‘NN08002’ (Marketed as WakeTMHaven) Red Raspberry

Mark Joseph Stephens¹ and Jenny R. Gaudion

The New Zealand Institute for Plant & Food Research Limited, Motueka Research Centre, 55 Old Mill Road, Motueka 7198, New Zealand

Lisa A. Jones

Plant and Food Research USA, c/o Northwest Plant Company, 8021 Woodland Road, Ferndale, WA 98248

Julia R. Enfield

Northwest Plant Company, 8021 Woodland Road, Ferndale, WA 98248

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

‘NN08002’ is a new florican-fruited red raspberry (*Rubus idaeus* L.) cultivar from The New Zealand Institute for Plant & Food Research Limited (PFR) and Northwest Plant Company (NWPCo.) joint raspberry breeding program. It is owned by Pacific Berries LLC (a company jointly owned by PFR and NWPCo. based in Lynden, WA) and marketed as WakeTMHaven in the United States. In this article, we describe the origin of this new cultivar, its characteristics, and use. It was derived from a family from a controlled cross between ‘Wakefield’ (marketed as WakeTMField) and NR14. ‘NN08002’ is a florican-fruited cultivar that produces high yields of medium-large, firm fruit in the midseason and is well suited to machine harvest and processing applications. ‘NN08002’ plants appear to have resistance to *Raspberry bushy dwarf virus* (RBDV) and tolerance root rot caused by *Phytophthora rubi* [(Wilcox and Duncan) Man in’t Veld].

Origin

The new cultivar of red raspberry, ‘NN08002’ (*Rubus idaeus* L.), was created as the result of a planned cross in the course of a breeding program carried out by The New Zealand Institute for PFR [formerly the Horticulture and Food Research Institute of New Zealand Limited (HortResearch)] in Lynden, WA. The controlled cross performed to produce the population from which ‘NN08002’ was selected was carried out in Lynden, WA, in 2006, and 119 seedlings planted into the field in 2007. The original plant of the new cultivar was selected during the 2008 summer and given the breeders’ code ‘NN08002’.

‘NN08002’ was selected as a seedling within a family targeted to produce cultivars that can be easily machine harvested with excellent fruit quality. The parents used to make the cross were ‘Wakefield’ (U.S. Plant Patent 21,185) as the seed parent and selection NR14 (unpatented) as the pollen parent from the PFR–NWPCo breeding program (Fig. 1). ‘Wakefield’ (Stephens et al., 2012) (‘Lewis’ × 86105M57) was selected from the Motueka-based PFR breeding program and first commercialized in the Pacific Northwest.

It has high yields of medium-red-colored, nice tasting, very firm fruit that release very well for machine harvest and has shown the ability to freeze well for individually quick frozen (IQF) markets. ‘Wakefield’ pedigree includes lineage from the United States and United Kingdom. ‘Wakefield’ seed parent ‘Lewis’ (Finn et al., 2001) came from the U.S. Department of Agriculture–Agricultural Research Service (USDA-ARS) breeding program in Corvallis, OR. Lewis has large medium-red-colored fruit that are firm and plants susceptible to root rot and RBDV. ‘Wakefield’ pollen parent, selection 86105M57, was selected in New Zealand (NZ) from a cross generated by the then Scottish Crop Research Institute (SCRI), now James Hutton Institute, Dundee, UK (Fig. 1).

NR14 (‘Waimea’ × ‘Meeker’) was an unreleased, unpatented selection from the PFR–NWPCo program. NR14 was high yielding and machine harvestable, but the fruit were too soft for commercial production. ‘Waimea’ was selected in NZ from a cross generated by SCRI by the Motueka-based PFR breeding program from a half sib cross to ‘Wakefield’ and had firm fruit that was machine harvestable as well as RBDV resistance. Both 86105M57 and ‘Waimea’ were derived from the Scottish selection 82224D4, a third-generation derivative of the Asiatic raspberry species *Rubus pileatus*

Fig. 1. Pedigree of ‘NN08002’ (marketed as WakeTMHaven) red raspberry (*Rubus idaeus* L.), including inbreeding coefficients.

Received for publication 22 May 2017. Accepted for publication 11 July 2017.

We gratefully acknowledge the help from Enfield Farms Inc. for growing and harvesting trials, Robert R. Martin (USDA-ARS) for virus testing and virus freeing.

¹Corresponding author. E-mail: jo.stephens@plantandfood.co.nz.

Fig. 2. 'NN08002' (marketed as Wake™Haven) red raspberry (*Rubus idaeus* L.) fruiting bush growing in a field showing upright primocanes and hanging fruiting laterals.

Fig. 3. 'NN08002' (marketed as Wake™Haven) red raspberry (*Rubus idaeus* L.) fruit and removed receptacles on 1 cm grid.

Focke which contributes very coherent and firm fruit, and potential resistance to root and fruit rot. 'Meeker' has been the dominant machine-harvested commercial cultivar grown in the Pacific Northwest since the 1980s (Moore and Daubeney, 1993) and consistently produces high yields suitable for machine harvest and process markets.

Key characteristics of 'NN08002' are

- a) High-yielding plant that is suited to machine harvest (Fig. 2.).
- b) The ability to form medium-large-sized fruit that are very firm, easy to pick, medium-light red in color (Figs. 3 and 4), conical in shape (Figs. 3 and 4), and early midseason ripening.
- c) Semispineless canes (Fig. 5).
- d) Plant that tolerates high infection pressure from RBDV and from root rot caused by *Phytophthora rubi*, without succumbing to infection from either disease.

When compared with the parent 'Wakefield' in the United States, the new cultivar has larger, lighter colored fruit that ripens about one week earlier in the season. When compared with NR14, the new cultivar has larger and firmer fruit, and a plant with stronger vigor. Like both of its parents, 'NN08002' is presumed to be heterozygous at the gene loci for spines (Ss) (Lewis, 1939) and has more spines at the base of the plant and few in the middle cane sections.

The new cultivar was first asexually propagated in 2010, being reproduced by tissue culture. The resulting plants propagated true-to-type, demonstrating that the characteristics of the new cultivar are stable and are clonally transmitted without change through succeeding generations.

Amongst other trials, 'NN08002' was tested and evaluated as an advanced selection in 2012 and 2013 at Enfield Farms Inc., Lynden, WA. 'NN08002' was included in a randomized complete block design trial along with five other advanced selections (data not presented) and commercial cultivars; 'Meeker' (Moore and Daubeney, 1993), 'Wakefield' (Stephens et al., 2012), and 'Willamette' (Daubeney, 1989). For each, there were three replicates, each of six plants, and all were planted as ex-tissue culture plugs (spacing 0.7 m between plants, 3 m between rows) in May 2011. The trial was harvested in 2012 when plants were 1-year old (known as the "baby" crop) and 2-year old in 2013. Percent budbreak and flowering time during spring were recorded weekly for each plot. Each six-plant plot was machine harvested with an over-the-row XL 2007 harvester (Littau, Stayton, OR). All genotypes were harvested every 2–2.5 d between 5 July and 7 Aug. in 2012 and 1 July and 12 Aug. in 2013, and fruit weights per plot were recorded at each harvest date. For each plot, a smooth curve of cumulative yield vs. date was interpolated to derive the midharvest date (the date at which 50% of the final yield had been harvested) and harvest span (the number of

Fig. 4. 'NN08002' (marketed as Wake™Haven) red raspberry (*Rubus idaeus* L.) fruit.

days over which the middle 95% of the crop was picked).

Firmness measurements (the mean of 25 fruit per plot replicate $\times$ 3 harvest dates: early, mid, and late) were made using a FirmTech 2 firmness tester (Bioworks Inc., Wamego, KS) and mean berry weight of each sample of 25 fruit recorded. The FirmTech was set to measure the peak force during a 2-mm compression from the outside of each of the 25 fruit, which were placed collar down. Juice samples were extracted from 25 fruit per plot on each of the three harvest dates using a potato ricer to remove pulp and seeds, combined, and 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). Total ellagitannin determined by HPLC was quantified using purified Sanguin H6 as a standard. Vitamin C was measured as part of the polyphenol HPLC method. It had a retention time shorter than any of the polyphenols and was quantified relative to an authentic standard at 247 nm.

Soluble solids content was recorded on juice samples using a digital pocket refractometer (PAL-1; Atago, Tokyo, Japan), and for pH and 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 as combined years to examine cultivar $\times$ year interaction and as separate years using R 3.1.2 (R Core Development Team, 2015). Cultivar $\times$ year interaction was examined and where significant interaction existed data from both years are presented.

Performance and Description

In the field, 'NN08002' plants broke buds significantly earlier than all comparator cultivars and flowered around the same time as 'Meeker', earlier than 'Wakefield', and later than 'Willamette' (Table 1). 'NN08002' fruit ripened significantly earlier than 'Wakefield' in both years and around the same time as 'Meeker' in 2013. Length of harvest was similar to 'Wakefield' over both years although significantly longer than 'Willamette' and 'Meeker'. 'NN08002' had high fruit machine harvested yield and in both harvest seasons, and yielded significantly higher than 'Meeker' and 'Willamette'. In 2013, 'NN08002' yielded 4.8 kg/plant which was significantly higher than all other cultivars. Fruit of 'NN08002' were large in size (averaging 4.8 g) and significantly larger than the comparator cultivars (Table 1; Fig. 2). Fruit were slightly firmer than that of 'Wakefield' and significantly firmer than 'Meeker' and 'Willamette' (Table 1). 'NN08002' had lower soluble solid content than 'Wakefield' and 'Meeker' (Table 2). 'NN08002' had a fruit acidity significantly lower than that of 'Wakefield'

Fig. 5. 'NN08002' (marketed as Wake™Haven) red raspberry (*Rubus idaeus* L.) primocanes compared with 'Meeker' and 'Wakefield' showing the differences in spine production. 'NN08002' is semi-spineless.

Table 1. Comparison of mean time of budbreak, flowering, and fruit harvest measurements for the red raspberry (*Rubus idaeus* L.) replicated trial harvested in 2012 (1-year old plants) and 2013 (2-year old plants) in Lynden, WA. Data for traits with significant cultivar × year interaction ($P < 0.001$) are presented as separate years.

Cultivar	50% budbreak (date)	50% open flowers 2012 (date)	50% open flowers 2013 (date)	Mid harvest date 2012	Mid harvest date 2013	Harvest span (d) ²	Machine harvested yield 2012 (kg/plant)	Machine harvested yield 2013 (kg/plant)	Berry wt (g)	Fruit firmness (N)
NN08002	11 Mar.	13 June	4 June	14 July	16 July	33	1.8	4.8	4.8	0.44
Willamette	3 Apr.	31 May	30 May	13 July	13 July	28	0.6	2.1	3.4	0.24
Wakefield	11 Apr.	17 June	3 June	22 July	21 July	32	1.7	2.9	3.9	0.41
Meeker	10 Apr.	12 June	3 June	18 July	17 July	31	1.0	3.4	3.4	0.24
Mean	28 Mar.	12 June	3 June	18 July	18 July	31	1.3	3.8	3.8	0.33
SED ³	4.6	1.1	0.8	0.9	0.7	1.14	0.17	0.54	0.13	0.01
<i>P</i> ⁴	***	***	***	***	***	***	***	***	***	***

²Ninety-five percent of fruit harvested by machine.

³SE of difference between means.

⁴Significance *P* value *** $P < 0.001$.

Table 2. Mean fruit chemistry measurements for the red raspberry (*Rubus idaeus* L.) replicated trial harvested in 2012 (1-year old plants) and 2013 (2-year old plants) in Lynden, WA.

Cultivar	Soluble solids (%)	Acidity (%)	pH	Total anthocyanins (mg/100 g)	Total ellagitannins (mg/100 g)	Total phenolics (mg/100 mL)	Total vitamin C (mg/100 mL)
NN08002	9.9	1.9	3.1	59.8	51.7	2.7	29.2
Willamette	9.3	2.1	3.2	95.1	36.1	6.6	26.2
Wakefield	11.2	2.3	3.1	94.5	67.1	2.2	21.8
Meeker	11.2	1.5	3.3	57.6	36.6	5.9	18.4
Mean	10.5	2.0	3.1	84.6	57.7	3.9	23.7
SED ²	0.28	0.05	0.02	4.61	5.47	0.35	1.01
<i>P</i> ³	***	***	***	***	***	***	***

²SE of difference between means.

³Significance *P* value *** $P < 0.001$.

but significantly higher than that of ‘Meeker’ (Table 2). Fruit total anthocyanins for ‘NN08002’ were significantly lower than that of ‘Wakefield’ and ‘Willamette’ and not significantly different from than that of ‘Meeker’. ‘NN08002’ fruit had ellagitannin levels lower than that of ‘Wakefield’ but higher than that of ‘Meeker’ and ‘Willamette’, and the opposite applied for phenolic acid with ‘NN08002’ having lower levels than ‘Meeker’ and ‘Willamette’ but higher levels than ‘Wakefield’ (Table 2). Vitamin C levels in ‘NN08002’ fruit were significantly higher than all cultivars measured (Table 2). ‘NN08002’ had the same fruit juice pH as ‘Wakefield’ and significantly lower than ‘Meeker’ (Table 2).

‘NN08002’ plants are semispineless (Fig. 5), and canes are not pubescent, indicating the lack of gene H (Jennings and Brydon, 1989).

Currently, ‘NN08002’ is propagated by tissue culture and root cuttings methods. 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.

‘NN08002’ is being marketed under the Wake™ family brand as Wake™Haven.

Pest and Disease Reaction

Since the selection of this clone in 2008, numerous tests for RBDV have been carried

out on ‘NN08002’ in the United States using enzyme-linked immunosorbent assay (courtesy of the Horticultural Crops Research Unit USDA-ARS, Corvallis, OR). Despite high field pressure, RBDV has never been detected in trial plots of ‘NN08002’. The parents of ‘NN08002’ have also shown tolerance to RBDV, and from this, we suggest that ‘NN08002’ is likely to be resistant to RBDV found in the United States. ‘NN08002’ has been observed growing well in fields infected with root rot caused by *Phytophthora rubi*, and we suggest that it has some degree of tolerance to root rot. Resistance to aphids is unknown.

Adaptability and Uses

‘NN08002’ is a florican-fruited cultivar that is easily harvested by machine and harvested fruit processed well, particularly as IQF fruit. Observations indicate that this cultivar is well suited to regions that offer a medium-high amount of winter chill; for example, observations to date suggest ‘NN08002’ performs well in areas that confer chilling typically found in USDA Plant Hardiness zones 8–10 (USDA Plant Hardiness Zone Map, 2012).

Availability

‘NN08002’ has a U.S. Plant Patent Pending and is marketed in the United States as

Wake™Haven. For more information about ‘NN08002’, please contact NWP or PFR.

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