Flowering and Fruiting Morphology of Hardy Kiwifruit, *Actinidia arguta*

Chantalak Tiyayon and Bernadine Strik
Department of Horticulture, Oregon State University
4017 ALS, Corvallis, OR 97331, USA
Email: strikb@science.oregonstate.edu

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Abstract

Morphology of *Actinidia arguta* 'Ananasnaya' vines was studied in 1998 and 1999 in Oregon, USA. Vines were three years old (1998) and trained on a pergola trellis. The origination of one-year-old fruiting wood had no effect on percent fruitful shoots or the number of clusters or fruit per meter of cane. One-year-old canes produced fruitful shoots along their entire length, but were most productive from nodes 6 to 26. In 1999, of 2085 nodes/vine left after winter pruning, bud break was 47%, 85% of the shoots continued to grow past 15cm long, and 83% of these were fruitful. The most productive flowering zone on shoots was from nodes 6 to 12. There was no relationship between yield per vine and return bloom the following year. Fruit set was 74%. There was a significant linear relationship between fresh fruit weight and seed number.

INTRODUCTION

The hardy kiwifruit [*Actinidia arguta* (Sieb. et Zucc.) Miq]. 'Ananasnaya' is grown commercially on approximately 42 hectares in Oregon, USA. 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 and Cahn, 1998). However, any differences in morphology between these two commercial species of kiwifruit may necessitate alternative production practices for the hardy kiwifruit.

In all *Actinidia* species, only one-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 ages.

Snowball (1997 a and c), in New Zealand, recorded 45 to 50% bud break in *A. arguta*, with only 12 to 13% fruitful shoots, whereas *A. deliciosa* had 46% bud break with 90% fruitful shoots. The percentage of flowering shoots in *A. deliciosa* was highest from nodes 6 to about 30, although fruiting canes could still be productive to node 40 (Snowball, 1997b).

Burge et al. (1987) found that flower production in *A. deliciosa* was less on vines that had a high yield the previous season, and this reduction was primarily because of fewer flowers per shoot. Biennial bearing of *A. arguta* has not been reported.

Adequate pollination of 'Hayward' kiwifruit flowers has been shown to be important for good fruit size, as seed number is correlated with fruit weight (Grant and Ryugo, 1984).

The objectives of this study were to determine: 1) the effect of wood origin on fruitfulness; 2) the relationship between seed number and fruit size; and 3) the relationship between flower number and yield over several years in the hardy kiwifruit.

MATERIALS AND METHODS

This study was carried out at a commercial hardy kiwifruit ('Ananasnaya') vineyard in Sheridan, Oregon, USA. Vines were planted in 1995 at a 4.6 m x 4.6 m spacing on raised beds and trained to a 2 m-high pergola. Experimental vines were pruned and otherwise maintained as standard for commercial production (Strik and Cahn, 1998).

In 1998, ten vines at each site were randomly selected from a larger population of uniformly sized vines. The fruiting canes were divided into five origins/types: spurs borne from the cordon; one-year-old canes borne from the cordon; one-year-old canes which grew as a result of summer pruning of last year's growth (one-year-old tipped); and one-year-old canes borne from two-year-old wood.

Three canes/spurs were sub-sampled for each wood type per vine and measured for: cane length; cane diameter at the midpoint of the cane; number of nodes; number of shoots; and number of fruit clusters and fruit on each shoot. Percent bud break, the number of fruit per cluster and the number of clusters and fruit per meter of cane length were calculated.

In 1999, seven vines were selected and node and shoot number of all one-year-old canes on each vine were counted and percent bud break calculated. Six one-year-old canes and four spurs from each vine were sub-sampled and the node position of each fruitful shoot recorded. The percentage of fruitful shoots was calculated.

In 1998 and 1999, total flower and fruit number, yield and fruit weight were recorded on seven vines. In 1999, 20 marketable and 10 non-marketable (< 1.7 cm in diameter) were collected per vine and individual fruit fresh weight and seed number measured. In 2000, yield data were collected on five of the seven vines.

Means of vegetative and fruiting components of wood origin were compared by analysis of variance (PROC GLM) with treatment means compared using a protected LSD (The SAS System, Version 6.12, SAS Institute Inc., Cary, NC). Regression analysis was used for the relationship of fruit weight with seed number.

RESULTS AND DISCUSSION

Wood Origin

Wood origin significantly affected all components except percent fruitful shoots and number of fruit clusters and fruit per meter of cane length (Table 1). One-year-old canes from the cordon had a greater node number than other wood origins. Spurs were 13% the length, had a significantly shorter internode length, and a smaller diameter than one-year-old canes from the cordon (Table 1).

In 1998, percent bud break ranged from 34 to 57%. In 1999, percent bud break, counted when new shoots were approximately 3 cm long, was 47% (of 2,085 nodes/vine), but only 85% continued to grow (recorded when shoots were approximately 15 cm long; data not shown). Snowball (1997 a and c), in New Zealand, recorded 45 to 50% bud break in *A. arguta*, with only 12 to 13% fruitful shoots. Percent fruitful shoots averaged 57% in 1998 and 83% in 1999 – higher perhaps because vines were maturing. The percent fruitful shoots found in our study are much higher than the 12 to 13% fruitful shoots reported by Snowball (1997a and c) in *A. arguta* grown in New Zealand.

In 1998, on one-year-old canes, percent bud break for shoots that grew increased from node 1 (2%) to node 18 (71%), then decreased to node 60. Canes were productive almost along their entire length, although fruit number/node decreased on the more distal part of long canes (Fig. 1). One-year-old canes borne from the cordon were more productive at the distal nodes than the one-year-old tipped or one-year-old from two-year-old canes. The most productive part of the cane was generally from nodes 6 to 26 for all canes (Fig. 1), due mainly to a higher percentage of bud break and fruitful shoots in this zone (Tiyayon and Strik, 2002). 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. Spurs were most fruitful in the mid-section (data not shown).

Yield and Fruit Size

Yield increased for almost all vines from 1998 (30 kg/vine on average) to 1999 (49 kg/vine) to 2000 (53 kg/vine). This was likely a result of the vines aging from four to six years old during this same time period. Vines are not considered mature until year 7 or 8. There was no relationship between yield per vine in 1998 and return bloom the

following spring (Fig. 2). For example, a vine with 13.5 kg fruit had 11,089 flowers the next spring and one with a yield of 24 kg produced 10,508 flowers. Thus yield did not appear to affect flower bud initiation, at least in immature vines. Flower bud initiation for the next year's crop in *A. arguta* 'Ananasnaya' starts in July, during early fruit development (Tiyayon, 2001) and thus results may not be similar in mature, higher yielding vines.

In this study, vines produced an average of 9,367 flowers in 1999 and had 74% fruit set. Fruit drop after set was not observed, confirming observations by Ferguson (1984). Of the total average yield produced per vine in 1999 (51 kg), 85% was marketable, 11% was non-marketable, and 4% was over ripe. Fruit were harvested in early September when soluble solids was 8 to 10% (a commercial standard). Mature vine yield of 'Ananasnaya' in Oregon has been reported to be as high as 74 kg (Strik, unpublished).

The average marketable fruit weight was 7.3 g with an average of 151 seeds per fruit. The relationship between seed number per fruit and fruit fresh weight was linear ($y = 0.036x + 1.76$; $r^2 = 0.876$, $P < 0.0001$).

In summary, one-year-old canes of hardy kiwifruit are very fruitful regardless of origin. Percentage of fruitful shoots was higher than reported in other studies (Snowball, 1997 a and c). Vines have a capacity for very high yield as the immature vines in this study produced as many as 11,089 flowers with a fruit set of 74%. We did not observe biennial bearing in these immature vines.

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Tables

Table 1. Effect of wood type/origin on vegetative and fruiting components of hardy kiwifruit, 1998

Wood origination [z]	Cane length (cm)	Cane diameter (mm)	Internode length (cm)	Node/ cane	Bud break (%)	Fruitful shoot (%)	Fruit/ cane	Cluster/ cane	Fruit/m[y]	Clusters/m[y]
Spurs from cordon	11.6 b[w]	4.4 b	1.2 c	9.4 c	34.5 c	49.4	9.2 b	5.5 b	81	51
One-year-old from cordon	89.7 a	7.9 a	2.5 b	35.6 a	45.1 b	62.1	90.5 a	46.1 a	112	56
One-year-old tipped	83.6 a	7.8 a	3.2 a	26.4 b	57.4 a	60.9	68.6 a	38.7 a	89	49
One from two-year-old	72.5 a	6.1 ab	2.8 ab	26.8 b	52.8 a	56.6	68.9 a	35.9 a	97	51
Significance [x]	***	*	***	***	***	NS	***	***	NS	NS

z: Wood origination: one-year-old tipped = a one-year-old cane that grew as a result of summer tipping (only portion after the summer pruning cut measured); one from two-year-old = originated directly from a two-year-old cane.
y: per m of fruiting cane length
x: NS, *, **, ***: Non-significant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively
w: means followed by the same letter are not significantly different by LSD ($P>0.05$)

Figures

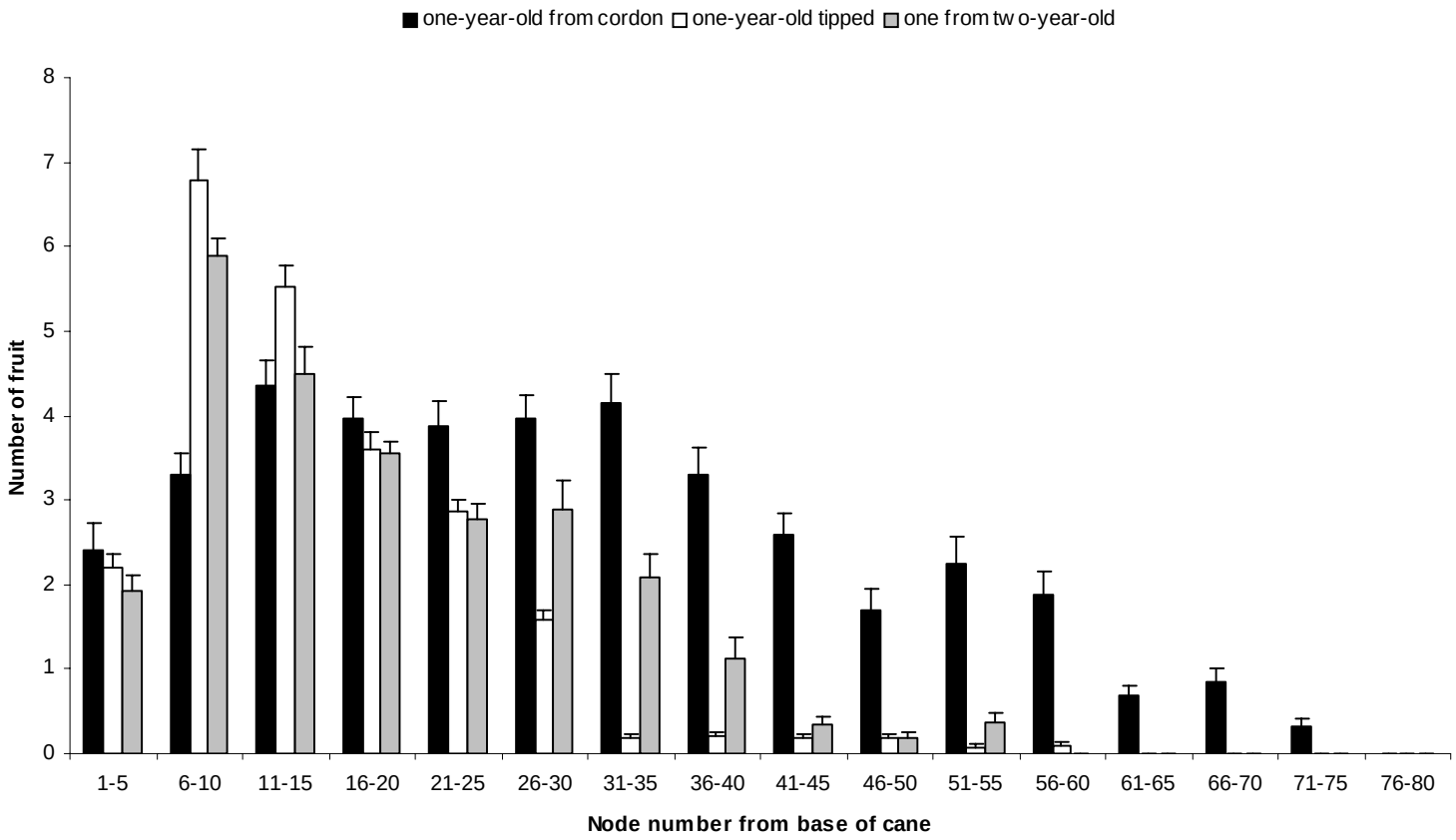

Fig. 1. Average number of fruit per shoot produced at nodes of fruiting canes of different origin, 1998 (data are an average of 3 canes per vine, on each of 10 vines; non-breaking buds were counted as "0"). Means + SE are presented for each group of 5 nodes (n=10).

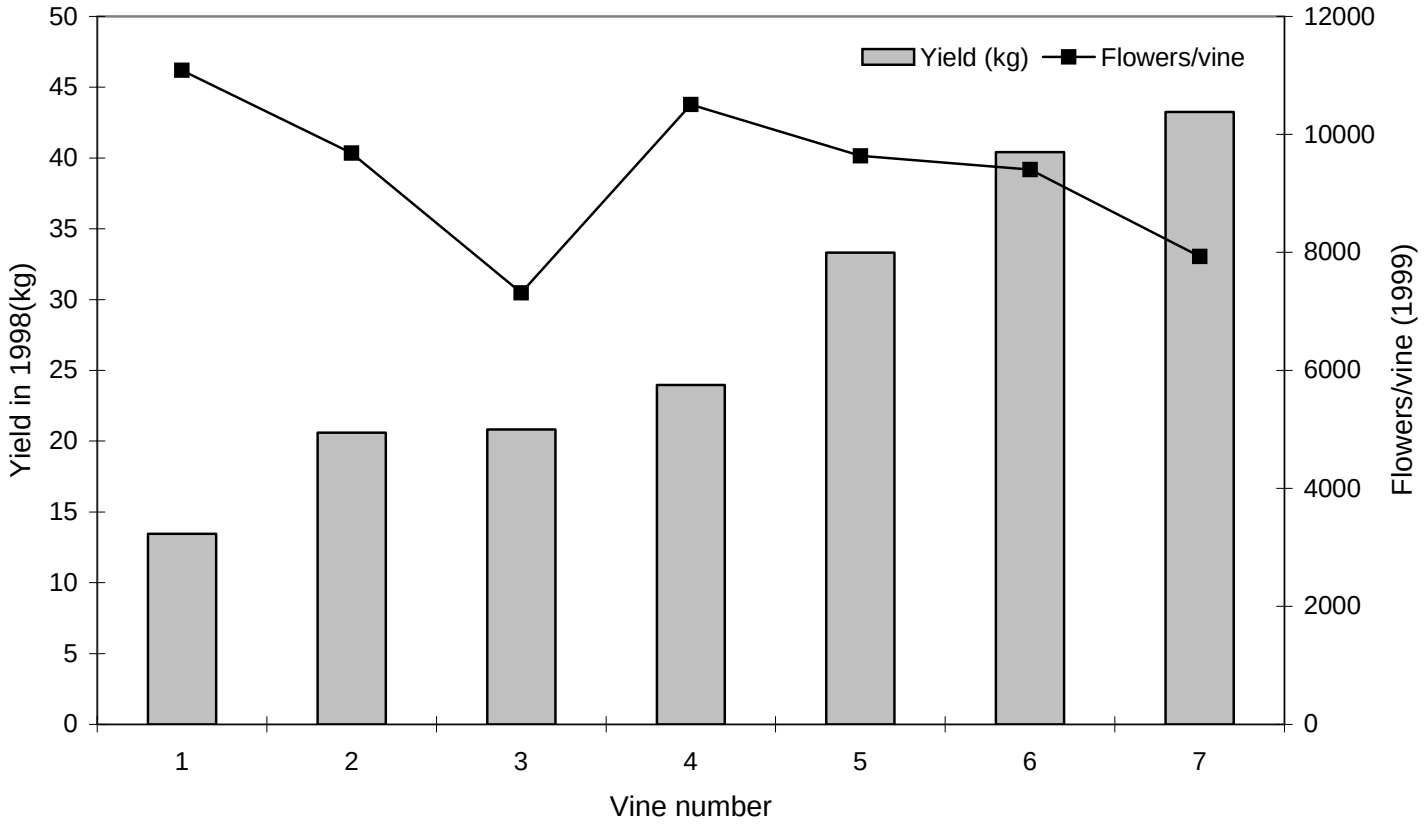

Fig. 2. Effect of yield per vine in 1998 on return bloom (1999) per vine for seven ‘Ananasnaya’ vines at a commercial vineyard. Vines were four years old in 1998.