Earliness increased with N rate. As N rate increased from 1.9 to 3.7 g per pot, the days to heading and harvest decreased with negligible change at 5.6 g per pot. In previous field studies, maturity was delayed with increasing N rate (2, 3). Similarly, plant vigor and size increased with N rate. Leaf number and area, stem diameter, plant height, top dry weight, and head fresh weights increased as N increased to 3.7 g per pot, but little or no additional increases in growth occurred with the 5.6 g per pot N rate. In contrast, floret chlorophyll, leaf and root dry weights increased linearly with increasing N rate.

Phosphorus accounted for lesser, but significant amounts of variation in chlorophyll concentration of florets (26%), root dry weight (23%), and plant height (15%) (Table 2). As P rate increased to 0.14 g per pot, floret chlorophyll and plant height increased, but increasing the P rate to 0.21 g per pot did not induce any additional increases. In contrast, root dry weights were highest with 0.21 g P per pot. Phosphorus did not significantly interact with N to affect any growth variables measured. Phosphorus did not significantly affect any head quality characteristics monitored in this study.

Influence of N on quality. The overall quality of heads increased with N rate (Table 2). As N rate increased from 1.9 to 5.6 g per pot, broccoli head solidity increased linearly, while the incidence of cracked heads decreased linearly with increasing N rate. Bolting was reduced significantly from 63% to 3% as N rate increased from 1.9 to 3.7 g per pot. At the 1.9 g N rate, head color was predominantly lime, but as N rate increased, head color intensified from a lime/olive to an olive/emerald. At the 5.6 g N rate, 46% of the heads were emerald color but 49% were olive. Higher N rates than those used in this study may intensify and increase the incidence of emerald color. Arjona (1) reported leaf chlorophyll of field-grown broccoli to increase with N rate. The incidence of brown bead was most severe at the lowest N rate affecting 72% of the heads, but as N rate increased to 5.6 g per pot, major brown bean was reduced to 6%, with 21% of the heads showing minor senescent florets. At N rates of 1.9 g to 3.7 g, the shape of the heads was mostly flat, concave, or hilly. However, at the 5.6 g per pot rate, the majority of the heads were dome- or flat-shaped. Hollow stem was common at all N rates in our study, but as N rate increased, the incidence of hollow stem decreased by 51%. In contrast, hollow stem in the field has been reported to increase with N rate (4, 7). Nitrogen did not interact with P to affect any head quality factors measured.

Production of quality broccoli in the greenhouse in this study required 5.6 g N per pot. Although the effect of P on quality and growth was small, 0.21 g P per pot should be used with high N since root dry weights were enhanced with high P. In this study, vigor and quality of greenhouse-grown broccoli at high N was equivalent to quality of field-grown broccoli. Further research studies attempting to determine the effects of stress on broccoli growth and development may use this fertility regime and methodology to produce control plants of acceptable quality in similar greenhouse environments.

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Variability in Flower Bud Number Among Peach and Nectarine Cultivars

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Abstract. **Thirty-six peach and nectarine [*Prunus persica* (L.) Batsch] cultivars were evaluated for flower bud number (flower buds/node) over 2 years. Cultivar, year, and year × cultivar effects were highly significant. Cultivars released from California breeding programs generally had fewer flower buds than those from eastern U.S. programs, suggesting that selection for cropping consistency in eastern breeding programs has resulted in release of cultivars with many flower buds. Variance component estimates from this study and from 2 years of sampling trees of 'Redhaven' indicates that sampling over years and increasing the number of shoots sampled per tree is warranted. Variability among trees within cultivar was low.**

Yield among peach cultivars varies considerably. Yield is a complex trait controlled by the interaction of numerous genetic and environmental factors. In woody fruit crops, an important yield component is the number of flower buds produced the season before flowering. In peach, cultivars with many flower buds are desirable in production areas where winter or spring freezes can be expected to kill some flower buds, because it increases the probability that sufficient live buds will remain to produce a commercial crop. However, since only a low percentage of peach flower buds are needed for a full crop, cultivars with fewer flower buds may be desirable in areas with little risk of flower-bud freeze injury, since this may reduce the cost of fruit thinning. Blake (1) rated numerous older peach cultivars and peach plant introductions for flower bud number. Byrne (3) demonstrated that high flower-bud number was a primary factor associated with superior fruit set in 'Texstar' peach. The purpose of this investigation was to characterize peach and nectarine cultivars for flower-bud number (flower buds/node) during two years. Variance component estimates were calculated to provide information relative to improving sampling efficiency for this trait. This information will be useful to breeders interested in selecting for this trait in a breeding program.

Sixteen nectarine and 20 peach cultivars (Table 1) propagated on 'Lovell' seedling rootstock were studied. Trees were planted in Jan. 1982 in a completely randomized design with three replications at the Sandhills

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Table 1. Analysis of variance and variance component estimates for experiment examining cultivar variation in peach and nectarine for flower-bud number (flower buds/node).[z]

Source of Variation	df	Significance tests: F Value	Significance tests: Prob.	Variance component estimate
Year	1	229.7	<0.01	0.026
Cultivar	35	25.1	<0.01	0.056
Tree (Cultivar)	72	0.3	NS	0.001
Year × Cultivar	35	4.1	<0.01	0.011
Shoot (Tree Year)	1294			0.033

[z]Study included 36 cultivars, three replications of each cultivar, and 2 years of observation. Variance component estimates were obtained using the 'PROC VARCOMP' procedure of SAS (7).

Table 2. Flower-bud number (flower buds/node) of 36 peach and nectarine cultivars in 1986 and 1987.[z]

1986 Cultivar	1986 Buds/node	1987 Cultivar	1987 Buds/node
Harko*	1.59[z]	Harko*	1.23
Encore	1.39	Nectared 4*	1.14
Nectared 4*	1.26	Carolina Red*	1.06
Carolina Red*	1.24	Nectared 7*	1.05
Hardired*	1.23	Hardired*	1.03
Jim Wilson	1.23	Encore	1.00
Ouachita Gold	1.21	Sunglo*[c]	0.94
Nectared 7*	1.20	Jim Wilson	0.89
Ruston Red	1.20	Sunland	0.84
Starlite	1.16	Early Loring	0.79
Calred[c]	1.13	Ruston Red	0.78
Sunglo*[c]	1.12	Redhaven	0.76
Redhaven	1.07	Durbin*	0.74
Newhaven	1.05	Starlite	0.70
Redskin	1.04	Sunprince	0.70
Sunland	1.03	Ouachita Gold	0.70
Sunprince	1.03	Redskin	0.68
Sweet Sue	1.02	Jim Dandee	0.66
Sweethaven	0.93	Firebrite*[c]	0.64
Havis	0.91	Crimson Gold*[c]	0.64
Jim Dandee	0.87	Flavortop*[c]	0.62
Jayhaven	0.86	Calred[c]	0.62
Summer Beaut*[c]	0.86	Newhaven	0.61
Fantasia*[c]	0.82	Summer Beaut*[c]	0.58
Early Loring	0.81	Sweet Sue	0.57
Durbin*	0.76	Jayhaven	0.55
Crimson Gold*[c]	0.72	Cullinan	0.54
Firebrite*[c]	0.65	Sweethaven	0.51
Flavortop*[c]	0.63	Fantasia*[c]	0.48
Redgold*[c]	0.56	Redgold*[c]	0.46
Cullinan	0.53	Independence*[c]	0.45
Independence*[c]	0.53	Earlibird*[c]	0.44
Late Gold*[c]	0.53	Havis	0.42
Earlibird*[c]	0.46	Topaz	0.40
Topaz	0.44	Sentry	0.38
Sentry	0.43	Late Gold*[c]	0.35
$LSD_{(0.05)}$ =	0.12	$LSD_{(0.05)}$ =	0.09

[z]Each value represents the mean of 3 single-tree replications calculated from 7 shoots/tree.
* = nectarine; [c] = cultivar released from California breeding program.

Research Station, Jackson Springs, N.C. For each cultivar, one tree was sampled from each replication in Feb. 1986 and 1987, with the same trees sampled both years. Seven shoots of previous season's growth were removed at random from the periphery of each tree. The number of nodes and flower buds on each shoot were counted. Flower bud number was expressed as the number of flower buds present per node. Analysis of variance was conducted using shoots, years, and trees as random effects, and cultivars as a fixed effect. Variance components were estimated using the "PROC VARCOMP' procedure of SAS (7). Additional information on variance component estimates and insight into sampling procedures for this trait were obtained by sampling 10 trees of 'Redhaven' peach on 'Lovell' seedling rootstock in both years as described, except 25 shoots per tree were sampled. Variance component estimation was conducted as described.

Cultivar Study. Year, cultivar, and year × cultivar effects were highly significant ($P < 0.01$) (Table 1). Variation between trees within cultivar [tree(cultivar)] was nonsignificant. Since the year × cultivar effect was significant, cultivar performance is shown separately for each year (Table 2). In 1986, values of flower buds/node ranged from a low of 0.43 for 'Sentry' peach to a high of 1.59 for 'Harko' nectarine. The mean value over all cultivars was 0.92 flower buds/node. In 1987, the mean value for flower buds/node was 0.70, with a low and high of 0.35 and 1.23 for 'Late Gold' and 'Harko' nectarines, respectively. Comparison of cultivar rankings between years using Spearman's Rank Correlation Test (8) yielded a rank correlation coefficient of $r = 0.82$ ($P < 0.001$), which confirms that cultivar ranks were in substantial agreement in the 2 years of observation. The highly significant year × cultivar interaction (Table 1) is in part due to a change in the magnitude of cultivar differences from one year to the next, not just to changes in rank. The significant difference between the overall flower-bud number means in the 2 years may be due to environmental differences between the summers of 1985 and 1986. Growing conditions in 1985 were normal. However, trees were under moderate to severe moisture stress during the dry summer of 1986, which may have reduced flower-bud initiation and subsequent flower-bud numbers in the 1987 counts.

A preponderance of cultivars of California origin have a low flower-bud number (Table 2). Cultivars of California origin comprised seven out of the 10 lowest ranked cultivars in 1986, and zero out of the 10 highest ranked. In 1987, the lowest ranked cultivars were equally represented between California and eastern U.S. germplasm, but only one cultivar of California origin was represented in the top 10 cultivars. This suggests that selection for cropping consistency under the harsher environment of the eastern United States and Canada may have been associated with an increase in flower-bud number in breeding populations. Likewise, under mild California conditions, with little or no risk of flower-bud freeze injury, intense selection for fruit size may have been associated with a reduction in flower-bud number, since reduced initial fruit numbers would be favorable to increased fruit size.

It is noteworthy that two of the cultivars with nearly the lowest number of flower in both years, 'Topaz' and 'Sentry', have 'Loring' as a parent (4). Field observations have shown that 'Loring' produces a low number of flower buds. Likewise, the high ranking nectarine cultivars 'Harko', 'Carolina Red', 'Hardired', 'Nectared 4', and 'Nectared 7' share similar pedigrees (2, 5, 6, 9). These observations suggest that genetic variance plays a major role in trait expression, and that selection for this trait should be effective.

Examination of the variance component

Table 3. Variance component estimates for experiment examining variation in flower bud number in 'Redhaven' peach.[z]

Source of variation	df	Variance component estimate
Year	1	0.109
Tree	9	0.000
Year × Tree	9	0.003
Shoot(Tree)	479	0.028

[z]Sampling was conducted using 25 shoots on each of ten trees in 2 years. Estimates were obtained using the 'PROC VARCOMP' procedure of SAS (7).

estimates (Table 1) reveals that the shoots within tree component of variation is of much greater magnitude than the tree within cultivar component. This suggests that when examining cultivar effects, increasing the number of shoots sampled per tree would be more beneficial than increasing the number of trees sampled. The relative magnitude of the variance estimate for the year component suggests that sampling in more than one season would be necessary to adequately characterize cultivars or germplasm for flower-bud number.

'Redhaven' Sampling Study. The year–variance component estimate was greatest, followed by the shoot within tree source of variation (Table 3). Variation between individual trees was negligible. These results are in agreement with the cultivar study.

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Various Interstem Effects in Combination with 'Marubakaido N-1' Rootstock on 'Fuji' Apple Growth

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Abstract. **The influence of CG.10, CG.47, CG.80, and M.27 as interstems on 'Marubakaido N-1' (*Malus prunifolia,* var. *Ringo*) rootstock on growth and yield of 'Fuji' apples was evaluated. Trees on M.9 were included as a standard. The order of influence of interstocks from small to large trees was as follows: M.27, CG.80, CG.10, and CG.47. Trees on CG.10/'Marubakaido N-1' and CG.80/'Marubakaido N-1' were similar in size to those of M.9. Trees on M.9 and CG.10/ 'Marubakaido N-1' produced larger fruit than those on other interstems. Trees on CG.10/'Marubakaido N-1' and M.9 were most efficient, followed by M.27/'Marubakaido N-1', CG.80/'Marubakaido N-1', and CG.47/'Marubakaido N-1'.**

Many researchers have demonstrated the effects of M.8, M.9, M.26, M.27, and M.7 interstems on tree growth and productivity (1, 2, 5–9, 11). Understocks used in these interstem trials were MM.104 (9), MM.106 (6, 7), MM.111 (5–7, 11), M.2 (4), Alnarp 2 (2), Ottawa 11 (12), and domestic seedling (1, 12). In Japan, 'Marubakaido' (*Malus prunifolia,* var. *Ringo*) has been used as a rootstock for apple trees. Recently, 'Marubakaido N-1', one of the weeping-form clones of 'Marubakaido', selected and named at the Nagano Fruit Tree Experiment Station, has been propagated vegetatively for use as an understock in conjunction with M.26 or chlorotic-leaf-spot-virus (CLSV)-free M.9 interstocks.

The CG rootstocks originated as open-pollinated seedling of M.8 by Brase at the New York State Agricultural Experiment Station in 1953 (3). These rootstocks have not been introduced in the United States because most have proved very susceptible to fire blight (*Erwinia amylovora*) (4). However, since fire blight has not been recorded in Japan, we considered it appropriate to evaluate orchard performance of these stocks.

This paper examines the effects of CG.10, CG.47, CG.80, and M.27 interstems in combination with 'Marubakaido N-1' understock on the orchard performance of 'Fuji' apple trees during 9 years at the Nagano Fruit Tree Experiment Station.

One-year-old 'Fuji' apple trees with 300-mm-long interstems of CG.10, CG.47, CG.80, and M.27 over 200-mm-long shanks of 'Marubakaido N-1' were planted in Mar. 1978 at a spacing of 1.5 × 4 m. For comparison, trees grafted directly on the CLSV-free M.9 were included. Trees were planted with the soil line 50 mm below the stempiece/rootstock union. Orchard care was similar to commercial practices for apple culture in the area, with 10 to 12 pesticide sprays per year and a fall application of 150 $kg \cdot ha^{-1}$ of N. The soil was well-drained sandy loam ≈500 mm deep. All trees were trained to the slender spindle training system. A randomized block design was used with five-tree plots replicated three times. Means were separated by Duncan's multiple-range test following analysis of variance.

Trunk girth 15 cm above the scion/stempiece union, tree height and tree spread were measured annually. Annual yield and average fruit weight were recorded. Trunk cross-sectional area, a useful estimate of tree size (12), was calculated the 9th year after plant-

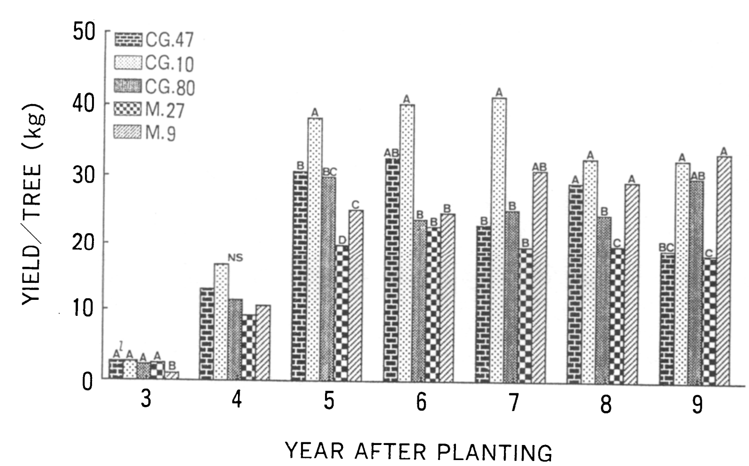

Fig. 1. Annual yield per tree of 'Fuji' apple trees on M.9 rootstock and CG.10, CG.47, CG.80, and M.27 interstems.

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