AN ABSTRACT OF THE THESIS OF

Natalia R. Salinas for the degree of Master of Science in Horticulture presented on August 10, 2015

Title: Validation of Molecular Markers Associated with Perpetual Flowering (PF) and Soluble Solids Content (SSC) in Strawberry (*Fragaria* x*ananassa* Duch. ex Rozier)

Abstract approved:

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Nahla V. Bassil

Strawberry is economically the most important berry crop grown worldwide and breeders are continuously striving to develop improved cultivars. So far, marker assisted breeding (MAB) in strawberry has been limited to the private sector. However, loci controlling some traits of economic importance such as perpetual flowering (PF) and soluble solids content (SSC) associated with fruit sweetness were recently mapped in the cultivated strawberry, a prerequisite to enabling MAB. The first objective of this research was to investigate usefulness of markers linked to the *FaPFRU* locus controlling PF in 'Capitola' and strawberry germplasm containing the same *F. virginiana* subsp. *glauca* source collected by Bringhurst in Utah's Wasatch Mountains through 'Tribute' and 'Seascape', and from other sources such as 'Pan American' through 'Fort-Laramie', and an unknown source through 'Sarian'. The second objective was to assess the ability of an SSC-associated simple sequence repeat (SSR) marker for predicting high soluble solids content in different environments in strawberry.

Five SSR markers (EMFvi136, Bx89, Bx215, Bx56 and Bx63) that are linked to PF on linkage group IVb were used to genotype 893 strawberry individuals. Based on Mendel's Law of Inheritance, parentage was confirmed for most seedlings. Those that had unlikely genotypes or alleles were identified in each of the mapping and breeding populations from Michigan State University (MSU) and those of the USDA-ARS in Corvallis (ORUS). Off type frequencies in breeding populations were 17.1%, on average. Furthermore, multiple genotypes of parents were identified and included: 'Fort Laramie' and FRA 1701 in the MSU breeding programs and 'Tillamook' and 'Puget Reliance' in the ORUS program. Genotype of the FRA 1701 used as parent was different between both programs. Six alleles were associated with PF in the entire dataset: EMFvi136_167, Bx89_251, Bx89_262, Bx215_129 and Bx56_209. However, none of these alleles were present in the FRA 1701-derived progeny and could not be used to predict PF. Since Bx215 mapped closest to the *FaPFRU* locus, we used repeated rounds of ANOVA to identify combinations of alleles at this SSR that best explained the PF trait in the breeding populations. The presence of 129 and absence of 160 increased predictivity of PF from 63% to ~80% while the absence of 129, 123, 127 and 134 predicted OF in 100% of the germplasm where the original source of PF was that obtained from the *F. virginiana* subsp. *glauca* from the Wasatch Mountains through 'Capitola', 'Seascape' and 'Tribute'. In 'Sarian'-derived germplasm, other alleles, 123 and 134 or 127, were predictive of PF. Establishing allele composition at each subgenome using microsatellite allele dose and configuration establishment MADCE for Bx215, Bx56 and Bx63 identified the associated alleles as shared among three or four of the subgenomes, thus unable to predict PF based on allele presence in all PF individuals. Absence of these

alleles was more predictive of once flowering and could be used to eliminate those individuals and therefore increase the proportion of PF progeny to evaluate. Determining haplotypes in this region and evaluating haplotype association with PF could be much more accurate in predicting PF than allele presence or absence and should be investigated.

Soluble solid content-associated EMFv006 was used to genotype 602 individuals. Alleles and genotypes associated with low (209, 215), medium (207, 213, 217) and high SSC (219, 221) were obtained. Plants with the 213:219 EMFvi006 genotype always had higher SSC than those with the 213:209 or 213:215 genotypes in all states except for California. When converted to functional alleles and analyzed by ANOVA in each of the states, a consistent increase in SSC mean was observed between genotypes with the lower SSC types and the higher SSC genotypes in each of the states and years. Heritability (H^2) was low (0.02-0.09) in all states but NH_12 indicating that this trait is highly influenced by environmental conditions. The proportion of phenotypic variance (PVE) was high in comparison with those of H^2 in all states except for CA_12 and ranged from 0.65 in MI_11 to 0.86 in NH_12, indicating that most of the genotypic variance observed can be explained by this locus that can strongly predict differences in SSC content. Much of the variability seen in the SSC trait in this study could be explained by differences in environments and fruit ripening at the time of harvest and their effects on SSC as SSC is very sensitive to environmental factors such as temperature and harvest date. It may be necessary to develop a more standardized protocol of measuring SSC across states and years to obtain more reliable SSC data for each individual. Most importantly, this study

illustrates the usefulness of introgressing novel alleles from wild accessions into the cultivated gene pool. Both alleles consistently associated with high SSC, 219 and 221, originated from wild *F. virginiana* parents (FRA 1701-I1, and FRA 1701, respectively) from the "supercore" and were not present in any of the *F.* ×*ananassa* cultivars genotyped in this study except for an old European selection, 'Jucunda', of unknown pedigree.

Based on the results obtained in this study, breeders may be able to select progeny with desired flowering type and increased soluble solid content after evaluating the alleles present in their parental material.

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Validation of Molecular Markers Associated with Perpetual Flowering (PF) and Soluble Solids Content (SSC) in Strawberry (*Fragaria* x*ananass*a Duch. ex Rozier)

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Natalia R. Salinas

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Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Natalia R. Salinas, Author

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Nahla Bassil assisted with teaching the MADCE technique, interpreting the results, editing of the thesis and planning the overall RosBREED project. Chad Finn assisted with phenotype protocol, editing of the thesis and planning the overall RosBREED project. Jim Hancock assisted in editing the thesis and planning the overall RosBREED project. Lichun Cai for support in the statistical analysis.

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DEDICATION

To my grandparents, María E., Manuel M., Rosa M. and Manuel M.. And to my sweet, intelligent little cousin Osmara Betzabé.

General Introduction

Taxonomy

Species

The cultivated strawberry belongs to the genus *Fragaria* L., family Rosaceae, subfamily Rosoideae, tribe Potentilleae (Eriksson et al., 1998). Species in the *Fragaria* genus share relatively uniform growing and morphologic traits (Liston et al., 2014). *Fragaria* species are low-growing, herbaceous perennials where pollination is done by insects and dispersion of seeds by strawberry consumer animals. Usually, leaves are evergreen and trifoliate. Flowers are always actinomorphic, generally have five white petals, pistils and stamens. However, *F. iinumae* is deciduous and has 6-8 petals and *F. vesca* subsp. *bracteata* has anther pistillate flowers. Stolons are monopodial where plantlet grow at every internode or sympodial, where plantlets develop at alternate internodes. The mature receptacles are very diverse in color, shape and position of achenes and calyx, and could be used to differentiate species (Liston et al., 2014).

The *Fragaria* genus has species with different ploidy levels that include eleven diploids: *F. bucharica* Losink, *F. chinensis* Losink, *F. daltoniana* J. Gay, *F. iinumae* Makino, *F. mandshurica* Staudt, *F. nilgerrensis* Schlecht., *F. nipponica* Makino, *F. nubicola* Lindl., *F. pentaphylla* Losink, *F. vesca* L., and *F. viridis* Duch.; five tetraploids: *F. corymbosa* Losink, *F. gracilis* A. Los., *F. moupinensis* (French.) Card., *F. orientalis* Losinsk, and *F. tibetica* Staudt & Dickoré; one pentaploid: *F.* ×*bringhurstii* Staudt, one hexaploid: *F. moschata* Duch.; three octoploids: *F. virginiana* Miller, *F. chiloensis* (L.) Miller and *F.* ×*ananassa* Duch., and two decaploids: *F. iturupensis* Staudt and *F.*

cascadensis Hummer (Hancock et al., 1999, Hummer et al., 2011 and Hummer, 2012). Other naturally occurring pentaploids from California and Northeast China have been reported but remain unnamed (Liston et al., 2014) and *F. iturupensis* also shows octoploidy (Rousseau-Gueutin et al., 2009).

Fragaria ×ananassa is the species that is primarily commercially cultivated. This species is an allo-octoploid (2n = 8x = 56) outcrosser that arose from a chance hybridization in the mid-1700s between *F. virginiana* and *F. chiloensis* (Hancock et al., 1999).

Origin

It has been difficult to find evidence of the first cultivation of strawberry; however, it is believed that Romans and even Greeks already grew this plant in ancient times (Lee, 1966). Strawberries have been named in poems especially due to their ornamental value. By the 1300s, strawberries were cultivated in European home gardens as ornamental and medicinal plants. By the 1500s, strawberries began having horticultural importance for their fruit while deeper botanical knowledge was being developed. At the end of the 1500s, two strawberry species with tasty and small fruit size were commonly cultivated: the alpine strawberry (*F. vesca*) and the musk strawberry (*F. moschata*). In the 1600s, *F. virginiana* arrived to Europe from eastern North America; however, how this journey occurred is not known. By the end of the 1600s, cultivation of the alpine strawberry predominated over the other species (Lee, 1966).

The origin of the first octoploid strawberries is not clear and for a long time it has been suggested that they arose in East Asia (Hancock et al., 1999). However, the finding of a single achene fossil collected in Canada suggests Beringia as the possible origin of the octoploid clade (Liston et al., 2014). Then, they may have spread across the Bering Strait to North America and adapted to certain environmental conditions and differentiated into *F. virginiana* and *F. chiloensis*. *Fragaria chiloensis* probably arrived to Chile and Hawaii with the help of bird migrations. In Chile, the indigenous Mapuches and Picunches grew *F. chiloensis* and selected for large white and red fruited types until 1551. Around the 1500s, the Spanish distributed the Chilean strawberry northward to Perú, Colombia and Ecuador (Finn et al., 2013).

In the 1700s, the French spy Amédée Frézier was impressed by the quality and especially the size of strawberries grown in Concepción, Chile and brought five plants home with him to France (Lee, 1966; Hancock et al., 1999). However, all of these genotypes were female *F. chiloensis* plants that in order to produce fruit required the pollen from a male or hermaphroditic individual. In 1766, Antoine Duchesne was the first to notice that only strawberries with large fruit such as *F. moschata*, and *F. virginiana* could pollinate the Chilean strawberry and get successful fruit set (Lee, 1966). Later, it was common to observe strawberry plants with uncommon red large-sized fruit in European gardens. This was the first documented hybridization between *F. chiloensis* and *F. virginiana* giving as a result the hybrid *F. ×ananassa* (Hancock et al., 1999).

Production and economic importance

Currently, *F.* ×*ananassa* is economically the most important soft fruit species grown worldwide. Strawberries are cultivated in more than 75 countries and most of its production occurs in the northern hemisphere (Folta and Gardiner, 2009). The United States is the largest producer of strawberries in the world (Hancock, 2000). Other countries leading the strawberry production are Turkey, Spain, Egypt, Korea, Mexico and Poland (Feng et al., 2012). In 2012, the U.S. produced 16.3 billion kilograms, 29% of the total world's strawberry production. Production destined to the fresh market was about 13.7 billion kilograms, valued at $US 2.2 billion and it constituted 80% of the total production in the U.S. in 2012. The remaining 20%, approximately 2.7 billion kilograms of strawberries were processed with an approximate value of $US 200 million (Boris et al., 2013).

Strawberries are grown on more than 23,475 ha in the U.S. and the main producers are California, Florida, Oregon, North Carolina, Washington, Pennsylvania, Michigan, Wisconsin, New York and Ohio (USDA's NASS, 2013; USDA, 2014). California is the nation's leader in producing strawberries (USDA's NASS, 2013). In 2014, 88% of the total fresh and frozen strawberry production in the U.S., which accounts for 1.0 billion kilograms of strawberries and $US 2.6 billion, was produced in California (California Strawberry Commission, 2015).

Seventy three percent of the strawberry crop in California was sold as fresh fruit and 23% as frozen fruit (USDA's NASS, 2013). Moderate days, low humidity, and specialized production practices allow the California industry to supply fruit most of the year (Boris et al., 2013). Californian fruit production between January and May comes primarily from June-bearing or commonly referred to as short-day (SD) plants grown in southern California and fruit produced between April and November is mostly from day neutral (DN) plants growing in northern California (Finn, pers. comm.). The rest of North America including Oregon produces fruit mainly from SD plants, although that is changing as the reflowering 'Albion' becomes increasingly used around North America for local fresh fruit sales (Strik, 2012).

Eighty five percent of the total strawberry production in Oregon is sold as frozen fruit. The fresh fruit is sold mainly locally (Strik, 2012). Oregon strawberries are well known for their excellent taste, juicy texture, deep red color and intense sweetness. These characteristics are the result of the interaction of environmental, cultural and genetic factors. Long mild springs, early summers, lots of rain during the winter and spring, cool nights and warm, dry sunny days during ripening make berries ripen slowly and accumulate sugars (OSC, 2013). Based on plant sales, the predominant SD cultivars grown in the Pacific Northwest are 'Totem', 'Hood', 'Tillamook', 'Puget Reliance', and 'Rainier' with 'Albion' being the most important DN type (P. Moore, pers. comm.).

While breeding for cultivars with high quality fruit, high yields and disease tolerance will still be the first priorities, developing tolerance to drought and more

extreme temperatures will also likely become more important in order for strawberry production to remain profitable.

Breeding history

Antoine Duchesne devoted a lot of effort to the study of *Fragaria*. As a result of his experimentations and observations on strawberries he published the book L´Histoire Naturelle des Fraisiers (Duchesne, 1766). Certainly, Duchesne's studies about separation of sexes in strawberry contributed greatly to the breeding of this crop (Lee, 1966).

While the first hybridization that resulted in *F.* ×*ananassa* occurred in France, production of cultivars first happened in England (Lee, 1966). Michael Keens, an English gardener obtained an erect and strong plant with round fruit that he named 'Keens Imperial', which in turn was used as parent in 1819 to produce 'Keens seedling' that had larger fruit, smaller seed and a strong red color. The most extensive breeding program was developed by Thomas Laxton in the 1860s in England. His first release was 'Noble', which was cold hardy, disease resistant and was grown in many countries including Italy and Scandinavia. The second release was 'Royal Sovereign' that had exceptional flavor, and high yield but was susceptible to mildew and virus diseases. Other relevant cultivars released by Laxton were 'Scarlet Queen', 'Leader', and 'Duke'(Lee, 1966).

In the United States, strawberry production began in the 1800s when *F. virginiana* and 'Methven Scarlet', progeny of 'Keens seedling', were grown together (Darrow,

1966). In 1840, ‘Hovey’, selected from a progeny of ‘Methven Scarlet’ started to gain importance. ‘Hovey’ was the first American cultivar and had large size, good hardiness, good production and fine flavor. However, it was in 1858, when the production of strawberries increased greatly by the introduction of ‘Wilson’, from a progeny of ‘Hovey’ and ‘Ross Phoenix’. The cultivated acreage increased 50 fold by 1880. ‘Wilson’ is the direct precursor of modern cultivars and dominated the markets until 1900 because it had deep red large fruit, was exceptionally productive and was widely adapted to different types of soil (Darrow, 1966).

From 1900 to 1950 nine important cultivars were grown in North America [‘Marshall’(known as ‘Banner’ in California), ‘Klondike’, ‘Missionary’, ‘Dunlap’, ‘Howard 17’ (‘Premier’), ‘Aberdeen’, ‘Blakemore’, ‘Fairfax’, and ‘Aroma’] (Darrow, 1966). These became predominant in many parts of the country due to their adaptation to the various biotic and abiotic stresses present in those regions. Over time breeders released cultivars that had higher yields, improved quality, especially ones that were firmer and better adapted for shipping and other environmental conditions. Since the mid-1900s, the number of breeding programs has greatly decreased with programs more focused developing cultivars with broader production areas including: California (e.g., ‘Chandler’, ‘Camarosa’, ‘Diamante’, ‘Albion’), Florida (e.g., ‘Sweet Charlie’, ‘Strawberry Festival’), the Pacific Northwest (e.g., ‘Northwest’, ‘Hood’, ‘Totem’, ‘Tillamook’), the mid-Atlantic (e.g., ‘Guardian’, ‘Redchief’, ‘Earliglow’, ‘Allstar’), northeast (e.g., ‘Honeoye’, ‘Jewel’, ‘Clancy’), and northern Great Plains (e.g., ‘Winona’).

Public breeding programs in the US

The most important public breeding programs in North America are in California and Florida, although there are significant public efforts in Washington, Michigan, Oregon, New York, North Carolina, Wisconsin, and Nova Scotia. The common objectives of these strawberry breeding programs are to obtain high yielding cultivars resistant to virus, bacterial, and/or fungal diseases and with high fruit quality. Each program has specific traits they are focusing on based on their local industry. For example, adaptation to long distance shipping is important in California, while fruit quality characteristics that are suited for processing are crucial in the Pacific Northwest; and cold hardiness is critical in the upper Midwest and the Northeast.

Today, strawberry breeding at the University of California (UC) is the most significant public program in the world and their SD and DN cultivars are popular worldwide. The UC strawberry breeding program began in 1926 with the leadership of W. T. Howes and A.G. Plakidas and has continued at the Davis station since 1946. Several successful cultivars were released like ‘Lassen’, ‘Shasta’, ‘Fresno’ and others. These cultivars have been commercially successful because planting systems that optimize their performance were developed parallel to their breeding (Darrow, 1966). Royce Bringhurst and V. Voth guided the program to prominence with ever increasing fruit quality and yield. Bringhurst’s incorporation of the DN characteristic from wild *F. virginiana* into commercially viable cultivars was one of the more remarkable breeding

accomplishments and propelled the DN cultivars developed from this effort such as ‘Diamante’ and ‘Albion’ to worldwide prominence.

Douglas V. Shaw, was the lead breeder for UC-Davis from 1986-2014. During this time, 20 cultivars were developed such as the SD ‘Chandler’ (which while not of much importance in California is widely grown in the southeast U.S.), ‘Camarosa’, ‘Ventana’ and ‘Camino Real’, and the DN ‘Diamante’, ‘Aromas’ and ‘Albion’. This program focuses on obtaining SD and DN cultivars with production efficiency, fruit quality, harvest efficiency and environmental tolerance. Under these four categories, the most important traits are primarily yield, production pattern, uniform color, ability to ship the fruit, attractive fruit appearance, tasty flavor, open plant architecture, resistance to rain and specific pest and diseases such as powdery mildew, *Verticillium dahlia* and *Phytophthora cactorum* (Shaw, 2004).

The Pacific Northwest breeding effort includes the USDA-ARS/Oregon State University program, Washington State University and the Agriculture and Agri-Foods Canada breeding program in British Columbia. In Oregon, the program was begun in 1911 by V.R. Gardner. He was followed in succession by C.E. Schuster, G.M. Darrow, F.J. Lawrence, and C.E. Finn. The cultivars from this program with the biggest impact have been ‘Hood’ and ‘Tillamook’. In Washington, the program has been based in Puyallup, Washington. The primary breeders at Puyallup have been C.D. Schwartze, T. Sjulin, and P.P. Moore with their most important releases being ‘Northwest’, ‘Rainier’, ‘Shuksan’, ‘Puget Reliance’ and ‘Puget Crimson’. The British Columbia program was

begun by H.A. Daubeny in the late 1950s and C. Kempler and M. Dossett followed him as breeders. Their most important release has been ‘Totem’. The primary cultivars in the processing industry in the Pacific Northwest over the past 100 years have been ‘Marshall’, ‘Northwest’, ‘Hood’, ‘Totem’, ‘Puget Reliance’ and ‘Tillamook’ (C. Finn, pers. comm.).

The strawberry breeding programs in the Northwest have had common goals focused on superior quality fruit for the processing industry that is economical to produce. Some of the most important traits for breeding are: virus tolerance of the plants, fruit size, uniform fruit shape, intense red internal and external color, intense flavor, high soluble solids content, pH at 3.5 or below (helps to keep anthocyanins from oxidizing and so they stay red in the processed product), good fruit firmness and good fruit integrity after being frozen and thawed (low drip loss). In order to facilitate harvesting of these berries, an open canopy is necessary with large, visible fruit whose calyxes are easily removed (easily “capped”) (C. Finn, pers. comm.).

Florida, with its warm, humid climate, can be a tough place to grow strawberries, but these conditions allow them to produce strawberries from December to March when other parts of the country cannot. While initial breeding efforts begun in the 1940s by A. Brooks focused on developing disease resistant cultivars, the programs of C. Howard, C. Chandler, and V. Whitaker who followed him built on this valuable germplasm. They have focused on developing cultivars that will ripen in midwinter, that can be shipped, and that have excellent fruit quality. ‘Florida Ninety’, ‘Florida Belle’, ‘Dover’, ‘Sweet

Charlie' and 'Strawberry Festival' have been the cultivars from this program with the greatest impact.

In the Midwest and the Northeast, the breeders have focused on developing superior cultivars for perennial matted row production in a cold climate where the fruit is usually sold nearby. The University of Minnesota under C. Stushnoff and J. Luby developed cultivars such as 'Winona' and 'Mesabi' in collaboration with the USDA-ARS in Beltsville, MD that met these criteria. Cornell University breeders J.C. Sanford, D.K. Ourecky, and C.A. Weber in Geneva, NY have similar criteria and have released the critically important 'Jewel' and 'Honeoye' strawberries. In Nova Scotia, Agriculture and Agri-Food Canada cultivars developed by D. Craig and A. Jamieson such as 'Annapolis' and 'Kent' have proven to be widely adapted and popular due to their high quality fruit.

While Michigan State University through J.F. Hancock has done a small amount of cultivar development, their efforts have largely focused on germplasm development and genetics research. Hancock started improving the strawberry germplasm at Michigan State University arranging crosses between wild species and cultivars. He has also had an ongoing "FVC Strawberry Reconstruction" project where first selections were made within *F. virginiana* and *F. chiloensis* and then these improved species selections were intercrossed to try to capture most of these species variability in a relatively small number of breeding populations. A main objective of the MSU program is to obtain DN cultivars that show high yield, canopy that allows fruit to be exposed, large and red bright fruit, and sweet aromatic fruit (Sebolt, 2010).

The mid-Atlantic strawberry breeding effort was historically very important at the USDA-ARS program in Beltsville, MD. This program was begun in the 1920s and was led over the decades by G.M. Darrow, D.H. Scott, A.D. Draper, G.J. Galletta, S. Hokanson, and K. Lewers. Red stele root rot resistance (*Phytophthora fragariae*) was an overriding objective for this program from its early days until the turn of the century. The most important cultivars released from this program include: 'Allstar', 'Earliglow,' 'Guardian', 'Redchief', 'Surecrop', 'Tribute' and 'Tristar'.

Perpetual flowering in strawberry

Strawberries can be classified as once flowering (OF) or perpetual flowering plants (PF). This flowering response is based on the interaction between photoperiod and temperature (Stewart and Folta, 2010; Heide et al., 2013). Once flowering plants are also called short-day (SD), seasonal flowering, single cropping plants, or June-bearing (Gaston et al., 2013; Van Delm et al., 2013). These plants begin flower bud initiation (FBI) at temperatures between 15-18°C during SD (<14h of daylight) and have only one harvest period (Heide et al., 2013). Multiple terms including everbearing, remontant and long day (LD) plants have been used interchangeably to indicate PF strawberries. However, it is necessary to make distinctions between them. As reviewed by Heide et al. (2013), everbearing plants can be qualitative or obligatory LD plants at high temperatures (27°C), quantitative LD plants at intermediate temperature (15-21°C) and day-neutral (DN) at low temperatures (<10°C) (Sønsteby and Heide, 2007). At temperatures below

10°C, SD and DN behave as DN plants (Heide et al., 2013). DN plants also have been referred to as recurrent or PF plants (Van Delm et al., 2013).

In order to standardize the use of terms referring to the flowering and fruiting habits in strawberry, we will use the terminology used by Gaston et al., (2013) for flowering throughout the remainder of this thesis: once flowering (OF) and perpetual flowering (PF).

Molecular resources in strawberry

Molecular resources such as a reference genome sequence, expressed sequence tags (ESTs), linkage maps and DNA markers are useful tools that make up the necessary infrastructure needed to elucidate the underlying genes and mechanisms responsible for expression of many traits of economic importance.

Reference genome sequences

A draft genome was assembled from the diploid woodland strawberry, *Fragaria vesca* L subsp. *vesca* Hawaii-4 (Shulaev et al., 2011). A total of 34,809 genes were identified with most of them being supported by transcriptome mapping. Recently, a new assembly, Fvb, was generated using more saturated linkage maps obtained by target enrichment and next generation sequencing (NGS) (Tennessen et al., 2014). A new bioinformatics pipeline, POLiMAPS (Phylogenetics Of Linkage-Map-Anchored Polyploid Subgenomes) (Tennessen et al., 2014), was recently developed to identify

linkage markers in polyploids and to differentiate homeologous linkage groups based on phylogenetic position. When applying POLiMAPS in octoploid *Fragaria*, it first identifies variants at approximately one-eight frequency being heterozygous in one homeolog that then are used to construct linkage groups. For these LG SNPs, all original Illumina reads that mapped to the reference genome Fvb are identified and phylogenetic analysis are arranged using sequenced whole genomes of *F. iinumae*, *F. vesca*, at least one outgroup taxon, and optionally other diploid *Fragaria* species (Tennessen et al., 2014).

Gene annotation in *F. vesca* has been recently reassessed with the Maker pipeline resulting in 2,286 additional predicted protein coding genes (Darwish et al., 2015). This new annotation, named TowU_Fve, resulted from the analysis of updated data sources that included assemblies of RNA-Seq transcriptomes, RefSeq alignments of plant transcripts, current annotations, and *ab initio* gene predictions. Previous gene annotations in *F. vesca* L subsp. *vesca* 'Hawaii-4', were assessed using GeneMark-ES+ and Gnomon (Shulaev et al., 2011; Darwish et al., 2013).

A virtual *F.* ×*ananassa* reference genome sequence, FANhybrid_r1.2 was recently created using NGS and by eliminating heterozygous regions (Hirakawa et al., 2014). FANhybrid_r1.2 was used to analyze the genomic structure of the octoploid genome by comparison to some of its wild diploid species, *F. iinumae*, *F. nipponica*, *F. nubicola* and a tetraploid species, *F. orientalis* (Hirakawa et al., 2014). Further studies are needed to assess the usefulness of this reference genome sequence.

Expressed sequence tags

cDNA sequence information is crucial for supporting gene annotation, for understanding gene expression in different tissues, and for elucidating genes and molecular mechanisms underlying environmental and developmental regulation. Single pass Sanger sequencing of cloned cDNAs, known as expressed sequence tags or ESTs, provided the bulk of cDNA information before the advent of next generation sequencing, which in recent years has resulted in an enormous amount of new sequence data.

To date, 47,826 ESTs for *F. vesca* are available at the National Center for Biotechnology Information (NCBI) (April, 2015). An EST library from heat-stressed seedlings of the diploid woodland strawberry, *F. vesca* subsp. *vesca* f. *semperflorens* cv. Yellow Wonder, proved useful for the development of simple sequence repeat (SSR) markers that were shown to have cross transference across 13 *Fragaria* species (Bassil et al., 2006b). Subsequently, a large number (41,430) of ESTs from abiotically stressed *F. vesca* 'Hawaii 4'seedlings and adult plant tissues became available (Rivarola et al., 2011) and the contigs derived from them proved to be a valuable resource for annotating the *F. vesca* 'Hawaii 4' genome sequence.

Recently, a very large amount of cDNA sequence data (RNAseq) from developing flower tissues and tissues from early stages of fruit development has become publicly available for the diploid strawberry. The Strawberry Genomic Resource (SGR) database, available at http://bioinformatics.towson.edu/strawberry/, was developed to

enable easy access to and mining of the sequences and the information about gene regulation in these tissues (Darwish et al., 2013). The sequences are from YW5AF7, an inbred line of *F. vesca* subsp. *vesca* f. *semperflorens* cv. Yellow Wonder, and thus they provide a valuable resource for identifying single nucleotide polymorphisms (SNPs) between the cultivar whose genome was sequenced, and YW5AF7. The data, obtained from over twenty five replicated cDNA libraries in a two dimensional (developmental stage x tissue) manner has allowed an in depth analysis of the molecular mechanisms of early fruit development (Kang et al., 2013), the identification of tissue specific gene networks in the stem tip, which will become the fleshy tissue of the berry after pollination, and found that an unusually large number of F-box containing genes are expressed at a specific stage in anther development (Hollender et al., 2014). Darwish et al. (2015) used these extensive transcriptome resources to generate a more accurate annotation of the *F. vesca* genome, TowU_Fve, and identified over 2000 additional coding sequences.

To date, (April, 2015), there are 10,855 ESTs publicly available for the octoploid strawberry, *F.* ×*ananassa*, the majority of which, 8,343, are from various stages of fruit ripening (Carbone et al., 2006; Bombarely et al., 2010). Additional ESTs for *F.* ×*ananassa* were obtained from different plant tissues of 'Strawberry Festival' (Folta et al., 2005, 2010) subjected to 30 different treatments, including growth regulators, light conditions, pharmacological agents and stresses. Over 1,300 unique transcripts were assembled from 1,847 ESTs. Of these, 1,105 were found to be homologous to reported proteins or other Rosaceae ESTs (Folta et al., 2005). Using the Roche 454 platform, Folta

et al., (2010), assembled transcriptome data from eight tissue types and a medley of specialized tissue subjected to 30 treatments into 32,000 contigs, which were later used, together with the *F. vesca* ESTs, in annotation of the *F. vesca* reference genome sequence (Shulaev et al., 2011).

Linkage maps

Linkage maps are now available for populations from multiple *Fragaria* species including *F. vesca* (Davis and Yu, 1997; Sargent et al., 2004, 2006, 2008; Vilanova et al., 2008), *F. vesca* subsp. *bracteata* (Tennessen et al., 2013), *F. chiloensis* (Goldberg et al., 2010; Tennessen et al., 2014), *F. ×ananassa* subsp. *cuneifolia* (Govindarajulu et al., 2013), and *F. virginiana* (Spigler et al., 2008, 2010; Tennessen et al., 2014). A linkage map constructed from an interspecific F_2 cross between the two closely-related diploid species, *F. vesca* (FV) and *F. bucharica* (FB) (Sargent et al., 2004, 2006, 2008; Vilanova et al., 2008) has become a reference linkage map in strawberry.

The linkage maps constructed for diploid and octoploid strawberry species have been useful to elucidate the structure of genomes and chromosomes (Davis and Yu, 1997; Lerceteau-Kohler et al., 2003; Sargent et al., 2004, 2006, 2008, 2009; Rousseau-Gueutin et al., 2008; Vilanova et al., 2008; Tennessen et al., 2014; van Dijk et al., 2014), and to understand the inheritance of relevant traits such as PF (Sugimoto et al., 2005; Weebadde et al., 2008; Gaston et al., 2013; Castro et al., 2015), resistance to diseases (Haymes et al., 1997; Lerceteau-Köhler et al., 2005), gender (Spigler et al., 2008, 2010; Goldberg et al.,

2010; Govindarajulu et al., 2013; Tennessen et al., 2013), and fruit quality (Zorrilla - Fontanesi et al., 2011; Lerceteau-Kohler et al., 2012).

The first linkage map for strawberry was obtained for the diploid (2n =2x=14) strawberry *F. vesca* (Davis and Yu, 1997). The inbred line 'Baron Solemacher' was fertilized with pollen from a wild *F. vesca*. The F_2 progeny from selfing a single F1 plant was used to obtain a map that is 445cM long and had 80 markers distributed in seven linkage groups. Deng and Davis (2001) used a candidate gene approach for six enzymes in the anthocyanin biosynthetic pathway and two F_2 populations segregating for yellow fruit color (*c*) from 'Yellow Wonder' to show that a mutation in the flavanone 3-hydroxylase gene was likely responsible for the yellow fruit color. The FV × FB reference strawberry population was first constructed with 78 markers resulting in seven linkage groups with a total size of 448 cM (Sargent et al., 2004). This map was later refined and enriched with additional markers such as SSRs, gene-specific markers, RFLPs, SNPs and ESTs (Sargent et al., 2006, 2007, 2008, 2011; Vilanova et al., 2008; Celton et al., 2010; Ruiz - Rojas et al., 2010; Illa et al., 2011; Shulaev et al., 2011; Zorrilla - Fontanesi et al., 2011) to generate one marker per 1.09 cM across the seven linkage groups (Sargent et al., 2011).

Segregation of the female and male trait in strawberry has been studied in the octoploids *F. virginiana* (Spigler et al., 2008, 2010), *F. chiloensis* (Goldberg et al., 2010), *F. ×ananassa* subsp. *cuneifolia* (Govindarajulu et al., 2013), and the diploid *F. vesca* subsp. *bracteata* (Tennessen et al., 2013). Recently, dense linkage maps were generated

by addition of SNPs generated by targeted sequence capture (Tennessen et al., 2014) to existing SSR-containing maps for the octoploids *F. virginiana* subsp. *virginiana* (Spigler et al., 2008, 2010) and *F. chiloensis* (Goldberg et al., 2010). For the female and male *F. virginiana* subsp. *virginiana*, 3,875 SNPs were distributed into 28 linkage groups representing the haploid chromosomes while 2,542 SNPs were added onto the *F. chiloensis* linkage groups.

A high-density linkage map was recently developed from the F_1 progeny from a cross between *F. vesca* subsp. *bracteata* parents (Tennessen et al., 2013). Targeted enrichment was used to sequence 200 bp fragments containing SNPs with mean coverage >100x. In total, 7,802 filtered markers were mapped and seven linkage maps were obtained for this population. Results from this study indicate that the male sterility trait is dominant, segregates 1:1 and the gene is located in chromosome 4. Govindarajulu et al. (2013) reported that male sterility is also dominant in the natural hybrid *F. ×ananassa* subsp. *cuneifolia*, and that these plants show a disruption of dimorphism in secondary sexual traits.

Tennessen et al. (2014) proposed a new genome model for the octoploid strawberry $A_vA_vB_iB_iB_1B_1B_2B_2$ to replace the more widely accepted AAA'A'BBB'B' model first proposed by Bringhurst (1990). Contrary to what was widely accepted, these results support that *F. vesca* and *F. iinumae* contributed with one sub-genome each, and one unknown autotetraploid ancestor closely-related to *F. iinumae* contributed to the other two sub-genomes of the octoploid *F. ×ananassa* (Tennessen et al., 2014). Sargent

et al. (2015) have published results that are completely consistent with Tennessen et al. (2014); however, they propose a different nomenclature for the subgenomes.

Linkage maps have been constructed for the cultivated strawberry from several crosses: ‘Tribute’ × ‘Honeoye’ (Weebadde et al., 2008; Castro et al., 2015), ‘Capitola’ × ‘CF1116’ (Lerceteau-Kohler et al., 2003; Rousseau-Gueutin et al., 2008); ‘Redgauntlet’ × ‘Hapil’ (Sargent et al., 2009), ‘232’ × ‘1392’ (Zorrilla - Fontanesi et al., 2011), and ‘Holiday’ × ‘Korona’ (van Dijk et al., 2014). Isobe et al. (2013) constructed an integrated high density linkage map from five parent-specific maps obtained from three mapping populations that included the crosses ’02-19’ × ‘Sachinoka’, ‘Kaorino’ × ‘Akihime’, and self-pollination of ‘0212921’ (Isobe et al., 2013). Relevant phylogenetic and functional genomic knowledge for the *Fragaria* species are being elucidated from these studies. Also, useful genetic tools have been developed such as the Microsatellite Allele Dose and Configuration Establishment (MADCE) approach that facilitates the establishment of the full allelic configuration in the progeny and parents (van Dijk et al., 2012).

The PF trait has been investigated in three populations: ‘Ever Berry’ ×‘Toyonoka’ (Sugimoto et al., 2005), ‘Tribute’ × ‘Honeoye’ (Weebadde et al., 2008; Castro et al., 2015) and ‘Capitola’ × ‘CF1116’ (Gaston et al., 2013). A linkage map was initially constructed using 71 random amplified polymorphic DNA (RAPD) markers in 199 seedlings from the cross ‘Ever Berry’ × ‘Toyonoka’ (Sugimoto et al., 2005). Results suggested that the PF trait was inherited as a monogenic dominant trait.

A linkage map was constructed from 127 progeny from a cross between the PF ‘Tribute’ and the OF ‘Honeoye’ using amplified fragment length polymorphism (AFLP) markers and single dose restriction fragment (SDRF) (Weebadde et al., 2008). This map had a length of 1541 cM with 43 groups. Results from this study indicated that the inheritance of the PF trait is polygenetic since none of the eight QTL explained more than 36% of the phenotypic variation (Weebadde et al., 2008). Recently, another linkage map was constructed to investigate PF from the same population using SSRs and Sequenced Characterized Amplified Region (SCAR) markers. ‘Tribute’ and ‘Honeoye’ maps had 119 and 179 markers in 34 and 42 linkage groups, respectively. The PF trait was mapped on LG IV-T-1 and segregated 1:1 in states with hot summers such as Maryland (MD), Minnesota (MN) and Michigan (MI); however, it is unclear if the trait should be treated as dominant or recessive. In the cooler summers of California (CA) and Oregon (OR), plants more frequently expressed the PF trait (Castro et al., 2015).

Rousseau-Gueutin et al. (2008) also constructed a linkage map for a population segregating for PF. This linkage map was obtained from 213 intraspecific F1 population plants derived from a cross between the PF ‘Capitola’ and OF ‘CF1116’. The female and male maps were constructed with 807 single-dose markers. The female and male maps were 2,582 cM and 2,165 cM long and were distributed in 28 and 26 linkage groups, respectively. Then Gaston et al., (2013, using the ‘Capitola’ ×‘CF1116’ linkage maps, found a single QTL called *FaPFRU* that controlled flowering and runnering in strawberry.

Transferability of markers, strong colinearity between the reference diploid *F. vesca* map and the octoploids 'Capitola' × 'CF1116' (Rousseau-Gueutin et al., 2008), 'Redgauntlet' × 'Hapil' (Sargent et al., 2009) and 'Holiday' × 'Korona' (van Dijk et al., 2014), and disomic inheritance have been demonstrated. Moreover, QTL analyses for 17 agronomic and fruit quality traits were conducted in '232' (Sel.4-43 × 'Vilanova') × '1392' ('Gaviota' × 'Camarosa') octoploid map (Zorrilla - Fontanesi et al., 2011). The first linkage map with comprehensive haplotype information was obtained from 92 seedlings of an F*1* population from a cross between 'Holiday' and 'Korona' (van Dijk et al., 2014). The map was 2050 cM long and included 508 markers distributed in 28 linkage groups (van Dijk et al., 2014). The MADCE method facilitated establishment of the full allelic configuration in the progeny and parents (van Dijk et al., 2012).

DNA markers

Molecular markers that have been used in *Fragaria* include RAPD, AFLPs, SSRs and more recently SNPs. These markers were used to detect variation at the DNA level to assess genetic diversity, distinguish plants from closely-related individuals, construct linkage maps to find QTLs and enable marker-assisted breeding in strawberry (Whitaker, 2011).

Arbitrary PCR-based marker systems include RAPDs and AFLPs. These markers are dominant markers since only the dominant allele is scored in heterozygous individuals (Jiménez and Collada, 2008) and have reproducibility problems between

different laboratories (Folta and Gardiner, 2009). On the contrary, co-dominant markers, including SSRs and SNPs, identify both alleles in a diploid heterozygous individual providing more accurate information and are reproducible among laboratories (Jiménez and Collada, 2008).

RAPDs have been used in strawberry to assess population genetic diversity, identify cultivars and construct linkage maps (Hummer et al., 2011). Populations of wild *F. virginiana* and *F. chiloensis* in North America were distinguished molecularly through the analysis of molecular variance (AMOVA) using RAPDs (Harrison et al., 2000). Also, North and South American *F. chiloensis* populations were separated with these markers. However, RAPDs were not useful to distinguish the *F. chiloensis* subspecies (Porebski and Catling, 1998). Moreover, RAPDs were used in cultivar identification to facilitate the protection of intellectual property (Whitaker, 2011). RAPDs were used to distinguish clones of 'Onebor' (Marmolada^{TM}) in a legal lawsuit (Congiu et al., 2000) and to construct the first linkage map for the diploid *F. vesca* (Davis and Yu, 1997).

AFLPs have been used mainly for cultivar identification (Degani et al., 2001) and linkage map construction (Hummer et al., 2011; Whitaker, 2011). Nineteen strawberry cultivars were differentiated using 35 polymorphic markers and nine cultivars showed unique AFLPs bands (Degani et al., 2001). Linkage maps for the cross 'Capitola' × 'CF1116' (Lerceteau-Kohler et al., 2003) and 'Tribute' × 'Honeoye' (Weebadde et al., 2008) were also obtained with AFLP markers.

SSRs have been widely used in strawberry to assess genetic diversity of populations (Hokanson et al., 2006; Hancock et al., 2010), identify cultivars (Lewers et al., 2005; Bassil et al., 2006a) and obtain linkage maps (Sargent et al., 2004, 2006, 2008, 2009; Rousseau-Gueutin et al., 2008; Spigler et al., 2008, 2010; Vilanova et al., 2008; Goldberg et al., 2010; Zorrilla - Fontanesi et al., 2011; Lerceteau-Kohler et al., 2012; Gaston et al., 2013; van Dijk et al., 2014; Castro et al., 2015). Sequences from the species *F.* ×*ananassa* (Rousseau-Gueutin et al., 2008; Sargent et al., 2009; van Dijk et al., 2014), *F. vesca* (Sargent et al., 2004, 2006) and *F. virginiana* (Spigler et al., 2010) have been used to find SSRs that proved highly transferable within *Fragaria*, enabling comparative mapping and synteny studies.

In the octoploid strawberry, SNPs have been identified using a targeted sequence capture approach (Tennessen et al., 2013, 2014) to generate highly dense linkage maps that facilitated defining the genome composition of the octoploid genome with respect to its diploid ancestors and led to a better understanding of the inheritance of male sterility in strawberry. Also, bioinformatically, SNPs have been obtained by aligning and subsequent filtering of Illumina-derived sequences of one diploid and 19 octoploid strawberry accessions to the reference 'Hawaii-4' sequence (Bassil and Davis et al., 2015). Up to 90,000 SNPs were placed on an Axiom® array, a new high-throughput genotyping platform that will facilitate marker-assisted breeding in strawberry through the generation of saturated linkage maps, identification of economically important QTLs and genome-wide association studies (Bassil et al., 2015).

Marker assisted breeding in strawberry

So far, marker assisted breeding (MAB) in strawberry has been limited mostly to the private sector (Whitaker, 2011). Furthermore, a limited number of traits of economic importance including PF (Gaston et al., 2013), fruit quality (Zorrilla - Fontanesi et al., 2011), and disease resistance (Haymes et al., 1997; Lerceteau-Köhler et al., 2005), have been mapped in the cultivated strawberry, a prerequisite to enabling MAB.

Quantitative trait loci (QTLs) associated with PF were analyzed in the progeny of the PF 'Capitola' and the OF 'CF1116' and a single QTL, *FaPFRU*, was found to control PF and runnering in the octoploid strawberry (Gaston et al., 2013). Another population obtained from the cross 'Tribute' × 'Honeoye' was used to construct linkage maps. The PF trait was located in the group IV-T-1 and two microsatellites (ChFaM 148-184T and ChFaM 011-163T) were close to it (Castro et al., 2015).

Markers associated with resistance to red stele root rot caused by *Phytophthora fragariae* var. *fragariae* (Haymes et al., 1997; van de Weg, 1997; Mathey, 2013), and to anthracnose caused by *Colletotrichum acutatum* pathogenicity group 2 (Denoyes-Rothan et al., 2005; Lerceteau-Köhler et al., 2005) are available in strawberry. RAPD markers linked to the dominant *Rpf1* gene that controls resistance to *Phytophthora fragariae* var. *fragariae* were identified in the 'Md683' ×'Senga Sengana' population (Haymes et al., 1997). Two SCAR markers were also developed (Haymes et al., 2000).

Recently, an SSR marker developed by Eric van de Weg's group in the Netherlands (Wageningen University and Research Centre) linked to *Rpf1* was tested in a set of 130 individuals that included cultivars, selections and supercore accessions (Hancock et al., 2001; Mathey, 2013). The SSR marker was absent in the wild *F. chiloensis* and *F. virginiana* accessions but appeared useful in predicting resistance from *Rpf1* at a rate of 87.5% in *F.* ×*ananassa* (Mathey, 2013). Two SCAR markers were developed in the 'Capitola' × 'Pajaro' population from AFLP loci associated with the *Rca2* gene that confers resistance to *Colletotrichum acutatum* pathogenicity group 2 (Denoyes-Rothan et al., 2005). These two SCARs predicted the trait correctly in 81% of resistant plants and 61% of susceptible plants (Lerceteau-Köhler et al., 2005).

RosBREED objectives

RosBREED is a multi-institutional USDA-NIFA-SCRI-funded project whose objective is to enable marker assisted breeding in the Rosaceae family including strawberry (Iezzoni et al., 2009). To achieve this goal in strawberry, breeders in the US established a germplasm set of 890 individuals that include the Crop Reference Set and the Breeding Pedigree Set. Both sets of germplasm were provided from multiple institutions including: the USDA-ARS Horticulture Crops Research Unit (HCRU), Michigan State University (MSU), the USDA-ARS National Clonal Germplasm Repository (NCGR), the University of Florida (UF), the University of New Hampshire (UNH), the Instituto Andaluz de Investigación y Formación Agraria y Pesquera (IFAPA) in Spain, East Malling Research (EMR) in the United Kingdom, the Institut National de

la Recherche Agronomique (INRA) in France, and the Center for Genetic Resources (PB-WUR) in The Netherlands. Driscoll Strawberry Associates (Watsonville, CA) provided critical support, as they imported the European material into the U.S. using their long-established quarantine and propagation facilities (Mathey et al., 2013)

Genome scanning capabilities were developed in the form of a 90K Axiom array (Bassil et al., 2015). Association between phenotypic data and genotypic data is progressing by using pedigree-based analyses implemented in the FlexQTL software (Bink, 2005; Bink et al., 2008).

Research objectives

The objectives of my research were to:

- Investigate usefulness of markers associated with PF in 'Capitola' in other strawberry germplasm containing the same *F. virginiana* subsp. *glauca* source collected by Bringhurst in Utah's Wasatch Mountains, Pan American through 'Fort-Laramie' and an unknown source through 'Sarian'.
- Assess the ability of an SSC-associated SSR marker for predicting high soluble solids in different environments in strawberry.

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Validation of Molecular Markers Associated with Perpetual Flowering in Strawberry (*Fragaria ×ananassa* Duch. ex Rozier)

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Abstract

Development of effective molecular markers for marker-assisted selection (MAS) requires previous identification of regions in the genome that control perpetual flowering (PF) and validation of marker association with this trait outside the discovery population. SSRs Bx89, Bx215, Bx56 and Bx63 flanking the *FaPFRU* (*Fragaria* Perpetual Flowering and Runnering) locus located in the female linkage group named LGIVb-f found in the 'Capitola' × CF1116 population and EMFvi136 associated with a perpetual flowering (PF) QTL located in female linkage group LGIV-T-1 in the 'Tribute' × 'Honeoye' population were used to validate association with PF in 893 accessions comprised of cultivars, seedling populations linked by pedigree and selections representing diverse strawberry breeding germplasm. These populations included five mapping populations, 16 Michigan State University (MSU) and 19 USDA-ARS (ORUS) breeding populations. Flowering data was collected on most of these individuals for at least two seasons in Michigan, New Hampshire and Oregon and one season in California. Plants were considered PF plants if they flowered in the spring and on or after 17 July. After separation of PCR fragments by capillary electrophoresis, Microsatellite Allele Dose and Configuration Establishment (MADCE) was used to determine allele composition in the four strawberry subgenomes for the amplicons generated by

EMFvi136, Bx215, Bx56 and Bx63 but not those generated by Bx89 since allele peaks did not show good quality. Based on presence in progeny of alleles different from those found in the parents, parentage was confirmed and seedlings that had unlikely genotypes or alleles based on Mendel's Law of Inheritance was identified in each of the mapping and breeding populations where an off-type rate of 16.8%, and 17.36% were observed in the MSU and ORUS breeding programs, respectively. Multiple genotypes of 'Fort Laramie' and FRA 1701 in the MSU breeding programs and 'Tillamook' and 'Puget Reliance' in the ORUS program were found. The genotype of the FRA 1701 used as a parent was different between the programs. Six alleles were associated with PF in the entire dataset: EMFvi136_167, Bx89_251, Bx89_262, Bx215_129 and Bx56_209. In 'Capitola'- derived progeny Bx89_262, Bx215_129, Bx56_209 and Bx63_149 were confirmed to predict the PF trait at a comparable marker trait association (MTA) rate. The highest MTA was for MI_13 (88%), OR_12 (72%) and MI_12 (68%) while it was less than 50% in CA_12 and OR_13. When evaluating MTA in families with the same source of PF, moderate to high MTA for allele presence at each of these five alleles was found in 'Seascape' and 'Tribute'- derived germplasm, the highest %MTA (~83%) was found for EMFvi136_167, Bx215_129 and Bx63_149. In 'Fort Laramie'- derived progeny, the greatest MTA percentages (60-90%) were obtained with EMFvi136_167. EMFvi136_167 and Bx89_262 were equally effective at predicting PF (> 70%) in the 'Sarian'_CF progeny while none of these alleles were found in FRA_1701 or any of the inferred FRA 1701 parents. Bx215 mapped closest to the *FaPFRU* locus, we used repeated rounds of ANOVA to identify combinations of alleles at this SSR that best explained the PF trait in the breeding populations. The presence of 129 and absence of

160 increased predictivity of PF from 63% to ~80% while the absence of 129, 123, 127 and 134 predicted OF in 100% of the germplasm where the original source of PF was that obtained from the *F. virginiana* subsp. *glauca* from the Wasatch Mountains through 'Capitola', 'Seascape' and 'Tribute'. In 'Sarian'-derived germplasm, other alleles, 123 and 134 or 127, were predictive of PF. Establishing allele composition at each subgenome using MADCE for Bx215, Bx56 and Bx63 identified the associated alleles as shared among three or four of the subgenomes, thus unable to predict PF based on allele presence in all PF individuals. These alleles could be present in the subgenome that does not have the functional gene controlling PF. Absence of these alleles was more predictive of once flowering and could be used to eliminate those individuals and therefore increase the proportion of PF progeny to evaluate. Determining haplotypes in this region and evaluating haplotype association with PF could be much more accurate in predicting PF than allele presence or absence and should be investigated.

Classification of strawberry according to photoperiod/temperature interaction

Strawberries can be classified into once flowering (OF) or perpetual flowering (PF) plants (Stewart and Folta, 2010; Heide et al., 2013). This flowering response is based on the interaction between photoperiod and temperature (Stewart and Folta, 2010; Heide et al., 2013). Once flowering plants are also called short-day (SD), seasonal flowering, single cropping plants, or June-bearing (Gaston et al., 2013; Van Delm et al., 2013). These plants begin flower bud initiation (FBI) at 15-18°C during short days (<14h of daylight) and have only one harvest period (Heide et al., 2013). Multiple terms

including everbearing, remontant and long day (LD) plants have been used interchangeably to indicate perpetual flowering strawberries. However, it is necessary to make distinctions between them. As reviewed by Heide et al. (2013), everbearing plants can be qualitative (obligatory) LD plants at high temperatures (27°C), quantitative LD plants at intermediate temperature (15-21°C) and DN plants at lower temperatures (9-10°C) (Sønsteby and Heide, 2007). At temperatures below 10°C, SD and DN behave as DN plants (Heide et al., 2013). Day neutral plants also have been referred to as recurrent or perpetual flowering plants (Van Delm et al., 2013).

In order to standardize the use of terms referring to the flowering and fruiting habits in strawberry, we will use the terminology used by Gaston et al. (2013) for flowering throughout this thesis: once flowering (OF) and perpetual flowering (PF).

Sources of perpetual flowering

The first description of the PF trait in strawberry was of *F. vesca* subsp. *vesca* f. *semperflorens,* a diploid PF strawberry, grown in Europe and England in the mid-1700s (Darrow, 1966). These were known as 'Alpine', 'Quatre Saisons' and 'everbearing'. Two types of *F. vesca* subsp. *vesca* f. *semperflorens* have been described based on the ability to produce runners. The runnered type grew in the wild in Bargemon and Mt. Cenis France and produced few branch crowns and small berries; and the runnerless type was obtained from Gaillon and produced many crowns and bigger berries than the runnered type. 'Baron Solemacher', 'Reine des Vallées' and 'Red Gaillon' are runnerless while 'Brilliant' and 'Belle de Meaux' are runnered types.

There are three important sources of the PF trait in the cultivated octoploid strawberry. One comes from Europe and two from the U.S. (Hancock, 2000). ‘Gloede’s Seedling’, the first octoploid PF strawberry in Europe was introduced in France in 1866 (Darrow, 1966). Abbé Thivolet in France recognized the potential value of this trait and bred the first large-fruited PF, ‘St Joseph’ also known as ‘Constance Feconde’, ‘Leone XIII’ and ‘Rubicunda’ and then ‘St Antoine de Padoue’. From there, several PF cultivars such as Sans Rivale, Profusion, Appelever, Sanvoir and Liberation d’Orleans were obtained. In Holland, three cultivars, ‘Repita’, ‘Revada’ and ‘Elista’ were bred by H.G. Kronenberg and L.M. Wassenaar at the Horticultural Research Institute at Wageningen. ‘Climax’, considered as a two-crop cultivar, resulted from a cross between OF plants, was also one of the first PF cultivars in Europe. It was used in crosses to generate ‘Talisman’, and ‘Redgauntlet’ (Darrow, 1966).

In the United States, the first commercially important PF cultivar was ‘Pan American’, a variant of ‘Bismarck’ and descendent of ‘Wilson’, which was introduced by Samuel Cooper in New York in 1902 (Darrow, 1966). In 1908, Harlow Rockhill used ‘Pan American’ as a parent, obtaining ‘Progressive’ that was the leading cultivar for many years. Other important PF cultivars were released such as ‘Rockhill’, ‘Twentieth Century’, ‘Gem’, ‘Ozark Beauty’, ‘Ogallala’, ‘Glenheart’ and ‘Geneva’.

The most recently discovered and widely used source of PF in the US comes from the *F. virginiana* subsp. *glauca* accession collected in the Wasatch Mountains close to Salt Lake City, Utah (Bringhurst and Voth, 1980). Bringhurst and Voth (1980) mostly backcrossed OF cultivars with a single clone, Cal 65.65-601, of the *F. virginiana* subsp. *glauca*. From this source, ‘Hecker’, ‘Aptos’, ‘Brighton’, ‘Fern’, ‘Selva’, ‘Muir’, ‘Mrak’,

and ‘Yolo’ were directly obtained and this source is in the ancestry of all modern PF cultivars.

In recent years, elite accessions of *F. chiloensis* and *F. virginiana* have been evaluated for many important traits including PF and were intercrossed in an attempt to widen the gene pool and introduce new sources of this trait in the cultivated strawberry (Hancock et al., 2010). The 12 PF *F. virginiana* accessions used in these crosses came from Ontario (Frederick 9, Montreal River 10), Wyoming (LH 10-6), Montana (LH 28-1, LH 30-4, LH 39-15, LH 40-4, LH 50-4), Minnesota (RH 23, RH 30) and Alberta (RH 43, N8417). Superior OF and PF individuals were identified in offspring of these accessions (Stegmeir et al., 2010) and are being used in breeding (J. Hancock and C. Finn, personal communication). The PF trait was especially strong in the elite selections FVC 18 (with a selection out of the cross between Montreal River 10 and RH 23 as a parent) and average in FVC 8 (with a selection from the cross between RH30 and LH50-4 as a parent) that also showed high yields, strong vigor, high flower numbers and large fruit.

Control of perpetual flowering

Fragaria vesca

The OF trait referred to as ‘seasonal flowering’ in the diploid woodland strawberry, *F. vesca*, is controlled by a single gene, where the recessive *ss* condition confers perpetual flowering (Brown and Wareing, 1965). A 2bp-deletion in the first exon of the coding region of the TERMINAL FLOWER 1 (*TFL1*) gene homolog *FvTFL1*

controls the perpetual flowering trait (Iwata et al., 2012). The deletion caused a frame shift that led to a premature stop codon, disabling the protein. Individuals with the genotype *fvtfl1/ fvtfl1* had PF behavior and individuals with *FvTFL1/ FvTFL1* and *FvTFL1/ fvtfl1* had a OF behavior. Sequences of this region from different accessions and population structure analysis separated samples into two well-defined groups: one contained samples mainly from the European Alps and the other contained samples originating from other regions in Europe and North America. Results also suggested that PF in *F. vesca* might have originated in the Alps (Iwata et al., 2012).

The *FvTFL1* gene mapped to LG6 (Sargent et al., 2004) and in its dominant form was a floral repressor and controlled cycling between vegetative and reproductive phases in the diploid *F. vesca* (Koskela et al., 2012). Under LD conditions, the dominant allele of *FvTFL1* (OF genotypes) was transcribed and suppressed flowering; on the contrary, under SD conditions this gene was not transcribed and flower bud initiation occurred. The protein is not produced when the plant has the recessive alleles *fvtfl1/ fvtfl1* (PF genotypes). Overexpressing or silencing the *FvTFL1* gene did not affect the photoperiodic control of development of runners, and suggested that this gene was not involved in the regulation of vegetative growth in strawberry (Koskela et al., 2012).

Fragaria ×ananassa

Fragaria ×ananassa is an allo-octoploid (2n = 8x = 56) outcrosser that arose from a chance hybridization in the mid-1700s between *F. virginiana* and *F. chiloensis* (Hancock et al., 1999). Tennessen et al., (2014) proposed a new genome model for the

octoploid strawberry $A_vA_vB_iB_iB_1B_1B_2B_2$ to replace the more widely accepted AAA'A'BBB'B' model first proposed by Bringhurst (1990). Contrary to what was widely accepted, these results support that *F. vesca* and *F. iinumae* contributed one sub-genome each, and one unknown autotetraploid ancestor closely-related to *F. iinumae* contributed to the other two sub-genomes of the octoploid *F. ×ananassa* (Tennessen et al., 2014, Sargent et al., 2015).

Different genetic models have been proposed for perpetual flowering in *F. ×ananassa*. These genetic models were dependent on the parents used and the different environments where the studies were conducted (Hancock et al., 2008; Andolfatto et al., 2011). One model indicated that this trait is mainly regulated by a single dominant gene (Sugimoto et al., 2005; Gaston et al., 2013); while another model identified recessive control (Scott, 1959). Some have also reported quantitative inheritance of this trait (Powers, 1954; Hancock et al., 2002) and several quantitative trait loci (QTL) have been identified (Gaston et al., 2013; Weebadde et al., 2007).

A linkage map was constructed from the cross between the PF 'Tribute' and the OF 'Honeoye' (Weebadde et al., 2008). Using amplified fragment length polymorphism (AFLP) markers and single dose restriction fragments (SDRFs), 127 seedlings were genotyped. The map had a length of 1541 cM with 43 groups and was used to find QTL associated with perpetual flowering. Flowering phenotype was scored for the 127 clonally propagated seedlings in five different states (MI, MN, MD, OR and CA). None of the eight found QTLs explained more than 36% of the phenotypic variation suggesting

that the PF trait was controlled by several genes in this population (Weebadde et al., 2008). Recently, another linkage map was constructed to investigate PF in this 'Tribute' x 'Honeoye' population using SSRs and SCAR markers (Castro et al., 2015). The maps had 119 and 179 markers in 34 and 42 linkage groups, respectively (Castro et al., 2015). Results showed that the PF trait, number of flowering weeks and runner production were mapped to a single location on the LG IV-T-1 between the marker ChFaM148-184T in and ChFaM011-163T with positions 49.3 and 69.4, respectively in the 'Tribute' map. The PF trait segregated 1:1 in states with hot summers such as MD, MN, and MI. In western CA and OR, where the summers are cooler, there were more PF individuals than OF.

Another F_1 population of 213 seedlings from a cross between the PF 'Capitola' and the OF 'CF1116' was used to investigate PF in strawberry (Rousseau-Gueutin et al., 2008). The female and male linkage maps, constructed with 807 SD markers, were 2582 cM and 2165 cM long and distributed in 28 and 26 linkage groups, respectively (Rousseau-Gueutin et al., 2008). Using this map, a single major QTL named *FaPFRU* located on LG IV was found to control perpetual flowering and runnering with opposite effects (Gaston et al., 2013). If a genotype contained the wild allele, it produced more stolons than inflorescences, while the alternate allele of the *FaPFRU* gene resulted in production of more inflorescences than stolons, balancing the sexual and asexual reproduction (Gaston et al., 2013). This agreed with previous observations (Jennings, 1989) that OF cultivars tend to produce more runners from unbranched crowns while PF cultivars developed several crowns with many inflorescences and few stolons.

Current situation of breeding for perpetual flowering

In order to select accurately for perpetual flowering, breeders hope to use marker-assisted selection (MAS). Development of effective molecular markers for MAS requires previous identification of regions in the genome that control PF and validation of marker association with this trait outside the discovery population.

The objective of this study is to validate marker association with PF in four SSRs, Bx89 (~101cM), Bx215 (108.1cM), Bx56 (110.1cM) and Bx63 (118.1cM) flanking the *FaPFRU* locus (106 cM) (B. Denoyes, personal communication) and the SSR EMFvi136 (~80cM) associated with one QTL identified in the 'Tribute' × 'Honeoye' population (J. Hancock, personal communication) in 893 accessions comprised of cultivars, seedling populations linked by pedigree and selections representing diverse strawberry breeding germplasm.

Materials and Methods

Plant material

The 893 *Fragaria* individuals are separated into two reference germplasm sets, the freely distributed Crop Reference Set (CRS) and the private mapping populations. The strawberry germplasm was obtained from multiple institutions including: the USDA-ARS Horticulture Crops Research Unit (ORUS), Michigan State University (MSU), the USDA-ARS National Clonal Germplasm Repository (NCGR), the University of Florida

(UF), the University of New Hampshire (UNH), the Instituto Andaluz de Investigación y Formación Agraria y Pesquera (IFAPA) in Spain, East Malling Research (EMR) in the United Kingdom, the Institut National de la Recherche Agronomique (INRA) in France, and the Center for Genetic Resources (PB-WUR) in The Netherlands. Driscoll Strawberry Associates (Watsonville, CA) imported the European material into the U.S. using their long-established quarantine and propagation facilities (Mathey, 2013).

The four European mapping populations are the INRA, EMR, NL (PB-WUR), and the IFAPA populations (Mathey, 2013). The INRA population consisted of 55 seedlings from the 'Capitola' × CF1116 ('Pajaro' ×['Earliglow'×'Chandler']) cross. The EMR population is comprised of 51 individuals from 'Redgauntlet' × 'Hapil'. The NL (PB-WUR) population is comprised of 24 individuals from 'Holiday' × 'Korona'. The IFAPA population is comprised of 50 individuals from '232' (Sel. 4-43 × 'Vilanova') × '1392' ('Gaviota' ×'Camarosa').

The CRS group is comprised of 17 MSU populations of which 16 have 10 individuals each and one population of 65 progeny; 19 ORUS populations of 10 individuals each; 215 diverse cultivars; 35 wild accessions from the USDA-ARS-NCGR "supercore" collection, 24 wild accessions representing *F. vesca*, *F. chiloensis*, *F. virginiana* and *F. iturupensis*, and 24 individuals from four populations of synthetic *Fragaria* ×*ananassa* (Mathey, 2013).

Two plants of each accession in the form of rooted runners were planted in Michigan, Oregon, New Hampshire, California, and Florida, in August 2010. In June 2011, the INRA, EMR, and PB-WUR populations were planted at each location as multi-crowned plants. The IFAPA population was distributed and planted in September 2011 as bare-root runners (Mathey, 2013).

Phenotyping

The PF trait was collected on most of these individuals for at least two seasons. In 2011 and 2012, plants were considered PF plants if they flowered in the Spring and on or after 17 July (Mathey et al., 2013). The date 17 July was chosen as it represented the first date of flowering evaluation four weeks after the longest day of the year (21 June). Flowers emerging within four weeks of the longest day were likely initiated under shorter days.

Phenotypic data for 2013 was recorded for the four European populations and the 'Honeoye' x 'Tribute' population, parents and 38 cultivars in OR and MI. In total, data was recorded in 2013 from 291 individuals. In 2013, PF data was collected between the second week of March and the last week of September. Presence or absence of open flowers in each individual was recorded weekly. The perpetual flowering trait was determined based on Mathey et al. (2013) as the number of weeks flowering was observed from the first bloom after 17 July.

Genotyping

Young leaves were collected from field-grown plants and the DNA was extracted from 30-50 mg of tissue using the Omega E-Z 96 Plant DNA Kit (OMEGA Bio-Tek, www.omegabiotek.com). DNA was quantified using the Quant-iT PicoGreen dsDNA Assay Kit (Life Technology). DNA stocks were diluted to 3 ng/µl and DNA was amplified in four multiplex PCR reactions (Table 1.1) with the Type-It Multiplex Microsatellite PCR Qiagen kit (QIAGEN, http://www.qiagen.com) in a total volume of 15 µL. Each PCR reaction had 8.3 µL of 2x Type-it Multiplex PCR Master Mix (Qiagen), 1.7 µL of 10X multiplex primer mix, 1.7 µL of Q-solution and 3.3 µL of 3 ng/µl DNA. The final primer concentration for each fluorescently labeled forward standard and reverse pig-tailed primers was 0.05µM for EMFvi136, 0.1µM for Bx215, Bx56 and Bx63 and 0.17 µM for Bx89.

Thermocycler amplification was performed in a PTC-225 Thermal Cycler (MJ Research, Inc., Waltham, MA) using a Touch Down 52 program, which consisted of an initial denaturation of 95 °C for 5 min; 10 cycles of 95 °C for 30 s; 62 °C for 1.5 min minus 1°C per cycle; and 72 °C for 30 s; followed by 29 cycles of 95°C for 30 s; 52 °C for 1.5 min; 72 °C for 30 s; and a final extension at 60 °C for 30 min. The PCR products were kept at 4 °C until removed from the thermocycler (Mathey 2013). PCR success was assessed by 3% agarose gel electrophoresis. Allele composition at each SSR locus was determined after separation by capillary electrophoresis either with the ABI 3730 (Applied Biosystems) for multiplexes 1, 3 and 4 at Oregon State University's Center for Genome Research and Biocomputing (CGRB) core laboratory or the Beckman CEQ

8000 (Beckman Coulter, Inc, Pasadena, CA) for multiplex 2 at the NCGR laboratory. GeneMapper IDXv. 4.1 software (Life Technologies Corp., Carlsbad, CA) and the Beckman CEQ 8000 (Beckman Coulter, Inc, Pasadena, CA) software, respectively, were used for allele visualization and scoring.

Microsatellite Allele Dose and Configuration Establishment (MADCE)

The MADCE approach facilitates the establishment of the full allelic configuration in an individual (van Dijk et al., 2012). This technique consists of three main steps performed initially in bi-parental populations and described in detail by van Dijk et al. (2012): qualitative interpretation of microsatellite data, quantitative interpretation of microsatellite data, and parental allele configuration and allele segregation verification. The qualitative interpretation consists of identifying the alleles that are present or absent in the progeny (van Dijk et al., 2012). This allows the identification of the homologous alleles in the parents that are also known as repulsion alleles. The quantitative interpretation consists of calculating the average of the allele peak areas in both parents and progeny (Example in Table 1.22, Step 1). The area of each allele is then divided by the average of the allele peak areas and multiplied by the factor 8 (Table 1.22, Step 2). The resulting value is known as the ratio values of each allele. The ratio value distribution of one allele in the progeny permits us to determine the allelic doses. The conversion of the allele areas to allele doses (Table 1.22, Step 3) is followed by the identification of the homologous alleles in the parents. All of the previous steps allow an estimation of allelic doses and find the allelic configuration for one marker in

the progeny and the parents (Table 1.22, Step 4). The distribution of alleles in the four subgenomes is subsequently verified in other populations and can then be imputed in unrelated cultivars.

We used MADCE to establish the allele composition in the four strawberry subgenomes for amplicons generated by SSR markers EMFvi136 in 886 individuals, Bx215 in 383 individuals, Bx56 in 384 individual and Bx63 in 820 individuals. SSR Bx89 was analyzed as a dominant marker with presence and absence of alleles since the occurrence of small peaks and stutters complicated the completion of MADCE.

Statistical analysis

The PF trait was compared between individuals with a specific allele and individuals without a specific allele using a t-test at each of the SSRs (Tables 1.2 - 1.6). For each allele, number, mean and P-value were calculated. Alleles occurring in fewer than five individuals were considered rare and excluded from the analysis.

For the six alleles at five loci where the most significant association to the PF trait was found (EMFvi136_167, Bx89_251, Bx89_262, Bx215_129, Bx56_209 and Bx63_149), we calculated the percentage of individuals where presence of the significantly associated allele was associated with expression of the PF trait, and where absence of the allele was associated with absence of the PF phenotype, called marker trait association (MTA). MTA for the six alleles was obtained first for all the samples that had

phenotypic data and genotypic data for each of these alleles per state per year. MTA was also calculated for each state and year in all the samples based on each of the nine PF sources including: 'Capitola', 'Sarian'_CF, 'Tribute', 'Fort Laramie'_NCGR, 'Fort Laramie'_I1, 'Seascape'_CF, FRA_1701, FRA_1701_I1, and FRA_1701_I2.

Since Bx215 (108.1cM) and Bx56 (110.1cM) (B. Denoyes, personal communication) were mapped closest to the *FaPFRU* locus in the 'Capitola' x CF1116 mapping population, we compared the percentage of individuals where presence of the significantly associated allele (Bx215_129 and Bx56_209) was associated with expression of the PF trait, and where absence of the allele was associated with absence of the PF phenotype in each state per PF source ('Capitola', 'Sarian', 'Tribute', 'Fort Laramie'_NCGR, 'Fort Laramie'_I1, FRA_1701, FRA_1701_I1, FRA_1701_I2 and 'Seascape') in breeding populations. When genotypes of progeny of some families did not match that of their listed parent ('Fort Laramie', or FRA 1701), the genotype of the parent used was inferred based on that of the progeny and the other parent, and is referred to as: 'Fort Laramie'_I1, FRA_1701_I1 or FRA_1701_I2 to match that of the progeny of each family.

At Bx215, the combination of alleles that best explained the PF trait in the populations was estimated using repeated ANOVA tests in the statistical package R version 0.98.501, 2009-2013. The first round consisted of running an ANOVA test by comparing PF means when alleles were absent to means when alleles were present for each of the alleles amplified with Bx215. The most significant allele was identified based

on three criteria including: the smallest P values, the greatest difference between PF means, similar variances and number of samples greater than six. Then, individuals were separated into two groups: one containing the allele and the other one not containing it. The ANOVA test was run again in each of the subsamples and the most significant allele was again identified. Subsets were obtained again based on presence and absence of the identified alleles and ANOVA tests were run and alleles were identified once more. Each of the combinations of presence and absence of alleles obtained were then analyzed with the actual PF phenotypic data and the percentage of individuals with or without the PF trait was obtained.

Results

SSR performance

EMFvi136 amplified 47 different alleles in 886 individuals: 32 in the 805 *F.* ×*ananassa*; 23 in the 22 *F. chiloensis*; 29 in the 43 *F. virginiana*; 16 in the 23 individuals representing synthetic *F.* ×*ananassa*; and 5 in the 7 *F. vesca* individuals (Table 1.2). There were 12 unique alleles present in *F. virginiana*, one in *F.* ×*ananassa* and one in *F. chiloensis.* 38 of the 47 amplified alleles consisted of a series of alleles that are different from each other by one base pair (bp). In addition to the one bp differences between the majority of the alleles (illustrated in Fig. 1.1 for alleles 141 and 142), stuttering before alleles made it challenging to distinguish a stutter from an allele as exemplified by the 139 allele (Fig. 1.1). Establishing the allelic configuration using MADCE in the European, MSU and ORUS populations identified null alleles in each of the four

subgenomes and helped us distinguish true alleles from artifacts. The four subgenomes were named in this study as A, B, C and D. Nine alleles were subgenome-specific while the remaining 19 alleles were shared among two, three or four subgenomes in 618 individuals (Table 1.7).

Primer pair Bx89 amplified 19 alleles in 810 samples made up of 743 *F.* ×*ananassa,* 19 *F. chiloensis,* 23 *F. virginiana,* 23 synthetic *F.* ×*ananassa* and 2 *F. vesca* genotypes (Table 1.3). Four alleles were unique to *F.* ×*ananassa* and one was only found in the *F. chiloensis* individuals. The main challenge when scoring this marker was due to the presence of small peaks of size 246, 262 and 272-274 bp (illustrated at 260-262 and 271-273 in Fig. 1.2). Also, non-uniform wide peaks were observed for some alleles as shown for alleles 247, 257, 262 and 267 (Fig. 1.3). Allele configuration could not be established for this SSR, most likely due to inefficient amplification as observed by small non-uniform peaks. It was thus scored as a dominant marker.

Bx215 produced 22 alleles in 383 individuals comprised of 359 *F.* ×*ananassa,* 2 *F. chiloensis,* 12 *F. virginiana,* and 10 synthetic *F.* ×*ananassa* genotypes (Table 1.4). The number of unique alleles was three in each of *F.* ×*ananassa* and *F. virginiana* individuals and two in the samples representing synthetic *F.* ×*ananassa.* Challenges of scoring at this locus included single bp differences between alleles 126, 127, 128 and 129 in addition to stutters before alleles 129, 158 and 160 obstructing discrimination of stutter from alleles 127 and 158 (Fig. 1.4). Establishing allelic composition using MADCE was challenging due to the presence of null alleles at each of the subgenomes and multiple shared alleles

between two, three or the four subgenomes. MADCE was conducted for the INRA, NL, 14 MSU and 14 ORUS populations. Null alleles were detected in each of the subgenomes and two alleles, 132 and 143 were specific to sub-genome C while the remaining alleles were shared among subgenomes (Table 1.7).

Bx56 amplified 18 alleles in 384 individuals that included 360 *F.* ×*ananassa*, 2 *F. chiloensis*, 12 *F. virginiana*, and 10 synthetic *F.* ×*ananassa* (Table 1.5) genotypes. There were two unique alleles in *F.* ×*ananassa* and three in *F. virginiana*. Allele calling was easy at Bx56 due to lack of stutters or other artifacts except at 221, which had a small area in few cases (Fig. 1.5). The allelic configuration for parents and progeny from Europe, MSU and ORUS was relatively easy to establish with MADCE. Single bp differences between alleles were observed at alleles 213, 214 and 215 and null alleles were found in subgenomes A, B and D. (Table 1.7). Six of the 13 alleles generated in 303 individuals were subgenome-specific while the remaining seven were shared among subgenomes.

Bx63 produced nine alleles in a total set of 820 individuals made up of 754 *F.* ×*ananassa*, 16 *F. chiloensis*, 24 *F. virginiana*, 24 synthetic *F.* ×*ananassa*, *a*nd 2 *F. vesca* genotypes (Table 1.6). One allele (142) was common between *F.* ×*ananassa* and *F. virginiana*. Bx63 was easy to score due to the absence of stutter and one bp differences between alleles (Fig. 1.6). Establishing allelic configuration using MADCE was also easily completed because of subgenome specificity in all but three alleles. Alleles 139, 142, and 145 were specific to sub-genome A. Alleles 127 and 135 were specific to sub-

genomes C and B, respectively. Allele 149 segregated in sub-genomes A and B; 123 in subgenomes C & D, while 133 was shared among the four subgenomes (Table 1.7).

Parentage verification

Based on the allelic composition obtained with MADCE for SSRs EMFvi136, Bx215, Bx56 and Bx63 and allele segregation at Bx89, parentage was confirmed and seedlings that had unlikely genotypes or alleles based on Mendel's Law of Inheritance were identified in each of the European (four), MSU (17) and ORUS (19) populations (Appendix Table 3.1-3.4). Of the four European mapping populations, parent plants or DNA were provided and genotypic composition at each of the SSRs verified their parental relationship to the seedlings. Plants were obtained from parents '232' and '1392' along with progeny of the IFAPA population. Plants from two different sources, NCGR, in Corvallis, OR, and PB-WUR in the NL, were propagated and evaluated from 'Redgauntlet', 'Holiday' and 'Korona'.

Two genotypes were observed for 'Redgauntlet' at EMFvi136, Bx63 (Table 1.9.) and Bx89 (Table 1.11) that distinguished the NCGR source from that of the PB-WUR in the NL. The genotype of the NCGR 'Redgauntlet' matched that of the maternal parent of the EMR population while that of 'Hapil' obtained from PB-WUR matched that of the pollen parent at EMFvi136 and was inferred at Bx63. Presence of the 167 allele at EMFvi136 in the A subgenome in two seedlings (EMR_16 and EMR_99) and its absence in either parents indicated possible outcrossing (Table 1.12).

‘Holiday’ and ‘Korona’ obtained from PB-WUR were confirmed as parents of the NL population. The genotypes of ‘Holiday’-CF matched that of ‘Holiday’-NL at each of the SSR tested: EMFvi136, Bx63 (Table 1.9) and Bx89 (Table 1.11). The genotype of ‘Korona’-CF was different from that of ‘Korona’-NL at EMFvi136 and Bx63 (Table 1.9). Genotypes of each of the 24 seedlings matched those obtained from this cross (Appendix Table 3.2).

‘232’-CF and ‘1392’-CF were also confirmed as parents of the IFAPA population and all progeny appeared to result from this cross based on genotypes at EMFvi136 and Bx63 (Appendix Table 3.2). The genotypes of ‘Capitola’ and CF1116 obtained from France matched those of the parents of the INRA population based on genotypic data at Bx215, Bx56 (Table 1.10) and Bx63 (Table 1.9). CF1116 was inferred at EMFvi136, which resulted in two seedlings as possible outcrosses: INRA_116 and INRA_165 due to the presence of alleles 165 and 169, respectively, which are absent in the parents (Table 1.12).

Plants from the parents of the MSU and ORUS populations were planted in the field in Oregon for phenotypic evaluation, and included all parents of the synthetic *F.* ×*ananassa* populations except for JH_101-1. The genotypes of MSU_49, MSU_56, ‘Earliglow’, ‘Totem’, ‘Seascape’ and ‘Tribute’ matched that of the parent plant used in all of the crosses in this study (Table 1.8). The genotype of ‘Tribute’ from the field also matched that obtained from the NCGR at EMFvi136, Bx215 and Bx56.

The genotypes of field-grown plants of ‘Honeoye’, ‘Fort Laramie’ and FRA 1701 did not match genotypes of parents used in one or more of the MSU crosses. The three ‘Honeoye’ samples (‘Honeoye’-NCGR and plants at two locations in the Oregon field: ‘Honeoye’-CF_14-74 and ‘Honeoye’-CF_6-73) had different genotypes (Table 1.9 - 1.11). ‘Honeoye’-CF_14-74 and ‘Honeoye’-CF_6-73 had different genotypes at Bx89 (Table 1.11) and Bx63 (Table 1.9). The genotype of ‘Honeoye’-NCGR matched that of the parent used in each of the four MSU crosses: MSU_9-9, MSU_9-12, MSU_9-13, and MSU_9-16 and was subsequently used to confirm parentage in the progeny. The genotype of the field-planted ‘Fort Laramie’ matched that of the female parents in each of the four crosses where it was used (MSU_9-8, MSU_9-9, MSU_9-10 and MSU_9-11) but was different from that of the pollen parent for MSU_9-18. For the FRA 1701 parent, the genotype of the field plant did not match that of the parent in any of the MSU populations. When inferred as FRA_1701_I1, it matched that of the male parent for MSU_9-4 and for some of the progeny of MSU_9-1 as well as the female parent for MSU_9-5 at EMFvi136 and Bx63 but not in MSU_9-12 (Table 1.8). FRA_1701_I2 was then inferred as the male parent for some of the MSU_9-12 progeny at EMFvi136 and Bx63.

Allele and genotype segregation allowed us to identify seedlings that did not segregate according to pedigree. In MSU_9-16 (‘Tribute’ ×‘Honeoye’), the largest population of 65 seedlings, four individuals (MSU_9-16-8, MSU_9-16-50, MSU_9-16-57 and MSU_9-16-61) had one to three alleles not present in either parent (Table 1.12 - 2.14): 206 at Bx56 in MSU_9-16-8; 160 at EMFvi136 in MSU_9-16-50; 169 and 121 at

EMFvi136 in MSU_9-16-57; and 159 and 144 at EMFvi136, and 280 at Bx89 in MSU_9-16-61. In the remaining 16 MSU populations of 10 seedlings each, presence of alleles in the progeny not observed in the parents was seen in seven populations: MSU_9-2; MSU_9-6, MSU_9-8; MSU_9-9; MSU_9-13, MSU_9-15 and MSU_9-18. However, deviation from Mendelian segregation of the genotypes present in the parents as determined by MADCE was observed for individuals from two populations (MSU_9-2, and MSU_9-6) at mostly one of two SSRs, Bx215 and EMFvi136 and included: MSU_9-2-1, MSU_9-2-10, MSU_9-6-9 and MSU_9-6-10 at Bx215; MSU_9-6-4 and MSU_9-6-8 at EMFvi136 and at Bx215. In MSU_9-6-2, genotype at EMFvi136 and Bx63 did not segregate according to pedigree (Appendix Table 3.2 -3.3).

The number of seedlings whose genotype contained alleles not present in either parent ranged from one in MSU_9-10 (MSU_9-10-1) and MSU_9-17 (MSU_9-17-2) to seven in MSU_9-1 (MSU_9-1-2, MSU_9-1-4, MSU_9-1-5, MSU_9-1-6, MSU_9-1-7, MSU_9-1-9, and MSU_9-1-10) (Table 1.12 - 1.14). MSU_9-10-1 had 206 and 226 at Bx56 and the allelic configuration at Bx215 did not show a correct segregation from the parents based on dosage. MSU_9-17-2 had 161 and 163 at EMFvi136 and 126 at Bx215. MSU_9-1-2, MSU_9-1-4, MSU_9-1-6, MSU_9-1-7, MSU_9-1-9, and MSU_9-1-10 had 137 at EMFvi136 and 145 at Bx63 while MSU_9-1-5 had 137 at EMFvi136. Populations MSU_9-4, MSU_9-11 and MSU_9-14 had two seedlings each that contained alleles different from those found in the parents (Table 1.12 - 1.14). MSU_9-4-7 had 135 at EMFvi136 and MSU_9-4-3 had 145 at Bx63 in addition to 135 at EMFvi136. MSU_9-11-7 had 167 at MSU_9-11-8 had 163 at EMFvi136 in addition to an allelic configuration

based on dosage that did not match their pedigree at Bx63. MSU_9-14-3 contained different alleles than its parents at EMFvi136 (149), Bx215 (128) and Bx56 (217) while MSU_9-14-7 had the 275 allele not present in either parent at Bx89. Genotypes of both MSU_9-14-3 and MSU_9-14-7 did not agree with their parental derivation at Bx63.

Populations MSU_9-3, MSU_9-5, and MSU_9-12 had four seedlings each that contained different alleles from their respective parents (Table 1.12 - 1.14). MSU_9-3-3, MSU_9-3-5, MSU_9-3-6, and MSU_9-3-9 had different alleles than those present in the parents at each of the five SSRs evaluated in this study. MSU_9-5-2 had the 131 allele at EMFvi136 while MSU_9-5-6, MSU_9-5-7, and MSU_9-5-8 had the 137 allele at EMFvi136 and 145 at Bx63. In MSU_9-12, one offspring, MSU_9-12-4 had a variant allele (147) at EMFvi136 while the remaining three (MSU_9-12-3, MSU_9-12-7, and MSU_9-12-8) varied at two SSRs, EMFvi136 and Bx63 (Table 1.9).

There were five individuals that had similar alleles to parents but genotypes that did not match the parental contributions including: MSU 9-17-6 at Bx215; MSU_9-4-8 at EMFvi136 and Bx63; MSU_9-5-9 at EMFvi136; and MSU_9-11-2 and MSU_9-11-4 at Bx56 (Appendix Table 3.2 - 3.3).

In the ORUS populations, genotypes of ‘Totem’ matched that of the parent plant in all three crosses where it was used (Table 1.8). The genotype of FRA_1701 matched that of the male parent for all seedlings of ORUS_3306 and ORUS_3317 and for some of the ORUS_3277 and ORUS_3304 progeny. The genotype of ‘Sarian’ from the field

(‘Sarian’-CF) was different from that of Sarian_ORUS_2691-1 (Table 1.10) and matched that of the female parent for ORUS_3319, ORUS_3320, and some of the progeny of ORUS_3321 in addition to the male parent for ORUS_3318.

The genotypes of field-grown plants of ‘Fort Laramie’, ORUS_2427-1, ‘Puget Reliance’ and ‘Tillamook’ did not match genotypes of parents used in one or more of the ORUS crosses (Table 1.8). ‘Fort Laramie’-CF did not match any of the parents for the ORUS crosses. When inferred, the genotype of ‘Fort Laramie’-I1 matched that of the female parent of ORUS_3316 and the male parent of ORUS_3324 at EMFvi136, Bx215, Bx56 and Bx63. Neither of the two genotypes of ‘Fort_Laramie’ was concordant with seedlings genotypes for the ORUS_3314 and ORUS_3315 populations. ‘Fort_Laramie’_I2 was inferred as the female parent for ORUS_3314 at EMFvi136 and Bx63 and ‘Fort_Laramie’_I3 as the female parent for ORUS_3315 at EMFvi136, Bx215, Bx56 and Bx63.

Genotypes for the two ORUS 2427-1 plants in the field, ORUS 2427-1_CF_1-21 and ORUS 2427-1_CF_1-22, were different from each other (Table 1.10). The genotype of ORUS 2427-1_CF_1-22 matched that of the female parent for some of the seedlings of ORUS_3277 and for all seedlings for ORUS_3278 and ORUS_3279 (Table 1.8). When genotypes of either plant did not match that of the parent of the ORUS_3314, ORUS_3319 and ORUS_3322 populations, they were inferred. The inferred genotype of ORUS 2427-1_I1 matched that of the male parent for all progeny of ORUS_3319 and some of the progeny of ORUS_3322 at EMFvi136, Bx215, Bx56 and Bx63 (Table 1.9 -

1.10). The inferred genotype of ORUS 2427-1_I2 matched that of the male parent for ORUS_3314 at EMFvi136 and Bx63.

The genotype of the 'Puget Reliance' individual planted in the field matched that of the male parent only for ORUS_3315 at EMFvi136 and Bx63 and was inferred at Bx215 and Bx56 but none of the other four populations where it was used as a parent: ORUS_3317, ORUS_3318, ORUS_3323, or ORUS_3326 (Table 1.8). Puget Reliance_I1 was inferred as the female parent for progeny of ORUS_3317 at EMFvi136 and Bx63 and ORUS_3318 at EMFvi136, Bx215, Bx56 and Bx63 (Table 1.9 - 1.11) and as the male parent for some of the progeny of ORUS_3323, and all progeny of ORUS_3326 at EMFvi136, Bx215, Bx56 and Bx63.

The genotype of the 'Tillamook' individual planted in the field matched that of the female parent for ORUS_3324 and ORUS_3325 and the male parent for some of the seedlings of ORUS_3321 (Table 1.8). The genotype of the 'Tillamook' individual obtained from the NCGR was different from that planted in the field and matched that of the female parent for ORUS_3305 at EMFvi136, Bx215, Bx56 and Bx63 (Table 1.9 - 1.11). Neither genotype matched that of the female parent of the ORUS_3304 population. 'Tillamook'_I1 was inferred at EMFvi136 and Bx63 and its genotype matched that of the female parent for some of the progeny for ORUS_3304.

Allele and genotype segregation allowed us to identify progeny that did not segregate according to pedigree in the 19 ORUS populations of 10 seedlings each.

Presence of different alleles in the seedlings was not observed in eight populations: ORUS_3278, ORUS_3279, ORUS_3306, ORUS_3315, ORUS_3317, ORUS_3318, ORUS_3324 and ORUS_3325. However, deviation from Mendelian segregation based on allele composition in the parents and progeny identified by MADCE was found in two seedlings in each of the ORUS_3279 [(ORUS_3279-4 at Bx215); (ORUS_3279-8 at Bx215 and Bx56)], ORUS_3315 [(ORUS_3315-11 and ORUS_3315-12 at EMFvi136 and Bx56); (ORUS_3315-11 at Bx215)], ORUS_3325 populations (ORUS_3325-5 and ORUS_3325-11 at Bx215), and in eight seedlings in ORUS_3318 [(ORUS_3318-1, ORUS_3318-8 and ORUS_3318-9 at EMFvi136); (ORUS_3318-6 and ORUS_3318-10 at Bx215); (ORUS_3318-12 at EMFvi136 and Bx215); (ORUS_3318-14 at Bx215 and Bx56); and ORUS_3318-4 at EMFvi136, Bx215 and Bx56)] (Appendix Table 3.2 - 3.4).

The number of seedlings whose genotype contained alleles not present in either parent ranged from one in ORUS_3305, ORUS_3316 and ORUS_3320 to six in ORUS_3304 and ORUS_3321 (Tables 1.12 - 1.14). ORUS_3305-7 and ORUS_3316-9 had the 147 and 143 alleles, respectively, at EMFvi136. ORUS_3320-1 had different alleles at three SSRs: 129, 165, 144, 137 and 139 at EMFvi136; 142 at Bx63; and 211 and 219 at Bx56. Two individuals with alleles that were not found in the parents were observed in each of the ORUS_3319 and ORUS_3326 populations: ORUS_3319-5 and ORUS_3319-7 had the 169 allele at EMFvi136 and ORUS_3326-2 and ORUS_3326-4 had the 163 and 141 alleles, respectively, at EMFvi136. ORUS_3326-4 also showed allelic composition discordance at Bx215 and Bx63 (Appendix Table 3.2 - 3.3).

Three individuals with alleles that were different from the parents were observed in each of three populations: ORUS_3314, ORUS_3322 and ORUS_3323 (Table 1.12 - 1.14). In ORUS_3314, both parents (‘Fort_Laramie’ ×‘ORUS_2427-1’) were inferred at EMFvi136 and Bx63. Each of the three seedlings had a different allele at EMFvi136: 161 in ORUS_3314-2 and ORUS_3314-10; and 147 in ORUS_3314-15. At EMFvi163, one allele, 169, was also present in, ORUS_3322-2, ORUS_3322-5 and ORUS_3322-12 at EMFvi136 and another allele, 163 in ORUS_3323-3, ORUS_3323-7 and ORUS_3323-9 that were not present in either of the parents. These individuals, ORUS_3323-3, ORUS_3323-7 and ORUS_3323-9 also showed discordance in the allelic configuration at Bx215 (Appendix Table 3.3).

Five individuals were observed in ORUS_3277, and six in ORUS_3304 and ORUS_3321 to have alleles that were different from those in the parents (Table 1.12 - 1.14). ORUS_3277-1, ORUS_3277-2, ORUS_3277-3, ORUS_3277-4 and ORUS_3277-5 had the 129 allele at Bx63. In ORUS_3304-2, ORUS_3304-6, ORUS_3304-8, ORUS_3304-9, ORUS_3304-11 and ORUS_3304-13 three to five alleles not present in the parents were found at EMFvi136. Allele differences at one (Bx215 in ORUS_3321_6); two [(EMFvi136 and Bx63 in ORUS_3321-2 and ORUS_3321-3); (EMFvi136 and Bx215 in ORUS_3321_7)]; and four SSRs (all but Bx89 in ORUS_3321-8 and ORUS_3321-9) were found in the ORUS_3321 population.

The percentage of outcrosses considering only the samples with alleles different from those present in the parents was 16.8% [27/(16*10)] in the MSU breeding program and 17.36% [33/(19*10)] for the ORUS program.

Marker trait association with perpetual flowering

Association between the PF phenotype and alleles at each of the five SSRs was determined after calculating the number of samples, means and P-values obtained from a comparison between individuals with each of the specific alleles and individuals without these alleles using a t-test (Tables 1.15 - 1.18) for each state, year and allele. Rare alleles occurring in less than five individuals were not included in the analysis resulting in 23 at EMFvi136; 16 at Bx89; 10 at Bx215; and 7 alleles at Bx56 and Bx63. Only results obtained with alleles that showed significant association are indicated (Tables 1.15 - 1.18). For all the states, but CA_12 and OR_13, six common alleles consistently showed high significance: EMFvi136_159, EMFvi136_167, Bx89_251, Bx215_129, Bx56_209 and Bx63_149. Even though EMFvi136_159 was associated at P-value $\leq$ 0.05 with PF in all states and years (Tables 1.15 - 1.18), differences between means for PF and non PF plants were low and ranged from 0.10 in MI_12 to 0.18 in MI_11. Therefore, MTA was not analyzed further for this allele. The presence of EMFvi136_167 and Bx63_149 was significantly associated with PF in all states and years except for OR_2013 and differences between means for PF and non PF plants were moderate to high and ranged from 0.27 – 0.46 and 0.23 – 0.55, respectively (Table 1.16 -1.18). Bx89_251 was significantly associated with PF in all states and years except for OR_2012 and OR_2013

and differences between means for PF and non PF plants ranged from 0.16 in NH_12 to 0.36 in MI_11 (Table 1.16 - 1.18).The presence of Bx215_129 or Bx56_209 was significantly associated with PF in all states and years except for CA_2012 and OR_2013 and differences between means were moderate to high and ranged from 0.27 in OR_11 and 0.6 in MI_13, and from 0.2 in OR_11 to 0.5 in MI_13, respectively (Table 1.16 - 1.18). Bx89_262 showed significant association in OR and MI for all years but MI_13 and the difference between means for PF and no PF plants was between 0.13 in OR_12 and 0.34 in OR_13. Based on statistically significant allele association with PF in most states except for CA_12 and OR_13 and the highest difference between means for PF and non PF plants, the six alleles (EMFvi136_167, Bx89_251, Bx89_262, Bx215_129, Bx56_209 and Bx63_149) were analyzed further.

Presence of these six alleles was evaluated in PF and OF parents used in the MSU and ORUS breeding populations included in this study. All but the Bx89_251 allele associated with PF were present in three parents used as sources of this trait in the MSU and ORUS populations including 'Fort_Laramie'_NCGR, 'Seascape', and 'Tribute' (Table 1.11). 'Sarian' had only EMFvi136_167, Bx89_251, and Bx89_262 while FRA 1701_1 did not have any of these six alleles. In 'Capitola', all but Bx63_149 were present while the latter was found in the OF parent CF1116. Most of these alleles were also found in the OF parents used (Table 1.9 - 1.11). Out of the nine OF parents used, only two, 'Honeoye' and MSU_56, did not have any of these alleles. 'Tillamook'_CF and 'Totem'-CF had only Bx56_209. 'Puget Reliance'-CF had Bx89_262 in addition to Bx56_209. ORUS_2427-1-CF22 had two PF-associated alleles, Bx89_251 and

Bx56_209, while three were found in ‘Tillamook’-1819.001 (Bx89_251, Bx89_262, and Bx56_209). In MSU_49, four of the six alleles were present (Bx89_262, Bx215_129, Bx56_209 and Bx63_149) and ‘Earliglow’_CF had all but EMFvi136_167. Bx56_209 was the most frequent PF associated allele in the OF parents and it was present in seven of the nine parents (all but ‘Honeoye’ and MSU_49).

The number of samples genotyped with the five SSRs across the states and years was variable (Fig. 1.7). Most of the samples were genotyped with EMFvi136, Bx89, and Bx63 and a subset of samples with Bx215 and Bx56. MTA values using the entire data set (Fig. 1.7) indicated that Bx89_251 and Bx63_149 resulted in MTA greater than 70% in MI, NH and OR except for MI_2011 at Bx89_251 where it reached 68%.

MTA was subsequently analyzed in breeding germplasm derived from each of the nine sources of the PF trait that contained some of these six alleles: ‘Capitola’, ‘Seascape’_CF, ‘Tribute’, ‘Fort Laramie’_NCGR, ‘Fort Laramie’_I1, and ‘Sarian’_CF, (Fig. 1.8 - 1.13). For the progeny of ‘Capitola’, association rate between Bx89_262, Bx215_129, Bx56_209 and Bx63_149 and PF was identical across each of the three states (CA, MI, and OR) and years where PF was recorded (Fig. 1.8). The highest MTA was for MI_13 (88%), OR_12 (72%) and MI_12 (68%) while it was less than 50% in CA_12 and OR_13. In ‘Seascape’ and ‘Tribute’-derived germplasm, most of the individuals were perpetual flowering in CA_12 irrespective of allele presence at each of these SSRs (Fig. 1.9 - 1.10). A similar pattern of MTA at each of the five alleles was observed. In OR_11, OR_12, MI_11 and MI_12, where the largest numbers of

individuals were phenotyped for this trait and genotyped for these alleles, MTA was moderate to high for allele presence at each of these five SSRs. Still, these alleles were also frequently present in OF individuals. Higher MTA was observed in MI than in OR at all but EMFvi136_167 where the % MTA was similar. Very few of the individuals were perpetual flowering when any of these five alleles were absent.

MTA profiles of 'Fort-Laramie'-NCGR and 'Fort_Laramie'-I1 at each of the five PF_associated alleles were different. The greatest MTA percentages (60-90%) in individuals derived from the 'Fort_Laramie'-NCGR PF source were obtained with EMFvi136_167 (Fig. 1.11). Bx215_129, Bx56_209 or Bx63_149 were present in PF and in OF progeny, specifically in the MSU_9-8 and MSU_9-10 populations where the OF parents, 'Earliglow' and MSU_49, respectively, had each of these alleles. In the subsample with the Fort_Laramie'_I1 source, Bx215_129 and Bx63_149 resulted in percentages of MTA between 70-98% in MI_11, MI_12, OR_11 and OR_12 (Fig. 1.12).

For the 'Sarian'_CF source, all three alleles, EMFvi136_167, Bx89_262 and Bx56_209, had high percentages of coincidence (>60%) across most states (Fig. 1.13).

Genotype association

Since Bx215 mapped closest to the *FaPFRU* locus (B. Denoyes, personal communication) and resulted in high MTA with PF where present, we assessed genotype association with PF. The combination of alleles that best explained the PF trait in the

breeding populations was estimated using repeated ANOVA tests comparing the mean for PF trait between presence and absence of the allele for all of the obtained alleles (Table 1.19 - 1.21). In the first round of ANOVA tests, the presence of 129 showed highest association with the PF trait (Table 1.19). In the second round, two groups were analyzed: individuals with 129 (Y.129) and individuals without 129 (N.129) (Table 1.20). The presence of 136, 143 and 160 in the group containing 129 and the presence of 123 in the group lacking 129 were associated with absence and presence of the PF trait, respectively. 136 and 160 were shared among three or four of the subgenomes based on MADCE analysis while 143 was specific to subgenome C (Table 1.7). In the third round of ANOVA, we looked at differences among groups containing the three alleles found to influence PF: 123, 143 and 129 in combination with all others in four groups: individuals with alleles 129 and 143 Y129.Y143; individuals with 129 and without 143 (Y.129.N.143); individuals without 129 and with 123 (N.129.Y.123); and individuals without 129 and 123 (N.129.N.123) (Table 1.21). For each of the four groups, the ANOVA tests were run again for association of presence and absence of each of the alleles with means of the PF trait. The absence of 160 was found to be most associated with the PF trait in the group with the allelic combination Y.129.N.143. For individuals with N.129.Y.123 combination, presence of 134 was significantly associated with the PF trait. For the group without alleles 129 and 123 (N.129.N.123), the presence of allele 127 was associated with the PF trait.

In total, seven different allelic combinations were obtained: Y129.Y143, Y129.N143.Y160, Y129.N143.N160, N129.Y123.Y134, N129.Y123.N134,

N129.N123.Y127 and N129.N123.N127 (Fig. 1.14). These seven allelic combinations can be classified into three categories: highly predictive for the presence of PF trait, highly predictive for the absence of the PF trait, and not predictive. The two highly predictive allelic combinations for the PF trait were Y129.N143.N160 and N129.Y123.Y134 and had 77.3% and 60% of individuals that expressed the PF trait, respectively. The three highly predictive allelic combinations for the absence of the PF trait were N129.Y123.N134 and N129.N123.N127 where 100% of the individuals were OF and N129.N123.Y127 where OF accounted for 83% of individuals (Fig. 1.14). The allelic combinations that were least predictive were those with Y129.Y143.N160 and Y129.N143.Y160 where 48 and 42%, respectively, of individuals with that genotype were PF (Fig. 1.14). Based on these results, four alleles (129, 123, 127 and 134) appear to enhance the PF trait, while 143 and 160 appear to have a negative effect on the PF trait.

Discussion

SSR performance

Reliability of the MADCE methodology for dose estimation and correct interpretation of allelic configuration depends on the overall quality of the amplified peaks with regards to lack of stutter in addition to narrow, well-separated, and defined peaks. It also depends on the quality of the reference allele. We used average-based reference alleles for each SSR (van Dijk et al., 2012). Bx56 and Bx63 were easier to score than EMFvi136, Bx89 and Bx215. Bx56 and Bx63 had well-defined peaks with no stutters or artifacts (Fig. 1.5 - 1.6) and completing MADCE was relatively easy. Most of

the alleles except for the largest (221 bp at Bx56) appeared to amplify efficiently that also made scoring alleles easy (Appendix Table 3.2 - 3.3).

EMFvi136, Bx89 and Bx215 were more difficult to score because of presence of one-bp difference alleles, stutters and small peaks indicating inefficient amplification (Fig. 1.1 - 1.4). Furthermore, the presence of null alleles, a large number of alleles, and multiple shared alleles, complicated assignment of alleles to subgenomes and establishment of an accurate allelic configuration. MADCE was completed only for EMFvi136 and Bx215. Confirmation of this allelic configuration is needed through mapping in multiple populations as recommended by van Dijk et al. (2012).

Parentage verification

We first confirmed parental genotypes using the genotype of the majority of progeny in multiple populations that shared the same parent at each SSR. For example, the genotype of 'Tribute' was verified at each SSR after checking the genotypes of the progeny from the MSU_9-16 mapping population in addition to those of MSU_9-15 and MSU_9-17. We then used 'allele presence' in progeny and absence in the parent at one or more SSRs to identify individuals that may be outcrosses, which resulted in an off type rate of 16.8% in the MSU breeding program and 17.36% for the ORUS program. This rate is comparable to that reported in apple at the WSU breeding program (Peace, 2015).

Based on allelic configuration establishment, seven additional progeny from the MSU breeding program and 12 from the ORUS program did not have the expected genotype based on their parentage (Appendix Table 3.2 - 3.3). We did not include these in calculating the out-crossing rate as their genotypes were mostly non-concordant with their stated pedigree at the challenging EMFvi136 and Bx215 loci where the established allelic configuration needs further verification by linkage mapping. Many of these populations were also genotyped with the Affymetrix IStraw90® Axiom array (Bassil and Davis et al., 2015). The resulting genome-wide SNP genotypes will be used to confirm parentage.

Unexpectedly, multiple genotypes were identified for some of the parents used in the MSU and the ORUS breeding populations. In the MSU breeding programs, multiple genotypes of 'Fort Laramie' and FRA 1701 were used in the crosses. In the ORUS program, multiple genotypes were found for 'Tillamook' and 'Puget Reliance'. Also, the genotype of the FRA 1701 used as parent in the MSU populations was different from that used in the ORUS populations. While two genotypes were observed for 'Sarian' (Table 1.8), only one matched that used as parent for the ORUS populations. It is important to mention that 'Sarian' is not clonally propagated rather it is seed propagated with a very uniform phenotype and is presumably homozygous (C. Finn, personal communication). Since two genotypes were obtained for 'Sarian', we believe it is necessary to clonally propagate a 'Sarian' plant if interested in using one 'Sarian' genotype as a parent. If propagated from seed, there is a greater likelihood of multiple parental genotypes. In both of these breeding programs, it is common to propagate plants by runners and use multiple

plants as sources of female and pollen parents. Some of these could have been purchased from nurseries, obtained from the National Clonal Germplasm Repository (NCGR) (T. Mackey and J. Hancock, personal communication) or present on site. Misidentified strawberry cultivars are often impossible to identify at the seedling or vegetative stage as fruits are essential for distinguishing these cultivars by knowledgeable breeders or technicians. Strawberry plants at the NCGR are not allowed to fruit to maintain identity and prevent seedling emergence and contamination. Mislabeling at any stage of acquisition through propagation and labeling cannot be detected without fruit examination or DNA-based fingerprinting. Such errors in identity are not uncommon as described by Hummer and Bassil (2013).

To shed light on the stages at which pollen contamination could occur at the MSU and ORUS breeding programs, we describe the crossing protocol for each of these programs. While a similar protocol is used by both programs, some steps are different.

In the ORUS breeding program, the majority of crosses are done in the field and flowers are emasculated with a small straight edge scalpel blade just before opening or when barely open prior to pollen dehiscence (T. Mackey, personal communication). Emasculated flowers are bagged to allow the pistil to mature and become receptive. To collect pollen, tweezers are used to pull anthers off into pollen tins. Tweezers are soaked in 95% ethanol and the area is wiped before moving to the next pollen parent. Pollen tins remain open for the night to allow drying. Five to seven days later (depending on weather), the bags are taken off from the emasculated flowers and a small brush specific

to the pollen parent is used to deposit pollen on the surface of the stigma. Each flower is bagged until fruit and seed development. Fingers are rinsed with 95% ethanol before conducting another controlled cross. Each pollen tin (pollen parent) has its own brush and all pollen tins are stored together. Opportunities for foreign pollen to land on the stigma exist and could have occurred at one of the many stages between emasculation and pollination. If using a barely open flower as the source of pollen or female parent, rogue pollen could be present prior to artificial crossing. When emasculating, if the scalpel blade is mistakenly not rinsed between crosses, it could be a source of pollen contamination. All pollen tins are kept together, which could be a place where rogue pollen grains from fingers and/or tins contaminate a tin. Also, foreign pollen floating around could land in pollen tins when open for the night to allow drying after anther harvest. Crosses made in the greenhouse are not bagged and while insect and wind activity are minimal, they could occur and cross pollination could occur during this stage. Incompletely sterilized fingers could also carry foreign pollen.

In the MSU breeding program, where all the crosses are done in the greenhouse, flowers are emasculated and pollinations are done immediately after emasculation with a small brush (J. Hancock, personal communication). Fingers are not rinsed but tweezers and brushes are soaked between crosses. Foreign pollen could be present if flowers are barely open, from un-bagged crosses, or pollen carried over with unwashed fingers between crosses. Contamination could also have occurred through unrestricted movement of insects.

Based on this SSR analysis, mixed pollen could have led to the outcrosses when used FRA_1701 as a pollen parent in ORUS_3304, MSU_9-1, and MSU_9-12; ORUS_2427-1 in ORUS_3322; 'Puget_Reliance' in ORUS_3323; 'Tillamook'-CF in ORUS_3321; or 'Tribute'_662.001 in MSU_9-3. Different genotypes for plants used as the female parent were possible for FRA_1702 in population MSU_9-5.

Allele association with PF

As previously reported by Mathey (2013) for this trait in 2011 and 2012, genotypic differences, variability due to location, genotype by location interactions as well as significant differences between 2011 and 2012 were detected for PF. California on average had the longest continual weeks in flower, as expected and previously reported by Weebadde et al. (2008), probably due to the cooler average summer temperatures that do not inhibit OF plants from continuing to bloom. Perpetual flowering was least expressed in NH and most in CA. Weebadde (2008) also found Eastern and Western differences; California and Oregon had the highest percentage of PF progeny while Maryland had the least. In this study, CA and OR had the highest percentages of PF progeny. The average temperature in June were lowest in the western states (16.12 in CA_13; 15.36 in OR_11, 15.68 in OR_12, and 16.48 in OR_13) and highest in the eastern states (21.19 in MI_11; 21.90 in MI_12; 20.9 in MI_13; 18.44 in NH_11; and 18.49 in NH_12) (www.usclimatedata.com). We agree with Mathey (2013) that a more stringent evaluation of PF is needed to evaluate them. Having strong genotype × location interactions for PF shows the complexity of this trait and that the genotypes are

responding differentially in each environment. Therefore MTA is expected to vary among the different environments.

When analyzed MTA of all six alleles in the entire data set, CA_12 and OR_13 had the lowest percentage of MTA for all the alleles but Bx56_209 (Fig. 1.7). This is not surprising for California and could have been an artifact of the small data set in OR_13 and the poor quality of the strawberry plants growing in the field for two to three fruiting seasons possibly due to virus pressure. In MI_11, MI_12, MI_13, NH_11 and NH_12, most of the individuals with no MTA had the allele but did not express the PF trait (Fig. 1.7), which could have resulted from the higher temperatures suppressing flowering in PF plants. Analyzing MTA in the entire dataset does not differentiate between sources of PF. Therefore we analyzed allele association based on the PF parent source including: 'Capitola', 'Seascape'_CF, 'Tribute', 'Fort Laramie'_NCGR, 'Fort Laramie'_I1, and 'Sarian'_CF. As expected in the progeny of 'Capitola' (Fig. 1.8) where these alleles were found, Bx89_262, Bx215_129, Bx56_209 and Bx63_149 were similarly able to predict the PF trait. For populations derived from 'Seascape' and 'Tribute, MTA was moderate to high for allele presence at each of these five alleles and the highest %MTA was found for EMFvi136_167, Bx215_129 and Bx63_149. Since 'Capitola', 'Seascape' and 'Tribute' share ancestry from *F. virginiana* subsp. *glauca* accession collected in the Wasatch Mountains (Bringhurst and Voth, 1980) as the source of this trait, alleles associated with PF in 'Capitola' can be applied to predicting PF in 'Seascape'- and 'Tribute'-derived germplasm.

Perpetual flowering in ‘Fort-Laramie’, however, is derived from ‘Pan American’, a variant of ‘Bismarck’ and descendent of ‘Wilson’, which was introduced by Samuel Cooper in New York in 1902 (Darrow, 1966). We were not able to identify which of the two ‘Fort-Laramie’ plants used as a parent is true-to-type and only had the NCGR source to genotype. We could only infer the genotype of the other, ‘Fort_Laramie’_I1 at EMFvi136, Bx215, Bx56 and Bx63. ‘Fort_Laramie’_I1 had EMFvi136_167 while ‘Fort_Laramie’-NCGR had all but the Bx89_251 allele. Absence of Bx215_129 and that of Bx63_149 were most predictive of OF as these alleles were either derived from the PF parent ‘Seascape’ in MSU_9-18, or they were absent from both parents in ORUS 3316 and ORUS 3324. In ‘Fort_Laramie’-NCGR-derived populations, since Bx215_129, Bx56_209 and Bx63_149 were present in the OF parents, ‘Earliglow’ and MSU_49, in MSU_9-8 and MSU_9-10, OF and PF progeny had these alleles that could not predict this trait. It is interesting that ‘Earliglow’ was one of the parents found to have positive general combining ability (GCA) effects for PF (Mathey, 2013) despite its OF behavior. However acquiring PF from two OF parents has been reported as is the case for ‘Auchincruive Climax’ derived from a cross between two OF strawberries (TD-8 and ‘Aberdeen’) (Darrow, 1966). Higher MTA at EMFvi136_167 was due to its presence only in the PF parent in all of the populations in which it was evaluated.

All three alleles present in the ‘Sarian’_CF source, EMFvi136_167, Bx89_262 and Bx56_209, had high percentages of coincidence (>60%) across most states (Fig. 1.13). High MTA at Bx56_209 was caused by its presence in all of the OF parents used in these crosses: ‘Puget Reliance’ in ORUS 3318; ORUS 2427-1 in ORUS 3319; ‘Totem’

in ORUS 3320; and ‘Tillamook’ in ORUS 3321. EMFvi136_167 and Bx89_262 were equally effective at predicting PF (> 70%), particularly in MI_11, NH_11, OR_11 and OR_12 as the former was specific to the PF parent and the latter was also present in the ‘Tillamook’ parent of ORUS 3321. Since neither FRA_1701, FRA_1701_I1 nor FRA_1701_I2 had any of the six alleles, they could not be used to predict PF in germplasm derived from this PF source.

Each of the five SSRs evaluated in this study were mapped to LGIV-f-b in ‘Capitola’ × CF1116 where a single major QTL, *FaPFRU*, is believed to control perpetual flowering (Gaston et al., 2013). They occur on this linkage group in the following order: EMFvi136 (~80cM), Bx89 (~101cM), *FaPFRU* locus (106 cM), Bx215 (108.1cM), Bx56 (110.1cM) and Bx63 (118.1cM) (B. Denoyes, personal communication). While EMFvi136 was the farthest (26 cM) from the *FaPFRU* locus, the allele associated with PF, 167, was specific to a single subgenome and not found in any of the OF parents evaluated in this study. Its distance away from the PF locus increases the chances of recombination between this allele and the *FaPFRU* locus, but its subgenome specificity facilitated detection of association, where present. MTA percentages observed with allele EMFvi136_167 in the ‘Capitola’, ‘Seascape’, ‘Tribute’, ‘Fort Laramie’-NCGR, ‘Fort Laramie’- I, and ‘Sarian’-derived populations in the different states and years ranged from 21-98%, 57-81%, 50-100%, 52-89%, 35-62% and 58-86%, respectively. Each of the remaining alleles is shared among two or more subgenomes. Therefore, if the active PF gene is linked to one or more of these alleles on only one of the subgenomes (as inheritance data indicates), their presence on another

subgenome will not be associated with PF and will prevent their usefulness for predicting PF. We believe that looking at the haplotypes in this region of the genome is necessary to identify haplotypes that are associated with this trait and could be much more accurate in predicting PF than allele presence or absence. Genotyping of all parents and use of MADCE to establish allele configuration uncovered the reason why the presence of these alleles is not predictive in some cases.

Genotype association

In order to assess whether we can increase the accuracy of prediction of the PF trait at Bx215, the allele closest to the *FaPFRU* locus, we used repeated ANOVA to identify the combination of alleles at this SSR that best explained the PF trait in the breeding populations. In the *F. virginiana* subsp. *glauc*a from the Wasatch Mountains of Utah-derived germplasm through 'Capitola', 'Seascape' and 'Tribute', the presence of 129 and absence of 160 increased predictivity of PF to ~80% while the absence of 129, 123, 127 and 134 predicted OF in 100% of the germplasm. In 'Sarian'-derived germplasm, it is the presence of 123 and 134 or 127 that was predictive of PF. Unfortunately, each of these alleles is shared among three or four of the subgenomes and their presence or absence cannot be predictive of PF or OF in 100% of the cases.

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Table 1.1. SSR primers used to genotype strawberry individuals.

SSR	QTL Source	Multiplex no.	Capillary electrophoresis platform	Reference
EMFvi136	‘Tribute’ × ‘Honeoye’	2	Beckman CEQ 8000	(Hancock, personal communication; Sargent et al., 2003)
Bx89	'Capitola' × CF1116	1	ABI 3730	(Beatrice Denoyes, personal communication; Gaston et al. 2013)
Bx215	'Capitola' × CF1116	4	ABI 3730	(Beatrice Denoyes, personal communication; Gaston et al., 2013)
Bx56	'Capitola' × CF1116	3	ABI 3730	(Beatrice Denoyes, personal communication; Gaston et al., 2013)
Bx63	'Capitola' × CF1116	1	ABI 3730	(Beatrice Denoyes, personal communication; Gaston et al., 2013)

Table 1.2. Alleles amplified by EMFvi136 in 886 strawberry samples consisting of 22 *F. chiloensis*, 7 *F. vesca*, 29 *F. virginiana*, 805 *F. ×ananassa* and 23 synthetic *F. × ananassa*. Presence of allele (+) and absence of allele (.)

Alleles	***F. chiloensis***	***F. vesca***	***F. virginiana***	***F. ×ananassa***	**Synthetic *F. ×ananassa***
113 [z]	.	.	+	.	.
114 [z]	.	.	+	.	.
119	+	.	+	+	+
121	+	.	+	+	+
123	+	.	+	+	+
125 [z]	+	.	.	+	.
126 [z]	.	.	+	.	.
127	.	.	+	+	+
129	+	.	+	+	.
131 [z]	.	.	+	+	.
133 [z]	.	.	+	.	.
134 [z]	+	.	+	+	.
135 [z]	.	.	+	+	.
136	+	.	+	+	.
137	.	.	+	+	+
138 [z]	.	.	+	.	.
139	+	.	+	+	.
140 [z]	.	.	+	.	.
141	+	.	+	+	.
142	+	+	+	+	+
143 [z]	.	.	+	+	.
144	+	+	+	+	.
145	.	.	+	+	.
146 [z]	.	.	+	.	.
147	.	.	+	+	+
148 [z]	.	.	+	.	.
149 [z]	.	.	+	+	.
150 [z]	.	.	+	.	.
151 [z]	.	.	+	.	.
154	+	.	+	.	+

Alleles	***F. chiloensis***	***F. vesca***	***F. virginiana***	***F. ×ananassa***	**Synthetic *F. ×ananassa***
155	+	.	+	+	.
156 [z]	.	.	+	+	.
157	+	.	+	+	+
159	+	.	+	+	+
160	.	.	+	+	+
161	+	+	+	+	+
162 [z]	+	.	.	+	.
163	+	+	+	+	+
165	+	+	+	+	+
167	+	.	+	+	+
169	+	.	+	+	+
170 [z]	.	.	+	.	.
171 [z]	+	.	+	.	.
173 [z]	.	.	+	+	.
175 [z]	.	.	+	.	.
185 [z]	.	.	.	+	.
365 [z]	+	.	.	.	.
Number of individuals	22	7	29	805	23

[z] Rare alleles (alleles present in less than five individuals)

Table 1.3. Alleles amplified by Bx89 in 810 strawberry samples consisting of 19 *F. chiloensis*, 2 *F. vesca*, 23 *F. virginiana*, 743 *F. ×ananassa* and 23 synthetic *F. ×ananassa*. Presence of allele (+) and absence of allele (.)

Alleles	***F. chiloensis***	***F. vesca***	***F. virginiana***	***F. × ananassa***	**Synthetic *F. ×ananassa***
247	+	.	+	+	+
251	+	.	+	+	+
253	.	.	.	+	.
257	+	.	+	+	+
259[z]	.	.	.	+	.
262	+	.	+	+	+
265[z]	.	.	.	+	.
267	+	+	+	+	+
269	+	.	+	+	+
271	.	.	+	+	.
273	+	.	+	+	+
274	.	.	.	+	.
275	+	+	+	+	+
278	+	.	+	+	.
279	+	+	+	+	+
280	+	.	.	+	+
283[z]	+	.	.	+	.
285	+	.	+	+	+
291[z]	+	.	.	.	.
Number of individuals	19	2	23	743	23

[z] Rare alleles (alleles present in less than five individuals)

Table 1.4. Alleles amplified by Bx215 in 383 strawberry samples consisting of 2 *F. chiloensis*, 12 *F. virginiana*, 359 *F.* ×*ananassa* and 10 synthetic *F.* × *ananassa*. Presence of allele (+) and absence of allele (.)

Alleles	***F. chiloensis***	***F. virginiana***	***F.* ×*ananassa***	**Synthetic *F.* ×*ananassa***
120 [z]	.	+	.	.
123	.	+	+	.
126	+	+	+	.
127	+	+	+	+
128	.	+	+	.
129	+	+	+	+
130 [z]	.	+	+	+
132 [z]	+	+	+	+
134	+	+	+	+
136	+	+	+	+
138	.	+	+	.
143	+	+	+	.
145 [z]	.	.	.	+
147 [z]	.	+	.	.
150 [z]	.	.	+	.
152 [z]	+	+	.	+
154 [z]	.	+	.	.
155 [z]	.	+	+	.
156 [z]	.	.	+	.
158	.	.	+	.
160	.	.	+	+
162 [z]	.	.	.	+
Number of individuals	2	12	359	10

[z] Rare alleles (alleles present in less than five individuals)

Table 1.5. Alleles amplified by Bx56 in 384 strawberry samples consisting of 2 *F. chiloensis*, 12 *F. virginiana*, 360 *F.* ×*ananassa* and 10 Synthetic *F.* × *ananassa*. Presence of allele (+) and absence of allele (.)

Alleles	***F. chiloensis***	***F. virginiana***	***F.* ×*ananassa***	**Synthetic *F.* ×*ananassa***
197	.	.	+	.
200[z]	.	+	.	.
203	+	+	+	+
206	+	+	+	+
209	+	+	+	+
211[z]	.	+	+	.
212[z]	.	+	.	.
213	.	+	+	+
214[z]	.	+	+	+
215[z]	+	+	+	+
217[z]	.	+	.	.
218[z]	.	.	+	.
219	.	+	+	.
221	+	+	+	+
222[z]	.	+	+	+
224[z]	.	.	+	+
226[z]	.	.	+	+
230[z]	.	+	.	+
Number of individuals	2	12	360	10

[z] Rare alleles (alleles present in less than five individuals)

Table 1.6. Alleles amplified by Bx63 in 820 strawberry samples consisting of 16 *F. chiloensis*, 2 *F. vesca*, 24 *F. virginiana*, 754 *F. ×ananassa* and 24 synthetic *F. ×ananassa*. Presence of allele (+) and absence of allele (.)

Alleles	***F. chiloensis***	***F. vesca***	***F. virginiana***	***F. ×ananassa***	**Synthetic *F. ×ananassa***
123[z]	+	+	+	+	+
127	+	.	+	+	+
129	+	.	+	+	+
133[z]	+	+	+	+	+
135	+	.	+	+	+
139	.	.	+	+	+
142	.	.	+	+	.
145	.	.	+	+	+
149	+	.	.	+	+
Number of individuals	16	2	24	754	24

[z] Rare alleles (alleles present in less than five individuals)

Table 1.7. Alleles in each of the four subgenomes for SSRs EMFvi136, Bx215, Bx56 and Bx63 in the parents and progeny of the European, MSU and ORUS populations. Alleles that are specific to one subgenome are in bold and italics while those found to be associated with perpetual flowering are in bold and underlined.

EMFvi136				**Bx215**				**Bx56**				**Bx63**			
Subgenomes				**Subgenomes**				**Subgenomes**				**Subgenomes**			
A	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
0	0	0	0	0	0	0	0	0	0		0	0	0	0	0
119	119			123	123	123	123	***197***						123	123
		121	121	126	126	126	126	***203***						***127***	
123	123		123	127	127	127	127	206			206		129	129	
	127	127	127	128		128		**209**	**209**			133	133	133	133
129				**129**	**129**	**129**		***211***					***135***		
131		131				***132***			213	213		***139***			
134					134	134	134	***214***				***142***			
	135	135		136	136	136	136	215		215	215	***145***			
			136		138	138	138			***217***		**149**	**149**		
	137	137	137			***143***			219	219	219				
		139	139			155	155	221			221				
		141	141			158	158	224			224				
			142		160	160	160				***226***				
		143	143												
		144													
145	145														
155	147	147													
		149													
	155														
		156													
157	157	157													
159	159	159													
	160	160	160												
161	161		161												
163	163	163	163												
165	165														
167															
169	169	169													

Table 1.8. Individuals genotyped and inferred individuals with respective breeding populations in which they were used as parents. Inferred individuals are indicated with the letter 'I'. Parentage is indicated even when the population had high percentage of individuals that had alleles different to alleles in the parents or progeny had allelic segregation distortion.

Parent	Pop1	Pop2	Pop3	Pop4
Redgauntlet_CF	EMR_(F)			
Redgauntlet_NL[z]	Not a parent			
Hapil_NL	EMR_(M)			
IFAPA_1392	IFAPA_(F)			
IFAPA_232	IFAPA_(M)			
Capitola_FR_CF	INRA_(F)			
CF1116_FR	INRA_(M)			
Holiday_CF	NL_(F)			
Holiday_NL[y]	NL_(F)			
Korona_CF	Not a parent			
Korona-NL	NL_(M)			
MSU_49	MSU_9-1_(F) [x]	MSU_9-2_(F)	MSU_9-3_(F) [x]	MSU_9-10_(M)
MSU_56	MSU_9-4_(F)	MSU_9-11_(M)	MSU_9-14_(M)	MSU_9-17_(M)
Seascape-CF	MSU_9-2_(M)	MSU_9-6_(M)	MSU_9-13_(F)	MSU_9-14_(F)
	MSU_9-18_(F)	ORUS_3278_(M)	ORUS_3305_(M)	ORUS_3322_(F) [x]
	ORUS_3323_(F) [x]			
Tribute_662.001	MSU_9-3_(M) [x]	MSU_9-15_(F)	MSU_9-16_(F)	MSU_9-17_(F)
	ORUS_3279_(M)	ORUS_3325_(M)	ORUS_3326_(F)	
Earliglow-CF	MSU_9-5_(M) [w]	MSU_9-6_(F)	MSU_9-8_(M)	MSU_9-15_(M)
Totem-CF	ORUS_3306_(F)	ORUS_3316_(M)	ORUS_3320_(M)	
Sarian- 2691.1	Not a parent			
Sarian-CF	ORUS_3318_(M) [v]	ORUS_3319_(F)	ORUS_3320_(F)	ORUS_3321_(F) [x]
FortLaramie_NCGR	MSU_9-8_(F)	MSU_9-9_(F)	MSU_9-10_(F)	MSU_9-11_(F)

Parent	Pop1	Pop2	Pop3	Pop4
FortLaramie_I1	MSU_9-18_(M_I)	ORUS_3316_(F)	ORUS_3324_(M_I)	
FortLaramie_I2	ORUS_3314_(F_I) [u]			
FortLaramie_I3	ORUS_3315_(F)			
FRA_1701	ORUS_3277_(M) [x]	ORUS_3304_(M) [x]	ORUS_3306_(M)	ORUS_3317_(M)
FRA_1702_I1	MSU_9-1_(M_I) [x]	MSU_9-4_(M_I)	MSU_9-5_(F) [w]	
FRA_1702_I2	MSU_9-12_(M) [x]			
Honeoye-215.001	MSU_9-9_(M)	MSU_9-12_(F) [x]	MSU_9-13_(M)	MSU_9-16_(M)
Honeoye-CF_14-74	Not a parent			
Honeoye_CF_6-73	Not a parent			
ORUS 2427-1_CF_1-22	ORUS_3277_(F) [x]	ORUS_3278_(F)	ORUS_3279_(F)	
ORUS 2427-1_CF_ 1-21	Not a parent			
ORUS 2427_I1	ORUS_3319_(M_I)	ORUS_3322_(M_I) [x]		
ORUS 2427_I2	ORUS_3314_(M_I) [u]			
Puget Reliance-CF	ORUS_3315_(M)			
Puget Reliance_I1	ORUS_3317_(F_I)	ORUS_3318_(F_I) [v]	ORUS_3323_(M_I) [x]	ORUS_3326_(M_I)
Tillamook_NCGR	ORUS_3305_(F)			
Tillamook-CF	ORUS_3321_(M) [x]	ORUS_3324_(F)	ORUS_3325_(F)	
Tillamook_I1	ORUS_3304_(F) [x]			

[z] Plant obtained from PB-WUR, NL and coded as E-60174.

[y] Plant obtained from PB-WUR, NL and coded as E-71006.

[x] Possible pollen mix.

[w] Two female plants were possibly used in the cross.

[v] No alleles different than the parents but segregation distortion.

[u] Both parents are inferred.

Table 1.9. Phenotype and allelic distribution in EMFvi136 and Bx63 for parents of breeding populations. Alleles for inferred parents are in italics and alleles different to the correct parents are underlined. Alleles with significant association to the PF trait are in bold. PF parents have darker fill. Missing data is indicated with a dot.

Parent	Expected phenotype	EMFvi136								Bx63							
		A1	A2	B1	B2	C1	C2	D1	D2	A1	A2	B1	B2	C1	C2	D1	D2
Capitola_FR_CF	PF	161	**167**	157	159	0	147	139	141	133	133	133	133	127	127	123	123
FortLaramie_I1	PF	***167***	*163*	*157*	*159*	*0*	*147*	*127*	*141*	*133*	*139*	*133*	*133*	*127*	*133*	*123*	*123*
FortLaramie_I2	PF	*157*	*169*	*0*	*159*	*139*	*147*	*127*	*141*	*133*	*139*	*135*	*133*	*127*	*133*	*123*	*123*
FortLaramie_I3	PF	***167***	*163*	*157*	*165*	*0*	*141*	*0*	*123*	*133*	*139*	*133*	*133*	*127*	*133*	*123*	*123*
FortLaramie_NCGR	PF	**167**	169	157	159	0	147	136	127	**149**	**149**	133	133	127	127	123	123
FRA_1701	PF	129	161	155	165	0	144	0	139	133	142	133	133	133	133	123	123
FRA_1702_I1	PF	*161*	*169*	*163*	*123*	*160*	*0*	*142*	*139*	*133*	*139*	*133*	*135*	*133*	*127*	*123*	*123*
FRA_1702_I2	PF	*123*	*163*	*161*	*159*	*0*	*160*	*139*	*141*	*133*	*139*	*133*	*135*	*127*	*133*	*123*	*123*
Korona_CF	PF	161	169	161	119	147	160	139	137	139	139	133	133	0	133	123	123
Korona-NL	PF	161	**167**	157	159	0	147	136	127	*133*	***149***	*0*	*133*	*133*	*129*	*123*	*123*
Redgauntlet_CF	PF	161	163	157	159	0	147	0	127	133	139	133	133	127	133	123	123
Redgauntlet_NL [z]	PF	161	163	159	163	0	0	0	139	133	133	133	135	127	129	123	123
Seascape-CF	PF	161	**167**	159	159	0	160	127	139	133	**149**	133	133	133	133	123	123
Tribute_662.001	PF	119	**167**	157	159	147	147	139	127	139	**149**	133	133	127	133	123	123
CF1116_FR	OF	*161*	***167***	*157*	*159*	*147*	*160*	*127*	*141*	*133*	***149***	*133*	*133*	*127*	*133*	*123*	*123*
Earliglow-CF	OF	119	169	157	159	0	147	139	141	139	**149**	133	133	127	133	123	123
Hapil_NL	OF	119	163	157	161	0	160	139	139	*133*	*133*	*133*	*135*	*127*	*129*	*123*	*123*
Holiday_CF	OF	119	157	157	157	0	137	139	141	139	139	133	133	127	127	123	123
Holiday_NL [y]	OF	119	157	157	157	0	137	139	141	139	139	133	133	127	127	123	123

Parent	Expected phenotype	EMFvi136								Bx63							
		A1	A2	B1	B2	C1	C2	D1	D2	A1	A2	B1	B2	C1	C2	D1	D2
Honeoye_CF_6-73	OF	157	161	157	163	0	139	139	141	139	133	133	133	127	133	123	123
Honeoye-215.001	OF	157	161	157	163	0	139	139	141	133	139	133	135	127	127	123	123
Honeoye-CF_14-74	OF	157	161	157	163	0	139	139	141	133	133	133	135	127	127	123	123
IFAPA_1392	OF	161	**167**	159	165	0	127	127	127	133	133	133	133	127	127	123	123
IFAPA_232	OF	161	**167**	157	159	0	160	127	139	133	133	133	133	127	133	123	123
MSU_49	OF	161	169	157	157	0	139	139	141	133	**149**	133	133	127	127	123	123
MSU_56	OF	157	169	157	159	0	127	0	141	139	139	133	133	127	127	123	123
ORUS 2427_I1	OF	*157*	*161*	*157*	*159*	*0*	*147*	*127*	*127*	*133*	*139*	*133*	*135*	*133*	*133*	*123*	*123*
ORUS 2427_I2	OF	***167***	*163*	*157*	*159*	*0*	*127*	*127*	*127*	*133*	*133*	*133*	*133*	*127*	*133*	*123*	*123*
ORUS 2427-1_CF_1-22	OF	157	161	157	159	0	127	127	127	133	133	133	133	127	133	123	123
Puget Reliance_I1	OF	*169*	*165*	*157*	*157*	*147*	*0*	*123*	*139*	*133*	*139*	*133*	*133*	*127*	*133*	*123*	*123*
Puget Reliance-CF	OF	157	169	157	159	0	147	127	127	133	133	133	133	127	133	123	123
Sarian-CF	OF	**167**	**167**	159	159	127	147	0	127	133	133	133	133	127	133	123	123
Tillamook_I1	OF	*157*	*161*	*0*	*127*	*159*	*160*	*160*	*139*	*133*	*133*	*133*	*133*	*127*	*133*	*123*	*123*
Tillamook_NCGR	OF	*0*	*161*	*0*	*169*	*157*	*159*	*123*	*127*	133	133	133	133	133	133	123	123
Tillamook-CF	OF	157	161	159	159	0	0	127	127	133	133	133	133	127	133	123	123
Totem-CF	OF	0	157	157	159	0	0	123	123	133	139	133	133	127	127	123	123

[z] Plant obtained from PB-WUR, NL and coded as E-60174.

[y] Plant obtained from PB-WUR, NL and coded as E-71006.

Table 1.10. Phenotype and allelic distribution in Bx215 and Bx56 for parents of breeding populations. Alleles for inferred parents are in italics and alleles different to the correct parents are underlined. Alleles with significant association to the PF trait are in bold. PF parents have darker fill. Missing data is indicated with a dot.

Parent	Expected phenotype	Bx215								Bx56							
		A1	A2	B1	B2	C1	C2	D1	D2	A1	A2	B1	B2	C1	C2	D1	D2
Capitola_FR_CF	PF	**129**	136	**129**	134	134	136	0	127	203	206	**209**	213	215	215	221	221
FortLaramie_I1	PF	*0*	*127*	*136*	*136*	*134*	*143*	*0*	*143*	*203*	*206*	*213*	*213*	*215*	*215*	*0*	*221*
FortLaramie_I3	PF	*136*	*136*	*0*	*136*	*0*	*138*	*0*	*160*	*203*	*203*	***209***	***209***	*215*	*215*	*0*	*221*
FortLaramie_NCGR	PF	127	**129**	160	**129**	143	**129**	0	127	203	203	**209**	**209**	215	215	0	221
Redgauntlet_CF [z]	PF	0	127	136	136	123	134	0	158	203	206	**209**	213	215	215	0	224
Seascape-CF	PF	**129**	136	**129**	134	136	143	0	134	197	206	**209**	213	215	215	221	221
Tribute_662.001	PF	**129**	136	0	**129**	134	158	127	138	0	203	**209**	213	215	215	0	215
CF1116_FR	OF	127	136	127	134	136	138	0	158	203	203	213	213	215	215	0	221
Earliglow-CF	OF	0	**129**	**129**	136	123	127	134	160	203	206	**209**	213	215	215	221	221
Honeoye-215.001	OF	127	136	0	136	0	127	126	158	203	203	213	213	215	219	219	221
Honeoye-CF_14-74	OF	134	**129**	136	**129**	123	127	0	134	203	**209**	**209**	206	215	215	221	221
MSU_49	OF	**129**	136	**129**	138	127	127	158	160	203	203	**209**	**209**	215	215	215	221
MSU_56	OF	127	136	0	136	136	160	127	158	203	215	213	213	215	219	0	219
ORUS 2427_I1	OF	*0*	*136*	*134*	*136*	*123*	*143*	*126*	*160*	*197*	*206*	***209***	*213*	*215*	*219*	*219*	*221*
ORUS 2427-1_CF_ 1-21	OF	136	134	136	134	136	134	136	0	203	206	**209**	213	215	215	221	0
ORUS 2427-1_CF_1-22	OF	127	136	136	138	0	134	134	123	203	206	**209**	213	215	215	0	221

Parent	Expected phenotype	Bx215								Bx56							
		A1	**A2**	**B1**	**B2**	**C1**	**C2**	**D1**	**D2**	**A1**	**A2**	**B1**	**B2**	**C1**	**C2**	**D1**	**D2**
Puget Reliance_I1	OF	*136*	*127*	*136*	*123*	*143*	*138*	*158*	*160*	*203*	*206*	***209***	*213*	*215*	*215*	*0*	*221*
Puget Reliance-CF	OF	*136*	*136*	*0*	*123*	*0*	*143*	*127*	*158*	*203*	*206*	***209***	*213*	*215*	*215*	*0*	*221*
Sarian- 2691.1	OF	**129**	136	**129**	134	0	134	0	127	203	214	**209**	213	215	215	221	221
Sarian-CF	OF	0	136	127	134	123	134	0	136	203	206	213	213	215	215	0	221
Tillamook_NCGR	OF	123	136	0	136	134	158	138	136	206	206	**209**	213	215	215	221	221
Tillamook-CF	OF	0	136	127	136	134	136	0	134	203	206	**209**	213	213	215	0	221
Totem-CF	OF	*127*	*136*	*0*	*138*	*0*	*138*	*134*	*160*	*203*	*206*	***209***	***209***	*215*	*215*	*0*	*215*

[z] Allelic configuration needs confirmation with progeny.
[y] Plant obtained from PB-WUR, NL and coded as E-60174.
[x] Plant obtained from PB-WUR, NL and coded as E-71006.

Table 1.11. Presence (1) and absence (0) of Bx89 alleles for parents of breeding populations. Inferred parents are in italics and alleles different to the correct parents are underlined. Alleles with significant association to the PF trait are in bold. Alleles with significant association to the PF trait are in bold. Missing data is indicated with a dot.

Parent	**Expected phenotype**	**Bx89**																			
		247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
Capitola_FR_CF	PF	0	0	**1**	0	1	0	**1**	0	1	1	0	1	0	1	0	1	0	0	0	0
FortLaramie_NCGR	PF	0	0	0	0	1	0	**1**	0	0	0	0	1	0	0	0	1	0	0	0	0
FRA_1701	PF	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0
Korona_CF	PF	0	0	**1**	1	1	0	0	0	1	1	0	0	0	1	0	0	1	0	0	0
Redgauntlet_CF	PF	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	1	0	0	0	0
Redgauntlet_NL[z]	PF	1	0	0	0	1	0	**1**	0	1	1	0	0	1	1	0	1	0	0	0	0
Seascape-CF	PF	0	0	0	0	1	0	**1**	0	1	1	0	1	0	0	0	0	0	0	0	0
Tribute_662.001	PF	0	0	0	0	1	0	**1**	0	1	1	0	1	0	0	0	1	0	0	0	0
Earliglow-CF	OF	1	0	**1**	0	1	0	**1**	0	1	1	0	0	0	0	0	1	0	0	0	0
Holiday_CF	OF	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0
Holiday_NL[y]	OF	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0
Honeoye_CF_6-73	OF	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0
Honeoye-215.001	OF	1	0	0	0	1	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0
Honeoye-CF_14-74	OF	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
IFAPA_1392	OF	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
IFAPA_232	OF	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_49	OF	0	0	0	0	1	0	**1**	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_56	OF	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0

Parent	Expected phenotype	Bx89																			
		247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
ORUS 2427_I1	OF	1	0	**1**	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	1	0
ORUS 2427-1_CF_1-22	OF	1	0	**1**	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	1	0
Puget Reliance-CF	OF	0	0	0	0	1	0	**1**	0	1	1	0	0	0	0	0	1	0	0	0	0
Sarian-CF	OF	0	0	**1**	0	1	0	**1**	0	1	1	0	0	0	0	0	0	0	0	0	0
Tillamook_NCGR	OF	0	0	**1**	0	1	0	**1**	0	1	1	0	0	0	0	0	1	0	0	0	0
Tillamook-CF	OF	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
Totem-CF	OF	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0

[z] Plant obtained from PB-WUR, NL and coded as E-60174.

[y] Plant obtained from PB-WUR, NL and coded as E-71006.

Table 1.12. Genotypes at EMFvi136 and Bx63 for progeny that had alleles (underlined) not present in parents. Alleles with a question mark need confirmation. Missing data is represented with a dot.

Progeny	EMFvi136								Bx63							
	A1	A2	B1	B2	C1	C2	D1	D2	A1	A2	B1	B2	C1	C2	D1	D2
EMR_16	161	167	157	157	0	147	0	127	133	139	133	133	0	133	123	123
EMR_99	161	167	157	161	0	147	139	127	133	139	133	133	0	127	123	123
INRA_116	161	169	159	159	0	0	127	141	133	149	133	133	127	127	123	123
INRA_165	161	167	161	165	0	147	139	127	133	149	133	133	127	127	123	123
MSU_9-1-2	161	169	157	160	0	137	139	139	145	149	133	135	127	133	123	123
MSU_9-1-4	161	161	0	157	137	139	141	142	133	145	133	135	127	127	123	123
MSU_9-1-5	161	161	0	157	0	137	139	139	133	133	133	133	127	127	123	123
MSU_9-1-6	161	169	157	160	0	137	139	139	133	145	133	133	127	133	123	123
MSU_9-1-7	161	161	157	160	0	137	139	141	133	145	133	135	127	133	123	123
MSU_9-1-9	161	161	0	157	0	137	139	141	133	145	133	135	127	127	123	123
MSU_9-1-10	161	161	0	157	0	137	139	142	145	149	133	135	127	127	123	123
MSU_9-3-3	161	169	157	163	0	160	139	141	133	149	133	135	127	133	123	123
MSU_9-3-5	.	.	.	.	.	.	.	.	133	149	133	135	127	133	123	123
MSU_9-3-6	161	169	137	157	0	137	139	142	133	145	133	135	127	127	123	123
MSU_9-3-9	161	161	137	157	139	135	137	139	145	149	133	135	127	127	123	123

Progeny	EMFvi136								Bx63							
	A1	A2	B1	B2	C1	C2	D1	D2	A1	A2	B1	B2	C1	C2	D1	D2
MSU_9-4-3	157	161	159	135	137	127	0	139	139	145	133	133	127	127	123	123
MSU_9-4-7	161	169	157	135	0	137	141	142	.	.	.	.	.	.	.	.
MSU_9-5-2	161	169	157	159	131	147	139	141	133	149	133	133	127	127	123	123
MSU_9-5-6	161	169	0	157	0	137	141	142	145	149	133	135	127	127	123	123
MSU_9-5-7	161	169	0	157	0	137	141	142	145	149	133	133	127	127	123	123
MSU_9-5-8	161	169	0	159	137	147	139	139	139	145	133	133	133	133	123	123
MSU_9-11-7	167	167	159	159	0	127	0	127	133?	139?	133	133	127?	133?	123	123
MSU_9-11-8	157	167	159	163	127	147	0	127	139	149	133	133	133?	133?	123	123
MSU_9-12-3	161	167	157	159	0	0	127	141	139	149	133	135	127	133	123	123
MSU_9-12-4	161	163	161	163	159	147	163	141	133	133	133	135	127	133	123	123
MSU_9-12-7	145	161	155	157	147	141	143	141	139	142	133	135	127	127	123	123
MSU_9-12-8	157	161	157	157	160	137	139	139	139	145	133	135	127	133	123	123
MSU_9-14-3	161	161	157	159	149	160	127	141	133	133?	133	133	123	133	123	123
MSU_9-14-7	157	167	157	159	0	127	0	127	139	149	133	133	127	127?	123	133
MSU_9-16-50	161	161	159	165	160	121	0	127	.	.	.	.	.	.	.	.
MSU_9-16-57	161	169	159	165	0	147	0	121	133	139	133	135	127	127	123	123
MSU_9-16-61	159	167	159	165	144	147	0	127	139	139	133	133	127	133	123	123

Progeny	EMFvi136								Bx63							
	A1	A2	B1	B2	C1	C2	D1	D2	A1	A2	B1	B2	C1	C2	D1	D2
MSU_9-17-2	119	161	159	163	0	147	139	141	139	139	133	133	127	133	123	123
ORUS_3277-1	161	161	159	165	0	144	127	139	133	142	133	129	127	133	123	123
ORUS_3277-2	129	157	159	155	0	144	127	139	133	133	133	129	127	133	123	123
ORUS_3277-3	129	157	155	157	0	0	127	139	133	133	133	129	127	133	123	123
ORUS_3277-4	157	161	157	165	0	144	127	139	133	142	133	129	127	133	123	123
ORUS_3277-5	129	157	157	165	0	0	127	139	133	133	133	129	133	133	123	123
ORUS_3304-2	157	161	0	155	144	147	0	139	133	133	133	133	133	133	123	123
ORUS_3304-6	161	131	0	145	159	159	0	160	133	133	133	133	127	133	123	123
ORUS_3304-8	157	163	0	147	0	159	0	160	133	133	133	133	133	133	123	123
ORUS_3304-9	161	131	0	145	159	159	0	160	133	133	133	133	127	133	123	123
ORUS_3304-11	157	163	0	147	0	159	0	160	133	133	133	133	133	133	123	123
ORUS_3304-13	163	155	145	147	0	159	0	160	133	142	133	133	127	133	123	123
ORUS_3305-7	161	167	159	147	0	159	127	127	133	149	133	133	133	133	123	123
ORUS_3314-2	161	163	0	159	0	139	127	141	133	133	133	133	127	133	123	123
ORUS_3314-10	157	167	0	157	0	147	161	127	133	139	133	133	133	133	123	123
ORUS_3314-15	167	169	157	159	147	163	127	141	133	133	133	133	133	133	123	123
ORUS_3316-9	157	167	157	159	159	143	123	141	133	133	133	133	127	127	123	123

Progeny	EMFvi136								Bx63							
	A1	A2	B1	B2	C1	C2	D1	D2	A1	A2	B1	B2	C1	C2	D1	D2
ORUS_3319-5	167	169	159	159	0	147	127	127	133	133	133	135	127	133	123	123
ORUS_3319-7	167	169	157	159	0	147	127	127	133	133	133	133	127	133	123	123
ORUS_3320-1	129	157	159	165	144	137	139	127	133	142	133	133	133	133	123	123
ORUS_3321-2	161	167	159	159	156	147	0	127	133	133	133	133	133	129	123	133
ORUS_3321-3	134	167	159	159	0	156	127	127	133	133	133	135	127	129	123	133
ORUS_3321-7	167	169	157	159	147	147	123	127	133	133	133	133	127	127	123	123
ORUS_3321-8	161	167	159	159	156	147	127	127	133	133	133	133	133	129	123	123
ORUS_3321-9	161	167	159	159	0	156	127	127	133	133	133	133	127	129	123	123
ORUS_3322-2	157	161	157	159	147	169	127	127	133	149	133	133	133	133	123	123
ORUS_3322-5	157	167	157	159	147	169	127	127	133	149	133	133	133	133	123	123
ORUS_3322-12	157	161	169	159	147	160	127	139	133	149	133	133	133	133	123	123
ORUS_3323-3	0	167	157	159	0	163	127	141	133	139	133	133	127	133	123	123
ORUS_3323-7	161	167	157	159	163	160	139	141	133	139	133	133	127	133	123	123
ORUS_3323-9	0	161	157	159	0	163	139	141	133	139	133	133	127	133	123	123
ORUS_3326-2	119	163	157	159	147	147	0	127	133	139	133	133	127	133	123	123
ORUS_3326-4	119	167	157	159	147	147	139	141	149?	149	133	133	133	133	123	123

Table 1.13. Genotypes at Bx215 and Bx56 for progeny that had alleles (underlined) not present in parents. Alleles with a question mark need confirmation. Missing data is represented with a dot.

Progeny	Bx215								Bx56							
	A1	A2	B1	B2	C1	C2	D1	D2	A1	A2	B1	B2	C1	C2	D1	D2
MSU_9-3-2	136	136	0	138	127	136	158	160	0	203	209	213	215	215	0	215
MSU_9-3-3	126	136	126	129	0	127	0	160	203	206	209	213	215	215	219	221
MSU_9-3-5	126	136	126	129	127	158	0	160	203	206	209	209	215	215	0	219
MSU_9-3-6	136	136	138	126	0	127	127	160	203	203	209	209	215	215	0	219
MSU_9-3-9	129	136	138	126	127	127	0	160	203	203	209	209	215	215	0	219
MSU_9-10-1	127	129	129	136	127	134	0	127	203	206	209	209	215	215	0	226
MSU_9-14-3	136	128	134	136	0	136	0	158	206	215	209	213	215	217	221	221
MSU_9-16-8	136	136	0	136	127	158	127	158	203	209	209	213	215	215	0	206
MSU_9-17-2	136	136	136	126	126	134	0	127	0	203	213	213	215	219	0	219
ORUS_3320-1	136	136	0	134	132	128	0	136	211	206	209	209	215	219	0	219
ORUS_3321-6	136	136	127	127	134	134	0	155	203	203	213	213	215	215	0	221
ORUS_3321-7	0	136	127	136	123	138	134	158	203	206	209	213	215	215	0	0
ORUS_3321-8	136	136	0	0	123	155	134	134	0	206?	213	213	215	215	0	0
ORUS_3321-9	136	136	127	136	134	134	0	155	0	203?	213	213	215	215	215?	221?
ORUS_3323-3	136	136	134	136	127?	136	0	158	203	206	213	213	215	215	221	221
ORUS_3323-7	136	136	134	136	127?	136?	0	158	203	206	213	213	215	215	221	221
ORUS_3323-9	127	136	134	136	143	143	0	136?	197	203	213	213	215	215	221	221

Table 1.14. Presence (1) and absence (0) of alleles at Bx89 for progeny that had alleles (underlined) not present in parents.

Progeny	Bx89																			
	247	**248**	**251**	**253**	**257**	**259**	**262**	**265**	**267**	**269**	**271**	**273**	**274**	**275**	**278**	**279**	**280**	**283**	**285**	**291**
MSU_9-3-3	0	0	0	0	1	0	1	0	1	0	**1**	0	0	0	0	1	0	0	0	0
MSU_9-3-5	0	0	0	0	1	0	0	0	1	0	**1**	1	0	0	0	1	0	0	0	0
MSU_9-3-6	0	0	0	0	1	0	1	0	0	0	**1**	1	0	0	0	1	0	0	0	0
MSU_9-3-9	0	0	0	0	1	0	1	0	1	0	**1**	1	0	0	0	1	0	0	0	0
MSU_9-14-7	0	0	0	0	1	0	1	0	1	1	0	1	0	**1**	0	1	0	0	0	0
MSU_9-16-61	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	**1**	0	0	0
ORUS_3320-1	0	0	0	0	1	0	0	0	1	1	0	1	0	0	**1**	0	0	0	0	0

Table 1.15. Comparison of means of the PF trait between individuals that had the allele (Y) and individuals that did not have the alleles (N) obtained with SSRs EMFvi136, Bx89, Bx215, Bx56 and Bx63 for California in 2012 (CA_2012) obtained with t-tests.

CA_2012			
Allele	**Number (Y/N)**	**Mean (Y/N)**	**Mean difference** **P-value**
EMFvi136_127	448/371	0.91/0.86	0.05*
EMFvi136_159	549/270	0.92/0.84	0.08***
EMFvi136_167	365/454	0.93/0.86	0.07***
Bx89_251	389/374	0.93/0.85	0.08***
Bx89_267	701/62	0.90/0.77	0.13***
Bx89_269	513/250	0.91/0.85	0.06*
Bx215_127	175/41	0.97/0.90	0.07***
Bx63_149	208/550	0.94/0.87	0.07**

***, **, *, and · = $p \leq 0.001$, $p \leq 0.01$ $p \leq 0.05$ and $p \leq 0.1$, respectively.

Table 1.16. Comparison of means of the PF trait between individuals that had the allele (Y) and individuals that did not have the alleles (N) obtained with SSRs EMFvi136, Bx89, Bx215, Bx56 and Bx63 in Michigan (MI) in years 2011, 2012 and 2013 obtained with t-tests.

	MI_2011			MI_2012			MI_2013		
Allele	**Number (Y/N)**	**Mean (Y/N)**	**Mean difference P-value**	**Number (Y/N)**	**Mean (Y/N)**	**Mean difference P-value**	**Number (Y/N)**	**Mean (Y/N)**	**Mean difference P-value**
EMFvi136_127	295/240	0.36/0.24	0.12**						
EMFvi136_136	31/504	0.48/0.3	0.18*						
EMFvi136_137							55/176	0.4/0.21	0.19**
EMFvi136_141							88/143	0.34/0.2	0.14*
EMFvi136_147	272/263	0.38/0.23	0.15***	385/342	0.21/0.11	0.10***			
EMFvi136_159	337/198	0.37/0.19	0.18***	472/255	0.2/0.1	0.10***	157/74	0.29/0.17	0.12*
EMFvi136_167	213/322	0.62/0.1	0.52***	314/413	0.32/0.05	0.27***	111/120	0.41/0.11	0.30***
Bx89_251	242/264	0.50/0.14	0.36***	347/340	0.25/0.08	0.17***	158/67	0.32/0.10	0.22***
Bx89_262	351/155	0.40/0.11	0.29***	503/184	0.21/0.06	0.15***			
Bx89_269	312/194	0.39/0.18	0.21***	452/235	0.21/0.08	0.13***	173/52	0.29/0.13	0.16*
Bx89_271							32/193	0.62/0.19	0.43***
Bx215_129	102/61	0.72/0.32	0.40***	124/88	0.44/0.12	0.32***	42/33	0.66/0.06	0.60***
Bx56_209	218/55	0.55/0.18	0.37***	256/81	0.37/0.11	0.26***	78/35	0.52/0.02	0.50***
Bx63_149	163/338	0.67/0.14	0.53***	206/476	0.37/0.08	0.29***	78/144	0.61/0.06	0.55***

***, **, *, and · = $p \leq 0.001$, $p \leq 0.01$ $p \leq 0.05$ and $p \leq 0.1$, respectively.

Table 1.17. Comparison of means of the PF trait between individuals that had the allele (Y) and individuals that did not have the alleles (N) obtained with SSRs EMFvi136, Bx89, Bx215, Bx56 and Bx63 in New Hampshire (NH) in 2011 and 2012 obtained with t-tests.

	NH_2011			NH_2012		
Allele	**Number (Y/N)**	**Mean (Y/N)**	**Mean difference** P-value	**Number (Y/N)**	**Mean (Y/N)**	**Mean difference** P-value
EMFvi136_136	9/213	0.77/0.23	0.54***	9/238	0.66/0.19	0.47***
EMFvi136_159	126/96	0.32/0.17	0.15*	142/105	0.26/0.14	0.12*
EMFvi136_167	66/156	0.57/0.12	0.45***	64/183	0.6/0.14	0.46***
Bx89_251	86/113	0.38/0.13	0.25***	110/116	0.29/0.13	0.16**
Bx89_269	118/81	0.29/0.16	0.13*			
Bx215_129	35/21	0.62/0.19	0.43***	33/19	0.45/0.15	0.3*
Bx56_209	81/19	0.48/0.10	0.38**	77/17	0.35/0.11	0.24·
Bx63_149	55/143	0.52/0.12	0.40***	53/172	0.37/0.14	0.23***

***, **, *, and · = $p \leq 0.001$, $p \leq 0.01$ $p \leq 0.05$ and $p \leq 0.1$, respectively.

Table 1.18. Comparison of means of the PF trait between individuals that had the allele (Y) and individuals that did not have the alleles (N) obtained with SSRs EMFvi136, Bx89, Bx215, Bx56 and Bx63 in Oregon (OR) in 2011 and 2012 obtained with t-tests.

	OR_2011			OR_2012			OR_2013		
Allele	**Number (Y/N)**	**Mean (Y/N)**	**Mean difference P-value**	**Number (Y/N)**	**Mean (Y/N)**	**Mean difference P-value**	**Number (Y/N)**	**Mean Y/N)**	**Mean difference P-value**
EMFvi136_127	340/282	0.3/0.21	0.09**	476/396	0.19/0.13	0.06**			
EMFvi136_147	315/307	0.29/0.22	0.07*	424/448	0.2/0.13	0.07**			
EMFvi136_159	405/217	0.31/0.16	0.15***	583/289	0.2/0.09	0.11***	217/73	0.65/0.49	0.16*
EMFvi136_167	264/358	0.46/0.11	0.35***	389/483	0.31/0.04	0.27***			
Bx89_251	263/324	0.36/0.18	0.18***	415/390	0.21/0.12	0.09***			
Bx89_262	404/183	0.32/0.13	0.19***	595/210	0.20/0.07	0.13***	221/45	0.69/0.35	0.34***
Bx89_269	369/218	0.32/0.15	0.17***	543/262	0.20/0.10	0.10***	213/53	0.68/0.45	0.23**
Bx89_274				99/706	0.25/0.16	0.09*	5/261	1.00/0.62	0.38.
Bx215_123				20/205	0.60/0.26	0.34***			
Bx215_129	105/63	0.47/0.20	0.27***	130/95	0.42/0.12	0.30***			
Bx56_206							50/66	0.84/0.59	0.25**
Bx56_209	241/59	0.43/0.23	0.2**	281/93	0.36/0.11	0.25***			
Bx56_221							95/21	0.76/0.38	0.38***
Bx63_149	177/405	0.43/0.18	0.25***	223/578	0.34/0.10	0.24***			

***, **, *, and . = $p \leq 0.001$, $p \leq 0.01$ $p \leq 0.05$ and $p \leq 0.1$, respectively.

Table 1.19. First round of comparisons using ANOVA of means of the PF trait between individuals that had the allele (Y) and individuals that did not have the allele (N) obtained with the Bx215, as implemented in the statistical package R version 0.98.501, 2009-2013. Results are shown for the alleles with the most significant differences only. The allele showing the most significant difference is in bold.

Alleles	**Number(Y/N)**	**Mean(Y/N)**	**SD(Y/N)**	**Mean difference** **ANOVA_P-value**
123	45/256	0.56/0.37	0.50/0.48	0.19*
129	**145/156**	**0.62/0.19**	**0.49/0.40**	**0.43*** **
136	282/19	0.37/0.84	0.48/0.37	(-)0.47 ***
143	85/216	0.29/0.44	0.46/0.50	(-) 0.15 *
155	3/298	1/0.39	0.00/0.48	0.61*

***, **, *, and · = $p \leq 0.001$, $p \leq 0.01$ $p \leq 0.05$ and $p \leq 0.1$, respectively.

Table 1.20. Second round of comparisons using ANOVA of means of the PF trait between individuals that had the allele (Y) and individuals that did not have the allele (N) obtained with Bx215, as implemented in the statistical package R version 0.98.501, 2009-2013. The comparisons were done independently in two groups: individuals with 129 (Y.129) and without 129 (N.129). Results are shown for the alleles with the most significant differences only. The alleles showing the most significant difference is in bold.

Allele 129	**Alleles**	**Number(Y/N)**	**Mean(Y/N)**	**SD(Y/N)**	**Mean difference** ANOVA_P-value
Y.129	Y.134	103/42	0.67/0.5	0.47/0.50	0.17$^{\cdot}$
Y.129	Y.136	126/19	0.59/0.84	0.50/0.37	(-)0.25*
Y.129	**Y.143**	**44/101**	**0.48/0.68**	**0.505/0.467**	**(-)0.2***
Y.129	Y.158	65/80	0.71/0.55	0.46/0.50	0.16$^{\cdot}$
Y.129	Y.160	39/106	0.46/0.68	0.505/0.468	(-)0.22*
N.129	**Y.123**	**27/129**	**0.44/0.14**	**0.50/0.35**	**0.3*****
N.129	Y.143	41/115	0.1/0.23	0.30/0.42	(-)0.13$^{\cdot}$
N.129	Y.158	53/103	0.11/0.23	0.32/0.42	(-)0.12$^{\cdot}$
N.129	Y.160	42/114	0.31/0.15	0.47/0.36	0.16*

***, **, *, and $^{\cdot}$ = $p \leq 0.001$, $p \leq 0.01$ $p \leq 0.05$ and $p \leq 0.1$, respectively.

Table 1.21. Third round of comparisons using ANOVA of means of the PF trait between individuals that had the allele (Y) and individuals that did not have the alleles (N) obtained with Bx215, as implemented in the statistical package R version 0.98.501, 2009-2013. The comparisons were done independently in four groups with the allelic combination: Y.129.Y.143, Y.129.N.143, N.129.Y.123 and N.129.N.143. Results are shown for the alleles with the most significant differences only. The allele showing the most significant allele is in bold.

Allele 129	**Allele 143-123**	**Alleles**	**Number(Y/N)**	**Mean(Y/N)**	**SD(Y/N)**	**Mean difference** **ANOVA_P-value**
Y.129	Y.143	Y.136	38/6	0.42/0.83	0.50/0.41	(-)0.41$^{\cdot}$
Y.129	N.143	Y.158	55/46	0.76/0.59	0.43/0.50	0.17$^{\cdot}$
Y.129	**N.143**	**Y.160**	**26/75**	**0.42/0.77**	**0.50/0.42**	**(-)0.35*****
N.129	**Y.123**	**Y.134**	**20/7**	**0.6/0**	**0.50/0.0**	**0.6****
N.129	Y.123	Y.143	8/19	0.13/0.58	0.35/0.51	(-)0.45*
N.129	**N.123**	**Y.127**	**107/22**	**0.17/0**	**0.38/0.00**	**0.17***
N.129	N.123	Y.158	46/83	0.07/0.18	0.25/0.39	(-) 0.11$^{\cdot}$
N.129	N.123	Y.160	28/101	0.29/0.1	0.46/0.30	0.19*

***, **, *, and $^{\cdot}$ = $p \leq 0.001$, $p \leq 0.01$ $p \leq 0.05$ and $p \leq 0.1$, respectively.

Table 1.22. Establishment of the full allelic configuration for Bx56 in five progeny from the 'Capitola' × CF1116 population using the MADCE approach (van Dijk et al., 2012).

Step 1. Area peaks for alleles 203, 206, 209, 213, 215 and 221 and the area peak average per individual

Alleles	**203**	**206**	**209**	**213**	**215**	**221**	**Average**
Capitola	24757	26333	30295	26030	49595	10958	20996.0
CF1116	72851	0	0	76902	102524	7186	32432.9
INRA_99	16424	25345	27889	24041	46463	5255	18177.1
INRA_197	17319	21965	26197	23381	43587	5549	17249.8
INRA_58	42589	0	28373	26006	47195	5198	18670.1
INRA_98	14503	20756	0	38787	52671	4761	16434.8
INRA_138	44626	0	0	54032	48496	5657	19101.4

Step 2. Ratio values obtained by dividing each area peak by the corresponding individual area peak average and by multiplying this result by the factor 8

Alleles	**203**	**206**	**209**	**213**	**215**	**221**
Capitola	9.4	10.0	11.5	9.9	18.9	4.2
CF1116	18.0	0.0	0.0	19.0	25.3	1.8
INRA_99	7.2	11.2	12.3	10.6	20.4	2.3
INRA_197	8.0	10.2	12.1	10.8	20.2	2.6
INRA_58	18.2	0.0	12.2	11.1	20.2	2.2
INRA_98	7.1	10.1	0.0	18.9	25.6	2.3
INRA_138	18.7	0.0	0.0	22.6	20.3	2.4

Table 1.22. Continued

Step 3. Allele doses for six alleles. In this case, ratio values of 7.1 - 12.3 represents one dose and ratio values of 18.0 - 25.3, two doses for alleles 203, 206, 209, 213 and 215. For allele 221, one allele dose has a range of ratio values of 1.8-2.6 and two allele dose has a value of 4.2.

Alleles	**203**	**206**	**209**	**213**	**215**	**221**	**Total**
Capitola	1	1	1	1	2	2	7
CF1116	2			2	2	1	7
INRA_99	1	1	1	1	2	1	7
INRA_197	1	1	1	1	2	1	7
INRA_58	2		1	1	2	1	7
INRA_98	1	1		2	2	1	7
INRA_138	2			2	2	1	7

Step 4. Allelic configuration in the four subgenomes that were arbitrarily named as A, B, C and D. Value '0' represents a null allele.

Alleles	**Bx56_A1**	**Bx56_A2**	**Bx56_B1**	**Bx56_B2**	**Bx56_C1**	**Bx56_C2**	**Bx56_D1**	**Bx56_D2**
Capitola	203	206	209	213	215	215	221	221
CF1116	203	203	213	213	215	215	221	0
INRA_99	203	206	209	213	215	215	221	0
INRA_197	203	206	209	213	215	215	221	0
INRA_58	203	203	209	213	215	215	221	0
INRA_98	203	206	213	213	215	215	221	0
INRA_138	203	203	213	213	215	215	221	0

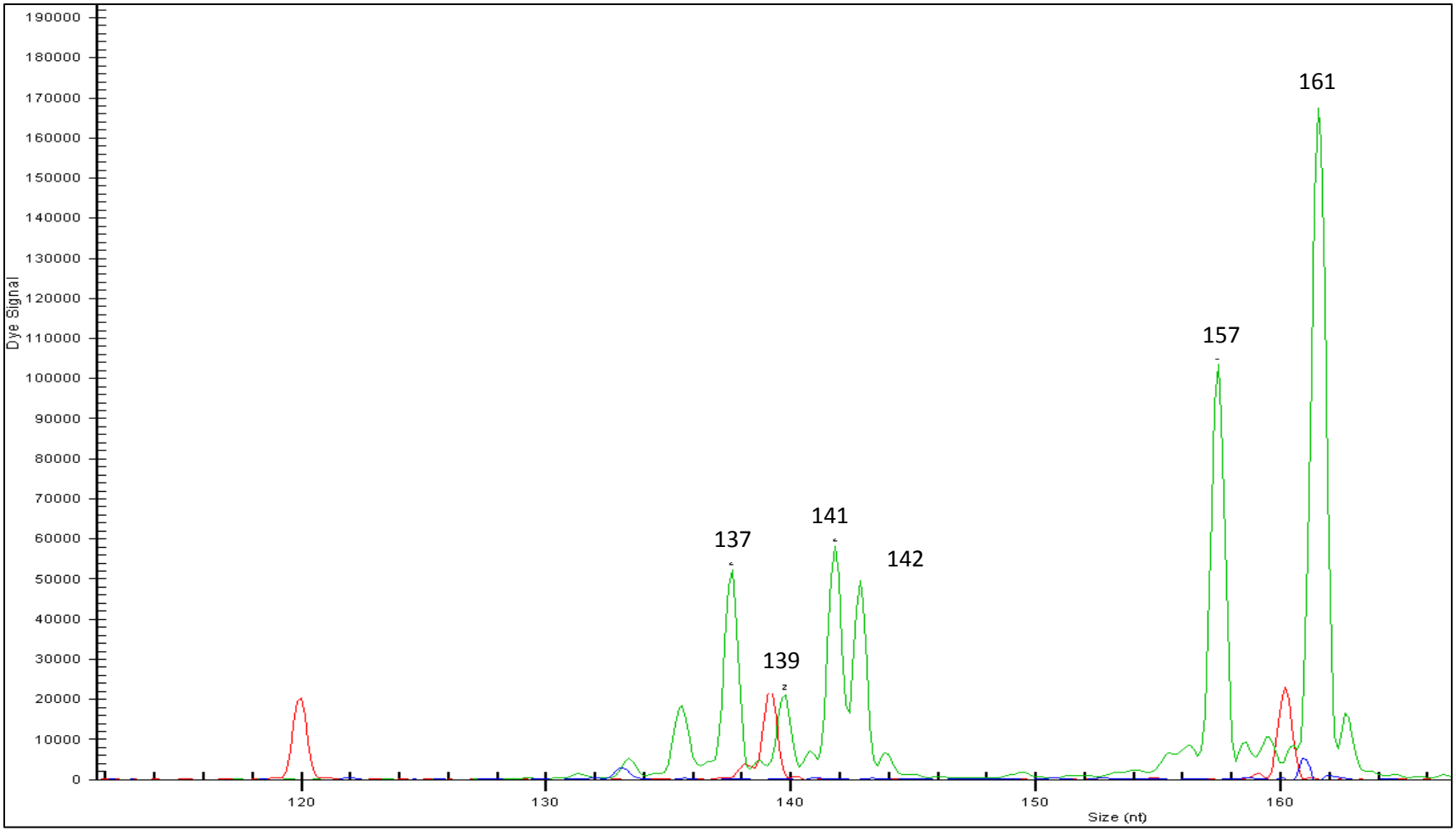


Fig. 1.1.Electropherograms of MSU_9-1-4 at EMFvi136 illustrating stutter peak at 135, and alleles 139 (stutter in some individuals and allele in others), 141 and 142 (1 bp difference), in addition to the 157 and 161 alleles.

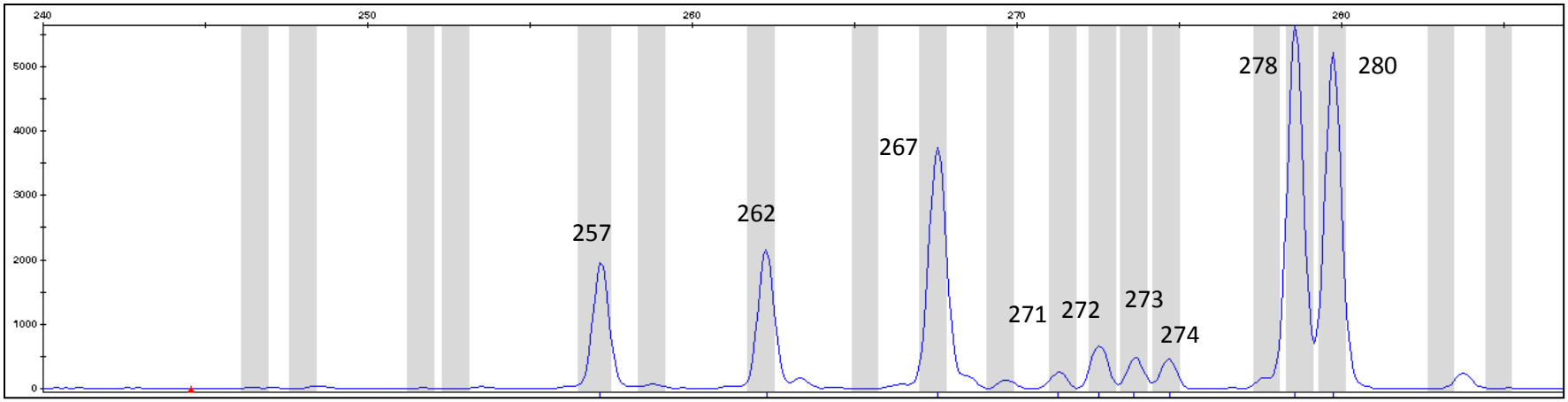


Fig. 1.2.Elecropherogram of ORUS_3214-12 with Bx89 illustrating small peaks (271, 272, 273, and 274).

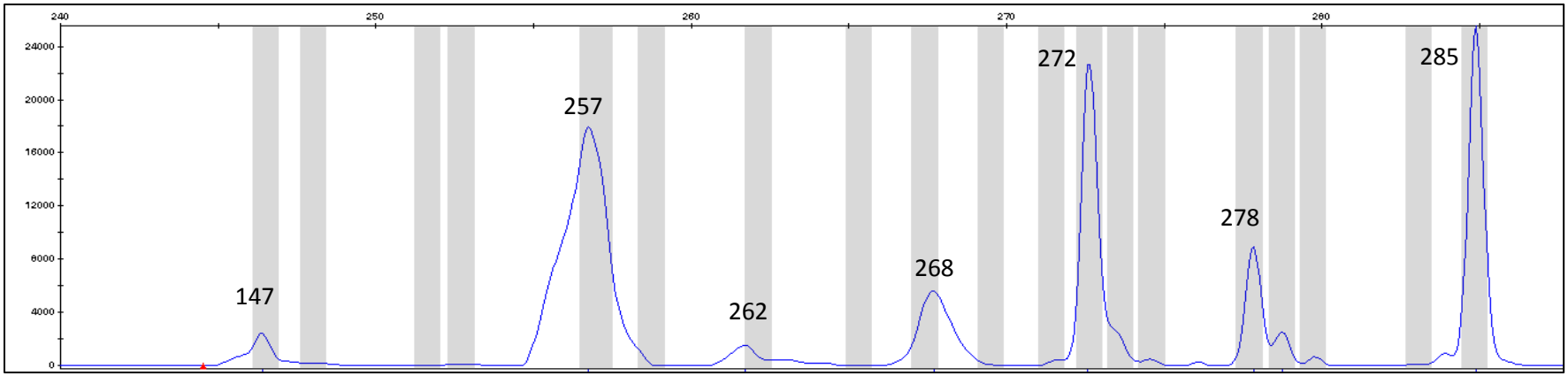


Fig. 1.3.Elecropherogram of ORUS_3277-5 with Bx89 illustrating non-uniform peaks (247, 257, 262 and 268).

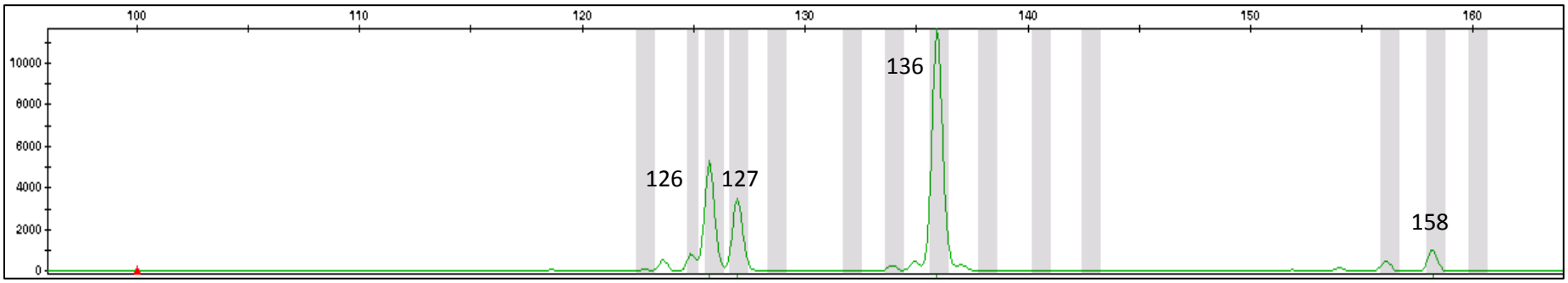


Fig. 1.4.Elecropherogram of ‘Honeoye’_CF (R14-74) with Bx215 illustrating one base pair differences between alleles 126 and 127 and stutter preceding allele 158.

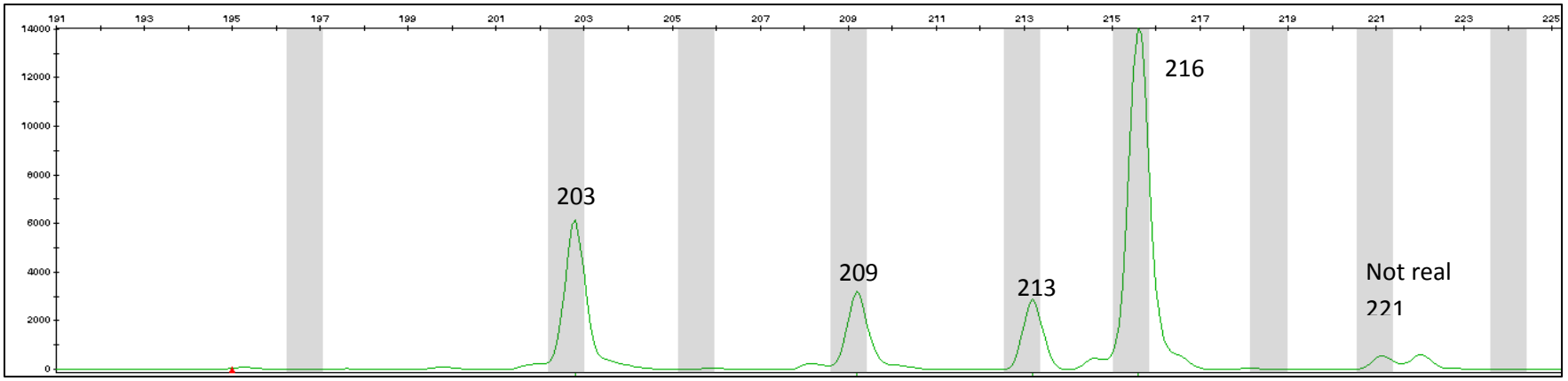


Fig. 1.5. Electropherogram of ‘Liberation_d_Orleans’ with Bx56 illustrating when allele 221 was not real.

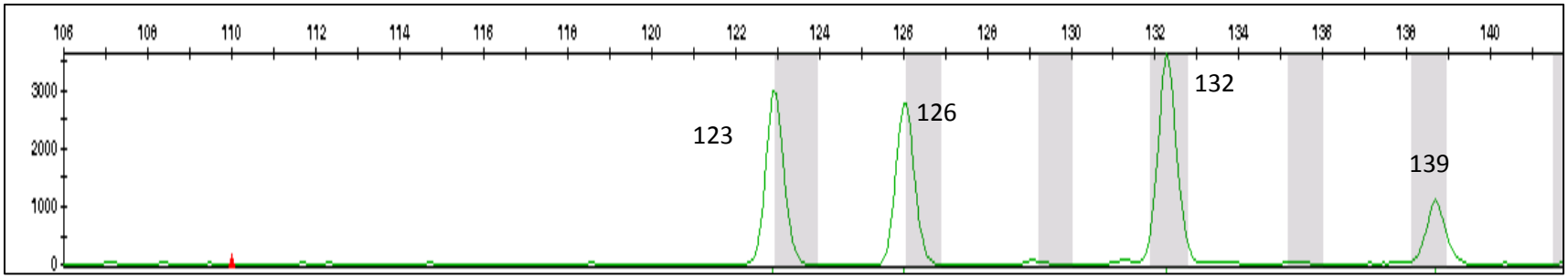


Fig. 1.6.Electropherogram of ‘Honeoye’ at Bx63 illustrating easy to score alleles that are well separated and with no stutter or single base pair differences.

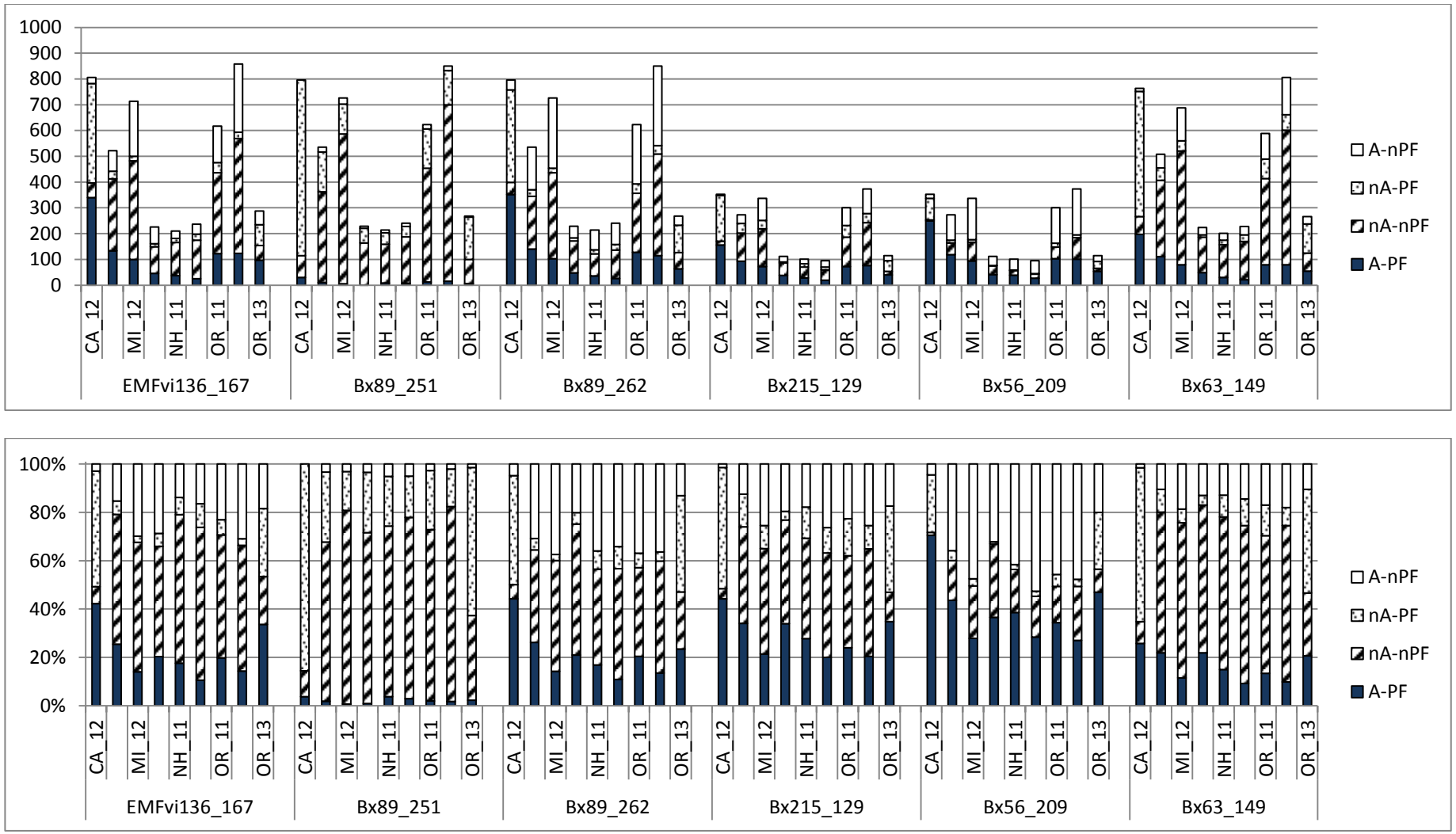


Fig. 1.7.Actual number (A) and percentage (B) of MTA (A-PF, nA-nPF) and non MTA (nA-PF, A-nPF) samples for the six alleles EMFvi136_167, Bx89_251, Bx89_262, Bx215_129, Bx56_209 and Bx63_149 for all the samples that had phenotypic data and genotypic data for at least one allele per state per year.

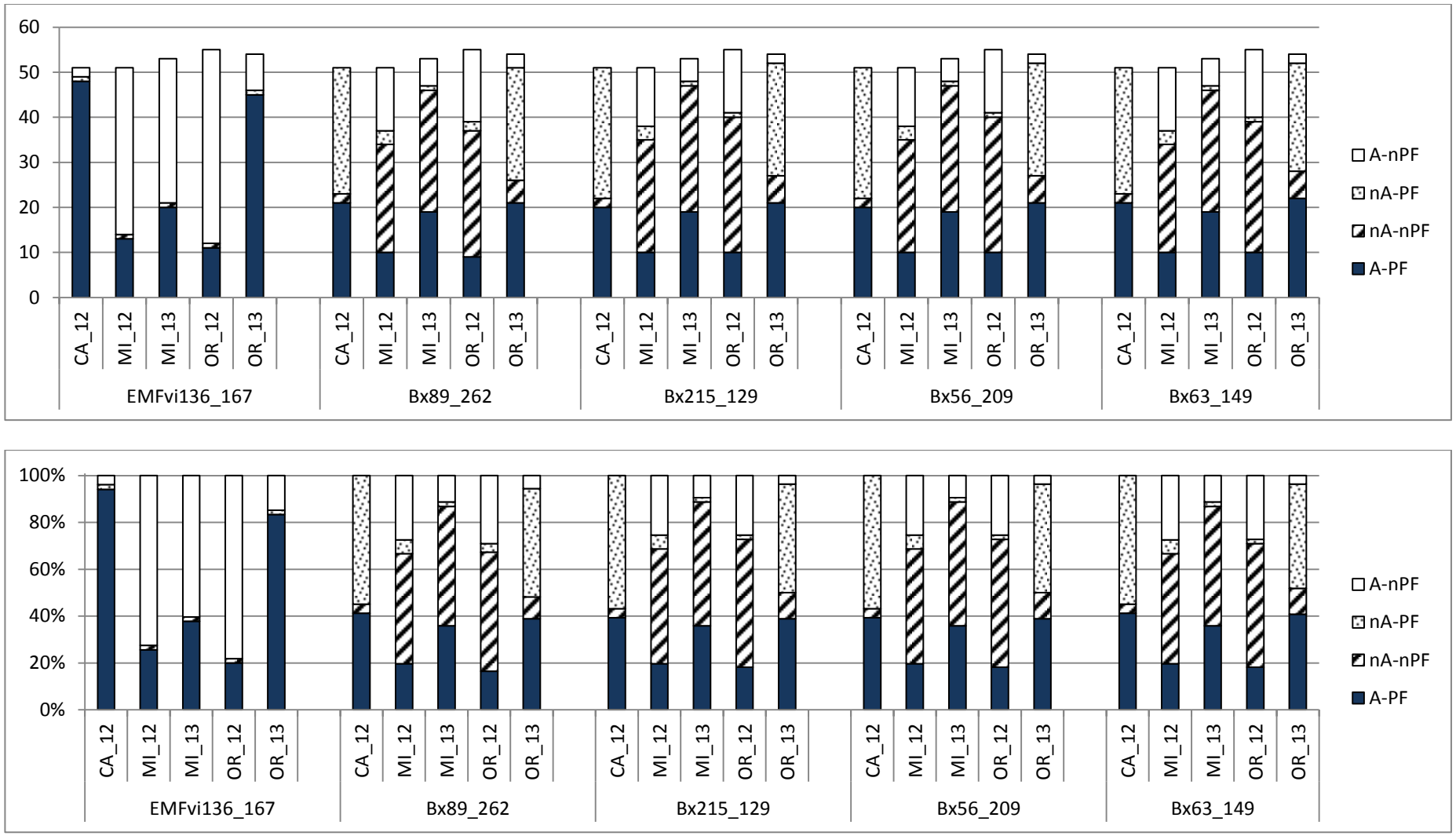


Fig. 1.8. Actual number (A) and percentage (B) of MTA (A-PF, nA-nPF) and non MTA (nA-PF, A-nPF) samples for the six alleles EMFvi136_167, Bx89_251, Bx89_262, Bx215_129, Bx56_209 and Bx63_149 for progeny of 'Capitola' per state per year.

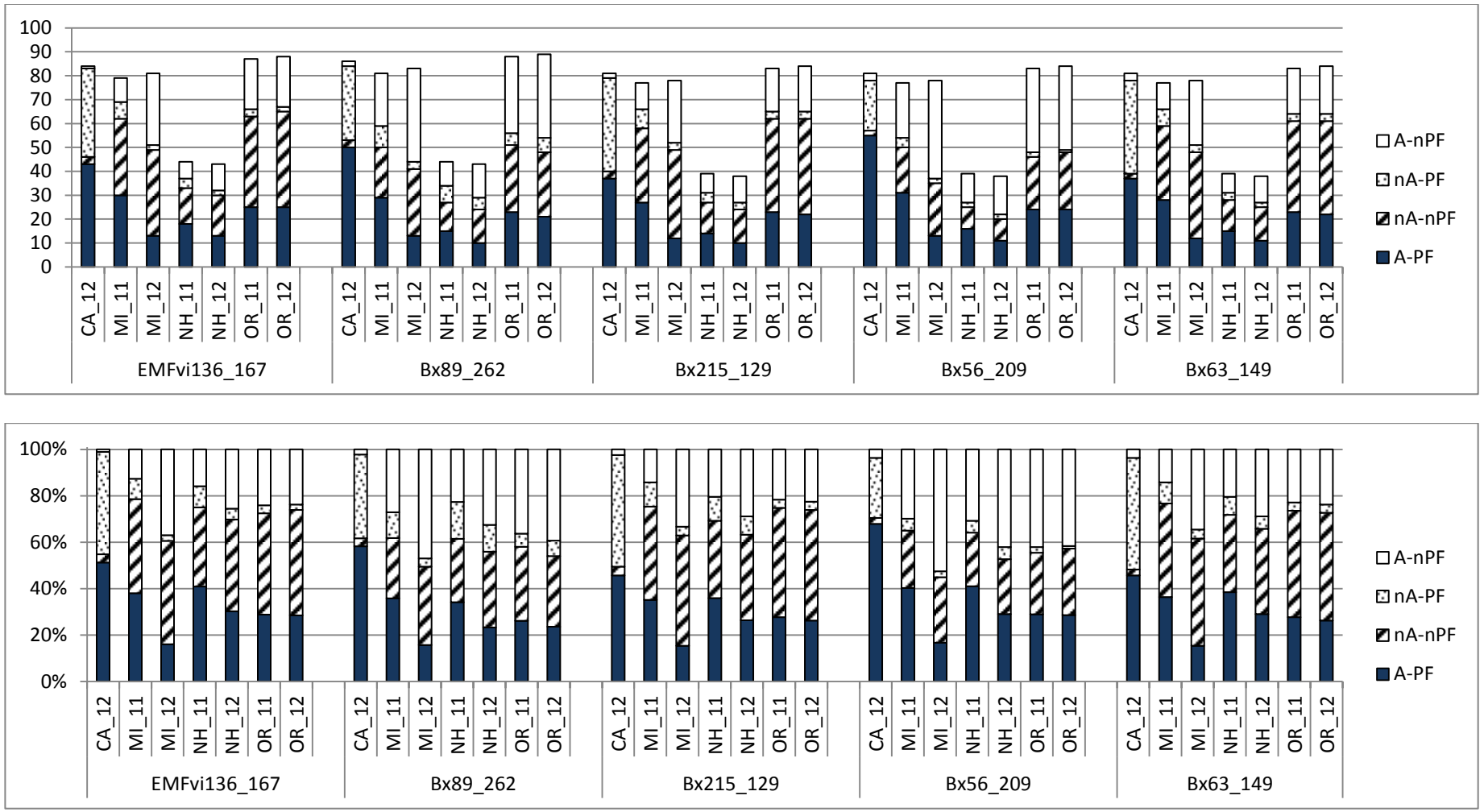


Fig. 1.9. Actual number (A) and percentage (B) of MTA (A-PF, nA-nPF) and non MTA (nA-PF, A-nPF) samples for the six alleles EMFvi136_167, Bx89_251, Bx89_262, Bx215_129, Bx56_209 and Bx63_149 for progeny of 'Seascape' per state per year.

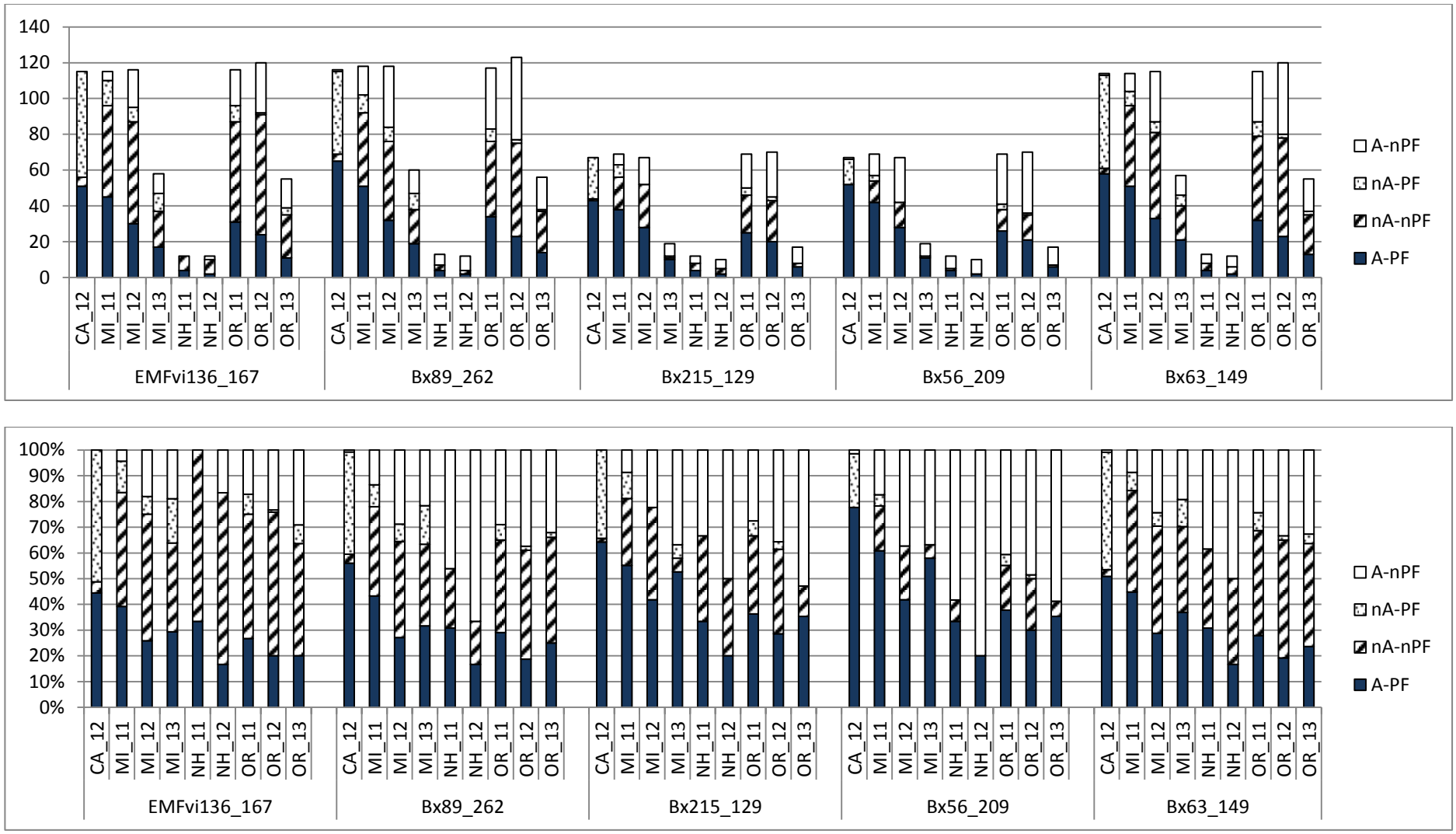


Fig. 1.10. Actual number (A) and percentage (B) of MTA (A-PF, nA-nPF) and non MTA (nA-PF, A-nPF) samples for the six alleles EMFvi136_167, Bx89_251, Bx89_262, Bx215_129, Bx56_209 and Bx63_149 for progeny of 'Tribute' per state per year.

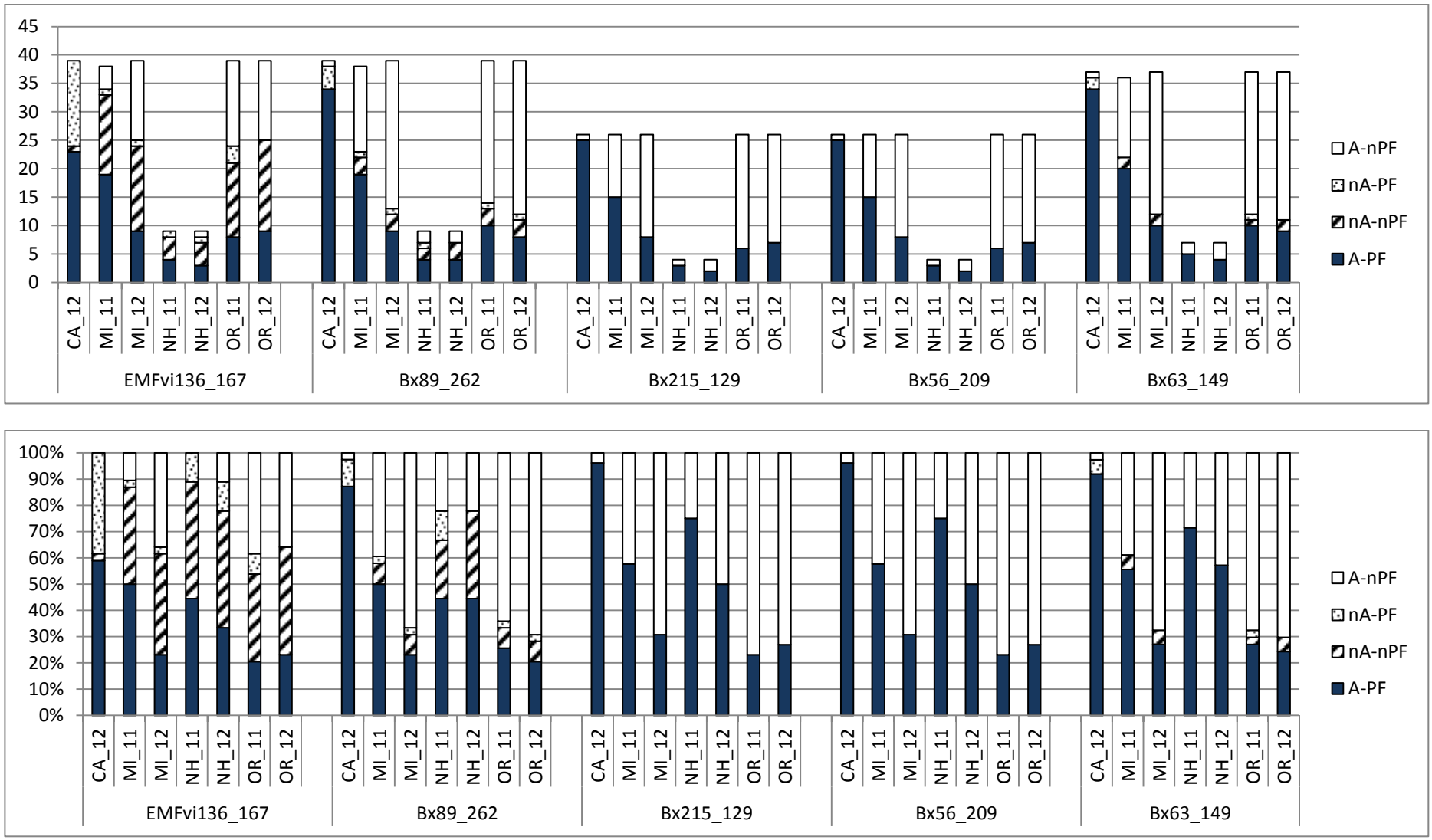


Fig. 1.11. Actual number (A) and percentage (B) of MTA (A-PF, nA-nPF) and non MTA (nA-PF, A-nPF) samples for the six alleles EMFvi136_167, Bx89_251, Bx89_262, Bx215_129, Bx56_209 and Bx63_149 for progeny of 'Fort Laramie NCGR' per state per year

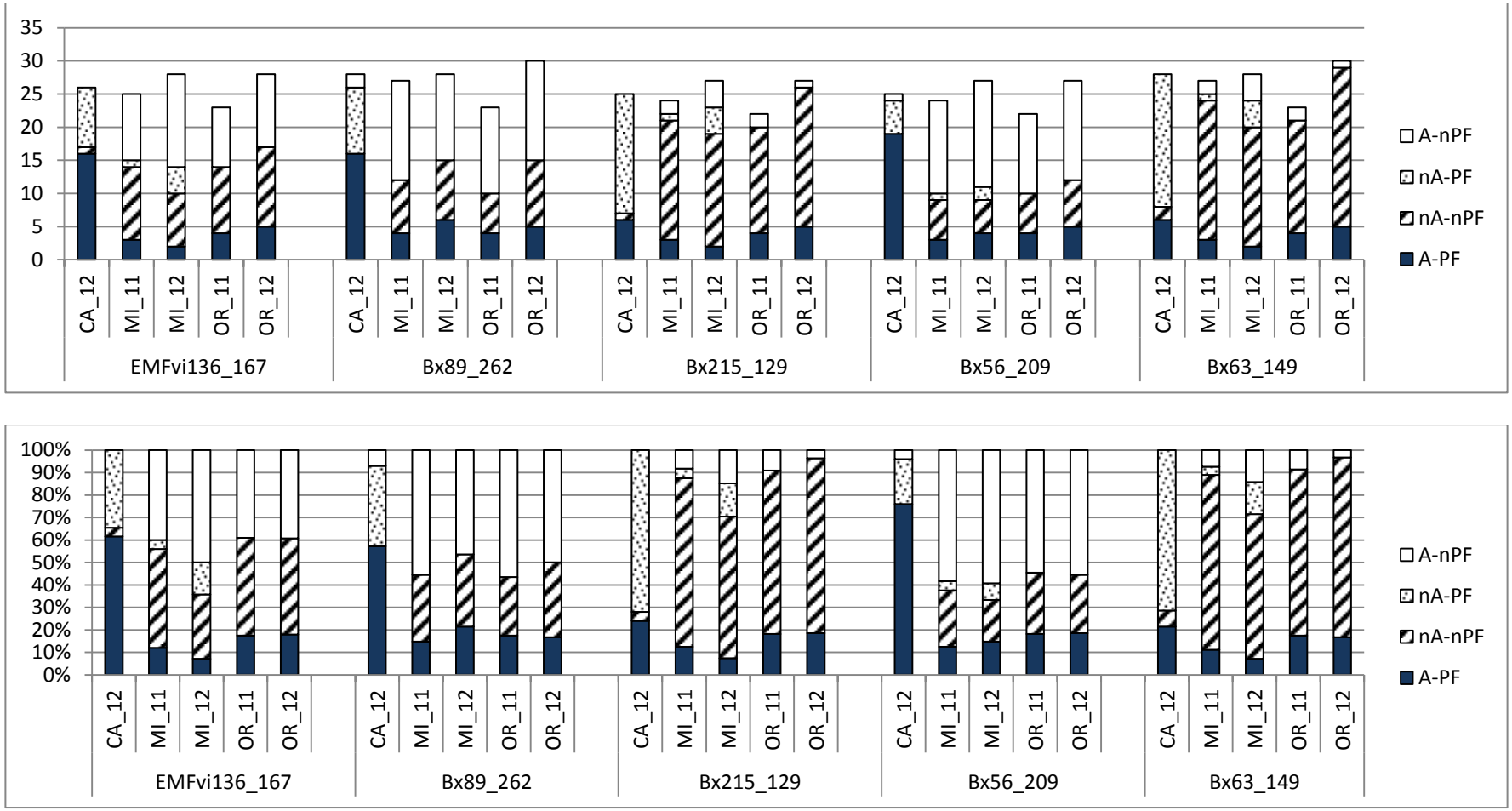


Fig. 1.12. Actual number (A) and percentage (B) of MTA (A-PF, nA-nPF) and non MTA (nA-PF, A-nPF) samples for the six alleles EMFvi136_167, Bx89_251, Bx89_262, Bx215_129, Bx56_209 and Bx63_149 for progeny of 'Fort Laramie I' per state per year.

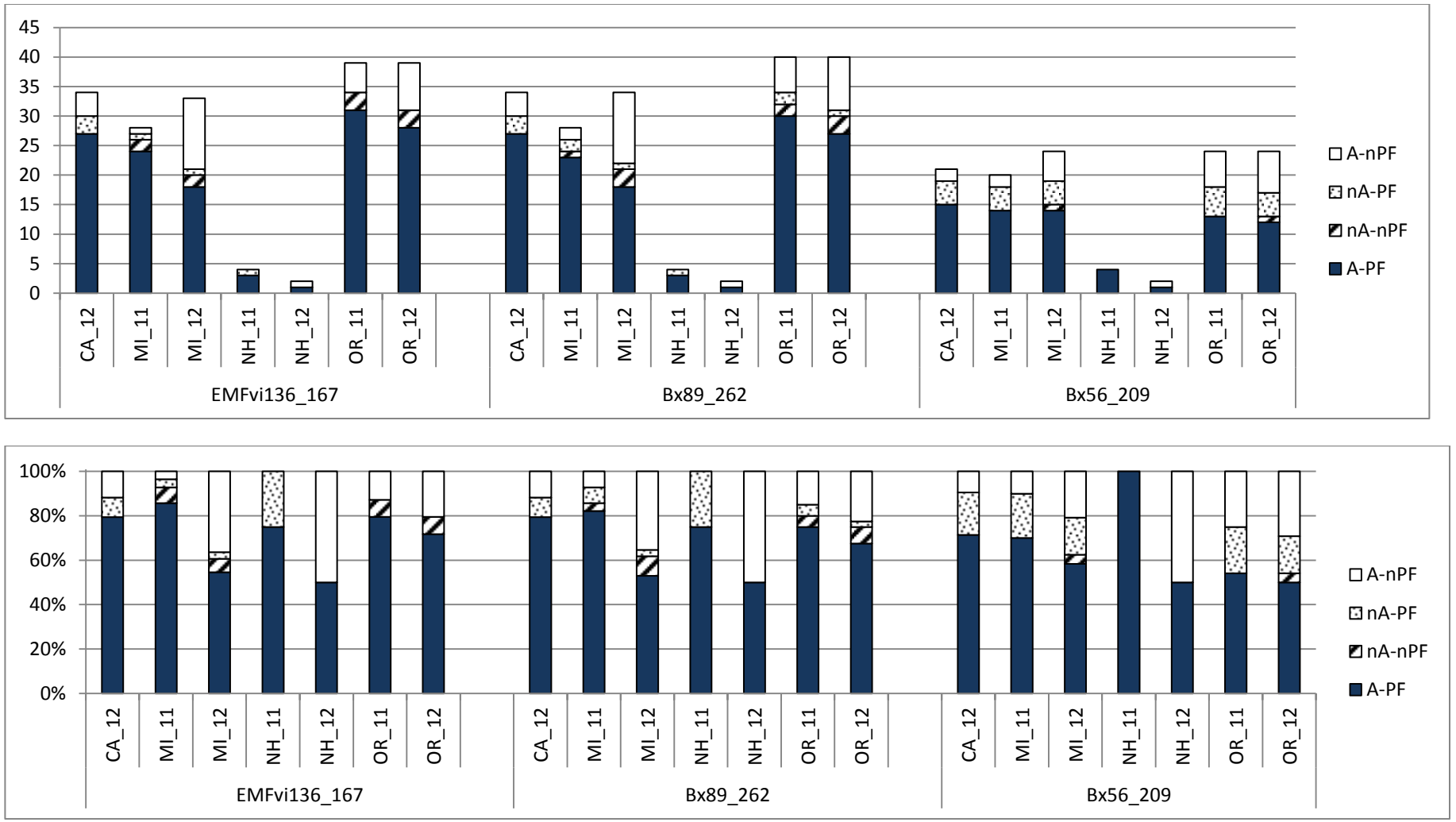


Fig. 1.13. Actual number (A) and percentage (B) of MTA (A-PF, nA-nPF) and non MTA (nA-PF, A-nPF) samples for the six alleles EMFvi136_167, Bx89_251, Bx89_262, Bx215_129, Bx56_209 and Bx63_149 for progeny of 'Sarian' per state per year.

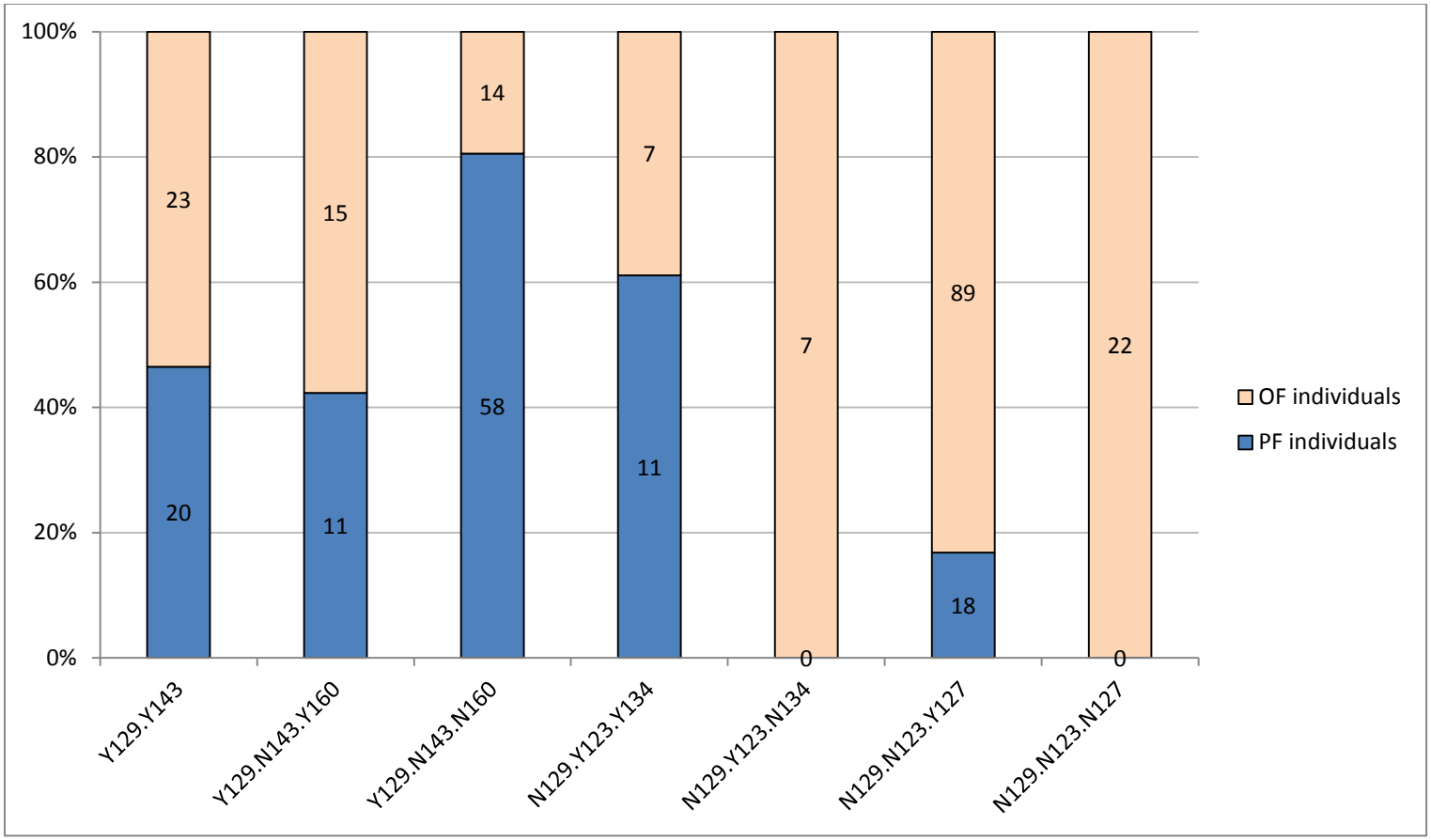


Fig. 1.14.Percentage of PF and OF individuals in each of the seven different combinations of alleles of Bx215. Actual number of individuals are indicated inside the bars.

Validation of Molecular Markers Associated with Soluble Solids Content (SSC) in Strawberry (*Fragaria* x*ananass*a Duch. ex Rozier)

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Additional index words. marker-assisted breeding, flavor, SSRs, RosBREED.

Abstract

Strawberry (*Fragaria* x*ananass*a Duch. ex Rozier) is a non-climacteric fruit whose swollen receptacle is valued for its characteristic red color, sweetness, fruity flavor and aroma. This study evaluated the usefulness of a subgenome-specific SSR marker located in LGVI-a, EMFv006, located close to a stable QTL for soluble solids content (SSC) in the 'Capitola' × CF1116 population, in predicting SSC in a broad range of germplasm encompassing 893 worldwide cultivars, selections and breeding populations. Percent of soluble solids was measured for an average of five primary or secondary fruits for each genotype in California, Michigan, New Hampshire and Oregon in 2011 and 2012. Segregation patterns in one of the four subgenomes obtained with EMFvi006 indicated that some of the progeny were incorrectly labeled by pedigree. Two alleles were associated with low SSC: EMFv006_209 in MI_12, NH_11 and NH_12, and EMFv006_215 in MI_11, OR_11 and OR_12; and two alleles were associated with high SSC: EMFv006_219 in MI_12, NH_12 and OR_12, and EMFv006_221 in MI_12, NH_11, OR_11 and OR_12. Plants with the 213:219 EMFvi006 genotype always had higher SSC than those with the 213:209 or 213:215 genotypes in all states except for California. When converted to functional alleles and analyzed by ANOVA in each of the

states, a consistent increase in SSC mean was observed between genotypes with the lower SSC types and the higher SSC genotypes in each of the states and years. Heritability (H^2) was low (0.02-0.09) in all states but NH_12 indicating that this trait is highly influenced by environmental conditions. The proportion of phenotypic variance (PVE) explained by EMFv006 was high in comparison with those of H^2 in all states except for CA_12 and ranged from 0.65 in MI_11 to 0.86 in NH_12, indicating that most of the genotypic variance observed can be explained by this locus. Much of the variability seen in SSC in this study could be explained by differences in environments and fruit ripening at the time of harvest and their effects on SSC as SSC is sensitive to environmental factors such as temperature as well as harvest date. It may be necessary to develop a more standardized protocol of measuring SSC across states and years to obtain more reliable SSC data for each individual. Most importantly, this study illustrates the usefulness of introgressing novel alleles from wild accessions into the cultivated gene pool. Both alleles consistently associated with high SSC, 219 and 221, originated from wild *F. virginiana* parents (FRA 1701-I1, and FRA 1701, respectively) from the "supercore" and were not present in any of the *F.* ×*ananassa* cultivars genotyped in this study except for an old European selection, 'Jucunda', of unknown pedigree.

Soluble solids content (SSC) definition and importance

Strawberry (*Fragaria* x*ananass*a Duch. ex Rozier) is a non-climacteric fruit whose swollen receptacle is valued for its characteristic red color, sweetness, fruity flavor and aroma. The seeds or achenes on the surface are the true fruit. Strawberries are also rich in bioactive compounds with antioxidant activity against cellular oxidation reactions in vitro (Capocasa et al. 2008). Comprehensive analyses of chemical composition and sensory perception of 35 strawberry cultivars and selections representing most of the commercial acreage across North America showed that overall liking was most greatly influenced by sweetness and strawberry flavor intensity (Schwieterman et al., 2014). More and more breeding programs are paying special attention to sweetness and fruit quality in strawberry and other members of the Rosaceae family (Pozo-Insfran et al., 2006; Lerceteau-Kohler et al., 2012).

The development of aromatic compounds, sugars, acids and even texture in fruit contribute to the flavor phenotype. During ripening, sugars increase and total acids decrease. A high content of both compounds results in an intense flavor that is desirable in strawberry (Zorrilla-Fontanesi et al., 2011). Glucose, fructose and sucrose are the main soluble sugars in strawberry (Cordenunsi et al., 2002). Citric and malic acids are the principal organic acids (Zorrilla-Fontanesi et al., 2011). Ethyl butanoate, mesifurane, ethyl hexanoate, ethyl 3-methylbutanoate, hexyl acetate, and γ –dodecalactone are the main aroma compounds (Jetti et al., 2007).

The soluble solids content (SSC) is a refractometric index that indicates the proportion (%) of dissolved solids (sugars, acids and other substances) in a solution. SSC is expressed in degrees Brix (^{o}Brix) and is measured with a refractometer (Lara et al., 2007). Since sugars comprise 80% – 90% of the SSC in strawberry (Perkins-Veazie, 1995), it has been used as an indicator of sweetness. At 20°C, the optimal temperature to measure soluble solids in a solution, ^{o}Brix is equivalent to the sugar percentage. For example, 60° Brix corresponds to a sugar content of 60% (http://www.pce-iberica.es/medidor-detalles-tecnicos/refractometros-tablas.htm). Mitcham et al. (2013) stated that 'for acceptable flavor, a minimum of 7% soluble solids and/or a maximum of 0.8% titratable acidity are recommended'.

QTL analyses for SSC

Many genes are involved in the biochemical pathways that control fruit development and ripening and a large number of QTLs appear to control important fruit quality traits (Zorrilla-Fontanesi et al., 2011; Lerceteau-Kohler et al., 2012). Zorrilla-Fontanesi et al. (2011) found 33 QTLs associated with 14 horticultural and fruit quality traits in a progeny of 95 individuals from a cross between two strawberry selections, '232' (Sel. 4-43 × 'Vilanova') and '1392' ('Gaviota' × 'Camarosa'). Some of the evaluated traits were yield, fruit firmness, titratable acidity (TA), anthocyanins and SSC that were measured during three consecutive years. The female parent '232' was high yielding while the male parent '1392' had superior firmness, and high SSC and TA. A genetic map was created with a total of 338 molecular markers composed by 250 SSRs,

77 AFLP and 11 other molecular markers that were arranged into 26 and 25 linkage groups for the female and male maps, respectively. Approximately 37% of the QTLs showed stability over time. Three QTLs for SSC were observed: *sscV-M.4* in 2007 that co-located with yield-related QTLs and explained 11.6% of the phenotypic variation; *sscII-F.1* in 2009 that explained 17.6% of the variation; and *sscVI-M.3* in 2007 and 2009 that explained 10.7% and 12.7% of the phenotypic variation, respectively. An AFLP marker, cct/aca-146, was closely associated with *sscVI-M.3*.

The inheritance of fruit quality traits was also analyzed in a segregating population of 193 seedlings from a cross between 'Capitola' and CF1116 (Lerceteau-Kohler et al., 2012). 'Capitola' has large fruits with low SSC and high TA while CF1116 has small fruits with high SSC and lower TA. A previously constructed map was used to identify 87 unique QTLs associated with 19 fruit traits including texture, color, anthocyanin, sugar and organic acid contents that were measured during two or three consecutive years. Twenty five percent of the QTLs found were homoeo-QTLs, located at orthologous positions on different homeologous linkage groups (LGs). One of the three QTLs for SSC was found on LGVIa at 40 cM in the female and male linkage maps and it explained 6% and 8% of the phenotypic variation, respectively (Lerceteau-Kohler et al., 2012). This QTL was stable and observed over three years in the male map and over two years in the female map (Lerceteau-Kohler et al., 2012; B. Denoyes, personal communication). The presence of this QTL in both parents suggests potential allelic forms of the same gene responsible for the variation. An SSR marker, EMFv006, was located close to this stable QTL.

The objective of this study was to evaluate the usefulness of this SSR in predicting SSC in a broad range of germplasm encompassing 893 worldwide cultivars, selections and breeding populations.

Materials and Methods

Plant material

The 893 *Fragaria* genotypes included in this study represented a freely distributed Crop Reference Set (CRS) and private mapping populations. The strawberry germplasm was obtained from multiple institutions including the USDA-ARS Horticulture Crops Research Unit (HCRU), Michigan State University (MSU), the USDA-ARS National Clonal Germplasm Repository (NCGR), the University of Florida (UF), the University of New Hampshire (UNH), the Instituto Andaluz de Investigación y Formación Agraria y Pesquera (IFAPA) in Spain, East Malling Research (EMR) in the United Kingdom, the Institut National de la Recherché Agronomique (INRA) in France, and the Center for Genetic Resources (PB-WUR) in The Netherlands. Driscoll Strawberry Associates (Watsonville, CA) imported the European material into the U.S. using their long-established quarantine and propagation facilities (Mathey, 2013).

The four European mapping populations are the INRA, EMR, NL (PB-WUR), and the IFAPA populations (Mathey, 2013). The INRA population consisted of 55

progeny from the ‘Capitola’ × CF1116 (‘Pajaro’ × [‘Earliglow’×‘Chandler’]) cross. The EMR population was comprised of 51 individuals from ‘Redgauntlet’ × ‘Hapil’. The NL (PB-WUR) population was comprised of 24 individuals from ‘Holiday’ × ‘Korona’. The IFAPA population consisted of 50 individuals from ‘232’ (Sel. 4-43 × ‘Vilanova’) × ‘1392’ (‘Gaviota’ × ‘Camarosa’).

The CRS group was comprised of 17 MSU breeding families of which 16 had 10 individuals each and one population of 65 seedlings; 19 ORUS breeding families of 10 individuals each from the USDA-ARS, HCRU breeding program; 215 individuals representing diverse cultivars; 35 wild accessions from the USDA-ARS-NCGR “supercore” collection (Hancock et al., 2001), 24 wild accessions representing *F. vesca, F. chiloensis, F. virginiana* and *F. iturupensis,* and 24 individuals and/or seedlings from four populations of synthetic *Fragaria* ×*ananassa* (Mathey, 2013).

Two plants of each accession in the form of rooted runners were planted in the field in California, Michigan, New Hampshire and Oregon in August 2010 (Mathey, 2013). In June 2011, the INRA, EMR, and PB-WUR populations were planted at each location as multi-crowned plants. The IFAPA population was distributed and planted in September 2011 as bare-root runners (Mathey, 2013).

Phenotyping

In NH, MI and OR, an average of five primary or secondary fruits were harvested once for each genotype when 30-50% of total fruit on the plant was ripe. The same protocol was used in CA with the difference that all the genotypes were harvested at the same time in late June. In the mild Watsonville (CA) climate, fruit can be allowed to hang on the plant for a long time without deterioration. Fruit samples were collected in plastic bags in the field and kept frozen at -20°C until lab analysis. In order to quantify SSC, frozen fruit samples were thawed at room temperature and homogenized by rolling a glass bottle over the plastic bag. The resulting pulp was used to measure the percent of soluble solids on a refractometer (ATAGO "Pocket" Digital Refractometer PAL-S, Tokyo, Japan).

Genotyping

Young leaves were collected from field-grown plants and the DNA was extracted from 30-50 mg of tissue using the Omega E-Z 96 Plant DNA Kit (OMEGA Bio-Tek, www.omegabiotek.com). DNA was quantified using the Quant-iT PicoGreen dsDNA Assay Kit (Life Technology). DNA stocks were diluted to 3 ng/µl and DNA was amplified in one multiplex PCR reactions with the Type-It Multiplex Microsatellite PCR Qiagen kit (QIAGEN, http://www.qiagen.com) in a total volume of 15 µL. Each PCR reaction had 8.3 µL of 2x Type-it Multiplex PCR Master Mix (Qiagen), 1.7 µL of 10X

multiplex primer mix, 1.7 µL of Q-solution, 0.025 µM of each fluorescently labeled forward standard and reverse pig-tailed primer for EMFv006 (James et al., 2003) and 3.3 µL of 3 ng/µl DNA. The PCR reaction was multiplexed with primer pairs EMFvi136 and ARSLF008. Genotypic information at this locus was obtained for 877 individuals (Appendix Table 2.1)

DNA amplification was performed in a PTC-225 Thermal Cycler (MJ Research, Inc., Waltham, MA) using a Touch Down 52 program that consisted of an initial denaturation of 95 °C for 5 min; 10 cycles of 95 °C for 30 s; 62 °C for 1.5 min minus 1°C per cycle; and 72 °C for 30 s; followed by 29 cycles of 95°C for 30 s; 52 °C for 1.5 min; 72 °C for 30 s; and a final extension at 60 °C for 30 min. The PCR products were kept at 4 °C until removed from the thermocycler. PCR success was assessed by 3% agarose gel electrophoresis. Allele composition at this SSR locus was determined after separation by capillary electrophoresis with the Beckman CEQ 8000 (Beckman Coulter, Inc, Pasadena, CA) at the NCGR laboratory. The Beckman CEQ 8000 software was used for allele visualization and scoring. Up to two PCR products were obtained from each octoploid strawberry individuals indicating subgenome specificity of this SSR. Therefore, amplification of a single product indicated homozygosity at this locus.

Statistical analysis

Statistical analysis was conducted on 609 individuals for which phenotypic data was available from more than one state (Appendix Table 3.5). Four datasets were

analyzed: all samples (609), breeding populations (316), cultivars (101) and mapping populations (142). SSC means were compared between individuals with each allele and individuals without that allele using a t-test. For each allele, number, mean and P-value were calculated. Rare alleles occurring in <5 individuals (205, 211, 223, 225, 227, 233 and 239) were excluded from the analysis (Table 2.1).

Genotype association was conducted in all samples (N=609) and a subset of samples from the breeding populations (N=316). For each state, ANOVA tests and pairwise comparisons using t-tests were done in the statistical package R version 0.98.501, 2009-2013. Four functions were used: 1) aggregate to calculate SSC means of the genotypes; 2) table to calculate the number of each genotype; 3) summary to test the significance of genotypes associated with SSC based on ANOVA, P-value shown as Pr(>F); and 4) Pairwise.t.test. Genotypes observed in less than five individuals were considered rare and excluded from the analysis.

All the alleles were then converted to their functional type: high (H), medium (M), low (L) and unknown (X) effect on SSC mean based on significant allele and genotype associations obtained. Each individual was assigned to one of these ten combinations: LL; LM, LH, MM, MH, HH, LX, MX, HX, XX. ANOVA test was performed between SSC means in the ten groups in each state and year. The proportion of phenotypic variance explained by these genotypes (Locus PVE = SS genotype/ [SS genotype+SS residual]), the heritability of the SSC trait, defined as the ratio of the total genetic variance to phenotypic variance implicated in the SSC at this locus (H = variance

of genotype/ (variance of genotype + variance of residual) and the proportion of PVE over H was calculated in each dataset.

Results

Percent soluble solids content ranged between 3.1 and 19.5 in 2011 and between 3.0 and 16.6 in 2012 in the OR, MI, CA and NH field-grown genotypes evaluated. The greatest SSCs were observed in MI and CA (Mathey et al., 2013).

EMFv006 performance

This SSR was easy to score and amplified up to two alleles indicating subgenome specificity (Figure 2.1). It amplified 14 alleles in 877 strawberry samples: 10 in the 795 *F.* × *ananassa*; 9 in the 22 *F. chiloensis*; 10 in the 28 *F. virginiana*; 8 in the 25 individuals representing synthetic *F.* × *ananassa*; and 2 in the 7 *F. vesca* individuals (Table 2.1). Twenty individuals (13 *F.* × *ananassa*, 5 *F. vesca* and *F. virginiana*) had null alleles (Appendix Table 2.1). Two unique alleles (227 and 239) were present in *F. virginiana*, one (223) in *F.* × *ananassa* and one (205) in *F. chiloensis.* Seven alleles (205, 211, 223, 225, 227, 233 and 239) were rare and occurred in less than five individuals.

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Allele association with SSC

SSC means were compared between individuals with a specific allele and individuals without a specific allele using t-test in four datasets: all samples (609), breeding populations (316), cultivars (101) and mapping populations (142). Only in datasets representing all the samples and breeding populations were there significant differences in SSC between presence and absence of alleles. When all the individuals were analyzed (Table 2.2) alleles that were most significantly associated with low SSC were: EMFv006_209 in MI_12, NH_11 and NH_12, and EMFv006_215 in MI_11, OR_11 and OR_12. Alleles that were significantly associated with high SSC were EMFv006_219 in MI_12, NH_12 and OR_12, and EMFv006_221 in MI_12, NH_11, OR_11 and OR_12. However, the number of individuals with EMFv006_221 was very small (1-9) in comparison with individuals lacking this allele. When considering only individuals from the MSU and ORUS breeding populations, EMFv006_215 was still significantly associated with low SSC in MI_11, OR_11 and OR_12 in addition to NH_11 and NH_12. EMFv006_219 and EMFv006_221 were still significantly associated with high SSC in the same states.

In general, genotypes were significantly associated with SSC in all locations except for CA_2012. Plants with the 213:219 EMFvi006 genotype always had higher SSC than those with the 213:209 or 213:215 genotypes (Table 2.4). The difference in SSC between plants with the high SSC genotype (213:219) and those with the lower SSC genotypes (213:209 or 213:215) ranged from 0.93 in OR_2011 to 3.33 in NH_2012.

Significant differences were observed between 213:219 and 213:209 or 213:315 in all states (MI, NH and OR) but California and in all years (Table 2.4).

EMFv006_219 was present in: six out of 10 seedlings of the three MSU breeding populations that had the *F. virginiana* FRA 1702-I1 as a parent (MSU 9-1, MSU 9-4 and MSU 9-5); two seedlings each in MSU 9-12 (MSU_9-12-1 and MSU_9-12-5) and ORUS 3304 (ORUS 3304-8 and ORUS 3304-11); one in MSU_9-14-3 and MSU_9-16-57; one in each of *F. vesca*, subsp. *vesca* (Hawaii0_TD), *F. vesca*, subsp. *bracteata* (FRA 1952), and *F. chiloensis* (FRA 368) accessions; and six *F. virginiana* subsp. *virginiana* accessions (FRA 982, FRA 1557, FRA 1697, FRA 1700, L1) or offspring [LB 48 or FRA 1996 (FRA 1994 ×FRA 1992)] (Appendix Table 2.1).

EMFv006_221 was present in *F. virginiana* FRA 1701 and in two to three seedlings each of the four ORUS breeding populations where it was used as a parent [(ORUS 3277-8 and ORUS 3277-10); (ORUS 3306-2 and ORUS 3306-13); (ORUS 3304-2, ORUS 3304-2-5, and ORUS 3304-2-10); and (ORUS 3317-2, ORUS 3317-3, and ORUS 3317-5)]; one in the *F. chiloensis* FRA 48 accession; and one in an old selection of *F ×ananassa*, 'Jucunda', released in 1854 by John Salter, in Hammersmith, England and introduced to the US in 1858 (Darrow, 1966) (Appendix Table 2.1).

The alleles were then converted to their functional type. A total of seven alleles were analyzed: EMFv006_209 and EMFv006_215 were placed in the low SSC mean group (L), EMFv006_207, EMFv006_213 and EMFv006_217 in the medium SSC mean

group (M) and EMFv006_219 and EMFv006_221 in the high SSC mean group (H). A total of six different genotype possibilities (LL, LM, LH, MM, MH and HH) were compared in each state and year. The remaining alleles were rare and excluded from the analysis. Significant differences were observed between means of the functional genotypes in each state but CA_12 although the standard deviations were high. The heritability (H) across all the states ranged from 2.2% in MI_12 to 20.9% in NH_12 (Table 2.5-2.8) while PVE explained by these functional genotypes ranged from 1.9% in MI_12 to 17.9% in NH_12. In CA_12 PVE was 0.5%. Values of PVE/H ranged from 0.65 in MI_11 and 0.86 in MI_12 and NH_12.

Discussion

Strawberry flavor results from the combination of aromatic compounds, sugars, acids and even texture in fruit. The overall liking of 35 North American commercial strawberries was most influenced by sweetness and strawberry flavor intensity (Schwieterman et al., 2014). A high content of sugars and acids results in an intense flavor that is desirable (Zorrilla-Fontanesi et al., 2011). Lately, flavor has become more important in strawberry breeding programs and fruit quality mapping is being investigated intensively.

EMFv006, an SSR marker mapped closed to a SSC QTL in LGVI-a in the cross ‘Capitola’ × CF1116, amplified alleles, in one of the four subgenomes of the octoploid strawberry, making it very easy to score just like in a diploid. Amplification of a single

allele indicated homozygosity at this locus and was confirmed by segregation in multiple populations (Appendix Table 2.1).

Segregation patterns at EMFv006 indicated that some of the progeny were incorrectly labeled by pedigree. For example, each of the six 219-containing non-FRA 1702-I1-derived seedlings was an outcross as supported by presence of alleles in these seedlings that were not present in either parents at one to five SSRs (chapter 2) to evaluate association with the perpetual flowering (PF) trait: ORUS 3304-8 and ORUS 3304-11 at EMFvi136; MSU 9-14-3 at EMFvi136, Bx63, Bx215 and Bx56; MSU_9-16-57 at EMFvi136 and Bx63; and MSU 9-3-6 and MSU 9-3-9 at each of the five SSRs evaluated in the PF study. In these outcrosses, FRA 1702-I1 could have been the source of pollen.

The two alleles, EMFv006_219 and EMFv006_221 that were found to be associated with high SSC were obtained from wild accessions of *F. virginiana*, FRA 1702-I1 and FRA 1701, respectively. The origin of FRA 1701-I1 is unknown, but 221-containing FRA 1701, RH 30, (PI 612499) was collected from Minnesota. This accession was chosen to be in the "supercore" originally described by Hancock et al. (2001) and established to widen the germplasm base of the cultivated strawberry. FRA 1701 was described as a partial hermaphrodite with cyclic flowering that is resistant to black root rot, scorch and spot (Hancock et al., 2001). In fact, three of the five *F. virginiana* accessions that had the 219 allele were also from the "supercore": FRA 1557 (PI 612323, NC 96-48-1), a female from Alabama with high productivity and resistance to *C.*

acutatum, leaf scorch and leaf blight; FRA 1697 (PI 612495, LH 50-4), a hermaphrodite, cyclic flowering plant from Montana with extremely large and numerous fruits, and possible cold hardiness; and FRA 1700 (PI 612498, RH 23), a partially hermaphroditic plant from Minnesota with cyclic flowering and large fruit that is also resistant to black root rot, scorch and leaf spot (Hancock et al., 2000). Other 219-containing *F. virginiana* subsp. *virginiana* accessions included FRA 982 (PI 552275) collected from Maine, L1 (FRA 1994, PI 660769) from New Hampshire and its offspring [LB 48 or FRA 1996 (FRA 1994 ×FRA 1992)]. Sources of the 219 and 221 alleles in *F. chiloensis* were obtained from Alaska in FRA 368 (PI 551735) and Oregon in FRA 48 (PI 551459), respectively. Association of these two alleles with high SSC is also supported by the high positive general combining ability (GCA = 0.8) for these two parents analyzed jointly as FRA 1702 by Mathey (2013).

The seven alleles common in this germplasm set were converted to three functional alleles where L (209 or 215) was associated with low SSC; M (207, 213 or 217) with medium SSC; and H (219 or 221) with high SSC. When analyzed by ANOVA, a consistent increase in SSC mean was observed between LL or LM and MH genotypes in each of the states and years (Table 2.5-2.8). The standard deviation was however high and heritability was low (0.02-0.09) in all states but in NH_12 where it was moderate (0.20). SSC was reported to have moderate values of broad-sense heritability (H^2 = 0.35) in seedlings from controlled crosses among genotypes representative of the University of California advanced-generation germplasm in 1987 (Shaw et al., 1987) and higher values (H^2 = 0.40) in 19 full-sib families from a 5 x 4 factorial mating design, six additional bi-

parental crosses and 14 control genotypes that included some of the parents from the UF breeding material. These moderate to high values of H^2 indicate that this trait is highly influenced by environmental conditions. Mathey (2013) reported in this germplasm set variability in genotype, location, and year (2011 and 2012), in addition to significant location × year interactions for both years for SSC. Percent soluble solids were greater in California and Michigan than in Oregon and New Hampshire.

Previous studies have also reported variable (low, medium and high) values of narrow-sense heritabilities (h^2) for the SSC trait in strawberry. Low h^2 (0.07) was obtained in seedlings from controlled crosses among genotypes representative of the University of California advanced-generation germplasm (Shaw et al., 1987); medium h^2 (0.21) in 19 full-sib families from a 5 x 4 factorial mating design, six additional biparental crosses and 14 control genotypes that included some of the parents from the UF breeding material; and h^2 (0.25) in the 35 populations of 10 progeny each included in this study and that represent crosses between Midwestern and Pacific Northwestern adapted once flowering (OF) and PF individuals from a number of diverse genetic backgrounds (Mathey, 2013); and high h^2 (0.67) in F_1 hybrids between OF and PF Japanese and Korean cultivars by Murti et al. (2012).

Values of PVE (R2), which shows the proportion of phenotypic variance explained by these functional genotypes at this locus, were high in comparison to the values of H^2 in all states except for CA_12. In other words, PVE (R2)/ H values were high and ranged from 0.65 in MI_11 to 0.86 in NH_12, indicating that most of the genotypic variance observed can be explained by this locus that can strongly predict differences in SSC content. These results are supported by previous estimation of GCA

and specific combining ability (SCA) for SSC obtained by Mathey (2013). GCA and SCA variance components for SSC were significant (0.22) and GCA variance components were greater than those for SCA (0.11), suggesting that additive effects are more important than non-additive effects. This increases the chance to see breeding gain in SSC when selecting specific parents with high SSC as previously shown by Shaw (1990) in the University of California germplasm. Progenies with two parents selected for high SSC had the highest mean SSC (11.6) and parents selected for low SSC had the lowest mean SSC (9.1). Populations created by selection of parents with high SSC (divergent selection) followed by intermating expressed additive genetic variances (h^2 = 0.41) that were 2.3 times larger than those estimated for controls for SSC (h^2 = 0.15) (Shaw, 1990). Shaw (1990) highlighted that the gains are contingent upon selection under commercial cultivation conditions.

Much of the variability seen in the SSC trait in this study could be explained by differences in environments and fruit ripening at the time of harvest and their effects on SSC. Seasonal variation in SSC was observed in 410 genotypes of the strawberry breeding program at the University of Florida (Hasing et al., 2013). Genotype by environment interaction for SSC was also reported in the University of California germplasm by Shaw (1990), who concluded that gain in SSC in response to selection for breeding value is contingent upon selection under commercial cultivation conditions. In this study, SSC values were estimated once when 30-50% of total fruit on the plant was ripe, as feasible in a breeding program. Since SSC is very sensitive to environmental factors such as temperature as well as harvest date, it may be necessary to develop a more

standardized protocol across states and years to measure SSC taking into account exact harvest date, prevailing environmental conditions (temperature, light intensity), and whether primary and secondary fruit should be analyzed separately. In order to obtain more accurate measurements of SSC for an individual, it is necessary to replicate SSC measurements, use objective means of determining the fruit ripening stage and a comparable harvest date for SSC measurements.

Most importantly, this study illustrates the usefulness of introgressing novel alleles from wild accessions into the cultivated gene pool. Both alleles consistently associated with high SSC, 219 and 221, originated from wild *F. virginiana* parents from the "supercore" and were not present in any of the *F.* ×*ananassa* cultivars genotyped in this study except for an old European selection, 'Jucunda', of unknown pedigree.

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Table 2.1. Alleles amplified by EMFv006 in 877 strawberry samples consisting of 22 *Fragaria chiloensis*, 7 *F. vesca*, 28 *F. virginiana*, 795 *F. ×ananassa* and 25 synthetic *F. ×ananassa* genotypes. Presence of allele (+) and absence of allele (.)

Alleles	***F. chiloensis***	***F. vesca***	***F. virginiana***	***F. ×ananassa***	**Synthetic *F. ×ananassa***
205[z]	+	.	.	.	.
207	+	.	+	+	+
209	+	.	+	+	+
211[z]	.	+	+	+	.
213	+	.	+	+	+
215	.	.	+	+	+
217	+	.	+	+	+
219	+	+	+	+	+
221	+	.	+	+	.
223[z]	.	.	.	+	+
225[z]	+	.	.	.	+
227[z]	.	.	+	.	.
233[z]	+	.	.	+	.
239[z]	.	.	+	.	.
Number of individuals	22	7	28	795	25

[z] Rare alleles (alleles present in less than five individuals).

Table 2.2.Comparison of soluble solids content (SSC) means between all individuals (N=610) that had the allele (Y) and individuals that did not have the alleles (N) obtained with SSR EMFv006 for all the states (CA=California, MI=Michigan, NH=New Hampshire, OR=Oregon) and years (2011, 2012) with t-tests.

State/Year	Allele	Number (Y/N)	Mean (Y/N)	Mean difference P-value
OR_11	EMFv006_207	191/290	8.8/8.5	0.3*
OR_12	EMFv006_207	175/277	7.3/7.5	(-0.2)*
MI_12	EMFv006_209	116/422	9.7/10.3	(-0.6)**
NH_11	EMFv006_209	12/111	8.2/9.3	(-1.1)**
NH_12	EMFv006_209	30/85	7.5/9.0	(-1.5)**
MI_11	EMFv006_211	1/206	5.0/11.3	(-6.3).
CA_12	EMFv006_213	398/140	9.6/10.0	(-0.4)*
OR_11	EMFv006_213	355/126	8.5/8.9	(-0.4)*
MI_11	EMFv006_215	47/160	10.5/11.5	(-1)**
OR_11	EMFv006_215	126/355	8.2/8.8	(-0.6)***
OR_12	EMFv006_215	123/329	7.1/7.5	(-0.4)**
MI_12	EMFv006_219	20/518	11.4/10.2	1.2**
NH_12	EMFv006_219	17/98	10.2/8.4	1.8**
OR_12	EMFv006_219	13/439	8.7/7.4	1.3***
MI_12	EMFv006_221	6/532	11.7/10.2	1.5.
NH_11	EMFv006_221	1/122	12.4/9.2	3.2*
OR_11	EMFv006_221	9/472	10.6/8.6	2***
OR_12	EMFv006_221	6/446	9.1/7.4	1.7**

***, **, * = and . = $p \leq 0.001$, $p \leq 0.01$ $p \leq 0.05$and $p \leq 0.1$, respectively.

Table 2.3.Comparison of soluble solids content (SSC) means between individuals from breeding populations (N=316) that had the allele (Y) and individuals that did not have the alleles (N) obtained with SSR EMFv006 for all the states (CA=California, MI=Michigan, NH=New Hampshire, OR=Oregon) and years (2011, 2012) with t-tests.

State/Year	Allele	Number (Y/N)	Mean (Y/N)	Mean difference P-value
CA_12	EMFv006_207	101/182	10.5/9.7	0.8***
NH_12	EMFv006_207	16/53	7.9/9.3	(-1.4)*
OR_11	EMFv006_207	116/183	8.9/8.4	0.5*
CA_12	EMFv006_213	222/61	9.7/10.9	(-1.2)***
MI_11	EMFv006_215	39/85	10.7/11.6	(-0.9)*
NH_11	EMFv006_215	23/66	8.8/9.5	(-0.7).
NH_12	EMFv006_215	16/53	7.9/9.3	(-1.4)*
OR_11	EMFv006_215	103/196	8.1/8.9	(-0.8)***
OR_12	EMFv006_215	82/143	7.1/7.6	(-0.5)**
MI_12	EMFv006_219	19/265	11.4/10.4	1*
NH_12	EMFv006_219	17/52	10.2/8.5	1.7**
OR_12	EMFv006_219	13/212	8.7/7.4	1.3**
NH_11	EMFv006_221	1/88	12.4/9.3	3.1*
OR_11	EMFv006_221	9/290	10.6/8.5	2.1***
OR_12	EMFv006_221	6/219	9.1/7.4	1.7**

***, **, * = and . = $p \leq 0.001$, $p \leq 0.01$ $p \leq 0.05$and $p \leq 0.1$, respectively.

Table 2.4.Comparison of soluble solids content (SSC) means between all individuals (N=610) that had the genotype 213:219 and individuals that had 213:215 or 213:209 for all the states (MI=Michigan, NH=New Hampshire, OR=Oregon) and years (2011, 2012) obtained with pairwise comparison using t-tests.

State	High SSC genotype	Low SSC genotype	High SSC mean	Low SSC mean	Difference in SSC means Pvalue
MI_11	213:219	213:215	12.05	10.25	1.8*
MI_11	213:219	213:209	12.05	10.1	1.95*
MI_12	213:219	213:209	11.28	9.59	1.69**
MI_12	213:219	213:215	11.28	10.09	1.19*
NH_11	213:219	213:215	9.49	8.50	0.99*
NH_11	213:219	213:209	9.49	8.19	1.3*
NH_12	213:219	213:209	10.33	7.00	3.33***
NH_12	213:219	213:215	10.33	8.17	2.16**
OR_11	213:219	213:215	9.02	7.80	1.22**
OR_11	213:219	213:209	9.02	8.09	0.93*
OR_12	213:219	213:215	8.71	7.25	1.46***
OR_12	213:219	213:209	8.71	7.35	1.36**

***, **, * and $^{\cdot}$ = $p \leq 0.001$, $p \leq 0.01$ $p \leq 0.05$and $p \leq 0.1$, respectively.

Table 2.5. ANOVA results for each genotypic combination for California in 2012 (CA_12). Values for phenotypic variance [PVE(R2)], heritability (H), and PVE/H.

Location/Year	CA_12			
Genotype	LL	LM	MM	MH
Number	33	202	250	26
Mean	9.7	9.6	9.7	10.2
SD	1.9	1.9	1.9	1.4
Pvalue	0.507			
PVE(R^2)	0.5%			
H	0%			
PVE/H	NE			

Table 2.6. ANOVA results for each genotypic combination for Michigan (MI). Values for phenotypic variance [PVE(R2)], heritability (H), and PVE/H.

Location/Year	MI_11			MI_12			
Genotype	LM	MM	MH	LL	LM	MM	MH
Number	58	119	10	35	201	254	17
Mean	10.6	11.6	12.1	9.8	10.0	10.3	11.3
SD	2.1	2.3	1.8	1.9	2.0	2.1	2.1
Pvalue	0.011			0.024			
PVE(R^2)	4.8%			1.9%			
H	7.4%			2.2%			
PVE/H	0.65			0.86			

Table 2.7. ANOVA results for each genotypic combination for New Hampshire (NH). Values for phenotypic variance [PVE(R2)], heritability (H), and PVE/H.

Location/Year	NH_11			NH_12			
Genotype	LM	MM	MH	LL	LM	MM	MH
Number	33	57	17	9	30	43	16
Mean	8.6	9.5	9.5	8.1	7.5	8.9	10.3
SD	1.6	1.3	1.2	1.9	1.7	2.2	2.4
Pvalue	0.0160			0.0003			
PVE(R^2)	7.6%			17.9%			
H	9.3%			20.9%			
PVE/H	0.82			0.86			

Table 2.8. ANOVA results for each genotypic combination for Oregon (OR). Values for phenotypic variance [PVE(R2)], heritability (H), and PVE/H.

Location/Year	OR_11				OR_12			
Genotype	LL	LM	MM	MH	LL	LM	MM	MH
Number	16	165	244	26	34	183	195	10
Mean	8.5	8.2	8.7	9.4	7.5	7.2	7.4	8.7
SD	1.4	1.5	1.7	1.7	1.2	1.2	1.4	0.9
Pvalue	0.0002				0.0030			
PVE(R^2)	4.3%				3.2%			
H(Heritability)	6.2%				4.2%			
PVE/H	0.69				0.76			

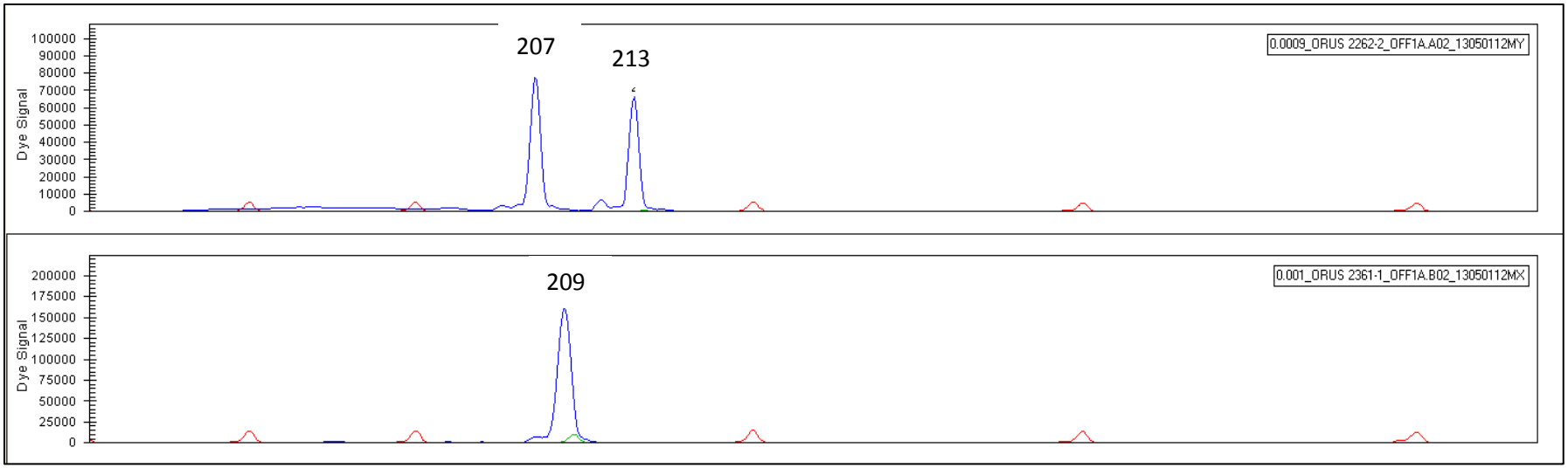


Fig. 2.1.Electropherograms of ‘Charm’ (ORUS_2262-2) and ORUS_2361-1at EMFv006 illustrating well defined peaks

CONCLUSIONS: Validation of Molecular Markers Associated with Perpetual Flowering (PF) and Soluble Solids Content (SSC) in Strawberry (*Fragaria* x*ananass*a Duch. ex Rozier)

Strawberry is economically the most important berry crop grown worldwide and breeders are continuously striving to develop improved cultivars. So far, marker assisted breeding (MAB) in strawberry has been limited to the private sector. Furthermore, a limited number of traits of economic importance such as perpetual flowering (PF), fruit quality, and disease resistance, have been mapped in the cultivated strawberry, a prerequisite to enabling MAB. The first objective of this research was to investigate usefulness of markers associated with PF in 'Capitola' in germplasm containing the same *F. virginiana* subsp. *glauca* source collected by Bringhurst in Utah's Wasatch Mountains through 'Tribute' and 'Seascape', and from other sources such as Pan American through 'Fort-Laramie', and an unknown source through 'Sarian'. The second objective was to assess the ability of an SSC-associated SSR marker for predicting high soluble solids in different environments in strawberry.

Based on presence in seedlings of alleles different from those found in the parents, parentage was confirmed and progeny that had unlikely genotypes or alleles based on Mendel's Law of Inheritance was identified in each of the mapping and breeding populations where an outcrossing rate of 16.8%, and 17.36% were observed in the MSU and ORUS breeding programs, respectively. Multiple genotypes of parents were identified and included 'Fort Laramie' and FRA 1701 in the MSU breeding

programs and ‘Tillamook’ and ‘Puget Reliance’ in the ORUS program. Genotype of the FRA 1701 used as a parent was different in the two programs. Six alleles were associated with PF in the entire dataset: EMFvi136_167, Bx89_251, Bx89_262, Bx215_129 and Bx56_209. In ‘Capitola’- derived progeny Bx89_262, Bx215_129, Bx56_209 and Bx63_149 were confirmed to predict the PF trait at a comparable rate. When evaluating MTA in families with the same source of PF, moderate to high MTA for allele presence at each of these five alleles was also found in ‘Seascape’ and ‘Tribute’- derived germplasm The highest %MTA (~83%) was found for EMFvi136_167, Bx215_129 and Bx63_149. In ‘Fort_Laramie’- derived progeny, the greatest MTA percentages (60-90%) were obtained with EMFvi136_167. EMFvi136_167 and Bx89_262 were equally effective at predicting PF (> 70%) in the ‘Sarian’_CF progeny while none of these alleles were found in FRA_1701 or any of the inferred FRA 1701 parents. When we used ANOVA to identify combinations of alleles that best explained the PF trait at Bx215 that maps close to the *FaPFRU* locus controlling this trait, the presence of 129 and absence of 160 increased predictivity of PF from 63% to ~80% while the absence of 129, 123, 127 and 134 predicted OF in 100% of the germplasm derived from the *F. virginiana* subsp. *glauc*a from the Wasatch Mountains in Utah (USA). In ‘Sarian’-derived germplasm, other alleles, 123 and 134 or 127, were predictive of PF. Establishing allele composition at each subgenome using MADCE for Bx215, Bx56 and Bx63 identified the associated alleles as shared among three or four of the subgenomes, thus unable to predict PF based on allele presence in all PF individuals. These alleles could be present in the subgenome that does not have the functional gene controlling PF. Absence of these alleles was more predictive of once flowering and could be used to eliminate those individuals and

therefore increase the proportion of PF progeny to evaluate. Determining haplotypes in this region and evaluating haplotype association with PF could be much more accurate in predicting PF than allele presence or absence and should be investigated.

Two EMFv006 alleles were associated with low SSC: 209 in MI_12, NH_11 and NH_12, and 215 in MI_11, OR_11 and OR_12; and two alleles were associated with high SSC: 219 in MI_12, NH_12 and OR_12, and 221 in MI_12, NH_11, OR_11 and OR_12. Plants with the 213:219 genotype also always had higher SSC than those with the 213:209 or 213:215 genotypes in all states except for California. When converted to functional alleles and analyzed by ANOVA in each of the states, a consistent increase in SSC mean was observed between genotypes with the lower SSC types and those with higher SSC genotypes in each of the states and years. Heritability (H^2) was low (0.02-0.09) in all states but NH_12 (0.20) indicating that this trait is highly influenced by environmental conditions. The proportion of phenotypic variance (PVE) was high in comparison with those of H^2 in all states except for CA_12 and ranged from 0.65 in MI_11 to 0.86 in NH_12, indicating that most of the genotypic variance observed can be explained by this locus that can strongly predict differences in SSC content. Much of the variability seen in the SSC data in this study could be explained by differences in environments and fruit ripening at the time of harvest and their effects on SSC which is very sensitive to environmental factors such as temperature and harvest date. We believe that a more standardized protocol of measuring SSC across states and years is needed to generate more reliable SSC data for each individual. Most importantly, this study illustrated the usefulness of introgressing novel alleles from wild accessions into the cultivated gene pool. Both alleles consistently associated with high SSC, 219 and 221,

originated from wild *F. virginiana* parents (FRA 1701-I1, and FRA 1701, respectively) from the "supercore" and were not present in any of the *F.* ×*ananassa* cultivars genotyped in this study except for an old European selection, 'Jucunda', of unknown pedigree.

APPENDIX

Appendix Table 3.1. Phenotypic and genotypic information for the PF trait in nine states/years for individuals analyzed in this study (breeding populations, cultivars, supercore collection, wild accessions and synthetic *F.* x*ananassa*). For each breeding population all possible parents are in the first rows with darker background, the confirmed female and male parent are indicated with superscript "m" and "l", respectively. PF plants are indicated with value "1" and no PF plants with value "0". Individuals that were genotyped with 6 SSR and did not present alleles different to those in the parents are indicated with "√", individuals with different alleles are indicated with "√^{OC}". Missing data is represented with a dot.

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
European populations																	
EMR population (Redgauntlet × Hapil)[h]																	
Redgauntlet_NL[z, k, g]	NJ_1052	Auchincruive_Climax	.	.	.	.	.	.	.	.	.	√	√	√	.	.	√
Redgauntlet_CF[m, j]	NJ_1051	Auchincruive_Climax	1	0	1	0	.	.	1	1	1	√	√	√	√	√	√
Hapil_NL[l, i]	Gorella	Souv_de_CharlesMachiroux	.	.	.	.	.	.	.	.	.	√	√	.	.	.	.
EMR_1	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_2	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_3	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_6	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	1	.	0	1	√	√	√	.	.	√
EMR_10	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	1	.	0	1	√	√	√	.	.	√
EMR_11	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_12	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_13	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	1	.	1	1	√	√	√	.	.	√
EMR_16	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	1	1	√	√^{OC}	√	.	.	√
EMR_17	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	1	.	0	1	√	√	√	.	.	√
EMR_20	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	1	.	0	1	√	√	√	.	.	√
EMR_21	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_25	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
EMR_28	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_29	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_30	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	1	.	1	1	√	√	√	.	.	√
EMR_32	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_34	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_36	Redgauntlet_CF	Hapil_NL	0	.	0	0	.	1	.	0	1	√	√	√	.	.	√
EMR_43	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_45	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	1	.	0	1	√	√	√	.	.	√
EMR_48	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_51	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_54	Redgauntlet_CF	Hapil_NL	0	.	0	0	.	1	.	0	1	√	√	√	.	.	√
EMR_55	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	0	√	√	√	.	.	√
EMR_56	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_57	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_58	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	1	.	0	0	√	√	√	.	.	√
EMR_59	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_63	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	0	√	√	√	.	.	√
EMR_65	Redgauntlet_CF	Hapil_NL	0	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_66	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_67	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	1	.	0	1	√	√	√	.	.	√
EMR_70	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	0	√	√	√	.	.	√
EMR_71	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√
EMR_73	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	1	.	0	1	√	√	√	.	.	√
EMR_76	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	0	.	0	1	√	√	√	.	.	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
EMR_82	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	.	.	0	1	√	√	√	.	.	√
EMR_84	Redgauntlet_CF	Hapil_NL	0	.	0	0	.	.	.	0	1	√	√	√	.	.	√
EMR_85	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	.	.	0	1	√	√	√	.	.	√
EMR_92	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	.	.	0	1	√	√	√	.	.	√
EMR_98	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	.	.	0	0	√	√	√	.	.	√
EMR_99	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	.	.	0	0	√	√ OC	√	.	.	√
EMR_103	Redgauntlet_CF	Hapil_NL	0	.	0	.	.	.	.	0	0	√	√	√	.	.	√
EMR_104	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	.	.	0	1	√	√	√	.	.	√
EMR_105	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	.	.	0	1	√	√	√	.	.	√
EMR_113	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	.	.	0	1	√	√	√	.	.	√
EMR_130	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	.	.	0	1	√	√	√	.	.	√
EMR_133	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	.	.	0	1	√	√	√	.	.	√
EMR_159	Redgauntlet_CF	Hapil_NL	1	.	0	0	.	.	.	0	1	√	√	√	.	.	√
EMR_172	Redgauntlet_CF	Hapil_NL	0	.	0	0	.	.	.	0	1	√	√	√	.	.	√
NL population (Holiday × Korona)[g]																	
Holiday_CF[m, d, j]	Raritan	NY_844	1	0	0	0	0	0	0	0	0	√	√	√	.	.	√
Holiday_NL[y, m, i]	Raritan	NY_845	1	.	0	0	.	.	.	0	0	√	√	√	.	.	√
Korona_NL[l, i]	Tamella	Induka	.	.	.	.	.	.	.	.	.	.	√	.	.	.	.
Korona_CF [d]	Tamella	Induka	1	.	0	0	.	.	0	0	1	√	√	√	.	.	√
H-02316	Holiday_CF	Korona_NL	0	.	.	.	.	.	.	0	0	√	√	√	.	.	√
H-02317	Holiday_CF	Korona_NL	1	.	0	0	.	.	.	0	1	√	√	√	.	.	√
H-02321	Holiday_CF	Korona_NL	0	.	0	0	.	.	.	0	0	√	√	√	.	.	√
H-02322	Holiday_CF	Korona_NL	1	.	0	0	.	.	.	0	0	√	√	√	.	.	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
H-02324	Holiday_CF	Korona_NL	1	.	0	0	.	.	.	0	0	√	√	√	.	.	√
H-02331	Holiday_CF	Korona_NL	1	.	0	0	.	.	.	0	1	√	√	√	.	.	√
H-02356	Holiday_CF	Korona_NL	1	.	0	0	.	.	.	0	1	√	√	√	.	.	√
H-02369	Holiday_CF	Korona_NL	1	.	0	0	.	.	.	0	1	√	√	√	.	.	√
H-02374	Holiday_CF	Korona_NL	0	.	0	0	.	.	.	0	1	√	√	√	.	.	√
H-02379	Holiday_CF	Korona_NL	0	.	.	.	.	.	.	0	1	√	√	√	.	.	√
H-02385	Holiday_CF	Korona_NL	0	.	.	.	.	.	.	0	0	√	√	√	.	.	√
H-02401	Holiday_CF	Korona_NL	0	.	0	0	.	.	.	0	0	√	√	√	.	.	√
H-02406	Holiday_CF	Korona_NL	0	.	0	0	.	.	.	0	1	√	√	√	.	.	√
H-02410	Holiday_CF	Korona_NL	0	.	0	0	.	.	.	0	0	√	√	√	.	.	√
H-02465	Holiday_CF	Korona_NL	1	.	0	0	.	.	.	0	1	√	√	√	.	.	√
H-02475	Holiday_CF	Korona_NL	1	.	0	0	.	.	.	0	1	√	√	√	.	.	√
H-02485	Holiday_CF	Korona_NL	1	.	0	0	.	.	.	0	1	√	√	√	.	.	√
H-02501	Holiday_CF	Korona_NL	1	.	0	0	.	.	.	0	0	√	√	√	.	.	√
H-02529	Holiday_CF	Korona_NL	1	.	.	.	.	.	.	0	0	√	√	√	√	√	√
H-02549	Holiday_CF	Korona_NL	1	.	.	.	.	.	.	0	0	√	√	√	.	.	√
H-02552	Holiday_CF	Korona_NL	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
H-02572	Holiday_CF	Korona_NL	1	.	.	.	.	.	.	0	0	√	√	√	√	√	√
H-02622	Holiday_CF	Korona_NL	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
H-02637	Holiday_CF	Korona_NL	1	.	0	0	.	.	.	0	1	√	√	√	.	.	√
IFAPA population (IFAPA_1392 × IFAPA_232)[f]																	
IFAPA_1392[m, f]	Esp	Gaviota	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
IFAPA_232[l, f]	Esp	Sel.4-43	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
IFAPA_93-4	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
IFAPA_93-6	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	√	.	.	√
IFAPA_93-8	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	√	.	.	√
IFAPA_93-11	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	√	.	.	√
IFAPA_93-12	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	√	.	.	√
IFAPA_93-13	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
IFAPA_93-15	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
IFAPA_93-16	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
IFAPA_93-21	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
IFAPA_93-24	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	√	.	.	√
IFAPA_93-26	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
IFAPA_93-32	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	√	.	.	√
IFAPA_93-33	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
IFAPA_93-34	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	√	.	.	√
IFAPA_93-36	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
IFAPA_93-37	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
IFAPA_93-42	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
IFAPA_93-46	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	√	.	.	√
IFAPA_93-47	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
IFAPA_93-50	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	√	.	.	√
IFAPA_93-54	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
IFAPA_93-56	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
IFAPA_93-57	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
IFAPA_93-58	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	√	.	.	√
IFAPA_93-59	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	√	.	.	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
IFAPA_93-60	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
IFAPA_93-61	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	√	.	.	√
IFAPA_93-62	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
IFAPA_93-64	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	√	.	.	√
IFAPA_93-65	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	.	.	.	.
IFAPA_93-66	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	.	.	.	.
IFAPA_93-69	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	.	.	.	.
IFAPA_93-70	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	.	.	.	.
IFAPA_93-72	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	.	.	.	.
IFAPA_93-73	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	.	.	.	.
IFAPA_93-74	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	.	.	.	.
IFAPA_93-75	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	.	.	.	.
IFAPA_93-76	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	.	.	.	.
IFAPA_93-79	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	.	.	.	.
IFAPA_93-80	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	.	.	.	.
IFAPA_93-81	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	.	.	.	.
IFAPA_93-82	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	.	.	.	.
IFAPA_93-84	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	.	.	.	.
IFAPA_93-85	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	.	.	.	.
IFAPA_93-86	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	.	.	.	.
IFAPA_93-90	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	.	.	.	.
IFAPA_93-92	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	.	.	.	.
IFAPA_93-93	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	.	.	.	.
IFAPA_93-94	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	0	√	√	.	.	.	.

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
IFAPA_93-96	IFAPA_1392	IFAPA_232	1	.	.	.	.	.	.	0	1	√	√	.	.	.	.
INRA population (Capitola × CF1116)[e]																	
Capitola_FR_CF[m, e]	Cal_75.121-101	Parker	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
CF1116_FR[l, za]	Pajaro	(Earliglow×Chandler)	.	.	.	.	.	.	.	.	.	.	.	.	√	√	√
INRA_5	Capitola_FR_CF	CF1116_FR	.	.	0	1	.	.	.	0	0	√	√	√	√	√	√
INRA_6	Capitola_FR_CF	CF1116_FR	1	.	0	1	.	.	.	0	1	√	√	√	√	√	√
INRA_8	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
INRA_9	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
INRA_10	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	0	√	√	√	√	√	√
INRA_11	Capitola_FR_CF	CF1116_FR	1	.	0	1	.	.	.	0	1	√	√	√	√	√	√
INRA_12	Capitola_FR_CF	CF1116_FR	1	.	1	1	.	.	.	1	1	√	√	√	√	√	√
INRA_14	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
INRA_15	Capitola_FR_CF	CF1116_FR	1	.	.	0	.	.	.	0	1	√	√	√	√	√	√
INRA_16	Capitola_FR_CF	CF1116_FR	1	.	.	0	.	.	.	0	1	√	√	√	√	√	√
INRA_19	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
INRA_30	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
INRA_34	Capitola_FR_CF	CF1116_FR	.	.	1	1	.	.	.	1	1	√	√	√	√	√	√
INRA_37	Capitola_FR_CF	CF1116_FR	1	.	0	1	.	.	.	0	0	√	√	√	√	√	√
INRA_43	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
INRA_47	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	0	√	√	√	√	√	√
INRA_58	Capitola_FR_CF	CF1116_FR	1	.	0	1	.	.	.	0	1	√	√	√	√	√	√
INRA_59	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
INRA_61	Capitola_FR_CF	CF1116_FR	1	.	1	1	.	.	.	1	1	√	√	√	√	√	√
INRA_76	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	0	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
INRA_79	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
INRA_94	Capitola_FR_CF	CF1116_FR	1	.	1	1	.	.	.	1	1	√	√	√	√	√	√
INRA_95	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
INRA_97	Capitola_FR_CF	CF1116_FR	1	.	0	1	.	.	.	1	1	√	√	√	√	√	√
INRA_98	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
INRA_99	Capitola_FR_CF	CF1116_FR	.	.	1	0	.	.	.	0	1	√	√	√	√	√	√
INRA_103	Capitola_FR_CF	CF1116_FR	1	.	.	.	.	.	.	0	1	√	√	√	√	√	√
INRA_104	Capitola_FR_CF	CF1116_FR	1	.	1	1	.	.	.	0	1	√	√	√	√	√	√
INRA_108	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	0	√	√	√	√	√	√
INRA_110	Capitola_FR_CF	CF1116_FR	1	.	1	0	.	.	.	0	1	√	√	√	√	√	√
INRA_116	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√ OC	√	√	√	√
INRA_122	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	1	1	√	√	√	√	√	√
INRA_124	Capitola_FR_CF	CF1116_FR	0	.	.	0	.	.	.	0	1	√	√	√	√	√	√
INRA_126	Capitola_FR_CF	CF1116_FR	.	.	1	1	.	.	.	0	1	√	√	√	√	√	√
INRA_134	Capitola_FR_CF	CF1116_FR	1	.	1	1	.	.	.	1	1	√	√	√	√	√	√
INRA_135	Capitola_FR_CF	CF1116_FR	1	.	0	1	.	.	.	0	0	√	√	√	√	√	√
INRA_138	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	1	1	√	√	√	√	√	√
INRA_141	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
INRA_147	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
INRA_148	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	0	√	√	√	√	√	√
INRA_151	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
INRA_153	Capitola_FR_CF	CF1116_FR	1	.	1	1	.	.	.	1	1	√	√	√	√	√	√
INRA_157	Capitola_FR_CF	CF1116_FR	1	.	0	1	.	.	.	0	1	√	√	√	√	√	√
INRA_161	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
INRA_165	Capitola_FR_CF	CF1116_FR	1	.	0	1	.	.	.	0	.	√	√ OC	√	√	√	√
INRA_167	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
INRA_172	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
INRA_175	Capitola_FR_CF	CF1116_FR	1	.	0	1	.	.	.	1	1	√	√	√	√	√	√
INRA_181	Capitola_FR_CF	CF1116_FR	0	.	1	0	.	.	.	0	1	√	√	√	√	√	√
INRA_195	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
INRA_196	Capitola_FR_CF	CF1116_FR	1	.	0	1	.	.	.	1	1	√	√	√	√	√	√
INRA_197	Capitola_FR_CF	CF1116_FR	1	.	1	1	.	.	.	0	1	√	√	√	√	√	√
INRA_201	Capitola_FR_CF	CF1116_FR	1	.	1	.	.	.	.	0	1	√	√	√	√	√	√
INRA_204	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
INRA_216	Capitola_FR_CF	CF1116_FR	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
MSU populations																	
MSU_9-1 population (MSU_49 × FRA_1702)[c]																	
MSU_49[m, d]	Jewel	Mesabi	1	1	0	0	0	0	0	0	0	√	√	√	√	√	√
FRA_1702_I1[1]	.	.	.	.	.	.	.	.	.	.	.	√	√	.	.	.	√
MSU_9-1-1	MSU_49	FRA_1702_I1	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
MSU_9-1-2	MSU_49	FRA_1702_I1	1	0	0	.	0	0	0	0	.	√	√ OC	√	.	.	√ OC
MSU_9-1-3	MSU_49	FRA_1702_I1	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
MSU_9-1-4	MSU_49	FRA_1702_I1	1	0	0	.	0	0	0	0	.	√	√ OC	√	.	.	√ OC
MSU_9-1-5	MSU_49	FRA_1702_I1	1	0	0	.	0	0	0	0	.	√	√ OC	√	.	.	√
MSU_9-1-6	MSU_49	FRA_1702_I1	1	0	0	.	0	0	0	0	.	√	√ OC	√	.	.	√ OC
MSU_9-1-7	MSU_49	FRA_1702_I1	1	0	0	.	0	0	0	0	.	√	√ OC	√	.	.	√ OC

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
MSU_9-1-8	MSU_49	FRA_1702_I1	1	0	0	.	0	0	1	0	.	√	√	√	.	.	√
MSU_9-1-9	MSU_49	FRA_1702_I1	1	0	0	.	0	0	0	0	.	√	√ OC	√	.	.	√ OC
MSU_9-1-10	MSU_49	FRA_1702_I1	1	0	0	.	0	0	0	0	.	√	√ OC	√	.	.	√ OC
MSU_9-2 population (MSU_49 × Seascape)[c]																	
MSU_49[m, j]	Jewel	Mesabi	1	1	0	0	0	0	0	0	0	√	√	√	√	√	√
Seascape_CF[l, j]	Selva	Douglas	1	1	1	1	.	.	1	1	1	√	√	√	√	√	√
MSU_9-2-1	MSU_49	Seascape_CF	1	.	.	.	0	0	0	0	.	√	√	√	√	√	√
MSU_9-2-2	MSU_49	Seascape_CF	1	0	0	.	0	0	0	0	.	√	√	√	√	√	√
MSU_9-2-3	MSU_49	Seascape_CF	1	.	.	.	1	0	1	1	.	√	√	√	√	√	√
MSU_9-2-4	MSU_49	Seascape_CF	1	1	0	.	1	0	1	1	.	√	√	√	√	√	√
MSU_9-2-5	MSU_49	Seascape_CF	1	1	1	.	1	0	1	1	.	√	√	√	√	√	√
MSU_9-2-6	MSU_49	Seascape_CF	1	.	.	.	0	0	0	0	.	√	√	√	√	√	√
MSU_9-2-7	MSU_49	Seascape_CF	1	0	0	.	0	0	0	0	.	√	√	√	√	√	√
MSU_9-2-8	MSU_49	Seascape_CF	1	.	.	.	0	0	0	0	.	√	√	√	√	√	√
MSU_9-2-9	MSU_49	Seascape_CF	1	0	0	.	1	0	0	0	.	√	√	√	√	√	√
MSU_9-2-10	MSU_49	Seascape_CF	1	1	0	.	1	1	1	1	.	√	√	√	√	√	√
MSU_9-3 population (MSU_49 × Tribute)[c]																	
MSU_49[m, j]	Jewel	Mesabi	1	1	0	0	0	0	0	0	0	√	√	√	√	√	√
Tribute_662.001[l, b]	USEB_18	MDUS_4258	.	.	.	.	.	.	.	.	.	√	√	√	√	√	√
MSU_9-3-1	MSU_49	Tribute_662.001	1	1	1	.	1	0	0	1	.	√	√	√	√	√	√
MSU_9-3-2	MSU_49	Tribute_662.001	1	0	0	.	0	0	0	0	.	√	√	√	√	√	√
MSU_9-3-3	MSU_49	Tribute_662.001	.	0	0	.	0	0	0	0	.	√	√ OC	√ OC	√ OC	√ OC	√ OC
MSU_9-3-4	MSU_49	Tribute_662.001	1	1	1	.	1	0	0	0	.	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
MSU_9-3-5	MSU_49	Tribute_662.001	.	.	.	.	0	.	.	0	.	.	.	√ OC	√ OC	√ OC	√ OC
MSU_9-3-6	MSU_49	Tribute_662.001	1	0	0	.	0	0	0	0	.	√	√ OC	√ OC	√ OC	√ OC	√ OC
MSU_9-3-7	MSU_49	Tribute_662.001	1	1	0	.	1	1	1	0	.	√	√	√	√	√	√
MSU_9-3-8	MSU_49	Tribute_662.001	1	1	1	.	1	1	0	0	.	√	√	√	√	√	√
MSU_9-3-9	MSU_49	Tribute_662.001	1	0	0	.	0	0	0	0	.	√	√ OC	√ OC	√ OC	√ OC	√ OC
MSU_9-3-10	MSU_49	Tribute_662.001	1	0	0	.	0	0	0	0	.	√	√	√	√	√	√
MSU_9-4 population (MSU_56 × FRA_1702)[c]																	
MSU_56[m, j]	Cabot	Cavendish	1	0	0	0	0	0	0	0	0	√	√	√	√	√	√
FRA_1702_I1[l]	.	.	.	.	.	.	.	.	.	.	.	√	√	.	.	.	√
MSU_9-4-1	MSU_56	FRA_1702_I1	1	0	0	.	1	1	0	1	.	√	√	√	.	.	√
MSU_9-4-2	MSU_56	FRA_1702_I1	1	0	0	.	0	0	0	0	.	√	√	.	.	.	.
MSU_9-4-3	MSU_56	FRA_1702_I1	1	0	0	.	0	0	0	0	.	√	√ OC	√	.	.	√ OC
MSU_9-4-4	MSU_56	FRA_1702_I1	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
MSU_9-4-5	MSU_56	FRA_1702_I1	1	0	0	.	0	0	0	1	.	√	√	√	.	.	√
MSU_9-4-6	MSU_56	FRA_1702_I1	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
MSU_9-4-7	MSU_56	FRA_1702_I1	1	0	0	.	0	0	0	0	.	√	√ OC	.	.	.	.
MSU_9-4-8	MSU_56	FRA_1702_I1	1	0	0	.	0	0	0	1	.	√	√	√	.	.	√
MSU_9-4-9	MSU_56	FRA_1702_I1	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
MSU_9-4-10	MSU_56	FRA_1702_I1	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
MSU_9-5 population (FRA_1702 × Earliglow)[c]																	
FRA_1702_I1[m]	.	.	.	.	.	.	.	.	.	.	.	√	√	.	.	.	√
Earliglow_CF[l, j]	MDUS_2359	MDUS_2713	1	.	0	0	0	0	0	0	0	√	√	√	√	√	√
MSU_9-5-1	FRA_1702_I1	Earliglow_CF	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
MSU_9-5-2	FRA_1702_I1	Earliglow_CF	1	0	0	.	0	0	0	0	.	√	√ OC	√	.	.	√
MSU_9-5-3	FRA_1702_I1	Earliglow_CF	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
MSU_9-5-4	FRA_1702_I1	Earliglow_CF	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
MSU_9-5-5	FRA_1702_I1	Earliglow_CF	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
MSU_9-5-6	FRA_1702_I1	Earliglow_CF	1	0	0	.	0	0	0	0	.	√	√ OC	√	.	.	√ OC
MSU_9-5-7	FRA_1702_I1	Earliglow_CF	1	0	0	.	0	0	0	0	.	√	√ OC	√	.	.	√ OC
MSU_9-5-8	FRA_1702_I1	Earliglow_CF	1	0	0	.	0	0	0	0	.	√	√ OC	√	.	.	√ OC
MSU_9-5-9	FRA_1702_I1	Earliglow_CF	0	0	0	.	0	0	0	0	.	√	√	√	.	.	√
MSU_9-5-10	FRA_1702_I1	Earliglow_CF	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
MSU_9-6 population (Earliglow × Seascape)[c]																	
Earliglow_CF[m, j]	MDUS_2359	MDUS_2713	1	.	0	0	0	0	0	0	0	√	√	√	√	√	√
Seascape_CF[l, j]	Selva	Douglas	1	1	1	1	.	.	1	1	1	√	√	√	√	√	√
MSU_9-6-1	Earliglow_CF	Seascape_CF	1	1	0	.	1	1	1	1	.	√	√	√	√	√	√
MSU_9-6-2	Earliglow_CF	Seascape_CF	0	0	0	.	0	0	1	0	.	√	√	√	√	√	√
MSU_9-6-3	Earliglow_CF	Seascape_CF	1	1	0	.	1	1	1	1	.	√	√	√	√	√	√
MSU_9-6-4	Earliglow_CF	Seascape_CF	1	0	0	.	0	0	0	0	.	√	√	√	√	√	√
MSU_9-6-5	Earliglow_CF	Seascape_CF	1	1	1	.	1	1	1	1	.	√	√	√	√	√	√
MSU_9-6-6	Earliglow_CF	Seascape_CF	1	1	0	.	0	0	0	0	.	√	√	√	√	√	√
MSU_9-6-7	Earliglow_CF	Seascape_CF	1	0	0	.	0	0	0	0	.	√	√	√	√	√	√
MSU_9-6-8	Earliglow_CF	Seascape_CF	1	0	0	.	0	0	0	0	.	√	√	√	√	√	√
MSU_9-6-9	Earliglow_CF	Seascape_CF	1	1	0	.	1	1	1	1	.	√	√	√	√	√	√
MSU_9-6-10	Earliglow_CF	Seascape_CF	1	1	0	.	1	1	0	1	.	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
MSU_9-8 population (Fort Laramie × Earliglow)[c]																	
FortLaramie_NCGR[m, b]	Geneva	S.65122	0	.	1	0	.	.	1	0	1	√	√	√	√	√	√
Earliglow_CF[l, j]	MDUS_2359	MDUS_2713	1	.	0	0	0	0	0	0	0	√	√	√	√	√	√
MSU_9-8-1	FortLaramie_NCGR	Earliglow_CF	1	0	0	.	0	0	1	0	.	√	√	√	.	.	√
MSU_9-8-2	FortLaramie_NCGR	Earliglow_CF	1	1	1	.	1	0	1	1	.	√	√	√	√	√	√
MSU_9-8-3	FortLaramie_NCGR	Earliglow_CF	1	1	1	.	1	1	1	0	.	√	√	√	.	.	√
MSU_9-8-4	FortLaramie_NCGR	Earliglow_CF	1	1	1	.	1	1	1	1	.	√	√	√	√	√	√
MSU_9-8-5	FortLaramie_NCGR	Earliglow_CF	1	.	0	.	1	1	1	0	.	√	√	√	.	.	√
MSU_9-8-6	FortLaramie_NCGR	Earliglow_CF	.	.	.	.	.	.	.	.	.	.	√	.	.	.	.
MSU_9-8-7	FortLaramie_NCGR	Earliglow_CF	1	0	0	.	0	0	0	0	.	√	√	√	√	√	√
MSU_9-8-8	FortLaramie_NCGR	Earliglow_CF	1	0	0	.	0	0	0	0	.	√	√	.	.	.	.
MSU_9-8-9	FortLaramie_NCGR	Earliglow_CF	1	0	0	.	0	0	0	0	.	√	√	.	.	.	.
MSU_9-8-10	FortLaramie_NCGR	Earliglow_CF	1	1	1	.	1	1	0	1	.	√	√	√	√	√	√
MSU_9-9 population (Fort Laramie × Honeoye)[c]																	
FortLaramie_NCGR[m, b]	Geneva	S.65122	0	.	1	0	.	.	1	0	1	√	√	√	√	√	√
Honeoye_215.001[l, b]	Vibrant	Holiday										√	√	√	√	√	√
MSU_9-9-1	FortLaramie_NCGR	Honeoye_215.001	1	1	0	.	.	.	1	1	.	√	√	√	√	√	√
MSU_9-9-2	FortLaramie_NCGR	Honeoye_215.001	1	1	1	.	.	.	1	0	.	√	√	√	√	√	√
MSU_9-9-3	FortLaramie_NCGR	Honeoye_215.001	1	1	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-9-4	FortLaramie_NCGR	Honeoye_215.001	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-9-5	FortLaramie_NCGR	Honeoye_215.001	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-9-6	FortLaramie_NCGR	Honeoye_215.001	1	1	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-9-7	FortLaramie_NCGR	Honeoye_215.001	0	0	0	.	.	.	0	0	.	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
MSU_9-9-8	FortLaramie_NCGR	Honeoye_215.001	1	1	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-9-9	FortLaramie_NCGR	Honeoye_215.001	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-9-10	FortLaramie_NCGR	Honeoye_215.001	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-10 population (Fort Laramie × MSU_49)[c]																	
FortLaramie_NCGR[m, b]	Geneva	S.65122	0	.	1	0	.	.	1	0	1	√	√	√	√	√	√
MSU_49[l, j]	Jewel	Mesabi	1	1	0	0	0	0	0	0	0	√	√	√	√	√	√
MSU_9-10-1	FortLaramie_NCGR	MSU_49	1	0	0	.	.	.	0	0	.	√	√	√	√ OC	√ OC	√
MSU_9-10-2	FortLaramie_NCGR	MSU_49	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-10-3	FortLaramie_NCGR	MSU_49	1	1	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-10-4	FortLaramie_NCGR	MSU_49	1	1	0	.	.	.	1	1	.	√	√	√	√	√	√
MSU_9-10-5	FortLaramie_NCGR	MSU_49	1	1	1	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-10-6	FortLaramie_NCGR	MSU_49	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-10-7	FortLaramie_NCGR	MSU_49	1	1	1	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-10-8	FortLaramie_NCGR	MSU_49	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-10-9	FortLaramie_NCGR	MSU_49	1	1	1	.	.	.	0	1	.	√	√	√	√	√	√
MSU_9-10-10	FortLaramie_NCGR	MSU_49	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-11 population (Fort Laramie × MSU_56)[c]																	
FortLaramie_NCGR[m, b]	Geneva	S.65122	0	.	1	0	.	.	1	0	1	√	√	√	√	√	√
MSU_56[l, j]	Cabot	Cavendish	1	0	0	0	0	0	0	0	0	√	√	√	√	√	√
MSU_9-11-1	FortLaramie_NCGR	MSU_56	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
MSU_9-11-2	FortLaramie_NCGR	MSU_56	1	1	1	.	.	.	1	1	.	√	√	√	√	√	√
MSU_9-11-3	FortLaramie_NCGR	MSU_56	1	1	0	.	.	.	0	1	.	√	√	√	.	.	√
MSU_9-11-4	FortLaramie_NCGR	MSU_56	1	1	0	.	.	.	0	0	.	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
MSU_9-11-5	FortLaramie_NCGR	MSU_56	1	1	0	.	.	.	1	0	.	√	√	√	.	.	√
MSU_9-11-6	FortLaramie_NCGR	MSU_56	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
MSU_9-11-7	FortLaramie_NCGR	MSU_56	1	0	0	.	.	.	1	0	.	√	√ OC	√	.	.	√
MSU_9-11-8	FortLaramie_NCGR	MSU_56	1	1	1	.	.	.	0	0	.	√	√ OC	√	.	.	√
MSU_9-11-9	FortLaramie_NCGR	MSU_56	1	1	0	.	.	.	0	1	.	√	√	√	.	.	√
MSU_9-11-10	FortLaramie_NCGR	MSU_56	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
MSU_9-12 population (Honeoye × FRA_1702)[c]																	
Honeoye_215.001[m, b]	Vibrant	Holiday										√	√	√	√	√	√
FRA_1702_I2[l]	.	.	.	.	.	.	.	.	.	.	.	√	√	.	.	.	√
MSU_9-12-1	Honeoye_215.001	FRA_1702_I2	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
MSU_9-12-2	Honeoye_215.001	FRA_1702_I2	1	0	0	.	0	.	0	0	.	√	√	√	.	.	√
MSU_9-12-3	Honeoye_215.001	FRA_1702_I2	1	1	0	.	1	1	0	0	.	√	√ OC	√	√	√	√ OC
MSU_9-12-4	Honeoye_215.001	FRA_1702_I2	1	0	0	.	0	0	0	0	.	√	√ OC	√	.	.	√
MSU_9-12-5	Honeoye_215.001	FRA_1702_I2	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
MSU_9-12-6	Honeoye_215.001	FRA_1702_I2	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
MSU_9-12-7	Honeoye_215.001	FRA_1702_I2	1	0	0	.	0	0	0	0	.	√	√ OC	√	.	.	√ OC
MSU_9-12-8	Honeoye_215.001	FRA_1702_I2	1	0	0	.	0	0	0	0	.	√	√ OC	√	.	.	√ OC
MSU_9-12-9	Honeoye_215.001	FRA_1702_I2	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
MSU_9-12-10	Honeoye_215.001	FRA_1702_I2	1	0	.	.	0	0	0	0	.	√	√	√	.	.	√
MSU_9-13 population (Seascape × Honeoye)[c]																	
Seascape_CF[m, j]	Selva	Douglas	1	1	1	1	.	.	1	1	1	√	√	√	√	√	√
Honeoye_215.001[l, b]	Vibrant	Holiday										√	√	√	√	√	√
MSU_9-13-1	Seascape_CF	Honeoye_215.001	1	0	0	.	0	0	0	0	.	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
MSU_9-13-2	Seascape_CF	Honeoye_215.001	1	1	.	.	1	1	1	1	.	√	√	√	√	√	√
MSU_9-13-3	Seascape_CF	Honeoye_215.001	0	1	1	.	0	0	0	0	.	√	√	√	√	√	√
MSU_9-13-4	Seascape_CF	Honeoye_215.001	.	1	0	.	1	1	0	0	.	√	√	√	√	√	√
MSU_9-13-5	Seascape_CF	Honeoye_215.001	.	1	0	.	0	.	0	0	.	√	√	√	√	√	√
MSU_9-13-6	Seascape_CF	Honeoye_215.001	1	0	0	.	0	0	0	0	.	√	√	√	√	√	√
MSU_9-13-7	Seascape_CF	Honeoye_215.001	1	0	0	.	0	0	0	0	.	√	√	√	√	√	√
MSU_9-13-8	Seascape_CF	Honeoye_215.001	1	0	0	.	0	0	0	0	.	√	√	√	√	√	√
MSU_9-13-9	Seascape_CF	Honeoye_215.001	1	1	0	.	0	1	0	0	.	√	√	√	√	√	√
MSU_9-13-10	Seascape_CF	Honeoye_215.001	1	0	0	.	1	1	0	0	.	√	√	√	√	√	√
MSU_9-14 population (Seascape × MSU_56)[c]																	
Seascape_CF[m, j]	Selva	Douglas	1	1	1	1	.	.	1	1	1	√	√	√	√	√	√
MSU_56[l, j]	Cabot	Cavendish	1	0	0	0	0	0	0	0	0	√	√	√	√	√	√
MSU_9-14-1	Seascape_CF	MSU_56	1	0	0	.	0	0	0	0	.	√	√	√	√	√	√
MSU_9-14-2	Seascape_CF	MSU_56	1	1	0	.	1	1	1	1	.	√	√	√	√	√	√
MSU_9-14-3	Seascape_CF	MSU_56	1	0	.	.	0	0	0	0	.	√	√ OC	√	√ OC	√ OC	√
MSU_9-14-4	Seascape_CF	MSU_56	1	1	1	.	1	1	1	1	.	√	√	√	√	√	√
MSU_9-14-5	Seascape_CF	MSU_56	1	1	1	.	1	0	1	1	.	√	√	.	.	.	.
MSU_9-14-6	Seascape_CF	MSU_56	1	0	0	.	0	0	0	0	.	√	√	.	.	.	.
MSU_9-14-7	Seascape_CF	MSU_56	1	1	0	.	1	0	1	1	.	√	√	√ OC	√	√	√
MSU_9-14-8	Seascape_CF	MSU_56	1	1	0	.	1	1	1	1	.	√	√	.	.	.	.
MSU_9-14-9	Seascape_CF	MSU_56	1	1	0	.	1	1	0	0	.	√	√	.	.	.	.
MSU_9-14-10	Seascape_CF	MSU_56	1	.	0	.	1	0	0	0	.	√	√	.	.	.	.

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
MSU_9-15 population (Tribute × Earliglow)[c]																	
Tribute_662.001[m, b]	USEB_18	MDUS_4258	.	.	.	.	.	.	.	.	.	√	√	√	√	√	√
Earliglow_CF[l, j]	MDUS_2359	MDUS_2713	1	.	0	0	0	0	0	0	0	√	√	√	√	√	√
MSU_9-15-1	Tribute_662.001	Earliglow_CF	1	1	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-15-2	Tribute_662.001	Earliglow_CF	.	0	.	.	.	.	.	0	.	.	√	.	.	.	.
MSU_9-15-3	Tribute_662.001	Earliglow_CF	1	1	1	.	.	.	0	1	.	√	√	√	√	√	√
MSU_9-15-4	Tribute_662.001	Earliglow_CF	1	0	.	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-15-5	Tribute_662.001	Earliglow_CF	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-15-6	Tribute_662.001	Earliglow_CF	1	1	1	.	.	.	0	1	.	√	√	√	√	√	√
MSU_9-15-7	Tribute_662.001	Earliglow_CF	1	1	.	.	.	.	1	0	.	√	√	√	√	√	√
MSU_9-15-8	Tribute_662.001	Earliglow_CF	1	1	1	.	.	.	1	1	.	√	√	√	√	√	√
MSU_9-15-9	Tribute_662.001	Earliglow_CF	1	1	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-15-10	Tribute_662.001	Earliglow_CF	1	1	1	.	.	.	1	1	.	√	√	√	√	√	√
MSU_9-16 population (Tribute × Honeoye)[c]																	
Tribute_662.001[m, b]	USEB_18	MDUS_4258	.	.	.	.	.	.	.	.	.	√	√	√	√	√	√
Honeoye_215.001[l, b]	Vibrant	Holiday										√	√	√	√	√	√
MSU_9-16-1	Tribute_662.001	Honeoye_215.001	1	1	1	0	.	.	0	1	0	√	√	√	√	√	√
MSU_9-16-2	Tribute_662.001	Honeoye_215.001	1	1	1	1	.	.	1	0	0	√	√	√	√	√	√
MSU_9-16-3	Tribute_662.001	Honeoye_215.001	1	1	0	0	.	.	1	1	.	√	√	√	√	√	√
MSU_9-16-4	Tribute_662.001	Honeoye_215.001	1	0	0	0	.	.	0	0	0	√	√	√	√	√	√
MSU_9-16-5	Tribute_662.001	Honeoye_215.001	1	1	1	1	.	.	1	1	0	√	√	√	√	√	√
MSU_9-16-6	Tribute_662.001	Honeoye_215.001	1	1	0	0	.	.	1	0	.	√	√	√	√	√	√
MSU_9-16-7	Tribute_662.001	Honeoye_215.001	1	1	1	0	.	.	0	0	0	√	√	√	√	√	√
MSU_9-16-8	Tribute_662.001	Honeoye_215.001	1	0	0	1	.	.	0	0	0	√	√	√	√	√ OC	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
MSU_9-16-9	Tribute_662.001	Honeoye_215.001	1	1	1	0	.	.	1	0	0	.	.	√	√	√	√
MSU_9-16-10	Tribute_662.001	Honeoye_215.001	1	1	0	0	.	.	0	0	0	√	√	√	√	√	√
MSU_9-16-11	Tribute_662.001	Honeoye_215.001	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-12	Tribute_662.001	Honeoye_215.001	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-13	Tribute_662.001	Honeoye_215.001	1	1	1	0	.	.	1	1	.	√	√	√	√	√	√
MSU_9-16-14	Tribute_662.001	Honeoye_215.001	1	0	.	0	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-15	Tribute_662.001	Honeoye_215.001	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-16	Tribute_662.001	Honeoye_215.001	1	.	0	.	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-17	Tribute_662.001	Honeoye_215.001	1	1	0	1	.	.	1	1	1	√	√	√	.	.	√
MSU_9-16-18	Tribute_662.001	Honeoye_215.001	1	1	1	.	.	.	1	1	1	√	√	√	√	√	√
MSU_9-16-19	Tribute_662.001	Honeoye_215.001	1	1	0	1	.	.	1	0	0	√	√	√	.	.	√
MSU_9-16-20	Tribute_662.001	Honeoye_215.001	1	1	0	0	.	.	1	1	1	√	√	√	.	.	√
MSU_9-16-21	Tribute_662.001	Honeoye_215.001	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-22	Tribute_662.001	Honeoye_215.001	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-23	Tribute_662.001	Honeoye_215.001	1	1	1	1	.	.	1	1	0	√	√	√	√	√	√
MSU_9-16-24	Tribute_662.001	Honeoye_215.001	1	1	1	1	.	.	1	1	1	√	√	√	√	√	√
MSU_9-16-25	Tribute_662.001	Honeoye_215.001	1	.	0	0	.	.	.	0	0	√	√	√	.	.	√
MSU_9-16-26	Tribute_662.001	Honeoye_215.001	1	1	1	1	.	.	1	1	1	√	√	√	√	√	√
MSU_9-16-27	Tribute_662.001	Honeoye_215.001	1	0	1	0	.	.	0	0	1	√	√	√	.	.	√
MSU_9-16-28	Tribute_662.001	Honeoye_215.001	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-29	Tribute_662.001	Honeoye_215.001	1	1	1	1	.	.	.	0	0	√	√	√	.	.	√
MSU_9-16-30	Tribute_662.001	Honeoye_215.001	1	0	0	0	.	.	1	0	0	√	√	√	.	.	√
MSU_9-16-31	Tribute_662.001	Honeoye_215.001	1	1	1	1	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-32	Tribute_662.001	Honeoye_215.001	1	1	1	1	.	.	1	1	0	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
MSU_9-16-33	Tribute_662.001	Honeoye_215.001	1	.	1	1	.	.	.	0	0	√	√	√	.	.	√
MSU_9-16-34	Tribute_662.001	Honeoye_215.001	1	0	0	1	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-35	Tribute_662.001	Honeoye_215.001	.	1	0	1	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-36	Tribute_662.001	Honeoye_215.001	1	1	0	0	.	.	.	0	1	√	√	√	.	.	√
MSU_9-16-37	Tribute_662.001	Honeoye_215.001	1	1	1	1	.	.	1	1	0	√	√	√	√	√	√
MSU_9-16-38	Tribute_662.001	Honeoye_215.001	0	0	0	0	.	.	0	0	.	√	√	.	.	.	.
MSU_9-16-39	Tribute_662.001	Honeoye_215.001	1	1	0	0	.	.	0	0	1	√	√	√	.	.	√
MSU_9-16-40	Tribute_662.001	Honeoye_215.001	0	0	0	1	.	.	1	0	.	√	√	√	.	.	√
MSU_9-16-41	Tribute_662.001	Honeoye_215.001	1	1	0	1	.	.	1	1	0	√	√	√	.	.	√
MSU_9-16-42	Tribute_662.001	Honeoye_215.001	1	1	1	1	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-43	Tribute_662.001	Honeoye_215.001	1	1	1	1	.	.	1	1	1	√	√	√	√	√	√
MSU_9-16-44	Tribute_662.001	Honeoye_215.001	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-45	Tribute_662.001	Honeoye_215.001	1	0	0	1	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-46	Tribute_662.001	Honeoye_215.001	1	0	0	0	.	.	0	0	.	√	√	√	.	.	√
MSU_9-16-47	Tribute_662.001	Honeoye_215.001	.	1	1	0	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-48	Tribute_662.001	Honeoye_215.001	1	0	1	0	.	.	1	0	.	√	√	√	.	.	√
MSU_9-16-49	Tribute_662.001	Honeoye_215.001	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-50	Tribute_662.001	Honeoye_215.001	1	1	0	0	.	.	1	0	0	√	√ OC	.	.	.	.
MSU_9-16-51	Tribute_662.001	Honeoye_215.001	1	0	1	1	.	.	1	0	0	√	√	√	.	.	√
MSU_9-16-52	Tribute_662.001	Honeoye_215.001	1	1	1	1	.	.	1	0	1	√	√	√	√	√	√
MSU_9-16-53	Tribute_662.001	Honeoye_215.001	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.
MSU_9-16-54	Tribute_662.001	Honeoye_215.001	1	1	0	1	.	.	.	.	.	.	.	.	.	.	.
MSU_9-16-55	Tribute_662.001	Honeoye_215.001	1	1	1	1	.	.	1	0	1	√	√	√	.	.	√
MSU_9-16-56	Tribute_662.001	Honeoye_215.001	.	1	0	0	.	.	0	0	1	√	√	√	.	.	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
MSU_9-16-57	Tribute_662.001	Honeoye_215.001	1	1	1	1	.	.	0	0	0	√	√ OC	√	.	.	√
MSU_9-16-58	Tribute_662.001	Honeoye_215.001	0	0	0	1	.	.	0	0	1	√	√	√	.	.	√
MSU_9-16-59	Tribute_662.001	Honeoye_215.001	1	0	0	1	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-60	Tribute_662.001	Honeoye_215.001	0	0	0	0	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-61	Tribute_662.001	Honeoye_215.001	1	0	0	0	.	.	0	0	1	√	√ OC	√ OC	.	.	√
MSU_9-16-62	Tribute_662.001	Honeoye_215.001	1	.	.	.	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-63	Tribute_662.001	Honeoye_215.001	1	.	0	.	.	.	0	0	0	√	√	√	.	.	√
MSU_9-16-64	Tribute_662.001	Honeoye_215.001	1	1	1	1	.	.	0	0	1	√	√	√	√	√	√
MSU_9-16-65	Tribute_662.001	Honeoye_215.001	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
MSU_9-17 population (Tribute × MSU_56)[c]																	
Tribute_662.001[m, b]	USEB_18	MDUS_4258	.	.	.	.	.	.	.	.	.	√	√	√	√	√	√
MSU_56[l, j]	Cabot	Cavendish	1	0	0	0	0	0	0	0	0	√	√	√	√	√	√
MSU_9-17-1	Tribute_662.001	MSU_56	1	1	0	.	.	.	1	0	.	√	√	√	√	√	√
MSU_9-17-2	Tribute_662.001	MSU_56	1	0	0	.	.	.	0	0	.	√	√ OC	√	√ OC	√	√
MSU_9-17-3	Tribute_662.001	MSU_56	1	1	0	.	.	.	1	0	.	√	√	√	√	√	√
MSU_9-17-4	Tribute_662.001	MSU_56	1	1	0	.	.	.	1	1	.	√	√	√	√	√	√
MSU_9-17-5	Tribute_662.001	MSU_56	1	0	1	.	.	.	0	0	.	√	√	√	.	.	√
MSU_9-17-6	Tribute_662.001	MSU_56	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-17-7	Tribute_662.001	MSU_56	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-17-8	Tribute_662.001	MSU_56	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-17-9	Tribute_662.001	MSU_56	1	1	0	.	.	.	1	1	.	√	√	√	√	√	√
MSU_9-17-10	Tribute_662.001	MSU_56	1	1	0	.	.	.	1	1	.	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
MSU_9-18 population (Seascape × Fort Laramie)[c]																	
Seascape_CF[m, j]	Selva	Douglas	1	1	1	1	.	.	1	1	1	√	√	√	√	√	√
FortLaramie_I1[l]			.	.	.	.	.	.	.	.	.	.	√	.	√	√	√
MSU_9-18-1	Seascape_CF	FortLaramie_I1	.	0	0	.	.	.	.	0	.	√	√	√	√	√	√
MSU_9-18-2	Seascape_CF	FortLaramie_I1	.	0	1	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-18-3	Seascape_CF	FortLaramie_I1	1	1	0	.	.	.	0	1	.	√	√	√	√	√	√
MSU_9-18-4	Seascape_CF	FortLaramie_I1	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-18-5	Seascape_CF	FortLaramie_I1	1	1	1	.	.	.	0	0	.	√	√	√	√	√	√
MSU_9-18-6	Seascape_CF	FortLaramie_I1	1	1	1	.	.	.	1	1	.	√	√	√	√	√	√
MSU_9-18-7	Seascape_CF	FortLaramie_I1	1	0	0	.	.	.	1	1	.	√	√	√	√	√	√
MSU_9-18-8	Seascape_CF	FortLaramie_I1	1	1	0	.	.	.	1	1	.	√	√	√	√	√	√
MSU_9-18-9	Seascape_CF	FortLaramie_I1	1	.	1	.	.	.	1	1	.	√	√	√	√	√	√
MSU_9-18-10	Seascape_CF	FortLaramie_I1	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS populations																	
ORUS_3277 population (ORUS 2427-1× FRA_1701)[d]																	
ORUS 2427-1_CF_1-22[m, j]	Pinnacle	ORUS_1723-3	1	0	0	0	0	0	0	0	0	√	√	√	.	.	√
FRA_1701[l, r, a]	0	0	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
ORUS_3277-1	ORUS 2427-1_CF_1-22	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√ OC
ORUS_3277-2	ORUS 2427-1_CF_1-22	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√ OC
ORUS_3277-3	ORUS 2427-1_CF_1-22	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√ OC
ORUS_3277-4	ORUS 2427-1_CF_1-22	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√ OC
ORUS_3277-5	ORUS 2427-1_CF_1-22	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√ OC

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
ORUS_3277-6	ORUS 2427-1_CF_1-22	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3277-7	ORUS 2427-1_CF_1-22	FRA_1701	1	0	0	.	.	0	0	0	.	√	√	√	.	.	√
ORUS_3277-8	ORUS 2427-1_CF_1-22	FRA_1701	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
ORUS_3277-9	ORUS 2427-1_CF_1-22	FRA_1701	0	0	0	.	0	.	0	0	.	√	√	√	.	.	√
ORUS_3277-10	ORUS 2427-1_CF_1-22	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3278 population (ORUS 2427-1× Seascape)[d]																	
ORUS 2427-1_CF_1-22[m, j]	Pinnacle	ORUS_1723-3	1	0	0	0	0	0	0	0	0	√	√	√	.	.	√
Seascape_CF[l, j]	Selva	Douglas	1	1	1	1	.	.	1	1	1	√	√	√	√	√	√
ORUS_3278-1	ORUS 2427-1_CF_1-22	Seascape_CF	1	0	0	.	.	.	.	.	.	.	.	√	√	√	.
ORUS_3278-4	ORUS 2427-1_CF_1-22	Seascape_CF	1	0	0	.	.	.	1	0	.	√	√	√	√	√	√
ORUS_3278-5	ORUS 2427-1_CF_1-22	Seascape_CF	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3278-6	ORUS 2427-1_CF_1-22	Seascape_CF	1	1	1	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3278-7	ORUS 2427-1_CF_1-22	Seascape_CF	1	.	0	.	0	0	0	0	.	√	√	√	√	√	√
ORUS_3278-8	ORUS 2427-1_CF_1-22	Seascape_CF	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3278-9	ORUS 2427-1_CF_1-22	Seascape_CF	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3278-10	ORUS 2427-1_CF_1-22	Seascape_CF	1	0	0	.	.	.	0	1	.	√	√	√	√	√	√
ORUS_3278-12	ORUS 2427-1_CF_1-22	Seascape_CF	1	1	1	.	.	.	1	0	.	√	√	√	√	√	√
ORUS_3278-13	ORUS 2427-1_CF_1-22	Seascape_CF	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3279 population (ORUS 2427-1 × Tribute)[d]																	
ORUS 2427-1_CF_1-22[m, j]	Pinnacle	ORUS_1723-3	1	0	0	0	0	0	0	0	0	√	√	√	.	.	√
Tribute_662.001[l, b]	USEB_18	MDUS_4258	.	.	.	.	.	.	.	.	.	√	√	√	√	√	√
ORUS_3279-3	ORUS 2427-1_CF_1-22	Tribute_662.001	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3279-4	ORUS 2427-1_CF_1-22	Tribute_662.001	1	1	1	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3279-5	ORUS 2427-1_CF_1-22	Tribute_662.001	1	1	0	.	.	.	1	1	.	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
ORUS_3279-6	ORUS 2427-1_CF_1-22	Tribute_662.001	1	1	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3279-7	ORUS 2427-1_CF_1-22	Tribute_662.001	1	1	1	.	.	.	1	0	.	√	√	√	√	√	√
ORUS_3279-8	ORUS 2427-1_CF_1-22	Tribute_662.001	0	1	0	.	0	0	0	0	.	√	√	√	√	√	√
ORUS_3279-9	ORUS 2427-1_CF_1-22	Tribute_662.001	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3279-13	ORUS 2427-1_CF_1-22	Tribute_662.001	1	1	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3279-14	ORUS 2427-1_CF_1-22	Tribute_662.001	1	1	1	.	.	.	1	0	.	√	√	√	√	√	√
ORUS_3279-15	ORUS 2427-1_CF_1-22	Tribute_662.001	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3304 population (Tillamook × FRA_1701)[d]																	
Tillamook_NCGR[b]	Cuesta	Puget_Reliance	.	.	.	.	.	.	.	.	.	.	.	.	√	√	√
Tillamook_CF[d]	Cuesta	Puget_Reliance	.	0	0	0	.	.	0	0	1	√	√	√	.	.	√
Tillamook_I1[m]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
FRA_1701[l, r, a]	0	0	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
ORUS_3304-1	Tillamook_I1	FRA_1701	0	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3304-2	Tillamook_I1	FRA_1701	0	0	0	.	.	.	0	0	.	√	√ OC	√	.	.	√
ORUS_3304-5	Tillamook_I1	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3304-6	Tillamook_I1	FRA_1701	1	0	0	.	.	.	0	0	.	√	√ OC	√	.	.	√
ORUS_3304-7	Tillamook_I1	FRA_1701	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
ORUS_3304-8	Tillamook_I1	FRA_1701	1	0	0	.	.	.	0	0	.	√	√ OC	√	.	.	√
ORUS_3304-9	Tillamook_I1	FRA_1701	1	0	0	.	.	.	0	0	.	√	√ OC	√	.	.	√
ORUS_3304-10	Tillamook_I1	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3304-11	Tillamook_I1	FRA_1701	1	0	0	.	.	.	0	0	.	√	√ OC	√	.	.	√
ORUS_3304-13	Tillamook_I1	FRA_1701	1	0	0	.	.	.	0	0	.	√	√ OC	√	.	.	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
ORUS_3305 population (Tillamook × Seascape)[d]																	
Tillamook_CF[d]	Cuesta	Puget_Reliance	.	0	0	0	.	.	0	0	1	√	√	√	.	.	√
Tillamook_NCGR[m, b]	Cuesta	Puget_Reliance	.	.	.	.	.	.	.	.	.	.	.	.	√	√	√
Seascape_CF[l, j]	Selva	Douglas	1	1	1	1	.	.	1	1	1	√	√	√	√	√	√
ORUS_3305-1	Tillamook_NCGR	Seascape_CF	0	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3305-2	Tillamook_NCGR	Seascape_CF	1	1	0	.	.	.	1	1	.	√	√	√	√	√	√
ORUS_3305-3	Tillamook_NCGR	Seascape_CF	1	1	1	.	.	.	1	1	.	√	√	√	√	√	√
ORUS_3305-5	Tillamook_NCGR	Seascape_CF	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3305-6	Tillamook_NCGR	Seascape_CF	0	1	1	.	.	.	0	0	.	.	√	√	√	√	√
ORUS_3305-7	Tillamook_NCGR	Seascape_CF	1	1	0	.	1	1	1	0	.	√	√ OC	√	√	√	√
ORUS_3305-10	Tillamook_NCGR	Seascape_CF	1	1	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3305-11	Tillamook_NCGR	Seascape_CF	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3305-13	Tillamook_NCGR	Seascape_CF	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3305-14	Tillamook_NCGR	Seascape_CF	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3306 population (Totem × FRA_1701)[d]																	
Totem_CF[m, j]	Puget_Beauty	Northwest	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
FRA_1701[l, r, a]	0	0	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
ORUS_3306-2	Totem_CF	FRA_1701	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
ORUS_3306-3	Totem_CF	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3306-4	Totem_CF	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3306-5	Totem_CF	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3306-6	Totem_CF	FRA_1701	1	0	0	.	.	.	.	0	.	√	√	√	.	.	√
ORUS_3306-8	Totem_CF	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3306-11	Totem_CF	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
ORUS_3306-13	Totem_CF	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3306-14	Totem_CF	FRA_1701	1	.	.	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3306-15	Totem_CF	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3314 population (Fort Laramie × ORUS 2427-1)[d]																	
ORUS 2427-1_CF_1-22 [d]	Pinnacle	ORUS_1723-3	1	0	0	0	0	0	0	0	0	√	√	√	.	.	√
FortLaramie_NCGR[b]	Geneva	S.65122	0	.	1	0	.	.	1	0	1	√	√	√	√	√	√
FortLaramie_I2[m]			.	.	.	.	.	.	.	.	.	.	√	.	.	.	.
ORUS 2427_I1[l]			.	.	.	.	.	.	.	.	.	.	√	.	.	.	√
ORUS_3314-1	FortLaramie_I2	ORUS 2427_I2	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
ORUS_3314-2	FortLaramie_I2	ORUS 2427_I2	1	0	0	.	.	.	0	0	.	√	√ OC	√	.	.	√
ORUS_3314-4	FortLaramie_I2	ORUS 2427_I2	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3314-5	FortLaramie_I2	ORUS 2427_I2	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3314-6	FortLaramie_I2	ORUS 2427_I2	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3314-10	FortLaramie_I2	ORUS 2427_I2	0	0	0	.	.	.	0	0	.	√	√ OC	√	.	.	√
ORUS_3314-11	FortLaramie_I2	ORUS 2427_I2	1	.	0	.	.	.	.	0	.	√	√	√	.	.	√
ORUS_3314-12	FortLaramie_I2	ORUS 2427_I2	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3314-14	FortLaramie_I2	ORUS 2427_I2	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3314-15	FortLaramie_I2	ORUS 2427_I2	1	0	0	.	.	.	0	0	.	√	√ OC	√	.	.	√
ORUS_3315 population (Fort Laramie × Puget Reliance)[d]																	
FortLaramie_NCGR[b]	Geneva	S.65122	0	.	1	0	.	.	1	0	1	√	√	√	√	√	√
FortLaramie_I3[m]			.	.	.	.	.	.	.	.	.	.	√	.	.	.	√
Puget Reliance_CF[l, j]	WSU_1945	BC_77-2-72	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
ORUS_3315-1	FortLaramie_I3	Puget Reliance_CF	1	.	0	.	.	.	0	0	.	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
ORUS_3315-2	FortLaramie_I3	Puget Reliance_CF	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3315-4	FortLaramie_I3	Puget Reliance_CF	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3315-6	FortLaramie_I3	Puget Reliance_CF	0	0	0	.	.	.	.	0	.	√	√	√	√	√	√
ORUS_3315-10	FortLaramie_I3	Puget Reliance_CF	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3315-11	FortLaramie_I3	Puget Reliance_CF	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3315-12	FortLaramie_I3	Puget Reliance_CF	0	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3315-13	FortLaramie_I3	Puget Reliance_CF	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3315-14	FortLaramie_I3	Puget Reliance_CF	0	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3315-15	FortLaramie_I3	Puget Reliance_CF	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3316 population (Fort Laramie × Totem)[d]																	
FortLaramie_NCGR[b]	Geneva	S.65122	0	.	1	0	.	.	1	0	1	√	√	√	√	√	√
FortLaramie_I1[m]			.	.	.	.	.	.	.	.	.	.	√	.	.	.	.
Totem_CF[l, j]	Puget_Beauty	Northwest	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
ORUS_3316-1	FortLaramie_I1	Totem_CF	1	0	0	.	.	.	.	0	.	√	√	√	√	√	√
ORUS_3316-2	FortLaramie_I1	Totem_CF	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3316-3	FortLaramie_I1	Totem_CF	0	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3316-4	FortLaramie_I1	Totem_CF	1	0	0	.	.	.	.	0	.	√	√	√	√	√	√
ORUS_3316-5	FortLaramie_I1	Totem_CF	1	0	1	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3316-6	FortLaramie_I1	Totem_CF	1	0	.	.	.	.	.	0	.	.	√	√	.	.	√
ORUS_3316-7	FortLaramie_I1	Totem_CF	1	0	0	.	.	.	.	0	.	√	√	√	√	√	√
ORUS_3316-8	FortLaramie_I1	Totem_CF	0	0	.	.	.	.	.	0	.	.	√	√	.	.	√
ORUS_3316-9	FortLaramie_I1	Totem_CF	1	0	0	.	.	.	0	0	.	√	√ OC	√	√	√	√
ORUS_3316-10	FortLaramie_I1	Totem_CF	1	.	0	.	.	.	0	0	.	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
ORUS_3317 population (Puget Reliance × FRA_1701)[d]																	
Puget Reliance_CF [d]	WSU_1945	BC_77-2-72	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
Puget Reliance_I1[m]	.	.	.	.	.	.	.	.	.	.	.	.	√	.	.	.	√
FRA_1701[l, r, a]	0	0	1	0	0	.	0	0	0	0	.	√	√	√	√	.	√
ORUS_3317-1	Puget Reliance_I1	FRA_1701	1	0	0	.	.	.	0	1	.	√	√	√	.	.	√
ORUS_3317-2	Puget Reliance_I1	FRA_1701	0	0	0	.	0	0	.	0	.	√	√	√	.	.	√
ORUS_3317-3	Puget Reliance_I1	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3317-4	Puget Reliance_I1	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3317-5	Puget Reliance_I1	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3317-6	Puget Reliance_I1	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3317-7	Puget Reliance_I1	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3317-9	Puget Reliance_I1	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3317-10	Puget Reliance_I1	FRA_1701	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3317-11	Puget Reliance_I1	FRA_1701	0	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3318 population (Puget Reliance × Sarian)[d]																	
Puget Reliance_CF[d]	WSU_1945	BC_77-2-72	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
Puget Reliance_I1[m]	.	.	.	.	.	.	.	.	.	.	.	.	√	.	√	√	√
Sarian_CF[l,j]	Pinnacle	ORUS_1723-3	1	0	0	0	0	0	0	0	0	√	√	√	√	√	√
ORUS_3318-1	Puget Reliance_I1	Sarian-CF	1	1	1	.	.	.	1	1	.	√	√	√	√	√	√
ORUS_3318-2	Puget Reliance_I1	Sarian-CF	1	1	0	.	.	.	1	1	.	√	√	√	√	√	√
ORUS_3318-4	Puget Reliance_I1	Sarian-CF	1	0	1	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3318-6	Puget Reliance_I1	Sarian-CF	1	1	0	.	.	.	1	0	.	√	√	√	√	√	√
ORUS_3318-8	Puget Reliance_I1	Sarian-CF	.	1	1	.	.	.	1	1	.	√	√	√	√	√	√
ORUS_3318-9	Puget Reliance_I1	Sarian-CF	1	1	1	.	1	1	1	0	.	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
ORUS_3318-10	Puget Reliance_I1	Sarian-CF	.	1	1	.	.	.	0	1	.	√	√	√	√	√	√
ORUS_3318-11	Puget Reliance_I1	Sarian-CF	1	1	1	.	.	.	1	1	.	√	√	.	√	√	.
ORUS_3318-12	Puget Reliance_I1	Sarian-CF	1	1	1	.	.	.	1	0	.	√	√	√	√	√	√
ORUS_3318-14	Puget Reliance_I1	Sarian-CF	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3319 population (Sarian × ORUS 2427-1)[d]																	
Sarian_CF[m, j]	Pinnacle	ORUS_1723-3	1	0	0	0	0	0	0	0	0	√	√	√	√	√	√
ORUS 2427_I1[l]	Pinnacle	ORUS_1723-3	1	0	0	0	0	0	0	0	0	√	√	√	.	.	√
ORUS_3319-1	Sarian-CF	ORUS 2427_I1	1	.	0	.	.	.	1	0	.	√	√	√	.	.	√
ORUS_3319-2	Sarian-CF	ORUS 2427_I1	1	.	.	.	.	.	1	1	.	√	√	√	.	.	√
ORUS_3319-3	Sarian-CF	ORUS 2427_I1	1	.	.	.	.	.	1	1	.	√	√	√	.	.	√
ORUS_3319-4	Sarian-CF	ORUS 2427_I1	1	.	.	.	.	.	0	1	.	√	√	√	.	.	√
ORUS_3319-5	Sarian-CF	ORUS 2427_I1	0	1	1	.	.	.	0	1	.	√	√ OC	√	√	√	√
ORUS_3319-6	Sarian-CF	ORUS 2427_I1	0	.	0	.	1	0	0	0	.	√	√	√	√	√	√
ORUS_3319-7	Sarian-CF	ORUS 2427_I1	1	.	1	.	.	.	1	1	.	√	√ OC	√	√	√	√
ORUS_3319-8	Sarian-CF	ORUS 2427_I1	1	.	0	.	.	.	1	1	.	√	√	√	√	√	√
ORUS_3319-9	Sarian-CF	ORUS 2427_I1	.	.	0	.	.	.	1	0	.	√	√	.	.	.	.
ORUS_3319-10	Sarian-CF	ORUS 2427_I1	.	.	0	.	.	.	1	0	.	.	√	√	.	.	√
ORUS_3320 population (Sarian × Totem)[d]																	
Sarian_CF[m, j]	Pinnacle	ORUS_1723-3	1	0	0	0	0	0	0	0	0	√	√	√	√	√	√
Totem_CF[l, j]	Puget_Beauty	Northwest	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
ORUS_3320-1	Sarian-CF	Totem_CF	1	1	0	.	1	.	0	0	.	√	√ OC	√ OC	√ OC	√ OC	√ OC
ORUS_3320-2	Sarian-CF	Totem_CF	1	1	1	.	.	.	1	1	.	√	√	√	√	√	√
ORUS_3320-3	Sarian-CF	Totem_CF	1	.	1	.	.	.	1	1	.	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
ORUS_3320-4	Sarian-CF	Totem_CF	1	1	1	.	.	.	1	1	.	√	√	√	√	√	√
ORUS_3320-5	Sarian-CF	Totem_CF	.	1	1	.	.	.	1	0	.	√	√	√	.	.	√
ORUS_3320-6	Sarian-CF	Totem_CF	1	.	0	.	.	.	1	1	.	√	√	√	.	.	√
ORUS_3320-7	Sarian-CF	Totem_CF	.	1	0	.	.	.	1	1	.	√	√	√	.	.	√
ORUS_3320-8	Sarian-CF	Totem_CF	1	1	0	.	.	.	1	1	.	√	√	√	.	.	√
ORUS_3320-9	Sarian-CF	Totem_CF	1	1	1	.	.	.	1	1	.	√	√	√	√	√	√
ORUS_3320-10	Sarian-CF	Totem_CF	1	1	1	.	.	.	1	1	.	√	√	√	√	√	√
ORUS_3321 population (Sarian × Tillamook)[d]																	
Tillamook_1819.001 [b]	Cuesta	Puget_Reliance	.	.	.	.	.	.	.	.	.	.	.	.	√	√	√
Sarian_2691.1 [b]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	√	.	.
Sarian_CF[m, j]	Pinnacle	ORUS_1723-3	1	0	0	0	0	0	0	0	0	√	√	√	√	√	√
Tillamook_CF[l, j]	Cuesta	Puget_Reliance	.	0	0	0	.	.	0	0	1	√	√	√	.	.	√
ORUS_3321-1	Sarian-CF	Tillamook_CF	1	0	.	.	.	.	1	1	.	√	√	√	.	.	√
ORUS_3321-2	Sarian-CF	Tillamook_CF	1	1	.	.	.	.	1	1	.	√	√ OC	√	.	.	√ OC
ORUS_3321-3	Sarian-CF	Tillamook_CF	0	1	.	.	.	.	1	1	.	√	√ OC	√	.	.	√ OC
ORUS_3321-4	Sarian-CF	Tillamook_CF	1	1	0	.	.	.	0	1	.	√	√	√	.	.	√
ORUS_3321-5	Sarian-CF	Tillamook_CF	0	.	0	.	.	.	1	0	.	√	√	√	.	.	√
ORUS_3321-6	Sarian-CF	Tillamook_CF	1	1	1	.	.	.	1	1	.	√	√	√	√ OC	√	√
ORUS_3321-7	Sarian-CF	Tillamook_CF	1	1	1	.	1	.	1	1	.	√	√ OC	√	√ OC	√	√
ORUS_3321-8	Sarian-CF	Tillamook_CF	1	1	1	.	.	.	1	1	.	√	√ OC	√	√ OC	√	√ OC
ORUS_3321-9	Sarian-CF	Tillamook_CF	1	1	1	.	.	.	1	1	.	√	√ OC	√	√ OC	√	√ OC
ORUS_3321-10	Sarian-CF	Tillamook_CF	1	1	0	.	.	.	1	1	.	√	√	√	.	.	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
ORUS_3322 population (Seascape × ORUS 2427-1)[d]																	
ORUS 2427-1_CF_1-22 [d]	Pinnacle	ORUS_1723-3	1	0	0	0	0	0	0	0	0	√	√	√	.	.	√
Seascape_CF[m, j]	Selva	Douglas	1	1	1	1	.	.	1	1	1	√	√	√	√	√	√
ORUS 2427_I1[l]			.	.	.	.	.	.	.	.	.	.	√	.	√	√	√
ORUS_3322-2	Seascape_CF	ORUS 2427_I1	1	1	0	.	.	.	1	0	.	√	√ OC	√	√	√	√
ORUS_3322-4	Seascape_CF	ORUS 2427_I1	1	.	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3322-5	Seascape_CF	ORUS 2427_I1	1	1	1	.	.	.	0	1	.	√	√ OC	√	√	√	√
ORUS_3322-7	Seascape_CF	ORUS 2427_I1	1	0	0	.	1	0	0	0	.	√	√	√	√	√	√
ORUS_3322-8	Seascape_CF	ORUS 2427_I1	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3322-9	Seascape_CF	ORUS 2427_I1	1	1	1	.	.	.	1	1	.	√	√	√	√	√	√
ORUS_3322-11	Seascape_CF	ORUS 2427_I1	1	0	.	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3322-12	Seascape_CF	ORUS 2427_I1	0	1	0	.	.	.	0	0	.	√	√ OC	√	√	√	√
ORUS_3322-13	Seascape_CF	ORUS 2427_I1	1	0	0	.	.	.	0	1	.	√	√	√	√	√	√
ORUS_3322-14	Seascape_CF	ORUS 2427_I1	1	1	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3323 population (Seascape × Puget Reliance)[d]																	
Puget Reliance_CF [d]	WSU_1945	BC_77-2-72	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
Seascape_CF[m, j]	Selva	Douglas	1	1	1	1	.	.	1	1	1	√	√	√	√	√	√
Puget Reliance_I1[l]	.	.	.	.	.	.	.	.	.	.	.	.	√	.	√	√	√
ORUS_3323-1	Seascape_CF	Puget Reliance_I1	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3323-2	Seascape_CF	Puget Reliance_I1	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3323-3	Seascape_CF	Puget Reliance_I1	1	0	0	.	.	.	0	0	.	√	√ OC	√	√	√	√
ORUS_3323-4	Seascape_CF	Puget Reliance_I1	1	1	1	.	.	.	1	0	.	√	√	√	√	√	√
ORUS_3323-6	Seascape_CF	Puget Reliance_I1	1	1	0	.	.	.	1	1	.	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
ORUS_3323-7	Seascape_CF	Puget Reliance_I1	1	.	0	.	.	.	0	0	.	√	√ OC	√	√	√	√
ORUS_3323-9	Seascape_CF	Puget Reliance_I1	1	0	0	.	0	0	0	0	.	√	√ OC	√	√	√	√
ORUS_3323-12	Seascape_CF	Puget Reliance_I1	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3323-13	Seascape_CF	Puget Reliance_I1	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3323-14	Seascape_CF	Puget Reliance_I1	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3324 population (Tillamook × Fort Laramie)[d]																	
Tillamook_NCGR[b]	Cuesta	Puget_Reliance	.	.	.	.	.	.	.	.	.	.	.	.	√	√	√
Tillamook_CF[m, j]	Cuesta	Puget_Reliance	.	0	0	0	.	.	0	0	1	√	√	√	.	.	√
FortLaramie_I1[l]			.	.	.	.	.	.	.	.	.	.	√	.	√	√	√
ORUS_3324-1	Tillamook_CF	FortLaramie_I1	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3324-3	Tillamook_CF	FortLaramie_I1	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3324-4	Tillamook_CF	FortLaramie_I1	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3324-9	Tillamook_CF	FortLaramie_I1	1	0	1	.	0	0	0	0	.	√	√	√	√	√	√
ORUS_3324-10	Tillamook_CF	FortLaramie_I1	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3324-11	Tillamook_CF	FortLaramie_I1	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3324-12	Tillamook_CF	FortLaramie_I1	1	.	0	.	.	.	.	0	.	√	√	√	√	√	√
ORUS_3324-13	Tillamook_CF	FortLaramie_I1	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3324-14	Tillamook_CF	FortLaramie_I1	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3324-15	Tillamook_CF	FortLaramie_I1	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3325 population (Tillamook × Tribute)[d]																	
Tillamook_NCGR[b]	Cuesta	Puget_Reliance	.	.	.	.	.	.	.	.	.	.	.	.	√	√	√
Tillamook_CF[m, j]	Cuesta	Puget_Reliance	.	0	0	0	.	.	0	0	1	√	√	√	.	.	√
Tribute_662.001[l, b]	USEB_18	MDUS_4258	.	.	.	.	.	.	.	.	.	√	√	√	√	√	√
ORUS_3325-2	Tillamook_CF	Tribute_662.001	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
ORUS_3325-4	Tillamook_CF	Tribute_662.001	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3325-5	Tillamook_CF	Tribute_662.001	1	0	0	.	.	.	1	0	.	√	√	√	√	√	√
ORUS_3325-8	Tillamook_CF	Tribute_662.001	.	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3325-9	Tillamook_CF	Tribute_662.001	1	0	0	.	0	.	0	1	.	√	√	√	√	√	√
ORUS_3325-10	Tillamook_CF	Tribute_662.001	1	1	1	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3325-11	Tillamook_CF	Tribute_662.001	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3325-12	Tillamook_CF	Tribute_662.001	1	1	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3325-13	Tillamook_CF	Tribute_662.001	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_3325-15	Tillamook_CF	Tribute_662.001	1	0	0	.	.	.	1	0	.	√	√	√	.	.	√
ORUS_3326 population (Tribute × Puget Reliance)[d]																	
Puget Reliance_CF[d]	WSU_1945	BC_77-2-72	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
Tribute_662.001[m, b]	USEB_18	MDUS_4258	.	.	.	.	.	.	.	.	.	√	√	√	√	√	√
Puget Reliance_I1[l]	.	.	.	.	.	.	.	.	.	.	.	√	.	√	√	√
ORUS_3326-1	Tribute_662.001	Puget Reliance_I1	1	0	0	.	.	0	0	0	.	√	√	√	.	.	√
ORUS_3326-2	Tribute_662.001	Puget Reliance_I1	1	0	0	.	.	.	0	0	.	√	√ OC	√	.	.	√
ORUS_3326-3	Tribute_662.001	Puget Reliance_I1	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3326-4	Tribute_662.001	Puget Reliance_I1	1	0	0	.	.	.	0	0	.	√	√ OC	√	√	√	√
ORUS_3326-5	Tribute_662.001	Puget Reliance_I1	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3326-11	Tribute_662.001	Puget Reliance_I1	1	1	1	.	.	.	1	0	.	√	√	√	√	√	√
ORUS_3326-12	Tribute_662.001	Puget Reliance_I1	1	1	1	.	.	.	1	1	.	√	√	√	√	√	√
ORUS_3326-13	Tribute_662.001	Puget Reliance_I1	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
ORUS_3326-14	Tribute_662.001	Puget Reliance_I1	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_3326-15	Tribute_662.001	Puget Reliance_I1	1	0	0	.	.	.	1	0	.	√	√	√	.	.	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
Parents of populations																	
Capitola-FR_CF[e]	Cal_75.121-101	Parker	1	.	0	0	.	.	.	0	1	√	√	√	√	√	√
CF1116-FR[za]	Pajaro	(Earliglow×Chandler)	.	.	.	.	.	.	.	.	.	.	.	.	√	√	√
E-60174-NL (Redgauntlet) [k]	NJ_1052	Auchincruive_Climax										√	√	√	.	.	√
E-71006-NL (Holiday) [i]	Raritan	NY_845	1	.	0	0	.	.	.	0	0	√	√	√	.	.	√
Earliglow_CF[j]	MDUS_2359	MDUS_2713	1	.	0	0	0	0	0	0	0	√	√	√	√	√	√
FortLaramie_NCGR[b]	Geneva	S.65122	0	.	1	0	.	.	1	0	1	√	√	√	√	√	√
FRA_1701[a]	0	0	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
Hapil-NL[i]	Gorella	Souv_de_CharlesMachiroux	.	.	.	.	.	.	.	.	.	√	√	.	.	.	.
Holiday_CF[j]	Raritan	NY_844	1	0	0	0	0	0	0	0	0	√	√	√	.	.	√
Honeoye_215.001[a]	Vibrant	Holiday										√	√	√	√	√	√
IFAPA_1392[j]	Esp	Gaviota	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
IFAPA_232[j]	Esp	Sel.4-43	1	.	.	.	.	.	.	0	1	√	√	√	.	.	√
Korona-CF[j]	Tamella	Induka	1	.	0	0	.	.	0	0	1	√	√	√	.	.	√
Korona-NL[i]	Tamella	Induka	.	.	.	.	.	.	.	.	.	.	√	.	.	.	.
MSU_49 [j]	Jewel	Mesabi	1	1	0	0	0	0	0	0	0	√	√	√	√	√	√
MSU_56[j]	Cabot	Cavendish	1	0	0	0	0	0	0	0	0	√	√	√	√	√	√
ORUS 2427-1_CF_1-22 [j]	Pinnacle	ORUS_1723-3	1	0	0	0	0	0	0	0	0	√	√	√	.	.	√
Puget Reliance_CF[j]	WSU_1945	BC_77-2-72	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
Redgauntlet_CF[j]	NJ_1051	Auchincruive_Climax	1	0	1	0	.	.	1	1	1	√	√	√	√	√	√
Sarian_2691.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	√	.	.
Sarian_CF[d]	Pinnacle	ORUS_1723-3	1	0	0	0	0	0	0	0	0	√	√	√	√	√	√
Seascape_CF[j]	Selva	Douglas	1	1	1	1	.	.	1	1	1	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
Tillamook_NCGR[b]	Cuesta	Puget_Reliance	.	.	.	.	.	.	.	.	.	.	.	.	√	√	√
Tillamook_CF[d]	Cuesta	Puget_Reliance	.	0	0	0	.	.	0	0	1	√	√	√	.	.	√
Totem_CF[j]	Puget_Beauty	Northwest	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
Tribute_662.001[b]	USEB_18	MDUS_4258	.	.	.	.	.	.	.	.	.	√	√	√	√	√	√
Tribute_CF[j]	USEB_18	MDUS_4258	1	0	0	0	.	.	1	1	0	√	√	√	√	√	√
Cultivars																	
Aberdeen[a]	Likely_Lake_Stevens	Likely_Chesapeake	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Aberdeen-NL[i]	Likely_Lake_Stevens	Likely_Chesapeake	.	.	.	.	.	.	.	.	.	√	√	.	.	.	.
Aiko[j]	Cal_46.5-1	Cal_59.51-11	1	.	0	.	.	.	1	0	.	√	√	√	√	√	√
Albion[j]	Diamante	Cal_94.16-1	0	0	1	1	1	0	1	1	0	√	√	√	√	√	√
Albritton[j]	NC__1065	NC__1053	1	.	0	.	.	.	0	0	.	√	√	√	.	.	√
E-82246 NL (Allstar)[g]	US_4419	MDUS_3184										√	√	√	.	.	√
Allstar[j]	US_4419	MDUS_3184	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Ambrosia_Late[j]	0	0	1	.	0	.	.	.	.	0	.	√	√	√	.	.	√
Annapolis[j]	K74-5	Earliglow	1	.	.	.	.	.	0	0	.	√	√	√	.	.	√
Apollo[j]	NC_1759	NC_1729	1	.	.	.	.	.	.	0	.	√	√	√	.	.	√
ArKing[j]	Cardinal	Ark_5431	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Aromas[j]	Cal_87.112-6	Cal_88.270-1	1	1	1	1	.	.	1	1	1	√	√	√	√	√	√
Atlas[j]	NC_1759	Albritton	0	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Badgerglo[j]	Sparkle	Stelemaster	.	.	0	.	.	.	.	0	.	√	√	√	.	.	√
Beaver[j]	0	0	0	.	0	.	.	.	.	0	.	√	√	√	.	.	√
Benizuru[j]	(Miyazaki_x_The_Sun)	Fukuba	1	.	.	.	.	.	0	0	.	√	√	√	.	.	√
Benton[j]	OSC_2414	Vale	0	0	0	.	.	.	0	0	.	√	√	√	.	.	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
Blakemore[j]	Missionary	Howard_17	1	0	0	.	.	.	0	0	.	√	√	√	.	.	.
Bountiful[j]	Linn	Totem	1	.	0	.	.	.	0	0	.	√	√	√	.	.	√
Bounty [j]	Jerseybelle	Senga_Sengana	0	.	0	.	.	.	0	0	.	√	√	√	.	.	√
British_Sovereign [j]	0	0	.	1	0	.	.	.	0	0	.	√	√	√	√	√	√
Brunswick [j]	Cavendish	Honeoye	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Cabot[j]	K87-5	K86-19	0	0	0	.	.	.	1	0	.	√	√	√	.	.	√
Cal_51S-1[j]	Lassen	Lassen	1	.	.	.	.	.	0	0	.	√	√	.	.	.	.
Cal_59.39-1[j]	Rockhill2ndBC	0	.	.	1	.	.	.	0	1	1	.	√	√	.	.	√
Camarosa[j]	Douglas	Cal_72.361-105	1	0	0	0	.	.	0	0	0	√	√	√	√	√	√
Cardinal[j]	Earlibelle	Ark_5063	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Catskill[j]	Marshall	Howard_17	0	.	0	.	.	.	0	1	.	√	√	√	.	.	√
Cavendish[j]	Glooscap	Annapolis	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Chandler[j]	Douglas	Cal_72.361-105	1	.	.	.	0	0	0	0	1	√	√	√	√	√	√
Charm (ORUS_2262-2)[j]	Puget_Reliance	B754	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
Clancy[j]	MDUS_4774	MDUS_5199	0	0	0	.	.	.	0	1	.	√	√	√	.	.	√
Climax[j]	0	0	1	.	.	.	.	.	1	1	.	√	√	√	√	√	√
Columbia[j]	WSU_157	WSU_175	.	.	1	.	.	.	.	0	.	√	√	√	√	√	√
Cruz[j]	Cal_37.20-45	Sequoia	1	.	.	.	.	.	1	0	.	√	√	√	√	√	√
Daroyal[j]	Elsanta	Parker	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Darrow 5[j]	0	0	.	.	.	.	.	.	.	.	.	.	√	.	.	.	.
Darselect[j]	Elsanta	Parker	0	.	.	.	.	.	0	0	.	√	√	√	.	.	√
Delitej	Albritton	MDUS_2650	0	.	0	.	.	.	.	0	.	√	√	√	.	.	√
Delmarvel[j]	Earliglow	Atlas	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
Diamante[j]	Cal_87.112-6	Cal_88.270-1	1	1	0	1	1	0	1	0	1	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
Direktor_Paul_Wallbaum[j]	Georg_Soltwedel?	FrauMiezeSchindler	1	.	.	.	.	.	.	0	.	√	√	√	√	√	√
Donner[j]	Cal_145.52	Cal_222.4	1	.	0	.	.	.	0	0	.	√	√	√	.	.	√
Dover[j]	Florida_Belle	FL_71-189	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Earlibelle[j]	Albritton	MDUS_2101	1	.	.	.	0	0	0	0	.	√	√	√	.	.	√
Elsanta[j]	Gorella	Holiday	.	0	0	0	0	0	0	0	0	√	√	√	√	√	√
Eros[j]	Elsanta	Allstar	0	0	0	.	.	.	0	0	.	.	√	√	.	.	√
Ettersburg_121[j]	F.chil.Cape.Mendicino	Alpine(F.vesca)	0	.	.	.	.	.	0	0	.	√	√	√	√	√	√
Evangeline[j]	K88-4	NYUS_119	0	.	0	.	.	.	.	0	.	√	√	√	.	.	√
Evie-2[j]	Everglade	J92D12	.	.	.	0	.	.	.	0	0	√	√	√	√	√	√
Fairfax[j]	Royal_Sovereign	Howard_17	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Fern[j]	Tufts	Cal_69.62-103	1	1	1	1	.	.	1	1	1	√	√	√	√	√	√
Firecracker[j]	ORUS_850-48	Totem	0	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Florence[j]	Tiogax(Redgauntx(WiltgxGorel))	(Providence_self)	1	.	0	0	.	.	.	0	1	√	√	√	.	.	√
Florida_90[j]	Missionary	OP26	0	.	0	.	.	.	.	0	.	√	√	√	.	.	√
Florida_Belle[j]	Sequoia	Earlibelle	1	0	0	.	0	0	0	0	.	√	√	√	√	√	√
Florida_Elyana[j]	FL_96-114	FL_95-200	1	0	.	.	0	0	0	0	.	√	√	√	.	.	√
Florida_Radiance[j]	Winter_Dawn	FL_99-35	.	0	.	.	0	.	1	1	.	√	√	√	√	√	√
Galletta[j]	NCH_87-22	Earliglow	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Glooscap[j]	Micmac	Bounty	0	.	.	.	.	.	0	0	.	√	√	√	.	.	√
Gorella[j]	Juspa	US_3763	1	.	0	.	.	.	0	0	.	√	√	√	.	.	√
Governor_Simcoe[j]	Holiday	Guardian	1	0	.	0	.	.	.	0	1	√	√	√	√	√	√
Guardian[j]	NC_1768	Surecrop	1	.	0	.	.	.	1	0	.	√	√	√	√	√	√
Harunoka[j]	Kurume103	Dana	1	.	.	.	.	.	0	0	.	√	√	√	.	.	√
Hecker[j]	Cal_65.65-601	Cal_66.96-101	1	.	1	0	.	.	1	1	1	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
Hogyoku[j]	Fukuba	OP70	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
Hood[j]	OSC_2315	Puget_Beauty	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Howard_17[j]	Seedling#1Howard	Crescent	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Hummi_Grandee[j]	0	0	1	.	.	.	.	.	0	0	.	√	√	√	.	.	√
Idea[j]	((GorellaxMDUS3184)xTioga)	Etna	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Independence[j]	ORUS_850-48	ORUS_750-1	.	.	0	.	.	.	.	0	.	√	√	√	.	.	√
E-65056 (Induka)[i]	Holiday	Korona	1	.	.	.	.	.	.	0	1	√	√	.	.	.	√
Jerseybelle[j]	NJ_953	NJ_925	1	.	0	.	.	.	0	0	.	√	√	√	.	.	√
Jewel[j]	NY_1221	Holiday	1	0	0	.	.	.	.	0	.	√	√	√	√	√	√
Joe[j]	(MiddlefieldxChairsFav)xSharpless	Gandy	1	.	.	.	.	.	0	0	.	√	√	√	.	.	√
Jucunda[j]	0	0	1	.	0	.	.	.	.	0	.	√	√	√	.	.	√
Jurica[j]	Senga48	So_308	.	0	0	.	.	.	0	0	.	√	√	.	.	.	.
Kaiser_Samling[j]	Konig.von.Sachsen	UNK7	1	.	0	.	.	.	.	0	.	√	√	√	.	.	√
Kent[j]	K68-58	Raritan	1	.	0	.	.	.	0	0	.	√	√	√	√	√	√
Klondike[j]	Pickerproof	Hoffman	1	0	0	.	.	.	.	0	.	√	√	√	.	.	√
Koro103[j]	Marshall	Fairfax	1	.	0	.	.	.	0	0	.	√	√	√	.	.	√
Kurume103[j]	0	0	1	.	.	.	.	.	0	0	.	√	√	√	.	.	√
L'Amour[j]	NYUS_256	Cavendish	1	.	.	.	.	.	0	0	.	√	√	.	.	.	.
Lassen[j]	Cal_21.9	Cal_161.1	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Lateglow[j]	Tamella	MDUS_3184	1	.	0	.	.	.	0	0	.	√	√	√	√	√	√
Liberation_d_Orleans[j]	0	0	1	.	1	.	.	.	0	1	.	√	√	√	√	√	√
Linn[j]	OSC_2414	MDUS_3184	1	.	0	.	.	.	0	0	.	√	√	√	.	.	√
Mara_des_Bois[j]	Hummi_GentoxOstara	RedgauntletxKorona	1	1	1	1	.	.	1	1	1	√	√	√	√	√	√
Marlate[j]	Jerseybelle	((KlonmxMidl)x(TennShipxMidl))	1	.	0	.	.	.	0	0	.	√	√	√	.	.	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
Marshall[j]	F.virginiana	UNK18	1	0	0	.	.	.	.	0	.	√	√	√	.	.	√
Massey[j]	US_634	Blakemore	1	.	0	.	.	.	.	0	.	√	√	√	.	.	√
MDUS_3184[j]	NC__1768	Surecrop	1	.	.	.	.	.	0	0	.	√	√	√	√	√	√
MDUS_3816[j]	NJ_459	MDUS_2927	1	.	.	.	.	.	0	0	.	√	√	.	.	.	.
MDUS_4258[j]	MDUS_2713	MDUS_3364	.	.	0	.	.	.	.	0	.	√	√	√	.	.	√
MDUS_683[j]	Fairfax	Scot_BK-46	1	.	0	.	.	.	0	0	.	√	√	√	.	.	√
Melody[j]	SCRI66M1	Senga_Sengana	.	.	.	.	.	.	0	0	.	√	√	√	.	.	√
Mesabi[j]	Glooscap	MNUS_99	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Micmac[j]	Tioga	K61-87	1	.	0	.	.	.	.	0	.	√	√	√	.	.	√
Midland[j]	Howard_17	Redheart	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Midway[j]	Dixieland	Temple	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Miyazaki[j]	0	0	1	0	0	.	.	.	0	0	.	√	√	.	.	.	.
Northwest[j]	Brightmore	OSC_456	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
NW_90054-37[j]	WA_87010-7	ORUS_984-49	1	.	.	.	.	.	0	0	.	√	√	√	.	.	√
Nyoho[j]	Kei_210	Reiko	1	.	.	.	.	.	0	0	.	√	√	√	.	.	√
Oberschlesien[j]	Jucunda	Sharpless	1	.	0	.	.	.	.	0	.	√	√	√	.	.	√
Ogallala[j]	(RockhillxCheyenne3)	(MidlandxCheyenne2)	1	.	0	0	.	.	1	1	0	√	√	√	√	√	√
Ooishi-shikinari2[j]	0	0	1	.	.	.	.	.	1	0	.	√	√	√	√	√	√
ORUS_1083-135[j]	ORUS_869-13	OSC_3727	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_1239R-21[j]	Sumas	ORUS_973-1	1	.	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_1267-236[j]	Redcrest	ORUS_869-13	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_1384-3[j]	ORUS_1009-1	ORUS_850-4	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
ORUS_1391-1[j]	ORUS_1027-1	ORUS_850-4	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_1407-76[j]	F.chiloensis(PatPoint)	UNK19	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
ORUS_1735-1[j]	Puget_Reliance	ORUS_1267-250	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
ORUS_1754-1[j]	WA_88097-47	ORUS_1735-1	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
ORUS_1769-1[j]	Annapolis	ORUS_1376-16	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
ORUS_1827-2[j]	Laguna	Totem	1	0	0	.	0	1	0	0	.	√	√	√	√	√	√
ORUS_1947-2[j]	ORUS_1376-16	ORUS_1083-135	1	0	0	.	0	0	1	0	.	√	√	√	.	.	√
ORUS_1963-5[j]	Tangi	NW_90054-36	1	0	0	.	0	0	1	0	.	.	√	√	√	√	√
ORUS_2427-4[j]	Pinnacle	ORUS_1723-3	1	0	0	0	0	0	0	0	.	√	√	√	.	.	√
ORUS_2490-1[j]	ORUS_1722-2	Pinnacle	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
ORUS_2676-1[j]	Puget_Reliance	ORUS_2161-1	.	.	.	.	.	.	0	0	.	√	√	√	.	.	√
ORUS_2742-1[j]	Sweet_Bliss	Valley_Red	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
ORUS_2781-1[j]	Puget_Summer	ORUS_2016-1	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
ORUS_740-7[j]	OSC_4681	Benton	0	.	.	.	.	.	0	0	.	√	√	√	.	.	√
OSC_4474[j]	OSC_4681	Benton	0	.	0	.	.	.	0	0	.	√	√	√	.	.	√
OSC_4816[j]	OSC_4681	Benton	1	.	0	.	.	.	0	0	.	√	√	√	.	.	√
OSC_4817[j]	OSC_4681	Benton	0	.	0	.	.	.	0	0	.	√	√	√	.	.	√
OSC_4916[j]	OSC_4681	Benton	1	.	0	.	.	.	.	0	.	√	√	√	.	.	√
Ourown[j]	Gem	Temple	1	.	1	.	.	.	.	1	.	√	√	√	√	√	√
Ozark_Beauty[j]	Redrich	Twentieth_Century	1	.	.	.	.	.	0	0	.	√	√	√	.	.	√
Pelican[j]	FL_82-1556P	LA_8311	.	.	0	.	.	.	.	0	.	√	√	.	.	.	.
Perle_de_Prague[j]	0	0	1	.	1	0	.	.	1	1	1	√	√	√	√	√	√
Pinnacle[j]	Laguna	ORUS_1267-250	1	.	0	.	.	.	0	0	.	√	√	√	.	.	√
Puget_Beauty[j]	OSC_1765	Sparkle	0	1	0	.	.	.	0	0	.	√	√	√	.	.	√
Puget_Reliance[j]	WSU_1945	BC_77-2-72	1	0	0	0	.	.	0	0	0	√	√	√	.	.	√
Puget_Summer[j]	Nanaimo	ORUS_1076-124	0	.	.	.	.	.	0	0	.	√	√	√	.	.	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
Rainier [j]	WSU_685	Columbia	1	.	0	.	.	.	0	0	.	√	√	√	.	.	√
Record	Idea	Marmolada(Onebor)	.	0	0	.	.	.	.	.	.	.	.	.	.	.	.
Redchief [j]	NC_1768	Surecrop	.	.	0	.	.	.	.	0	.	√	√	.	.	.	.
Redcoat [j]	Sparkle	Valentine	1	.	0	.	.	.	.	0	.	√	√	√	√	√	√
Redcrest[j]	Linn	Totem	1	.	0	.	.	.	0	0	.	√	√	√	.	.	√
Redgem [j]	Benton	OSC_3596	1	.	0	.	.	.	.	0	.	√	√	√	.	.	√
Redglow[j]	Fairland	Tenn_Shipper	0	.	0	.	.	.	0	0	.	√	√	√	.	.	√
Repita[j]	Ada_Herzberg	Auchincruive_Climax	1	1	0	.	.	.	0	0	.	√	√	√	.	.	√
Robinson[j]	Howard_17	Washington	1	.	0	.	.	.	0	0	.	√	√	√	√	√	√
Rosa_Linda[j]	FL_87-418	FL_87-200	.	0	0	.	0	0	1	0	.	√	√	√	.	.	√
Salinas[j]	Cal_37.2-11	Cal_42.17-18	0	0	0	.	.	.	0	0	.	√	√	.	√	√	.
Sarian[j]	Sunrise	Tioga	1	.	.	0	.	.	1	1	0	√	√	√	√	√	√
Scott[j]	F1_hybrid	F1_hybrid	1	.	0	.	.	.	.	0	.	√	√	√	.	.	√
Selva[j]	Cal_70.3-117	Cal_71.98-605	1	.	.	.	.	.	0	0	.	√	√	√	√	√	√
Seneca[j]	NY_1261	Holiday	1	.	0	.	.	.	0	0	.	√	√	√	.	.	√
Senga_Sengana[j]	Markee	Sieger	1	.	0	.	.	.	.	0	.	√	√	√	.	.	√
Sequoia[j]	Cal_52.16-15	Cal_51.51-1	1	0	1	0	.	.	0	1	1	√	√	√	√	√	√
Shasta[j]	Cal_67.5	Cal_177.21	1	.	0	.	.	.	.	1	.	√	√	√	.	.	√
Shuksan[j]	WSU_685	Columbia	1	0	0	.	.	.	1	0	.	√	√	√	√	√	√
Sierra[j]	Nich_Ohmer	Cal_86.6	1	0	0	0	.	.	1	1	1	√	√	.	√	√	.
Siletz	OSC_2012	OSC_1816	.	0	0	.	.	.	.	.	.	.	.	.	.	.	.
Sparkle[j]	Fairfax	Aberdeen	.	.	0	.	.	.	.	0	.	√	√	√	.	.	√
Stelemaster[j]	Fairland	MDUS_683	1	.	0	.	.	.	.	0	.	√	√	√	.	.	√
Stolo[j]	Puget_Reliance	Whonnock	1	.	.	.	.	.	0	0	.	√	√	.	.	.	.

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
Strawberry_Festival[j]	Rosa_Linda	Oso_Grande	0	0	0	0	0	0	1	0	1	√	√	√	.	.	√
Streamliner[j]	0	0	1	.	0	.	.	.	.	0	.	√	√	√	.	.	√
Sumas[j]	Cheam	Tioga	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Sumner[j]	Titan	MDUS_2856	.	0	0	.	.	.	0	1	.	√	√	.	.	.	.
Sunrise[j]	US_4152	Stelemaster	1	0	0	.	.	.	0	0	.	√	√	.	.	.	.
Surecrop[j]	Fairland	MDUS_1972	0	.	0	.	.	.	.	0	.	.	√	.	.	.	.
Sweet_Bliss[j]	B753	ORUS_1735-1	1	0	.	.	0	0	1	0	.	√	√	√	√	√	√
Sweet_Charlie [j]	FL_80-456	Pajaro	1	0	0	.	0	0	1	1	.	√	√	√	√	√	√
Sweet_Sunrise [j]	BC_91-14-31	WA_94023-1	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
Talisman-NL[i]	NJ_1051	Auchincruive_Climax	.	.	.	.	.	.	.	.	.	.	√	.	.	.	.
Tamella[j]	Gorella	Talisman	.	.	.	.	.	.	0	0	.	√	√	√	.	.	√
Tamella-NL[i]	Gorella	Talisman	.	.	.	.	.	.	.	.	.	.	√	.	.	.	.
Tangi[j]	LA_59-2012	LA_59-138	1	.	0	.	.	.	0	0	.	√	√	√	.	.	√
Temple[j]	Aberdeen	Fairfax	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Tioga[j]	Cal_42.8-16	Lassen	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Toro[j]	Cal_37.20-45	Sequoia	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
Treasure[j]	A3	Oso_Grande	1	0	.	.	0	0	0	1	.	√	√	√	√	√	√
Tufts[j]	Tioga	Cal_46.5-1	1	.	0	.	.	.	.	0	.	.	√	.	.	.	.
Tyee[j]	Totem	Olympus	1	.	0	.	.	.	.	0	.	√	√	√	.	.	√
Valley_Red[j]	Anaheim	Puget_Reliance	1	.	0	.	.	.	0	0	.	√	√	√	.	.	√
Valley_Sunset[j]	K94-15	K95-24	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Veestar[j]	Valentine	Sparkle	1	.	0	.	.	.	0	0	.	√	√	.	.	.	.
Ventana[j]	Cal_93.170-606	Cal_92.35-601	1	0	0	.	.	.	0	0	.	√	√	√	√	√	√
Wendy[j]	K96-5	Evangeline	1	0	0	.	.	.	0	0	.	√	√	.	.	.	.

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
White_Carolina[j]	0	0	1	.	0	.	.	.	0	0	.	√	√	√	.	.	√
Winona[j]	Earliglow	MNUS_52	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√
Winter_Dawn[j]	FL_93-103	FL_95-316	1	0	0	.	0	0	1	0	.	√	√	√	√	√	√
Super core collection																	
FRA_1088[x, a]	0	0	0	.	.	.	0	0	0	0	.	√	√	√	.	.	√
FRA_1092[x, a]	0	0	.	.	.	.	0	0	0	0	.	√	√	√	.	.	√
FRA_110[r, a]	0	0	1	0	0	.	.	.	1	1	.	√	√	.	.	.	.
FRA_1100[x, a]	0	0	0	.	.	.	0	.	0	0	.	√	√	√	.	.	√
FRA_1104[x, a]	0	0	0	.	.	.	.	.	0	0	.	√	√	√	.	.	√
FRA_1108[x, a]	0	0	0	0	0	.	0	0	.	0	.	√	√	√	.	.	√
FRA_1408[r, a]	0	0	0	0	0	.	0	0	.	0	.	√	√	√	.	.	√
FRA_1414[r, a]	0	0	.	0	0	.	0	0	0	0	.	√	√	.	.	.	.
FRA_1435[r, a]	0	0	.	.	.	.	0	0	0	0	.	√	√	√	.	.	√
FRA_1455[r, a]	0	0	.	.	.	.	0	0	0	0	.	√	√	√	.	.	√
FRA_1557[r, a]	0	0	.	0	.	.	0	0	0	.	.	√	√	√	.	.	√
FRA_1580[r, a]	0	0	0	0	0	.	0	0	0	0	.	√	√	√	.	.	√
FRA_1620[r, a]	0	0	.	0	0	.	0	0	0	0	.	√	√	√	.	.	√
FRA_1690[w, a]	0	0	0	.	0	.	.	.	0	0	.	√	√	√	.	.	√
FRA_1691[x, a]	0	0	0	0	.	.	0	0	0	0	.	√	√	√	.	.	√
FRA_1692[x, a]	0	0	.	0	.	.	0	0	0	0	.	√	√	√	.	.	√
FRA_1694[r, a]	0	0	1	0	.	.	1	0	1	0	.	√	√	√	√	√	√
FRA_1695[r, a]	0	0	1	0	.	1	0	0	0	1	1	√	√	√	√	√	√
FRA_1696[r, a]	0	0	1	.	.	.	1	0	.	0	.	√	√	√	.	.	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
FRA_1697[r, a]	0	0	1	.	.	.	1	0	1	1	.	√	√	√	√	√	√
FRA_1698[r, a]	0	0	1	.	.	.	.	.	1	1	.	√	√	√	√	√	√
FRA_1699[r, a]	0	0	1	0	0	0	0	0	0	0	1	√	√	√	√	√	√
FRA_1700[r, a]	0	0	1	.	.	0	1	1	1	0	1	√	√	√	√	√	√
FRA_1701[r, a]	0	0	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
FRA_1703[r, a]	0	0	1	0	.	0	0	1	0	1	1	√	√	√	√	√	√
FRA_24[x, a]	0	0	0	0	0	.	.	.	0	0	.	√	√	√	.	.	√
FRA_34[x, a]	0	0	0	0	0	.	0	0	0	0	.	√	√	√	.	.	√
FRA_357[x,a]	0	0	.	.	0	.	0	0	0	0	.	√	√	√	.	.	√
FRA_372[x,a]	0	0	1	.	0	.	0	0	0	0	.	√	√	.	.	.	.
FRA_42[x,a]	0	0	0	0	0	.	0	.	0	0	.	√	√	√	.	.	√
FRA_48[x,a]	0	0	.	0	0	.	0	.	.	0	.	√	√	√	.	.	√
FRA_58[r,a]	0	0	1	.	.	.	0	0	0	0	.	√	√	√	.	.	√
FRA_688[x,a]	0	0	1	0	.	.	0	.	.	0	.	√	√	.	.	.	.
FRA_796[x,a]	0	0	1	0	.	.	0	.	0	0	.	√	√	√	.	.	√
FRA_982[r,a]	0	0	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
Wild accessions																	
Del_Norte[x, j]	0	0	0	0	0	.	0	0	0	0	.	√	√	√	.	.	√
F.chil.Cape.Mendicino[x, j]	0	0	.	.	.	.	.	.	0	0	.	√	√	.	.	.	.
FRA_368[x, j]	0	0	1	0	0	.	0	0	0	0	.	√	√	√	√	√	√
ORUS_2361-1[x, j]	F.chiloensis(ScottsCreek)	FRA_1075	1	0	.	.	0	0	0	0	.	√	√	√	√	√	√
FRA_743[x, j]	0	0	0	.	.	.	0	0	0	0	.	√	√	√	.	.	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
Yaquina_B[w, j]	0	0	.	.	0	.	.	.	0	0	.	√	√	√	.	.	√
F.iturupensis[v, j]	0	0	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.
F.vesca bracteata[t, j]	0	0	.	.	.	.	.	.	1	1	.	√	√	.	.	.	.
FRA_1952[t, j]	0	0	.	.	0	.	.	.	0	0	.	√	√	.	.	.	.
FRA_504[t, j]	0	0	.	0	0	.	.	.	.	1	.	.	√	.	.	.	.
Hawaii0_TD [u,j]	0	0	1	1	.	.	1	1	1	0	.	√	√	√	.	.	√
Hawaii4_TD [u,j]	0	0	1	1	0	.	1	1	1	0	.	.	√	√	.	.	√
Yellow_Wonder[u, j]	0	0	.	.	0	.	.	.	1	0	.	.	√	.	.	.	.
FRA_1948[s, j]	0	0	0	.	0	.	.	.	1	0	.	.	√	.	.	.	.
BC12[q, j]	0	0	1	1	1	.	1	1	1	1	.	√	√	√	√	√	√
BC6[r, j]	0	0	1	0	0	.	0	0	1	0	.	.	√	√	.	.	√
FRA_101[p, j]	0	0	1	.	.	.	.	.	.	0	.	.	√	.	.	.	.
FRA_1343[r, j]	0	0	1	.	0	.	.	.	.	0	.	√	√	.	.	.	.
FRA_1356[r, j]	0	0	.	.	.	.	.	.	.	.	.	.	√	.	.	.	.
FRA_1356[r, j]	0	0	1	.	0	.	.	.	0	0	.	√	√	.	.	.	.
L1[r, j]	0	0	1	0	0	.	1	1	0	1	.	√	√	√	√	√	√
L2[r, j]	0	0	1	0	0	.	0	0	1	0	.	√	√	√	√	√	√
BCPink[o, j]	0	0	1	1	1	.	1	1	1	1	.	√	√	√	√	√	√
LB48[o, j]	L1	BC6	1	1	1	.	0	1	1	0	.	√	√	√	√	√	√
Synthetic *F. xananassa*																	
FVC_8-1[n, j]	JH_101-1	RH30xLH50-4	1	0	0	0	0	0	1	0	0	√	√	√	√	√	√
FVC_8-2[n, j]	JH_101-1	RH30xLH50-4	1	1	1	1	.	.	1	1	1	√	√	√	√	√	√
FVC_8-3[n, j]	JH_101-1	RH30xLH50-4	0	0	0	0	0	0	0	0	1	√	√	√	√	√	√

Individual	Female parent	Male parent	CA_12	MI_11	MI_12	MI_13	NH_11	NH_12	OR_11	OR_12	OR_13	EMFv006	EMFvi136	Bx89	Bx215	Bx56	Bx63
FVC_8-4[n, j]	JH_101-1	RH30xLH50-4	1	1	1	1	1	1	0	1	1	√	√	√	√	√	√
FVC_8-5[n, j]	JH_101-1	RH30xLH50-4	1	0	0	0	0	0	0	0	1	√	√	√	√	√	√
FVC_10-1[n, j]	SCxNAH	RH30xLH50-4	1	0	0	.	1	0	0	1	.	√	√	√	.	.	√
FVC_10-2[n, j]	SCxNAH	RH30xLH50-4	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
FVC_11-1[n]	Fred9xLH50-4	SCXMAR1A	1	0	0	0	0	0	.	.	.	.	.	.	.	.	.
FVC_11-2[n, j]	Fred9xLH50-4	SCXMAR1A	1	0	0	0	0	0	0	0	1	√	√	√	√	√	√
FVC_11-3[n, j]	Fred9xLH50-4	SCXMAR1A	1	1	1	1	1	1	1	1	1	√	√	√	√	√	√
FVC_11-4[n, j]	Fred9xLH50-4	SCXMAR1A	.	1	1	0	.	.	1	1	1	√	√	√	√	√	√
FVC_11-5[n, j]	Fred9xLH50-4	SCXMAR1A	1	1	0	.	1	1	1	1	1	√	√	√	√	√	√
FVC_11-6[n, j]	Fred9xLH50-4	SCXMAR1A	1	0	0	.	0	0	0	0	.	√	√	√	√	√	√
FVC_16-1[n, j]	JH_101-1	MR10xRH23	1	1	0	0	0	0	1	0	1	√	√	√	√	√	√
FVC_17-1[n, j]	JH_101-1	MR10xN8688	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
FVC_18-1[n, j]	SCxFRA24	MR10xRH23	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
FVC_28-1[n, j]	HM1xNAH	RH30xMR10	1	0	0	1	0	0	.	0	1	√	√	√	√	√	√
FVC_30-1[n, j]	JH_101-1	Fred9xLH50-4	1	0	0	.	0	0	1	0	.	√	√	√	.	.	√
FVC_30-2[n, j]	JH_101-1	Fred9xLH50-4	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
FVC_30-3[n, j]	JH_101-1	Fred9xLH50-4	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
FVC_30-4[n, j]	JH_101-1	Fred9xLH50-4	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
FVC_30-5[n, j]	JH_101-1	Fred9xLH50-4	1	0	0	.	0	0	0	0	.	√	√	√	.	.	√
FVC_30-6[n, j]	JH_101-1	Fred9xLH50-4	0	0	0	.	.	.	0	0	.	√	√	√	.	.	√
JH_101-1[n, j]	F. chiloensis	UNK17	1	0	0	.	.	.	0	0	.	√	√	√	.	.	√

[z]Plant obtained from PB-WUR, NL and coded as E-60174

[y]Plant obtained from PB-WUR, NL and coded as E-71006

[x]Species *F. chiloensis*

[w]Species *F. chiloensis*, subspecies *pacifica*

[v]Species *F. iturupensis*

[u]Species *F. vesca*

[t]Species *F. vesca*, subspecies *bracteata*

[s]Species *F. vesca*, subspecies *bracteata americana*

[r]Species *F. virginiana*

[q]Species *F. virginiana*, subspecies *glauca*

[p]Species *F. virginiana*, subspecies *platypetala*

[o]Hybrid

[n]Wild derived *F. ×ananassa*

[m] Female parent

[l] Male parent

[k]NL_CF

[j]CF

[i]NL

[h]UK_CF

[g]NL_CF

[f]SP_CF

[e]FR_CF

[d]OR_CF

[c]MI_CF

[b] NCGR

[a] NCGR_CF

[za] FR

When superscripts [k] to [za], are placed in a population name, the source corresponds to the progeny of that population. Each parent has their own source

Appendix Table 3.2. Genotypes at EMFvi136 and Bx63 of parents of the populations from multiple plants, where available, and progeny. Genotypes of parents that match those used in each cross are in bold. Alleles not present in either parent are underlined. Inferred genotypes are in italics. For each breeding population all possible parents are in the first rows with darker background, the confirmed female and male parent are indicated with superscript "m" and "l", respectively. The allelic configuration was confirmed for the European, MSU and ORUS population only. Missing data is represented with a dot.

	EMFvi136								Bx63							
Individual	**A1^{zb}**	**A2^{zb}**	**B1^{zb}**	**B2^{zb}**	**C1^{zb}**	**C2^{zb}**	**D1^{zb}**	**D2^{zb}**	**A1^{zc}**	**A2^{zc}**	**B1^{zc}**	**B2^{zc}**	**C1^{zc}**	**C2^{zc}**	**D1^{zc}**	**D2^{zc}**
European populations																
EMR population (Redgauntlet × Hapil)^{h}																
Redgauntlet_NL$^{z, k, g}$	161	163	159	**163**	0	**0**	0	**139**	133	**133**	133	**135**	127	**129**	123	123
Redgauntlet_CF$^{m, j}$	**161**	**163**	**157**	**159**	**0**	**147**	**0**	**127**	**133**	**139**	**133**	**133**	**127**	**133**	**123**	**123**
Hapil_NL$^{l, i}$	**119**	**163**	**157**	**161**	**0**	**160**	**139**	**139**	***133***	***133***	***133***	***135***	***127***	***129***	***123***	***123***
EMR_1	119	163	157	161	0	160	0	139	139	139	133	133	0	127	123	123
EMR_2	119	163	157	159	0	160	0	139	133	139	133	133	0	127	123	123
EMR_3	161	163	157	159	147	160	139	127	133	139	133	135	0	133	123	123
EMR_6	161	163	161	159	0	160	0	139	139	139	133	135	0	127	0	123
EMR_10	163	163	157	159	147	160	139	127	133	133	133	135	0	133	123	123
EMR_11	119	161	157	157	147	160	139	127	139	139	0	133	0	133	123	123
EMR_12	119	163	157	157	0	147	139	127	133	139	0	133	127	127	123	123
EMR_13	163	163	157	159	147	160	0	139	133	133	133	135	0	133	123	123
EMR_16	161	**167**	157	157	0	147	0	127	133	139	133	133	0	133	123	123
EMR_17	163	163	157	159	0	0	0	139	133	133	0	135	127	127	123	123

Individual	A1^{zb}	A2^{zb}	B1^{zb}	B2^{zb}	C1^{zb}	C2^{zb}	D1^{zb}	D2^{zb}	A1^{zc}	A2^{zc}	B1^{zc}	B2^{zc}	C1^{zc}	C2^{zc}	D1^{zc}	D2^{zc}
EMR_20	119	163	157	157	0	160	139	127	133	139	133	133	0	127	123	123
EMR_21	119	163	157	159	147	160	0	139	139	139	133	133	0	133	123	123
EMR_25	163	163	157	157	0	0	0	139	133	133	0	135	127	127	123	123
EMR_28	119	163	157	159	0	160	139	127	133	139	133	133	0	127	123	123
EMR_29	119	161	157	161	0	147	139	127	139	139	133	133	0	127	123	123
EMR_30	163	163	157	157	147	160	139	127	133	133	0	135	0	127	123	123
EMR_32	163	163	161	159	0	147	139	127	139	139	133	133	0	127	123	123
EMR_34	119	163	161	159	147	160	0	139	133	139	0	133	0	127	123	123
EMR_36	161	163	157	159	0	147	139	127	133	139	0	135	0	133	123	123
EMR_43	163	163	157	159	0	160	139	127	133	133	0	135	127	133	123	123
EMR_45	119	161	157	161	0	0	0	139	139	139	0	133	127	127	123	123
EMR_48	163	163	157	159	147	160	0	139	133	133	0	135	127	127	123	123
EMR_51	163	163	157	159	147	160	0	139	133	133	0	135	127	127	123	123
EMR_54	163	163	161	159	147	160	139	127	133	139	0	135	0	127	0	123
EMR_55	119	163	161	159	0	0	0	139	139	139	0	133	127	127	123	123
EMR_56	161	163	157	161	0	160	139	127	133	139	0	135	0	127	0	123
EMR_57	163	163	157	161	147	160	139	127	139	139	133	135	0	133	123	123
EMR_58	119	161	157	161	0	0	139	127	139	139	0	133	127	127	123	123
EMR_59	161	163	161	159	147	160	0	139	133	139	0	135	0	133	123	123
EMR_63	119	161	157	161	0	0	139	127	139	139	133	133	0	127	123	123
EMR_65	119	163	157	159	0	160	0	139	133	139	133	133	0	127	123	123
EMR_66	119	163	161	159	0	0	139	127	139	139	0	133	127	127	123	123

Individual	A1^{zb}	A2^{zb}	B1^{zb}	B2^{zb}	C1^{zb}	C2^{zb}	D1^{zb}	D2^{zb}	A1^{zc}	A2^{zc}	B1^{zc}	B2^{zc}	C1^{zc}	C2^{zc}	D1^{zc}	D2^{zc}
EMR_67	161	163	157	157	147	160	0	139	133	139	133	135	0	133	123	123
EMR_70	119	161	157	157	0	147	139	127	139	139	133	133	0	127	123	123
EMR_71	119	161	161	159	0	0	139	127	139	139	0	133	0	127	0	123
EMR_73	163	163	157	159	147	160	0	139	139	139	133	133	0	133	123	123
EMR_76	119	163	157	157	0	147	0	139	133	139	133	133	0	127	123	123
EMR_82	119	161	161	159	0	147	139	127	139	139	0	133	0	127	123	123
EMR_84	119	161	157	161	0	0	0	139	139	139	0	133	127	127	123	123
EMR_85	119	163	161	159	0	0	139	127	139	139	0	133	127	127	123	123
EMR_92	161	163	161	159	0	0	0	139	139	139	133	135	127	127	123	123
EMR_98	119	161	157	159	0	160	139	127	139	139	133	133	0	127	123	123
EMR_99	161	**167**	157	161	0	147	139	127	133	139	133	133	0	127	123	123
EMR_103	119	161	157	161	0	0	139	127	139	139	0	133	0	127	123	123
EMR_104	161	163	157	161	147	160	0	139	139	139	133	135	0	133	123	123
EMR_105	163	163	157	161	0	147	0	139	133	139	133	135	0	127	123	123
EMR_113	163	163	157	157	147	160	0	139	133	139	0	133	0	133	123	123
EMR_130	163	163	161	159	0	147	139	127	133	139	0	135	0	133	123	123
EMR_133	119	161	157	157	0	147	0	139	139	139	133	133	0	127	123	123
EMR_159	119	163	157	157	0	147	0	139	133	139	133	133	0	127	123	123
EMR_172	163	163	161	159	0	147	139	127	139	139	0	133	127	127	123	123
NL population (Holiday × Korona)[g]																
Holiday_CF[m, d, j]	**119**	**157**	**157**	**157**	**0**	**137**	**139**	**141**	**139**	**139**	**133**	**133**	**127**	**127**	**123**	**123**
Holiday_NL[y, m, i]	**119**	**157**	**157**	**157**	**0**	**137**	**139**	**141**	**139**	**139**	**133**	**133**	**127**	**127**	**123**	**123**

Individual	A1^{zb}	A2^{zb}	B1^{zb}	B2^{zb}	C1^{zb}	C2^{zb}	D1^{zb}	D2^{zb}	A1^{zc}	A2^{zc}	B1^{zc}	B2^{zc}	C1^{zc}	C2^{zc}	D1^{zc}	D2^{zc}
Korona_NL[l, i]	**161**	**167**	**157**	**159**	**0**	**147**	**136**	**127**	***133***	***149***	***0***	***133***	***133***	***129***	***123***	***123***
Korona_CF [d]	**161**	**169**	**161**	**119**	**147**	**160**	**139**	137	139	139	133	133	**0**	133	123	123
H-02316	157	161	157	157	0	0	136	141	133	139	0	133	127	129	123	123
H-02317	119	167	157	159	0	147	136	141	139	149	133	133	127	133	123	123
H-02321	119	167	157	157	0	0	127	141	139	149	0	133	127	129	123	123
H-02322	119	161	157	159	137	147	136	139	133	139	0	133	127	133	123	123
H-02324	119	161	157	159	0	147	127	141	133	139	133	133	127	133	123	123
H-02331	157	167	157	159	0	147	127	139	139	149	133	133	127	133	123	123
H-02356	157	167	157	157	0	0	127	141	139	149	133	133	127	129	123	123
H-02369	119	161	157	159	0	137	136	139	133	139	133	133	127	129	123	123
H-02374	157	161	157	159	0	0	136	141	133	139	133	133	127	129	123	123
H-02379	119	167	157	159	0	147	127	141	139	149	133	133	127	133	123	123
H-02385	157	161	157	159	0	147	136	141	139	149	0	133	127	133	123	123
H-02401	119	161	157	157	0	137	136	139	133	139	133	133	127	129	123	123
H-02406	119	161	157	159	0	137	127	139	133	139	133	133	127	129	123	123
H-02410	157	161	157	157	0	0	127	141	133	139	133	133	127	129	123	123
H-02465	157	167	157	159	0	0	127	141	139	149	0	133	127	129	123	123
H-02475	157	167	157	159	0	0	127	141	139	149	0	133	127	129	123	123
H-02485	119	161	157	157	137	147	136	139	133	139	133	133	127	133	123	123
H-02501	157	161	157	157	137	147	136	139	133	139	133	133	127	133	123	123
H-02529	157	167	157	159	0	147	127	141	139	149	133	133	127	133	123	123
H-02549	157	161	157	157	0	147	127	141	133	139	133	133	127	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
H-02552	157	161	157	157	0	147	127	141	133	139	133	133	127	133	123	123
H-02572	119	161	157	159	0	0	136	141	139	149	133	133	127	129	123	123
H-02622	119	161	157	157	0	0	127	141	133	139	133	133	127	129	123	123
H-02637	119	167	157	157	0	147	127	141	133	139	133	133	127	133	123	123
IFAPA population (IFAPA_1392 × IFAPA_232)[f]																
IFAPA_1392[m, f]	**161**	**167**	**159**	**165**	**0**	**127**	**127**	**127**	**133**	**133**	**133**	**133**	**127**	**127**	**123**	**123**
IFAPA_232[l, f]	**161**	**167**	**157**	**159**	**0**	**160**	**127**	**139**	**133**	**133**	**133**	**133**	**127**	**133**	**123**	**123**
IFAPA_93-4	161	167	159	159	0	127	0	127	133	133	133	133	127	127	123	123
IFAPA_93-6	161	161	157	159	0	127	0	127	133	133	133	133	127	133	123	123
IFAPA_93-8	167	167	159	159	0	160	127	127	133	133	133	133	127	133	123	123
IFAPA_93-11	161	161	157	165	0	160	127	139	133	133	133	133	127	127	123	123
IFAPA_93-12	167	167	159	159	0	0	127	127	133	133	133	133	127	127	123	123
IFAPA_93-13	161	167	157	159	0	160	127	139	133	133	133	133	127	133	123	123
IFAPA_93-15	161	161	159	165	0	127	0	127	133	133	133	133	127	127	123	123
IFAPA_93-16	161	167	159	159	0	127	0	127	133	133	133	133	127	127	123	123
IFAPA_93-21	167	167	159	159	0	160	127	139	133	133	133	133	127	133	123	123
IFAPA_93-24	167	167	157	159	0	160	0	127	133	133	133	133	127	127	123	123
IFAPA_93-26	161	161	157	159	0	0	127	139	133	133	133	133	127	133	123	123
IFAPA_93-32	167	167	157	159	0	0	127	139	133	133	133	133	127	133	123	123
IFAPA_93-33	167	167	159	159	0	160	127	139	133	133	133	133	127	133	123	123
IFAPA_93-34	161	167	159	159	0	0	127	139	133	133	133	133	127	127	123	123
IFAPA_93-36	167	167	159	159	0	0	127	139	133	133	133	133	127	127	123	123

Individual	A1^{zb}	A2^{zb}	B1^{zb}	B2^{zb}	C1^{zb}	C2^{zb}	D1^{zb}	D2^{zb}	A1^{zc}	A2^{zc}	B1^{zc}	B2^{zc}	C1^{zc}	C2^{zc}	D1^{zc}	D2^{zc}
IFAPA_93-37	167	167	157	159	127	160	0	127	133	133	133	133	127	133	123	123
IFAPA_93-42	161	167	159	159	0	160	0	127	133	133	133	133	127	127	123	123
IFAPA_93-46	161	161	159	159	0	127	0	127	133	133	133	133	127	127	123	123
IFAPA_93-47	161	167	157	159	0	0	127	139	133	133	133	133	127	133	123	123
IFAPA_93-50	161	167	159	159	0	127	0	127	133	133	133	133	127	127	123	123
IFAPA_93-54	161	161	159	159	0	0	127	139	133	133	133	133	127	127	123	123
IFAPA_93-56	161	161	159	159	0	127	0	127	133	133	133	133	127	133	123	123
IFAPA_93-57	161	161	157	159	0	160	0	127	133	133	133	133	127	133	123	123
IFAPA_93-58	161	167	157	165	0	160	127	139	133	133	133	133	127	133	123	123
IFAPA_93-59	161	167	157	159	0	160	127	139	133	133	133	133	127	133	123	123
IFAPA_93-60	167	167	159	159	0	127	127	127	133	133	133	133	127	127	123	123
IFAPA_93-61	167	167	159	159	0	160	127	139	133	133	133	133	127	127	123	123
IFAPA_93-62	161	161	159	159	0	127	0	127	133	133	133	133	127	133	123	123
IFAPA_93-64	161	161	159	159	0	0	127	139	133	133	133	133	127	127	123	123
IFAPA_93-65	161	167	159	159	0	127	0	127	.	.	.	.	.	.	.	.
IFAPA_93-66	167	167	157	159	0	160	127	139	.	.	.	.	.	.	.	.
IFAPA_93-69	161	167	157	159	0	160	0	127	.	.	.	.	.	.	.	.
IFAPA_93-70	161	161	157	159	0	0	127	139	.	.	.	.	.	.	.	.
IFAPA_93-72	161	167	159	159	0	0	127	139	.	.	.	.	.	.	.	.
IFAPA_93-73	161	167	159	159	0	160	127	139	.	.	.	.	.	.	.	.
IFAPA_93-74	161	161	159	159	127	160	0	127	.	.	.	.	.	.	.	.
IFAPA_93-75	161	161	159	159	0	0	0	127	.	.	.	.	.	.	.	.

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
IFAPA_93-76	161	161	157	159	0	160	127	139	.	.	.	.	.	.	.	.
IFAPA_93-79	161	167	157	159	0	160	0	127	.	.	.	.	.	.	.	.
IFAPA_93-80	161	167	159	159	0	160	127	139	.	.	.	.	.	.	.	.
IFAPA_93-81	161	167	159	159	0	0	127	139	.	.	.	.	.	.	.	.
IFAPA_93-82	161	161	157	159	0	0	127	139	.	.	.	.	.	.	.	.
IFAPA_93-84	161	167	157	159	0	0	127	139	.	.	.	.	.	.	.	.
IFAPA_93-85	161	167	157	159	0	0	127	139	.	.	.	.	.	.	.	.
IFAPA_93-86	161	167	157	159	0	127	0	127	.	.	.	.	.	.	.	.
IFAPA_93-90	161	161	157	159	0	160	0	127	.	.	.	.	.	.	.	.
IFAPA_93-92	161	167	159	159	0	160	0	127	.	.	.	.	.	.	.	.
IFAPA_93-93	161	167	159	159	0	127	0	127	.	.	.	.	.	.	.	.
IFAPA_93-94	161	161	159	159	0	127	0	127	.	.	.	.	.	.	.	.
IFAPA_93-96	167	167	159	159	0	127	0	127	.	.	.	.	.	.	.	.
INRA population (Capitola × CF1116)[e]																
Capitola_FR_CF[m, e]	**161**	**167**	**157**	**159**	**0**	**147**	**139**	**141**	**133**	**133**	**133**	**133**	**127**	**127**	**123**	**123**
CF1116_FR[l, za]	***161***	***167***	***157***	***159***	***147***	***160***	***127***	***141***	**133**	**149**	**133**	**133**	**127**	**133**	**123**	**123**
INRA_5	167	167	159	159	147	147	127?	?	133	149	133	133	127	127	123	123
INRA_6	167	167	157	159	0	160	127	141	133	149	133	133	127	133	123	123
INRA_8	161	167	157	159	147	160	139	141	133	133	133	133	127	133	123	123
INRA_9	167	167	159	159	147	147	141	141	133	133	133	133	127	127	123	123
INRA_10	161	167	159	159	147	147	139	141	133	133	133	133	127	127	123	123
INRA_11	167	167	159	159	0	160	139	141	133	149	133	133	127	127	123	123

Individual	A1^{zb}	A2^{zb}	B1^{zb}	B2^{zb}	C1^{zb}	C2^{zb}	D1^{zb}	D2^{zb}	A1^{zc}	A2^{zc}	B1^{zc}	B2^{zc}	C1^{zc}	C2^{zc}	D1^{zc}	D2^{zc}
INRA_12	167	167	157	159	0	147	127	141	133	149	133	133	127	127	123	123
INRA_14	167	167	159	159	0	147	127	141	133	133	133	133	127	127	123	123
INRA_15	161	167	159	159	0	147	141	141	133	133	133	133	127	127	123	123
INRA_16	167	167	157	159	147	160	141	141	133	149	133	133	127	133	123	123
INRA_19	161	167	157	159	0	147	139	141	133	133	133	133	127	127	123	123
INRA_30	167	167	159	159	0	160	139	141	133	133	133	133	127	133	123	123
INRA_34	167	167	157	159	147	160	127	141	133	149	133	133	127	133	123	123
INRA_37	167	167	157	159	0	147	127	141	133	149	133	133	127	127	123	123
INRA_43	167	167	157	159	0	160	139	141	133	133	133	133	127	133	123	123
INRA_47	161	167	157	159	0	160	141	141	133	133	133	133	127	133	123	123
INRA_58	167	167	159	159	147	147	139	141	133	149	133	133	127	127	123	123
INRA_59	167	167	157	159	0	147	141	141	133	149	133	133	127	127	123	123
INRA_61	167	167	157	159	0	147	139	127	133	149	133	133	127	127	123	123
INRA_76	167	167	159	159	147	147	139	141	133	133	133	133	127	127	123	123
INRA_79	167	167	157	159	0	160	127	141	133	133	133	133	127	127	123	123
INRA_94	161	167	159	159	147	147	127	141	133	149	133	133	127	127	123	123
INRA_95	167	167	159	159	0	160	141	141	133	133	133	133	127	133	123	123
INRA_97	167	167	157	159	147	160	127	141	133	149	133	133	127	133	123	123
INRA_98	161	167	157	159	0	160	139	141	133	133	133	133	127	133	123	123
INRA_99	161	167	159	159	0	160	139	141	133	149	133	133	127	133	123	123
INRA_103	161	167	159	159	0	160	139	141	133	133	133	133	127	133	123	123
INRA_104	167	167	157	159	147	160	139	141	133	149	133	133	127	133	123	123

Individual	A1^{zb}	A2^{zb}	B1^{zb}	B2^{zb}	C1^{zb}	C2^{zb}	D1^{zb}	D2^{zb}	A1^{zc}	A2^{zc}	B1^{zc}	B2^{zc}	C1^{zc}	C2^{zc}	D1^{zc}	D2^{zc}
INRA_108	167	167	157	159	0	147	139	141	133	133	133	133	127	127	123	123
INRA_110	161	167	159	159	147	147	141	141	133	133	133	133	127	127	123	123
INRA_116	161	**169**	159	159	0	**0**	127	141	133	149	133	133	127	127	123	123
INRA_122	167	167	157	159	147	147	127	141	133	149	133	133	127	127	123	123
INRA_124	161	167	157	159	147	147	139	141	133	133	133	133	127	127	123	123
INRA_126	167	167	157	159	147	160	141	141	133	149	133	133	127	133	123	123
INRA_134	161	167	159	159	147	147	127	141	133	149	133	133	127	133	123	123
INRA_135	167	167	159	159	0	160	139	127	133	133	133	133	127	133	123	123
INRA_138	167	167	159	159	147	147	139	141	133	133	133	133	127	127	123	123
INRA_141	167	167	157	159	147	147	127	141	133	133	133	133	127	127	123	123
INRA_147	161	167	159	159	0	147	141	141	133	133	133	133	127	127	123	123
INRA_148	167	167	159	159	0	147	139	127	133	133	133	133	127	127	123	123
INRA_151	167	167	159	159	0	147	139	141	133	133	133	133	127	127	123	123
INRA_153	167	167	157	159	0	147	139	141	133	149	133	133	127	127	123	123
INRA_157	161	167	159	159	0	160	139	127	133	149	133	133	127	133	123	123
INRA_161	161	167	157	159	147	147	127	141	133	133	133	133	127	127	123	123
INRA_165	161	167	161	**165**	0	147	139	127	133	149	133	133	127	127	123	123
INRA_167	161	167	159	159	0	160	127	141	133	133	133	133	127	133	123	123
INRA_172	161	167	157	159	147	147	139	141	133	149	133	133	127	127	123	123
INRA_175	161	167	159	159	0	147	139	127	133	149	133	133	127	127	123	123
INRA_181	167	167	159	159	147	147	141	141	133	133	133	133	127	127	123	123
INRA_195	167	167	157	159	0	147	141	141	133	133	133	133	127	127	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
INRA_196	167	167	157	159	0	147	139	141	133	149	133	133	127	127	123	123
INRA_197	167	167	159	159	0	160	139	141	133	149	133	133	127	133	123	123
INRA_201	167	167	159	159	0	160	139	141	133	133	133	133	127	133	123	123
INRA_204	167	167	157	159	0	147	141	141	133	133	133	133	127	127	123	123
INRA_216	167	167	157	159	147	147	141	141	133	133	133	133	127	127	123	123
MSU populations																
MSU_9-1 population (MSU_49 × FRA_1702)[c]																
MSU_49[m, d]	**161**	**169**	**157**	**157**	**0**	**139**	**139**	**141**	**133**	**149**	**133**	**133**	**127**	**127**	**123**	**123**
FRA_1702_I1[l]	***161***	***169***	***163***	***123***	***160***	***0***	***142***	***139***	***133***	***139***	***133***	***135***	***133***	***127***	***123***	***123***
MSU_9-1-1	161	161	157	163	0	0	139	141	133	133	133	135	127	127	123	123
MSU_9-1-2	161	169	157	**160**	0	**137**	139	139	**145**	149	133	135	127	133	123	123
MSU_9-1-3	161	161	157	163	0	160	139	139	133	133	133	133	127	133	123	123
MSU_9-1-4	161	161	**0**	157	**137**	139	141	142	133	**145**	133	135	127	127	123	123
MSU_9-1-5	161	161	**0**	157	0	**137**	139	139	133	133	133	133	127	127	123	123
MSU_9-1-6	161	169	157	**160**	0	**137**	139	139	133	**145**	133	133	127	133	123	123
MSU_9-1-7	161	161	157	**160**	0	**137**	139	141	133	**145**	133	135	127	133	123	123
MSU_9-1-8	161	161	123	157	0	160	139	141	133	133	133	135	127	133	123	123
MSU_9-1-9	161	161	**0**	157	0	**137**	139	141	133	**145**	133	135	127	127	123	123
MSU_9-1-10	161	161	**0**	157	0	**137**	139	142	**145**	149	133	135	127	127	123	123
MSU_9-2 population (MSU_49 × Seascape)[c]																
MSU_49[m, j]	**161**	**169**	**157**	**157**	**0**	**139**	**139**	**141**	**133**	**149**	**133**	**133**	**127**	**127**	**123**	**123**

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
Seascape_CF[l, j]	**161**	**167**	**159**	**159**	**0**	**160**	**127**	**139**	**133**	**149**	**133**	**133**	**133**	**133**	**123**	**123**
MSU_9-2-1	161	167	157	159	0	160	139	141	133	133	133	133	127	133	123	123
MSU_9-2-2	161	169	157	159	0	0	139	139	133	149	133	133	127	133	123	123
MSU_9-2-3	161	167	157	159	0	160	127	139	133	149	133	133	127	133	123	123
MSU_9-2-4	167	169	157	159	0	160	139	141	149	149	133	133	127	133	123	123
MSU_9-2-5	167	169	157	159	0	139	127	139	149	149	133	133	127	133	123	123
MSU_9-2-6	161	161	157	159	0	139	127	139	149	149	133	133	127	133	123	123
MSU_9-2-7	161	161	157	159	0	139	127	139	133	149	133	133	127	133	123	123
MSU_9-2-8	161	161	157	159	0	0	139	139	133	133	133	133	127	133	123	123
MSU_9-2-9	161	169	157	159	139	160	127	141	133	133	133	133	127	133	123	123
MSU_9-2-10	161	167	157	159	0	160	127	139	133	149	133	133	127	133	123	123
MSU_9-3 population (MSU_49 × Tribute)[c]																
MSU_49[m, j]	**161**	**169**	**157**	**157**	**0**	**139**	**139**	**141**	**133**	**149**	**133**	**133**	**127**	**127**	**123**	**123**
Tribute_662.001[l, b]	**119**	**167**	**157**	**159**	**147**	**147**	**139**	**127**	**139**	**149**	**133**	**133**	**127**	**133**	**123**	**123**
MSU_9-3-1	161	167	157	157	0	147	139	141	133	149	133	133	127	127	123	123
MSU_9-3-2	119	161	157	157	0	147	127	139	133	149	133	133	127	133	123	123
MSU_9-3-3	161	169	157	**163**	0	**160**	139	141	133	149	133	**135**	127	133	123	123
MSU_9-3-4	167	169	157	157	139	147	127	141	149	149	133	133	127	127	123	123
MSU_9-3-5	.	.	.	.	.	.	.	.	133	149	133	**135**	127	133	123	123
MSU_9-3-6	161	169	**137**	157	0	**137**	139	142	133	**145**	133	**135**	127	127	123	123
MSU_9-3-7	167	169	157	159	0	147	139	141	149	149	133	133	127	127	123	123
MSU_9-3-8	161	167	157	157	0	147	127	139	133	149	133	133	127	133	123	123

Individual	A1^{zb}	A2^{zb}	B1^{zb}	B2^{zb}	C1^{zb}	C2^{zb}	D1^{zb}	D2^{zb}	A1^{zc}	A2^{zc}	B1^{zc}	B2^{zc}	C1^{zc}	C2^{zc}	D1^{zc}	D2^{zc}
MSU_9-3-9	161	**161**	**137**	157	139	**135**	**137**	139	**145**	149	133	**135**	127	127	123	123
MSU_9-3-10	119	169	157	159	0	147	139	141	139	149	133	133	127	133	123	123
MSU_9-4 population (MSU_56 × FRA_1702)[c]																
MSU_56[m, j]	**157**	**169**	**157**	**159**	**0**	**127**	**0**	**141**	**139**	**139**	**133**	**133**	**127**	**127**	**123**	**123**
FRA_1702_I1[l]	***161***	***169***	***163***	***123***	***0***	***160***	***139***	***142***	***133***	***139***	***133***	***135***	***127***	***133***	***123***	***123***
MSU_9-4-1	157	161	157	163	0	0	139	141	133	139	133	135	127	127	123	123
MSU_9-4-2	157	161	157	163	0	0	139	141	.	.	.	.	.	.	.	.
MSU_9-4-3	157	161	159	**135**	137	127	0	139	139	**145**	133	133	127	127	123	123
MSU_9-4-4	161	169	157	163	0	160	141	142	133	139	133	133	127	133	123	123
MSU_9-4-5	157	161	123	157	0	160	141	142	139	139	133	135	127	133	123	123
MSU_9-4-6	157	161	159	163	127	160	0	142	133	139	133	133	127	133	123	123
MSU_9-4-7	161	169	157	**135**	0	137	141	142	.	.	.	.	.	.	.	.
MSU_9-4-8	157?	157?	123	159	0	127	0	142	0?	139?	133	133	127	127	123	123
MSU_9-4-9	161	169	123	157	0	0	139	141	133	139	133	135	127	127	123	123
MSU_9-4-10	157	161	157	163	0	0	141	142	133	139	133	133	127	127	123	123
MSU_9-5 population (FRA_1702 × Earliglow)[c]																
FRA_1702_I1[m]	***161***	***169***	***163***	***123***	***0***	***160***	***139***	***142***	***133***	***139***	***133***	***135***	***127***	***133***	***123***	***123***
Earliglow_CF[l, j]	**119**	**169**	**157**	**159**	**0**	**147**	**139**	**141**	**139**	**149**	**133**	**133**	**127**	**133**	**123**	**123**
MSU_9-5-1	119	161	159	163	0	160	139	141	133	139	133	133	127	133	123	123
MSU_9-5-2	161	169	157	159	**131**	147	139	141	133	149	133	133	127	127	123	123
MSU_9-5-3	119	161	157	163	0	0	139	141	133	139	133	135	127	127	123	123
MSU_9-5-4	119	161	159	163	0	147	139	142	133	139	133	133	127	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
MSU_9-5-5	161	169	123	159	0	0	141	142	133	139	133	135	127	133	123	123
MSU_9-5-6	161	169	0	157	0	**137**	141	142	**145**	**149**	133	135	127	127	123	123
MSU_9-5-7	161	169	0	157	0	**137**	141	142	**145**	**149**	133	133	127	127	123	123
MSU_9-5-8	161	169	0	159	**137**	147	139	139	139	**145**	133	133	133	133	123	123
MSU_9-5-9	119	157	159?	159?	147	160	139	142	139	139	133	133	127	133	123	123
MSU_9-5-10	161	169	123	157	0	0	139	142	133	149	133	133	127	127	123	123
MSU_9-6 population (Earliglow × Seascape)[c]																
Earliglow_CF[m, j]	**119**	**169**	**157**	**159**	**0**	**147**	**139**	**141**	**139**	**149**	**133**	**133**	**127**	**133**	**123**	**123**
Seascape_CF[l, j]	**161**	**167**	**159**	**159**	**0**	**160**	**127**	**139**	**133**	**149**	**133**	**133**	**133**	**133**	**123**	**123**
MSU_9-6-1	167	169	159	159	0	147	139	141	149	149	133	133	133	133	123	123
MSU_9-6-2	0?	119?	157?	157?	0	147	139	141	139?	139?	133	133	133	133	123	123
MSU_9-6-3	119	161	157	159	0	147	127	139	133	139	133	133	133	133	123	123
MSU_9-6-4	161	169	159	159	0	147	139	139	149	149	133	149?	0?	133	123	123
MSU_9-6-5	167	169	159	159	147	160	139	139	149	149	133	133	133	133	123	123
MSU_9-6-6	119	161	157	159	0	147	127	141	133	139	133	133	133	133	123	123
MSU_9-6-7	119	167	157	159	0	147	139	139	139	149	133	133	133	133	123	123
MSU_9-6-8	119?	169?	157	159	0	147	139?	139?	139	149	133	133	127	133	123	123
MSU_9-6-9	167	169	159	159	0	0	127	141	149	149	133	133	127	133	123	123
MSU_9-6-10	167	169	157	159	0	147	139	141	149	149	133	133	133	133	123	123
MSU_9-8 population (Fort Laramie × Earliglow)[c]																
FortLaramie_NCGR[m, b]	**167**	**169**	**157**	**159**	**0**	**147**	**136**	**127**	**149**	**149**	**133**	**133**	**127**	**127**	**123**	**123**
Earliglow_CF[l, j]	**119**	**169**	**157**	**159**	**0**	**147**	**139**	**141**	**139**	**149**	**133**	**133**	**127**	**133**	**123**	**123**

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
MSU_9-8-1	169	169	157	159	0	147	127	141	149	149	133	133	127	133	123	123
MSU_9-8-2	167	169	157	157	0	0	139	136	149	149	133	133	127	127	123	123
MSU_9-8-3	167	169	157	159	0	147	136	141	149	149	133	133	127	127	123	123
MSU_9-8-4	167	169	157	157	0	147	136	141	149	149	133	133	127	133	123	123
MSU_9-8-5	169	169	157	159	0	0	139	136	149	149	133	133	127	127	123	123
MSU_9-8-6	119	167	157	159	0	147	139	136	.	.	.	.	.	.	.	.
MSU_9-8-7	169	169	157	159	0	147	127	141	149	149	133	133	127	133	123	123
MSU_9-8-8	169	169	157	157	0	147	139	127	.	.	.	.	.	.	.	.
MSU_9-8-9	169	169	157	157	0	147	139	127	.	.	.	.	.	.	.	.
MSU_9-8-10	167	169	157	159	0	147	139	136	149	149	133	133	127	133	123	123
MSU_9-9 population (Fort Laramie × Honeoye)[c]																
FortLaramie_NCGR[m, b]	**167**	**169**	**157**	**159**	**0**	**147**	**136**	**127**	**149**	**149**	**133**	**133**	**127**	**127**	**123**	**123**
Honeoye_215.001[l, b]	**157**	**161**	**157**	**163**	**0**	**139**	**139**	**141**	**133**	**139**	**133**	**135**	**127**	**127**	**123**	**123**
MSU_9-9-1	161	167	159	163	0	147	136	139	133	149	133	133	127	127	123	123
MSU_9-9-2	157	169	157	163	0	139	136	139	133	149	133	133	127	127	123	123
MSU_9-9-3	161	167	157	159	139	147	127	141	133	149	133	135	127	127	123	123
MSU_9-9-4	161	169	157	159	0	147	136	141	139	149	133	135	127	127	123	123
MSU_9-9-5	157	169	157	159	0	147	127	139	139	149	133	133	127	127	123	123
MSU_9-9-6	161	167	157	163	139	147	127	141	133	149	133	135	127	127	123	123
MSU_9-9-7	157	169	159	163	0	139	127	139	133	149	133	133	127	127	123	123
MSU_9-9-8	161	167	157	163	0	147	127	139	133	149	133	135	127	127	123	123
MSU_9-9-9	161	169	157	157	0	147	136	139	139	149	133	133	127	127	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
MSU_9-9-10	157	169	159	163	0	139	136	141	133	149	133	133	127	127	123	123
MSU_9-10 population (Fort Laramie × MSU_49)[c]																
FortLaramie_NCGR[m, b]	**167**	**169**	**157**	**159**	**0**	**147**	**136**	**127**	**149**	**149**	**133**	**133**	**127**	**127**	**123**	**123**
MSU_49[l, j]	**161**	**169**	**157**	**157**	**0**	**139**	**139**	**141**	**133**	**149**	**133**	**133**	**127**	**127**	**123**	**123**
MSU_9-10-1	161	169	157	159	0	139	127	141	133	149	133	133	127	127	123	123
MSU_9-10-2	169	169	157	157	0	147	139	127	149	149	133	133	127	127	123	123
MSU_9-10-3	167	169	157	159	139	147	127	141	133	149	133	133	127	127	123	123
MSU_9-10-4	161	167	157	159	0	0	139	127	149	149	133	133	127	127	123	123
MSU_9-10-5	161	167	157	157	0	0	136	141	133	149	133	133	127	127	123	123
MSU_9-10-6	161	167	157	159	0	0	136	141	133	149	133	133	127	127	123	123
MSU_9-10-7	161	167	157	159	0	0	139	127	133	149	133	133	127	127	123	123
MSU_9-10-8	161	169	157	157	0	0	139	127	133	149	133	133	127	127	123	123
MSU_9-10-9	167	169	157	157	0	147	136	141	149	149	133	133	127	127	123	123
MSU_9-10-10	169	169	157	157	0	147	139	127	149	149	133	133	127	127	123	123
MSU_9-11 population (Fort Laramie × MSU_56)[c]																
FortLaramie_NCGR[m, b]	**167**	**169**	**157**	**159**	**0**	**147**	**136**	**127**	**149**	**149**	**133**	**133**	**127**	**127**	**123**	**123**
MSU_56[l, j]	**157**	**169**	**157**	**159**	**0**	**127**	**0**	**141**	**139**	**139**	**133**	**133**	**127**	**127**	**123**	**123**
MSU_9-11-1	157	167	159	159	0	147	136	141	139	149	133	133	127	127	123	123
MSU_9-11-2	167	169	157	159	0	147	136	141	139	149	133	133	127	127	123	123
MSU_9-11-3	167	169	157	157	0	0	127	141	139	149	133	133	127	127	123	123
MSU_9-11-4	157	167	159	159	0	0	127	141	139	149	133	133	127	127	123	123
MSU_9-11-5	167	169	157	159	0	127	0	136	139	149	133	133	127	127	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
MSU_9-11-6	157	169	157	159	0	147	136	141	139	149	133	133	127	127	123	123
MSU_9-11-7	167	**167**	159	159	0	127	0	127	133?	139?	133	133	127?	133?	123	123
MSU_9-11-8	157	167	159	**163**	127	147	0	127	139	149	133	133	133?	133?	123	123
MSU_9-11-9	157	167	157	159	127	147	0	136	139	149	133	133	127	127	123	123
MSU_9-11-10	167	169	159	159	0	147	127	141	139	?	133	133	127	127	123	123
MSU_9-12 population (Honeoye × FRA_1702)[c]																
Honeoye_215.001[m, b]	**157**	**161**	**157**	**163**	**0**	**139**	**139**	**141**	**133**	**139**	**133**	**135**	**127**	**127**	**123**	**123**
FRA_1702_I2[l]	***123***	***163***	***161***	***159***	***0***	***160***	***139***	***141***	***133***	***139***	***133***	***135***	***127***	***133***	***123***	***123***
MSU_9-12-1	123	157	159	163	139	160	139	141	133	139	133	133	127	127	123	123
MSU_9-12-2	157	163	157	161	0	139	141	141	139	139	135	135	133	133	123	123
MSU_9-12-3	161	**167**	157	159	0	0	**127**	141	139	**149**	133	135	127	133	123	123
MSU_9-12-4	161	163	161	163	**159**	**147**	**163**	141	133	133	133	135	127	133	123	123
MSU_9-12-5	123	157	159	163	139	160	139	141	133	139	133	133	127	127	123	123
MSU_9-12-6	123	161	157	161	0	139	139	141	139	139	135	135	127	127	123	123
MSU_9-12-7	**145**	161	**155**	**157**	**147**	**141**	143	141	139	**142**	133	135	127	127	123	123
MSU_9-12-8	157	161	**157**	**157**	160	137	139	139	139	**145**	133	135	127	133	123	123
MSU_9-12-9	157	161	157	161	0	160	139	141	139	139	135	135	127	127	123	123
MSU_9-12-10	157	161	157	161	0	139	139	141	133	133	133	135	127	133	123	123
MSU_9-13 population (Seascape × Honeoye)[c]																
Seascape_CF[m, j]	**161**	**167**	**159**	**159**	**0**	**160**	**127**	**139**	**133**	**149**	**133**	**133**	**133**	**133**	**123**	**123**
Honeoye_215.001[l, b]	**157**	**161**	**157**	**163**	**0**	**139**	**139**	**141**	**133**	**139**	**133**	**135**	**127**	**127**	**123**	**123**
MSU_9-13-1	161	161	159	163	0	160	127	139	133	133	133	133	127	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
MSU_9-13-2	161	167	157	159	0	160	139	141	139	149	133	135	127	133	123	123
MSU_9-13-3	161	167	157	159	0	160	127	139	133	149	133	135	127	133	123	123
MSU_9-13-4	157	167	157	159	0	0	127	139	139	149	133	133	127	133	123	123
MSU_9-13-5	161	167	159	163	0	139	127	141	133	149	133	135	127	133	123	123
MSU_9-13-6	161	167	157	159	0	160	127	139	133	139	133	135	127	133	123	123
MSU_9-13-7	161	161	157	159	0	0	139	139	133	139	133	135	127	133	123	123
MSU_9-13-8	157	161	157	159	139	160	127	141	133	139	133	133	127	133	123	123
MSU_9-13-9	157	167	159	163	0	139	127	141	133	139	133	133	127	133	123	123
MSU_9-13-10	161	167	157	159	0	0	127	139	139	149	133	135	127	133	123	123
MSU_9-14 population (Seascape × MSU_56)[c]																
Seascape_CF[m, j]	**161**	**167**	**159**	**159**	**0**	**160**	**127**	**139**	**133**	**149**	**133**	**133**	**133**	**133**	**123**	**123**
MSU_56[l, j]	**157**	**169**	**157**	**159**	**0**	**127**	**0**	**141**	**139**	**139**	**133**	**133**	**127**	**127**	**123**	**123**
MSU_9-14-1	157	161	157	159	0	160	139	141	133	139	133	133	127	133	123	123
MSU_9-14-2	167	169	159	159	127	160	0	127	139	149	133	133	127	133	123	123
MSU_9-14-3	161	161	157	159	**149**	160	127	141	133?	133?	133	133	123	133	123	123
MSU_9-14-4	157	167	157	159	0	127	0	127	139	149	133	133	127	133	123	123
MSU_9-14-5	157	167	159	159	127	160	0	139	.	.	.	.	.	.	.	.
MSU_9-14-6	157	161	157	159	0	0	139	141	.	.	.	.	.	.	.	.
MSU_9-14-7	157	167	157	159	0	127	0	127	139	149	133	133	127?	127?	123	133
MSU_9-14-8	161?	167?	157	159	127	160	0	139	.	.	.	.	.	.	.	.
MSU_9-14-9	161	169	159	159	0	127	0	127	.	.	.	.	.	.	.	.
MSU_9-14-10	167	169	157	159	0	127	0	139	.	.	.	.	.	.	.	.

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
MSU_9-15 population (Tribute × Earliglow)[c]																
Tribute_662.001[m, b]	**119**	**167**	**157**	**159**	**147**	**147**	**139**	**127**	**139**	**149**	**133**	**133**	**127**	**133**	**123**	**123**
Earliglow_CF[l, j]	**119**	**169**	**157**	**159**	**0**	**147**	**139**	**141**	**139**	**149**	**133**	**133**	**127**	**133**	**123**	**123**
MSU_9-15-1	119	169	159	159	0	147	139	127	139	149	133	133	127	127	123	123
MSU_9-15-2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MSU_9-15-3	119	167	157	157	147	147	139	139	139	149	133	133	127	133	123	123
MSU_9-15-4	119	169	157	157	0	147	139	139	139	139	133	133	127	133	123	123
MSU_9-15-5	119	169	157	157	0	147	139	141	139	149	133	133	127	127	123	123
MSU_9-15-6	167	169	157	159	147	147	127	141	149	149	133	133	127	133	123	123
MSU_9-15-7	119	167	157	159	147	147	139	139	139	149	133	133	133	133	123	123
MSU_9-15-8	167	169	157	159	0	147	139	141	149	149	133	133	127	127	123	123
MSU_9-15-9	119	169	159	159	0	147	139	139	139	149	133	133	127	127	123	123
MSU_9-15-10	167	169	157	159	147	147	139	141	149	149	133	133	133	133	123	123
MSU_9-16 population (Tribute × Honeoye)[c]																
Tribute_662.001[m, b]	**119**	**167**	**157**	**159**	**147**	**147**	**139**	**127**	**139**	**149**	**133**	**133**	**127**	**133**	**123**	**123**
Honeoye_215.001[l, b]	**157**	**161**	**157**	**163**	**0**	**139**	**139**	**141**	**133**	**139**	**133**	**135**	**127**	**127**	**123**	**123**
MSU_9-16-1	157	167	159	163	0	147	139	139	139	149	133	133	127	133	123	123
MSU_9-16-2	161	167	159	163	0	147	127	139	133	149	133	135	127	127	123	123
MSU_9-16-3	157	167	157	157	139	147	127	141	139	149	133	133	127	133	123	123
MSU_9-16-4	119	161	159	163	0	147	127	139	139	149	133	135	127	133	123	123
MSU_9-16-5	161	167	157	163	0	147	139	141	133	149	133	135	127	127	123	123
MSU_9-16-6	157	167	157	163	0	147	139	139	133	149	133	135	127	127	123	123

Individual	A1^{zb}	A2^{zb}	B1^{zb}	B2^{zb}	C1^{zb}	C2^{zb}	D1^{zb}	D2^{zb}	A1^{zc}	A2^{zc}	B1^{zc}	B2^{zc}	C1^{zc}	C2^{zc}	D1^{zc}	D2^{zc}
MSU_9-16-7	161	167	159	163	0	147	127	139	139	149	133	135	127	133	123	123
MSU_9-16-8	119	157	157	163	0	147	127	139	133	139	133	133	127	127	123	123
MSU_9-16-9	.	.	.	.	.	.	.	.	133	149	133	133	127	127	123	123
MSU_9-16-10	119	161	157	159	0	147	127	139	139	139	133	135	127	127	123	123
MSU_9-16-11	119	157	157	163	0	147	127	139	133	139	133	133	127	127	123	123
MSU_9-16-12	119	157	159	163	0	147	127	139	133	139	133	133	127	127	123	123
MSU_9-16-13	157	167	157	157	0	147	127	139	139	149	133	135	127	133	123	123
MSU_9-16-14	119	157	157	159	0	147	127	139	139	139	133	133	127	127	123	123
MSU_9-16-15	119	161	157	157	0	147	139	139	139	139	133	133	127	127	123	123
MSU_9-16-16	161	167	157	159	0	147	139	139	139	149	133	135	127	127	123	123
MSU_9-16-17	157	167	157	159	0	147	139	139	139	149	133	135	127	127	123	123
MSU_9-16-18	157	167	157	159	0	147	139	139	139	149	133	133	127	133	123	123
MSU_9-16-19	161	167	159	163	139	147	127	141	139	149	133	135	127	133	123	123
MSU_9-16-20	157	167	157	157	139	147	127	141	139	149	133	135	127	133	123	123
MSU_9-16-21	119	161	159	163	0	147	139	141	133	139	133	135	127	133	123	123
MSU_9-16-22	119	157	157	157	0	147	127	141	139	139	133	133	127	127	123	123
MSU_9-16-23	157	167	157	159	0	147	139	141	139	149	133	133	127	127	123	123
MSU_9-16-24	157	167	157	157	0	147	139	139	139	149	133	133	127	127	123	123
MSU_9-16-25	161	167	159	163	0	147	139	139	133	139	133	135	127	133	123	123
MSU_9-16-26	161	167	159	163	0	147	139	141	133	149	133	135	127	127	123	123
MSU_9-16-27	119	157	159	163	0	147	139	139	133	139	133	133	127	127	123	123
MSU_9-16-28	119	161	157	159	0	147	127	139	139	139	133	135	127	127	123	123

Individual	A1^{zb}	A2^{zb}	B1^{zb}	B2^{zb}	C1^{zb}	C2^{zb}	D1^{zb}	D2^{zb}	A1^{zc}	A2^{zc}	B1^{zc}	B2^{zc}	C1^{zc}	C2^{zc}	D1^{zc}	D2^{zc}
MSU_9-16-29	119	161	157	159	0	147	139	139	139	149	133	135	127	127	123	123
MSU_9-16-30	119	157	157	163	0	147	139	141	133	139	133	133	127	127	123	123
MSU_9-16-31	161	167	159	163	0	147	127	141	133	149	133	135	127	127	123	123
MSU_9-16-32	161	167	157	159	0	147	139	139	139	149	133	135	127	133	123	123
MSU_9-16-33	119	157	157	159	0	147	139	141	139	139	133	133	127	127	123	123
MSU_9-16-34	119	161	157	163	0	147	139	141	133	139	133	135	127	127	123	123
MSU_9-16-35	119	157	157	163	0	147	139	139	133	149	133	135	127	127	123	123
MSU_9-16-36	119	157	157	163	0	147	139	139	133	149	133	135	127	127	123	123
MSU_9-16-37	161	167	157	157	0	147	139	139	139	149	133	135	127	127	123	123
MSU_9-16-38	119	161	157	163	139	147	127	141	.	.	.	.	.	.	.	.
MSU_9-16-39	161	167	157	163	0	147	127	141	133	149	133	135	127	133	123	123
MSU_9-16-40	119	161	157	159	0	147	127	141	139	139	133	135	127	127	123	123
MSU_9-16-41	157	167	157	159	139	147	127	141	133	149	133	135	127	133	123	123
MSU_9-16-42	161	167	157	159	139	147	127	141	139	149	133	133	127	127	123	123
MSU_9-16-43	157	167	157	159	0	147	139	141	139	149	133	135	127	133	123	123
MSU_9-16-44	161	167	157	159	0	147	139	139	139	139	133	135	127	133	123	123
MSU_9-16-45	161	167	157	159	139	147	127	141	139	149	133	135	127	133	123	123
MSU_9-16-46	119	157	159	163	0	147	139	139	133	139	133	135	127	127	123	123
MSU_9-16-47	119	161	157	157	0	147	127	141	139	139	133	135	127	133	123	123
MSU_9-16-48	119	157	157	157	0	147	139	139	139	139	133	133	127	133	123	123
MSU_9-16-49	119	161	157	163	0	147	127	139	133	139	133	135	127	127	123	123
MSU_9-16-50	161	161	159	165	**160**	121	**0**	**127**	.	.	.	.	.	.	.	.

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
MSU_9-16-51	161	167	157	163	0	147	139	141	139	149	133	133	127	133	123	123
MSU_9-16-52	157	167	159	163	0	147	127	139	133	149	133	135	127	133	123	123
MSU_9-16-53	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MSU_9-16-54	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MSU_9-16-55	119	157	157	157	139	147	127	141	133	149	133	135	127	133	123	123
MSU_9-16-56	157	167	159	163	0	147	127	139	133	149	133	133	127	133	123	123
MSU_9-16-57	161	**169**	159	165	0	147	**0**	**121**	133	139	133	135	127	127	123	123
MSU_9-16-58	119	161	157	157	139	147	127	141	139	149	133	135	127	127	123	123
MSU_9-16-59	119	161	159	163	0	147	139	141	133	139	133	135	127	133	123	123
MSU_9-16-60	119	157	157	157	0	147	139	141	133	139	133	133	127	133	123	123
MSU_9-16-61	**159**	167	159	165	**144**	147	0	127	139	139	133	133	127	133	123	123
MSU_9-16-62	119	157	157	159	0	147	139	141	139	139	133	133	127	127	123	123
MSU_9-16-63	119	161	157	163	0	147	139	141	139	139	133	133	127	133	123	123
MSU_9-16-64	161	167	157	159	0	147	127	139	139	149	133	135	127	133	123	123
MSU_9-16-65	119	157	157	163	139	147	127	141	133	139	133	133	127	127	123	123
MSU_9-17 population (Tribute × MSU_56)[c]																
Tribute_662.001[m, b]	**119**	**167**	**157**	**159**	**147**	**147**	**139**	**127**	**139**	**149**	**133**	**133**	**127**	**133**	**123**	**123**
MSU_56[l, j]	**157**	**169**	**157**	**159**	**0**	**127**	**0**	**141**	**139**	**139**	**133**	**133**	**127**	**127**	**123**	**123**
MSU_9-17-1	157	167	157	159	0	147	139	141	139	139	133	133	127	133	123	123
MSU_9-17-2	119	**161**	159	**163**	0	147	139	141	139	139	133	133	127	133	123	123
MSU_9-17-3	119	157	157	157	0	147	139	141	139	149	133	133	127	127	123	123
MSU_9-17-4	167	169	157	159	127	147	0	127	139	149	133	133	127	133	123	123

Individual	A1^{zb}	A2^{zb}	B1^{zb}	B2^{zb}	C1^{zb}	C2^{zb}	D1^{zb}	D2^{zb}	A1^{zc}	A2^{zc}	B1^{zc}	B2^{zc}	C1^{zc}	C2^{zc}	D1^{zc}	D2^{zc}
MSU_9-17-5	119	157	157	159	0	147	139	141	139	139	133	133	127	133	123	123
MSU_9-17-6	119	157	157	157	127	147	0	127	139	139	133	133	127	133	123	123
MSU_9-17-7	119	157	159	159	127	147	0	139	139	139	133	133	127	127	123	123
MSU_9-17-8	119	157	157	159	127	147	0	139	139	139	133	133	127	133	123	123
MSU_9-17-9	167	169	157	159	127	147	139	141	139	149	133	133	127	127	123	123
MSU_9-17-10	167	169	157	159	127	147	0	127	139	149	133	133	127	127	123	123
MSU_9-18 population (Seascape × Fort Laramie)[c]																
Seascape_CF[m, j]	**161**	**167**	**159**	**159**	**0**	**160**	**127**	**139**	**133**	**149**	**133**	**133**	**133**	**133**	**123**	**123**
FortLaramie_I1[l]	***167***	***163***	***157***	***159***	***0***	***147***	***127***	***141***	***133***	***139***	***133***	***133***	***127***	***133***	***123***	***123***
MSU_9-18-1	161	163	159	159	147	160	127	127	133	139	133	133	133	133	123	123
MSU_9-18-2	161	163	159	159	0	147	127	139	133	139	133	133	133	133	123	123
MSU_9-18-3	167	167	159	159	147	160	127	141	133	149	133	133	133	133	123	123
MSU_9-18-4	167	167	157	159	0	147	127	127	133	149	133	133	133	133	123	123
MSU_9-18-5	161	163	159	159	0	160	139	141	133	139	133	133	127	133	123	123
MSU_9-18-6	167	163	159	159	0	160	127	127	139	149	133	133	127	133	123	123
MSU_9-18-7	167	163	159	159	0	160	127	139	139	149	133	133	127	133	123	123
MSU_9-18-8	167	163	159	159	0	147	139	141	139	149	133	133	133	133	123	123
MSU_9-18-9	167	167	159	159	0	160	127	139	139	149	133	133	127	133	123	123
MSU_9-18-10	167	167	159	159	0	147	127	139	133	133	133	133	133	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS populations																
ORUS_3277 population (ORUS 2427-1× FRA_1701)[d]																
ORUS 2427-1_CF_1-22[m, j]	**157**	**161**	**157**	**159**	**0**	**127**	**127**	**127**	**133**	**133**	**133**	**133**	**127**	**133**	**123**	**123**
FRA_1701[l, r, a]	**129**	**161**	**155**	**165**	**0**	**144**	**0**	**139**	**133**	**142**	**133**	**133**	**133**	**133**	**123**	**123**
ORUS_3277-1	161	161	159	165	0	144	127	139	133	142	133	**129**	127	133	123	123
ORUS_3277-2	129	157	159	155	0	144	127	139	133	133	133	**129**	127	133	123	123
ORUS_3277-3	129	157	155	157	0	0	127	139	133	133	133	**129**	127	133	123	123
ORUS_3277-4	157	161	157	165	0	144	127	139	133	142	133	**129**	127	133	123	123
ORUS_3277-5	129	157	157	165	0	0	127	139	133	133	133	**129**	133	133	123	123
ORUS_3277-6	129	157	157	165	0	144	127	139	133	142	133	133	133	133	123	123
ORUS_3277-7	161	161	159	155	0	144	127	139	133	133	133	133	133	133	123	123
ORUS_3277-8	161	161	157	165	0	0	127	139	133	133	133	133	133	133	123	123
ORUS_3277-9	157	161	159	165	0	144	127	139	133	142	133	133	127	133	123	123
ORUS_3277-10	129	161	157	165	0	144	127	139	133	142	133	133	127	133	123	123
ORUS_3278 population (ORUS 2427-1× Seascape)[d]																
ORUS 2427-1_CF_1-22[m, j]	**157**	**161**	**157**	**159**	**0**	**127**	**127**	**127**	**133**	**133**	**133**	**133**	**127**	**133**	**123**	**123**
Seascape_CF[l, j]	**161**	**167**	**159**	**159**	**0**	**160**	**127**	**139**	**133**	**149**	**133**	**133**	**133**	**133**	**123**	**123**
ORUS_3278-1	.	.	.	.	.	.	.	.	133	133	133	133	127	133	123	123
ORUS_3278-4	161	167	159	159	0	0	127	127	133	149	133	133	127	133	123	123
ORUS_3278-5	161	161	159	159	0	160	127	139	133	133	133	133	127	133	123	123
ORUS_3278-6	157	167	159	159	0	160	127	127	133	133	133	133	127	133	123	123
ORUS_3278-7	157	167	157	159	0	0	127	127	133	133	133	133	127	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS populations	161	161	159	159	0	160	127	139	133	133	133	133	127	133	123	123
ORUS_3278-9	157	161	159	159	0	0	127	139	133	133	133	133	133	133	123	123
ORUS_3278-10	157	167	159	159	0	0	127	127	133	133	133	133	133	133	123	123
ORUS_3278-12	161	167	159	159	0	0	127	127	133	149	133	133	133	133	123	123
ORUS_3278-13	157	161	157	159	0	160	127	127	133	133	133	133	127	133	123	123
ORUS_3279 population (ORUS 2427-1× Tribute)[d]																
ORUS 2427-1_CF_1-22[m, j]	**157**	**161**	**157**	**159**	**0**	**127**	**127**	**127**	**133**	**133**	**133**	**133**	**127**	**133**	**123**	**123**
Tribute_662.001[l, b]	**119**	**167**	**157**	**159**	**147**	**147**	**139**	**127**	**139**	**149**	**133**	**133**	**127**	**133**	**123**	**123**
ORUS_3279-3	119	157	157	159	0	147	127	139	133	139	133	133	127	133	123	123
ORUS_3279-4	161	167	159	159	0	147	127	127	133	149	133	133	127	133	123	123
ORUS_3279-5	157	167	157	159	0	147	127	139	133	139	133	133	127	133	123	123
ORUS_3279-6	119	157	159	159	0	147	127	127	133	139	133	133	127	133	123	123
ORUS_3279-7	161	167	159	159	0	147	127	139	133	149	133	133	133	133	123	123
ORUS_3279-8	119	157	157	157	0	147	127	127	133	139	133	133	133	133	123	123
ORUS_3279-9	119	161	157	159	0	147	127	127	133	139	133	133	127	133	123	123
ORUS_3279-13	157	167	157	159	0	147	127	139	133	149	133	133	127	133	123	123
ORUS_3279-14	161	167	159	159	0	147	127	139	133	149	133	133	133	133	123	123
ORUS_3279-15	119	157	157	159	0	147	127	127	133	139	133	133	133	133	123	123
ORUS_3304 population (Tillamook × FRA_1701)[d]																
Tillamook_NCGR[b]	.	.	.	.	.	.	.	.	133	133	133	133	133	133	123	123
Tillamook_CF[d]	157	161	159	159	0	0	127	127	133	133	133	133	127	133	123	123
Tillamook_I1[m]	***157***	***161***	***0***	***127***	***159***	***160***	***160***	***139***	***133***	***133***	***133***	***133***	***127***	***133***	***123***	***123***

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS populations	**129**	**161**	**155**	**165**	**0**	**144**	**0**	**139**	**133**	**142**	**133**	**133**	**133**	**133**	**123**	**123**
ORUS_3304-1	129	161	0	155	159	144	160	139	133	133	133	133	133	133	123	123
ORUS_3304-2	157	161	0	155	144	**147**	0	139	133	133	133	133	133	133	123	123
ORUS_3304-5	161	161	165	127	159	144	0	139	133	142	133	133	127	133	123	123
ORUS_3304-6	161	**131**	0	**145**	159	159	0	160	133	133	133	133	127	133	123	123
ORUS_3304-7	129	161	165	127	159	144	0	139	133	133	133	133	133	133	123	123
ORUS_3304-8	157	**163**	0	**147**	0	159	0	160	133	133	133	133	133	133	123	123
ORUS_3304-9	161	**131**	0	**145**	159	159	0	160	133	133	133	133	127	133	123	123
ORUS_3304-10	129	**157**	165	127	159	144	0	139	133	142	133	133	133	133	123	123
ORUS_3304-11	157	**163**	0	**147**	0	159	0	160	133	133	133	133	133	133	123	123
ORUS_3304-13	**163**	**155**	**145**	**147**	0	159	0	160	133	142	133	133	127	133	123	123
ORUS_3305 population (Tillamook × Seascape)[d]																
Tillamook_CF[d]	**157**	161	**159**	159	0	0	**127**	**127**	133	133	133	133	127	133	123	123
Tillamook_NCGR[m, b]	**0**	***161***	***0***	***169***	***157***	***159***	***123***	***127***	**133**	**133**	**133**	**133**	**133**	**133**	**123**	**123**
Seascape_CF[l, j]	**161**	**167**	**159**	**159**	**0**	**160**	**127**	**139**	**133**	**149**	**133**	**133**	**133**	**133**	**123**	**123**
ORUS_3305-1	161	161	0	159	157	160	123	127	133	133	133	133	133	133	123	123
ORUS_3305-2	0	167	0	159	159	160	127	139	133	149	133	133	133	133	123	123
ORUS_3305-3	161	167	0	159	157	160	123	127	133	149	133	133	133	133	123	123
ORUS_3305-5	0	161	169	159	157	160	127	127	133	133	133	133	133	133	123	123
ORUS_3305-6	.	.	.	.	.	.	.	.	133	149	133	133	133	133	123	123
ORUS_3305-7	161	167	159	**147**	0	159	127	127	133	149	133	133	133	133	123	123
ORUS_3305-10	0	161	169	159	157	160	123	127	133	133	133	133	133	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS_3305-11	161	161	0	159	159	160	127	139	133	133	133	133	133	133	123	123
ORUS_3305-13	0	161	169	159	157	160	123	139	133	133	133	133	133	133	123	123
ORUS_3305-14	161	161	0	159	159	160	123	139	133	149	133	133	133	133	123	123
ORUS_3306 population (Totem × FRA_1701)[d]																
Totem_CF[m, j]	**0**	**157**	**157**	**159**	**0**	**0**	**123**	**123**	**133**	**139**	**133**	**133**	**127**	**127**	**123**	**123**
FRA_1701[l, r, a]	**129**	**161**	**155**	**165**	**0**	**144**	**0**	**139**	**133**	**142**	**133**	**133**	**133**	**133**	**123**	**123**
ORUS_3306-2	129	157	157	165	0	0	123	139	133	142	133	133	127	133	123	123
ORUS_3306-3	157	161	155	157	0	0	123	139	133	133	133	133	127	133	123	123
ORUS_3306-4	129	157	155	157	0	0	123	139	133	133	133	133	127	133	123	123
ORUS_3306-5	129	157	157	165	0	0	123	139	139	142	133	133	127	133	123	123
ORUS_3306-6	157	161	157	165	0	0	123	139	139	142	133	133	127	133	123	123
ORUS_3306-8	157	161	157	165	0	144	123	139	133	142	133	133	127	133	123	123
ORUS_3306-11	157	161	157	165	0	0	123	139	133	142	133	133	127	133	123	123
ORUS_3306-13	0	129	159	165	0	0	123	139	139	142	133	133	127	133	123	123
ORUS_3306-14	129	157	157	165	0	144	123	139	139	142	133	133	127	133	123	123
ORUS_3306-15	0	161	159	165	0	144	123	139	139	142	133	133	127	133	123	123
ORUS_3314 population (Fort Laramie × ORUS 2427-1)[d]																
ORUS 2427-1_CF_1-22 [d]	**157**	**161**	157	159	0	127	127	127	133	133	133	133	127	133	123	123
FortLaramie_NCGR[b]	**167**	169	**157**	159	**0**	147	**136**	**127**	**149**	**149**	**133**	133	127	**127**	123	123
FortLaramie_I2[m]	***157***	***169***	***0***	***159***	***139***	***147***	***127***	***141***	***133***	***139***	***135***	***133***	***127***	***133***	***123***	***123***
ORUS 2427_I1[l]	***167***	***163***	***157***	***159***	***0***	***127***	***127***	***127***	***133***	***133***	***133***	***133***	***127***	***133***	***123***	***123***
ORUS_3314-1	163	169	159	159	0	147	127	127	133	139	133	135	127	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS_3314-2	**161**	163	0	159	0	139	127	141	133	133	133	133	127	133	123	123
ORUS_3314-4	167	169	157	159	0	147	127	141	133	133	133	135	133	133	123	123
ORUS_3314-5	157	163	159	159	0	147	127	141	133	139	133	133	133	133	123	123
ORUS_3314-6	157	167	157	159	0	139	127	141	133	133	133	133	127	127	123	123
ORUS_3314-10	157	167	0	157	0	147	**161**	127	133	139	133	133	133	133	123	123
ORUS_3314-11	157	163	159	159	0	139	127	141	133	139	133	133	127	127	123	123
ORUS_3314-12	167	169	157	159	0	147	127	127	133	133	133	135	127	133	123	123
ORUS_3314-14	163?	163?	0	159	0	147	0?	127?	139?	139?	133	133	127	133	123	123
ORUS_3314-15	167	169	157	159	**147**	**163**	127	141	133	133	133	133	133	133	123	123
ORUS_3315 population (Fort Laramie × Puget Reliance)[d]																
FortLaramie_NCGR[b]	167	**169**	157	**159**	0	**147**	**136**	**127**	**149**	**149**	133	133	127	**127**	123	123
FortLaramie_I3[m]	***167***	***163***	***157***	***165***	***0***	***141***	***0***	***123***	***133***	***139***	***133***	***133***	***127***	***133***	***123***	***123***
Puget Reliance_CF[l, j]	**157**	**169**	**157**	**159**	**0**	**147**	**127**	**127**	**133**	**133**	**133**	**133**	**127**	**133**	**123**	**123**
ORUS_3315-1	163	169	157	159	0	147	123	127	133	139	133	133	127	133	123	123
ORUS_3315-2	167	169	157	159	147	141	123	139	133	133	133	133	127	133	123	123
ORUS_3315-4	157	167	159	165	147	141	123	139	133	139	133	133	127	133	123	123
ORUS_3315-6	163	169	157	159	0	147	123	127	133	139	133	133	127	133	123	123
ORUS_3315-10	167	169	157	159	0	0	123	127	133	133	133	133	127	127	123	123
ORUS_3315-11	0?	169?	157	157	147?	147?	123	127	133	133	133	133	133	133	123	123
ORUS_3315-12	157	167	159?	163?	0	147	123	127	133	139	133	133	127	133	123	123
ORUS_3315-13	163	169	157	159	0	147	123	127	133	139	133	133	127	133	123	123
ORUS_3315-14	157	167	159	165	0	147	123	127	133	139	133	133	127	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS_3315-15	157	167	157	165	0	0	123	127	133	139	133	133	127	127	123	123
ORUS_3316 population (Fort Laramie × Totem)[d]																
FortLaramie_NCGR[b]	167	**169**	157	159	0	147	**136**	**127**	**149**	**149**	133	133	127	**127**	123	123
FortLaramie_I1[m]	***167***	***163***	***157***	***159***	***0***	***147***	***127***	***141***	***133***	***139***	***133***	***133***	***127***	***133***	***123***	***123***
Totem_CF[l, j]	**0**	**157**	**157**	**159**	**0**	**0**	**123**	**123**	**133**	**139**	**133**	**133**	**127**	**127**	**123**	**123**
ORUS_3316-1	0	167	159	159	0	0	123	127	139	139	133	133	127	127	123	123
ORUS_3316-2	157	167	157	159	0	147	123	141	133	139	133	133	127	133	123	123
ORUS_3316-3	157	163	157	159	0	0	123	141	139	139	133	133	127	127	123	123
ORUS_3316-4	157	167	157	157	0	0	123	141	133	139	133	133	127	127	123	123
ORUS_3316-5	157	163	157	159	0	147	123	127	139	139	133	133	127	127	123	123
ORUS_3316-6	.	.	.	.	.	.	.	.	133	139	133	133	127	127	123	123
ORUS_3316-7	157	163	157	159	0	147	123	141	133	139	133	133	127	133	123	123
ORUS_3316-8	.	.	.	.	.	.	.	.	139	139	133	133	127	133	123	123
ORUS_3316-9	157	167	157	159	**159**	**143**	123	141	133	133	133	133	127	127	123	123
ORUS_3316-10	0	167	159	159	0	147	123	141	133	139	133	133	127	133	123	123
ORUS_3317 population (Puget Reliance × FRA_1701)[d]																
Puget Reliance_CF [d]	**157**	169	157	**159**	0	147	**127**	**127**	133	**133**	133	133	127	133	123	123
Puget Reliance_I1[m]	***169***	***165***	***157***	***157***	***147***	***0***	***123***	***139***	***133***	***139***	***133***	***133***	***127***	***133***	***123***	***123***
FRA_1701[l, r, a]	**129**	**161**	**155**	**165**	**0**	**144**	**0**	**139**	**133**	**142**	**133**	**133**	**133**	**133**	**123**	**123**
ORUS_3317-1	129	165	165	157	147	0	123	139	139	142	133	133	133	133	123	123
ORUS_3317-2	129	169	165	157	147	0	123	139	139	142	133	133	133	133	123	123
ORUS_3317-3	161	165	165	157	147	0	123	139	139	142	133	133	133	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS_3317-4	129	169	155	157	144	0	123	139	133	133	133	133	127	133	123	123
ORUS_3317-5	161	165	155	157	144	0	123	139	139	142	133	133	127	133	123	123
ORUS_3317-6	161	165	165	157	147	144	123	139	139	142	133	133	133	133	123	123
ORUS_3317-7	161	169	165	157	147	0	123	139	133	142	133	133	133	133	123	123
ORUS_3317-9	129	169	155	157	144	0	123	139	133	133	133	133	133	133	123	123
ORUS_3317-10	161	165	165	157	144	0	123	139	139	142	133	133	127	133	123	123
ORUS_3317-11	129	169	165	157	144	0	123	139	139	142	133	133	127	133	123	123
ORUS_3318 population (Puget Reliance × Sarian)[d]																
Puget Reliance_CF[d]	**157**	169	157	**159**	0	147	**127**	**127**	133	**133**	133	133	127	133	123	123
Puget Reliance_I1[m]	***165***	***169***	***157***	***157***	***0***	***147***	***123***	***139***	***133***	***139***	***133***	***133***	***127***	***133***	***123***	***123***
Sarian_CF[l,j]	**167**	**167**	**159**	**159**	**127**	**147**	**0**	**127**	**133**	**133**	**133**	**133**	**127**	**133**	**123**	**123**
ORUS_3318-1	167	169	157	159	0?	0?	123?	139?	133	133	133	133	127	127	123	123
ORUS_3318-2	165	167	157	159	0	127	0	123	133	139	133	133	127	127	123	123
ORUS_3318-4	165	169	157	157	147	147	0	123	0?	139	133	133	133	133	123	123
ORUS_3318-6	165	167	157	159	0	147	123	127	133	139	133	133	127	133	123	123
ORUS_3318-8	165	167	157	159	0	0?	123?	139?	133	139	133	133	127	127	123	123
ORUS_3318-9	165	167	157	159	0	0?	123?	139?	133	139	133	133	127	127	123	123
ORUS_3318-10	165	167	157	159	0	147	123	127	133	139	133	133	133	133	123	123
ORUS_3318-11	167	169	157	159	0	127	0	123	.	.	.	.	.	.	.	.
ORUS_3318-12	167	169	157	159	0	147	123?	139?	133	133	133	133	133	133	123	123
ORUS_3318-14	165	165	157	157	0	147	0	123	139	139	133	133	127	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS_3319 population (Sarian × ORUS 2427-1)[d]																
Sarian_CF[m, j]	**167**	**167**	**159**	**159**	**127**	**147**	**0**	**127**	**133**	**133**	**133**	**133**	**127**	**133**	**123**	**123**
ORUS 2427_I1[l]	***157***	***161***	***157***	***159***	***0***	***147***	***127***	***127***	***133***	***139***	***133***	***135***	***133***	***133***	***123***	***123***
ORUS_3319-1	161	167	159	159	127	147	0	127	133	139	133	135	133	133	123	123
ORUS_3319-2	161	167	157	159	127	147	0	127	133	139	133	135	133	133	123	123
ORUS_3319-3	161	167	157	159	127	147	0	127	133	133	133	133	133	133	123	123
ORUS_3319-4	161	167	159	159	127	147	0	127	133	139	133	135	127	133	123	123
ORUS_3319-5	167	**169**	159	159	127	147	0	127	133	133	133	135	127	133	123	123
ORUS_3319-6	157	167	157	159	0	127	0	127	133	133	133	133	127	133	123	123
ORUS_3319-7	167	**169**	157	159	127	147	0	127	133	133	133	133	127	133	123	123
ORUS_3319-8	161	167	159	159	127	147	0	127	139	139?	135	135?	133	133	123	123
ORUS_3319-9	161	167	157	159	127	147	0	127	.	.	.	.	.	.	.	.
ORUS_3319-10	.	.	.	.	.	.	.	.	133	133	133	133	127	133	123	123
ORUS_3320 population (Sarian × Totem)[d]																
Sarian_CF[m, j]	**167**	**167**	**159**	**159**	**127**	**147**	**0**	**127**	**133**	**133**	**133**	**133**	**127**	**133**	**123**	**123**
Totem_CF[l, j]	**0**	**157**	**157**	**159**	**0**	**0**	**123**	**123**	**133**	**139**	**133**	**133**	**127**	**127**	**123**	**123**
ORUS_3320-1	**129**	157	159	**165**	**144**	**137**	**139**	127	133	**142**	133	133	**133**	133	123	123
ORUS_3320-2	0	167	159	159	0	147	123	127	133	139	133	133	127	133	123	123
ORUS_3320-3	157	167	157	159	0	147	123	127	133	139	133	133	127	127	123	123
ORUS_3320-4	157	167	159	159	0	127	0	123	133	133	133	133	127	127	123	123
ORUS_3320-5	157	167	159	159	0	147	123	127	133	133	133	133	127	133	123	123
ORUS_3320-6	157	167	159	159	0	147	123	127	133	133	133	133	127	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS_3320-7	157	167	159	159	0	127	0	123	133	139	133	133	127	127	123	123
ORUS_3320-8	157	167	159	159	0	147	123	127	133	133	133	133	127	133	123	123
ORUS_3320-9	157	167	159	159	0	147	123	127	133	133	133	133	127	127	123	123
ORUS_3320-10	157	167	159	159	0	147	123	127	133	139	133	133	127	133	123	123
ORUS_3321 population (Sarian × Tillamook)[d]																
Tillamook_1819.001 [b]	.	.	.	.	.	.	.	.	133	133	133	133	133	133	123	123
Sarian_2691.1 [b]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sarian_CF[m, j]	**167**	**167**	**159**	**159**	**127**	**147**	**0**	**127**	**133**	**133**	**133**	**133**	**127**	**133**	**123**	**123**
Tillamook_CF[l, j]	**157**	**161**	**159**	**159**	**0**	**0**	**127**	**127**	**133**	**133**	**133**	**133**	**127**	**133**	**123**	**123**
ORUS_3321-1	161	167	159	159	0	147	127	127	133	133	133	133	133	133	123	123
ORUS_3321-2	161	167	159	159	**156**	147	0	127	133	133	133	133	133	**129**	123	133
ORUS_3321-3	**134**	167	159	159	0	**156**	127	127	133	133	133	**135**	127	**129**	123	133
ORUS_3321-4	161	167	159	159	0	127	0	127	133	133	133	133	127	127	123	123
ORUS_3321-5	157	167	159	159	0	127	0	127	133	133	133	133	127	127	123	123
ORUS_3321-6	161	167	159	159	0	127	0	127	133	133	133	133	127	127	123	123
ORUS_3321-7	167	**169**	**157**	159	**147**	147	123	127	133	133	133	133	127	127	123	123
ORUS_3321-8	161	167	159	159	**156**	147	127	127	133	133	133	133	133	**129**	123	123
ORUS_3321-9	161	167	159	159	0	**156**	127	127	133	133	133	133	127	**129**	123	123
ORUS_3321-10	161	167	159	159	0	127	0	127	133	133	133	133	127	133	123	123
ORUS_3322 population (Seascape × ORUS 2427-1)[d]																
ORUS 2427-1_CF_1-22 [d]	157	161	157	159	0	**127**	127	127	133	**133**	133	**133**	**127**	133	123	123
Seascape_CF[m, j]	**161**	**167**	**159**	**159**	**0**	**160**	**127**	**139**	**133**	**149**	**133**	**133**	**133**	**133**	**123**	**123**

Individual	A1^{zb}	A2^{zb}	B1^{zb}	B2^{zb}	C1^{zb}	C2^{zb}	D1^{zb}	D2^{zb}	A1^{zc}	A2^{zc}	B1^{zc}	B2^{zc}	C1^{zc}	C2^{zc}	D1^{zc}	D2^{zc}
ORUS 2427_I1[l]	***157***	***161***	***157***	***159***	***0***	***147***	***127***	***127***	***133***	***139***	***133***	***135***	***133***	***133***	***123***	***123***
ORUS_3322-2	157	161	157	159	147	**169**	127	127	133	149	133	133	133	133	123	123
ORUS_3322-4	161	161	159	159	0	147	127	127	133	139	133	135	133	133	123	123
ORUS_3322-5	157	167	157	159	147	**169**	127	127	133	149	133	133	133	133	123	123
ORUS_3322-7	161	161	157	159	0	147	127	139	133	139	133	133	133	133	123	123
ORUS_3322-8	161	161	159	159	0	147	127	139	133	139	133	135	133	133	123	123
ORUS_3322-9	161	167	157	159	147	160	127	139	133	149	133	133	133	133	123	123
ORUS_3322-11	161	161	159	159	0	160	127	139	133	133	133	133	133	133	123	123
ORUS_3322-12	157	161	**169**	159	147	160	127	139	133	149	133	133	133	133	123	123
ORUS_3322-13	161	161	159	159	0	147	127	139	139	149	133	135	133	133	123	123
ORUS_3322-14	161	167	157	159	0	147	127	139	139	149	133	133	133	133	123	123
ORUS_3323 population (Seascape × Puget Reliance)[d]																
Puget Reliance_CF [d]	**157**	169	157	**159**	0	147	**127**	**127**	133	**133**	133	133	127	133	123	123
Seascape_CF[m, j]	**161**	**167**	**159**	**159**	**0**	**160**	**127**	**139**	**133**	**149**	**133**	**133**	**133**	**133**	**123**	**123**
Puget Reliance_I1[l]	***165***	***169***	***157***	***157***	***0***	***147***	***123***	***139***	***133***	***139***	***133***	***133***	***127***	***133***	***123***	***123***
ORUS_3323-1	161	169	157	159	0	160	123	127	133	133	133	133	127	133	123	123
ORUS_3323-2	161	169	157	159	147	160	123	127	133	133	133	133	133	133	123	123
ORUS_3323-3	0	167	157	159	0	**163**	127	141	133	139	133	133	127	133	123	123
ORUS_3323-4	167	169	157	159	147	160	123	139	133	149	133	133	133	133	123	123
ORUS_3323-6	167	169	157	159	147	160	123	127	133	133	133	133	133	133	123	123
ORUS_3323-7	161	**167**	157	159	**163**	160	139	141	133	139	133	133	127	133	123	123
ORUS_3323-9	0	161	157	159	0	**163**	139	141	133	139	133	133	127	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS_3323-12	161	169	157	159	0	160	123	139	133	139	133	133	127	133	123	123
ORUS_3323-13	161?	167?	157	159	0	0	139	127	133	133	133	133	127	133	123	123
ORUS_3323-14	161	169	157	159	0	160	123	127	133	133	133	133	127	133	123	123
ORUS_3324 population (Tillamook × Fort Laramie)[d]																
Tillamook_NCGR[b]	.	.	.	.	.	.	.	.	133	133	133	133	**133**	133	123	123
Tillamook_CF[m, j]	**157**	**161**	**159**	**159**	**0**	**0**	**127**	**127**	**133**	**133**	**133**	**133**	**127**	**133**	**123**	**123**
FortLaramie_I1[l]	***167***	***163***	***157***	***159***	***0***	***147***	***127***	***141***	***133***	***139***	***133***	***133***	***127***	***133***	***123***	***123***
ORUS_3324-1	161	167	159	159	0	0	127	127	133	133	133	133	127	133	123	123
ORUS_3324-3	157	167	157	159	0	0	127	141	133	133	133	133	127	133	123	123
ORUS_3324-4	161	163	157	159	0	147	127	141	133	139	133	133	133	133	123	123
ORUS_3324-9	157	163	159	159	0	147	127	141	133	139	133	133	133	133	123	123
ORUS_3324-10	157	163	157	159	0	0	127	141	133	139	133	133	127	133	123	123
ORUS_3324-11	157	163	159	159	0	147	127	127	133	139	133	133	133	133	123	123
ORUS_3324-12	157	167	159	159	0	147	127	141	133	133	133	133	133	133	123	123
ORUS_3324-13	157	163	157	159	0	147	127	141	133	133	133	133	133	133	123	123
ORUS_3324-14	157	167	159	159	0	0	127	141	133	133	133	133	127	133	123	123
ORUS_3324-15	161	163	159	159	0	0	127	127	139	139	133	133	127	127	123	123
ORUS_3325 population (Tillamook × Tribute)[d]																
Tillamook_NCGR[b]	.	.	.	.	.	.	.	.	133	133	133	133	**133**	133	123	123
Tillamook_CF[m, j]	**157**	**161**	**159**	**159**	**0**	**0**	**127**	**127**	**133**	**133**	**133**	**133**	**127**	**133**	**123**	**123**
Tribute_662.001[l, b]	**119**	**167**	**157**	**159**	**147**	**147**	**139**	**127**	**139**	**149**	**133**	**133**	**127**	**133**	**123**	**123**
ORUS_3325-2	119	161	157	159	0	147	127	127	133	139	133	133	127	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS_3325-4	119	161	159	159	0	147	127	127	133	139	133	133	127	133	123	123
ORUS_3325-5	119	157	157	159	0	147	127	139	133	139	133	133	127	133	123	123
ORUS_3325-8	119	161	157	159	0	147	127	127	133	139	133	133	127	127	123	123
ORUS_3325-9	119	161	157	159	0	147	127	139	133	139	133	133	127	127	123	123
ORUS_3325-10	161	167	157	159	0	147	127	139	133	149	133	133	127	127	123	123
ORUS_3325-11	119	157	159	159	0	147	127	127	133	139	133	133	133	133	123	123
ORUS_3325-12	119	157	159	159	0	147	127	127	133	139	133	133	127	133	123	123
ORUS_3325-13	119	161	159	159	0	147	127	139	133	139	133	133	127	127	123	123
ORUS_3325-15	119	157	159	159	0	147	127	127	133	139	133	133	127	133	123	123
ORUS_3326 population (Tribute × Puget Reliance)[d]																
Puget Reliance_CF[d]	**157**	169	157	**159**	0	147	**127**	**127**	133	**133**	133	133	127	133	123	123
Tribute_662.001[m, b]	**119**	**167**	**157**	**159**	**147**	**147**	**139**	**127**	**139**	**149**	**133**	**133**	**127**	**133**	**123**	**123**
Puget Reliance_I1[l]	***165***	***169***	***157***	***157***	***0***	***147***	***123***	***139***	***133***	***139***	***133***	***133***	***127***	***133***	***123***	***123***
ORUS_3326-1	119	165	157	157	0	147	123	139	139	139	133	133	127	127	123	123
ORUS_3326-2	119	**163**	157	159	147	147	**0**	127	133	139	133	133	127	133	123	123
ORUS_3326-3	119	169	157	159	147	147	123	127	133	139	133	133	133	133	123	123
ORUS_3326-4	119	**167**	157	159	147	147	139	**141**	149	149	133	133	133	133	123	123
ORUS_3326-5	119	165	157	157	147	147	123	127	139	139	133	133	133	133	123	123
ORUS_3326-11	165	167	157	157	0	147	123	139	139	149	133	133	127	127	123	123
ORUS_3326-12	165	167	157	159	0	147	123	127	139	149	133	133	127	127	123	123
ORUS_3326-13	119	169	157	157	147	147	123	139	133	139	133	133	127	133	123	123
ORUS_3326-14	119	169	157	157	0	147	123	127	133	139	133	133	127	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS_3326-15	119	169	157	159	0	147	123	127	133	139	133	133	127	133	123	123
Parents of populations																
Capitola-FR_CF[e]	161	167	157	159	0	147	139	141	133	133	133	133	127	127	123	123
CF1116-FR[za]	***161***	***167***	***157***	***159***	***147***	***160***	***127***	***141***	**133**	**149**	**133**	**133**	**127**	**133**	**123**	**123**
E-60174-NL (Redgauntlet) [k]	161	163	159	163	0	0	0	139	133	133	133	135	127	129	123	123
E-71006-NL (Holiday) [i]	119	157	157	157	137	139	139	141	139	139	133	133	127	127	123	123
Earliglow_CF[j]	119	169	157	159	0	147	139	141	139	149	133	133	127	133	123	123
FortLaramie_NCGR[b]	167	169	157	159	0	147	136	127	149	149	133	133	127	127	123	123
FRA_1701[a]	129	161	155	165	0	144	0	139	133	142	133	133	133	133	123	123
Hapil-NL[i]	119	163	157	161	0	160	139	139	*133*	*133*	*133*	*135*	*127*	*129*	*123*	*123*
Holiday_CF[j]	119	157	157	157	137	139	139	141	139	139	133	133	127	127	123	123
Honeoye_215.001[a]	157	161	157	163	0	139	139	141	133	139	133	135	127	127	123	123
IFAPA_1392[j]	161	167	159	165	0	127	127	127	133	133	133	133	127	127	123	123
IFAPA_232[j]	161	167	157	159	0	160	127	139	133	133	133	133	127	133	123	123
Korona-CF[j]	161	169	161	119	147	160	139	137	139	139	133	133	0	133	123	123
Korona-NL[i]	161	167	157	159	0	147	136	127	*133*	*149*	*0*	*133*	*133*	*129*	*123*	*123*
MSU_49 [j]	161	169	157	157	0	139	139	141	133	149	133	133	127	127	123	123
MSU_56[j]	157	169	157	159	0	127	0	141	139	139	133	133	127	127	123	123
ORUS 2427-1_CF_1-22 [j]	157	161	157	159	0	127	127	127	133	133	133	133	127	133	123	123
Puget Reliance_CF[j]	157	169	157	159	0	147	127	127	133	133	133	133	127	133	123	123
Redgauntlet_CF[j]	161	163	157	159	0	147	0	127	133	139	133	133	127	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
Sarian_2691.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sarian_CF[d]	167	167	159	159	127	147	0	127	133	133	133	133	127	133	123	123
Seascape_CF[j]	161	167	159	159	0	160	127	139	133	149	133	133	133	133	123	123
Tillamook_NCGR[b]	***0***	***161***	***0***	***169***	***157***	***159***	***123***	***127***	133	133	133	133	133	133	123	123
Tillamook_CF[d]	157	161	159	159	0	0	127	127	133	133	133	133	127	133	123	123
Totem_CF[j]	0	157	157	159	0	0	123	123	133	139	133	133	127	127	123	123
Tribute_662.001[b]	119	167	157	159	147	147	139	127	139	149	133	133	127	133	123	123
Tribute_CF[j]	119	167	157	159	147	147	139	127	133	139	133	133	127	133	123	123
Cultivars																
Aberdeen[a]	161	161	161	157	0	147	136	0	139	133	133	133	127	133	123	123
Aberdeen-NL[i]	161	161	0	157	0	147	136	0	.	.	.	.	.	.	.	.
Aiko[j]	161	145	157	157	160	127	139	141	139	133	133	133	127	127	123	123
Albion[j]	167	167	159	157	160	0	127	127	133	149	133	133	133	133	123	123
Albritton[j]	0	119	159	161	160	137	139	139	139	133	133	133	127	133	123	123
E-82246 NL (Allstar)[g]	167	161	157	157	147	0	127	127	.	.	.	.	.	.	.	.
Allstar[j]	167	161	157	157	0	147	127	127	139	149	133	133	133	129	123	123
Ambrosia_Late[j]	169	161	161	159	160	131	0	136	139	133	133	133	127	?	123	123
Annapolis[j]	169	161	157	157	147	147	127	141	139	139	133	133	133	133	123	123
Apollo[j]	161	161	159	157	0	147	0	141	133	133	133	133	127	127	123	123
ArKing[j]	119	161	159	159	160	147	139	127	139	149	133	133	127	127	123	123
Aromas[j]	167	167	159	157	160	0	127	127	133	149	133	133	127	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
Atlas[j]	119	161	161	161	160	147	139	127	139	149	133	133	127	127	123	123
Badgerglo[j]	157	119	159	159	0	0	127	141	139	139	133	133	127	133	123	123
Beaver[j]	169	161	165	157	127	0	127	127	139	133	133	133	127	127	123	123
Benizuru[j]	167	161	167	167	163	147	163	163	139	133	133	133	127	133	123	123
Benton[j]	169	161	0	157	147	147	147	127	139	133	133	133	127	133	123	123
Blakemore[j]	169	119	157	161	137	147	139	141	139	133	133	133	127	133	123	123
Bountiful[j]	169	161	157	157	0	147	123	136	133	133	133	133	127	133	123	123
Bounty[j]	157	163	159	159	127	147	139	141	133	133	133	135	127	133	123	123
British_Sovereign[j]	161	161	165	0	160	147	136	141	139	133	133	133	127	127	123	123
Brunswick[j]	169	161	157	157	137	0	139	127	139	149	133	133	129	133	123	123
Cabot[j]	119	157	159	157	0	147	139	141	139	139	133	133	127	133	123	123
Cal_51S-1[j]	167	161	159	157	160	0	139	127	.	.	.	.	.	.	.	.
Cal_59.39-1[j]	167	167	159	159	160	160	123	136	149	149	133	135	0	129	123	123
Camarosa[j]	161	161	165	157	160	0	127	127	133	133	133	133	127	133	123	123
Cardinal[j]	169	159	159	159	0	147	139	127	139	139	133	133	127	133	123	123
Catskill[j]	167	167	165	157	160	137	139	0	133	133	133	133	133	133	123	123
Cavendish[j]	161	161	147	119	160	137	139	139	139	139	133	133	133	133	123	123
Chandler[j]	161	161	165	159	160	147	0	127	133	133	133	133	127	133	123	123
Charm (ORUS_2262-2)[j]	157	157	159	163	0	123	127	127	133	133	133	133	127	133	123	123
Clancy[j]	167	157	159	157	139	147	136	141	139	149	133	133	127	133	123	123
Climax[j]	163	161	163	157	159	147	0	136	139	139	133	133	133	133	123	123
Columbia[j]	161	167	159	157	137	0	139	127	133	133	133	133	127	127	123	123

Individual	A1^{zb}	A2^{zb}	B1^{zb}	B2^{zb}	C1^{zb}	C2^{zb}	D1^{zb}	D2^{zb}	A1^{zc}	A2^{zc}	B1^{zc}	B2^{zc}	C1^{zc}	C2^{zc}	D1^{zc}	D2^{zc}
Cruz[j]	167	161	159	157	0	147	139	127	133	133	133	133	127	127	123	123
Daroyal[j]	167	163	159	157	0	127	139	141	133	133	133	135	127	127	123	123
Darrow 5[j]	161	161	161	157	157	157	0	0	.	.	.	.	.	.	.	.
Darselect[j]	167	161	157	159	0	147	139	127	139	133	133	133	127	133	123	123
Delitej	161	119	159	167	160	137	139	141	139	133	133	133	127	133	123	123
Delmarvel[j]	161	119	161	159	0	147	127	141	139	139	133	133	127	133	123	123
Diamante[j]	167	167	159	159	160	0	127	127	133	149	133	133	133	133	123	123
Direktor_Paul_Wallbaum[j]	169	167	161	161	161	0	136	136	133	133	133	135	127	127	123	123
Donner[j]	167	167	159	157	160	147	139	127	133	133	133	133	127	133	123	123
Dover[j]	167	161	165	159	0	147	127	0	133	133	133	133	127	133	123	123
Earlibelle[j]	169	119	159	159	137	0	139	127	139	133	133	133	127	127	123	123
Elsanta[j]	167	161	157	157	0	139	139	139	139	149	133	133	127	127	123	123
Eros[j]	.	.	.	.	.	.	.	.	139	139	133	133	127	129	123	123
Ettersburg_121[j]	161	161	159	0	0	123	136	136	139	133	133	135	127	127	123	123
Evangeline[j]	161	167	157	163	0	139	139	141	139	133	133	133	127	127	123	123
Evie-2[j]	167	167	159	157	0	0	127	136	133	133	133	133	127	133	123	123
Fairfax[j]	169	157	159	157	137	147	139	127	133	133	133	133	127	133	123	123
Fern[j]	167	167	159	157	137	147	139	127	133	149	133	133	127	133	123	123
Firecracker[j]	167	157	157	136	0	147	123	123	133	133	133	133	127	133	123	123
Florence[j]	161	161	163	163	159	147	139	0	139	139	133	133	129	133	123	123
Florida_90[j]	161	167	157	119	139	147	141	141	139	139	133	133	127	127	123	123
Florida_Belle[j]	167	167	159	159	160	0	127	127	133	133	133	133	133	129	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
Florida_Elyana[j]	167	167	159	159	160	0	127	127	133	133	133	133	123	133	123	123
Florida_Radiance[j]	161	167	159	159	160	137	139	127	133	133	133	133	127	133	123	123
Galletta[j]	169	161	157	159	160	0	139	141	133	149	133	133	127	133	123	123
Glooscap[j]	157	161	159	157	0	0	139	141	133	133	133	133	127	127	123	123
Gorella[j]	161	167	157	163	139	137	139	139	133	133	133	135	127	127	123	123
Governor_Simcoe[j]	157	161	157	157	139	147	127	141	139	133	133	133	127	133	123	123
Guardian[j]	0	161	157	0	0	147	136	127	139	133	133	133	133	133	123	123
Harunoka[j]	167	167	161	159	147	147	0	127	133	133	133	133	133	133	123	123
Hecker[j]	161	167	159	159	0	0	123	127	133	149	133	133	127	133	123	123
Hogyoku[j]	167	167	161	159	147	147	0	127	133	133	133	133	133	133	123	123
Hood[j]	161	157	161	157	0	0	127	123	133	133	133	133	127	127	123	123
Howard_17[j]	169	161	157	147	137	147	136	139	139	139	133	133	133	133	123	123
Hummi_Grandee[j]	161	161	157	159	0	147	0	141	133	133	133	133	127	133	123	123
Idea[j]	173	163	159	159	160	160	139	127	139	133	133	133	127	127	123	123
Independence[j]	169	169	157	157	127	147	127	127	133	133	133	133	127	133	123	123
E-65056 (Induka)[i]	169	161	159	159	147	137	127	139	133	149	133	133	127	133	123	123
Jerseybelle[j]	157	167	159	159	137	0	139	141	133	149	133	133	127	127	123	123
Jewel[j]	169	157	157	157	139	141	0	141	139	149	133	133	127	133	123	123
Joe[j]	167	161	161	159	160	0	139	141	133	133	133	133	127	133	123	123
Jucunda[j]	161	167	159	163	0	136	136	136	133	133	133	135	127	127	123	123
Jurica[j]	169	157	159	157	147	147	139	0	.	.	.	.	.	.	.	.
Kaiser_Samling[j]	161	167	159	173	0	0	136	136	133	133	135	135	127	127	123	123

Individual	A1^{zb}	A2^{zb}	B1^{zb}	B2^{zb}	C1^{zb}	C2^{zb}	D1^{zb}	D2^{zb}	A1^{zc}	A2^{zc}	B1^{zc}	B2^{zc}	C1^{zc}	C2^{zc}	D1^{zc}	D2^{zc}
Kent[j]	161	157	157	157	157	0	139	141	139	133	133	133	127	127	123	123
Klondike[j]	167	157	163	163	147	147	119	141	139	139	133	133	133	133	123	123
Koro103[j]	169	167	161	157	137	147	139	0	139	133	133	133	127	133	123	123
Kurume103[j]	167	167	161	157	147	147	139	127	133	133	133	133	127	133	123	123
L'Amour[j]	167	161	159	157	147	147	141	139	.	.	.	.	.	.	.	.
Lassen[j]	167	161	157	157	160	147	127	141	133	133	133	133	133	133	123	123
Lateglow[j]	167	161	161	159	137	147	136	139	133	149	133	133	127	133	123	123
Liberation_d_Orleans[j]	167	167	167	185	261	161	127	127	133	149	133	133	127	133	123	123
Linn[j]	169	161	161	157	147	147	139	136	133	133	133	133	133	133	123	123
Mara_des_Bois[j]	167	161	159	157	160	0	136	127	139	149	133	133	127	129	123	123
Marlate[j]	167	167	159	159	0	127	139	141	139	133	133	133	127	127	123	123
Marshall[j]	167	167	165	159	160	0	127	0	133	133	133	133	133	133	123	123
Massey[j]	159	157	119	157	137	147	139	0	139	133	133	133	127	133	123	123
MDUS_3184[j]	169	167	159	157	137	147	139	127	133	149	133	133	127	127	123	123
MDUS_3816[j]	119	169	157	159	137	147	139	139	.	.	.	.	.	.	.	.
MDUS_4258[j]	169	167	159	157	0	147	127	136	149	149	133	133	127	127	123	123
MDUS_683[j]	161	161	161	157	0	147	0	136	139	133	133	133	127	133	123	123
Melody[j]	169	157	159	163	137	147	139	127	133	133	133	135	127	133	123	123
Mesabi[j]	161	157	157	157	173	0	139	0	139	133	133	133	127	133	123	123
Micmac[j]	161	161	161	159	159	0	139	0	133	133	133	133	133	133	123	123
Midland[j]	169	149	165	159	121	147	145	141	133	149	133	133	133	133	123	123
Midway[j]	167	167	165	163	163	137	139	147	133	133	133	133	127	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
Miyazaki[j]	157	161	173?	147	147	137	136	139	.	.	.	.	.	.	.	.
Northwest[j]	157	167	159	0	160	0	139	123	139	139	133	133	127	133	123	123
NW_90054-37[j]	169	167	157	157	137	139	139	123	133	133	133	133	127	127	123	123
Nyoho[j]	169	167	159	159	160	147	127	127	133	133	133	133	127	133	123	123
Oberschlesien[j]	161	167	161	159	0	0	136	136	133	?	133	133	127	127	123	123
Ogallala[j]	161	167	163	163	159	145	136	142	139	133	133	133	127	127	123	123
Ooishi-shikinari2[j]	163	167	163	159	160	147	127	145	139	149	133	?	127	127	123	123
ORUS_1083-135[j]	0	157	157	157	147	147	127	123	133	133	139	133	127	127	123	123
ORUS_1239R-21[j]	0	157	159	157	0	147	127	123	133	133	139	133	127	133	123	123
ORUS_1267-236[j]	157	157	0	127	147	147	127	123	133	133	139	133	127	127	123	123
ORUS_1384-3[j]	169	169	169	157	159	123	136	136	133	133	133	133	127	127	123	123
ORUS_1391-1[j]	169	167	157	157	0	147	136	127	133	133	139	133	127	133	123	123
ORUS_1407-76[j]	157	161	159	119	159	137	139	0	133	133	133	133	127	129	123	123
ORUS_1735-1[j]	169	169	157	159	147	147	123	127	133	133	133	133	127	133	123	123
ORUS_1754-1[j]	157	157	157	157	165	0	123	123	133	133	?	133	127	127	123	123
ORUS_1769-1[j]	161	157	159	157	137	147	127	139	139	133	133	135	127	?	123	123
ORUS_1827-2[j]	161	159	159	159	0	127	123	127	139	133	133	133	127	133	123	123
ORUS_1947-2[j]	157	157	157	159	137	0	127	139	133	133	133	133	127	127	123	123
ORUS_1963-5[j]	.	.	.	.	.	.	.	.	133	133	133	133	127	127	123	123
ORUS_2427-4[j]	161	157	157	159	147	0	136	127	133	133	133	133	127	133	123	123
ORUS_2490-1[j]	169	157	159	159	159	0	127	139	133	133	133	133	127	133	123	123
ORUS_2676-1[j]	169	167	157	157	160	159	0	123	133	133	133	133	127	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS_2742-1[j]	169	157	165	159	160	147	123	127	133	133	133	133	127	133	123	123
ORUS_2781-1[j]	.	.	.	.	.	.	.	.	133	133	133	133	127	133	123	123
ORUS_740-7[j]	169	161	157	159	160	0	123	0	139	139	133	133	127	133	123	123
OSC_4474[j]	157	167	159	157	0	147	139	127	139	133	133	133	127	127	123	123
OSC_4816[j]	169	161	161	157	157	147	123	123	139	139	133	133	127	133	123	123
OSC_4817[j]	119	157	0	157	159	0	127	123	139	133	133	133	127	127	123	123
OSC_4916[j]	0	157	147	159	147	147	127	123	139	133	133	133	127	133	123	123
Ourown[j]	169	167	161	161	139	147	136	141	149	149	133	133	133	133	123	123
Ozark_Beauty[j]	169	161	161	157	147	147	139	141	133	149	133	133	133	133	123	123
Pelican[j]	161	167	165	157	160	147	139	127	.	.	.	.	.	.	.	.
Perle_de_Prague[j]	157	161	163	163	159	147	0	136	139	133	133	133	133	129	123	123
Pinnacle[j]	161	157	159	159	0	0	127	127	133	133	133	133	127	133	123	123
Puget_Beauty[j]	169	157	165	157	0	147	123	123	139	133	133	133	127	133	123	123
Puget_Reliance[j]	169	157	157	159	0	147	127	127	133	133	133	133	127	133	123	123
Puget_Summer[j]	157	161	159	157	0	137	139	123	133	133	133	133	127	127	123	123
Rainier[j]	167	167	159	159	136	136	127	136	139	133	133	133	127	133	123	123
Record	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Redchief[j]	0	167	0	157	127	147	136	136	.	.	.	.	.	.	.	.
Redcoat[j]	161	167	167	159	0	137	136	139	133	149	133	133	127	127	123	123
Redcrest[j]	161	157	159	0	139	147	139	123	139	133	133	133	127	133	123	123
Redgem[j]	169	119	159	0	147	147	127	0	133	133	133	133	127	127	123	123
Redglow[j]	119	161	157	157	0	137	139	141	133	139	133	133	127	127	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
Repita[j]	159	167	159	159	0	147	139	141	139	139	133	133	127	133	123	123
Robinson[j]	169	167	159	157	0	137	136	139	133	149	133	133	127	133	123	123
Rosa_Linda[j]	161	167	159	157	160	147	139	127	133	133	133	133	123	133	123	123
Salinas[j]	145	167	157	157	160	137	139	139	.	.	.	.	.	.	.	.
Sarian[j]	167	167	159	159	0	147	127	127	133	133	133	133	127	133	123	123
Scott[j]	161	163	159	163	0	0	139	0	133	133	133	133	123	133	123	123
Selva[j]	157	167	165	157	0	0	127	123	133	149	133	133	133	133	123	123
Seneca[j]	157	161	157	157	0	139	141	141	139	133	133	133	127	127	123	123
Senga_Sengana[j]	163	119	157	161	0	160	139	139	139	149	133	133	127	127	123	123
Sequoia[j]	161	161	159	157	160	0	139	139	139	133	133	133	127	133	123	123
Shasta[j]	169	167	159	159	160	137	139	127	133	133	133	133	127	133	123	123
Shuksan[j]	167	167	159	159	159	0	123	123	133	133	133	133	127	133	123	123
Sierra[j]	161	157	163	159	0	147	163	136	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sparkle[j]	169	161	159	157	137	147	139	0	133	133	133	133	127	133	123	123
Stelemaster[j]	169	157	157	157	0	147	127	136	139	133	133	133	133	133	123	123
Stolo[j]	161	167	165	157	160	0	0	123	.	.	.	.	.	.	.	.
Strawberry_Festival[j]	161	161	159	157	0	147	127	127	133	133	133	133	127	133	123	123
Streamliner[j]	169	167	159	157	137	0	139	136	133	149	133	133	127	133	123	123
Sumas[j]	167	0	167	157	160	0	147	127	133	133	133	133	127	133	123	123
Sumner[j]	161	0	159	157	137	147	127	139	.	.	.	.	.	.	.	.
Sunrise[j]	161	167	157	163	137	139	139	139	.	.	.	.	.	.	.	.

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
Surecrop[j]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sweet_Bliss (ORUS 2180-1)[j]	167	169	157	159	147	147	127	123	133	149	133	133	127	133	123	123
Sweet_Charlie [j]	161	167	159	159	160	137	139	127	133	133	133	133	127	127	123	123
Sweet_Sunrise (ORUS 2240-1)[j]	169	161	119	157	147	0	123	127	139	133	133	133	127	127	123	123
Talisman-NL[i]	161	163	157	163	159	0	136	0	.	.	.	.	.	.	.	.
Tamella[j]	163	167	163	157	159	0	139	136	133	149	133	133	127	129	123	123
Tamella-NL[i]	167	163	157	163	159	137	136	139	.	.	.	.	.	.	.	.
Tangi[j]	157	157	163	163	119	139	141	141	139	133	133	133	127	133	123	123
Temple[j]	119	167	163	157	163	147	141	139	139	139	133	133	133	133	123	123
Tioga[j]	161	167	165	157	160	147	127	127	139	133	133	133	133	133	123	123
Toro[j]	161	167	159	157	160	147	139	127	139	133	133	133	127	133	123	123
Treasure[j]	161	167	157	157	127	0	127	127	133	133	133	133	127	129	123	123
Tufts[j]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tyee[j]	157	161	159	159	0	147	127	123	133	133	133	133	127	133	123	123
Valley_Red[j]	161	157	165	159	160	147	127	123	139	133	133	133	133	133	123	123
Valley_Sunset[j]	161	167	161	157	0	0	127	127	139	133	133	133	127	127	123	123
Veestar[j]	167	167	165	163	137	147	139	163	.	.	.	.	.	.	.	.
Ventana[j]	161	167	159	159	137	147	139	127	139	133	133	133	127	127	123	123
Wendy[j]	161	161	157	163	0	147	139	141	.	.	.	.	.	.	.	.
White_Carolina[j]	167	161	163	163	163	161	161	142	133	?	135	133	127	129	123	123
Winona[j]	161	161	161	157	127	147	139	141	139	139	133	133	129	133	123	123
Winter_Dawn[j]	161	161	159	157	160	0	127	127	133	133	133	133	127	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
Super core collection																
FRA_1088[x, a]	161	161	161	157	157	157	0	0	133	133	133	133	129	129	123	123
FRA_1092[x, a]	161	161	161	159	155	0	0	0	133	133	133	133	129	129	123	123
FRA_110[r, a]	161	161	161	161	137	137	151	137	.	.	.	.	.	.	.	.
FRA_1100[x, a]	161	161	161	161	161	157	0	0	133	133	133	133	129	129	123	123
FRA_1104[x, a]	161	161	161	163	157	0	0	0	133	133	133	133	129	129	123	123
FRA_1108[x, a]	161	161	161	157	155	0	0	0	133	133	133	133	129	129	123	123
FRA_1408[r, a]	150	161	163	163	163	146	145	145	133	133	135	133	133	133	123	123
FRA_1414[r, a]	163	163	163	155	131	131	0	151	.	.	.	.	.	.	.	.
FRA_1435[r, a]	163	163	0	165	144	139	141	127	133	142	133	133	133	133	123	123
FRA_1455[r, a]	163	163	163	165	144	139	141	127	133	142	133	133	133	133	123	123
FRA_1557[r, a]	161	161	114	0	140	160	139	170	139	133	133	133	127	133	123	123
FRA_1580[r, a]	129	161	163	165	131	146	0	151	133	133	133	133	133	133	123	123
FRA_1620[r, a]	157	161	155	165	137	156	135	0	139	133	135	135	127	?	123	123
FRA_1690[w, a]	119	165	165	163	163?	125	365	0	133	133	133	133	129	129	123	123
FRA_1691[x, a]	163	0	159	159	155	0	123	121	133	133	133	133	129	129	123	123
FRA_1692[x, a]	119	119	161	161	154	144	142	154	133	133	133	133	129	129	123	123
FRA_1694[r, a]	161	161	161	159	163	163	157	142	139	142	133	133	129	133	123	123
FRA_1695[r, a]	161	161	161	159	163	163	157	142	139	142	133	133	129	133	123	123
FRA_1696[r, a]	163	163	163	163	126	138	141	145	139	139	133	135	129	133	123	123
FRA_1697[r, a]	161	161	135	159	134	156	149	127	139	133	133	135	129	133	123	123
FRA_1698[r, a]	129	113	159	159	160	160	133	127	139	133	133	133	129	129	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
FRA_1699[r, a]	167	0	159	159	121	144	127	127	139	133	133	135	127	127	123	123
FRA_1700[r, a]	169	161	147	159	137	160	142	123	133	145	133	133	127	133	123	123
FRA_1701[r, a]	129	161	144	165	144	155	139	139	133	133	133	133	133	133	123	123
FRA_1703[r, a]	169	0	175	159	121	160	148	123	133	133	133	133	127	127	123	123
FRA_24[x, a]	167	167	161	161	161	0	136	136	133	133	?	133	127	127	123	123
FRA_34[x, a]	119	161	161	155	121	121	121	171	133	133	133	133	129	129	123	123
FRA_357[x,a]	163	169	165	159	161	121	134	121	133	133	133	133	129	129	123	123
FRA_372[x,a]	119	167	161	155	0	154	136	136	.	.	.	.	.	.	.	.
FRA_42[x,a]	163	163	0	155	125	121	121	121	133	133	133	133	129	129	123	123
FRA_48[x,a]	161	169	161	155	123	123	123	123	133	133	135	133	129	129	123	123
FRA_58[r,a]	167	157	163	165	157	157	143	148	133	133	133	133	129	129	123	123
FRA_688[x,a]	161	161	161	157	157	157	0	0	.	.	.	.	.	.	.	.
FRA_796[x,a]	161	161	161	157	0	0	162	162	133	133	129	133	129	129	123	123
FRA_982[r,a]	167	165	159	165	147	159	149	151	139	142	133	133	129	133	123	123
Wild accessions																
Del_Norte[x, j]	119	161	159	157	121	121	121	121	133	133	133	133	129	129	123	123
F.chil.Cape.Mendicino[x, j]	157	157	159	157	125	0	141	139	.	.	.	.	.	.	.	.
FRA_368[x, j]	119	167	119	159	155	155	0	0	133	149	133	133	127	129	123	123
ORUS_2361-1[x, j]	161	161	157	161	0	154	0	129	133	133	133	133	129	129	123	123
FRA_743[x, j]	161	161	161	161	157	157	0	0	133	133	133	133	129	129	123	123
Yaquina_B[w, j]	157	161	159	159	0	125	123	123	133	133	133	133	129	129	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
F.iturupensis[v, j]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F.vesca bracteata[t, j]	142	144	0	0	0	0	0	0	.	.	.	.	.	.	.	.
FRA_1952[t, j]	161	163	0	0	0	0	0	0	.	.	.	.	.	.	.	.
FRA_504[t, j]	142	144	0	0	0	0	0	0	.	.	.	.	.	.	.	.
Hawaii0_TD [u,j]	163	165	0	0	0	0	0	0	0	0	133	0	0	0	123	0
Hawaii4_TD [u,j]	0	0	0	0	0	0	0	0	0	0	133	133	0	0	0	0
Yellow_Wonder[u, j]	0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.
FRA_1948[s, j]	161	161	161	161	161	161	0	0	.	.	.	.	.	.	.	.
BC12[q, j]	167	161	157	159	147	157	145	127	133	133	133	133	129	129	123	123
BC6[r, j]	0	0	0	0	0	0	0	0	133	133	133	133	133	133	123	123
FRA_101[p, j]	0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.
FRA_1343[r, j]	119	161	167	0	154	0	155	136	.	.	.	.	.	.	.	.
FRA_1356[r, j]	157	173	159	159	160	139	127	141	.	.	.	.	.	.	.	.
FRA_1356[r, j]	157	173	159	159	160	139	127	141	.	.	.	.	.	.	.	.
L1[r, j]	163	163	155	165	163	156	157	139	133	133	133	133	129	133	123	123
L2[r, j]	167	129	154	165	147	137	171	139	139	139	133	133	127	133	123	123
BCPink[o, j]	167	161	163	0	147	155	121	136	133	133	133	133	129	133	123	123
LB48[o, j]	119	163	163	159	155	139	141	141	133	133	133	133	129	129	123	123
Synthetic *F. xananassa*																
FVC_8-1[n, j]	161	169	157	165	160	160	123	127	133	133	133	133	129	133	123	123
FVC_8-2[n, j]	161	161	167	165	160	0	121	127	149	133	133	133	129	133	123	123

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D2[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
FVC_8-3[n, j]	163	163	163	165	163	163	142	142	139	139	135	139	133	133	123	123
FVC_8-4[n, j]	161	167	157	159	160	160	121	127	149	133	133	133	133	133	123	123
FVC_8-5[n, j]	161	167	157	159	160	160	121	127	133	133	133	133	133	133	123	123
FVC_10-1[n, j]	161	119	0	157	160	154?	123	127?	133	133	133	133	129	133	123	123
FVC_10-2[n, j]	161	169	119	157	160	154?	123	0	133	133	133	133	129	133	123	123
FVC_11-1[n]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
FVC_11-2[n, j]	161	161	0	159	160	154	127	0	133	133	133	133	129	133	123	123
FVC_11-3[n, j]	167	161	161	159	160	0	127	0	133	149	133	133	129	133	123	123
FVC_11-4[n, j]	167	0	159	159	147	154	127	0	133	149	133	133	127	129	123	123
FVC_11-5[n, j]	167	0	159	159	147	154	127	0	133	149	133	133	127	129	123	123
FVC_11-6[n, j]	167	161	157	159	160	121	127	0	133	133	133	133	127	129	123	123
FVC_16-1[n, j]	161	167	159	157	160	127	0	121	139	139	133	133	127	133	123	123
FVC_17-1[n, j]	161	119	154	157	160	127	123	123	133	139	133	133	127	133	123	123
FVC_18-1[n, j]	169	161	119	157	160	154	123	123	139	139	133	133	127	129	123	123
FVC_28-1[n, j]	161	161	159	0	160	154	127	0	133	145	133	133	133	133	123	123
FVC_30-1[n, j]	161	161	159	167	0	160	127	0	133	133	133	133	127	129	123	123
FVC_30-2[n, j]	167	0	159	159	147	154	127	0	145	133	133	133	129	133	123	123
FVC_30-3[n, j]	167	0	159	159	147	154	127	0	133	133	133	133	133	133	123	123
FVC_30-4[n, j]	161	0	159	165	159	160	127	142	133	133	133	133	129	133	123	123
FVC_30-5[n, j]	161	161	159	169	137	160	127	0	145	133	133	133	129	133	123	123
FVC_30-6[n, j]	161	161	159	165	0	160	127	0	133	133	133	133	133	133	123	123
JH_101-1[n, j]	161	161	165	159	160	127	121	0	133	133	133	133	129	133	123	123

[z]Plant obtained from PB-WUR, NL and coded as E-60174
[y]Plant obtained from PB-WUR, NL and coded as E-71006
[x]Species *F. chiloensis*
[w]Species *F. chiloensis*, subspecies *pacifica*
[v]Species *F. iturupensis*
[u]Species *F. vesca*
[t]Species *F. vesca*, subspecies *bracteata*
[s]Species *F. vesca*, subspecies *bracteata americana*
[r]Species *F. virginiana*
[q]Species *F. virginiana*, subspecies *glauca*
[p]Species *F. virginiana*, subspecies *platypetala*
[o]Hybrid
[n]Wild derived *F. ×ananassa*
[m] Female parent
[l] Male parent
[k]NL_CF
[j]CF
[i]NL
[h]UK_CF
[g]NL_CF
[f]SP_CF
[e]FR_CF
[d]OR_CF
[c]MI_CF
[b] NCGR
[a] NCGR_CF
[za] FR
[zb] Subgenome at EMFvi136
[zc] Subgenome at Bx63
When superscripts [k] to [za], are placed in a population name, the source corresponds to the progeny of that population. Each parent has their own source

Appendix Table 3.3. Genotypes at Bx215and Bx56 of parents of the populations from multiple plants, where available, and progeny. Genotypes of parents that match those used in each cross are in bold. Alleles not present in either parent are underlined. Inferred genotypes are in italics. For each breeding population all possible parents are in the first rows with darker background, the confirmed female and male parent are indicated with superscript "m" and "l", respectively. The allelic configuration was confirmed for the European, MSU and ORUS populations only. The question mark represents configurations that are not concordant to the Mendelian segregation or needs confirmation. Missing data is represented with a dot.

	Bx215								**Bx56**							
Individual	**A1^{zb}**	**A2^{zb}**	**B1^{zb}**	**B2^{zb}**	**C1^{zb}**	**C2^{zb}**	**D1^{zb}**	**D3^{zb}**	**A1^{zc}**	**A2^{zc}**	**B1^{zc}**	**B2^{zc}**	**C1^{zc}**	**C2^{zc}**	**D1^{zc}**	**D2^{zc}**
European populations																
EMR population (Redgauntlet × Hapil)[h]																
Redgauntlet_CF[m, j]	0?	127?	136?	136?	123?	134?	0?	158?	203?	206?	209?	213?	215?	215?	0?	224?
NL population (Holiday × Korona)[g]																
H-02529	129?	136?	0?	129?	134?	134?	127?	158?	203?	224?	209?	213?	215?	215?	215?	221?
H-02572	129?	136?	129?	134?	0?	132?	127?	158?	0?	203?	209?	213?	215?	215?	215?	221?
INRA population (Capitola × CF1116)[e]																
Capitola_FR_CF[m, e]	**129**	**136**	**129**	**134**	**134**	**136**	**0**	**127**	**203**	**206**	**209**	**213**	**215**	**215**	**221**	**221**
CF1116_FR[l, za]	**127**	**136**	**127**	**134**	**136**	**138**	**0**	**158**	**203**	**203**	**213**	**213**	**215**	**215**	**0**	**221**
INRA_5	127	129	127	129	134	136	0	158	203	203	209	213	215	215	221	221
INRA_6	127	129	129	134	136	136	0	158	203	206	209	213	215	215	221	221
INRA_8	136	136	127	134	136	138	0	158	203	206	213	213	215	215	0	221
INRA_9	127	136	134	134	134	136	0	127	203	203	213	213	215	215	221	221
INRA_10	136	136	127	134	134	138	0	127	203	203	213	213	215	215	0	221
INRA_11	129	136	129	134	136	138	127	158	203	206	209	213	215	215	0	221

Individual	$A1^{zb}$	$A2^{zb}$	$B1^{zb}$	$B2^{zb}$	$C1^{zb}$	$C2^{zb}$	$D1^{zb}$	$D3^{zb}$	$A1^{zc}$	$A2^{zc}$	$B1^{zc}$	$B2^{zc}$	$C1^{zc}$	$C2^{zc}$	$D1^{zc}$	$D2^{zc}$
INRA_12	127	129	127	129	134	136	0	158	203	203	209	213	215	215	221	221
INRA_14	127	136	134	134	134	136	0	127	203	203	213	213	215	215	221	221
INRA_15	127	136	134	134	134	136	0	127	203	203	213	213	215	215	221	221
INRA_16	127	129	129	134	136	136	0	158	203	206	209	213	215	215	221	221
INRA_19	127	136	127	134	136	138	0	158	203	203	213	213	215	215	0	221
INRA_30	136	136	134	134	136	138	0	127	203	206	213	213	215	215	0	221
INRA_34	127	129	129	134	136	136	0	158	203	206	209	213	215	215	221	221
INRA_37	127	129	129	134	136	138	127	158	203	203	209	213	215	215	0	221
INRA_43	136	136	134	134	136	136	127	158	203	206	213	213	215	215	221	221
INRA_47	136	136	134	134	136	136	127	158	203	206	213	213	215	215	221	221
INRA_58	127	129	134	134	136	138	0	127	203	203	209	213	215	215	0	221
INRA_59	127	129	127	129	134	136	0	158	203	203	209	213	215	215	221	221
INRA_61	127	129	129	134	136	138	127	158	203	203	209	213	215	215	0	221
INRA_76	136	136	127	134	134	138	0	127	203	203	213	213	215	215	0	221
INRA_79	136	136	134	134	136	136	127	158	203	206	213	213	215	215	221	221
INRA_94	127	129	129	134	134	136	0	127	203	203	209	213	215	215	221	221
INRA_95	136	136	127	134	136	136	0	0	203	206	213	213	215	215	221	221
INRA_97	127	129	129	134	136	136	0	158	203	206	209	213	215	215	221	221
INRA_98	136	136	127	134	136	138	0	158	203	206	213	213	215	215	0	221
INRA_99	129	136	134	134	136	138	0	127	203	206	209	213	215	215	0	221
INRA_103	136	136	134	134	136	138	0	127	203	206	213	213	215	215	0	221
INRA_104	129	136	129	134	136	138	127	158	203	206	209	213	215	215	0	221

Individual	A1^{zb}	A2^{zb}	B1^{zb}	B2^{zb}	C1^{zb}	C2^{zb}	D1^{zb}	D3^{zb}	A1^{zc}	A2^{zc}	B1^{zc}	B2^{zc}	C1^{zc}	C2^{zc}	D1^{zc}	D2^{zc}
INRA_108	127	136	127	134	136	138	0	158	203	203	213	213	215	215	0	221
INRA_110	127	136	127	134	134	136	0	0	203	203	213	213	215	215	221	221
INRA_116	127	129	129	134	134	136	0	127	203	203	209	213	215	215	221	221
INRA_122	127	129	127	129	134	136	0	158	203	203	209	213	215	215	221	221
INRA_124	127	136	127	134	136	138	0	158	203	203	213	213	215	215	0	221
INRA_126	127	129	129	134	136	136	0	158	203	206	209	213	215	215	221	221
INRA_134	127	129	129	134	134	136	0	127	203	206	209	213	215	215	221	221
INRA_135	136	136	134	134	136	138	0	127	203	206	213	213	215	215	0	221
INRA_138	136	136	127	134	134	138	0	127	203	203	213	213	215	215	0	221
INRA_141	127	136	134	134	136	136	127	158	203	203	213	213	215	215	221	221
INRA_147	127	136	134	134	136	136	127	158	203	203	213	213	215	215	221	221
INRA_148	136	136	127	134	134	138	0	127	203	203	213	213	215	215	0	221
INRA_151	127	136	127	134	136	138	0	158	203	203	213	213	215	215	0	221
INRA_153	127	129	129	134	136	138	127	158	203	203	209	213	215	215	0	221
INRA_157	129	136	134	134	136	138	0	127	203	206	209	213	215	215	0	221
INRA_161	127	136	134	134	134	136	0	127	203	203	213	213	215	215	221	221
INRA_165	127	129	129	134	134	136	0	127	203	203	209	213	215	215	221	221
INRA_167	136	136	134	134	136	138	0	127	203	206	213	213	215	215	0	221
INRA_172	127	136	127	134	136	138	0	158	203	203	213	213	215	215	0	221
INRA_175	127	129	129	134	134	138	0	127	203	203	209	213	215	215	0	221
INRA_181	127	136	134	134	134	136	0	127	203	203	213	213	215	215	221	221
INRA_195	127	136	134	134	136	136	127	158	203	203	213	213	215	215	221	221

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D3[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
INRA_196	127	129	129	134	136	138	127	158	203	203	209	213	215	215	0	221
INRA_197	129	136	134	134	136	138	0	127	203	206	209	213	215	215	0	221
INRA_201	136	136	134	134	136	138	0	127	203	206	213	213	215	215	0	221
INRA_204	127	136	134	134	136	136	127	158	203	203	213	213	215	215	221	221
INRA_216	127	136	134	134	136	136	127	158	203	203	213	213	215	215	221	221
MSU populations																
MSU_9-2 population (MSU_49 × Seascape)[c]																
MSU_49[m, j]	**129**	**136**	**129**	**138**	**127**	**127**	**158**	**160**	**203**	**203**	**209**	**209**	**215**	**215**	**215**	**221**
Seascape_CF[l, j]	**129**	**136**	**129**	**134**	**136**	**143**	**0**	**134**	**197**	**206**	**209**	**213**	**215**	**215**	**221**	**221**
MSU_9-2-1	136	136	0?	134	127	136	134	158	203	206	209	213	215	215	221	221
MSU_9-2-2	129	136	129	138	127	143	134	158	197	203	209	213	215	215	215	221
MSU_9-2-3	129	136	129	138	127	136	134	160	203	206	209	209	215	215	215	221
MSU_9-2-4	129	129	129	134	127	143	0	158	197	203	209	209	215	215	221	221
MSU_9-2-5	129	129	129	138	127	143	134	160	197	203	209	209	215	215	215	221
MSU_9-2-6	129	136	129	138	127	136	134	160	203	206	209	209	215	215	215	221
MSU_9-2-7	129	136	129	134	127	136	0	160	203	206	209	213	215	215	221	221
MSU_9-2-8	136	136	134	138	127	143	0	160	197	203	209	213	215	215	215	221
MSU_9-2-9	136	136	134	138	127	136	0	158	203	206	209	213	215	215	215	221
MSU_9-2-10	136	136	0?	134	127	143	134	160	197	203	209	213	215	215	221	221
MSU_9-3 population (MSU_49 × Tribute)[c]																
MSU_49[m, j]	**129**	**136**	**129**	**138**	**127**	**127**	**158**	**160**	**203**	**203**	**209**	**209**	**215**	**215**	**215**	**221**

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D3[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
Tribute_662.001[l, b]	**129**	**136**	**0**	**129**	**134**	**158**	**127**	**138**	**0**	**203**	**209**	**213**	**215**	**215**	**0**	**215**
MSU_9-3-1	129	136	129	138	127	158	127	158	203	203	209	209	215	215	0	215
MSU_9-3-2	136	136	0	138	127	136?	158	160	0	203	209	213	215	215	0	215
MSU_9-3-3	**126**	136	**126**	129	0	127	**0**	160	203	**206**	209	213	215	215	**219**	221
MSU_9-3-4	129	129	129	129	127	158	127	158	203	203	209	209	215	215	0	215
MSU_9-3-5	126	136	126	129	127	158	0	160	203	**206**	209	209	215	215	0	**219**
MSU_9-3-6	136	136	138	**126**	**0**	127	127	160	203	203	209	209	215	215	0	**219**
MSU_9-3-7	129	129	129	138	127	134	127	158	203	203	209	209	215	215	215	221
MSU_9-3-8	129	136	0	129	127	158	138	158	0	203	209	209	215	215	0	215
MSU_9-3-9	129	136	138	**126**	**127**	127	**0**	160	203	203	209	209	215	215	0	**219**
MSU_9-3-10	129	136	0	129	127	134	138	158	203	203	209	213	215	215	215	221
MSU_9-6 population (Earliglow × Seascape)[c]																
Earliglow_CF[m, j]	**0**	**129**	**129**	**136**	**123**	**127**	**134**	**160**	**203**	**206**	**209**	**213**	**215**	**215**	**221**	**221**
Seascape_CF[l, j]	**129**	**136**	**129**	**134**	**136**	**143**	**0**	**134**	**197**	**206**	**209**	**213**	**215**	**215**	**221**	**221**
MSU_9-6-1	129	129	129	134	123	143	0	160	197	206	209	209	215	215	221	221
MSU_9-6-2	136?	136?	134	123?	123?	136	0	160	206	206	213	213	215	215	221	221
MSU_9-6-3	0	136	134	136	123	143	0	160	197	206	213	213	215	215	221	221
MSU_9-6-4	129	129	134	136	123	143	0	134	197	206	209	213	215	215	221	221
MSU_9-6-5	129	129	129	134	123	136	0	134	206	206	209	209	215	215	221	221
MSU_9-6-6	0	136	134	136	123	143	0	160	197	206	213	213	215	215	221	221
MSU_9-6-7	129	136	129	134	123	143	0	160	197	206	209	213	215	215	221	221
MSU_9-6-8	129	129	129	134	123	136	0	160	203	206	209	213	215	215	221	221

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D3[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
MSU_9-6-9	129	129	129	134	0?	143	0	134	197	203	209	209	215	215	221	221
MSU_9-6-10	0	129	129	129	0?	123	134	134	206	206	209	209	215	215	221	221
MSU_9-8 population (Fort Laramie × Earliglow)[c]																
FortLaramie_NCGR[m, b]	**127**	**129**	**160**	**129**	**143**	**129**	**0**	**127**	**203**	**203**	**209**	**209**	**215**	**215**	**0**	**221**
Earliglow_CF[l, j]	**0**	**129**	**129**	**136**	**123**	**127**	**134**	**160**	**203**	**206**	**209**	**213**	**215**	**215**	**221**	**221**
MSU_9-8-2	129	129	160	129	127	129	0	160	203	203	209	209	215	215	221	221
MSU_9-8-4	129	129	160	129	129	123	0	160	203	206	209	209	215	215	221	221
MSU_9-8-7	129	129	129	129	123	143	0	160	203	206	209	209	215	215	221	221
MSU_9-8-10	0	129	129	129	129	123	0	134	203	206	209	209	215	215	221	221
MSU_9-9 population (Fort Laramie × Honeoye)[c]																
FortLaramie_NCGR[m, b]	**127**	**129**	**160**	**129**	**143**	**129**	**0**	**127**	**203**	**203**	**209**	**209**	**215**	**215**	**0**	**221**
Honeoye_215.001[l, b]	**127**	**136**	**0**	**136**	**0**	**127**	**126**	**158**	**203**	**203**	**213**	**213**	**215**	**219**	**219**	**221**
MSU_9-9-1	129	136	0	129	127	143	126	127	203	203	209	213	215	215	0	221
MSU_9-9-2	127	129	129	136	0	143	127	158	203	203	209	213	215	215	0	221
MSU_9-9-3	129	136	0	129	127	143	126	127	203	203	209	213	215	219	219	221
MSU_9-9-4	129	136	129	136	127	143	126	127	203	203	209	213	215	219	219	221
MSU_9-9-5	129	136	129	136	127	143	127	158	203	203	209	213	215	215	0	221
MSU_9-9-6	129	136	0	160	127	129	126	127	203	203	209	213	215	219	219	221
MSU_9-9-7	127	129	129	136	0	143	127	158	203	203	209	213	215	215	0	?
MSU_9-9-8	129	136	0	160	127	129	126	127	203	203	209	213	215	219	219	221
MSU_9-9-9	129	136	129	136	127	143	127	158	203	203	209	213	215	215	0	221
MSU_9-9-10	127	129	129	136	0	143	127	158	203	203	209	213	215	215	0	221

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D3[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
MSU_9-10 population (Fort Laramie × MSU_49)[c]																
FortLaramie_NCGR[m, b]	**127**	**129**	**160**	**129**	**143**	**129**	**0**	**127**	**203**	**203**	**209**	**209**	**215**	**215**	**0**	**221**
MSU_49[l, j]	**129**	**136**	**129**	**138**	**127**	**127**	**158**	**160**	**203**	**203**	**209**	**209**	**215**	**215**	**215**	**221**
MSU_9-10-1	127	129	129	**136**	127	**134**	0	127	203	**206**	209	209	215	215	0	**226**
MSU_9-10-2	127	136	129	129	127	143	0	160	203	203	209	209	215	215	215	221
MSU_9-10-3	129	129	160	138	127	129	127	160	203	203	209	209	215	215	0	215
MSU_9-10-4	127	136	129	129	127	143	0	158	203	203	209	209	215	215	215	221
MSU_9-10-5	127	136	160	129	127	129	0	158	203	203	209	209	215	215	215	221
MSU_9-10-6	127	136	129	129	127	143	0	160	203	203	209	209	215	215	215	221
MSU_9-10-7	129	136	129	138	127	143	127	158	203	203	209	209	215	215	0	215
MSU_9-10-8	129	136	160	138	127	129	127	158	203	203	209	209	215	215	0	215
MSU_9-10-9	129	129	160	129	127	129	127	158	203	203	209	209	215	215	215	221
MSU_9-10-10	129	129	160	138	127	129	127	158	203	203	209	209	215	215	0	215
MSU_9-11 population (Fort Laramie × MSU_56)[c]																
FortLaramie_NCGR[m, b]	**127**	**129**	**160**	**129**	**143**	**129**	**0**	**127**	**203**	**203**	**209**	**209**	**215**	**215**	**0**	**221**
MSU_56[l, j]	**127**	**136**	**0**	**136**	**136**	**160**	**127**	**158**	**203**	**215**	**213**	**213**	**215**	**219**	**0**	**219**
MSU_9-11-2	127	129	160	136	136	129	0	158	203	203	209?	0	215	215	219?	219
MSU_9-11-4	129	136	129	136	143	160	0	127	203	203	209	219?	215	215	215?	221?
MSU_9-12 population (Honeoye × FRA_1702)[c]																
Honeoye_215.001[m, b]	127	136	0	136	0	127	126	158	203	203	213	213	215	219	219	221
FRA_1702_I2[l]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MSU_9-12-3	127?	129?	0?	136?	0?	143?	126?	134?	197?	203?	209?	213?	215?	219?	219?	221?

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D3[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
MSU_9-13 population (Seascape × Honeoye)[c]																
Seascape_CF[m, j]	**129**	**136**	**129**	**134**	**136**	**143**	**0**	**134**	**197**	**206**	**209**	**213**	**215**	**215**	**221**	**221**
Honeoye_215.001[l, b]	**127**	**136**	**0**	**136**	**0**	**127**	**126**	**158**	**203**	**203**	**213**	**213**	**215**	**219**	**219**	**221**
MSU_9-13-1	136	136	0	134	127	136	0	126	203	206	213	213	215	219	219	221
MSU_9-13-2	129	136	0	134	127	136	0	126	203	206	209	213	215	219	219	221
MSU_9-13-3	129	136	0	129	127	143	126	134	197	203	209	213	215	219	219	221
MSU_9-13-4	129	136	129	134	127	143	0	158	197	203	209	213	215	215	221	221
MSU_9-13-5	129	136	0	129	127	143	126	134	197	203	209	213	215	219	219	221
MSU_9-13-6	136	136	0	134	127	136	0	126	203	206	213	213	215	219	219	221
MSU_9-13-7	136	136	0	134	127	143	0	126	197	203	213	213	215	219	219	221
MSU_9-13-8	127	136	134	136	136	136	0	158	203	206	213	213	215	215	221	221
MSU_9-13-9	127	136	134	136	136	136	0	158	203	206	213	213	215	215	221	221
MSU_9-13-10	129	136	0	129	127	143	126	134	197	203	209	213	215	219	219	221
MSU_9-14 population (Seascape × MSU_56)[c]																
Seascape_CF[m, j]	**129**	**136**	**129**	**134**	**136**	**143**	**0**	**134**	**197**	**206**	**209**	**213**	**215**	**215**	**221**	**221**
MSU_56[l, j]	**127**	**136**	**0**	**136**	**136**	**160**	**127**	**158**	**203**	**215**	**213**	**213**	**215**	**219**	**0**	**219**
MSU_9-14-1	136	136	134	136	136	160	0	127	203	206	213	213	215	215	221	221
MSU_9-14-2	127	129	0	129	136	136	134	158	203	206	209	213	215	219	219	221
MSU_9-14-3	136	**128**	134	136	**0**	136	0	158	206	215	209	213	215	**217**	221	221
MSU_9-14-4	129	136	0	129	143	160	127	134	197	203	209	213	215	215	0	221
MSU_9-14-7	129	136	0	129	143	160	127	134	197	203	209	213	215	215	0	221

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D3[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
MSU_9-15 population (Tribute × Earliglow)[c]																
Tribute_662.001[m, b]	**129**	**136**	**0**	**129**	**134**	**158**	**127**	**138**	**0**	**203**	**209**	**213**	**215**	**215**	**0**	**215**
Earliglow_CF[l, j]	**0**	**129**	**129**	**136**	**123**	**127**	**134**	**160**	**203**	**206**	**209**	**213**	**215**	**215**	**221**	**221**
MSU_9-15-1	0	136	129	136	127	134	127	134	203	203	209	213	215	215	0	221
MSU_9-15-2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MSU_9-15-3	0	129	129	136	123	158	138	160	203	206	209	213	215	215	215	221
MSU_9-15-4	0	136	0	136	127	158	138	160	0	203	213	213	215	215	215	221
MSU_9-15-5	0	129	129	136	127	158	138	160	203	203	209	209	215	215	0	?
MSU_9-15-6	129	129	0	129	123	158	127	134	203	206	209	209	215	215	0	221
MSU_9-15-7	129	136	0	129	123	158	134	138	0	206	209	213	215	215	215	221
MSU_9-15-8	0	129	129	129	127	134	138	160	203	203	209	209	215	215	0	221
MSU_9-15-9	0	129	129	136	127	134	138	160	203	203	209	213	215	215	0	221
MSU_9-15-10	129	129	0	129	123	158	134	138	0	206	209	209	215	215	215	221
MSU_9-16 population (Tribute × Honeoye)[c]																
Tribute_662.001[m, b]	**129**	**136**	**0**	**129**	**134**	**158**	**127**	**138**	**0**	**203**	**209**	**213**	**215**	**215**	**0**	**215**
Honeoye_215.001[l, b]	**127**	**136**	**0**	**136**	**0**	**127**	**126**	**158**	**203**	**203**	**213**	**213**	**215**	**219**	**219**	**221**
MSU_9-16-1	129	136	129	136	0	134	127	158	0	203	209	213	215	215	215	221
MSU_9-16-2	129	136	0	129	127	134	126	127	203	203	209	213	215	219	0	219
MSU_9-16-3	129	136	129	136	0	158	127	158	0	203	209	213	215	215	215	221
MSU_9-16-4	129	136	0	136	127	134	126	127	0	203	209	213	215	215	**0**	**219**
MSU_9-16-5	129	136	0	129	127	158	126	127	0	203	209	213	215	219	215	219
MSU_9-16-6	127	136	0	129	127	158	126	138	0	203	209	213	215	219	215	219

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D3[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
MSU_9-16-7	129	136	0	129	0	134	126	127	0	203	209	213	215	219	0	219
MSU_9-16-8	136	136	0	136	127	158	127	158	203	**209**	209	213	215	215	0	**206**
MSU_9-16-9	129	136	0	129	127	158	127	158	0	203	209	213	215	215	215	219
MSU_9-16-10	136	136	0	136	127	134	126	127	203	203	213	213	215	219	0	219
MSU_9-16-13	129	136	129	136	0	158	126	127	0	203	209	213	215	219	215	219
MSU_9-16-18	129	136	0	129	127	134	138	158	0	203	209	213	215	215	215	221
MSU_9-16-23	127	129	129	136	0	134	127	158	203	203	209	213	215	215	0	215
MSU_9-16-24	127	129	0	136	127	134	138	158	203	203	209	213	215	215	0	215
MSU_9-16-26	127	136	0	129	127	134	126	138	203	203	209	213	215	219	0	219
MSU_9-16-32	127	136	0	129	0	134	126	138	0	203	209	213	215	219	0	219
MSU_9-16-37	127	136	0	129	0	134	126	138	0	203	209	213	215	219	0	219
MSU_9-16-43	127	136	0	129	0	134	126	138	0	203	209	213	215	219	0	219
MSU_9-16-52	129	136	0	129	0	134	126	127	0	203	209	213	215	219	0	219
MSU_9-16-64	129	136	0	129	0	134	126	127	0	203	209	213	215	219	0	219
MSU_9-17 population (Tribute × MSU_56)[c]																
Tribute_662.001[m, b]	**129**	**136**	**0**	**129**	**134**	**158**	**127**	**138**	**0**	**203**	**209**	**213**	**215**	**215**	**0**	**215**
MSU_56[l, j]	**127**	**136**	**0**	**136**	**136**	**160**	**127**	**158**	**203**	**215**	**213**	**213**	**215**	**219**	**0**	**219**
MSU_9-17-1	136	136	0	136	136	158	127	158	0	203	213	213	215	219	**0**	**219**
MSU_9-17-2	136	136	136	**126**	**126**	134	**0**	127	0	203	213	213	215	219	**0**	**219**
MSU_9-17-3	127	136	0	136	136	158	138	158	0	203	213	213	215	215	0	215
MSU_9-17-4	127	129	0	129	136	158	138	158	0	203	209	213	215	219	**0**	**219**
MSU_9-17-6	136	136	0	136	134	160	?	127	0	203	213	213	215	215	0	215

Individual	A1^{zb}	A2^{zb}	B1^{zb}	B2^{zb}	C1^{zb}	C2^{zb}	D1^{zb}	D3^{zb}	A1^{zc}	A2^{zc}	B1^{zc}	B2^{zc}	C1^{zc}	C2^{zc}	D1^{zc}	D2^{zc}
MSU_9-17-7	127	136	0	136	134	160	127	138	203	203	213	213	215	215	0	215
MSU_9-17-8	136	136	0	0	134	160	127	138	0	203	213	213	215	215	0	215
MSU_9-17-9	129	136	0	129	134	160	127	127	203	203	209	213	215	215	0	215
MSU_9-17-10	129	136	0	129	134	160	127	127	203	203	209	213	215	215	0	215
MSU_9-18 population (Seascape × Fort Laramie)[c]																
Seascape_CF[m, j]	129	136	129	134	136	143	0	134	**197**	**206**	**209**	**213**	**215**	**215**	**221**	**221**
FortLaramie_I1[l]	*0*	*127*	*136*	*136*	*134*	*143*	*0*	*143*	***203***	***206***	***213***	***213***	***215***	***215***	***0***	***221***
MSU_9-18-1	0	136	134	136	143	136	0	0	206	206	213	213	215	215	221	221
MSU_9-18-2	0	136	134	136	143	143	0	0	197	206	213	213	215	215	221	221
MSU_9-18-3	0	129	129	136	143	136	0	134	206	206	209	213	215	215	221	221
MSU_9-18-4	0	129	129	136	143	136	0	134	197	206	209	213	215	215	221	221
MSU_9-18-5	127	136	134	136	143	136	0	0	203	206	213	213	215	215	221	221
MSU_9-18-6	127	136	129	136	134	143	0	0	203	206	209	213	215	215	221	221
MSU_9-18-7	127	129	129	136	143	136	0	134	203	206	209	213	215	215	221	221
MSU_9-18-8	0	136	129	136	143	143	0	134	197	206	209	213	215	215	221	221
MSU_9-18-9	127	136	129	136	134	143	0	0	203	206	209	213	215	215	221	221
MSU_9-18-10	0	136	134	136	143	143	0	0	197	206	213	213	215	215	221	221
ORUS populations																
ORUS_3278 population (ORUS 2427-1× Seascape)[d]																
ORUS 2427-1_CF_1-22[m, j]	**127**	**136**	**136**	**138**	**0**	**134**	**134**	**123**	**203**	**206**	**209**	**213**	**215**	**215**	**0**	**221**
Seascape_CF[l, j]	**129**	**136**	**129**	**134**	**136**	**143**	**0**	**134**	**197**	**206**	**209**	**213**	**215**	**215**	**221**	**221**

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D3[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS_3278-1	127	136	134	136	0	136	0	134	203	206	209	213	215	215	221	221
ORUS_3278-4	127	129	129	136	0	143	134	134	197	203	209	213	215	215	221	221
ORUS_3278-5	127	136	134	136	0	136	0	134	203	206	213	213	215	215	221	221
ORUS_3278-6	127	136	134	136	0	136	0	134	203	206	209	213	215	215	221	221
ORUS_3278-7	127	136	134	136	0	143	0	134	197	203	209	213	215	215	0	221
ORUS_3278-8	127	136	134	136	0	136	0	134	203	206	213	213	215	215	221	221
ORUS_3278-9	136	136	134	136	0	143	0	134	197	206	209	213	215	215	221	221
ORUS_3278-10	136	136	134	136	0	143	0	134	197	206	209	213	215	215	221	221
ORUS_3278-12	129	136	134	136	0	143	0	134	197	206	209	213	215	215	221	221
ORUS_3278-13	127	136	134	136	0	136	0	134	203	206	209	213	215	215	221	221
ORUS_3279 population (ORUS 2427-1× Tribute)[d]																
ORUS 2427-1_CF_1-22[m, j]	**127**	**136**	**136**	**138**	**0**	**134**	**134**	**123**	**203**	**206**	**209**	**213**	**215**	**215**	**0**	**221**
Tribute_662.001[l, b]	**129**	**136**	**0**	**129**	**134**	**158**	**127**	**138**	**0**	**203**	**209**	**213**	**215**	**215**	**0**	**215**
ORUS_3279-3	127	136	0	136	0	158	134	138	203	206	209	213	215	215	0	0
ORUS_3279-4	129	136	0?	129	0	134	127	134	0	203	209	213	215	215	0	221
ORUS_3279-5	136	136	0	136	0	158	127	134	0	203	209	213	215	215	215	221
ORUS_3279-6	136	136	0	136	134	158	127	134	0	203	209	213	215	215	0	215
ORUS_3279-7	129	136	0	136	0	134	134	138	0	206	209	213	215	215	0	215
ORUS_3279-8	136	136	0	136	158?	158	0	134	0	221?	209	213	215	215	215	215
ORUS_3279-9	136	136	0	136	134	158	127	134	203	206	213	213	215	215	0	0
ORUS_3279-13	136	136	129	138	0	134	127	134	203	206	209	209	215	215	0	0
ORUS_3279-14	129	136	0	136	0	134	134	138	0	206	209	213	215	215	0	221

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D3[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS_3279-15	136	136	0	136	0	158	134	138	0	206	209	213	215	215	0	215
ORUS_3305 population (Tillamook × Seascape)[d]																
Tillamook_CF[d]	**0**	136	**127**	136	134	**136**	**0**	**134**	**203**	206	209	213	215	215	**0**	221
Tillamook_NCGR[m, b]	**123**	**136**	**0**	**136**	**134**	**158**	**138**	**136**	**206**	**206**	**209**	**213**	**215**	**215**	**221**	**221**
Seascape_CF[l, j]	**129**	**136**	**129**	**134**	**136**	**143**	**0**	**134**	**197**	**206**	**209**	**213**	**215**	**215**	**221**	**221**
ORUS_3305-1	136	136	134	136	136	158	0	138	206	206	213	213	215	215	221	221
ORUS_3305-2	129	136	0	129	134	158	0	136	206	206	209	209	215	215	221	221
ORUS_3305-3	129	136	0	134	136	158	0	138	206	206	209	213	215	215	221	221
ORUS_3305-5	136	136	0	134	143	158	0	136	197	206	209	213	215	215	221	221
ORUS_3305-6	129	136	0	129	134	158	0	136	206	206	209	209	215	215	221	221
ORUS_3305-7	129	123	0	134	134	143	0	136	197	206	209	213	215	215	221	221
ORUS_3305-10	136	136	134	136	143	158	0	138	197	206	209	213	215	215	221	221
ORUS_3305-11	136	136	0	134	134	136	0	136	206	206	213	213	215	215	221	221
ORUS_3305-13	136	136	134	136	143	158	0	138	197	206	209	213	215	215	221	221
ORUS_3305-14	129	136	0	134	134	143	0	138	197	206	209	213	215	215	221	221
ORUS_3315 population (Fort Laramie × Puget Reliance)[d]																
FortLaramie_NCGR[b]	**127**	**129**	**160**	**129**	**143**	**129**	**0**	**127**	203	203	209	209	215	215	0	221
FortLaramie_I3[m]	***136***	***136***	***0***	***136***	***0***	***138***	***0***	***160***	***203***	***203***	***209***	***209***	***215***	***215***	***0***	***221***
Puget Reliance_CF[l, j]	***136***	***136***	***0***	***123***	***0***	***143***	***127***	***158***	***203***	***206***	***209***	***213***	***215***	***215***	***0***	***221***
ORUS_3315-1	136	136	0	123	143	138	127	160	203	206	209	213	215	215	215	221
ORUS_3315-2	136	136	0	136	143	138	127	160	203	206	209	213	215	215	215	221
ORUS_3315-4	136	136	0	136	143	138	127	160	203	206	209	213	215	215	215	221

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D3[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS_3315-6	136	136	0	123	143	138	127	158	203	206	209	213	215	215	215	221
ORUS_3315-10	136	136	0	0	143	138	127	160	203	203	209	213	215	215	215	221
ORUS_3315-11	136	136	0	123	0	138	0	160?	206	206?	209	0	215	215	215	221
ORUS_3315-12	136	136	136	123	143	138	127	160	203	206	209	213	213?	215?	215?	215
ORUS_3315-13	136	136	0	136	143	138	127	158	203	206	209	213	215	215	215	221
ORUS_3315-14	136	136	0	123	143	138	127	160	203	206	209	213	215	215	215	221
ORUS_3315-15	136	136	0	0	0	138	127	160	203	203	209	213	215	215	215	221
ORUS_3316 population (Fort Laramie × Totem)[d]																
FortLaramie_NCGR[b]	127	129	160	129	143	129	0	127	203	203	209	209	215	215	0	221
FortLaramie_I1[m]	***0***	***127***	***136***	***136***	***134***	***143***	***0***	***143***	***203***	***206***	***213***	***213***	***215***	***215***	***0***	***221***
Totem_CF[l, j]	***127***	***136***	***0***	***138***	***0***	***138***	***134***	***160***	***203***	***206***	***209***	***209***	***215***	***215***	***0***	***215***
ORUS_3316-1	0	127	136	138	143	138	0	134	203	203	209	213	215	215	0	221
ORUS_3316-2	127	136	136	138	143	138	0	160	203	206	209	213	215	215	215	221
ORUS_3316-3	127	136	136	138	143	138	0	160	203	203	209	213	215	215	215	221
ORUS_3316-4	0	127	136	138	0	138?	0	160	203	203	209	213	215	215	0	215
ORUS_3316-5	127	136	136	138	134	138	0	160	203	203	209	213	215	215	0	221
ORUS_3316-7	127	136	136	138	143	138	0	160	203	206	209	213	215	215	215	221
ORUS_3316-9	127	136	0	136	0	143	0	134	203	203	209	213	215	215	0	221
ORUS_3316-10	127	136	136	138	143	138	0	134	203	206	209	213	215	215	0	221
ORUS_3318 population (Puget Reliance × Sarian)[d]																
Puget Reliance_I1[m]	***136***	***127***	***136***	***123***	***143***	***138***	***158***	***160***	***203***	***206***	***209***	***213***	***215***	***215***	***0***	***221***
Sarian_CF[l,j]	**0**	**136**	**127**	**134**	**123**	**134**	**0**	**136**	**203**	**206**	**213**	**213**	**215**	**215**	**0**	**221**

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D3[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS_3318-1	127	136	127	136	134	138	0	160	203	203	209	213	215	215	0	221
ORUS_3318-2	127	136	127	136	134	138	0	160	203	203	209	213	215	215	221	221
ORUS_3318-4	123?	136	136	138?	123	138	0	158	206	206	209	209?	215	215	215?	221
ORUS_3318-6	0	123?	127	136	134	138	158	136	203	206	209	213	215	215	0	221
ORUS_3318-8	127	136	127	136	134	138	0	160	203	203	209	213	215	215	221	221
ORUS_3318-9	127	136	127	136	134	138	0	160	203	203	209	213	215	215	0	221
ORUS_3318-10	123?	136	134	136	123	138	0	160	206	206	209	213	215	215	0	221
ORUS_3318-11	127	136	127	136	134	138	0	160	203	203	209	213	215	215	221	221
ORUS_3318-12	123?	136	134	136	123	138	0	160	206	206	209	213	215	215	0	221
ORUS_3318-14	136	136	127	138?	123	138	158	160	203	206	209	209?	215	215	0	215?
ORUS_3319 population (Sarian × ORUS 2427-1)[d]																
Sarian_CF[m, j]	**0**	**136**	**127**	**134**	**123**	**134**	**0**	**136**	**203**	**206**	**213**	**213**	**215**	**215**	**0**	**221**
ORUS 2427_I1[l]	***0***	***136***	***134***	***136***	***123***	***143***	***126***	***160***	***197***	***206***	***209***	***213***	***215***	***219***	***219***	***221***
ORUS_3319-5	0	136	127	136	143	134	126	0	197	203	209	213	215	219	0	219
ORUS_3319-6	136	136	127	134	0?	134	0?	136	203	206	209	213	215	215	221	221
ORUS_3319-7	0	136	127	136	134	123	0	160	203	206	209	213	215	215	0	221
ORUS_3319-8	0	136	134	136	123	123	0	126	206	206	213	213	215	219	219	221
ORUS_3320 population (Sarian × Totem)[d]																
Sarian_CF[m, j]	**0**	**136**	**127**	**134**	**123**	**134**	**0**	**136**	**203**	**206**	**213**	**213**	**215**	**215**	**0**	**221**
Totem_CF[l, j]	***127***	***136***	***0***	***138***	***0***	***138***	***134***	***160***	***203***	***206***	***209***	***209***	***215***	***215***	***0***	***215***
ORUS_3320-1	136	136	0	134	132	128	0	136	211	206	209	209	215	**219**	0	**219**
ORUS_3320-2	127	136	134	138	123	138	0	134	203	206	209	213	215	215	0	221

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D3[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS_3320-3	0	127	127	138	134	138	160	136	203	203	209	213	215	215	0	215
ORUS_3320-4	127	136	0	127	134	138	160	136	203	203	209	213	215	215	0	221
ORUS_3320-5	127	136	0	134	123	138	134	136	.	.	.	.	.	.	.	.
ORUS_3320-9	.	.	.	.	.	.	.	.	203	203	209	213	215	215	0	221
ORUS_3320-10	127	136	134	138	123	138	0	160	203	206	209	213	215	215	0	221
ORUS_3321 population (Sarian × Tillamook)[d]																
Tillamook_1819.001 [b]	**123**	136	**0**	136	134	**158**	**138**	**136**	**206**	206	209	213	**215**	215	**221**	221
Sarian_2691.1 [b]	**129**	136	**129**	134	**0**	134	0	**127**	203	**214**	**209**	213	215	215	**221**	221
Sarian_CF[m, j]	**0**	**136**	**127**	**134**	**123**	**134**	**0**	**136**	**203**	**206**	**213**	**213**	**215**	**215**	**0**	**221**
Tillamook_CF[l, j]	**0**	**136**	**127**	**136**	**134**	**136**	**0**	**134**	**203**	**206**	**209**	**213**	**213**	**215**	**0**	**221**
ORUS_3321-6	136	136	127	127	134	134	0	**155**	203	203	213	213	215	215	0	221
ORUS_3321-7	0	136	127	136	**123**	**138**	**134**	**158**	203	206	209	213	215	215	0	0
ORUS_3321-8	136	136	0	0	**123**	**155**	134	134	0?	206?	213	213	215	215	0	0
ORUS_3321-9	136	136	127	136	134	134	0	**155**	0?	203?	213	213	215	215	215?	221?
ORUS_3322 population (Seascape × ORUS 2427-1)[d]																
ORUS 2427-1_CF_1-22 [d]	**127**	136	136	**138**	**0**	**134**	**134**	**123**	**203**	206	209	213	215	215	**0**	221
Seascape_CF[m, j]	**129**	**136**	**129**	**134**	**136**	**143**	**0**	**134**	**197**	**206**	**209**	**213**	**215**	**215**	**221**	**221**
ORUS 2427_I1[l]	***0***	***136***	***134***	***136***	***123***	***143***	***126***	***160***	***197***	***206***	***209***	***213***	***215***	***219***	***219***	***221***
ORUS_3322-2	0	129	129	136	143	136	0	160	197	206	209	209	215	215	221	221
ORUS_3322-4	0	136	134	136	123	143	0	126	197	206	213	213	215	219	219	221
ORUS_3322-5	129	136	129	134	143	143	0	160	197	197	209	209	215	215	0?	221
ORUS_3322-7	136	136	134	136	123	143	0	160	197	206	213	213	215	215	221	221

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D3[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS_3322-8	0	136	134	136	143	143	0	126	197	197	213	213	215	219	219	221
ORUS_3322-9	129	136	129	134	123	136	0	160	206	206	209	209	215	215	0?	221
ORUS_3322-11	0	136	134	136	136	136	0?	136	206	206	213	213	215	215	221	221
ORUS_3322-12	0	136	134	136	123	136	0	160	206	206	209	213	215	215	0?	221
ORUS_3322-13	129	136	129	134	143	143	0	126	197	197	209	213	215	219	219	221
ORUS_3322-14	129	136	129	134	143	143	0	160	197	197	209	213	215	215	221	221
ORUS_3323 population (Seascape × Puget Reliance)[d]																
Seascape_CF[m, j]	**129**	**136**	**129**	**134**	**136**	**143**	**0**	**134**	**197**	**206**	**209**	**213**	**215**	**215**	**221**	**221**
Puget Reliance_I1[l]	***127***	***136***	***136***	***123***	***143***	***138***	***158***	***160***	***203***	***206***	***209***	***213***	***215***	***215***	***0***	***221***
ORUS_3323-1	127	136	134	136	136	138	0	160	203	206	209	213	215	215	0	221
ORUS_3323-2	136	136	134	123	136	138	0	158	206	206	209	213	215	215	0	221
ORUS_3323-3	136	136	134	136	127?	136?	0	158	203	206	213	213	215	215	221	221
ORUS_3323-4	129	136	129	123	136	138	134	158	206	206	209	209	215	215	0	221
ORUS_3323-6	129	136	129	123	136	138	134	158	206	206	209	209	215	215	0	221
ORUS_3323-7	136	136	134	136	127?	136?	0	158	203	206	213	213	215	215	221	221
ORUS_3323-9	127	136	134	136	143	143	0?	136?	197	203	213	213	215	215	221	221
ORUS_3323-12	127	136	134	136	136	138	0	158	203	206	209	213	215	215	0	221
ORUS_3323-13	127	136	134	136	0?	143?	0	158	197	203	213	213	215	215	221	221
ORUS_3323-14	127	136	134	136	136	138	0	160	203	206	209	213	215	215	0	221
ORUS_3324 population (Tillamook × Fort Laramie)[d]																
Tillamook_NCGR[b]	**123**	136	**0**	136	134	**158**	**138**	**136**	**206**	206	209	213	215	215	**221**	221
Tillamook_CF[m, j]	**0**	**136**	**127**	**136**	**134**	**136**	**0**	**134**	**203**	**206**	**209**	**213**	**215**	**215**	**0**	**221**

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D3[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
FortLaramie_I1[l]	***0***	***127***	***136***	***136***	***134***	***143***	***0***	***143***	***203***	***206***	***213***	***213***	***215***	***215***	***0***	***221***
ORUS_3324-1	127	136	136	136	134	143	0	0	203	206	213	213	215	215	221	221
ORUS_3324-3	127	136	136	136	134	136	0	0	203	206	209	213	215	215	221	221
ORUS_3324-4	0	136	136	136	134	136	0	0	206	206	213	213	215	215	0	221
ORUS_3324-9	0	136	136	136	136	143	0	134	206	206	209	213	215	215	0	221
ORUS_3324-10	127	136	136	136	136	143	0	134	203	206	209	213	215	215	0	221
ORUS_3324-11	0	136	136	136	136	143	0	134	206	206	209	213	215	215	221	221
ORUS_3324-12	0	136	136	136	136	143	0	134	206	206	209	213	215	215	0	221
ORUS_3324-13	0	136	136	136	134	136	0	0	206	206	209	213	215	215	221	221
ORUS_3324-15	127	127	136	136	134	143	0	0	203	203	213	213	215	215	221	221
ORUS_3325 population (Tillamook × Tribute)[d]																
Tillamook_NCGR[b]	**123**	136	**0**	136	134	**158**	**138**	**136**	**206**	206	209	213	**215**	215	**221**	221
Tillamook_CF[m, j]	**0**	**136**	**127**	**136**	**134**	**136**	**0**	**134**	**203**	**206**	**209**	**213**	**213**	**215**	**0**	**221**
Tribute_662.001[l, b]	**129**	**136**	**0**	**129**	**134**	**158**	**127**	**138**	**0**	**203**	**209**	**213**	**215**	**215**	**0**	**215**
ORUS_3325-2	136	136	0	136	134	158	127	134	0	203	213	213	215	215	0	221
ORUS_3325-4	136	136	0	136	134	134	0	127	203	206	213	213	215	215	0	0
ORUS_3325-5	136	136	0	136	134	158	127?	138	203	206	213	213	215	215	0	221
ORUS_3325-8	136	136	0	136	134	158	0	127	203	203	213	213	215	215	0	221
ORUS_3325-9	136	136	0	127	134	158	0	138	203	203	213	213	215	215	0	0
ORUS_3325-10	129	136	127	129	134	158	0	138	203	203	209	213	215	215	0	0
ORUS_3325-11	136	136	0	136	134	158	0?	134	0	206	209	213	215	215	0	221
ORUS_3325-12	136	136	0	136	134	134	0	127	0	203	209	209	213	215	0	215

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D3[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
ORUS_3325-13	136	136	0	127	134	134	0	138	203	203	213	213	215	215	0	221
ORUS_3326 population (Tribute × Puget Reliance)[d]																
Tribute_662.001[m, b]	**129**	**136**	**0**	**129**	**134**	**158**	**127**	**138**	**0**	**203**	**209**	**213**	**215**	**215**	**0**	**215**
Puget Reliance_I1[l]	***136***	***127***	***136***	***123***	***143***	***138***	***158***	***160***	***203***	***206***	***209***	***213***	***215***	***215***	***0***	***221***
ORUS_3326-4	0	129?	129	136	138	158	158	136?	206	0	209	213	215	215	215	221
ORUS_3326-11	127	129	129	136	134	138	127	158	203	203	209	209	215	215	0	221
ORUS_3326-12	127	129	129	136	134	138	127	158	203	203	209	209	215	215	0	221
Parents of populations																
Capitola-FR_CF[e]	129	136	129	134	134	136	0	127	203	206	209	213	215	215	221	221
CF1116-FR[za]	**127**	**136**	**127**	**134**	**136**	**138**	**0**	**158**	**203**	**203**	**213**	**213**	**215**	**215**	**0**	**221**
Earliglow_CF[j]	0	129	129	136	123	127	134	160	203	206	209	213	215	215	221	221
FortLaramie_NCGR[b]	127	129	160	129	143	129	0	127	203	203	209	209	215	215	0	221
Honeoye_215.001[a]	127	136	0	136	0	127	126	158	203	203	213	213	215	219	219	221
MSU_49[j]	129	136	129	138	127	127	158	160	203	203	209	209	215	215	215	221
MSU_56[j]	127	136	0	136	136	160	127	158	203	215	213	213	215	219	0	219
ORUS 2427-1_CF_1-22[j]	127	136	136	138	0	134	134	123	203	206	209	213	215	215	0	221
Redgauntlet_CF[j]	0?	127?	136?	136?	123?	134?	0?	158?	203?	206?	209?	213?	215?	215?	0?	224?
Sarian_2691.1	129	136	129	134	0	134	0	127	203	214	209	213	215	215	221	221
Sarian_CF[d]	0	136	127	134	123	134	0	136	203	206	213	213	215	215	0	221
Seascape_CF[j]	129	136	129	134	136	143	0	134	197	206	209	213	215	215	221	221
Tillamook_NCGR[b]	123	136	0	136	134	158	138	136	206	206	209	213	215	215	221	221

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D3[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
Tillamook_CF[d]	0	136	127	136	134	136	0	134	203	206	209	213	215	215	0	221
Tribute_662.001[b]	129	136	0	129	134	158	127	138	0	203	209	213	215	215	0	215
Tribute_CF[j]	129	136	0	129	134	158	127	138	0	203	209	213	215	215	0	215
Cultivars																
Aiko[j]	127	127	136	138	138	134	158	0	203	203	209	213	215	215	221	221
Albion[j]	134	129	136	129	136	134	0	0	206	206	209	213	215	215	221	221
Aromas[j]	127	129	136	129	136	134	158	0	206	203	209	213	215	215	221	221
British_Sovereign [j]	127	132	136	136	136	150	160	0	211	203	209	213	215	215	221	221
Camarosa[j]	127	136	136	136	0	134	158	136	206	203	213	213	215	215	221	221
Chandler[j]	127	134	136	136	136	134	0	0	206	203	213	213	215	215	221	221
Climax[j]	132	136	134	138	123	0	158	0	206	209	209	215	215	215	221	0
Columbia[j]	127	127	136	136	136	134	158	0	203	203	209	213	215	219	219	221
Cruz[j]	127	127	136	136	0	134	158	0	203	203	213	213	215	215	0	221
Diamante[j]	127	129	136	129	136	134	134	0	206	206	209	213	215	215	221	221
Direktor_Paul_Wallbaum[j]	127	127	136	136	136	150	0	0	203	203	213	213	215	215	215	0
Elsanta[j]	127	127	129	129	136	136	158	158	203	203	209	213	215	215	221	221
Ettersburg_121[j]	127	127	136	134	130	0	126	126	203	209	209	215	215	219	221	224
Evie-2[j]	127	134	136	136	123	134	0	0	206	203	213	213	215	215	221	221
Fern[j]	134	136	129	129	134	143	127	0	197	203	209	213	215	215	221	221
Florida_Belle[j]	134	134	136	136	123	143	0	0	197	206	213	213	215	215	221	221
Florida_Radiance[j]	127	127	136	136	138	0	134	134	203	203	213	213	215	215	0	221

Individual	A1^{zb}	A2^{zb}	B1^{zb}	B2^{zb}	C1^{zb}	C2^{zb}	D1^{zb}	D3^{zb}	A1^{zc}	A2^{zc}	B1^{zc}	B2^{zc}	C1^{zc}	C2^{zc}	D1^{zc}	D2^{zc}
Governor_Simcoe[j]	127	136	136	136	0	123	158	160	206	203	209	213	215	215	215	221
Guardian[j]	136	138	138	160	0	123	158	158	206	209	209	215	215	215	221	221
Hecker[j]	127	129	136	129	123	0	134	134	206	203	209	209	215	215	221	221
Jewel[j]	127	156	129	129	136	136	158	158	203	209	213	215	215	215	221	221
Kent[j]	127	127	136	136	136	0	158	158	203	203	209	213	215	215	215	221
Lateglow[j]	129	136	134	129	0	0	158	127	203	209	209	215	215	215	221	221
Liberation_d_Orleans[j]	127	129	129	129	130	136	0	160	203	203	209	213	215	215	215	0
Mara_des_Bois[j]	127	129	136	129	132	134	158	0	203	209	213	215	215	215	221	0
MDUS_3184[j]	127	129	136	129	0	134	127	160	203	203	209	213	215	215	221	221
Ogallala[j]	127	136	129	129	136	138	158	132	0	203	209	213	219	219	219	221
Ooishi-shikinari2[j]	127	127	129	129	138	134	0	132	203	203	209	209	215	215	0	221
ORUS_1384-3[j]	127	127	136	136	136	0	160	160	203	203	209	213	215	215	219	221
ORUS_1827-2[j]	136	136	134	134	138	0	127	0	206	203	209	213	215	215	221	221
ORUS_1963-5[j]	127	127	136	136	136	0	158	160	203	203	209	209	215	215	215	221
Ourown [j]	127	136	129	129	123	0	160	132	206	206	209	213	215	215	219	221
Perle_de_Prague [j]	134	136	132	138	123	0	158	0	206	209	209	215	215	215	221	0
Redcoat [j]	127	127	129	129	134	134	0	132	203	203	209	213	215	215	224	221
Robinson[j]	127	136	129	129	138	143	158	0	197	203	209	213	215	0	219	221
Salinas[j]	136	136	134	134	138	0	127	0	206	203	209	213	215	215	221	221
Sarian[j]	136	129	134	129	134	0	0	127	203	214	209	213	215	215	221	221
Selva[j]	129	136	134	129	123	143	134	0	197	206	209	213	215	215	221	221
Sequoia[j]	127	136	136	136	138	134	158	0	206	203	213	213	215	215	0	221

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D3[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
Shuksan[j]	127	134	136	136	134	143	160	0	197	203	213	213	215	215	224	221
Sierra[j]	0	136	134	0	123	138	160	132	206	209	209	215	215	215	221	222
Sweet_Bliss (ORUS 2180-1)[j]	134	136	129	129	123	138	158	0	206	203	209	209	215	215	215	0
Sweet_Charlie [j]	127	127	136	136	134	134	0	0	203	203	213	213	215	215	221	221
Toro[j]	127	134	136	136	136	138	158	0	206	203	213	213	215	215	0	221
Treasure[j]	127	127	136	136	134	134	158	0	218	203	213	213	215	215	221	221
Ventana[j]	127	127	136	134	138	134	0	138	203	203	209	213	215	215	0	221
Winter_Dawn[j]	127	136	134	136	138	143	134	0	197	203	213	213	215	215	0	221
Super core collection																
FRA_1694[r, a]	136	136	134	132	136	143	132	132	209	209	213	213	219	219	221	221
FRA_1695[r, a]	136	136	134	132	136	143	132	132	209	209	213	213	219	219	221	221
FRA_1697[r, a]	136	136	136	136	128	128	155	0	217	209	209	215	215	219	223	220
FRA_1698[r, a]	136	136	136	136	0	130	126	126	206	206	209	213	215	215	215	0
FRA_1699[r, a]	136	136	138	138	143	143	127	127	203	203	209	209	213	213	221	221
FRA_1700[r, a]	136	136	130	128	130	128	126	126	209	206	209	215	215	215	0	221
FRA_1703[r, a]	136	136	128	128	136	154	126	126	214	206	209	213	215	215	0	221
Wild accessions																
FRA_368[x, j]	132	129	136	129	136	143	152	127	203	209	209	215	215	215	221	221
ORUS_2361-1[x, j]	134	134	136	136	132	0	126	0	206	206	209	215	215	215	221	221
BC12[q, j]	120	136	134	132	136	152	0	132	209	209	200	219	221	221	221	222

Individual	A1[zb]	A2[zb]	B1[zb]	B2[zb]	C1[zb]	C2[zb]	D1[zb]	D3[zb]	A1[zc]	A2[zc]	B1[zc]	B2[zc]	C1[zc]	C2[zc]	D1[zc]	D2[zc]
L1[r, j]	136	136	130	130	136	136	143	147	213	209	209	215	215	215	221	221
L2[r, j]	136	136	130	130	128	128	134	138	0	209	209	211	215	215	215	0
BCPink[o, j]	130	129	130	129	123	134	132	132	206	206	209	215	212	215	0	221
LB48[o, j]	136	136	130	130	136	136	130	138	0	206	209	209	213	215	221	221
Synthetic *F. xananassa*																
FVC_8-1[n, j]	136	136	136	136	134	134	0	0	206	206	209	213	215	215	221	226
FVC_8-2[n, j]	129	130	136	132	134	0	0	0	206	209	213	215	215	215	221	221
FVC_8-3[n, j]	136	136	134	136	145	152	160	0	214	209	209	215	215	215	224	230
FVC_8-4[n, j]	129	134	136	136	136	134	0	0	206	206	209	209	215	215	221	0
FVC_8-5[n, j]	136	136	136	136	134	134	0	0	206	206	209	209	215	215	221	0
FVC_11-2[n, j]	132	134	136	136	136	0	0	162	206	209	213	215	215	215	221	222
FVC_11-3[n, j]	136	129	129	132	134	0	0	162	0	206	209	209	215	215	215	221
FVC_11-4[n, j]	127	129	129	134	136	136	0	162	203	206	209	209	215	215	221	0
FVC_11-5[n, j]	127	129	129	132	134	136	0	162	203	0	209	209	215	215	215	221
FVC_11-6[n, j]	127	134	136	136	136	0	134	134	203	206	209	213	215	215	221	0
FVC_16-1[n, j]	136	136	134	138	0	0	126	128	0	206	209	209	215	215	215	0
FVC_28-1[n, j]	136	136	136	134	134	0	0	0	206	206	209	209	215	215	226	221

[z]Plant obtained from PB-WUR, NL and coded as E-60174

[y]Plant obtained from PB-WUR, NL and coded as E-71006

[x]Species *F. chiloensis*

[w]Species *F. chiloensis*, subspecies *pacifica*

[v]Species *F. iturupensis*

[u]Species *F. vesca*

[t]Species *F. vesca*, subspecies *bracteata*

[s]Species *F. vesca*, subspecies *bracteata americana*

[r]Species *F. virginiana*

[q]Species *F. virginiana*, subspecies *glauca*

[p]Species *F. virginiana*, subspecies *platypetala*

[o]Hybrid

[n]Wild derived *F.* ×*ananassa*

[m] Female parent

[l] Male parent

[k]NL_CF

[j]CF

[i]NL

[h]UK_CF

[g]NL_CF

[f]SP_CF

[e]FR_CF

[d]OR_CF

[c]MI_CF

[b] NCGR

[a] NCGR_CF

[za] FR

[zb] Subgenome at Bx215

[zc] Subgenome at Bx56

When superscripts [k] to [za], are placed in a population name, the source corresponds to the progeny of that population. Each parent has their own source

Appendix Table 3.4. Presence (1) and absence (0) of alleles obtained with SSR Bx89 of parents of the populations and progeny. Genotypes of parents that match those used in each cross are in bold. For each breeding population all possible parents are in the first rows with darker background, the confirmed female and male parent are indicated with superscript "F" and "M", respectively. Missing data is represented with a dot.

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
European populations																				
EMR population (Redgauntlet × Hapil)[h]																				
Redgauntlet_NL[z, k, g]	**1**	0	0	0	1	0	**1**	0	1	1	0	0	**1**	1	0	1	0	0	0	0
Redgauntlet_CF[m, j]	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	1	0	0	0	0
Hapil_NL[l, i]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
EMR_1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_2	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_3	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_6	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
EMR_10	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_11	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0
EMR_12	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
EMR_13	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_16	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
EMR_17	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_20	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
EMR_21	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
EMR_25	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
EMR_28	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_29	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_30	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0
EMR_32	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
EMR_34	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_36	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_43	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_45	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_48	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_51	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_54	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
EMR_55	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
EMR_56	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_57	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_58	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_59	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_63	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_65	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_66	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
EMR_67	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
EMR_70	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
EMR_71	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
EMR_73	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_76	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
EMR_82	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
EMR_84	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_85	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
EMR_92	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
EMR_98	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
EMR_99	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	1	0
EMR_103	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_104	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_105	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
EMR_113	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
EMR_130	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
EMR_133	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
EMR_159	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
EMR_172	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
NL population (Holiday × Korona)[g]																				
Holiday_CF[m, d, j]	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0
Holiday_NL[y, m, i]	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
Korona_NL[l, i]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Korona_CF [d]	0	0	1	1	1	0	0	0	1	1	0	0	0	1	0	0	1	0	0	0
H-02316	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
H-02317	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
H-02321	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
H-02322	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
H-02324	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
H-02331	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
H-02356	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
H-02369	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
H-02374	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
H-02379	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
H-02385	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
H-02401	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
H-02406	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
H-02410	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
H-02465	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
H-02475	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
H-02485	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
H-02501	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
H-02529	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
H-02549	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
H-02552	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
H-02572	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
H-02622	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
H-02637	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
IFAPA population (IFAPA_1392 × IFAPA_232)[f]																				
IFAPA_1392[m, f]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
IFAPA_232[l, f]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
IFAPA_93-4	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
IFAPA_93-6	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
IFAPA_93-8	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
IFAPA_93-11	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
IFAPA_93-12	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
IFAPA_93-13	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
IFAPA_93-15	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
IFAPA_93-16	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
IFAPA_93-21	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
IFAPA_93-24	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
IFAPA_93-26	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
IFAPA_93-32	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
IFAPA_93-33	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
IFAPA_93-34	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
IFAPA_93-36	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
IFAPA_93-37	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
IFAPA_93-42	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
IFAPA_93-46	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
IFAPA_93-47	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
IFAPA_93-50	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
IFAPA_93-54	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
IFAPA_93-56	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
IFAPA_93-57	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
IFAPA_93-58	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
IFAPA_93-59	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
IFAPA_93-60	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
IFAPA_93-61	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
IFAPA_93-62	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
IFAPA_93-64	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
INRA population (Capitola × CF1116)[e]																				
Capitola_FR_CF[m, e]	0	0	1	0	1	0	1	0	1	1	0	1	0	1	0	1	0	0	0	0
CF1116_FR[l, za]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
INRA_5	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
INRA_6	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
INRA_8	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_9	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
INRA_10	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
INRA_11	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
INRA_12	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_14	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
INRA_15	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
INRA_16	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_19	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_30	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
INRA_34	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_37	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_43	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
INRA_47	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
INRA_58	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
INRA_59	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_61	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_76	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
INRA_79	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
INRA_94	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
INRA_95	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
INRA_97	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_98	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_99	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
INRA_103	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
INRA_104	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_108	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_110	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
INRA_116	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
INRA_122	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_124	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_126	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_134	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
INRA_135	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
INRA_138	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
INRA_141	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_147	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
INRA_148	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
INRA_151	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_153	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_157	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
INRA_161	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_165	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_167	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
INRA_172	0	0	1	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
INRA_175	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
INRA_181	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
INRA_195	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_196	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_197	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
INRA_201	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
INRA_204	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
INRA_216	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU populations																				
MSU_9-1 population (MSU_49 × FRA_1702)[c]																				
MSU_49[m, d]	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
FRA_1702_I1[l]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MSU_9-1-1	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0
MSU_9-1-2	0	0	0	0	1	0	1	0	0	0	1	1	0	0	0	1	0	0	0	0
MSU_9-1-3	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_9-1-4	1	0	0	0	1	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0
MSU_9-1-5	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-1-6	0	0	1	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-1-7	0	0	0	1	1	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0
MSU_9-1-8	0	0	0	0	1	0	1	0	1	0	1	1	0	0	0	1	0	0	0	0
MSU_9-1-9	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0
MSU_9-1-10	0	0	0	0	1	0	1	0	1	0	1	1	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
MSU_9-2 population (MSU_49 × Seascape)[c]																				
MSU_49[m, j]	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
Seascape_CF[l, j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
MSU_9-2-1	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-2-2	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-2-3	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-2-4	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0
MSU_9-2-5	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0
MSU_9-2-6	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-2-7	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-2-8	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-2-9	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-2-10	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-3 population (MSU_49 × Tribute)[c]																				
MSU_49[m, j]	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
Tribute_662.001[l, b]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-3-1	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-3-2	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-3-3	0	0	0	0	1	0	1	0	1	0	**1**	0	0	0	0	1	0	0	0	0
MSU_9-3-4	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-3-5	0	0	0	0	1	0	0	0	1	0	**1**	1	0	0	0	1	0	0	0	0
MSU_9-3-6	0	0	0	0	1	0	1	0	0	0	**1**	1	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
MSU_9-3-7	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0
MSU_9-3-8	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-3-9	0	0	0	0	1	0	1	0	1	0	1	1	0	0	0	1	0	0	0	0
MSU_9-3-10	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-4 population (MSU_56 × FRA_1702)[c]																				
MSU_56[m, j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
FRA_1702_I1[l]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MSU_9-4-1	1	0	0	0	1	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0
MSU_9-4-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSU_9-4-3	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
MSU_9-4-4	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_9-4-5	0	0	0	0	1	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0
MSU_9-4-6	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-4-7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSU_9-4-8	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-4-9	1	0	0	0	1	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0
MSU_9-4-10	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_9-5 population (FRA_1702 × Earliglow)[c]																				
FRA_1702_I1[m]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Earliglow_CF[l, j]	1	0	1	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-5-1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-5-2	0	0	1	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
MSU_9-5-3	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_9-5-4	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0
MSU_9-5-5	0	0	0	0	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0
MSU_9-5-6	0	0	0	0	1	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0
MSU_9-5-7	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0
MSU_9-5-8	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-5-9	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
MSU_9-5-10	0	0	0	0	1	0	1	0	0	0	1	1	0	0	0	1	0	0	0	0
MSU_9-6 population (Earliglow × Seascape)[c]																				
Earliglow_CF[m, j]	1	0	1	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
Seascape_CF[l, j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
MSU_9-6-1	0	0	1	0	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0
MSU_9-6-2	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-6-3	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-6-4	0	0	0	1	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
MSU_9-6-5	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
MSU_9-6-6	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-6-7	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-6-8	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-6-9	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
MSU_9-6-10	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
MSU_9-8 population (Fort Laramie × Earliglow)[c]																				
FortLaramie_NCGR[m, b]	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0
Earliglow_CF[l, j]	1	0	1	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-8-1	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-8-2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
MSU_9-8-3	0	0	1	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
MSU_9-8-4	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_9-8-5	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0
MSU_9-8-6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSU_9-8-7	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_9-8-8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSU_9-8-9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSU_9-8-10	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-9 population (Fort Laramie × Honeoye)[c]																				
FortLaramie_NCGR[m, b]	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0
Honeoye_215.001[l, b]	1	0	0	0	1	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0
MSU_9-9-1	0	0	0	0	1	0	1	0	1	0	1	1	0	0	0	1	0	0	0	0
MSU_9-9-2	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_9-9-3	0	0	0	0	1	0	1	0	1	0	1	1	0	0	0	1	0	0	0	0
MSU_9-9-4	0	0	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0
MSU_9-9-5	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-9-6	0	0	0	0	1	0	1	0	1	0	1	1	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
MSU_9-9-7	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_9-9-8	0	0	0	0	1	0	1	0	1	0	1	1	0	0	0	1	0	0	0	0
MSU_9-9-9	0	0	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0
MSU_9-9-10	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_9-10 population (Fort Laramie × MSU_49)[c]																				
FortLaramie_NCGR[m, b]	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0
MSU_49[l, j]	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_9-10-1	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_9-10-2	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0
MSU_9-10-3	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-10-4	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_9-10-5	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_9-10-6	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_9-10-7	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-10-8	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-10-9	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-10-10	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_9-11 population (Fort Laramie × MSU_56)[c]																				
FortLaramie_NCGR[m, b]	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0
MSU_56[l, j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-11-1	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-11-2	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
MSU_9-11-3	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_9-11-4	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
MSU_9-11-5	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_9-11-6	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-11-7	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
MSU_9-11-8	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-11-9	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-11-10	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
MSU_9-12 population (Honeoye × FRA_1702)[c]																				
Honeoye_215.001[m, b]	1	0	0	0	1	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0
FRA_1702_I2[l]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MSU_9-12-1	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-12-2	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
MSU_9-12-3	0	0	0	0	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0
MSU_9-12-4	0	0	0	0	1	0	1	0	1	0	1	0	0	0	0	1	0	0	0	0
MSU_9-12-5	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-12-6	0	0	0	0	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0
MSU_9-12-7	0	0	0	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0
MSU_9-12-8	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-12-9	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
MSU_9-12-10	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
MSU_9-13 population (Seascape × Honeoye)[c]																				
Seascape_CF[m, j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
Honeoye_215.001[l, b]	1	0	0	0	1	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0
MSU_9-13-1	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0
MSU_9-13-2	0	0	0	0	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0
MSU_9-13-3	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0
MSU_9-13-4	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-13-5	0	0	0	0	1	0	1	0	1	1	1	0	0	0	0	1	0	0	0	0
MSU_9-13-6	0	0	0	0	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0
MSU_9-13-7	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
MSU_9-13-8	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-13-9	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-13-10	0	0	0	0	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0
MSU_9-14 population (Seascape × MSU_56)[c]																				
Seascape_CF[m, j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
MSU_56[l, j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-14-1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-14-2	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
MSU_9-14-3	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-14-4	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
MSU_9-14-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSU_9-14-6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
MSU_9-14-7	0	0	0	0	1	0	1	0	1	1	0	1	0	1	0	1	0	0	0	0
MSU_9-14-8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSU_9-14-9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSU_9-14-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSU_9-15 population (Tribute × Earliglow)[c]																				
Tribute_662.001[m, b]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
Earliglow_CF[l, j]	1	0	1	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-15-1	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
MSU_9-15-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSU_9-15-3	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-15-4	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0
MSU_9-15-5	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-15-6	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
MSU_9-15-7	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-15-8	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-15-9	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
MSU_9-15-10	0	0	1	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
MSU_9-16 population (Tribute × Honeoye)[c]																				
Tribute_662.001[m, b]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
Honeoye_215.001[l, b]	1	0	0	0	1	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0
MSU_9-16-1	1	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-16-2	0	0	0	0	1	0	1	0	1	1	1	1	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
MSU_9-16-3	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-16-4	0	0	0	0	1	0	1	0	1	1	1	1	0	0	0	1	0	0	0	0
MSU_9-16-5	0	0	0	0	1	0	1	0	1	0	1	1	0	0	0	1	0	0	0	0
MSU_9-16-6	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-16-7	0	0	0	0	1	0	1	0	1	1	1	1	0	0	0	1	0	0	0	0
MSU_9-16-8	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-16-9	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-16-10	0	0	0	0	1	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0
MSU_9-16-11	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-16-12	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-16-13	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-16-14	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-16-15	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-16-16	0	0	0	0	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0
MSU_9-16-17	0	0	0	0	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0
MSU_9-16-18	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-16-19	0	0	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0
MSU_9-16-20	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-16-21	0	0	0	0	1	0	0	0	1	1	1	1	0	0	0	1	0	0	0	0
MSU_9-16-22	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-16-23	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-16-24	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
MSU_9-16-25	0	0	0	0	1	0	0	0	1	1	1	1	0	0	0	1	0	0	0	0
MSU_9-16-26	0	0	0	0	1	0	1	0	0	1	1	1	0	0	0	1	0	0	0	0
MSU_9-16-27	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-16-28	0	0	0	0	1	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0
MSU_9-16-29	0	0	0	0	1	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0
MSU_9-16-30	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-16-31	0	0	0	0	1	0	1	0	0	1	1	1	0	0	0	1	0	0	0	0
MSU_9-16-32	0	0	0	0	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0
MSU_9-16-33	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-16-34	0	0	0	0	1	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0
MSU_9-16-35	0	0	0	0	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0
MSU_9-16-36	0	0	0	0	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0
MSU_9-16-37	0	0	0	0	1	0	1	0	1	0	1	1	0	0	0	1	0	0	0	0
MSU_9-16-38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSU_9-16-39	0	0	0	0	1	0	1	0	1	0	1	1	0	0	0	1	0	0	0	0
MSU_9-16-40	0	0	0	0	1	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0
MSU_9-16-41	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-16-42	0	0	0	0	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0
MSU_9-16-43	0	0	0	0	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0
MSU_9-16-44	0	0	0	0	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0
MSU_9-16-45	0	0	0	0	1	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0
MSU_9-16-46	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
MSU_9-16-47	0	0	0	0	1	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0
MSU_9-16-48	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-16-49	0	0	0	0	1	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0
MSU_9-16-50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSU_9-16-51	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
MSU_9-16-52	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-16-53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSU_9-16-54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSU_9-16-55	0	0	0	0	1	0	1	0	1	1	1	0	0	0	0	1	0	0	0	0
MSU_9-16-56	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-16-57	0	0	0	0	1	0	0	0	1	1	1	1	0	0	0	1	0	0	0	0
MSU_9-16-58	1	0	0	0	1	0	1	0	0	0	1	1	0	0	0	1	0	0	0	0
MSU_9-16-59	0	0	0	0	1	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0
MSU_9-16-60	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-16-61	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	**1**	0	0	0
MSU_9-16-62	1	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
MSU_9-16-63	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-16-64	0	0	0	0	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0
MSU_9-16-65	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-17 population (Tribute × MSU_56)[c]																				
Tribute_662.001[m, b]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_56[l, j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
MSU_9-17-1	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-17-2	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-17-3	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-17-4	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-17-5	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-17-6	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
MSU_9-17-7	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
MSU_9-17-8	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-17-9	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-17-10	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-18 population (Seascape × Fort Laramie)[c]																				
Seascape_CF[m, j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
FortLaramie_I1[l]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MSU_9-18-1	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
MSU_9-18-2	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
MSU_9-18-3	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
MSU_9-18-4	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MSU_9-18-5	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
MSU_9-18-6	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
MSU_9-18-7	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
MSU_9-18-8	0	0	1	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
MSU_9-18-9	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
MSU_9-18-10	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS populations																				
ORUS_3277 population (ORUS 2427-1× FRA_1701)[d]																				
ORUS 2427-1_CF_1-22[m, j]	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	1	0
FRA_1701[l, r, a]	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0
ORUS_3277-1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0
ORUS_3277-2	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
ORUS_3277-3	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0
ORUS_3277-4	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0
ORUS_3277-5	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	1	0
ORUS_3277-6	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0
ORUS_3277-7	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3277-8	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0
ORUS_3277-9	0	0	0	0	1	0	0	0	1	1	0	1	0	0	1	0	0	0	0	0
ORUS_3277-10	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0
ORUS_3278 population (ORUS 2427-1× Seascape)[d]																				
ORUS 2427-1_CF_1-22[m, j]	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	1	0
Seascape_CF[l, j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_3278-1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0
ORUS_3278-4	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_3278-5	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
ORUS_3278-6	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3278-7	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0
ORUS_3278-8	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3278-9	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_3278-10	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3278-12	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3278-13	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0
ORUS_3279 population (ORUS 2427-1× Tribute)[d]																				
ORUS 2427-1_CF_1-22[m, j]	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	1	0
Tribute_662.001[l, b]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3279-3	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3279-4	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_3279-5	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3279-6	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3279-7	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_3279-8	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	1	0
ORUS_3279-9	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3279-13	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	1	0
ORUS_3279-14	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3279-15	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3304 population (Tillamook × FRA_1701)[d]																				
Tillamook_NCGR[b]	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
Tillamook_CF[d]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
Tillamook_I1[m]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
FRA_1701[l, r, a]	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0
ORUS_3304-1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3304-2	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3304-5	0	0	0	0	1	0	0	0	1	1	0	1	0	0	1	0	0	0	0	0
ORUS_3304-6	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3304-7	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3304-8	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3304-9	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3304-10	0	0	0	0	1	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0
ORUS_3304-11	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3304-13	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3305 population (Tillamook × Seascape)[d]																				
Tillamook_CF[d]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
Tillamook_NCGR[m, b]	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
Seascape_CF[l, j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_3305-1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3305-2	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
ORUS_3305-3	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3305-5	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3305-6	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
ORUS_3305-7	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_3305-10	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3305-11	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_3305-13	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3305-14	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_3306 population (Totem × FRA_1701)[d]																				
Totem_CF[m, j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
FRA_1701[l, r, a]	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0
ORUS_3306-2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
ORUS_3306-3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
ORUS_3306-4	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
ORUS_3306-5	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
ORUS_3306-6	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3306-8	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3306-11	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
ORUS_3306-13	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0
ORUS_3306-14	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3306-15	0	0	0	0	1	0	0	0	1	1	0	1	0	0	1	0	0	0	0	0
ORUS_3314 population (Fort Laramie × ORUS 2427-1)[d]																				
ORUS 2427-1_CF_1-22 [d]	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	1	0
FortLaramie_NCGR[b]	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0
FortLaramie_I2[m]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
ORUS 2427_I1[l]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ORUS_3314-1	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0
ORUS_3314-2	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3314-4	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0
ORUS_3314-5	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3314-6	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3314-10	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3314-11	1	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3314-12	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0
ORUS_3314-14	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3314-15	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3315 population (Fort Laramie × Puget Reliance)[d]																				
FortLaramie_NCGR[b]	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0
FortLaramie_I3[m]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Puget Reliance_CF[l, j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3315-1	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3315-2	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3315-4	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3315-6	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3315-10	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3315-11	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3315-12	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
ORUS_3315-13	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
ORUS_3315-14	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3315-15	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3316 population (Fort Laramie × Totem)[d]																				
FortLaramie_NCGR[b]	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0
FortLaramie_I1[m]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Totem_CF[l, j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3316-1	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_3316-2	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3316-3	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3316-4	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3316-5	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0
ORUS_3316-6	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3316-7	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3316-8	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0
ORUS_3316-9	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3316-10	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_3317 population (Puget Reliance × FRA_1701)[d]																				
Puget Reliance_CF [d]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
Puget Reliance_I1[m]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
FRA_1701[l, r, a]	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0
ORUS_3317-1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
ORUS_3317-2	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3317-3	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3317-4	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3317-5	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3317-6	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3317-7	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3317-9	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3317-10	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3317-11	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3318 population (Puget Reliance × Sarian)[d]																				
Puget Reliance_CF[d]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
Puget Reliance_I1[m]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sarian_CF[l,j]	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3318-1	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3318-2	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0
ORUS_3318-4	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3318-6	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3318-8	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3318-9	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3318-10	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3318-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
ORUS_3318-12	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
ORUS_3318-14	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3319 population (Sarian × ORUS 2427-1)[d]																				
Sarian_CF[m, j]	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS 2427_I1[l]	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	1	0
ORUS_3319-1	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	1	0	0	0
ORUS_3319-2	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3319-3	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3319-4	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	1	0	0	0
ORUS_3319-5	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	1	0	0	0
ORUS_3319-6	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	1	0
ORUS_3319-7	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3319-8	0	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0	1	0	0	0
ORUS_3319-9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORUS_3319-10	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3320 population (Sarian × Totem)[d]																				
Sarian_CF[m, j]	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
Totem_CF[l, j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3320-1	0	0	0	0	1	0	0	0	1	1	0	1	0	0	**1**	0	0	0	0	0
ORUS_3320-2	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_3320-3	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3320-4	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3320-5	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
ORUS_3320-6	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3320-7	0	0	1	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_3320-8	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3320-9	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3320-10	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3321 population (Sarian × Tillamook)[d]																				
Tillamook_1819.001 [b]	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
Sarian_2691.1 [b]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sarian_CF[m, j]	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
Tillamook_CF[l, j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3321-1	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3321-2	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3321-3	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3321-4	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3321-5	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3321-6	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3321-7	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3321-8	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3321-9	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3321-10	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3322 population (Seascape × ORUS 2427-1)[d]																				
ORUS 2427-1_CF_1-22 [d]	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	1	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
Seascape_CF[m, j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS 2427_I1[l]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ORUS_3322-2	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0
ORUS_3322-4	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	1	0	0	0
ORUS_3322-5	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3322-7	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3322-8	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	1	0	0	0
ORUS_3322-9	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3322-11	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3322-12	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3322-13	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	1	0	0	0
ORUS_3322-14	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3323 population (Seascape × Puget Reliance)[d]																				
Puget Reliance_CF [d]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
Seascape_CF[m, j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
Puget Reliance_I1[l]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ORUS_3323-1	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3323-2	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3323-3	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3323-4	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3323-6	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3323-7	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
ORUS_3323-9	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3323-12	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3323-13	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_3323-14	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_3324 population (Tillamook × Fort Laramie)[d]																				
Tillamook_NCGR[b]	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
Tillamook_CF[m, j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
FortLaramie_I1[l]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ORUS_3324-1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3324-3	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3324-4	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3324-9	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3324-10	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_3324-11	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3324-12	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3324-13	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
ORUS_3324-14	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_3324-15	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
ORUS_3325 population (Tillamook × Tribute)[d]																				
Tillamook_NCGR[b]	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
Tillamook_CF[m, j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
Tribute_662.001[l, b]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
ORUS_3325-2	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3325-4	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3325-5	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3325-8	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3325-9	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3325-10	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3325-11	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3325-12	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_3325-13	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_3325-15	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_3326 population (Tribute × Puget Reliance)[d]																				
Puget Reliance_CF[d]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
Tribute_662.001[m, b]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
Puget Reliance_I1[l]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ORUS_3326-1	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3326-2	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3326-3	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3326-4	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3326-5	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3326-11	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_3326-12	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
ORUS_3326-13	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
ORUS_3326-14	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_3326-15	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
Parents of populations																				
Capitola-FR_CF[e]	0	0	1	0	1	0	1	0	1	1	0	1	0	1	0	1	0	0	0	0
CF1116-FR[za]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
E-60174-NL (Redgauntlet) [k]	1	0	0	0	1	0	1	0	1	1	0	0	1	1	0	1	0	0	0	0
E-71006-NL (Holiday) [i]	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0
Earliglow_CF[j]	1	0	1	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
FortLaramie_NCGR[b]	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0
FRA_1701[a]	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0
Hapil-NL[i]																				
Holiday_CF[j]	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0
Honeoye_215.001[a]	1	0	0	0	1	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0
IFAPA_1392[j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
IFAPA_232[j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
Korona-CF[j]	0	0	1	1	1	0	0	0	1	1	0	0	0	1	0	0	1	0	0	0
Korona-NL[i]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MSU_49 [j]	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
MSU_56[j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS 2427-1_CF_1-22 [j]	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	1	0
Puget Reliance_CF[j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
Redgauntlet_CF[j]	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	1	0	0	0	0
Sarian_2691.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sarian_CF[d]	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
Seascape_CF[j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
Tillamook_NCGR[b]	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
Tillamook_CF[d]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
Totem_CF[j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
Tribute_662.001[b]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
Tribute_CF[j]	0	0	1	0	1	0	1	0	1	1	0	1	0	1	0	0	0	0	0	0
Cultivars																				
Aberdeen[a]	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
Aberdeen-NL[i]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aiko[j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
Albion[j]	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Albritton[j]	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0
E-82246 NL (Allstar)[g]	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	1	0	0
Allstar[j]	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
Ambrosia_Late[j]	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Annapolis[j]	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
Apollo[j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
ArKing[j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
Aromas[j]	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0
Atlas[j]	0	0	0	0	0	0	1	0	1	1	0	0	1	0	0	1	0	0	0	0
Badgerglo[j]	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Beaver[j]	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
Benizuru[j]	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
Benton[j]	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
Blakemore[j]	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
Bountiful[j]	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
Bounty[j]	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
British_Sovereign[j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
Brunswick[j]	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
Cabot[j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
Cal_51S-1[j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cal_59.39-1[j]	0	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0
Camarosa[j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
Cardinal[j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
Catskill[j]	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
Cavendish[j]	0	0	0	0	1	0	0	0	1	1	0	0	1	0	0	0	1	0	0	0
Chandler[j]	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Charm (ORUS_2262-2)[j]	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0
Clancy[j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
Climax[j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
Columbia[j]	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0
Cruz[j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
Daroyal[j]	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
Darrow 5[j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Darselect[j]	0	0	0	0	1	0	0	0	1	1	0	0	1	0	0	1	0	0	0	0
Delitej	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0
Delmarvel[j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0
Diamante[j]	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0
Direktor_Paul_Wallbaum[j]	0	0	0	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0
Donner[j]	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0
Dover[j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
Earlibelle[j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
Elsanta[j]	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
Eros[j]	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
Ettersburg_121[j]	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0
Evangeline[j]	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0
Evie-2[j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
Fairfax[j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
Fern[j]	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0
Firecracker[j]	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	1	0
Florence[j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
Florida_90[j]	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
Florida_Belle[j]	0	0	0	1	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
Florida_Elyana[j]	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Florida_Radiance[j]	0	0	0	1	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0
Galletta[j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
Glooscap[j]	1	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
Gorella[j]	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
Governor_Simcoe[j]	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
Guardian[j]	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
Harunoka[j]	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
Hecker[j]	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0
Hogyoku[j]	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
Hood[j]	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0
Howard_17[j]	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
Hummi_Grandee[j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Idea[j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Independence[j]	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0
E-65056 (Induka)[i]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jerseybelle[j]	1	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Jewel[j]	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
Joe[j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
Jucunda[j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
Jurica[j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
Kaiser_Samling[j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
Kent[j]	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
Klondike[j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
Koro103[j]	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
Kurume103[j]	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0
L'Amour[j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lassen[j]	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
Lateglow[j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
Liberation_d_Orleans[j]	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0
Linn[j]	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
Mara_des_Bois[j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
Marlate[j]	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Marshall[j]	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
Massey[j]	1	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
MDUS_3184[j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
MDUS_3816[j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MDUS_4258[j]	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0
MDUS_683[j]	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
Melody[j]	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0
Mesabi[j]	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
Micmac[j]	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0
Midland[j]	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
Midway[j]	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
Miyazaki[j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Northwest[j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
NW_90054-37[j]	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
Nyoho[j]	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0
Oberschlesien[j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	1	0	0	0
Ogallala[j]	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0
Ooishi-shikinari2[j]	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0
ORUS_1083-135[j]	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0
ORUS_1239R-21[j]	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
ORUS_1267-236[j]	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0
ORUS_1384-3[j]	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0
ORUS_1391-1[j]	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0
ORUS_1407-76[j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	1	0
ORUS_1735-1[j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_1754-1[j]	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_1769-1[j]	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	1	0	0	0
ORUS_1827-2[j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
ORUS_1947-2[j]	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
ORUS_1963-5[j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_2427-4[j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
ORUS_2490-1[j]	0	0	0	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
ORUS_2676-1[j]	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0
ORUS_2742-1[j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
ORUS_2781-1[j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0
ORUS_740-7[j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0
OSC_4474[j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
OSC_4816[j]	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	1	0	0	0
OSC_4817[j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
OSC_4916[j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0
Ourown[j]	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0
Ozark_Beauty[j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	1	0	0	0
Pelican[j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Perle_de_Prague[j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
Pinnacle[j]	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
Puget_Beauty[j]	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
Puget_Reliance[j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
Puget_Summer[j]	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
Rainier[j]	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0
Record	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Redchief[j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Redcoat[j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
Redcrest[j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
Redgem[j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	1	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
Redglow[j]	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0
Repita[j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
Robinson[j]	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0
Rosa_Linda[j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
Salinas[j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sarian[j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
Scott[j]	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
Selva[j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
Seneca[j]	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
Senga_Sengana[j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
Sequoia[j]	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0
Shasta[j]	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
Shuksan[j]	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
Sierra[j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sparkle[j]	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0
Stelemaster[j]	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
Stolo[j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Strawberry_Festival[j]	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0
Streamliner[j]	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0
Sumas[j]	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	1	0
Sumner[j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
Sunrise[j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Surecrop[j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sweet_Bliss (ORUS 2180-1)[j]	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
Sweet_Charlie [j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
Sweet_Sunrise (ORUS 2240-1)[j]	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	1	0	0	1	0
Talisman-NL[i]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tamella[j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
Tamella-NL[i]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tangi[j]	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Temple[j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
Tioga[j]	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
Toro[j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
Treasure[j]	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0
Tufts[j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyee[j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
Valley_Red[j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
Valley_Sunset[j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
Veestar[j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ventana[j]	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Wendy[j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
White_Carolina[j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	1	0	1	0	0	0
Winona[j]	0	0	0	0	1	0	0	0	1	0	1	1	0	1	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
Winter_Dawn[j]	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
Super core collection																				
FRA_1088[x, a]	0	0	0	0	1	0	1	0	0	0	0	1	0	0	1	0	1	0	0	0
FRA_1092[x, a]	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0
FRA_110[r, a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRA_1100[x, a]	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0
FRA_1104[x, a]	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	1	0	1	0
FRA_1108[x, a]	0	0	0	0	1	0	1	0	0	0	0	1	0	0	1	0	1	0	0	0
FRA_1408[r, a]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
FRA_1414[r, a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRA_1435[r, a]	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0
FRA_1455[r, a]	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0
FRA_1557[r, a]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
FRA_1580[r, a]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	1	0	0	0	0	0
FRA_1620[r, a]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
FRA_1690[w, a]	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	0	1	0	0	0
FRA_1691[x, a]	1	0	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0
FRA_1692[x, a]	0	0	1	0	1	0	1	0	1	0	0	0	0	1	0	0	1	0	0	0
FRA_1694[r, a]	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
FRA_1695[r, a]	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
FRA_1696[r, a]	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
FRA_1697[r, a]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
FRA_1698[r, a]	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
FRA_1699[r, a]	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
FRA_1700[r, a]	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
FRA_1701[r, a]	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0
FRA_1703[r, a]	0	0	1	0	1	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0
FRA_24[x, a]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
FRA_34[x, a]	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0
FRA_357[x,a]	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0
FRA_372[x,a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRA_42[x,a]	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0
FRA_48[x,a]	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	1	0
FRA_58[r,a]	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0
FRA_688[x,a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRA_796[x,a]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	1	0	0	0	1	0
FRA_982[r,a]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
Wild accessions																				
Del_Norte[x, j]	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	1	1	0
F.chil.Cape.Mendicino[x, j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRA_368[x, j]	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
ORUS_2361-1[x, j]	0	0	1	0	1	0	1	0	1	0	0	0	0	0	1	0	1	0	1	0
FRA_743[x, j]	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	1	0	1	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
Yaquina_B[w, j]	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	1
F.iturupensis[v, j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F.vesca bracteata[t, j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRA_1952[t, j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRA_504[t, j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hawaii0_TD [u,j]	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
Hawaii4_TD [u,j]	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Yellow_Wonder[u, j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRA_1948[s, j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC12[q, j]	0	0	0	0	1	0	1	0	0	0	0	1	0	1	0	1	0	0	0	0
BC6[r, j]	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
FRA_101[p, j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRA_1343[r, j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRA_1356[r, j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRA_1356[r, j]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L1[r, j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
L2[r, j]	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
BCPink[o, j]	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0
LB48[o, j]	0	0	0	0	1	0	1	0	1	0	1	0	0	1	0	0	0	0	0	0
Synthetic *F.* x *ananassa*																				
FVC_8-1[n, j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
FVC_8-2[n, j]	1	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
FVC_8-3[n, j]	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
FVC_8-4[n, j]	1	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
FVC_8-5[n, j]	1	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
FVC_10-1[n, j]	0	0	1	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	1	0
FVC_10-2[n, j]	0	0	1	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	1	0
FVC_11-1[n]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FVC_11-2[n, j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
FVC_11-3[n, j]	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0
FVC_11-4[n, j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
FVC_11-5[n, j]	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
FVC_11-6[n, j]	0	0	1	0	1	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0
FVC_16-1[n, j]	1	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
FVC_17-1[n, j]	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	1	0	0	0
FVC_18-1[n, j]	1	0	0	0	1	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0
FVC_28-1[n, j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
FVC_30-1[n, j]	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0
FVC_30-2[n, j]	1	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	1	0	0	0
FVC_30-3[n, j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
FVC_30-4[n, j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0
FVC_30-5[n, j]	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
FVC_30-6[n, j]	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0

Individual	247	248	251	253	257	259	262	265	267	269	271	273	274	275	278	279	280	283	285	291
JH_101-1[n, j]	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0

[z]Plant obtained from PB-WUR, NL and coded as E-60174

[y]Plant obtained from PB-WUR, NL and coded as E-71006

[x]Species *F. chiloensis*

[w]Species *F. chiloensis*, subspecies *pacifica*

[v]Species *F. iturupensis*

[u]Species *F. vesca*

[t]Species *F. vesca*, subspecies *bracteata*

[s]Species *F. vesca*, subspecies *bracteata americana*

[r]Species *F. virginiana*

[q]Species *F. virginiana*, subspecies *glauca*

[p]Species *F. virginiana*, subspecies *platypetala*

[o]Hybrid

[n]Wild derived *F.* ×*ananassa*

[m] Female parent

[l] Male parent

[k]NL_CF

[j]CF

[i]NL

[h]UK_CF

[g]NL_CF

[f]SP_CF

[e]FR_CF

[d]OR_CF

[c]MI_CF

[b] NCGR

[a] NCGR_CF

[za] FR

When superscripts [k] to [za], are placed in a population name, the source corresponds to the progeny of that population. Each parent has their own source

Appendix Table 3.5. Phenotypic data for SSC in California (CA), Michigan (MI), New Hampshire (NH) and Oregon (OR) in 2011 and 2012 and genotypic information obtained with EMFv006 for individuals analyzed in this study (breeding populations, cultivars, supercore collection, wild accessions and synthetic *F.* x*ananassa*). For each breeding population all possible parents are in the first rows with darker background, the confirmed female and male parent are indicated with superscript "m" and "l", respectively. Missing data is represented with a dot.

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
European populations												
EMR population (Redgauntlet × Hapil)												
Redgauntlet_NL[z, k, g]	NJ_1052	Auchincruive_Climax	.	9	.	7.1	.	.	.	7	209	209
Redgauntlet_CF[m, j]	NJ_1051	Auchincruive_Climax	11	.	.	6.4	.	.	.	.	209	209
Hapil_NL[l, i]	Gorella	Souv_de_CharlesMachiroux	.	.	.	.	.	.	.	.	.	.
EMR_1[zb]	Redgauntlet_CF	Hapil_NL	.	8	.	12	.	.	.	7.9	209	209
EMR_2[zb]	Redgauntlet_CF	Hapil_NL	.	9.5	.	11	.	.	.	8	209	209
EMR_3	Redgauntlet_CF	Hapil_NL	.	7.3	.	.	.	.	.	7.5	209	209
EMR_6[zb]	Redgauntlet_CF	Hapil_NL	.	8.6	.	7.8	.	.	.	7	209	209
EMR_10	Redgauntlet_CF	Hapil_NL	.	9.1	.	.	.	6.5	.	7.8	209	209
EMR_11[zb]	Redgauntlet_CF	Hapil_NL	.	9.4	.	5.9	.	.	.	7.1	209	213
EMR_12[zb]	Redgauntlet_CF	Hapil_NL	.	10	.	8.6	.	.	.	7.5	209	209
EMR_13[zb]	Redgauntlet_CF	Hapil_NL	.	8.4	.	7	.	6.7	.	7.4	209	213
EMR_16[zb]	Redgauntlet_CF	Hapil_NL	.	11	.	9.4	.	.	.	9.6	209	215
EMR_17[zb]	Redgauntlet_CF	Hapil_NL	.	9.3	.	11	.	6.9	.	7.6	209	213
EMR_20[zb]	Redgauntlet_CF	Hapil_NL	.	11	.	8.1	.	.	.	9.3	209	209

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
EMR_21[zb]	Redgauntlet_CF	Hapil_NL	.	10	.	9.5	.	.	.	7.1	209	213
EMR_25[zb]	Redgauntlet_CF	Hapil_NL	.	9.3	.	9.2	.	8.8	.	6.7	209	209
EMR_28	Redgauntlet_CF	Hapil_NL	.	8.4	.	.	.	.	.	7.4	209	213
EMR_29[zb]	Redgauntlet_CF	Hapil_NL	.	9.3	.	10	.	6.5	.	7.2	209	213
EMR_30[zb]	Redgauntlet_CF	Hapil_NL	.	7.1	.	9	.	8.5	.	7.3	209	213
EMR_32[zb]	Redgauntlet_CF	Hapil_NL	.	9.3	.	9.9	.	6.7	.	7.1	209	209
EMR_34[zb]	Redgauntlet_CF	Hapil_NL	.	9.7	.	11	.	.	.	7.3	209	213
EMR_36[zb]	Redgauntlet_CF	Hapil_NL	.	7.1	.	8.3	.	6.3	.	5.4	209	213
EMR_43[zb]	Redgauntlet_CF	Hapil_NL	.	12	.	6.8	.	6.5	.	6.7	209	213
EMR_45[zb]	Redgauntlet_CF	Hapil_NL	.	9	.	11	.	7.8	.	7.8	209	213
EMR_48[zb]	Redgauntlet_CF	Hapil_NL	.	8.4	.	8.8	.	5.4	.	6	209	213
EMR_51[zb]	Redgauntlet_CF	Hapil_NL	.	9.3	.	9.2	.	6	.	5.8	209	213
EMR_54	Redgauntlet_CF	Hapil_NL	.	9.8	.	.	.	5.9	.	6.8	209	213
EMR_55[zb]	Redgauntlet_CF	Hapil_NL	.	7.2	.	10	.	8.2	.	6.1	209	213
EMR_56	Redgauntlet_CF	Hapil_NL	.	8.8	.	.	.	.	.	4.6	209	213
EMR_57[zb]	Redgauntlet_CF	Hapil_NL	.	7.1	.	12	.	7.2	.	7.1	209	209
EMR_58[zb]	Redgauntlet_CF	Hapil_NL	.	9.1	.	8.4	.	8.8	.	6.9	209	209
EMR_59[zb]	Redgauntlet_CF	Hapil_NL	.	8.3	.	7.4	.	.	.	7.7	209	213
EMR_63[zb]	Redgauntlet_CF	Hapil_NL	.	8.6	.	7.7	.	.	.	5.8	209	213
EMR_65[zb]	Redgauntlet_CF	Hapil_NL	.	7.8	.	8.8	.	6.4	.	5.7	209	209
EMR_66[zb]	Redgauntlet_CF	Hapil_NL	.	8.8	.	9.9	.	5.8	.	6.3	209	209
EMR_67[zb]	Redgauntlet_CF	Hapil_NL	.	8.4	.	7	.	8.2	.	8.1	209	213
EMR_70[zb]	Redgauntlet_CF	Hapil_NL	.	10	.	10	.	.	.	7.7	209	209

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
EMR_71[zb]	Redgauntlet_CF	Hapil_NL	.	11	.	16	.	6.9	.	7.1	209	213
EMR_73[zb]	Redgauntlet_CF	Hapil_NL	.	8.4	.	10	.	7.3	.	7.4	209	209
EMR_76[zb]	Redgauntlet_CF	Hapil_NL	.	8.3	.	9.1	.	7	.	8.2	209	213
EMR_82[zb]	Redgauntlet_CF	Hapil_NL	.	10	.	11	.	.	.	9.1	209	213
EMR_84[zb]	Redgauntlet_CF	Hapil_NL	.	11	.	16	.	.	.	9.1	209	209
EMR_85[zb]	Redgauntlet_CF	Hapil_NL	.	9.9	.	10	.	.	.	8.9	209	213
EMR_92[zb]	Redgauntlet_CF	Hapil_NL	.	10	.	9.2	.	.	.	6.3	209	213
EMR_98[zb]	Redgauntlet_CF	Hapil_NL	.	11	.	8.1	.	.	.	5.4	209	209
EMR_99[zb]	Redgauntlet_CF	Hapil_NL	.	11	.	11	.	.	.	8.1	215	213
EMR_103[zb]	Redgauntlet_CF	Hapil_NL	.	8.7	.	7.4	.	.	.	7.4	209	209
EMR_104	Redgauntlet_CF	Hapil_NL	.	8.5	.	.	.	.	.	7.4	209	213
EMR_105[zb]	Redgauntlet_CF	Hapil_NL	.	11	.	11	.	.	.	7.8	209	213
EMR_113[zb]	Redgauntlet_CF	Hapil_NL	.	11	.	9.8	.	.	.	9.1	209	209
EMR_130[zb]	Redgauntlet_CF	Hapil_NL	.	9.6	.	15	.	.	.	7.4	209	209
EMR_133	Redgauntlet_CF	Hapil_NL	.	11	.	.	.	.	.	7.4	209	209
EMR_159[zb]	Redgauntlet_CF	Hapil_NL	.	8.2	.	9.7	.	.	.	6.7	209	213
EMR_172[zb]	Redgauntlet_CF	Hapil_NL	.	10	.	7.6	.	.	.	7.7	209	209
NL population (Holiday ×Korona)												
Holiday_CF[m, d, j]	Raritan	NY_844	14	9.1	.	8	8.4	.	7.8	6.6	213	213
Holiday_NL[y, m, i]	Raritan	NY_845	.	9.5	.	8.6	.	.	.	7.3	213	213
Korona_NL[l, i]	Tamella	Induka	11	11	.	13	.	.	.	7.2	213	209
Korona_CF [d]	Tamella	Induka	11	11	.	13	.	.	.	7.2	213	209
H-02316	Holiday_CF	Korona_NL	.	8.9	.	.	.	.	.	.	209	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
H-02317[zb]	Holiday_CF	Korona_NL	.	12	.	8.4	.	.	.	7.8	207	213
H-02321	Holiday_CF	Korona_NL	.	11	.	.	.	.	.	6.5	209	213
H-02322[zb]	Holiday_CF	Korona_NL	.	8.6	.	8.4	.	.	.	6.6	207	213
H-02324[zb]	Holiday_CF	Korona_NL	.	13	.	13	.	.	.	7.3	207	213
H-02331[zb]	Holiday_CF	Korona_NL	.	10	.	8.6	.	.	.	6.5	209	213
H-02356[zb]	Holiday_CF	Korona_NL	.	11	.	8.8	.	.	.	8	209	213
H-02369[zb]	Holiday_CF	Korona_NL	.	6.9	.	10	.	.	.	6.8	209	213
H-02374[zb]	Holiday_CF	Korona_NL	.	12	.	9.5	.	.	.	5.3	207	213
H-02379	Holiday_CF	Korona_NL	.	9.5	.	.	.	.	.	.	209	213
H-02385	Holiday_CF	Korona_NL	.	8.5	.	.	.	.	.	.	209	213
H-02401	Holiday_CF	Korona_NL	.	11	.	.	.	.	.	7	209	213
H-02406	Holiday_CF	Korona_NL	.	12	.	.	.	.	.	6.3	209	213
H-02410[zb]	Holiday_CF	Korona_NL	.	13	.	12	.	.	.	8.4	207	213
H-02465[zb]	Holiday_CF	Korona_NL	.	9	.	9.5	.	.	.	6.6	207	213
H-02475[zb]	Holiday_CF	Korona_NL	.	10	.	11	.	.	.	10	209	213
H-02485	Holiday_CF	Korona_NL	.	8.9	.	.	.	.	.	6.8	207	213
H-02501[zb]	Holiday_CF	Korona_NL	.	8.4	.	8.8	.	.	.	7.5	207	213
H-02529	Holiday_CF	Korona_NL	.	7.5	.	.	.	.	.	.	207	213
H-02549	Holiday_CF	Korona_NL	.	11	.	.	.	.	.	.	209	213
H-02552	Holiday_CF	Korona_NL	.	7.7	.	.	.	.	.	.	209	213
H-02572	Holiday_CF	Korona_NL	.	11	.	.	.	.	.	.	207	213
H-02622	Holiday_CF	Korona_NL	.	12	.	.	.	.	.	.	209	213
H-02637	Holiday_CF	Korona_NL	.	9.2	.	.	.	.	.	7.8	207	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
IFAPA population (IFAPA_1392 ×IFAPA_232)												
IFAPA_1392[m, f]	Esp	Gaviota	.	7.6	.	.	.	.	.	.	213	215
IFAPA_232[l, f]	Esp	Sel.4-43	.	7.3	.	.	.	.	.	.	213	215
IFAPA_93-4	IFAPA_1392	IFAPA_232	.	12	.	.	.	.	.	.	213	215
IFAPA_93-6	IFAPA_1392	IFAPA_232	.	8.3	.	.	.	.	.	.	213	215
IFAPA_93-8	IFAPA_1392	IFAPA_232	.	6.6	.	.	.	.	.	.	213	215
IFAPA_93-11	IFAPA_1392	IFAPA_232	.	9.5	.	.	.	.	.	.	213	215
IFAPA_93-12	IFAPA_1392	IFAPA_232	.	7.7	.	.	.	.	.	.	213	215
IFAPA_93-13	IFAPA_1392	IFAPA_232	.	9.8	.	.	.	.	.	.	213	215
IFAPA_93-15	IFAPA_1392	IFAPA_232	.	11	.	.	.	.	.	.	213	215
IFAPA_93-16	IFAPA_1392	IFAPA_232	.	8.2	.	.	.	.	.	.	213	215
IFAPA_93-21	IFAPA_1392	IFAPA_232	.	8.9	.	.	.	.	.	.	213	215
IFAPA_93-24	IFAPA_1392	IFAPA_232	.	7.1	.	.	.	.	.	.	215	215
IFAPA_93-26	IFAPA_1392	IFAPA_232	.	6.5	.	.	.	.	.	.	215	215
IFAPA_93-32	IFAPA_1392	IFAPA_232	.	8.1	.	.	.	.	.	.	213	215
IFAPA_93-33	IFAPA_1392	IFAPA_232	.	8.5	.	.	.	.	.	.	213	215
IFAPA_93-34	IFAPA_1392	IFAPA_232	.	8	.	.	.	.	.	.	213	215
IFAPA_93-36	IFAPA_1392	IFAPA_232	.	11	.	.	.	.	.	.	213	215
IFAPA_93-37	IFAPA_1392	IFAPA_232	.	10	.	.	.	.	.	.	213	215
IFAPA_93-42	IFAPA_1392	IFAPA_232	.	8.7	.	.	.	.	.	.	215	215
IFAPA_93-46	IFAPA_1392	IFAPA_232	.	9.2	.	.	.	.	.	.	213	215
IFAPA_93-47	IFAPA_1392	IFAPA_232	.	9.4	.	.	.	.	.	.	213	215
IFAPA_93-50	IFAPA_1392	IFAPA_232	.	6.9	.	.	.	.	.	.	213	215

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
IFAPA_93-54	IFAPA_1392	IFAPA_232	.	8.4	.	.	.	.	.	.	213	215
IFAPA_93-56	IFAPA_1392	IFAPA_232	.	8.3	.	.	.	.	.	.	213	215
IFAPA_93-57	IFAPA_1392	IFAPA_232	.	6.4	.	.	.	.	.	.	213	215
IFAPA_93-58	IFAPA_1392	IFAPA_232	.	7.9	.	.	.	.	.	.	215	215
IFAPA_93-59	IFAPA_1392	IFAPA_232	.	8.3	.	.	.	.	.	.	213	215
IFAPA_93-60	IFAPA_1392	IFAPA_232	.	11	.	.	.	.	.	.	213	215
IFAPA_93-61	IFAPA_1392	IFAPA_232	.	12	.	.	.	.	.	.	213	215
IFAPA_93-62	IFAPA_1392	IFAPA_232	.	11	.	.	.	.	.	.	213	215
IFAPA_93-64	IFAPA_1392	IFAPA_232	.	9.7	.	.	.	.	.	.	213	215
IFAPA_93-65	IFAPA_1392	IFAPA_232	.	8.6	.	.	.	.	.	.	215	215
IFAPA_93-66	IFAPA_1392	IFAPA_232	.	8.3	.	.	.	.	.	.	213	215
IFAPA_93-69	IFAPA_1392	IFAPA_232	.	9.2	.	.	.	.	.	.	215	215
IFAPA_93-70	IFAPA_1392	IFAPA_232	.	7.4	.	.	.	.	.	.	213	215
IFAPA_93-72	IFAPA_1392	IFAPA_232	.	9.1	.	.	.	.	.	.	213	215
IFAPA_93-73	IFAPA_1392	IFAPA_232	.	9	.	.	.	.	.	.	213	215
IFAPA_93-74	IFAPA_1392	IFAPA_232	.	8.9	.	.	.	.	.	.	213	215
IFAPA_93-75	IFAPA_1392	IFAPA_232	.	9.1	.	.	.	.	.	.	213	215
IFAPA_93-76	IFAPA_1392	IFAPA_232	.	12	.	.	.	.	.	.	215	215
IFAPA_93-79	IFAPA_1392	IFAPA_232	.	8.9	.	.	.	.	.	.	213	215
IFAPA_93-80	IFAPA_1392	IFAPA_232	.	8.6	.	.	.	.	.	.	213	215
IFAPA_93-81	IFAPA_1392	IFAPA_232	.	8.7	.	.	.	.	.	.	213	215
IFAPA_93-82	IFAPA_1392	IFAPA_232	.	11	.	.	.	.	.	.	213	215
IFAPA_93-84	IFAPA_1392	IFAPA_232	.	9.9	.	.	.	.	.	.	213	215

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
IFAPA_93-85	IFAPA_1392	IFAPA_232	.	9.2	.	.	.	.	.	.	213	215
IFAPA_93-86	IFAPA_1392	IFAPA_232	.	9	.	.	.	.	.	.	213	215
IFAPA_93-90	IFAPA_1392	IFAPA_232	.	10	.	.	.	.	.	.	213	215
IFAPA_93-92	IFAPA_1392	IFAPA_232	.	5.7	.	.	.	.	.	.	215	215
IFAPA_93-93	IFAPA_1392	IFAPA_232	.	5.9	.	.	.	.	.	.	215	215
IFAPA_93-94	IFAPA_1392	IFAPA_232	.	9.8	.	.	.	.	.	.	213	215
IFAPA_93-96	IFAPA_1392	IFAPA_232	.	8.3	.	.	.	.	.	.	213	215
INRA population (Capitola ×CF1116)												
Capitola_FR_CF[m, e]	Cal_75.121-101	Parker	.	7.6	.	.	.	.	.	.	207	207
CF1116_FR[l, za]	Pajaro	(Earliglow×Chandler)	.	.	.	.	.	.	.	.	.	.
INRA_5	Capitola_FR_CF	CF1116_FR	.	.	.	.	.	.	.	6.6	215	215
INRA_6[zb]	Capitola_FR_CF	CF1116_FR	.	9.1	.	9	.	.	.	6.7	207	215
INRA_8[zb]	Capitola_FR_CF	CF1116_FR	.	9.1	.	7.4	.	.	.	6.3	207	213
INRA_9[zb]	Capitola_FR_CF	CF1116_FR	.	8.2	.	8.7	.	.	.	6.2	207	215
INRA_10	Capitola_FR_CF	CF1116_FR	.	11	.	.	.	.	.	7.6	215	213
INRA_11[zb]	Capitola_FR_CF	CF1116_FR	.	10	.	7.5	.	.	.	7.1	207	213
INRA_12[zb]	Capitola_FR_CF	CF1116_FR	.	8.7	.	14	.	.	.	6.6	207	215
INRA_14[zb]	Capitola_FR_CF	CF1116_FR	.	8.1	.	6.8	.	.	.	6.7	215	213
INRA_15	Capitola_FR_CF	CF1116_FR	.	9	.	.	.	.	.	7.1	207	215
INRA_16	Capitola_FR_CF	CF1116_FR	.	6.9	.	.	.	.	.	7.4	215	213
INRA_19	Capitola_FR_CF	CF1116_FR	.	8.9	.	.	.	.	.	8	215	215
INRA_30	Capitola_FR_CF	CF1116_FR	.	8.9	.	.	.	.	.	8.7	215	215
INRA_34[zb]	Capitola_FR_CF	CF1116_FR	.	11	.	8.2	.	.	.	7.7	207	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
INRA_37[zb]	Capitola_FR_CF	CF1116_FR	.	8.5	.	8.8	.	.	.	6.5	207	213
INRA_43[zb]	Capitola_FR_CF	CF1116_FR	.	11	.	7.9	.	.	.	6.3	215	213
INRA_47	Capitola_FR_CF	CF1116_FR	.	7.7	.	.	.	.	.	6.3	215	213
INRA_58[zb]	Capitola_FR_CF	CF1116_FR	.	9.3	.	8.2	.	.	.	6.1	207	213
INRA_59[zb]	Capitola_FR_CF	CF1116_FR	.	9.8	.	7.7	.	.	.	7.6	207	213
INRA_61[zb]	Capitola_FR_CF	CF1116_FR	.	11	.	8	.	.	.	7.3	215	215
INRA_76	Capitola_FR_CF	CF1116_FR	.	13	.	.	.	.	.	7.5	215	213
INRA_79	Capitola_FR_CF	CF1116_FR	.	10	.	.	.	.	.	7.1	207	215
INRA_94[zb]	Capitola_FR_CF	CF1116_FR	.	9	.	7	.	.	.	7.9	215	213
INRA_95	Capitola_FR_CF	CF1116_FR	.	8.9	.	.	.	.	.	7	215	213
INRA_97[zb]	Capitola_FR_CF	CF1116_FR	.	8	.	8.6	.	.	.	6.6	207	215
INRA_98[zb]	Capitola_FR_CF	CF1116_FR	.	7.2	.	8.7	.	.	.	7.1	207	215
INRA_99[zb]	Capitola_FR_CF	CF1116_FR	.	.	.	8.1	.	.	.	6.2	207	213
INRA_103	Capitola_FR_CF	CF1116_FR	.	7.7	.	.	.	.	.	6.9	215	215
INRA_104	Capitola_FR_CF	CF1116_FR	.	9.7	.	.	.	.	.	7.2	215	213
INRA_108[zb]	Capitola_FR_CF	CF1116_FR	.	7	.	9.1	.	.	.	6.3	207	215
INRA_110	Capitola_FR_CF	CF1116_FR	.	12	.	.	.	.	.	6.2	215	213
INRA_116[zb]	Capitola_FR_CF	CF1116_FR	.	9.9	.	8.8	.	.	.	7.5	215	213
INRA_122[zb]	Capitola_FR_CF	CF1116_FR	.	8	.	12	.	.	.	5.4	207	215
INRA_124	Capitola_FR_CF	CF1116_FR	.	9.9	.	.	.	.	.	6.5	207	213
INRA_126	Capitola_FR_CF	CF1116_FR	.	.	.	.	.	.	.	8	207	215
INRA_134[zb]	Capitola_FR_CF	CF1116_FR	.	11	.	9.7	.	.	.	7.3	207	215
INRA_135[zb]	Capitola_FR_CF	CF1116_FR	.	7.8	.	9.1	.	.	.	6.2	207	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
INRA_138[zb]	Capitola_FR_CF	CF1116_FR	.	9.8	.	8.4	.	.	.	6.7	215	213
INRA_141[zb]	Capitola_FR_CF	CF1116_FR	.	11	.	9.2	.	.	.	8.8	215	213
INRA_147	Capitola_FR_CF	CF1116_FR	.	12	.	.	.	.	.	7.1	207	215
INRA_148	Capitola_FR_CF	CF1116_FR	.	7.8	.	.	.	.	.	7.5	207	213
INRA_151	Capitola_FR_CF	CF1116_FR	.	11	.	.	.	.	.	8	215	215
INRA_153[zb]	Capitola_FR_CF	CF1116_FR	.	9	.	10	.	.	.	7	215	213
INRA_157	Capitola_FR_CF	CF1116_FR	.	10	.	.	.	.	.	7.8	207	215
INRA_161[zb]	Capitola_FR_CF	CF1116_FR	.	9.5	.	8.4	.	.	.	6.8	207	213
INRA_165	Capitola_FR_CF	CF1116_FR	.	9.7	.	.	.	.	.	7	215	213
INRA_167[zb]	Capitola_FR_CF	CF1116_FR	.	8.3	.	7.8	.	.	.	7.7	215	213
INRA_172	Capitola_FR_CF	CF1116_FR	.	7.9	.	.	.	.	.	6.4	207	213
INRA_175[zb]	Capitola_FR_CF	CF1116_FR	.	8.1	.	11	.	.	.	6	207	213
INRA_181[zb]	Capitola_FR_CF	CF1116_FR	.	12	.	10	.	.	.	8	215	213
INRA_195[zb]	Capitola_FR_CF	CF1116_FR	.	8.6	.	11	.	.	.	7.4	215	213
INRA_196[zb]	Capitola_FR_CF	CF1116_FR	.	9.1	.	9.9	.	.	.	7.1	207	215
INRA_197[zb]	Capitola_FR_CF	CF1116_FR	.	8.4	.	12	.	.	.	8.1	207	213
INRA_201[zb]	Capitola_FR_CF	CF1116_FR	.	8.4	.	13	.	.	.	7.5	207	213
INRA_204	Capitola_FR_CF	CF1116_FR	.	11	.	.	.	.	.	7.1	215	213
INRA_216	Capitola_FR_CF	CF1116_FR	.	11	.	.	.	.	.	7.3	207	215
MSU populations												
MSU_9-1 population (MSU_49 × FRA_1702)[c]												
MSU_49[m, d]	Jewel	Mesabi	13	11	.	13	.	.	9.2	.	213	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
FRA_1702_I1[l]	.	.	.	.	.	.	.	.	.	.	.	.
MSU_9-1-1[zb]	MSU_49	FRA_1702_I1	6.1	9.8	12	12	.	.	8	.	213	219
MSU_9-1-2[zb]	MSU_49	FRA_1702_I1	11	10	10	12	9.3	10	8.3	7	213	213
MSU_9-1-3[zb]	MSU_49	FRA_1702_I1	11	8.7	12	12	6.2	8.4	.	.	213	219
MSU_9-1-4[zb]	MSU_49	FRA_1702_I1	12	8	.	12	10	11	8.2	.	213	219
MSU_9-1-5[zb]	MSU_49	FRA_1702_I1	.	9.1	11	12	9.3	8.3	8	.	213	213
MSU_9-1-6	MSU_49	FRA_1702_I1	11	10	.	10	.	13	.	.	213	219
MSU_9-1-7[zb]	MSU_49	FRA_1702_I1	12	.	9.7	.	.	.	5.5	.	213	219
MSU_9-1-8[zb]	MSU_49	FRA_1702_I1	11	13	.	8.5	8.3	6.4	9.5	8.1	213	213
MSU_9-1-9[zb]	MSU_49	FRA_1702_I1	9.8	12	13	9.5	9	6.9	7.6	6.3	213	213
MSU_9-1-10	MSU_49	FRA_1702_I1	9.7	.	.	.	9	.	.	8	213	219
MSU_9-2 population (MSU_49 × Seascape)[c]												
MSU_49[m, j]	Jewel	Mesabi	13	11	.	13	.	.	9.2	.	213	213
Seascape_CF[l, j]	Selva	Douglas	9.7	8.6	.	12	.	.	.	6.2	213	215
MSU_9-2-1	MSU_49	Seascape_CF	14	8.6	11	.	7.4	12	6.4	.	215	213
MSU_9-2-2[zb]	MSU_49	Seascape_CF	11	7	11	9.7	8.5	.	5.9	.	213	213
MSU_9-2-3[zb]	MSU_49	Seascape_CF	8.6	8.3	9.8	.	.	.	6.1	.	215	213
MSU_9-2-4[zb]	MSU_49	Seascape_CF	.	7.3	8.9	8.1	11	.	10	5.3	213	213
MSU_9-2-5[zb]	MSU_49	Seascape_CF	8.9	8.4	13	7	6.2	.	8.8	.	213	213
MSU_9-2-6[zb]	MSU_49	Seascape_CF	.	7.8	.	.	8	.	6.5	6.9	215	213
MSU_9-2-7[zb]	MSU_49	Seascape_CF	13	7.6	.	10	.	.	4.9	7.7	215	213
MSU_9-2-8[zb]	MSU_49	Seascape_CF	8.9	9	.	.	.	7.7	8.3	7.2	215	213
MSU_9-2-9[zb]	MSU_49	Seascape_CF	7.9	10	.	9.2	8.1	.	7.9	7.3	213	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
MSU_9-2-10[zb]	MSU_49	Seascape_CF	12	.	9.7	13	9.6	8.3	9.2	.	213	213
MSU_9-3 population (MSU_49 × Tribute)[c]												
MSU_49[m, j]	Jewel	Mesabi	13	11	.	13	.	.	9.2	.	213	213
Tribute_662.001[l, b]	USEB_18	MDUS_4258	13	9.6	14	12	.	.	11	.	213	213
MSU_9-3-1[zb]	MSU_49	Tribute_662.001	13	8.1	13	9.5	11	.	6.1	.	213	213
MSU_9-3-2[zb]	MSU_49	Tribute_662.001	.	11	.	8.1	8.8	8.8	10	6.1	213	213
MSU_9-3-3[zb]	MSU_49	Tribute_662.001	.	.	12	8.2	9.1	.	7.9	10	213	213
MSU_9-3-4[zb]	MSU_49	Tribute_662.001	9.2	8.5	13	9.3	8.7	9.1	6.7	.	213	213
MSU_9-3-5	MSU_49	Tribute_662.001	.	.	.	.	.	.	.	.	.	.
MSU_9-3-6[zb]	MSU_49	Tribute_662.001	.	7.7	.	8.2	11	11	8	.	213	219
MSU_9-3-7	MSU_49	Tribute_662.001	.	8.5	.	12	.	7.7	.	.	213	213
MSU_9-3-8[zb]	MSU_49	Tribute_662.001	.	7.7	.	9.4	9.8	11	6.4	.	213	213
MSU_9-3-9[zb]	MSU_49	Tribute_662.001	12	10	12	12	9.5	8.4	8.7	.	213	219
MSU_9-3-10[zb]	MSU_49	Tribute_662.001	.	8.4	11	11	8.7	14	7.6	.	213	213
MSU_9-4 population (MSU_56 × FRA_1702)[c]												
MSU_56[m, j]	Cabot	Cavendish	.	9.3	12	13	.	.	8.9	8	213	213
FRA_1702_I1[l]	.	.	.	.	.	.	.	.	.	.	.	.
MSU_9-4-1[zb]	MSU_56	FRA_1702_I1	13	8.7	.	9.7	8.4	13	8.1	9	213	219
MSU_9-4-2[zb]	MSU_56	FRA_1702_I1	12	9.8	11	10	11	12	10	9.4	213	219
MSU_9-4-3[zb]	MSU_56	FRA_1702_I1	12	13	.	11	8.8	7.4	11	6.8	213	213
MSU_9-4-4[zb]	MSU_56	FRA_1702_I1	14	9.5	.	14	9.9	17	12	.	213	219
MSU_9-4-5[zb]	MSU_56	FRA_1702_I1	12	10	.	11	9.6	.	7.4	.	213	219
MSU_9-4-6[zb]	MSU_56	FRA_1702_I1	11	7.6	.	13	9	8.2	7.6	6.9	213	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
MSU_9-4-7[zb]	MSU_56	FRA_1702_I1	13	9.7	12	13	10	7.5	8.3	.	213	213
MSU_9-4-8[zb]	MSU_56	FRA_1702_I1	14	11	.	8.5	9.6	9.2	13	9.7	213	219
MSU_9-4-9[zb]	MSU_56	FRA_1702_I1	.	9.6	10	.	10	7.9	9.3	7	213	219
MSU_9-4-10[zb]	MSU_56	FRA_1702_I1	11	9.1	.	15	9.9	9.3	11	11	213	213
MSU_9-5 population (FRA_1702 × Earliglow)[c]												
FRA_1702_I1[m]	.	.	.	.	.	.	.	.	.	.	.	.
Earliglow_CF[l, j]	MDUS_2359	MDUS_2713	15	.	.	.	10	.	9	9.5	213	213
MSU_9-5-1[zb]	FRA_1702_I1	Earliglow_CF	15	10	.	12	13	11	14	11	213	213
MSU_9-5-2[zb]	FRA_1702_I1	Earliglow_CF	.	8.2	13	11	11	13	10	10	207	213
MSU_9-5-3[zb]	FRA_1702_I1	Earliglow_CF	13	11	.	13	10	8.9	12	8.7	219	213
MSU_9-5-4[zb]	FRA_1702_I1	Earliglow_CF	13	10	.	12	12	8.9	11	7.8	213	213
MSU_9-5-5[zb]	FRA_1702_I1	Earliglow_CF	13	11	12	8.6	9.5	12	10	7.9	219	213
MSU_9-5-6[zb]	FRA_1702_I1	Earliglow_CF	11	8.6	.	9.9	9.5	8.2	9.8	7.5	219	213
MSU_9-5-7[zb]	FRA_1702_I1	Earliglow_CF	13	10	12	11	8.4	8.5	8.9	.	219	213
MSU_9-5-8[zb]	FRA_1702_I1	Earliglow_CF	11	11	16	15	8.4	11	8.2	.	219	213
MSU_9-5-9[zb]	FRA_1702_I1	Earliglow_CF	14	11	.	13	11	12	11	10	213	213
MSU_9-5-10[zb]	FRA_1702_I1	Earliglow_CF	12	.	.	14	12	13	7.1	9.7	219	213
MSU_9-6 population (Earliglow × Seascape)[c]												
Earliglow_CF[m, j]	MDUS_2359	MDUS_2713	15	.	.	.	10	.	9	9.5	213	213
Seascape_CF[l, j]	Selva	Douglas	9.7	8.6	.	12	.	.	.	6.2	213	215
MSU_9-6-1[zb]	Earliglow_CF	Seascape_CF	10	8.9	16	14	8.9	.	8.7	9.3	213	213
MSU_9-6-2[zb]	Earliglow_CF	Seascape_CF	15	7.8	.	11	.	.	7.8	6.1	213	213
MSU_9-6-3[zb]	Earliglow_CF	Seascape_CF	13	8	13	6.7	9.3	13	9.6	7.5	213	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
MSU_9-6-4[zb]	Earliglow_CF	Seascape_CF	11	6.9	.	10	11	.	11	.	213	213
MSU_9-6-5[zb]	Earliglow_CF	Seascape_CF	12	7.7	12	9.9	9.4	.	8.4	7.9	213	213
MSU_9-6-6[zb]	Earliglow_CF	Seascape_CF	12	12	15	14	9.8	.	12	.	213	213
MSU_9-6-7[zb]	Earliglow_CF	Seascape_CF	13	9.5	.	16	.	12	10	7.3	213	215
MSU_9-6-8[zb]	Earliglow_CF	Seascape_CF	12	9.6	.	13	8.3	7	8.9	6.7	213	213
MSU_9-6-9[zb]	Earliglow_CF	Seascape_CF	13	12	.	8.7	8.3	15	9.1	7.7	213	213
MSU_9-6-10[zb]	Earliglow_CF	Seascape_CF	12	12	12	9.9	9.2	14	11	8.3	213	215
MSU_9-8 population (Fort Laramie × Earliglow)[c]												
FortLaramie_NCGR[m, b]	Geneva	S.65122	.	.	.	.	.	.	.	.	.	.
Earliglow_CF[l, j]	MDUS_2359	MDUS_2713	15	.	.	.	10	.	9	9.5	213	213
MSU_9-8-1[zb]	FortLaramie_NCGR	Earliglow_CF	10	8.1	.	7.9	7.7	7	8.8	.	207	213
MSU_9-8-2[zb]	FortLaramie_NCGR	Earliglow_CF	10	10	11	11	8.5	.	8.9	6.2	215	213
MSU_9-8-3[zb]	FortLaramie_NCGR	Earliglow_CF	10	8.7	11	9.2	8.4	.	6.5	.	215	213
MSU_9-8-4[zb]	FortLaramie_NCGR	Earliglow_CF	11	.	.	9.7	7.8	8.1	8.3	7.6	207	213
MSU_9-8-5[zb]	FortLaramie_NCGR	Earliglow_CF	11	9.9	.	11	11	6.6	8.4	.	215	213
MSU_9-8-6[zb]	FortLaramie_NCGR	Earliglow_CF	11	6	12	10	8	7.1	.	.	215	213
MSU_9-8-7[zb]	FortLaramie_NCGR	Earliglow_CF	11	9.6	.	12	9.7	9.5	9.2	5.6	207	213
MSU_9-8-8[zb]	FortLaramie_NCGR	Earliglow_CF	12	6	.	13	7.4	7.3	11	8	215	213
MSU_9-8-9[zb]	FortLaramie_NCGR	Earliglow_CF	11	9.2	12	10	.	5.9	8.8	8	207	213
MSU_9-8-10[zb]	FortLaramie_NCGR	Earliglow_CF	.	11	.	9.7	7.6	.	6.8	.	215	213
MSU_9-9 population (Fort Laramie × Honeoye)[c]												
FortLaramie_NCGR[m, b]	Geneva	S.65122	.	.	.	.	.	.	.	.	.	.
Honeoye_215.001[l, b]	Vibrant	Holiday	11	10	.	.	.	.	11	.	207	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
MSU_9-9-1[zb]	FortLaramie_NCGR	Honeoye_215.001	9.7	9.1	10	8.2	.	.	6.1	8	215	213
MSU_9-9-2[zb]	FortLaramie_NCGR	Honeoye_215.001	8	12	11	11	.	.	7.2	.	207	215
MSU_9-9-3[zb]	FortLaramie_NCGR	Honeoye_215.001	6.1	6.9	11	9.8	.	.	6.2	.	207	213
MSU_9-9-4[zb]	FortLaramie_NCGR	Honeoye_215.001	13	7.8	16	8.5	.	.	7.4	5.3	207	215
MSU_9-9-5[zb]	FortLaramie_NCGR	Honeoye_215.001	10	.	.	9	.	.	7.6	7.4	215	213
MSU_9-9-6[zb]	FortLaramie_NCGR	Honeoye_215.001	11	10	.	10	.	.	7.2	7.4	215	213
MSU_9-9-7[zb]	FortLaramie_NCGR	Honeoye_215.001	13	11	12	10	.	.	7.9	.	207	207
MSU_9-9-8[zb]	FortLaramie_NCGR	Honeoye_215.001	13	9.9	10	11	.	.	6.8	.	207	213
MSU_9-9-9[zb]	FortLaramie_NCGR	Honeoye_215.001	.	6.8	.	13	.	.	6.4	7.4	215	213
MSU_9-9-10[zb]	FortLaramie_NCGR	Honeoye_215.001	10	10	10	8.2	.	.	7.4	6.8	207	207
MSU_9-10 population (Fort Laramie × MSU_49)[c]												
FortLaramie_NCGR[m, b]	Geneva	S.65122	.	.	.	.	.	.	.	.	.	.
MSU_49[l, j]	Jewel	Mesabi	13	11	.	13	.	.	9.2	.	213	213
MSU_9-10-1[zb]	FortLaramie_NCGR	MSU_49	11	11	.	13	.	.	6.5	7.5	213	215
MSU_9-10-2[zb]	FortLaramie_NCGR	MSU_49	12	11	.	7	.	.	9.4	6.4	213	215
MSU_9-10-3[zb]	FortLaramie_NCGR	MSU_49	10	10	7	8.1	.	.	7.5	6.8	213	215
MSU_9-10-4[zb]	FortLaramie_NCGR	MSU_49	12	7.7	.	9.1	.	.	6	6.5	213	215
MSU_9-10-5[zb]	FortLaramie_NCGR	MSU_49	9	8.4	12	16	.	.	7.5	.	213	207
MSU_9-10-6[zb]	FortLaramie_NCGR	MSU_49	11	9.4	11	9.9	.	.	7.2	7.6	213	215
MSU_9-10-7[zb]	FortLaramie_NCGR	MSU_49	.	7.3	8.1	6.8	.	.	9	8.9	213	215
MSU_9-10-8[zb]	FortLaramie_NCGR	MSU_49	11	10	11	8.6	.	.	7.2	9.2	213	215
MSU_9-10-9[zb]	FortLaramie_NCGR	MSU_49	11	9.3	11	7.9	.	.	7.4	.	213	207
MSU_9-10-10[zb]	FortLaramie_NCGR	MSU_49	.	11	9.6	8.1	.	.	6.1	5.3	213	207

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
MSU_9-11 population (Fort Laramie × MSU_56)[c]												
FortLaramie_NCGR[m, b]	Geneva	S.65122	10	12	.	6.2	.	.	.	7.1	207	215
MSU_56[l, j]	Cabot	Cavendish	.	9.3	12	13	.	.	8.9	8	213	213
MSU_9-11-1[zb]	FortLaramie_NCGR	MSU_56	12	12	.	8.7	.	.	9.7	6.7	213	207
MSU_9-11-2[zb]	FortLaramie_NCGR	MSU_56	12	8.3	11	.	.	.	6.8	.	213	215
MSU_9-11-3[zb]	FortLaramie_NCGR	MSU_56	7.3	9	9.5	10	.	.	5.9	6	213	207
MSU_9-11-4[zb]	FortLaramie_NCGR	MSU_56	11	9.4	9.4	8.8	.	.	6.4	.	213	207
MSU_9-11-5[zb]	FortLaramie_NCGR	MSU_56	13	10	11	11	.	.	5.5	7.5	213	215
MSU_9-11-6[zb]	FortLaramie_NCGR	MSU_56	12	9.6	.	7.7	.	.	7.3	.	213	207
MSU_9-11-7[zb]	FortLaramie_NCGR	MSU_56	12	7.1	8.9	10	.	.	8.6	7.5	213	215
MSU_9-11-8[zb]	FortLaramie_NCGR	MSU_56	9.8	7.5	9.2	10	.	.	8.6	8.5	213	215
MSU_9-11-9[zb]	FortLaramie_NCGR	MSU_56	.	7.1	.	9.9	.	.	7.7	7.5	213	207
MSU_9-11-10[zb]	FortLaramie_NCGR	MSU_56	.	11	.	8.9	.	.	.	7.6	213	215
MSU_9-12 population (Honeoye × FRA_1702)[c]												
Honeoye_215.001[m, b]	Vibrant	Holiday	.	.	.	.	.	.	.	.	.	.
FRA_1702_I2[l]	.	.	.	.	.	.	.	.	.	.	.	.
MSU_9-12-1[zb]	Honeoye_215.001	FRA_1702_I2	.	12	.	.	.	7.8	8	9	219	213
MSU_9-12-2[zb]	Honeoye_215.001	FRA_1702_I2	14	10	.	.	.	.	7.4	7	213	213
MSU_9-12-3[zb]	Honeoye_215.001	FRA_1702_I2	15	8.7	.	9.8	7.8	.	9.6	.	215	213
MSU_9-12-4[zb]	Honeoye_215.001	FRA_1702_I2	.	9.3	11	12	11	10	9.9	10	207	207
MSU_9-12-5[zb]	Honeoye_215.001	FRA_1702_I2	9.7	11	13	10	8.8	.	9.5	9.2	219	213
MSU_9-12-6[zb]	Honeoye_215.001	FRA_1702_I2	9.4	9.5	6.4	9.2	8.7	6.4	8.4	6.2	213	213
MSU_9-12-7[zb]	Honeoye_215.001	FRA_1702_I2	8.7	9.2	.	.	13	.	8.4	6.8	207	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
MSU_9-12-8[zb]	Honeoye_215.001	FRA_1702_I2	13	14	.	10	9.6	7.5	9.7	.	207	213
MSU_9-12-9	Honeoye_215.001	FRA_1702_I2	10	9.5	.	.	.	6	8.1	.	213	213
MSU_9-12-10	Honeoye_215.001	FRA_1702_I2	13	9.6	.	.	12	8	7.9	.	207	213
MSU_9-13 population (Seascape × Honeoye)[c]												
Seascape_CF[m, j]	Selva	Douglas	9.7	8.6	.	12	.	.	.	6.2	213	215
Honeoye_215.001[l, b]	Vibrant	Holiday	.	.	.	.	.	.	.	.	.	.
MSU_9-13-1[zb]	Seascape_CF	Honeoye_215.001	9.9	.	.	7.1	8.9	.	7.6	.	207	215
MSU_9-13-2[zb]	Seascape_CF	Honeoye_215.001	10	10	.	.	11	.	8.4	7.1	215	213
MSU_9-13-3[zb]	Seascape_CF	Honeoye_215.001	17	.	.	8.6	6.9	6.8	6.6	4.9	207	215
MSU_9-13-4[zb]	Seascape_CF	Honeoye_215.001	.	.	.	8.5	13	5.8	7.1	.	207	215
MSU_9-13-5[zb]	Seascape_CF	Honeoye_215.001	.	.	.	9.9	9.7	.	7.4	.	211	213
MSU_9-13-6[zb]	Seascape_CF	Honeoye_215.001	12	7.9	.	12	.	7.5	7.6	5.1	207	215
MSU_9-13-7[zb]	Seascape_CF	Honeoye_215.001	11	9.2	.	11	8	8.4	9	5.8	207	213
MSU_9-13-8[zb]	Seascape_CF	Honeoye_215.001	12	7.6	.	7.6	10	7	4.8	.	215	213
MSU_9-13-9[zb]	Seascape_CF	Honeoye_215.001	11	.	.	9.4	6.7	.	7.9	3.2	207	215
MSU_9-13-10[zb]	Seascape_CF	Honeoye_215.001	12	13	.	14	10	7.7	.	5.3	207	213
MSU_9-14 population (Seascape × MSU_56)[c]												
Seascape_CF[m, j]	Selva	Douglas	9.7	8.6	.	12	.	.	.	6.2	213	215
MSU_56[l, j]	Cabot	Cavendish	.	9.3	12	13	.	.	8.9	8	213	213
MSU_9-14-1[zb]	Seascape_CF	MSU_56	11	13	.	8.9	10	6.9	12	9.4	213	213
MSU_9-14-2[zb]	Seascape_CF	MSU_56	12	11	11	9.2	8.6	6.6	8	5.7	213	215
MSU_9-14-3[zb]	Seascape_CF	MSU_56	11	14	.	.	.	8.6	8.7	7.5	219	215
MSU_9-14-4[zb]	Seascape_CF	MSU_56	13	10	16	10	8.5	7.1	6.6	.	213	215

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
MSU_9-14-5[zb]	Seascape_CF	MSU_56	12	10	.	7.3	8.9	6	6.3	.	213	215
MSU_9-14-6[zb]	Seascape_CF	MSU_56	11	11	9.3	13	.	.	8.5	5.9	213	213
MSU_9-14-7[zb]	Seascape_CF	MSU_56	10	13	10	9.5	7	.	7.5	6.6	213	215
MSU_9-14-8[zb]	Seascape_CF	MSU_56	12	9.1	.	12	9.3	8.3	7.7	6.5	213	215
MSU_9-14-9[zb]	Seascape_CF	MSU_56	14	10	15	9.6	8.3	6.9	9	6.9	213	213
MSU_9-14-10[zb]	Seascape_CF	MSU_56	9.3	12	.	8.3	7.7	.	8.1	.	213	213
MSU_9-15 population (Tribute × Earliglow)[c]												
Tribute_662.001[m, b]	USEB_18	MDUS_4258	13	9.6	14	12	.	.	11	.	213	213
Earliglow_CF[l, j]	MDUS_2359	MDUS_2713	15	.	.	.	10	.	9	9.5	213	213
MSU_9-15-1[zb]	Tribute_662.001	Earliglow_CF	.	10	11	9.3	.	.	8.2	9.3	213	213
MSU_9-15-2	Tribute_662.001	Earliglow_CF	.	.	.	.	.	.	.	.	0	0
MSU_9-15-3[zb]	Tribute_662.001	Earliglow_CF	12	11	15	8.8	.	.	10	.	213	213
MSU_9-15-4	Tribute_662.001	Earliglow_CF	10	9.7	.	.	.	.	7.7	.	213	213
MSU_9-15-5[zb]	Tribute_662.001	Earliglow_CF	14	9.1	.	9.8	.	.	8.5	9.4	213	213
MSU_9-15-6[zb]	Tribute_662.001	Earliglow_CF	9.6	6.6	.	8.1	.	.	10	11	213	213
MSU_9-15-7[zb]	Tribute_662.001	Earliglow_CF	10	6.7	14	.	.	.	7.9	.	213	213
MSU_9-15-8[zb]	Tribute_662.001	Earliglow_CF	6.2	11	.	9.5	.	.	9.6	7.7	213	213
MSU_9-15-9[zb]	Tribute_662.001	Earliglow_CF	12	11	.	8	.	.	8.5	.	213	213
MSU_9-15-10[zb]	Tribute_662.001	Earliglow_CF	9.4	9.6	10	11	.	.	10	.	213	213
MSU_9-16 population (Tribute × Honeoye)[c]												
Tribute_662.001[m, b]	USEB_18	MDUS_4258	13	9.6	14	12	.	.	11	.	213	213
Honeoye_215.001[l, b]	Vibrant	Holiday	.	.	.	.	.	.	.	.	.	.
MSU_9-16-1[zb]	Tribute_662.001	Honeoye_215.001	13	9.4	14	8.1	.	.	.	.	213	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
MSU_9-16-2[zb]	Tribute_662.001	Honeoye_215.001	11	7.7	16	8.8	.	.	7.3	.	213	213
MSU_9-16-3[zb]	Tribute_662.001	Honeoye_215.001	11	12	.	9.3	.	.	7.3	.	207	213
MSU_9-16-4[zb]	Tribute_662.001	Honeoye_215.001	14	12	.	11	.	.	7.8	.	213	213
MSU_9-16-5[zb]	Tribute_662.001	Honeoye_215.001	9.3	10	11	14	.	.	7.3	7.2	213	213
MSU_9-16-6[zb]	Tribute_662.001	Honeoye_215.001	12	11	.	9.6	.	.	6.7	.	207	213
MSU_9-16-7	Tribute_662.001	Honeoye_215.001	9.9	8.2	.	9.6	.	.	.	.	213	213
MSU_9-16-8[zb]	Tribute_662.001	Honeoye_215.001	11	8.8	12	9.1	.	.	6.9	.	207	213
MSU_9-16-9[zb]	Tribute_662.001	Honeoye_215.001	13	8.7	14	13	.	.	6.7	.	.	.
MSU_9-16-10[zb]	Tribute_662.001	Honeoye_215.001	11	11	.	9.1	.	.	9	.	213	213
MSU_9-16-11[zb]	Tribute_662.001	Honeoye_215.001	10	10	15	14	.	.	8.2	6.4	207	213
MSU_9-16-12[zb]	Tribute_662.001	Honeoye_215.001	12	.	13	7.2	.	.	10	.	213	213
MSU_9-16-13[zb]	Tribute_662.001	Honeoye_215.001	8.9	9.1	19	11	.	.	9.1	.	213	213
MSU_9-16-14	Tribute_662.001	Honeoye_215.001	12	7.5	.	.	.	.	9.4	.	207	213
MSU_9-16-15[zb]	Tribute_662.001	Honeoye_215.001	14	13	.	10	.	.	7.9	.	207	213
MSU_9-16-16[zb]	Tribute_662.001	Honeoye_215.001	11	5.9	.	10	.	.	7.3	.	213	213
MSU_9-16-17[zb]	Tribute_662.001	Honeoye_215.001	16	10	.	13	.	.	8.4	.	213	213
MSU_9-16-18[zb]	Tribute_662.001	Honeoye_215.001	.	.	9.9	12	.	.	8.7	5.5	207	213
MSU_9-16-19[zb]	Tribute_662.001	Honeoye_215.001	11	8.9	.	8.6	.	.	7.2	.	207	213
MSU_9-16-20[zb]	Tribute_662.001	Honeoye_215.001	12	8	10	15	.	.	10	7.9	213	213
MSU_9-16-21[zb]	Tribute_662.001	Honeoye_215.001	11	11	.	10	.	.	9.2	.	213	213
MSU_9-16-22[zb]	Tribute_662.001	Honeoye_215.001	12	8.8	.	12	.	.	11	6.6	213	213
MSU_9-16-23[zb]	Tribute_662.001	Honeoye_215.001	.	.	10	11	.	.	8.4	.	207	213
MSU_9-16-24[zb]	Tribute_662.001	Honeoye_215.001	11	6.4	.	12	.	.	7.7	.	207	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
MSU_9-16-25[zb]	Tribute_662.001	Honeoye_215.001	9.8	6.9	.	9.4	.	.	7.9	6.9	213	213
MSU_9-16-26[zb]	Tribute_662.001	Honeoye_215.001	12	8	.	9.7	.	.	7.9	.	213	213
MSU_9-16-27[zb]	Tribute_662.001	Honeoye_215.001	11	9.7	14	14	.	.	9	5.8	207	213
MSU_9-16-28[zb]	Tribute_662.001	Honeoye_215.001	12	11	.	13	.	.	8.8	.	213	213
MSU_9-16-29[zb]	Tribute_662.001	Honeoye_215.001	12	12	.	15	.	.	11	.	207	213
MSU_9-16-30[zb]	Tribute_662.001	Honeoye_215.001	13	8.8	.	9.3	.	.	8.6	.	213	213
MSU_9-16-31[zb]	Tribute_662.001	Honeoye_215.001	11	8.9	11	8.1	.	.	5.9	.	213	213
MSU_9-16-32[zb]	Tribute_662.001	Honeoye_215.001	13	8	12	10	.	.	9.1	.	207	213
MSU_9-16-33	Tribute_662.001	Honeoye_215.001	13	8.6	.	9.6	.	.	.	.	207	213
MSU_9-16-34[zb]	Tribute_662.001	Honeoye_215.001	14	8.6	11	9.9	.	.	8.2	.	207	213
MSU_9-16-35[zb]	Tribute_662.001	Honeoye_215.001	.	.	14	10	.	.	.	.	207	213
MSU_9-16-36[zb]	Tribute_662.001	Honeoye_215.001	.	.	9.3	9.7	.	.	8.7	.	207	213
MSU_9-16-37[zb]	Tribute_662.001	Honeoye_215.001	10	7.3	.	13	.	.	9.7	8	207	213
MSU_9-16-38	Tribute_662.001	Honeoye_215.001	10	14	.	.	.	.	5.5	.	213	213
MSU_9-16-39[zb]	Tribute_662.001	Honeoye_215.001	12	10	.	11	.	.	9.2	.	213	213
MSU_9-16-40	Tribute_662.001	Honeoye_215.001	13	12	.	.	.	.	.	.	207	213
MSU_9-16-41[zb]	Tribute_662.001	Honeoye_215.001	12	7.5	12	13	.	.	.	.	213	213
MSU_9-16-42[zb]	Tribute_662.001	Honeoye_215.001	9.1	8.4	12	13	.	.	7.1	10	213	213
MSU_9-16-43[zb]	Tribute_662.001	Honeoye_215.001	13	8.9	.	11	.	.	9.2	.	213	213
MSU_9-16-44[zb]	Tribute_662.001	Honeoye_215.001	13	8.5	12	9	.	.	.	5.7	207	213
MSU_9-16-45[zb]	Tribute_662.001	Honeoye_215.001	12	8.9	.	11	.	.	9.4	.	213	213
MSU_9-16-46[zb]	Tribute_662.001	Honeoye_215.001	11	7.5	13	11	.	.	7.6	.	213	213
MSU_9-16-47[zb]	Tribute_662.001	Honeoye_215.001	.	.	.	14	.	.	8.9	6.3	207	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
MSU_9-16-48[zb]	Tribute_662.001	Honeoye_215.001	.	8.6	.	11	.	.	8.2	.	207	213
MSU_9-16-49[zb]	Tribute_662.001	Honeoye_215.001	10	10	11	9.2	.	.	8.9	.	207	213
MSU_9-16-50[zb]	Tribute_662.001	Honeoye_215.001	.	9.2	.	9.1	.	.	6.7	.	207	217
MSU_9-16-51[zb]	Tribute_662.001	Honeoye_215.001	.	7.8	.	8.5	.	.	9.9	.	213	213
MSU_9-16-52[zb]	Tribute_662.001	Honeoye_215.001	12	9.7	7.1	12	.	.	15	8	213	213
MSU_9-16-53	Tribute_662.001	Honeoye_215.001	.	.	.	15	.	.	.	.	.	.
MSU_9-16-54	Tribute_662.001	Honeoye_215.001	.	7.4	.	.	.	.	.	.	.	.
MSU_9-16-55[zb]	Tribute_662.001	Honeoye_215.001	9.9	10	.	13	.	.	9.6	.	213	213
MSU_9-16-56[zb]	Tribute_662.001	Honeoye_215.001	.	.	.	10	.	.	6.8	.	207	213
MSU_9-16-57[zb]	Tribute_662.001	Honeoye_215.001	12	9.2	.	12	.	.	8	.	219	217
MSU_9-16-58	Tribute_662.001	Honeoye_215.001	10	9.6	.	.	.	.	8	.	213	213
MSU_9-16-59[zb]	Tribute_662.001	Honeoye_215.001	13	8.9	.	.	.	.	7.3	7.1	213	213
MSU_9-16-60[zb]	Tribute_662.001	Honeoye_215.001	.	5.6	.	12	.	.	7.5	.	207	213
MSU_9-16-61[zb]	Tribute_662.001	Honeoye_215.001	.	8.2	.	8.4	.	.	9.9	9.2	207	217
MSU_9-16-62	Tribute_662.001	Honeoye_215.001	12	11	.	.	.	.	7.2	.	207	213
MSU_9-16-63	Tribute_662.001	Honeoye_215.001	13	13	.	.	.	.	7.4	.	207	213
MSU_9-16-64[zb]	Tribute_662.001	Honeoye_215.001	9.8	6.4	.	8	.	.	10	6.8	207	213
MSU_9-16-65[zb]	Tribute_662.001	Honeoye_215.001	12	.	14	13	.	.	5.7	7.5	213	213
MSU_9-17 population (Tribute × MSU_56)[c]												
Tribute_662.001[m, b]	USEB_18	MDUS_4258	13	9.6	14	12	.	.	11	.	213	213
MSU_56[l, j]	Cabot	Cavendish	.	9.3	12	13	.	.	8.9	8	213	213
MSU_9-17-1[zb]	Tribute_662.001	MSU_56	13	8.1	8.7	12	.	.	.	.	213	213
MSU_9-17-2	Tribute_662.001	MSU_56	13	8.8	.	14	.	.	.	.	213	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
MSU_9-17-3[zb]	Tribute_662.001	MSU_56	13	10	12	9.6	.	.	9.1	.	207	213
MSU_9-17-4[zb]	Tribute_662.001	MSU_56	12	9.9	.	14	.	.	7.5	7.3	213	213
MSU_9-17-5[zb]	Tribute_662.001	MSU_56	9.4	9.3	11	11	.	.	9.5	.	213	213
MSU_9-17-6[zb]	Tribute_662.001	MSU_56	12	12	.	11	.	.	7.4	7.8	213	213
MSU_9-17-7[zb]	Tribute_662.001	MSU_56	11	7.8	.	7.9	.	.	6.8	6.4	213	213
MSU_9-17-8[zb]	Tribute_662.001	MSU_56	12	9	15	10	.	.	8	8.2	213	213
MSU_9-17-9[zb]	Tribute_662.001	MSU_56	12	8	9.6	12	.	.	6.4	.	213	213
MSU_9-17-10[zb]	Tribute_662.001	MSU_56	18	.	9.6	13	.	.	8.7	7.8	213	213
MSU_9-18 population (Seascape × Fort Laramie)[c]												
Seascape_CF[m, j]	Selva	Douglas	9.7	8.6	.	12	.	.	.	6.2	213	215
FortLaramie_I1[l]			.	.	.	.	.	.	.	.	.	.
MSU_9-18-1[zb]	Seascape_CF	FortLaramie_I1	9.6	12	.	9.8	.	.	.	7.5	213	215
MSU_9-18-2[zb]	Seascape_CF	FortLaramie_I1	13	10	12	7.7	.	.	9.1	7.7	213	213
MSU_9-18-3[zb]	Seascape_CF	FortLaramie_I1	.	7.2	.	8	.	.	9.4	6	213	213
MSU_9-18-4[zb]	Seascape_CF	FortLaramie_I1	12	11	.	11	.	.	8.7	7.7	213	215
MSU_9-18-5[zb]	Seascape_CF	FortLaramie_I1	9.5	7.4	11	10	.	.	9	7.6	215	215
MSU_9-18-6[zb]	Seascape_CF	FortLaramie_I1	12	7.4	9.5	10	.	.	7.2	8.1	213	213
MSU_9-18-7[zb]	Seascape_CF	FortLaramie_I1	11	9.4	.	11	.	.	10	6.6	213	215
MSU_9-18-8[zb]	Seascape_CF	FortLaramie_I1	13	9.9	.	10	.	.	9	7	213	215
MSU_9-18-9[zb]	Seascape_CF	FortLaramie_I1	9.2	7.1	.	12	.	.	7.4	.	213	215
MSU_9-18-10[zb]	Seascape_CF	FortLaramie_I1	11	12	9.1	9.5	.	.	7.2	7.8	215	215

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
ORUS populations												
ORUS_3277 population (ORUS 2427-1× FRA_1701)[d]												
ORUS 2427-1_CF_1-22[m, j]	Pinnacle	ORUS_1723-3	10	9	.	8.4	.	.	.	.	207	213
FRA_1701[l, r, a]	0	0	.	8.3	.	.	12	9.5	.	.	221	213
ORUS_3277-1[zb]	ORUS 2427-1_CF_1-22	FRA_1701	11	11	.	.	.	.	9.9	9.1	213	213
ORUS_3277-2[zb]	ORUS 2427-1_CF_1-22	FRA_1701	12	14	11	14	.	.	.	11	207	213
ORUS_3277-3[zb]	ORUS 2427-1_CF_1-22	FRA_1701	9.8	11	11	11	.	.	11	10	213	213
ORUS_3277-4[zb]	ORUS 2427-1_CF_1-22	FRA_1701	12	.	.	12	.	.	8.6	7.4	213	213
ORUS_3277-5[zb]	ORUS 2427-1_CF_1-22	FRA_1701	12	12	16	6.6	.	.	.	10	213	213
ORUS_3277-6[zb]	ORUS 2427-1_CF_1-22	FRA_1701	9.6	8.4	12	.	.	.	11	9.9	213	213
ORUS_3277-7[zb]	ORUS 2427-1_CF_1-22	FRA_1701	9.3	11	.	8.9	.	9.6	8.8	9.7	213	213
ORUS_3277-8[zb]	ORUS 2427-1_CF_1-22	FRA_1701	8.7	14	13	.	.	8.3	9.3	12	207	221
ORUS_3277-9[zb]	ORUS 2427-1_CF_1-22	FRA_1701	12	11	.	9.5	.	.	9	8.5	207	213
ORUS_3277-10	ORUS 2427-1_CF_1-22	FRA_1701	8.1	9.7	.	.	.	.	.	.	207	221
ORUS_3278 population (ORUS 2427-1× Seascape)[d]												
ORUS 2427-1_CF_1-22[m, j]	Pinnacle	ORUS_1723-3	10	9	.	8.4	.	.	.	.	207	213
Seascape_CF[l, j]	Selva	Douglas	9.7	8.6	.	12	.	.	.	6.2	213	215
ORUS_3278-1[zb]	ORUS 2427-1_CF_1-22	Seascape_CF	12	10	11	12	.	.	.	.	.	.
ORUS_3278-4[zb]	ORUS 2427-1_CF_1-22	Seascape_CF	11	7.2	.	16	.	.	8.1	8.5	213	213
ORUS_3278-5[zb]	ORUS 2427-1_CF_1-22	Seascape_CF	15	.	.	9	.	.	6.3	4.5	207	213
ORUS_3278-6[zb]	ORUS 2427-1_CF_1-22	Seascape_CF	12	13	11	7.7	.	.	7.5	6.2	207	215
ORUS_3278-7[zb]	ORUS 2427-1_CF_1-22	Seascape_CF	13	8.7	.	8.8	.	.	10	5.1	207	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
ORUS_3278-8[zb]	ORUS 2427-1_CF_1-22	Seascape_CF	11	.	.	15	.	.	8.2	6.4	207	215
ORUS_3278-9[zb]	ORUS 2427-1_CF_1-22	Seascape_CF	10	11	.	9.7	.	.	8.7	6	215	213
ORUS_3278-10[zb]	ORUS 2427-1_CF_1-22	Seascape_CF	13	7.1	.	8.8	.	.	7.7	4.6	207	215
ORUS_3278-12[zb]	ORUS 2427-1_CF_1-22	Seascape_CF	14	.	.	12	.	.	9.1	8.2	207	215
ORUS_3278-13[zb]	ORUS 2427-1_CF_1-22	Seascape_CF	10	7.7	.	8.8	.	.	9.4	5.3	207	215
ORUS_3279 population (ORUS 2427-1× Tribute)[d]												
ORUS 2427-1_CF_1-22[m, j]	Pinnacle	ORUS_1723-3	10	9	.	8.4	.	.	.	.	207	213
Tribute_662.001[l, b]	USEB_18	MDUS_4258	13	9.6	14	12	.	.	11	.	213	213
ORUS_3279-3[zb]	ORUS 2427-1_CF_1-22	Tribute_662.001	12	.	.	13	.	.	9.7	7.5	207	213
ORUS_3279-4[zb]	ORUS 2427-1_CF_1-22	Tribute_662.001	11	9.9	.	11	.	.	10	.	213	213
ORUS_3279-5[zb]	ORUS 2427-1_CF_1-22	Tribute_662.001	15	12	10	8.6	.	.	8.9	.	207	213
ORUS_3279-6[zb]	ORUS 2427-1_CF_1-22	Tribute_662.001	11	.	.	9.9	.	.	12	7.4	213	213
ORUS_3279-7[zb]	ORUS 2427-1_CF_1-22	Tribute_662.001	13	11	.	13	.	.	8.2	7.7	213	213
ORUS_3279-8[zb]	ORUS 2427-1_CF_1-22	Tribute_662.001	12	12	8.4	12	.	10	7.8	6.3	213	213
ORUS_3279-9[zb]	ORUS 2427-1_CF_1-22	Tribute_662.001	.	12	.	11	9.5	.	9.1	5.4	213	213
ORUS_3279-13[zb]	ORUS 2427-1_CF_1-22	Tribute_662.001	13	.	9.5	7.3	.	.	7.9	6.9	207	213
ORUS_3279-14[zb]	ORUS 2427-1_CF_1-22	Tribute_662.001	12	.	12	10	.	.	8.9	5.4	207	213
ORUS_3279-15[zb]	ORUS 2427-1_CF_1-22	Tribute_662.001	13	8.5	.	8.9	.	.	8.7	7.4	207	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
ORUS_3304 population (Tillamook × FRA_1701)[d]												
Tillamook_NCGR[b]	Cuesta	Puget_Reliance	.	.	.	.	.	.	.	.	.	.
Tillamook_CF[d]	Cuesta	Puget_Reliance	.	.	11	11	.	.	7.1	6.1	213	209
Tillamook_I1[m]	.	.	.	.	.	.	.	.	.	.	.	.
FRA_1701[l, r, a]	0	0	.	8.3	.	.	12	9.5	.	.	221	213
ORUS_3304-1[zb]	Tillamook_I1	FRA_1701	10	11	.	16	.	.	12	9	207	213
ORUS_3304-2[zb]	Tillamook_I1	FRA_1701	.	12	.	.	.	.	10	8.3	207	221
ORUS_3304-5[zb]	Tillamook_I1	FRA_1701	12	12	.	12	.	.	11	7.5	213	221
ORUS_3304-6[zb]	Tillamook_I1	FRA_1701	9.2	11	.	11	.	.	9.7	7	207	207
ORUS_3304-7	Tillamook_I1	FRA_1701	10	14	.	.	8	11	9	10	213	213
ORUS_3304-8[zb]	Tillamook_I1	FRA_1701	4.5	9.7	7.1	9.5	.	.	9.4	9.7	215	219
ORUS_3304-9[zb]	Tillamook_I1	FRA_1701	10	9.5	.	9.6	.	.	6.5	5.7	207	207
ORUS_3304-10[zb]	Tillamook_I1	FRA_1701	13	8.5	.	8.9	.	.	11	9.1	209	221
ORUS_3304-11[zb]	Tillamook_I1	FRA_1701	8.4	12	10	15	.	.	.	9.3	215	219
ORUS_3304-13[zb]	Tillamook_I1	FRA_1701	.	15	.	.	.	.	13	11	207	207
ORUS_3305 population (Tillamook × Seascape)[d]												
Tillamook_CF[d]	Cuesta	Puget_Reliance	.	.	11	11	.	.	7.1	6.1	213	209
Tillamook_NCGR[m, b]	Cuesta	Puget_Reliance	.	.	.	.	.	.	.	.	.	.
Seascape_CF[l, j]	Selva	Douglas	9.7	8.6	.	12	.	.	.	6.2	213	215
ORUS_3305-1	Tillamook_NCGR	Seascape_CF	8.8	16	13	.	.	.	.	.	215	213
ORUS_3305-2[zb]	Tillamook_NCGR	Seascape_CF	8.3	8.7	8	13	.	.	6.4	.	215	213
ORUS_3305-3[zb]	Tillamook_NCGR	Seascape_CF	8.7	8.2	9.7	11	.	.	8.3	.	207	213
ORUS_3305-5[zb]	Tillamook_NCGR	Seascape_CF	11	9.9	.	7.4	.	.	8.3	7.9	207	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
ORUS_3305-6[zb]	Tillamook_NCGR	Seascape_CF	.	9.5	.	12	.	.	7.4	.	0	0
ORUS_3305-7[zb]	Tillamook_NCGR	Seascape_CF	10	8.8	.	10	8.1	6.2	6.7	.	207	213
ORUS_3305-10[zb]	Tillamook_NCGR	Seascape_CF	11	7.5	.	9.7	.	.	8.2	.	207	213
ORUS_3305-11[zb]	Tillamook_NCGR	Seascape_CF	8.9	6.8	.	10	.	.	.	5.1	215	213
ORUS_3305-13[zb]	Tillamook_NCGR	Seascape_CF	13	9.3	15	7.3	.	.	3.1	6.2	215	215
ORUS_3305-14[zb]	Tillamook_NCGR	Seascape_CF	10	9.8	.	9.3	.	.	8.8	.	207	215
ORUS_3306 population (Totem × FRA_1701)[d]												
Totem_CF[m, j]	Puget_Beauty	Northwest	12	8.8	11	14	.	.	8.7	7.5	207	207
FRA_1701[l, r, a]	0	0	.	8.3	.	.	12	9.5	.	.	221	213
ORUS_3306-2[zb]	Totem_CF	FRA_1701	11	8.9	13	14	12	8.4	11	.	207	221
ORUS_3306-3[zb]	Totem_CF	FRA_1701	11	11	6.5	14	.	.	11	9.3	207	213
ORUS_3306-4[zb]	Totem_CF	FRA_1701	.	11	14	14	.	.	12	.	207	213
ORUS_3306-5	Totem_CF	FRA_1701	.	12	10	.	.	.	.	.	207	213
ORUS_3306-6[zb]	Totem_CF	FRA_1701	11	12	.	7	.	.	13	8.1	207	213
ORUS_3306-8	Totem_CF	FRA_1701	15	11	.	.	.	.	.	.	207	213
ORUS_3306-11	Totem_CF	FRA_1701	.	10	.	.	.	.	.	13	207	213
ORUS_3306-13[zb]	Totem_CF	FRA_1701	11	9.7	.	12	.	.	11	.	207	221
ORUS_3306-14[zb]	Totem_CF	FRA_1701	.	12	.	.	.	.	13	9.3	207	213
ORUS_3306-15[zb]	Totem_CF	FRA_1701	11	12	13	.	.	.	14	8.4	207	213
ORUS_3314 population (Fort Laramie × ORUS 2427-1)[d]												
ORUS 2427-1_CF_1-22 [d]	Pinnacle	ORUS_1723-3	10	9	.	8.4	.	.	.	.	207	213
FortLaramie_NCGR[b]	Geneva	S.65122	10	12	.	6.2	.	.	.	7.1	207	215
FortLaramie_I2[m]			.	.	.	.	.	.	.	.	.	.

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
ORUS 2427_I2[l]			.	.	.	.	.	.	.	.	.	.
ORUS_3314-1	FortLaramie_I2	ORUS 2427_I2	.	11	.	.	.	.	11	.	215	213
ORUS_3314-2[zb]	FortLaramie_I2	ORUS 2427_I2	.	13	.	.	.	.	8.1	7.8	207	215
ORUS_3314-4[zb]	FortLaramie_I2	ORUS 2427_I2	8.4	12	10	.	.	.	7	7.3	213	213
ORUS_3314-5[zb]	FortLaramie_I2	ORUS 2427_I2	13	10	.	13	.	.	.	7.8	207	213
ORUS_3314-6[zb]	FortLaramie_I2	ORUS 2427_I2	11	11	.	11	.	.	9.4	.	207	213
ORUS_3314-10[zb]	FortLaramie_I2	ORUS 2427_I2	12	9.3	.	8.6	.	.	6.3	7.7	213	213
ORUS_3314-11[zb]	FortLaramie_I2	ORUS 2427_I2	12	13	.	10	.	.	11	7.2	207	215
ORUS_3314-12[zb]	FortLaramie_I2	ORUS 2427_I2	11	11	.	9.3	.	.	9.3	6.6	213	213
ORUS_3314-14[zb]	FortLaramie_I2	ORUS 2427_I2	12	11	.	13	.	.	7.9	6.1	215	213
ORUS_3314-15[zb]	FortLaramie_I2	ORUS 2427_I2	12	13	11	.	.	.	7.8	.	213	213
ORUS_3315 population (Fort Laramie × Puget Reliance)[d]												
FortLaramie_NCGR[b]	Geneva	S.65122	10	12	.	6.2	.	.	.	7.1	207	215
FortLaramie_I3[m]			.	.	.	.	.	.	.	.	.	.
Puget Reliance_CF[l, j]	WSU_1945	BC_77-2-72	11	9.9	13	8.8	5.9	.	10	10	207	217
ORUS_3315-1[zb]	FortLaramie_I3	Puget Reliance_CF	11	.	.	11	.	.	9	5	207	213
ORUS_3315-2[zb]	FortLaramie_I3	Puget Reliance_CF	10	9.2	.	9.2	.	.	7.7	6.2	207	213
ORUS_3315-4[zb]	FortLaramie_I3	Puget Reliance_CF	12	11	12	9.4	.	.	6.8	7.2	207	213
ORUS_3315-6[zb]	FortLaramie_I3	Puget Reliance_CF	10	6.8	11	9.6	.	.	9.7	.	207	213
ORUS_3315-10[zb]	FortLaramie_I3	Puget Reliance_CF	11	11	.	9.7	.	.	8.7	7.1	207	215
ORUS_3315-11[zb]	FortLaramie_I3	Puget Reliance_CF	11	11	.	11	.	.	10	.	207	213
ORUS_3315-12[zb]	FortLaramie_I3	Puget Reliance_CF	11	15	.	11	.	.	8.3	7.2	207	215
ORUS_3315-13[zb]	FortLaramie_I3	Puget Reliance_CF	11	13	8.6	10	.	.	.	7.6	207	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
ORUS_3315-14[zb]	FortLaramie_I3	Puget Reliance_CF	9.1	11	11	9.9	.	.	8.4	6.8	207	215
ORUS_3315-15[zb]	FortLaramie_I3	Puget Reliance_CF	13	.	17	12	.	.	8.3	7.2	207	213
ORUS_3316 population (Fort Laramie × Totem)[d]												
FortLaramie_NCGR[b]	Geneva	S.65122	10	12	.	6.2	.	.	.	7.1	207	215
FortLaramie_I1[m]			.	.	.	.	.	.	.	.	.	.
Totem_CF[l, j]	Puget_Beauty	Northwest	12	8.8	11	14	.	.	8.7	7.5	207	207
ORUS_3316-1[zb]	FortLaramie_I1	Totem_CF	11	.	.	10	.	.	7.8	8.6	207	213
ORUS_3316-2[zb]	FortLaramie_I1	Totem_CF	8.9	9.6	.	11	.	.	8.7	5.8	207	215
ORUS_3316-3[zb]	FortLaramie_I1	Totem_CF	13	11	.	.	.	.	6.7	7	207	215
ORUS_3316-4[zb]	FortLaramie_I1	Totem_CF	10	11	.	12	.	.	9.3	6.6	207	215
ORUS_3316-5[zb]	FortLaramie_I1	Totem_CF	11	13	.	13	.	.	8.2	8.4	207	215
ORUS_3316-6	FortLaramie_I1	Totem_CF	12	10	.	.	.	.	.	.	0	0
ORUS_3316-7[zb]	FortLaramie_I1	Totem_CF	.	12	.	13	.	.	.	5.8	207	213
ORUS_3316-8	FortLaramie_I1	Totem_CF	.	11	.	.	.	.	.	.	0	0
ORUS_3316-9[zb]	FortLaramie_I1	Totem_CF	13	12	.	11	.	.	7.5	6.7	207	215
ORUS_3316-10[zb]	FortLaramie_I1	Totem_CF	.	12	.	.	.	.	13	10	207	215
ORUS_3317 population (Puget Reliance × FRA_1701)[d]												
Puget Reliance_CF [d]	WSU_1945	BC_77-2-72	11	9.9	13	8.8	5.9	.	10	10	207	217
Puget Reliance_I1[m]	.	.	.	.	.	.	.	.	.	.	.	.
FRA_1701[l, r, a]	0	0	.	8.3	.	.	12	9.5	.	.	221	213
ORUS_3317-1	Puget Reliance_I1	FRA_1701	.	11	13	.	.	.	.	.	207	213
ORUS_3317-2[zb]	Puget Reliance_I1	FRA_1701	.	11	.	12	.	.	11	.	207	221
ORUS_3317-3[zb]	Puget Reliance_I1	FRA_1701	8.4	10	.	.	.	.	11	9.6	207	221

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
ORUS_3317-4	Puget Reliance_I1	FRA_1701	13	12	.	.	.	.	9.3	.	207	213
ORUS_3317-5[zb]	Puget Reliance_I1	FRA_1701	10	9.3	.	12	.	.	11	8.4	207	221
ORUS_3317-6[zb]	Puget Reliance_I1	FRA_1701	11	13	.	.	.	.	13	6.5	207	213
ORUS_3317-7[zb]	Puget Reliance_I1	FRA_1701	13	13	13	11	.	.	12	7.2	207	213
ORUS_3317-9	Puget Reliance_I1	FRA_1701	11	11	.	.	.	.	10	8.4	207	213
ORUS_3317-10[zb]	Puget Reliance_I1	FRA_1701	9.8	12	12	14	.	.	12	10	207	213
ORUS_3317-11[zb]	Puget Reliance_I1	FRA_1701	.	15	.	6.2	.	.	9.1	.	207	213
ORUS_3318 population (Puget Reliance × Sarian)[d]												
Puget Reliance_CF[d]	WSU_1945	BC_77-2-72	11	9.9	13	8.8	5.9	.	10	10	207	217
Puget Reliance_I1[m]	.	.	.	.	.	.	.	.	.	.	.	.
Sarian_CF[l,j]	Pinnacle	ORUS_1723-3	7.9	.	.	.	.	.	10	.	215	209
ORUS_3318-1[zb]	Puget Reliance_I1	Sarian-CF	14	15	.	11	.	.	9.6	.	207	215
ORUS_3318-2[zb]	Puget Reliance_I1	Sarian-CF	9.7	11	.	8.7	.	.	8	7.1	207	215
ORUS_3318-4[zb]	Puget Reliance_I1	Sarian-CF	13	9.9	.	10	.	.	9.8	9.6	207	207
ORUS_3318-6[zb]	Puget Reliance_I1	Sarian-CF	15	7.7	.	14	.	.	3.8	.	207	209
ORUS_3318-8[zb]	Puget Reliance_I1	Sarian-CF	.	.	.	8.8	.	.	9.6	7.1	207	209
ORUS_3318-9[zb]	Puget Reliance_I1	Sarian-CF	14	12	10	12	11	.	11	9.4	207	215
ORUS_3318-10[zb]	Puget Reliance_I1	Sarian-CF	.	.	14	11	.	.	7.7	.	207	209
ORUS_3318-11[zb]	Puget Reliance_I1	Sarian-CF	14	11	.	9.4	.	.	10	.	207	209
ORUS_3318-12[zb]	Puget Reliance_I1	Sarian-CF	12	14	11	14	.	.	7.5	.	207	215
ORUS_3318-14[zb]	Puget Reliance_I1	Sarian-CF	11	12	.	17	.	.	9.4	8.7	207	207
ORUS_3319 population (Sarian × ORUS 2427-1)[d]												
Sarian_CF[m, j]	Pinnacle	ORUS_1723-3	7.9	.	.	.	.	.	10	.	215	209

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
ORUS 2427_I1[l]	Pinnacle	ORUS_1723-3	.	.	.	.	.	.	.	.	.	.
ORUS_3319-1[zb]	Sarian-CF	ORUS 2427_I1	12	7.6	.	13	.	.	7.2	5.4	213	215
ORUS_3319-2[zb]	Sarian-CF	ORUS 2427_I1	.	11	.	.	.	.	7.9	6.6	213	209
ORUS_3319-3[zb]	Sarian-CF	ORUS 2427_I1	.	9.5	.	.	.	.	9.1	9.1	213	209
ORUS_3319-4	Sarian-CF	ORUS 2427_I1	11	14	.	.	.	.	7.1	.	213	215
ORUS_3319-5	Sarian-CF	ORUS 2427_I1	6	.	.	.	.	.	10	10	213	215
ORUS_3319-6[zb]	Sarian-CF	ORUS 2427_I1	10	7	.	10	.	.	4.9	.	213	209
ORUS_3319-7	Sarian-CF	ORUS 2427_I1	9.5	14	.	.	.	.	.	8.2	213	209
ORUS_3319-8[zb]	Sarian-CF	ORUS 2427_I1	.	.	.	11	.	.	.	9.6	213	209
ORUS_3319-9	Sarian-CF	ORUS 2427_I1	.	.	.	.	.	.	.	7	213	209
ORUS_3319-10	Sarian-CF	ORUS 2427_I1	.	.	.	.	.	.	.	.	0	0
ORUS_3320 population (Sarian × Totem)[d]												
Sarian_CF[m, j]	Pinnacle	ORUS_1723-3	7.9	.	.	.	.	.	10	.	215	209
Totem_CF[l, j]	Puget_Beauty	Northwest	12	8.8	11	14	.	.	8.7	7.5	207	207
ORUS_3320-1[zb]	Sarian-CF	Totem_CF	11	14	12	10	8.1	.	10	7.2	213	213
ORUS_3320-2	Sarian-CF	Totem_CF	9.3	8.7	.	.	.	.	6.8	.	207	215
ORUS_3320-3[zb]	Sarian-CF	Totem_CF	10	9.5	.	.	.	.	8.7	7.9	207	215
ORUS_3320-4[zb]	Sarian-CF	Totem_CF	12	12	11	12	.	.	12	7.7	207	209
ORUS_3320-5[zb]	Sarian-CF	Totem_CF	11	11	11	12	.	.	7.1	7.2	207	215
ORUS_3320-6[zb]	Sarian-CF	Totem_CF	6.9	.	.	11	.	.	8.9	.	207	215
ORUS_3320-7[zb]	Sarian-CF	Totem_CF	14	.	.	15	.	.	8.6	.	207	215
ORUS_3320-8[zb]	Sarian-CF	Totem_CF	5.8	14	11	15	.	.	7.5	.	207	215
ORUS_3320-9[zb]	Sarian-CF	Totem_CF	9.7	8.4	.	11	.	.	9.5	.	207	215

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
ORUS_3320-10[zb]	Sarian-CF	Totem_CF	8.9	12	16	9.6	.	.	8.2	8.7	207	209
ORUS_3321 population (Sarian × Tillamook)[d]												
Tillamook_1819.001 [b]	Cuesta	Puget_Reliance	.	.	.	.	.	.	.	.	.	.
Sarian_2691.1 [b]	.	.	.	.	.	.	.	.	.	.	.	.
Sarian_CF[m, j]	Pinnacle	ORUS_1723-3	7.9	.	.	.	.	.	10	.	215	209
Tillamook_CF[l, j]	Cuesta	Puget_Reliance	.	.	11	11	.	.	7.1	6.1	213	209
ORUS_3321-1	Sarian-CF	Tillamook_CF	11	9	.	.	.	.	5.7	.	215	213
ORUS_3321-2	Sarian-CF	Tillamook_CF	13	10	.	.	.	.	11	.	215	213
ORUS_3321-3[zb]	Sarian-CF	Tillamook_CF	11	6.4	.	.	.	.	8.4	11	209	215
ORUS_3321-4[zb]	Sarian-CF	Tillamook_CF	11	8.9	.	14	.	.	8.5	.	215	213
ORUS_3321-5	Sarian-CF	Tillamook_CF	20	12	.	.	.	.	8.5	.	209	213
ORUS_3321-6[zb]	Sarian-CF	Tillamook_CF	9.4	9.2	7	8.4	.	.	7.6	.	215	213
ORUS_3321-7[zb]	Sarian-CF	Tillamook_CF	9	.	.	13	9.7	.	9.7	.	207	215
ORUS_3321-8[zb]	Sarian-CF	Tillamook_CF	13	16	11	11	.	.	.	.	209	215
ORUS_3321-9[zb]	Sarian-CF	Tillamook_CF	10	11	9.3	13	.	.	.	.	215	213
ORUS_3321-10	Sarian-CF	Tillamook_CF	12	.	.	.	.	.	8	.	209	209
ORUS_3322 population (Seascape × ORUS 2427-1)[d]												
ORUS 2427-1_CF_1-22 [d]	Pinnacle	ORUS_1723-3	10	9	.	8.4	.	.	.	.	207	213
Seascape_CF[m, j]	Selva	Douglas	9.7	8.6	.	12	.	.	.	6.2	213	215
ORUS 2427_I1[l]			.	.	.	.	.	.	.	.	.	.
ORUS_3322-2[zb]	Seascape_CF	ORUS 2427_I1	11	12	.	8.3	.	.	7.8	6	213	215
ORUS_3322-4[zb]	Seascape_CF	ORUS 2427_I1	11	8.4	.	9.5	.	.	3.2	5.2	213	213
ORUS_3322-5[zb]	Seascape_CF	ORUS 2427_I1	13	9	.	9.4	.	.	7.5	6.4	213	215

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
ORUS_3322-7[zb]	Seascape_CF	ORUS 2427_I1	12	7.9	14	9.4	7.4	.	6.6	6.8	213	215
ORUS_3322-8[zb]	Seascape_CF	ORUS 2427_I1	11	8.8	10	12	.	.	7.1	4.6	213	215
ORUS_3322-9[zb]	Seascape_CF	ORUS 2427_I1	12	8.9	.	11	.	.	8.7	.	213	213
ORUS_3322-11[zb]	Seascape_CF	ORUS 2427_I1	14	11	.	.	.	.	12	5.8	207	215
ORUS_3322-12[zb]	Seascape_CF	ORUS 2427_I1	13	13	.	9.4	.	.	9.1	6.8	213	213
ORUS_3322-13[zb]	Seascape_CF	ORUS 2427_I1	11	8.3	.	8.7	.	.	7.1	5.4	213	213
ORUS_3322-14[zb]	Seascape_CF	ORUS 2427_I1	11	10	.	10	.	.	7.4	7	213	215
ORUS_3323 population (Seascape × Puget Reliance)[d]												
Puget Reliance_CF [d]	WSU_1945	BC_77-2-72	11	9.9	13	8.8	5.9	.	10	10	207	217
Seascape_CF[m, j]	Selva	Douglas	9.7	8.6	.	12	.	.	.	6.2	213	215
Puget Reliance_I1[l]	.	.	.	.	.	.	.	.	.	.	.	.
ORUS_3323-1[zb]	Seascape_CF	Puget Reliance_I1	13	11	.	8.4	.	.	9.6	5.6	207	213
ORUS_3323-2[zb]	Seascape_CF	Puget Reliance_I1	12	7.1	.	6.9	.	.	8.3	6.2	207	213
ORUS_3323-3[zb]	Seascape_CF	Puget Reliance_I1	10	9.4	11	11	.	.	10	8	213	213
ORUS_3323-4[zb]	Seascape_CF	Puget Reliance_I1	11	8.1	.	9.1	.	.	7.1	7	207	213
ORUS_3323-6	Seascape_CF	Puget Reliance_I1	8.9	10	.	10	.	.	.	.	207	215
ORUS_3323-7[zb]	Seascape_CF	Puget Reliance_I1	.	8.2	.	8.3	.	.	11	8.4	213	213
ORUS_3323-9[zb]	Seascape_CF	Puget Reliance_I1	12	11	.	16	.	7.2	8.8	8.4	215	213
ORUS_3323-12[zb]	Seascape_CF	Puget Reliance_I1	12	9.1	.	11	.	.	8.3	7.3	207	215
ORUS_3323-13[zb]	Seascape_CF	Puget Reliance_I1	10	9.4	.	9.3	.	.	9.6	7.8	215	215
ORUS_3323-14[zb]	Seascape_CF	Puget Reliance_I1	12	8	9.2	12	.	.	9.6	7.2	207	213
ORUS_3324 population (Tillamook × Fort Laramie)[d]												
Tillamook_NCGR[b]	Cuesta	Puget_Reliance	.	.	.	.	.	.	.	.	.	.

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
Tillamook_CF[m, j]	Cuesta	Puget_Reliance	.	.	11	11	.	.	7.1	6.1	213	209
FortLaramie_I1[l]			.	.	.	.	.	.	.	.	.	.
ORUS_3324-1[zb]	Tillamook_CF	FortLaramie_I1	11	11	.	9.7	.	.	10	.	213	213
ORUS_3324-3[zb]	Tillamook_CF	FortLaramie_I1	9.3	12	11	8.2	.	.	8.3	7.1	209	215
ORUS_3324-4[zb]	Tillamook_CF	FortLaramie_I1	12	13	9.8	8.5	.	.	6.3	6.3	209	215
ORUS_3324-9[zb]	Tillamook_CF	FortLaramie_I1	11	7.9	.	8.9	8.2	.	7.2	6.5	209	213
ORUS_3324-10[zb]	Tillamook_CF	FortLaramie_I1	9.8	8.8	.	8.2	.	.	10	6.8	209	215
ORUS_3324-11[zb]	Tillamook_CF	FortLaramie_I1	12	12	.	10	.	.	8.7	.	209	215
ORUS_3324-12[zb]	Tillamook_CF	FortLaramie_I1	10	10	.	9.8	.	.	9.6	8.7	215	213
ORUS_3324-13[zb]	Tillamook_CF	FortLaramie_I1	11	11	11	8.4	.	.	9.2	8.1	215	213
ORUS_3324-14[zb]	Tillamook_CF	FortLaramie_I1	11	7.6	.	16	.	.	8.8	7.9	215	213
ORUS_3324-15[zb]	Tillamook_CF	FortLaramie_I1	10	10	11	8.3	.	.	8.6	8.2	213	213
ORUS_3325 population (Tillamook × Tribute)[d]												
Tillamook_NCGR[b]	Cuesta	Puget_Reliance	.	.	.	.	.	.	.	.	.	.
Tillamook_CF[m, j]	Cuesta	Puget_Reliance	.	.	11	11	.	.	7.1	6.1	213	209
Tribute_662.001[l, b]	USEB_18	MDUS_4258	13	9.6	14	12	.	.	11	.	213	213
ORUS_3325-2[zb]	Tillamook_CF	Tribute_662.001	.	12	.	10	.	.	8.7	7.7	209	213
ORUS_3325-4[zb]	Tillamook_CF	Tribute_662.001	8.2	9.4	.	12	.	.	9.5	7.3	209	213
ORUS_3325-5[zb]	Tillamook_CF	Tribute_662.001	8.1	7.3	.	9	.	.	5.7	6.4	209	213
ORUS_3325-8[zb]	Tillamook_CF	Tribute_662.001	.	.	.	11	.	.	6	5.7	209	213
ORUS_3325-9[zb]	Tillamook_CF	Tribute_662.001	9.8	6.7	.	9.4	.	.	8.4	.	209	213
ORUS_3325-10[zb]	Tillamook_CF	Tribute_662.001	7.4	8.8	.	7.4	.	.	7.8	7	213	213
ORUS_3325-11[zb]	Tillamook_CF	Tribute_662.001	10	10	.	12	.	.	7.8	.	213	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
ORUS_3325-12[zb]	Tillamook_CF	Tribute_662.001	8.5	7.1	.	6.3	.	.	8.2	5.2	213	213
ORUS_3325-13[zb]	Tillamook_CF	Tribute_662.001	17	9.8	.	.	.	.	7.9	7.8	213	213
ORUS_3325-15[zb]	Tillamook_CF	Tribute_662.001	9.5	9.9	.	14	.	.	8.2	5.6	209	213
ORUS_3326 population (Tribute × Puget Reliance)[d]												
Puget Reliance_CF[d]	WSU_1945	BC_77-2-72	11	9.9	13	8.8	5.9	.	10	10	207	217
Tribute_662.001[m, b]	USEB_18	MDUS_4258	13	9.6	14	12	.	.	11	.	213	213
Puget Reliance_I1[l]	.	.	.	.	.	.	.	.	.	.	.	.
ORUS_3326-1[zb]	Tribute_662.001	Puget Reliance_I1	11	7.9	12	13	.	6.7	8.6	7	213	207
ORUS_3326-2[zb]	Tribute_662.001	Puget Reliance_I1	9.9	9	.	9.2	.	.	9	9	213	215
ORUS_3326-3[zb]	Tribute_662.001	Puget Reliance_I1	12	7.6	.	11	.	.	7.6	6.6	213	207
ORUS_3326-4[zb]	Tribute_662.001	Puget Reliance_I1	9.3	11	.	9.8	.	.	7.9	7.1	213	215
ORUS_3326-5[zb]	Tribute_662.001	Puget Reliance_I1	11	.	.	10	.	.	6.4	.	213	213
ORUS_3326-11[zb]	Tribute_662.001	Puget Reliance_I1	10	7	.	11	.	.	7.2	5.9	213	213
ORUS_3326-12[zb]	Tribute_662.001	Puget Reliance_I1	16	7	13	10	.	.	9.2	7.4	213	207
ORUS_3326-13[zb]	Tribute_662.001	Puget Reliance_I1	12	.	8	12	9.3	.	.	7.6	213	207
ORUS_3326-14[zb]	Tribute_662.001	Puget Reliance_I1	16	.	.	7.9	.	.	10	6	213	207
ORUS_3326-15[zb]	Tribute_662.001	Puget Reliance_I1	11	9	.	11	.	.	7.7	7.1	213	207
Parents of populations												
Capitola-FR_CF[e]	Cal_75.121-101	Parker	.	7.6	.	.	.	.	.	.	207	207
CF1116-FR[za]	Pajaro	(Earliglow×Chandler)	.	.	.	.	.	.	.	.	.	.
E-60174-NL (Redgauntlet) [k, zb]	NJ_1052	Auchincruive_Climax	.	9	.	7.1	.	.	.	7	209	209

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
E-71006-NL (Holiday) [i, zb]	Raritan	NY_845	.	9.5	.	8.6	.	.	.	7.3	213	213
Earliglow_CF[j, zb]	MDUS_2359	MDUS_2713	15	.	.	.	10	.	9	9.5	213	213
FortLaramie_NCGR[b, zb]	Geneva	S.65122	10	12	.	6.2	.	.	.	7.1	207	215
FRA_1701[a]	0	0	.	8.3	.	.	12	9.5	.	.	221	213
Hapil-NL[i]	Gorella	Souv_de_CharlesMachiroux	.	.	.	.	.	.	.	.	.	.
Holiday_CF[j]	Raritan	NY_844	.	.	.	.	.	.	.	.	.	.
Honeoye_215.001[a]	Vibrant	Holiday	.	.	.	.	.	.	.	.	.	.
IFAPA_1392[j]	Esp	Gaviota	.	7.6	.	.	.	.	.	.	213	215
IFAPA_232[j]	Esp	Sel.4-43	.	7.3	.	.	.	.	.	.	213	215
Korona-CF[j, zb]	Tamella	Induka	11	11	.	13	.	.	.	7.2	213	209
Korona-NL[i]	Tamella	Induka	11	11	.	13	.	.	.	7.2	213	209
MSU_49 [j, zb]	Jewel	Mesabi	13	11	.	13	.	.	9.2	.	213	213
MSU_56[j, zb]	Cabot	Cavendish	.	9.3	12	13	.	.	8.9	8	213	213
ORUS 2427-1_CF_1-22 [j]	Pinnacle	ORUS_1723-3	10	9	.	8.4	.	.	.	.	207	213
Puget Reliance_CF[j]	WSU_1945	BC_77-2-72	.	.	.	.	.	.	.	.	.	.
Redgauntlet_CF[j]	NJ_1051	Auchincruive_Climax	11	.	.	6.4	.	.	.	.	209	209
Sarian_2691.1	.	.	.	.	.	.	.	.	.	.	.	.
Sarian_CF[d]	Pinnacle	ORUS_1723-3	7.9	.	.	.	.	.	10	.	215	209
Seascape_CF[j, zb]	Selva	Douglas	9.7	8.6	.	12	.	.	.	6.2	213	215
Tillamook_NCGR[b]	Cuesta	Puget_Reliance	.	.	.	.	.	.	.	.	.	.
Tillamook_CF[d, zb]	Cuesta	Puget_Reliance	.	.	11	11	.	.	7.1	6.1	213	209
Totem_CF[j, zb]	Puget_Beauty	Northwest	12	8.8	11	14	.	.	8.7	7.5	207	207

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
Tribute_662.001[b, zb]	USEB_18	MDUS_4258	13	9.6	14	12	.	.	11	.	213	213
Tribute_CF[j, zb]	USEB_18	MDUS_4258	13	9.6	14	12	.	.	11	.	213	213
Cultivars												
Aberdeen[a, zb]	Likely_Lake_Stevens	Likely_Chesapeake	10	9.2	14	9.7	.	.	10	.	217	209
Aberdeen-NL[i]	Likely_Lake_Stevens	Likely_Chesapeake	.	.	.	.	.	.	.	.	0	0
Aiko[j, zb]	Cal_46.5-1	Cal_59.51-11	11	11	.	7.9	.	.	6.1	.	207	215
Albion[j, zb]	Diamante	Cal_94.16-1	14	8.2	.	9.7	7.1	.	6.8	.	213	215
Albritton[j]	NC__1065	NC__1053	13	12	.	.	.	.	.	7.3	207	209
E-82246 NL (Allstar)[g]	US_4419	MDUS_3184	.	11	.	.	.	.	.	7.7	209	213
Allstar[j, zb]	US_4419	MDUS_3184	10	8.7	12	12	.	.	5.7	.	213	209
Ambrosia_Late[j]	0	0	11	.	.	.	.	.	.	.	215	209
Annapolis[j, zb]	K74-5	Earliglow	11	12	.	.	.	.	11	9.8	213	209
Apollo[j]	NC_1759	NC_1729	7.7	.	.	.	.	.	11	.	209	209
ArKing[j, zb]	Cardinal	Ark_5431	9.1	8.1	.	7.8	.	.	5.6	5.5	213	213
Aromas[j, zb]	Cal_87.112-6	Cal_88.270-1	10	8.6	.	7.9	.	.	8.6	.	213	215
Atlas[j, zb]	NC_1759	Albritton	12	7.4	12	8.3	.	.	7.5	7.5	213	209
Badgerglo[j]	Sparkle	Stelemaster	.	.	.	12	.	.	.	.	207	209
Beaver[j]	0	0	.	11	.	.	.	.	14	.	215	209
Benizuru [j]	(Miyazaki_x_The_Sun)	Fukuba	11	11	.	.	.	.	10	.	213	209
Benton[j, zb]	OSC_2414	Vale	13	8.6	.	9.5	.	.	11	8.8	207	209
Blakemore[j, zb]	Missionary	Howard_17	12	11	12	11	.	.	.	9	213	213
Bountiful[j]	Linn	Totem	.	10	.	10	.	.	.	.	207	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
Bounty [j]	Jerseybelle	Senga_Sengana	.	6.7	.	13	.	.	.	.	207	213
British_Sovereign [j, zb]	0	0	.	.	.	12	.	.	7.8	.	209	209
Brunswick [j, zb]	Cavendish	Honeoye	14	9.3	7.2	9.6	.	.	5.4	.	213	209
Cabot [j, zb]	K87-5	K86-19	.	11	10	9.6	.	.	8.6	8.2	213	213
Cal_51S-1 [j, zb]	Lassen	Lassen	9.7	6.9	.	.	.	.	7.9	7	213	215
Cal_59.39-1 [j]	Rockhill2ndBC	0	.	.	.	.	.	.	.	.	0	0
Camarosa [j, zb]	Douglas	Cal_72.361-105	11	9.3	11	8.1	.	.	7.3	.	213	215
Cardinal [j, zb]	Earlibelle	Ark_5063	10	.	13	11	.	.	9.8	8.2	213	209
Catskill [j, zb]	Marshall	Howard_17	13	9.1	.	9.2	.	.	9.1	7.8	215	209
Cavendish [j, zb]	Glooscap	Annapolis	.	.	11	7.7	.	.	6.6	7	213	213
Chandler [j]	Douglas	Cal_72.361-105	13	12	.	.	6.1	.	5.3	.	207	215
Charm (ORUS_2262-2) [j, zb]	Puget_Reliance	B754	14	9.1	.	11	.	11	7.3	8.3	207	213
Clancy [j, zb]	MDUS_4774	MDUS_5199	11	.	14	9.7	.	.	8.1	7.4	207	209
Climax [j]	0	0	9.1	9.1	.	.	.	.	.	6.9	209	209
Columbia [j]	WSU_157	WSU_175	.	.	.	.	.	.	.	.	213	223
Cruz [j]	Cal_37.20-45	Sequoia	15	8.3	.	.	.	.	10	.	213	215
Daroyal [j, zb]	Elsanta	Parker	13	9	.	11	.	.	7.1	5.8	207	215
Darrow 5 [j]	0	0	.	.	.	.	.	.	.	.	0	0
Darselect [j]	Elsanta	Parker	11	.	.	.	.	.	9.8	.	213	215
Delitej	Albritton	MDUS_2650	14	6.7	.	9.4	.	.	.	.	207	213
Delmarvel [j]	Earliglow	Atlas	12	9.8	.	.	12	9.4	.	11	213	209
Diamante [j, zb]	Cal_87.112-6	Cal_88.270-1	17	.	9.2	7.4	.	.	8.3	.	213	215

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
Direktor_Paul_Wallbaum[j]	Georg_Soltwedel?	FrauMiezeSchindler	12	.	.	.	.	.	.	.	209	209
Donner[j]	Cal_145.52	Cal_222.4	11	7.9	.	.	.	.	.	8.6	213	209
Dover[j, zb]	Florida_Belle	FL_71-189	12	6	10	8.4	.	.	8	6.1	213	209
Earlibelle[j, zb]	Albritton	MDUS_2101	12	14	.	.	12	7.9	8.4	6.3	213	209
Elsanta[j, zb]	Gorella	Holiday	.	.	9.2	13	9.1	.	5.9	.	213	213
Eros[j, zb]	Elsanta	Allstar	.	6.5	12	9.5	.	.	5.8	.	0	0
Ettersburg_121[j, zb]	F.chil.Cape.Mendicino	Alpine(F.vesca)	11	8.1	.	.	.	.	8.9	9.6	207	209
Evangeline[j]	K88-4	NYUS_119	.	9.4	.	.	.	.	.	.	207	213
Evie-2[j, zb]	Everglade	J92D12	.	.	.	.	.	.	14	7.1	215	215
Fairfax[j, zb]	Royal_Sovereign	Howard_17	.	6.4	.	.	.	.	14	7.6	207	213
Fern[j, zb]	Tufts	Cal_69.62-103	12	11	.	8.1	.	.	8.8	.	215	209
Firecracker[j, zb]	ORUS_850-48	Totem	11	12	14	9.7	.	.	11	9.2	207	209
Florence[j, zb]	Tiogax(Redgauntx(WiltgxGorel))	(Providence_self)	.	9.4	.	12	.	.	.	6.5	207	215
Florida_90[j]	Missionary	OP26	11	12	.	.	.	.	8.9	.	213	209
Florida_Belle[j, zb]	Sequoia	Earlibelle	10	10	.	.	.	.	6.9	5.4	213	209
Florida_Elyana[j, zb]	FL_96-114	FL_95-200	18	9.5	.	.	.	.	6.4	5	215	209
Florida_Radiance[j, zb]	Winter_Dawn	FL_99-35	13	11	.	.	.	.	5.8	6.2	213	213
Galletta[j]	NCH_87-22	Earliglow	10	8	.	.	.	.	6.9	.	213	215
Glooscap[j, zb]	Micmac	Bounty	11	7.1	.	.	.	.	9.4	8.5	213	209
Gorella[j]	Juspa	US_3763	.	.	.	13	.	.	.	.	213	209
Governor_Simcoe[j, zb]	Holiday	Guardian	11	10	12	.	.	.	13	7.9	213	213
Guardian[j, zb]	NC_1768	Surecrop	15	11	7.1	11	.	.	7.5	.	213	209
Harunoka[j]	Kurume103	Dana	11	11	.	.	.	.	.	10	209	209

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
Hecker[j]	Cal_65.65-601	Cal_66.96-101	11	11	.	.	.	.	14	.	213	213
Hogyoku[j]	Fukuba	OP70	15	11	.	.	12	.	.	10	209	209
Hood[j, zb]	OSC_2315	Puget_Beauty	13	12	18	13	.	.	9.1	8.6	207	207
Howard_17[j, zb]	Seedling#1Howard	Crescent	11	.	.	16	.	.	9.3	8.5	207	217
Hummi_Grandee[j, zb]	0	0	14	.	.	.	.	.	6.4	7.6	209	209
Idea[j, zb]	((GorellaxMDUS3184)xTioga)	Etna	9	7.5	.	9.1	.	.	8.7	5.7	213	209
Independence[j]	ORUS_850-48	ORUS_750-1	.	.	.	.	.	.	.	.	217	209
E-65056 (Induka)[i]	Holiday	Korona	.	8.6	.	.	.	.	.	.	207	207
Jerseybelle[j]	NJ_953	NJ_925	10	8.6	.	.	.	.	.	.	207	213
Jewel[j]	NY_1221	Holiday	.	.	.	.	.	.	9.6	.	213	213
Joe[j, zb]	(MiddlefieldxChairsFav)xSharpless	Gandy	9.6	9.9	.	.	.	.	11	7.5	213	209
Jucunda[j]	0	0	15	.	.	8.4	.	.	.	.	221	209
Jurica[j, zb]	Senga48	So_308	.	.	10	8.8	.	.	7.1	8.2	207	207
Kaiser_Samling[j, zb]	Konig.von.Sachsen	UNK7	11	.	.	9.5	.	.	.	7.8	213	209
Kent[j, zb]	K68-58	Raritan	13	16	.	10	.	.	.	7.5	213	209
Klondike[j, zb]	Pickerproof	Hoffman	9.8	10	12	9.3	.	.	.	8	213	213
Koro103[j]	Marshall	Fairfax	.	12	.	.	.	.	8.1	.	207	213
Kurume103[j]	0	0	14	8.5	.	.	.	.	7.1	.	213	213
L'Amour[j, zb]	NYUS_256	Cavendish	13	.	11	.	.	.	11	9.6	213	209
Lassen[j, zb]	Cal_21.9	Cal_161.1	8.7	9.2	9.5	7.8	.	.	10	3.3	215	215
Lateglow[j, zb]	Tamella	MDUS_3184	12	.	.	11	.	.	9.6	8.8	213	209
Liberation_d_Orleans[j]	0	0	11	11	.	.	.	.	.	7.5	213	209
Linn[j]	OSC_2414	MDUS_3184	11	16	.	13	.	.	.	.	213	209

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
Mara_des_Bois[j, zb]	Hummi_GentoxOstara	RedgauntletxKorona	12	7.6	10	.	.	.	8.3	7.1	209	209
Marlate[j, zb]	Jerseybelle	((KlonmxMidl)x(TennShipxMidl))	11	10	.	9.5	.	.	.	8.2	213	213
Marshall[j]	F.virginiana	UNK18	.	12	11	.	.	.	.	.	213	215
Massey[j]	US_634	Blakemore	10	11	.	11	.	.	.	.	207	209
MDUS_3184[j]	NC__1768	Surecrop	16	11	.	.	.	.	7.4	.	213	209
MDUS_3816[j, zb]	NJ_459	MDUS_2927	.	9	.	.	.	.	8.4	8.6	213	217
MDUS_4258[j]	MDUS_2713	MDUS_3364	.	.	.	.	.	.	.	.	207	215
MDUS_683[j]	Fairfax	Scot_BK-46	11	8.4	.	8.9	.	.	9.9	.	217	209
Melody[j]	SCRI66M1	Senga_Sengana	11	.	.	.	.	.	.	7.9	207	213
Mesabi[j, zb]	Glooscap	MNUS_99	12	7.5	8.7	6.9	.	.	.	7.6	213	209
Micmac[j]	Tioga	K61-87	11	8.9	.	.	.	.	.	7.2	207	209
Midland[j, zb]	Howard_17	Redheart	12	10	.	9.5	.	.	.	8.4	211	209
Midway[j, zb]	Dixieland	Temple	11	.	.	8.3	.	.	7.5	.	213	215
Miyazaki[j, zb]	0	0	11	15	10	.	.	.	6.8	.	213	209
Northwest[j, zb]	Brightmore	OSC_456	11	12	.	11	.	.	7.2	7.1	207	213
NW_90054-37[j, zb]	WA_87010-7	ORUS_984-49	13	10	.	.	.	.	9.9	7.4	207	223
Nyoho[j]	Kei_210	Reiko	11	8.6	.	.	.	.	8.6	10	213	209
Oberschlesien[j, zb]	Jucunda	Sharpless	9.2	7.5	.	7.5	.	.	.	7.2	213	209
Ogallala[j, zb]	(RockhillxCheyenne3)	(MidlandxCheyenne2)	12	9.4	.	8.3	.	.	9.4	.	213	213
Ooishi-shikinari2[j]	0	0	11	14	.	.	.	.	.	.	213	213
ORUS_1083-135[j, zb]	ORUS_869-13	OSC_3727	11	10	11	8.7	.	.	8.6	7.9	207	207
ORUS_1239R-21[j, zb]	Sumas	ORUS_973-1	9.5	6.7	.	.	.	.	10	7.8	207	209
ORUS_1267-236[j, zb]	Redcrest	ORUS_869-13	13	11	11	13	.	.	8.4	8.7	207	207

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
ORUS_1384-3[j, zb]	ORUS_1009-1	ORUS_850-4	9.5	10	.	.	.	.	11	7.4	217	209
ORUS_1391-1[j, zb]	ORUS_1027-1	ORUS_850-4	12	.	.	12	.	.	8.4	.	217	213
ORUS_1407-76[j, zb]	F.chiloensis(PatPoint)	UNK19	11	12	.	11	.	.	11	8.8	209	209
ORUS_1735-1[j, zb]	Puget_Reliance	ORUS_1267-250	13	8.2	.	13	.	9.5	8.1	6	207	207
ORUS_1754-1[j, zb]	WA_88097-47	ORUS_1735-1	14	13	.	.	10	14	9.3	8	207	207
ORUS_1769-1[j, zb]	Annapolis	ORUS_1376-16	14	8.7	11	12	9.6	6.9	10	8.8	213	213
ORUS_1827-2[j, zb]	Laguna	Totem	11	6.2	14	.	10	6	9.3	6.1	207	213
ORUS_1947-2[j, zb]	ORUS_1376-16	ORUS_1083-135	11	.	13	10	8.4	8.9	8.8	8.4	207	207
ORUS_1963-5[j, zb]	Tangi	NW_90054-36	12	13	11	8.6	9	10	.	.	0	0
ORUS_2427-4[j, zb]	Pinnacle	ORUS_1723-3	9.5	.	.	11	.	8	8.6	6.7	215	209
ORUS_2490-1[j, zb]	ORUS_1722-2	Pinnacle	.	.	16	9.3	.	12	.	6.7	209	209
ORUS_2676-1[j]	Puget_Reliance	ORUS_2161-1	.	.	.	.	.	.	.	8	207	215
ORUS_2742-1[j, zb]	Sweet_Bliss	Valley_Red	11	8.4	.	7.1	6.9	.	7.5	6.8	207	207
ORUS_2781-1[j, zb]	Puget_Summer	ORUS_2016-1	12	13	.	13	7.8	9.2	7.4	5.8	213	215
ORUS_740-7[j]	OSC_4681	Benton	.	.	.	.	.	.	.	8.2	207	209
OSC_4474[j, zb]	OSC_4681	Benton	15	10	.	.	.	.	11	9	207	213
OSC_4816 [j, zb]	OSC_4681	Benton	13	6.3	.	11	.	.	.	8.4	207	207
OSC_4817 [j]	OSC_4681	Benton	10	13	.	.	.	.	8.9	7.5	207	207
OSC_4916 [j, zb]	OSC_4681	Benton	13	10	.	9.9	.	.	.	7.7	207	207
Ourown [j, zb]	Gem	Temple	.	.	.	11	.	.	11	7.5	217	209
Ozark_Beauty [j]	Redrich	Twentieth_Century	.	.	.	.	.	.	6.9	.	213	209
Pelican [j]	FL_82-1556P	LA_8311	.	.	.	7.3	.	.	.	.	213	209
Perle_de_Prague [j]	0	0	11	10	.	8.9	.	.	.	.	209	209

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
Pinnacle [j, zb]	Laguna	ORUS_1267-250	11	12	.	.	.	.	9.5	6.2	213	209
Puget_Beauty [j, zb]	OSC_1765	Sparkle	.	10	.	.	.	.	9.7	6.4	207	207
Puget_Reliance [j]	WSU_1945	BC_77-2-72	11	9.9	13	8.8	5.9	.	10	10	207	217
Puget_Summer [j, zb]	Nanaimo	ORUS_1076-124	14	14	.	.	.	.	9.5	11	207	209
Rainier [j]	WSU_685	Columbia	10	13	.	8.9	.	.	.	.	213	213
Record	Idea	Marmolada(Onebor)	.	.	.	12	.	.	.	.	.	.
Redchief [j]	NC_1768	Surecrop	.	.	.	8.8	.	.	.	.	233	209
Redcoat [j, zb]	Sparkle	Valentine	.	12	.	9.5	.	.	7.7	.	213	209
Redcrest[j]	Linn	Totem	.	.	.	.	.	.	.	8.5	207	209
Redgem [j, zb]	Benton	OSC_3596	14	9.4	.	14	.	.	10	6.1	207	209
Redglow[j, zb]	Fairland	Tenn_Shipper	11	15	.	12	.	.	3.5	.	213	213
Repita[j, zb]	Ada_Herzberg	Auchincruive_Climax	.	11	.	9.6	.	.	9.6	.	213	209
Robinson[j, zb]	Howard_17	Washington	11	11	.	10	.	.	7.8	8.8	213	215
Rosa_Linda[j, zb]	FL_87-418	FL_87-200	.	.	.	10	6.1	.	11	.	207	209
Salinas[j, zb]	Cal_37.2-11	Cal_42.17-18	13	.	18	8.8	.	.	8.1	.	207	213
Sarian[j]	Sunrise	Tioga	7.9	.	.	.	.	.	10	.	215	209
Scott[j, zb]	F1_hybrid	F1_hybrid	12	11	.	8.3	.	.	.	7	213	215
Selva[j, zb]	Cal_70.3-117	Cal_71.98-605	9.8	7.3	.	.	.	.	6.6	4.7	207	213
Seneca[j]	NY_1261	Holiday	12	.	.	.	.	.	.	.	207	213
Senga_Sengana[j]	Markee	Sieger	8.9	8.1	.	6.3	.	.	.	.	213	213
Sequoia[j]	Cal_52.16-15	Cal_51.51-1	12	9.7	.	.	.	.	.	6.1	213	213
Shasta[j]	Cal_67.5	Cal_177.21	10	.	.	9.8	.	.	.	.	213	213
Shuksan[j, zb]	WSU_685	Columbia	15	8.7	11	12	.	.	10	7.7	207	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
Sierra[j, zb]	Nich_Ohmer	Cal_86.6	11	8.5	.	10	.	.	9.4	8.2	209	209
Siletz, zb	OSC_2012	OSC_1816	.	.	12	10	.	.	.	.	.	.
Sparkle[j]	Fairfax	Aberdeen	.	.	.	.	.	.	.	.	207	209
Stelemaster[j]	Fairland	MDUS_683	.	9.8	.	.	.	.	.	.	213	209
Stolo[j, zb]	Puget_Reliance	Whonnock	12	8.3	.	.	.	.	8	7.3	207	213
Strawberry_Festival[j, zb]	Rosa_Linda	Oso_Grande	15	8.8	11	6.3	7.6	.	7.4	7.9	213	209
Streamliner[j]	0	0	.	7.6	.	.	.	.	.	.	213	215
Sumas[j, zb]	Cheam	Tioga	15	7.9	.	10	.	.	11	8	207	213
Sumner[j, zb]	Titan	MDUS_2856	.	.	.	9.5	.	.	7.7	8.1	207	209
Sunrise[j, zb]	US_4152	Stelemaster	12	8.4	.	9.3	.	.	7.6	7.6	213	209
Surecrop[j]	Fairland	MDUS_1972	14	9.3	.	.	.	.	.	.	0	0
Sweet_Bliss (ORUS 2180-1)[j, zb]	B753	ORUS_1735-1	11	9	10	.	.	11	8.7	7	207	213
Sweet_Charlie [j, zb]	FL_80-456	Pajaro	13	11	.	.	.	.	8.4	6.8	213	209
Sweet_Sunrise (ORUS 2240-1)[j, zb]	BC_91-14-31	WA_94023-1	11	8.6	11	9.4	9.2	8.8	7.8	6.5	207	213
Talisman-NL[i]	NJ_1051	Auchincruive_Climax	.	.	.	.	.	.	.	.	0	0
Tamella[j]	Gorella	Talisman	.	.	.	.	.	.	7.4	.	213	209
Tamella-NL[i]	Gorella	Talisman	.	.	.	.	.	.	7.4	.	213	209
Tangi[j, zb]	LA_59-2012	LA_59-138	14	13	.	9	.	.	.	7.8	209	213
Temple[j, zb]	Aberdeen	Fairfax	14	13	.	9.2	.	.	7.5	7.7	213	213
Tioga[j, zb]	Cal_42.8-16	Lassen	13	7.6	7.6	11	.	.	7.6	8	213	215
Toro[j, zb]	Cal_37.20-45	Sequoia	13	8.1	6.7	.	.	.	8.2	6.4	207	213
Treasure[j, zb]	A3	Oso_Grande	13	12	.	.	10	.	8.8	5.9	213	213

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
Tufts[j]	Tioga	Cal_46.5-1	11	9.8	.	.	.	.	.	.	0	0
Tyee[j, zb]	Totem	Olympus	.	9.3	.	.	.	.	11	8.6	207	213
Valley_Red[j, zb]	Anaheim	Puget_Reliance	14	9	.	.	.	.	7.1	6	207	213
Valley_Sunset[j, zb]	K94-15	K95-24	.	.	.	8.3	.	.	7.6	.	209	209
Veestar[j, zb]	Valentine	Sparkle	12	10	.	11	.	.	9.5	8.5	213	215
Ventana[j, zb]	Cal_93.170-606	Cal_92.35-601	12	8.1	.	10	.	.	8.5	.	213	215
Wendy[j, zb]	K96-5	Evangeline	13	9.1	.	7.6	.	.	5.8	7.3	207	209
White_Carolina[j]	0	0	.	9.9	.	.	.	.	.	.	211	209
Winona[j, zb]	Earliglow	MNUS_52	.	.	9.3	.	.	.	3.2	7.9	213	209
Winter_Dawn[j, zb]	FL_93-103	FL_95-316	12	8.9	.	7.9	7.6	6.7	7.6	7.6	213	209
Super core collection												
FRA_1088[x, a]	0	0	.	.	.	.	.	.	.	.	207	209
FRA_1092[x, a]	0	0	11	.	.	.	.	.	.	.	207	209
FRA_110[r, a]	0	0	.	.	.	.	.	.	.	.	211	211
FRA_1100[x, a]	0	0	.	9	.	.	.	.	.	8.6	209	209
FRA_1104[x, a]	0	0	13	.	.	.	.	.	11	8.3	207	207
FRA_1108[x, a]	0	0	9.9	7.2	.	.	7.7	.	.	.	209	209
FRA_1408[r, a, zb]	0	0	12	11	15	12	9.5	11	14	9.5	239	215
FRA_1414[r, a, zb]	0	0	9.8	.	12	11	8.5	9.4	10	8	209	209
FRA_1435[r, a]	0	0	11	.	.	.	.	.	13	.	211	209
FRA_1455[r, a]	0	0	17	.	.	.	.	.	13	.	211	209
FRA_1557[r, a]	0	0	11	.	.	.	11	9.1	7.7	.	219	209

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
FRA_1580[r, a, zb]	0	0	8.7	12	5	12	7.8	8.5	7.8	6.5	211	227
FRA_1620[r, a]	0	0	.	.	.	.	.	.	.	.	207	207
FRA_1690[w, a]	0	0	9.1	8.7	.	.	.	.	.	.	205	209
FRA_1691[x, a]	0	0	.	8	.	.	12	8.2	.	.	233	209
FRA_1692[x, a]	0	0	.	.	.	.	.	6.5	.	.	209	209
FRA_1694[r, a]	0	0	.	5.3	.	.	10	6.7	.	.	207	209
FRA_1695[r, a]	0	0	.	3	.	.	.	7.8	.	.	207	209
FRA_1696[r, a]	0	0	.	11	.	.	.	.	.	.	207	213
FRA_1697[r, a]	0	0	9.6	10	.	.	8.5	12	12	.	219	209
FRA_1698[r, a]	0	0	.	8.1	.	.	.	.	.	.	207	213
FRA_1699[r, a, zb]	0	0	14	8.5	11	6.9	9.8	8.4	8.4	8	207	209
FRA_1700[r, a]	0	0	.	4	.	.	11	11	.	.	219	219
FRA_1701[r, a]	0	0	.	8.3	.	.	12	9.5	.	.	221	213
FRA_1703[r, a]	0	0	.	5.1	.	.	.	.	.	.	217	217
FRA_24[x, a]	0	0	14	10	.	.	.	.	12	7.2	209	209
FRA_34[x, a]	0	0	.	.	.	.	.	.	.	.	209	209
FRA_357[x,a]	0	0	.	.	.	.	.	.	.	.	209	209
FRA_372[x,a]	0	0	14	15	.	.	.	.	12	9.3	207	209
FRA_42[x,a]	0	0	.	12	.	11	.	.	.	.	217	225
FRA_48[x,a]	0	0	.	.	.	.	.	.	.	.	213	221
FRA_58[r,a]	0	0	.	.	.	.	.	.	.	.	213	213
FRA_688[x,a]	0	0	.	.	.	.	.	.	.	.	209	209
FRA_796[x,a]	0	0	.	.	.	.	.	.	.	.	207	209

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
FRA_982[r,a]	0	0	13	7	18	.	12	.	.	10	219	215
Wild accessions												
Del_Norte[x, j]	0	0	.	.	.	.	.	.	.	.	217	209
F.chil.Cape.Mendicino[x, j]	0	0	.	6	.	.	.	.	.	.	209	209
FRA_368[x, j]	0	0	12	.	.	.	9.6	.	.	9.2	213	219
ORUS_2361-1[x, j]	*F.chiloensis*(ScottsCreek)	FRA_1075	8.3	.	.	.	.	.	.	.	209	209
FRA_743[x, j]	0	0	12	.	.	.	.	.	9	8.8	207	207
Yaquina_B[w, j]	0	0	.	.	.	11	.	.	.	.	217	209
F.iturupensis[v, j]	0	0	.	.	.	.	.	.	.	.	.	.
F.vesca bracteata[t, j]	0	0	.	.	.	.	.	.	.	.	0	0
FRA_1952[t, j]	0	0	.	.	.	.	.	.	.	.	219	219
FRA_504[t, j]	0	0	.	.	.	.	.	.	.	.	0	0
Hawaii0_TD [u,j]	0	0	15	9.1	.	.	9.6	9.7	.	.	211	219
Hawaii4_TD [u,j]	0	0	15	5.6	.	.	9.5	11	12	.	0	0
Yellow_Wonder[u, j]	0	0	12	.	.	.	.	.	.	.	0	0
FRA_1948[s, j]	0	0	5.9	.	.	.	.	.	11	.	0	0
BC12[q, j]	0	0	.	8.4	.	.	.	10	.	.	207	215
BC6[r, j]	0	0	.	5.6	.	.	10	.	9.6	.	0	0
FRA_101[p, j]	0	0	.	.	.	.	.	.	.	.	0	0
FRA_1343[r, j]	0	0	9.4	7.9	.	11	.	.	.	.	207	209
FRA_1356[r, j]	0	0	12	7.9	.	.	.	.	11	5.8	213	209
FRA_1356[r, j]	0	0	12	7.9	.	.	.	.	11	5.8	213	209

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
L1[r, j]	0	0	.	12	.	.	12	9.7	.	.	211	219
L2[r, j]	0	0	.	.	.	.	11	.	8.7	.	215	215
BCPink[o, j, zb]	0	0	.	7.7	11	7.4	.	.	9.9	.	223	213
LB48[o, j]	L1	BC6	.	9.5	12	.	8.4	.	.	.	225	219
Synthetic *F. xananassa*												
FVC_8-1[n, j, zb]	JH_101-1	RH30xLH50-4	12	7.5	.	7.9	11	9.2	10	.	217	217
FVC_8-2[n, j, zb]	JH_101-1	RH30xLH50-4	12	10	8.9	10	.	.	14	8.5	207	207
FVC_8-3[n, j]	JH_101-1	RH30xLH50-4	.	11	.	.	11	.	8	.	223	209
FVC_8-4[n, j, zb]	JH_101-1	RH30xLH50-4	7.5	7.3	.	7.6	8.8	.	11	8.5	217	213
FVC_8-5[n, j, zb]	JH_101-1	RH30xLH50-4	10	7.7	11	7.2	9.8	7.7	.	.	207	213
FVC_10-1[n, j, zb]	SCxNAH	RH30xLH50-4	12	12	.	9.7	.	.	8.6	6.1	207	213
FVC_10-2[n, j, zb]	SCxNAH	RH30xLH50-4	.	.	8.6	.	.	.	10	8.8	213	209
FVC_11-1[n]	Fred9xLH50-4	SCXMAR1A	8	8.4	.	7	.	.	.	.	.	.
FVC_11-2[n, j, zb]	Fred9xLH50-4	SCXMAR1A	7.1	8.6	.	11	8.7	.	9.1	5.5	207	209
FVC_11-3[n, j, zb]	Fred9xLH50-4	SCXMAR1A	8.7	8.4	7.9	8.4	.	.	7.2	8	207	209
FVC_11-4[n, j, zb]	Fred9xLH50-4	SCXMAR1A	.	.	9	9.9	11	.	7.2	7.1	207	213
FVC_11-5[n, j, zb]	Fred9xLH50-4	SCXMAR1A	11	9	.	11	7.9	.	9.4	6.9	213	209
FVC_11-6[n, j, zb]	Fred9xLH50-4	SCXMAR1A	11	11	.	.	.	.	8.9	8.7	213	217
FVC_16-1[n, j, zb]	JH_101-1	MR10xRH23	10	9.8	11	8.2	9.5	13	9.7	7.9	207	213
FVC_17-1[n, j, zb]	JH_101-1	MR10xN8688	11	7.4	12	7.5	10	8.4	10	6.6	207	213
FVC_18-1[n, j, zb]	SCxFRA24	MR10xRH23	11	8.4	11	9.6	6.1	6.2	8.7	8	213	209
FVC_28-1[n, j, zb]	HM1xNAH	RH30xMR10	9.7	6.4	8	8	7.6	9.1	8.2	8.3	207	209
FVC_30-1[n, j, zb]	JH_101-1	Fred9xLH50-4	10	7.2	.	9.7	.	9.3	9.6	7.9	207	209

Individual	Female parent	Male parent	CA_11	CA_12	MI_11	MI_12	NH_11	NH_12	OR_11	OR_12	EMFv006	
											1A	1B
FVC_30-2[n, j, zb]	JH_101-1	Fred9xLH50-4	9.2	9.2	.	9.4	12	8.6	8.4	9.4	207	213
FVC_30-3[n, j, zb]	JH_101-1	Fred9xLH50-4	8.9	8.6	9.3	7.7	7.8	7.4	8.8	7.5	213	209
FVC_30-4[n, j, zb]	JH_101-1	Fred9xLH50-4	11	7.5	9	7.5	9.8	.	6.8	7.9	207	215
FVC_30-5[n, j, zb]	JH_101-1	Fred9xLH50-4	7.4	9.9	11	6.8	11	.	7.7	7.7	217	215
FVC_30-6[n, j, zb]	JH_101-1	Fred9xLH50-4	9	11	6.2	6.4	.	.	10	6.5	217	215
JH_101-1[n, j, zb]	*F. chiloensis*	UNK17	10	5.8	.	10	.	.	9.3	8.2	207	217

[z]Plant obtained from PB-WUR, NL and coded as E-60174

[y]Plant obtained from PB-WUR, NL and coded as E-71006

[x]Species *F. chiloensis*

[w]Species *F. chiloensis*, subspecies *pacifica*

[v]Species *F. iturupensis*

[u]Species *F. vesca*

[t]Species *F. vesca*, subspecies *bracteata*

[s]Species *F. vesca*, subspecies *bracteata americana*

[r]Species *F. virginiana*

[q]Species *F. virginiana*, subspecies *glauca*

[p]Species *F. virginiana*, subspecies *platypetala*

[o]Hybrid

[n]Wild derived *F.* ×*ananassa*

[m] Female parent

[l] Male parent

[k]NL_CF

[j]CF

[i]NL

[h]UK_CF

[g]NL_CF

[f]SP_CF

[e]FR_CF

[d]OR_CF

[c]MI_CF

[b] NCGR

[a] NCGR_CF

[za] FR

[zb] SSC measurements done for more than one state.

When superscripts [k] to [za], are placed in a population name, the source corresponds to the progeny of that population. Each parent has their own source