Klondike Valley Nursery Variety Trial 2020

Kim Melton & John Lenart
www.klondikevalleynursery.com

CANADIAN AGRICULTURAL PARTNERSHIP
Yukon
Canada

Table of Contents

Introduction....2
Team and Acknowledgements....2
Site....3
  Facility....3
  Environment....3
Methods....6
  Cultivation....6
  Selections....6
  Characteristics....7
  Phenology....9
Results....10
  Tree Characteristics....10
  Fruit Characteristics....12
Discussion....17
  Discrepancies....17
  Pests and Disease....17
  Phenology....17
    Bloom Period....17
    Harvest....21
  Yield....22
  Cold Hardiness....23
Concluding Remarks....26
References....27
Appendix A: Cultivar Descriptions....28

Introduction

The goal of this year's work was to generate comprehensive, regionally-reliable descriptions of a subset of hard fruit cultivars being trialed at Klondike Valley Nursery (KVN). These include characterizing the trees' growing habits, care requirements, phenology, hardiness and fruit. We used the 2020 growing season to fill in gaps in our data and add another year's observations to our existing database. Post-season, the 2020 dataset was amalgamated with those from previous years (3-5 years total depending on variables) and analyzed with the specific questions from this project in mind; there remains much to be gleaned from this dataset. Reports from other nurseries and research stations were reviewed and any discrepancies with our observations noted. Over time, we anticipate refining these descriptions and adding more cultivars. This report details methodologies and the characters assessed, main findings and trends, and the cultivar descriptions themselves summarized in Appendix A. We hope that this work will be helpful to home and commercial growers across the north in making appropriate selections for their sites and support them in joining those of us who already know the satisfaction of biting into an apple we've grown ourselves.

Team and Acknowledgements

The central team carrying out the work in 2020 was comprised of Kim Melton (lead and co-owner of KVN), John Lenart (co-owner of KVN) and three interns: Keira Nichol, Clara Reid and Sabrina Clarke. We received funding from the Canadian Agricultural Partnership's (CAP) Yukon Research and Innovation Program so support the work of Kim and John. We are also grateful to ECOCanada, CAP's Agriculture Training Program, Yukon Government's Staffing Up Program, Yukon Government's Student Career Placement Program and the Jim Gowans Yukon Local Food endowment from the University of Alberta for supporting our interns to a living wage. We also gratefully acknowledge our interns and volunteers from previous years who have contributed to our orchard and dataset. While this report will be circulated among the agricultural community across the north, we are also working on translating the most relevant information into a publication to be made available to the general public in 2021; our thanks to the Yukon Innovation Prize for supporting that project. We thank Acti-Sol for their kind donation of a supply of fertilizer.

We specifically thank the following collaborators:

- April Stainsby, MSc Plant Science
- Warren Walters, technician (retired), Summerland Research and Development Centre, British Columbia
- Fiona Schmiegelow, Professor and Director, Northern ENCS Program, University of Alberta
- Rachel Pugh, Yukon Research Centre
- Justin Schaeffer and Lisa Taylor, Fruit Research Technicians, Plant Sciences, University of Saskatchewan

Site

Facility

Klondike Valley Nursery (KVN) is located on on the banks of the Klondike River approximately 18km east of Dawson City, Yukon, owned and operated by John Lenart and Kim Melton. John has been experimenting with hard fruit trees on the site since the 1980s and began a collaboration with the University of Saskatchewan's Fruit Breeding Program in 2002. The most promising survivors of the 450 unreleased apple cultivars introduced at that time are among the selections being included in this year's analysis. Kim joined the nursery in 2016 and brought with her a background in the biological sciences and an interest in refining research questions and methods.

Our activities comprise a commercial nursery, an experimental orchard focused on northern fruit research and gardens to feed ourselves and our team. The experimental orchard is comprised of 6000 sqft of sheltered growing sites and 2 acres of field-grown selections. This includes over 150 apple trees (65 cultivars), over 100 haskap bushes (14 varieties) as well as smaller numbers of pears, cherries and other berries. Our mission is to provide northerners with appropriate plant material and relevant information to support productive growing of both food and ornamental plants, while engaging in and modelling an intentional lifestyle with a light footprint. We also supply the local market with apples, haskaps, grapes and pears, grown without the use of synthetic fertilizers, pesticides or herbicides.

We have seen an increase in demand for apple trees over the last four years and are at capacity for production on our site thanks to our remoteness and access. We are hopeful that by making the results of our research widely available we will encourage others to join us as both fruit growers and propagators. Having more plantspeople – those who propagate and share plants – in the territory will help minimize risks of pest and disease introduction inherent in importing live plants from elsewhere, as well as provide economic benefits within the territory. Our work stems from a desire to share our passion for living sustainably, which includes growing our own food. We believe that fruit trees and berry bushes are great 'gateway' plants, developing over years along with the grower and yielding many delights along the way, forming a long-term bond between grower and growing.

Environment

KVN sits on the bottom of the Klondike River valley at 64.06°N, 139.06°W. Individual planting sites have been converted from mature white spruce forest and black spruce lowlands bordering the adjacent fen complex. All have wet, cold soils, are high in organic matter and slightly acidic (eg: 4.4% total organic carbon, pH 6.4-6.5, *personal communication, C. Poeplau*). They are generally underlain with sand and permafrost and have been worked as agricultural soils for 3-30 years; in the longer-developed sites, much of the permafrost has melted or receded below the water table. We are participating in a circumpolar study led by German researcher Dr. Christopher Poeplau looking at the transition from boreal forest to agricultural soils that may give us more insights into how our activities are modifying the environment and soils; we look forward to their results.

Figure 1: Images from Klondike Valley Nursery study sites. Map (i) shows relative locations of Field (a-e), Lower House (f,g) and Steelhouse (h). KVN is approximately 18km east of Dawson City, Yukon. Map courtesy Google Maps, accessed Dec 2020.

Currently we have three main zones or sites with ‘inside’ and ‘outside’ trees – Field, Lower house & Steelhouse – depicted and mapped in Figure 1. While most trees are permanently in a shelter due to the extreme conditions at our site, some are containerized and move with the seasons and others receive seasonal coverings for freeze protection and season extension. In recent years, we have made efforts to shift much of our experimental work to a single site (Field) within the property with more consistent soil, light and exposure (Lenart, John 2017) and to standardize our cultivation methods as much as possible while still respecting the needs of different cultivars.

The science we carry out tends more towards the observational than the experimental, found under the controlled settings of a laboratory or a large test site with many replicates. This reflects the long time frames required to see results in tree fruit research and how marginal environment our environment is for their survival – more extreme than many other areas of the territory (see Figure 2). Our work begins with simply finding which cultivars will survive and what techniques are required to support them, and following such success we maintain existing trees even as our techniques and sheltering regimes evolve. While we now plant new trees in consistent environments, we still use existing plantings in other variations of seasonal sheltering and containerization for comparative purposes, with the understanding that we are not attempting statistical rigour.

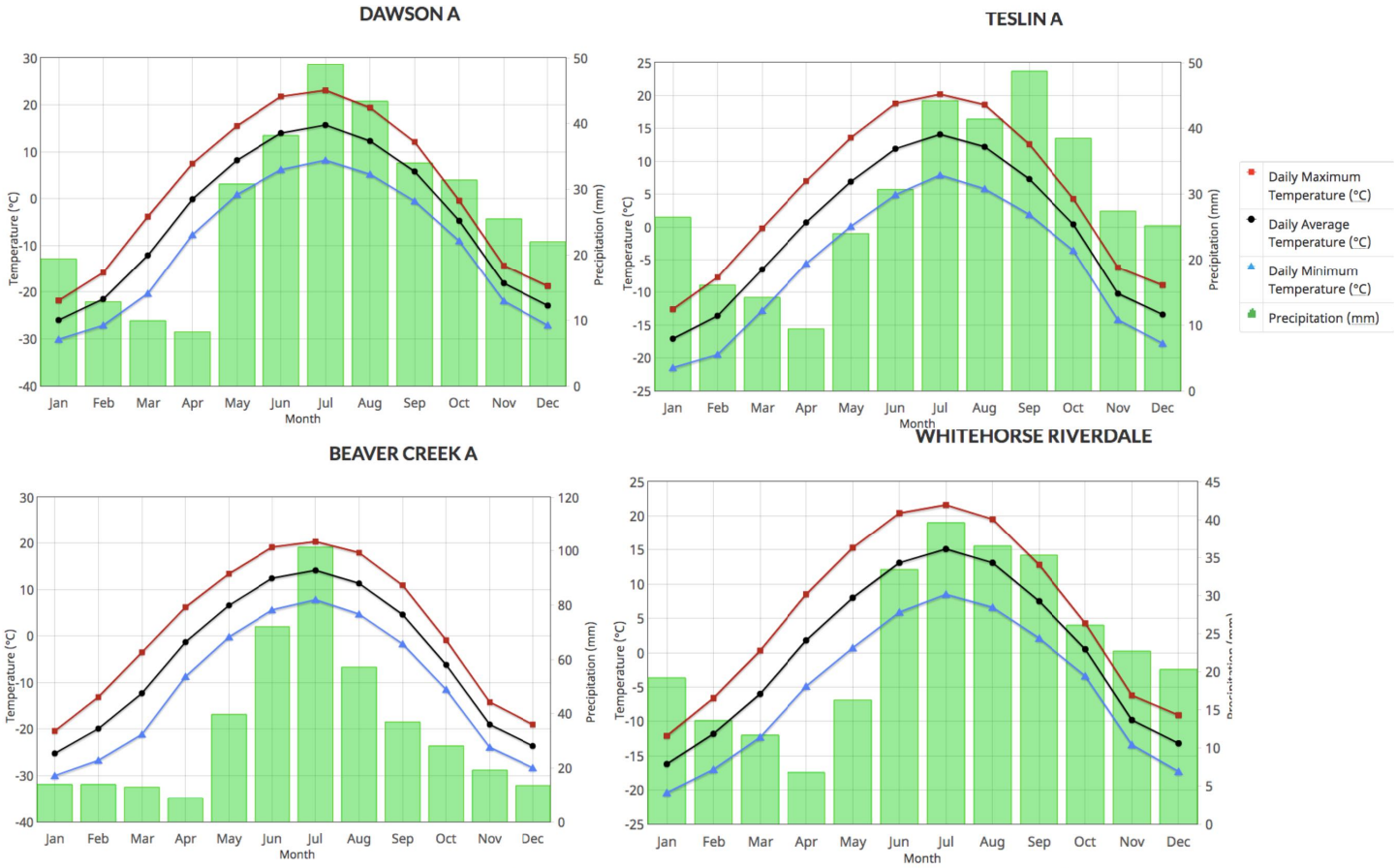

Figure 2: Temperature and precipitation graphs for Canadian climate normals (1981-2010) for four Yukon community weather stations (Canada 2011). Note that the vertical scales differ between graphs and that our site is routinely 2° colder than the Dawson weather station..

Methods

Cultivation

The main model we are currently using involves trees planted in-ground (vs containerized) in permanent coldframes: long, modular tunnels large enough to contain dwarf trees and that allow larger trees to expand to a secondary canopy above the roof (see Figure 1a, b & c). Temperatures in representative environments in the Field site have been monitored with HOBO dataloggers since 2017 (outside air, air inside four different shelters, outside ground and ground inside one shelter). All trees are supplied with drip irrigation and we maintain a weed free zone to the drip line beneath the trees. Trees receive individualized programs of fertilization based on multiple years of assessment, adapted in-season as needed. When planting we incorporate a high volume of compost (derived from orchard mowings, largely clovers). Other amendments we are currently using include Acti-sol 5-3-2 fertilizer (pelletized hen manure, certified for organic use) and bonemeal, as well as trace minerals including boron, potassium and magnesium where soil tests and/or plant phenotype indicates need. We generally fertilize in May and do a second round in late June or early July where required; additional feeding, particularly on containerized fruit-bearing trees may continue into August. Table 1 shows a sample of fertilizer applications from this year. Along with tree condition and appearance, the colour and vigour of ground cover plants in and around the primary root zone of the trees is used as an indicator of soil fertility and nutrient availability. Annual plants like strawberry blight offer an up-to-the-moment visual representation of basic nutrient and moisture availability. A single ornamental pansy accompanying a containerized tree is a good indicator of daily soil conditions as the growth rate, colour, bloom production and turgor of such plants is readily visible and prone to rapid decline when conditions become deficient.

Table 1: Sample fertilizer regimes for apple trees

Tree	**Age (years)**	**Trunk diameter (cm)**	**5-3-2 Acti-Sol Hen Manure**	**4-10-0 Bonemeal**
5-19-20/Ott3[a], in-ground	6	3.0	1250ml[b] (5c)	500ml (2c)
Sunnybrook/Baccata, in-ground	25	10.8	2500ml (10c)	500ml (2c)
4-10-36/Baccata, containerized	8	4.2	200ml + 100ml[c]	100ml + 50ml
Trailman/Baccata, containerized	10	5.7	300ml + 375ml	200ml + 175ml

[a] *Trees are listed as cultivar / rootstock*

[b] *For ease of application we use a volume based quantity of fertilizer*

[c] *spring application + midsummer application*

All amounts assume maintenance level – trees neither deficient or overly vigorous

Selections

Cultivars included in this assessment are listed in Table 2. They were chosen based on popularity among customers, success to date in the territory and potential commercial value (unreleased selec-

tions). The sample includes trees grown in a variety of conditions in order to maximize replicates for a given cultivar (1-5). They differ in seasonal exposure to outdoor conditions and in whether they are containerized or planted in-ground. Observations from different trees of the same cultivar were pooled, taking into account the different growing conditions, in order to generate generalized descriptions. Though we have included pears in our assessment, we have not seen sufficient numbers of trees at different sites to adequately provide detailed descriptions individually; they are grouped in Appendix A.

Table 2: Cultivars assessed

Apples	*Pears*	*Unreleased apples (UofS accession no.)*
Autumn Delight	Bolshaya	18-19-13
Bolonoyev's Early	Early Gold	18-28-1
Collet	Krazulya	18-28-19
Fort Mac Mac	Ure	4-6-46
Lammers #2		5-19-20
Norda		
Noret		
Norland		
Parkland		
PF12		
Prairie Sun		
Rescue		
September Ruby		
Summer Red		
Trailman		

Characteristics

Characteristics to be described were selected based on customer requests and industry standards. They can broadly be grouped into those associated with the tree itself (phenology, growth, fruiting) and those related to the fruit (flavour, size, uses, storage etc). The planned methods associated with each characteristic are listed in Tables 3 & 4. Changes in methods are listed as footnotes beneath the tables, and over the course of the study and analysis we refined how the characters are grouped for better understanding. For ease of reference, details on how we reported the characters are found in the results section in Tables 5 & 8.

Table 3: Tree Characteristics

Category	*Questions to be answered*	*Methods*
Phenology	What is the regional bloom window for the cultivar? Which cultivars are appropriate matches for cross-pollination?	Daily assessment through May: swelling, silver tip, green tip, tight cluster, open cluster, pink, first bloom, full bloom, burst buds (pears), late blooms, fruit set
Growth Habit	What are the recommended pruning regime and site considerations for each cultivar based on form and vigour?	Single assessment in July: Form, vigour, spread/ height, spur-forming vs tip-bearing, blind wood
Harvest Determinations	What is the regional ripening window? How do I know when to harvest? Can I expect to harvest all fruit at once? Does the cultivar tend to drop ripe fruit?	Use previous years data to predict harvest window; one week before predicted start, begin daily assessment using appearance and scent. Use Iodine starch test to determine accuracy of assessment[a].
Thinning	Does the cultivar have a tendency towards June drop? What is the recommended thinning regime?	Use previous years' data to predict June drop tendency; test through weekly estimate of set fruit and account for thinning[b].
Windfall	Is the cultivar appropriate for windy locations?	Note any dropped fruit through the course of the season[c].
Yield	What is the expected yield per tree (kg/cm diameter of trunk)?	Weigh all fruit from each tree; measure diameter 10cm above graft (July)[e]
Hardiness	What temperature can different parts of the tree survive (eg: flower buds)?	Note presence/extent of any cold damage in spring and the conditions under which it occurred; review data from previous years on survival and damage and correlate with temperature data
Phenology	Do selections vary in onset of dormancy?	Weekly evaluation from August 20 to September 30; note whether growth has stopped and state of leaves[d]
Pathogens and Pests	What pathogens or pests do I need to look out for? Are cultivars differentially affected or prone?	Note any occurrences of pests or pathogens affecting blooms, fruit, bark or roots throughout the season

[a]The iodine starch test was not employed this season due to capacity challenges. Best efforts were made to assess fruit for prime picking window based on previous experience and subjective sensory analysis.

[b]We found qualitative observation to be adequate to distinguish those trees with a high tendency towards self-thinning

[c]We amalgamated this character with the tendency for the fruit to hang on the tree as it ripens under harvest determinations

[d]We did not have capacity to complete this as methodically as planned; see discussion on cold hardiness

[e]We shifted this to September once growth for the year was complete

Table 4: Fruit Characteristics

Questions to be answered	*Methods*
What are the physical characteristics of the fruit?	Assess 10 representative fruit from each tree on harvest for: weight, diameter, height, colour (photos and description), brix measure[a]
What is the flavour, texture and palatability of the fruit?	Assess in-house; hold tasting panel[b] (orient tasters, use questionnaire)
How well does the fruit keep?	Reassess fruit every two weeks after harvest with in-house tasting

[a]*Brix value was measured only for those fruit we juiced, including only one cultivar in this assessment*
[b]*Public tasting was transitioned to questionnaires due to Covid-19*

Phenology

While discussion of most characters is found in the results section, a brief background of phenology and related methodology is provided here. Phenology refers to the timing of events, in our case notably bloom and ripening. While a few of our apple cultivars are recognized as relatively self-fertile (including Rescue, Summer Red, Yellow Transparent (Matney, Casey 2019)) most require cross-pollination from a compatible cultivar to set fruit. The prime factor that determines appropriate partners among our commercially available apple varieties is timing of bloom, as of course they need overlap (they are all to our knowledge genetically compatible). The literature tells us that while environmental factors contribute majorly to the onset and duration of bloom, the relative order of bloom among varieties is generally consistent (Moore, James N. 1983). Anecdotally we have found this to be true at our site and we anticipate corroboration by our bloom data. As there is wide variation across communities in the north (see Figure 2 for some examples), and even within communities spatial positioning, buildings and surrounding vegetation and many other factors affect microclimate, we have opted for ranking cultivars into early, middle and late categories for both bloom and ripening.

To arrive at the bloom window ranking, comprehensive bloom assessments were carried out in the springs of 2018, 2019 and 2020. During the assessments, the orchard was walked every two to three days through May and early June and trees were described in terms of stage of development (eg: swelling, silver tip, green tip, tight cluster, pink, bloom (first, early, middle, late), petal drop; not all stages were used for all years). Where solitary blooms appeared well outside of the main bloom period, a note was made but this was not included in the main bloom period. Ripening dates were based on recorded dates of harvest. We combined each year’s first bloom and harvest dates to give a season length, which we then averaged across trees and years to get an average for each cultivar. Note that for all of these characters, as large a sample size as possible was used, extending to cultivars beyond those described in this report.

A secondary aspect of this portion of the study comes from combining bloom data with temperature data. In haskap (Bors, Bob 2016), the weather in a given spring can effectively expand or contract the overall bloom period and thus bring varieties generally thought to be temporally incompatible into sync or vice versa. We hypothesize that the same might be true for apples.

Finally, bloom assessments and harvesting were opportunities to note cold damage, insect and disease presence and any other other abnormalities. The cold damage notes were then available for later review in combination with temperature data to better understand lag times in damage manifestation and sensitivities at relevant stages.

Results

Characteristics have been divided into those relating to the tree and those relating to the fruit, and organized in a slightly different manner than presented in the Methods for ease of presentation. The same information has been condensed into a more accessible narrative format in Appendix A. Further details of selected characteristics are found in the 'Discussion' section.

Tree Characteristics

The following characteristics were described based on observations made during this year's orchard walk-throughs and notes from previous years. The characteristics are defined in Table 5 and have been scored for each cultivar in Table 6. Though this document is not intended as a growing guide, a brief description of some of the consequences of different characters is noted in Table 5. We compared our observations to those from other sources (University of Saskatchewan field notes, catalogues of other nurseries and orchardist handbooks) and have noted any discrepancies. In all result tables, 'i' is used for insufficient information, and 'n/a' for not applicable.

Table 5: Tree Characteristics Described

Shorthand	*Description*
BrHa leggy, compact, open, upright, spreading	What is the tree's branching habit? Compact trees are more desirable in our climate as they are less prone to breakage under snowload. Prune leggy limbs hard in the spring to keep them more compact.
Hardy very, somewhat, tender	How hardy is the tree? Very hardy trees may survive and even fruit with little or no winter protections in warmer parts of the Yukon. Tender trees are recommended for greenhouses or coldframes.
Spur high, medium, low	What is the tree's tendency to form fruiting spurs? Though all of these varieties are 'spur-forming' as opposed to 'tip-bearing', some varieties form fruit spurs or short fruiting branches much more readily than others. Summer pruning of upright shoots to 3-4 buds may induce formation of such branches, particularly useful for those varieties with a low tendency to form them on their own.
Vigour semi-dwarf, normal, vigorous, dwarfs well	How vigorous is the tree? Does a dwarf rootstock effectively control it's vigour? Dwarf trees (either natural or rootstock-induced) are suited to shelters and greenhouses, though dwarf rootstocks tend to be less hardy than standard Siberian crabapple.
Bloom early, middle, late; short, medium, long	When does the tree bloom? This is based on when the tree begins to bloom

Shorthand	*Description*
SThin yes, somewhat, no	Does the tree self-thin? Many cultivars shed developing fruit during the 'June drop', some to a large degree. This should be taken into account when thinning fruit; thinning to final desired numbers should be done after the June drop for self-thinning varieties.
Hang yes, somewhat, no	Does fruit hang on the tree as it ripens? If fruit does not hang on well and has a tendency to fall, it is not suited to a windy site. Further, it may require close attention to avoid losing fruit to damage from bruising during falls or rodents etc once on the ground. Note that some trees abort underdeveloped fruit just prior to ripening.
Ripen early, middle, late	When does the fruit ripen? We have classed trees as early, middle and late. At our site, this coincides with Aug 15-30, Sep 1-10 and after Sep 10. Actual dates will vary based on microclimate.
HarvL short, medium, extended	What is the length of harvest, ie: is all of the fruit ripe at once (short) or does picking occur over a longer period (medium to extended)?
HarvD fragrance, drop, pick unripe, easy pick	What cues tell me the apples are ready to harvest? Generally speaking, harvest when seeds are 1/2 brown for a longer shelf life and fully brown for prime eating immediately. Most apples will undergo a shift in background colour from green to yellow, white or pink as they ripen, including all in this group. In addition, some develop a strong fragrance, some drop and many come off easily in the hand with a slight bend of the stem when ready ('easy pick' quality). When harvesting fruit that are hanging on well, stems can be cut to lessen stress on the tree and save time. Pears should always be picked underripe and allowed to finish in cool storage to prevent the formation of stones. Warm them up a few at a time to ripen quickly on the counter.
Season	Average season length for cultivar from bloom to harvest, recorded in days.

Table 6: Tree Characteristics by Cultivar

Cultivar	**BrHa**	**Hardy**	**Spur**	**Vigour**	**Bloom**	**SThin**	**Ripen**	**Hang**	**HarvD**	**HarvL**	**Season**
Apples											
Autumn Delight	o	v	h	d, dw	m, l	n	l	y	ep	m	111
Bolonoyev's Early	u	s	m	v	e/m, i	n	m	n	d/ep	m	87
Collet	c	s	h	n, dw	m, l	n	m	y	ep	e	105
Fort Mac Mac	o	s	h	n	e, l	y	e	n	d/ep	m	104

Cultivar	BrHa	Hardy	Spur	Vigour	Bloom	SThin	Ripen	Hang	HarvD	HarvL	Season
Lammers #2	c	v	h	sd, dw	m, i	n	l	y		s	113
Norda	c	t	m	n, dw	e/m, m	n	m	s	ep	e	104
Noret	o	v	h	n	e, l	n	e	y		m	92
Norland	c	s	h	sd	m, s	y	e	n	d/ep	s	88
Parkland	lo	s	m	v	m, l	n	e	n	ep	m	96
PF12	s	s	h	n	m, l	n	m	s	ep	e	107
Prairie Sun	c	s	h	d, dw	e/m, l	n	e/m	n	d/ep	m	96
Rescue	o	v	h	n	m, m	n	e/m	y		s	90
September Ruby	us	s	m	v, dw	m, s	n	l	s	ep	s	110
Summer Red	s	s	m	n, dw	m, m	n	l	y	ep	s	115
Trailman	o	v	h	n	e/m, m	s	m	y		m	100
18-19-13	c	s	m	v	m, s	s	m	n	d/ep	s	104
18-28-1	u	s	m	v	e/m, l	s	e	n	d/ep	e	100
18-28-19	o, l	v	h	v, dw	e/m, l	s	e	s	f/ep	m	88
4-6-46	o	s	h	n, dw	m, l	s	e	y	f/ep	e	n/a
5-19-20	o	t	h	V, dw	m/l, l	s	l	s	ep	m	96
Pears											
Bolshaya	u	s/t	l	v, dw	e, m	y	m	n/a	pu/ep	n/a	109
Early Gold	u	t	l	v	e, m	y	e	n/a	pu/ep	n/a	110
Krazulya	u	t	m	v, dw	e, l	y	m	n/a	pu/ep	n/a	106
Ure	u	t	l	v	e, l	y	m	n/a	pu/ep	n/a	109

Fruit Characteristics

We have been keeping detailed notes on fruit characteristics and storage capacity for many years and have also held tastings in the past where we have asked participants to rate and describe fruit, ranging from formal gatherings to sample tables at the Dawson Market. This year, we did not hold a public tasting due to the pandemic; instead, we sold bags of numbered apples along with questionnaires modelled on University of Saskatchewan sensory evaluation forms to interested customers. Unfortunately, the return rate was low. We did however have a very helpful session with local chef Calhoun Keating-Malay that contributed many descriptions and suggested uses. We reviewed all of these data when developing the descriptions in this report.

Though it is possible to break down the experience of eating an apple into its constituent parts of flavour and texture, and even further than that into levels of acidity, sweetness, astringency, specific aromatic flavours etc, we find integrated descriptions to be more useful. Therefore, we have written long-form descriptions to convey the flavour and texture (Table 7) and used scoring and shorthand only for those characters to which it applies easily, such as colour, size and shape (Table 9, defined in Table 8). We compared our descriptions to published accounts in other nursery catalogues and selection profiles from research programs. Where our description showed significant difference from one or more of these accounts, we have made a note.

Table 7: Fruit Descriptions – Flavour and Texture

Cultivar	**Fruit Flavour & Texture**
Apples	
Autumn Delight	Crisp, juicy and adventurous. Substantial texture, good sweet/tart balance with a complex flavour that varies throughout the eating.
Bolonoyev's Early	Bright and 'cidery', medium firmness. Holds well for juicing for six weeks.
Collet	Sweet, firm apple that makes excellent creamy sauce.
Fort Mac Mac	Very nice balance of sweet and tart. Fine-grained white flesh, firm without being hard, sweet without being sticky. 'Fuzzy peach' mouthfeel.
Lammers #2	Light and crisp, softens quickly in storage but retains flavour. When underripe, has a faint grassy taste and smell. Juicy and sweet with a hint of tart. Notes of lime, could play a distinctive role in cooking.
Norda	Fragrant with a floral aroma reminiscent of hibiscus. Texture is firm and substantial, lends itself to a thoughtful chew. Flavour remains consistent and gentle throughout eating. Simple yet rich.
Noret	Very firm. Upfront flavour of brown sugar and molasses followed by bright tart notes then a quick floral finish. Skin noticeable. Suggested uses include chutney and muffins.
Norland	Medium firm flesh with slight grain, making it crisp on picking. Fully ripe fruit softens quickly in storage. Thin skin. Flavour is subtle and delicate, airy with soft notes of grapefruit. There is a slow build to medium sweetness followed by a tart finish. Excellent sweet/tart balance with some astringency. Best for fresh eating; could be marinated/ pickled. Picking slightly green can extend shelf life 6 weeks.
Parkland	Excellent sweet, crisp apple for fresh eating. Thinning is important as undersize fruit lack in both flavour and texture.
PF12	Soft to the teeth with tender light skin and a summery fragrance evocative of dandelions. Subtle flavour with more sweet than tart, holds up well to baking. The flavour has a creamy full-bodied nature which works well as a smoothie base, ie: subbing in for a banana.
Prairie Sun	Soft, light and sweet with tender skin and notes of strawberry. Lots of flavour in a delicate, airy texture with a slightly starchy finish. Excellent fresh eating and for juice cut with water.

Cultivar	**Fruit Flavour & Texture**
Rescue	Complexly sour with a little sweet, mellows if left on the tree. Skin noticeable. Medium astringency and medium firmness. Suggested for juice in early prairie trials (Friends of the Garden 1991); sauces well.
September Ruby	Firm and substantial, flavour brightens with a quick steam though texture is not up to frying. Tart beginning rounds out to medium sweetness. If picked a little green, store for at least two weeks for best flavour.
Summer Red	Beautiful dark red, classic appearance with prominent lenticels. Firm, breaking white flesh. Fresh taste with good sweet/tart balance. Large fruit that store well, keeping through Christmas.
Trailman	Small bronze-gold barrels pack a lot of flavour. Quick burst of juice and sweetness with a lemony tang. Often sticky sweet. Excellent snacking, potential for candying.
18-19-13	Firm and crisp, flavour flowery and rich then sour. Rarely has bitter aftertaste in the skin. Suggest using in salad. Prized by those who like sour apples, pale green flesh.
18-28-1	Picked slightly green, fruit are crisp, sour and bright. If stored two weeks, flavour matures and mellows to much more sweetness and sourness shifts to a tart note, while texture softens to melt-in-your mouth. Skin very supple. Great for fresh eating, and sauces well if stored. Fragrant
18-28-19	Freshly picked are bright, juicy and springy with a coarse grain, can be slightly nutty and often evoke honey. Flavour is sweet with bright tart notes. Suggest adding to a glass of water and pairing with mint. Picking underripe can extend shelf-life to two months.
4-6-46	Fragrant red and green apple with a soft, buttery mouthfeel. Easy to eat, fine-grained, reminiscent of pineapple. Flavour has notes of red wine that would pair well with cheese. Recommended for juicing, though not cider, and apple butter. Excellent for fresh eating.
5-19-20	If picked a little green, store min two weeks for best flavour. Pleasant, juicy apple with medium crispness and gentle tang. Coarse grained, firm. Half ripe fruit have an earthiness to them. Tart start fades to sweet.
Pears	
Bolshaya	Sweet, complex. Can have phenolic overtones if overripe.
Early Gold	Sweet and smooth, soft and luscious. Skin less prominent than Ure. Great fresh eating.
Krazulya	Sweet, complex and smooth. Delicate soft texture.
Ure	Bright with classic ‘pear’ flavour, skin can be tough and has tendency to crack if left too long on the tree. Keeps well, ripening over two months in cold storage. Excellent poached.

Table 8: Fruit Characteristics Described

Shorthand	*Description*
Colour green, red, pink, yellow, gold; pale, dark, bright; wash, blush, speckle, stripes; prominent lenticels	Skin colour when ripe. Apples generally have a background and foreground colour and often a wash or blush, separated in the table by a "/". Colours may be modified, eg: 'pg' for 'pale green'. Note that blushes and washes are related to UV exposure, so fruit in heavy shade is unlikely to develop these tones.
Size small, medium, large; uniform, variable	Average fruit size: small < 5cm, medium 5cm – 7cm, large > 7cm; whether crop on a single tree tends to be uniform or variable.
Max	Maximum size recorded over the sampling time: width x height in mm (weight in grams).
Density	A measure of subjective texture/chewiness? Some apple flesh just dissolves as it's chewed, others are substantial while others near woodiness.
Shape round, blocky, elongate, barrel-shaped, oblate, conic, ovoid; uniform, variable; irregular	Apple shape. Oblate: flattened at the top and bottom. Conic is used when the apple is wider at the top (stem) than at the base. Elongate apples are taller than they are broad. Uniform and variable refer to the variation among the fruit on the tree; irregular refers to the shape of an individual fruit. Examples from commercial varieties – macintosh: round; red delicious: blocky/conic
Flesh white, cream, yellow, green, red, pink; pale, bright, deep; venation; browns quickly or slowly	Flesh colour when ripe.
Uses dessert, juice, sauce, cider, cooking, pickling, preserves, drying	Suggested fruit uses. 'Dessert' is synonymous with 'fresh eating'. Cooking refers to apples that hold both texture and flavour when baked or fried.
Store	How long will the apple store? This is based on cold storage (2-5°C) at relatively high humidity. Time is in weeks or months.

Table 9: Fruit Characteristics by Cultivar

Cultivar	**Colour**	**Avg Size**	**Max Size (wt)**	**Shape**	**Uses**	**Store**	**Flesh**
Apples							
Autumn Delight	py/br rpi w	m u	7.5x7.0 (125)	c/u	d*	6 mths	y
Bolonoyev's Early	py	m	7.0x5.8 (90)	ro/ob	jc	4 wks	c
Collet	gr/r	m	7.2x6.8 (155)	bl/ob/u	s*dc		
Fort Mac Mac	py/ rw	m	7.0 x 5.5	ro/u	d	4 wks	w/piv/br sl
Lammers #2	py	s u	6.0 x 5.7 (90)	ov/u	c	3-6 wks	br sl
Norda	py/ pr w	m u	8.0 x 7.3 (200)	ba/u	d*c	6 mths	pc

Cultivar	Colour	Avg Size	Max Size (wt)	Shape	Uses	Store	Flesh
Noret	by/br bl	s u	3.5 x 3.5 (25)	r/u	d p pr	3-5 wks	cy
Norland	pyg/r st	m	6.5 x 6.5 (110)	rd/c/e	d*	3-4 wks	c br qu
Parkland	pc/ rpi w	m		c	d	1 mth	cw
PF12	pyc, rst	m	6.5 x 5.5 (114)	ro	d	1 mth	y
Prairie Sun	py/prbl	m	8.4 x 6.3 (216)	ro/ob	d dr	1 mth	c br qu
Rescue	y/r	s u		ro/ob	s j pr	2-3 wks	pc
September Ruby	r / gr st	m	7.6 x 6.7 (175)	bl/c	d	2-3 mths	pgrw piv
Summer Red	r / pl	m-l	8.2 x 7.7 (205)	bl/c	d	2-3 mths	
Trailman	dy/r bl	s u	4.2 x 4.3 (45)	ov/u	d p pr	4-6 wks	cy
18-19-13	pgr/r str	m	(110)	ob	d	6-8 wks	pgr piv
18-28-1	gr-py	m v	8.5 x 7.8 (245)	ro/bl/v/i	sc	3-4 wks	pi v
18-28-19	goy/r bl	m v	8.5 x 7.7 (230)	ro	d*	3-4 wks	
4-6-46		m v	9.9 x 8.3 (239)	ro	d*j	4-6 wks	
5-19-20	py/br	m	8.2 x 6.6 (180)	ro/ob	d	4-6 wks	br qu
Pears							
Bolshaya	pgo/r bl		5.9 x 6.1 (100)		d	4-6 wks	
Early Gold	dgo		5.3 x 6.9 (90)		d	4-6 wks	
Krazulya	go/br bl		5.7 x 6.4 (105)		d	4-6 wks	
Ure	gr to pgo		5.4 x 5.8 (70)		c	2-3 mths	

Discussion

While many of the characteristics we've covered in this analysis are explained in the Results Tables, we have selected a few for further discussion. These include Discrepancies, Pests and Disease, Phenology, Yield and Cold Hardiness.

Discrepancies

The following are discrepancies we have noted between our observations and descriptions from other sources. Some of these may represent errors, artefacts of small sample size or differences of opinion, and others may be real differences resulting from our extreme growing environment.

- In the release notes from the University of Saskatchewan *Prairie Sun* and *Autumn Delight* are not recommended for gardeners, but only professional growers because of the care they require to perform well. Given the paucity of appropriate cultivars for our region, we continue to recommend them;
- Release notes for *Prairie Sun* and *Autumn Delight* from the University of Saskatchewan state that they are both resistant to oxidative browning; we have found *Prairie Sun* to brown quite quickly, and *Autumn Delight* to a slightly lesser degree;
- Our *Noret* fruit is generally smaller than suggested in the cultivar notes from the University of Saskatchewan (5cm); it is one of the only trees that goes through the entire growing season outside at our site, so we expect in more temperate regions of the territory fruit will be larger;
- *Summer Red* is noted as moderately vigorous in Peters Prairie Apple Cultivars while we have it as vigorous; it is also listed as good for cooking and juicing as well as dessert

Pests and Disease

In analyzing notes from the last five years, we did not observe any tendency for pests or disease to be attracted to or cause more damage in any particular cultivar. We continue to observe incidence of scale insects and tarnished plant bugs, particularly in greenhouse or shelter environments. Both are easily managed through mechanical removal provided regular observations are made to prevent outbreaks. Diatomaceous earth has proven effective in preventing wide spread plant bug damage among crops of nursery trees. An unidentified superficial fungus has been observed on the bark of some of our oldest trees, but it has not appeared to negatively affect production or tree health.

Phenology

Bloom Period

To test the assumption that cultivars bloom in the same relative order despite seasonal variation (which could be viewed as a proxy for environmental variation across sites), we gathered the bloom starts dates for all trees with at least two years of bloom data. In order to compare across years, we adjusted those starts dates to represent a proportion of the start dates of a given year, with the earliest bloom start as 0 and the latest as 1. Figure 3 shows these adjusted bloom start dates plotted against individual trees on the x-axis. The total vertical distance represents 31, 32 or 41 days depending on the year

(2020, 2019 and 2018 respectively). Despite a certain amount of scatter, we can see that in general the trees do bloom in a similar order each year.

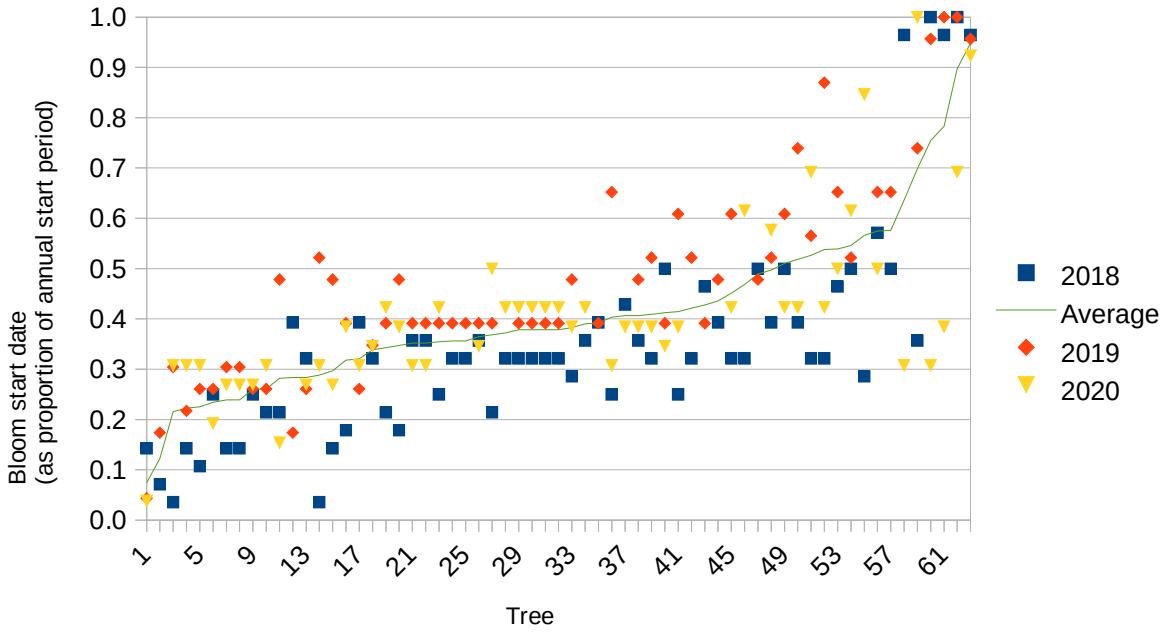

Figure 3: Bloom start dates adjusted to represent proportion of start period for given year

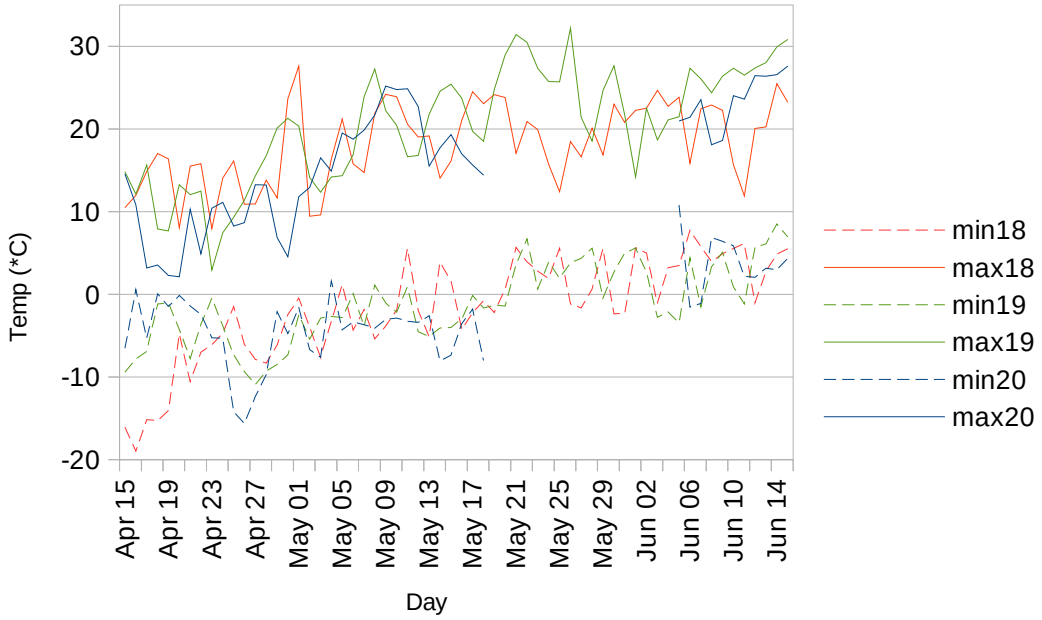

Figure 4: Daily spring minimum/maximum temperatures in the Field site over three years

This figure (3) also allows us to see annual trends across the orchard, irrespective of growing conditions (this dataset includes trees in all sites, inside and out, containerized and in-ground). In 2018 the start dates were generally earlier than average while in 2020 many were later than average. This reflects, we think, the cool temperatures at the end of April 2020 (see Figure 4), as bloom is triggered primarily by growing degree days (cumulative hours above a threshold temperature) (eg: (Chaves et al. 2014)). Note that a technical malfunction caused a data gap for temperature during the bloom window in 2020.

To understand timing compatibility for cross-pollination we began by grouping trees by site (eg: field shelter, field outside, lower shelter, lower outside) for each year of data to account for environmental variation. For each group we plotted the bloom start and end dates against the individual trees to look for patterns of overlap and exclusion in bloom period. As an example, Figures 5, 6 & 7 show the bloom periods for trees in field shelters (n=28-30) over three years. In these and in the vast majority of cases most trees showed overlap, with very few deserving note as potentially incompatible on the basis of timing. We ascribed early, middle and late labels to the trees, averaging their designations across trees and sites to come up with a generalized description for each cultivar.

Of the commercially available apples included in this assessment, only Fort Mac Mac and Noret were consistently ‘early’ and none fall into the late category (a reminder that the entire dataset, including many cultivars not listed here, were included in the original analysis to generate the categories). Therefore, we are confident in suggesting that in the majority years, provided environmental factors are conducive to a productive bloom year, all varieties listed in this report will cross-pollinate. None of the unreleased apple selections included in this assessment showed a tendency towards extremely early or late blooming, making us hopeful that should we gain rights to share any of these trees with the public they will fit well with those already available to northern growers. The pears observed all bloom earlier than the apples, but among them there appears to be sufficient overlap that they can work as pollination partners. As pears tend to be more selective when it comes to the genetics of their pollinators, our next step is to confirm interchangeability of the cultivars we grow through isolation experiments.

As regards the hypothesis that bloom season characteristics might be predicted by spring temperatures, we must conclude that our data is insufficient to attempt to answer such a question. The average bloom period varied from 7.8 days in 2018 to 9.1 in 2019 and 11.9 in 2020, and was much more variable in 2020 than the other two years (as reflected in Figures 5, 6 & 7). While we can attempt to draw links between these observations and our temperature data, the amount of ways in which the season can vary (both in weather and in phenology) is large enough that we are hazarding best guesses in doing so. Perhaps following further years of data collection we will be able to draw more conclusions; it would also be advantageous to gather data from across the northern part of the country to get a better sense of just how disparate or consistent patterns like bloom period are across environments.

Anecdotally, we have received reports of non-overlapping bloom times in the Southern Lakes region that have surprised us, given that our mature trees of the same cultivars overlap well. We are hopeful that this reflects the juvenility of the trees and low numbers of bloom sites, although it is possible that microclimatic influences at the customer’s site play a role. We advise growers to pay close attention to

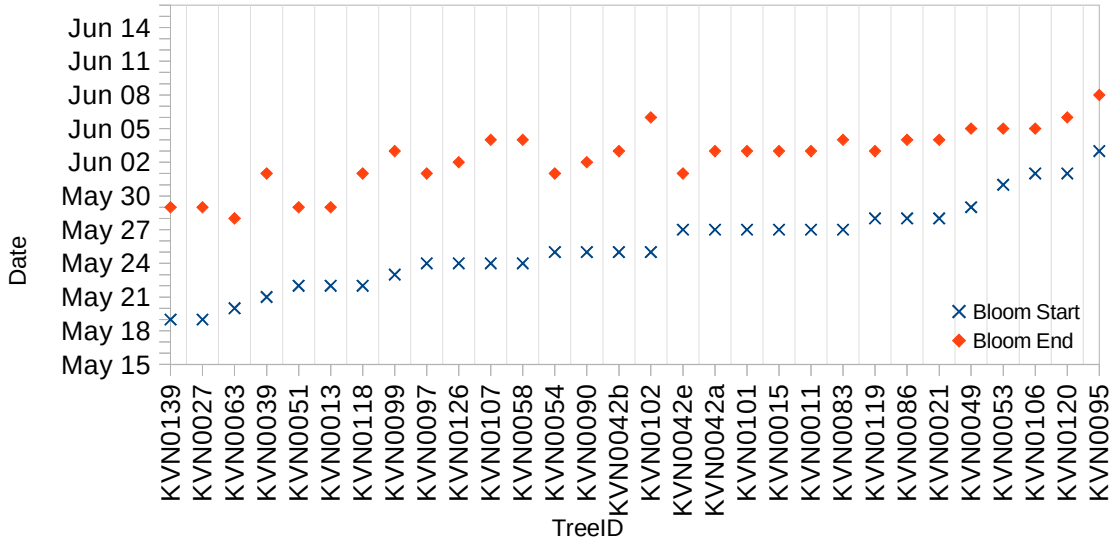

Figure 5: Bloom periods for apple trees in field shelters in 2018

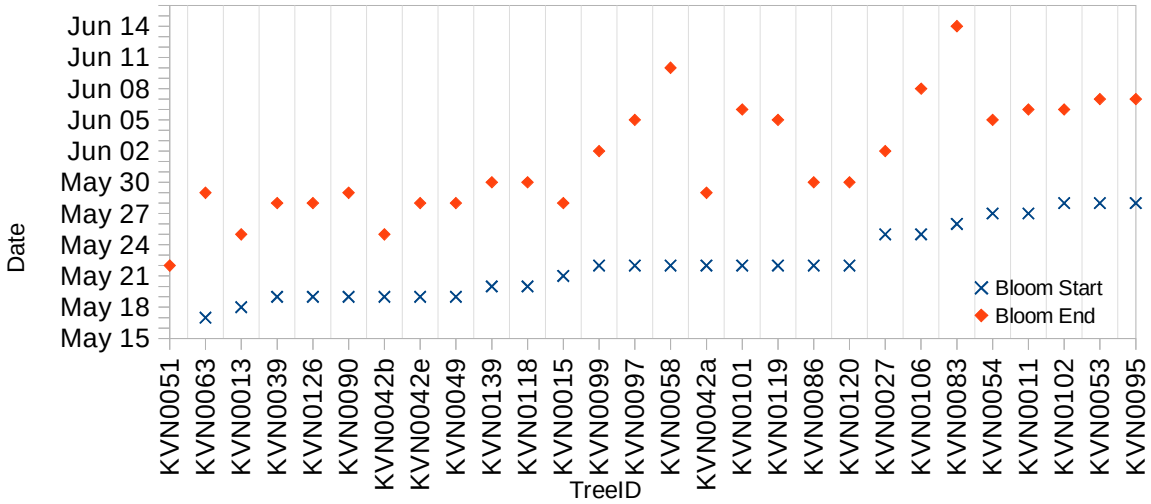

Figure 6: Bloom periods for apple trees in field shelters in 2019

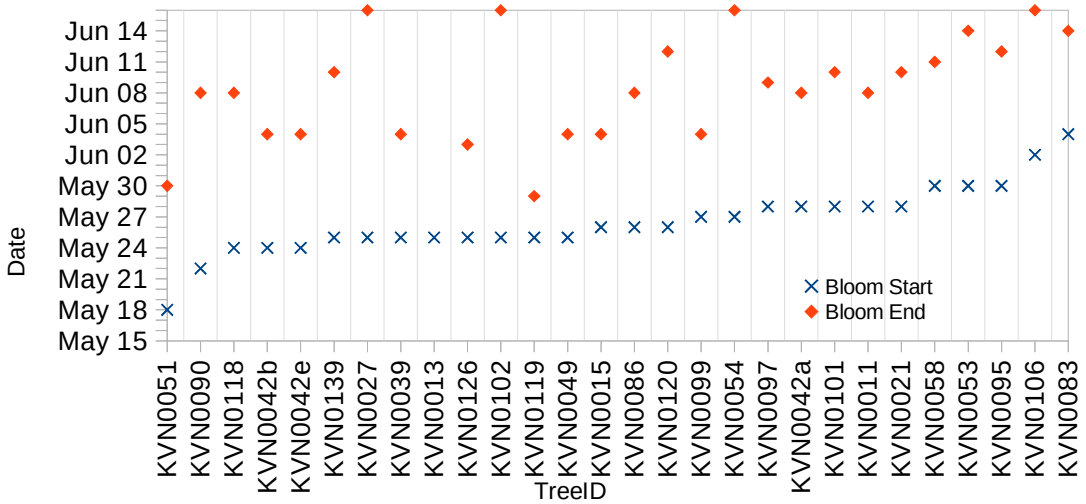

Figure 7: Bloom periods for apple trees in field shelters in 2020

such differences prior to planting, and as an example, to plant an early blooming tree in a site that is slightly cooler in the spring, with a later cultivar in warmer site to increase chances of overlap.

Harvest

The ripening window for different cultivars was determined through recording dates of harvest in 2020 and amalgamating the data with those from the past 3-5 years depending on availability. An average harvest date was determined for each cultivar, with variation in environment being taken into account. These harvest dates were broken down into 'early', which for us is before the end of August, 'late' harvests after September 10th and 'middle' season harvests in between. In our case, harvest time equates to ripening as we are selling our apples weekly for fresh eating. Individual growers may choose to harvest slightly underripe (eg: at half brown seed) to increase shelf life.

Pears are slightly different, in that they should be harvested underripe to prevent stone formation and, in the case of Ure, cracking. They will reach a stage where they come off in the hand despite still being green and firm when they should be harvested.

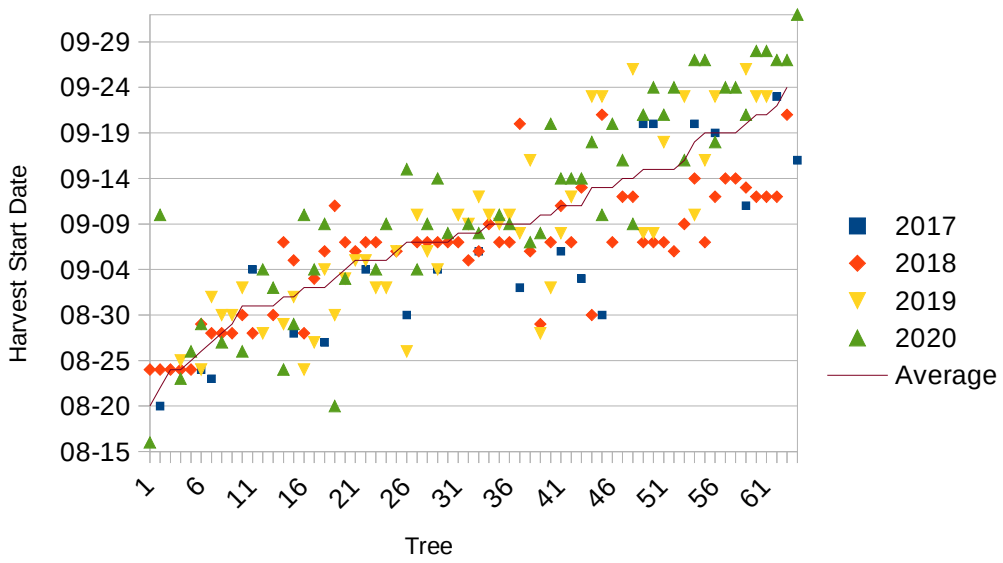

Figure 8: Harvest Start Dates for Whole Orchard

Figure 8 shows the harvest data for our entire orchard (trees with two or more years of data) over four years, with the average harvest date as a line. As with bloom, weather patterns are evident (see Figure 9), for example the long, warm fall in 2020 that allowed harvest dates to stretch far beyond final picking in previous years. In 2018, the drop to -10°C in mid-September would have precipitated harvest of any remaining fruit on trees even if unripe, to prevent excessive cold damage. Once again, our conditions are not a laboratory setting; we operate so close to the margins of where growing these crops is possible that we often don't get the season to allow us to see full ripening on many of the varieties we work with. The season length we have listed in Table 6 may therefore be an underestimation given the

likelihood that at least in some years we harvest late fruit before the crop is completely ripe. We hope gardeners will find these values a familiar proxy for the ‘days to maturity’ on any seed packet.

Figure 9: Daily minimum/maximum temperatures during apple harvest over three years

Yield

In order to compare yields from different trees, we have used a measure of weight of fruit (kg) per cm of tree diameter, which we measure ˜4cm above the graft point each year. While the exact height of measurement varies based on trunk morphology, we keep it consistent each year by marking the location on each tree. As our trees vary widely in age and form, this at least gives us some measure of comparison. After reviewing the data, we find that the inconsistency in harvest we attribute to environmental variation (notably spring freezes) makes it difficult to provide any useful measure for others to predict variation between their trees based on cultivar. In addition, the sample size for most cultivars is far too small. For interest’s sake, we have included Figure 10 to show this ratio for a selection of trees, values averaged for one to three years as available, using only years with moderate to excellent crops thar remain sustainable (discarding overcropped years that led to biennial bearing). We do see that one tree, a 4-6-46 on a standard *Malus baccata* rootstock, had an outstanding crop this year that exceeds any we have seen by this measure. This is exciting as far as potential for an unreleased selection and gives us something to shoot for in the rest of the orchard as we continue to refine our cultivation methodologies. Note that the Noret at the low end of the spectrum is our only fully mature tree that enjoys

the whole growing season exposed to our valley-bottom temperatures – in more temperature climes it can be expected to do better than this.

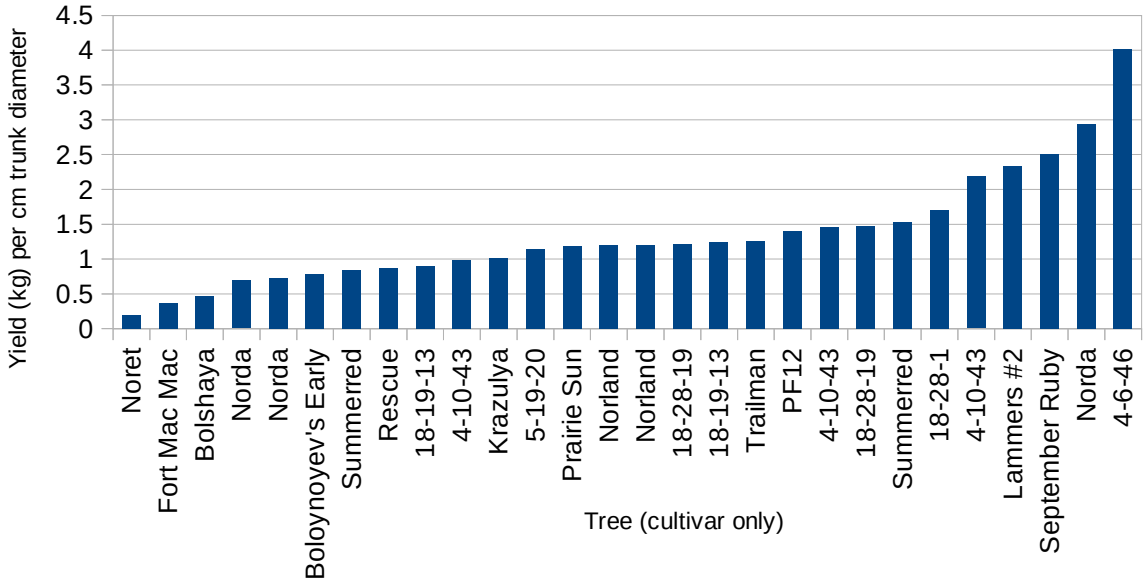

Figure 10: Yield of fruit per cm trunk diameter for a selection of apple trees, averaged over one to four years depending on data availability. Note that rootstocks are not included on x axis for ease of viewing.

Cold Hardiness

No discussion of growing hard fruit north of sixty is complete without a mention of cold hardiness. The term ‘cold hardiness’ itself is problematic in that it refers to a large complex of characters (Palonen, Pauliina 1997). Hardiness varies by genotype; scion hardiness can affect that of the rootstock and vice versa. The threshold of temperature a tree can withstand changes through different stages of growth and dormancy and also varies among tissues. The duration of the cold has an impact, as do cultivation practices such as pruning, fertilizing and harvesting, which can all affect a tree’s ability to enter dormancy (“Tree Fruit Cold Hardiness - Pruning Effects” 2017). When we see cold damage in a tree, it often appears days, weeks or even months after the damage has occurred, and linking observations to a specific event is not easy. In laboratory situations, specific parts of trees are subjected to a series of temperatures for different periods of time to better understand these relationships and susceptibilities. We make do with the experimental conditions nature gives us. As with other measures of tree growth and behaviour, we therefore rank our trees with relative descriptions of hardiness (as in Table 6) and beyond that provide practices a grower can undertake to mitigate the dangers of cold.

Looking at deep winter cold first, we find that the mechanism behind apple survival through freezing tells us what temperatures to avoid. This mechanism, supercooling, maintains cellular water in xylem

tissues and ceases catastrophically to function at -40°C (Moore, James N. 1983). More recent work has further defined this threshold (eg: (Pramsohler, Manuel and Neuner, Gilbert 2012)) but for our purposes it is enough to know that keeping the entire tree above this threshold is a good way to avoid lethal damage. The simple tarp wraps and poly shelters we recommend are effective at mitigating this risk; Figure 11 is an example from our largest shelter. Though less efficient than our smaller ones, even in this shelter the air temperature never got colder than -30°C despite prolonged periods outside below -35°C. Ground temperatures are even more impressive (we do shovel snow into the shelters to help insulate the ground, though only a few inches compared to what accumulates outside), seldom approaching -20°C. This is a good thing as apple tree roots are much less hardy than their aerial portions.

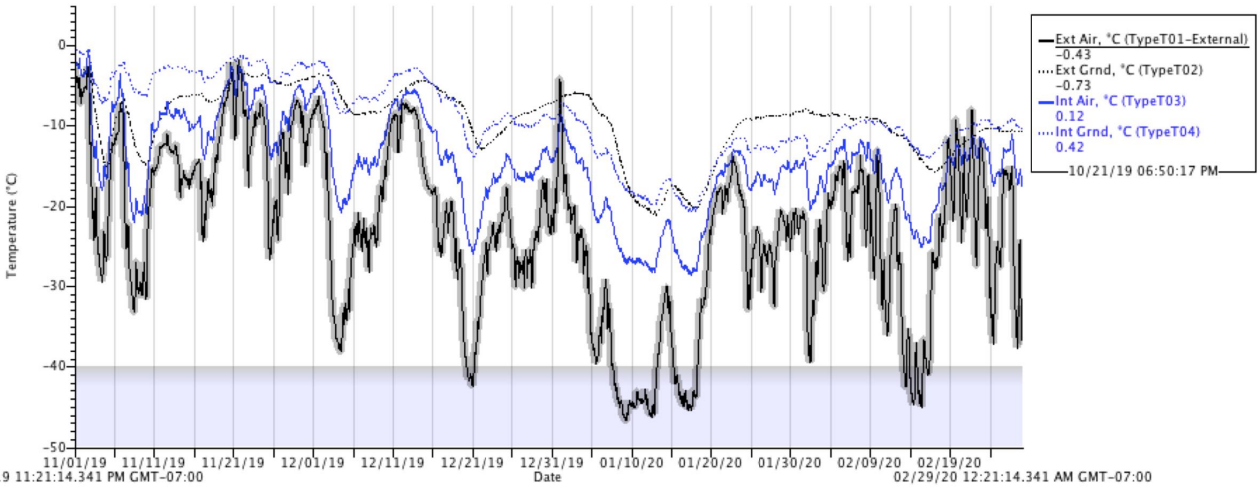

Figure 11: Temperature (hourly) in and near large field shelter (Dell's) during winter 2019-2020

With simple methods we can easily avoid the worst winter cold, which hits when trees are at their hardiest. Much more challenging is managing temperature as trees acclimate and deacclimate (seasonal development and loss of hardiness); we certainly observe freeze damage regularly, affecting bark, cambium, flowers and leaves despite knowing through temperature loggers that we have not exceeded damaging cold in mid-winter. Strategies can be employed both to manage temperature and to support trees entering and maintaining the appropriate stage of dormancy.

In fall and early winter, vulnerabilities exists if temperatures drop before sufficient snow accumulates and if trees fail to acclimate sufficiently before cold hits. Hardening begins at the tips of the branches and works its way down (Palonen, Pauliina 1997). When we see a sharp temperature drop in the forecast in the absence of snow, we use a mulch around the base of the tree to protect the lower more vulnerable portions (peat, leaf debris or straw; extra precautions to protect trees from rodents likely to nest in mulch materials are required). Once adequate snow is available, we mound it around trees in all our sheltering conditions. Avoiding late fertilization and fall pruning, which stimulate growth, are ways to help trees go dormant in good time. In our lengthy period of observation of growing woody plants in the Yukon, an increase in winter tree mortality appears to be linked to trees going into winter drought-stressed, which is in line with previous findings (Quamme, H. A. 1989).

Once apples achieve full dormancy, a chilling requirement must be met before they will respond to environmental cues to deacclimate. This is generally reported as a number of hours and explains why temperate tree fruits have a southern limit to their range. Cultivars can vary significantly in their chilling requirements, for example 400h for Anna and 3000h for Northern Spy. Learning more about the chilling requirements of the cultivars that can survive our conditions may be helpful, particularly in light of changing climates; a longer chilling requirement may help trees retain dormancy through mid-winter fluctuations. Studies in Finland and New Brunswick have shown that warming events in February followed by cold were much more damaging than similar temperature sequences in early winter (Palonen, Pauliina 1997). This supports our own anecdotal evidence, and may be of particular concern for the southern Yukon where we have heard reports of mid-late winter thawing events from our customer base over the last few years. If sufficient snowpack is lost, mulch may be added later in the winter when severe cold can still occur. As for aerial portions, it may bear out that in milder but more variable parts of the territory sealed shelters become just as important as they are in Dawson, for different reasons. By preventing trees from experiencing warm temperatures in mid-winter, we may prevent them from beginning to deacclimate and becoming more susceptible to cold damage in late winter or early spring.

Once the chilling requirement is met, trees are poised for cues of spring. At this point, the deacclimation is usually irreversible once begun, with thresholds of tolerance decreasing over time, in flower buds for example as shown in Table 10. While the specifics vary among apple varieties, the trend is consistent, and the stage of development is the deciding factor in a tree's susceptibility to damage (Moore, James N. 1983).

Table 10: Lethal temperatures through flower bud development for apples

	silver tip	green tip	1/2" green	tight cluster	early pink	full pink	full bloom
T (°C) 10%[a]	-9.5	-7.8	-5	-2.8	-2.2	-2.2	-2.2
T (°C) 90%[a]	-17.2	-12.2	-9.4	-6.1	-4.4	-3.9	-3.9

[a]Temperature required to kill 10% or 90% of buds *adapted from (Phillips, Michael 1998)*

This is one reason we encourage any kind of shelter be opened up early in the spring for equilibration with outside temperatures and to prevent early deacclimation, as daytime temperatures inside shelters can quickly bring a tree up to the growing degree day threshold that will trigger breaking dormancy while night time temperatures are still damaging or lethal to the more sensitive tissues.

Damage varies in the type of tissue affected, the speed at which the damage becomes evident and the duration to which the damage persists. In 2016, a freeze event in June damaged late blooms and developing fruit to such an extent that, even within our shelters covered with extra tarps, the majority of the year's crop was lost. This shows the importance of timing, not just severity, in a freeze event.

The spring of 2020 gifted us with an opportunity to assess the effect of a spring freeze on the trees at our site. The range of conditions at our site makes it most useful to examine the variation in damage within a single shelter (a subset of 5-30 trees). In the Far West Shelter (similar to Figure 1a) we saw the most extreme effects of the freeze event: two six year old trees were killed by damage to the cambium, a Summer Red and a Fort Mac Mac. The damage did not become evident until weeks later, when the

trees failed to progress beyond the initial stages of bloom and blisters began to appear on the bark. Investigation revealed brown, watery tissues beneath the outer bark. Even after carving out these damaged tissues the Summer Red did not survive. The Fort Mac Mac we removed from the ground (the ground was also saturated due to river floodwaters at the time), its roots soaked repeatedly in an attempt to flush out toxins generated in the damaged tissue. By fall, it finally did begin to leaf out in a couple of sites, and it remains to be seen if it can recover next season. Recovery ability is another variable that differs between cultivars and would be worth further investigation in a climate where damage is inevitable. Looking back at the temperature data from the spring (Figure 4) we see that the worst cold was in late April, a full month before we noticed anything wrong with the trees. A Norda on Ottawa 3 in the same shelter suffered nearly no impact to fruit set and only partial damage to fruit and leaves. A young dwarfed Autumn Delight lost half of its fruit and showed some persistent damage to the leaves and fruit. By the time we noticed damage, all four of these trees were at a similar stage of bud development, however we cannot say for sure where they were at a month earlier, as cultivars differ in their pace of deacclimation (Palonen, Pauliina 1997). We hesitate to draw any conclusions about cultivar ‘hardiness’ from this isolated incident, but anticipate continued data collection and further analysis of our existing dataset in the future to see if we can discover any useful patterns.

Concluding Remarks

While it may be tempting to select trees for a home orchard on the basis of a hardiness zone rating or a picture of the fruit alone, we encourage growers to go a step further. Matching up detailed local knowledge of a site with specific information regarding cultivars and cultivation techniques is, in our view, the best recipe for success. In this report, and those that precede and will succeed it, we attempt to provide growers with that information so that they can best make use of the opportunities and respond to the vulnerabilities offered by their particular location and environment. In this way we hope to continue to support others in the north in growing rewarding crops for themselves and their communities.

References

Bors, Bob. 2016. “Haskap Compatibility, Flowering and Ripening Charts for U of SK Varieties.” University of Saskatchewan, Fruit Research Program.

Canada, Environment and Climate Change. 2011. “Station Results - 1981-2010 Climate Normals and Averages - Climate - Environment and Climate Change Canada.” October 31, 2011. https://climate.weather.gc.ca/climate_normals/

Chaves, Bernardo, Melba Ruth Salazar-Gutierrez, Tory Schmidt, Karen Lewis, Nairanjana Dasgupta, Ines Hanrahan, Fiorella Castillo, Sean Hill, and Gerrit Hoogenboom. 2014. *Modeling Development and Growth of Apples*.

Friends of the Garden. 1991. “Edible Apples in Prairie Canada.” U of A Devonian Botanic Garden, University of Alberta.

Lenart, John, Melton, Kim. 2017. “Fruit Tree Shelters.” Yukon Research and Demonstration Program. www.klondikevalley.com/resources.html

Matney, Casey. 2019. “Growing Fruit Trees in Alaska.” *University of Alaska Fairbanks Cooperative Extension Service*.

Moore, James N., Jannick, Jules, ed. 1983. *Methods in Fruit Breeding*. Purdue University Press.

Palonen, Pauliina, Buszard, Deborah. 1997. “Current State of Cold Hardiness Research on Fruit Crops.” *Canadian Journal of Plant Sciences*, no. 77: 399–420.

Phillips, Michael. 1998. *The Apple Grower: A Guide for the Organic Orchardist*. Vermont: Chelsea Green.

Pramsohler, Manuel, Hacker, Jurgen, and Neuner, Gilbert. 2012. “Freezing Pattern and Frost Killing Temperature of Apple (Malus Domestica) Wood under Controlled Conditions and in Nature.” *Tree Physiology*, no. 32 (May): 819–28.

Quamme, H. A., Brownlee, R. T. 1989. “Observation of Winter Injury to the Roots of Apple Trees Associated with Sprinkler Irrigation Pattern.” *Canadian Journal of Plant Sciences*, no. 69: 617–21.

“Tree Fruit Cold Hardiness - Pruning Effects.” 2017. Penn State Extension. 2017. https://extension.psu.edu/tree-fruit-cold-hardiness-pruning-effects

Appendix A: Cultivar Descriptions

Commercially Available Apples

Autumn Delight
Open dwarf tree with good natural form that requires rigorous fruit thinning to achieve proper fruit size and heavy annual pruning once the tree reaches maturity; fruit buds are inconspicuous to an untrained eye. For these reasons it is not advisable to make this a first tree in your orchard. Works well on dwarfing rootstock for small spaces and has proven to be remarkably hardy at our site, though the fruit requires a long season (111 days) so we keep it sheltered. Ripens mid- to late September at our site and hangs on well. We pick once the background colour has shifted from green to pale yellow beneath a red-pink wash that often covers most of the fruit, and the apples comes off easily into the hand. Apples are uniformly medium-sized with a slightly tapered base. The skin is translucent and the flesh is pale yellow, often with lovely pink tones. Fruit is crisp, juicy and substantial. Flavour is sweet and complex and has been described as ‘adventurous’, varying through the eating. Keeps very well; we often eat the last fruit in April.

Bolonoyev’s Early
Vigorous, upright tree that produces oblate, medium-sized pale yellow apples with tender, fine-grained flesh that ripen in our early-mid season (end of August/beginning of September). We are still early in our investigations and suspect it is quite hardy, knowing of at least one tree surviving in Dawson City proper, and are eager to hear reports from other locations. It bears the distinction of being our shortest season apple, ripening fruit in only 87 days from bloom. Fruit have a tendency to drop once ripe, and if they do hang on the skin will go glassy around the base as they become overripe. The light skin makes the fruit prone to bruising, but we get around this by juicing them. Flavour of fresh fruit is bright and ‘cidery’. Last year they gave us juice with a 13.7%Brix value, perfectly acceptable for cider and quite pleasant and spicy on its own. Fruit will hold 4-6 weeks for juicing, but are prime for fresh eating 3-4 weeks refrigerated.

Collet
Compact tree of normal vigour that forms spur-like branches and has obvious flower buds, making it a good tree for beginner pruners. Dwarfs well. Though generally rated as a zone 3 we have found it to be very hardy, particularly if the trunk and roots are well-protected, the higher limbs blooming and ripening unprotected at our site . Blooms in our middle to late season and does not self-thin. Medium-sized, oblate apples ripen at the beginning of September (middle, 105 days) and hang on well, though come off easily into the hand when ripe. Note that fruit retains a green background colour when ripe and develops a strong red over-colour. Ripens over an extended season. Fruit can be mushy if grown under plastic. Makes excellent creamy applesauce, one of the best we’ve tried.

Fort Mac Mac

Open tree with normal vigour that forms spur-like branches readily so the tree is forgiving and adaptable to a variety of pruning techniques. With medium hardiness, it blooms very early and ripens at the end of August at our site, taking approximately 104 days. The tree does self-thin, so final fruit thinning should wait until the end of June. Ripe fruit is uniformly round in shape and largely covered with a red wash over a pale yellow background. Has a tendency to drop ripe fruit, crop ripening over a week or so and apples coming off easily into the hand when ready. Excellent dessert apple with fine-grained white flesh sporting pink venation, firm without being hard, sweet without being sticky. Very nice balance of sweet and tart and a 'fuzzy peach' mouthfeel. Browns slowly when cut open.

Lammers #2

Very hardy, compact tree, easy to maintain with moderate annual pruning. Semi-dwarf that dwarfs well, prone to overcropping so fruit must be thinned to prevent biennial bearing. Blooms mid-season but ripens late, requiring a long fall and long overall season at over 110 days. At our site, often requires harvest by cutting to prevent freeze damage, followed by at least two weeks storage to finish. Fruit are on the small side though larger than an applecrab, yellow when ripe and uniformly ovoid. Light and crisp, they soften quickly in storage but retain flavour and are best eaten within 3-6 weeks of harvest. Underripe fruit have a faint grassy taste and smell, while ripe fruit are juicy and sweet with a hint of tart. They offer notes of lime and could play a distinctive role in cooking. Flesh browns very slowly.

Norda

One of the more tender trees we grow, requires winter shelter and a medium-long season (104 days). Broad open tree with many short fruiting branches, so pruning is readily learned on this variety. Dwarfs well to a compact tree. Norda can be fussy about inputs and water but the fruit is well worth the effort. Apples ripen early September (sheltered) for us over a couple of weeks. Underdeveloped fruit are often shed just before ripening; enjoy any with bruises right away and store the others along with the bulk of the crop. They will ripen further in storage and remain edible through April. Once shedding begins, check fruit every day or two and pick those that come off in the hand. The background colour of ripe fruit shifts to very pale yellow, covered with a red wash. Mature crops are uniform, the fruit barrel-shaped and medium-sized, though in small crops fruit may get quite large. Texture is firm and substantial, lending itself to a thoughtful chew. Apples are fragrant with a floral aroma reminiscent of hibiscus and flavour remains consistent and gentle throughout eating. Simple yet rich. Keeps well, six months in good conditions.

Noret

Very hardy tree with open form and normal vigour. An excellent first tree for a home garden orchard. Good tendency to form short fruiting branches with minimal annual pruning once mature. Beautiful pink and white blooms start early and continue over a long period. Requires thinning to two or three fruit per cluster to maintain fruit size if the crop set is a large one. Ripens early (92 days) and hangs, so can be picked over a period of two or three weeks to enjoy fresh; once picked they have a short shelf life. We often cut the long stems with snips. Fruit are small and uniform, bright yellow with a red blush when ripe and very firm. An upfront flavour of brown sugar and molasses is followed by bright tart notes then a quick floral finish. Skin is noticeable; suggested uses include chutney and muffins.

Norland

Compact semi-dwarf tree that produces our earliest full-size prime dessert apple at 88 days. Easy to shape and maintain with annual pruning with conspicuous fruit buds. Reasonably hardy in Whitehorse, requiring winter wraps in harsh environments. Not suited to year-round shelters as fruit goes mushy under plastic. Blooms in the middle of our bloom season for a short period. Self-thins, so wait until the last week of June to complete fruit thinning to one or two fruit per cluster, with clusters at least 6” apart. Has a tendency to drop fruit as they ripen, so check apples daily once the first are ready. Ripe fruit are heavily striped with red over a pale yellow-green background, uniformly medium-sized and round with a slight taper towards the calyx. Apples have medium firm flesh with slight grain, crisp on picking. Fully ripe fruit softens quickly in storage (4 weeks). Thin-skinnned apples have a subtle and delicate flavour, airy with soft notes of grapefruit. There is a slow build to medium sweetness followed by a tart finish; overall an excellent sweet/tart balance with some astringency. Best for fresh eating; could be marinated/pickled. Pick slightly green ($^1/_2$ brown seed) to extend shelf life by 2 weeks.

Parkland

Vigorous, open tree that requires attention to pruning to promote short fruiting branches as tree has a tendency to be leggy and tip bearing. Medium hardiness among our cultivars, requiring winter sheltering. A middle-season bloomer with huge white flowers over a protracted period that does not self-thin – make sure to thin fruit well to counter tendency to overbear and as undersize fruit have substandard flavour and texture. Prime fruit however are a real treat: excellent flavour, sweet and crisp. Fruit come off easily in the hand when ripe and will drop, bruising easily; the background colour shifts from green to pale cream overlain with a pink-red wash. Fruit are medium-sized. Eat within 1 month or sauce.

PF12

Open tree with normal vigour, prone to developing large, readily visible fruit buds on new main shoots as well as short fruiting branches. Easy to keep in productive condition with normal pruning. Medium hardiness, though fruit requires just under 110 days to ripen so we grow it under shelter. Blooms and ripens in the middle of our seasons, both over a long period. Does not self-thin. Some tendency to drop when ripe, comes off easily in the hand when ready. Ripe fruit are medium-sized and round, with gentle red striping over a pale yellow-cream background. Soft to the teeth with tender light skin and a summery fragrance evocative of dandelions. Subtle flavour with more sweet than tart, holds up well to baking. The flavour has a creamy full-bodied nature which works well as a smoothie base, ie: subbing in for a banana. Best for fresh eating within 1 month; sauce or dry the rest.

Prairie Sun

Compact dwarf tree that responds well to heavy pruning and further dwarfing through rootstock choice. Fruit buds are large and numerous, so pruning heavily is important and easily mastered on this tree. Mid-range hardiness in our orchard with a medium season for fruit development (96 days). Blooms early for a long period and does not self-thin. Ripens towards the end of August for us (early-mid) and drops when ripe. Check every day once first fruit ripen and pick all that come off with a slight twist. Fruit are round and oblate, pale yellow when ripe and can develop a pale red blush in good sun. Generally of medium size, they can get very large on a healthy, well-thinned tree. Soft, light and sweet with tender skin and notes of strawberry. Lots of flavour in a delicate, airy texture with a slightly starchy finish. Excellent fresh eating and recommended for juice cut with water. Browns quickly, best eaten within 1 month of harvest. Dries well.

Rescue

Very hardy applecrab with upright form that develops short fruiting branches with ease. An easily grown short season apple with large blooms mid-season with an early/mid harvest. For best results, snip off every other fruit cluster after fruit is set, especially on young trees. Apples hang on well, we often harvest with snips once seeds are brown and apples are almost entirely crimson over a pale yellow background. More sour notes than the other other applecrabs we grow, fresh-picked they have a complex flavour with a touch of sweetness that mellows if left on the tree. Skin noticeable, medium astringency and medium firmness. Stores only 2-3 weeks, but often used in sauce or preserves.

September Ruby
Vigorous, spreading tree that requires regular annual pruning to manage size and form. Somewhat hardy, we grow it under shelter as the medium-long (100 day) season sets ripening to mid-late September at our site with blooming mid-season. Does not self-thin; thin fruit to one or maximum two per cluster (if few fruiting sites). Fruit are on the large end of medium-sized, blocky and conic with green striping visible through a largely red exterior. Pick when you see the first drops and fruit comes off easily with a twist; they ripen over a short window. Firm and substantial, aart beginning rounds out to medium sweetness. If flavour has dulled in storage, it will brighten with a quick steam though texture is not up to frying. Flesh can retain a slight green shade and often has pink venation. If picked a little green, store for at least two weeks for improved flavour. Will keep 2-3 months.

Summer Red
Strong tree of normal vigour that dwarfs well. Medium tendency to form fruiting spurs or branches. Not cold hardy and requires a long season (115 days), blooming for us in mid-late May and not ripening until the end of September. Fruit requires thinning. Fruit colours long before it is ripe, pick when seed is half brown. Ripe fruit is a deep dark red with prominent white lenticels and has a tendency to drop. Medium to large fruit with firm, breaking white flesh with a tight grain. Fresh taste with good sweet/tart balance. Medium-large fruit that store well, keeping through Christmas.

Trailman
Very hardy applecrab with spreading form, fine branches and normal vigour. Readily develops short fruiting branches. Medium season-length, it blooms in our early-mid season and ripens beginning of September. Fruit does self-thin so wait until end of June to thin to three fruit per cluster while trees are small; mature trees can handle a higher fruit load with four and five fruit per cluster if well-spaced. Small apples are ripe when the background colour shifts to golden, often sporting a red or pink blush in the sun. Fruit hangs on and can be cut off the tree over a week or two to enjoy fresh, or *en masse* if processing. Fruit are bright and sticky sweet, packing a lot of flavour: a quick burst of juice and sweetness with a lemony tang. Delightful snacking, potential for candying. Stores 4-6 weeks. An excellent first tree.

Unreleased apples (UofS accession no.)

18-19-13
Compact vigorous tree requiring shelter at our site for fruit to mature (104 days). Blooms and ripens in the middle of our seasons. Self-thins somewhat. Fruit ripens to medium size, with a pale green-yellow background colour covered in red stripes. Texture is firm and crisp, flavour flowery and rich then sour. Rarely has bitter aftertaste in the skin. Prized by those who like sour apples, works well in salad. Has pale green flesh often with pink venation.

18-28-1

Upright vigorous tree with medium hardiness and a medium season-length. Blooms early for a long period of time and ripens early. Fruit can be variable in shape and size, but are generally medium-large and blocky, shifting from green to pale yellow when ripe. Fruit drop readily and daily checks on the tree are recommended once fruit begin to ripen. An extended harvest period reflects the extended bloom period. Picked slightly green, fruit are crisp, sour and bright. If stored two weeks, flavour matures and mellows to much more sweetness and sourness shifts to a tart note, while texture softens to melt-in-your mouth. Skin very supple. Great for fresh eating and sauces well if stored. Fragrant. Best for fresh eating within a month of picking.

18-28-19

Open, spreading tree with lots of vigour, but dwarfs well. Very hardy. Blooms early for an extended period and ripens early, one of our shortest cultivars (88 days). Doesn't self-thin to any large degree. Can have a tendency to drop fruit as they ripen. Ripe fruit shift from green to pale yellow, with a red blush in the sun. Fruit can get very large and are light for their size, fruit size can be variable on a given tree. Freshly picked fruit are bright, juicy and springy with a coarse grain, can be slightly nutty and often evoke honey. Excellent fresh eating. Flavour is sweet with bright tart notes. Suggest adding to a glass of water and/or pairing with mint. Picking underripe can extend shelf-life from 4 to 8 weeks.

4-6-46

Open, somewhat hardy tree with normal vigour. Dwarfs well with a high tendency to form short fruiting branches. Blooms in the middle of our bloom season for a long time and ripens early. Fruit hangs on well and can be harvested over a long period of time, checking every day or two for those that come off easily. Fruit can vary greatly in size and get very large – our largest was almost 10cm across – though are still medium on average. Holds the record for weight of fruit per cm of trunk at our site. Shape is round and uniform. Fruit are fragrant with a soft, buttery mouthfeel coming from a fine grain that makes them easy to eat. Some people detect pineapple. Flavour has notes of red wine that would pair well with cheese. Recommended for juicing, though not cider, and apple butter. Excellent for fresh eating. Keeps 4-6 weeks.

5-19-20
Open, vigorous tree that dwarfs well and has a high tendency towards developing fruiting sites. Tender at our site, requiring shelter. Ripens late despite a shorter ripening season (96 days). Self thins to a degree, so some thinning required. Round fruit can get quite large if well-thinned, ripening to red against a pale white background. If picked a little green, store minimum two weeks for best flavour. Pleasant, juicy apple with medium crispness and gentle tang. Coarse grained and firm, a tart start fades to sweet. Reliable producer with very pretty fruit.

Pears
All pears are tender enough that any attempt to grow them in our northern environment should be undertaken only with experience and commitment. Ure and Early Gold are the only suitable varieties readily commercially available, although “Russian Beauty” available at T&T in the 2021 catalogue is likely Bolshaya. They require long warm summers and so need to be grown in the warmest sites, or within coldframes where a dwarfing rootstock is recommended. We do not have enough experience with newer Russian selections like Krazulya and Bolshaya to fully describe them, however we look forward to continued work with more information forthcoming in the near future. We continue to experiment with multivariety trees using Saskatoon berry and cotoneaster as rootstocks so that others may join us in learning more about successful techniques for growing pears in the north.