Presentation Summaries
American Cranberry Growers Association  
2019 Summer Field Day  
Thursday August 15, 2019  
Rutgers University

P.E. Marucci Center for Blueberry & Cranberry Research & Extension,  
Chatsworth, NJ

Parking will be available at the Center’s shop (across cranberry bogs).  
Transportation for tours will be provided at the Center.  
Restrooms located at the Center, adjacent to Conference Room.

CRANBERRY BOGS:

8:00–8:30 Refreshments

8:30–8:45 Opening Remarks  
   Shawn Cutts, President, American Cranberry Growers Association

8:45–9:10 Weed Control in Newly Planted Cranberry Beds (Lower Bogs)  
   Thierry Besancon and Baylee L. Carr, P.E. Marucci Center, Chatsworth, NJ

9:10–9:25 Cranberry Germplasm Collection: Fuel for Breeding Future Varieties (Bog 1)  
   Nicholi Vorsa, Jennifer Johnson-Cicalese, and Susan Vancho, P.E. Marucci Center, Chatsworth, NJ

9:25–9:40 Liming to Mitigate pH Lowering Properties of Liquid Fertilizer Applications (Bog 5)  
   Nicholi Vorsa and Jennifer Johnson-Cicalese, P.E. Marucci Center, Chatsworth, NJ

9:40–10:05 Managing Fruit Quality (Bog 7)  
   Peter Oudemans, P.E. Marucci Center, Chatsworth, NJ

10:05–10:20 Effects of Reduced Winter Flooding (Bog 9)  
   Nicholi Vorsa and Jennifer Johnson-Cicalese, P.E. Marucci Center, Chatsworth, NJ

10:20–10:35 2018 Haines Planting: Buggy Sanding to Aid Establishment (Bog 19)  
   Nicholi Vorsa and Jennifer Johnson-Cicalese, P.E. Marucci Center, Chatsworth, NJ

10:35–11:00 On-going Research on Sucking Insect Pests (Bog 19)  
   Cesar Rodriguez-Saona, Vera Kryyczenko-Roth, Robert Holdcraft, P.E. Marucci Center, Chatsworth, NJ, and James Polashock, USDA-ARS
CONFERENCE ROOM

11:20–11:30 Cranberry Statistics
  *Bruce A Eklund*, State Statistician, U.S. Department of Agriculture | National Agricultural Statistics Service

11:30–11:55 Markers for Disease Resistance
  *James Polashock*, Research Plant Pathologist, USDA-ARS

12:00–1:00 LUNCH
Grasses vs Sedges vs Rushes...

Weed identification is the requisite first step to planning a successful weed management program. Weeds vary widely in their response to individual management techniques. Without proper identification of all weeds present, control measures are likely to fail. To an undiscerning eye, grasses, sedges, and rushes can unfortunately look very similar and often thought of as the same... Ability to properly separate grasses from sedges and rushes is critical since postemergence herbicides used for controlling grasses (Select, Poast...) will not have activity on sedges and rushes (and vice-versa). Thus, it is important to be able to recognize some of the anatomical features that characterize grasses, sedges, and rushes.

Grasses are in the *Graminaceae* family, sedges are in the *Cyperaceae* family, and rushes are in the *Juncaceae* family.

- In grasses, the stems (culms) are cylindrical and covered in nodes (swollen joints); if you were to cut open a grass, you would notice that the culms are hollow, and the nodes are solid. Leaf blade of grasses appears flattened with leaves staggered along the culm.
- Sedges have no nodes and the culms are solid and triangular in cross section. Sedge leaves are narrow and typically V-shaped, often only developing at the base of the plant and not on the stem.
- Rushes are round like grasses, but are similar to sedges in that they have solid culms and an absence of nodes.

A useful mnemonic to remember the differences between the three groups:

- **Sedges have edges,**
- **Rushes are round,**
- **Grasses have nodes from the top to the ground.**

Controlling Sedges

Screening and evaluating herbicides already registered on other minor crops, and that can provide efficient control of perennial weeds, is ranked as a research priority by both the ACGA and the Cranberry Institute. Sedges remain challenging to control, not only because of the very limited number of effective herbicides but also because of the perennial nature of some sedge species (yellow nutsedge e.g.), their ability to form dense vegetative mats, and anatomical features that may prevent sufficient herbicide absorption by the weed (waxy cuticle and V-shaped leaves e.g.).

A field study was conducted in 2019 to evaluate weed control efficacy of two herbicides applied prior and/or after sedge emergence. The trial has been set up at the P.E. Marucci Center (Chatsworth, NJ) in a bed planted in 2018 with various cranberry crosses under evaluation by Dr. Vorsa. Treatments consisted...
in mesotrione (Callisto®) or rimsulfuron (Pruvin®) applied at the maximum labeled rate of 1 and 4 oz a.i./A prior to sedge emergence (PRE on 5/1) or when sedges were 2 to 4" tall (early POST on 5/31). Split applications were also included with the maximum labeled rate equally divided between PRE and early POST applications, or between early POST and late POST (30 days after early POST on 7/1) applications. Non-treated weedy and hand-weeded checks were also included. Treatments were applied with a CO2-backpack sprayer delivering 30 GPA at 40 psi.

![Diagram of sedge control 4 weeks after late POST application for Cyperus bipartitus and Kyllinga pumila](image)

**Fig. 1** Sedge control 4 weeks after late POST application for *Cyperus bipartitus* (a) and *Kyllinga pumila* (b)

**Fig. 2** Rush control 4 weeks after late POST application

Rush (*Juncus* sp.) control (Fig.2) was significantly better with rimsulfuron (>90%) regardless of rate/timing of application than with mesotrione for which control did not exceed 55% to 75%.

Mid-summer infestation of lesser Canadian St. Johnswort (*Hypericum canadense*) was not controlled with either mesotrione or rimsulfuron applications, even for treatments that benefitted from a late POST application on July 1st.

Crop injury: leaf chlorosis was noted until mid-July for all treatments that received POST applications of mesotrione. However, symptoms disappeared by the end of July. With the exception of the hand-weeded check, cranberry vine stunting reached 23 to 32% for all treatments, regardless of timing of application.

**Weed Identification Resources**


<table>
<thead>
<tr>
<th>Source</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rutgers</td>
<td><a href="http://njaes.rutgers.edu/weeds/">http://njaes.rutgers.edu/weeds/</a></td>
</tr>
<tr>
<td>UMass</td>
<td><a href="http://extension.umass.edu/landscape/weed-herbarium">http://extension.umass.edu/landscape/weed-herbarium</a></td>
</tr>
<tr>
<td>Virginia Tech</td>
<td><a href="https://weedid.cals.vt.edu/">https://weedid.cals.vt.edu/</a></td>
</tr>
<tr>
<td></td>
<td><a href="https://weeds.cals.vt.edu/pages/weedid.php">https://weeds.cals.vt.edu/pages/weedid.php</a></td>
</tr>
<tr>
<td>PennState</td>
<td><a href="http://plantscience.psu.edu/research/centers/turf/extension/plant-id">http://plantscience.psu.edu/research/centers/turf/extension/plant-id</a></td>
</tr>
<tr>
<td>Ohio State</td>
<td>Perennial and Biennial weeds: <a href="http://www.oardc.ohio-state.edu/weedguide/">http://www.oardc.ohio-state.edu/weedguide/</a></td>
</tr>
<tr>
<td>Univ. of Missouri</td>
<td><a href="http://weedid.missouri.edu/">http://weedid.missouri.edu/</a></td>
</tr>
</tbody>
</table>
Cranberry Germplasm Collection: Fuel for Breeding Future Varieties (Bog 1)
Nicholi Vorsa, Jennifer Johnson-Cicalese and Susan Vancho,
P.E. Marucci Center, Chatsworth, NJ

Germplasm: the genetic material of a species, collected for use in study, conservation, and breeding

As a woody perennial fruit species, cranberry is subject to environmental stresses over all seasons. Over the course of recent decades, biotic stresses such as new diseases and insects, and abiotic stresses, e.g., climactic stresses, have emerged. Fungal fruit rots, a phytoplasma disease, false-blossom, heat stress and ‘sun scald’ have all been exacerbated by the warming climate. Through breeding and selection, development of genotypes that are more resistant to current stresses offer the potential of better adapted varieties. Native germplasm offers the genetic diversity needed for genetic enhancement. In this germplasm collection, for example, accessions have been identified that offer diverse sources of fruit rot resistance and possible ‘sun scald’ tolerance.

The germplasm of the American cranberry, Vaccinium macrocarpon Ait., can be defined as varieties that have been domesticated from native populations over the last 200 years, and plant material that exists currently in native populations. Beginning in 1985, the NJAES/Rutgers program began assembling cranberry collections from 1) other State Agricultural Experiment Station programs in Massachusetts, Wisconsin and Washington; 2) old cranberry beds around the country; 3) and wild germplasm from native populations across the geographic distribution of American cranberry, including NJ, DE, WV, PA, NY, MA, ME, MI, and WI in the United States, and NB in Canada.

This collection represents a considerable portion of the available genetic diversity of cranberry and is an invaluable resource, a ‘gene pool’, to our breeding program. Fruit chemistry screens of the collection have identified wide ranges in levels of flavor components such as the organic acids - malic acid, citric acid, quinic acid and benzoic acid, and sugars - fructose and glucose; as well as compounds associated with human health including anthocyanins, proanthocyanidins and flavonols. Differences among accessions in disease and insect resistance, fruit size and shape, yield and growth habit have also been identified. Fruit rot resistance was identified in four diverse accessions in this germplasm collection, including accessions from New Jersey, Massachusetts, Washington, and New Brunswick, Canada, which have been integrated extensively in the breeding for fruit rot resistance.

In addition, changes in cranberry markets and products, such as sweetened dried cranberries, present new challenges for processors and growers, and fruit quality traits such as fruit size, color and firmness are increasingly important. Within our germplasm collection, accessions are being identified to be used as parents in breeding for these traits. Genotyping-by-sequencing (GBS) of breeding populations have identified quantitative-trait-loci (QTL) for fruit rot resistance and lower acidity. As improvements continue to be made to the cranberry genetic map, additional markers will be identified that will facilitate our breeding efforts.

This valuable collection has been carefully maintained, and added to, at the Marucci Center for the past 34 years. In 2010, after about 20 years, the germplasm collection plots had become increasingly heterogeneous, infiltrated with ‘off-types’, even though they were established from a single propagule. Therefore, vine was reselected from each plot in the collection based on fruit characteristics, and then DNA (SCAR) fingerprinted to reestablish the germplasm collection. In 2019, in order to maintain this genetic resource, every germplasm accession was again repropagated from a single vine, and replanted on May 29 in Bog 1.
In 2018, a trial was started to see if pelletized lime, dolomite, might improve the health of the cranberry beds, and we presented preliminary results at last year’s ACGA meeting. We did this trial because of the declining health of our cranberry beds over the previous decade. The 20 half-acre beds at the Marucci Center were constructed and cranberry plantings established during the 1960’s to early 2000’s. Up until 2008, the beds were fertilized by air with granular fertilizer. The aerial applications were thought problematic due to the unevenness of fertilizer distribution. In 2008, fertilization was converted over to liquid fertilizer with a boom to provide for more even coverage. After about 5 years, the beds appeared to be stressed especially during fruit development and harvest season, cv. Mullica Queen in Bed 5, for example, exhibited discolored orange leaves in mid to late August. Stress symptoms appeared to progress each subsequent year, especially in comparison to beds ‘Lower 5’ and ‘Upper 5’. The principal difference in their management was liquid fertilizer on Beds 1-20, versus granular fertilizer on Lower 5 and Upper 5. When tissue analysis was done in September 2017, calcium, magnesium, and manganese levels were found to be severely deficient in beds receiving liquid fertilizer, while beds receiving granular had levels in the normal/sufficient range. For example, Ca was 0.25% in Bed 5 and 0.66% in Lower 5 (normal range is 0.50-0.91).

In the 2018 trial, four liming treatments were applied on May 9, 2018 to a Mullica Queen bed (Bog 5): 1) no lime, 2) ½ ton/acre, 3) 1 ton/acre, and 4) 2 ton/acre. Plots are 20’ x 50’, with three replications (Figure 1). From visual evaluations in July/early August 2018, we observed greener, healthier growth on the lime-treated plots. Tissue analysis done on August 6, 2018 showed higher levels of calcium and magnesium in the lime-treated plots compared to the no lime treatment, 0.70% vs. 0.48% Ca, and 0.20% vs. 0.13% Mg, respectively. No differences were found between the ½ ton, 1 ton, and 2 ton rates of lime.

In June 2019, a dramatic difference was apparent in the no-lime versus lime-treated plots in this bed. The lime-treated plots had many more flowers compared to the no-lime plots, making the plots much lighter in color due to the abundance of pink flowers (Figure 2). The lack of flowers made the no-lime plots appear darker green. This fall we will evaluate the effect of lime on yield.
**Figure 1.** Lime applications on May 9, 2018 on Bog 5.

<table>
<thead>
<tr>
<th></th>
<th>Rep 1</th>
<th>Rep 2</th>
<th>Rep 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 ton/acre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>No lime</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>½ ton/acre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ton/acre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ton/acre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>½ ton/acre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>No lime</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 ton/acre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 ton/acre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ton/acre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>½ ton/acre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>No lime</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20’</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50’</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2.** Aerial photo on June 19, 2019 of Bog 5. Dark green strips are from the reduced number of flowers on the 'No Lime' plots.
Managing Fruit Quality (Bog 7)

Chris Constantelos, Dave Jones, Julian Allen, Michael Mars, Dave Nuhn, Tim Waller and Peter Oudemans

Introduction: Fruit quality is governed by both biotic and abiotic factors. Fungal fruit rot is one major biotic factor and overheating is an abiotic factor. Managing fruit quality requires a multipronged approach and decisions how fruit is protected may also require estimation of economic factors. In this project we have adopted three general objectives:

A. Test and develop use patterns for new and old types of fungicides for controlling field rot. Results are preliminary and data for this will be presented at the winter ACGA meeting

B. Test strategies for managing overheating. Materials are being tested for overheating protection. (Fig. 1)

Shade Cloth: can reduce solar radiation and berry temperature.
Raynox is a wax designed to prevent sunburn in apples
VaporGard is a material designed to reduce evaptranspiration
Parka is a phospholipid designed to enhance the cuticle
Surround and Reflections are materials designed to increase albedo

C. Develop methods to estimate risk for heat exposure. The use of a sensor to measure internal berry temperature is under investigation. The “berries” record temperatures similar to direct measurements of berry temperatures. (Fig. 2)

Fig. 1. Layout for an experiment testing different methods for overheating management

Fig. 2. A comparison internal berry temperature measured using artificial fruit and direct measurements of real fruit. Panel A shows solar radiation. Panel B shows leaf wetness and shows the timing of a mid-day cooling irrigation run. Panel C shows the internal and shaded temperatures of artificial berries and measured temperatures of real berries.
Response to reduced winter flood during 2018-2019 winter (Bed 9 and 12)
Nicholi Vorsa, Peter Oudemans and Jennifer Johnson-Cicalese, P.E. Marucci Center for Blueberry & Cranberry Research & Extension, Rutgers University, Chatsworth, NJ

Winters during the last two decades have been noticeably milder in New Jersey. Cranberry growers on the west coast in Oregon, Washington and British Columbia typically do not have a ‘winter flood’. Growers in Massachusetts usually only flood for limited periods during the winter. In recent years, some Massachusetts growers apparently have not flooded at all for the winter. In states and regions with severe winters, as in Wisconsin and eastern Canada, the winter flood is needed to prevent damage to floral inflorescence primordia which are typically set in late summer, fall and possibly early winter. In addition, the winter flood prevents foliar desiccation, since cranberry retains its leaves through the winter, providing a large surface area for water loss. Cranberry is particularly prone to desiccation when the ground is frozen; not allowing for replenishment of water loss. In New Jersey, it is a standard practice to winter-flood from mid-December to mid-April. Little to no information is available as to whether four months of winter flood induces stress in the cranberry plant.

To begin obtaining information on the effect of a minimal winter flood on cranberry beds in New Jersey and whether a long winter flood effects productivity, flooding was reduced in Beds 9 (cv. Crimson Queen) and 12 (cv. Stevens). The beds were flooded only when there was a risk of ground freezing, and then in late winter if freezing temperatures were anticipated. The beds were flooded during three periods: January 11- February 3, 2019, February 27-March 4-10, 2019, March 16-20, 2019.

In addition, in November, December, January, February and March, sets of uprights with flower buds were collected in Bed 9 (Dan Schiffhauer) and subjected to artificial freezing temperatures of -28 to -2 °F over a 24 hour period (Ehlenfeldt and Martin, USDA-ARS). The uprights were held under refrigeration until March, when they were planted in potted media and their growth and flowering was observed. These freezing tests were inconclusive, since controls (uprights not subjected to freezing) had variable flowering. Uprights from December, January and February subjected to -2  °F did produce flowers to some extent.

The main observation we made on the effect of minimal winter flood was that Beds 9 and 12 came into bloom much earlier than beds where the winter flood was maintained from January to April. The beds will continue to be observed during the 2019 growing season.
Cranberry Bed Establishment: 1st Year Over-Ground Sanding Application (Bog 19)
Nicholi Vorsa and Jennifer Johnson-Cicalese, P.E. Marucci Center for Blueberry & Cranberry Research & Extension, Rutgers University, Chatsworth, NJ

The primary objective with cranberry bed renovation and establishment with new varieties is to achieve vegetative establishment as rapidly as possible. Once the variety is planted, either through mowings or rooted cuttings, the initial goal is to stimulate vigorous stolon growth, i.e., runners, during the first growing season. Secondly, the objective is to have the runners root along the length of the runner as much as possible. Observations have indicated that a light layer of sand over the runners will both stimulate runner rooting as well as upright growth.

Bed 19 was planted May 2018 with rooted cuttings of the Haines variety that were donated by Integrity Propagation. The bed was fertilized with granular fertilizer during the 2018 growing season to stimulate runner growth. In addition, in an attempt to get the runners to root down, a new sanding approach was tried. Sanding cranberry beds in New Jersey typically involves ‘barge sanding’. The sand filtering through the water will likely not press aerial vines down, but instead filter around vines not prostrate to the bed surface. Since Bed 19 is in the establishment phase, the option to apply a layer of sand with a ground rig, that is, a tractor-pulled hopper, was possible, presenting an opportunity to explore this method of sanding in first-year planted beds. The question being, would the ground sand application provide improved covering, i.e., pressing down of runners not completely prostrate? Haines & Haines lent us a hopper that was pulled by a Kubota L3540 (3400 lbs) and about ¼ inch of sand was applied on February 27, 2019 to the non-flooded Bed 19. The middle strip was not sanded. It was thought that since the vines were fully dormant, they would not be significantly damaged. Initial observations indicate that vines were not damaged by over-ground sanding method, and upright density might be higher in the sanded area. We will continue monitoring the bed. Future weed control management will be carried with Dr. Besançon’s collaboration.
Blunt-nosed leafhoppers (Fig. 1) pose a serious threat to cranberries because they are vectors of cranberry false blossom, an important disease of cranberries caused by a phytoplasma that decreases the crop’s productivity. Infected cranberries show abnormality in plant morphology such as witches’ broom where several branches appear at the internode, and the color of infected plants is noticeable red. Flowers are also replaced by a whorl of leaves (phyllody) in severely infected plants.

Control management tactics to prevent spread of this disease have targeted blunt-nosed leafhoppers mainly through the use of broad-spectrum insecticides. However, the continued availability of these insecticides, such as organophosphates and carbamates, for use in cranberries is under threat from the FQPA of 1996. In the last decade, the pesticide industry has experienced a mini-revolution in terms of discovery of novel insecticides that are not only very selective and effective at very low rates but also safe to the environment and human health. Most notable of these recent discoveries include methoxyfenozyde (Intrepid), spinoteram (Delegate), acetamiprid (Assail), rynaxypyr (Altacor), novaluron (Rimon), and indoxacarb (Avaunt). These insecticides have proven to be very effective against lepidopteran pests (i.e., chewing caterpillars) such as Sparganothis fruitworm, cranberry fruitworm, spotted fireworm, and blackheaded fireworm. However, they have no control over piercing-sucking insects (order Hemiptera) such as leafhoppers. Because of this, we have seen recent increases in population size and damage cause by this insect pest.

This summer we conducted studies to investigate a novel method to manage false blossom disease. Instead of targeting the vector, we targeted the disease itself by using products that increase the immune defenses of plants.

**Methods**

**Test various products to increase the immune defenses in cranberries against false blossom disease**

Phytoplasma-infected and uninfected cranberries were propagated clonally by stem
cuttings and placed in a greenhouse for rooting. Plants were allowed to grow in the greenhouse (Fig. 2). A colony of gypsy moth was maintained at the Philip E. Marucci Entomology Laboratory. Gypsy moth was used to assess levels of resistance in cranberries against herbivores. Our previous studies have shown that cranberries infected by false blossom disease are more susceptible to gypsy moth than uninfected plants.

False-blossom infected and uninfected cranberry plants were treated with the following six activators of defenses:
1) Lifegard WG Biological Plant Activator (Certis),
2) Actigard 50WG (Syngenta),
3) Blush 2X (Fine Americas, Inc.),
4) Regalia (Marrone BioInnovations),
5) Cranberry extract 1 (Ocean Spray),
6) Cranberry extract 2 (Ocean spray).
Controls were untreated plants. Plants were treated either once or twice a month for a total of three months (N = 6 chemical treatments x 2 times intervals = 12 treatments + control). At the end of each month, plants were tested for phytoplasma expression (PCR), growth, and resistance to leafhoppers and gypsy moth. In addition, plant material was collected from each treatment for C/N and proanthocyanidin analyses. To test for leafhopper and gypsy moth resistance, uprights of infected and uninfected plants were enclosed using plastic vials or bags, respectively. Four leafhopper nymphs or three gypsy moth neonates were added to each vial or bag. Ten replicates of each treatment were used. The number of live leafhoppers and gypsy moths, and their weights, were recorded after 21 and 10 days, respectively. In addition, at the end of the experiment, we collected root (belowground) and leaf (aboveground) tissues to quantify levels of carbohydrates.
USDA’s National Agricultural Statistics released the 2018 Non-citrus Fruit and Nut Final Summary noon June 18, 2019. Production increased from 2017 to 2018 for all reporting States. Prices received per barrel decreased for all reporting States between 2017 and 2018. New Jersey Price per Barrel was the highest among the four reporting States. New Jersey growers were again second nationally in barrels per acre.

https://www.nass.usda.gov/Publications/Reports_By_Date/index.php

NASS released the production forecast for the 2019 crop August 12, 2019. This cranberry forecast is included in the Crop Production report. This includes the National and State level forecasts.

You can get State and Regional customized reports:


Look under ‘I want to’ on the left.
Markers for Disease Resistance

James Polashock, USDA-ARS
Joseph Kawash, ORISE Scholar
Nicholi Vorsa, Rutgers, P.E. Marucci Center

Since cranberries are woody perennials, traditional breeding takes many years. The bottlenecks are the time it takes for establishment and evaluation of field plots. We are working toward reducing these bottlenecks using molecular markers and high-throughput evaluation (called phenotyping). Markers for desired traits will be used to screen seedlings and limit those to be field-evaluated to only the ones that harbor the desired markers. High-throughput phenotyping will facilitate field evaluation through image capture and analysis.

Marker development requires:
   1. cranberry reference genome
   2. genotyping system
   3. populations segregating for the desired trait(s)
   4. quantitative phenotyping
   5. bioinformatics processing
   6. marker system and validation

We have the products to meet the first 5 requirements with our first marker target being disease resistance. We are currently validating 3 disease resistance-associated markers toward completing the 6th requirement. However, the entire process is continual as we add new targets and markers. To date, the phenotyping has been done manually. To speed progress, a high-throughput system is required. The high-throughput system we hope to acquire captures images and processes those images to estimate numerous phenotypic targets such as disease resistance, flowering time, yield estimation, etc.

Only those plants that harbor the ‘Resistant marker’ and lack the ‘Susceptible marker’ are selected for field evaluation.