Cranberry survey Report

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More information about the Vaccinium planning project can be found at Vaccinium web page:
https://pgnglab.plantsforhumanhealth.ncsu.edu/vaccinium-project/

Summary report.

This report summarizes the results of the cranberry breeding trait survey that was distributed between November 2016 and February 2017 at cranberry growers' winter meeting in New Jersey, Wisconsin, and the Canadian province of British Columbia. The survey was part of a U.S. Department of Agriculture-funded planning grant titled "Research and extension initiative for cranberry and blueberry: Current and future needs". The objectives of the project were to: 1) establish the first blueberry and cranberry multi-state breeding and extension research initiative; 2) engage the stakeholders using a survey to identify breeding priorities (i.e. breeding traits, breeding practices); 3) outline objectives for a USDA-NIFA Specialty Crop Research Initiative grant proposal that will enlarge the genetic, genomic and phenotypic resources of blueberry and cranberry, and develop tools to accelerate the selection of improved cultivars. The project involved 25 collaborators from 14 institutions including blueberry and cranberry breeders and allied scientists who are experts in plant pathology, entomology, food science, post-harvest physiology, genetics and genomics, economy and extension and crop production.

Overall, industry responses to the survey identified the most important trait for breeding priority in cranberries were fruit quality, particularly firmness, fruit size, and anthocyanin content. These traits can improve processing handling and efficiency and consequently affect price premiums received by growers and drive consumer demand, which are all critical factors to the economic viability of the cranberry industry. Among diseases, resistance to field fruit rot ranked the most important trait across all states. There were differences across states in importance assigned to other disease resistance traits, insect resistance and tolerance to abiotic stress. These findings will be useful for breeders and associated scientists seeking to develop an advanced DNA based selection strategy that will accelerate the development of new cultivars with improved traits the global cranberry industry.

Introduction

North America is the top producer of cranberries and blueberries in the world. These crops are amongst the very few native North American crops and are closely related members of the Vaccinium genus. Recognition of the health benefits of cranberry and blueberry consumption have contributed to a rapid increase in production over the last few decades. However, both industries are facing new challenges including scarcity of labor, increased disease and insect pressures coupled with restrictions on chemical control products, new fruit quality standards based on processing technology, as well as increased abiotic stresses as a consequence of erratic weather patterns. Consequently, the production and processing industries face a need for new cultivars with improved or tailored characteristics to meet dynamic industry and market challenges. To satisfy these needs, US Vaccinium stakeholders consider breeding improved cultivars a high priority. Indeed, grower associations representing the blueberry and cranberry industries at the state or regional levels, have consistently provided financial and strategic support to research institutions to sustain existing breeding programs. However, additional resources are needed to develop the necessary genomic and genetic resources and tools to integrate genomic information with high-throughput phenotyping, which will accelerate the development of new cultivars with improved traits. Similar coordinated genomics-based approach have been highly successful in other fruit crop groups such as the Rosaceae and Vitis. The lack of a coordinated multi-state research program for cranberry and blueberry, limits the development of interdisciplinary and transformational research programs that allow the integration of research and extension activities to address new production challenges. In addition, since the application of this technology requires extensive training, knowledge, and significant investments it is critical to focus on the genetic traits of maximum value. Hence, the overall goal of this study was to identify and coordinate research priorities and breeding trait targets based on the various industry sectors and plan to further integrate genomic/phenotypic data to develop a sustainable technical platform to accelerate and increase the efficiency of cultivar development and adoption. The potential of genomic approaches to enhance crop improvement, particularly through genomic selection, is enormous. Genomics research has not yet been translated into routine practical breeding application in cranberry or blueberry breeding.

Methods

Research priorities from 3 state and provincial blueberry commodity groups (Massachusetts, Wisconsin and British Columbia-Canada) and three national research organizations (Small Fruit Crop Germplasm Committee, Northwest Center for Small Fruits Research, and Cranberry Institute) were extracted from recent research grant proposal requests and research priority recommendations to create an initial list of production-related needs and to identify clusters of fruit and plant traits that could directly or indirectly provide benefits to the cranberry

industry. The cranberry industry refers to nurseries, producers, packers, processors, breeders, and non-breeder researchers. Five trait clusters were identified heuristically from this list including: (1) fruit quality, (2) disease resistance, (3) insect pest resistance, (4) plant abiotic stress tolerance and (5) other plant traits. The survey was designed around these 5 trait clusters and 42 specific fruit and plant traits. The fruit quality cluster included 6 traits, the disease resistance cluster included 12 traits, the insect pest resistance cluster included 15 traits, the plant stress tolerance cluster included 5 traits and the other plant traits cluster included 4 traits.

The survey asked participants to rank the importance of traits to their farming operation in the 5 trait clusters (question 1-5) and overall (question 6). Within each cluster, we asked the respondent to rank the 1st, 2nd, 3rd, most important and the 1st, 2nd, 3rd, etc. least important trait for a successful cultivar. Note that each cluster of traits included an “other trait” option, in case we missed an important trait in the selected list of traits presented to the respondents.

Other questions in the survey included categorical questions to define the respondent’s role in the supply chain (e.g., grower, nursery operator, packer, processor, breeder, and non-breeder scientist); the size of the cranberry operation expressed in cultivated area; the number of years involved in the decision-making process of the cranberry operation; the list of cranberry cultivars with the largest cultivated area in the cranberry operation; whether a new cultivar was planted during the last 5 years; and the name of the state where the largest cultivated area of the cranberry operation was located.

The cranberry industry survey was conducted at grower meetings across two U.S. states and British Columbia (Canada) between November 2016 and February 2017. The names of the meetings were: (1) the Wisconsin Cranberry School in January 2017; (2) the American Cranberry Grower Association Winter Meeting in New Jersey in January 2017; and (3) British Columbia (Canada) in February 2017. The survey was distributed by extension and research faculty working closely with the local industry. Given the timeline for the planning meeting the survey was not distributed at the Massachusetts grower association meeting. Distribution of the survey to the MA growers is ongoing through an on line survey and is planned through participation to a grower meeting in December 2017.

The survey form, which was approved by the Institutional Review Board, Washington State University IRB #15708, is available at the Vaccinium Planning Project webpage https://pgnglab.plantsforhumanhealth.ncsu.edu/vaccinium-project/survey/

Results

A total of 116 responses were obtained: 78 from Wisconsin, 16 from New Jersey, and 22 from the Canadian province of British Columbia. On average across regions, 92% of respondents were growers, 4% were associated with packing houses, 3% with cranberry processing companies, 3% were breeders, and 2%

were non-breeder researchers (**Table 1**). Note that these numbers do not add to 100% as some respondents marked more than one category.

The average size of the cranberry operations was 192 ha (**Table 2**). This size varied across regions, with the largest size in acres in the New Jersey (275 ha), followed by the Wisconsin (187 ha), and British Columbia (CA) (155 ha).

Average number of years involved in the decision making process of cranberry operations was 14 years (**Table 3**). The years of experience varied across regions with an average of 16, 14 and 13 years of experience for New Jersey, Wisconsin, and British Columbia, respectively. Survey responses from NJ and BC included the highest percent of respondents with 1-5 years of experience while responses from NJ and WI included the highest percent of respondents with >20 years of experience (**Table 3**).

Summary statistics indicated that 52.6% of respondents felt that among the five cluster of traits fruit quality was most important, 26.7% indicated disease resistance, and 11.2% indicated plant stress tolerance, 8.6% insect resistance, and 0.9% other plant characteristics (**Table 4**). New Jersey presented the highest percent of responses identifying disease resistance as the most important trait, fruit quality was the most important for Wisconsin and British Columbia.

Among the fruit quality traits, on average 33.6% of respondents indicated that firmness was the most important attribute, 25% indicated it was fruit size, and 19% anthocyanin content (**Table 5**). Fruit firmness was the top trait in all regions, followed by fruit size in WI and BC, and shelf life in NJ and WI.

Among the disease resistance traits, on average 48.3% respondents indicated the most important trait was resistance to field fruit rot followed by Early Rot and Phyllosticta leaf drop (**Table 6**). Resistance to field fruit rot was the top ranked trait in NJ and WI, while false blossom was most important for BC. The 2nd highest ranked trait was Early Rot and Phyllosticta leaf drop resistance in WI and Upright dieback resistance in BC.

Among insect pest resistance traits, 41% of respondents indicated that resistance to cranberry fruitworm was the most important insect pest resistance trait, followed by Blackheaded fireworm with 17% (**Table 7**). Resistance to Blunt-nosed leafhoppers, Cranberry fruitworm, and Blackheaded fireworm were the top ranked trait in NJ, WI, and BC, respectively.

Among the plant stress tolerance traits, 59.5% of respondents indicated that fall and spring frost tolerance was the most important trait, followed by heat stress with 19.8% (**Table 8**). Fall and spring frost tolerance was the top ranked trait in BC and WI, while heat stress was the most important in NJ.

As expected, in all regions Yield had the highest percent of respondents marking it as the most important trait, followed by Flowering/fruit set (**Table 9**).

Table 1. Respondents' occupations by States (survey Q7)

Occupation	Percentage of respondents who marked each occupation as identified themselves			
	New Jersey	Wisconsin	British Columbia	Average
Grower	81.3	96.2	86.4	92.2
Nursery	0.0	0.0	0.0	0.0
Processing house	0.0	3.9	4.6	3.5
Packing house	0.0	6.4	0.0	4.3
Breeder	0.0	3.9	0.0	2.6
Non-breeding researcher	0.0	0.0	9.1	1.7
Other	12.5	2.6	0.0	3.5

Table 2: Size of operation summarized by States (survey Q8)

State	Percentage of respondents who expressed their blueberry operation fall into the corresponding size category (Ha)							
	<15	15-24	25-49	50-99	100-249	250-499	>500	Average (St. Dev.)
New Jersey	0.0	6.7	6.7	6.7	33.3	20.0	26.7	275.1 (178.3)
Wisconsin	1.3	2.6	5.2	23.4	48.1	11.7	7.8	186.5 (131.6)
British Columbia	18.2	9.1	9.1	13.6	27.3	18.2	4.6	155.0 (152.0)

Table 3. Number of years involved in the decision-making process summarized by States (survey Q9)

State	Percentage of respondents who marked each category					
	5-9	10-14	15-19	16-20	>20	Average (St. dev.)
New Jersey	18.75	0	12.5	12.5	56.25	15.69 (6.71)
Wisconsin	14.1	20.51	10.26	15.38	39.74	14.12 (6.47)
British Columbia	18.18	27.27	9.09	18.18	27.27	12.64 (6.69)

Table 4. The MOST important group of characteristics for a new cultivar by States (survey Q6)

Characteristic for a new cultivar	Percentage of respondents who marked each category as a top characteristic for a new cultivar			
	New Jersey	Wisconsin	British Columbia	Average
Disease resistance	50.0	25.6	13.6	26.7
Fruit quality traits	31.3	56.4	54.6	52.6
Insect pest resistance	0.0	7.7	18.2	8.6
Plant stress tolerance	18.8	9.0	13.6	11.2
Other plant characteristics	0.0	1.3	0.0	0.9

Table 5. The MOST important fruit quality trait summarized by states (survey Q1)

Fruit quality trait	Percentage of respondents who marked each category as a top fruit quality trait			
	New Jersey	Wisconsin	British Columbia	Average
Anthocyanin content (TAcy)	31.3	19.2	9.1	19.0
Firmness	31.3	33.3	36.4	33.6
Flavor	0.0	3.9	9.1	4.3
Fruit size	6.3	25.6	36.4	25.0
Shelf life	12.5	11.5	4.6	10.3
Sweetness	6.3	1.3	0.0	1.7
Other fruit quality traits	0.0	5.1	0.0	3.5

Table 6. The MOST important disease resistance trait summarized by states (survey Q2)

Disease resistance trait	Percentage of respondents who marked each category as a top disease resistance trait			
	New Jersey	Wisconsin	British Columbia	Average
Bitter rot	6.3	6.4	0.0	5.2
Cottonball	6.3	7.7	0.0	6.0
Cranberry canker	0.0	0.0	0.0	0.0
Early Rot and Phyllosticta leaf drop	0.0	28.2	0.0	19.0
Fairy ring	6.3	0.0	0.0	0.9
False blossom	0.0	0.0	45.5	8.6
Field fruit rot	68.8	52.6	18.2	48.3
Leaf spots	6.3	0.0	0.0	0.9
Nematodes	0.0	0.0	4.6	0.9
Phytophthora	6.3	1.3	0.0	1.7
Storage rots	0.0	3.8	0.0	2.6
Upright dieback	0.0	0.0	27.3	5.2
Other disease	0.0	0.0	0.0	0.0

Table 7. The MOST important insect pest resistance trait summarized by states (survey Q3)

Insect pest resistance trait	Percentage of respondents who marked each category as a top insect pest resistance trait			
	New Jersey	Wisconsin	British Columbia	Average
Blackheaded fireworm	18.8	12.8	31.8	17.2
Blunt-nosed leafhoppers	25.0	0.0	0.0	3.5
Cranberry blossomworm	12.5	1.3	0.0	2.6
Cranberry fruitworm	6.3	59.0	0.0	40.5
Cranberry weevil	0.0	0.0	0.0	0.0
Cranberry tipworm	0.0	5.1	0.0	11.2
Flea beetle	0.0	5.1	0.0	3.5
Girdler	0.0	0.0	18.2	3.5
Grub	18.8	0.0	0.0	2.6
Root weevil	0.0	0.0	0.0	0.0
Scale insects	0.0	0.0	0.0	0.0
Sparganothis fruitworm	6.3	16.7	0.0	12.1
Spotted fireworm	6.3	0.0	4.6	1.7
Thrips	0.0	0.0	0.0	0.0
Toadbugs	6.3	0.0	0.0	0.9
Other insects	0.0	0.0	0.0	0.0

Table 8. The MOST important stress factor summarized by states (survey Q4)

Plant stress tolerance	Percentage of respondents who marked each category as a top plant stress tolerance			
	New Jersey	Wisconsin	British Columbia	Average
Drought resistance	12.5	12.8	4.6	11.2
Fall and spring frost tolerance	12.5	69.2	59.1	59.5
Heat stress	75.0	10.3	13.6	19.8
Yellow vine	0.0	0.0	0.0	0.0
Mid-winter cold hardiness	0.0	3.9	13.6	5.2
Other stress	0.0	3.9	4.6	3.5

Table 9. The MOST important other plant trait summarized by regions (survey Q5)

Other plant trait	Percentage of respondents who marked each category as a top other plant trait			
	New Jersey	Wisconsin	British Columbia	Average
Early harvest	0.0	6.4	0.0	4.3
Flowering/fruit set	12.5	24.4	27.3	23.3
Yield	87.5	64.1	72.7	69.0
Runnering habit	0.0	1.3	0.0	0.9
Other plant traits	0.0	3.9	0.0	2.6