

'Lewis' Red Raspberry

Chad E. Finn¹ and Francis J. Lawrence²

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

Geoff Langford³

The Horticulture and Food Research Institute of New Zealand Ltd., Canterbury Research Centre, P.O. Box 51, Lincoln, New Zealand

Patrick P. Moore⁴

Washington State University, Puyallup, WA 98371

Brian Yorgey⁵

Department of Food Science, Oregon State University, Corvallis, OR 97331

Bernadine C. Strik⁴

Department of Horticulture, Oregon State University, Corvallis, OR 97331

Additional index words. *Rubus idaeus*, fruit breeding

'Lewis' (Fig. 1) is a new florican fructing red raspberry (*Rubus idaeus* L.) from the U.S. Dept. of Agriculture–Agricultural Research Service (USDA–ARS) breeding program in Corvallis, Ore., released in cooperation with the Horticulture and Food Research Institute of New Zealand, Oregon State Agricultural Experiment Station, the Washington Agricultural Research Center, and the Idaho Agricultural Experiment Station. 'Lewis' is an outstanding fresh-market cultivar with large, glossy, attractive, and firm fruit. In the Pacific Northwest, yields of 'Lewis' were similar to 'Meeker', but the fruit are consistently larger and firmer than those of 'Meeker'. In New Zealand, yields of 'Lewis' were very good and the fruit were medium-large, medium-red, very firm, shiny, and separated easily from the torus. 'Lewis' was originally released due to its superior performance in New Zealand in research trials and growers' production fields as a fresh market fruit. Subsequently, small commercial plantings have been established in California climates that are similar to New Zealand.

'Lewis' is named for Meriwether Lewis, who along with William Clark, made a remarkable exploratory trip from the eastern United States in the early 1800s, as well as for Henry Lewis who was an active explorer/surveyor in New Zealand and for whom Lewis Pass, among other sites, is named.

Origin

'Lewis' was selected in 1978 from a cross between ORUS 1570 and ORUS 1748 and tested as ORUS 576-47 (Fig. 2). The parents in the pedigree represent a diverse mix of cultivars and selections from the USDA–ARS, Washington State Univ., Scottish Crop

along with native *R. idaeus* var. *strigosus* (Michaux) Maxim. material from Mt. Mitchell, N.C. 'Lewis' and 'Coho' (Finn et al., 2001) are the first cultivars released with the native *R. idaeus* var. *strigosus* from North Carolina in their derivation.

The cultivar has been tested in Aurora, Ore. [Oregon State Univ.–North Willamette Research and Extension Center (OSU–NWREC)], Mt. Vernon [Washington State Univ. (WSU)] and Puyallup, Wash. (WSU), and various grower sites throughout New Zealand. The most thorough testing in research plots was done in the United States. From 1987 to 1992, 'Lewis' was evaluated in nonreplicated trials at OSU–NWREC including 50-m long rows that were machine harvested and the yield measured. More recent replicated trials at OSU–NWREC (planted in 1996), Mt. Vernon (planted in 1992), and Puyallup (planted in 1992), were arranged in a randomized complete-block design, with three replications of three plants each used for fresh fruit characteristics, harvest season, yield, and fruit weight. Plants were planted 1.2 m apart within plots and 2.4 m between plots. The yields in the Mt. Vernon planting were unusually large for all cultivars. The replicated trial in Aurora, Ore., was not planted on raised beds and the planting in general suffered heavily from *Phytophthora* root rot (caused by *Phytophthora fragariae* var. *rubi* Wilcox and Duncan). During the harvest season, fruit were harvested one to two times each week depending on the environmental conditions. Fruit weight data for a season was obtained from the weight of a randomly selected subsample of 25 fruit at each harvest. Annual average fruit weight was calculated from these measurements after adjusting for the proportion of the



Fig. 1. 'Lewis' red raspberry.

Received for publication 15 Sept. 2000. Accepted for publication 6 Apr. 2001. This research was partially funded by the Oregon Raspberry and Blackberry Commission. We gratefully acknowledge the assistance of Derek Peacock, Kirsten Wennstrom, Connie Pace, Joe DeFrancesco, Helen Cahn, and Gina Koskela; Harvey Hall's efforts to introduce and propagate 'Lewis' in New Zealand; and Robert Martin's USDA–ARS lab for their use of thermotherapy to free 'Lewis' of known viruses and for determining its virus negative status. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.

¹Research Geneticist.

²Research Geneticist (retired).

³Scientist.

⁴Professor.

⁵Senior Research Assistant.

force necessary to separate 10 fruit from the torus and the force necessary to close the opening of 10 fruit were measured with a push-pull spring gauge (Hunter Spring Mechanical Force Gauge Series L; Ametek, Hatfield, Pa.). Fruit from each harvest were frozen and bulked. A thawed subsample from this bulked sample was used to determine soluble solids, titratable acidity (as a percentage of citric acid) and, from 100-g purée samples extracted with an acid ethanol solvent, the anthocyanin content as determined at 535 nm absorbance. At Puyallup, the force required to close the opening of five fruit with a push-pull spring gauge was measured to determine firmness (Moore et al., 1990). These data, collected from 1994–95 in Washington and from 1998–99 in Oregon, were analyzed as a split-plot in time with cultivar as the main plot and year as the subplot. While the planting included many genotypes, only the data from the cultivars ('Meeker' and 'Willamette' in all trials; 'Chilcotin', 'Chilliwick', 'Comox', 'Glen Ample', 'Tulameen' in Washington trials, and 'Qualicum' in the Mt. Vernon trial) were included in the analysis. The fruit ripening season was characterized by the dates at which 5%, 50%, and 95% of the total fruit yield were reached (Tables 1 and 2). In Oregon, subjective evaluations were made two to three times each year for primocane and florican vigor, fresh fruit characteristics including firmness, color, shape, texture when eaten, and flavor, and ease of fruit separation from the plant in all plots and averaged. In all trials, a minimal fungicide program was fol-

Fruit samples from the Puyallup trial were frozen on trays and sent as bulk frozen samples to the OSU Dept. of Food Science, where they were prepared as pureed products (Yorgey et al., 1996). 'Tulameen', 'Chilcotin', 'Meeker', 'Willamette', 'Comox', 'Lewis', and several advanced breeding selections were evaluated by 30 representatives of the raspberry industry. The samples were presented blindly to the panel and they were asked to evaluate color, appearance, flavor, and overall quality and assign a rank score for each genotype for each trait. A Kruskal-Wallis analysis of rank was used to determine probability of significant differences (Yorgey et al., 1996).

Description and performance

There was a significant cultivar × year interaction for yield and fruit weight (Tables 1 and 2). In Oregon, 'Lewis' had greater yields than 'Meeker' and 'Willamette', the most widely grown cultivars in the Pacific Northwest (Daubeny et al., 1989; Moore and Daubeny, 1993), in its first harvest season (Table 1). 'Lewis' is susceptible to phytophthora root rot when not grown on raised beds; thus its second-year (1999) harvest was much smaller than it should have been due to root rot infestation. In Washington, 'Lewis' had similar yield to the other commercial cultivars in the trials, however, in Puyallup, its yield over 2 years was greater than 'Chilliwick' (Table 2). Several of these commercial cultivars, especially 'Comox', have been noted for their high or excep-

Kempler, 1995). In unreplicated, machine-harvested trials at OSU–NWREC, 'Lewis' yielded slightly less than that of 'Meeker' (Table 3).

'Lewis' is large fruited. In Oregon trials, 'Lewis' fruit were generally heavier than 'Meeker', but this was not always significantly so (Tables 1, 3, and 4). In Washington, 'Lewis' was usually heavier than 'Chilliwick' and depending on the year, similar to most other cultivars (Table 2), including 'Tulameen', which is noted for its exceptionally large fruit (Daubeny and Anderson, 1991). New Zealand growers responding to a questionnaire reported that 'Lewis' was larger or much larger than 'Southland' and 'Fairview', and similar to 'Skeena'.

'Lewis' fruit are firm. In subjective evaluations of fresh fruit, 'Lewis' was consistently rated as firmer than 'Meeker' and 'Willamette' (data not shown). While there were no firmness differences among the commercial cultivars and 'Lewis' in 1994, in Puyallup, as measured objectively, 'Lewis' was firmer than 'Meeker', 'Willamette', and 'Chilliwick' in 1995 (Table 2). In unreplicated trials at OSU–NWREC, 'Lewis' had firmer fruit than 'Meeker' and 'Willamette', was similar to 'Chilliwick', and was softer than 'Coho' (Table 4). Fruit rot is generally low in 'Lewis' and in some years it was lower than 'Chilcotin' and 'Tulameen' (Table 2).

'Lewis' fruit are attractive, more conical than 'Meeker' and 'Willamette', and have a bright fresh color more similar to 'Meeker' than 'Willamette'. Fresh fruit samples have had soluble solid levels similar to 'Coho' and 'Meeker', greater than 'Willamette', and less than 'Chilliwick' (Table 4). The titratable acidity of 'Lewis' is intermediate between 'Meeker' and 'Willamette' (Table 4). 'Lewis' has fewer pyrenes per unit of fresh weight than 'Coho', 'Meeker', 'Chilliwick' or 'Willamette' (Table 4). Fresh flavor was rated similar to 'Meeker' and not as intense as 'Willamette' (data not shown).

'Lewis' is a late-season ripening berry. In Oregon and Puyallup, while 'Lewis' begins to ripen ≈7 d later than 'Meeker', its overall season is fairly similar (Tables 1, 2, and 4). Further north in Mt. Vernon, 'Lewis' reached 5%, 50%, and 95% ripe fruit later than all cultivars (Table 2). In all three replicated trials, 'Lewis's' fruiting season was 27 d long (Tables 1 and 2).

While 'Lewis' is predicted to be primarily a fresh market berry, it was evaluated for its processing characteristics by Yorgey et al. (1996) whose results are summarized here. As an IQF (individually quick frozen) berry, 'Lewis' was better for color and appearance than 'Willamette' and poorer than 'Tulameen'. 'Lewis' was similar for flavor and overall quality to all other cultivars in the evaluation except for 'Tulameen', which was rated better than 'Lewis'. As a pureed product, 'Lewis' was ranked similar to 'Chilcotin' and 'Meeker' and poorer than 'Willamette', 'Tulameen', and 'Comox' for color. Its appearance was ranked

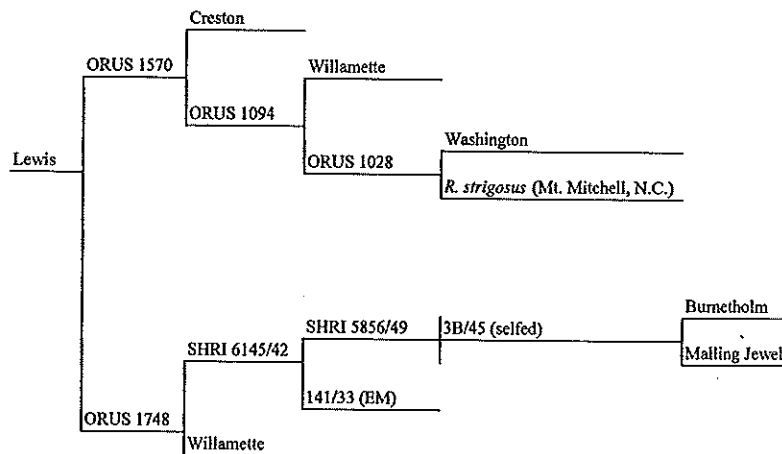


Fig 2. 'Lewis' red raspberry pedigree.

Table 1. Fruit weight, yield, and harvest season for raspberry genotypes planted in 1996 at OSU–North Willamette Research and Extension Center.

Cultivar	Fruit wt (g)			Yield (kg·ha ⁻¹)			Harvest season [†]		
	1998	1999	1998–99	1998	1999	1998–99	5%	50%	95%
Lewis	3.2 a	3.3 a	3.3 a	11559 a	4848 b	8203 a	7 July	20 July	3 Aug.
Meeker	2.6 b [‡]	2.9 a	2.8 b	7607 b	10204 a	8906 a	30 June	20 July	3 Aug.
Willamette	3.0 a	3.2 a	3.1 a	7497 b	10035 a	8766 a	30 June	12 July	26 July

[†]Date at which the yield reached the given percentage of the total yield.

[‡]Mean separation within columns by Duncan's multiple range test, $P \leq 0.05$.

Cultivar	Yield (kg·ha ⁻¹)			Fruit rot (%)		Fruit wt (g)		Fruit firmness (N) ²		Harvest season ³			Length (days)
	1994	1995	2-year total	1994	1995	1994	1995	1994	1995	5%	50%	95%	
<i>Puyallup, Wash.</i>													
Chilcotin	9,016 d ⁴	17,037 c	26,045 bc	14.0 a	16.7 ab	3.56 c	3.61 b	1.27 b	1.56 bc	16 June b	29 June b	18 July ab	32 a
Chilliwack	10,318 d	12,833 c	23,149 c	5.7 c	17.0 ab	3.06 d	2.70 c	2.15 a	1.49 c	18 June b	29 June b	11 July c	23 b
Comox	12,944 cd	16,941 c	29,883 bc	7.0 bc	22.7 a	4.03 b	3.90 b	2.20 a	1.63 a-c	17 June b	1 July b	14 July bc	27 ab
Glen Ample	18,189 a	26,202 a	44,400 a	4.0 c	24.7 a	4.68 a	4.74 a	2.3 a	1.83 ab	20 June b	1 July b	18 July ab	28 ab
Lewis	17,628 ab	18,189 bc	35,818 ab	3.3 c	15.0 ab	4.44 ab	3.45 b	2.08 ab	1.73 ab	25 June a	7 July a	22 July a	27 ab
Meeker	16,506 a-c	25,021 ab	41,526 a	6.0 bc	12.0 b	3.46 cd	3.10 bc	1.57 b	1.32 c	18 June b	5 July a	20 July ab	32 a
Tulameen	12,413 cd	16,251 c	28,664 bc	10.0 ab	20.0 ab	3.90 bc	4.66 a	1.66 b	1.87 a	18 June b	1 July b	16 July b	29 ab
Willamette	13,012 cd	17,627 bc	30,633 bc	7.0 bc	20.7 ab	3.39 cd	3.36 bc	1.70 b	1.42 c	17 June b	26 June c	11 July c	24 b
<i>Mt. Vernon, Wash.</i>													
Chilcotin	36,662 a-c	39,962 a	76,633 ab	---	---	4.21 b-d	3.97 a-c	---	---	20 June bc	2 July bc	22 July b	32 a
Chilliwack	28,941 c	31,538 a	60,478 b	---	---	3.62 d	3.33 cd	---	---	22 June b	3 July bc	17 July e	25 d-f
Comox	38,332 a-c	39,365 a	77,704 ab	---	---	4.35 a-d	4.13 ab	---	---	20 June bc	4 July b	18 July de	27 b-d
Glen Ample	29,883 a	47,161 a	77,053 a	---	---	4.74 ab	4.48 a	---	---	21 June bc	4 July b	21 July bc	30 ab
Lewis	32,548 a-c	39,708 a	72,263 ab	---	---	4.44 a-c	3.91 a-d	---	---	28 June a	9 July a	25 July a	27 b-d
Meeker	32,900 a-c	28,148 a	61,048 ab	---	---	3.71 cd	3.41 cd	---	---	21 June bc	4 July b	20 July b-d	29 a-c
Qualicum	41,542 ab	44,294 a	85,829 ab	---	---	4.93 ab	4.38 ab	---	---	22 June b	4 July b	19 July c-e	26 c-f
Tulameen	34,180 ab	36,550 a	70,730 ab	---	---	5.10 a	4.49 a	---	---	20 June bc	2 July bc	20 July b-d	29 a-c
Willamette	22,844 a-c	28,171 a	51,028 ab	---	---	3.68 cd	3.29 d	---	---	19 June c	29 June c	12 July f	23 f

¹Firmness, which is given in Newtons, and is the force required to close the opening of the fruit as measured with push-pull spring gauge, was obtained from five fruit from each harvest.

²Mean for 1994 and 1995.

³Mean separation within columns by Duncan's multiple range test, $P \leq 0.05$.

Table 3. Comparison of yields of mechanically-harvested and hand-harvested 'Lewis' and 'Meeker' red raspberry plants in 1992 at OSU-NWREC (Aurora, Ore.). Yield was harvested from 50-m rows; 37 m were machine harvested, 6 m were hand harvested and 7 m separated the harvest treatments.

Cultivar	Yield (kg·ha ⁻¹)		Machine yield as a %	
	Machine	Hand	of hand harvest	Fruit wt (g)
Meeker	9041.5	10494.6	86.2	2.95
Lewis	7310.6	9412.8	77.7	3.64

similar to 'Chilcotin', 'Meeker', and 'Comox' and poorer than 'Willamette' and 'Tulameen'. For flavor and overall quality, 'Lewis' was ranked similarly to 'Willamette', 'Tulameen', and 'Comox', poorer than 'Meeker' and better than 'Chilcotin'. In summary, 'Lewis' should be considered as a berry for the fresh market but it has acceptable quality when processed.

'Lewis' can be mechanically harvested. Over years, in unreplicated plots, the force to release fruit was similar for 'Lewis', 'Meeker', and 'Chilliwack' (Table 4). In subjective evaluation of unreplicated trials, 'Lewis' typically was rated similar to 'Meeker' and 'Willamette' for ease of fruit removal. While 'Lewis' had a lower recovery of machine

harvested fruit when compared to hand harvest than did 'Meeker' (Table 3), the percentage of loss was within the range of 7.1% to 35.2% found for 'Meeker' in more detailed studies (Strik et al., 1998).

'Lewis' is susceptible to phytophthora rootrot in the Pacific Northwest (*P. fragariae* var. *rubi*) and New Zealand [*P. cactorum* (Lebert & Cohn) Schroeter]. In plots uninfected by root rot, its primocanes were consistently rated more vigorous than 'Meeker' and similar to 'Willamette', while its floricanes were rated less vigorous than both cultivars. 'Lewis' canes are generally smooth within the fruiting zone of the plant but prickles occur basipetally.

While 'Lewis' has not been noted for susceptibility to any cane or foliar diseases in the Pacific Northwest, it is susceptible to rust [*Kuehneola uredinis* (Lk.) Arth.] in New Zealand. In New Zealand, it also has been noted to be very susceptible to raspberry budmoth (*Heterocrossa rubrophaga* Dugdale) attack, especially in overwintering buds. 'Lewis' has tested positive for raspberry bushy dwarf virus in the field as determined by enzyme-linked immunosorbent assay (ELISA), but it is not known how quickly it becomes infected.

Adaptability and uses

'Lewis' appears well adapted to the North American Pacific Northwest and to New Zealand's Central and Southern districts. Its large, attractive, glossy, and firm fruit coupled with very good yields are particularly suited to the fresh market. While 'Lewis' is acceptable for processing, this is not recommended as the primary market for this cultivar.

Table 4. Fruiting characteristics of 'Lewis' and four Pacific Northwest red raspberry cultivars based on plants grown in unreplicated plots at OSU-NWREC (Aurora, Ore.). Genotypes were evaluated for 1-4 years.

Cultivar	Years evaluated	Fruit wt (g) ²	Fruit firmness (N) ³		Soluble solids (%)	Titratable acidity (%) ⁴	Color (mg antho.·100 g·frt ⁻¹) ⁵	Pyrene no.·5 g ⁻¹	Individual pyrene wt (mg)	Pyrene wt as % of fruit wt	Harvest date		Release (N) ⁶
			pH	pH							First	Last	
Chilliwack	1989-90	3.50	2.25	3.12	13.20	2.10	58.66	117.0	1.50	3.50	20 June	15 July	1.15
Coho	1990	3.60	3.19	3.09	12.60	2.13	---	129.0	1.58	4.10	10 July	7 Aug.	---
Lewis	1987-90	3.68	2.32	3.10	12.50	1.85	45.12	103.8	1.55	3.23	27 June	28 July	1.12
Meeker	1988-90	2.90	1.83	3.20	12.07	1.58	36.10	137.7	1.51	4.13	28 June	26 July	1.17
Willamette	1988-90	3.13	1.96	2.99	10.87	2.30	61.67	119.0	1.61	3.83	20 June	12 July	1.33

¹Average of 50 fruit per harvest.

²Average of 10 fruit/harvest; force necessary to close fruit opening as measured with push-pull spring gauge.

³Expressed as percent citric acid.

⁴Anthocyanins from 100-g fruit puree extracted with an acid ethanol solvent, absorbance determined at 535 nm.

⁵Average of 10 fruit/harvest; force necessary to separate fruit from torus as measured with push-pull spring gauge.

to our breeding program [it is a parent of 'Coho' (Finn et al., 2001)], as well as in other programs.

Availability

'Lewis' nuclear stock has tested negative for tomato ringspot, raspberry bushy dwarf, and tobacco streak viruses by ELISA and has indexed negative on grafting to *R. occidentalis* L. 'Lewis' is not patented. However, when this germplasm contributes to the development of a new cultivar, hybrid, or germplasm, it is requested that appropriate recognition be given to the source. Further information or a list of nurseries propagating 'Lewis' is available on written request to Chad Finn, USDA-ARS, Northwest Center for Small Fruit Research, Horticultural Crops Research Laboratory, 3420 NW Orchard Ave., Corvallis, OR 97330, or

RESEARCH INSTITUTE OF NEW ZEALAND LTD., Canterbury Research Centre, P.O. Box 51, Lincoln, New Zealand. The USDA-ARS and the Horticulture and Food Research Institute of New Zealand do not have commercial quantities for sale. In addition, genetic material of this release has been deposited in the National Plant Germplasm System, accession number CRUB 1109 or PI 553534, where it will be available for research purposes, including development and commercialization of new cultivars.

Literature Cited

- Daubeny, H.A. 1987. 'Chilliwack' and 'Comox' red raspberries. *HortScience* 22:1343-1345.
- Daubeny, H.A. and A. Anderson. 1991. 'Tulameen' red raspberry. *HortScience* 26:1336-1338.
- Daubeny, H.A. and C. Kempler. 1995. 'Qualicum' red raspberry. *HortScience* 30:1470-1472.
- Daubeny, H.A., F.J. Lawrence, and G.R. McGregor.

- 1997-98.
- Finn, C.E., F.J. Lawrence, B. Yorgey, and B.C. Strik. 2001. 'Coho' red raspberry. *HortScience* 36:1159-1161.
- Moore, P.P. and H.A. Daubeny. 1993. 'Meeker' red raspberry. *Fruit Var. J.* 47:2-4.
- Moore, P.P., T.M. Sjulín, B.H. Barritt, and H.A. Daubeny. 1990. 'Centennial' red raspberry. *HortScience* 25:484-485.
- Strik, B.C., H. Cahn, C. Pace, and P. Anderson. Production System. 1998. Physiology research and cooperative breeding program—Improving machine harvest efficiency and production of red raspberries. 1997-98 Progress Reports to Agricultural Research Foundation for the Oregon Raspberry/Blackberry Commission. Corvallis, Ore.
- Yorgey, B., D. Farkas, and C. Finn. 1996. Evaluation of processing quality of advanced caneberry breeding selections. 1995-96 Reports to the Agricultural Research Foundation for the Oregon Raspberry and Blackberry Commission.