populations of poultry which are still used in giving students training in cell research and techniques in the genetic improvement of poultry breeds. The bulk of this research dealt with decreasing fat composition in poultry meats—an item of importance to the American consumer today.



Graduates Jannette Bartlett (left) '85, '89 and Camille Wright '91 are both poultry majors. Jannette conducts research here; Camille is working on a master's. Both plan to get a Ph.D. and teach or do research.

Besides Maloney, other faculty in the animal science program are Ralph Noble, Sandra Solaiman, Abraham Woldeghebriel and David Scarfe.

Noble is an animal reproductive physiologist. In addition to teaching courses in reproduction and physiology, he conducts research in embryo transfer and estrus synchronization in goats and cattle. These techniques have to do with increasing the number and improving the quality of offspring for goat and cattle producers. Noble also advises the Pre-Vet Club which sponsors trips and other out-of-classroom activities for students.

Sandra Solaiman's expertise is nutrition, and she specializes in ruminant nutrition. Ruminants are animals that have four-compartment stomachs such as sheep, goats, cattle, deer, giraffes. Solaiman's research has been on forage utilization and how ruminants metabolize trace minerals.

Solaiman also serves on the Animal Care Committee for the campus which impacts on all faculty who are using animals for research. "Practices have tightened up on the use of animals for research at the university. There are new guidelines in place and dialogue on the issue of animal rights versus the benefits for humans of using animals in research continues," Solaiman says.

Abraham Woldeghebriel is an animal nutritionist who specializes in monogastric (having a one-compartment stomach) animals, particularly swine. Other monogastrics are poultry and—humans. Horses are another, but they are unique among monogastrics because they can digest grasses.

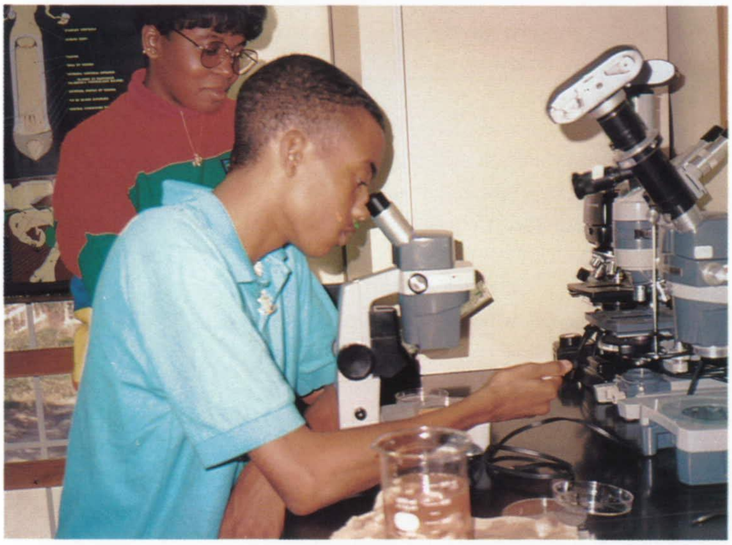
Woldeghebriel has expanded his research to a new area—computer modeling. With computer modeling, it is possible to predict such things as animal growth, animal-environment interactions, and cash returns.

Generally, the animal science faculty provide continuing education for farmers,

RALPH NOBLE

Tuskegee students participate in a regional goat show.

Students gather around Maurice Maloney for a demonstration on eartagging.



Students Marcus Woods and Alberta Greene practice collection of ova from cow ovaries.

Ralph Noble and Sandra Solaiman at a recent goat field day.

especially limited resource farmers in th area. They hold field days often in con junction with Jody Blackwell who is Ex tension veterinarian on campus. Blackwe teaches large animal medicine and surger in the School of Veterinary Medicine.

"I also teach a field services course i which I take veterinary students on farr visits just as a private vet would make These are real visits which may requir client education, preventive measures t be taken with animals and the drawing u of treatment regimens," Blackwell explain "The visits are similar to the county visi I make for the Alabama Cooperative Ex tension System."

Blackwell is on call to Tuskegee ex tension agents Walter Baldwin, Alphons Elliott, George Hunter, Lucious Rodge (all were animal science students here and Paul Young for any problem faced b an Alabama livestock producer in any are of animal care.

Every year there is a Goat Day o campus. Every year it draws quite a crowd According to Solaiman who has been th organizer of this event, "We are intereste in small farmers, in trying to improve th quality of their goats. We try to offer program that touches on the basics—nu trition, health, reproduction. But each yea we have something new for goat producer to think about. It's continuing educatio for them.

"This year we focused on goat meat— the production part of it and the market ing. We brought Frank Pinkerton in from Langston University as a resource perso on goat marketing.

"We also sponsored a workshop o raising goats on kudzu and other unwante vegetation in forestland. We want to see goats can reduce the use of chemicals as control measure. The concept fits in wit the whole idea of sustainable agriculture We are in our second year of research o this topic for the U.S. Forest Service."

According to Dean and Research Di rector Walter Hill, "We are trying to pro mote the goat industry in the state o Alabama and throughout the Southeast David Scarfe, animal nutritionist and vet erinarian, joined our team in 1990 to con centrate on this effort. He's headquartere at the Soil Conservation Office in Grov Hill, not too far from Mobile."

Scarfe is very optimistic about the otential of the industry. He is in the rocess of compiling initial data on progress hus far. "I began a year ago with 24 goat armers identified. Now there are more han 120 on my mailing list, either producers or serious about getting into it.

"In 1991 close to $300,000 was earned rom mohair sales by Alabama producers." rior to 1987, no Angoras were found in he state, Scarfe says.

Tuskegee University's strongest programs in terms of enrollment today are ngineering and business. But in terms of s unique heritage, agriculture certainly anks at the top.

The heritage was built by the niversity's founder, Booker T. Washington, who had such effective concern about he poor farm families he met on his tour of he area his new school was to serve.

The heritage was built by agricultural cientists and teachers such as George Vashington Carver whose desire was to each and use the power of research to help he "man furthest down." There were many thers who lived out strong commitments o service and to preparing Tuskegee students well.

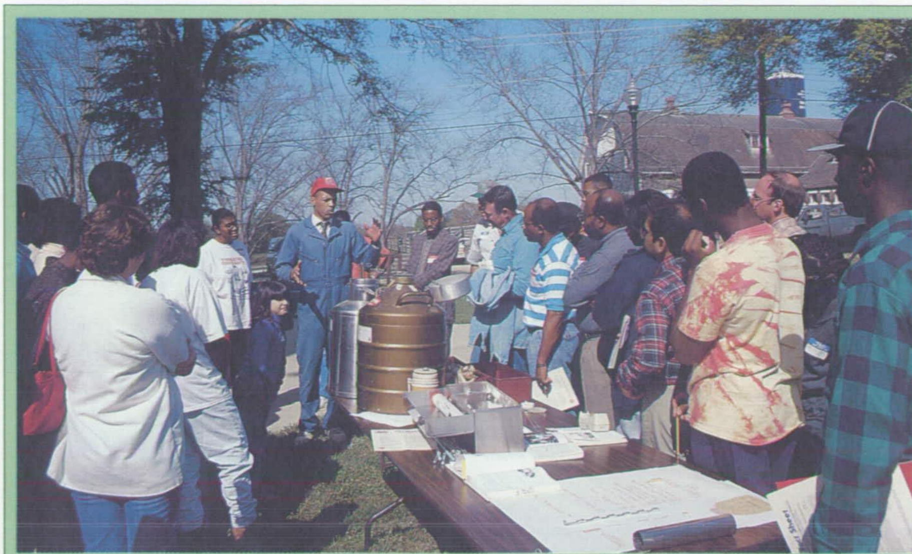
It was strengthened by eminent graduates such as Thomas Campbell, W.B. Hill, nd many others, who were Extension pioeers in a segregated society.

The heritage was built by innovations uch as the Movable School and the eadership Tuskegee gave through extenion services to struggling black farmers nd rural families. All this was connected vith the agricultural division here.

Frederick Patterson, Tuskegee's third resident, was a part of it. A veterinarian, e started the School of Veterinary Mediine which remains the only one of its kind n an historically black university campus.

Today, the animal science program—long with the other programs in agriculure and home economics, continues to nake its contribution to this heritage as it repares veterinarians, extension agents, nimal scientists, teachers, researchers, ivestock producers and many others who vill serve the public across the nation and n developing countries. In one way or nother, animals will be an important part f the future of these young people.

Marie Loretan



Ralph Noble doing what he loves best—teaching, demonstrating, working with animals.

A self-transplanted Chicagoan

This animal scientist and livestock farmer was a city boy.

Like many another city boy with Southern roots, Ralph Noble was sent to his grandparents during the summer. One set had a farm in Oklahoma and the other in Mississippi.

"That's how my interest in livestock started," Noble explains. "By the time I got to college it grew to how livestock can lessen world hunger. Now my interest has expanded to include producing meat animals more efficiently and economically." He has a livestock farm outside Tuskegee.

My training at Tuskegee and the University of Illinois is reflected in the research I do here. It focuses on trying to get superior-producing animals to have more offspring.

Noble is referring to his work on embryo transfer and estrus synchronization. "Estrus" refers to the period when a female animal is in heat. "Synchronization" refers to bringing greater regularity to the timing of these periods.

"There are times of the year when goats, for example, are not productive. I'm trying to get them to breed year-round." They do in some parts of the world, he says.

"Our approach here involves natural mating during the estrous season and artificial induction in the anestrous season. Already we have more than doubled the production of what a same size goat herd would produce in normal, seasonal breeding.

"We have gone from estrus synchronization now to superovulation for embryo transfer. This means we give the female animal fertility drugs to raise the number of eggs shed per estrus and therefore to increase the lifetime production of offspring. In this way we increase the efficiency of producing animals without in any way jeopardizing the health of the female.

"I am interested in the small farmer," Noble says. "You might not impact on the industry, but you do impact on the lives of the farm families. I would rather work with 100 farmers with 10 cows each and help them raise their standard of living than 10 farmers with huge herds.

"I like to teach small farmers how to reduce their out-of-pocket expenses, how to make their land more productive, how to produce food for the home as well as the market. I like to work with students of all ages.

"Tuskegee University stands for this type of outreach," Noble says. "I guess that's why I fit in here."

Main Street in Hurtsboro, Alabama, just across the Macon County line, used to be bustling at Saturday midday. The empty shops await new life.

SELF-HELP OR HELPING HAND?

A case was made for using both strategies to revitalize rural America during Tuskegee University's 100th Farmers Conference.

When Booker T. Washington held the first Farmers Conference in 1892, he had two objectives: to learn from the people themselves about their problems and their remedies and to see how his new school might help them. For most blacks, it was little more than a generation past Emancipation. Farming was the predominant way of life.

In his welcome message for the Farmers Conference 100 years later, President Benjamin Payton stressed the university's "commitment to continue the legacy of Booker T. Washington in providing education and helpful techniques for the masses through outreach and service." This time, however, a broad range of issues, and not just farming, needs to be addressed.

For some years now there has been a decline in the number of persons, particularly blacks, who make a substantial amount of their living operating their own farms. Farmers, especially small-scale farmers, have come to rely on the rural economy for help and, when the rural economy is in decline—as it undoubtedly is, everyone is hurt, farmer and non-farmer alike.

Is this the way it has to be? Aren't there strategies for keeping farmers on the farm and making a comfortable living? Aren't there strategies for revitalizing rural America?

These issues were among the many talked about during the celebration of the 100th annual Farmers Conference at Tuskegee University. Extension personn here formed the backbone of a wider cam pus/community committee planning th two-day event.

Velma Blackwell, Extension admini trator, noted that, though issues and prol

SHERELLE WILLIAMS

"America has to find a way to keep the farmer on the land."

E. (Kika) de la Garza

"There is strength in rural America."

Winthrop Rockefeller

ems change over the years, "we still are oncerned about people's involvement in he identification and solutions of their wn problems as we work together to improve the human condition."

Helping celebrate the Centennial were he Honorable E. (Kika) de la Garza, hairman of the House Agriculture Committee; Winthrop Rockefeller, chairman f the President's Council on Rural America; Deborah Cannon Wolfe, a dynamic educator and professor emerita at Queens College in New York; William Clark, an Extension Youth Specialist in Maryland; farmers—current and retired, aculty and other professionals, youth leaders and friends of agriculture.

The Merit Farm Family award and recgnition of former awardees, the university hoir and community singing, a parade, a orum on health and family well-being in ural Alabama were important items on he agenda for the 700 participants. This ear's award was presented to the Albert Perry Family of Bullock County who, in onor of the Centennial, was also given a horoughbred Angus bull by the Department of Agricultural Sciences.

But the serious discussion at the Farmers Conference was the state of agriculture nd rural America. De la Garza, who has een in Congress for more than 20 years, ays government has a larger responsibility han it has accepted relative to the nation's armers. He says institutions like Tuskegee University that have a history of administering programs to support rural America eed more government grants, and the ederal government should also design more olicies and programs with the special needs f farmers in mind.

He noted that Europeans take the approach: "We have made a commitment to ur farmers; we are going to keep them on he land." Their farmers are subsidized. rices on select crops have been propped p here, but the trend in recent U.S. policy as been to move away from this practice nd to urge the international community o do the same.

Referring to a saying he used to hear ack home that "if you work the land you ust feel the vibration," de la Garza said it s almost sinful that those who have the ibration cannot always stay on the land." He hailed the farmers of America as the

Farmer Albert Perry at the recreation site to clean up for a ballgame.

Merit farmer and more

Bullock County's Albert Perry wins Centennial Award.

The Albert James Perry family of Bullock County was the recipient of the 1992 Merit Farm Family Award at the 100th Annual Farmers Conference. His father, Henry Perry, won it in 1963. Between them the two Perrys have contributed to successful family farming for over half a century.

For Albert, it has not always been smooth sailing. Perry says, "My ship almost sank on more than one occasion." But he persevered with hard work and the help of his wife, Erma, and his brothers and sisters. Only "Red" among his four brothers has stayed in farming. He works with Albert at a fixed salary. But the others pitch in as needed on their days off or after work. It is still very much a Perry family affair.

The operation consists primarily of 48 brood cows, two bulls and 16 calves, 100 to 150 acres of corn, six acres of vegetables, 350 acres of hay. "Last year, we bailed 31,000 square bales and 1,800 round bales. We also cut about $15,000 worth of pulpwood each year," Perry says.

Albert and Erma have two children: Courtney, 4, and Cordarius, 5 months. The family attends the Hardaway AME Church where he is a steward-trustee, Sunday School teacher, choir member and Outstanding Member for 1991.

Albert has been a youth leader since high school. Recently, the extended Perry family built a 30 x 60 ft. community center pavilion on Perry land. There is also a pond for fishing, softball and volleyball fields, a basketball court, and other recreational facilities. The Perrys have played an important role in Extension-sponsored youth activities and have made the pavilion available for day camps.

In addition to tending his own crops, Albert teaches young people how to grow vegetables. He also conducts demonstrations through the Montgomery State Farmers Market. He prepares many gardens for community and county residents. Some of them pay; most of them don't.

Tuskegee University extension agents and specialists have vegetable demonstration plots at the Bullock County Prison. Albert helps in providing assistance, resources and tours for farmers.

Booker T. Washington once said, "We shall continue to prosper in proportion as each individual proves his usefulness in the community, as each individual makes himself such a pillar in property and character that his community will feel that he cannot be spared."

Tuskegee University's founder would be proud that the Merit Farm Family Award was given to such a contributing member, such a pillar in his community, as Albert Perry is in his part of Bullock County, Alabama.

Paul Young and Lynn Ballard-Siaway

Those early years

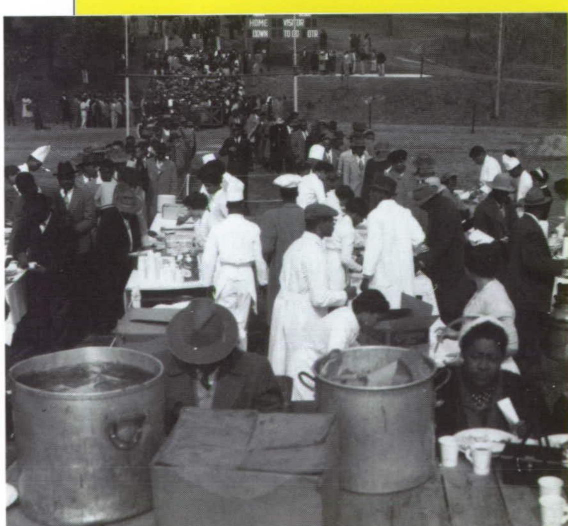
The Farmers Conference was important to Dr. Washington and the farmers.

TUSKEGEE UNIVERSITY ARCHIVES

Heading home from Tuskegee.

TUSKEGEE UNIVERSITY ARCHIVES

Parading in their finest.



TUSKEGEE UNIVERSITY AZRCHIVES

Enjoying the barbecue.

"To Dr. Washington's surprise, this first conference brought 500 farm people to Tuskegee Institute. To this gathering many came afoot. Great numbers, in order to be on time for the opening session, left home as early as midnight, in various types of vehicles and conveyances, including wagons drawn by oxen.

"At this and at subsequent conferences, Dr. Washington always conducted the program and discussions in such an informal manner that the farmers were assured of their welcome to the school and readily made to feel that they were an integral part of the meetings.

"Usually someone was called upon to lead an old time plantation melody. Soon all present joined in, humming, nodding, and softly patting their feet. Many times when the climax of a spiritual was reached, the atmosphere was surcharged with that oneness of spirit which so completely characterizes the Negro rural church gathering. The constraints of fear and self-consciousness were swept away, and kindred souls felt only the stir of emotion which served to open their hearts and minds. Dr. Washington, in his tactful way of approaching the most delicate subjects, would launch into his program, calling the attention of the people to the vital facts affecting their lives, without offending or embarrassing them.

"Of all the important events that crowded Dr. Washington's calendar as the years passed, none received more consideration, none was more important to him than the annual home-coming of the Negro farmers to Tuskegee. There was no group of people in the whole country whose cause lay nearer his heart than that of the Negro farmers."

—Thomas Monroe Campbell in *The Movable School Goes to the Negro Farmer*

true "environmentalists" because the know the importance of good water, a and soil.

He decried the growing lack of govern mental commitment to our farmers an pledged to reverse that trend. Whatev the strategies, America has to find a way t keep farmers on the land, he said.

Winthrop Rockefeller offered anoth approach. Instead of turning to the gov ernment, Rockefeller said initiatives t revitalize rural America should come fro rural America itself. There is strength i rural America, Rockefeller maintains.

The role of government is to suppo initiatives that come from the local com munity. He called on the federal govern ment to become "resolute" in promotin and supporting self-dependence and lea ership in rural American communities.

He said we can no longer do "today's jo with yesterday's tools and still be in bus ness tomorrow." An ingredient of the wa we do business today should includ Rockefeller explained, the preparation youth for leadership positions. He speci cally cited the need to prepare today youth to take responsibility for their ow development.

Rockefeller's comments echoed tho made by Thomas G. Johnson of Virgin Polytechnic Institute and State Universi in December at the Professional Agricu tural Workers Conference here. Johnso called for an entrepreneurial awakening rural America.

He said most of rural America is caug in a struggle between "a restructuring U. economy and an advancing rest of t world." He said rural America must fi niches in the emerging global econon and suggested that "its most promisi possibilities will be related to its resour base (land, water, recreational opportu ties), lack of urban problems (high cri rates, environmental degradation and hi cost of living), or life-style."

If institutions like Tuskegee are to involved in helping revitalize rural Ameri and bring it into a global economy, wh should be their focus?

For sure, Deborah Cannon Wolfe tol banquet audience, we cannot contin teaching our youth as we have been a expect to compete in a global mark Wolfe, a member of the New Jersey Sta

SHERELLE WILLIAMS

/hat's a parade without a marching band!

Alabama farmers Aaron and Nettie P. Sellers

3oard of Education and a long-time educa-or—for a time at Tuskegee, was the key-note speaker for the T. M. Campbell Me-morial Banquet. Campbell '06 was the first ederally-appointed farm demonstration gent (forerunner of the present Extension ystem) in the nation.

Wolfe suggested Tuskegee University ould do no better than reflect on the deals of its founder. She said Dr. Vashington's goals still apply: "That a tudent shall be so educated that he or she hall be able to meet conditions as they xist, to be able to do the things the world vants done; that every student that gradu-tes shall have enough skill coupled with intelligence and moral character to enable him or her to make a living for himself and others..."

In today's world as in Washington's, she told the audience, "...some of us may need help from government, from friends and family, but all of us need a personal vision and an individualized plan for self-sufficiency for the exercise and enjoyment of the basic freedoms for ourselves and our families—freedom from want, freedom from unemployment and underemployment...

"From the beginning," she said, "Tuskegee was a partnership between head, heart and hand as a method of uplifting the individual and moving the race ahead."

Wolfe said our hands still "...belong to us but not in the old ways. We use them as we employ our brains and extend our hearts to manage the diversity of the global marketplace...proud of our role in forging new realities in the campaign for human freedom."

She said we must all "...as Booker T. Washington said, 'lay down our buckets where we are'...and share our abilities that God has given us so we can make America what it can be." A fitting formula for anybody's personal vision!

Self-help, giving a helping hand, an appropriate role for government leadership and support—all are needed.

J. J. Johnson III

Dynamic teacher and educator Deborah Cannon Wolfe told her audience that, at minimum, education today ought to focus on what she considers the major problems of our times, the "seven Ps:" population control, pollution, prejudice, poverty, pot and substance abuse, protection from violence and crime, and persecution and war.

SHERELLE WILLIAMS

"From the beginning Tuskegee was a partnership between head, heart and hand..."

Deborah Cannon Wolfe

ROBERT ZABAWA

Kirkwood, built in 1860.

GREENE WIT

Another important "e" is the econ
graze in fields once heavy with cot
As for the people, they are having

Mention Greene County to an Alabamian not from the west central part of the state and about the only image popping to mind will be that of a greyhound racing track. Yes, Greene County is home to Greenetrack, the second of three dog tracks to be built in Alabama in recent years.

Greenetrack is mighty important to the economy of this very rural county whose borders are largely formed by the Sipsey and Black Warrior rivers which converge to form the Tombigbee River at its southernmost point. With Interstate 59 running through the county, bettors from Gadsden, Birmingham and Tuscaloosa have convenient access to the facility. The track draws from Mississippi and Tennessee too.

It is an example of entrepreneurs picking an accessible central location having officials eager to cooperate to develop a successful business around an activity that people seem to want. One of Greene County's greatest fears is the development of a fourth track in the city of Birmingham since much of its clientele could easily be lost to it. The schools and other agencies have come to rely heavily on Greentrack revenues. Very heavily.

To understate things, the economy of Greene County, like much of the Black Belt of Alabama, has been in decline. According to the Center for Demographic and Cultural Research, for example, Greene County has the third lowest per capita personal income ($8,376) in the state.

Of the 67 Alabama counties, Greene County ranks 61st for its 11.3 percent average annual unemployment rate, 65th both for the percent of families needing food stamps (34.8%) and for the percentage of single parent families with children under 18.

Unfortunately, these indicators do not reflect the industry and efforts of the citizens of Greene County, from farmer to businessman to educator, or the efforts of those who work together to improve the lives of the people, particularly those in need. Two such individuals are Tuskegee University Cooperative Extension Program agents Lucious Rodgers and Gwendolyn Johnson. The key word in their job title is "cooperative," because it takes cooperation with many others in the county to tackle the problems at hand.

For Gwendolyn Johnson, a seven-year veteran of Tuskegee Extension, the benefits of cooperation lie in the sharing of resources in order to make good things happen. For example, Johnson supplies the health information for the Fat-Free Exercise Class conducted by a certified instructor at West Alabama Health Services. The result is people learn to lead healthier liv by counting calories, measuring food grou and exercising instead of turning to jur food or crash diets.

Similarly, Johnson conducts a pr gram in cooperation with the West Al bama Mental Health Center, helping cl ents with nutrition and money manag ment techniques. According to Johnso "It started with the agency making ind vidual referrals to me, more and more a the time. They pretty much have the sam needs, so I meet with them as a group now

In addition, Johnson serves as co sultant to nutrition sites for the elderly ar three preschool centers. "My work i volves a lot of interaction with the staffs these centers, at West Alabama Heal Services, at the mental health center, se eral others. I spend a lot of my time on th telephone with them and at the copy m chine duplicating information availab through the national and statewide Exte sion network. My job is to get informatio to the point where it reaches the peop who need it.

"We visit the sites too and get to kno most everybody. An Extension worker ge to know a lot of people in the coun because so much of our job involves wor ing with organizations that help peopl Like these other organizations, Extensio

N 'E'

Vest Alabama county where cattle *new* enterprises *are badly needed.* *er as never before.*

ROBERT ZABAWA

Greenetrack, opened in 1977.

thinks of itself as 'helping people to help themselves.'"

Despite this heavy program load, Johnson finds time to work with a 4-H Teen Club. She started it four years ago when Charlie and Vernon Randall of the Lewiston community came to her about the lack of recreational activities and facilities for youth outside of Eutaw, the county seat. The Randalls donated a club house, the Department of Parks and Recreation donated equipment, adult volunteer helpers stepped forward, and the teen club became reality.

Membership in the club is based on service to the community and to one's self. Johnson explains, "Teens have to do service projects benefitting the elderly in the community. I'm talking about things like helping to clean up a house or bringing fresh vegetables from the club's garden. The seniors need to know people care, and the teens need to know they can contribute so it's good for both of them."

"The service to self part means that each member makes a commitment to either go to college or a trade school after graduating from high school. So far four club members have reached their college goal, and two more will be entering in the fall of the year."

But all is not work. The teens have taken several trips to Tuskegee University and the NASA Space Flight Center in Huntsville. There have been activities at the farmers market in Demopolis in Marengo County, and they have been active in community events such as a Cancer Society jog-a-thon.

A high point came when the club members put together a rap on teen pregnancy prevention that was played on radio

Author Robert Zabawa (center) with agents Gwendolyn Johnson and Lucious Rodgers at quarterly staff meeting.

GWENDOLYN JOHNSON

As these teens might say: "4-H Teen Club members always conduct themselves in a serious manner on trips........Not."

C-2

ROBERT ZABAWA

Johnson and nutritionist Margaret Cooper prepare session for parents at one of the preschool centers.

stations throughout the Black Belt as a public service announcement.

No wonder Greenetrack gave them a grant to support enrichment activities last year. What better investment than in youth trying to help themselves and others in their community?

County commissioner Gary Spencer says, "We all need to pull together. The bigger the team, the better. We like the way Johnson and Rodgers are bringing people together."

Cooperation for agriculture agent Lucious Rodgers comes mainly from getting small-scale farmers to work together for a common goal. According to Rodgers, "This is necessary. In the 15 years I've worked in this county, there is much less farming going on. I've seen a lot of changes in just the area of farming."

Over the three agricultural census periods (1978, 1982, and 1987) while he has been in Greene County, the number of farms has declined by over 16 percent. Over that same period of time, Rodgers has seen the dominance of cotton decline, and he has witnessed the rise and fall of row crops such as soybeans, corn and wheat, as well as the fluctuations of the beef and swine markets.

Dramatic changes such as these impact farms in many ways. According to the U.S. Department of Agriculture, over 60 percent of those on the farm do not consider farming their principal occupation. With the average farmer's age at over 56 years, it is evident that fewer young people are entering agriculture, full or part-time.

Over the same three census periods, black farmers, who traditionally fall in the very small category, saw their numbers decline by over 26 percent and their land base decrease by over 39 percent.

These trends reflect a county with very small farms where 75% of them generate less than $10,000 in sales. Almost half of them generate less than $2,500 in sales. But this $2,500 or less is not to be considered unimportant to the individual farmer. On the contrary.

It is because the vast majority of farms in Greene County are small-scale, part-time operations that cooperative effort is needed. This effort is focused on two co-ops with approximately 20 members each. Originally started to encompass both swine and cattle, they now focus exclusively on upgrading their cattle herds through the use of purebred Brangus bulls.

The first bulls were supplied through the efforts of Tuskegee University and Heifer Project International and were used in conjunction with purebred cows. Over the years, however, the decision was made to shift to hardier "grade" or crossbred cows because they didn't need as intensive care as the purebreds. "Now we're trying to get the best calves possible from the co-op's five bulls and grade cows," Rodgers says.

According to Rodgers, the benefits of the co-ops are three-fold. "First, the farmers can work together toward a common goal. Because they jointly own the bulls, they can then concentrate on their cows, calves and pastures. Second, the members can purchase items such as corn and feed in bulk at a lower cost than they could on an individual basis. Third, the members can get together socially to discuss problems and ways to improve their farms."

Another activity of Rodgers' has been trying to get more people to grow home gardens. "Somehow people got away from growing home gardens. I'm trying to reverse this, telling people how they can save money, eat better tasting and more nutritious food, maybe even earn a little money at the farmers' market—all with a garden. It's catching on a little better each year."

Home beautification is another area Rodgers emphasizes. Bright-colored flowers or the varied shapes and shades of green in shrubbery add a touch of beauty and make homeowners feel better about their residences, however humble they may be, Rodgers thinks. When extensive landscaping is done, it also increases the value of the real estate.

Finally, a new area that is a priority focus of Tuskegee Extension is water quality. According to Rodgers, "Many if not most of my rural clients use private wells, and they are concerned about the quality of their water—more so than I at first realized. They've become more concerned about whether the chemicals they use on crops, livestock and pests are getting into their drinking water."

Tuskegee University has a water quality laboratory which tests for nitrates, lead, pesticide residues and pH in private wells. Nitrate contamination can result from leaching fertilizers as well as from the drainage of sewage. Extension agents can be contacted about the testing and can provide the water sample bottles for this service.

In the final analysis, however, it is not what Lucious Rodgers or Gwen Johnson or anyone else does as an individual that gets a job done, but the cooperative efforts of the many—in government, the private sector and neighbor helping neighbor—that keep the population of 10,000 or so thinking that the grass is still green enough in their county.

And don't forget, that's Greene with an "e." For new *enterprises* that can boost the *economy*.

Robert Zabawa

Rodgers and Extension veterinarian Jody Blackwell check on farmer's pregnant cow.

EARNING HOW-TO

"If you help them earn income, you help them stay out of trouble," 4-H specialist says.

Clark (rear) challenges teens to come up with marketable ideas.

Bill Clark is convinced the lack of earning power is significant among the reasons why many of today's youth turn to harmful activities.

A 4-H Extension Agent with the state of Maryland, Clark tells youth: "Let's learn some responsible ways to earn money. When you can't get a job through the private sector, create yourself a job."

That is the message Clark brought to Black Belt youth leaders at the Centennial Farmers Conference. Clark started the "Learn and Earn" program in 1984 in the Baltimore area and has brought his ideas to West Virginia, Pennsylvania, New York, New Jersey, and now Alabama.

"There was a need to make 4-H relevant to urban youth," Clark, a former Tuskegeean says. "I think Learn and Earn is, and it works with rural youth too."

Erskine McKinnon, recruiter here, organized the session. He remembered how effective Clark was in motivating youth.

During the workshop, Clark walked the young people through the mechanics of starting their own business. The first step was an exercise in "brainstorming"—the more ideas, the better. None was considered too wild.

After going through a lengthy list of ideas, the students narrowed the options, searching for business opportunities that would yield the highest profits with minimum and affordable investments .

They first discussed the education and training necessary for each business. Then they were encouraged to look at practical businesses—ones they would be capable of managing.

They learned the necessity of production and marketing plans, public relations, and all the other elements in operating a successful business. They used businesses such as pet walking, doing laundry, babysitting, craftmaking, a dating service as examples.

"It gives them something positive to do and enhances their self-esteem," Clark, says of Learn and Earn. But he adds that learning should not take a back seat to earning. "We emphasize school first," Clark says. "Whatever you have to do, build it around your schoolwork," he tells them.

Inspired by Clark's Learn and Earn concept, two Macon County youth, Jared Buchanan and Wilbur Willis III, (front left and right, top picture) plan to launch a button business. Both are Booker T. Washington High School students. They have already used income from their lawn service to help finance the button venture.

Meanwhile, Tuskegee Extension's youth specialist Rebecca Jackson says plans are in high gear for "Entrepreneurial Days" in several Black Belt counties this summer. She's talking craft sales in some counties and produce in others with farmers networked to help. Good luck and good earning!

J. J. Johnson III

MAKING CHOICES

Medicine is appealing, but for now it's General Dietetics for Lisa Fisher.

A clarinetist with the Crimson Pipers, Lisa Fisher clowns before game with junior Xavier Wilson, another future dietitian.

She had a choice to make, and for Lisa Fisher it was an easy one. As a high school senior, she could be in a debutante ball or she could tour several black college campuses.

In choosing the tour, she chose Tuskegee University. "The minute I saw the campus, I knew this was it," she said. Four years later and a senior general dietetics student, the Cincinnati native does not regret her decision.

She describes life in Tuskegee as slower, cleaner, and quieter than back in Cincinnati, but that is what she was looking for. "It's a nice setting to be in. People here are striving to reach goals; they want to accomplish something," Lisa says about most students here.

She was considering several majority schools, but her mother, a graduate of Kentucky State, convinced her she would be more comfortable at an historically black institution. She could devote her energies to study and not to proving herself.

Lisa originally declared an academic major in biology hoping for a career in medicine. But then she heard a talk about career options including general dietetics.

"Dietitians are a vital part of the health care team," Lisa told herself. "I will still be helping people. "

"Proper nutrition is something a lot of people need to learn about, especially young people," Lisa says. And contrary to popular belief, she maintains, "Dietetics is a lot more than I thought.

"A dietitian has nothing to do with actually cooking meals, but she should know proper preparations," Lisa explains. "She also has to know what happens to the food—and the patient—after it's ingested." Optimum nutritional care for the client is the goal.

Doctors, Lisa says, prescribe diets for patients but rely on dietitians for food selection, quality and appropriate quantities, depending on the illness.

The general dietetics program includes a lot of science: biology and chemistry, nutritional sciences, and also behavioral and social sciences. Although she followed a biomedical science track in high school, Lisa tells that she failed the second part of general chemistry in her sophomore year.

According to Lisa, "Failing the class opened my eyes to the fact that I needed to get serious." She went into the chemistry class with a 3.4 academic average. Failing really hurt her GPA. "That woke me up to the fact that I just wasn't studying enough."

Lisa began putting in at least four hours of study each night. She graduated this May with better than a 3 point GPA. She was honored by the Alabama Dietetic Association as the outstanding senior from Tuskegee University and received a $1000 scholarship.

But life for Lisa at Tuskegee University has not been all general dietetics. Some of her time is devoted to playing the clarinet in the marching band, Alpha Kappa Alpha Sorority, Tau Beta Sigma band society, and even some volunteer work.

Medicine? It has taken a back seat to general dietetics, but it has not been ruled out as a career. Medical school will, however, have to wait until she earns a master's degree in public health nutrition. She's been accepted for the graduate program at the University of Tennessee in Knoxville.

"Probably within the next five years, I'll make a decision on medical school. I'm just not ready right now."

J. J. Johnson III

Copper Levels in Select Tissue of Goats Fed Different Broiler Litter Diets

S.G. Solaiman, M.A. Qureshi, C. S.Williams and M. A. Maloney

Poultry production is the second largest agricultural industry in Alabama. Since ruminants are able to digest ne fiber and nonprotein nitrogen in broiler tter (BL), an industry by-product, it is eing used as a source of nitrogen in rumiant diets. Broiler litter as a feed has high sh content ranging from 10-30% on a dry natter basis and contains high quantities f major and/or trace minerals.

Copper (Cu) has been identified to be ne of the major trace minerals in BL (100-00 ppm). Copper is an accumulative element and, when animals are fed BL, their ssue may tend to accumulate copper. This udy was conducted to evaluate copper vels in select tissue of goats fed different vels of BL and to detect any adverse effects of prolonged feeding of BL on the ultrastructure of these same select tissues.

Twenty one growing goats of Nubian crossing were utilized in a completely randomized design. Four to six animals each were randomly assigned to diets containing 0(A), 20(B), 40(C) and 60(D) percent BL on an as-fed basis. Each treatment initially had equal numbers of males and females. The animals were fed the various diets for 182 days. Blood samples were collected every four weeks. Animals were slaughtered and different tissues were collected and analyzed for Cu. Selected tissues were also prepared for electron microscopic observation .

Tissue copper levels in goats fed different BL diets are found in Table 1. Copper tended to accumulate in spleen, muscle, and rumen wall as the level of BL increased in the diets. Diets did not influence ($P>.10$) tissue copper residue (TCR, µmol/g) in hair, rumen wall, spleen, lungs, kidney, muscle and liver. However, diets affected ($P<.05$) TCR of blood plasma, reticulum, omasum and feces. No difference was observed in TCR between sexes (Table 2) except for liver being higher ($P<.05$) in males than females.

No significant changes were observed in the ultrastructure of the liver, kidney and muscle. However, with the high BL diets, a profusion of the smooth endoplasmic reticulum, which is responsible for detoxification of drugs or pollutants in liver cells, was observed. There was also a slight increase in basal lamina thickness in kidney cells (where filtration occurs). There was no apparent change in the muscle structure.

In conclusion, broiler litter can safely be incorporated up to 60 percent in the diet with no significant change in tissue copper residue in the edible tissue of goats.

Sandra Solaiman, Animal Nutritionist; M. Arif Qureshi, Research Technician; Carol Williams, Assistant Director, Transmission Electron Microscopy Facility; and Maurice Maloney, Animal Scientist.

Table 1. Tissue copper levels in goats fed different broiler litter diets.

Tissue	Diets (% BL) A (0)	B (20)	C (40)	D (60)
Rumen*	1.57a	2.23ab	2.62b	2.36b
Reticulum	1.18a	2.31b	2.30b	1.67ab
Omasum	2.76a	4.99b	4.60b	3.25a
Kidney	3.94	3.18	3.21	3.54
Liver	237.44	201.31	245.27	226.77
Lung	3.15	2.76	2.43	3.05
Spleen*	1.18a	1.71ab	1.44ab	2.36b
Muscle	0.79	0.79	0.92	2.20
Hair	1.77ab	1.44a	2.95b	1.45a
Feces	42.72a	156.82b	189.89b	166.34b
Plasma	1.22a	1.23a	1.24a	1.31ab

Means within a row with different superscripts are different ($p< .05$) except * ($P<.09$).

Table 2. Tissue copper as affected by sex.

Tissue	Sex: Male N=10	Female N=11
Plasma	1.25	1.26
Spleen	1.84	1.51
Kidney	3.64	3.61
Liver	263.98a	191.42b
Hair	2.13	1.69
Rumen	2.26	2.13
Reticulum	2.00	1.69
Omasum	4.10	3.69
Lung	2.89	2.80
Muscle	1.74	2.02
Feces	174.11a	103.77b

Means within the row with different superscripts are different ($P<.05$).

Development and Evaluation of a Healthier Burger Using A Soybean Paste Additive

John Y. Lu and Sylvia Porteous

It is said that Americans consume seven billion pounds of ground beef each year. Regular ground beef contains about 20% fat including saturated fat and cholesterol. Consumption of fat-rich foods has been linked to the number one cause of death in the U.S.—cardiovascular disease (CVD). Saturated fats and cholesterol are blamed as contributing factors to artherosclerosis.

Recently, Dr. Dale Hoffman of Auburn University successfully introduced a low fat hamburger which is marketed by the McDonalds chain as the "McLean." The key to its success is the use of carrageenan which is a polysaccharide from seaweed. It prevents moisture loss during cooking, which allows the use of 10% water to replace an equivalent amount of fat in the ground beef. Because of the carrageenan, the lowfat patties taste just as juicy as high fat burgers when cooked.

The Food Science Laboratory at Tuskegee University has investigated the feasibility of adding cooked soybeans to beef patties. Soybeans are an important crop in this country and in Alabama. Soybeans contain protein, dietary fiber and polyunsaturated fatty acid especially linolenic acid which is a precursor of omega-3 fatty acid. Omega-3 fatty acid and dietary fiber have received much attention recently because of reports that they may be effective in reducing blood lipids and CVD. Soy protein is also reported to reduce the blood cholesterol level as well.

Table 1. Formulation for six patties

	Regular	TU Burger
Ground beef	250 g	150 g
Soybeans	0 g	100 g
Chopped onions	30 g	30 g
Bread crumbs	56 g	56 g
Black pepper	0.5 tsp	0.5 tsp
Salt	1 tsp	1 tsp
Flour	3 tbsp	3 tbsp
Vegetable shortening	2 tbsp	2 tbsp

Materials and Methods

Soybeans purchased from a seed store were cooked at 120°C (15 lb. pressure) for 20 min, rinsed 2-3 times, homogenized in a blender to paste and used to prepare the meat patties. Two types of meat patties were prepared; one was regular and the other had soybean paste added—the TU burger. The formula is shown in Table 1.

Product acceptability was evaluated by serving in a hamburger bun with lettuce, a slice of tomato, pickles, and seasoned with ketchup. Twenty faculty, staff and students at Tuskegee University evaluated the product using a 5 point scale, with 1 being Dislike Very Much, 3—Neither Like nor Dislike and 5—Like Very Much. Nutrient composition was analyzed using the nutrition software, *The Food Processor II*, developed by ESHA Research of Salem, Oregon on a Macintosh SE 30.

Results/Discussion

Sixty-three percent of the panelists indicated that the TU burger was excellent and 37% said it was good. The mean score was 4.75 indicating that the TU burger was highly acceptable. Panelists commented that the product was flavorful, juicy and its color was appealing to the eye. The nutrient content of the TU burger and the regular burger were compared. The results showed that the TU burger contained less calori (9.4%), total fat (12.6%), saturated f (23.5%) and cholesterol (40%) but con tained more moisture (7.4%), carboh drates (16%), dietary fiber (59%) an polyunsaturated fatty acids (47%).

In terms of vitamins and minerals, T patties had higher Vitamin A, thiami riboflavin, folacin, calcium, phosphoru potassium and less sodium than the regul patties. Juiciness as commented by pane ists is due to higher moisture content a tributable to the presence of soy protei and dietary fiber which are known to ho water well.

Unlike carageenan which is availab only from industrial suppliers, soybeans a directly available from farmers or seed stor in Alabama. One bushel (60 lbs) of so beans costs only $7-8. Soybeans conta 40-45% protein, so on a dry weight bas soybeans are a much cheaper source protein.

The addition of soybeans also reduce saturated fat, cholesterol and sodium a increased the level of polyunsaturated fat acids and some vitamins which may have positive effect on one's health.

John Y. Lu, Food Scientist, and Sylvi Porteous, Student.

Table 2. Nutrients per serving.

	Regular	TU Burger
Protein	14.1 g	11.9 g
Carbohydrates	10.1 g	11.8 g
Fat (Total)	12.4 g	10.8 g
Saturated	4.1 g	3.2 g
Monounsaturated	5.4 g	4.4 g
Polyunsaturated	1.5 g	2.3 g
Vitamin A	0.03 RE	0.2 RE
Thiamin	0.08 mg	0.1 mg
Riboflavin	0.14 mg	0.15 mg
Niacin	2.9 mg	2.1 mg
B6	0.12 mg	0.13 mg
B12	0.93 ug	0.6 ug
Folacin	10.2 ug	17.1 ug
Vitamin C	0.31 mg	0.6 mg
Vitamin E	3.16 mg	4.2 mg
Calcium	20.6 mg	34.8 mg
Iron	1.7 mg	2.1 mg
Phosphorus	90.6 mg	109.8 mg
Potassium	158.8 mg	196.8 mg
Sodium	1164.5 mg	442.3 mg
Zinc	2.8 mg	1.9 mg
Moisture (%)	40.0	44.24
Dietary fiber	0.96 g	1.6 g
Calories	211	191
Cholesterol	41.6 mg	25.1 mg

The Acceptability of the 'Scotch Bonnet' Hot Pepper

Errol G. Rhoden and Norma Dawkins

With the current popularity of hot and spicy foods, a hot pepper which has been measured to be 170 times hot-er than fresh jalapenos might be a wel-ome addition to choices of hot peppers in he American market. The 'Scotch Bon-et' hot pepper is round in shape and right yellow in color. It is native to tropi-al climates and could be produced in the varm season of the southern temperate one. It is possible that the production of his pepper may find a niche in specialized narkets.

The use of hot peppers has always ascinated people of various cultures but it vas not until 1912 that Dr. W. C. Scoville leveloped a systematic method for measur-ng the hotness of a pepper. It is his scale hat gave the very high rating to the 'Scotch Bonnet' hot pepper.

Capsaicin is the chemical present in ot peppers which causes the strong sensa-ion in the nerves of the nose, mouth and hroat. It is concentrated in a thin mem-rane holding the seeds and can be ana-yzed using liquid chromatography.

According to Scoville, peppers are lried and dissolved in alcohol, then di-uted with sugar-tinged water. The result-ng solution is then further diluted until he resulting mixture no longer burns the nouth of the taster. The hotter the pepper, he more sugar-tinged water or dilution is equired and therefore the higher the rat-ng. These ratings make up what is called he Scoville Scale. The table below shows he hotness of various foods as measured by the Scoville Scale. The objective of this study was to determine the acceptability of 'Scotch Bonnet' hot pepper in three southern cities.

Scoville Units of Various Foods

Food	Pungency (Scoville Units)
Chili con carne	15-30
Paprika (dry, ground)	0-150
Taco sauce	300
Chili pepper (dry, ground)	975
Jalapenos (fresh, green)	1,500-4,500
Tabasco sauce	4,500
Jalapenos (dry, ground)	15,000-30,000
Hot red peppers (dry, ground)	15,000-120,000
'Scotch Bonnets'	250,000*
Pure capsaicin	15,000,000

Source: Cal-Compack Foods, CA
*Dr. B. D. Marsh, Lincoln University, MO.

'Scotch Bonnet' hot peppers were prepared for distribution in Huntsville and Tuskegee, Alabama and Louisville, Kentucky. Samples consisting of six fully-mature hot peppers were given to each participant in the sensory test along with an evaluation form. Each participant was asked to rate the 'Scotch Bonnet' on color intensity, flavor, shape, hotness and overall acceptability. In addition, each respondent was asked what factors they considered in purchasing hot peppers? Fifty samples were prepared for each city and the number of respondents were 45 from Tuskegee, 30 from Huntsville and 18 from Louisville.

In all three locations, the greatest percentage of the respondents preferred the bright yellow 'Scotch Bonnet.' Fifty-three percent of the participants returning the questionnaire in Tuskegee considered the hot peppers very spicy and 57% each from Huntsville and Louisville considered the flavor extremely spicy. At the same time, no one found the shape of the hot peppers unacceptable. Very high percent-ages—60 in Tuskegee, 71 in Huntsville, 89 in Louisville — found the peppers to be extremely hot. Some even noted that the 'Scotch Bonnet' was too hot.

Respondents were also asked to express their willingness to purchase 'Scotch Bonnet' based on aroma , color, and shape if the peppers were available in their supermarkets. Eighty-nine percent of Tuskegee's respondents and 100% each from Huntsville and Louisville would purchase 'Scotch Bonnet' for aroma. When asked what color was preferred in a hot pepper, 46% of the Tuskegee respondents chose yellow, 37% chose red, and 17% liked green peppers. Fifty-nine percent of the respondents in Huntsville and 40 percent in Louisville liked the yellow color. When asked what shape was preferred, 40% in Tuskegee, 58% in Huntsville and 44% in Louisville preferred the round shape. However, a third or more in each location said that shape was not an important criterion in their selection of a hot pepper.

In the purchase of hot peppers, there were five response factors that were listed as important: hotness, color, storage, size and price. The factor most important in Tuskegee was the size of the peppers, while in Huntsville, storage was considered the most important. On the other hand, 70% of the respondents from Louisville said that the hotness of the peppers was the factor they would consider most important.

Although many of the participants admitted that 'Scotch Bonnet' was extremely hot, they said they were willing to purchase the peppers if they were made available in the grocery stores. Because of their hotness, fewer would be needed to produce the desired effect.

It appears the 'Scotch Bonnet' could find a place in the hot pepper market in the U.S. Mexican, Chinese, Cajun and other dishes might be enhanced with this very colorful and flavorful hot pepper which would grow well in the warm climate and sandy soils of the Southeast.

Errol G. Rhoden, Agronomist, and Norma Dawkins,Graduate Student. Acknowledgment: We extend appreciation to Claudine Dorman of Louisville and Pauline Lindo of Huntsville for assisting with the survey.

The Effects of Photoperiod on Two Sweetpotato Cultivars Grown Hydroponically

D. G. Mortley, C. K. Bonsi, W. A. Hill, P. A. Loretan, C. E. Morris, A. A. Trotman and P. P. David

The National Aeronautics and Space Administration (NASA) and cooperating institutions are studying the growth of select food crops for future long-term, manned space missions. Studies on sweetpotato are being carried out at Tuskegee University using a nutrient film technique (NFT) system. Prior studies have shown that continuous light (24 h photoperiod) enhanced storage root yield of 'Georgia Jet' sweetpotatoes while storage root yield of 'TI-155' was inhibited as compared to a 12 h photoperiod. This study examines the growth and yield responses of these same sweetpotato cultivars using various photoperiods.

Four 15 cm long vine cuttings each of the two cultivars were placed at 25 cm spacing in separate growing channels (15cm x 15 cm x 1.2m) within reach-in environmental growth chambers. Plants were exposed to 12, 15, 18 and 21 h light while irradiance at canopy level averaged 427 $\mu mol\ m^{-2} s^{-1}$ using a mixture of cool white fluorescent and incandescent lights. The relative humidity was maintained at 70 ± 5% in each chamber. A temperature regime of 28°C (light) for 12 hours and 22°C (dark) for 12 hours was maintained in each chamber.

Each channel had its own 30.4-L volume reservoir. A modified half-Hoagland solution with 1:2.4 N/K ratio was used. The nutrient solution pH was maintained between 5.5 and 6.0 by the addition of either dilute NaOH or H_2SO_4. Temperature and electrical conductivity were monitored. Solutions were changed every two weeks and were topped with deionized water if the volume fell to ≤8 L prior to the end of the 2 wk interval.

Nutrient solution is pumped by small submersible pumps from each reservoir to the high end of each channel which has a 1% slope. The nutrient solution then spreads across the channel as a thin film as it flows toward the drain and back into the reservoir by gravity. The flow rate to each channel is set at 1 L min^{-1} by utilizing a bypass line back to the reservoir with a control valve. The vine cuttings are held upright within the channel by an assembly attached to the sides of the channel by black-white vinyl. As the foliage grows, it is supported by and trained onto a string from above the channel. The storage roots develop in the space below the assembly raising it as the roots enlarge.

Results in the table show that each cultivar responded differently to varying photoperiods. For both cultivars, the num ber of storage roots produced per plant wa highest when plants were exposed to 21 of light. Storage root fresh weights in creased linearly for both cultivars wit increasing photoperiod. The data sugge that photoperiods greater than 18 h re duced storage root fresh weights for 'T 155.' Regardless of the photoperiod, highe storage root fresh weights were observe for 'TI-155'; highest foliage fresh weigh were observed for 'Georgia Jet.' These re sults indicate that 'TI-155' plants, in re sponse to increasing photoperiod, allocate more photosynthates to storage roots the expense of foliage whereas 'Georg Jet' allocated a greater amount of phot synthates to foliage over storage roots.

This study showed that growth sweetpotato under varying photoperio will be different depending on the cultiva In addition, storage root number and yie were increased with increasing photoper ods.

This research is supported by fun from NASA (Grant No. NAG10-002 and USDA/Cooperative State Researc Service (Grant No.ALX-SP-1).

Desmond Mortley, Horticulturist; Conra Bonsi, Plant Breeder; Walter Hil Agronomist; Philip Loretan, Enginee Carlton Morris, Materials Specialis Audrey Trotman, Microbiologist; Paulir David, Horticulturist.

Response of 'TI-155' and 'Georgia Jet' sweetpotatoes grown in NFT to varying photoperiods.

			Fresh Weight (g/plant)	
Photoperiod (PPD)	**Cultivar**	**No.**	**Storage Root**	**Foliage**
12	Ga Jet	2.4	254	759
	TI-155	4.0	530	558
15	Ga Jet	3.7	513	690
	TI-155	3.5	658	606
18	Ga Jet	3.1	602	613
	TI-155	5.4	808	541
21	Ga Jet	5.1	699	625
	TI-155	8.2	791	519
Significance	Cultivar	0.01	0.0001	0.01
	PPD	0.001	0.0001	NS
	PPD linear	NS	0.008	NS

Increasing Low-income Family Participation in the Montgomery State Farmers Market

N. Baharanyi, N. Tackie, A. Pierce, C. Woolery, R. Zabawa and R. Hopkinson

Farmers markets are urban or suburban sites where growers bring fresh produce and sell directly to consumers, ıus avoiding several intermediaries. These arkets are supported by local or state overnments or by non-profit organizaons. They are set up for several reasons ıch as to support family farms and provide esh, inexpensive food to urban residents Sommer and Sandra, 1985; Associated ress, 1990). Certainly, the Montgomery tate Farmers Market (MSFM) established 1986 is no exception.

Though the MSFM as a whole has een a success, there is still a need to ontinue promoting the participation of ea farmers and consumers, especially low ıcome families. Indeed, while the number f farm families has been declining in the outh, that of families living below the overty line has seen an increase in the last 0 years. Additionally, research has shown ıat poor families living in public housing ıffer economically and nutritionally from ıe lack of nearby shopping oportunities ıat provide good quality and affordable ood.

Some public housing projects in Iontgomery, on the other hand, are relavely close to the MSFM and are almost xclusively black. Since a portion of the aditional diet of black households inudes fresh fruits and vegetables, all sold at ıe MSFM, it was necessary to find out bout this group's socio-economic characristics and attitudes about the market in rder to both serve this clientele in Exnsion programs and promote the market.

Using a questionnaire developed for ıis purpose, a systematic random samling was used by targeting every third ouse for interview in the Cleveland Court, atterson Court, Victor Tulane Court, ibbs Village, Highland Village, Smiley ourt, Cedar Park, Richardson Terrace, nd Riverside Heights housing projects in ıe summer of 1991 (Sample I). The total umber of houses reached was 476 out of 361 houses. In early fall of 1991, 178 andomly selected low-income consumers ere provided with transportation and oney (in the form of produce coupons) as ıcentives to buy produce from the MSFM. hey were interviewed at the end of the ıopping trip to find out what they thought bout the transportation and produce coupon program (Sample II). The completed questionnaires were tabulated and analyzed using descriptive statistics.

Based on Sample I, it was found that a significant portion of the respondents (47 percent) were between 20 and 39 years of age, and an overwhelming majority, 84 percent, were female. Most of the respondents attended high school but not all completed their secondary education. In addition, most of them (91 percent) relied on an annual income of $10,000 or less. The respondents also indicated a preference for fresh produce as most of them shopped for fresh fruits and vegetables at least once per week. These include but are not limited to collard greens, cabbage, lettuce, cucumbers, potatoes, watermelons, apples, canteloupes and peaches, which are mostly bought from the local supermarket or grocery store.

Almost all of the housing residents did not use the MSFM before. Yet, at least 72 percent said that they were aware of its existence. Their limited participation was due mainly to lack of direct transportation to the market and the existence of roadside markets and grocery opportunities nearby.

In Sample II, respondents were provided transportation and coupons through the MSFM Consumer Education Outreach Office to enable them to buy produce at the MSFM on different days. A post-shopping interview revealed that the housing residents heard about the MSFM through friends and neighbors (20.9 percent), their housing office (19.6 percent), community center (14.6 percent), Community Action workers (7.9 percent), TV (5.6 percent), the newspaper (1.7 percent), and the radio (1.1 percent). Additionally, 12.9 percent of the respondents heard about the MSFM through other means such as word of mouth, advertisement, and leaflets; and 2.2 percent received the information from the research team.

About 79 percent of them said they usually shopped at their local supermarkets. For the MSFM visit, they spent an average amount of about $10. Sixty-eight percent stated that the prices at the MSFM were lower than the other local prices; 73 percent believed the quality was better, and 49 percent believed that it was convenient to shop there. Finally, when asked what would make them go more often to the MSFM, 71.3 percent said transport, 6.8 percent said transportation and money, 6.2 percent said other things such as good social atmosphere, more variety of produce and convenience, 3.9 percent said lower prices, 2.2 percent said money, 1.1 percent said food stamps.

Based on the study, the low-income consumers do not participate in the MSFM because of existing grocery stores in their neighborhoods and lack of transportation. When provided means to participate (transport and $10 produce coupon each), they expressed great satisfaction with the MSFM and stated that they would use the market more often. Programs emphasizing transportation, fresh and cheaper produce stand a better chance for increasing low-income family participation in the MSFM.

Ntam Baharanyi, Agricultural Economist; Nii O. Tackie, Research Associate; Atheal Pierce and Cecil Woolery, Graduate Students; Robert Zabawa, Social Scientist; and Rupert Hopkinson, Economist.
Acknowledgement: Special appreciation goes to the Alabama Department of Agriculture and Industries and work-study students Julie Ngola, Cheryl Edwards, Marigold Thompson and Gwen Lawrence who helped in the study. Funding came from USDA/Agricultural Marketing Service.

NEW DIRECTIONS

African women are planning for change beyond traditional roles.

This Cameroonian wraps cassava in specia leaves and will sell them at the market. Afr can women lead in produce marketing.

One year ago Tuskegee University signed a linkage agreement with Sokoine University of Agriculture in Morogoro, Tanzania. A project funded by the U.S. Agency for International Development, it provides funds for faculty development and joint research and extension activities.

One extension objective during the past year was to bring community focus to the status of women in rural Africa, particularly to those cultural practices that are considered repressive to women. Deeply imbedded in the various cultures, these practices will take time to change.

But with global communications comes heightened global awareness and African women themselves are calling for change. At a recent Women in Development (WID) workshop, several Tanzanian presenters echoed the call for the abolition of some of the practices. These included parents' attaching greater importance to a boy than to a girl, men's inheriting women from deceased relatives, and women not being allowed to inherit landed properties. Setting the stage for collaboration in addressing these issues was a primary goal.

In her opening speech, Rose Lugembe, Principal Secretary of the Tanzanian Ministry of Community Development, Women's Affairs, and Children highlighted the important role played by African women in the production of food for the family. Given this role, the Tuskegee-Sokoine WID workshop sought to develop cooperative relationships between Sokoine University and various other organizations to ensure that women are given consideration equal to men in development planning.

A Tuskegee technical team consisting of Gladys Lyles, professor of sociology, Eloise Carter, a nutritionist and associate director of International Programs, and the author who serves as project coordinator, was joined by Janet Poley, director of Communication, Information and Technology with USDA Extension. They met with a cross-section of community leaders and Sokoine faculty and staff.

USAID's new director, Dale Pfeiffer, also addressed the group. He gives women's issues very high priority. The worksho identified and explored important gende issues as they affect health, nutrition, ag riculture, politics, and law. Participant committed themselves to a plan.

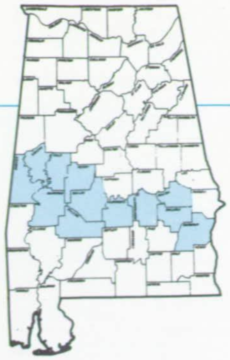
That plan for future actions, whic was developed at the meeting, gives in sight into the way gender impacts on th daily life of the African woman. It calls fo encouraging young African women t pursue careers in science, for informin village women through extension effort about new developments in WID activi ties, and for sensitizing men to variou gender concerns.

Arthur Siawa

ROBERT ZABAWA

These Senegalese formed a goat producers' cooperative to raise seed money for a health center/nursery. (They are breaking up fodder.)

Plant breeder Essie Blay perfects genetic engineering skills at Tuskege Her goal? To start a biotech lab back in Ghana to benefit farmers.



Five of the farmers attending the 100th Annual Farmers Conference at Tuskegee University were asked the following question:

WHAT ARE YOU MOST PROUD OF IN ALL YOUR YEARS OF FARMING?

Francis Griffin, Barbour County. I am just proud to be able to farm. You raise all those cows and hogs and watch those crops come up. I guess I love aising cows more than anything. I have lose to 200 head. I also raise cotton, peanuts, and of course lots of hay. If you get he right season you can do all right. I had good year last year with my cotton and eanuts.

I enjoy that farm so much I spend more ime on it than on anything. I have 420 cres of my own and more than 700 altogether counting what I rent. To me, farming is good, honest living. (Griffin won the Merit Farm Award in 1990).

Fred Bennett, Butler County. I am most proud of the relationship that has developed between myself and Tuskegee University. As a young 4-H'er I spent 10 days in class with Dr. Carver that caused me to want to be a farmer. When I made that decision, I knew hat I was going to look to Tuskegee for scientific guidance.

Then, there was something else. About 13 years after I started my own farm in 1943, I was able to buy a test-performance thoroughbred bull for the little herd I had. He had the capability of siring calves that would put on the maximum amount of weight for the minimum amount of feed. That was my first experience of moving into the scientific method of farming. I still have what I call a top-quality herd even in retirement, and it all started with Tuskegee.

Then in 1959 I was really thrilled to know that Tuskegee U niversity thought I had absorbed the teaching they had given me through the Extension Service to have given me the Merit Farmer award.

Aaron Sellers, Bullock County. The thing that meant most to me turned out to be forestry. Over the years I bought land five different times so that now I have a total of 221 acres. But I was never able to pay cash. But I set out 30 acres of pine trees back in '68 and again in '78 and, when I cut those, I brought myself clear out of debt. And you know what I did? I asked the cutter to leave 10 trees per acre. Those trees bear seed every year and you know the wind scatters them and the cows will mash them into the ground. Every 10 years I have the seed trees.

I have 16 head of brood cows and a bull, and five sows and a boar. Along with 52 acres of pecans, they helped balance the budget. But not every year was good. The best year I had on row-cropping was with peanuts when I was able to make 11 tons on 12 acres grossing $700 a ton.

I have lived good and made money. Some years I didn't. In this area where we live we don't have but one item now with a guaranteed price—peanuts. (Sellers won the '81 Merit Farm Award.)

Willie Carter, Wilcox County. What am I most proud of? Watching things grow. I just like farming. Period. I've been in it all my life. I have cattle and hay on 213 acres and right now there is good money in cattle. I used to rowcrop but no more. I decided to put some of that into timberland.

Albert Perry, Bullock County. I am just happy to be my own boss. Right now I wouldn't ask to be in no better place. This is what happened. After high school, I had my mind on the city where the good jobs used to be.

But my father told me that, when I got 21 years old, he would turn over his whole farm in my name. I didn't believe him, but you had to take a chance. So I waited and stayed helping him on the farm. My oldest brother was killed in Vietnam, and the next one was in the service. I was the third. Sure enough, when I was 21, he did it.

Besides my livestock and hay, I've built up a good six-acre vegetable business. People come to my farm for half my sales now. The other half is through phone sales and peddling.

If I had it to do over again, 80% I would stay in farming; 20% I would have gone on with my education and maybe be a vo ag teacher. But I am happy the way I am now.

Algie Key, Jr. '60, '66, the president of the Agriculture and Home Economics Alumni Association, died April 14 after an extended illness. He was active in his position as district agent for the Tuskegee University Cooperative Extension Program up until shortly before his death.

Both of Key's degrees were in agricultural education; he also did further study here in Extension administration.

A native of the Hardaway Community in Macon County, Key spent 20 years as district agent. During that time he served on numerous committees from local to national levels. He was president of the Alabama Cooperative Extension Service Employees Organization from 1984-86. Prior to his work in Extension, he was an agribusiness instructor in Wilcox County for 10 years.

Key was chairperson of the Greater St. Mark Missionary Baptist Church Board of Trustees and Deacons and was a past president of Kappa Alpha Psi Fraternity. He was a former chairperson of the Tuskegee University Staff Senate.

Key is survived by his wife, Vesta, two daughters, Melanie and Karen, his mother, nine sisters and six brothers among many other relatives and friends.

Key was well-loved for his humanity and sense of humor. He was one of the persons instrumental in setting up the annual Alumni Scholarship Banquet. He was very concerned about the education and support of students.

The Algie Key Scholarship Fund has been established in his memory, and the family requests donations be made to that in lieu of flowers. Memorials may be sent to the School, in care of Louise Herron, 105 Campbell Building.

The newly-landscaped Thomas M. Campbell Building bears silent witness to a rich history

BUILDING HONORS CAMPBELL '06

The School of Agriculture and Home Economics recognizes one of its own.

The first work he did as a student here was at the horse barn, according to Thomas Campbell. On Founder's Day 1992 the Farm Mechanization Building (originally the horse barn) was renamed the Thomas Monroe Campbell Building. The story of this alumnus merits retelling.

Born in 1883, Campbell was raised on a small farm in Georgia near the Carolina border. In January 1899 Thomas left home on foot headed to Tuskegee, Alabama where he heard poor but aspiring African-Americans could work their way through a school there. With 35 cents in his pocket, he worked odd jobs along the way and finally arrived by train four months later.

Providence must have led him to study agriculture for the impact he would make on the lives of rural black farmers, on the growth of agricultural education programs at Tuskegee and on the evolution of the Cooperative Extension program in the U.S.

According to history buff B.D. Mayberry, former dean of agriculture here, Booker T. Washington "felt a definite need to reach directly the most backward black farmers." He raised money to equip a wagon with tools and material "for demonstrating methods of improved farming and living" up and down the dirt roads of the area.

Upon his graduation in 1906, Campbell was employed to operate the School on Wheels (Dr. Carver's design) which later became world famous as the "Movable School." On November 12 of that year, Campbell was appointed the first Farm Demonstration Agent by the U.S. Department of Agriculture.

The work of Campbell—and others appointed soon after—paved the way for the creation in 1914 of the Cooperative Extension System, which became "one of the most significant and far-reaching measures for the education of adults ever adopted." Many nations still try to copy it.

Campbell described the practical effects of his work in his book, *The Movable School Goes to the Negro Farmer*: "Wherever it visits, the Movable School seeks to leave the house and premises whitewashed; build a new poultry house or repair the old one; leave hot beds and cold frames in the garden; leave the orchard pruned, wormed and sprayed; leave shuck mats and rag rugs on the floor; and more than all, it endeavors to leave the family thrilled with the beauty and attractiveness of an old home made new, and ready to carry out any program that may provide for further transformation....Frequently those who have seen the work done, go back home and improve their own premises."

In his book, *The Role of Tuskegee Institute in the Education of Black Farmers*, Allen Jones says, "It was the work and influence of Thomas M. Campbell that made Tuskegee Institute the center of Negro agricultural extension work in the deep South. While Campbell used his position to spread the ideas of Booker T. Washington, he made his greatest contribution to black farmers and to his race by constantly pressuring the USDA to hire more black extension agents and to expand its extension operations among black farmers."

Lynn Ballard-Siaway and Marie Loretan

The late P.H. Polk, famed photographer at Tuskegee, took this photo of the Thomas Campbell family around 1932.

HE BELIEVED IN PEOPLE

"Mr. Campbell believed so strongly in what he was doing that he had the capacity to pass that strength on to others. He believed wholeheartedly in teaching by doing (he said he picked it up from Booker T. Washington). When I was appointed Home Demonstration Agent in 1930, he said, 'I want you to go out there and, instead of telling people what to do, show them how to do it.' He harped on that.

"Another strong point that I remember about him, he told us how important it was to get good friendly relations with all the people in our county, particularly the preacher. He would say, 'Get him on your side, then the county health officer, the county nurse, the probate judge, the banker. Let the people know what you are trying to do.' We had to take newsletter writing and courses in photography. We had no choice.

"I remember Mr. Campbell as a person who had more than the usual amount of tact and diplomacy. One time we were at the State Fair in Montgomery—back in the days when we had two of everything. Everything was separate but unequal. Mr. Hyman, executive secretary to Mr. Campbell, and a team of us who worked on the Movable School had to go one Sunday to keep the Negro division of the State Fair open. It was a big day, Family Day. When we got to the pavillion entrance, there was a rookie officer who stopped us as Hyman attempted to drive in and barked, 'You can't bring that thing in here.' As Hyman went to say something to him, he repeated more loudly, 'You can't bring that thing in here.' Hyman got out and said, 'We are on duty.' 'Park out here somewhere,' the officer said.

"Just then, that black Buick came around and that black pipe was sticking out on one side. Mr. Campbell asked, 'What's the matter?' Hyman explained that the officer said we couldn't go in. Mr. Campbell said, 'Follow me.' Mr. Campbell drove up to the officer, looked at him and said, 'It is almost time for that pavillion to open.' In we went.

"Then he pulled over and parked and said, 'It's time for us to have a little meeting. The officer doesn't understand. Sometimes you have to have the patience and the courage to talk to them and explain to them and, once they understand, they will act differently.'

"Mr. Campbell believed in the power of the song. He believed that if he could get people singing together, they could start talking. If you got them talking then it was much easier to get them to start working together. One of the songs he always liked to sing was 'Get on board this noble vessel/ It is making for the landing.'

"I remember him as a man who had confidence in people. He believed that the man furthest down could be reached if somebody who had the know-how and the care would reach down there to him and would have the patience until he started on his way up.

"I will always appreciate 'Mr. T. M.' or 'Big Chief,' as we used to call him, and those 10 years I worked under him and had his supervision."

Elizabeth Benson '28
Tuskegee, Ala.

"I worked as administrative assistant to Mr. Campbell when he was field agent over Alabama, Florida, Georgia, Louisiana, Mississippi, South Carolina and Texas. I learned more from Mr. Campbell about how to deal with people than I did from any of my formal education, and this helped me in advancing my career.

"We worked together very closely, but most of the time it was strictly business. He was pleasant, but he didn't play very much.

"He was well aware of racial issues. At that time, he used to try to arrange to have me, Gould Beech who was with *The Progressive Farmer*, and the son of the publisher of *The Advertiser* —I forget his name, get together over in Dorothy Hall. We would just sit and exchange ideas. Mr. Campbell wasn't there. He just wanted the white people to see there were black folk who could express themselves; that was his way of trying to improve race relations. He did a good job, I think, because at that time things weren't easy for anybody.

"He helped to resolve a number of situations that were 'warm' in certain areas. Dr. Moton (Tuskegee's second president) used to call on Mr. Campbell often to smooth ruffled waters. And he did it without being an Uncle Tom."

Lucien A. Green '27
Retired Director
Tuskegee VA Medical Center

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THE MERIT FARM FAMILY

This award was given for 1992 to the Albert Perry Family of Bullock County at Tuskegee's 100th Annual Farmers Conference. The historic gathering had a little bit of everything: reminiscing, speeches, a parade, singing, recognitions, a banquet and—sober reflection on the plight of rural America. *The story begins on page 10.*

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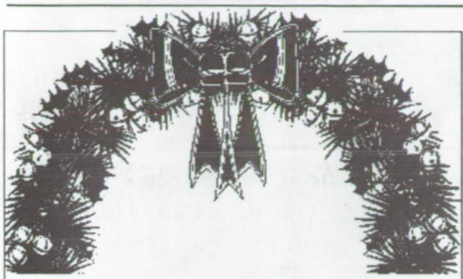
TUSKEGEE Gram



Seasons Greetings

from the President

As the holiday season approaches, Mrs. Payton and I would like to extend warm wishes to everyone for a prosperous and joyous holiday season.

I would like to thank the Tuskegee University family and friends for your contributions and support of the university's programs and services.

May the spirit of the season bring you peace and happiness.

Left to right: Architect Charles Raine, Miss TU Lesley Barbré, President Benjamin Payton, and Superintendent of the National Park Service Willie C. Madison cut the ribbon during a ceremony for James D. Tantum Hall when it reopened Sunday (December 6) as a residence hall for women. Tantum has central kitchen and laundry facilities, study rooms, central heat and air conditioning and accommodations for a Residence Hall proctor.

NASA provides training in computer networking for scientific research

Approximately 50 faculty, staff, and students took the opportunity to receive training in computer networking technology in support of collaborative interdisciplinary scientific research.

The National Space and Aeronautics Administration (NASA)/Goddard Space Flight Center offered the training through its newly-established MU-SPIN Program, the Minority University-Space Interdisciplinary Network.

MU-SPIN offers technical and logistical assistance and training to faculty, staff, and students in a wide range of network-related issues, which include campus and wide area (including international) network planning, installation and management, scientific network applications, and access to Internet services and resources.

Recognizing that minorities have long been under-represented in NASA research programs, the MU-SPIN initiative is aimed at Historically Black Colleges and Universities (HBCUs), Minority Universities (MUs), and other universities with large minority student enrollment.

Spearheading the effort to bring MU-SPIN to the campus was the Tuskegee University NASA/CELSS Center (TUNACC) in cooperation with the George Washington Carver Agricultural Experiment Station, the Tuskegee University Office of Computer Services and the School of Veterinary Medicine Biomedical Information Management Systems.

MU-SPIN representatives, Drs. Aftab Ahmad, Mou-Liang Kung, and Nagi Wakim, recently conducted three sessions in two days of training on campus. The first covered how to plan, design and install an Ethernet-based Local Area Network (LAN) of PCs and MACs. This system would allow department/laboratories to communicate by computer.

Secondly, an overview of other network protocols was given with an in-depth look at .X500 service, implementation and management of TCP-IP-based networks, and TCP-IP services for those involved with campus wide networking.

The final session introduced participants to Internet, its resources and services-scientific data systems, on-line library

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is published twice monthly for members of the Tuskegee University extended family. Call or write to be added to the mailing list.

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Lynne P. Bessellieu
EDITOR

NASA

Continued from Page 1

catalogs, public domain software, and government information systems.

John M. Klineberg, director of NASA/Goddard Space Flight Center, said, "On-line access to distributed data systems and increasingly powerful computer systems are a necessary part of modern research. We are proud to offer HBCUs and MUs this access, and we look forward to the science, technology, and education contributions which will surely follow."

TUNACC is presently engaged in life sciences research for NASA - how to produce, process, and recycle the inedible plant parts of sweet potato and peanuts for future long-term, manned space applications. The TUNACC team includes faculty, staff and students from the Schools of Agriculture and Home Economics, Engineering and Architecture, Education, Veterinary Medicine, and the College of Arts and Sciences.

According to Dr. Philip Loretan, TUNACC coordinator and the campus coordinator for the training sessions, "Those attending the MU-SPIN workshop were very pleased with the level of training given. For those who missed them, there will be more."

Food and nutritional sciences program—

Beyond classroom instruction through experimental learning at the USDA

She is a sophomore from Atlanta, Ga, who interned with the USDA in Hyattsville, Maryland, in their Human Nutrition Information Service (HNIS).

Ava Bozeman was a Nutrition Research Aide. Her internship was funded by a USDA Capacity Building Grant through arrangements between the Department of Home Economics and the USDA.

The grant is titled, "Strengthening and Expanding Academics in Food and Nutrition for the 21st Century."

As a Nutrition Research Aide, the Food and Nutritional Sciences major worked with the office of the Administrator and reported directly to the Assistant to the Administrator, Allana Moshfegh.

Other duties included providing technical and administrative support to the Interagency Board for Nutrition Monitoring and Related Research (IBNMRR), which consists of twenty-two federal agencies.

IBNMRR is responsible for implementing the National Nutrition Monitoring Advisory Committee (NNMAC), a group of nine outside experts appointed by the Congress and the President to provide advice and guidance to the secretaries of the Department of Agriculture and the Department of Health and Human Services.

Bozeman was responsible for coordinating and compiling technical briefing materials for Assistant Secretaries of the USDA, DHHS, and other officials for this quarterly meeting of the IBNMRR, as well as briefing materials for the biannual meeting of the NNMAC members. This was a tough task since these two meetings overlapped.

How did Bozeman fare in all this? Very well indeed, as best described by excerpts from a letter "Justification Statement for Special Service Award for Ava Bozeman" written by Moshfegh, her supervisor:

"Ava was given minimal direction for carrying out these tasks and fulfilled the projects in a competent and timely manner. She carried out these tasks with professionalism under tight deadlines, giving special attention to format, order and content."

Moshfegh furthers stated, "Her services have been invaluable over the summer for meeting the timeliness and activities for implementing the various requirements of the National Nutrition Monitoring and Related Research Act of 1990."

Bozemen's performance was recognized through a Service Award as stated by Moshfegh, "for substantial contributions in carrying out the requirements of the NNMRR act of 1990 and providing exemplary technical and administrative support to the Assistant to the Administrator..."

An additional letter from the Administrator recognized Bozeman's accomplishments.

"We are all proud of the way Ava represented herself, the Department of Home Economics, and Tuskegee University."

Bozeman's modest response was, "I had a chance to learn about the work done by the HNIS in dealing with food consumption, public nutrition knowledge and attitudes, dietary nutrition education techniques, and food composition. My experience with the USDA introduced me to the many career opportunities available in Food and Nutritional Sciences."

The Food and Nutritional Sciences Program (FNS) in the Department of Home Economics has been in operation since 1927. The FNS offers both B.S. and M.S. degrees with Human Nutrition of Food Science option. The Human Nutrition option benefits from the diversity of course offerings in the Dietetics Program, also in the Department of Home Economics.

Career opportunities in FNS are limitless. The FNS program at Tuskegee University is rich in its curriculum and research, as well as outreach into the communities, industry and governmental agencies.

The students in FNS have the opportunity for summer internships and work experiences to provide the link between classroom instruction and the application of learned knowledge to real world and student performance. Ava Bozeman is part of its success story.

Season outlook starts with a new attitude

By Wendell H. Paris, Jr.

Hardworking, aggressive, poised, and intelligent are the words that will describe the 1992-93 Golden Tiger Basketball team. First year coach Lonnie Williams has accepted the challenge of rebuilding and redirecting a team that produced only a 45-111 record in the last six seasons.

The team has lost key players Gary Hunt and Robert Franklin, but Coach Williams feels that the team will not be drastically effected by their loss because of the new attitude of the basketball team. He stated, "I feel that this year's team will be more of a team. This team has a new attitude. We have many fine players that are going to learn to play together, however, this process takes time. But even with the adjustments that are going to be made, I know that we will have a better defensive team than last year."

Coach Williams feels that the team's new cohesive attitude will be one of the deciding factors that will determine whether the team will have a winning season. The other factors that will determine the season's outcome are: good shot selection, good rebounding, and good substitution. Coach Williams stated, "We will be more selective with our shots and crash the boards better. It is very important that our veterans...give us experienced performances consistently every game."

But, the veterans are not the only players on the basketball team, as Coach Williams explains, "The only thing that concerns me right now is the inexperience of everyone that has not played with us, and are not certain as to what their role on the team is. We have three junior college players coming into our program from three different programs, and a freshman that has never played in a college game." Coach Williams says that in spite of the inexperience of the new recruits, we (as fans) should not be discouraged. With the experience of the veterans, and the willingness of the novices, the performance of the team should balance out. "It is going to take some time to get this team working as one unit," he says, "but I am confident that if we (the team) stay focused and healthy by mid-January, we will start to gel."

So, according to Coach Williams, we as fans should be patient and have faith in the Golden Tiger Basketball Team. With hard work, and discipline, the Golden Tigers will be a forced to be reckoned with.

TU Lady Tigers say "transition is our mission"

The Lady Tigers are suited up and ready for the challenges that face the 1992-93 basketball season. Although the team is fairly young in terms of experience, the new women's basketball Coach Angelia Nelson feels confident about their playing abilities.

"Our main goal is to make sure that we're fundamentally sound," Coach Nelson said. "We're not yet playing up to our potential, but that's good. I don't want them to reach their potential too soon."

Coach Nelson believes that it's better for the team to peak by midseason. She is confident that the Lady Tigers will make it to the SIAC tournament. Their season outlook is to "work hard and if not win every game, make them close games. Transition is our mission."

The lineup this year is different in that Samaria Ashford is now playing the position of point guard and Vanessa White is the forward. Coach Nelson views these changes bring a positive aspect to the team and feels the team is a lot stronger.

White is seen as a key player, scoring 20 points against West Georgia and 35 against Talledega. She has improved her ball-handling skills since last year. As for her post moves, "I'd put her against any guy!" asserts Nelson.

As point guard, Ashford has great control over the players in that she practically runs the show. Dorita Heard is an aggressive, three-point shooter who shot four three-pointers against Talledega. Freshman Tiffany Sanders scored six points in the first game. Nelson is expecting a lot of good things from her as the team progresses. Starting seniors Kendrya Joseph and Charlita Perry are strong rebounders and sharp on the offense.

A crucial aspect of the Lady Tigers is academics. A firm believer in the playing ability of her team, Coach Nelson also believes in academic excellence, which she instills in the players.

How does Coach Nelson feel about Tuskegee University and the Lady Tigers?

"I love it! I really enjoy it. The people are very friendly. As far as coaching, I wouldn't want another group," Nelson says. "The girls are mannerable and they respect me. We spend a lot of time together, for they are very family-oriented, and that contributes to their success." This closeness is what will help them succeed, says Nelson.

Billboard

TUSKEGEE UNIVERSITY RECEIVES GE GRANT

General Electric Foundation will contribute a grant totalling $50,000 to Tuskegee University. The funds will be used in support of the University's Recruitment and Retention programs (FASTREC and Tutorials) in the School of Engineering.

A Visual Celebration of the Tuskegee Experience

In celebration of the historic majesty of Tuskegee University, **Harmony House Publishing** presents a brilliant photo essay titled *Tuskegee University: Then and Now.* The one hundred and two page odyssey will transport you back in time to the rich treasure chest of Tuskegee, the institution, its people and its aura. Familiar scenes, old and new, will awaken the Tuskegee Experience in the hearts and minds of all that love and cherish Mother Tuskegee. The architectural genius of Robert Taylor, the mystic view of Tuskegee at twilight, the historic black and white photos reborn from the school's archives will bring Tuskegee alive in this lavish, hardcover keepsake.

After a year long preparation and painstaking efforts on behalf of Harmony House and Tuskegee University, this book is in the final stages of completetion. However, the publisher is issuing this volume by advance reservation only. It will not be published for mass-market editions. Orders are encouraged immediately to receive first edition copies by March 1993. As a holiday gift idea, a handsome gifted card and envelope are available. This priceless part of Tuskegee University history is valued at $39.95. To make reservations for this collectors item contact: *Tuskegee University: Then and Now,* c/o Harmony House, P.O. Box 90, Prospect, KY 40059.

Coming Up AT TUSKEGEE UNIVERSITY

Staff Personnel Christmas Holiday Schedule

Monday	December 21	Office Open
Tuesday	December 22	Office Open
Wednesday	December 23	Office Closed Extra Day Off
Thursday	December 24	Office Closed
Official Holiday/Christmas Eve		
Friday	December 25	Office Closed
Christmas Day		
Saturday	December 26	Office Closed
Sunday	December 27	Office Closed
Monday	December 28	Office Closed
Tuesday	December 29	Office Closed
Wednesday	December 30	Office Closed
Thursday	December 31	Office Closed
Friday	January 1	Office Closed
Monday	January 4	Office **OPEN**
Regular Schedule		

☐ December 31
WOMEN'S BASKETBALL
vs. West Georgia College
Carrollton, Ga.
5 :30 p.m. EST

☐ January 2
WOMEN AND MEN'S BASKETBALL
vs. Columbus College
Columbus, Ga.
5 :30 p.m. and 7:30 p.m. EST

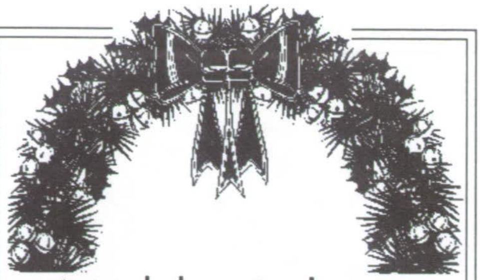
☐ January 9
WOMEN'S BASKETBALL
vs. Troy State University
Troy, Ala.
7:30 p.m.

☐ January 11
SECOND SEMESTER CLASSES BEGIN

☐ January 12
WOMEN'S BASKETBALL
vs. Morris Brown College
Atlanta, Ga.
6:00 p.m. EST

☐ January 13
MEN'S BASKETBALL
vs. Troy State University
Troy, Ala.
7:30 p.m. EST

☐ January 16
MEN'S BASKETBALL
vs. Morehouse College
James Center Arena
7:00 p.m.



A Holiday Gathering

You and Your Spouse or Guest
are invited to the
President's Annual
Christmas Party
for
Tuskegee University
Faculty and Staff
on Thursday, December 17, 1992
from 6:30 to 9:00 p.m.
Logan Hall

Attire: After Five
(Adults Only)

☐ January 16
WOMEN'S BASKETBALL
vs. Spelman College
James Center Arena
5:00 p.m.

☐ January 17
CARVER DAY OBSERVANCE

☐ January 18
MARTIN LUTHER KING, JR. OBSERVANCE

TUSKEGEE Gram

Tuskegee University
Information & Public Relations
Tuskegee, AL 36088

Bulk Rate
U.S. Postage
Non-Profit
PAID
Montgomery, AL
Permit No. 683

Appendix 3 - "Space Agriculture" Brochure

For general information, contact

School of Agriculture and Home Economics
Campbell Building
Tuskegee University
Tuskegee, AL 36088

For student applications, write to

Office of Admissions
Tuskegee University
Tuskegee, AL 36088

UNIVERSITAS TUSKEGEENSIS
1881
SCIENTIA PRINCIPATUS OPERA

Space Agriculture

TUSKEGEE UNIVERSITY

A U. S. space objectives have these aims: a clearer understanding of global climate change and the impact of human activities on the earth's biosphere (called *Mission to Planet Earth*) and the exploration of space (*Mission from Planet Earth*). Because future long-term space explorers will have to grow their own food in life-supportive enclosures, a new branch of an old science was born — space agriculture. NASA selected Tuskegee University to look into growing sweetpotatoes for space.

About sweetpotatoes, space and Tuskegee Univ

Most of the diet of space explorers on long-term missions will come from pest-free plants brought from earth.

Sixty percent of the human diet comes from carbohydrates, the main source of energy.

Sweetpotato, a carbohydrate, is one of several crops (wheat, rice, soybean, peanut, lettuce, potato, a few others) NASA is studying for a space diet.

A team of Tuskegee University scientists has developed a system for growing sweetpotatoes without soil for space purposes and patented it in 1989.

Soil would be much too heavy to carry into space so sweetpotatoes will be grown hydroponically. A thin film of nutrient-added water makes them grow.

George Washington Carver developed many food uses for sweetpotato while teaching at Tuskegee University in the early 1900s.

Sweetpotato is now used for main dishes, fries, desserts, drinks, salads, chips, candy, ice cream, even a burger.

Flour can be made from sweetpotato and from it breads, pancakes, cookies, cakes, doughnuts and noodles.

Tuskegee University scientists say sweetpotato is the crop "most suited for space" because i propagates and grows easily and can be usec in a variety of ways (among other things)

These sweetpotato products were among thos displayed at Tuskegee University's recen international sweetpotato symposium

, did you know that....

The nutritious sweetpotato has been named a heart healthy food and is also thought to be anti-carcinogenic.

Sweetpotato and other yellow/orange foods promote healthy eyes and good vision because of their high vitamin A content.

The leaf tips of sweetpotato are eaten in many countries as a green vegetable.

Tuskegee University food scientists are studying the consumption of sweetpotato leaves as a way to lower blood cholesterol.

Sweetpotato is a dual vegetable—the leaves can be eaten as well as the roots. Not many vegetables can claim this.

Sweetpotato is the seventh largest crop in the world and has saved numerous populations from starvation in troubled times.

Sweetpotato is produced in most of the less-developed and heavily-populated areas of the world where food needs will increase dramatically.

Today's biotechnology offers the possibility of someday improving crop production and solving these pressing global food needs.

Tuskegee University is pioneering research in gene transfer and identification of molecular markers in sweetpotato for crop improvement purposes.

Initial success with gene transfer (blue part) into sweetpotato at Tuskegee infers the future possibility of adding traits such as higher protein content, insect and disease resistance.

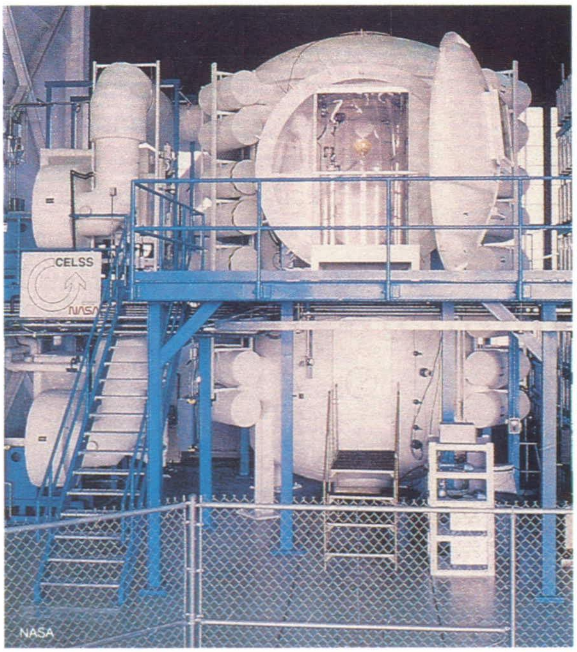
Consider that...

Spin-offs from space research have led to such things as CAT scanning, blood purifiers, multi-layer insulated clothing, cordless tools.

Spin-offs have benefitted the environment through new solar energy technology, remote sensing of natural resources, weather predictive tools.

A spin-off from sweetpotato for space research has been to know better how to grow them on earth.

Tuskegee University was designated a Center to study how to produce and process sweet-potatoes and peanuts and recycle their inedible parts under space conditions.



NASA tests its space crops in the Biomass Production Chamber at Kennedy Space Center in Florida.

Many of our nation's future space scientists and engineers are in elementary and high school now learning the tools of math and science.

NASA (the National Aeronautics and Space Administration), the U.S. Department of Agriculture and Tuskegee University are looking for students interested in science and engineering.

Maybe you—or someone you know—might want to be a pioneer in space exploration. Let us know who you are.

Tuskegee University was named a space grant college to help NASA identify and train youth to be the space scientists, engineers and technicians of the future.

Tuskegee scientists, students and NASA officials inspect sweetpotato plants in greenhouse.

Appendix 4 - Flyers and Application Forms

INTERESTED IN SPACE SCIENCE/ ENGINEERING?

SCHOLARSHIPS AVAILABLE IN:

Plant and Soil Sciences <> Biology <> Chemistry
Food Science <> Nutritional Science
Biochemistry <> Microbiology <> Physics
Engineering : Mechanical, Electrical, Chemical, Aerospace
Computer Science <> Mathematics

Advanced undergraduate and graduate students will be needed to assist in the research projects of the Tuskegee University NASA CELSS Center described below. Work study positions are available starting the Fall of 1992, and full or partial tuition scholarships will also be available to eligible students who are U.S. citizens. The working groups are interested in receiving applications from students of the disciplines listed above, but anyone can apply.

Tuskegee University is one of seven colleges chosen by NASA to conduct major research in support of future long-term, manned space missions. Tuskegee has been asked to study how to produce and process sweetpotatoes and peanuts for space missions and to recycle their inedible parts.

Six working groups have been established on campus to focus on different aspects of this project. Their efforts will be directed toward: (1) developing systems for producing these two crops for Controlled Ecological Life Support Systems or CELSS, as NASA calls this program; (2) plant breeding/genetic engineering to find the sweetpotato/peanut varieties most adaptable to CELSS; (3) developing and processing food products suitable for space consumption; (4) recycling plant wastes; (5) computer modeling of plant growth; and (6) microgravity applications and controls.

Applications are available for either work-study or full- or part-time tuition scholarships in Room 100 at the George Washington Carver Agricultural Experiment Station which is located in the Campbell Building.

Tuskegee University

Founded by Booker T. Washington

School of
Agriculture & Home Economics

July 24, 1992

MEMORANDUM

TO: Deans, Directors and Departments

FROM: Walter A. Hill
Dean and Research Director

RE: Scholarships

Please find enclosed announcement and application forms for the Tuskegee University NASA CELSS Center Scholarship program which has been initiated at Tuskegee University. Please note the applications should be returned quickly since positions will be selected for **Fall 1992**.

Please pass this information on to those who may be interested in applying for this scholarship. Several copies of the announcement are provided, so that you may post them in a prominent space within your department or school. Feel free to duplicate as needed. If you have any questions about the scholarship, please do not hesitate to contact Dr. Phil Loretan at 205/727-8129. Thank you for your cooperation in this matter.

Enclosures

Tuskegee, Alabama 36088

Tuskegee University
Tuskegee University NASA CELSS Center (TUNACC)

Student Application

Name ____
Campus Address ____
____
Telephone No.____________________
Soc. Sec. No. ____________________ Gender ____________________
Citizenship ____________________ Underrepresented ____________________
minority-specify, (African American,
Hispanic, Pacific Islander, Other)

Present college enrollment (please attach a resume and/ or transcript)
University ____________ Department ____________
Specific discipline (if Applicable) ____________________
Classification ____________ GPA ____________
Expected degree and date of graduation: Degree__________ Date __________
High School Background (please attach transcript)
Name of High School ____________________
Address ____________________
____
ACT Scores ________ SAT Scores ______ GPA ______ Class Standing ______

If applying to Tuskegee University, please fill in the following:
School or College:____________________
Department:____________________
Degree sought:____________________
Degree expected:____________________

Relevant work experience, publications, projects, honors, extracurricular and community activities:

The following areas are being researched under TUNACC:

1 developing hydroponic and environmental systems for growing crops for space missions
2. plant breeding/genetic engineering for space missions
3. developing and processing food products suitable for space missions
4. recycling plant wastes and waste management in space
5. computer modeling of plant growth in space
6. microgravity applications and controls in space

In which of the above areas are you most interested?

Give reasons.

If currently enrolled in Tuskegee University, what kind of financial support do you presently have? What kind of support (workstudy, partial tuition, full tuition, other) are your seeking from TUNACC?

Names and office telephone number for references of two professors who have taught you. If you are matriculating at Tuskegee University the reference should be from Tuskegee University.

Reference 1____________________ Tel.____________________

Reference 2____________________ Tel.____________________

Applicant's Signature______________________________

Telephone where you can be reached most easily ________________ Daytime

________________ Evening

Date________________________

Please return completed application to:

TUNACC Applicants
Office of the Dean
School of Agriculture and
Home Economics
Rm 100 Campbell Bldg.
Tuskegee University
Tuskegee, AL 36088

Appendix 5 - Tuskegee University NASA Tracking Form

10/92
NTF

Tuskegee University Center for Food Production, Processing
and Waste Management in Controlled Ecological Life Support Systems

Date ____________________

NASA TRACKING FORM

NASA requires us to keep track of individuals who have been part of the Center team.

Campus Address Update

NAME ______________________________ SSN ____________________
Last First Middle

Address ______________________________
Street name and number (Residence Hall,.........)

____
City State Zip Code

Tel. No. ( ) ______________________________
Area Code Number

Permanent Address Contact

Name, address and telephone number of a person who would always know how to contact you (e.g., mother, father, grandparent, etc......)

NAME ______________________________
Last First Middle

Address ______________________________
Street name and number (P. O. Box, Rural route)

____
City State Zip Code

Tel. No. ( ) ______________________________
Area Code Number

Address After Leaving Tuskegee University

Address where you will be located when you leave Tuskegee (please let us know about any changes in address, promotions, job changes, marital status, further education,....

NAME ______________________________
Last First Middle

Address ______________________________
Street name and number (P. O. Box, Rural route,.......)

____
City State Zip Code

Tel. No. ( ) ______________________________

Fax No. ( ) ______________________________

NOTE: the enclosed stamped envelope addressed to the Center Coordinator should make it easy for you to stay in contact with us when you leave Tuskegee University to live somewhere else.

Appendix 6 - *Quantum - Highlighting Commercial Applications of Alabama's Scientific Achievements*

olume 1, No. 3 Summer 1990

Quantum

Highlighting Commercial Applications Of Alabama's Scientific Achievements

THE TRANSGENIC MOUSE

The fascinating diversity of Alabama scientific achievement is most evident in this issue of **QUANTUM.** *From the development of a potential new blood substitute for the world's trauma victims, to the enhancement of food stocks through new growth techniques, Alabama research institutions are consistent leaders in developing commercial solutions to world problems.*

On a periodic basis, this column will feature updates on the progress of OADI companies and other emerging technologies previously featured in **QUANTUM.** *In October 1987, Executive Technologies, Inc. (ETI) became the first tenant company to graduate from OADI. It has achieved remarkable success since that time.*

With just three employees during its start-up phase, ETI developed a full text storage and retrieval software system called SearchExpress. SearchExpress has the capacity to scan and retrieve the equivalent of a small library of information. Since graduation from OADI, over 10,000 copies of SearchExpress have been sold to a customer base totalling over 1,000 users. ETI sales revenues have been increasing each year by 25% since 1987. SearchExpress customers include companies such as Unisys, Rockwell International, and the U.S. Government Printing Office which bought 2,300 SearchExpress programs in March of this year to be used for accessing records concerning the nation's toxic chemical release inventory.

ETI is now located in a new office facility in Birmingham's Southside area and is home to ten employees. Further research is underway on a complementary second product which should be available on the market later this summer. ETI is a great example of focused product management and rapid entrance into a very competitive market. The SearchExpress program has virtually sold itself, following marketing efforts that have been limited to three trade shows a year, target mailings, and no advertising. We congratulate ETI on its success and expect continued growth in years to come.

If you are an individual pursuing inventive concepts, innovative designs, and other technologies with commercial potential, OADI is available to assist you. For further information on the OADI program or to receive an application for tenancy, please contact Gigi Gingras or Clark Gillespy, Program Managers.

We hope you enjoy reading **QUANTUM** *and we welcome your comments and ideas for future editions.*

Martin R. Tilson, Jr.
Director

OF
MIC

The accident victim is bl
death, his body robbed of th
giving oxygen transported b
blood. With a person's life h
the balance, medical rescue
often work with limited reso
race against the clock. Ther
time to determine blood typ
even if known, the particula
type needed may not be imm
available. A solution to this
may be found in the lowly m

AND
MEN

rmingham, Alabama. After
y seven years of intense
arch efforts at The Univerity of
ama at Birmingham (UAB), a
of biochemists has developed
etically altered mouse that can
uce human hemoglobin.
oglobin is the oxygen-carrying
ponent of whole blood that can
e to keep an accident victim
long enough for transportation
ull-service medical care facility
ltimate blood-typing and
fusion.
The production of this human
tance in a lower order animal
esents a major breakthrough in
earch for acceptable blood
titutes," said Dr. Tim Townes,
biochemistry research scien-
Such genetically altered ani-
are often referred to as
sgenic" since the gene of other
nals are transferred to the
ed animals.
get a mouse to produce human
oglobin, the UAB researchers
sed a way to genetically alter the
se so as to make one of its genes
e "human". The experimental
se's fertilized eggs
microinjected with
an alpha globin
beta globin genes.
se human genes evolve during
development and become a part
e mouse's genetic make-up.
transgenic mouse then passes
new trait on to its progeny. These
e are currently producing a
oglobin substance that is
prised of 50 percent human
50 percent mouse
oglobin.
he UAB researchers have a
nt pending on this important
ess for developing a blood
titute. As recently noted in the
York Times, the market for
an blood is extremely large, with between 12 to 14 million units of blood used annually in the United States. Worldwide, this figure is 3 to 4 times larger. In dollars, the annual global market is valued at $8 billion.

The hemoglobin produced from transgenic animals has the substantial advantage of freedom from contagion. Human blood contaminants such a hepatitis and AIDs viruses have simply not been found in the transgenic mouse nor the hemoglobin it produces.

The next step to be taken by the UAB researchers is to form a development company that will refine the microinjection procedure to develop either a strain of mice that will produce 95-100% pure human hemoglobin or a lesser concentration of human hemoglobin that is more easily separated from the co-existing mouse hemoglobin. The development company will seek to

(Continued on back cover)

Auburn, Alabama. With the goal of improving the world's food supply, Auburn University scientists are genetically altering growth genes in fish. Using a method similar to that used on their transgenic mouse counterparts, catfish grown in special research ponds at Auburn have been successfully injected with a human growth hormone gene.

The objective of these efforts is not to grow an abnormally large fish species, but rather to enhance the normal growth process. Instead of taking nine months to mature, a transgenic fish might take six months. On a large scale, this improved growth rate would have a profound impact on the supply of seafood, leading to significantly improved nutrition in the world. "We want to produce a fish that will reach optimum market size more quickly and efficiently," noted Lowell Frobish, Director of AU's Alabama Agricultural Experiment Station. Savings in feed cost and labor would also be obtained, according to Frobish.

Testing is continuing in an effort to determine if the new genetic profile of the transgenic fish can successfully be passed on to succeeding generations.

For more information on transgenic fish, contact Lowell Frobish, Director, Alabama Agricultural Experiment Station, Samford Hall, Auburn University, AL 36849, (205) 844-2237.

SPUD LIGHT

You are millions of miles away from the nearest grocery store and what do you do? This is one of the practical problems facing the United States' space program which will be engaged in long-term manned space missions within 15 years. In setting up and inhabiting an outpost on the planet Mars, as President Bush suggested last June, it will be impossible to bring along sufficient food stocks and impractical to continually resupply the mission crews. There is only one solution to providing three square meals a day.

Tuskegee, Alabama. Tuskegee University is conducting on-going research under the auspices of NASA's Life Sciences Division to study the growth of the sweet potato in a space environment. The sweet potato is one of eight crops being studied that could provide the basis for a balanced and varied diet for a space inhabitant. As part of NASA's "Controlled Ecological Life Support System" program, Tuskegee's research is aimed at hydroponically growing the sweet potato. Hydroponics refers to the growing of plants without the traditional medium of soil.

Media other than soil, such as sand, gravel, and sawdust, were initially evaluated, but these posed potential problems, given the mass and volume limitations on space cargo. The Tuskegee team of over twenty Ph.D. scientists then successfully experimented with a nutrient film technique (NFT), which involves the passing of a thin film of nutrient-enriched water solution over the root system of the sweet potato plant. This NFT method uses no solid growing medium.

Tuskegee's redesigned NFT system

(Continued on back cover)

OF MICE AND MEN

joint venture its efforts with corporate partners.

The refined microinjection and gene alteration technology will be licensed to companies that will apply the technology to larger animals, such as pigs. It is estimated that a "farm" of 10,000 genetically altered pigs could produce enough hemoglobin to supply the world's present needs.

Genetically altered animals can offer other benefits. For example, UAB's process for creating the transgenic mouse has been used to replicate human sickle hemoglobin, the cause of sickle cell anemia. This disease affects 10% of the nation's black population. UAB researchers are working to develop technology that would replace the sickled gene with a normal gene to overcome the disease. "Ultimately, these efforts could lead to the development of gene transplantation technology that will cure diseases in much the same fashion that organ transplants replace defective organs," noted Dr. Townes.

For more information on the "transgenic" mouse, contact Tim Townes, Ph.D., Associate Professor, Dept. of Biochemistry, University of Alabama at Birmingham, University Station, Birmingham, AL 35294, (205) 934-4753.

SPUD LIGHT

has earned the University a patent and is producing sweet potatoes on a consistent basis. The sweet potato plant has several unique aspects. First of all, a small section of the vine can easily be cut off and used to start a new plant, and secondly, the sweet potato serves as a dual vegetable. In addition to the storage root, which we normally think of as the sweet potato, the tender leaves which form near the vine tip make an excellent green vegetable.

The second phase of this research focuses on quantifying parameters (e.g. temperature, humidity, light intensity, etc.) for plant growth using artificial lighting systems and enclosed environments. After basic conditions are determined at Tuskegee, follow-up research with large communities of plants will be conducted at the Biomass Production Chamber (BPC) at the Kennedy Space Center. The BPC is a three-story production facility that will be used to test the sweet potato individually and as it interacts with the other seven space crops. "The Tuskegee Project has already provided much of the baseline information needed for initial training in the BPC," said Ralph Prince, agricultural engineer at Kennedy and technical monitor from NASA for the Tuskegee project.

Research related to the Tuskegee NFT system will not only serve the nation's space agriculture needs but will benefit earth-based farmer[s] providing better information on [how to] more efficiently grow sweet pota[toes] and other related root crops.

For more information, contact [...] A. Loretan, Ph.D., Associate Prof[essor], School of Agriculture and Home [Eco]nomics, Tuskegee University, Tusk[egee] 36088, (205) 727-8333.

BIOREACTO[R]

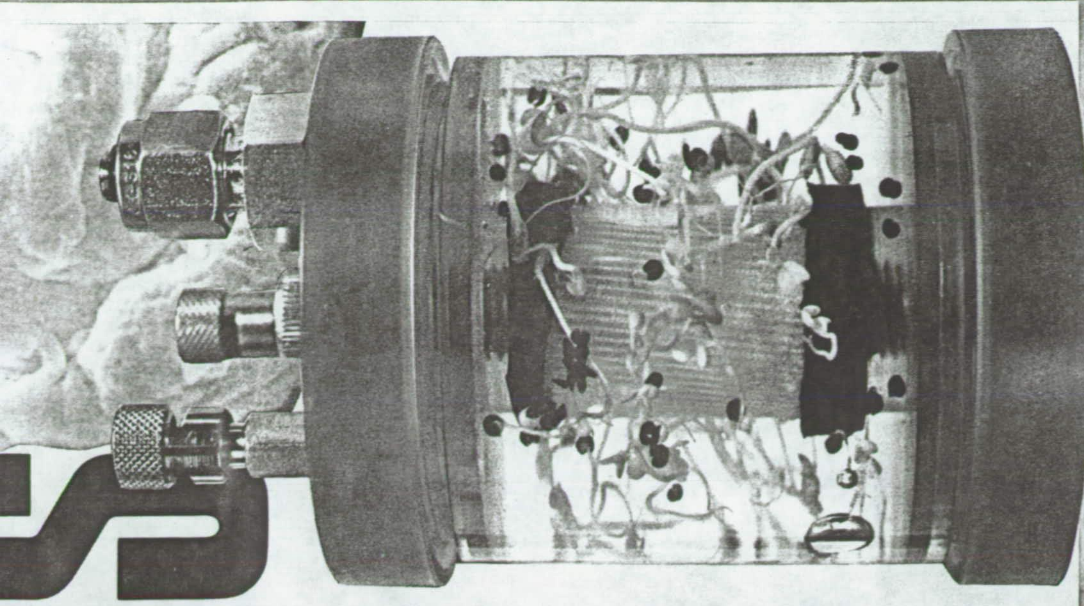
clonal antibodies for medical re[...] and enzymes that dissolve bloo[d ...] heart attack victims.

The growth of bioreactor tech[...] continues at UAH and will hope[...] lead to new discoveries in space [...] earth-based cell research.

For more information on the U[...] bioreactor technology, contact M[...] Lewis, Ph.D., Chief, Bioreactor L[abora]tory, Consortium for Space Life S[...] University of Alabama in Huntsv[ille], Huntsville, AL 35899, (205) 89[...]

Office for the Advancement of
Developing Industries
1075 13th Street South
Birmingham, Alabama 35205

BIOREACTORS



Huntsville, Alabama. In research related to the Tuskeegee effort (see "Spud Light"), The University of Alabama in Huntsville (UAH) is studying the effects of altered gravity on living systems. This is accomplished through the use of a "bioreactor", a device that promotes the reaction of nutrients, such as carbohydrates, proteins, and vitamins with a biological entity, so that life processes are carried out.

Specifically, the UAH bioreactor research focuses on the culture of both plant and animal cells in which the growing conditions can be carefully controlled. The horizontal design of UAH's bioreactor permits the simulation of the micro-gravity conditions of space. Fluid-filled chambers in these bioreactors rotate around a horizontal axis as opposed to conventional vertical bioreactors which propel cells in high motion (similar to an ice cream churn).

It is conceivable that this research will lead to the use of bioreactors to maintain plant stocks during space travel and lunar base habitation. While the UAH bioreactor focus is at the "micro" level (that is, on cell growth), the Tuskegee University research is focused at the "macro" level (that is, on plant growth). Both efforts provide significant benefits to the United States' space program.

Bioreactor technology is equally important for its Earth-based applications. For example, cell "mini-factories" grown in conventional bioreactors produce a vast number of commercial bioproducts such as mono-

(Continued on back cover)

Above: Plant seedlings being cultured in horizontal rotating bioreactor. Top left and right: Three-dimensional image of mammalian cell culture.

Quantum

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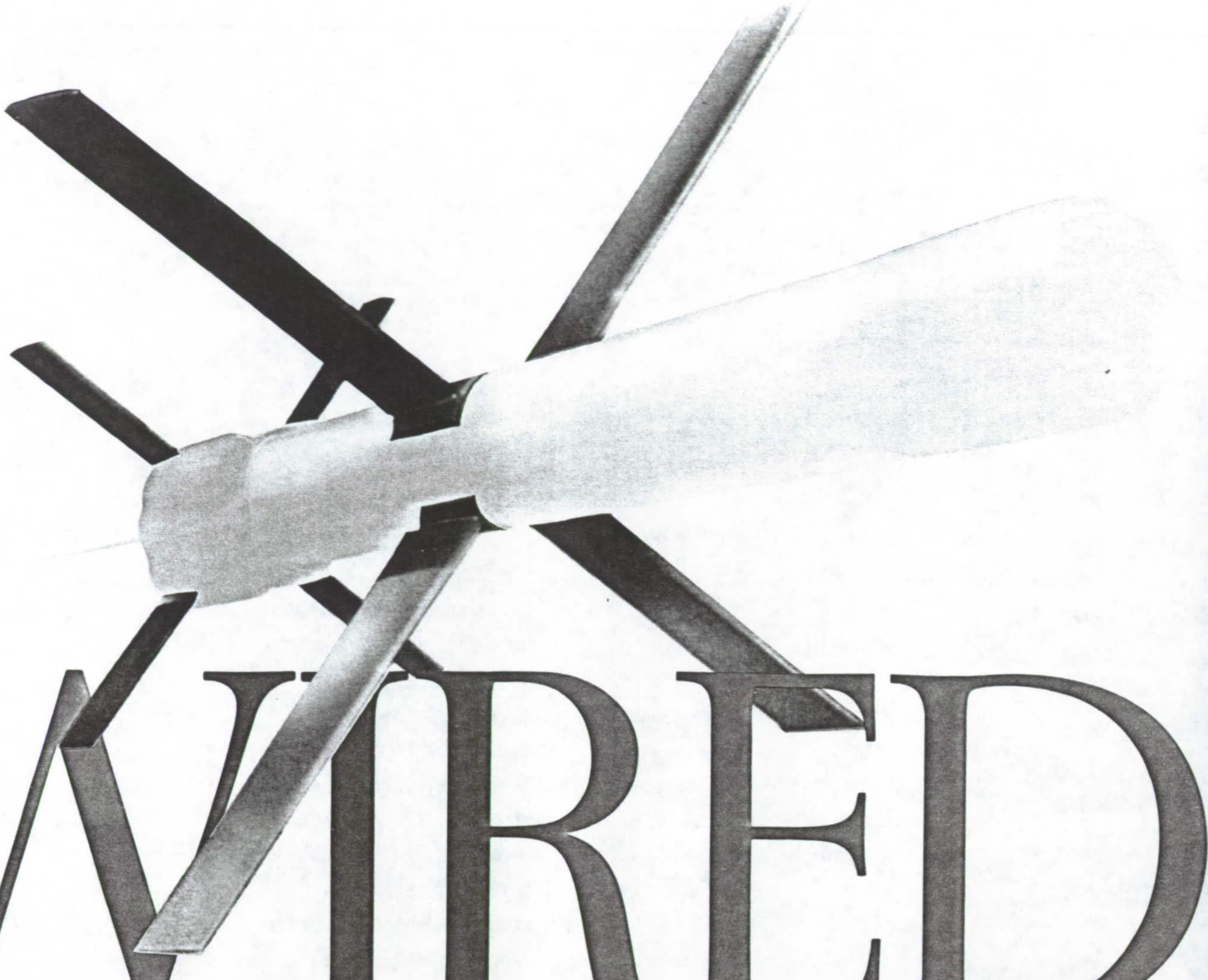

WIRED

The modern combat soldier has to be as much of an electronics wizard as he does a marksman or hand-to-hand combat expert. The weapons of conventional war now incorporate the most sophisticated technology available—microchip circuitry, advanced composite materials, fiber optics, and infrared video technology.

Birmingham, Alabama. The SRT-2000 "Programmable Tracker", engineered by Southern Research Technologies, Inc., (SRT) is a device that can be used to pinpoint targets located several kilometers away and is a vital new tool for the military.

This new device was originally developed to guide missiles to specific battlefield targets such as tanks. The fiber optic guided missile, or FOG-M, is equipped with a small imaging seeker (a low-cost TV camera) that relays what it "sees" back to the video processing hardware operated by ground personnel. One of the unique features of this system is that the missile and ground-based hardware are physically linked by a tiny fiber optic cable, which the missile pays out during its flight. Because the system utilizes fiber optics instead of radio waves for transmission, it is immune to jamming or other interference. The missile can readily be guided to direct hits on targets that are clearly viewed on monitors while the gunner remains in relative safety several kilometers away. In a conventional warfare setting, this system should not only save lives but also require fewer military personnel to eliminate enemy weaponry.

The SRT-2000 has a remarkably effective "tracking gate," which is a video overlay that surrounds the target on the monitor and separates it from the background. The target is followed manually with the tracking gate until the tracker locks on to the target; the tracker then follows that portion of the video screen that it now knows is the target and continuously feeds the location coordinates to the missile guidance computer. The system's overall advantages are its low cost, immediate availability, and an abundance of special features usually found only on more expensive systems.

The same technology could be used for surveillance purposes in, for example, an unmanned, remote-controlled ground-based vehicle. In this application, the use of the fiber optic scanning device would be a much more effective means of locating enemy positions and perhaps decreasing fatalities which might arise from direct human surveillance techniques.

The developer of the system, Sou ern Research Technologies, Inc., is wholly-owned subsidiary of Southe Research Institute, located in Birm ham, Alabama. The engineers at S have been designing, developing, a fabricating tracking systems since 1963. SRT's work on the first adap gate, optical-contrast tracker aided the development of the Maverick m sile. SRT is the exclusive developme contractor for the U.S. Army's FOG missile, which incorporates the SRT 2000 Programmable Tracker.

For more information on the SRT-20 Programmable Tracker, contact Eddie Odom, Product Marketing Manager, Southern Research Technologies, Inc., P.O. Box 12727, Birmingham, AL 35202, (205) 581-2900.

Appendix 7 - Agenda and Minutes of Advisory Committees

Site Visit
to the
Tuskegee University Center for Food Production Processing and Waste Management in Controlled Ecological Life Support Systems.

AGENDA
November 19 - 20, 1992

November 19, 1992

8:00p.m.	Holiday Inn - Opelika, AL Viewing of "Space Farms - The Adventure of Discovery" (27 min PBS special on Tuskegee University NASA Sweetpotato Research)-Dr. Raymond Wheeler

November 20, 1992

9:00a.m.	Project Overview - President's Board Room Dr. Benjamin F. Payton, President Tuskegee University On-Campus Advisory Committee, William L. Lester, Chrm. Center Working Group Leaders
9:30a.m.	Technical Progress Review - Center Working Group Leaders Growing Systems and Environmental Factors (GRO) Germplasm Development (GED) Waste Management and Recycling (WAM) Microgravity Applications and Controls (MAC) Plant Modeling (PAM) Nutrition and Food Processing (NAF)
11:00a.m.	Tour of Facilities and Student Presentations - Greenhouse/Environmental Growth Chambers Plant Molecular Genetics Laboratory Engineering-Microgravity Applications and Controls Lab
12:30p.m.	Working Lunch - Charles E. Tompkins Hall (Team) Continuation Proposal Review Interaction with Working Groups
2:15p.m.	Site Visit Team Meeting - Charles E. Tompkins Hall
2:45p.m.	Site Visit Team Response and Exit Comments - President's Board Room Benjamin F. Payton, President (Team Leaders and Advisory Committee)
3:00p.m.	Site Visit Team Departure

Minutes
Semi-Annual Meeting
of the
Tuskegee University NASA/CELSS Center (TUNACC)
On-Campus Advisory Committee
September 11, 1992
1:00-3:00p.m.
Rm 108 Campbell Building

Present: Dr. William L. Lester (Chrm), Deans Ollie Williamson and Walter A. Hill, Phil Loretan (sec'y), Desmond Mortley, Conrad Bonsi, J. Y. Lu, Heshmat Aglan and Audrey Trotman.

A. Viewing Video - "Space Farm - the Adventure of Discovery" (27 mins) produced by PBS and Kurtis Productions.

B. Technical presentations by leaders of the functional working groups: Growing Systems and Environmental Factors (GRO), Germplasm Development (GED), Nutrition and Food Processing (NAF), Microgravity Applications and Controls (MAC), Waste Management and Recycling (WAM) and Plant Modeling (PAM).

C. Business Meeting
1. Review of Tractell Document - Consideration by Committee of wide range of issues to be considered by University and leadership of TUNACC Center.
2. Students - A compilation of information about all 28 student awardees was distributed.
3. Faculty - the status and/or changes in status of faculty and staff at the Center was discussed, including Garner and Grant (specialists hired), three potential postdoctoral positions and faculty (Obiozor, Clayton, Kamau and Jeelani).
4. Semi-Annual Report - A draft of the semi-annual report was distributed for review.
5. Renovations - Possible renovations needed for the Center were discussed. Dr. Lester and Dr. Hill will draft a letter to Dr. Payton requesting permission to initiate the planning phase for these.
6. Addendum to Original Proposal - A proposal for funds over and above those listed in the original proposal, will be written for year 2 to meet unanticipated needs in building infrastructure on the Campus. They will include funds for: additional support for student training; optical fiber cable to increase the networking capability on campus; renovation costs and support for one or more postdoctoral and technician positions. Dr. Lester and the Committee will seek Dr. Payton's support in soliciting these funds and encouraged TUNACC to proceed with writing an addendum to the proposal.

D. Response and Summary -

Dr. Lester requested that TUNACC prepare a clear policy on authorship of team publications since this could be a later source of difficulty.

TUNACC was commended on their initial efforts and urged to continue to progress.

E. Adjourn - 3:15p.m.

Attachments - Handouts.

Semi-Annual Meeting
of the
Tuskegee University NASA/CELSS Center (TUNACC)
On-Campus Advisory Committee

AGENDA
September 11, 1992
1:00-3:00p.m.
Rm 108 Campbell Building

On-Campus Advisory Committee Members

William L. Lester, Chairman	James Ferguson
Ollie Williamson	Shaik Jeelani

Presiding - William L. Lester

1:00p.m. Welcome - William L. Lester

Perspective - Walter A. Hill

PBS & Kurtis Productions Space Agriculture Video

1:30p.m. Technical Presentations by Group Leaders - Phil Loretan
- Growing Systems and Environmental Factors (GRO) - Desmond Mortley
- Germplasm Development (GED) - Conrad Bonsi
- Nutrition and Food Processing (NAF) - J. Y. Lu
- Microgravity Applications and Control (MAC) - Heshmat Aglan
- Waste Management and Recycling (WAM) - Audrey Trotman
- Plant Modeling (PAM) - Conrad Bonsi

2:30p.m. Business Meeting
- Tractell Review Areas
- Students
- Faculty
- Semi-Annual Report (Draft)
- Renovations
- Addendum Proposal Outline

2:45p.m. Response and Summary - On-Campus Advisory Committee

THE TRACTELL PROJECT WITH THE NASA-HBCU RESEARCH CENTERS OF EXCELLENCE

INTRODUCTION

TRACTELL, Incorporated, Dayton, OH, serves as a subcontractor to the National Aeronautics and Space Administration (NASA) for the purpose of providing technical assistance to each of the seven Research Centers of Excellence at Historically Black Colleges and Universities (HBCUs). The TRACTELL technical assistance perspective covers a *Total Quality Management* (TQM) approach to the operation of these centers in the context that organizational efficiency is combined with operational efficiency for maximum overall benefits to the institution and to NASA in achieving the prime objective of significantly increasing the number of minority scientists and engineers. This project is sponsored by the Minority University Research and Education Program (MUREP) under the direction of Dr. Samuel Massenberg (NASA Headquarters, EU, 202-358-0970).

In the TRACTELL TQM approach, people, processes, organizations, and operations are interlinked over time to achieve a specified goal with optimum effort. Moreover, for each center, the operation is examined by TRACTELL from the perspective of positive and *total* integration of center activities into the institution such that the MUREP goal to strengthen the infrastructure of the institution can be achieved.

TECHNICAL ASSISTANCE EFFORTS

TRACTELL will provide technical assistance through on-site reviews, communique, and personal interactions with center personnel and others as appropriate. TRACTELL will make an initial visit to each Center and summarize guidelines for project execution and project administration. The objective of the initial visit is to assist the center director in developing a project management plan which will accomplish the objectives of the respective center in a manner consistent with the NASA MUREP program goals. The project management plans will include milestones networked to identify critical paths, resource requirements, intermittent evaluation, and quality control check points. Follow-up visits will be made as requested by the institution or the Director, MUREP.

As required, subsequent TRACTELL interactions will focus on specific issues identified by the Center, TRACTELL, or the Director, MUREP. Emphasis will be given to assisting individual principal investigators in project management, developing effective presentation skills, identifying additional sources of support for NASA Center activities, and other areas as needed. Each review, however, will be center-specific. Observations, comments and recommendations will be presented in a bi-monthly report to the Director, MUREP.

OUTLINE OF THE TRACTELL REVIEW AREAS

The TRACTELL team will continually interact with each NASA HBCU Research Center with emphasis on providing reviews on a wide range of issues to include but not be exclusively confined to the following areas.

- **PROJECT PLANNING AND EXECUTION**

PROJECT PLANNING

Publicity of Award to Institution
Milestoning Efforts - Progress Indicators
Employment of TQM Techniques
Reporting Requirements
Staffing
Symposia Design
Preparation for Center Review Visits
Preparation for Student Inclusion in Research
Grant Renewal Requirements

PROJECT EXECUTION

Research Progress
Visitation by PIs and Co-PIs to NASA Centers
Inclusion of Minority Faculty in Center Research
Incorporation of Minority Students in Center Research
Release Time Rules and Teaching Loads
Minority Business Enterprise Sub-Contracting
Majority or Minority Institution Linkages (Nature and Extent)
Quality Control of Research Results
Project Documentation and Record Keeping
Symposia and Site Visits by NASA Personnel

PLANNING FOR MINORITY STUDENT PARTICIPATION

Student Identification and Tracking
Student Retention
Student Summer Research Activities
Student Participation in Research Symposia
Student Publications

- **INSTITUTIONAL COMMITMENT AND INTEGRATION**

  Institutional Commitment
  Employment of TQM Techniques
  Infrastructure Growth Based on NASA Intervention
  Institutional Oversight of Center
  Relationship of Center to Academic Structure
  In-Kind Contributions

- **RESEARCH ADMINISTRATIVE SUPPORT SERVICES**

  Administrative Support for Sponsored Research Programs
  Accounting System for All Funds
  Literature Search Services
  Liaison with NASA
  Record Keeping

- **PROJECT DOCUMENTATION AND PROGRAM IMPACT**

  Availability of Project Documentation
  Adequacy and Completeness of Documentation
  Research Progress and Measurement Methods
  Minority Faculty Participation
  Faculty Research Contributions
  Student Research Participation
  Mainstreaming of Research
  Infrastructure Growth Based on NASA Intervention
  Minority Student Integration and Progress
  Student Tracking Methodology
  Student Retention
  Number of Graduate Students Produced
  Consistency of Goals with MUREP Requirements

- **GENERAL ASSESSMENT**

  Summarize Observations Regarding Each Center
  Summarize Assessments Relative to Overall Goal
  Provide Comments Directed to Center/Institution
  Report to NASA (MUREP)

Center For Food Production, Processing and Waste Management For CELSS
Student Scholarship and Research Assistantship Recipients, 1992-93

Group	Student Name	Major	Classification	Gender	Citizenship	Underrep Minority	GPA	Graduation Date	Award	Amount	Student SSN	Major Professor /Supervisor
GRO	Stephanie Burrell	PLSCI	Grad	F	USA	Y	2.6	1994	S/RA	$3,277 + 1966	437-55-7444	Mortley/Trotman
	Brendalyn Gill*	PLSCI	SR	F	USA	Y	2.5	1992	RA	3,277 + 990	254-53-9727	Mortley/Garner
	Victor Crocker*	PLSCI	SO	M	USA	Y	2.8	1995	RA	2,600 + 990	255-43-8976	Loretan
	Beverly Smith	BIOL	SR	F	USA	Y	2.7	1993	RA	1,639 + 990	254-55-9350	Mortley/Garner
	Derrick King	PLSCI	FR	M	USA	Y	3.1	1996	S	3,277	423-17-6901	W. Hill
MAC	Johnnifer Brown**	ME	SR	F	USA	Y		1993	RA	990	418-23-5742	Aglan
	Rudzoni Tshitahe	ME	Grad	M	RSA	Y	4.0	1994	RA	1,966	190-72-9048	Aglan
	Emory Carter***	EE	Grad	M	USA	Y	3.5	1993	RA	1,996	473-92-0221	Aglan
	Michelle Taylor***	EE	Grad	F	USA	Y		1992	RA	1,966	497-84-0613	Aglan
	Michelle Douglas	EE	Grad	F	USA	Y	3.0	1993	S/RA	3,277 + 1,966	350-62-5182	Loretan
	Varnachele Forbes	EE	Grad	F	USA	Y	2.7	1993	S/RA	3,277 + 1,966		Loretan
NAF	Wil Ofori	FDSCI	Grad	M	Perm Res	Y	3.6	1993	RA	1,966	416-11-1080	Kamau/Lu
	Ava Bozeman*	FDSCI	SO	F	USA	Y	3.1	1995	S/RA	3,277 + 990	255-101-3695	Lu
	Felicia Coles	FDSCI	JR	F	USA	Y	2.6	1994	RA	990	310-72-7515	Lu
PAM	David Johnson	CS	SR	M	USA	Y	3.1	1992	S/RA	1,639 + 990	589-10-8478	J. Hill
	Vicent Varner	CE	SO	M	USA	Y	3.4	1995	S/RA	1,639 + 990	254-33-1170	J. Hill
GED	Dionne Wells	BIOL	SR	F	USA	Y	3.4	1993	S/RA	3,277 + 990	580-15-5840	Prakash
	P. Young-Curtis	BIOL	SR	F	USA	Y	2.5	1993	RA	990	417-19-9269	David/Bonsi
	R. Gosukonda	PLSCI	Grad	M	India	N	3.8	1993	RA	1,966	422-37-4887	Prakash
WAM	Deloris Alexander	ENSCI	Grad	F	USA	Y	3.0	1995	S/RA	3,277 + 1,966	421-29-1877	Trotman
	Xiao Zhou	FDSCI	Grad	F	China	N	3.9	1992	RA	1,966	422-35-0965	Almazan
	Robert Cooper	EE	Grad	M	USA	Y	2.9	1993	RA	1,966	258-35-7823	Aviki
	Samantha Jenkins	CE	SR	F	USA	Y	2.8	1992	S/RA	1,639 + 990	417-84-3988	Trotman/Almazan
	Paul Drummond	ANSCI	SR	M	Jamaica	Y	3.7	1993	RA	990	416-37-2688	Trotman

*Awarded a Space Grant Scholarship in Association with the Center
** National Science Foundation Scholarship
*** GEM Scholarship

TOTAL AWARDS = $68,798
LIFE/AGRICULTURAL SCIENCES = 14 STUDENTS
ENGINEERING/COMPUTER SCIENCE = 10 STUDENTS
MALE = 10
FEMALE = 14
US CITIZENS/PERMANENT RESIDENTS = 20
INTERNATIONAL STUDENTS = 4

STATUS OF NEW FACULTY AND STAFF DESIGNATED IN THE PROPOSAL

Position	*Current Status*	*Comments*
Plant Specialist, GRO group	Hired L. Garner, 6/92, B.A. in Biology, William & Mary College; considerable greenhouse and laboratory experience	Working out very well; female, U.S. citizen
Food Science Specialist, NAF group	Hired P. Grant, 6/92, M.S. in Food Science, Tuskegee University; worked on the project as a graduate student	Working out well; female, underrepresented minority form the Bahamas
Post Doctorate, GED group	Position offered 9/92, to a Ph.D. in Molecular Biology with a food and plant science background	21 applicants; the candidate selected is a female, underrepresented minority, permanent resident
Post Doctorate, PAM group	Position advertised; few applicants; propose immediate hire of a highly qualified applicant with a bachelors degree in mathematics, M.S. in computer science and considerable plant science research experience	the candidate proposed is a US citizen and an African-American female; the candidate will be encouraged to seek the Ph.D. degree; additional funding is available from another grant to continue to seek the post-doc position
Post Doctorate,WAM group	Scheduled for hiring in the 2nd year of the project	priority will be to obtain a person with a Ph.D. in Engineering with waste management experience

CHANGE IN STATUS OF ORIGINAL FACULTY AND STAFF DESIGNATED IN THE PROPOSAL

Person/Position	*Change*	Comment
C. Obiozor, Electrical Engineer	reduced time on the project	inadequate progress
Clayton, Electrical Engineer	added to the project	replacement for Obiozor
D. Kamau, Food Technologist	added as a co-investigator, NAF	
S. Jeelani, Acting Head, School of Engineering and Architecture	replaced Vascar Harris on the local advisory committee	

Semi-Annual Report

Submitted to

Dr. Samuel Massenburg, Director
Minority University Research and Education Program
National Aeronautics and Space Administration
Washington, D.C. 20546

September 16, 1992

Tuskegee University Center
for Food Production, Processing and Waste Management
in Controlled Ecological Life Support Systems

Room 100 Campbell Building
Tuskegee University
Tuskegee, AL 36088

The Tuskegee University Center for Food Production, Processing and Waste Management in Controlled Ecological Life Support Systems (TUNACC) was approved in January 1992 and effectively initiated in April 1992. The overall goal of the Center is to develop information, technologies and talent for growing and processing selected food crops and their related wastes in controlled ecological life support systems (CELSS) for future long-term manned space missions. The Center will serve as a training ground for students, especially minority students, at all levels in science and engineering relative to the nation's space program.

The Center is composed of six functional working groups that interface on a continuous basis. In line with the specific proposal objectives the major responsibilities of each working group within the Center are outlined below:

Growing Systems and Environmental Factors (GRO) - To ascertain the best systems and environmental conditions for growing sweetpotato and peanut hydroponically for space missions.
Nutrition and Food Processing (NAF) - To analyze the nutrient composition of the edible parts (greens and roots/nuts) of plants grown under controlled environmental conditions and process these parts into a variety of nutritious and palatable foods.
Germplasm Development (GED) - To examine the germplasm available for peanut and sweetpotato; to select and breed the best lines for growing in a CELSS and manipulate them, when possible, to further improve them.
Waste Management and Recycling (WAM) - To ascertain quantities of inedible plant biomass available from sweetpotato and peanut in a CELSS, to analyze them for chemical composition and to establish how all organic and inorganic waste resources from hydroponic culture of these crops will be recovered and recycled in CELSS.
Microgravity Applications and Control (MAC) - To adapt our hydroponic growing systems for use under microgravity conditions and to design and build control systems required for the project.
Plant Modeling (PAM) - To establish a database from existing information, recommend and design experiments for retrieving needed information and, based on these data, produce mathematical relationships that will lead to models of plant growth and yield for sweetpotato and peanut in a CELSS.

Accomplishments to date:

1. **Research status -**

GRO: Variability of sweetpotato grown under the same environmental conditions in different growth chambers has been examined and results are being analyzed. The effect of biweekly foliage topping on sweetpotato is being studied for cv 'TI-155'. The initial hydroponic growing systems for peanut are being evaluated. The effect of pH on growth of sweetpotato continues with 'Ga Jet' cultivar presently being studied.

NAF: Nutritive composition of 'TI-155' sweetpotato biweekly shoot tip harvests have been determined and results are being analyzed. Nutritive composition analysis of 'Georgia Red' peanuts is in progress as biweekly field harvests continue. Processing of sweetpotatoes into flour and subsequently using up to 20% mixed with wheat flour in noodles for use as a space food continues with sensory evaluation indicating high acceptability.

GED: Field evaluation of over 150 accessions and selection of sweetpotato breeding lines for high dry matter (at least 25%) has been completed. Greenhouse evaluation of 17 of these selected high dry matter sweetpotato lines for adaptation to NFT system is in progress. Field evaluation of 'Georgia Red' peanuts is continuing and five additional peanut cultivars will be evaluated in the NFT system. Introduction of ASP-1 gene in sweetpotato has begun by establishing a reliable method to regenerate sweetpotato shoots adventitiously *in vitro*. Development of a reliable gene transfer system for peanut is being initiated by multiplying six candidate lines in the greenhouse. A postdoctoral research associate position has been offered to one of 22 applicants with experience or background in plant breeding and genetic engineering.

WAM: Determination of the proportion of edible to inedible portions of sweetpotato was done by analyzing data previously collected and chemical analysis of these different portions are in progress. Preliminary results from studies characterizing the microbial population in GRO NFT systems indicate that the nutrient solution composition influences the size of the microbial population.

MAC: A study of the existing stainless steel membrane nutrient delivery system indicated that the pore size was not uniform throughout and that flow along the length of the membrane was irregular. A survey of the literature in order to identify candidate membrane materials has focused on titanium and ceramic membranes that can offer better corrosion resistance than stainless steel. Two channels have been designed, constructed and are being tested, one with a titanium membrane and one with a stainless steel porous plate. Two computers and data acquisition systems have been acquired for control system development with the above systems.

PAM: A candidate with a mathematics background has been offered a position in plant modeling following a search for such personnel. Selected potato models have been ordered for modification and adaptability to sweetpotatoes. National networking capability for the campus is being sought by tying in to the Alabama Supercomputing Authority.

2. Workshop for TUNACC members and other administrators, faculty and staff -

A workshop sponsored by the NASA MUSPIN office on networking is scheduled on campus for September 24 and 25 for network users and managers.

3. Consultants to TUNACC Center -

Ralph Prince, a retired agricultural engineer from NASA Kennedy Space Center has visited the Center three times (May 12-14, July 14-16, August 18-20) to assist with working group plans and implementation. Richard Brown, control systems specialist at Georgia Institute of Technology, Atlanta, GA visited TUNACC September 14-16, 1992 to assist with control system development. Jill H. Hill, computer systems analyst, assists regularly with statistical analysis and environmental monitoring in greenhouse and growth chambers and computer-assisted fiscal management of the Center.

4. Travel by Team Members -

Four members attended the Fifty-second Annual Meeting of the Southern Region of the American Society of Horticultural Science in Lexington, KY on Feb. 1-5, 1992.

Seven members attended the Hydroponics Society of America Meeting, Orlando, Florida with tours of *Kennedy Space Center CELSS Project* and Epcot Center Land Exhibit, April 9-12, 1992.

Two members attended the Institute of Food Technologists, meeting in New Orleans, LA, June 20-26, 1992

Two members attended the 89th Annual Meeting of the American Society for Horticultural Science Meeting, Honolulu, Hawaii, July 30-August 6, 1992

One member attended the Space Station Freedom Utilization Conference, Huntsville, AL August 4-5, 1992

One member attended the World Space Congress - Cospar '92 Meeting, Washington, D. C., August 31-September 4, 1992.

Eight members will attend the Association of Research Directors Ninth Biennial Symposium, Atlanta, GA October 4-8, 1992.

Four members will attend the "Sweetpotato in Space" Symposium at Kagoshima University, Kagoshima, Japan and the Japanese Sweetpotato Symposium in Tokyo, Japan, November 25-December 2, 1992.

5. Minority Student Involvement -

Twenty-four students are working with the TUNACC team. Characterization of these students includes: 11 graduate/14 undergraduate, 14 life-agric sciences/10 engineering-computer sciences, 10 males/14 females, 20 U.S. citizen-permanent residents/4 international **and 22 out of 24 are underrepresented minorities**.

6. Inclusion of Minority Faculty -

Of the 20 faculty on the TUNACC team, eleven are underrepresented minorities and five are women. We have recently offered a post-doctoral research associate position in molecular biology to a female underrepresented minority.

7. 1992 Publications and Presentations -

Hill, W. A., D. G. Mortley, C. L. Mackowiak, P. A. Loretan, T. W. Tibbitts, R. M. Wheeler, C. K. Bonsi and C. E. Morris. 1992. Growing root, tuber and nut crops hydroponically for CELSS. Adv. Space Res. 12(5):125-131.

Bonsi, C. K., P. A. Loretan, W. A. Hill and D. G. Mortley. 1992. Response of sweetpotatoes to continuous light. HortScience 27(5):471.

Grant, P. J., J. Y. Lu, D. G. Mortley, P. A. Loretan, C. K. Bonsi and W. A.Hill. 1992. Nutrient composition of hydroponically grown sweetpotato storage roots as affected by frequency of nutrient solution change. (Accepted for publication in HortScience)

Mortley, D. G., C. K. Bonsi, W. A. Hill, P. A. Loretan, C. E. Morris, A. A. Trotman and P. P. David. 1992. Response of sweetpotato grown in NFT to different photoperiods. HortScience 27(6):177 (Abstract).

Loretan, P. A., C. K. Bonsi, D. G. Mortley, R. M. Wheeler, C. L. Mackowiak, W. A. Hill, C. E. Morris, A. A. Trotman and P. P. David. 1992. Effect of several environmental factors on sweetpotato growth. Paper 4.3-M.1.06. World Space Congress-1992, Washington, D.C. Aug. 31-Sept. 4, 1992. Submitted for publication in Adv. Space Res. (In review)

Mortley, D. G., C. K. Bonsi, W. A.Hill, P. A. Loretan and C. E. Morris. 1992. Sweetpotato growth and yield in nutrient film technique in response to irradiance and nitrogen to potassium ratio. Crop Science (In review).

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a. David, P. P., A. Almazan, C. K. Bonsi, D. G. Mortley and A. A. Trotman. 1992. Effects of biweekly topping on nutrient content of shoot tips and storage root yield of sweetpotato grown in an NFT system.

b. Trotman, A. A., D. G. Mortley and P. P. David. 1992. Effect of inoculation with *Azospirillum brasilense* on foliage and storage root yield of sweetpotato grown hydroponically in an NFT system.

c. Trotman, A. A., D. G. Mortley and P. P. David. 1992. Influence of horizontal versus vertical growth pattern on yield of sweetpotato grown in a nutrient film technique (NFT) system.

d. Gill, Brendalyn. 1992. Growth of sweetpotato in aeroponics compared to nutrient film technique.

To be presented at Association of Research Directors Ninth Biennial Symposium, Atlanta, GA, Oct. 4-8, 1992.

a. David, P. P., C. K. Bonsi, A. Almazan, D. G. Mortley and A. A. Trotman. 1992. Effects of biweekly topping on nutrient content of shoot tips and storage root yields of sweetpotato grown in an NFT system.

b. Mortley, D., C. Bonsi, P. Loretan, W. Hill, C. Morris, A. Trotman and P. David. 1992. Sweetpotato growth in nutrient film technique in response to varying photoperiods.

c. Aviki, F., S. Adeyeye, P. Loretan and D. Mortley. 1992. Growing sweetpotatoes hydroponically using a stainless-steel membrane.

d. Trotman, A. A., D. G. Mortley and P. P. David. 1992. Effect of inoculation with *Azospirillum brasilense* on nutrient uptake, foliage and storage root yield of sweetpotato grown hydroponically in an NFT system.

e. Almazan, A. M., P. Grant and D. Mortley. 1992. Sugar beet greens - a potential vegetable for the space station.

f. David, P., E. Martinez, C. Bonsi, D. Mortley, W. Hill, P. Loretan and C. Morris. 1992. Effect of constant pH vs periodic pH adjustment of nutrient solution on yield of sweetpotato using the nutrient film technique.

g. Mortley, D. G., P. Loretan, W. Hill, A. Trotman, P. David, C. Bonsi and C. Morris. 1992. Frequency of nutrient solution change affects yield and nutrient uptake of sweetpotato grown by use of nutrient film technique.

h. Trotman, A. A., C. E. Morris, D. G. Mortley and P. P. David. 1992. A new method for growing peanut hydroponically in an NFT system.

i. Gill, Brendalyn K. 1992. A comparative study of sweetpotato in two hydroponic systems.

8. Total Quality Management (TQM) -

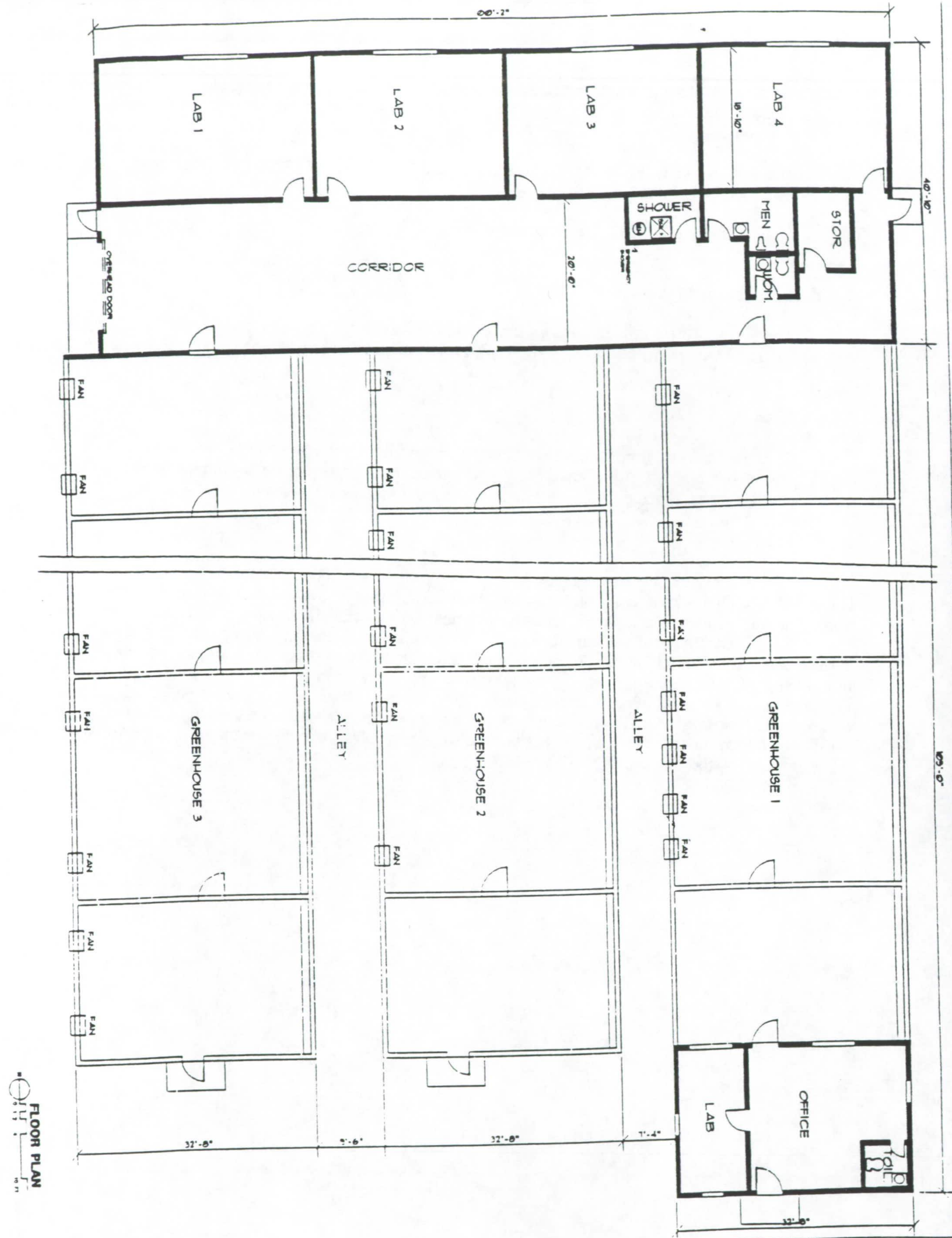
The Project Director, the Deans on the TUNACC Advisory Committee and two of the engineering faculty members of TUNACC participated in a week-long TQM workshop at Procter and Gamble Corporation, Cincinnati, Ohio.

9. Staffing -

Two staff specialist positions have been filled with the Center and one of those new staff members is an underrepresented minority. An offer has also been made to an underrepresented minority applicant (permanent resident) to fill a postdoctoral position. All three of these individuals are women.

10. Publicity -

The January 23, 1992 issue of Tuskegee Gram (circulation:3000) announced the Center grant to Tuskegee University and also served as a "news release" to outside print and video media concerning it. In addition, the Spring/Summer issue of Tuskegee Horizons (circulation:7000) carried the announcement. A color brochure (25,000 copies) titled "Space Agriculture," produced by Tuskegee University also announced the fact that the university was designated a Center for this work. Flyers and applications were also distributed on campus and sent to other HBCU's introducing TUNACC and hoping to attract prospective students to the Center. A video produced by Kurtis Productions and the Public Broadcasting System (PBS) for the "New Explorer" Series on PBS highlights the work of the Center based on the tradition of the work of George Washington Carver on the sweetpotato to research needed for it to be a food for space missions. This series also targets public school systems for classroom use and, for one, was purchased by the Chicago School System.

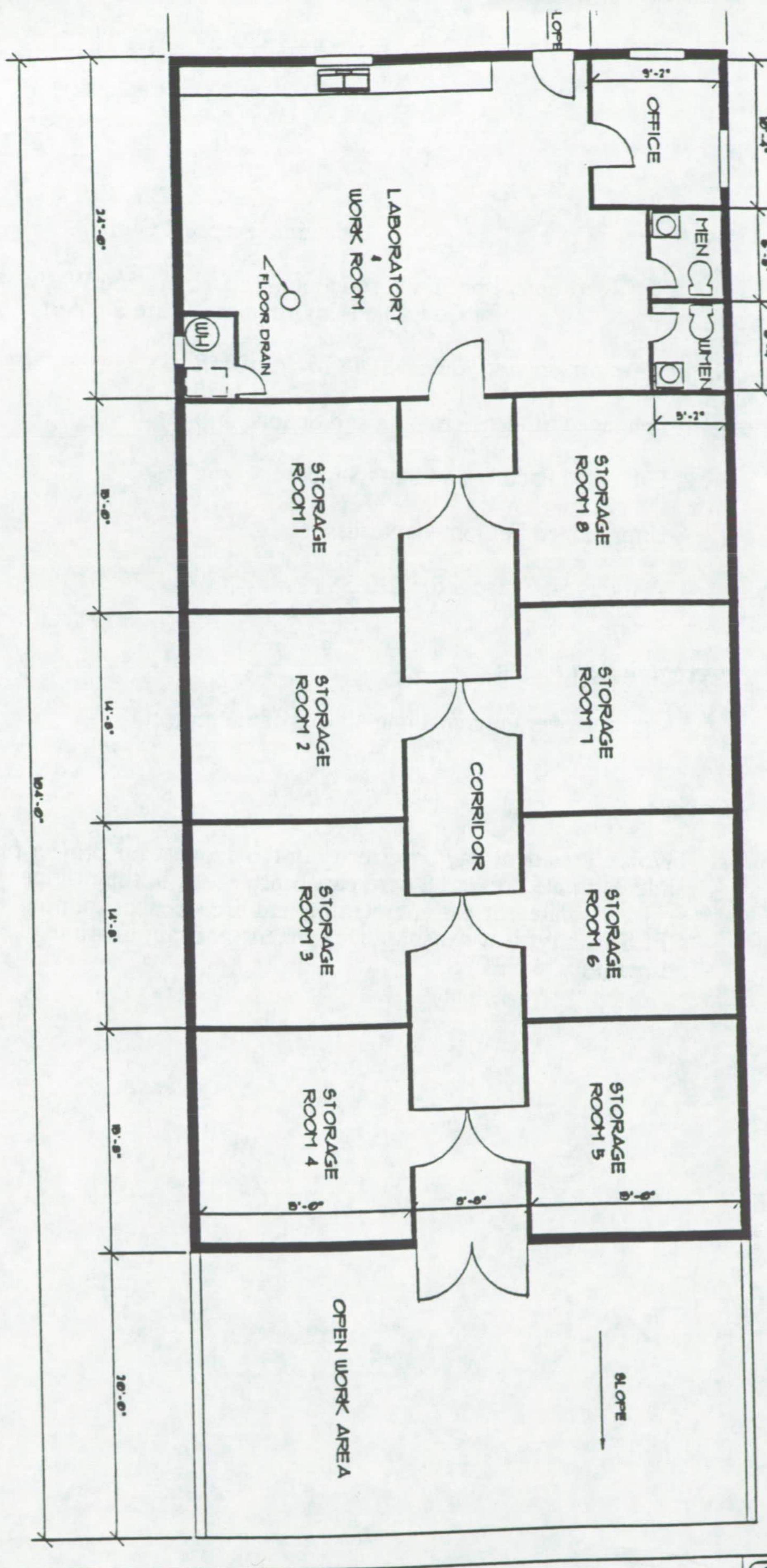


EXISTING GREENHOUSE COMPLEX
TUSKEGEE UNIVERSITY EXPERIMENT STATION
TUSKEGEE INSTITUTE, ALABAMA 36088

SHEET TITLE: FLOOR PLAN
DATE: SEPTEMBER 7, 1991
DRAWN BY: TONTE PETERS
CHECKED BY: DR. LORITAN

SHEET NO. A-1

peters design



FLOOR PLAN

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SHEET NO.: A-1	SHEET TITLE: FLOOR PLAN DATE: SEPTEMBER 11, 1991 DRAWN BY: TONTE PETERS CHECKED BY: DR. LORETAN	EXISTING POTATO CURING HOUSE TUSKEGEE UNIVERSITY EXPERIMENT STATION TUSKEGEE INSTITUTE, ALABAMA 36088

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Addendum Proposal Outline

Center For Food Production. Processing and Waste Management
for Controlled Environmental Life Support Systems

Areas of Need for Enhanced Research Core Capability

1. Enhanced Student Training and Scholarships

2. Enhanced Faculty and Staff Support

3. Unpredicted Equipment Needs

4. A focus on Sensors for CELSS

Projected Budget Increase

$3 million over the remaining 4 years of the project

Approach

Involve President Payton directly in this request for project fund enhancement based upon underestimated research core capability needs in the original proposal and progress of the project to date. Stress engineering and life sciences training, participation in space station CELSS activities, sensor development and application of molecular genetics to plant adaptability in CELSS.