'Carolina Wonder' and 'Charleston Belle': Southern Root-knot Nematode-Resistant Bell Peppers

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'Carolina Wonder' and 'Charleston Belle' are bell peppers (*Capsicum annuum* L.) that were approved for release on 28 Apr. 1997 by the Agricultural Research Service of the U.S. Dept. of Agriculture. The major attributes of 'Carolina Wonder' and 'Charleston Belle' are their high levels of resistance to the southern root-knot nematode [*Meloidogyne incognita* (Kofoid and White) Chitwood]. The southern root-knot nematode is a major pest of bell pepper, and is principally controlled at present by soil fumigation with methyl bromide. Controlling this nematode is one of the major reasons pepper production accounts for almost 12% of the preplant methyl bromide use in the United States (Crop Protection Coalition, 1995). Earlier studies at the U.S. Vegetable Laboratory suggest that none of the bell pepper cultivars currently available to U.S. growers have adequate resistance to southern root-knot nematodes (R.L. Fery and P.D. Dukes, Sr., unpublished data). In light of the potential future restrictions on the use of methyl bromide for soil fumigation, the development of resistant cultivars is critical for the continued production of bell peppers in areas where soils are infested with *M. incognita*.

Origin

'Carolina Wonder' and 'Charleston Belle' were developed at the U.S. Vegetable Laboratory, Charleston, S.C. They are the products of conventional recurrent backcrossing procedures (Fig. 1) to transfer the dominant *N* gene for root-knot nematode resistance from 'Mississippi Nemaheart' into 'Yolo Wonder B'.

and 'Keystone Resistant Giant' (Fery and Dukes, 1996; Hare, 1957, 1966). 'Carolina Wonder' and 'Charleston Belle' originated from bulked F₃ populations that were derived after completion of the sixth backcrosses.

Description

'Carolina Wonder' and 'Charleston Belle' are similar in appearance and maturity to 'Yolo

Wonder B' and 'Keystone Resistant Giant', respectively (Fig. 2). The two new cultivars have many characteristics in common. The plants have compact growth habits, and the period from transplanting to first harvest ranges from 63 to 70 d. The corolla color is white, and the stamens have white filaments and blue anthers. At full anthesis, the stigmas are positioned level with the anthers. The leaves are large and elliptic. The stems and leaves are glabrous. No visible anthocyanin is present in the leaves, stems, nodes, calyx, pedicel, or fruits. The fruits are attached to the pedicel in a pendant manner, and the pedicels are short, curved, and thick. The fruits are not deciduous, i.e., the calyx usually remains on the fruit at harvest.

The results of two sets of replicated field experiments conducted at Charleston, S.C., in 1996 indicated that the plant habit, fruit, and yield characteristics of 'Carolina Wonder' and 'Charleston Belle' are virtually identical to those of their respective recurrent parents 'Yolo Wonder B' and 'Keystone Resistant Giant' (Tables 1-3). Premium grade fruits (U.S. Fancy and U.S. No. 1) are large (mass per fruit ranged from 116 to 135 g for 'Carolina Wonder' and

Fig. 1. Pedigrees of (top) 'Carolina Wonder' and (bottom) 'Charleston Belle' peppers.

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Fig. 2. Single (left) 'Carolina Wonder' and (right) 'Charleston Belle' plants. Note the compact plant habits and the blocky, bell-shaped fruits.

Table 1. Plant height, plant width, and yield and mass per fruit of U.S. No. 1 and total marketable fruit for 'Carolina Wonder' vs. 'Yolo Wonder B' and 'Charleston Belle' vs. 'Keystone Resistant Giant' plots grown at Charleston, S.C. (Field Experiments IA and IB).^z

Cultivar	Plant height (cm)	Plant width (cm)	U.S. No. 1 fruit ^y		Total marketable fruit ^x	
			Yield (g/plant)	Mass/fruit (g)	Yield (g/plant)	Mass/fruit (g)
Field Experiment IA						
Carolina Wonder	43.0	61.6	831	134.6	980	124.6
Yolo Wonder B	41.2	56.0	731	138.0	809	128.5
F ratio	4.62 ^{ns}	2.68 ^{ns}	0.89 ^{ns}	2.26 ^{ns}	2.52 ^{ns}	2.56 ^{ns}
Field Experiment IB						
Charleston Belle	45.1	65.9	404	118.7	596	98.3
Keystone Resistant Giant	41.8	63.8	486	114.7	645	98.4
F ratio	2.25 ^{ns}	1.32 ^{ns}	0.71 ^{ns}	0.33 ^{ns}	0.22 ^{ns}	0.28 ^{ns}

^zData from randomized complete-block experiments with six replications (single-row plots; 10 plants per plot; intrarow spacing: 76 cm; interrow spacing: 102 cm). Yields are a total of five harvests.

^yIncludes U.S. Fancy grade (U.S. Dept. of Agriculture, 1989).

^xIncludes U.S. Fancy, U.S. No. 1, and U.S. No. 2 grades (U.S. Dept. of Agriculture, 1989).

^{ns}Nonsignificant at $P \leq 0.05$.

averaged ≈ 120 g for 'Charleston Belle'), blocky, and bell shaped ('Carolina Wonder': 7.7 cm wide $\times$ 8.4 cm long; 'Charleston Belle': 8.2 cm wide $\times$ 7.8 cm long). The shape at the peduncle attachment end of the fruits is cordate, and that at the blossom ends is sunken. The fruit walls are thick ('Carolina Wonder': 5.1 mm; 'Charleston Belle': 5.6 mm). Harvest-stage, mature-green fruits are dark green; the fruits mature to become bright red. The fruits are sweet and have three or four locules ('Carolina Wonder' = 3.65 locules; 'Charleston Belle' = 3.60 locules). Total marketable yield (U.S. Fancy, U.S. No. 1, and U.S. No. 2 grades) ranged from 980 to 1030 g per plant for 'Carolina Wonder' and from 596 to 1076 g per plant for 'Charleston Belle'.

'Carolina Wonder' and 'Charleston Belle' are homozygous for the *N* gene that conditions resistance to the southern root-knot nematode. The new cultivars have exhibited high levels of resistance in all greenhouse and field tests; the numbers of galls and egg masses on the

roots have always been minimal. The results of 1996 tests (Table 4) conducted in greenhouse soil benches infested with *M. incognita* race 3 showed that 'Carolina Wonder' and 'Charleston Belle' yielded 95% and 93%, respectively, fewer *M. incognita* eggs per gram of root than did their recurrent parents 'Yolo Wonder B' and 'Keystone Resistant Giant'. The resistance exhibited by 'Carolina Wonder' is equal to that exhibited by the resistant cultivar Carolina Cayenne (Fery et al., 1986; Thies et al., 1997). The resistance exhibited by 'Charleston Belle' is equal to that exhibited by the donor of the *N* gene, 'Mississippi Nemaheart'.

'Carolina Wonder' and 'Charleston Belle' are recommended for use by both home gardeners and commercial growers. They will be particularly useful for home gardeners, who do not have easy access to alternative production sites or the needed nematicides. Because the gene conditioning the root-knot nematode resistance trait is dominant, 'Carolina Won-

der' and 'Charleston Belle' are potentially valuable parental lines for developing root-knot nematode resistant hybrid bell cultivars. 'Carolina Wonder' and 'Charleston Belle' should perform well in all areas where their recurrent parents, 'Yolo Wonder B' or 'Keystone Resistant Giant,' have been grown successfully.

Availability

Breeder's seed of 'Carolina Wonder' and 'Charleston Belle' has been released to seed producers. Small samples of breeder's seed of each cultivar are available from R.L.F. for distribution to all interested research personnel. Genetic materials of these releases will be deposited in the National Plant Germplasm System where they will be available for research purposes, including the development and commercialization of new cultivars.

Table 2. Yield and mass per fruit of U.S. No. 1 and total marketable fruit for 'Carolina Wonder' vs. 'Yolo Wonder B' and 'Charleston Belle' vs. 'Keystone Resistant Giant' plots grown at Charleston, S.C. (Field Experiments IIA and IIB).^z

Cultivar	U.S. No. 1 fruit ^y		Total marketable fruit ^x	
	Yield (g/plant)	Mass/fruit (g)	Yield (g/plant)	Mass/fruit (g)
<i>Field Experiment IIA</i>				
Carolina Wonder	556	116.0	1030	89.4
Yolo Wonder B	526	116.3	973	85.1
F ratio	0.18 ^{ns}	0.05 ^{ns}	0.18 ^{ns}	1.65 ^{ns}
<i>Field Experiment IIB</i>				
Charleston Belle	550	119.1	1076	89.5
Keystone Resistant Giant	571	119.1	1015	87.6
F ratio	0.10 ^{ns}	0.00 ^{ns}	0.35 ^{ns}	0.25 ^{ns}

^zData from randomized complete-block experiments with 10 replications (single-row plots; five plants/plot; intrarow spacing: 30 cm; interrow spacing: 102 cm). Yields are a total of six harvests.

^yIncludes U.S. Fancy grade (U.S. Dept. of Agriculture, 1989).

^xIncludes U.S. Fancy, U.S. No. 1, and U.S. No. 2 grades (U.S. Dept. of Agriculture, 1989).

^{ns}Nonsignificant at $P \leq 0.05$.

Table 3. Comparison of fruit characteristics of the southern root-knot resistant 'Carolina Wonder' and 'Charleston Belle' and their respective susceptible recurrent parents 'Yolo Wonder B' and 'Keystone Resistant Giant' (Field Experiments IA and IB).

Cultivar	Fruit characteristic ^z			
	Width (cm)	Length (cm)	Wall thickness (mm)	Locules (no.)
<i>Field Experiment IA</i>				
Carolina Wonder	7.7 ± 0.1 ^y	8.4 ± 0.2	5.12 ± 0.09	3.65 ± 0.11
Yolo Wonder B	8.0 ± 0.1	8.7 ± 0.3	5.00 ± 0.13	3.45 ± 0.15
<i>Field Experiment IB</i>				
Charleston Belle	8.2 ± 0.1	7.8 ± 0.2	5.66 ± 0.10	3.60 ± 0.13
Keystone Resistant Giant	8.0 ± 0.1	7.9 ± 0.3	5.24 ± 0.09	3.45 ± 0.14

^zMeans of the 20 largest fruits from the bulked second and third harvests of randomized complete-block experiments.

^y±SE.

Table 4. Average root-gall index, average egg-mass index, and average number of eggs per gram fresh root tissue for 'Carolina Wonder' vs. 'Yolo Wonder B' and 'Charleston Belle' vs. 'Keystone Resistant Giant' plants grown in soil inoculated with the southern root-knot nematode, *Meloidogyne incognita* race 3 (Greenhouse Experiments IA and IB).^z

Cultivar	Gall index ^y	Egg mass index ^x	No. eggs/g fresh root tissue
<i>Greenhouse Experiment IA</i>			
Carolina Wonder	1.08	1.20	946
Yolo Wonder B	3.98	3.60	17,743
Carolina Cayenne ^w	1.05	1.15	534
LSD _{0.05}	0.21	0.37	3,906
<i>Greenhouse Experiment IB</i>			
Charleston Belle	1.25	1.30	1,652
Keystone Resistant Giant	3.95	3.95	25,119
Mississippi Nemaheart ^w	1.15	1.12	1,194
California Wonder ^v	3.90	3.58	22,960
LSD _{0.05}	0.33	0.75	8,509

^zRandomized complete-block experiments with four replications (five plants per plot; seeds planted on 13 Mar. 1996; seedlings transplanted into a steam-pasteurized mixture of soil, sand, and peat on 30 Apr. 1996; each seedling inoculated with 3200 *M. incognita* race 3 eggs on 8 May 1996; roots of all plants evaluated for galling and egg masses on 20 Aug. 1996). The NaOCl procedure described by Hussey and Barker (1973) was used to extract *M. incognita* eggs from a fibrous root sample taken from each plot.

^yRated on a scale of 1 to 5; 1 = no galls and 5 = galls covering ≥80% of root system.

^xRated on a scale of 1 to 5; 1 = no egg masses and 5 = egg masses covering ≥80% of root system.

^wResistant control.

^vSusceptible control.

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