

Seed-X

Astonishing results in a variety of applications

Seed Breeding
& Research

Seed-X.com





Environmental Effect

Genetic identity vs. environmental effect. Different seed lots of same line under varying growing conditions, location and season, and affected seed phenotypes.

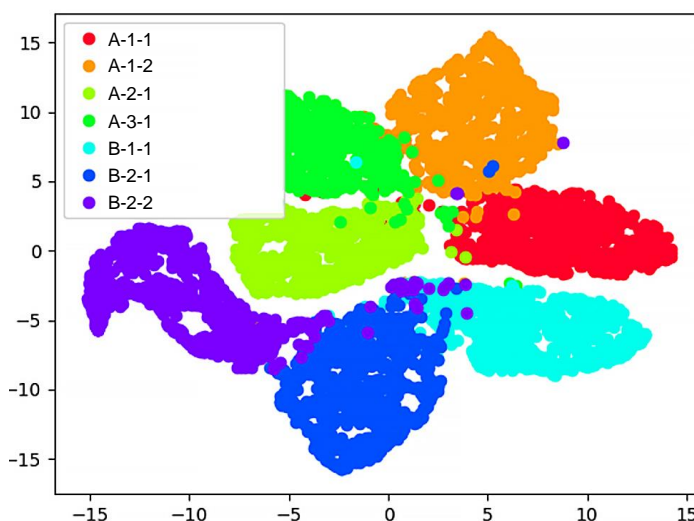
Target: Classification between 2 tomato seed types (F1) grown under different environments Genetic identity vs. environmental effect

Two tomato hybrids, A and B, were produced in three locations over four seasons. All seeds were treated according to common industry practices. Thousands of seeds from each variety were analyzed using Seed-X unique GeNee™ technology. For each line, images were split randomly into two groups: 90% training and 10% test. This process was repeated 10 times. Seed-X technology was used to predict seed for test set images.

For each seed image of these sets, Seed-X technology outputs the probability that the seed belongs to the trained hybrids. A similarity matrix was plotted to visualize the similarity between different varieties.

Two tomato hybrids A and B, were produced in three and four locations respectively. The above proximity distribution highlights:

1. A clear difference between line A and line B
2. Within each of the lines, the different seed lots share close phenotypes
3. A clear separation between the different lots (location/season).





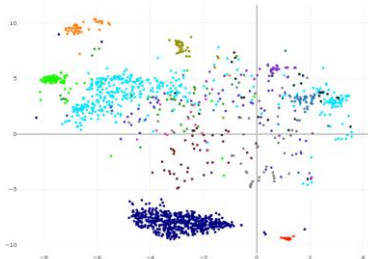
Proximity Distribution

Proximity distribution used scatter plots to visualize seed variance in a two-dimensional space.

Target: To identify connection between seed phenotype and the genetics of segregated populations or specific seeds within a segregated population.

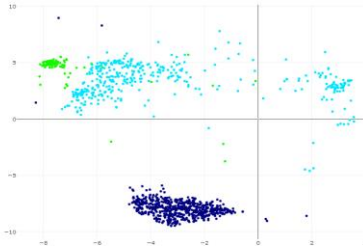
A tomato segregated family includes two parents, P1 and P2. Their F1, F2, eight F3 selections and two F4 selections were chosen. All seeds were treated according to common industry practices. Hundreds of seeds from each variety were analyzed using Seed-X unique GeNee™ technology. For each line, images were split randomly into two groups: 90% for training and 10% for testing. This process was repeated 10 times. Seed-X technology was used to predict origin of the test set seeds and to demonstrate relatedness to other family members.

Overall General distribution



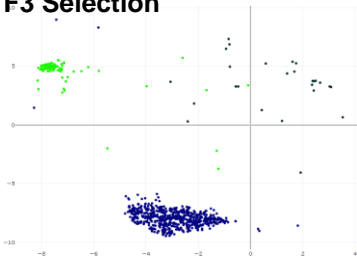
Overall distribution including the two parents, P1 and P2, their F1, F2, eight F3 selections, and two F4 selections

Highlight on P1, P2 and F2 Segregation



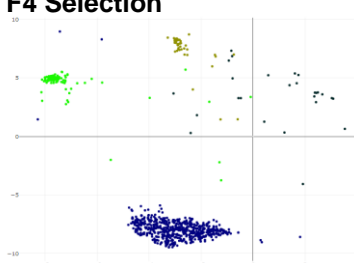
Parental lines represent two types of tomato plants: P1– small fruit size, good taste, P2- large fruit size, poor taste. F2 population segregates between the two parental lines

F3 Selection



F3 selected seeds distribute between the two parental lines, with a clear bias towards P1

F4 Selection



F4 seed distribution is significantly reduced, and the bias toward P1 is significant





Seed-X

Hybrid Classification

Confusion matrix of hybrid tomato seeds

Target: Classify tomato hybrids, based on seed phenotypes

Eight tomato hybrids, were grown in the same greenhouse, over the same season. All seeds were treated according to common industry practices. Thousands of seeds from each variety were analyzed using Seed-X unique GeNee™ technology. For each hybrid, images were split randomly into two groups: 90% training and 10% test. This process was repeated 10 times.

The Seed-X technology was used to predict the seed hybrid for the test set images. For each seed image of these sets, the Seed-X technology outputs the probability of the seed to belong to the trained hybrids.

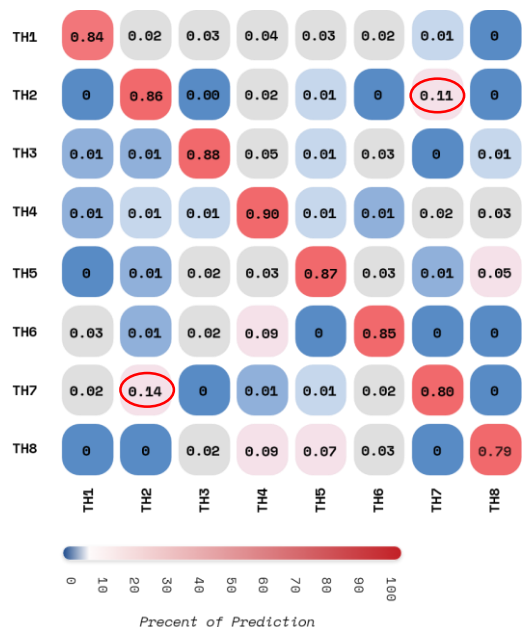
A confusion matrix was plotted to visualize the similarity between different varieties.

Confusion Matrix Results

In this Confusion Matrix, row labels indicate the real hybrids analyzed and column labels illustrate predicted hybrids. Numbers and colors assigned to each cell reflect the sum of seed images predicted as pertaining each hybrid.

For example, the first cell (first row, first column to the left) is marked with 126, which means that 84% (125/150) of "TH1" seeds of the "TH1" seeds (because they are in the "TH1" row) were indeed predicted as "TH1" (because they are in the "TH1" column). All values on the diagonal are correct predictions, where all other values are errors.

The confusions between TH2 and TH7 (marked by circles), prompted us to investigate the genetic connection between them. We found that these varieties share a common maternal parent.





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Hybrid Classification

Confusion matrix of hybrid tomato seeds

Target: Classified tomato hybrids, based on seed phenotypes

Eight tomato hybrids, were grown in the same greenhouse, over the same season. All seeds were treated according to common industry practices. Thousands of seeds from each variety were analyzed using Seed-X unique GeNee™ technology. For each isolate, images were split randomly into two groups: 90% training and 10% test. This process was repeated 10 times.

The Seed-X technology was used to predict the seed isolate for the test set images. For each seed image of these sets, the Seed-X technology outputs the probability of the seed to belong to the trained hybrids.

A Confusion matrix was plotted to visualize the similarity between different varieties.

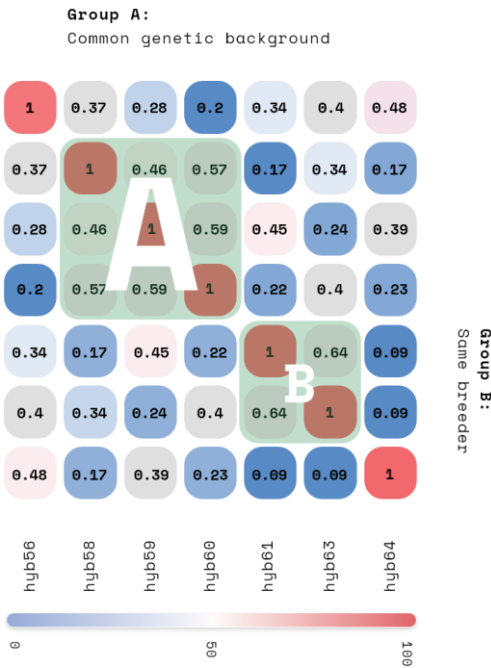
Confusion Matrix Results

This Confusion Matrix represents Seed-X GeNee™ envision distance analysis, comparing between tested hybrids.

The distance is represented in numbers, 0-1 scale, where 0 symbolizes no connection between the hybrids and 1 is exact match. The colors correlate to the number according to the color bar on the bottom. We highlight the groups of hybrids that show high Confusion.

Group A – Hyb58, 59 and 60; the maternal parent of these three hybrids originate from the same genetic background (M82).

Group B – we have no additional information regarding the genetic material, but these two lines come from the same breeder (might be considered to have the same genetic background).





Biotic Trait Detection

Isogenic Line Classification – Virus, Nematode and Fungus resistance

Target: Correlate seed phenotypes with biotic traits

Seeds of isogenic lines, presenting either resistance or susceptibility to different biotic stresses were grown under the same environmental conditions and in the same season.

All seeds were treated according to common industry practices. Thousands of seeds from each variety were analyzed using Seed-X unique GeNee™ technology.

For each variety, images were split randomly into two groups, 90% training and 10% test. This process was repeated 10 times. The Seed-X technology was used to predict seed isoline based on the test set images. The percentage of correct predictions for each line is presented at the table below.

Summary of results

Crop	Trait Group	Sub Trait	Precision*	Sensitivity**
Tomato	Virus	TSWV resistance	1	0.95
Tomato	Virus resistance	TYLCV resistance	1	0.96
Tomato	Virus	TMV resistance	0.96	0.94
Tomato	Nematode	Gene 1	0.97	0.92
Tomato	Nematode resistance	Gene 2	0.96	0.9
Melon	Fungus resistance	Powdery mildew resistance	0.97	0.89

* Precision: Rate of seeds-of-interest of all seeds predicted as such (including false positives)

** Sensitivity: Rate of seeds-of-interest predicted as such of all seeds-of-interest (including false negatives)





Consumer trait Detection

Isogenic Line Classification - Fruit Color, Shape, Size, Structure

Target: Correlate seed phenotypes and consumer traits

Seeds of isogenic lines, presenting different consumer traits were grown under the same environmental conditions and in the same season. All seeds were treated according to common industry practices. Thousands of seeds from each variety were analyzed using Seed-X unique GeNee™ technology.

For each isoline, images were split randomly into two groups: 90% training and 10% test. This process was repeated 10 times. The Seed-X technology was used to predict seed isoline based on the test set images. The percentage of correct predictions for each isoline is presented here.

Summary of results

Crop	Trait Group	Sub Trait	Precision*	Sensitivity**
Tomato	Fruit color	Purple/red	0.99	0.83
Tomato	Fruit color	Orange/red	0.95	0.69
Tomato	structure	Round/oval	0.93	0.9
Tomato	structure	Compact plant	0.82	0.71
Melon	Fruit color	Pale	0.96	0.96
Melon	Flesh color	Flesh	0.99	0.99
Melon	Structure	Shape	0.9	0.81
Melon	Taste	PH	0.91	0.81
Pepper	Color	Red/yellow	0.99	0.96
Pepper	Fruit size	Small/large	0.99	1
Pepper	Structure	Determinate	0.92	0.89

* Precision: Rate of seeds-of-interest of all seeds predicted as such (including false positives)

** Sensitivity: Rate of seeds-of-interest predicted as such of all seeds-of-interest (including false negatives)