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Effect of fruiting cane origin on fruitfulness of hardy kiwifruit, *Actinidia arguta*

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Abstract Morphology of *Actinidia arguta* 'Ananasnaya' vines was studied at two sites in Oregon, United States in 1998 and at one site in 1999. One-year-old fruiting wood was divided into five types/origins: spurs borne from the cordon; 1-year-old canes from the cordon; 1-year-old canes which grew as a result of summer pruning of last year's growth (1-year-old tipped); 1-year-old canes borne from 2-year-old wood; and 1-year-old canes borne from 3-year-old wood. Wood type had no effect on percent fruitful shoots or the number of fruit or clusters per metre of cane. One-year-old canes produced fruitful shoots along their entire length, but were less productive at the distal part of the cane. The most productive part of the cane was generally from nodes 6–40, depending on site, due, in general, to a higher percentage of budbreak and fruitful shoots. In 1999, budbreak was 47% and 85% of these continued to grow past 0.15 m long, and 83% of these were fruitful. The most productive flowering zone on shoots was from nodes 6–12. Results show that this species of kiwifruit is very fruitful on 1-year-old canes regardless of cane origin or length.

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Keywords pruning; wood age; budbreak; productivity; shoots; flower bud development; flower bud initiation

INTRODUCTION

The hardy kiwifruit (*Actinidia arguta* (Sieb. et Zucc.) Miq. 'Ananasnaya') is grown commercially in the United States, New Zealand, Canada, and Chile. Commercial production of this crop is relatively new and production practices for hardy kiwifruit have been adapted from those of *A. deliciosa* (A. Chev.) C.F. Liang et A.R. Ferguson 'Hayward' with little modification (Strik & Cahn 1998).

In all *Actinidia* species, only 1-year-old canes produce fruitful shoots. Volz et al. (1991) suggested that flower number in *A. deliciosa* is likely to be lower in fruiting wood borne from older wood.

Snowball (1997a,c), in New Zealand, recorded 45–50% budbreak in *A. arguta*, with only 12–13% fruitful shoots, whereas *A. deliciosa* had 46% budbreak with 90% fruitful shoots. The percentage of flowering shoots in *A. deliciosa* was highest from nodes 6 to c. 30, although fruiting canes could still be productive to node 40 (Snowball 1996, 1997b). On the shoot, flowers of *A. arguta* were borne from nodes 1–26 with node 14 being the most productive (Snowball 1997a).

The objectives of this study were to determine whether there is a difference in fruitfulness between canes of differing type or origin and to determine the distribution of fruiting shoots on canes, and the fruiting zone on shoots in *A. arguta* 'Ananasnaya'.

MATERIALS AND METHODS

In 1998, this study was carried out at two commercial hardy kiwifruit (*A. arguta* 'Ananasnaya') vineyards in Oregon—Sheridan and Stayton. At Sheridan, vines were planted in 1995 at a 4.6 × 4.6 m spacing on raised beds and trained to a 2 m high pergola. At Stayton, vines were planted in 1989 at a 4.6 × 4.6 m spacing and trained to a 2-m-high T-bar trellis. Experimental vines were pruned and otherwise maintained as standard for commercial production (Strik & Cahn 1998).

Ten vines at each site were randomly selected from a larger population of uniformly sized vines. The fruiting wood was divided into five types/origins: spurs borne from the cordon; 1-year-old canes from the cordon; 1-year-old canes which grew as a result of summer pruning of last year's growth (1-year-old tipped); 1-year-old canes borne from 2-year-old wood; and 1-year-old canes borne from 3-year-old wood. At Sheridan, only the first four wood types were available for study.

Three typical canes or spurs were subsampled for each wood type/origin per vine and measured for: length; diameter at the midpoint of the cane; number of nodes; number of shoots; and number of fruit clusters and fruit on each shoot. Percent budbreak, mean number of fruit per cluster, and fruit and cluster number per m of cane length were calculated.

In 1999, seven vines at only Sheridan were studied. In spring, the number of nodes and shoots of all 1-year-old canes on each vine were counted and percent budbreak calculated. Six typical 1-year-old canes and four spurs from each vine were subsampled and the node position of each fruitful shoot recorded. Percent fruitful shoots was calculated. Fifty flowering shoots (40 from 1-year-old canes and 10 from spurs) were randomly subsampled per vine with flower position and flower number at each leaf axil recorded.

Means of vegetative and fruiting components of wood origin and site were compared by analysis of variance (PROC GLM) with treatment means compared using a protected LSD (SAS System, Version 6.12, SAS Institute Inc., Cary, NC, United States). To facilitate data presentation in figures, means were calculated for each group of five nodes along fruiting canes ($n = 10$ vines in 1998; $n = 7$ vines in 1999).

Table 1 Effect of wood type/origin on vegetative and fruiting components of hardy kiwifruit (*Actinidia arguta*) at two sites in 1998. Means followed by the same letter within site are not significantly different by LSD ($P > 0.05$).

Wood type/ origin	Cane length (cm)	Cane diam. (mm)	Internode length (mm)	Bud-break (%)	Fruitful shoot (%)	Fruit/ cane	Clusters/ cane	Fruit/ cluster	Fruit/ m*	Clusters/ m*
Sheridan										
Spurs from cordon	11.6 b	4.4 b	12 c	34.5 c	49.4	9.2 b	5.5 b	1.6	81	51
1-year-old canes from cordon	89.7 a	7.9 a	25 b	45.1 b	62.1	90.5 a	46.1 a	2.0	112	56
1-year-old tipped	83.6 a	7.8 a	32 a	57.4 a	60.9	68.6 a	38.7 a	1.8	89	49
One from 2-year-old wood	72.5 a	6.1 ab	28 ab	52.8 a	56.6	68.9 a	35.9 a	2.0	97	51
LSD	21.4	2.4	4	6.7	12.5	27.3	14.9	0.3	47	25
Stayton										
Spurs from cordon	8.7 c	3.4 c	11 b	24.3	63.8	7.3 b	4.5 b	1.4	85	46
1-year-old canes from cordon	180.6 a	8.6 a	32 a	25.9	56.7	68.7 a	38.8 a	1.8	39	23
1-year-old tipped	151.4 ab	7.2 b	37 a	33.5	60.2	100.6 a	46.5 a	2.0	70	32
One from 2-year-old wood	118.6 b	5.9 b	31 a	30.3	60.3	58.4 ab	32.7 a	1.7	49	27
One from 3-year-old wood	154.0 ab	6.3 b	33 a	30.1	57.6	70.0 a	42.2 a	1.6	44	26
LSD	59.9	1.4	7	10.3	23.8	55.6	24.9	0.6	45	21

*Per m of fruiting cane length.

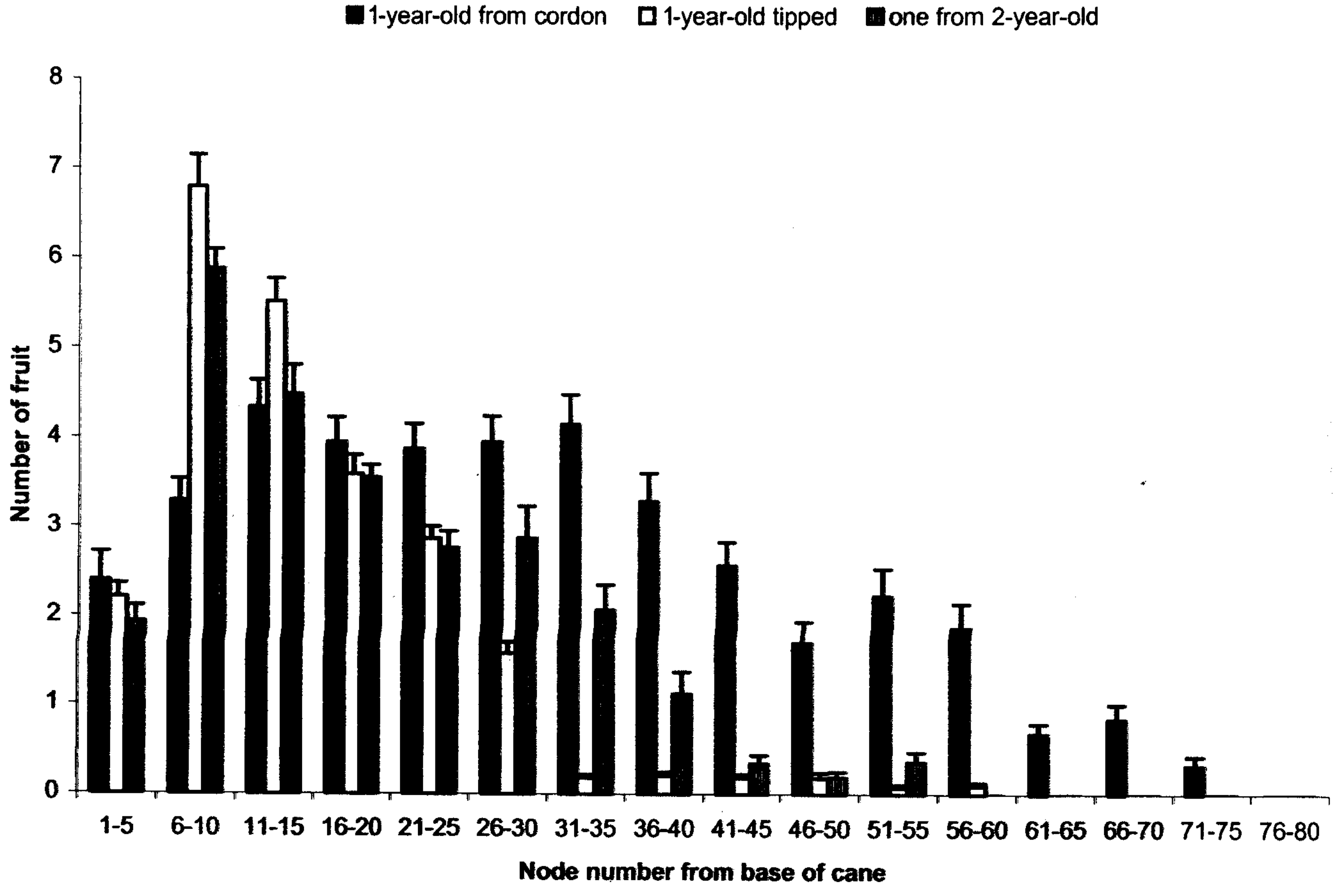

Fig. 1 Average number of fruit per shoot produced at nodes on fruiting canes of different origin at the Sheridan site, Oregon, United States, 1998 (data are an average of three canes per vine, on each of 10 vines; non-breaking buds were counted as "0"). Means + SE are presented for each group of five nodes ($n = 10$).

RESULTS AND DISCUSSION

1998

Site had a significant effect on cane length, internode length, number of nodes per cane, percent budbreak, and fruit and cluster number per m of cane length. There was a significant site by wood origin interaction only for cane length and the number of nodes per cane. However, because of cultural or management and vine age differences between sites, the results are presented by site for clarity (Table 1).

Sheridan site

Other than spurs, cane length did not differ by wood origin. Fruiting canes were, on average, 46% shorter (Table 1) and had 35% fewer nodes (data not shown) at Sheridan than at Stayton. This was likely because of management practices as the mature vines at Stayton were pruned to long canes. Spurs were c. 14% of the average length of fruiting canes, had a significantly shorter internode length and a lower percentage of budbreak. Percentage of budbreak ranged from 35 to 57 and was significantly lower on spurs and canes borne from the cordon (Table 1). Percentage of fruitful shoots was not affected by wood origin. Although the number of clusters and fruit per cane was affected by cane length and thus fruiting wood origin, the number of clusters and fruit per meter of cane/spur was not affected by wood origin (Table 1).

Fruiting canes were productive almost along their entire length, although average fruit number per shoot decreased on the more distal part of canes (Fig. 1). One-year-old canes borne from the cordon were more productive at the distal nodes than the 1-year-old tipped or 1-year-old from 2-year-old canes. In general, the most productive part of the cane was from nodes 6–26, mainly because of a higher percentage of budbreak and fruitful shoots in this zone (Fig. 2). Percent budbreak was low distal to node 55 even though buds did not appear dead. Spurs were most fruitful in the midsection (data not shown).

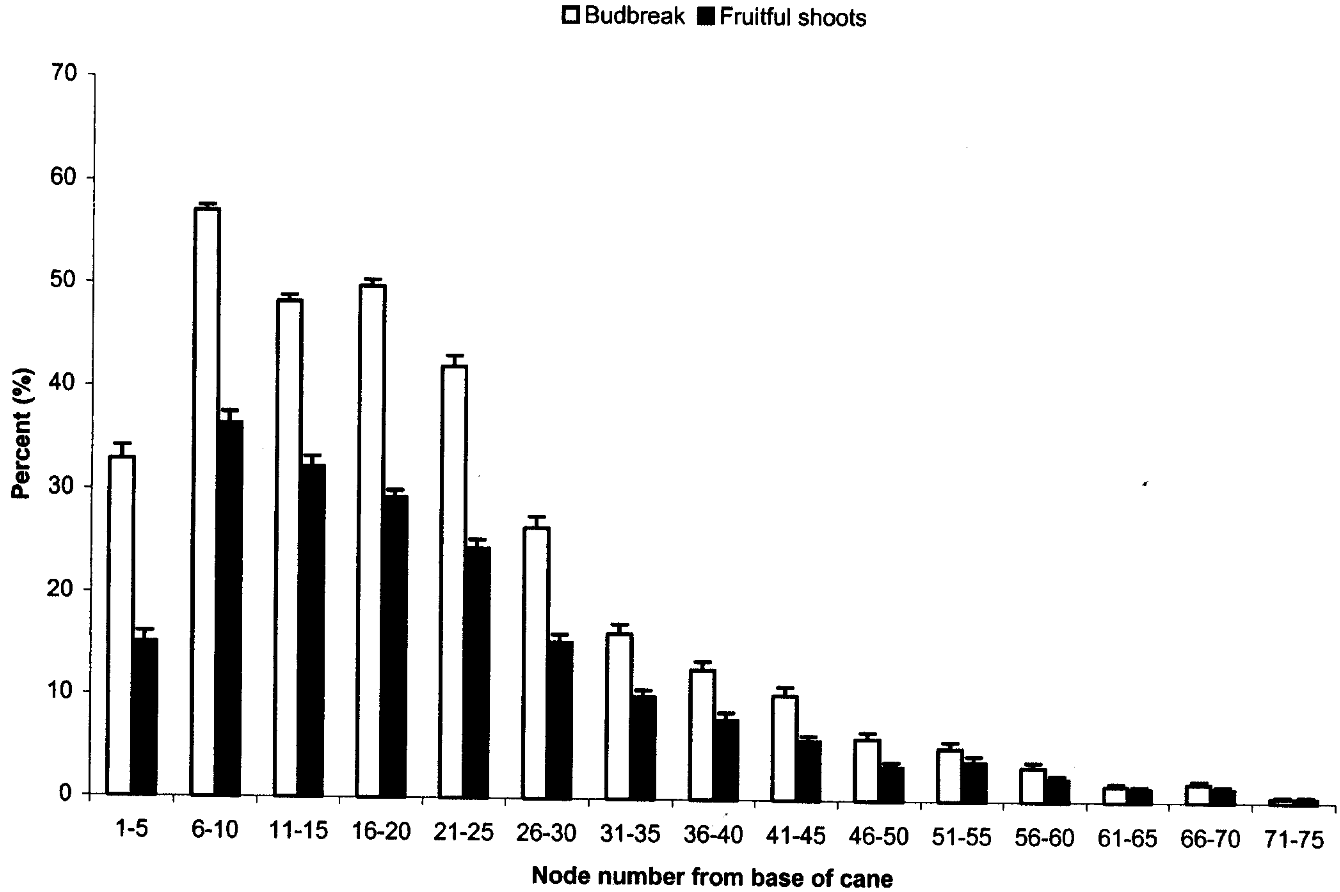

Fig. 2 Percent budbreak and percent fruitful shoots (only breaking buds counted) on 1-year-old canes (averaged over origin) at the Sheridan site , Oregon, United States, 1998. Means + SE are presented for each group of five nodes (n = 10 vines). Spur data not included.

Stayton site

There was a significant effect of wood origin/type on cane length, diameter, and internode length. Spurs averaged 6% the length of fruiting canes and had a smaller diameter and internode length. One-year-old canes borne from the cordon had a larger diameter than all other wood origins (Table 1). In contrast to our findings at Sheridan, percentage of budbreak was not affected by wood type/origin at Stayton (Table 1). Percent budbreak was also significantly higher at Sheridan than at Stayton (Table 1).

At Stayton, wood origin had no effect on percent fruitful shoots or fruit and cluster number per m of cane, as also observed at the Sheridan site. However, there were fewer clusters and fruit per m of cane at Stayton than at Sheridan (Table 1). Trellis system, vine age, and pruning severity may have had an important effect on these factors. Mulligan (1991) stated that a pergola trellis out-produced a T-bar in 'Hayward' by c. 20%. In this study, overall productivity (data not shown) at Stayton, where vines were trained to a T-bar, was less than at Sheridan, where vines were trained to a pergola, likely a result of the lower percentage of budbreak and fruit and clusters per m of cane (Table 1). At Sheridan, vines were not yet mature and had a more open canopy. Also, vines at Stayton were not pruned very severely, leaving many long canes with a high number of nodes per vine. In *A. deliciosa*, Habib & Agostini (1997) found that bud fertility decreased when the number of buds per cane increased. In addition, the combination of light, pruning, and vine age at Stayton may have resulted in canopy shading, which has been shown to reduce flower number (Tiyayon 2001).

In general, fruiting canes at Stayton were most productive and had the highest percentage of budbreak and fruitful shoots from nodes 6 to c. 30 (Fig. 3, 4). Many of the buds distal to node 65 did not break (Fig. 4), although they did not appear to

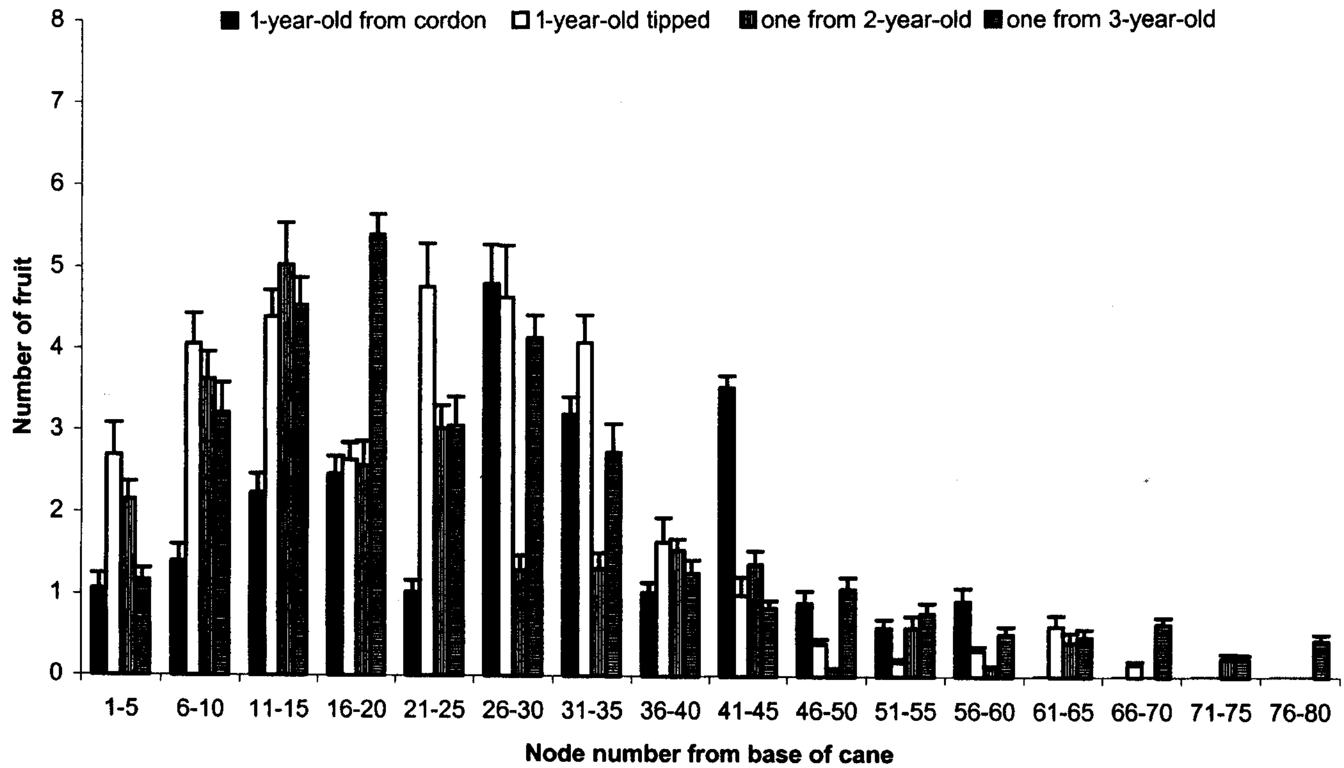

Fig. 3 Average number of fruit per shoot produced at nodes on fruiting canes of different origin at the Stayton site, Oregon, United States, 1998 (data are an average of three canes per vine, on each of 10 vines; non-breaking buds were counted as "0"). Means + SE are presented for each group of five nodes (n = 10 vines).

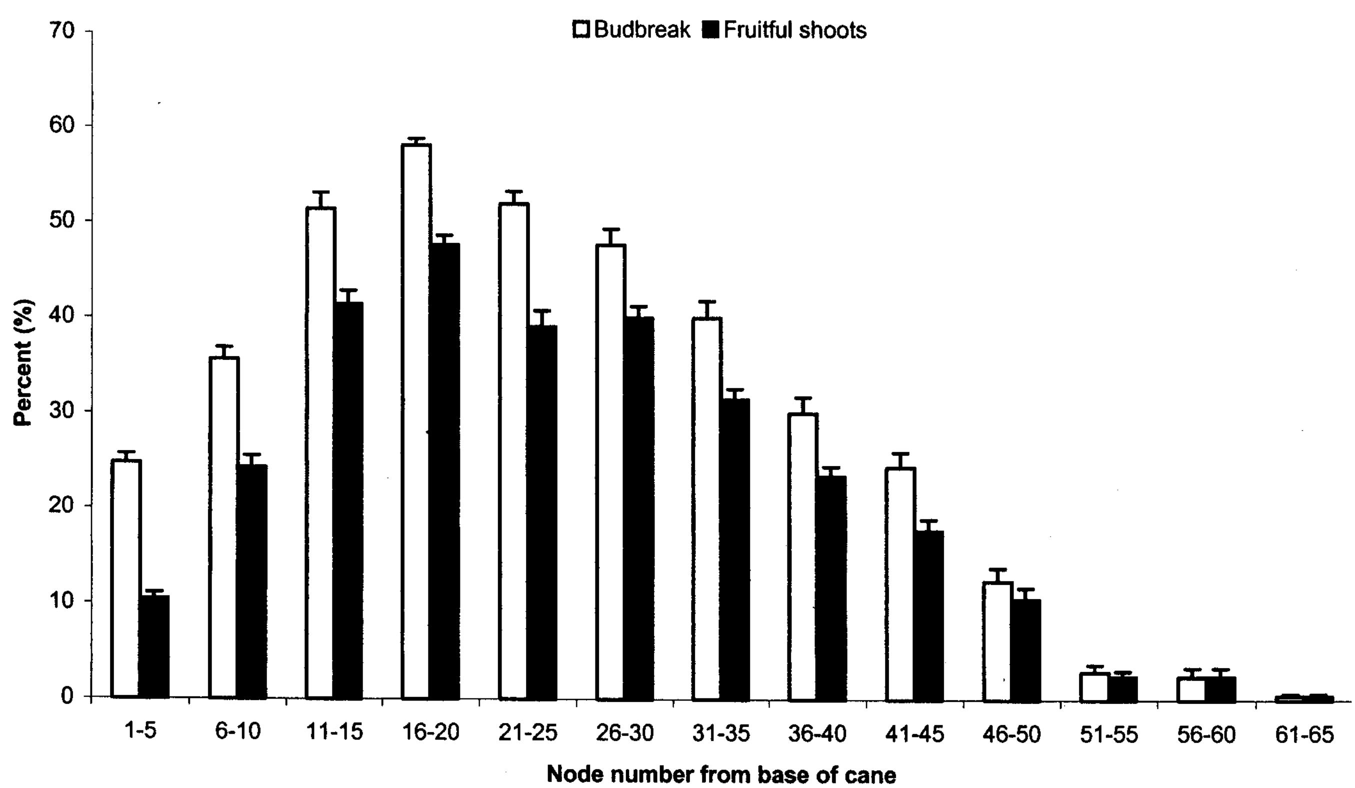

Fig. 4 Percent budbreak and percent fruitful shoots (only breaking buds counted) on 1-year-old canes (averaged over wood origin) at the Stayton site, Oregon, United States, 1998. Means + SE are presented for each group of five nodes (n = 7 vines). Spur data not included.

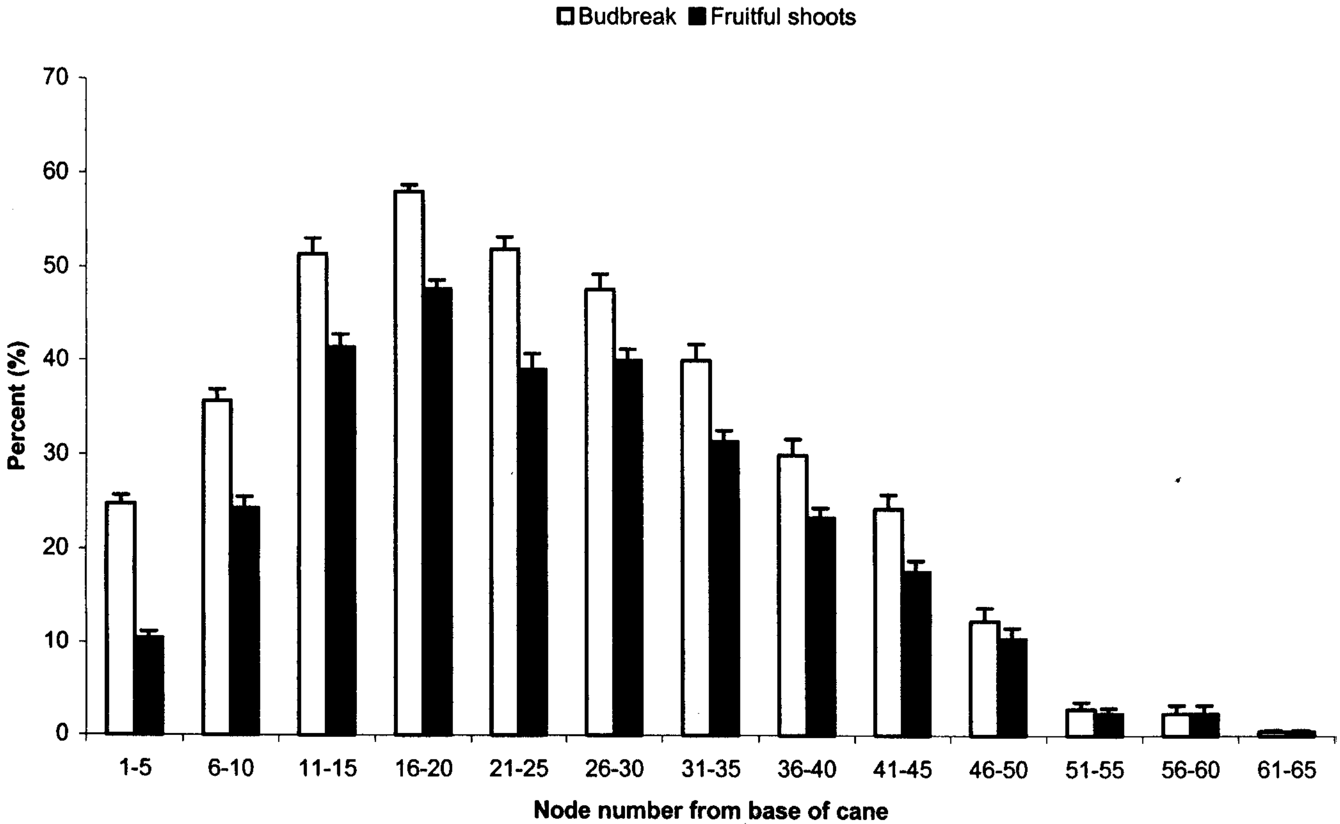

Fig. 5 Percent budbreak and percent fruitful shoots (only breaking buds counted) on 1-year-old canes at the Sheridan site, Oregon, United States, 1999. Means + SE are presented for each group of five nodes ($n = 7$ vines).

be dead. The non-fruitfulness of the distal portion of these long canes resulted in a non-significant effect of wood origin on fruit per m of cane (Table 1). In contrast to our findings at Sheridan, spurs were most fruitful in the basal section at Stayton (data not shown).

Percent fruitful shoots averaged 57% at Sheridan and 60% at Stayton (Table 1), much higher than the 13% fruitful shoots reported by Snowball (1997a,c) in *A. arguta* grown in New Zealand. In our study, the highest percentage of fruitful shoots was found between nodes 6 and 26–30 at both sites (Fig. 2, 4), as basal buds on canes tended to produce vegetative shoots.

1999

Percent budbreak, counted when new shoots were c. 30 mm long at Sheridan, was 47% (of 2085 nodes/vine), but only 85% continued to grow (recorded when shoots were c. 0.15 m long). Snowball found 45–50% budbreak (1997a,c) and 84% broken buds which became shoots in *A. arguta* (1997c). On 1-year-old canes, percent budbreak for shoots that grew past 0.15 m long increased from node 1–5 to node 16–20, then decreased to node 51 (Fig. 5). Compared to 1998 (Fig. 2), Sheridan had a similar percent budbreak but a higher percentage of fruitful shoots per cane in 1999 (Fig. 5). This may have been related to vines being more mature.

The most productive flowering zone on fruitful shoots was from nodes 6–11 on shoots from canes, and nodes 6–10 on shoots from spurs (Fig. 6), not dissimilar to the flower zone, nodes 4–14, reported by Snowball (1997a).

The cluster or inflorescence was typically a cyme of three flowers, but sometimes a cluster of two or a single flower was found at the proximal and the distal ends of the fruiting zone. Clusters of 4–6 flowers were rarely seen.

From observation of the persistent pedicels left on the canes after fruit harvest in 1998, buds at node positions that were productive in 1998 did not break in 1999. In 'Hayward', Brundell (1975) noted that flowering shoots arise only from buds developed in

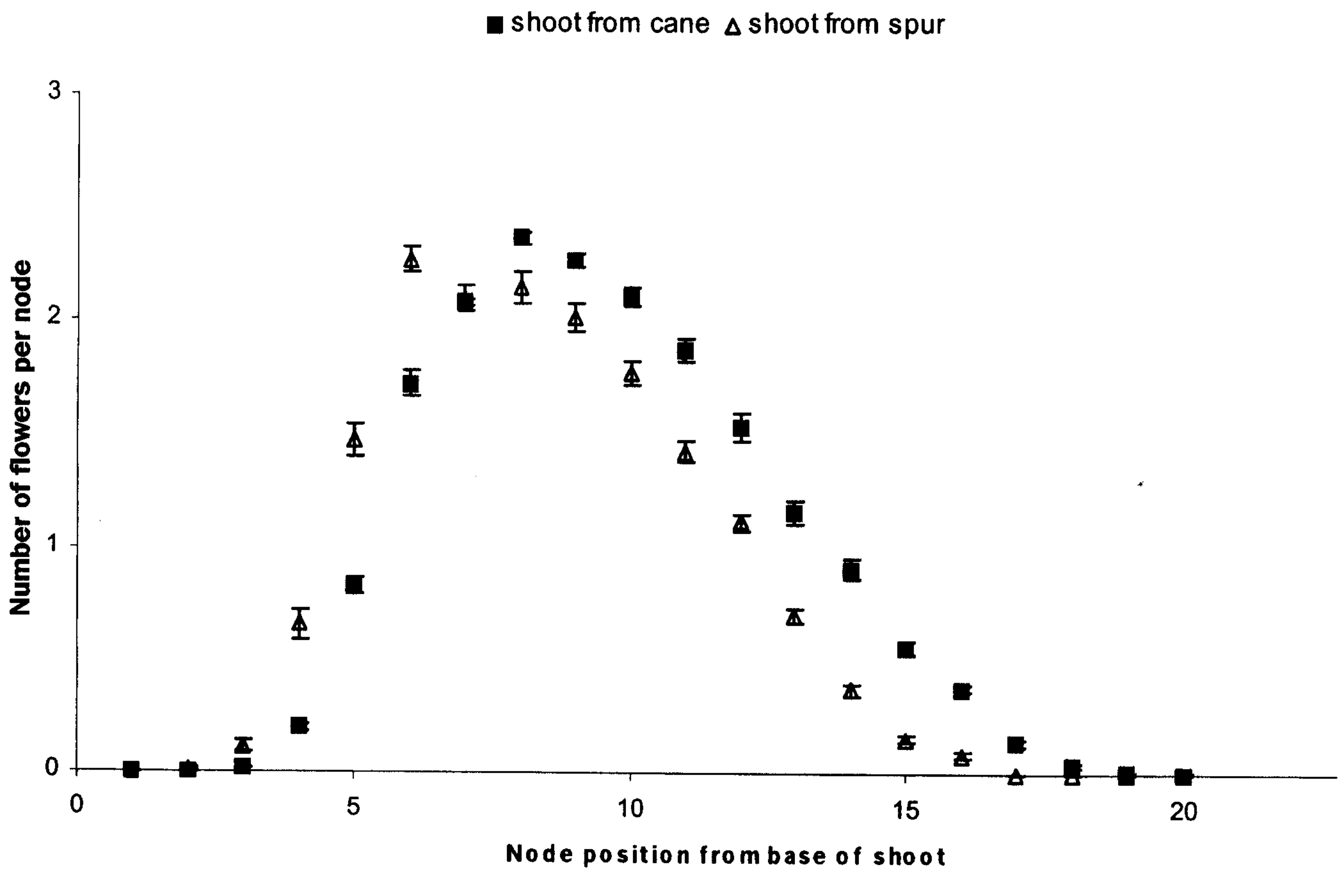

Fig. 6 Position of flowers on shoots borne from 1-year-old canes and spurs, Sheridan site, Oregon, United States, 1999 ($n = 7$ vines).

leaf axils of the previous season's shoots, distal to the flower-bearing axils. Walton et al. (2000) observed that canes of 'Hayward' that bore fruit the previous season were less productive than those that were vegetative. In this study, the data presented in Fig. 1–5 include canes that were vegetative or fruiting the previous season. Canes that were productive the previous year tended to produce fruitful shoots from nodes more distal than the fruitful zone of the previous year (node 17, Fig. 6). The former vegetative shoots produced fruit beginning at the base of canes. Thus, the presence of a zone of low productivity on shoots that bore fruit the last season was masked by budbreak along the entire cane in shoots that were vegetative the previous year. When plants are pruned, replacement canes are usually selected from shoots proximal to the cordon; these are usually vegetative shoots (Fig. 2, 5).

Our results indicate that the fruiting wood of *A. arguta* 'Ananasnaya' is very productive regardless of wood origin, type, or length. Vines are likely to need heavy pruning to prevent over cropping. Based on wood productivity, careful selection of fruiting wood at pruning seems unnecessary. However, further investigation of fruiting canes, differentiating between shoots that were reproductive or vegetative in the previous year, should be performed for better understanding of fruiting potential, in order to adjust pruning for maximum production.

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