

Development of a Grain Amaranth breeding program for Tennessee



Matthew W. Blair, Ranjita Thapa, Matthew Edwards
TSU (Tennessee State University), Nashville TN
Presentation : Amaranth Institute, Chicago, Illinois, USA
September 25th, 2015

Outline

- Origins and TSU
- Germplasm Screening
- Seed Savers Exchange
- USDA Core Collection
- DNA extraction
- Herbicide resistance
- Iowa State Breeding Lines
- Publicity and Visitors
- Photosynthesis by drone



Origins

- **Rodale Research Institute**, First job Amaranth
- **Geneticist / Bean Breeder** – breeding lines and varieties for the Andean region of South America, East Africa and the Caribbean.
- **Associate professor - Tennessee State University** : deploy tools of molecular biology for genetic diversity analysis of amaranth, marker assisted selection, and physiology studies.

Introduction to TSU, College of Agriculture, Human and Natural Sciences



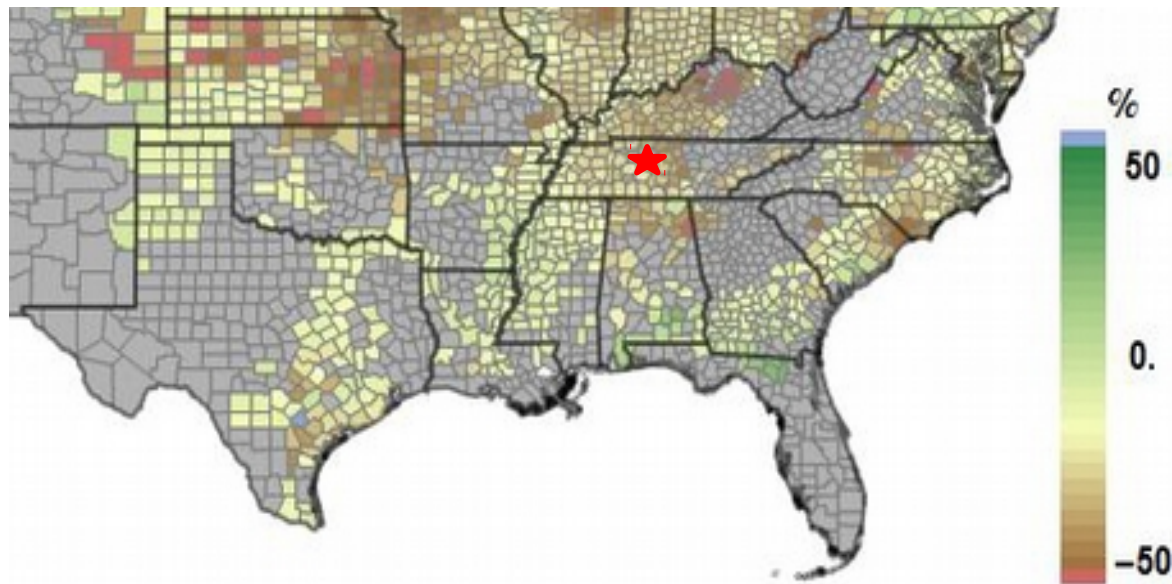
**College of Agriculture,
Human and Natural
Sciences**



TSU is an 1890s, land grant HBCU. in Nashville, Tennessee with a fast growing /great value agricultural training program characterized by low fees and costs for university students and a large number of faculty. TSU is a hub for plant and

Tennessee State University (TSU) Location center of Southeast

TSU is within a day's drive of many land-grant Universities the South / Southeast in a region of heavy climate change; hence the need for adaptation through genetic research.



Laboratory location

- **Laboratory wing includes 8 labs with two each in:**



Present Research Focus

- Genetic studies of new crops (subtropical legumes and pseudocereals).
- Adaptation to climate change (drought and heat tolerance).
- Training of students and visiting researchers from USA, Bangl., China, Colombia, Ghana, Kenya, Ethiopia, Nepal and South Sudan.

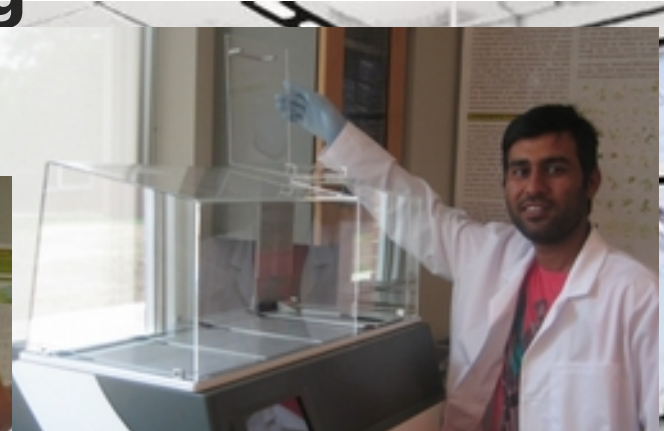
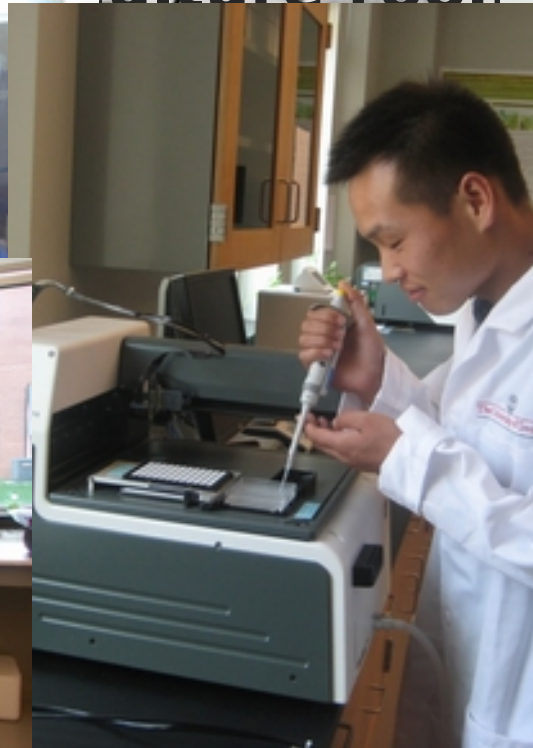
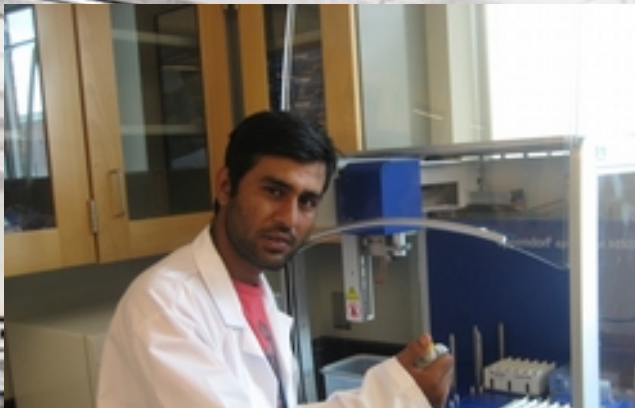
Genomic and Genetics Laboratory

- Genotyping with various markers
- SNP (single nucleotide polymorphism)
- SSR (simple sequence repeat)
- Marker conversion from GBS and seq.

Laboratory conditions

- Plant Genomics Laboratory - Ag. Biotech Bldg.
- Robotics for DNA marker amplification and fingerprinting

NA manipula
culture room



Amaranth Germplasm Screening

1) Seed Savers Exchange

(34 landrace varieties, from T. Johnson, Decorah, Iowa, never tested in South)

2) USDA - Core collection

(260 accessions, from David Brenner, Iowa State University,

Seed Savers Exchange

- *Experimental Design and Mgmt.:* RCBD, 2rep
- Unfertilized, no pesticide use, 3 m long rows
- Plots made of 3 rows separated by 50" spacing
- Greenhouse planted May 12th, 2015 (jiffy)
- Field planted June 5th, 2015 (by transplants)
- Planted into a field treated with Dual/Prowl for bean planting two weeks

Yield Traits measured



Figure 1. Scans of SSE Amaranth seeds

Seed Savers Exchange - Transplants in Greenhouse



Seed Savers Exchange - Transplants ready for Field Transfer



Seed Savers Exchange - Field Expt.

Expe



cates

Seed Savers Exchange - Field Expt.

Bordered by fast growing mung
bean

i) to note any lack of uniformity

ii) to compare leg



Seed Savers Exchange - Field Expt.

Good uniformity through
out experimental field



USDA - Core Collection

- Un-randomized experiment : Uniform field location and soils,
- Un-fertilized, no pesticide use
- Greenhouse planted April 29th, 2015 (jiffy pots)
- Field planted June 5th, 2015 (by transplants)
- Planted into a field treated with Dual/Prowl for bean planting two weeks earlier
- Uneven harvest **Yield Traits measured**
- 6 mo.

Field Experiments = Early

Experiment: short rows x non-

Greenhouse

Campus

replicated

Cumberland

River

Goat Barns



USDA - Core Collection -



Purple Leaves / Non-dwarf



Green Leaves / Dwarf Type

USDA - Core Collection - Stems



Green Stem / No Flange



Red Stem / Flange / Diameter

USDA - Core Collection - Flowers



Compact Panicle / Early Flowering Drooping panicle / Continuous Flowering

USDA - Core Collection -



Purple Leaf / Purple panicle



Red-green Leaf / Pink panicle

USDA - Core Collection - Flowers



Green Leaf / Orange panicle



Green Leaf / Yellow/Green panicle

USDA - Core Collection - Flowers



Compact Panicle / No Side Branches
Open panicle / Side Branches
to Flower Head

Seed Germination / DNA

In vitro growth used to create low starch tissue for DNA extraction

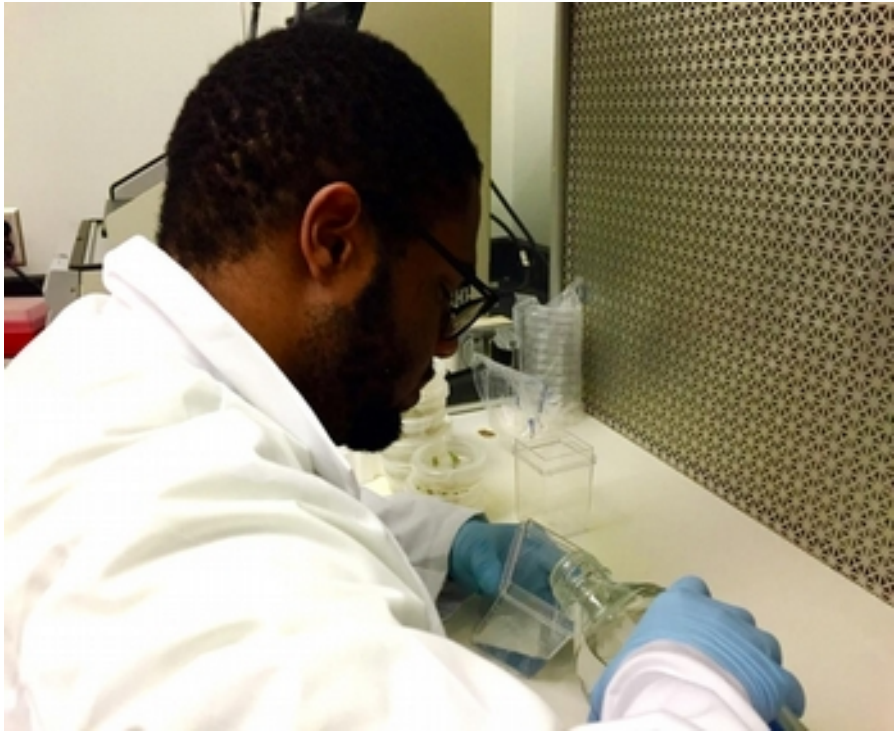


Figure 2. (a) Matthew Edwards pouring basal media; (b) Amaranth seedlings germinated in magenta boxes in growth chamber.

Herbicide Tolerant Parent

Parent 1: PI654437 (*A. hybridus*) – weedy amaranth with ALS inhibitor resistance to imazethapyr (BASF) donated by P. J. Tranel, University of Illinois collected from a soybean field in Edgar County, Illinois.

Herbicide Susceptible

Parent

**Parent 2: D136-1 relative
of PI558499 “Plainsman”**

– grain amaranth that is
susceptible to imazethapyr
(BASF).

F1 of the crosses were
screened with Pursuit®
herbicide treatments

F2 plants in



Figure 3. *Amaranth Population at early stages of development*

Iowa State University Breeding Lines (semi-dwarf)



Corn wind
barrier at end

Three reps of
four lines.

Plant height
can be
compared to
cowpea to
the left and
corn at end
of block

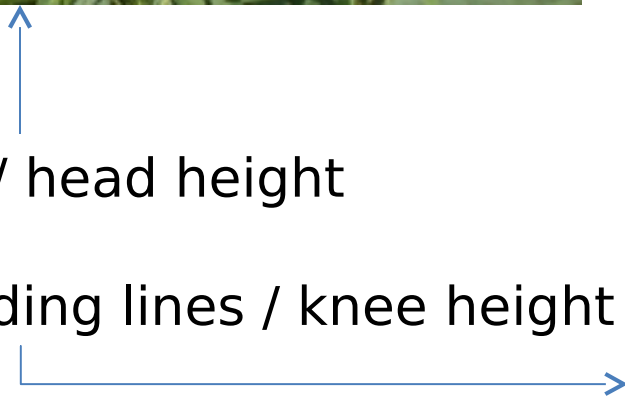
Average
height under

Semi-dwarf comparisons A breakthrough for the South



Most landraces / head height

Semi-dwarf breeding lines / knee height



Semi-dwarf comparisons breakthrough for the World



Normal height
Accessions



Semi-Dwarf
Breeding Lines

Dr. Dafeng Ding (Shandong Academy of Agricultural Sciences)

Promotional / Extension Brochures



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What you need to know about growing Grain Amaranth a high potential C₄ photosynthesis crop

Field Production (source: David Brenner, USDA)

Transplanting

- Varieties for Tennessee can be planted indoors in a nursery tray in April for subsequent transplanting in May.
- Seedlings can be transplanted at 2 or more weeks of age after a week of hardening and are planted into wet soil.
- Transplanting is done for efficient use of seeds, and it allows the growing area to be mechanically weeded just before the seedlings are transplanted. Herbicide may also be used.
- Planting in a nursery also reduces risk of plant stand loss due to damping off of a disease caused by *Pythium aphanidermatum*.

Direct seeding

- Direct seeding involves much less labor, but incurs a greater risk of poor stand due to diseases and predators of young seedlings.
- Poor competition with weeds must be considered during the first crucial initial weeks of growth.
- Sowing can be done in rows with spacing of 15cm between rows X 0.9m between plants to facilitate cultivation.
- Depth of seed sowing is 0.5-1cm for good germination.

Grain Yield potential:

Producing Countries: India, Mexico, Nepal and USA
Average U.S. (American) Yield= 670-1340 kg/ha
Potential Yield= 2,800-3,900 kg/ha or higher as C₄ crop



Candies prepared from Grain Amaranth are popular in Mexico and other countries where they provide good nutrition snacks, with high protein, high lysine amino acid and good vitamin content.



Amaranth crosses are conducted in the greenhouse and use genetic diversity such as *Amaranthus caudatus* (sort below) crossed with *A. hypochondriacus* (pictured above) to generate new varieties.



Dr. Blair and his research team are selecting the best varieties based on seed size, plant height, growth habit and yield potential.

Amaranth Candy (Alegrias*)

2 tablespoons raw grain amaranth
3 tablespoons honey
3 tablespoons light molasses or dark corn syrup
3 tablespoons butter
Vegetable oil

- Pop amaranth by placing in a very hot skillet one tablespoon at a time, stirring constantly for about 15 seconds until seeds pop.
- After they pop, transfer to a shallow bowl and add the next tablespoon of amaranth to the skillet. (You should have about 2 cups of popped grain.)
- Lightly coat a 9-by-13-inch pan with oil.
- Combine honey, molasses and butter in a large saucepan or skillet, bring slowly to a boil. Cook over medium heat 5 to 7 minutes, stirring constantly, until mixture turns golden brown and becomes thick and sticky.
- Add popped amaranth, stir with wooden spoon until amaranth is coated with syrup. Transfer to 9-by-13-inch pan, gently pushing mixture into corners of pan. Let cool, then cut into bars.
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Recipe credit: www.cooks.com

(*Alegrias: a traditional Mexican preparation of Grain Amaranth that can be shaped into different candies.

Amaranth Cereal: Aztec Wonder Grain

(Highly nutritious pseudo-cereal that
can be cooked, ground or popped)



"Think. Work. Serve."

Dr. Matthew W. Blair
Plant Breeding & Genetics
Agricultural Biotechnology Bldg., Rm. 112

Department of Agricultural and
Environmental Sciences

www.tnstate.edu/agriculturalprograms

Pamphlet also made for Leafy Amaranths

Treat yourself to Leafy Amaranths

Red Amaranth with Bacon and Onions

Ingredients

8 bacon slices, diced
1 large onion, diced
3 garlic cloves, minced
¼ cup red wine vinegar
1 tbsp dried chili flakes
1 tbsp honey
1 tsp salt
1 large bunch of red amaranth

Instructions

- ♦ Fry the bacon until it is mostly cooked. Do not let the bacon get crispy.
- ♦ Stir in the onion and cook until soft and transparent.
- ♦ Add the remaining ingredients, except the red amaranth.
- ♦ Let the red wine vinegar boil off for a minute or so and the garlic will puff up.
- ♦ Stir in the red amaranth and cook until it is just wilted. Do not overcook the greens.
- ♦ Serve immediately.



Recipe source: www.theblackpepper.com



College of Agriculture,
Human and
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Department of Agricultural and
Environmental Sciences

3500 John A. Merritt Blvd.
Nashville, TN 37209

Phone: (615) 963-5435 • Fax: (615) 963-5436
www.tnstate.edu/agriculturalprograms

Chandra Reddy, Ph.D. Dean and Director of Research/
Administrator of Extension

Carter Catlin, Ph.D. Associate Dean for Research

Samuel N. Nahshon, Ph.D. Department Head

For more information contact:

Dr. Matthew W. Blair, Ph.D.

mblair@tnstate.edu

Office: (615) 963-7647

Lab: (615) 963-6001

This project funded by Evans Allen grant at Tennessee State University.
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Leafy Amaranth: High Quality Vegetable

(An easy-to-grow, warm season
green leaf vegetable that can
replace spinach, kale or mustard
greens in main or side dishes)



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Use of Unmanned Aerial Vehicle Drone

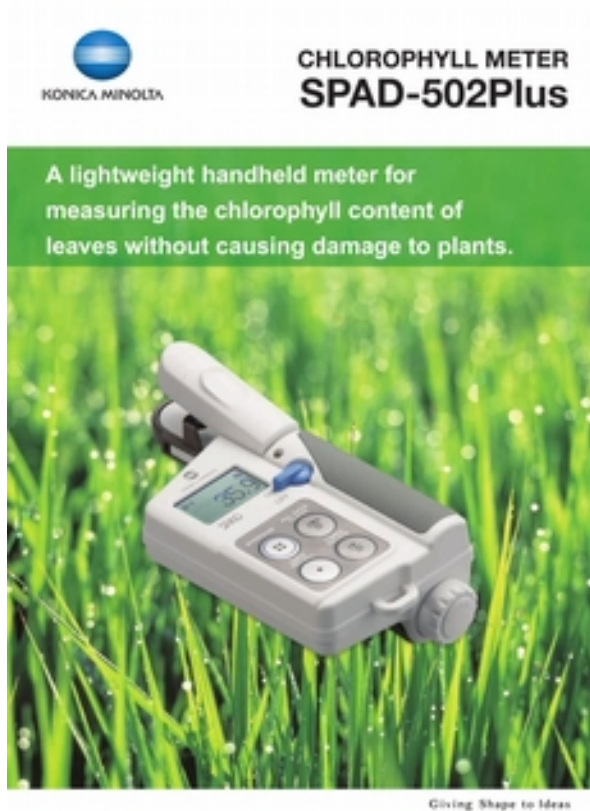


John Cross
(photographer)



Amaranth Field
shot on Sept. 8th

Photosynthesis Equipment



SPAD
reader



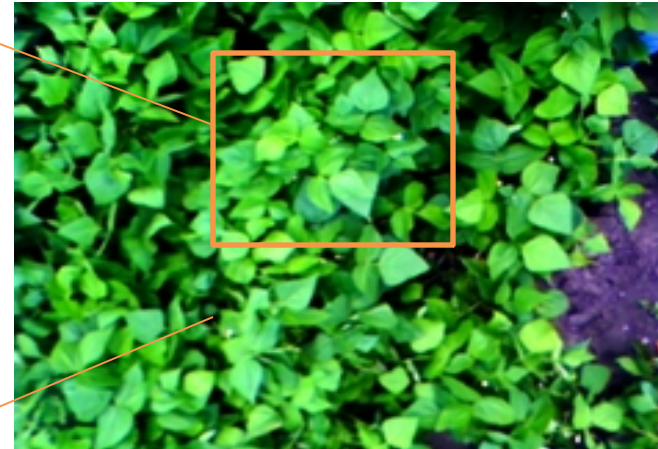
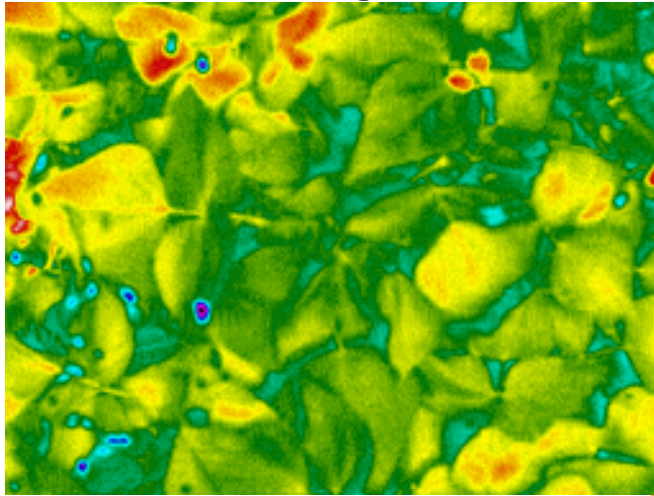
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Other Evaluations - Future

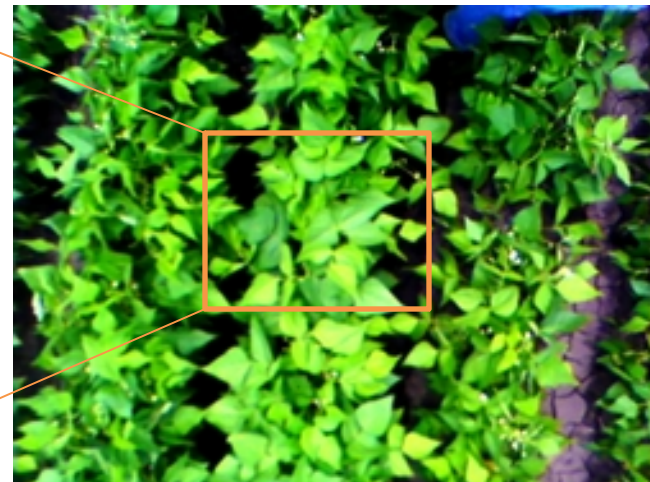
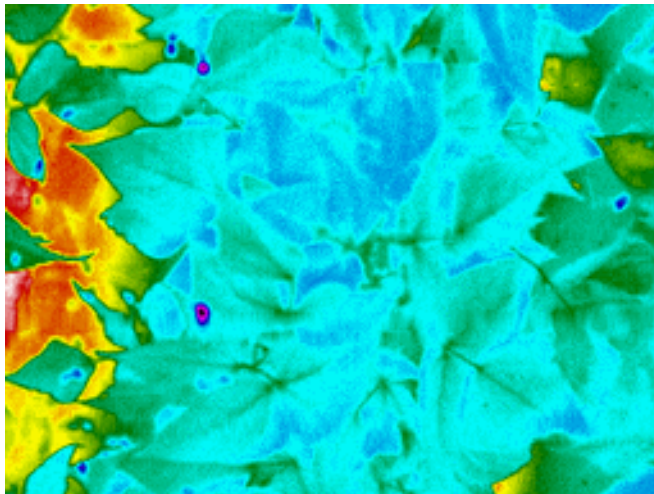
Thermographic image

Visible Light image

CAL143
Very susc.
Hotter canopy



DAB246
Tolerant
Cooler canopy





Wondershare™

Filmora

**Thanks very
much**

