

Final Report

**Grant Number 12-25-B-0814
Specialty Crop Block Grant Program
South Carolina Department of Agriculture**

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Introduction

The South Carolina Department of Agriculture (SCDA) received \$130,264.00 from the Specialty Crops Block Grant Program Number 12-25-B-0814. The SCDA used these funds in promoting specialty crops grown in the state at industry trade shows, updating the manual for the Certified Nursery Professionals Program, expanding the farm to fork “Fresh on the Menu” program, providing funds for research to determine the quality and nutritional value locally grown fruits and vegetables, and assisting the marketing efforts for our three State farmers markets to provide additional opportunities for vendors by increasing the number of people visiting these markets.

Project 1 – Trade Shows

Project Summary:

Trade show participation allowed the SCDA Certified SC Grown Branding Program to have an expanded presence at key domestic trade associations’ annual exhibit and conference offerings. The SCDA staff members promoted locally grown specialty crops by presentations at the booth level that interfaced with key retail chain executives as well as foodservice decision makers and wholesale distributors, to provide merchandising insight to place locally grown fruits and vegetables in an exciting ‘purchase me fresh’ and ‘near to my home’ category. We were able to successfully tell the ‘Certified SC Grown’ story due to the high numbers of qualified personnel that spent time at CSCG booths that were designed to be information centers on product availability, new products, food safety and GAP certifications, as well as product traceability.

Project Approach:

SCDA personnel worked the trade show with a SCDA booth dedicated to promoting Certified South Carolina Grown as well as fruit and vegetable producers. We assisted those companies with POP material, preshow mailers, scheduling of appointments with key attendees, educational materials and assisted personnel with product specific questions for program buy-in and concept support.

Goals and Outcomes Achieved:

The initial goal was to expand the ‘Certified SC Grown’ message to 25,000 attendees inclusive of key buyers from around the globe. Through the participation in the following trade shows and expositions, this goal was not only met, but was substantially exceeded. In addition to booth and grower activity the SCDA was also able to participate in seminars conducted by professional peers.

- Produce Marketing Association “Fresh Summit”

2008	Orlando, Florida	17,200 attendees
2009	Anaheim, California	20,435 attendees
- Southeast Produce Council “Southern Exposure”

2008	Orlando, Florida	1245 attendees
2009	Tampa, Florida	1322 attendees
- Eastern Produce Council “Certified SC Grown” Night

2008	West Orange, New Jersey	346 attendees
2009	West Orange, New Jersey	355 attendees

South Carolina firms were recruited to participate in the shows within the South Carolina pavilion. Many of these firms provided additional cost share funds to expand space. Specialty crop firms and associations participating with the SCDA in these trade shows include:

- Walter P. Rawl and Sons – Leafy greens, cilantro, green onions, other veg
- Williams Farms – Tomatos
- Coosaw Farms – Watermelons, Cantaloupes, Blueberries
- Chappell Farms – Peaches
- Sandifer Farms – Watermelons, Cantaloupes
- SC Peach Council – Peaches
- Melon One/F.H. Dicks – Watermelons
- McCrae Produce – Peaches, Strawberries, Tomatos, other veg
- Richter and Company – Peaches, onions, broccoli, bell pepper

Beneficiaries- Project One:

Growers, wholesalers, key retail and foodservice operators benefited from the latest in product availability, GAP information, merchandising approaches, promotional suggestions, food safety and new product development for implementation in local growing operations. Consumer preferences and trends were made available and gave all within the food chain targets and opportunities to capture with successful practices

Lessons Learned - Project One:

Consumers have experienced their desire to purchase Local Grown fruits and vegetables. This communication was reinforced at trade shows time and time again as ALL phases of bringing the products to the marketplace echoed the message on the trade show floor and seminars. Continual production of quality fruits and vegetables that provide healthy, convenient, and proven local acceptance will not be a fad but a way of life for those ever increasing consumers that want to consume and are willing to pay for its benefits.

Expenditures – Project One:

\$25,000 was allocated for this project and the entire amount was utilized in trade show execution that required travel, point of purchase materials, booth presentations and pre-show mailers to fully execute our trade show objectives.

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Additional Information – Project One:

PMA - 2008



PMA - 2008



PMA - 2008



Project Two – Certified Nursery Professional Training

Project Summary:

The SCNLA Certified Nursery Professional Testing program needed an update both in content of training materials and marketing the program. The grant allowed for the entire 15-chapter manual to be reviewed and updated by University faculty and industry experts and a CD of color photos of plant material to be developed. The test was then re-written. A logo was developed and then used on the manual cover, on the certificate given to those who pass the test and on a new decal given to those who passed. The existing file of Certified Nursery Professionals was updated with correct contact information so that those on the list could be marketed.

Project Approach:

The SCNLA Certified Nursery Professional Program is a 2-part test (a 160 question written test and a 120 plant identification test) that tests the skills of the participants in plant identification, plant growth and development, soils, water issues, plant nutrition, environmental issues, turfgrasses, integrated pest management practices, plant pests and diseases, nursery production, and various aspects of landscaping and retail sales. The test is usually given twice per year. Applicants must pass both sections with at least a 70% to become certified.

The original 450+ page manual that was published in 2001 needed to be updated to reflect the vast changes in environmental issues, and available horticultural products and plants.

The new study manual was promoted to the industry through trade magazines, web sites and at industry events. The SCNLA worked with the SCDA staff and other professionals to develop a “message” directed to consumers to tie the certification test and the benefits of using a certified professionals within the Certified SC program.

Press releases were sent to garden writers, garden clubs to promote the certification program. And information about the manual could be found on the SCNLA website. All interested persons in gaining certification were provided a copy of the manual upon request.

Outcomes and Goals Achieved:

The new manual provides those in the nursery industry and related fields (greenhouse industry landscape contractors, garden center staff, etc.) an up to date study guide and resource manual.

The updated file of current Certified Nursery Professionals allows the SC Nursery & Landscape Association to promote these CNP’s on the SCNLA website and to those looking to hire an industry professional.

The new logo unifies the various segments of the program in a way that we did not have in the past. The decals with the new logo were well received by the participants. They place the decal on their work vehicle or at their place of business. There are now 164 Certified Nursery Professionals on current list. A press release describing the updated manual and the Certified

Nursery Professional program was sent to garden writers across the state of South Carolina to help promote the program to the consumer. The new logo was also included.

The new CD of plant material with color photos provides a much better learning tool for studying for the plant identification portion of the test. In the past only black and white line drawings were available in the manual.

Beneficiaries and Lessons Learned:

Direct beneficiaries of this program are those who work in the nursery industry because they now have an up to date study manual and CD and a logo that helps them promote their skills, businesses and industries. Employers and consumers have a better-trained work force. 431 professionals gained their CNP's after this manual was released.

Keeping a program up to date and providing fresh marketing materials (logos) encourages potential participants to participate and benefit from a program. The better trained they are the better the services they can provide those they work for.

Expenditures – Project Two:

The \$20,000 that was budgeted for this project was spent as outlined in the original project proposal.

Contact Person:

Donna Shealy Foster, Executive Director, South Carolina Nursery and Landscape Association, (803) 743-8284, scplant@bellsouth.net

Project 3 – Fresh on the Menu

Project Summary:

The *Fresh on the Menu* project was initiated as a pilot project in the Charleston area of South Carolina. 60 restaurants participated in the pilot program. In this grant project we took *Fresh on the Menu* Statewide and offered the program to all restaurants across the state. The requirements are that the restaurants agree that 25% of their menu selections will include specialty crop products sourced from local South Carolina producers either directly or through Food Service channels when in season. We in turn promote *Fresh on the Menu* providing consumers with the ability to make an informed decision to dine at local restaurants that support the local food economy and South Carolina Specialty Crops, in particular-local fruits and vegetables. We also provide table top *Fresh on the Menu* signage for each restaurant as well as other point of sale promotional materials and logo's for menu use.

Project Approach:

We took the very successful pilot program and began to reach out to restaurants statewide about the opportunity. Many Chefs' in South Carolina have used local products to some extent for years. This provided them with tools to promote their support of local products to their customer

base. It also provided us with a benchmark for participation and increased sales opportunities for local producers as restaurant participation increased. We developed various P.O.P materials for restaurant kits that were made available to all participating restaurants. We kicked off the statewide program at two major events, The Charleston Food and Wine Festival and the Hilton Head Food and Wine Festival in March of 2009. We also combined outdoor media and advertisements in magazines with statewide coverage to promote Fresh on the Menu and participating restaurants. Key promotions coincided with seasonal availability of locally produced fruits and vegetables. Funds were leveraged with funds from our Certified SC Grown program to gain further reach statewide. To handle issues of availability and distribution, we worked with major Food Service vendors to develop weekly South Carolina sales sheets that included items that were available each week to restaurants from local producers. We also worked directly with restaurants and individual producers to develop direct sales and delivery opportunities for producers. The project was very successful.

Goals and Outcomes Achieved:

We had anticipated reaching 200 participating restaurants members with the state wide rollout of *Fresh on the Menu*. We actually achieved 252 members participating during this first full year of the project. Other goals were to increase the awareness of what is available locally and to increase sales opportunities for producers. By developing sales sheets with US Foodservice, Sysco, and Limehouse Produce, we were able to increase the total sales of South Carolina products through Food Service. We have also created new sales opportunities for individual producers directly with these companies and their wholesale suppliers. While those numbers are proprietary we were able to confirm that each saw an increase in sales of local products and that they also expanded the number of local producers that they source products from directly. This was confirmed by several fresh market producers across the state.

Beneficiaries:

Beneficiaries included producers who saw an increase in local sales, restaurants who determined that showcasing local products in their menu made a positive impact in their business, Food Service vendors who captured more sales of local items through their distribution centers, and consumers who were able to make an informed decision to support local producers when selecting restaurants.

Lessons Learned:

There is a tremendous opportunity to continue to expand this program across the state. We see opportunities to tweak the weekly sales sheet data to expand that service to other Food Service vendors to make available to additional local restaurants. We also see opportunities to expand membership in the program by working with vendors at Food Shows that many restaurant owners attend to promote the effort. This project has been very well received at the local level and throughout the grower and Food Service community.

Expenditures:

\$25,000.00 was budgeted for this project. All 25K was spent in P.O.P materials and media in promoting the project state wide as outlined in the original project.

Contact Person:

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Additional Information:





Chefs Know: when it comes to flavor, you can't beat fresh ingredients. That's why many of our restaurants are including in-season, locally grown and harvested fruits, vegetables, meats and seafood on their menus. For a more "taste-full" dining experience, look for *Certified SC Grown* produce and products that are "Fresh on the Menu." For a complete listing of participating restaurants, visit us at www.FreshOnTheMenu.com.

Certified South Carolina Grown peach & blueberry parfait



www.FreshOnTheMenu.com

Project 4 – Quality and Nutritional Program

Project Approach:

Oxidative stress and pro-inflammatory responses are known to provide the setting for most chronic diseases including cancer, diabetes, obesity, heart disease, asthma, Alzheimer's diseases and other prominent long-term illness that have high incidence rates in the State of South Carolina. For example, annual deaths from cancer and diabetes only are estimated at over 12,000 (9,100 and 3,186, respectively for cancer and diabetes). Consumption of fruits and vegetables containing anti-oxidative and anti-inflammatory compounds could mitigate the incidence of these diseases.

Among the few food crops (bitter melon, onion, garlic, beet, mustard, banana, fenugreek) containing anti-oxidative, anti-inflammatory, hypoglycemic and anti-hyperglycemic bioactives in their fruits or seeds (Tropical Plant Database: <http://www.rain-tree.com/bitmelon.htm>; Grover et al. 2002), bitter melon is the most extensively used for prevention and cure of cancer and diabetes (Chacko 2003; Kar et al. 2003; Saxena and Vikram 2004).

Bitter melon (syn. bitter gourd, balsam pear, snap melon; *Momordica charantia* L; family Cucurbitaceae; $2n = 22$) is grown traditionally in the tropical and subtropical areas in Asia, Amazon, East Africa, and the Caribbean as a food vegetable and medicine. This plant contains an array of biologically active chemicals mainly glycosides, saponins, alkaloids, fixed oils, triterpenes, and steroids (Raman and Lau 1996; <http://www.rain-tree.com/bitmelon.htm>). Several medicinal properties and actions of the leaf decoction and fruit juices of bitter melon have been well-documented in research. These include antidiabetic, antiviral, antitumor, antileukemic, antibacterial, antihelmintic, antimutagenic, antimycobacterial, antioxidant, antiulcer, anti-inflammatory, hypocholesterolemic, hypotriglyceridemic, hypotensive, immunostimulant and insecticidal properties (Ng et al. 1992; Raman and Lau 1996; Basch et al. 2003). A compiled list of publications on anticancer and cytotoxic; antiulcer; antidiabetic and hypoglycemic and cholesterol-lowering; antioxidant; and antifertility actions is available in the Tropical Plant database (<http://www.rain-tree.com/bitmelon.htm>).

All parts of this plant, mainly the fruits and the seeds, contain Momordin, α - and β -Momorcharin and Cucurbitacin-B that have anticancer actions (Grover and Yadav 2004; <http://www.rain-tree.com/bitmelon.htm>). They also contain steroidal saponins known as Charantin and insulin-like polypeptide (Plant Insulin, syn. Polypeptide-p) that have been clinically demonstrated to have hypoglycemic and anti-hyperglycemic activities (Grover et al. 2002) and established beneficial effects on diabetes, particularly of type-2, the most common form of the disease, as well as heart disease and stroke. Anti-oxidant properties of bitter melon and its traditional use in several countries worldwide have been well documented and reviewed in the recent literature (Sathishsekar and Subramanian 2005; Semiz and Sen 2007).

Bitter melon is grown in eight states of the United States and Puerto Rico and the Virgin Islands (USDA Plant Database: <http://plants.usda.gov/java/profile?symbol=MOCH2>). Many people in South Carolina also grow this crop, albeit on a small scale, in their farms or kitchen gardens for daily domestic consumption. From our personal meetings and correspondences with several stakeholders (growers and consumers) and during several meetings of the South Carolina Center

of Botanical Medicine in the last three years, we learnt that they are now aware that the bitter melon varieties cultivated in South Carolina and the fruits available in the retail markets have good yield and quality traits (large, long, white, glossy, non-spiny, and less bitter as compared to the small, round, green, dull, spiny and bitter taste of the medicinal varieties) but are inferior in medicinal properties, and are seriously looking for varieties with superior fruit traits coupled with high phytomedicine contents to combat many chronic diseases, particularly cancer and diabetes. Our major long-term goal, therefore, is to develop dual-purpose *least-bitter* bitter melon varieties with superior fruit traits coupled with high content of anticancer and antidiabetic phytomedicines. The goals for the present project were comprehensive evaluation of a germplasm and identify molecular markers to develop the dual-purpose varieties employing molecular breeding in future.

Project Summary:

A few specialty food crops including bitter melon, onion, garlic, beet, mustard, banana and fenugreek, contain anti-oxidative, anti-inflammatory, hypoglycemic and anti-hyperglycemic bioactives in their fruits or seeds and therefore their consumption can prevent and cure many chronic diseases including cancer and diabetes. Since among these crops, bitter melon is the most extensively used for prevention and cure of cancer and diabetes, we focused on this crop to improve its medicinal qualities. Evaluation of a bitter melon germplasm consisting of 22 genotypes belonging to two botanical varieties, *charantia* and *muricata*, exhibited high genetic diversity with regard to AFLP fingerprints, five fruit traits and contents of two phytomedicines, Cucurbitacin-B and Charantin, with proven anticancer and antidiabetes activities, respectively. Fruits of *muricata* genotypes were, in general, small, green, dull, globular and muricated (spiny), some of them being very rich in Cucurbitacin-B and Charantin contents. Fruits of *charantia* genotypes had varied fruit traits *inter se* with lower phytomedicine contents. Population structure analysis revealed four subpopulations within the germplasm. Association mapping using 255 AFLP markers identified some common markers linked with both fruit color and luster and among fruit size, shape and surface texture. Curcubitacin-B and Charantin had some common linked markers; however Charantin was associated with several other markers suggesting more complex genetic mechanism. Some markers were linked both to fruit traits and phytomedicine contents. Information derived on genetic diversity from this endeavor has facilitated selection of two highly divergent genotypes for developing dual-purpose varieties with desirable fruit traits coupled with higher phytomedicine contents through future breeding programs and the linked AFLP markers identified will accelerate such efforts. Demonstration to farmers and consumers on the growing practices, benefits and methods of using bitter melon to combat chronic diseases has created interest among them to cultivate bitter melon as a specialty crop and consuming bitter melon as functional food. Training imparted to students has attracted many more students towards the fields of nutraceutical research and extension.

2. Specific Objectives Targeted

1. Establishment and comprehensive evaluation of a germplasm with regard to genetic divergence, variability in fruit yield and quality traits and content of anticancer and antidiabetic phytomedicines.

2. Identification of parent varieties and molecular markers for marker-assisted breeding of dual-purpose varieties.
3. Organizing demonstrations for farmers and consumers to create awareness on the growing practices, varietal differences, and benefits and methods of consumption of fruits and fruit products.
4. Training of scientists/students through the project to strengthen future human resources for research and extension of dual-purpose fruits and vegetables for using as functional foods and dietary supplements.

3. Methodologies Employed and Results Obtained

3.1 Establishment of Germplasm

Seeds of a set of 18 improved varieties diverse geographical and breeding origin and four genotypes developed by us were grown in a greenhouse. Nine of these varieties belong to the botanical variety *Momordica charantia* var. *charantia* and the remaining 13 genotypes belong to the botanical variety *Momordica charantia* var. *muricata*. The list of the genotypes is provided in the Table 1.

Table 1 List of bitter melon genotypes in the germplasm established for evaluation.

Sl.	Name	Country	Sl.	Name	Country
Var. <i>charantia</i>			Var. <i>muricata</i>		
1	Hyb. Beauty Winner-1	China	10	Hyb. India Star	India
2	Large Top	China	11	Hyb. India Baby	India
3	Hyb. Taiwan White	Taiwan	12	Hyb. India Pearl	India
4	Taiwan White	Taiwan	13	India Long Green	India
5	Hyb. White Pearl	Taiwan	14	Hyb. India Green Queen	India
6	Taiwan Large	Taiwan	15	Japan Green Spindle	Japan
7	Hyb. Bangkok Large	Thailand	16	Japan Long	Japan
8	Hyb. Jumbo	Thailand	17	Small Baby	Thailand
9	Hong Kong Green	Hong Kong	18	Hyb. Baby Doll	Thailand
			19	CBM9	USA
			20	CBM10	USA
			21	CBM12	USA
			22	CBM18	USA

3.2 Variation in fruit Traits

3.2.1 Fruit Quality Traits

Observations recorded on five qualitative fruit characters including color (green, light green, white), shape (round, oblong, long), luster (non-glossy, glossy), surface (spiny, non-spiny) and size (large, medium, small) revealed contrasting variation among the accessions (Figure 1).

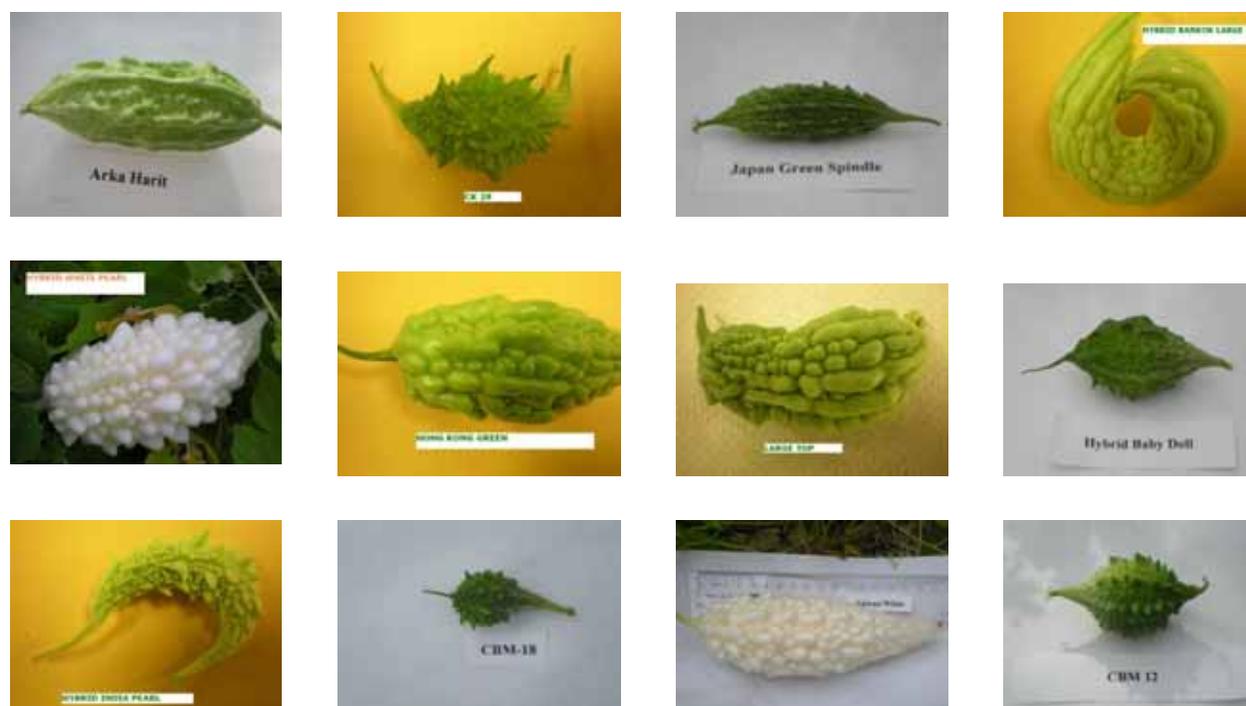


Figure 1 Variation in fruit traits in the germplasms evaluated (parents selected are the last two).

3.2.1 Fruit Weight

We compared fruit weights of 22 genotypes grown under randomized block design with three replications in the greenhouse. Analysis of Variance (ANOVA) revealed highly significant variation among these genotypes as evidenced by a very high F -value (128.58) and a very high P -value (<0.0001). CBM10, CBM12, CBM-18, Hybrid India Baby, Small Baby and Hybrid Baby Doll exhibited the lowest fruit weight based upon the Duncan's multiple range test for means comparison. Taiwan white exhibited significantly the highest fruit weight (Table 2).

Table 2 The mean values for fruit weight (FWT), and contents of Cucurbitacin-B (CCR-B) and Charantin (CHR) of 22 genotypes, showing statistical significance between varieties using the Duncan's multiple range test¹.

Sl.	Variety	FWT (g)	CCR-B ²	CHR ²
1	Hyb. India Star	74.83 ^{bc}	0.4 ^h	0.7 ^g
2	Hyb. India Baby	4.28 ^g	0.45 ^g	0.8 ^e
3	Hyb. India Pearl	72.26 ^{cd}	0.4 ^h	0.65 ^h
4	Small Baby	3.48 ^g	0.65 ^d	0.95 ^c
5	India Long Green	22.64 ^{ef}	0.45 ^g	0.75 ^f
6	Hyb. Taiwan White	63.6 ^d	0.4 ^h	0.8 ^e
7	Hyb. India Green Queen	25.29 ^e	0.45 ^g	0.8 ^e
8	Hyb. Baby Doll	5.1 ^g	0.35 ⁱ	0.7 ^g
9	Taiwan White	146.33 ^a	0.35 ⁱ	0.75 ^f
10	Hyb. Jumbo	70.87 ^{cd}	0.3 ^j	0.7 ^g
11	Japan Green Spindle	16.1 ^f	0.5 ^f	0.9 ^d

12	Taiwan Large	77.63 ^{bc}	-	-
13	Hong Kong Green	70.61 ^{cd}	0.5 ^f	0.9 ^d
14	Japan Long	78.69 ^{bc}	0.45 ^g	0.8 ^e
15	Large Top	83.87 ^b	-	-
16	Hyb. Bangkok Large	78.5b ^c	0.55 ^e	0.95 ^c
17	Hyb. White Pearl	82.37 ^b	0.55 ^e	0.95 ^c
18	Hyb. Beauty Winner	74.81 ^{bc}	0.7 ^c	1.1 ^b
19	CBM9	21.47 ^{ef}	-	-
20	CBM10	4.9 ^g	1.0 ^a	1.35 ^a
21	CBM12	3.84 ^g	0.7 ^c	1.1 ^b
22	CBM18	5.89 ^g	0.75 ^b	1.1 ^b

¹No significant difference was observed between the values having the same letter for the Duncan's multiple range tests at 5% probability level. ²mg/g powdered lyophilized fruits

3.3 Variation in Phytomedicine Contents

3.3.1 Extraction and Quantification of Phytomedicines

Extraction of cucurbitacin-B and charantin was performed using a Soxhlet extraction protocol from 1 g of powder of freeze-dried fruit chips. A final precipitate was dissolved in 200 μ l of 1:1 (v/v) chloroform-methanol mixture, and then adjusted to 2 ml with methanol. High-performance liquid chromatography (HPLC) analysis for cucurbitacin-B and charantin was performed with a ZORBAX Eclipse XDB-Phenyl column (5 μ m particle, 4.6 x 250 mm ID) in a mobile phase of 100:2 (v/v) methanol-water. Peaks of the germplasm samples corresponding to the standard peaks from pure samples of cucurbitacin-B and charantin were used for identification and quantification at wavelengths of 235 nm and 205 nm, respectively.

3.3.2 Variation in the Content of Phytomedicines

Contents of the anticancer phytomedicine, cucurbitacin-B (CCR-B) and the antidiabetes phytomedicine, charantin (CHR) 16 cultivated varieties and three genotypes (CBM10, 12, 18) are furnished in Table 2 with a graphical depiction in Figure 2. The variation in the contents of CCR-B and CHR among the 19 genotypes was estimated by Duncan's multiple range test and found to be highly significant at p-value < 0.0001. The average CCR-B and CHR content among the genotypes ranged from 0.3 to 1.0 mg/g and 0.65 to 1.35 mg/g of lyophilized fruit powders, respectively

In general, the genotypes CBM10, CBM12 and CBM18 along with Hybrid Beauty Winner exhibited significantly higher contents of CCR-B and CHR as compared to all other cultivars. Following means comparison using Duncan's multiple range test, CBM10 was found to have significantly the highest contents for CCR-B and CHR than any genotype. The mean of CHR content for CBM12, CBM18 and Hybrid Beauty Winner were not significantly different, while the mean content of CCR-B was significantly higher in CBM18 as compared to CBM12 and Hybrid Beauty Winner, which were not significantly different (Table 2).

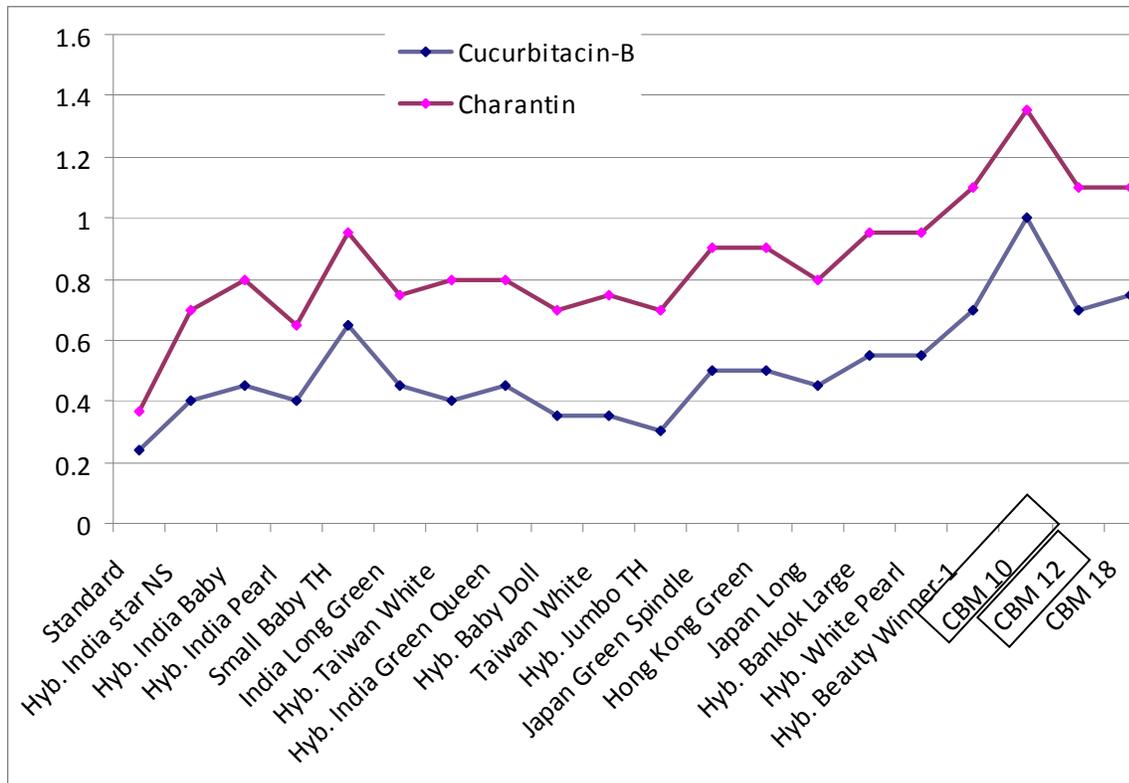


Figure 2 Relative content of Cucurbitacin-B and Charantin (in mg/g of powder from lyophilized fruit chips of 18 varieties and one advanced breeding line (CBM18). CBM10 and CBM12 are highlighted.

3.4 Evaluation of Molecular Genetic Diversity

3.4.1 DNA Isolation and Molecular Marker Analysis methods

Genomic DNA was extracted from fresh young leaves using the CTAB-PVP protocol described by Eldredge et al. (1992). AFLP analysis was performed essentially following Vos et al. (1995). An aliquot of 200 ng of genomic DNA was digested with *EcoRI* and *MseI*, ligated to *EcoRI* and *MseI* adapters and diluted 10-fold for pre-amplification. The pre-amplification reaction mixture was used for selective amplification using 10 primer combinations that included EAA, EAC and MCAA to MCCC. Pre-amplification PCR conditions, electrophoretic gel analysis and genotyping were performed as described in Olukolu et al. (2009). A representative figure of AFLP fingerprints of 22 genotypes is furnished in Figure 3.

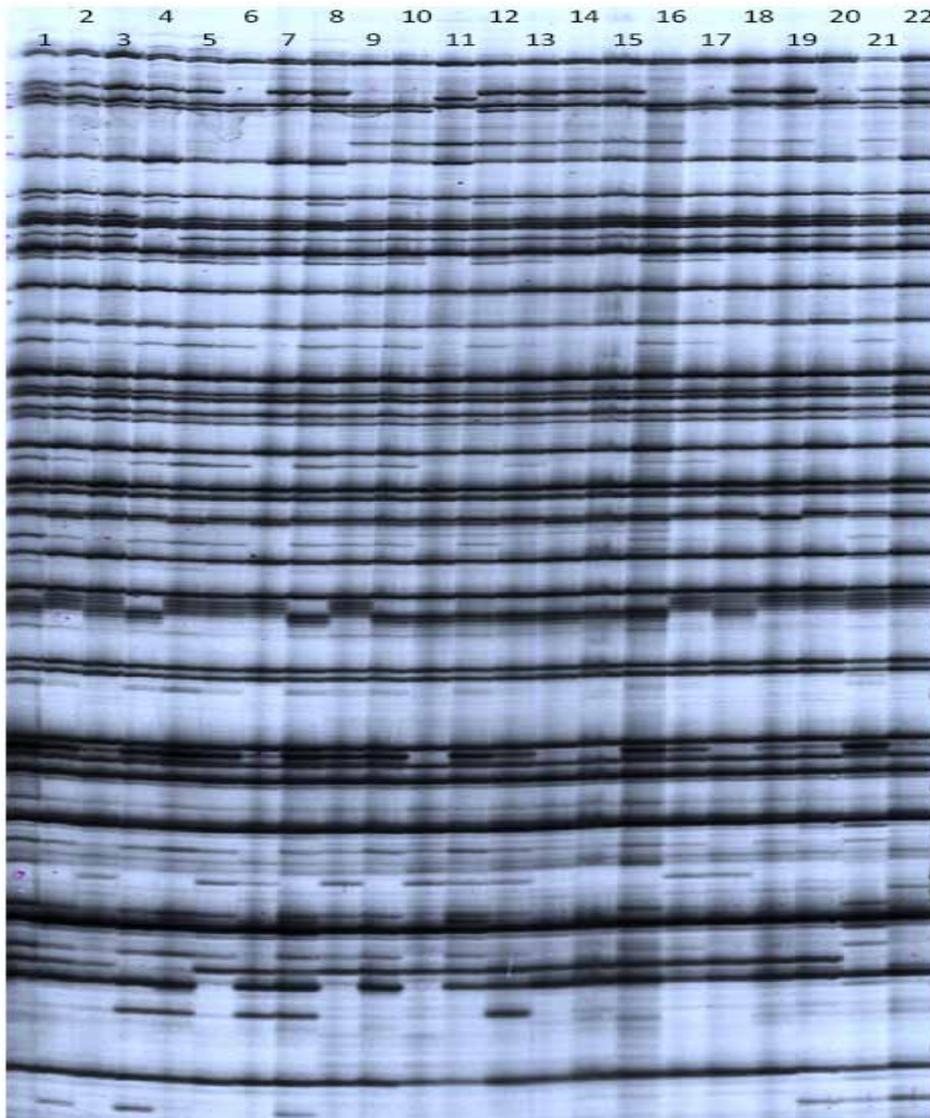


Figure 3 A representative section of an autoradiograph showing AFLP patterns of 22 bitter melon genotypes. Genotypes included 1. Hyb. India Star, 2. Hyb. India Baby, 3. Hyb. India Pearl, 4. Small Baby, 5. India Long Green, 6. Hyb. Taiwan White, 7. Hyb. India Green Queen, 8.

Hyb. Baby Doll, 9. Taiwan White, 10. Hyb. Jumbo, 11. Japan Green Spindle, 12. Taiwan Large, 13. Hong Kong Green, 14. Japan Long, 15. Large Top, 16. Hyb. Bangkok Large, 17. Hyb. White Pearl, 18. Hyb. Beauty Winner-1, 19. CBM9, 20. CBM10, 21. CBM12 and 22. CBM18.

3.4.2 Population Structure

Population structure was evaluated based on the model-based program STRUCTURE v2.3.3 (Pritchard et al. 2009, <http://pritch.bsd.uchicago.edu/>), using 255 AFLP loci. We attempted to determine the extent of population stratification within the panel of genotypes and their plausible ancestral relationship *inter se*. An admixture model for population structure analysis revealed the population to be optimally stratified into four subpopulations (Figure 4) with fixation indices values of 0.785, 0.663, 0.542 and 0.582 for subpopulations 1 (red), 2 (green), 3 (blue) and 4 (yellow), respectively, indicating subpopulation 1 with the highest diversity. Each of the subpopulations contained both *charantia* and *muricata* genotypes. There was no obvious correlation between population structure and geographical origin. The difficulty in drawing any meaningful correlation between origin and computed population structure could probably be due to the fact that the country of domestication might not necessarily represent the actual origin.

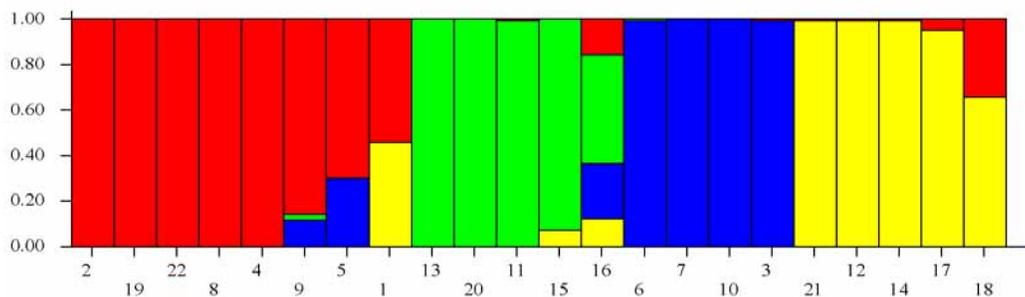


Figure 4 Bar plot showing population structure and ancestry of 22 bitter melon varieties and advanced breeding lines under an admixture model. The serial numbers on the X-axis correspond to Hyb. India Star, Hyb. India Baby, Hyb. India Pearl, Small Baby, India Long Green, Hyb. Taiwan White, Hyb. India Green Queen, Hyb. Baby Doll, Taiwan White, Hyb. Jumbo, Japan Green Spindle, Taiwan Large, Hong Kong Green, Japan Long, Large Top, Hyb. Bangkok Large, Hyb. White Pearl, Hyb. Beauty Winner-1, CBM9, CBM10, CBM12 and CBM18.

3.5 Identification of AFLP Markers for Molecular Breeding

Marker-trait association performed using STRAT software (<http://pritch.bsd.uchicago.edu/>) revealed several AFLP markers (Table 3) to be linked with the fruit traits at $P > 0.001$ level. Consequently, some of the fruit traits were linked to the same AFLP loci. Two markers associated with fruit color were also linked to fruit luster, although, fruit color was associated with many more (11) markers. This indicated involvement of more than one locus in controlling fruit color. All the three markers associated with fruit shape were also associated with fruit size, while only one or two markers associated with fruit surface texture was/were associated with fruit size that evidenced for a stronger linkage of fruit shape to fruit size than fruit surface texture, but again these requires verification by linkage mapping and QTL analysis.

Association test for phytomedicine contents revealed five of the seven markers to be associated with both CCR-B and CHR, while two of these markers were associated only with CCR-B and nine markers linked to CHR were also associated with fruit color. This reflects a plausible overlap in the biosynthetic pathways of these bioactives. Triterpenoid (CCR-B) and sterol (CHR) biosynthesis are known to have a common pathway from C₅ isoprenoids, isopentenyl diphosphate (IPP) and dimethylallyl diphosphate (DMAPP) to the formation of the C₃₀ units squalene and squalene 2,3-oxide (Flores-Sánchez et al. 2002). The association test also shows about five times more markers associated with CHR compared to CCR-B, indicating a more complex genetic mechanism for CHR production.

High genetic divergence in the germplasm as evidenced by diverse AFLP fingerprints and genetic variability in fruit traits and phytomedicine contents will facilitate selection of parents for developing better varieties with improved fruit yield and quality traits coupled with higher phytomedicine contents for using their fruits as functional food. In fact, the high genetic divergence in our germplasm has already paved the way for selection of two diverse parents, Taiwan White belonging to var. *charantia* and CBM12 belong to var. *muricata*. The AFLP markers associated with all the five fruit traits, and CCR-B and CHR contents will facilitate marker-assisted monitoring of the genes in breeding programs to develop varieties with desirable fruit traits and higher phytomedicine contents aiming at development of dual-purpose varieties as a source of functional foods.

Table 3 AFLP markers associated ($P < 0.001$) with fruit traits, taking population structure into consideration.

Size	Color	CHR	CHR	CCR-B
E11M47b12 ^b	E11M48b9 ^c	E11M47b8	E11M50b20	E11M47b1
E11M49b5 ^c	E11M48b25	E11M47b14	E11M50b23 ^c	E11M49b12 ^d
E11M51b25 ^b	E11M49b6	E11M47b18	E11M50b36	E11M49b25 ^c
E11M51b27 ^b	E11M49b14	E11M47b19	E11M50b43 ^{cd}	E11M50b43 ^c
E12M48b1 ^c	E11M49b15 ^c	E11M47b25	E11M51b12	E11M51b5
E12M48b28	E11M49b25 ^c	E11M48b9 ^c	E11M51b29	E12M47b6 ^d
	E11M50b23 ^c	E11M48b14	E12M47b3	E12M49b1 ^d
Shape	E11M50b43 ^c	E11M48b19	E12M47b6 ^d	
E11M47b12 ^b	E12M48b5 ^c	E11M48b25	E12M47b10	
E11M51b25 ^b	E12M49b10 ^a	E11M49b1	E12M48b1 ^c	
E11M51b27 ^b	E12M51b1 ^{ac}	E11M49b5 ^c	E12M48b5 ^c	
		E11M49b6	E12M49b1 ^d	
Surface	Luster	E11M49b12 ^d	E12M49b20	
E11M47b12 ^b	E12M49b10 ^a	E11M49b15 ^c	E12M51b1 ^c	

E11M49b4	E12M51b1 ^{ac}	E11M49b17	E12M51b6
E11M50b6		E11M49b25 ^{cd}	E12M51b10
E12M49b16		E11M50b18	E12M51b12

Note: Fruit traits showing association with same AFLP markers (shown with letter superscripts) indicate linkage between/among the traits.

4. Outreach Activities

4.1 Demonstration to Growers and Consumers

Twenty organic vegetable growers and consumers led by Mr. Azeez A. Mustafa President, Sumter Cooperative Farms came to learn about bitter melon in December 2009. We have organized their tour in the greenhouses and demonstrated on the growing practices and variation in the genotypes particularly between horticultural and medicinal genotypes. We explained the benefits of taking bitter melon fruits and the methods of consumption. We also cautioned them about the side effects and contra-indications and consult regularly their physicians for consumption of bitter melon fruits. Besides, we address to several emails we receive regularly from growers and consumers.

4.2 Publications in Newsletters and Popular magazines

Reports on the antidiabetic properties of bitter melon and our on-going works were published in the ‘Clemson University Impact Magazine’ for the Fall Semester of 2008, ‘South Carolina Farmer’ of Summer 2009 and several newsletters of the South Carolina Center for Botanical Medicine (SCCBM).

5. Development of Human Resources

5.1 Dr. Ishra Ameer, MD from the Redfern Health Center of the Clemson University had undergone a short-term voluntary training on extraction and quantification of bioactives from bitter melon fruits.

5.2 Four high-school students were mentored in 2009 through the Summer Program of Research Internship (SPRI) program of the Clemson University supported by the Howard Hughes Medical Institute (HHMI) through this and another USDA-NRI-CGP project.

6. Relevant Publications

1. Alexander M, Durbha S, Olukolu B, Kole P, Abbott AG, Kole C (2009) Genetic divergence in bitter melon with regard to DNA markers, fruit quality traits and therapeutic bioactives. 8th Annual Research Poster Presentation. 2009 Summer Program for Research Interns, Clemson University, July 17, 2009, p 3
2. Durbha S, Alexander M, Olukolu B, Kole P, Abbott AG, Kole C (2009) Screening of bitter melon (*Momordica charantia*) hybrids employing AFLP and SSR markers. 8th Annual Research Poster Presentation. 2009 Summer Program for Research Interns, Clemson University, July 17, 2009, p 9
3. Kole C, Olukolu B, Kole P, Abbott AG (2009a) Characterization of a *Momordica charantia* germplasm with AFLP and SSR markers. In: Molecular Markers in Horticulture Symposium, Oregon State University, Corvallis, OR, July 29-Aug 1, 2009

4. Kole C, Olukolu B, Kole P, Abbott AG (2009b) Towards molecular breeding of dual-purpose varieties in bitter melon (*Momordica charantia* L.). In: 4th International Cucurbit Symposium, September 21-26, 2009, Changsha, Hunan, China, p 21
5. Kole C, Olukolu B, Kole P, Abbott AG (2010) Towards phytomedomics with bitter melon (*Momordica charantia* L.) as a model. International Conference on the Status of Plant & Animal genome research, san Diego, CA, January 9-13, P164
6. Luo A, Shah H, Olukolu B, Kole P, Abbott AG, Kole C (2009) Genetic variability in bitter melon (*Momordica charantia*) with regard to the content of an antidiabetic phytomedicine 'charantin'. 8th Annual Research Poster Presentation. 2009 Summer Program for Research Interns, Clemson University, July 17, 2009, p 15
7. Shah H, Luo A, Olukolu B, Kole P, Abbott AG, Kole C (2009) Estimation of plant insulin content in a bitter melon (*Momordica charantia*) germplasm. 8th Annual Research Poster Presentation. 2009 Summer Program for Research Interns, Clemson University, July 17, 2009, p 20

GOALS AND OUTCOMES ACHIEVED

1. Identification of a horticultural variety, Taiwan White, with superior fruit traits but low phytomedicine contents and a medicinal genotype, CBM12, with inferior fruit traits but high phytomedicine contents.
2. Popularization of cultivation and consumption of bitter melon among growers and consumers.
3. Training of one scientist and four high-school students.

BENEFICIARIES

1. Vegetable growers of South Carolina who will cultivate bitter melon as a specialty crop for using as functional food.
2. Several natural and social scientists from and outside Clemson University became interested in this crop and started collaboration on development of dual purpose bitter melon varieties and popularization of their commercial cultivation.
3. Many students became interested in bitter melon research and started undergoing training in our program.

LESSONS LEARNED

1. Similar works should be initiated in our fruits (e.g. stone fruits, berries) and vegetables (e.g. onion, garlic, beet, mustard, banana, fenugreek, broccoli, cilantro, ginger, turmeric) for use as functional foods and dietary supplements.
2. Start-up funding is important to tailoring scientific works for the benefit of agriculture and health.

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Project 5 – Promotional Support for State Farmers Markets

Title:

Promotional Support for State Farmers Markets

Project Summary:

The goal of this project was to increase consumer awareness about activities that take place at the South Carolina State Farmers Markets. The SCDA wants consumers to recognize the market as a resource, and to realize that the operation is not limited to wholesalers, as well as invite the public to attend the Flower Festivals held.

Project Approach:

The focus on this project was to provide promotional funds to support seasonal activities at the three state farmers markets, and to assist vendors with promotions that will increase the sales of locally grown specialty crops, especially horticultural crops, through the state farmers market.

Goals and Outcomes Achieved:

The promotional program began in spring of 2009 to support Plant and Flower Shows at state farmers markets in Columbia, Greenville and Florence. The promotional campaign included billboards, radio, print and promotional signage.

2009 Midlands Plant & Flower Festival (April 2-5)

Radio Advertising – 100 spots on Citadel Broadcasting, B106.7 FM

Live broadcast from show on April 3, from 3-5 pm on B106.7

Banner on internet site for 2 weeks, with link to SCDA

Clear Channel Radio – 2 weeks of advertising beginning March 23

WCOS live broadcast on April 4, from 11am – 1pm.

Banner on internet site beginning March 8

Newspaper -

The State, 3x4 ads March 15, 20,21,22,27,28,29; April 3,4

100,000 impressions March 15 – April 3

Publications -
Cayce-

Color ads in Northeast News, Irmo News, Lake Murray News,

West Columbia News; March 19 and March 26

“Top 10 Things To Do” – Gardener Publications, March 12,19,16,
April 2

A survey conducted during the 2009 Columbia Spring Festival brought the following results:

- 48% heard about the Festival by newspaper, 14% from radio
- 12% of visitors were at the Market for the first time
- 36% of visitors were at their first Festival at the Market

2009 Pee Dee Farmers Market Flower Festival (October 2-4)

Radio Advertising - Quantum Radio

Television - Raycom TV
WPDE TV

Newspaper - Morning News, News & Press, News Journal, Dillon Herald

A survey conducted during the 2009 Pee Dee Fall Festival brought the following results:

- 30% learned about the Festival from television, 23% radio, 22% newspaper
- More than 38,000 people attended. 2008 attendance was 35,370.

Beneficiaries:

These very popular events will continue to be supported through SCDA funds, and future specialty crop block grants. All SC growers and producers who were vendors at the Plant and Flower Shows benefitted from the promotional campaign.

Lessons Learned:

Some of the comments gathered by SCDA personnel included that more information about the plants for sale was needed, more parking was desired, and more wagons to assist customers in their purchases were desired. The need for more advertising of the Festival was also listed as a concern.

Contact Person

Jackie Moore, SCDA, (803) 734-2210, jmoore@scda.sc.gov

Additional Information:

South Carolina Department of Agriculture

Hugh Weathers, Commissioner

Contact:

Stephen Hudson, 803-734-0648, sdhudson@sda.sc.gov

FOR IMMEDIATE RELEASE

March 20, 2009

Midland's Plant and Flower Festival held at Columbia Farmers Market

COLUMBIA, S.C. – With spring in the air, and flowers starting to bloom, now is a great time to get out into your yard or garden armed with new plants and flowers from the Midland's Plant and Flower Festival.

This annual event, held at the State Farmers Market located at 1001 Bluff Road in Columbia, across from Williams-Brice Stadium, is a rite of spring and will be held from April 2-5, 2009. Admission and parking are free, and the hours are 8 a.m. to 6 p.m. Thursday through Saturday and noon to 5 p.m. on Sunday.

The four-day Plant and Flower festival is a highlight of the spring as thousands of visitors from all over the state descend on the Farmers Market looking for numerous varieties of horticultural and agricultural products for their home gardens. Because of the wide variety of plants, and lawn and garden décor for sale, visitors are encouraged to bring along a wagon or cart to carry their purchases. Please don't forget to wear comfortable shoes!

"Every year we have a fantastic turnout and it seems there is always something for everyone," said South Carolina Commissioner of Agriculture, Hugh E. Weathers. "Get there early and enjoy what is always a great event."

This year there are more than 75 exhibitors on hand selling a wide variety of plants needed to make any yard the envy of the neighborhood. There will also be a booth for Clemson Extension's Master Gardeners to answer gardening questions. The Plant and Flower Festival is always a great place for the novice or experienced gardener. The festival will be held, rain or shine, in Shed 14 at the Farmers Market.

For more information, call the Jackie Moore, festival coordinator at 803-734-2144.

South Carolina Department of Agriculture

Hugh Weathers, Commissioner

Contact:

Stephen Hudson, 803-734-0648, sdhudson@scda.sc.gov

Becky Walton, 803-734-2182, bwalton@scda.sc.gov

FOR IMMEDIATE RELEASE

Fall Plant and Flower Festival held at the Pee Dee Market

COLUMBIA, S.C., September 30, 2009 – Searching for great deals on those fall plants for your yard? Then head straight to the Fall Plant and Flower Festival at the Pee Dee State Farmers Market, October 2-4, 2009.

This three-day festival has become an annual event for the market and offers some great plants and flowers to spruce up any fall garden. There will be numerous varieties of horticultural and agricultural products for the home gardener. If it's a little color you are looking to add to a yard, then check out an assortment of pumpkins, mums and decorative yard art also available at the Plant and Flower Festival. Novice gardeners can have their questions answered by the Clemson Master Gardeners who will be at the market answering gardening questions and holding gardening demonstrations.

"The festival is a great place to find the plants and flowers you need to beautify your yard this fall," said Hugh Weathers, South Carolina Commissioner of Agriculture. "If you're an experienced gardener or just getting started, you'll find just what you are looking for."

The Pee Dee Plant and Flower Festival will be held Friday and Saturday, from 8 a.m. to 6 p.m. and Sunday, from noon to 5 p.m. at the Pee Dee State Farmers Market, 2513 West Lucas Street in Florence. Parking and admission are free. Visitors are welcomed to bring along a cart or wagon to carry their purchases and to wear comfortable shoes.

For more information about the Pee Dee Plant and Flower Festival, call the Pee Dee Farmers Market at 843-665-5154.

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South Carolina Department of Agriculture

Hugh Weathers, Commissioner

Contact:

Stephen Hudson, 803-734-0648, sdhudson@scca.sc.gov

FOR IMMEDIATE RELEASE

Pee Dee State Farmers Market welcomes Southern Plant and Flower Festival

Festival celebrates 25 years and growing strong

COLUMBIA, S.C. April 10, 2009 – The South Carolina Department of Agriculture will celebrate 25 years of its signature event in the Pee Dee. This year marks the 25th annual Southern Plant and Flower Festival at the Pee Dee State Farmers Market.

This annual event, held at the Pee Dee State Farmers Market located at 2513 W. Lucas Street in Florence, is a highlight of spring as thousands of visitors from all over the state descend on the Farmers Market looking for numerous varieties of horticultural and agricultural products for their home gardens. This year's event is April 16-19, 2009. Admission and parking are free, and the hours are 8 a.m. to 6 p.m. Thursday through Saturday and noon to 5 p.m. on Sunday.

With spring in the air, and flowers starting to bloom, now is a great time to get out into your yard or garden armed with new plants and flowers from the Southern Plant and Flower Festival. This four-day festival offers a wide variety of plants, lawn and garden décor for sale. Visitors are encouraged to bring along a wagon or cart to carry their purchases. And comfortable shoes are a must!

"Every year we have a wonderful turnout and this year will be just as fantastic," said Hugh Weathers, South Carolina Commissioner of Agriculture. "I encourage anyone who is interested in planting something as small as an herb garden to a large outdoor masterpiece to join us. You'll find just what you are looking for at the Southern Plant and Flower Festival."

This year there will be about 100 exhibitors on hand selling a wide variety of plants needed to make any yard the envy of the neighborhood. There will also be a booth for Clemson Extension's Master Gardeners to answer gardening questions and to enlist gardeners in the Plant a Row for the hungry effort that is underway to help supply Harvest Hope Food Bank with fresh vegetables from local gardens. In the 20 counties served by Harvest Hope, gardeners are asked to plant an extra row of vegetables and donate them at local drop-off sites where the home-grown produce can be shared with those in need.

The Southern Plant and Flower Festival is always a great place for the novice or experienced gardener. The festival will be held, rain or shine at the Pee Dee State Farmers Market.

For more information, please call Jackie Moore, festival organizer at 803-734-2200.

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