Participatory Screening of Broccoli Varieties for Organic Systems in Western North Carolina

Report on preliminary results from 2012 trial

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And many organic and conventional farmers in western North Carolina.

Executive Summary

Identifying appropriate varieties for organic production in the mountains of Western North Carolina is considered a research priority by local growers. Broccoli has traditionally been bred for and grown in Southern California. One of the main challenges in growing broccoli in the Southeast is that varieties are not heat tolerant. In 2012, we received a grant from the Organic Farming Research Foundation to conduct a participatory screening of broccoli varieties for organic systems in western North Carolina.

A spring meeting was held with local growers to determine which varieties would be included, for what markets, and how the varieties would be evaluated. The growers chose 27 heading type and unusual (romenesco, rapini, and sprouting types) varieties. The trial was grown organically at the Mountain Research Station on the newly established Mountain Organic Research and Extension Unit. Each plot was evaluated by the researchers for sixteen traits determined by the growers and researchers at the spring meeting. In addition, 50 growers used consensus in small groups to rate the plots for quality during a summer workshop. An additional on-farm demonstration with twelve hybrid heading-type broccoli varieties was conducted at an organic farm in the Virginia piedmont.

These results are considered preliminary since it is only from one season. In addition this was a very high stress season. Packman is the commonly relied upon variety among organic growers in western North Carolina, so that was used as the control. The Oregon State University (OSU) West Coast and East Coast participatory populations and Arcadia performed the best on head color, with deep blue color. None of the varieties had a very domed head, as all were rated below at or below a low dome. Bay Meadows, Gypsy, and Belstar all performed in the top 5 of both bead uniformity and head smoothness, indicating they the most heat tolerant out of the varieties studied. Workshop participants rated the OSU East Coast Population as their favorite. Scientists rated Bay Meadows as the best quality. In general growers rated the varieties as more marketable than scientists did. In taste tests, Belstar, Batavia, Bay Meadows, and the OSU West Coast participatory population all were more likely to be purchased than Packman**.** Green Goliath yielded the greatest. Despite having close to the lowest yield, the OSU East Coast participatory population had the most side-shoots. The average of the ranks across all traits showed that Bay Meadows, Batavia, Belstar, the OSU West Coast participatory population and the OSU East Coast participatory population outranked Packman, in that order. Out of the unusual varieties, the Tipoff Romenesco, Atlantis, and Purple Peacock appeared to be the best performing varieties. On the on-farm demonstration, over all the traits measured, Fiesta came out as the top ranked variety, followed by Blue Wind, Gypsy and then Packman, however these results are from unreplicated data. Based on this one year of preliminary data, for every trait measured, several varieties outperformed Packman. Under these kinds of conditions, a grower in Western North Carolina could improve head yield, side-shoot yield, marketable quality, flavor, and other characteristics by using varieties like Bay Meadows, Batavia, Belstar, and the OSU West and East Coast participatory populations. There is a need to continue these studies for more than one year to have reliable data.

Introduction

Identifying appropriate varieties for organic production in the mountains of Western North Carolina is considered a research priority by local growers. Broccoli has traditionally been bred for and grown in Southern California and over 95% of all US broccoli is still grown there. There are 131 local broccoli growers listed in Local Food Guide of the Appalachian Sustainable Agriculture Project, and the vast majority (78%) are listed as certified organic or organic but not certified (2013). One of the main challenges in growing broccoli in the Southeast is that varieties are not heat tolerant. In 2011, we began participating in a five-year multistate project funded by USDA-SCRI, titled "Developing an Eastern Broccoli Industry". The goal of this project is to foster enough broccoli production year round on the East Coast to supply local markets, instead of shipping it from the West Coast. New heat tolerant varieties developed for Eastern growing conditions are being screened on-station and on-farm from Maine to South Carolina, but these screenings are currently happening only in conventional production systems. Since the best conventional varieties don't always perform the best under organic conditions we think it is important to add additional screening of varieties under certified organic growing conditions. In 2012, we received a grant from the Organic Farming Research Foundation to conduct a participatory screening of broccoli varieties for organic systems in western North Carolina. New lines of open-pollinated broccoli bred in the North on organic farms for CSA and market growers are promising as they could be better adapted to this region, improving farm profitability and resiliency to stress. We were excited to test these lines, along with many other varieties used by organic growers. Participatory methods used to screen these varieties helped involve farmers in planning and implementing this project.

Materials and Methods

Fig. 1. Flooding during planting.

Participatory Planning and Varieties. A spring meeting was held with local growers to determine which varieties would be included, for what markets, and how the varieties would be evaluated. Growers wanted to look at both heading type varieties for commercial markets and unusual (sprouting, rapini, romenesco) type varieties for retail markets. We were able to source seed for most of the varieties requested, 27 total (Table 1).

Field trial. The trial was grown organically, using only materials approved for organic production on transitional research station land (now certified organic). Broccoli was seeded on June 4 in a greenhouse. A soilless mix approved for organic production, McEnroe Organic Potting Lite mix, was used in 100-cell trays. The transplants were fertilized with Neptune's Harvest Fish and Seaweed emulsion on June 27 and July 10. Transplants were grown in

Fig. 2. Broccoli field trial.

the greenhouse for 6 weeks, hardened off on July 11, and transplanted into the field on July 18 (Fig. 1). While hardening off, deer grazed on many of the transplants, requiring us to reduce the plot size to 10 plants each (Fig. 2).

The trial was conducted on the Mountain Research Station on the newly established Mountain Organic Research and Extension Unit which was in transition during the study in 2012 and is now certified organic. Cow manure was incorporated in late winter and Neptune's Harvest Fish and Seaweed emulsion and Chilean nitrate were used for fertility. Broccoli was grown on white plastic beds with drip irrigation, with five foot spacing center-to-center between beds. Staggered double rows were used on each bed, with twelve inches between plants, resulting in six inches between plant spacing. The population was 17,424 plants per acre. Four replications of each variety were grown in a randomized complete block design, and the heading types and unusual types were in separate trials.

Table 1. Varieties included in the participatory organic broccoli trial.

	Variety	Type	Seed Source
Heading Types	Fiesta	hybrid	Bejo Seeds
	Belstar	Hybrid	Bejo Seeds
	Batavia	Hybrid	Bejo Seeds
	OSU East Coast Population	OP	Cornell University (Thomas Bjorkman)
	Bay Meadows	Hybrid	Johnny's Selected Seeds
	Blue Wind	Hybrid	Johnny's Selected Seeds
	Arcadia	Hybrid	Johnny's Selected Seeds
	Diplomat	Hybrid	Johnny's Selected Seeds
	Green Magic	Hybrid	Johnny's Selected Seeds
	Gypsy	Hybrid	Johnny's Selected Seeds
	OSU West Coast Population	OP	OSU (Jim Myers)
	Packman	Hybrid	Harris Seeds
	Green Goliath	Hybrid	Reimer
	Thompson	OP	Southern Exposure Seed Exchange
	De Cicco	OP	Southern Exposure Seed Exchange
	Nutri-Bud	OP	Southern Exposure Seed Exchange
	Premium crop	Hybrid	Southern Exposure Seed Exchange
	Waltham 29	OP	Southern Exposure Seed Exchange
	Umpqua	OP	Turtle Tree Seed
Unusual Types	Santee	sprouting - hybrid	Bejo Seeds
	Tipoff Romenesco	romenesco - hybrid	Fedco
	Green Lance	Chinese Kale - hybrid	Johnny's Selected Seeds
	Atlantis	BroccolixGailon – hybrid	Johnny's Selected Seeds
	Italia romenesco	romenesco - OP	Reimer
	Sorrento Broccoli raab	raab – OP	Southern Exposure Seed Exchange
	Green Sprouting Calabrese	calabrese - OP	Sow True Seeds
	Early Fall Rapini	raab – OP	Sow True Seeds
	Purple peacock	broccoli x kale - OP	Sustainable Seed Co.

Farmscaping of dill, cilantro, alyssum, calendula, and sunflowers was planted around the plot area to help attract beneficial insects (Fig. 3). There was significant harlequin bug and flea beetle populations, so row covers were used throughout August to try and block the pests from reaching the plants (Fig. 4). In addition, aphids and lepidopteron (caterpillar) pests were present. The insecticides Pyganic and Dipel were used for additional insect management. There was flooding during establishment in July and also throughout the season due to both excessive rain and unexpected poor drainage in that part of the field. The impact of that flooding likely would have been worse if the broccoli had not been grown on raised plastic beds. Pythium was present in the wettest plots, and alternaria was observed in August. Regalia was sprayed to prevent alternaria from spreading to new growth. Finally, with how wet the season was, black rot was observed in some of the flattest heads.

Fig. 3. Farmscaping around the broccoli.

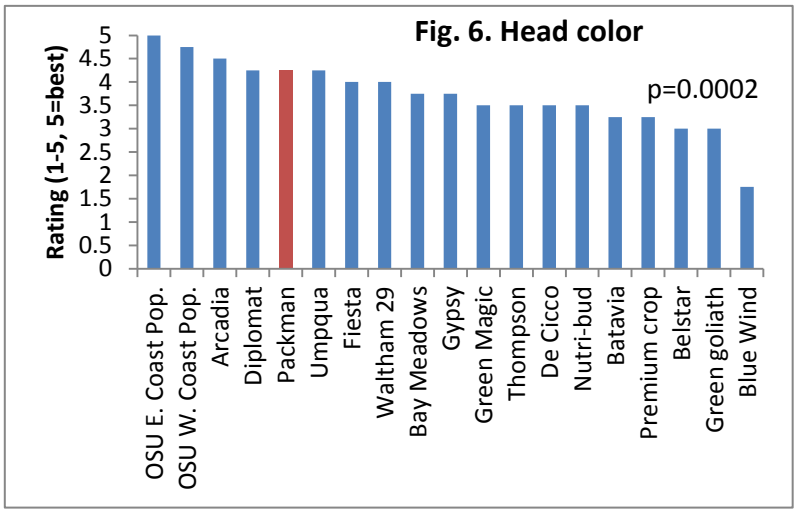
Fig. 4. Row covers for insect pest

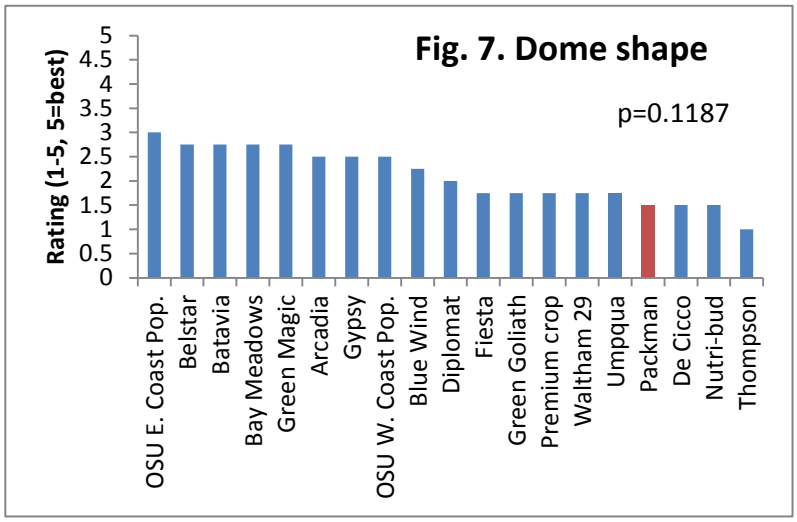
Evaluation. Each plot was evaluated by the researchers for sixteen traits determined by the growers and researchers at the spring meeting: head color, dome shape, head smoothness, head firmness, bead size, bead uniformity, holding ability, overall quality, yield, side-shoot ability, days to maturity, flavor, bitterness, sweetness, insect and disease resistance, and flaws due to heat stress. In addition, 50 growers used consensus in small groups to rate the plots for quality during a summer workshop (Fig. 5). The consensus process was a technique used for a group to come to agreement on a decision, in this case the decision was how to rate a broccoli plot.

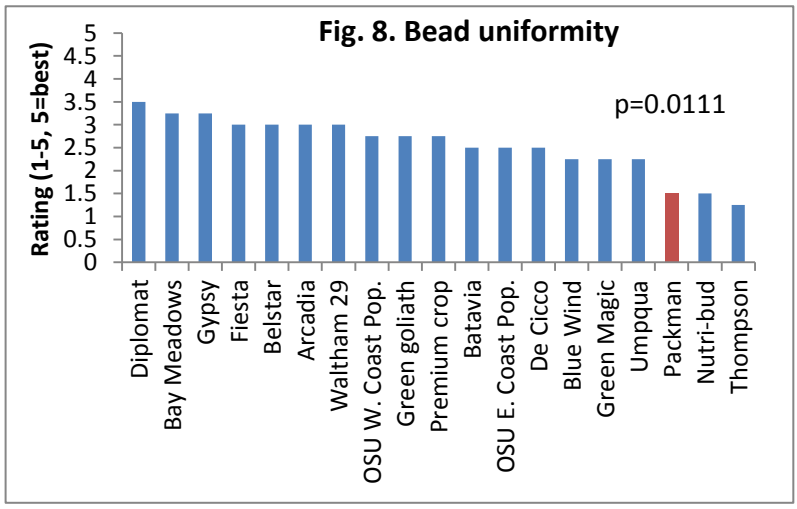
Fig. 5. Growers evaluating a plot at the workshop.

On-farm trial. An on-farm demonstration with hybrid heading-type broccoli varieties was conducted by Pam Dawling at the Twin Oaks Community Farm in the Virginia piedmont. Twelve hybrids were planted in late July, Fiesta, Batavia Belstar, Bay Meadows, Blue Wind, Arcadia, Diplomat, Green Magic, Gypsy, Packman, Tendergreen, and Premium Crop. A white ladino clover, crimson clover, and medium red clover cover crop was undersown in late August for weed management, nitrogen synthesis, and soil protection.

Results



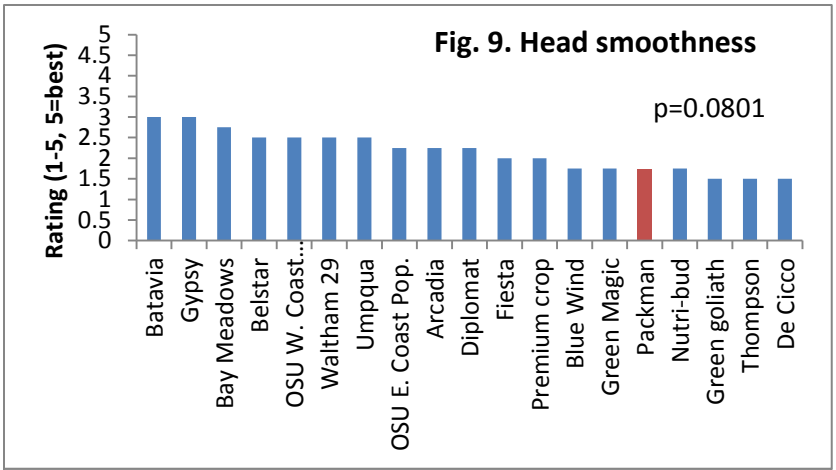


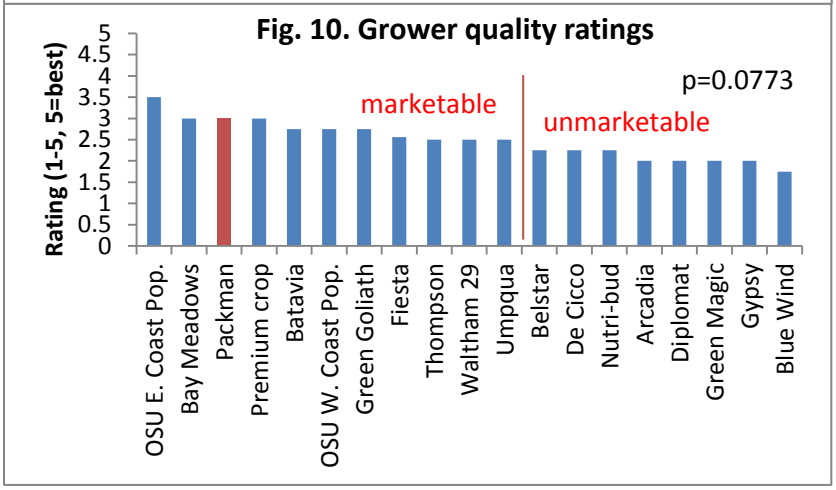


These results are considered preliminary since it is only from one season. In addition this was a very high stress season due to the deer grazing on the transplants, multiple flooding events, poor drainage of the soil, and high insect and disease pressure. The varieties that performed well under these conditions could be resilient to these kinds of stresses. Packman is the commonly relied upon variety among organic growers in western North Carolina, so that was used as the control.

Heading-type variety results. Head color is an important characteristic of marketability in broccoli. A deep blue-green is the goal, but some varieties in response to heat will turn more of a lime green-yellow, making the broccoli unmarketable (Fig. 11). The Oregon State University (OSU) West Coast and East Coast participatory populations and Arcadia performed the best on head color, with deep blue color (5 on the scale) (Fig. 6). Those varieties and Diplomat outperformed Packman (4 on the scale), and most varieties had at least a dark green head color (4 on the scale) The exceptions were Batavia, Premium Crop, Belstar, Green Goliath (all 3 on the scale), and Blue Wind was the only variety with more of a green-to-yellow head color (2 on the scale).

Fourteen of the varieties had a more

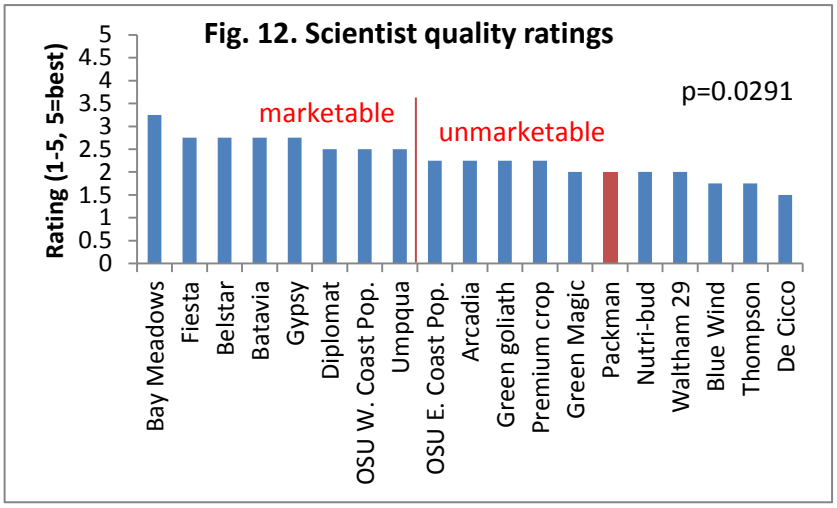




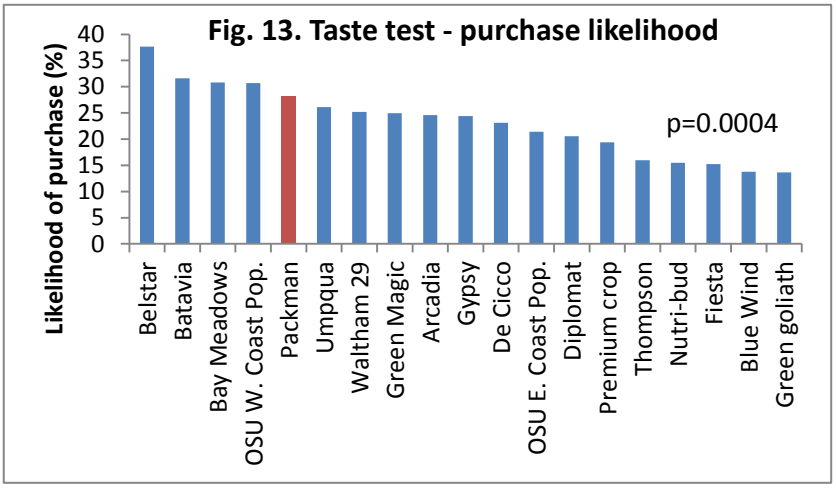
domed head shape compared to Packman although these results were not significant (Fig. 7). Dome shape is important both for market acceptability and to help shed moisture and reduce the incidence of black rot. None of the varieties had a very domed head, as all were rated below at or below a low dome (3 on the scale).

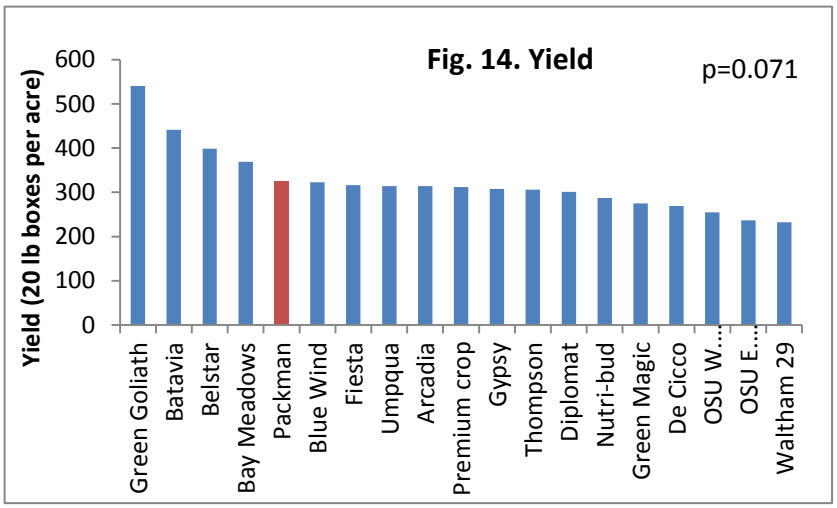
For two of the indicators of heat stress, bead uniformity and head smoothness (Fig. 11), almost all varieties performed better than Packman (Fig. 8 and 9). Diplomat, Bay Meadows, Gypsy, Fiesta, Belstar, Arcadia, and Waltham 29 all had bead uniformity above 3. Bead uniformity below 3 indicates an uneven looking head and the start of a 'cateye' appearance where small beads are surrounded by large beads (Fig. 11). Head smoothness is a characteristic indicating how smooth (5 on the scale) or rough and lumpy (1 on the scale) a broccoli head is. Batavia and Gypsy were the only varieties rated above 3 in head smoothness (Fig. 9). Bay Meadows, Gypsy, and Belstar all performed in the top 5 of both bead uniformity and head smoothness, indicating they were the most heat tolerant out of the varieties studied.

Fig. 11. On left, a heat stressed head, with yellow color, uneven bead size and rough head. On right, 'cateye' bead



Workshop participants rated the OSU East Coast Population as their favorite (Fig. 10). Bay Meadows was second, and Packman was rated third. Other varieties rated as marketable (above 3 on the scale) were Premium crop, Batavia, OSU

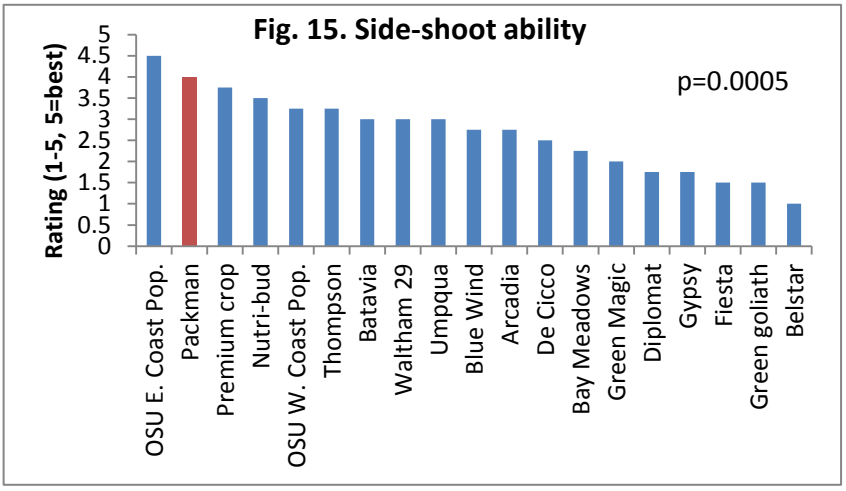




West Coast Population, Green goliath, Fiesta, Thompson, Waltham 29, and Umpqua.

Scientists rated almost all of the varieties as better quality than Packman (Fig. 12). Bay Meadows was rated as the best quality, with several others, Fiesta, Belstar, Batavia, Gypsy, Diplomat, OSU West Coast Population, and Umpqua, also rated as marketable. It was interesting that Bay Meadows was at the top of the ratings for both the scientists and the growers at the workshop, but the OSU East Coast Population (and Packman) fared much better in the grower rating than in the scientist rating. In general growers rated the varieties as more marketable than scientists did.

In taste tests (n=79), Belstar, Batavia, Bay Meadows, and the OSU West Coast participatory population all were more likely to be purchased than Packman, at 31% to 38% of respondents who said they would purchase those varieties (Fig. 13). When selecting broccoli in the store, respondents chose first based on shape, then color, then firmness, then bead size, and last taste.



Green Goliath yielded the greatest at 541 boxes per acre (20 pounds per box), followed by Batavia, Belstar, Bay Meadows, and then Packman in the 350 to 450 box range (Fig. 14). An optimal head size is 215 to 265 grams, and only Green Goliath, Batavia, and Belstar fell in this range. All other varieties had smaller than optimal heads.

Despite having close to the lowest yield, the OSU East Coast participatory population had the most side-shoots (Fig. 15). Packman was both 5th in yield and 2nd in side-shoot ability. Side-shoot yields are especially important to retail/direct market growers as it lengthens the growing season and can make up a significant portion of sales.

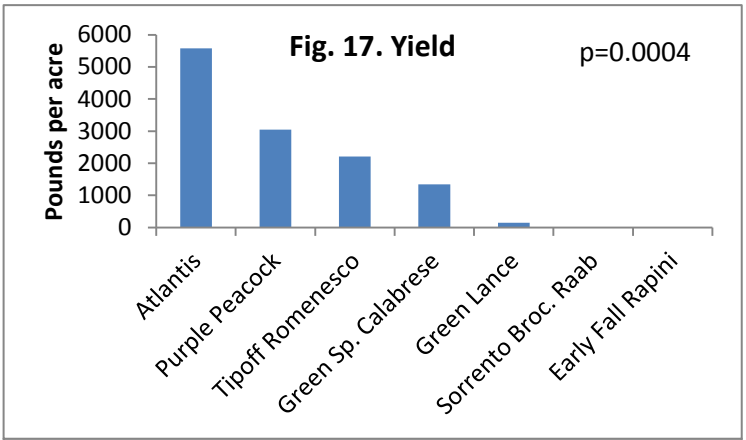
Table 2. Rank of varieties across all variables (1=best).

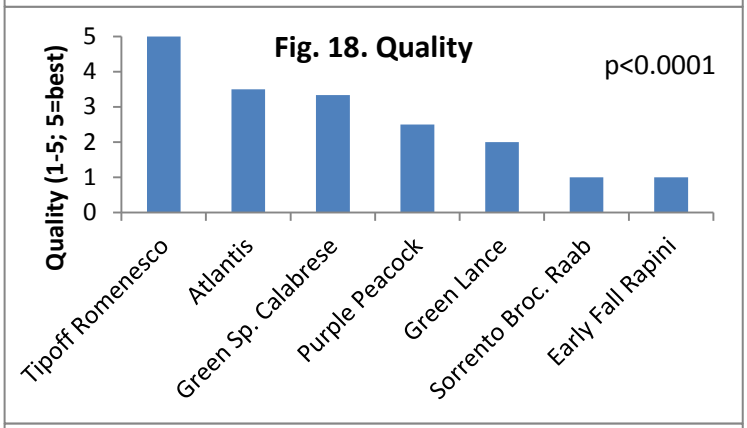
1	Bay Meadows	**11**	Diplomat
2	Batavia	**11**	Green Goliath
3	Belstar	**13**	Premium crop
4	OSU W. Coast Pop.	**14**	Waltham 29
5	OSU E. Coast Pop.	**15**	Blue Wind
6	Packman	**16**	Fiesta
7	Gypsy	**17**	Thompson
8	Umpqua	**18**	Nutri-Bud
9	Green Magic	**19**	De Cicco
10	Arcadia		

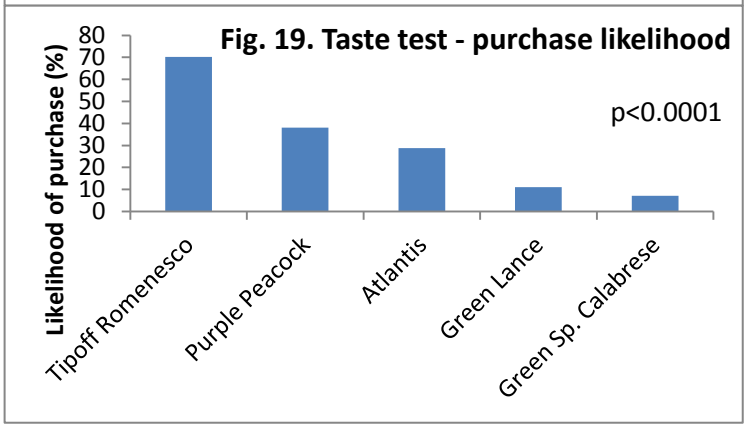
The average of the ranks across all variables showed that Bay Meadows, Batavia, Belstar, the OSU West Coast participatory population and the OSU East Coast participatory population outranked Packman, in that order (Table 2, Fig. 16).

Fig. 16. Marketable size heads, from left-to-right, Bay Meadows, Batavia, Belstar, OSU West Coast Population, OSU East Coast Population, and Packman.

Unusual variety results.



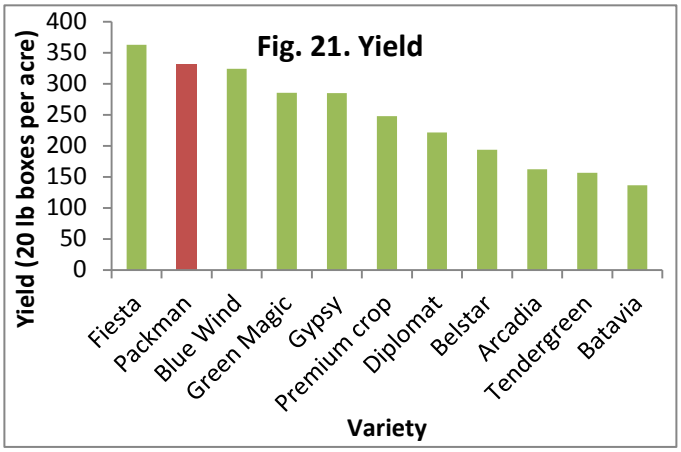


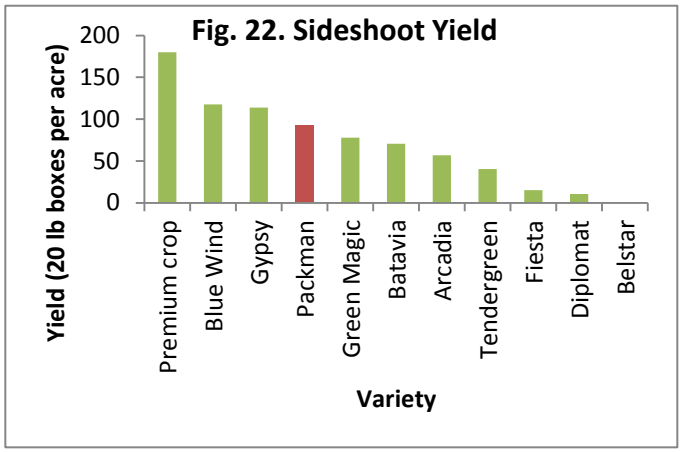


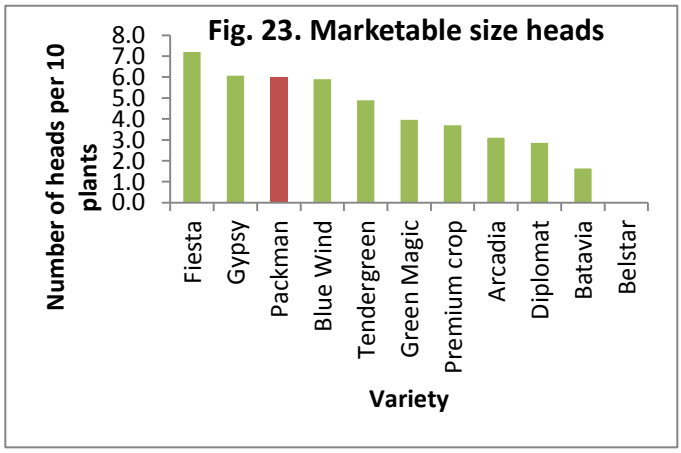
Some of the unusual varieties performed very well. Atlantis, a broccoli x gailon cross, had a very high yield at 5,500 pounds per acre (Fig. 17). Gailon is a Chinese broccoli typically with smaller tender stems and heads. Purple Peacock and Tipoff Romenesco had yields in the 2,000 to 3,000 pounds per acre range. Tipoff Romenesco also had the highest quality ratings of excellent quality (5 on the scale), followed by Atlantis (Fig. 18). In the taste tests, Tipoff Romenesco was the most likely to be purchased (70% of respondents), followed by purple peacock and then Atlantis (Fig. 19). Overall the Tipoff Romenesco, Atlantis, and Purple Peacock appeared to be the best performing varieties, and the romenesco in particular is very attractive (Fig. 20). Purple Peacock, a broccoli x kale cross, also had a very interesting purple color and curly foliage (Fig. 20). The Sorrento Broccoli Raab and Early Fall Rapini harvest was poor quality and unmarketable. Santee died mid-season and perhaps would have performed better as an overwintering crop. Italia Romenesco is late maturing and did not produce heads before the frost date.

Left, Atlantis; Middle, Tipoff Romenesco; Right, Purple Peacock.

On-farm demonstration results from Twin Oaks Community Farm







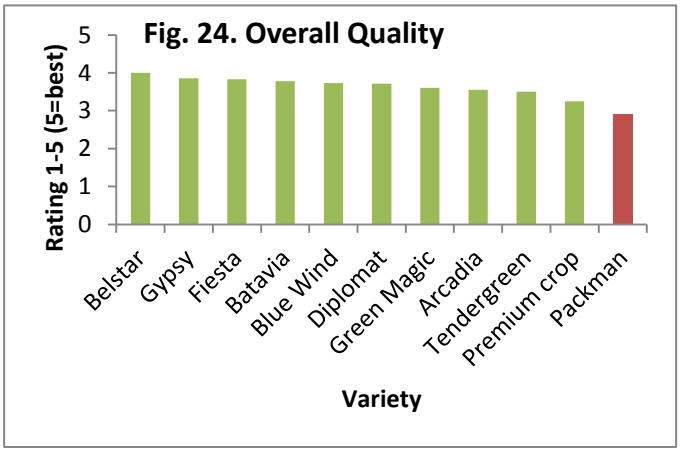


Table 3. Overall ranks of the varieties based on averages of all the measurements (1=best).	
Rank	**Variety**
1	Fiesta
2	Blue Wind
3	Gypsy
4	Packman
5	Premium crop
6	Green Magic
7	Diplomat
8	Belstar
9	Batavia
10	Arcadia
11	Tendergreen

Results from the on-farm demonstration at Twin Oaks Community Farm show that Fiesta had the highest crown yield, but low side-shoot yield (Fig. 21 and 22). Packman was 2nd in crown yield and 4th in side-shoot yield. The variety with the most side-shoots was Premium Crop. Fiesta had the most marketable size heads (four to five inches) followed by Gypsy then Packman (Fig. 23). All varieties were rated as marketable, with Belstar rated as the highest quality with a very good rating, and Packman as the lowest quality, rated at average (Fig. 24). Over all the variables measured, Fiesta came out as the top ranked variety, followed by Blue Wind, Gypsy and then Packman (Table 3). These results are not based on replicated data so the strength of the data is limited. However there is still value in research conducted on farm, especially in particpatory projects.

Conclusion

Based on this one year of preliminary data, for every characteristic measured, several varieties outperformed Packman. This indicates that under the very stressful conditions of the trial, other varieties are more resilient to those types of stresses than Packman. Under these kinds of conditions, a grower in Western North Carolina could improve head yield, side-shoot yield, marketable quality, flavor, and other characteristics by using varieties like Bay Meadows, Batavia, Belstar, and the OSU West and East Coast participatory populations. In addition, Bay Meadows, Gypsy, and Belstar all performed in the top 5 of both bead uniformity and head smoothness, indicating they were the most heat tolerant out of the varieties studied. There is a need to continue these studies for more than one year to have reliable data. Across the Northern United States there is a Northern Organic Vegetable Improvement Collaborative project (NOVIC) that has done participatory studies like this on many crops, in several states and on-farm. We see great value for a similar project for the Southeast.

Acknowledgments

We appreciate the contributions of the crew at the Mountain Research Station and North Carolina Department of Agriculture and Consumer Services in making this project happen, especially the efforts of Kaleb Rathbone, Kyle Miller, and Nathan Heath. We also appreciate the guidance from Dr. Thomas Bjorkman at Cornell University, Jared Zystro of Organic Seed Alliance, and Richard Boylan of the North Carolina Cooperative Extension; as well as the input from the many grower-participants, especially Pam Dawling at Twin Oaks Community Farm and Ira Wallace at Southern Exposure Seed Exchange who hosted on-farm demonstrations.

Note: The use of brand names and any mention or listing of commercial products or services does not imply endorsement by North Carolina State University nor discrimination against similar products or services not mentioned.