Vegetable Production and Nutritional Content in Season-Extension Systems

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This bulletin describes one part in a series of three projects conducted in 2009 and 2010 at the University of Wyoming's Sheridan Research and Extension Center. Peppers, tomatoes, and eggplants were grown both years in the field, in a high tunnel, or under row covers. Yields of each plant type were recorded, and total phenols, total flavonoids, and antioxidants were determined at the University of Nebraska-Lincoln's Small Molecule Analysis Lab. Results of yields and nutritional status depended on plant type and whether the plants were grown in the field, in a high tunnel, or under row covers. Tables of yield data and graphs of nutritional contents are included.

Funded by a Wyoming Department of Agriculture Specialty Crop Block Grant Program grant, the overall goal of this project was to develop and promote sustainable specialty horticultural practices for Wyoming. The specific objective was to evaluate several vegetable crops for yield and nutritional content using different fertilization levels. Basic yields as well as nutritional information gained from laboratory analyses of total phenols, total flavonoids, and antioxidant activity will be valuable to vegetable producers and consumers alike. Nutritional parameters of total flavonoids, total phenols, and antioxidants were assessed as these are important in overall human health. Flavonoids, naturally occurring compounds found in many plants, number more than 4,000. They can be found in many fruits, vegetables, and beverages including cranberry, apple, peanut, chocolate, onion, tea, and red wine.

Flavonoids have antioxidant activity, meaning they help neutralize free radicals (Cleveland Clinic, 2011), which can cause cancer and contribute to the aging process. Flavonoids act against cardiovascular diseases, ulcers, viruses, arthritis, and other ailments (Patel, 2008). Phenols are strong antioxidants as well, preventing free radical damage and decreasing chances of cancer and cardiovascular disease (Hollman, 2001). Antioxidants in general, as measured by oxygen radical absorbance capacity, are known to help eliminate free radicals from the body. Antioxidants can be found in a large variety of fruits, nuts, and vegetables (Nutrient Data Laboratory, 2007).

Trials of several varieties of tomatoes, peppers, beets, and carrots were grown to compare general performance, yield, and nutritional content under different fertilization schemes. Vegetables were planted at the University of Wyoming's Sheridan Research and Extension Center (ShREC), seven miles east of Sheridan, Wyoming, in May 2009 and May 2010. Transplants of tomatoes and peppers were used, and carrots and beets were direct-seeded into the plots.

Activities Performed and Outcomes

2009 Season-Extension Yields

Peppers, tomatoes, and eggplants were grown in a high tunnel, under row covers, or in the field during the summer of 2009 in the organic production plots at the University of Wyoming's Sheridan Research and Extension Center (ShREC).

Five plants of each of these varieties were planted May 20 in each location:

Peppers: 'King of the North', 'Purple Beauty'
Tomatoes: 'Rutgers', 'Cosmonaut'
Eggplants: 'Black Beauty', 'Turkish Orange'

These varieties were chosen because they had been successfully grown before at the ShREC and because of their ease of propagation from seeds. Plants were irrigated as needed during the growing season. No additional fertilizer was added. The production areas used in this study are in the process of gaining organic certification. Since organic matter and other natural sources of fertilizer have been incorporated over the last several years, no additional fertilization was deemed necessary in 2009.

Pepper yields:

Peppers 2009 (5 plants per location)			
	Total yield (g)		
Cultivar	Field	High tunnel	Row cover
King of the North	2,863	2,638	4,853
Purple Beauty	1,508	1,690	1,944

Yields of both pepper cultivars were highest under row covers. Lowest yields occurred in the high tunnel with 'King of the North' and in the field with 'Purple Beauty'.

Tomato yields:

Tomatoes 2009 (5 plants per location)			
	Total yield (g)		
Cultivar	Field	High tunnel	Row cover
Rutgers	20,865	15,581	17,112
Cosmonaut	15,846	14,082	7,796

Yields of tomatoes depended on location. Both varieties produced the most fruit in the field. 'Rutgers' produced the least amount of fruit in the high tunnel, while 'Cosmonaut' produced the least under the row cover.

Eggplant yields:

Eggplant 2009 (5 plants per location)			
	Total yield (g)		
Cultivar	Field	High tunnel	Row cover
Black	1,595	2,465	972
Turkish Orange	210	281	0

Neither variety of eggplant produced much fruit. Both yielded the most under the high tunnel, while 'Turkish Orange' yielded zero under the row cover.

2010 Season-Extension Yields

As in 2009, two varieties each of peppers, tomatoes, and eggplants were grown either in the field, under row cover, or in a high tunnel. Five plants of each variety were planted June 1. They included:

Peppers: 'King Crimson', 'California Wonder Orange'
Tomatoes: 'Rutgers', 'Cosmonaut'
Eggplant: 'Black Beauty', 'Turkish Orange'

Plants were irrigated as needed. Fertilizer was applied six times during the growing season using Drammatic® "O" organic fish and kelp fertilizer (2-5-0.2) at a rate of 1 tablespoon per gallon of water, with about 1 gallon of solution applied per plant per fertilization. Plants were fertilized in 2010 as it was thought that yields might be boosted in all three growing locations with additional nutrients.

Pepper yields:

Peppers 2010 (5 plants per location)			
	Total yield (g)		
Cultivar	Field	High tunnel	Row cover
King Crimson	201	195	35
California Wonder Orange	116	1,326	182

'California Wonder Orange' had the highest yields in the high tunnel and lowest in the field. Yields of 'King Crimson' were similar in the field and in the high tunnel but lowest under the row cover.

Tomato yields:

Tomatoes 2010 (5 plants per location)			
	Total yield (g)		
Cultivar	Field	High tunnel	Row cover
Rutgers	20,660	21,000	1,962
Cosmonaut	15,552	23,420	8,385

Both cultivars yielded most in the high tunnel, followed by the field. Plants under row covers produced far less than the other two locations.

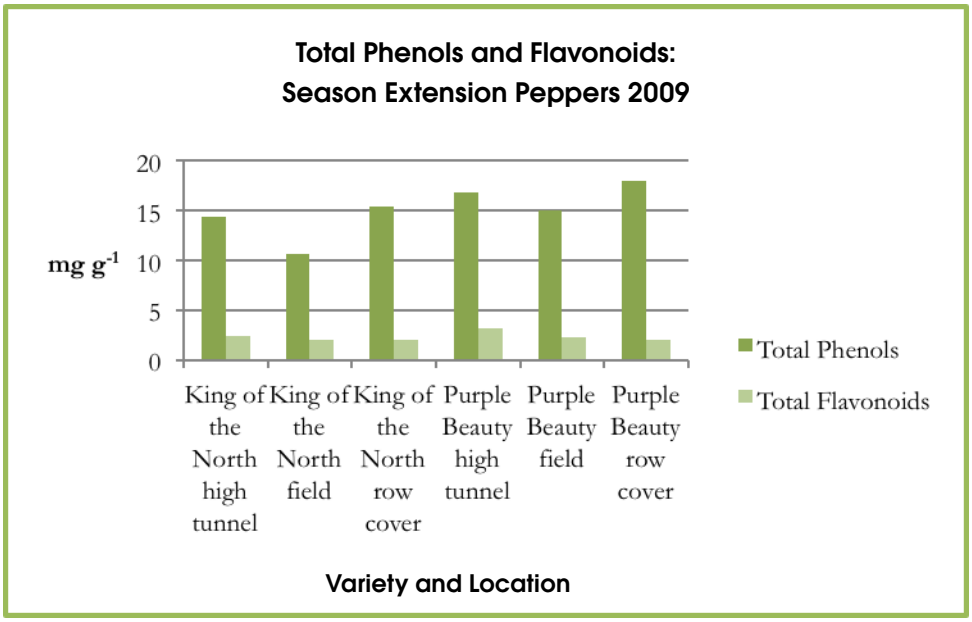
Eggplant yields:

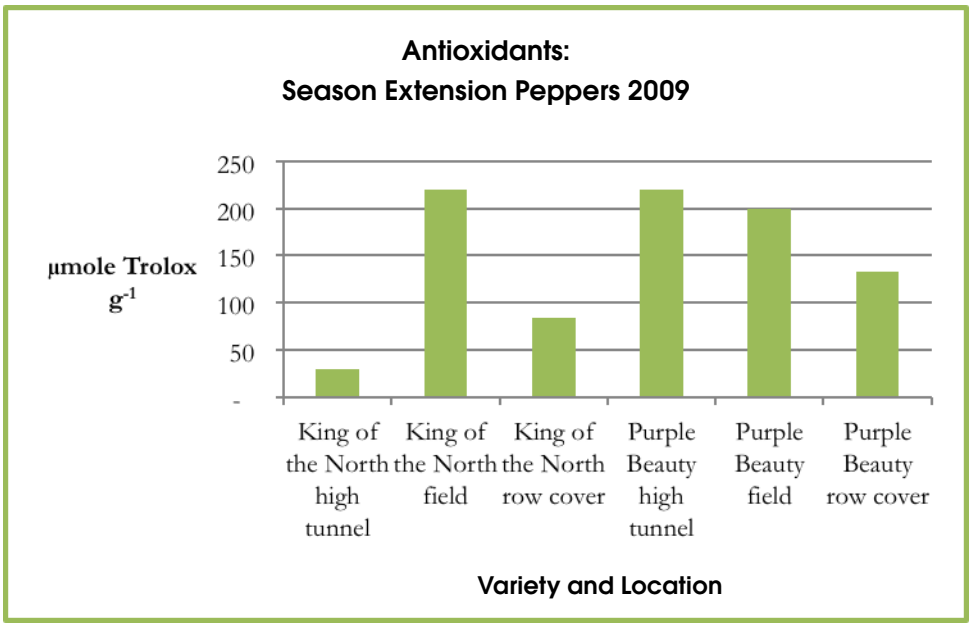
Eggplant 2010 (5 plants per location)			
	Total yield (g)		
Cultivar	Field	High tunnel	Row cover
Black Beauty	140	3,016	3,586
Turkish Orange	0	1,057	130

'Turkish Orange' did not yield much at any location. 'Black Beauty' grown under the row cover and in the high tunnel far out-produced plants grown in the field. Grasshopper infestations were problematic, leading to lower field production.

2009 Season-Extension Nutritional Analyses

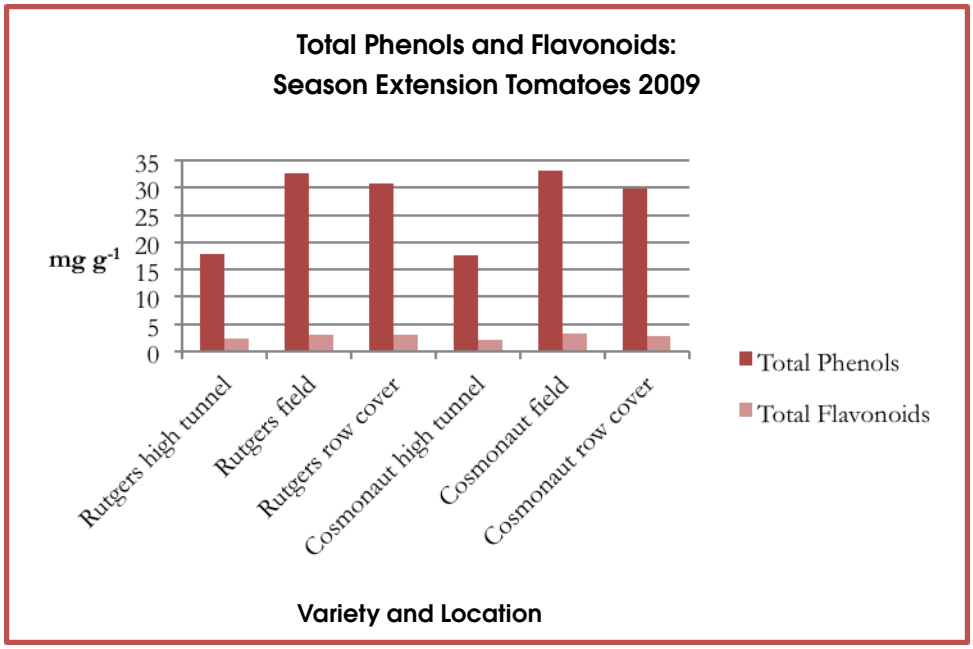
Pepper nutritional analyses:

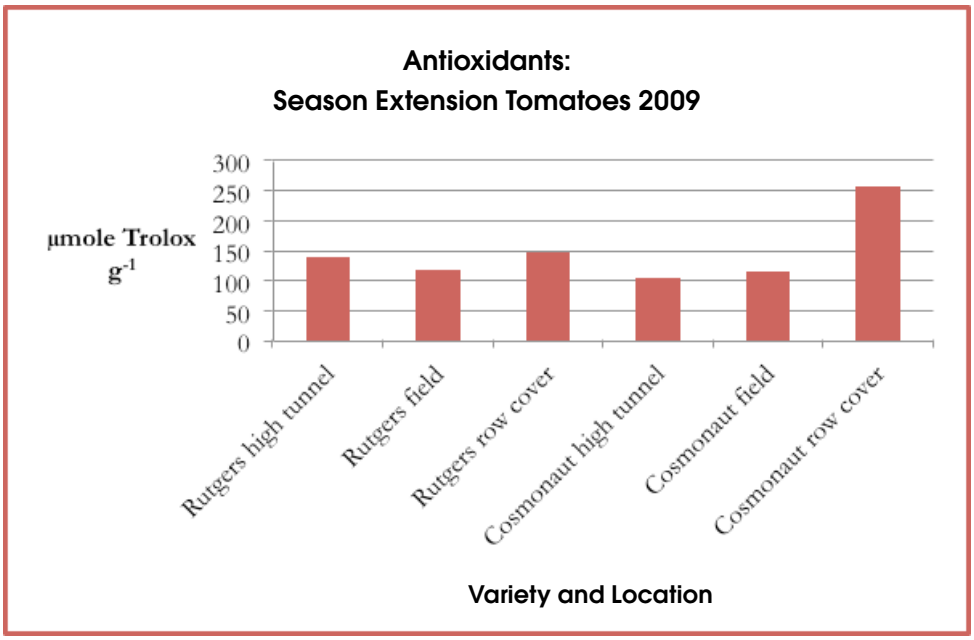




Total phenols were highest in both varieties under row covers, while total flavonoids were highest when grown in the high tunnel. Antioxidants, as measured by ORAC, were highest in the field for 'King of the North' and in the high tunnel for 'Purple Beauty'.

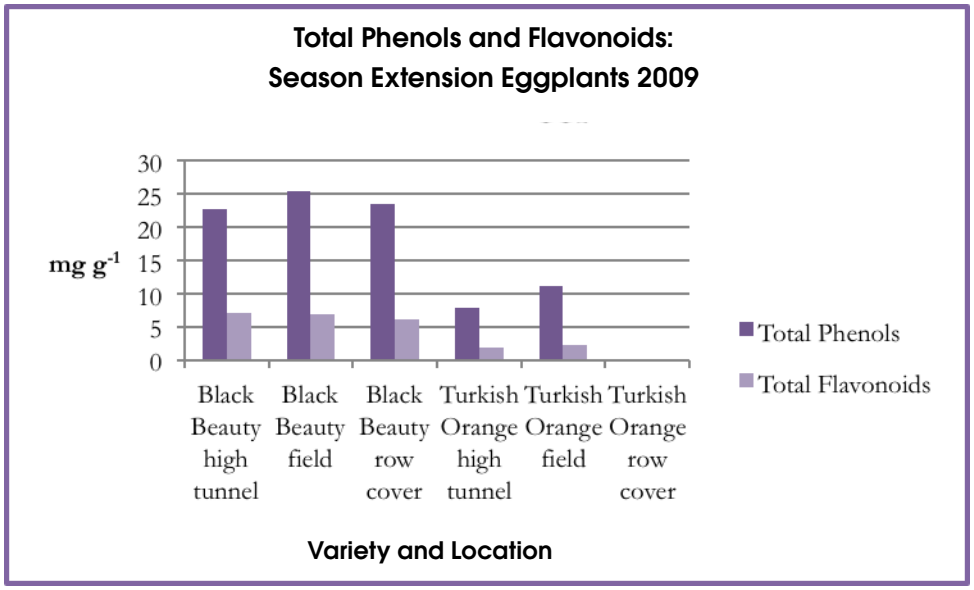
Tomato nutritional analyses:

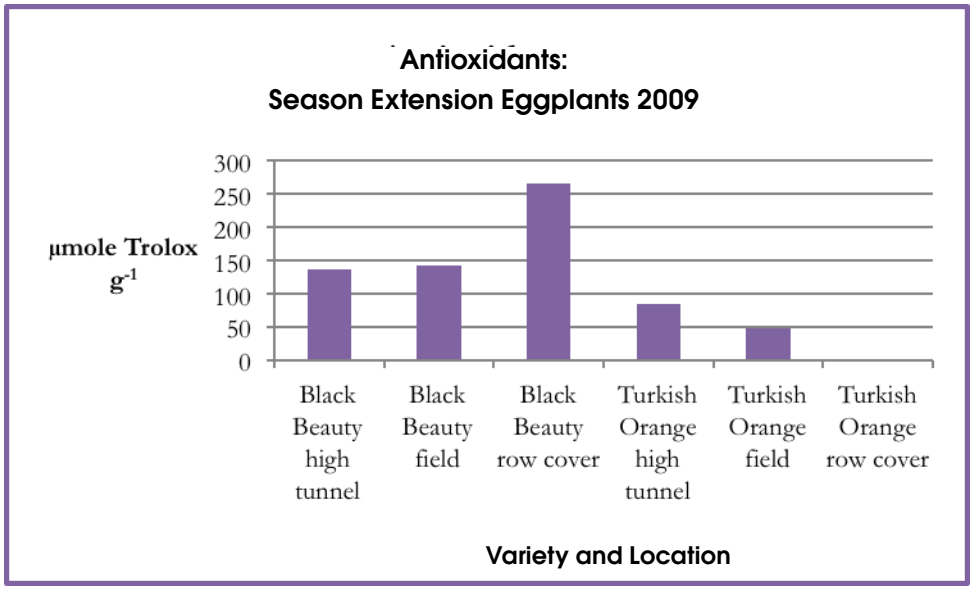




Total phenols and total flavonoids were highest for both cultivars when grown in the field, while highest antioxidant values were found when plants were grown under row covers.

Eggplant nutritional analyses:

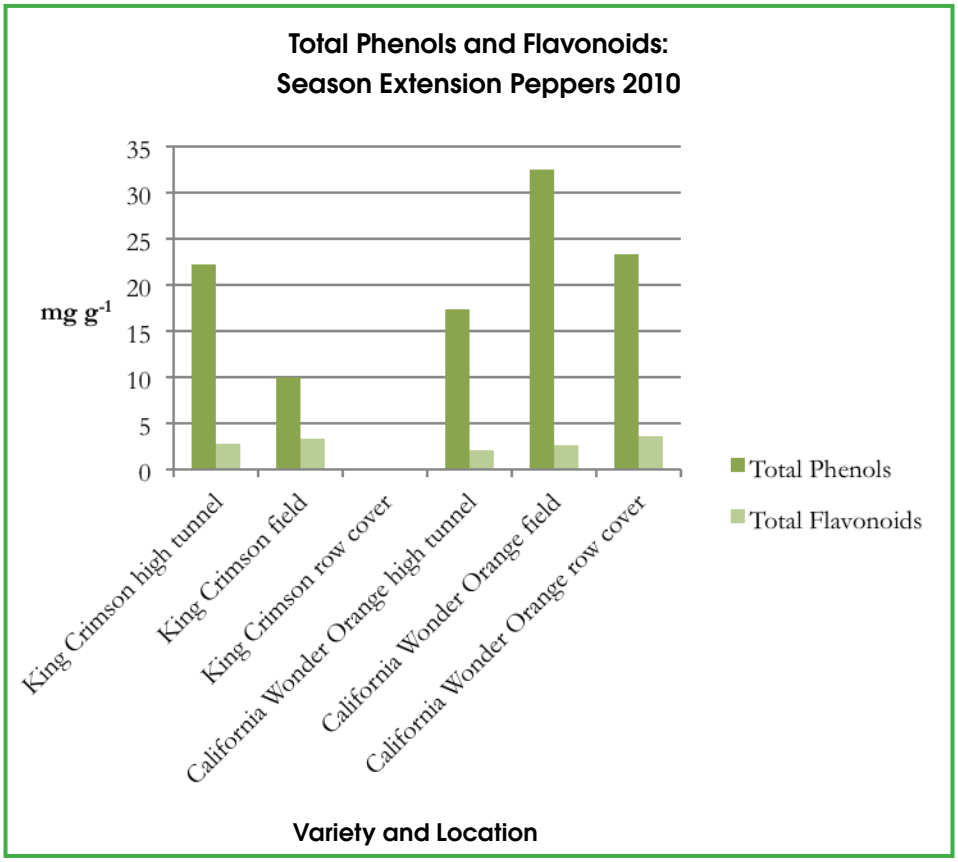


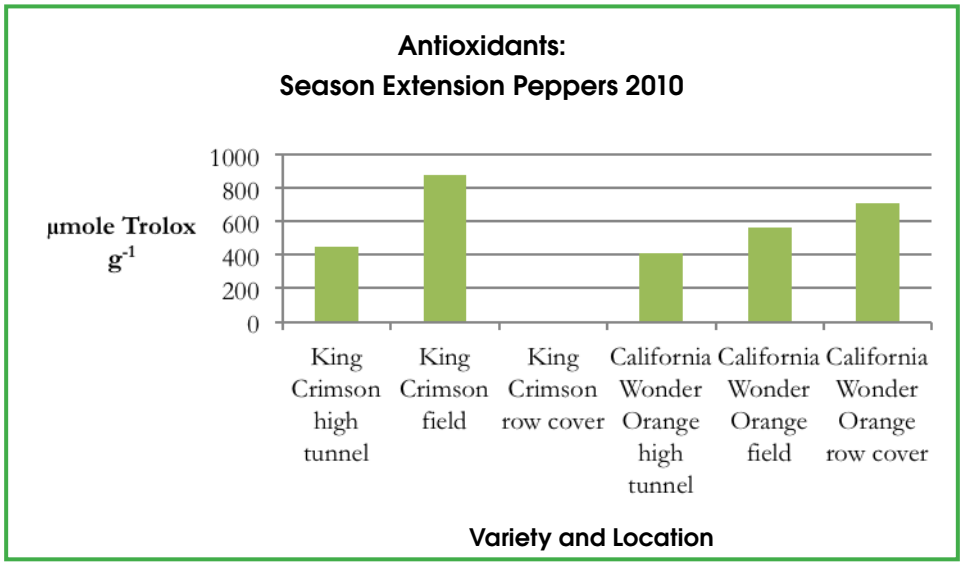


Total phenols were highest for both varieties when grown in the field. Total flavonoids were highest in 'Black Beauty' when grown under the high tunnel and in 'Turkish Orange' in the field. Antioxidants were highest when 'Black' was grown under row cover and in 'Turkish Orange' in the high tunnel. 'Turkish Orange' did not produce any fruit under the row covers so no nutritional data are available for that test.

2010 Season-Extension Nutritional Analyses

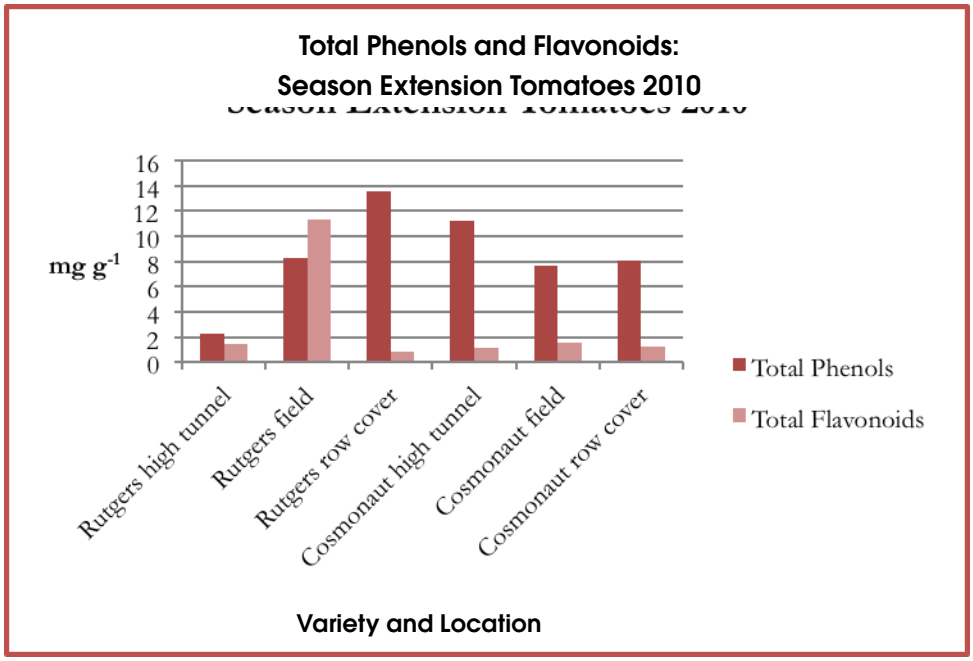
Pepper nutritional analyses:

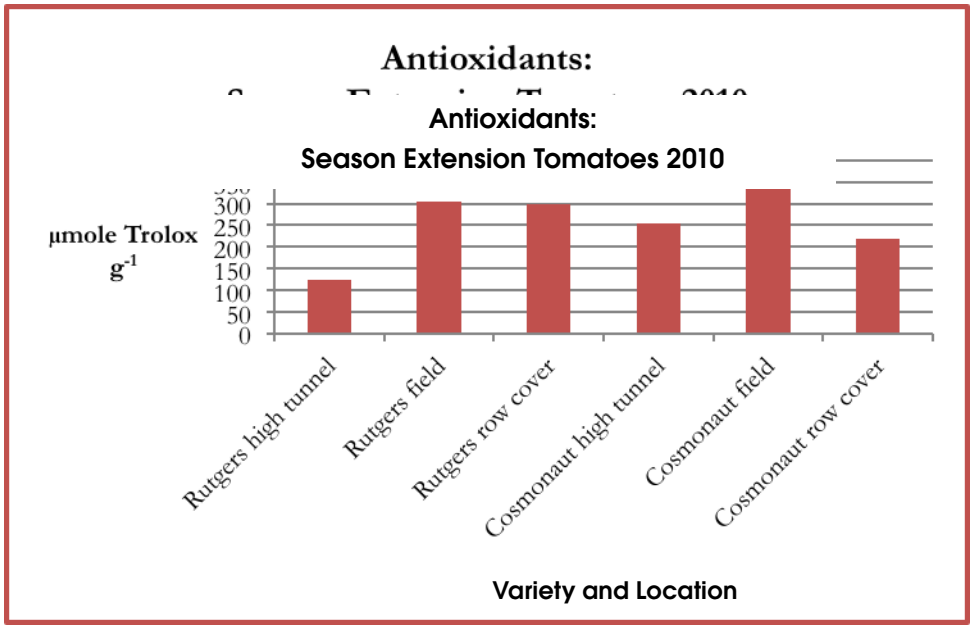




'King Crimson' produced highest total phenols under the high tunnel. Unfortunately, 'King Crimson' samples grown under row covers were unusable for analysis, so no antioxidant data are available. Field-grown 'California Wonder Orange' had the highest total phenols of the three growing locations. Total flavonoids were highest with 'King Crimson' in the field and 'California Wonder Orange' under row covers. Antioxidants were highest in the field for 'King Crimson' and under row covers for California Wonder Orange.

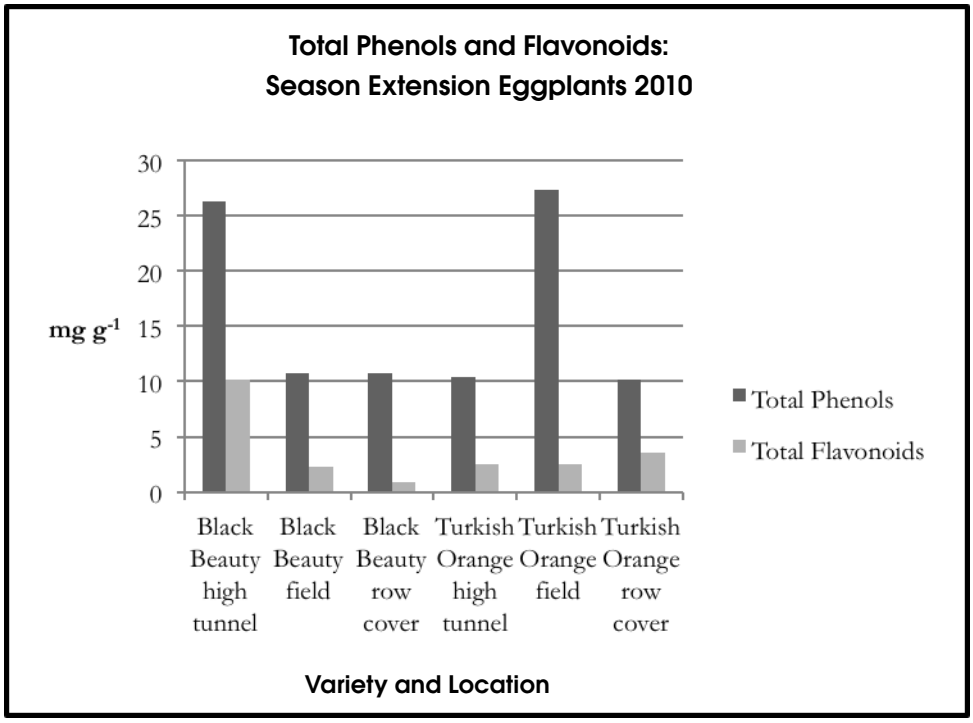
Tomato nutritional analyses:

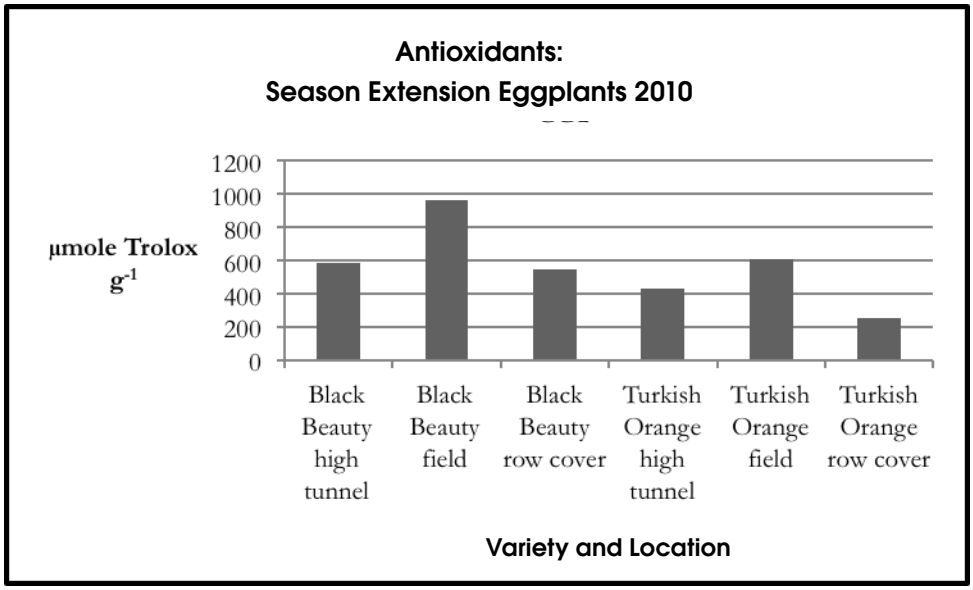




Highest total phenols appeared in row cover-grown 'Rutgers' and high tunnel-grown 'Cosmonaut'. Total flavonoids were highest in the field with both cultivars. Antioxidants were also highest in field-grown plants of both cultivars.

Eggplant nutritional analyses:





Total phenols and flavonoids varied by cultivar. Highest total phenols were found in high tunnel-grown 'Black Beauty' and field-grown 'Turkish Orange'. Highest total flavonoids were found in high tunnel-grown 'Black Beauty' and 'Turkish Orange' under row cover. Field-grown plants of both varieties had the highest antioxidant levels.

Impacts and Recommendations

For producers wanting to grow under season-extension conditions, either under row covers or in a high tunnel, of the varieties tested, suggestions would be 'King of the North' and 'California Wonder Orange' peppers and 'Rutgers' and 'Cosmonaut' tomatoes. Eggplant varieties cannot be recommended due to poor production both years.

From the 2009 season-extension studies, of the varieties tested, those somewhat nutritionally superior would be 'Purple Beauty' pepper and either 'Rutgers' or 'Cosmonaut' tomato (almost the same under row cover and high tunnel). From 2010 data, 'California Wonder Orange' pepper and 'Cosmonaut' tomato would be suggested. Again, eggplants cannot be recommended.

Some may wonder how late the season was actually extended under the high tunnel and the row cover in both years.

Last Harvest		Tomato	Eggplant	Pepper
2009	High tunnel	October 6	September 10	October 6
	Row cover	October 6	October 6	October 6
	Field	September 8	September 10	September 10
2010	High tunnel	October 17	September 23	September 23
	Row cover	September 23	September 23	August 26
	Field	September 10	September 10	September 10

It appears that the high tunnel and row cover extended the growing season about a month over the field in 2009. In 2010, growing under the high tunnel extended the harvest about five weeks over the field for tomato, two weeks for eggplant, and two to three weeks for pepper. Using season-extension systems can increase the growing season; however, it is not clear there was any impact on flavonoids, phenols, or antioxidants. Field-grown produce tended to show higher antioxidant activity, while phenols and flavonoids were more dependent on plant species. To determine real differences, further research will need to be conducted using a larger selection of varieties as well as a larger numbers of plants.

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