‘Wakefield’ Red Raspberry

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Additional index words. *Rubus idaeus*, fruit breeding, yield, machine harvest

‘Wakefield’ is a new florican-fruited red raspberry (*Rubus idaeus* L.) cultivar from The New Zealand Institute for Plant and Food Research Limited [Plant and Food Research (PFR)] and Northwest Plant Company joint raspberry breeding program. ‘Wakefield’ produces high yields of very firm, medium-sized fruit mid to late in the season that are well suited to machine harvesting and process markets. Machine-harvested fruit are very suitable for tunnel freezing to produce individual quick frozen (IQF) products. ‘Wakefield’ plants appear to have some tolerance to Raspberry Bushy Dwarf Virus (RBDV) and to root rot caused by *Phytophthora rubi* [(Wilcox and Duncan) Man in’t Veld].

Origin

The new cultivar of red raspberry was created in 1990 at PFR (formerly HortResearch), Motueka, New Zealand. The parents used to make the cross were the unpatented selection ORUS 576-47, since named ‘Lewis’ (Finn et al., 2001) from the Oregon State University, U.S. Department of Agriculture, Agriculture Research Service Rubus breeding program as the seed parent, and selection 86105M57 from the PFR New Zealand breeding program as the pollen parent. ‘Lewis’ (ORUS 1570 × ORUS 1748) was named after trials in New Zealand found it performed well in that country and has since found some favor as a later season fresh-market cultivar. 86105M57 (SCRI 8216B6 × SCRI 82224D4) was selected in New Zealand after seed of the cross was sent to New Zealand from the Scottish breeding program. 86105M57 was spineless, very vigorous and productive, and it had very long fruiting laterals up to 2 m long, which is considered to be unsuitable for any form of commercial use.

The pedigree of the new cultivar included the Scottish cultivars Glen Prosen, Glen Lyon Glen Moy, and Glen Yarra (not patented); the U.S. cultivars Meeker and Willamette (not

patented); the East Malling cultivar Malling Delight (not patented) and the British Columbian cultivar Haida (not patented). The background of ‘Wakefield’ also includes the species *R. pileatus* and *R. occidentalis* through the Scottish breeding program and the species *R. strigosus* through the Oregon Rubus breeding program. *R. pileatus* was used in Scotland as a source of resistance to *Botrytis cinerea*, and hybrids of this species and their derivatives showed increased resistance to this disease in both canes and fruits. *R. pileatus* is also a source of raspberry root rot resistance to *Phytophthora rubi* (Hall et al., 2009). *R. occidentalis* was incorporated in the Scottish breeding program as a source of improved fruit firmness and as such was in the background of all four Scottish cultivars in the background of 86105M57. The accession of *R. strigosus*, which has been used in the Oregon Rubus breeding program, originated from Mt. Mitchell, NC, and has shown good adaptation to heavy soils and resistance to raspberry root rot.

The cross (‘Lewis’ × 86105M57) performed to produce ‘Wakefield’ was carried out in a greenhouse in 1990 and after germination, the resulting seedlings were grown at PFR Motueka (lat. 41.058° S long. 172.584° E). A total of 115 seedlings were planted on land controlled by PFR in 1991. The original plant of the new cultivar was selected and given the breeders’ code 90352EK-6 during the 1993–94 Summer (Southern Hemisphere). It was further evaluated under selection code HR40 and named ‘Wakefield’ after the township of Wakefield near Nelson, New Zealand, and the early explorer Arthur Wakefield who was integral in the settlement of Nelson City in 1842. Key characters of ‘Wakefield’ are: 1) a plant that is partially crown-forming and produces smaller numbers of primocanes that are very vigorous, thick, and tend to branch later in the season on upper regions; 2) the ability to form very firm medium-sized dark red fruit (Fig. 1) of very good flavor, high soluble solids, and acidity in high yields on long fruiting laterals (Fig. 1) that ripen moderately late in the season; 3) the ability to machine harvest extremely well with little removal of green fruit; and 4) resistance to root rot caused by *Phytophthora rubi*.

When compared with the parent ‘Lewis’ in New Zealand, the new cultivar is found to form smaller fruit with darker color. ‘Wakefield’ is further distinguished from ‘Lewis’ by having fewer canes that are thicker and longer and producing fruit that are smaller (Fig. 1), less glossy, and requiring less force to separate the berry from the receptacle.

When compared with the parent 86105M57 in New Zealand, ‘Wakefield’ fruit were firmer and ‘Wakefield’ plants have significantly more spines on canes than 86105M57, which is spineless.

Performance and Description

‘Wakefield’ was tested and evaluated as an advanced selection between the years 1996 to 1998 at PFR Motueka, New Zealand, and in 2009 and 2010 at Enfield Farms Inc., Lynden, WA. In Washington, ‘Wakefield’ was included in a randomized complete block design trial along with three other genotypes (NR18, ‘Meeker’, and ‘Willamette’) and three replicates each of six plants (spacing 70 cm between plants, 3 m between rows), which was planted in May 2008. Percent budbreak during spring [recorded as the percentage of buds broken (0 = none, 10 = all)] and flowering time [recorded as percentage of flowers open (0 = none, 10 = all)] were recorded as scores for each plot. Each six-plant plot was machine-harvested every 2 to 2.5 d between 29 June and 7 Aug. in 2009 and 29 June and 11 Aug. in 2010, and fruit weights were recorded. For each plot, a loess smooth curve of cumulative yield vs. date was interpolated to derive the mid-harvest date (date at which 50% of the final yield had been harvested) and harvest span (number of days over which the middle 95% of the crop was picked).

Firmness measurements (mean of 25 fruit × three harvest dates: early, mid, and late) were made using a Firmtech 2 firmness tester (Bioworks Inc., KS) and mean berry weight was recorded. Juice samples were extracted from 25 fruit and three harvest dates using a potato ricer, combined, and were analyzed for total anthocyanin by high-performance liquid chromatography [HPLC (Shimadzu, Portland, OR)] in a manner similar to that described by Connor et al. (2005) and total ellagitannin determined by HPLC was quantified using purified Sanguin H6 as a standard. Antioxidant capacity was determined by ferric-reducing antioxidant power and total phenolics through the Folin assay using methods similar to those described by Benzei and Strain (1999) and Zhang et al. (2006), respectively. Soluble solids content was recorded using a digital pocket refractometer (PAL-1; Atago, Tokyo, Japan) and for total acidity measurements, 2 mL of berry juice in 40 mL of water was titrated with 0.1 M NaOH to pH 8.2 on an autotitrator (T70; Mettler Toledo, Zurich, Switzerland). Data were analyzed by analysis of variance using R 2.9.0 (R Core Development Team, 2010).

‘Wakefield’ was very well adapted to machine-harvesting because ripe fruit are

Received for publication 28 June 2012. Accepted for publication 6 Aug. 2012.

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Fig. 1. (A) 'Wakefield' planting in Lynden, WA. (B–C) 'Wakefield' fruit on plant.

Table 1. Mean time of budbreak (score 0 = no buds broken, 10 = all buds broken on 7 Apr. 2009), flowering score (0 = no open flowers, 10 = all flowers open on 8 June 2009), and fruit harvest measurements for first crop 2009 for the red raspberry replicated trial.

Genotype	Time of budbreak score	Flowering time score	50% fruit harvest date	Machine harvest span (d) ^y	Machine harvested yield (kg/plant)	Berry wt (g)	Fruit firmness (N)
Wakefield	2.0 c ^z	2 b	21 July a	31 a	2.0 a	3.3 a	0.51 a
Meeker	3.5 bc	4 ab	16 July ab	33 a	2.8 a	3.4 a	0.40 b
NR18	7.2 a	7 a	9 July c	32 a	2.0 a	3.0 a	0.37 b
Willamette	5.3 ab	7 a	13 July bc	31 a	3.0 a	3.4 a	0.39 b
SD	0.7	0.9	1.7	1.7	0.38	0.16	0.023

^zMeans within a column followed by the same letter are not significantly different ($P < 0.05$, Tukey's least significant difference).

^yNinety-five percent of fruit harvested by machine.

Table 2. Mean fruit chemistry measurements for the first crop 2009 for the red raspberry replicated trial.

Genotype	Fruit soluble solids (% Brix)	Fruit acidity (mg·g ⁻¹) ^y	Fruit total anthocyanins (mg/100 g) ^x	Fruit total ellagitannins (mg/100 g) ^w	Fruit total phenolics (mg/100 mL) ^v	FRAP ^u (Trolox equiv. μmol/100 g)
Wakefield	11.2 ab	22.4 a	66.9 ab	43.0 a	356.1 a	1245 a
Meeker	12.0 a ^z	13.3 c	52.1 b	32.0 ab	330.6 a	1062 a
NR18	10.7 ab	17.8 b	92.9 a	25.2 ab	342.0 a	1270 a
Willamette	10.5 b	18.3 b	89.3 a	20.7 b	311.4 a	1246 a
SD	0.4	0.74	8.78	5.35	36.2	94.6

^zMeans within a column followed by the same letter are not significantly different ($P < 0.05$, Tukey's least significant difference).

^yCitric acid equivalents.

^xCyanidin glucoside equivalents.

^wSanguin equivalents.

^vGallic acid equivalents.

^uFRAP = ferric-reducing antioxidant power.

very easily released from the plant laterals. In addition, very few non-ripe (green) fruit were accidentally removed by the machine in comparison with 'Meeker' (data not shown). Our results show 'Wakefield' fruit were significantly firmer than those of 'Meeker' and 'Willamette' and had comparable soluble solid contents (Tables 1–4). The ability to machine-harvest firm fruit makes 'Wakefield' very suited to production of fruit for IQF markets. 'Wakefield' fruit had higher acidity, anthocyanin content, and higher antioxidant capacity than those of 'Meeker' (Tables 2 and 4). In 2010, 'Wakefield' had higher machine-harvested yield than 'Willamette' and 'Meeker' and was harvested in a similar or later season than 'Meeker' and harvested significantly later than 'Willamette' (Table 3).

Using available pedigree information, we calculated the genetic contribution of *R. idaeus*, *R. strigosus*, and *R. pileatus* to 'Wakefield' to be 83.6%, 13.3%, and 3.1%, respectively. We calculated the inbreeding coefficient of 'Wakefield' to be zero, indicating that 'Wakefield' is not inbred (Fig. 2). However, it should be noted that the pedigrees of all ancestors were not necessarily complete.

'Wakefield' plants are semi-spineless and carry the Ss gene (Lewis, 1939) with

Table 3. Mean time of budbreak (score 0 = no buds broken, 10 = all buds broken on 1 Mar. 2010), flowering score (0 = no open flowers, 10 = all flowers open on 4 June 2010), and fruit harvest measurements for second crop 2010 for the red raspberry replicated trial.

Genotype	Time of budbreak score	Flowering time score	50% fruit harvest date	Harvest span (d) ^y	Machine harvested yield (kg/plant)	Berry wt (g)	Fruit firmness (N)
Wakefield	4.2 a ^z	2.0 a	21 July a	34.8 a	3.5 a	3.0 a	0.48 a
Meeker	0.5 b	2.3 a	22 July a	34.3 a	3.1 a	2.9 a	0.32 b
NR18	6.3 a	7.0 b	11 July b	33.8 a	3.6 a	2.8 a	0.26 c
Willamette	1.2 b	7.0 a	12 July b	29.6 a	2.7 a	3.2 a	0.25 c
SD	0.83	0.24	1.76	1.88	0.35	0.14	0.01

^zMeans within a column followed by the same letter are not significantly different ($P < 0.05$, Tukey's least significant difference).

^yNinety-five percent of fruit harvested by machine.

a moderate number of small spines near the base and fewer on upper parts of the canes. 'Wakefield' canes are pubescent (H gene) (Jennings and Brydon, 1989).

Measurements from our replicated trial on 'Wakefield' show that it has significant advantages over the current commercial cultivars Meeker and Willamette in terms of fruit yield, fruit quality, and disease resistance.

The new cultivar was first asexually propagated in 1994 in New Zealand, being reproduced by root cuttings, and since 2005, 'Wakefield' has been propagated by tissue culture. Currently 'Wakefield' is propagated by tissue culture methods because it produces

relatively low numbers of adventitious root shoots in a nursery compared with cultivars such as 'Meeker' and 'Willamette'. The resulting plants propagate true to type, demonstrating that the characteristics of the new cultivar are stable and can be transmitted without change through succeeding generations of multiplication.

Pest and Disease Reaction

'Wakefield' plants do not carry the gene *Bu* (Jones et al., 1982), which confers RBDV resistance; however, 'Wakefield' has not tested positive for the presence of RBDV in

Genotype	Fruit soluble solids (% Brix)	Fruit acidity (mg·g ⁻¹) ^y	Fruit total anthocyanins (mg/100 g) ^x	Fruit total ellagitannins (mg/100 g) ^w	Fruit total phenolics (mg/100 mL) ^v	FRAP ^u (Trolox equiv. μmol/100 g) ^u
Wakefield	12.3 a ^z	21.5 a	100.0 a	78.2 b	182.1 b	1212 a
Meeker	11.8 a	11.2 c	58.5 b	76.8 b	143.5 c	1050 b
NR18	10.5 b	16.2 b	101.1 a	102.1 a	206.7 a	1257 a
Willamette	9.9 b	16.7 b	100.1 a	66.4 c	173.5 b	1236 a
SD	0.28	0.73	3.41	2.45	4.82	26.7

^aFRAP = ferric-reducing antioxidant power.

'Wakefield' is the subject of a grant of a U.S. plant patent (grant no. PP 21,185). For more information about 'Wakefield', please contact Northwest Plant Company or Plant & Food Research.

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In 2012 a total of ≈ 240 ha of ‘Wakefield’ was planted in Whatcom County, WA, and the cultivar is well suited to machine-harvesting and process markets. It is likely ‘Wakefield’ will be well-adapted to USDA hardiness zones 8–10. In fertile soils and with good management, ‘Wakefield’ will produce high yields of medium-sized fruit very suited to machine harvest. In central and northern areas of New Zealand, ‘Wakefield’