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Horticulture Research

Tomato in High Tunnel, Variety Trial

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Cooperators:
- **Tim Landgraf - Kanawha**
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In a Nutshell

- Three farms conducted replicated variety trials in high tunnels of tomato varieties: Big Beef, Rebelski, Big Dena.

Key Findings

- No farm showed statistical differences in overall yield (lb/ft^2) among varieties.
- Landgraf and Quee had statistical differences in size and number of tomatoes, with Rebelski having more and smaller fruits than Big Beef.
- All farms will continue to use Big Beef as a high tunnel variety, and Matteson/Schick will also continue to use Big Dena, which held its size later into the season.

Project Timeline:
March - Sept. 2017

Big Beef at Matteson/Schick.

Background

Growing tomatoes in the high tunnel gives farmers an early jump on the tomato market, and can help protect the plants from some environmental stressors. In 2016, two farmers compared the varieties Mountain Fresh Plus and Rebelski in the high tunnel, curious if the determinate variety, Mountain Fresh Plus, would provide a better yield in a short window. Yield at both farms was lower than reported in other published high tunnel variety trials, but Rebelski yield outperformed Mountain Fresh Plus; at Tim Landgraf's by 1.4 lb/plant, and by 2.1 lb/plant at Mark Quee's (Kolbe, et al., 2016).

In the present project, three farmers selected two of three tomato varieties (Big Beef, Big Dena or Rebelski) to trial inside their high tunnels. These varieties were selected based on positive farmer experience, the varietal similarities, and the availability of organic and untreated seed, donated by Johnny's Seeds. Catalog descriptions of the varieties can be seen in **Table 1**.

Johnny's Seeds rates Rebelski its best all-around performer for the greenhouse (Johhnyseeds.com, 2017). No publications were available showing all three varieties in the same trial, in the field or in a high tunnel. Big Beef and Rebelski were both tested in a high tunnel trial at the University of New Hampshire. Both were among the best performers in the trial, with Big Beef producing 12 lb/plant and Rebelski producing 14 lb/plant. In 2011, Big Beef produced 23 lb/plant in the same trial (Sideman and Warren, 2013). Big Dena was included in a 2011 high tunnel variety trial at Cornell University. Yield averaged 19.6 lb/plant, with a mean fruit weight of 0.48 lb/fruit (Reid, et al., 2012). Among the varieties tested in that trial, Big Dena was a middle-performer.

"We have grown both of these tomato varieties [Rebelski and Big Beef] in our high tunnel, but have not kept variety specific data for them. This project will help us decide if both varieties are a benefit for us or just focus on one variety," said Landgraf. Matteson and Schick added, "We want to inspire other growers to grow something other than Rebelski. Big Beef is not considered a 'greenhouse' tomato and we like it a lot in our greenhouses. So it would be good to put it up against Big Dena (considered a good 'greenhouse' tomato) and see if the data proves it."

Table 1

Varietal information from Johnny's Selected Seeds 2017 Catalog

Variety	Days to Maturity	Cost ($/500 seeds)	Disease Resistance	Description
Big Beef	70	22.45	High Resistance to: Alternaria Stem Canker, Fusarium Wilt 1 & 2, Gray Leaf Spot, Nematodes, Tobacco Mosaic Virus, Verticillim Wilt	"Nice combination of size, taste, and earliness. Full-flavored, 10-12 oz., globe-shaped fruits ripen early for their size. AAS winner."
Big Dena	77	324.55	High Resistance to: Fusarium Wilt 1 & 2, Verticillim Wilt, Fusarium Crown and Root Rot, Leaf Mold, Tobacco Mosaic Virus, Tomato Mosaic Virus	"High yields of large, flavorful fruit. Vigorous, open plants produce very high yields of uniform, 10-12 oz., red fruits that are mostly smooth with slight shoulder ribs. Very good flavor with nice internal color and quality."
Rebelski	75	420.25	High Resistance to: Fusarium Wilt 1 & 2, Verticillim Wilt, Fusarium Crown and Root Rot, Leaf Mold, Powdery Mildew, Tobacco Mosaic Virus	"Greenhouse tomato for fresh market. Rebelski combines very good flavor, texture, presentation, and an excellent disease package. Bright red, shiny, ribbed fruits avg. 7-8 oz, and are crack-resistant. Enough firmness to withstand some handling. An excellent disease package keeps the crop healthy over a long season. Very high yield potential."

Methods

This project was conducted at three Iowa farms: Tim Landgraf (One Step at a Time Gardens in Kanawha), Lee Matteson and Rose Schick (Lee's Greens in Nevada), and Mark Quee (Scattergood Farm at Scattergood Friends School in West Branch).

Each farmer planted two tomato varieties inside a high tunnel in a randomized, paired trial. Landgraf used 10 plants per plot, Quee used 6 plants per plot; both farmers weighed and counted fruit by plot. Matteson and Schick planted four replications of 10 plants, but bulk-weighed by variety so no statistical analysis was performed. Spacing, mulch, trellis style, and planting date were determined by farm, and described in **Table 2**. Plants for the trial were started indoors and transplanted to the high tunnel (in-ground). Matteson and Schick planted into a heated high tunnel. The tomato varieties chosen were Big Beef and Rebelski or Big Dena. Big Beef and Rebelski seed was provided by Johnny's Selected Seeds.

Farmers harvested, counted and weighed tomatoes as fruit matured. Harvest windows are noted in **Table 2**.

Data were analyzed using JMP Pro 12 (SAS Institute Inc., Cary, NC) and comparisons among measured variables employ least squares means for accuracy. A repeated measures approach was used to examine the effects of harvest date, treatment, and their interaction on cumulative tomato yield. For some yield characteristics (percent cull, fruit weight) means are compared using Tukey's least significant difference (LSD). Statistical significance is reported at $P \leq 0.10$.

Table 2

Production practices and trial design by farm

Farm	Tim Landgraf	Mark Quee	Lee Matteson & Rose Schick
Varieties Trialed	Big Beef, Rebelski	Big Beef, Rebelski	Big Beef, Big Dena
Start Date	March 27	March 8	Jan. 11
Transplant Date	May 18	April 24	Feb. 24
In-Row Spacing	16 in.	24 in.	24 in.
Between-Row Spacing	48 in.	20 ft (48 in. bed)	24 in.
Trellis Style	2 leaders, Florida weave	2 leaders, clipped to string	Single leader, clipped to string
Management	Strip lower leaves; farm compost to high tunnel (~1 ft^3/30ft^2); worm castings with transplant.	Transplanted with 1 qt. worm compost; sprayed twice with Bt-k (Dipel DF).	All side shoots removed; some fruit thinning from large clusters. General fertilizer: 20-20-20 at 200ppm N; supplemental liquid Ca and K at fruit set until end of harvest.
Plants per Plot	10	6	10
Number of Reps	4	6	4*
Transplant to Harvest, Days	75	80	87
Harvest Window Dates; Days	Aug. 1-Oct. 2; 55	July 13-Sept. 27; 76	May 22-Oct. 4; 135

* Mattenson/Schick bulk-measured tomatoes during harvest. Without measurements by replication, no statistical analysis could be performed.

Results and Discussion

Monthly growing degree days and mean maximum daily temperature for the current year and historical averages are reported from the nearest weather station to each farm (**Table 3**). Because tomatoes were grown inside high tunnels, rainfall is not reported. 2017 had a cool August, with every site having GDDs for the month more than one standard deviation cooler than the historical average.

Figure 1 shows cumulative yields through the season at each farm. Bold lines represent the varietal average and lighter lines show the individual plot yields. Using repeated measures analysis, average yields for Big Beef were statistically higher during August at Landgraf and Quee, but by the end of the summer, there were no statistical differences in overall yield. At both farms, the earlier-maturing Big Beef showed higher yields early on, with Rebelski catching up toward the end of the season. Statistical analysis was not performed at

Table 3

Monthly growing degree days and mean maximum daily temperature for the period April 2017 – Sept. 2017 and the long-term averages.

Month	Landgraf, Kanawha				Quee, West Branch				Matteson/Schick, Nevada			
	GDD		Mean Max. Daily Temp. ˚F		GDD		Mean Max. Daily Temp. ˚F		GDD		Mean Max. Daily Temp. ˚F	
	2017	*Avg.*	*2017*	*Avg.*	*2017*	*Avg.*	*2017*	*Avg.*	*2017*	*Avg.*	*2017*	*Avg.*
Apr.	147	163	59	59	217	210	63	62	179	187	61	61
May	310	323	68	71	**331**	**417**	70	73	339	390	70	72
June	584	564	82	80	613	616	84	82	617	595	84	81
July	704	695	84	85	734	741	88	87	747	729	86	86
Aug.	518	**636**	77	82	**563**	**690**	81	85	**562**	**672**	79	84
Sept.	481	428	78	75	513	489	81	78	514	461	80	76

Climate data were accessed from the Iowa-North Central (120 years, Landgraf), Iowa City (120 years, Quee), and Iowa-Central (120 years, Matteson/Schick) weather stations (Iowa Environmental Mesonet, 2017).

GDD (base 50) values in bold indicate that the 2017 value was more than one standard deviation from the historical average.

Young tomato plants trellised with Florida weave at Landgraf.

Trial setup at Landgraf.

Matteson/Schick, but total yield for both varieties (Big Beef and Big Dena) at the end of harvest were within two pounds of one another. Similar to the pattern at Landgraf and Quee, Big Beef got off to a faster start, and fruit production from Big Dena eventually caught up in September.

The vertical dotted lines in **Figure 1** indicate the time period during which average yields of Big Beef exceeded those of Rebelski at $P \leq 0.10$ (Aug. 14 – Aug. 28 at Landgraf; Aug. 2 – Aug. 22 at Quee).

Figure 1

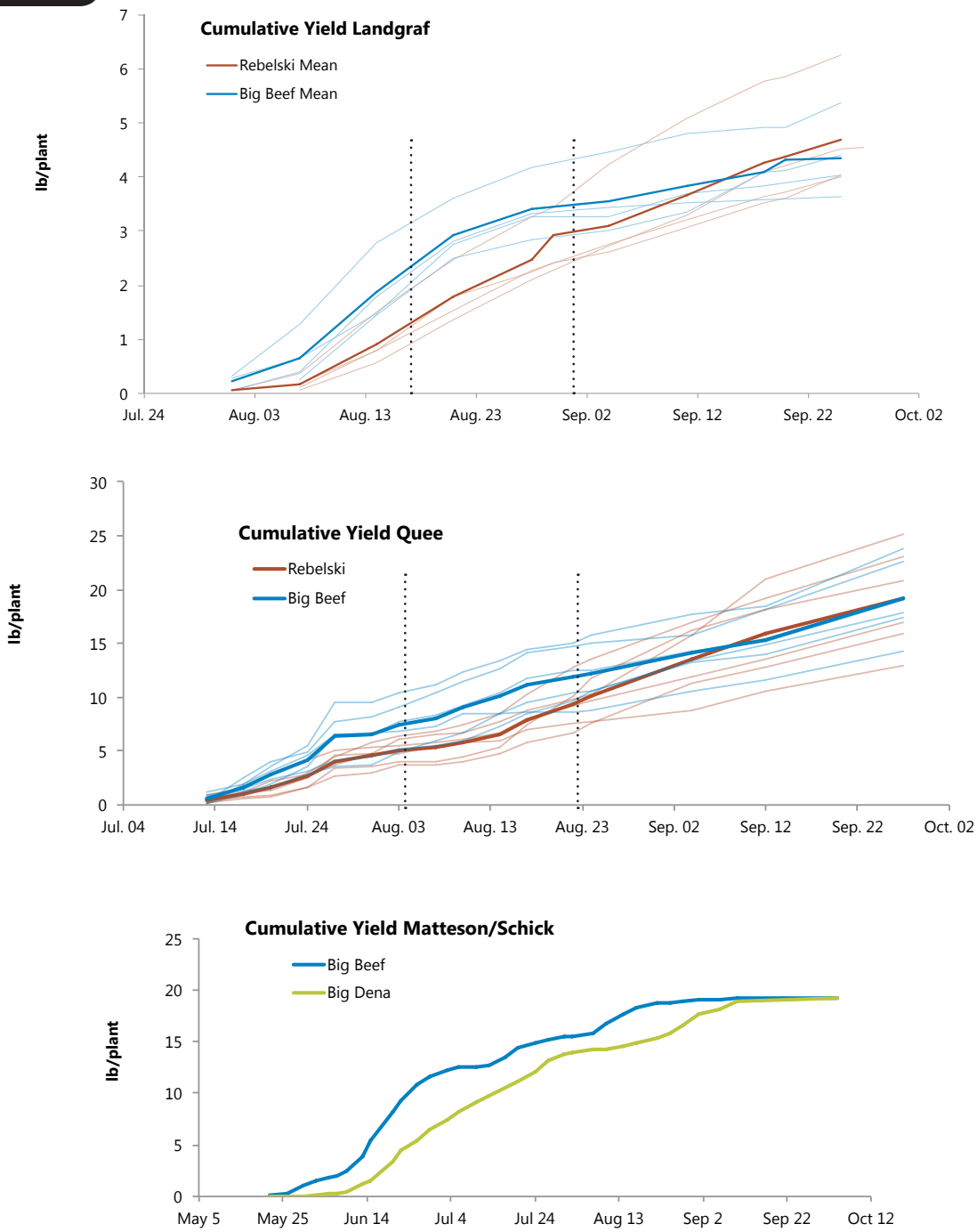

Figure 1: Cumulative yield shown in lb/plant at each farm. Bold lines are the average values for each variety; light lines are individual plot values. The last date is the final yield. The dotted vertical lines indicate the time period during which average yields of Rebelski and Big Beef were statistically different with 90% certainty. Final yield in lb/plant were not statistically different on any of the farms. (Statistical analysis could not be performed at Matteson/Schick due to bulk harvest).

Table 4

End-of-season yield and yield components for the two tomato varieties at each farm.

Farm	Yield (lb/plant)		Fruit Count (no. fruit/plant)		Mean Fruit Weight (lb/fruit)		Cull Fruit (% count of fruit)	
	Rebelski	*Big Beef*	*Rebelski*	*Big Beef*	*Rebelski*	*Big Beef*	*Rebelski*	*Big Beef*
Landgraf	4.7	4.4	14.0 a	10.2 b	0.34 b	0.43 a	.	.
Quee	19.2	19.2	43.9 a	35.9 b	0.43 b	0.53 a	6.1%	4.3%
	Big Dena	*Big Beef*	*Big Dena*	*Big Beef*	*Big Dena*	*Big Beef*	*Big Dena*	*Big Beef*
Matteson/Schick*	19.2	19.3	41	41.6	0.45	0.42	.	.

By farm and yield component, only values with different letters are statistically different with 90% certainty.

*Statistical analysis could not be performed at Matteson/Schick.

Yield per plant and yield components for the tomato varieties by farm can be seen in **Table 4**. None of the three farms reported yields per plant that were statistically different by variety. Quee and Matteson/Schick had very similar plant yields, at 19.2–19.3 lb/plant for both varieties they grew. Mattenson/Schick also reported that Big Dena had more larger fruit longer into the season, as shown in **Figure 2**. Both varieties, Big Beef and Rebelski, produced smaller fruit at the end of the harvest at Quee and Landgraf, too. Landgraf had lower yields, at 4.4 lb/plant for Big Beefand 4.7 lb/plant for Rebelski. Fruit weight (lb/fruit), however, differed between Rebelski and Big Beef at Landgraf (LSD = 0.02) and Quee (LSD = 0.03). This result is not surprising, because Rebelski typically has a smaller fruit. The higher number of fruit produced later in the season by Rebelski plants was sufficient to even up the overall yields at Landgraf and Quee. At Quee, Rebelski produced eight more fruit per plant than Big Beef, enough to result in a statistical difference (LSD = 5.42). The difference at Landgraf was less, at 3.8 more fruit per plant for Rebelski; but still showed a statistical difference (LSD = 2.16). Quee, the only farmer who tracked seconds, did not find a statistical difference in cull fruit.

Big Dena at Matteson/Schick.

Figure 2

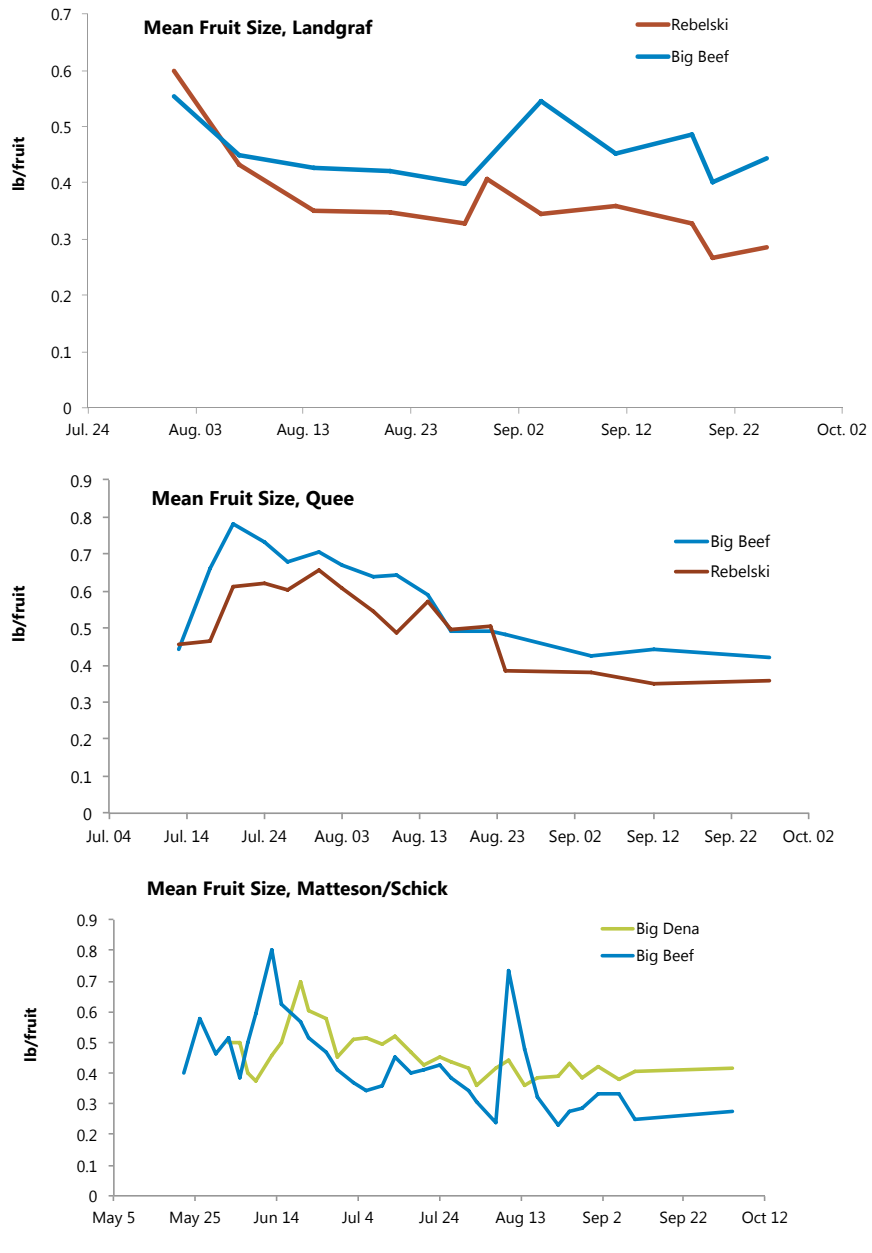

Figure 2. Average size of fruit (lb/fruit) by harvest date at each farm. Bold lines indicate the average values for each variety.

Economic Considerations

Enterprise budgets were not done for this project, but a back-of-the-envelope calculation provides some insight into the effect of seed cost on overall revenue. If all seeds purchased are successfully planted, the cost per seed (and thus, per plant) is $0.05 for Big Beef, $0.84 for Rebelski, and $0.65 for Big Dena. If tomato retail tomato price is assumed to be $3.30/lb, all three farms would make more revenue per plant using Big Beef, the cheaper seed, when factoring in seed cost (**Table 5**). However, if Rebelski seeds went unused or transplants failed, the seed cost would quickly diminish profitability, especially at Landgraf, where yields were lower. At Quee and Matteson/Schick, yields were high enough that seed cost had a much smaller impact on net income; each seed expense was less than $1, compared to $63 in revenue for the plant.

Table 5

Estimated revenue per plant, less seed cost, by variety at each farm*

Farm	Variety	Cost per seed ($/plant)	Yield (lb/plant)	Retail tomato price ($/lb)	Estimated revenue ($/plant)	Estimated Revenue – Seed Cost ($/ plant)
Landgraf	Big Beef	$0.05	4.4	$3.30	$14.52	$14.47
	Rebelski	$0.84	4.7	$3.30	$15.51	$14.67
Quee	Big Beef	$0.05	19.2	$3.30	$63.36	$63.31
	Rebelski	$0.84	19.2	$3.30	$63.36	$62.52
Matteson/ Schick	Big Beef	$0.05	19.3	$3.30	$63.69	$63.64
	Big Dena	$0.65	19.2	$3.30	$63.36	$62.71

*Values were estimated using lb/plant from **Table 4**, a tomato market value of $3.30/lb, and the cost of seed in **Table 1**.

These 2017 results are different than the 2016 results that compared Rebelski and Mountain Fresh Plus (Kolbe, et al. 2016). In 2016, yields for Rebelski were statistically higher than Mountain Fresh Plus, and the difference was great enough that the extra seed cost was worth it for the additional fruit production. Rebelski and Big Dena cost more because of the additional disease resistance bred into the variety, as shown in **Table 1**. For Quee, he plans to continue using Big Beef and other similarly-priced seeds as long as he does not have much disease or pest pressure in his high tunnels. If that changes, he will consider a more resistant seed variety.

Harvest at Quee.

Conclusions and Next Steps

Though total yield at each farm was not statistically different by variety, farmers responded to price, taste, size, and timing of harvest in their varietal choices moving forward.

Landgraf strongly preferred Big Beef, which was his favorite variety coming into the trial. "This trial was to test two tomato varieties in the high tunnel. We found a definite preference in the taste and texture of one variety over the other. We plan to continue using Big Beef in the high tunnel, and will discontinue planting the Rebelski variety," said Landgraf. Landgraf targets his tomato season to begin Aug. 1 to accommodate a July vacation, so his harvest window is typically shorter, ending at the beginning of October. However, he did note that yields this year were lower than normal, perhaps due to more cool, cloudy days; generation from his solar panels was low, too.

Quee, whose tomatoes are used primarily in the Scattergood Friends' School kitchen, did not have strong varietal preference, but plans to move forward with Big Beef based on the cost difference. "My market loves any tomatoes by mid-July and we appreciated still having tomatoes right up until frost. I found Big Beef and Rebelski indistinguishable in taste, color and for the most part, size. Anecdotally, it seemed that Rebelski had more small tomatoes which brought down the average, but it also produced ample large tomatoes. The flavor of both varieties did not compare well to some of our outdoor heirlooms."

Quee is mindful of the disease package of Rebelski, but for now, is confident in the health of their high tunnel. "I will probably continue to plant a few Rebelski just in case our soil-borne disease load reaches a tipping point in our high tunnels. But thus far, with seemingly little disease pressure, I will plant many more of the cheaper Big Beef," he said.

Schick and Matteson want tomatoes ready early in the season, and Big Beef is an early starter. However, the combination with Big Dena has advantages, too. "Big Beef has better name recognition at the farmers market, and its harvest started sooner. But it seems to do the traditional bell curve for harvest with tomato size declining as the season goes along which decreases the amount that can be sold to restaurant customers and more have to go to seconds," said Schick.

"It seemed to us that Big Dena has two flushes. Its harvest starts later than Big Beef, has a flush (in July), then has another one later (in late August). It also seems to keep its size better. We are considering using Big Dena as a variety to keep later into the fall because the size holds up and it has a later flush of fruit."

Harvest at Landgraf.

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