NCARS / NCCES CODE: **NC-26**
ON CAMPUS RESEARCH
REPORT PERIOD **01/01/2010-12/31/2010**
☐ INTERIM ☒ FINAL

IMPACT STATEMENT

Summary

It is not possible to identify economic impact from this project at this time. However, the two cultivars released most recently from the NCSU breeding project, Bailey and Sugg, were both subject to measurement of sensory quality as part of this ongoing project. Both Bailey and Sugg have superior flavor profiles compared to other virginia-type cultivars currently on the seed market.

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PROGRESS REPORT
TO
NORTH CAROLINA PEANUT GROWERS ASSOCIATION, INC.

TITLE: **Improvement of Sensory Quality and Composition of Virginia-type Peanuts**

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DEPARTMENT: **Biological and Agricultural Engineering,[1] Crop Science[2]**
USDA-ARS Market Quality and Handling Research Unit[3]

REPORT:

The objective of the project is to evaluate composition and sensory quality of breeding lines developed by the NCSU peanut breeding project using conventional procedures and near-infrared reflectance (NIR).

NIR spectroscopy was applied to 822 ground raw SMK peanut samples from 266 different breeding lines and checks entered in trials conducted at the NCDA Peanut Belt (PBRS), Upper Coastal Plains (UCPRS), and Border Belt Tobacco (BBTRS) Research Stations. The trials included the 2009 NCSU Advanced Yield Test (AYT, 100 entries) grown at all three locations. These entries included the 30 lines considered either entered as "official" entries in the 2009 Uniform Peanut Performance Test (UPPT) or as "local options" in only the North Carolina reps of the 2009 UPPT. Also included were samples from a three trials conducted only at PBRS and UCPRS [the Disease Preliminary Test (DPT, 72 entries), the Jumbo Pod Advanced test (JAT, 25 entries), and the Early Maturity Advanced Test (EAT, 36 entries)] and two trials conducted only at a single site [the Leaf Spot Advanced Test, Sprayed and Unsprayed (LAS and LAU, 72 entries) and the Tallury Advanced Test of wild-species-derived lines (TAT, 16 entries)]. Using the NIR instrument, light absorption/reflectance was measured at wavelengths from 400 to 2500 nm in 2-nm increments. Prediction equations developed from data collected in previous years to relate absorption at specific wavelengths to sensory attribute intensities of paste ground from roasted peanuts and scored by a professional sensory panel were used to predict intensities of the roasted peanut, sweet, and bitter sensory attributes or "flavor notes." One hundred fifty samples representing 34 different cultivars and breeding lines were selected to be processed and submitted to the sensory panel in NCSU's Department of Food, Bioprocessing, and Nutrition Sciences.

Correlations between observed and predicted values for roasted peanut, sweet, bitter, fruity / fermented/ and astringent sensory attributes were very poor. There were some correlations between different observed and predicted values, but these were not the same as found in previous years. In spite of the difficulties we have had in developing sufficiently robust prediction equations, we would like to continue to try. The NIR instrument can be used to scan hundreds or thousands of samples in the interval between harvest and the following planting season compared with the few dozens that can be scored by the sensory panel. If we can find predictions that even marginally correlated with observed sensory quality, the breeder can get reasonably good indication of the flavor profile of large numbers of preliminary and advanced breeding lines in order to eliminate from his program lines with inferior flavor.

The results from the samples that were actually subjected to sensory analysis were more satisfying. Sensory data collected on samples from the 2009 crop year were pooled with data collected in previous years, and the subset of the multiple-year data including those lines as well as released cultivars and breeding lines that are candidates for release was analyzed. This resulted in the analysis of 419 data points representing 36 entries and 39 trials conducted over a span of 14 years. Intensity of the fruity / fermented attribute and linear and quadratic effects of roast color were applied as covariates to data on roasted peanut, sweet, and bitter attributes as indicated by statistical tests. Means were adjusted to the average values of the applied covariates and to the average environmental effect. Statistical comparisons among the adjusted means were made using t-tests. Of the checks that had been tested over several years, Georgia Green, the dominant runner-type cultivar grown in the Southeastern peanut production region, had the best flavor profile. Florunner, the long-time flavor standard of the peanut processing industry, was significantly inferior to Georgia Green for the sweet and bitter attributes but not for roasted peanut. Only disease-resistant high-oleic NCSU breeding line N08075olCT was not statistically different from Georgia Green, but there were several lines equal to Georgia Green for roasted peanut and bitter. These lines were developed as part of our program of breeding for resistance to early leaf spot, Cylindrocladium black rot, Sclerotinia blight, and tomato spotted wilt virus, and they have superior disease resistance in addition to high yield and superior flavor profiles. In addition to having the yield, grade, and disease resistance growers demand, they meet our goal of improving the flavor of virginia-type lines meet or surpass that of Florunner.

The USDA-ARS Market Quality and Handling Research Unit (MQHRU) housed in NCSU's Department of Food, Bioprocessing, and Nutrition Sciences has a separate program to evaluate market quality in advanced breeding lines submitted for testing in the cooperative Uniform Peanut Performance Test (UPPT), but funds for those tests are limited. The UPPT is used as a final step in breeders' variety testing programs. Each participating breeder is limited to three entries per year. Most years, there are 10 to 17 entries in the UPPT. Entries tend to be lines with a high probability of release within one to two years. There were three NCSU lines formally entered in the 2009 UPPT (N05006, N05008, and N05024J), and composition and sensory data was acquired on samples of those lines grown at eight sites across the southern USA. In the North Carolina UPPT, there were 13 additional lines or "local options" included in the test. Although the USDA-ARS MQHRU has committed to compositional and sensory analysis of up to only ten local options per cooperator, they performed the sensory analysis on all 13 NCSU local options (Table 2). In the data collected in North and South Carolina and Virginia on selected lines, there was statistically significant variation among entries for the positive sensory attributes "roasted peanut," "sweet aromatic" and "sweet," and for the negative attributes "bitter." There was no detectable variation for the negative sensory attributes "dark roast" (indicative of over-roasting), "raw/beany" (indicative of under-roasting), "astringent," "stale/cardboard" (indicative of staleness or rancidity), or "fruity/fermented" (usually indicative of immaturity of the kernels or of too-high drying temperature). Among the lines tested in this program, Gregory, Bailey, Sugg, and disease-resistant lines N03088T, N03089T and N03090T (all sisters of the Bailey cultivar), exhibited superior profiles that were comparable to flavor standard runner-type Florunner. However, Georgia green had scores for the sweet and bitter sensory attributes that were superior to al the virginia-type lines except Gregory.

Table 1. Sensory means for 33 cultivars and breeding lines evaluated in the NCSU testing program in 2009 or tested as recently as 2007 and tested for at least five years.

	Extent of testing						Sensory attribute						
			Years										
Identity	Reps	Tests	No.	First	Last	Roast color	Over-roast	Under-roast	Roasted peanut	Sweet	Bitter	Fruity	Astringent
						*CIELAB L**	*flavor intensity units (1=imperceptible to 14=most intense)*						
N03090T	15	13	5	2003	2007	57.17±0.34^{f}	1.68±0.13^{abc}	2.02±0.12^{ab}	4.47±0.10^{abc}	3.68±0.10^{b-f}	2.38±0.08^{bcd}	1.56±0.08^{a-e}	3.00±0.07^{ab}
N07033olSm	10	7	3	2007	2009	57.70±0.41^{c-f}	1.73±0.16^{abc}	1.99±0.15^{ab}	4.54±0.12^{ab}	3.47±0.12^{c-k}	2.50±0.10^{c-f}	1.34±0.10^{ab}	3.19±0.08^{bcd}
N07036olSmT	9	7	3	2007	2009	58.21±0.43^{a-f}	1.59±0.17^{abc}	2.18±0.16^{abc}	4.46±0.13^{abc}	3.13±0.13^{kl}	2.63±0.10^{def}	1.36±0.10^{a-d}	3.10±0.09^{abc}
N07037olSm	10	7	3	2007	2009	58.46±0.41^{a-e}	1.52±0.16^{abc}	2.08±0.15^{abc}	4.41±0.12^{a-d}	3.32±0.12^{f-k}	2.61±0.10^{def}	1.41±0.10^{a-e}	3.14±0.08^{a-d}
N08069olJCT	12	8	3	2007	2009	57.54±0.38^{ef}	1.58±0.15^{abc}	2.11±0.14^{abc}	4.59±0.11^{ab}	3.74±0.11^{bc}	2.38±0.09^{bcd}	1.61±0.09^{cde}	3.02±0.08^{ab}
N08070olJC	6	5	2	2008	2009	57.85±0.52^{b-f}	1.74±0.21^{abc}	1.88±0.19^{ab}	4.58±0.15^{ab}	3.68±0.15^{b-f}	2.48±0.12^{b-f}	1.39±0.13^{a-d}	3.29±0.11^{bcd}
N08071olJC	6	4	2	2008	2009	58.61±0.52^{a-e}	1.78±0.21^{bc}	2.23±0.19^{abc}	4.44±0.15^{a-d}	3.55±0.15^{b-j}	2.41±0.12^{bcd}	1.35±0.13^{abc}	3.05±0.11^{ab}
N08072olCT	6	4	2	2008	2009	58.02±0.52^{a-f}	1.73±0.21^{abc}	2.22±0.19^{abc}	4.33±0.15^{a-e}	3.48±0.15^{b-k}	2.59±0.12^{def}	1.45±0.13^{a-e}	3.39±0.11^{d}
N08073olCT	5	4	2	2008	2009	58.99±0.56^{abc}	1.50±0.22^{abc}	2.10±0.20^{abc}	4.51±0.17^{abc}	3.62±0.17^{b-h}	2.69±0.13^{def}	1.43±0.14^{a-e}	3.14±0.12^{a-d}
N08074olC	11	8	3	2007	2009	58.13±0.40^{a-f}	1.94±0.16^{c}	1.94±0.14^{ab}	4.61±0.12^{a}	3.65±0.12^{b-f}	2.49±0.09^{b-f}	1.38±0.10^{a-d}	3.23±0.08^{bcd}
N08075olCT	5	5	3	2007	2009	58.87±0.56^{a-d}	1.51±0.22^{abc}	2.10±0.20^{abc}	4.61±0.16^{ab}	3.90±0.16^{ab}	2.38±0.13^{a-d}	1.36±0.14^{a-d}	3.13±0.12^{a-d}
N08081olJC	7	5	2	2008	2009	57.46±0.49^{ef}	1.86±0.19^{c}	1.91±0.18^{ab}	4.24±0.14^{b-e}	3.72±0.14^{b-e}	2.40±0.11^{bcd}	1.43±0.12^{a-e}	3.34±0.10^{cd}
N08082olJCT	7	5	2	2008	2009	57.86±0.48^{c-f}	1.81±0.19^{c}	1.85±0.18^{a}	4.74±0.14^{a}	3.64±0.14^{b-g}	2.30±0.11^{a-d}	1.33±0.12^{ab}	3.05±0.10^{ab}
N08085olJCT	10	8	3	2007	2009	57.82±0.41^{c-f}	1.88±0.16^{c}	2.05±0.15^{ab}	4.53±0.12^{ab}	3.60±0.12^{b-i}	2.36±0.10^{bcd}	1.33±0.10^{a}	3.13±0.08^{a-d}
N08087olJCT	9	5	2	2008	2009	57.57±0.43^{def}	1.81±0.17^{c}	1.94±0.16^{ab}	4.49±0.13^{abc}	3.73±0.13^{bcd}	2.45±0.10^{b-e}	1.42±0.11^{a-e}	3.23±0.09^{bcd}
N09019olJ	3	3	1	2009	2009	58.09±0.72^{a-f}	1.38±0.28^{abc}	2.17±0.26^{abc}	4.37±0.21^{a-e}	3.61±0.21^{b-i}	2.28±0.17^{a-d}	1.36±0.18^{a-d}	3.16±0.15^{a-d}
N09024olJ	4	3	1	2009	2009	59.43±0.63^{a}	1.18±0.25^{ab}	2.95±0.23^{d}	3.91±0.19^{e}	2.76±0.19^{l}	2.83±0.15^{f}	1.39±0.15^{a-d}	3.29±0.13^{bcd}
N09032ol	3	3	1	2009	2009	57.96±0.72^{a-f}	1.35±0.28^{abc}	2.06±0.26^{abc}	4.46±0.21^{a-d}	3.47±0.21^{b-k}	2.13±0.17^{ab}	1.39±0.18^{a-e}	2.98±0.15^{ab}
N09037ol	3	3	1	2009	2009	58.85±0.72^{a-e}	1.64±0.28^{abc}	1.88±0.26^{ab}	4.75±0.21^{a}	3.60±0.21^{b-j}	2.64±0.17^{def}	1.47±0.18^{a-e}	3.42±0.15^{cd}
N09053olCSm	4	3	1	2009	2009	58.26±0.63^{a-f}	1.51±0.25^{abc}	2.26±0.23^{abc}	4.32±0.18^{a-e}	3.14±0.18^{i-l}	2.65±0.15^{def}	1.41±0.15^{a-e}	3.28±0.13^{bcd}
N09068olCSm	4	3	1	2009	2009	59.39±0.63^{ab}	1.57±0.25^{abc}	2.31±0.23^{abc}	4.45±0.19^{a-d}	3.22±0.19^{f-l}	2.64±0.15^{def}	1.36±0.15^{a-d}	3.24±0.13^{bcd}
N09079olCSm	4	3	1	2009	2009	58.71±0.63^{a-e}	1.17±0.25^{a}	2.31±0.23^{abc}	4.04±0.18^{cde}	3.22±0.18^{g-l}	2.18±0.15^{abc}	1.38±0.15^{a-d}	2.86±0.13^{a}
NC 7	48	30	13	1995	2009	58.18±0.19^{a-f}	1.49±0.08^{abc}	2.47±0.07^{cd}	4.12±0.06^{de}	3.19±0.06^{ikl}	2.73±0.05^{f}	1.54±0.05^{a-e}	3.09±0.04^{ab}
NC-V 11	6	5	2	2007	2009	58.63±0.52^{a-e}	1.43±0.20^{abc}	2.45±0.19^{bcd}	4.24±0.15^{b-e}	3.21±0.15^{h-l}	2.43±0.12^{b-e}	1.37±0.13^{a-d}	2.99±0.11^{ab}
Gregory	34	23	9	1995	2009	58.69±0.23^{a-e}	1.33±0.09^{ab}	2.42±0.08^{c}	4.30±0.07^{b-e}	3.37±0.07^{f-k}	2.56±0.05^{def}	1.42±0.06^{a-e}	3.03±0.05^{ab}
Perry	15	14	5	1995	2009	58.02±0.34^{b-f}	1.52±0.14^{abc}	2.40±0.12^{bc}	4.24±0.10^{b-e}	3.15±0.10^{ikl}	2.70±0.08^{ef}	1.60±0.08^{b-e}	3.06±0.07^{ab}
Phillips	16	15	5	2001	2009	57.89±0.36^{c-f}	1.57±0.13^{abc}	2.00±0.12^{ab}	4.19±0.10^{cde}	3.45±0.10^{c-k}	2.51±0.08^{c-f}	1.50±0.08^{a-e}	3.02±0.07^{ab}
Brantley	26	17	7	2000	2009	58.31±0.26^{a-e}	1.58±0.10^{abc}	2.41±0.09^{bc}	4.07±0.08^{de}	3.17±0.08^{ikl}	2.71±0.06^{f}	1.53±0.06^{a-e}	3.17±0.05^{bcd}
Bailey	29	18	7	2003	2009	57.85±0.25^{c-f}	1.57±0.10^{abc}	2.09±0.09^{abc}	4.43±0.08^{a-d}	3.43±0.08^{e-k}	2.55±0.06^{def}	1.65±0.06^{de}	3.07±0.05^{ab}
Sugg	22	17	7	2003	2009	57.16±0.28^{f}	1.61±0.11^{abc}	2.00±0.10^{ab}	4.46±0.08^{abc}	3.77±0.08^{b}	2.43±0.07^{bcd}	1.46±0.07^{a-e}	3.03±0.06^{ab}
CHAMPS	6	3	1	2009	2009	58.53±0.52^{a-e}	1.41±0.21^{abc}	2.56±0.19^{cd}	4.32±0.15^{a-e}	3.37±0.15^{d-k}	2.60±0.12^{def}	1.39±0.13^{a-d}	3.09±0.11^{abc}
Florunner	34	14	9	1995	2009	57.73±0.25^{def}	1.75±0.10^{c}	2.32±0.09^{bc}	4.47±0.08^{abc}	3.54±0.08^{c-j}	2.41±0.06^{bcd}	1.73±0.06^{e}	3.02±0.05^{ab}
Georgia Green	30	15	6	1998	2009	57.45±0.25^{ef}	1.31±0.10^{ab}	2.19±0.09^{abc}	4.47±0.08^{abc}	4.19±0.08^{a}	2.11±0.06^{a}	1.89±0.06^{f}	2.88±0.05^{a}

a,b,c Line means followed by the same lower-case Roman letter are not different by t-test (P<0.05)

Table 2. Sensory means for 30 cultivars and breeding lines evaluated in the Uniform Peanut Performance Test 2009 or tested as recently as 2008 and tested for at least three years, data from locations in the Virginia-Carolina production region (Lewiston, NC, Suffolk, VA, and Blackville, SC).

	Extent of testing					Sensory attribute							
			Years				Dark	Raw /	Roasted	Sweet			Fruity /	
Identity	Reps	Tests	No.	First	Last	Roast color	roast	beany	peanut	aromatic	Sweet	Bitter	fermented	Astringent
						Hunter L	*flavor intensity units (0=imperceptible to 15=most intense)*							
Virginia						**50.26±0.23^{ns}**	**2.89±0.03^{ns}**	**2.08±0.03^{ns}**	**4.55±0.03^{ns}**	**2.86±0.02$^{\beta}$**	**2.25±0.03$^{\beta}$**	**2.64±0.03^{ns}**	**1.03±0.01^{ns}**	**0.04±0.02^{ns}**
N03088T	4	4	4	2005	2009	48.98±0.81^{d-g}	2.86±0.09^{ns}	2.08±0.09^{ns}	4.63±0.11^{a-f}	2.96±0.09^{a-e}	2.40±0.09^{a-e}	2.57±0.09^{abc}	1.01±0.03^{ns}	0.03±0.06^{abc}
N03089T	6	6	4	2005	2008	49.51±0.67^{c-g}	2.84±0.07^{ns}	2.09±0.08^{ns}	4.83±0.09^{a}	2.98±0.07^{a-d}	2.46±0.08^{a-d}	2.48±0.07^{ab}	1.01±0.03^{ns}	0.00±0.05^{ab}
N03090T	5	5	4	2005	2008	49.20±0.73^{d-g}	3.02±0.08^{ns}	1.91±0.08^{ns}	4.73±0.10^{a-d}	3.13±0.08^{a}	2.55±0.08^{a}	2.59±0.08^{abc}	1.07±0.03^{ns}	0.07±0.05^{abc}
N05006	4	4	2	2008	2009	51.76±0.81^{ab}	2.83±0.09^{ns}	2.17±0.09^{ns}	4.38±0.11^{efg}	2.75±0.09^{efg}	2.12±0.09^{fgh}	2.77±0.09^{cd}	1.06±0.03^{ns}	-0.03±0.06^{a}
N05008	6	6	2	2008	2009	50.79±0.67^{a-e}	2.92±0.07^{ns}	2.12±0.08^{ns}	4.42±0.09^{efg}	2.78±0.07^{d-g}	2.14±0.08^{fgh}	2.64±0.07^{abc}	1.02±0.03^{ns}	-0.01±0.05^{a}
N05024J	4	4	2	2008	2009	50.10±0.81^{a-f}	2.85±0.09^{ns}	2.12±0.09^{ns}	4.52±0.11^{b-g}	2.88±0.09^{b-g}	2.20±0.09^{d-h}	2.69±0.09^{bc}	1.03±0.03^{ns}	0.27±0.06^{e}
VT003069	10	9	5	2002	2009	50.25±0.53^{b-f}	2.99±0.06^{ns}	2.07±0.06^{ns}	4.61±0.07^{a-f}	2.83±0.06^{c-g}	2.23±0.06^{e-h}	2.73±0.06^{cd}	1.08±0.02^{ns}	0.01±0.04^{ab}
VT003194	3	3	1	2009	2009	50.57±0.93^{a-e}	2.86±0.10^{ns}	2.13±0.11^{ns}	4.48±0.13^{c-g}	2.85±0.10^{b-g}	2.22±0.11^{c-h}	2.60±0.10^{abc}	1.01±0.04^{ns}	0.15±0.07^{b-e}
VT024051	4	4	2	2008	2009	50.92±0.81^{a-e}	2.91±0.09^{ns}	2.08±0.09^{ns}	4.30±0.11^{g}	2.65±0.09^{g}	2.06±0.09^{h}	2.75±0.09^{cd}	1.01±0.03^{ns}	0.06±0.06^{abc}
NC 7	25	21	9	2001	2009	49.60±0.34^{d-g}	2.92±0.04^{ns}	2.07±0.04^{ns}	4.48±0.05^{d-g}	2.81±0.04^{efg}	2.15±0.04^{gh}	2.69±0.04^{c}	1.04±0.01^{ns}	0.02±0.03^{ab}
NC-V 11	6	6	6	2003	2009	51.22±0.67^{abc}	2.87±0.07^{ns}	2.17±0.08^{ns}	4.33±0.09^{g}	2.69±0.07^{g}	2.10±0.08^{gh}	2.74±0.07^{cd}	1.01±0.03^{ns}	0.02±0.05^{ab}
Gregory	5	5	5	2003	2009	51.50±0.73^{ab}	2.81±0.08^{ns}	2.05±0.08^{ns}	4.84±0.10^{a}	3.01±0.08^{abc}	2.35±0.08^{a-f}	2.49±0.08^{ab}	1.03±0.03^{ns}	0.01±0.05^{ab}
Bailey	9	9	5	2005	2009	49.53±0.54^{d-g}	2.88±0.06^{ns}	2.02±0.06^{ns}	4.56±0.07^{c-g}	2.89±0.06^{b-f}	2.34±0.06^{b-f}	2.60±0.06^{abc}	1.02±0.02^{ns}	0.04±0.04^{abc}
Sugg	7	7	5	2005	2009	49.48±0.62^{c-g}	3.02±0.07^{ns}	2.00±0.07^{ns}	4.57±0.08^{b-g}	2.91±0.07^{b-f}	2.32±0.07^{b-f}	2.65±0.07^{bc}	1.02±0.03^{ns}	0.00±0.04^{ab}
CHAMPS	14	11	7	2002	2009	50.47±0.46^{a-f}	2.82±0.05^{ns}	2.10±0.05^{ns}	4.51±0.06^{c-g}	2.81±0.05^{d-g}	2.16±0.05^{fgh}	2.62±0.05^{abc}	1.01±0.02^{ns}	0.01±0.03^{ab}
Runner						**49.85±0.30^{ns}**	**2.93±0.03^{ns}**	**2.04±0.03^{ns}**	**4.59±0.04^{ns}**	**2.93±0.03$^{\alpha}$**	**2.34±0.03$^{\alpha}$**	**2.62±0.03^{ns}**	**1.04±0.01^{ns}**	**0.07±0.02^{ns}**
C724-19-25	10	7	3	2006	2008	49.14±0.55^{d-g}	2.92±0.06^{ns}	2.00±0.06^{ns}	4.67±0.08^{a-e}	3.05±0.06^{ab}	2.47±0.06^{a-d}	2.49±0.06^{ab}	1.04±0.02^{ns}	0.04±0.04^{abc}
Exp 27-1516	3	3	1	2009	2009	50.90±0.93^{a-e}	2.72±0.10^{ns}	2.16±0.11^{ns}	4.39±0.13^{efg}	2.72±0.10^{efg}	2.19±0.11^{d-h}	2.55±0.10^{abc}	1.07±0.04^{ns}	0.09±0.07^{a-d}
GA052619	3	3	1	2009	2009	52.37±0.93^{a}	2.86±0.10^{ns}	2.06±0.11^{ns}	4.31±0.13^{fg}	2.69±0.10^{fg}	2.09±0.11^{fgh}	2.78±0.10^{cd}	1.04±0.04^{ns}	0.01±0.07^{ab}
GA052621	3	3	1	2009	2009	51.19±0.93^{a-d}	2.86±0.10^{ns}	2.09±0.11^{ns}	4.40±0.13^{efg}	2.72±0.10^{efg}	2.10±0.11^{fgh}	2.70±0.10^{bcd}	1.07±0.04^{ns}	0.01±0.07^{ab}
GA052675	3	3	1	2009	2009	50.95±0.93^{a-e}	2.92±0.10^{ns}	2.03±0.11^{ns}	4.52±0.13^{a-g}	2.88±0.10^{b-g}	2.09±0.11^{fgh}	2.78±0.10^{cd}	1.05±0.04^{ns}	-0.03±0.07^{a}
P/T 09-01	5	3	1	2009	2009	49.44±0.75^{c-g}	2.99±0.08^{ns}	2.01±0.09^{ns}	4.40±0.10^{efg}	2.77±0.08^{d-g}	2.25±0.09^{b-h}	2.93±0.08^{d}	1.07±0.03^{ns}	0.12±0.05^{a-d}
P/T 09-02	3	3	1	2009	2009	48.08±0.93^{fg}	3.09±0.10^{ns}	1.99±0.11^{ns}	4.76±0.13^{abc}	3.10±0.10^{ab}	2.50±0.11^{abc}	2.67±0.10^{abc}	1.08±0.04^{ns}	0.05±0.07^{abc}
TxL061816	7	6	2	2008	2009	51.62±0.63^{ab}	2.83±0.07^{ns}	2.10±0.07^{ns}	4.54±0.09^{c-g}	2.83±0.07^{c-g}	2.22±0.07^{d-h}	2.53±0.07^{abc}	1.04±0.03^{ns}	0.03±0.05^{ab}
TxL061821	6	6	2	2008	2009	50.27±0.67^{a-f}	2.97±0.07^{ns}	2.00±0.08^{ns}	4.73±0.09^{a-d}	3.03±0.07^{abc}	2.30±0.08^{b-g}	2.56±0.07^{abc}	1.02±0.03^{ns}	0.04±0.05^{abc}
UF08301	3	3	1	2009	2009	50.49±0.93^{a-f}	2.92±0.10^{ns}	2.03±0.11^{ns}	4.74±0.13^{a-d}	2.98±0.10^{a-e}	2.50±0.11^{ab}	2.53±0.10^{abc}	1.03±0.04^{ns}	0.20±0.07^{cde}
UF09302	3	3	1	2009	2009	48.83±0.93^{d-g}	3.02±0.10^{ns}	2.03±0.11^{ns}	4.58±0.13^{a-g}	3.11±0.10^{ab}	2.58±0.11^{a}	2.55±0.10^{abc}	1.01±0.04^{ns}	0.25±0.07^{de}
UF09303	3	3	1	2009	2009	47.72±0.93^{g}	3.06±0.10^{ns}	1.99±0.11^{ns}	4.69±0.13^{a-e}	3.03±0.10^{abc}	2.43±0.11^{a-e}	2.61±0.10^{abc}	1.03±0.04^{ns}	0.16±0.07^{b-e}
Florunner	26	22	9	2001	2009	49.32±0.33^{d-g}	2.96±0.04^{ns}	2.02±0.04^{ns}	4.70±0.05^{a-d}	3.02±0.04^{abc}	2.41±0.04^{a-e}	2.50±0.04^{ab}	1.04±0.01^{ns}	0.01±0.03^{ab}
Georgia Green	12	12	7	2002	2009	48.91±0.49^{efg}	2.82±0.05^{ns}	2.07±0.06^{ns}	4.77±0.07^{ab}	3.04±0.05^{ab}	2.53±0.06^{a}	2.47±0.05^{a}	1.04±0.02^{ns}	0.02±0.03^{ab}
Florida-07	3	3	2	2005	2009	48.54±0.94^{efg}	2.98±0.10^{ns}	2.01±0.11^{ns}	4.70±0.13^{a-e}	3.03±0.10^{abc}	2.47±0.11^{a-d}	2.60±0.11^{abc}	1.01±0.04^{ns}	0.05±0.07^{abc}

ns Denotes traits for which the F-test of variation among means was not significant (P<0.05).
α,β Market type means followed by the same lower-case Greek letter are not different by t-test (P<0.05).
a,b,c Line means followed by the same lower-case Roman letter are not different by t-test (P<0.05).