Title : **POSTHARVEST EVALUATION OF RASPBERRY AND BLACKBERRY SELECTIONS FOR USE IN TUNNELS IN WARM PRODUCTION AREAS**

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Research Proposal

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Objectives

The objectives of these experiments are to 1) develop a rapid protocol for shelf life evaluation of raspberries; 2) determine the fruit composition (soluble solids, acidity, total phenolics and total anthocyanins) and quality of raspberry and blackberry selections bred for the southeastern U.S., and 3) determine if tunnel production improves postharvest shelf life and quality of blackberries and raspberries

Justification

Raspberries and blackberries have become established market items in supermarkets, largely because increased production within and outside the U.S. has helped keep year-round shelf space in the produce aisle. Consumers continue to become more educated buyers, and actively seek fruits that are both flavorful and healthful. Raspberries have become a recognized source of ellagic acid, thought to have considerable potential as a chemopreventive agent, especially for esophageal cancer. Blackberries are as high in total phenolics and antioxidant scores as blueberries, and also are a good source of fiber.

The production of raspberries and blackberries under tunnels is common in Europe, especially Spain and the U.K. In California, almost 100% of the raspberry production is under tunnels. Growers in the northern U.S. have found that tunnel production results in higher yields and higher

quality fruit. However, in the south and eastern U.S., growers have not implemented tunnel production to any extent, due to many unknowns including economics and basic production protocol. But there is great interest and the researchers and Extension personnel at NCSU have established field trials of both blackberries and raspberries under tunnels.

A protocol for the post harvest evaluation blackberries grown in the field has been developed by previously by Perkins-Veazie and is used by breeders on the east coast. However, a protocol for the evaluation of raspberries in the field or under tunnels and blackberries grown under tunnels does not exist. Therefore we propose to develop a protocol for postharvest evaluation of raspberries. This protocol could be used for either field or tunnel production. We think that decreasing flower/berry wetness and wind action in a tunnel system may keep raspberry fruit firmer and free of decay by reducing spore infection and plant stress. In addition, we will compare fruit quality and composition of both raspberries and blackberries grown in the field and under tunnels. This is important to screen for selections most suitable for commercial markets in flavor, shelf life, and antioxidants.

Methodologies

A protocol was developed for postharvest rating of raspberries. In early harvests, it was apparent that fruit color (light red vs dark red), berry shrivel, and softness were primary issues that limited both initial appeal and subsequent shelf life. Decay was controlled to a large degree by use of fungicides in these trials, due to the extremely wet field conditions in 2009.

The protocol developed is as follows: Harvested berries were held for 4 to 7 days in one half pint clamshells at 4-5 C, 90% RH, until visible decay was seen, weights taken, then the whole clamshell subjectively rated for color and shrivel. Subjective ratings were 0 (no color change/shrivel, 1.0 slight, 2.0 moderate, and 3.0 severe). Firmness, decay, and leaky were recorded as 0 (none), or 1 (present). For firmness, each berry was removed from the clamshell and determined to be firm or soft by holding it between the fingers. This had to be a one time only decision as each time a raspberry was picked up, it became progressively softer. Berries were placed on a paper towel and counted as leaky if a spot of juice was seen on the towel. Last, each berry was picked up and examined for the presence of decay, especially in the torus area. To distinguish among the various scores, a summary (overall) score was calculated using 100%-[%soft+%leaky+%decay]. A rating of color above 2.0 was considered too dark for fresh market.

Five to 10 berries per clamshell were then tested for firmness quantitatively using an FDIX penetrometer with a 11 mm diameter flat probe, setting berries so the base (torus side) was directly on the hard surface. Resistance to compression (the point at which peak compression stopped) was determined in Newtons, pressing from the top of the berry down.

Berry color was measured quantitatively using a Hunter Ultrapro scanning colorimeter, with a 1.0 aperture and using reflection spectral exclusion in L*a*b*. These readings have not been fully summarized to see how well they distinguished bright red from dark red fruit.

In 2009, all funds were taken by the state before we were able to spend allocated money from this grant. Workers at NCDA in Salisbury harvested the fruit for us, and were able to provide many clamshells because of this, but I had less control over the commercial ripeness of the berries than I would have liked. It was clear after visiting farms in Lincolnton that we should be picking blackberries at a 1 to 2 firmness rating, and that raspberries should be picked as soon as they could be detached from the receptacle.

Results

'Latham' was determined to be a good standard of fruit of marginal quality after a short storage interval, being both lighter and firmer at harvest than several of the cultivars. 'Heritage' was too small and too dark at harvest to be a useful standard.

Raspberry color was a huge issue with the cultivars currently planted, both in tunnel and field fruit. Almost all cultivars were dark red even immediately after harvest (Table 1). Himbo Top, one of the lighter colored cultivars, was very leaky in storage. Nantahala and NC344 showed the most promise as selections with both light color and firmness following storage (Fig 2, 3).

A total of 400 raspberry clamshells, representing 3 selections and cultivars, were evaluated from Salisbury, in tunnel and row plantings. A total of 500 clamshells were tested from blackberries, most from Salisbury but some from numbered lines grown in Lincolnton, NC. Compression readings were useful in distinguishing soft from firm fruit, but not in separating individual cultivars (Table 2.)

Blackberry fruit from several University of Arkansas releases were evaluated in 2009 from field and tunnel fruit, including 'Natchez' (field only), 'Ouachita', 'Navaho', 'Arapaho', and 'Apache'. NC430, a North Carolina selection, was determined to be extremely firm when picked, with a good shelf life. However, fruit produced in tunnels was worse in postharvest quality than of the field grown fruit. This was an unexpected result and we are unable to explain why this happened (Tables 3, 4). The heat load was higher in tunnels with blackberries and raspberries and may have affected flower bud set and size in the previous fall for floricane fruiters. Shadecloth at 30 and 40% exclusion was present on tunnels with floricane and primocane plants, respectively. The generally rainy season may have decreased the already reduced light in the tunnels and adversely affected fruit quality. Neither temperature or light quality was recorded inside the tunnels during the summer months and will have to be done in the next season to better address issues on quality.

Analysis of antioxidants, acidity, and soluble solids content is still being done. However, total anthocyanin content in NC430 blackberries was consistently about half of fruit of Navaho and Apache (600 mg cyanidin-3-glucoside equiv/kg vs 1100 mg/kg, respectively).

Conclusions: Postharvest rating systems for blackberry and raspberry could be used to rapidly rate numerous clamshells of berries and separate selections of promise from those not suitable for fresh market. Latham proved to be a promising quality marker for baseline values in raspberry, while NC430 and Ouachita may offer new high quality

selections for postharvest quality in blackberry. While tunnels appeared to help postharvest quality of raspberries, they were deleterious to blackberry quality.

Impact Statement:

Using a postharvest protocol for rating, two raspberry selections were identified for fresh market use for warm season production of raspberries.

Citation(s) for any publications arising from the project: none to date. NC raspberry/blackberry portal has a video of the rating protocols for raspberry and blackberry (http://ncsu.edu/enterprises/blackberries-raspberries/production/postharvest/).

Figure 1. Raspberry cvs after 4 days at 5C. Left to right: Joan J, NC344, Latham.

Table 1. Postharvest evaluation of raspberry floricane study summary June 15-August 10 Salisbury, NC fruit in rows or tunnels. Fruit were held for 4 or 7 days at 5C, 90% RH.

Cultivar	tmt	sdays	no. boxes	shrivel	color (0 to 3)	color (0 to 9)	%soft	%leak	%mold	score
LATHAM	R	4	7	0.8	2.6	7.8	71	27	39	-37
LAUREN	R	4	6	1.0	2.5	7.5	36	25	52	-12
MOUTIERE	R	4	5	1.0	2.0	6.0	34	16	37	13
NC344	R	4	8	1.3	1.3	3.9	18	9	25	49
LATHAM	T	4	2	0.8	1.8	5.4	71	38	19	-28

MOUTIERE	T	4	6	1.1	1.9	5.7	46	29	24	0.4
LAUREN	T	4	7	1.7	2.6	7.8	40	22	15	22
NC344	T	4	5	0.6	2.1	6.3	24	7	9	60
ANNE*	R	7	3	1.3	0.0	0.0	77	65	50	-92
HimboTop	R	7	6	1.7	1.8	5.4	77	69	29	-76
LAUREN	R	7	13	2.0	2.4	7.2	67	34	23	-24
Abliss	R	7	6	1.9	2.0	6.0	59	55	5	-19
Joan J	R	7	5	2.0	2.0	6.0	58	60	0.4	-19
HERITAGE*	R	7	3	1.8	2.3	6.9	42	46	30	-17
A.Britten	R	7	5	1.9	1.3	3.9	69	39	7	-15
LATHAM	R	7	10	0.4	2.2	6.6	50	42	20	-13
CAROLYN	R	7	4	1.5	1.8	5.4	52	47	9	-2
NC344	R	7	15	1.0	0.9	2.7	62	22	18	-2
NC612*	R	7	3	0.5	1.3	3.9	73	15	9	2
Mandarin	R	7	17	0.5	1.5	4.5	66	17	11	6
MOUTIERE	R	7	14	1.4	2.0	6.0	49	22	21	7
Jaqulyn	R	7	5	1.5	1.5	4.5	58	26	2	14
NC548	R	7	12	0.9	2.0	6.0	45	17	11	27
DormanRed	R	7	8	0.0	0.0	0.0	44	15	4	37
LATHAM	T	7	28	0.8	2.4	7.2	77	43	11	-31
HimboTop	T	7	6	1.0	1.2	3.6	61	48	4	-14
MOUTIERE	T	7	16	1.0	1.2	3.6	59	40	10	-10
LAUREN	T	7	22	0.6	2.3	6.9	66	28	12	-6
Mandarin	T	7	18	0.4	1.3	3.9	66	18	9	6
Joan J	T	7	10	1.8	2.2	6.6	50	39	4	7
A.Britten	T	7	12	1.3	2.1	6.3	43	39	4	14
Caroline	T	7	7	1.6	1.5	4.5	50	32	0.4	17
Nantahala*	T	7	3	1.0	1.0	3.0	30	38	10	22
NC344	T	7	21	0.1	1.2	3.6	44	15	10	30

Score=100-(sum of soft, leak, and moldy berries). Range is +100 to -300.

Table 2. Quantitative values for firmness (compression) of blackberry and raspberry using a 5 lb load cell and Wagner FDIX gauge.

Fruit	Subjective rating	Compression (N)
Blackberry	1	10-17
	2	8-10
	3	4-7
	4-5	1-3
Raspberry	Firm	3-5
	Soft	0.9-2.5
	Mush	0.2-0.9

Figure 3. Wagner FDX force 1 gauge with 5 lb weight cell to measure f blackberries and raspberries.

Table 3. Summary of blackberry ratings for 2009

Selection	Field/ Tunnel	No. clamshells	% leak	% decay	% red	% soft (3,4,5)	Overall score
Apache	F	20	27.5	4.5	0.4	10.8	56.8
Arapaho	F	25	29.7	6.6	0.7	13.4	49.7
NC430	F	18	9.6	2.1	2.4	6.8	79.2
Navaho	F	45	38.6	3.5	1.2	16.2	40.5
Ouachita	F	35	16.8	3.7	1.8	4.1	73.7
Mean	F		**24.44**	**4.08**	**1.3**	**10.26**	**59.98**
Chester	F	4	36.5	5	1	9.9	57.7
Natchez	F	22	13.4	3.1	2.5	4.3	76.8
Apache	T	23	53.4	9.5	0	16.7	20.4
Arapaho	T	24	47.7	10.2	0.7	24.8	16.7
NC430	T	30	29.1	5.2	3.1	14.1	48.5
Navaho	T	36	26.8	7.9	0.6	16.7	48.1
Ouachita	T	36	23.4	6.4	4.3	6.9	58.9
Mean	T		**36.08**	**7.84**	**1.74**	**15.84**	**38.52**

Table 4. Postharvest quality of blackberries grown in tunnels or field production.

Selection	Field/ Tunnel	No. clamshells	% leak	% decay	% red	% soft (3,4,5)	Overall score
Apache	F	20	27.5	4.5	0.4	10.8	56.8
Apache	T	23	53.4	9.5	0	16.7	20.4
Arapaho	F	25	29.7	6.6	0.7	13.4	49.7
Arapaho	T	24	47.7	10.2	0.7	24.8	16.7
NC430	F	18	9.6	2.1	2.4	6.8	79.2
NC430	T	30	29.1	5.2	3.1	14.1	48.5
Navaho	F	45	38.6	3.5	1.2	16.2	40.5
Navaho	T	36	26.8	7.9	0.6	16.7	48.1
Ouachita	F	35	16.8	3.7	1.8	4.1	73.7
Ouachita	T	36	23.4	6.4	4.3	6.9	58.9

In each case,tunnel fruit had more leak and a poorer score. If difference between field, tunnel is >10%, is highlighted. Note that Navaho and Ouchita were not as different in T, F as the others.
Note: no replicate plots for tunnels.