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Horticulture Research

Summer Broccoli Variety Trial

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Cooperators:

- **Jill Beebout - Chariton**
- **Carmen Black -Solon**
- **Rick Hartmann - Minburn**
- **Alice McGary - Ames**
- **Jordan Scheibel - Grinnell**
- **Mark Quee - West Branch**

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CERES

Web Link:

http://bit.ly/pfi_horticulture

In a Nutshell

- Six farmers compared three broccoli varieties, Belstar, Gypsy and Imperial, to determine which produces better during summer months (harvest July – Sept.) in Iowa.

Key Findings

- Imperial had the highest yields at four of six farms, followed by Gypsy and Belstar.
- At three farms, Imperial had statistically higher yields than the other varieties.
- Plant spacing differed by farm, but average yield per area was 0.28 lb/ft^2 for Imperial, followed by Gypsy (0.27 lb/ ft^2), and Belstar (0.22 lb/ft^2)
- Following the indications of the data, most farmers strongly preferred Imperial as their summer broccoli variety.

Project Timeline:

April 2016 - November 2016

The broccoli variety trial at Scheibel's in June.

Background

Broccoli is classified as a cool-season crop, typically planted in the spring for June harvest and planted again in August for October harvest. Plant breeders, however, are developing varieties of broccoli that are more resistant to heat stress. For broccoli, heat stress is most harmful at the earliest discernible reproductive phase, continues through inflorescence production and floral initiation, lasting until the broccoli crown is 5-10 mm wide; a time span of 2-3 weeks (Bjorkman and Pearson, 1998). Temperatures above 86 ˚F can induce heat stress, and can cause broccoli crowns to have non-uniform bud sizes, flattened crowns, yellowing or head leafiness depending on the timing and severity of stress (Dufault, 1996; Bjorkman and Pearson, 1998; Farnham and Bjoerkman, 2011). Temperatures over 86 ˚F did not affect development of broccoli during vegetative growth or during maturation after the crown was 5-10 mm in diameter (Bjorkman and Pearson, 1998).

Other states have performed variety trials for broccoli tolerance to heat stress. Several of these studies included Gypsy, a variety from Johnny's Seeds. Results from Massachusetts extension showed that Gypsy performed well in harvest periods from Aug 22 – Sept. 5, with only some unevenness and head leafiness in the second succession (Cavanagh and Hazzard, 2007). Cornell University tested their broccoli hybrids in development by growing them in South Carolina's summer. Their newer varieties performed better than Gypsy, which suffered some yellowing and flattening of crowns, yielding many unmarketable heads in the hot weather trial (Farnham and Bjoerkman, 2011). Penn State Extension trialed 25 varieties, including Gypsy and Imperial, but grew them during spring and fall seasons, not focusing on the summer heat. In that trial, yields for both varieties were not significantly different than most other varieties tested. On plastic mulch, Imperial averaged 0.80 lb/crown, Gypsy averaged 0.89 lb/crown. On bare soil (at other locations), Imperial and Gypsy both averaged 0.62 lb/crown (PSU Extension, 2014).

Though a cool-season crop, demand for broccoli continues through the summer, so farmers in Iowa want to stretch their broccoli harvests through the hot months of July, August and September to capture the market when local supply is low, and to keep broccoli in their CSA boxes as often as possible. Carmen Black said, "I almost succeeded in delivering broccoli to my customers every week last summer, and am excited to try to do even better this summer by trying new varieties." Similarly, Jordan Scheibel said, "I have seen some success pushing broccoli beyond its traditional limits, especially with side shoots on some newer varieties. Broccoli is one of my top crops for CSA and farmers market and I would love to be able to have it every week of the season, like kale."

In this trial, a group of farmers chose two three varieties (Belstar, Gypsy and Imperial) to compare during 2016. These varieties were selected because of positive farmer experience, the varietal similarities, and the availability of organic and untreated seed.

Methods

This project was conducted at six Iowa farms: Jill Beebout (Blue Gate Farm in Chariton), Carmen Black (Sundog Farm in Solon), Rick Hartmann (Small Potatoes Farm in Minburn), Alice McGary (Mustard Seed Community Farm in Ames), Jordan Scheibel (Middle Way Farm in Grinnell), and Mark Quee (Scattergood Farm at Scattergood Friends School in West Branch).

Most farmers planted four replications of each of the three broccoli varieties in a randomized, replicated trial (some farmers planted only two varieties). Plants per plot at each farm ranged from 10 to 20, and spacing, mulch, and irrigation practice was determined by farm, and noted in **Table 1**. Plants for the trial were started indoors and transplanted to the field, except at Hartmann's farm, where broccoli was direct seeded. The broccoli varieties used were Belstar, Gypsy, and Imperial; if a farm compared only two varieties, Belstar and Imperial were used. All broccoli for the trial are hybrid varieties that were suggested by farmers based on their previous experience. Belstar is rated as "average" for heat tolerance by Johnny's, with 66 days to maturity. Gypsy is rated "good" for heat tolerance, with 58 days to maturity. Imperial is rated as "excellent," with 71 days to maturity. All broccoli seed for this trail was provided by Johnny's Selected Seeds.

Table 1

Production Practices and Trial Design by Farm

Farm	Start Date	Transplant Date	In-Row Spacing	Btwn-Row Spacing	Configuration	Mulch	Irrigation	Harvest Window	Plot (ft^2)
Jill Beebout	March 4; March 30	April 12; April 29	12 in.	24 in.	Staggered double row in 3 ft bed	None	Drip	June 17 - Nov. 15	150
Carmen Black	May 11; June 12	June 19; July 26	16 in.	36 in.	Single row	None	Drip, only early	Aug. 21 - Nov. 21	60
Rick Hartmann	Apr. 24[a]	-	12 in.	18 in.	Single row	None	Drip	July 21 - Aug. 21	36
Alice McGary	May 3; May 19	May 29; June 24	18. in	48. in.	Staggered double row	Partial with scythed rye; none	Watered at planting	Aug. 1 - Sept. 27	60
Mark Quee	April 11 - May 23	May 8 - June 17	18 in.	~30 in.	Double row in 63 in. bed	None	Drip	July 16 - Aug. 29	39; 47; 55
Jordan Scheibel	Apr. 20; May 9	May 30; June 20	12 in.	20-24 in.	30 in. raised bed	None	Drip	July 27 - Sept. 7	50

[a] Direct seeded into field

Farmers harvested and weighed broccoli heads and side shoots separately. Broccoli head quality was scored as "acceptable" or "unacceptable" based on USDA grading standards for head density, head color, bead size, head shape, and head leafiness (Dufault, 1996; USDA AMS, 1997). Planting and harvest dates are noted in **Table 1**.

Data were analyzed using JMP Pro 12 (SAS Institute Inc., Cary, NC) and comparisons among measured variables employ least squares means for accuracy. Mean separations among variety x succession combinations at each farm were conducted using linear contrasts to examine variety, succession, and their interaction on broccoli yield. Statistical significance is reported at the $P \leq 0.10$ and $P \leq 0.05$ levels.

Results and Discussion

Monthly rainfall and growing degree days for the current year and historical averages are reported from the nearest weather station to each farm (**Table 2**). Daily maximum temperatures for the sensitive period of broccoli (beginning 3 weeks prior to visible head development) is also reported by farm and by succession (**Figure 1**).

Across sites, June had above average growing degree days in 2016. For three farms, the jump in growing degree days was enough more than one standard deviation from the 120-year average. Many farms also had warm Septembers, and Scheibel had three months (June, August, and September) with growing degree days over one standard deviation from the mean. GDD50 2016 in **Table 2** is bold where differences were more than one standard deviation from the historical average. In addition to the warm temperatures, the summer of 2016 was wet in some places, and dry in others. June was very dry at Beebout and McGary, while July, August and September were wet for Black and Quee, Faux, Landgraf, McGary and Scheibel. Where precipitation was more than two inches different than the average, values are displayed in bold in **Table 2**.

Table 2

Monthly Precipitation (in.) and Growing Degree Days (GDD) (base 50˚F)[a]

Month	Beebout				Black and Quee				McGary				Hartmann				Scheibel			
	Precip.		GDD		Precip.		GDD		Precip.		GDD		Precip.		GDD		Precip.		GDD	
	2016	*Avg.*	*2016*	*Avg.*	*2016*	*Avg.*	*2016*	*Avg.*	*2016*	*Avg.*	*2016*	*Avg.*	*2016*	*Avg.*	*2016*	*Avg.*	*2016*	*Avg.*	*2016*	*Avg.*
April	3.9	3.7	191	216	1.5	3.4	192	210	4.1	3.3	221	196	3.5	3.4	208	189	2.5	3.4	171	181
May	3.7	4.6	359	402	3.9	4.2	390	418	4.3	4.4	405	394	5.7	4.5	377	388	3.2	4.3	380	379
June	**1.6**	5.0	673	597	4.3	4.7	681	616	**1.3**	4.8	**666**	590	3.0	4.9	**702**	592	**2.0**	4.5	**692**	574
July	5.4	4.5	704	723	**6.3**	4.4	711	741	**7.9**	3.7	684	716	5.3	4.1	720	714	**5.9**	3.8	715	705
Aug.	4.2	4.2	705	676	**5.5**	3.9	728	691	4.1	4.0	670	661	3.1	4.2	699	652	4.7	3.8	**733**	652
Sept.	5.4	4.1	**554**	471	1.9	3.6	573	489	**7.4**	3.6	**518**	459	5.5	4.2	**551**	445	3.5	3.8	**581**	449

[a]Monthly precipitation (in.) and growing degree days (base 50˚F) from the weather stations nearest farm locations (Iowa Environmental Mesonet, 2016). Beebout: CHARITON; Black and Quee: IOWA-CITY; Hartmann: PERRY; McGary: AMES-8-WSW; Scheibel: GRINNELL.

In addition to growing degree days, maximum temperature was charted for the sensitive phase of broccoli development at each farm. These results are shown in **Figure 1**, with each farmer a unique color, and each farmer's different successions a different marker shape. The horizontal dotted line indicates 86°F. Each marker above the dotted line indicates a day when broccoli plants were heat-stressed during their sensitive phase of development, three weeks prior to visible head development.

Figure 1

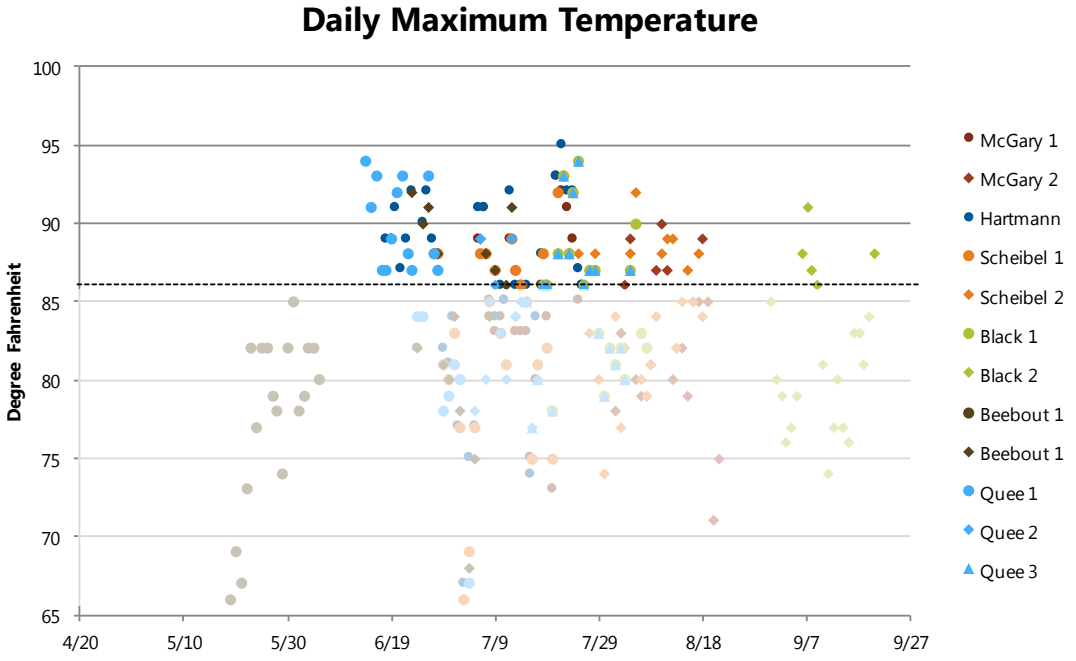

Figure 1. Daily Maximum Temperatures by Farm, Succession. For each succession at each farm, daily maximum temperatures are plotted. Farms are by color, multiple successions at each farm have unique markers. The dotted line indicates 86°F. Data for each farm is from the weather stations nearest farm locations (Iowa Environmental Mesonet, 2016). Beebout: CHARITON; Black and Quee: IOWA-CITY; Hartmann: PERRY; McGary: AMES-8-WSW; Scheibel: GRINNELL.

The number of days at or exceeding 86°F for each farm is shown in **Table 3**. For eight of the twelve successions across the farms, more than 40 percent of days during the sensitive development phase had daily high temperatures at or exceeding 86°F. The four remaining successions included the earliest (Beebout 1), the last two (McGary 2 and Black 2), and oddly, a cool window in early July (Quee 2). Unfortunately, no data were available on how many hours each day temperatures remained over 86°F.

Yield Across Farms

Looking at yield by area (lb/ft^2), Beebout had the highest single-variety yield – her first succession of Belstar produced 0.41 lb/ft^2. This succession was the earliest of any farm, and missed the extreme heat of the summer (arguably, the establishment of this succession was too early to qualify as a summer broccoli). Of the high summer broccoli, Scheibel had the highest broccoli yields, and Imperial was his top producer. Imperial was the top producer in seven of 12 successions, on four of the six farms. Of the all-farm average, Imperial had the highest yield (0.18 lb/ ft^2), followed by Gypsy (0.16 lb/ ft^2), and Belstar (0.15 lb/ ft^2) (**Figure 2**).

Table 3

Days Temperature ≥ 86 °F During Sensitive Phase

Farm, Succession	Sensitive Phase	Days ≥ 86 °F	% Days ≥ 86 °F
Beebout, 1	May 15 - June 5	0 of 21	0%
Quee, 1	June 14 - July 4	13 of 21	62%
Hartmann, 1[a]	June 18 - July 27	25/39	64%
Beebout, 2	June 23 - July 13	10 of 21	48%
Scheibel, 1	June 26 - July 24	13 of 27	48%
Quee, 2	June 28 - July 17	4 of 21	19%
McGary, 1	July 6 - July 27	9 of 21	43%
Quee, 3	July 15 - Aug. 4	11 of 21	52%
Black, 1	July 17 - Aug. 7	12 of 21	57%
Scheibel, 2	July 21 - Aug. 18	13 of 27	48%
McGary, 2	Aug. 1 - Aug 22	6 of 21	29%
Black, 2	Aug. 30 - Sept. 20	5 of 21	29%

[a] A longer sensitive phase was reported due to variability in time to head development.

Figure 2

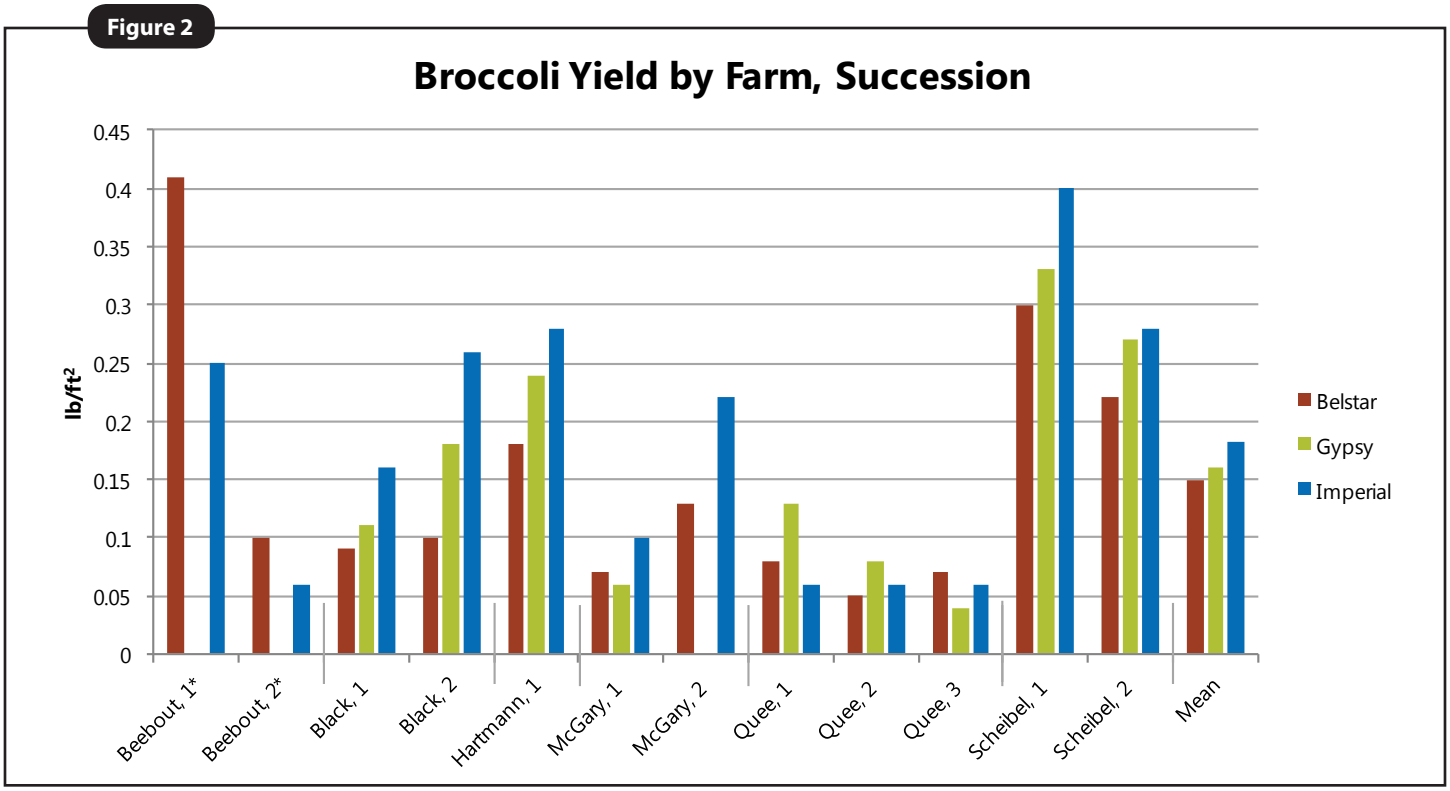

Figure 2: Broccoli Yield by Farm, Succession. Average yields (lb/ft^2) for each variety, by succession and farm are compared. The "Mean" value at the far right is the average of all farms and successions.
* Values for Beebout are not averages; broccoli was bulk weighed by variety.

Yield at Each Farm

Beebout, Chariton

Yield

Beebout had the earliest planting of broccoli across all farms, and left her broccoli plants in the ground the longest to continue harvesting side-shoots. Her successions were harvested from June and July through November. This suggests the first succession performed better; having better yields and better quality. In each succession, Belstar had better yields. Beebout was the only farm to report better yields for Belstar than Imperial (**Table 4**). This could be for two reasons. First, Beebout's first succession was quite early for summer broccoli – she began harvesting in mid-June. Second, Beebout continued harvesting side-shoots on both successions through November. McGary noted that Imperial seemed the slowest and least likely to produce side-shoots of the three varieties; it could be that Beebout's long harvest window with many sideshoot harvests favored Belstar.

Imperial toward the end of the season at Beebout's farm.

Table 4

Yield and Quality Characteristics for Summer Broccoli Varieties at the farm of Jill Beebout

		Yield				Quality			
Succession (harvest dates)	*Variety*	*Crown Weight (lb/ crown)*	*Crowns Yield (crowns/ plant)[a]*	*Plant Yield (total lb/ plant)[a]*	*Yield (lb/ ft²)*	*"A" head density*	*"A" head color*	*"A" bead size*	*"A" head shape*
Succession 1: (June 17-Nov. 15)	Belstar	0.32	0.74	0.62	0.41	70%	58%	85%	64%
	Gypsy	-	-	-	-	-	-	-	-
	Imperial	0.21	0.52	0.37	0.25	81%	91%	72%	75%
Succession 2: (July 25-Nov. 4)	Belstar	0.22	0.44	0.15	0.10	50%	78%	39%	39%
	Gypsy	-	-	-	-	-	-	-	-
	Imperial	0.14	0.44	0.09	0.06	42%	84%	58%	58%
Means	Succession 1	0.27	0.63	0.50	0.17	75%	74%	78%	69%
	Succession 2	0.18	0.44	0.12	0.04	46%	81%	48%	48%

By succession and yield category, values with the same letter are not statistically different ($P \leq 0.10$). Where no letters are reported after the numbers, there were no differences among values. For quality measures, percents indicate the percent of quality grading instances (usually during a harvest), where the broccoli was graded Acceptable "A" for a given category.

[a] Hartmann, McGary, and Quee reported number of plants living at time of harvest. Beebout, Scheibel, Black were calculated using number of plants planted, whether or not they survived to harvest.

[b] Plots for Beebout were not replicated, so no statistical analysis was performed.

Quality

For Beebout in Succession 1, Imperial had better head density, head color, and head shape. For head color, Beebout rated Belstar "acceptable" in only 58 percent of harvests; Imperial was rated "A" in 91 percent of harvests. Belstar, however, had more uniform bead size. In Succession 2, Imperial again scored higher for head color, bead size, and head shape, but Belstar had a slight advantage for head density.

An immature Belstar head, too light in color, at Beebout.

Black, Solon

Yield

Imperial was the clear winner for Black. It was statistically better than other varieties in crown weight (0.87 and 1.1 lb/crown), plant yield (1.04 lb/plant), and yield per square-foot (0.26 lb/ft^2) (**Table 5**). In Succession 2, where the statistical separation was most often seen, Gypsy was the middle producer - not statistically different from Belstar or Imperial. Belstar was the lowest producer for Black.

Belstar (left), Gypsy (center), and Imperial (right) at Black's.

Table 5

Yield and Quality Characteristics for Summer Broccoli Varieties at the farm of Carmen Black

		Yield				Quality			
Succession (harvest dates)	*Variety*	*Crown Weight (lb/ crown)*	*Crowns Yield (crowns/ plant)*[a]	*Plant Yield (total lb/ plant)*[a]	*Yield (lb/ ft^2)*	*"A" head density*	*"A" head color*	*"A" bead size*	*"A" head shape*
Succession 1: (Aug. 21-Aug. 28)	Belstar	0.73 ab	0.58	0.36	0.09	20%	20%	20%	100%
	Gypsy	0.49 b	0.86	0.45	0.11	75%	50%	25%	25%
	Imperial	0.87 a	0.71	0.62	0.16	50%	0%	0%	50%
Succession 2: (Oct. 13-Nov. 11)	Belstar	0.69 b	0.58	0.40 b	0.10 b	80%	40%	60%	80%
	Gypsy	0.7 b	1.02	0.70 ab	0.18 ab	100%	100%	100%	67%
	Imperial	1.1 a	0.93	1.04 a	0.26 a	100%	83%	100%	67%
Means	Succession 1	0.70	0.83	0.84	0.71	48%	23%	15%	58%
	Succession 2	0.83	0.84	0.71	0.18	93%	74%	87%	71%

By succession and yield category, values with the same letter are not statistically different ($P \leq 0.10$). Where no letters are reported after the numbers, there were no differences among values. For quality measures, percents indicate the percent of quality grading instances (usually during a harvest), where the broccoli was graded Acceptable "A" for a given category.

[a] Hartmann, McGary, and Quee reported number of plants living at time of harvest. Beebout, Scheibel, Black were calculated using number of plants planted, whether or not they survived to harvest.

Quality

For Black, quality was better in Succession 2 (the latest planting of any farm, **Table 1**). Belstar was rated as "Unacceptable" for density, color and size frequently in both successions, and Black noted that it was particularly "small and ugly." Black was not happy with Imperial's appearance in Succession 1, either. Still, she offered all varieties on the "free choice" table for her CSA customers, and they were very pleased to have additional broccoli, even if it was not perfect. "I wouldn't have put the discolored heads in the share, but at that time in the summer, we hadn't had broccoli for awhile so people were excited," said Black. "We also had more problems with cabbage worms in the later broccoli [Succession 2] than we ever have in October, due to the continued warm weather. I had to spray Dipel three times, and I usually never need it by that time of the year."

Prior to this project, Black had only grown Imperial as a summer broccoli. "After this trial, I feel empowered with my first choice – I will continue to grow Imperial and won't grow the other two."

Gypsy, with some discoloration, at Black's.

Imperial harvest at Black's.

Yellow-colored Belstar, at Black's.

Hartmann, Minburn

Yield and Quality

In Hartmann's trial, there were no statistical differences in yield, but the data indicate that Imperial was the better producer (0.58 lb/plant), than Gypsy (0.38 lb/plant) and Belstar (0.18 lb/plant) (**Table 6**). Hartmann also rated Imperial highest for quality of head density and color, though Gypsy scored better for bead size and head shape. Hartmann noted that Imperial had the most consistent and dark green heads, which were rated "A" 100% of the time for color. Gypsy, on the other hand, was prone to yellowing.

Broccoli in the field at Hartmann's, June 7.

Table 6

Yield and Quality Characteristics for Summer Broccoli Varieties at the farm of Rick Hartmann

		Yield				Quality			
Succession (harvest dates)	*Variety*	*Crown Weight (lb/ crown)*	*Crowns Yield (crowns/ plant)[a]*	*Plant Yield (total lb/ plant)[a]*	*Yield (lb/ ft²)*	*"A" head density*	*"A" head color*	*"A" bead size*	*"A" head shape*
Succession 1: (Aug. 15-Aug.21)	Belstar	-	-	0.36	0.18	63%	29%	55%	61%
	Gypsy	-	-	0.38	0.24	88%	74%	88%	93%
	Imperial	-	-	0.58	0.28	98%	100%	60%	75%

By succession and yield category, values with the same letter are not statistically different ($P \leq 0.10$). Where no letters are reported after the numbers, there were no differences among values. For quality measures, percents indicate the percent of quality grading instances (usually during a harvest), where the broccoli was graded Acceptable "A" for a given category.

[a] Hartmann, McGary, and Quee reported number of plants living at time of harvest. Beebout, Scheibel, Black were calculated using number of plants planted, whether or not they survived to harvest.

Belstar head is too yellow, at Hartmann.

Belstar (left) was lighter in color with a non-uniform head shape. Imperial (right) has better color and shape, at Hartmann.

McGary, Ames

Yield

McGary summarized her variety trial by stating Imperial as the clear winner for summer broccoli – the data back her up. In both successions, Imperial statistically outperforms the other varieties for crown weight and plant yield (**Table 7**). For Succession 2 Imperial beats Belstar in every category, with results statistically different for crown weight, plant yield, and area yield. Succession 2 was also statistically better than Succession 1, across variety. The difference between successions may have been due to field location. Said McGary, "Compared to Succession 2, the first succession was planted in an area with poorer soil. It seemed to have less organic matter, and perhaps less nutrients. During the hot and dry conditions this summer, we saw much lower plant health in this area than in others on the farm. Plants in this area also had higher mortality from insect pests (cabbage looper and grasshoppers). In the second succession, everything did better. Almost every plant survived, thrived, and produced harvestable broccoli."

Imperial on Sept. 1 at McGary.

Table 7

Yield and Quality Characteristics for Summer Broccoli Varieties at the farm of Alice McGary

		Yield				Quality			
Succession (harvest dates)	*Variety*	*Crown Weight (lb/ crown)*	*Crowns Yield (crowns/ plant)[a]*	*Plant Yield (total lb/ plant)[a]*	*Yield (lb/ ft²)*	*"A" head density*	*"A" head color*	*"A" bead size*	*"A" head shape*
Succession 1: (Aug. 21-Aug. 28)	Belstar	0.26 b	0.85	0.21 b	0.07	89%	5%	79%	58%
	Gypsy	0.22 b	0.82	0.18 b	0.06	84%	42%	53%	37%
	Imperial	0.37 a	0.80	0.30 a	0.10	81%	95%	100%	90%
Succession 2: (Oct. 13-Nov. 11)	Belstar	0.49 b	0.94	0.46 b	0.13 b	100%	67%	100%	60%
	Gypsy	-	-	-	-	-	-	-	-
	Imperial	0.66 a	1.02	0.67 a	0.22 a	100%	100%	100%	80%
Means	Succession 1	0.28 B	0.82	0.23 B	.08 B	85%	48%	77%	62%
	Succession 2	0.58 A	0.98	0.56 A	0.18 A	100%	83%	100%	70%

By succession and yield category, values with the same letter are not statistically different ($P \leq 0.10$). Where no letters are reported after the numbers, there were no differences among values. For quality measures, percents indicate the percent of quality grading instances (usually during a harvest), where the broccoli was graded Acceptable "A" for a given category.

[a] Hartmann, McGary, and Quee reported number of plants living at time of harvest. Beebout, Scheibel, Black were calculated using number of plants planted, whether or not they survived to harvest.

[b] Gypsy was removed to evaluate the difference between successions.

Quality

McGary's quality rankings between Succession 1 and Succession 2 again highlight the differences between the fields. Imperial has good ratings in all categories for both successions, but Belstar quality improved in Succession 2.

Yellowing on Belstar, Sept. 1 at McGary.

Scheibel, Grinnell

Yield

Similar to the results at other farms, Imperial performed the best at Scheibel. Imperial was statistically better than other varieties for plant yield (0.85 and 0.70 lb/plant) and area yield (0.40 and 0.28 lb/ft^2) as shown in **Table 8**. Gypsy was the next best variety for Scheibel, and Belstar was at the bottom. Yields were also statistically different by succession, with Succession 1 having overall better yields than Succession 2.

Quality

Scheibel typically noted good head density, except in Succession 1 of Imperial there was some spreading in the crowns. He noted many of these as "A/UA" for being on the border of "Acceptable" vs "Unacceptable," but for purposes of simple categorization, A/UA was re-labeled as "U." Scheibel scored Belstar lower in both successions for color; it was commonly too light-colored. In Succession 2, Gypsy had some issues with yellowing underneath, and Imperial struggled with "elongated, cone-shaped" heads that rendered a low score for head shape.

The broccoli variety trial at Scheibel's in June.

Table 8

Yield and Quality Characteristics for Summer Broccoli Varieties at the farm of Jordan Scheibel

		Yield				Quality			
Succession (harvest dates)	*Variety*	*Crown Weight (lb/ crown)*	*Crowns Yield (crowns/ plant)[a]*	*Plant Yield (total lb/ plant)[a]*	*Yield (lb/ ft^2)*	*"A" head density*	*"A" head color*	*"A" bead size*	*"A" head shape*
Succession 1: (Aug. 21-Aug. 28)	Belstar	0.73 ab	0.58	0.36	0.09	20%	20%	20%	100%
	Gypsy	0.49 b	0.86	0.45	0.11	75%	50%	25%	25%
	Imperial	0.87 a	0.71	0.62	0.16	50%	0%	0%	50%
Succession 2: (Oct. 13-Nov. 11)	Belstar	0.69 b	0.58	0.40 b	0.10 b	80%	40%	60%	80%
	Gypsy	0.70 b	1.02	0.70 ab	0.18 ab	100%	100%	100%	67%
	Imperial	1.10 a	0.93	1.04 a	0.26 a	100%	83%	100%	67%
Means	Succession 1	0.70	0.83	0.84	0.71	48%	23%	15%	58%
	Succession 2	0.83	0.84	0.71	0.18	93%	74%	87%	71%

By succession and yield category, values with the same letter are not statistically different ($P \leq 0.10$). Where no letters are reported after the numbers, there were no differences among values. For quality measures, percents indicate the percent of quality grading instances (usually during a harvest), where the broccoli was graded Acceptable "A" for a given category.

[a] Hartmann, McGary, and Quee reported number of plants living at time of harvest. Beebout, Scheibel, Black were calculated using number of plants planted, whether or not they survived to harvest.

Quee, West Branch

Yield

Growing conditions at Scattergood Farm (Quee) in 2016 were not good for broccoli – "We were just really hot and really wet; this is by far the worst broccoli year I've had since I started to seriously grow summer broccoli," said Quee. He continued, "Due to wet conditions, weeding suffered, plants looked unhappy, and the crowns were consistently ugly until the third succession, when a late combination of grasshoppers and rain seemed to cause rot in every crown." Under these conditions, Gypsy performed statistically better than the other two varieties in crown weight, plant yield, and area yield in Succession 1 (**Table 9**). This trend did not hold through the other successions, and no variety held a clear advantage at the end of the trial. Succession 3 saw statistically larger crowns than the earlier successions, but because of the crown rot, Quee stopped harvesting, giving Succession 3 a statistically lower crown yield compared to Successions 1 and 2.

Quality

Quee did not record quality indicators, but did note that Belstar seemed to do poorly in his starting system. They were often weak plants, prone to breaking, and for every succession the number of surviving Belstar transplants was the limiting factor in plot size.

Table 9

Yield and Quality Characteristics for Summer Broccoli Varieties at the farm of Mark Quee

		Yield			
Succession (harvest dates)	*Variety*	*Crown Weight (lb/ crown)*	*Crowns Yield (crowns/ plant)[a]*	*Plant Yield (total lb/ plant)[a]*	*Yield (lb/ ft²)*
Succession 1: (July 16-July 24)	Belstar	0.59 ab	0.56	0.31 b	0.08 b
	Gypsy	0.86 a	0.62	0.55 a	0.13 a
	Imperial	0.51 b	0.45	0.24 b	0.06 b
Succession 2: (July 30-Aug. 16)	Belstar	0.55	0.35	0.19	0.05
	Gypsy	0.50	0.44	0.21	0.08
	Imperial	0.59	0.40	0.24	0.06
Succession 3: (Aug. 16-Aug. 29)	Belstar	0.81 ab	0.36	0.26	0.07
	Gypsy	0.53 b	0.29	0.29	0.04
	Imperial	0.88 a	0.27	0.24	0.06
Means	Succession 1	0.65 AB	0.54 A	0.37	0.09
	Succession 2	0.55 B	0.40 AB	0.21	0.06
	Succession 3	0.74 A	0.31 B	0.26	0.06

By succession and yield category, values with the same letter are not statistically different ($P \leq 0.10$). Where no letters are reported after the numbers, there were no differences among values. For quality measures, percents indicate the percent of quality grading instances (usually during a harvest), where the broccoli was graded Acceptable "A" for a given category.

[a] Hartmann, McGary, and Quee reported number of plants living at time of harvest. Beebout, Scheibel, Black were calculated using number of plants planted, whether or not they survived to harvest.

Early succession broccoli heads at Quee have problems with color and uniformity.

Conclusions and Next Steps

Six farms tested three varieties of broccoli for summer production. Four of the farmers (Black, Hartmann, McGary and Scheibel) strongly preferred Imperial, while Beebout had success with Belstar. Quee's production was heavily impacted by weather conditions. On three of the farms (Black, McGary and Scheibel) Imperial had statistically higher yields in several of the measured categories. The color of Belstar was problematic on several farms, where the color was too light to be acceptable.

Several farmers noted that this was a particularly challenging summer for a trial on summer broccoli – warm and wet at most sites, with a very dry spell during June at McGary's. Said McGary, "It was probably a bad year to invest so much time in broccoli because we got a lot of ugly stuff. But it did show which could handle the stress the best. Imperial looked the best, Belstar looked the worst."

Estimating heat stress from daily maximum temperatures at the nearest weather station confirmed that there was likely heat stress to the plants, but was not refined enough to correlate with differences by succession at each farm.

By focusing on summer broccoli, Black plans to fine-tune her succession planning for next season. She said, "Next year I plan to do successions of summer broccoli three weeks apart, starting the first succession of Imperial three weeks earlier than this year." Imperial will be her only summer broccoli variety.

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