The Influence of Fruit Load on Biennial Bearing of Fuji Apple

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The Current Range of Apple Varieties in the South Tyrol

The South Tyrolean fruit industry produces 700,000 to 800,000 metric tons (t) of apples every year, which accounts for about 10% of the total apple production in the European Community. About half of it is sold in Italy, the other half abroad. Although our assortment of varieties consists of a fairly large number of varieties, the three main varieties Golden Delicious (44%), Rome Beauty (12.3%) and Red Delicious (11.8%) made up 68.1% of the South Tyrolean production in 1996. The more recent varieties Gala, Braeburn and Fuji are much discussed, but their share of production is, with the exception of Gala, rather modest. In 1996, Gala held a share of 4.8%, Braeburn 1.1% and Fuji 0.2%.

We asked our marketing people to predict the ideal assortment of varieties for the year 2000. According to their projections, the newcomer varieties should reach the following: Gala, 15%; Braeburn, 10%; Fuji, 5%. Their share in our total production is expected to increase at the expense of Rome Beauty, Gloster, Elstar and Jonathan. Golden Delicious and Red Delicious are also likely to decline a little.

The Availability of Fuji in South Tyrolean Nurseries

In the South Tyrolean nurseries, 4.7 million rootstocks were grafted in 1996-97. It is interesting to compare our present assortment of varieties and the ideal assortment in 2000 with tree propagation in our nurseries. As one can see from Table 1, the nurserymen are very cautious with Fuji. In the next planting season, about 264,000 trees will be available. This accounts for 5.6% of the total amount of young trees for sale. Figure 1 shows the number of Fuji/M.9 trees, by strains, for sale by South Tyrolean nurseries for the 1997-98 planting season.

At present, the Experiment Station at Laimburg and the Advisory Service recommend 4 strains: Kiku 8, Moriho-fu 3A, BC 2 and an Irradiated Strain. This choice is based on a color index developed by R. Stainer of the Laimburg Experiment Station, which is developed from the intensity of the stripes (rated into grades from 1 to 10) multiplied by the percentage of color. Values above 350 indicate good coloring.

In our fruit-growing area there exist many sites with favorable climatic conditions for Fuji. The long growing season from mid-March to the end of October and the considerable difference in temperature between day and night promote coloring.

If the share of the new varieties from our nurseries and the growers' interest in Fuji do not increase, we will not be able to meet the requirements of the ideal variety assortment for the year 2000.

Biennial Bearing, the Obstacle to Planting More Fuji in the South Tyrol

A typical family-managed orchard in South Tyrol has about 4 ha (10 acres) of apples. Due to the smallness of apple orchards, growers aim at high initial yields and high average yields per ha. Today both are feasible with well-feathered young trees on M.9 and a tree density of 3,000 to 4,000 trees/ha (1200 to 1600 trees/acre). The average yield in South Tyrol in the '90s is 40 t/ha, with a tendency to rise. There is nothing our growers fear more than varieties with a biennial bearing habit. As demonstrated in trials by our Experiment Station at Laimburg, Fuji tends to alternate very strongly under our climatic conditions. We observed this phenomenon also in our commercial orchards. Consequently, we have looked for ways to break this alternation. As the following examples will show, so far a combination of chemical thinning and hand thinning seems to be the most effective remedy for alternate bearing.

Our Experiences with Chemical Thinning of Fuji

The first important step toward a regulation of fruit set is chemical thinning. In trials at the Experiment Station at Laimburg, NAD (napthaleneacetamide) products had a negative effect on the fruit bud development for the following year. Compared to untreated check plots, the flowering of Fuji trees treated with NAD was reduced by 11%. The application of NAD also furthers the development of pigmy fruits. For these two reasons, we do not recommend NAD products for the thinning of Fuji.

In order to relieve the tree of excessive fruit load at the earliest possible date, we recommend applying Ethrel (ethephon) 30 ml/1000 liters at full bloom (FB). Under our conditions, a second application of a chemical thinner may become necessary if flowering and fruit set are good. For the second thinning, we recommend a mixture of Sevin (carbaryl) 50 ml/1000 liters plus a surfactant or mineral oil (100 ml/1000 liters) as soon as the largest fruitlets have reached a diameter of 12-13 mm. Additional chemical thinning with Sevin is recommended in cases of heavy fruitset no later than when the largest fruits have a diameter of 17-18 mm (Table 2). The full rate of Sevin (200 g/1000 liters) is very toxic to predatory mites. The same thinning effect

can be obtained by using only a quarter of the usual dosage, if a surfactant or mineral oil is added, so that predatory mites are preserved. The addition of ethephon to Sevin enhances its effectiveness and positively influences flower bud formation. In 1995 and 1996, 3 trials at Laimburg showed that the combination of ethephon and Sevin improved bud set by 8-15%.

Observations on Chemical Thinning in 4 Commercial Orchards

Yield/tree was recorded from the 2nd year onwards in 4 Fuji orchards (Fig. 2). The circle to the right of each group of bars stands for the intensity of flowering in 1997. A filled circle symbolizes heavy flowering, an empty one means no flowering (alternation).

Orchard 1: Tree spacing 3.0 x 0.6 m (5,555 trees/ha; 2249 trees/acre)
This orchard was thinned every year from the 3rd to the 5th leaf with one application of Sevin (100 ml/1000 liters) + mineral oil (100 ml/1000 liters). No chemical thinning occurred in the 2nd and the 6th leaf. In the 2nd leaf, the yield was 3.6 kg/tree (20 t/ha), in the 3rd leaf 12.4 kg/tree (69 t/ha) and in the 4th leaf 7.1 kg/tree (40 t/ha). After 15.4 kg/tree (85 t/ha) in the 5th leaf and only 2 kg/tree (11 t/ha) in the 6th leaf, the trees flowered abundantly in the following year. Although twice as much Sevin (100 ml/1000 liters) as we recommend was applied every year (1997), biennial bearing could not be avoided.

Orchard 2: Tree spacing 3.0 x 1.0 m (3,333 trees/ha; 1349 trees/acre)
In this orchard the trees were cropped for the first time in the 3rd leaf, yielding 3.5 kg/tree (11.7 t/ha). In the 4th leaf, the crop was 8.9 kg/tree (32.7 t/ha) and in the 5th leaf 15.6 kg (52 t/ha), after the trees had been thinned with Sevin (50 ml/1000 liters) + mineral oil (100 ml/1000 liters). In the 6th leaf (1997), the flowering was very variable and, on the whole, rather modest.

Orchard 3: Tree spacing 3.15 x 0.9 m (3,571 trees/ha; 1446 trees/acre)
As the original variety Gloster was not profitable, the trees were grafted and all the fruits were removed in the 2nd leaf. In the 3rd leaf, the crop was 4.2 kg/tree (15 t/ha) and in the 4th leaf 14.1 kg/tree (50t/ha) after a treatment with Sevin (50 ml/1000 liters)+ a surfactant (100 ml/1000 liters). In the 5th leaf, the yield was 18.4 kg/tree (65 t/ha). In that year (1996), the orchard had been treated with a mixture of Sevin (50 ml/1000 liters) + Ethrel (30 ml/1000 liters) + a surfactant (100 ml/1000 liters). Although the yields had been relatively high, according to our standards, in two consecutive years the trees flowered heavily again in the 6th leaf.

Orchard 4: Tree spacing 3.1 x 1.0 m (3,225 trees/ha; 1306 trees/acre)
Only whips were available at planting. Therefore, the crops up to the 4th leaf were low. In the 5th leaf, the production was 14.5 kg/tree (49.7 t/ha) and in the 6th leaf 26.8 kg/tree (86.4 t/ha). In spite of this high yield, the trees flowered again very well in the following year. In the last 3 years (1995-1997), Ethrel (30 ml/1000 liters) was applied at bloom and Sevin (50 ml/1000 liters) + a surfactant (100 ml/1000 liters) were used for the second thinning.

Evaluation of Chemical Fruit Thinning

In orchards 3 and 4, the pattern of the yields points to a positive influence of ethephon on the flowering habit of Fuji trees if applied around bloom or as an addition to carbaryl in orchard 3 and 4. We have noticed this positive effect also in other Fuji orchards. Our experiences confirm the first data of the Laimburg Experiment Station trials with ethephon as a thinning agent. However, these examples demonstrate also that chemical fruit thinning by itself is not always successful in breaking alternate bearing with Fuji.

The Influence of Hand Thinning on the Flowering of Fuji

As we have shown above, chemical thinning alone is not always a reliable means to overcome biennial bearing. Therefore, we tried to answer two questions:

1) To what extent does the number of fruits/tree influence fruit bud development for the following year?
2) How does the time of hand thinning influence alternate bearing?

Influence of Fruits/tree and Late Hand Thinning on Alternate Bearing

In 1995, we examined in a Fuji orchard in the 3rd leaf the influence of the number of fruits/tree on flower bud development for the following year. The trees were spaced 3.2 x 1.2 m (2,604 trees/ha; 1054 trees/acre). The planting material was unfeathered and, therefore, the trees were headed after planting in spring. In the 2nd leaf, the crop was 8.5 kg/tree (22.1 t/ha). In the 3rd leaf, the trees flowered heavily. In spite of the abundant flowering, the owner of the orchard decided not to thin chemically because he expected heavy fruit drop. Seventy-five days after full bloom, we counted about 82 fruits/tree. At this point, groups of 5 trees each were thinned to 40, 50 or 60 fruits/tree. As a result, the external quality, e.g., color and size, improved, but none of these variants affected the flowering process in the following year. This example confirms the experience that hand thinning after June drop on Fuji does not influence flower bud development for the next season (Fig. 3).

Influence of Fruits/tree and Early Hand Thinning on Alternate Bearing

In order to establish whether hand thinning at an early stage has a positive effect on flowering, we reduced the number of fruits per tree to four different fruit loads in a Fuji orchard in the second leaf (strain Naga-fu 6) on rootstock M.9, with a tree spacing of 3.3 x 1.1 m (2,754 trees/ha; 1115 trees/acre). At planting, the trees were very well feathered (at least 10 branches). In the 2nd leaf, the orchard was chemically thinned twice with Sevin (50 ml/1000 liters) plus a surfactant (100 ml/1000 liters). The first treatment took place when the fruit diameter was 12-13 mm and the second when it was 17-18 mm. Forty-five days after full bloom, we removed the fruits by hand.

Prior to thinning, we counted an average of 74 fruits on each tree. In Figure 4, the left bar in each group indicates the average number of fruits/tree before hand thinning. Groups of five trees were singled out, where 30, 35, 40 or 45 fruits, respectively, were left on the trees. On those trees where we had left only 30 or 35 fruits, we found an average of 269 and 173 blossom clusters per tree in the following year (3rd leaf). In both these treatments, every tree flowered very well. On trees with 40 or 45 fruits/tree in the previous year, we still found more than 100 blossom clusters per tree on an average. In these two groups, however, not all the trees flowered well, with some trees having only 13 blossom clusters. The check plot, which was only chemically thinned, produced an average of 35 blossom clusters per tree.

Evaluation of Early Hand Thinning

From these observations, we deduced that early hand thinning favorably influences flower bud development the following years. Trees with a maximum of 35 fruits in the 2nd leaf tended to flower well in the following year. In this group we counted 73 fruits/tree on an average in the 3rd leaf, which is considered to be a very good fruit set.

A fruit load of 40 or 45 fruits/tree in the 2nd leaf was clearly too exhausting for some trees. These trees flowered very irregularly in the 3rd leaf and their fruit load, 28 and 48 fruits/tree on an average, was not satisfactory.

Based on our observations, we tried to work out how many fruits a Fuji tree on M.9 in the 2nd to 4th leaf can produce without falling into an alternate bearing habit. The number of fruits/tree suggested in Table 3 requires ideal planting material (7 to 8 lateral branches with a length of 40 cm) and adequate growth. The numbers contain a certain margin to be sure to avoid alternation. We are counting on further field trials in 1997 to provide more data.

In 1998, we intend to explore the latest possible time for hand thinning to show an effect on flower bud set of Fuji. Hand thinning 45 days after full bloom falls in the period of June drop. At this time, many fruits have to be removed which would later on drop off anyway. Therefore, the expenditure of time is considerable. We have calculated that a Fuji orchard of 1 ha with 2,700 trees in the 2nd leaf requires 200-300 working hours for early hand thinning. Apart from the high labor costs of $2000-3000/ha, it is also an organizational problem to find enough workers for this seasonal job. When the trees are fully grown, one has to expect double the amount of time for thinning. Therefore, discovering up to what time hand thinning has an effect on flower bud set is of great economic importance.

Summary

Among all the new varieties in our fruit-growing area, Fuji requires the highest skill from the grower in order to obtain regular high yields of prime quality. The first step toward securing a satisfactory crop every year is chemical fruit thinning. At present, there are only two agents, ethephon and carbaryl, available for Fuji. Depending on the fruit load, we recommend one or two applications of ethephon and one or two treatments with carbaryl. Under our conditions, it is also advisable in most cases to reduce the number of fruits per tree by hand thinning. According to our experiences, this should be done as early as possible. Forty-five days after full bloom hand thinning still improves flowering in the following year, whereas at 75 days after bloom it is no longer effective.

Table 1. Apple variety share of the total production in 1996, predicted share in 2000 and trees for sale in 1997-98 in South Tyrol, Italy.

Varieties	Share in total production 1996 (%)	Predicted share 2000 (%)	Trees for sale 1997-98 (%)
Golden Delicious	44	40	52
Red Delicious	12	10	15
Rome Beauty	12.3	7	0
Jonagold	7.8	7	2
Granny Smith	7	7	0
Gala	4.8	15	13.6
Braeburn	1.2	8	8
Fuji	0.2	5	5.6
Others	10.7	1	3.8

Table 2. Chemical thinning of Fuji in South Tyrol, Italy.

Time	Product	Active ingredient (%)	Rate (ml/1000 liters)
full bloom	Ethrel	ethephon 39.5	30
12-13 mm[z]	Sevin +	carbaryl 49	50
	surfactant or mineral oil		100
17-18 mm[z]	(+ Ethrel)		30

[z]Largest fruit diameter.

Table 3. Optimum number of fruits/Fuji tree on M.9 after early hand thinning.

Year	Fruits/tree	t/ha[z]
2	20-25	10.8-13.5
3	40-45	21.6-24.3
4	50-60	27-32.4
5	80-90	43.2-48.6

[z]2,700 trees/ha.

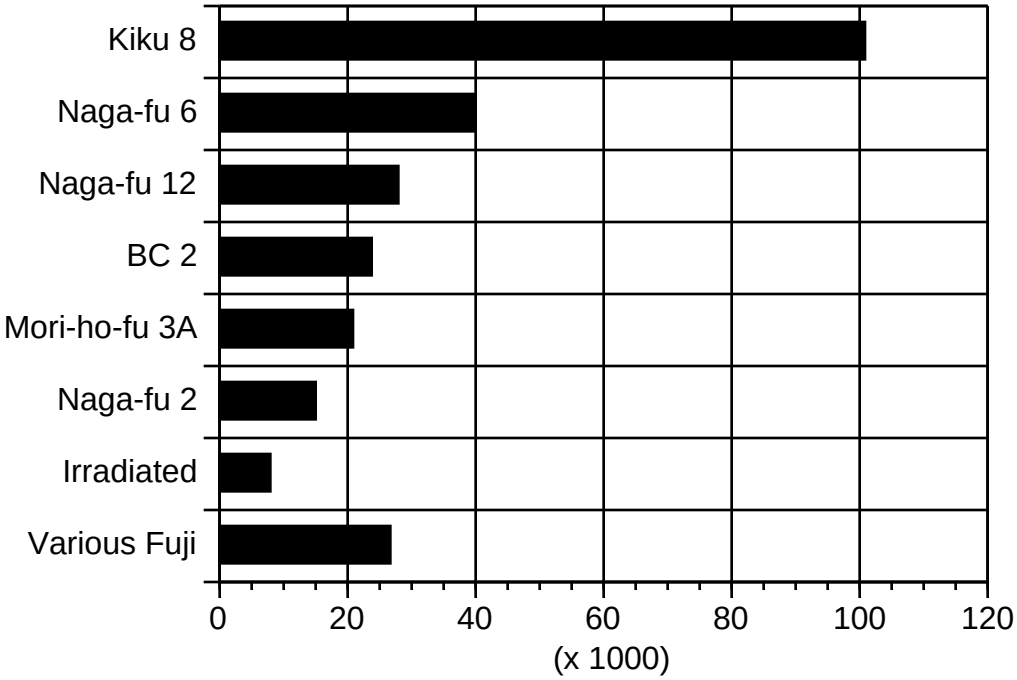

Figure 1. Fuji trees for sale for 1997/98 by the South Tyrolean nurseries.

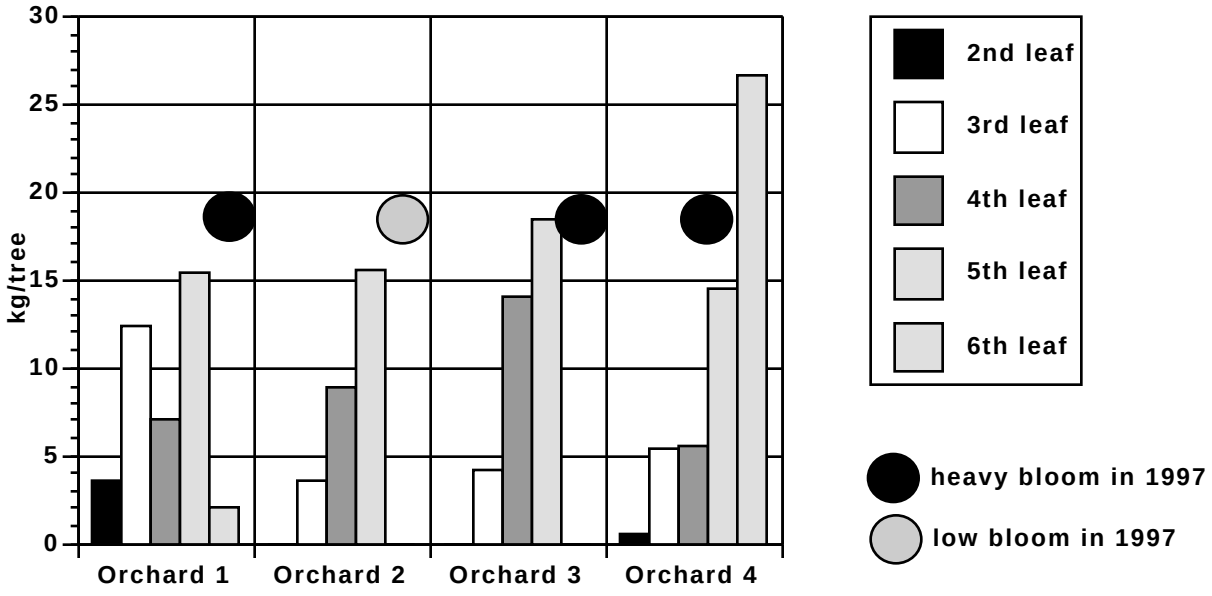

Figure 2. Effect of chemical thinning on yield/tree and flowering of Fuji/M.9 in four different orchards in the South Tyrol.

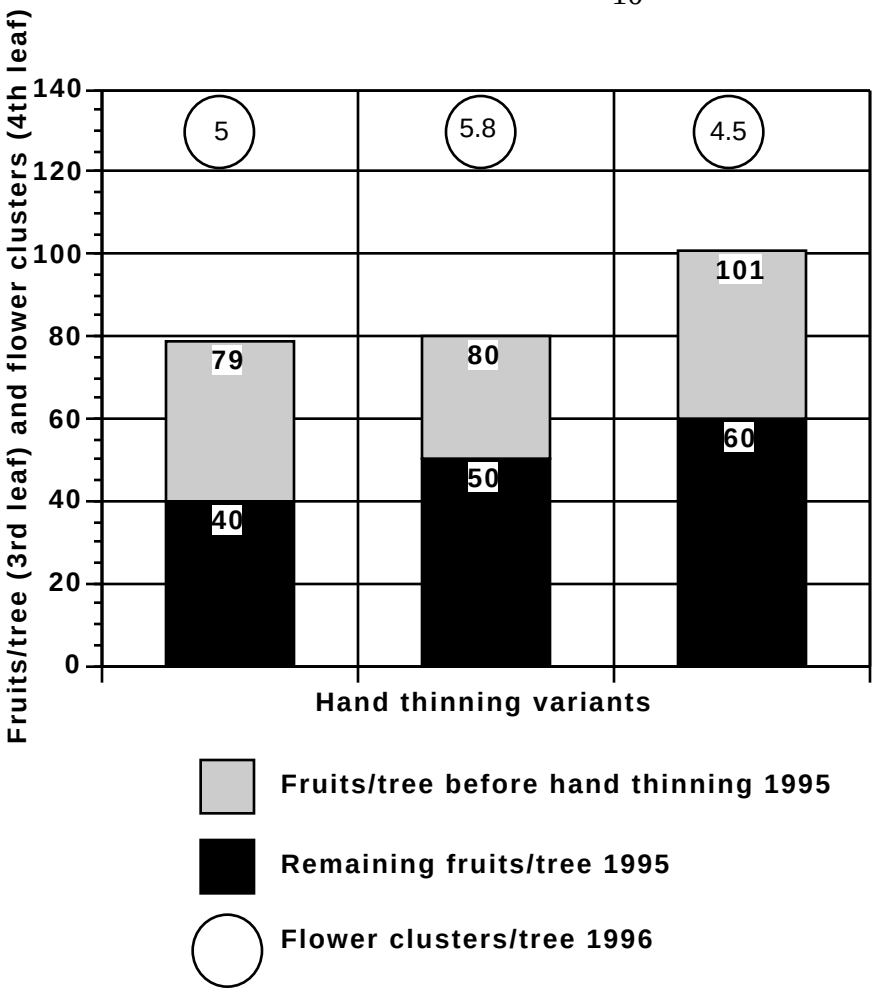

Figure 3. Influence of late hand thinning and number of fruits/tree on flowering of Fuji/M.9 in 1995/96.

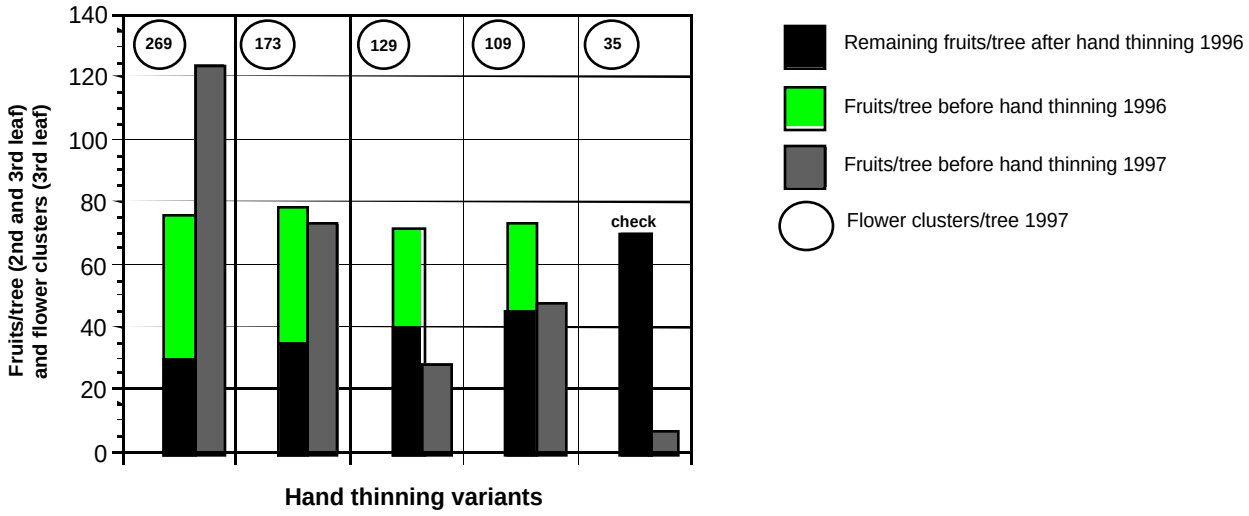

Figure 4. Influence of early hand thinning and the number of fruits/tree on flowering of Fuji/M.9 in 1996/97.