

# Impact of Cultivar and Production Practices on Yield and Phytonutrient Content of Organically Grown Watermelon

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**ABSTRACT.** Cultural practices can affect quality and phytonutrient content of watermelon [*Citrullus lanatus* var. *lanatus* (Thunb.) Matsum. & Nakai]. Knowing which cultivars perform well under various production systems, and how these systems affect quality, yield, and phytonutrient content is imperative to ensure high quality and yield. There is limited information on how watermelon cultivars perform when grown with

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The authors acknowledge Amy Helms, Buddy Faulkenberry, Bryan Deak, and Anthony Dillard for technical assistance. Special thanks go to Patty Buskirk for seeds, and Vicki and Joe Townsend for field space.

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Journal of Vegetable Science, Vol. 12(4) 2006  
Available online at <http://jvs.haworthpress.com>  
doi:10.1300/J484v12n04\_06

organic practices. Production characteristics of six watermelon cultivars from certified organic seed sources were compared under high (black plastic and mechanical cultivation for weed control) and low input (no-till) organic culture. The high input production method almost doubled the number of fruit produced for all cultivars; producing greater yields and heavier average fruit weights, but fruit had decreased quality (lower Brix and lycopene content) compared with the low-input production. 'Triple Star' was the most productive seedless cultivar in terms of number of fruit in both organic fields and had the highest marketable yield in the low-input field. 'Early Moonbeam' produced the largest number of fruit and the smallest fruit of the seeded cultivars. 'Allsweet', a seeded cultivar, had the highest marketable yield due to its larger size. 'Triple Star' had the highest quality (high lycopene and Brix content) in the low input field, but all triploid cultivars had similar quality aspects in the high input field. Among seeded cultivars, 'Allsweet' had the best quality at both locations; however, average lycopene content/fruit under low-input production was not significantly different when compared with 'Sugar Baby'. doi:10.1300/J484v12n04\_06 [Article copies available for a fee from The Haworth Document Delivery Service: 1-800-HAWORTH. E-mail address: <docdelivery@haworthpress.com> Website: <<http://www.HaworthPress.com>>.]

**KEYWORDS.** *Citrullus lanatus*, lycopene, organic, quality, watermelon

## INTRODUCTION

Many consumers consider organically produced fruit and vegetables to be healthier and safer than conventionally grown produce. Because of this, consumers are often willing to pay more for organically grown fruit (Whole Foods Market, 2005). Organic culture of some fruit and vegetables can increase vitamin C, iron, magnesium, phosphorus, and other nutritionally significant minerals with significantly less nitrates and lower heavy metals (Worthington, 2001). However, production of organic fruit and vegetables can be challenging, especially in climates where weed, insect, and disease control is necessary. Cultural practices can greatly affect the success of a crop in terms of marketable yield as well as nutrient content. There are conflicting reports on the yield and quality of tomato used in conventional versus organic farming systems. Colla et al. (2000) reported that tomato quality (Brix, titratable acidity, and color) was higher in conventional than in organic production even though yields did not differ between the two systems. However, Lumpkin

(2005) could not determine consistent effects on Brix, lycopene, and fruit quality between conventional and organic production. Caris-Veyrat et al. (2004) reported that organically grown tomatoes had higher lycopene and  $\beta$ -carotene content than conventionally grown fruit when data were expressed as fresh matter, but no significant difference was seen when the data were expressed as dry matter. A literature review which compared organically and conventionally grown foods (Woese et al., 1997) reported no consistent differences in  $\beta$ -carotene between organic and conventional treatments in 27 published studies, and no clear trend in total sugar content in 17 publications.

Lu et al. (2003) found that high-input management practices in watermelon produced greater marketable yield  $\text{ha}^{-1}$ , a higher number of marketable fruit/plant, and higher fruit weight than did low-input management practices. Cürük et al. (2004) reported that watermelon grown under protected organic conditions could produce greater total and marketable yields than those grown under protected conventional systems.

One challenge in converting to organic production is identifying cultivars that will respond well under the different system conditions, that is, disease and insect resistance, and weed pressure. Additionally, phytochemical content is important in gauging the overall impact of organic production. Seemingly, conflicting results show the importance of studying the performance of cultivars under local conditions. Knowing which cultivars perform best under various production systems, and analyzing how these systems affect quality, yield, and phytonutrient content will help maintain consistent high yielding, quality, organically grown watermelon. This project was undertaken to determine effects of cultivar and level of input in organic cultural practices on yield and phytonutrient content of watermelon from certified organic seed sources.

## MATERIALS AND METHODS

*Plant material.* Six watermelon cultivars (cvs.), that is, Early Moonbeam and Sugar Baby (Seeds of Change, Santa Fe, NM), and Allsweet, Triple Crown, Triple Prize, and Triple Star (Terra Organics LLC, Maxwell, CA) were used. The cvs. Early Moonbeam, Sugar Baby, and Allsweet are seeded and served as pollinators for the seedless cvs. Triple Crown, Triple Prize, and Triple Star. The cv. Early Moonbeam has yellow flesh, whereas the other cultivars are red fleshed.

*Culture.* Seeds were planted in Speedling flats containing Sunshine LC1 Mix (Sun Gro Horticulture, Seba Beach, Canada), and grown

at 24–29°C in a greenhouse. On May 19–20, 2005, 4.5-week-old seedlings were transplanted to three experimental fields. Ten plants of each of the six cultivars were planted 0.9 m apart in four rows on 3.7 m centers. The plants were grown using high-input organic cultural practices at Lane, OK, or low-input organic cultural practices at Center Point, OK (~19 km from Lane). All fields had Bernow fine-loamy, siliceous, thermic, Glossic Paleudalf soil and were pretreated using recommended rates of poultry litter for watermelon production (Roberts, 2002). Organic plots were treated biweekly with Neptune's Harvest Organic Fish Blend Fertilizer (NPK 2-3-1) (Ocean Crest Seafood's, Gloucester, MA) at a rate of 3 mL/plant. Drip irrigation supplied water as needed.

For high-input treatments, plastic mulch was applied to beds, and center strips between rows cultivated as needed for weed control. For low-input treatments, a no-till system with a mowed rye and vetch cover crop was used. One week after manual transplanting into the cover crop mulch, weeds within a 30 cm radius of the plants were removed by hand and the area between plants sprayed with vinegar (5% acetic acid). The vinegar was applied using a backpack CO<sub>2</sub> sprayer equipped with a XR8002VS nozzle at 276 kPa with an application volume of 187 L·ha<sup>-1</sup>.

Watermelons were harvested weekly over a 4 week period beginning on July 13. Numbers and weights of marketable and unmarketable fruit were determined. Approximately 20 ripe fruits of each cultivar from each location were cut longitudinally, and flesh from the center of the watermelon tested to determine Brix and lycopene content. Ripeness was determined using visual detection of color, texture, and seed development.

*Quality determination.* The Brix and lycopene contents were determined. Brix was determined using a digital refractometer (model PR 100, Atago, Gardiner, NY). Tissue from the center of the fruit was collected and stored in the dark at 4°C overnight, then pureed using a polytron homogenizer (Brinkmann Instruments, Inc., Westbury, New York), and tested for lycopene (red-fleshed fruit), and total carotenoid content (yellow-fleshed fruit), using a Hunter UltraScan XE (Hunter Associates Laboratory, Inc., Reston, VA) (Davis et al., 2003, 2006).

*Statistics.* At each location, cultivars were established in a randomized complete block with three replications. Data were subjected to analysis of variance (SAS, v. 8.0, Cary, NC), using PROC GLM. Responses to main effects were determined. Means were separated using the Ryan-Einot-Gabriel-Welsch multiple F-test.

## RESULTS AND DISCUSSION

*Yield.* 'Triple Star' was the most productive seedless cultivar at both locations in terms of number of fruit (241, and 119 per 40 plants), but 'Triple Crown' had a higher marketable yield in the high-input organic field due to larger fruit, and a higher percent of marketable fruit (Table 1). 'Triple Crown' in 2005 had an estimated net revenue of ~\$1,300/high-input hectare (Taylor et al., 2006). The highest marketable yield (719 kg) for a seeded cultivar was for 'Allsweet'. This appeared to be due to its higher average weight. 'Early Moonbeams' produced the largest number of seeded fruit (203), and the smallest fruit of the seeded cultivars, but quality was inferior to the other cultivars because it had a tendency to burst and had the lowest sugar content of all cultivars. Because of 'Early Moonbeam's' small size and low marketable yield, the estimated

TABLE 1. Effects of cultivars on yield and fruit-quality factors.

Cultivar	Total number of fruits	% marketable	Marketable yield (kg)	Average			
				Marketable fruit weight (kg)	Lycopene/ fruit ( $\mu\text{g}\cdot\text{g}^{-1}$ )	Brix	Total carotenoid ( $\mu\text{g}\cdot\text{g}^{-1}$ )
<i>High-input culture (Lane, OK)</i>							
Allsweet	103b <sup>2</sup>	72	719a	9.7a	45.3ab	10.9a	–
Early Moonbeam	203a	58	295b	2.5e	–	9.5c	1.9
Sugar Baby	87b	61	387b	7.3b	33.6c	9.6bc	–
Triple Star	241a	60	815a	5.8d	47.4ab	10.0bc	–
Triple Prize	192a	54	748a	7.2b	51.7a	10.1b	–
Triple Crown	186a	75	866a	6.3c	44.2b	10.0bc	–
<i>Low-input culture (Center Point, OK)</i>							
Allsweet	57a	60	294a	8.7a	53.7c	10.8abc	–
Early Moonbeam	116a	88	228a	2.2d	–	9.5d	2.9
Sugar Baby	65a	97	285a	4.5b	55.4c	10.4bc	–
Triple Star	119a	98	465a	4.0bc	69.8a	11.4a	–
Triple Prize	104a	97	427a	4.2bc	65.1ab	10.9ab	–
Triple Crown	88a	98	324a	3.8c	62.4b	10.0cd	–

<sup>2</sup>Values in a column followed by the same letter are not significantly different,  $P \leq 0.05$ , Ryan-Einot-Gabriel-Welsch multiple F-test.

net revenue for this cultivar/high-input hectare was only ~\$900 (Taylor et al., 2006). All seedless cultivars were similar in appearance and produced higher marketable yields than 'Allsweet', which is a cultivar recommended for planting in Oklahoma (Roberts, 2002). Our average fruit weight for 'Triple Crown' is comparable with this cultivar when grown in Mississippi using high-intensity conventional methods (Cushman et al., 2003). However, our yield in number of harvestable fruit greatly surpassed that from Mississippi (4.7 vs. 1 fruit/plant). These data indicate that 'Allsweet' would be a good choice of pollinator for 'Triple Star' or 'Triple Crown', whether using high-or low-input organic culture, especially considering it is easy to differentiate seeded from seedless fruit. However, since 'Allsweet' is a late-maturing cultivar, it needs to be determined if it blooms as early as the triploid watermelons. High-input organic production methods almost doubled the number of fruit produced for all cultivars, producing greater yields and heavier average fruit weights compared with the low-input production method.

The low-input management system had a much higher weed pressure than the high-input field (Webber et al., 2006). This possibly explains why the low-input organic field produced fruit that were, on average, 33% smaller, and produced 46% less fruit than the high-input field. Similar results were obtained by Lu et al. (2003) who demonstrated that yield was 2 or 3 times higher in high-input conventional watermelon fields than in low-input fields. Early signs of weed interference in the nontilled field and heavy late season weed presence, most likely caused decreases in fruit size and number. However, there was an increase in percent marketable fruit for the low-input organic field. This may be due to accelerated ripening due to stress factors, and/or weed coverage reducing bird damage.

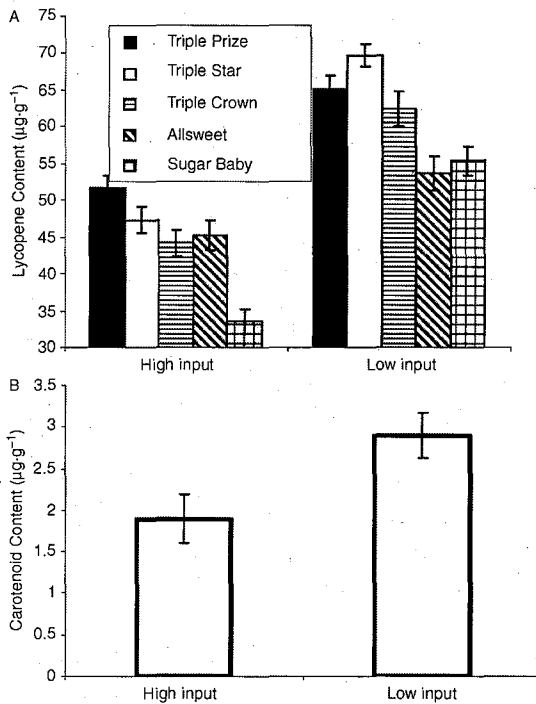
*Quality determination.* 'Triple Star' had the best quality in the low-input field. All triploids had similar quality in the high-input field (Table 1). Among seeded types, 'Allsweet' had the best quality at both locations; however, average lycopene/fruit under low-input production was not significantly different when compared with 'Sugar Baby'. Our Brix values were lower than previously reported (Cushman et al., 2003) for 'Triple Crown' (12.2 vs. 10.1), but similar for 'Allsweet' (10.3 vs. 10.9) (Perkins-Veazie, 2000, 2001, and personal communication). Lycopene content for 'Allsweet' was comparable with previous years' data (Perkins-Veazie, 2000, 2001, and personal communication), 45.3 versus 48.4  $\mu\text{g}\cdot\text{g}^{-1}$ . We tested total carotenoid content for 'Early Moonbeam', and found only trace amounts of carotenoids that agreed with previous

reports (Tadmor et al., 2004; Tadmor et al., 2005). Similar values were seen between the high- and low-input organic plots ( $2.5$  vs.  $2.2 \mu\text{g}\cdot\text{g}^{-1}$ ).

For lycopene, location, cultivar, and their interaction were significant. The interaction data are presented in Figure 1. There was a trend toward higher levels of lycopene in the low-input organic field compared with the high-input organic field (Figure 1A). There was no consistent difference in Brix between plots.

Our data are not consistent with previous reports on tomato, possibly due to the cultural practices chosen for this study, or it may be that watermelon quality traits react to production environments differently

FIGURE 1. The influence of cultural practice on watermelon carotenoid content. (A) Average lycopene content of five red-fleshed cultivars of watermelon grown using two different cultural methods. (B) Average total carotenoid content of 'Early Moonbeam' watermelon grown using cultural methods with different input levels. Standard errors are shown.



than tomato. For example, Colla et al. (2000) showed that tomato quality (Brix, titratable acidity, color) was higher in conventional than in organic plots even though yields did not differ between systems. Data from four paired farms containing organic and conventional production methods were used to test for tomato fruit quality (Brix, lycopene) (Lumpkin, 2005). Comparison between paired farms gave inconsistent, yet significant, differences for lycopene accumulation in two of the matched pairs. With such contradictory results, it was not possible to determine consistent effect on lycopene and fruit quality due to production practices. It is widely accepted that there is a genetic difference between cultivars in their potential for lycopene accumulation. Our data indicate that in watermelon this genetic potential can be greatly affected by environment and some germplasm appear to be affected to a greater extent than others. Therefore, it is important to study the interaction between organic cultural practices and individual watermelon cultivars to find optimum combinations to produce premium quality organic fruit.

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doi:10.1300/J484v12n04\_06