The Blossom-End Rot Toolkit – 2023 Season Report

Summary

The Blossom-End Rot (BER) Toolkit is a project funded by Western SARE that aims to help growers control BER and other physiological disorders of dry-farmed tomato. We tested five treatments to determine how they affect marketable yields, BER, and other physiological disorders in dry-farmed tomato.

- **Sheltering the crop using a windbreak** reduced BER at OSU Vegetable Research Farm from 1.6% to 1.2%.
- **Reducing the amount of composted chicken manure (Nutririch 4-3-2) applied** reduced BER, but on some sites it also reduced total yields and increased fruit losses to yellow shoulders. The highest marketable yields were found in the 50 lbs of nitrogen per acre plots on three sites, the 0 lbs of nitrogen per acre plots on two sites, and the 100 lbs of nitrogen per acre plots on one site. The optimum amount of fertilizer to apply is context dependent. On-farm trials also showed a relationship between amendment applications and soluble solids concentration (°Brix), with higher fertilizer application rates resulting in increased sugar in fruits.
- **Decreasing in-row spacing while simultaneously increasing between-row spacing** decreased fruit loss to sunscald at the OSU Vegetable Research Farm from 14.5% to 9.1%.
- **Trellising** resulted in larger fruits, higher marketable yields, and reduced incidence of sunscald at the OSU Vegetable Research Farm.

There was no effect of treatment on drought stress or sensory quality. It should be noted that taste-test participants only tasted tomatoes from the OSU Vegetable Research Farm trial, that many tasters were not impressed with the dry-farmed tomatoes, and that the tomatoes used for these taste tests had lower soluble solids (sugar) concentrations and lower titratable acidity than what was found in many of the on-farm trials. It is possible that factors that reduced BER and drought stress in the OSU Vegetable Research Farm trials also impacted their flavor.

We will pursue additional trials in 2024 to test how these treatments interact in order to find the optimum treatment combinations. Farmers who want to participate in larger trials in 2024 and 2025 will have to dedicate 0.28 acres of space to the trial. Alternatively, farmers could test a combination of the treatments (of their choosing) against a control. We will also continue our outreach activities, including field days and presentations, with a Dry-Farmed Variety Showcase planned for September 8 in Portland.

Introduction

Dry-farmed tomato is susceptible to a number of physiological disorders that make the crop unmarketable and can result in crop failure. Among these, the most devastating is blossom-end rot (BER). This project aims to help farmers control BER in dry-farmed tomato by testing a number of treatments, while also determining how these treatments affect other physiological disorders, marketable yield, plant drought stress, fruit weight, profitability, fruit soluble solids concentration and titratable acidity, and sensory evaluation.

Pictures of physiological disorders (clockwise from top left): light BER, heavy BER, sunscald, internal whitening, yellow shoulder and splitting, and yellow shoulder

The tools in the BER toolkit were selected because they have been shown to reduce BER incidence in trials conducted from 2019-2022. The tools were based on the hypothesis presented by Saure (2014, 2001). Saure hypothesized that BER was the result of a sequence of a) rapid growth that predisposes fruit to BER followed by b) severe stress that results in cell death at the fruit's blossom end (in the case of dry farming this would be drought stress). Therefore, the tools aim to either reduce drought stress or prevent rapid early season growth. The treatments are:

a) **Reducing drought stress by sheltering the crop from the wind** – Rows of corn were planted to the north of plots to reduce wind run through the tomato crop.

b) **Reducing rapid early season growth by limiting soil amendment application** – this included a reduced fertilizer treatment (50 lbs of N per acre) and a no fertilizer treatment.

c) **Reducing rapid early season growth by decreasing in-row spacing and increasing between row spacing** – We reduced the in-row spacing from 2’ 6” to 1’ 8” and the between-row spacing increased from 6’ 0” to 9’ 0” (see Figure 1).

d) **Trellising** – We trellised plants using a basket weave. We hypothesized that trellising would increase BER incidence and drought stress by elevating the crop and exposing it to the wind.

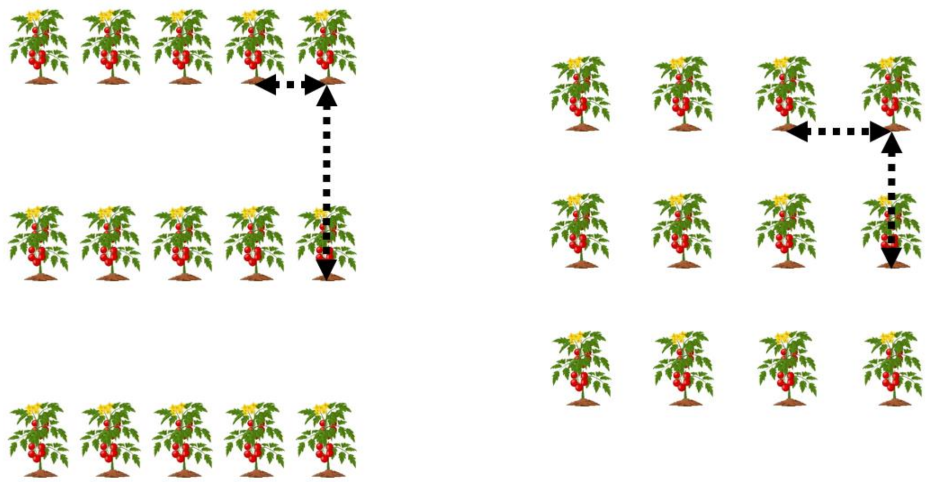


Figure 1: Demonstrating the different density treatments. On the right is a picture of the control plots, with 6 feet between rows and 2.5 feet in-row spacing. On the left is the reduced in-row spacing treatment, with 9 feet between rows and 1.67 in-row spacing. Both of these treatments result in 2904 plants per acre.

Trials

To test the effects of the treatments, two trials were conducted. The first was at the Oregon State University Vegetable Research Farm, and tested five treatments (sheltering, low amendment, no amendment, in-row spacing, and trellising) against a control. The treatments are detailed in Table 1.

Table 1: Descriptions of treatments used in the 2023 OSU Vegetable Research Farm trial

Treatment	NutriRich Application (lbsN/acre)	In-row spacing	Between-row spacing	Notes
No amendment	0	2’ 6”	6’ 0”	
Reduced amendment	50	2’ 6”	6’ 0”	
Control	100	2’ 6”	6’ 0”	
Reduced in-row spacing	100	1’ 8”	9’ 0”	
Sheltering	100	2’ 6”	6’ 0”	Corn planted north of plot
Trellising	100	2’ 6”	6’ 0”	Plants trellised with basket-weave

Picture: The OSU Vegetable Research Farm trial included six treatments replicated six times. Corn shelters were planted but may have been too small to be truly effective.

The second set of trials were conducted on commercial farms throughout the mid-Willamette Valley. These trials tested the effect of fertilizer application on diverse sites to determine an optimum application.

Picture: This site was former pasture that was converted to a tomato field this season. Low soil nutrient concentrations resulted in stark differences between fertility treatments. Here we can see that the 0 lbs of nitrogen per acre treatment (left) resulted in puny plants with few fruit. The right is the 100 lbs of nitrogen per acre treatment. Other farms with abundant soil nutrients showed little difference between the treatments, probably because high soil fertility made these additions negligible.

Results

Table 2 shows the effect of the different treatments on yield and fruit quality for dry-farmed tomato grown at the OSU Vegetable Research Farm. Treatments did not differ in total yield. Treatments did different in marketable yield, with the trellised treatments having higher marketable yields than the no amendment treatment, the control, and the sheltered treatment. Trellising also resulted in larger fruit than any other treatment. Treatment impacted BER incidence, with the reduced amendment treatment having lower BER than the control treatment. It should be noted that there was incredibly low BER incidence in the OSU Vegetable Research Farm trial. Treatment did not affect incidence of yellow shoulder, but it did effect incidence of sunscald. The trellising treatment had the lowest and reduced in-row spacing treatment had the second lowest incidence of sunscald.

Table 2: Yield and fruit quality data from the OSU Vegetable Research Farm

Treatments	Total yield (t/a)	Marketable yield (t/a)	Average fruit wt (lb)	BER (%)	Yellow shoulders (%)	Sunscald (%)
No amendments	19.2 (1.2)	13.2 (1.0) B	0.21 (0.004) B	1.2 (0.3) AB	15.2 (1.2)	13.0 (0.9) C
Reduced amendments	20.7 (1.2)	14.4 (1.0) AB	0.22 (0.004) B	1.0 (0.3) B	13.7 (1.1)	13.9 (0.9) C
Control	19.5 (1.2)	13.3 (1.0) B	0.21 (0.004) B	2.2 (0.6) A	12.0 (1.0)	14.5 (1.0) C
Reduced in-row spacing	18.8 (1.2)	14.2 (1.0) AB	0.22 (0.004) B	1.4 (0.4) AB	12.4 (1.0)	9.1 (0.8) B
Sheltering	19.0 (1.2)	13.2 (1.0) B	0.21 (0.004) B	1.2 (0.4) AB	13.5 (1.1)	12.9 (0.9) C
Trellising	21.2 (1.2)	16.6 (1.0) A	0.25 (0.004) A	1.6 (0.5) AB	13.0 (1.1)	6.3 (0.6) A

Results of the on-farm trials are presented in Table 3. Treatment did not affect total yield or marketable yield. However, treatment did effect average fruit size, with the no amendment treatment having larger fruit than the control. Fertilizer application treatment affected incidence of yellow shoulder; the control had half the yellow shoulder incidence than the no amendment treatment. Treatment also affected soluble solids concentration (sugar) with the control having a higher soluble solids concentration than the no amendment treatment.

Table 3: Yield and fruit quality data from on-farm trials.

Treatment	Total yield (t/a)	Marketable yield (t/a)	Average fruit wt (lb)	BER (%)	Yellow shoulder (%)	Sunscald (%)	Soluble Solids Concentration (°Brix)
No amendment (0 lbsN/acre)	11.8 (2.7)	6.0 (2.0)	0.16 (0.02) A	25.4 (10.9)	9.5 (3.1) A	10.3 (2.1)	7.0 (0.5) B
Reduced amendment (50 lbsN/acre)	13.3 (2.7)	6.9 (2.0)	0.15 (0.02) AB	38.4 (13.3)	6.2 (2.2) AB	8.2 (1.7)	7.5 (0.5) AB
Control (100 lbsN/acre)	13.1 (2.7)	6.2 (2.0)	0.14 (0.02) B	42.7 (13.8)	4.4 (1.6) B	9.1 (1.8)	7.9 (0.5) A

Site data is presented in Table 4. Farms differed considerably in soil and climate characteristics. Some farms had almost no wind while others were very windy. Wind direction depended on site and Figure 2 presents the wind run by direction for four of the sites. Some farms had very little soil fertility while others were extremely fertile.

Table 4: Trial site data

Farm	Soil AWHC	Wind Run (km)	Soil pH	Soil organic matter (%)	Estimated nitrogen release (ppm)	Soil phosphorus concentration (weak Bray, ppm)	Soil calcium concentration (ppm)
Jefferson	12	1443	5.4	4.3	131	159	1960
Albany	8	Bad sensor	5.9	4.9	141	174	2980
Monmouth	11	676	6.3	17.7	236	120	6260
Philomath	TBD	2054	4.8	5.8	161	31	2460
Sweet Home	TBD	1214	4.5	13.2	236	1	854
OSU Vegetable Research Farm	12	1801	5.6	2.1	83	39	2078

Soil pH and nutrient concentrations presented from the 0 amendment plot

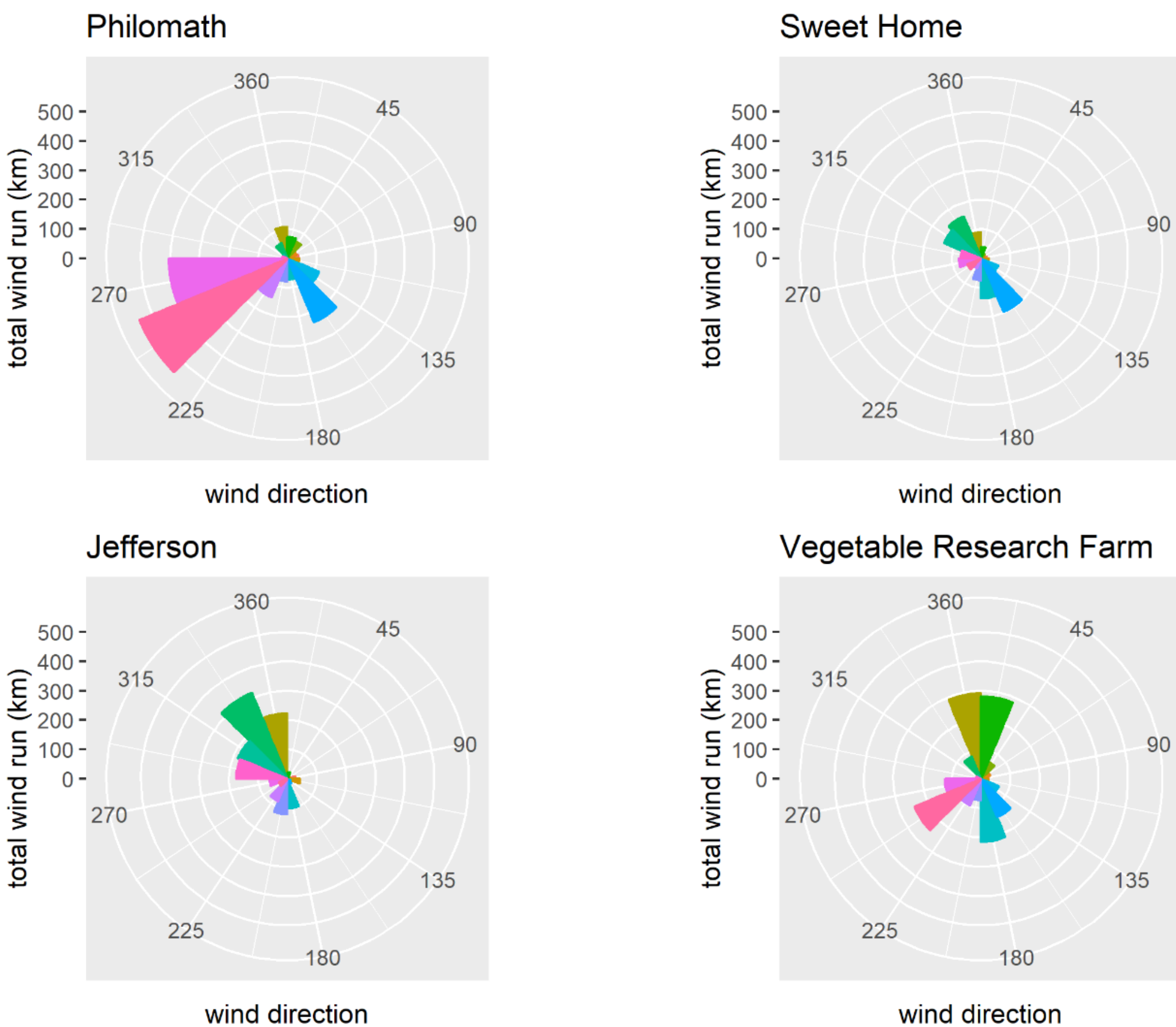


Figure 2: Wind run and direction differed by farm. At the Philomath farm most of the wind came from the west. For the Sweet Home Farm, wind came from the north and the south. For the Jefferson farm the wind came from the North and Northwest. At the Vegetable Research Farm, wind came from the north and from the west and south. Farmers can use this data when determining where to plant their windbreaks.

Farmers may want to compare how their farms did with everyone else. Table 5 presents the yield and fruit quality data for individual farms. The plot with the highest marketable yield has been indicated with a star.

Table 5: Farm data by plot.

Farm	Treatment (lbs of N per acre)	Total yield (lbs/plot)	Total fruit count (per plot)	Marketable yield (lbs/plot)	Average size (lbs)	BER incidence (%)	Yellow shoulder incidence (%)	Soluble Solids Concentration (°Brix)
Jefferson	**0***	**35**	**160**	**20**	**0.22**	**23**	**18**	**6.3**
	50	37	171	19	0.21	43	5	6.8
	100	27	142	12	0.19	40	11	6.5
Albany	0	57	490	27	0.12	47	1	7.8
	50	61	500	35	0.12	31	2	8.3
	100*	**74**	**660**	**42**	**0.11**	**39**	**1**	**9.7**
Monmouth	0	51	412	19	0.12	48	4	7.8
	50*	**63**	**541**	**28**	**0.12**	**44**	**6**	**7.9**
	100	57	510	18	0.11	54	2	8.1
Philomath	**0***	**26**	**202**	**8**	**0.13**	**72**	**12**	**7.8**
	50	21	224	3	0.09	87	4	9.1
	100	23	246	3	0.09	82	2	9.4
Sweet Home	0	7	57	4	0.13	0	25	6.4
	50*	**21**	**179**	**8**	**0.12**	**46**	**15**	**7.0**
	100	22	232	7	0.10	54	5	7.4
OSU Vegetable Research Farm	0	66	308	45	0.21	1	15	6.1
	50*	**71**	**327**	**49**	**0.22**	**1**	**14**	**6.0**
	100	67	327	46	0.21	3	12	6.0

*Starred treatments indicate highest marketable yield.

Site-specific recommendations

Jefferson – To reduce BER at this farm, I would recommend controlling wind from the north. Liming may help to improve total yields.

Albany – To reduce BER at this farm, I would recommend controlling wind from the north. Liming may help to improve total yields.

Monmouth – This farm benefits from being very sheltered from the wind, it had the lowest wind run in the trial. However, excessive soil nutrients from compost applications are resulting in large plants that have many small fruit with BER. Consider planting dry-farmed tomatoes on plots that have not received compost applications for multiple years.

Philomath – This farm had some of the highest rates of BER in the project. I would recommend planting a shelterbelt to the west to control wind speeds. Increasing soil pH may help plants root deeply. It is possible that subsoil compaction may be limiting root growth, I will have to do a better job of evaluating this possibility in 2024.

Sweet Home – Wind may be difficult to control here, as it appears to come from multiple directions. Improving soil pH and fertility will help to improve total yields. Subsoil constraints on root development may be present. I will be better equipped to evaluate whether roots are developing into the subsoil this year.

Discussion

BER incidence at the OSU Vegetable Research Farm was very low this growing season, and this may explain why we were not able to detect many treatment difference. We believe that the low BER incidence at the Vegetable Research Farm was due to the plant being less drought stressed, though we are unsure why they were less drought stressed this year than in previous years. Low BER was not the only way that the VRF trials differed from the on-farm trials. There was also higher yields, larger fruit, a higher incidence of yellow shoulder, and fruit had lower SSC. This may have been the result of careful soil prep in addition to lower soil fertility. However, we were able to detect an effect of some of the treatments. We will present the effect of each of the treatments.

Sheltering – Sheltering with blocks of corn did not appear to have much of an effect on BER in tomato at the OSU Vegetable Research Farm in 2023. This may be in part because the corn plots were too small to block the wind effectively. Wind run was also active from south and west. However, additional plots within the control and sheltering treatments were harvested in an attempt to test the effect of distance from the corn on BER incidence. While distance from the corn did not affect BER incidence, when all of these plots were included in the analysis a small but statistically significant effect was detected (1.2% BER in sheltered plots vs. 1.6% BER in the control plots). Italian dry farmers reportedly intercrop tomatoes with corn (Castronuovo et al. 2023).

Fertilizer application – The effect of fertilizer application was tested in both on-farm trials and at the OSU Vegetable Research Farm. We found some interesting results. First, increasing fertility appears to increase incidence of BER but it also decreased incidence of yellow shoulder. The optimum amount of fertility to add is probably site dependent, with current soil nutrient levels and degree of sheltering from the wind having some effect. Fertilizer application also effected fruit weight and soluble solids concentration. It may be that increasing fertilizer application causes plants to use water less efficiently, and that the decrease in fruit size and increase in soluble solids concentration is a result of the plants being more drought stressed.

In-row spacing – Decreasing the space between plants decreased the incidence of sunburn. Because the plants were closer together, it is possible that fruits were better covered by foliage.

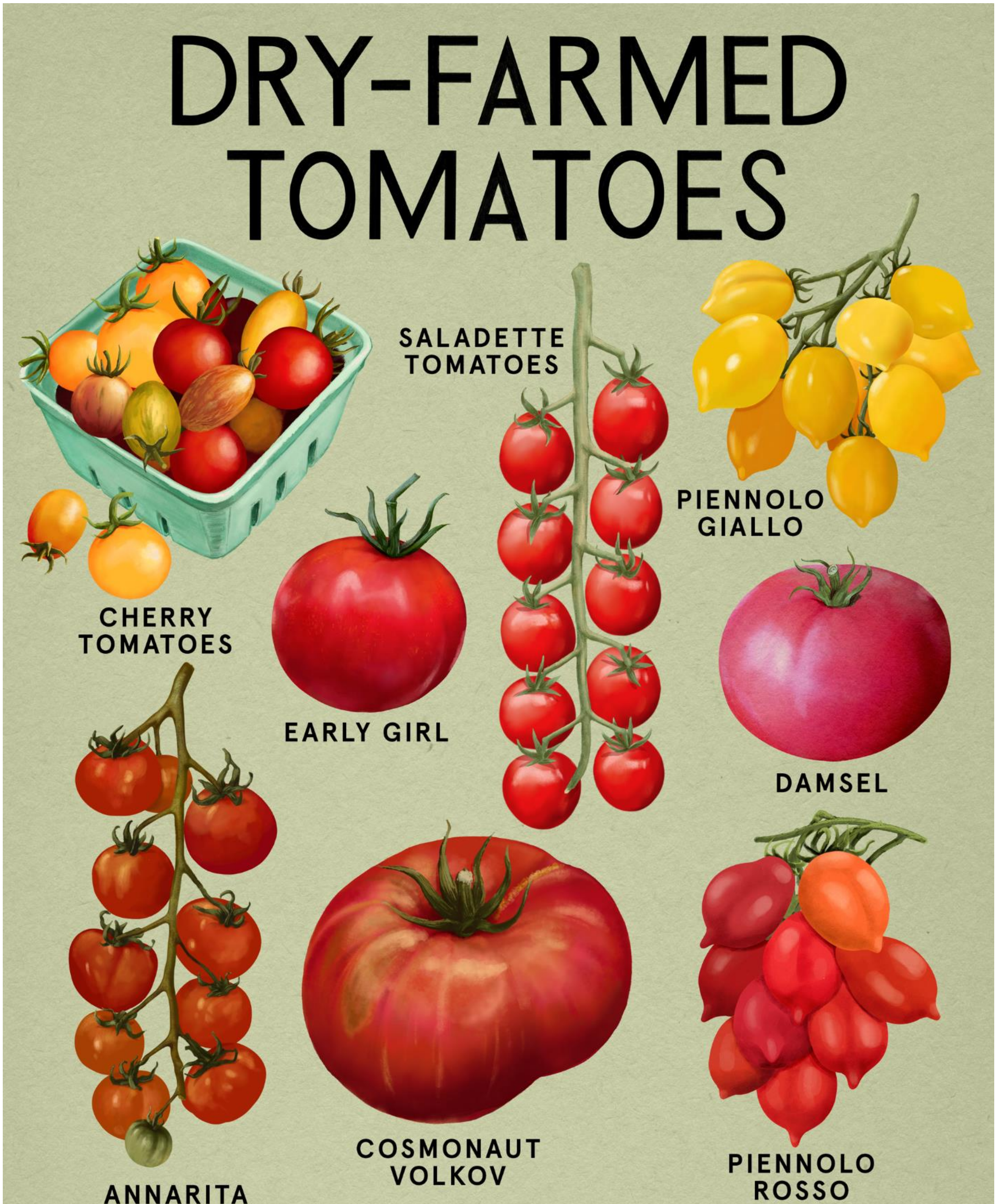
Trellising – These plots had the best results, with higher marketable yields, increased average fruit size, and reduced sunscalding. Trellising may have prevented sunscald by improving coverage. Plants that were allowed to sprawl would occasionally have vines break under the weight of the fruit, allowing light to penetrate the canopy. We expected that trellising would increase BER incidence, but this result was not observed.

Extension and Marketing

Part of the project was to inform growers on how to successfully dry farm tomatoes and how the BER toolkit could be used to control BER for dry-farmed tomatoes. Extension activities have included a field day at the OSU Vegetable Research Farm. Future extension activities will include the Dry Farming Collaborative Winter Convening on February 7th and the Small Farms Conference on February 17th. Outreach and marketing activities in 2023 included the Tomato Festival (see below).

Picture: Tomato Festival in Portland, OR (photo by: Shawn Linehan).

Marketing materials were also created to help farmers sell dry-farmed tomatoes and melons. These can either be delivered to or printed by farmers. Putting these materials in the hands of consumers may help to familiarize them with tomato and melon market classes, making them more adventurous (this work was funded with money from Oregon Department of Agriculture). An example poster is below.


DRY-FARMED TOMATOES
CHERRY TOMATOES
SALADETTE TOMATOES
PIENNOLO GIALLO
EARLY GIRL
DAMSEL
ANNARITA
COSMONAUT VOLKOV
PIENNOLO ROSSO

Next Steps

In 2024, we are going to focus on testing the interactions between the different treatments. To do this, I would want to conduct large trials at research farms and in on-farm trials. The alternative to this trial would be a smaller trial where farmers select a suite of tools to compare with a control (conventionally managed plot). We will also test how seedling production practices effect dry-farmed tomato success.

Large Trials

Large trials will consist of eight plots. Four of these will be sheltered by corn (or sunflowers) and four will be exposed to the wind. The tomato plots will be planted on the leeward side of the corn. Density and fertility treatments will be planted in a 2x2 factorial design. The total square feet of the trial is 12,000 (75’ x 160’). The trial would include 280 tomato plants, 40 of these would be plot plants and 240 would be border plants. This design is presented in figure 3.

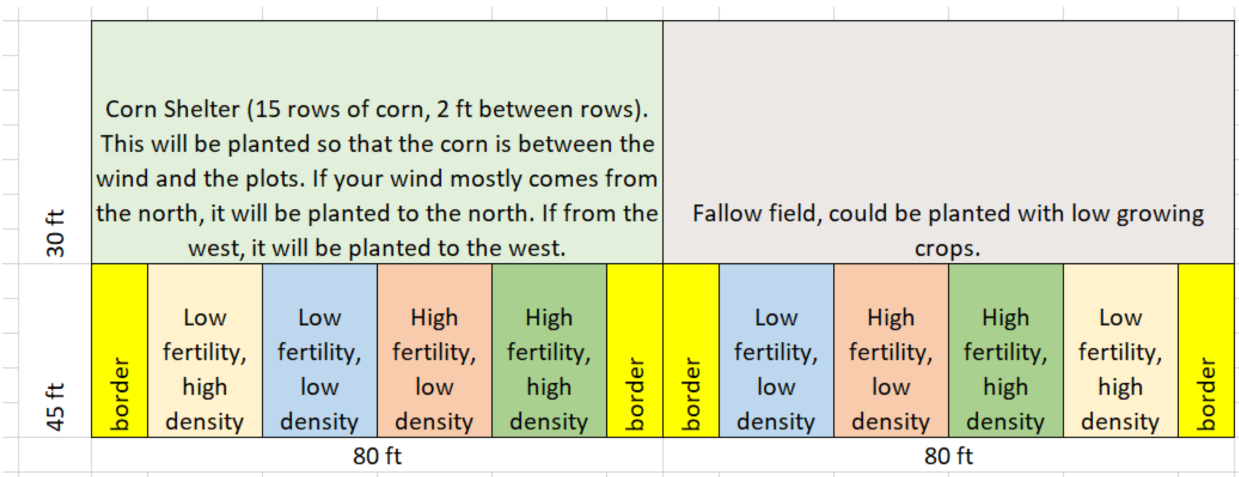


Figure 3: 2024 and 2025 example experimental design. Main and subplots will be randomized at each farm.

Small Trials

Unfortunately, I will probably not have the resources to conduct this trial at all farms. Additionally, farmers may be constrained in their total space, unable to accommodate a trial that is 0.28 acres. In this case, the alternative would be for the farmer to select a number of tools from the trial and test them against a control. I would be willing to discuss with farmers to determine which tools would be most appropriate. This was also trialed in 2023 to mixed success, results from these trials can be found in Table 6.

Table 5: Six farmers assessed the BER toolkit treatments against a control.

	1	**2**	**3**	**4**	**5**	**6**
Treatments	Sheltering	Spacing	Sheltering + Spacing	Sheltering + Spacing + Reduced Amendments	Sheltering + Spacing	Sheltering + Spacing
Effect on BER	Reduced BER	No effect	No effect	Somewhat reduced BER	Somewhat reduced BER	No effect
Effect on marketable yield	BER Toolkit performed worse	Similar	Similar	BER Toolkit performed best	Similar	Similar
Number of Marketable fruit	Fewer	Fewer	Similar	Similar	Similar	Similar
Notes	Coastal farm, corn blew onto tomatoes in storm.	No difference detected	No differences detected			No differences detected

Seedling Production Practices

Finally, I will plan to test how seedling production practices effect dry-farmed tomato outcomes. These trials could be planted as on-farm trials, either in the "fallow" portion of a large trial or as an alternative to the small trial.