"Seeds for Life"

Growing Food in a Changing Climate 2022

by the

Creston Community Seed Bank Society

September 5, 2023

We respectfully acknowledge that our work takes place on the traditional and unceded territory of the Ktunaxa Nation.

GROWING FOOD IN A CHANGING CLIMATE

Just like people, plants suffer when it gets really hot. On June 29, 2021, the temperature reached a record-breaking 41.4°C (106°F) in Creston, B.C., where our community seed bank is located. In the sweltering heat, we walked around our gardens at the College of the Rockies, Creston campus. Everywhere we looked, we saw droopy vegetable plants. They had curled leaves that were a dull blue-green colour - these plants were obviously in bad shape! Giving them extra water didn't help much.

The purpose of our Society is to grow and preserve a diverse supply of vegetable seeds for food security in our area. At a Directors' board meeting, we agreed that it was critical to have seeds of climate-adapted plants in the seed bank. But we looked at each other and realized we didn't know which of the 600 varieties in the seed bank were heat-tolerant. Would they grow in a warmer climate?

In early 2022, we decided to focus our work on methods to assess heat tolerance in vegetable crops. This would be a new project for us, so we expected lots of trial and error learning. We would, of course, save seeds from everything we grew. And hopefully be able to tell which varieties are the most heat-tolerant.

Creston Community Seed Bank Society gardens at the College of the Rockies, Creston, BC.

For funding, we applied for a grant to the Creston Valley Community Foundation, in partnership with Farm Folk City Folk of Vancouver. Farm Folk is a charitable organization dedicated to strengthening sustainable food systems in British Columbia. They, like us, know that seeds are an essential part of food systems. We also applied to Columbia Basin Trust for a grant. We were super excited when both organizations offered us funding for the project. Now the hard work began…

First we had to decide which types of plants we should grow for the project. Beans and tomatoes are easy to grow and save seeds from. Different varieties of beans need to be separated by only 6 metres to prevent cross-pollination (which would result in hybrid seeds). And different varieties of tomatoes don't need to be separated at all, if the flowers are protected from pollinators. That meant we could grow many varieties in our limited garden space. And we wanted the genetic diversity of heirloom, open-pollinated varieties. These have been grown in many different climates over the 75 or more years they have been in existence.

In March and April we got busy. Varieties of beans and tomatoes were decided upon. Supplies were purchased. Volunteers were recruited. The garden beds were prepared. And Nicolas Walser was hired as Project Coordinator.

Our exciting project was under way!

Gysi bean seeds.

What We Did

In April, we took seeds out of the seed bank's frozen storage for the varieties we wanted to grow. We found that we didn't have enough seeds of some varieties. Seeds of Diversity in Waterloo, Ontario, generously sent us seeds for our project.

We "started" tomatoes and pole beans indoors, because they have long growing seasons. Twelve plants each of 8 varieties of tomatoes were seeded in containers in early April. Three varieties of pole beans were seeded in early June. We planted the 300 bean seeds in peat pots so the plants in their pots could go directly into the ground when the weather warmed up.

Also in June, Nicolas set up our new weather station at the college gardens. It would give us hourly readings of temperature, rainfall, wind, and other weather conditions. If we saw heat-stressed plants, we would know exactly what temperatures were affecting them.

Nicolas planting bean seeds.

Nicolas and the volunteers planted the tomato plants into beds in the gardens. Then they put seeds of 3 varieties of bush beans directly in the ground. Bush beans have a shorter growing season so they didn't need to be seeded early in the greenhouse. The pots of pole bean plants went into the ground in late June, after trellises were built for them.

Volunteers "bagging" tomato flower buds. Note the pole bean trellises.

To prevent cross-pollination in the tomatoes, Nicolas and the volunteers put organza gift bags on several flower bud clusters on each plant. By doing this, we could save seeds from different varieties that are grown within a metre of each other. The bags prevent bees from transferring pollen from flowers of one variety to those of other tomato plants nearby. The flowers will produce tomatoes even in the bags, since tomatoes are self-pollinating. It seems like a contradiction, but tomato flowers can be pollinated with or without bees.

The Measurements

Finally, all the bean and tomato plants were growing well. It was time to figure out what we should measure to predict heat tolerance in these plants.

We knew that plant growth and fruit production could be affected by temperatures above about 32°C. For the tomato plants, growth and the amount of fruit harvested each week seemed like obvious things to measure. The beans were a little trickier. How does one measure growth in pole beans when they are 3 m tall?

Major Cook's pole bean on a tall trellis

Nicolas put measuring stakes in the bush bean rows and markers on the pole bean trellises so we could record the height of the plants each week. It did get a little difficult measuring the pole beans by the end of summer.

The tomato plants were a challenge. It was fairly easy to measure the height of each plant twice a week. But we thought that measuring actual growth could give us more precise information about the effect of high temperatures. So we chose 4 plants of each variety for detailed measurements once a week.

Nicolas marked one stem on each of these plants. Then he used a caliper to measure between leaf branches along the stem from the bottom of the plant to the new growth at the top. It was easy to do when the plants were young, but almost impossible when the plants were bushy and over 2 m tall. It took quite a lot of time and frustration.

Nicolas measuring weekly tomato growth.

The Harvest

We decided to save all the bean pods for seeds. They weren't harvested until October, when they were fully dry. Seed pods should be left on the plant until the seeds are mature so they will germinate well. We didn't need to do this with the tomatoes, as the seeds are mature in ripe fruit.

In August, the tomato harvest began. We picked all of the ripe or near-ripe fruit weekly. The tomatoes of each variety were kept separate from other varieties, and counted and weighed. The fruit that grew inside the organza bags were set aside to extract the seeds, but also weighed and counted.

The total number of tomatoes was 7148. The total weight was 866 kg (over 1900 lbs), of which 758 kg were donated to the Gleaners Food Bank. The rest were kept for saving seeds.

The Seeds

The tomatoes were processed by cutting them in half and squeezing out the pulp and seeds into a glass jar labeled with the variety name. We set the jars aside for a few days until the pulp was moldy and a little smelly. Tomato seeds have a gel coat that will inhibit sprouting. This fermentation process removes the gel. Then we pushed the pulp through a strainer. The seeds left in the

strainer were cleaned and dried, ready to be weighed and put into envelopes for storage.

Tomato pulp fermenting for seed extraction.

At the end of the season, we pulled out all the bean plants and put them in the greenhouse to dry until they were crispy brown. Now the fun began. The dry plants with attached pods were put into burlap bags. Then we members of the Board of Directors stomped on them to crush the pods and extract the seeds. The bags were emptied onto a screen over a bin. The beans went through the screen and the plants and pods stayed on the screen. These were put in the compost pile. The beans in the bin still had bits of pods and stems (called chaff). An air pump blew them away. Clean beans!

Susanne, Loretta, and Donna stomping on bags of dry bean plants and pods.

The Weights

At the end of the season, we pulled out all of the tomato and bean plants and weighed each variety separately. We also weighed the seeds of each variety of beans and tomatoes and tested them for germination. Most of these seeds went into the freezer for long-term storage. But we also kept some in short-term storage for community distribution. A lot were donated back to Seeds of Diversity.

The total weight of each plant, including its fruit or pods and seeds, indicates how well the variety grew over the summer. If a variety continues to grow, flower, and produce fruit and seeds even at high temperatures, it is heat tolerant.

Bean plant harvest.

What We Learned

Temperature

Temperature patterns for the summers of 2021 and 2022 were quite different. In 2021, the average maximum daily temperature for June was almost 6 degrees above normal and in July, about 7 degrees above normal. On the other hand, August was slightly cooler than normal.

Average maximum daily temperatures in 2022 more closely resembled normal temperatures, although it was very hot at the end of July and beginning of August. The highest temperature we recorded over the summer of 2022 was 38.7°C on July 31.

Average daily maximum temperatures and number of days above 32°C in 2021 and 2022. Creston weather station, Environment and Natural Resources, Canada.

	2021		2022	
	Number of days above 32°C	Average daily maximum temperature	Number of days above 32°C	Average daily maximum temperature
JUNE	10	28.4°C	0	22.8°C
JULY	27	33.9°C	11	30.6°C
AUGUST	3	25.9°C	14	31.5°C

Normal average maximum daily temperatures, Canadian Climate Normals 1981-2010: June 22.9°C, July 27.2°C, August 27.4°C

Temperatures above 32°C during the day and 21°C at night can inhibit pollination, and therefore fruit production. The temperatures at the end of July 2022 did rise above 21°C for a few hours at night, but always dropped below this by dawn.

According to some scientific studies, night temperatures are the key to identifying heat tolerant varieties. For tomatoes, if the plants set fruit when the night temperature is above 21°C, the variety is heat tolerant. Most varieties of

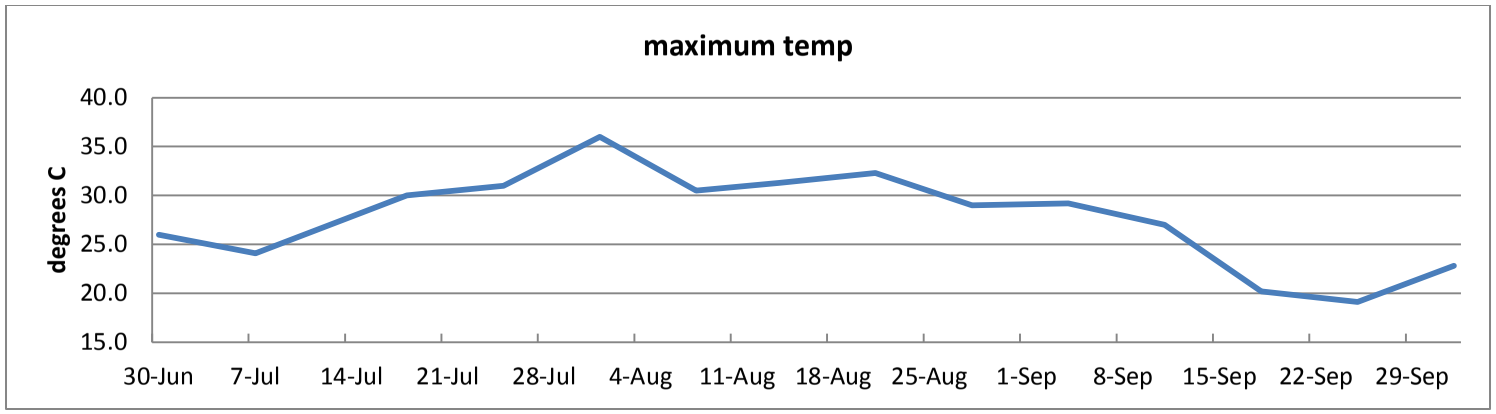
beans will not set seeds at night temperatures above 18^{o}C, but a few heat tolerant ones can set seeds at higher temperatures.

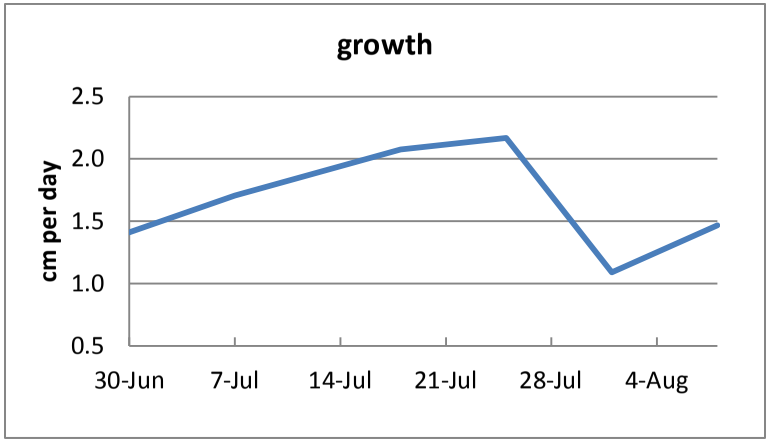
The Tomatoes

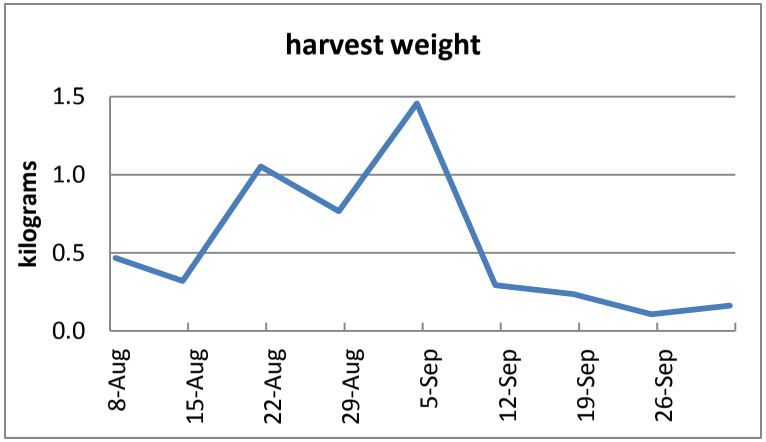
We found that when the weather got over 32^{o}C at the end of July and beginning of August, growth of the stem tips on all 28 tomato plants that we measured slowed down or stopped. Six to 8 weeks after the hot period, the weekly weight of the tomato harvest declined by over 60%. This is the time it takes for a tomato flower to produce a ripe tomato. It is well known that tomato flowers don't successfully pollinate at this temperature, so it is not surprising the harvest decreased. When the temperature dropped at the end of August, the plants started producing tomatoes again.

The following graphs (Figure 1) show an example of how tomato growth and harvest changed over the measurement period. The growth rate of Red Tomato of Montlhery increased to 2 cm per day until the temperature rose into the mid-30s C. The lowest growth rate of 1.1 cm/day coincided with the highest temperature of the summer.

Seven weeks later, the average tomato harvest weight for the 3 measured Red Tomato of Montlhery plants dropped from 1.4 kg to 0.3 kg. This pattern occurred in all of the tomato plants we measured. One variety, Tiger Tom, did not grow at all for the week after the highest temperature. As with the other varieties, the high temperatures only affected Tiger Tom for a couple of weeks, then tomato production resumed. For all of the tomato plants, the harvest weight decreased by an average of over 60% six to eight weeks after the high temperatures occurred.







↑ **flower to ripe fruit 6-7 weeks** ↑

Figure 1. Weekly average maximum temperature, daily average growth, and weekly average harvest for 3 plants of Red Tomato of Montlhery tomato 2022.

Although the tomato harvest weight decreased for a short period in summer, production made up for it in September, and the long warm period in October helped ripen them. The weight of final pick in mid-October was nearly as high as the total weight of the harvest through the summer, before the final pick. The total weight of the plants and fruit differed among the varieties, but this is likely a characteristic of the variety, not an indication of heat tolerance.

In mid-October, we knew we had better pick all of the green and ripe tomatoes on the vines – frost was threatening! Folks from Harvest Share, a program under the Creston Valley Food Action Coalition, came out and with our volunteers, picked every tomato. They recorded the number and weight of tomatoes for each variety. Over 300 kilograms were picked. This harvest amounted to 37% of the total tomato harvest over the summer. They split up the harvest and took half to the Gleaners Food Bank. The other half was distributed among the volunteers.

The final pick of the year.

The Beans

During the hot period at the end of July, growth of the three varieties of bush beans and Lazy Housewife pole bean slowed down slightly. We thought Lazy Housewife beans would be the most heat tolerant of all the pole beans, since the seeds came from North Carolina where the variety was developed. It seems to need a longer growing season than we have here, however. It was the last bean variety to produce and ripen pods.

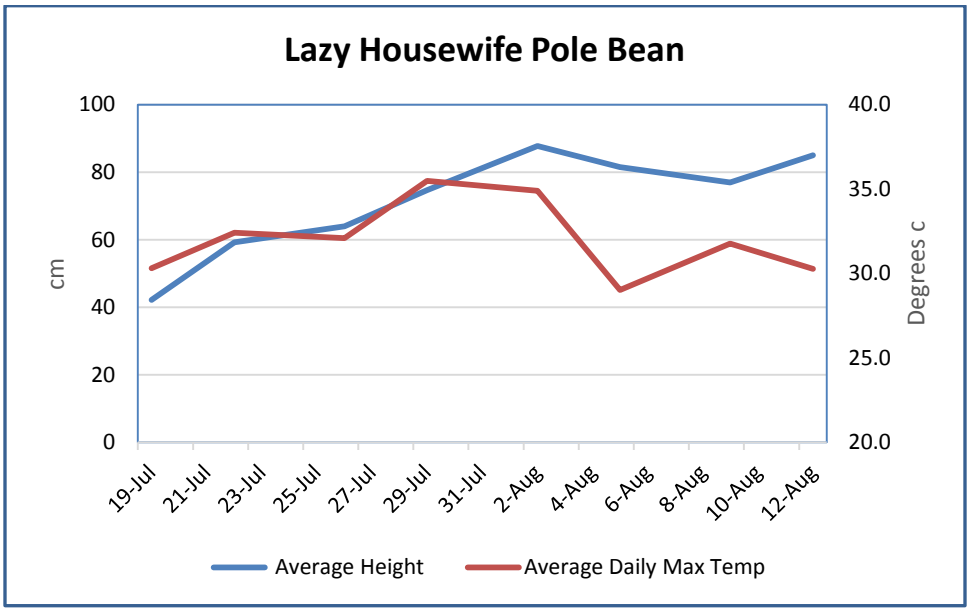


Figure 2. Average height of Lazy Housewife pole bean and maximum temperature, July-August 2022. Four measurements per date.

Mr. Tung's and Major Cook's pole beans kept growing strongly through the hottest period of summer. These varieties also produced the greatest weight of seeds of all the beans we grew. They are probably more heat tolerant than the other varieties of beans.

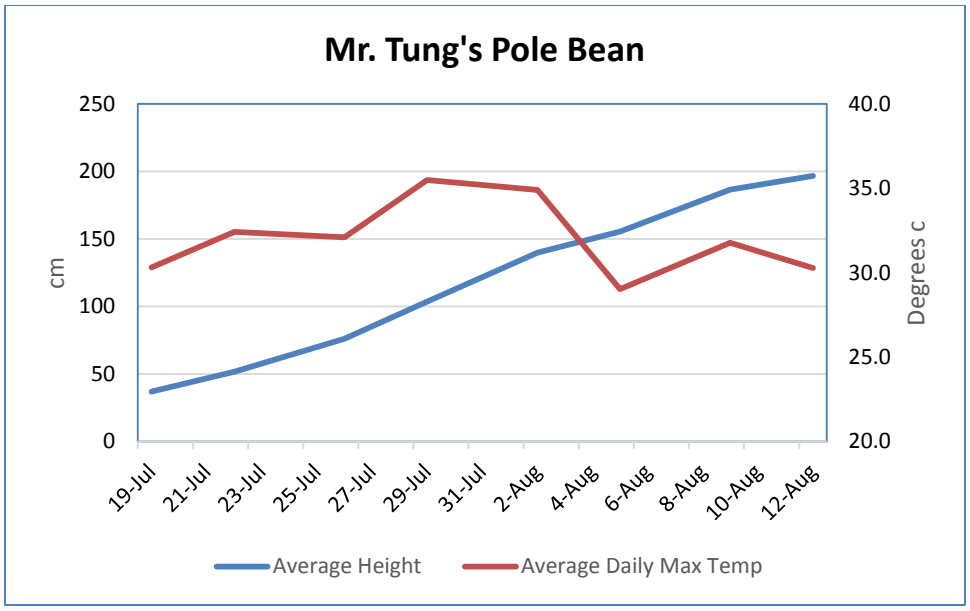


Figure 3. Average height of Mr. Tung's pole beans and maximum temperature, July-August 2022. Four measurements per date.

The height of the three varieties of bush beans leveled off when it got hot. Gysi bean was the tallest and the most productive.

Gysi bush bean and measuring stakes.

The Bottom Line

Identifying heat tolerance among varieties of tomato and bean plants is challenging. Many studies have been conducted on how these plants respond to excessive heat. But most of these were done on plants growing under controlled conditions in greenhouses or laboratories.

In our gardens at the college, conditions were not controlled. So growth factors like the amount of water and nutrients each plant received probably varied with its location in the garden. How would we know if a variety that seems to be heat intolerant is just not getting enough fertilizer? Our answer to this is to control as many factors as we can next year and use other techniques in addition to growth for heat tolerance assessment.

Beans and tomatoes are heat-loving vegetables. They can easily tolerate the 4 to 6 hours of temperatures in the mid-30s C that occurred during summer afternoons in 2022. Although tomato production was affected for a short time through this period, the long, relatively warm fall weather allowed the tomato plants to produce a huge crop. We donated most of the crop to the Gleaners Food Bank.

The beans also produced an abundant crop. We believe that the varieties that have been grown in British Columbia for decades (Mr. Tung's, Ireland Creek Annie's, and Gysi beans) and the English heirloom, Mr. Cook's bean, are well-adapted to our climate. But we don't know how well they would do during extremely hot summers.

We saw some evidence of heat stress, like curled leaves. But we couldn't see any obvious differences among the varieties we grew. We believe that it wasn't hot enough during 2022 to be able to identify the effects of heat on the plants.

Our conclusions are:

- The summer of 2022 was not particularly hot, so we couldn't determine differences in heat tolerance among the varieties of tomatoes and beans we grew.
- The weekly harvest of all varieties of tomato declined 6 to 8 weeks after a period of high afternoon temperatures, likely because these temperatures inhibited pollination.
- Measuring growth promises to be a way to predict heat tolerance. But the technique of measuring growth along the stems of plants is too time-consuming and needs to be simplified.

- Two varieties of beans, Mr. Tung's and Major Cook's, may be heat tolerant, as their productivity was higher than that of other varieties and they continued growing through the high temperatures at the end of July.
- Our gardens produced an amazing amount of produce, which indicates that they were well-managed.
- Our main goals in 2022 were to figure out a technique to predict heat tolerance in vegetable crops and identify heat tolerant varieties. But we generated more questions than answers from this work.

In 2023, we will refine the growth measurements and add measurements of foliage temperature and leaf chlorophyll. We will also grow other types of vegetables, like squash, peppers, and peas, and shade half of each crop.

Germination test Lazy Housewife beans.

Acknowledgements

We are very grateful to the Creston Valley Community Foundation for their generous support. Thank you Carol and the Board of Directors!

And thanks to David Catzel of Farm Folk City Folk, who spent time and effort getting the partnership and accounting set up. We also thank David for bringing his organization's threshing machines to the college and conducting a fascinating workshop on how to thresh and save seeds.

We are also grateful to Columbia Basin Trust for providing funding for the project.

Thank you Bob Wildfong and Angie Koch of Seeds of Diversity for your support.

And thank you Morgan Gautheir of the College of the Rockies Creston campus for providing us with a home.

Our volunteers are the mainstay of our organization. We greatly appreciate all the time and effort you put into the work at the community seed bank greenhouse and gardens.

Thanks also to David, Laura, and Gail for reviewing this report.

And most of all, we thank our Seed Bank Coordinator, Nicolas Walser, who keeps all the wheels turning...

The Board of Directors, Creston Community Seed Bank Society

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Supplementary Tables

Tomatoes

Table 1 Comments: All of the 8 tomato varieties we grew were heirlooms. Two varieties were determinate (bush) and 6 were indeterminate (vining). When we designed the project, it made sense to have different types of tomatoes, because we didn't know which type might be heat tolerant. But determinate types of plants stop growing after they have set fruit. Measuring growth in determinate tomatoes might not be useful for predicting heat tolerance.

Table 2 Comments: The varieties we grew differed in productivity and growth habits. The size of the fruit ranged from small (Dansk Export indeterminate and Tiger Tom) to huge (Guido). Prairie Fire had the highest weight for the size of the plant, typical of many determinate varieties. There were no obvious differences in growth or productivity that could be attributed to the effect of high summer temperatures.

Table 3 Comments: All of the varieties of beans we grew were heirlooms. Their countries of origin included China, France, England, America, and Canada. Most of these can be eaten in the immature pod stage, known as green or snap beans. The pods on Gysi and Ireland Creek Annie's beans are too tough to be eaten this way, and are allowed to mature, shelled out, and eaten as dry beans.

Table 4 Comments:

Except for Lazy Housewife bean, the plants were allowed to dry thoroughly before they were weighed. Dry weight measures only the actual bean plant, not the water contained in the leaves and stems. Lazy Housewife matured so late that it had to be cut and brought indoors to dry before frost, even though it was still green.

Table 1. Varieties of tomatoes for the climate adaptation project. Variety description from online and CCSB sources.						
	Days to harvest		Average Weight of Fruit, grams			
Variety	variety description	2022	variety description	2022	Description	notes
Dansk Export Det [1] (sicer) Dansk Export Ind (salad)	65-70 65-70	73 66	60-110 60-110	158 47	Compact semi-determinate plants. Productive and early even in hot weather. Danish heirloom. Indeterminate plants with small red fruit.	Seeds were result of cross pollination. Plant habit and size of fruit differed among the plants.
Frenki [2] (slicer)	70-80	78	170-225	204	Indeterminate. Red fruit have a classic tomato flavor. Rare heirloom from Macedonia.	As described.
Guido [2] (beefsteak)	70-80	73	280-570	348	Indeterminate. Red fruit have very good flavour. Very vigorous and productive. Heirloom from the Netherlands.	As described.
Prairie Fire [1] (salad-slicer)	70-80	66	60-110	64	Determinate. Small plants, modest production of red fruit. Good flavour.	Not included in growth measurements.
Rinaldo [1] (paste)	75-85	81	230-340	164	Indeterminate. Vigorous plants, elongated red fruit. Excellent sweet taste. Italian heirloom.	As described, except fruit smaller.
Red Tomato of Montlhery [1] (slicer)	70-80	73	110-230	112	Indeterminate. Red fruit with excellent "old style" tomato flavour. Very productive. Rare heirloom from Northern France.	As described.
Sandul Moldovan [2,3] (beefsteak)	75-85	73	230-450	291	Indeterminate. Large pink beefsteaks, slightly ribbed. Firm flesh, excellent flavour. High yield. Heirloom from Moldova.	Two seed sources - plants not uniform in characteristics.
Tiger Tom [1] (salad)	65-75	66	60-110	45	Indeterminate. Large rampant vines. Salad sized striped fruit have a very good sharp tart flavour. Heirloom from Slovak Republic.	Mostly as described. Flavour bland.
Seed Sources:	1: Creston Community Seed Bank; 2: Seeds of Diversity; 3: TomatoFest					

Table 2. Growth and productivity in tomato varieties for the climate adaptation project, 2022. *Creston Community Seed Bank Society.*									
Variety	**Average growth rate, cm/day**	**Total Harvest Weight, kg**	**Number of Fruit**	**Average Weight of one fruit**	**Average Weight of Fruit, kg**	**Average Weight of Plant, kg**	**Productivity**	**Number of fruit for seed extraction**	**Total Weight of Seeds, g**
Prairie Fire	not meas.	37	468	=	3.5	0.46	7.54	61	8.8
Sandul Moldovan	2.10	117	370		9.7	1.58	6.16	61	40
Rinaldo	2.70	118	690		9.8	1.68	5.81	66	8.4
Guido	2.30	189	559		15.8	4.03	3.92	44	20
Tiger Tom	1.70	100	2184		8.4	2.33	3.61	251	64
Dansk Export	1.80	96	1470		8.0	2.28	3.49	79	40
Frenki	1.90	103	521		8.7	2.67	3.25	57	24
Red Tomato of Montlhery	1.80	106	884		8.9	2.87	3.09	123	59
total		**866**	**7146**					**742**	264
Notes:	*2-3 plants measured per variety*	*12 plants except 10 for Prairie Fire*					*Fruit weight/plant weight*		

Table 3. Varieties of beans for the climate project. Description from online and seed bank sources. *All seeds from CCSBS except Lazy Housewife from Sow True Seed, Asheville, North Carolina.*

Variety	Type	Days to Harvest	Pod Shape	Bean Colour	Description
Lazy Housewife (Pole)	snap/ shell/dry	snap 78	thick, slightly flattened. Hairless ("greasy")	white	One of the first snap bean varieties to be completely stringless. It is so named because the housewife can be lazy preparing the beans for the table because they take less work. Medium-green pods are 4-5" long with distinctive shiny white seeds that look like pearls. U.S. heirloom from the 1800s.
Major Cook's (Pole)	snap/dry	snap 70	curved, round	tan mottled with purple	Snap, shell or dry. Robust, prolific, succulent pods, shelled beans have supreme flavour and texture, a genuine all rounder. C shaped pods are pretty at all stages, starting out with purple and white stripes on green pods and turning maroon when mature. Dry beans are tan with purple flecks. English heirloom.
Mr. Tung's (Pole)	snap	snap 65	round, long	brown	Mr.Tung's Bean Seeds were preserved by the Kerr family of Long Beach, BC since the early 1900s. Mr. Tung was in charge of the vegetable garden and planted these beans that he had brought from China.
Fin de Bagnol (Bush)	snap	snap 50-60	thin, round, filet	purple with light markings	This historic French string bean bears delicious, slender pods and does well in cool soil. This variety's tiny gourmet green beans are best eaten when picked every 2 or 3 days
Gysi (Bush)	dry	dry 80	round, long	goldy tan	Early and productive, medium-sized ochre flat bean. Originally from Werner Gysi of Enderby, BC. A rare variety.
Ireland Creek Annie's (Bush)	dry	dry 75	round, long	buff-yellow	English heirloom that has been grown since the 1930s on Ireland Creek Farm in British Columbia. With superb flavor, the beans make a tasty, thick sauce when stewed. The stocky 24" plants produce an abundant and reliable crop.

Table 4. Growth and productivity in bean varieties for the climate project.

Variety	Dry weight of plants, kg	Weight of seeds, kg	Productivity*	Maximum height of plants, cm	*Notes*
Lazy Housewife (Pole)	12.2	1.2	0.1	112	Plants were not dry when weighed and most pods and seeds were immature.
Major Cook's (Pole)	4.8	6.8	1.4	200	Height exceeded measuring device.
Mr. Tung's (Pole)	2.7	4.5	1.7	200	Earliest of the pole beans to mature. Height exceeded measuring device.
Fin de Bagnol (Bush)	2.3	1.6	0.7	66	
Gysi (Bush)	2.6	2.9	1.1	76	Developed in B.C.
Ireland Creek Annie's (Bush)	2.1	2.2	1.0	70	

**seed weight/plant weight*