**Title: Raspberry Breeding for the Southern Region**
**Grant Code: 2009-05**

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Additional Cooperators (these people have NCSU breeding material at research stations and/or at on-farm trials):
Drs. David Lockwood and Dennis Deyton, University of Tennessee
Dr. Kim Lewers, Beltsville, MD
Dr. Chad Finn, Corvallis, OR
Mr. Andy Rollins, Clemson University, SC (with James Cooley)
Mr. Eli Hernan, Biltmore Estate, NC
Mr. and Mrs. Harold Lineberger, Iron Station, NC
Ms. June Murry, Burnsville, NC
Mr. Jeremy DeLisle, Bakersville, NC

**Objectives:**
Our overall objective is raspberry variety development for the southern region of the United States.

Specific objectives of this proposal for 2009 were to:
1) continue crossing, planting and evaluating seedlings and selecting raspberry and to a lesser extent blackberry germplasm with desirable characteristics, including but not limited to heat tolerance, high and low chilling, primocane fruiting, and desirable fruit qualities,
2) establish and evaluation of advanced selection (unreplicated) and replicated trials of selections at 5 NCDA & CS Research Stations and at on-farm locations in NC and other states in the southern region
3) work with nurseries to increase planting stock of 'Nantahala' tested as NC451, and other promising selections and;
4) continue molecular mapping project to identify heat tolerant, high/low chilling and (new in 2009) primocane fruiting markers (not directly funded by these funds, but a closely related project).

**NOTE:** This is the fifth year in of the current breeding program. Significant progress has been made each year and documentation will be sent in as a separate report. Since this is a long-term project, the objectives remain essentially the same for the upcoming years.

**Methodologies and Results:**

Objective 1. Continue crossing and selection process. 2009 activities

- No. Crosses made in 2009: 31 (raspberry and blackberry)
- No. Seeds generated from 2007 crosses: 14,234
- No. Seedlings planted in spring/summer/fall 2009 (from 2008 crosses): 4128
- No. Selections made in 2009:16
- No. Selections discarded 2009: 11

Objective 2. Establish new trials at research stations using NC selections.

- Replicated trials of NC selections and cultivars of floricane fruiting raspberry and blackberry, primocane fruiting raspberry and blackberry were established in Laurel Springs and Mills River. Each trial was duplicated in and out of a high tunnel.

Objective 3. Increase planting stock of Nantahala:

- Currently 4 nurseries are licensed to propagate Nantahala ( 2 more than in 2008):
  1. Norcal Nursery, Inc.
  PO Box 1012
  Red Bluff, CA 96080
  Phone: 530-527-6200
  Fax: 530-527-2921
  Website: www.sakumabros.com
  Email: ronk@sakumabros.com
  2. North American Plants, LLC
  P.O. Box 743
  Lafayette, OR 97127
  Phone: 877 627 4636
  Fax: 503 474 0872
  Email: orders@naplants.com
  Website: www.naplants.com
  3. Nourse Farms Inc
  41 River Road
  South Deerfield, MA 01373
  Phone: 413-665-2658
  Fax: 413-665-7888
  Website: www.noursefarms.com
  Email: info@noursefarms.com
  4. Big Bear Springs Nursery
  81 Patterson Ave
  Bryson City, NC 28713
  callsyd@yahoo.com
- Plant Patent Application no. 11/998,754, considered ready for issue 11-10-2009.

'Nantahala' was tested for viruses at USDA and Univ Ark and was found free on known viruses (these tests are not available commercially).

Objective 4. Molecular mapping of *Rubus* for heat tolerance, high/low chilling and other traits.

- The objective of his project is to link heat tolerance in a segregating raspberry population (NC 497 X Qualicum) to molecular markers using SSR and AFLP technology.
- We anticipate the PhD student will graduate Dec. 2009. See draft thesis abstract below.


ABSTRACT (DRAFT)

MOLINA BRAVO, RAMÓN. Genetic and Quantitative Analysis of Red Raspberry (Rubus idaeus) for Heat Tolerance and Longer Chilling Requirement. (Under the direction of Bryon R. Sosinski and Gina E. Fernandez.)

Despite the high level of interest for growing raspberries (Rubus idaeus) in the southeastern US, production is limited by the lack of adapted, high quality cultivars. Breeding efforts are underway for increasing cultivar availability, however developing improved cultivars in *Rubus* is a slow and time-consuming process. In order to expedite the slow, but effective, breeding process, more molecular breeding tools need to be developed. Cultivars adapted to the southeastern US need to tolerate warm summers, and winters with wide temperature fluctuations. To address this issue, a genetic mapping population that segregates for tolerance to both climatic conditions has been developed from a cross between (*R. parvifolius* × 'Tulameen') × 'Qualicum'. This population was used for the construction of a genetic linkage map and for quantitative trait loci (QTL) analysis for heat tolerance, and for tolerance to fluctuating winter temperatures. Seven linkage groups were identified and were anchored to the already existing map. The majority of the linkage groups identified were of similar genetic size, and anchor markers were located at similar genetic distances relative to other markers in linkage groups. For significant QTL analysis, accurate phenotypic screening in the population is crucial. Because heat tolerance is a difficult trait to measure, a protocol was developed using chlorophyll fluorescence to assess heat tolerance. The protocol was used to measure heat tolerance in the mapping population, and after QTL analysis, 3 regions explained ~35% of the variation. Appropriate chilling requirement is necessary in woody perennials for tolerance to temperature fluctuations in the winter. Therefore, this trait was analyzed for the location of important QTL on the constructed map. Chilling requirements in the mapping population were estimated by measuring bud break in greenhouse conditions. These estimates were subjected to quantitative trait analysis, and three QTL were found in two separate season evaluations. In most cases, co-localization of these QTL occurred in the same region on the map. These regions explained the majority of the variation of the trait (100-64.5%). Other important horticultural traits segregated in the (R. parvifolius × 'Tulameen') × 'Qualicum' cross, and were evaluated for QTL analysis as well. The horticultural traits of importance were growth habit, prickle density, fruit color, fruit shape, and fruit size. In most cases, two field evaluations were performed. Several regions were identified as significant and the majority of the QTL were co-localized to the same region of the linkage map. In summary, this research has established a protocol that measures heat tolerance without relying on visual assessment, and has mapped important QTL for further molecular studies. This research has drawn a baseline foundation for the development of molecular technologies in improving heat tolerance and tolerance to winter temperature fluctuations in Rubus. Future research should focus on these regions to develop closely linked molecular markers for marker assisted breeding. A heat screening protocol was developed during the summer of 2008 using chlorophyll fluorescence. Chlorophyll fluorescence is routinely used as a physiological parameter that correlates well with heat

tolerance (Srinivasan et al. 1996). Our preliminary data indicates of the genotypes we screened, the cultivar ‘Mandarin’ is the most consistently heat tolerant genotype in our collection. The data also shows that of the parents of our mapping population, NC 497 (has Chinese germplasm in its heritage) is more heat tolerant than the other parent ‘Qualicum’, and seedlings are segregating for this trait (data not shown).

**Impact Statements**

Funding from the SRSFC has been the backbone of the NCSU raspberry and blackberry breeding program. This funding has facilitated the release of a new raspberry variety ‘Nantahala’. Funding from SRSFC also enabled us to evaluate our selections and seedlings at additional at Research Stations in NC and at on-farm throughout the southern United States. Further, in conjunction with other funding (GoldenLEAF) we are testing our advanced lines both in the field and under tunnels. And finally, we are making slow but significant progress on our molecular component. The breeding program would not have been able to sustain itself or grow if not for the SRSFC funding. Thank-you.

PUBLICATIONS RELATED TO PROJECT

1. Ballington, J.R. and G.E. Fernandez. 2008. *Rubus* breeding for the Southeastern United States. Acta Hort. 777:87-90.
2. Fernandez, Gina E., James R. Ballington and Susan J. Bryson. 2009. ‘Nantahala’ Red Raspberry. HortScience. 44: 25-26.
3. Shore, D. 2008. Southern Region Small Fruit Consortium combines strengths. http://www.cals.ncsu.edu/agcomm/magazine/fall08/n_consortium.html

PATENTS

Ballington, J.R., G.E. Fernandez and S.J Bryson. ‘Nantahala’ red raspberry. PPAF in 2007. (Application no. 11/998,754)

Figure 1.  Marketable yield (g/plant) of  floricane fruiting raspberries in Salisbury, NC, 2008.

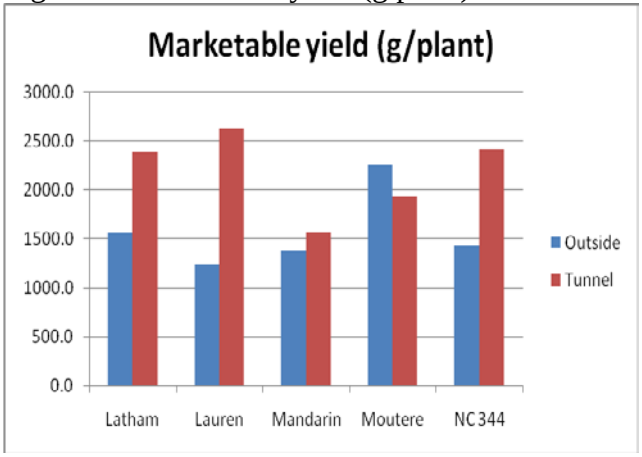


Figure 2. Marketable yield (g/plant) of primocane fruiting raspberries in Salisbury, NC 2008.

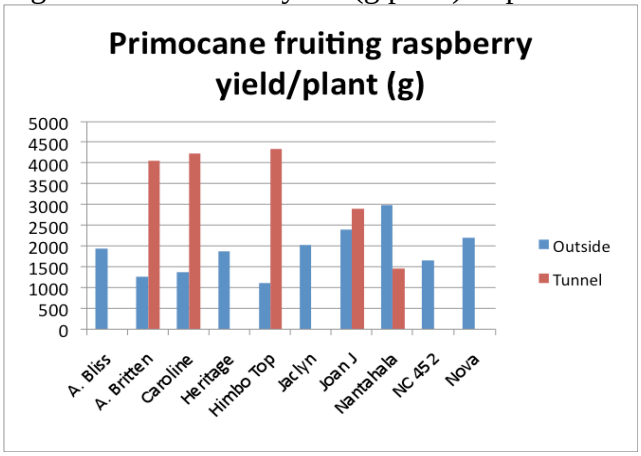


Figure 3. Marketable yield (g/plant) of primocane fruiting blackberries in Laurel Springs, NC 2008. Half of each plot was covered with a 1.25 oz/yd2 row cover in the spring, prior to primcane emergence.

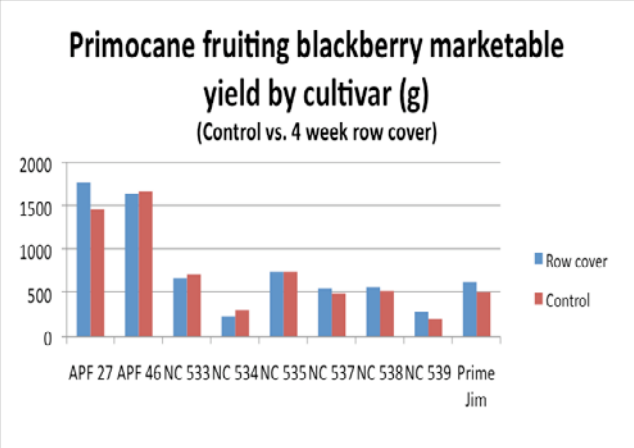

Figure 4. Fruit weight (g/plant) of primocane fruiting blackberries in Laurel Springs, NC 2008.