

‘Stolo’ Strawberry

Chaim Kempler², Hugh A. Daubeny¹, Brian Harding, and Lisa Frey
*Pacific Agri-Food Research Centre, Agriculture and Agri-Food Canada,
P.O. Box 1000 6947 #7 Highway, Agassiz, BC, Canada V0M 1A0*

Tom E. Baumann

*Agriculture Department, University of the Fraser Valley, Chilliwack, BC,
Canada V2P 6T4*

Chad E. Finn

*U.S. Department of Agriculture–Agricultural Research Service, Horticultural
Crops Research Unit, Northwest Center for Small Fruit Research, Corvallis,
OR 97330*

Shahrokh Khanizadeh

*Horticulture Research and Development Centre, Agriculture and Agri-Food
Canada, St-Jean-sur-Richelieu, QC, Canada J3B 3E6*

Andrew R. Jamieson

*Atlantic Food and Horticulture Research Center, Agriculture and Agri-Food
Canada, Kentville, NS, Canada B4N 1J5*

Kenna MacKenzie

*Pacific Agri-Food Research Centre, Agriculture and Agri-Food Canada,
Summerland, BC, Canada V0H 1Z0*

Patrick P. Moore

*Department of Horticulture and Landscape Architecture, Washington State
University, Puyallup, WA 98371*

Mark Sweeney

*BC Ministry of Agriculture, Fisheries and Food, Abbotsford, BC, Canada
V3G 2M3*

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‘Stolo’ is a new June-bearing strawberry (*Fragaria ×ananassa* Duchesne ex Rozier) cultivar from the Agriculture and Agri-Food Canada (AAFC), Pacific Agri-Food Research Center (PARC) in Agassiz, released in coop-

eration with the BC Ministry of Agriculture, Fisheries and Food, U.S. Department of Agriculture–Agricultural Research Service, Washington State University (WSU) Horticultural Research and Development Center, and AAFC sites in St-Jean-sur-Richelieu, QC, and Kentville, NS. ‘Stolo’ has been noted for high yields of late-season fruit with excellent quality suitable for both fresh and processing markets, good flavor, and tolerance to root weevil (*Otiorhynchus* sp.). Its glossy red fruit is primarily suited for the fresh market (Fig. 1A). The name ‘Stolo’ follows the PARC tradition of naming cultivars using names in the language of First Nations and comes from the Stolo First Nation residing in the Fraser Valley, BC, where the cultivar was developed and is currently grown. The word Stolo means “people of the river.”

Origin

‘Stolo’, tested as BC96-33-4, was bred by C. Kempler in 1995 and selected in Abbotsford, BC, by C. Kempler and H.A. Daubeny in 1997 among the progeny of a cross between ‘Puget Reliance’ and ‘Whonnock’ (Fig. 2). ‘Puget Reliance’ is a high-yielding, large-

fruited Pacific–Northwest (PNW) cultivar released by the WSU breeding program in Puyallup, WA (Moore, 1995; Moore et al., 1995) that is well adapted to Fraser Valley conditions. ‘Whonnock’ is a cross between ‘Sumas’ and ‘Hapil’ and was released from the PARC program in 1999. Although it was not adopted by growers in the PNW because of its unattractive, rough, and seedy fruit, ‘Whonnock’ was used extensively as a parent by the PARC breeding program because of its high yields and excellent tolerance to root weevils and soilborne diseases.

‘Stolo’ was tested at the AAFC-PARC Research Substation, Abbotsford, BC, the Oregon State University (OSU)–North Willamette Research and Extension Center (Aurora, OR), WSU Puyallup, at AAFC sites in St-Jean-sur-Richelieu, QC, and Kentville, NS, and in growers’ fields in British Columbia. At the research facilities, ‘Stolo’ was planted in multiple non-replicated and replicated matted row system trials. ‘Stolo’ was evaluated for 7 years (1999 to 2006) at the PARC substation. Plants were grown in eight-plant plots and were spaced 30 cm apart within the row and 122 cm between the rows. Rows were narrowed with a rotovator to 40 cm in March when new growth started. Fruits were harvested once per week, and fruit size for the season was calculated as a weighted mean based on the weight of randomly selected subsamples of 25 fruit at each harvest (Table 1). Fruit firmness was measured as the force required for a 4 mm diameter cylinder to penetrate to a depth of 6 mm in 10 randomly selected fruit on three harvest dates in each season (early, mid, and late harvest) (Hunter Spring Mechanical Force Gauge Series L; Ametek, Hatfield, PA). The percentages of *Botrytis* fruit rot were calculated after 24 and 48 h on 10 randomly selected fruit on three harvest dates each season and kept on plates at 20 °C under plastic wrap. The planting included other cultivars commonly grown in the PNW (Finn et al., 2009; P.P. Moore, personal communication). All data were subjected to analysis of variance using the General Linear Model Procedure of SAS (SAS Institute, Cary, NC) and means were separated using protected least significant difference.

Performance

‘Stolo’ is very productive, producing large, reasonably firm fruit suitable for the processing and fresh markets. The fruit is conical to long conical, nicely shaped with a rounded tip and reflexed calyx tips. Its achenes are situated in the profound position and its slightly concave fruit neck has a narrow band without achenes. ‘Stolo’ fruit (Fig. 1A) is lighter in skin color than that of ‘Totem’ and ‘Puget Reliance’ and is described as bright, light red externally and internally. The fruit is glossy and very attractive with a pleasant flavor and good balance of sugar and acidity (C. Kempler, unpublished data).

In trials planted at the PARC substation, ‘Stolo’ yield was significantly larger than that of ‘Rainier’, ‘Puget Summer’, ‘Totem’, and

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¹Research scientist (retired).

²To whom reprint requests should be addressed; e-mail chaim.kempler@agr.gc.ca.

'Puget Reliance', which are three of the main cultivars grown in the PNW (Table 1). 'Stolo' yield was similar to 'Tillamook', which is known for its productivity. 'Whonnock', a parent of 'Stolo', was the only cultivar that had significantly higher yield than 'Stolo'. 'Stolo' fruit size in these trials was larger than 'Totem' but smaller than 'Firecracker', 'Pinnacle', 'Rainier', and 'Tillamook'. *Botrytis* fruit rot percentage was similar to all of the other cultivars (Table 2) in the trial but was greater than 'Puget Summer', which ripens at a later, and typically drier, time of year (Table 1). The 'Stolo' harvest season is very similar to that of 'Rainier', 3 to 4 d later than 'Totem' and 4 to 6 d earlier than 'Puget Summer', which is known for its late-season production (Moore and Finn, 2002). The soluble solid content of 'Stolo' was similar to the other cultivars (Table 2). The titratable acidity of 'Stolo' fruit was significantly higher than that of the other tested cultivars except for 'Totem' (Table 2). Its pH was similar to the other tested cultivars (Table 2). The firmness of 'Stolo' fruit was softer than that of 'Pinnacle' and 'Redcrest' but not significantly different from the other cultivars. Its firmness is suitable for the fresh and processing markets, and it exhibits good postharvest quality.

In multiple-year, multiple-cultivar trials at the OSU–North Willamette Research and Extension Center, 'Stolo' produced a higher yield than that of 'Totem' (data not shown; C. Finn and P.P. Moore, personal communication). At a WSU–Mount Vernon trial, 'Stolo' tended to produce a high yield (Finn et al., 2009). In Kentville, NS, from 2005 to 2007, 'Stolo' demonstrated good plant health and high vigor. Large to medium-sized, symmetrical, bright red berries were produced in the late to very late season. 'Stolo' was also productive at Kentville, indicating broad adaptability (A.R. Jamieson, personal communication).

Plant Description

'Stolo' plants are vigorous with an erect growth habit and sufficient runner production to create a satisfactory matted row. 'Stolo' plants produce uniform matted rows with higher vigor and better cover on the second

year growth than most of the other cultivars with which it was compared (Table 3). A comparison of 'Stolo' leaf characteristics with other PNW cultivars is presented in Table 4. 'Stolo' petioles are longer than the other cultivars in the trial. Its peduncles are shorter than 'Totem' and not significantly different from 'Puget Reliance'. The situation of 'Stolo' inflorescence is slightly lower in the canopy than 'Totem' and 'Puget Reliance'. The leaves and petioles are pubescent, which gives them a silvery greenish appearance. 'Stolo' is easily distinguished in the field by its erect growth habit and its heavily pubescent leaves, which it inherited from its parent, 'Whonnock'. Under vigorous growing conditions, some leaves show

tip-burn-like symptoms that make this cultivar easy to distinguish in the field (Fig. 1B).

'Stolo' DNA has been characterized with three simple sequence repeat (SSR) markers, ARSFL9, ARSFL15, and ARSFL10 (Lewers et al., 2005), by the California Seed and Plant Laboratory, Inc. (Elverta, CA). The sizes of the polymerase chain reaction (PCR) amplification products were for ARSFL9: 202, 213, 221, 224 for ARSFL15: 173, 180, 188, 232 and for ARSFL10: 211, 231, 247, 263, 265. High-quality DNA extraction was performed on leaf tissue using the DNeasy Plant Mini Kit (Qiagen Inc., Germantown, MD). After an initial melting step for 1 min at 94 °C, SSR products were amplified by PCR for 35 cycles using a 15 s

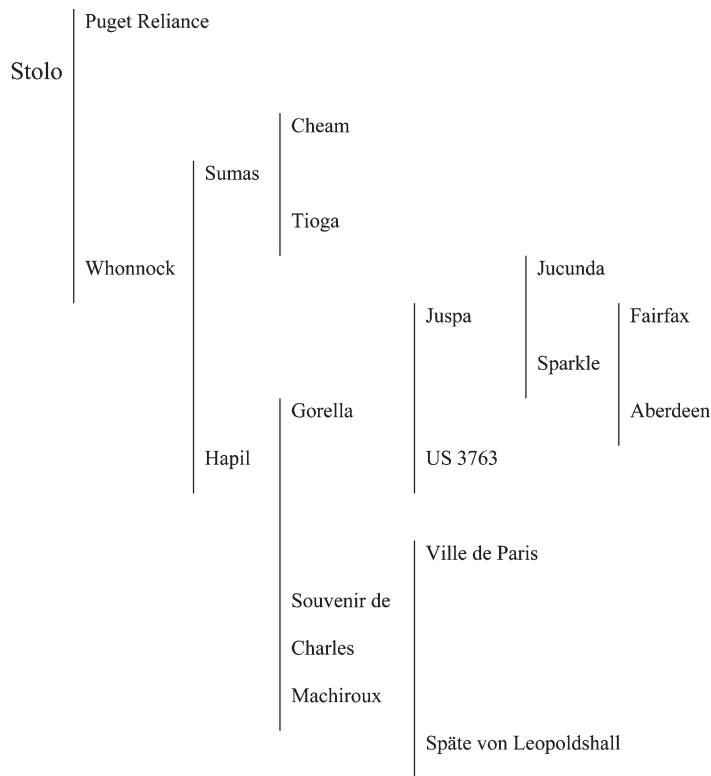


Fig. 2. Pedigree of 'Stolo' strawberry.

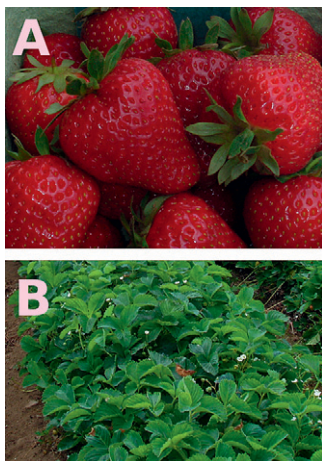


Fig. 1. 'Stolo' strawberry (A) fruit and (B) matted row showing some tip-burn-like symptoms.

Table 1. Yield, fruit weight, and harvest season of 'Stolo' and other Pacific–Northwest cultivars.^z

Cultivar	Yield (kg/10 m ²)	Fruit wt ^y (g)	Fruit rot (%)	Harvest season (date)			Harvest duration (d)
				Start (5%)	Mid point (50%)	End (95%)	
Stolo	11.94	10.2	13.8	9 June	20 June	30 June	22
Benton	10.79	10.1	10.5	4 June	14 June	27 June	24
Firecracker	11.14	11.8	13.2	4 June	14 June	24 June	21
Puget Reliance	8.57	11.0	11.6	5 June	13 June	26 June	22
Puget Summer	7.98	9.6	7.0	15 June	24 June	4 July	20
Pinnacle	10.21	13.2	16.2	2 June	12 June	25 June	24
Rainier	7.86	11.5	17.4	10 June	20 June	1 July	22
Redcrest	10.22	10.6	11.4	7 June	17 June	30 June	24
Sumas	10.13	9.3	14.1	5 June	14 June	26 June	21
Tillamook	11.98	16.0	9.1	2 June	12 June	25 June	24
Totem	8.34	8.9	13.1	6 June	16 June	26 June	21
Whonnock	14.47	9.4	17.8	5 June	16 June	26 June	22
LSD ^x	2.57	1.2	5.0	2	3	2	2

^zMeans are calculated from two to four replications in seven plantings harvested in 1999, 2000, 2001, 2003, 2004, 2005, and 2006, respectively.

^yFruit weight is an overall mean for all harvest years based on means of 25 fruit subsampled from each harvest.

^xMean separation within columns with least significant difference (LSD), *P* = 0.05.

Table 2. Fruit traits of 'Stolo' and other Pacific–Northwest cultivars.^z

Cultivar	pH	Titrateable acidity ^y (%)	Soluble solids ^y (%)	Firmness ^x (g)	<i>Botrytis</i> -incited fruit rot after 24 h ^w (%)	<i>Botrytis</i> -incited fruit rot after 48 h ^w (%)
Stolo	3.52	0.90	8.7	279	11.1	38.4
Firecracker	—	—	8.6	320	9.2	24.2
Puget Reliance	3.52	0.73	8.3	284	8.5	29.6
Puget Summer	3.46	0.45	7.6	317	0.0	6.3
Pinnacle	3.68	0.42	8.0	461	5.2	34.8
Rainier	—	—	7.7	257	1.3	21.3
Redcrest	—	—	9.4	523	4.0	25.9
Sumas	3.67	0.38	8.0	300	5.4	24.9
Tillamook	3.50	0.68	8.3	379	14.1	29.7
Totem	3.65	0.78	8.3	386	5.5	29.6
Whonnock	—	—	8.1	319	8.4	32.0
LSD ^y	0.12	0.14	1.6	108	12.0	21.0

^zMeans are calculated from seven plantings harvested in 1999, 2000, 2001, 2003, 2004, 2005, and 2006, respectively.

^yTitrateable acidity expressed as percent citric acid; percent soluble solids at 20 °C.

^xMeasured as the force required for a 4 mm diameter cylinder to penetrate to a depth of 6 mm in 10 randomly selected fruit on three harvest dates in each season.

^wPercent of *Botrytis* incited fruit scored after 24 and 48 h on 10 randomly selected fruit on three harvest dates in each season placed on a plate at 20 °C and covered with plastic wrap.

^zMean separation in columns by least significant difference (LSD), $P = 0.05$.

Table 3. Rating of plant vigor and plot cover of 'Stolo' and other Pacific–Northwest cultivars grown in matted rows in Abbotsford, BC.^z

Clone	Plant vigor ^z			Plot cover ^z		
	Planting yr	Yr 1	Yr 2	Planting yr	Yr 1	Yr 2
Benton	7.0	4.4	4.1	6.3	3.8	3.3
Hood	8.5	4.7	2.8	9.5	4.7	1.0
Pinnacle	8.3	6.5	7.5	7.9	1.0	6.5
Puget Reliance	8.1	5.7	5.0	7.6	6.0	4.3
Rainier	9.7	5.4	0.8	9.1	4.0	1.4
Stolo	8.5	6.4	6.9	8.9	6.9	6.6
Sumas	—	4.6	4.4	—	4.3	3.1
Tillamook	6.8	7.3	7.0	6.3	7.3	7.4
Totem	8.3	5.5	4.1	7.9	4.7	3.7
Whonnock	10.0	5.9	5.7	10.0	6.5	6.9
LSD ^x	1.6	2.1	2.5	1.8	1.7	2.1

^zRating of seven replicated trials planted between 1999 and 2006.

^xScored on a 0 to 10 scale (0 = low vigor or low plot cover; 10 = high vigor or plot cover).

^zMean separation in columns by least significant difference (LSD), $P = 0.05$.

Table 4. Leaf and inflorescence characteristics of 'Stolo' compared with other Pacific–Northwest cultivars.

Clone	Central leaflet ^z			Petiole (cm)	Peduncle ^z (cm)
	Length (cm)	Width (cm)	Serration no.		
Puget Reliance	8.0	6.5	18.3	20.8	11.2
Stolo	8.2	6.6	19.9	23.7	12.0
Tillamook	10.0	8.4	20.0	21.4	9.8
Totem	7.5	6.7	22.4	21.8	13.6
LSD ^y	0.4	0.4	1.0	1.6	1.3

^zMean of 10 leaves and inflorescences from each of four replicates collected July 2006.

^yMean separation in columns by least significant difference (LSD), $P = 0.05$.

denaturation step at 94 °C, a 30 s annealing step at 60 °C, and a 45 s extension step at 72 °C. A final extension step at 72 °C for 15 min was included. SSR products were separated by capillary electrophoresis using the ABI 3100 16 capillary Genetic Analyzer (Life Technologies Corporation, Carlsbad, CA) and sized by comparison with the Applied Biosystems Genescan 400HD ROX size standard (Life Technologies Corporation, Carlsbad, CA).

Disease and Pest Reaction

'Stolo' is highly tolerant to the virus complex that consists of *strawberry mottle*, *strawberry crinkle*, and *strawberry mild yellow-edge*

that are transmitted by aphids and commonly present in the PNW (Martin and Tzanetakis, 2006). 'Stolo' shows susceptibility to powdery mildew [*Podosphaera aphanis* (Wallr.) U. Braun & S. Takam, formerly *Sphaerotheca macularis* Wallr. Ex. Fr.] when grown in a greenhouse but it does not appear to be a problem when grown under field conditions. 'Stolo' shows good field resistance to red stele caused by *Phytophthora fragariae* Hickman. 'Stolo' is highly tolerant to high populations of black vine weevil (*Otiorhynchus sulcatus*, Fabricius), obscure root weevil (*Sciopithes obscurus*, Horn) and strawberry root weevil (*O. ovatus*) larvae. In field observations, 'Stolo' and its parent, 'Whonnock', performed

very well under heavy root weevil pressure (Kempfer et al., 2007; P.P. Moore, C. Finn, and C. Kempfer, unpublished data). In a trial, young, potted, daughter plants of 'Stolo', 'Kent', and 'Annapolis' were artificially inoculated with eggs of black vine weevil. After 6 weeks, all 'Stolo' plants were healthy with good root mass, whereas the other two cultivars showed poor growth with heavy root feeding (Kempfer et al., 2007). Although 'Kent' and 'Annapolis' roots appeared to be pruned off by larval feeding, many 'Stolo' roots showed only surface feeding. This apparent tolerance to larval feeding was also observed on the 'Stolo' parent, 'Whonnock'. The other parent, 'Puget Reliance', is susceptible to weevils (Moore et al., 1995). 'Stolo' is tolerant only to the larva stage, because the plants will still support adult weevils that feed on strawberry foliage resulting in characteristic notching. However, root weevil feeding by adults causes only cosmetic damage, whereas larval feeding on the roots and tunneling through the crown can cause significant plant damage. 'Stolo's tolerance may be heritable because one of its parents, 'Whonnock', is also tolerant. Therefore, it has potential for growers in areas with known root weevil populations and in breeding programs.

'Stolo' is especially noted for maintaining economical yield on commercial growers fields attributed to the tolerance to root weevils that has been inherited from its parent, 'Whonnock', and to tolerance to virus complexes common in the PNW (M. Sweeney, personal observation).

Availability

'Stolo' was released in 2006 because of its excellent fruit quality, high yield, and resistance to pests and diseases. Certified 'Stolo' plants are being propagated under royalty agreements with Sakuma Bros Farm, Burlington, WA. For licensing information, contact Okanagan Plant Improvement Company (PICO), P.O. Box 6000, Summerland, BC, V0H 1Z0, Canada. E-mail: info@picocorp.com.

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