The Cultivation of Fuji in South Tyrol and in Italy

Hermann Mantinger, Research Center for Agriculture and Forestry
Laimburg, Italy

South Tyrol Apple Growing Area

South Tyrol is the most northern province of Italy, embedded in the Alp valleys of the Etsch River and the Eisack River, and shares borders in the north with Austria (Tyrol province) and in the west with Switzerland (Fig. 1).

South Tyrol has at present a pome fruit growing area of about 17,600 ha (43,500 acres), 6.5% of the total cultivated area, with a production between 750,000 and 800,000 metric tons (t) per year. Of the total, 99% are apples and only 1% pears. This amount represents more than one-third of the Italian apple production and about 10% of the apple production of the European Union (EU).

The growing area extends from the southern border of the province at an elevation of 230 m (750 ft) for about 100 km (62 miles) upstream in the Etsch River to the upper Vinschgau Valley, where the highest apple orchards are located at an altitude of about 1000 m (3300 ft) (Fig. 1). The different altitudes and topography with hilly areas and different soil types provide extremely variable growing conditions with many small ecological niches. The farms usually are small, mainly family enterprises, with an average farm size of 3 ha (7.4 acres). The farms are often made up of several separated orchards which may lie relatively far from one another.

The whole Etsch Valley is planted with apple orchards and virtually every spring the low-lying areas in the valley bottom are affected by late frosts. The major part of the whole apple growing area is equipped with overhead irrigation for frost protection, which during the summer is used for ordinary irrigation.

The whole harvest can be placed in CA storage (with up to 70% ultra-low-oxygen storage). About 80% of the farmers are organized in marketing cooperatives, the remaining farmers sell their fruits to private fruit traders (12-15%) or to fruit auctions (8%). About half of the overall production is exported (to Germany, Austria, Switzerland, Scandinavian countries, etc.), the remainder is sold in the local markets in Italy.

Evolution of the Variety-spectrum and Present Situation

Almost 50% of the whole apple production of South Tyrol is Golden Delicious, followed by Morgenduft (Rome Beauty) with 12.3%, Red Delicious with 11.8%, Granny Smith with 7.1%, Jonagold with 6.8%, and Gala with 4.8% (Figure 2).

The production of young trees in nurseries is represented in Fig. 3. This provides information about the future trend of varieties. It follows that the main varieties to be planted in new orchards are :

- Golden Delicious (50%) with the clone B mainly for hill and slope areas and the less russetting-susceptible clones Smoothee and Rheinders for the valley bottoms.
- Gala (16%), with Royal Gala, Mondial Gala, Galaxy.
- Red Delicious (15%): mainly the spur variety Red Chief, but also the standard-types Topred, Hapke, High Early.
- Braeburn (8%).
- Fuji is newly increasing with 4% of the total nursery production.

The first Fuji trees (4000 trees) were planted in 1990. For 1997, 264,000 young trees are available, amounting to 5.6% of the total nursery output. This is still a rather small quantity. It is however the general aim to have Fuji reach 3-5% of the total production, depending on the growing area, by the year 2000.

The advantages of Fuji are seen as follows:

- Fuji achieves the highest prices all over the world. Therefore this variety should be recommended to some extent also in South Tyrol.
- Fuji has very good eating qualities and an excellent storability.
- There are only a few physiological disorders (except watercore).
- Despite of the long growing period, Fuji matures completely in the main growing area. Also in the Po Valley and further south in Italy there are no problems with the late maturity of Fuji.

The problems of Fuji are:

- The rather weak and late formation of the overcolor.
- The fruit is easily affected by watercore; above a certain degree this can lead to the development of brown core during prolonged storage.
- The main problem, however, is biennial bearing: the variety requires sufficient and early thinning in order to achieve good quality and to break the biennial bearing habit.

- Fuji is not well known among European consumers and it is therefore not possible to assess its acceptance.

Recommendations for the Cultivation of Fuji

In order to get early and high yields of best quality, the following measures are recommended:

Plant Material. Fuji is a variety that produces a rather low number of lateral branches. If trees without or with only a few lateral branches are planted, the tree canopy must be formed and developed in the orchard. These circumstances normally bring about vigorous growth and delayed onset of yield.

Because of the improved production techniques in the nurseries, it is now possible to obtain first quality plants also with Fuji (Table 1). These are 1-year-old trees on M.9 and a trunk diameter of at least 11 mm (10 cm above the graft) and with at least 5-7 lateral branches at a height between 50 and 80 cm (20 and 32 inches). Also available are so-called Knip-trees, a 2-year-old nursery tree with a 1-year-old canopy and several flat lateral shoots. With such trees, the initial yields can be significantly increased with Fuji (Fig. 5). The vigor of such trees can thus be contained without much labor (hardly any bending), so that narrower plant distances and higher plant densities are possible.

Plant distances for Fuji on M.9 range from 3-3.2 x 1-1.2m (9.8-10.5 x 3.3-3.9 ft), about 2600-3300 trees/ha (1050-1335 trees/acre).

Improvement of Fruit Color. An improvement of fruit color can be obtained by respecting an optimal leaf/fruit ratio (thinning absolutely essential), with a favorable light distribution in the canopy and in the presence of young, strong fruit wood. Another option is the choice of better colored clones of Fuji. According to our marketing experts, clones with a higher proportion of overcolor and distinct striping have the best chance of commercial success. At the Research Station Laimburg as well as in commercial orchards, mutants of Fuji from different origins are being compared with regard to color intensity and striping.

Of 21 mutants being evaluated, one group of clearly striped types (group A), one group of blushed-striped (group B) and a third group of blushed mutants (group C) have been selected. In Table 2, such clones and origins have been listed according to their color characteristics:

- Group A, the striped types, Kiku 8, Moriho-fu 3A, and Fuji Irradiated Strain, show an optimal striping and an excellent overcolor. Kiku 8 shows striping also on the shadow side, which has

been observed in no other of the examined clones. The other striped types Fuji Standard, Kiku 4, and Yataka achieve sufficient coloring only under especially favorable conditions.

- Group B includes the blushed-striped types. These achieve, depending on the weather conditions, barely sufficient striping in combination with a good overcolor. Naga-fu 12, Naga-fu 6, Kiku 7, Aki-fu 1, BC2, and Fuji 1/1 achieve just sufficient striping for sale.
- Group C includes the completely blushed types. These are Fuji Spur, Naga-fu 1, Naga-fu 2, Kiku 2, Kiku 6, Kobayashi, and Ho-fu. These clones are not being considered for further propagation.

First experiences show that completely blushed clones are somewhat more susceptible to russetting. These clones also show an increased susceptibility to flesh browning during storage. Until now no other differences concerning taste, storability, yield and the biennial bearing tendency have been observed.

Only the mutant Yataka ripens about 5-12 days earlier than the other clones, depending on weather. Also the fruit flesh loses firmness earlier: after 6 months of cold storage penetrometer values of 4.4 kg/cm^2 were recorded for Yataka, and 6.2 kg/cm^2 for standard Fuji.

In summary, from the 21 mutants under examination, the following could be selected as distinct improvements of the standard type with respect to color and striping intensity and are being recommended for cultivation: Kiku 8, Irradiated Strain, Moriho-fu 3A, Naga-fu 12, BC 2.

Biennial Bearing. One of the predominant problems of Fuji is biennial bearing. Thinning of Fuji is more difficult than other varieties, and moreover even sufficient thinning does not always bring about a satisfactory flower bud differentiation for the following year. Therefore, for this variety, chemical thinning assumes paramount importance.

Our thinning trials so far have revealed the following:

- The auxin products NAD and NAA are not suitable for the thinning of Fuji. Firstly, the thinning effect is too low (Tables 3 and 4) and, secondly, there is no increase of fruit size. Often many small fruits, the so-called pigmy fruits, remain after auxin treatments.
- Thinning with Carbaryl is cheaper and more reliable if applied at a mean fruit size of 10-12 mm (measured on 2-year or older wood) and with sufficient water dosage. In our IP-program Carbaryl is admitted only at a dosage of 50 g/1000 liters (25 g a.i./1000 liters) + 100 g mineral oil. The effect of this dosage is often too low for achieving an optimal leaf/fruit ratio (Table 4). In the case of this rather late thinning, the effect on flower bud differentiation for the following year is not always reliable.
- A mixture of NAA+Carbaryl+mineral oil (50+50+100 g/1000 liters) gave a much better result (Tables 3 and 4). The danger of many pigmy fruits remains also with this NAA combination.
- Even more effective has been the application of Ethrel at a dosage of 30 g/1000 liters at the beginning of flowering and, if necessary, to carry out a second treatment with Carbaryl 50 g/1000 liters + mineral oil 100 g/1000 liters at a fruit size of 12 mm (Table 3, treatment 4). With this strategy, not only a good thinning effect can be achieved but also an increased flower bud differentiation and thus a break of the biennial bearing cycle.

For achieving a good effect with chemical thinning, it is important that the tree pruning is performed properly. It can frequently be observed that trees on M.9 have much weak fruit wood in the inner part of the canopy. It is essential that this as well as old, worn-out wood is removed with pruning. Only in this way can chemical thinning achieve a clearly better effect, with positive consequences on quality and biennial bearing.

In any case, hand thinning should also be carried out. This is absolutely necessary for achieving optimal fruit quality in terms of fruit size, color, and in particular with respect to the intrinsic quality parameters. It should be mentioned, however, that the European market in contrast to Japan and other eastern countries does not appreciate very large fruits. For all varieties, fruit sizes above 90 mm (3.5 inches) lose market value or can even not be sold. This fact should be considered for hand thinning. For our pedoclimatic conditions, an ideal leaf/fruit ratio for optimal fruit size and quality as well as for avoiding biennial bearing could be around 30-40 leaves/fruit. Other factors are also of considerable importance, such as equal light distribution in the canopy, good foliage conditions, contained shoot growth, etc.

The determinant role of additional hand thinning is evidenced in the example of Table 4: the mean fruit size could be increased by 23 to 77 g. In addition fruit color, sugar content and therefore quality in general improved.

Harvest and Storage. For the determination of the optimal harvest date in our growing area, the following maturity values are recommended for Fuji:

- Starch index: 3.0-3.5 (scale from 0 to 5). In the range 4 and above, the incidence of watercore clearly increases. In addition, during long-term storage the fruits become softer and have a higher incidence of rots. There is also an increased reduction of acidity (Table 5). Such fruits lose taste (too sweet, insipid).
- Sugar (soluble solids) content: 12.5-14° Brix: fruits with a sugar content lower than 13° Brix are significantly less tasty.
- Acidity: 4.0 - 4.5 g/liter(as malic acid). At harvest under our growing conditions, acid values between 3.5 and 4.5 g/liter are common. After a storage period of 8 months in ULO (1% oxygen and 1% carbon dioxide), the acid content dropped to about 2.5 g/liter. In the case of prolonged shelf-storage, the acid content can drop even below 2g/liter (Table 5), which can have extremely negative consequences on the taste of the fruits.
- Firmness: Penetrometer values should range between 7.5 and 8.5 kg/cm^2. The optimal harvest date in our farming area lies between the 10th and the 15th October. Depending on the weather and the area, this date may vary some days forwards or backwards. Except for watercore Fuji is not susceptible to other physiological disorders (bitter bit, flesh browning, scald, etc.). Scald, however, can become a problem in storage if Fuji is harvested too early. The results in Table 6 show this clearly.

On the other hand, if Fuji is harvested too late, the incidence of watercore increases sharply. Fruits with medium to strong incidence of watercore may be affected by flesh browning in CA storage after February. In extreme cases, formation of caverns can be observed or other typical symptoms of suffocation (anoxia). Overmature fruits are more easily affected by rot fungi. Therefore, the following recommendations are given for the storage of Fuji:

- Healthy fruits or fruits with slight watercore (under 10% of the fruit section area) are suitable for the long-term storage in CA-ULO.
- If the watercore is between 15% and 25% of the fruit section area, a time between 3 and 5 months in the CA-storage with minimum 1.8% oxygen and more than 1.5% carbon dioxide is recommended. Step-cooling is recommended when bringing the apples into the storage room.

- Fruits with more than 25% watercore of the fruit section area are not suitable for CA storage, even if the watercore during storage degrades. Also in such cases irreversible damages to the fruit flesh have been observed, which first lead to flesh browning, then to heavy fermentation processes with concomitant deterioration of the taste.

Fuji is sensitive to carbon dioxide. For a healthy and good product, the following storage conditions are recommended:

Temperature: 0.8 to 1.4°C
Relative humidity: 90-93%
Oxygen: 1.2 to 1.8% (1.2% with healthy fruits harvested early, 1.5-1.8% with mature fruits)
Carbon dioxide: below 1.5%

Acceptance of Fuji by the Consumers

Fuji is barely known in the European markets. Therefore, acceptance by the consumers is difficult to predict. It is a common belief that in the northern countries of Europe sweet-sour apples such as Elstar, Jonagold, Granny Smith, Boskoop, etc. are preferred. In the southern countries, on the other hand, rather sweet apples such as Red Delicious, Golden Delicious, Gala, etc. are preferred. This might no longer be completely true: e.g., the variety Gala, a rather sweet apple, is sold at very good prices also in northern parts of Europe (Germany, Scandinavian countries, etc.). In this case, the crispness and juiciness of the apple as well as the wonderful appearance (color) may be responsible for the high acceptance. It could, therefore, be assumed that Fuji has equally good sale prospects since it is a firm, crisp fruit which maintains these properties even after months of storage.

In all the countries where Red Delicious has encountered good acceptance (e.g., Italy, Spain, France, Yugoslavia, Greece), also Fuji could be accepted without problems. This hypothesis was proved by taste trials in Milan (1000 participants) and Rimini (250 participants) organized by the Research Center Laimburg in cooperation with our producer-organizations VOG, Vi.P and ESO and COO-Ferrara. On these occasions, the unbiased consumers highly appreciated the taste of Fuji in comparison with Braeburn, Gala, Golden Delicious and Jonagold (Table 7). The participants immediately asked where they could buy this variety. This surely is a promising sign for the acceptance of Fuji by Italian consumers.

In the main growing areas in Italy, there is a certain interest in new plantations of Fuji. A study of the Centro Ortofrutticolo in Ferrara has revealed that currently in the regions Emilia Romagna,

Veneto and Piemonte approximately 344 ha (850 acres) are planted with this variety (Table 8). In the last 3 years Fuji was increasingly planted, mainly in the Emilia Romagna region (44-89 ha new plantations per year), but also in Piemonte 20-45 ha per year were planted.

The future will reveal how Fuji will be accepted in the countries of northern Europe. Marketing organizations are challenged to present this new variety to the consumer using a clear marketing concept. Obviously a minimum production of about 50,000 t is necessary for this purpose to provide reasonable advertising.

Today nobody can yet predict whether the strongly increasing plantings of Fuji in other growing areas (South America, USA, Eastern countries and particularly China) as well as the intense discussion about Pink Lady may cause problems for future marketing of Fuji.

Table 1. Feathering of young Fuji trees on M.9: Paturyl (=10% benzyladenine) treatments in the nursery (M. Junker, 1995).

			% trees with branches > 30 cm (12 inches)		
			Number of branches		
Treatment	Dose	Spray times	3	5	8
1. Control	--	--	66 a[z]	40 a	13 a
2. Paturyl + N.M.[y]	0.6% + 0.2%	May 24, June 2, 9 and 16	80 ab	68 b	46 b
3. Paturyl + N.M.	1.0% + 0.2%	May 24, June 2, 9 and 16	84 b	76 b	52 b

[z]values within a column with the same letter are not significantly different.

[y]Tween 20.

Table 2. Evaluation of different strains of Fuji (Stainer—Laimburg, 1993-1996).

Strain	Evaluation[y]	% color	Extent of striping[z]	Group
Kiku 8	+	75	8.0	
Irradiated strain	+	63	6.4	
Moriho-fu 3A	+	60	6.8	A
Fuji standard	-	55	7.0	(striped)
Kiku 4	-	50	6.3	
Fuji standard vf	-	41	7.5	
Yataka	-	40	7.0	
Naga-fu 12	+	80	5.5	
Naga-fu 6	+	71	5.3	
Kiku 7	+	70	5.5	B
Aki-fu 1	+	65	5.4	(intermediate
BC 2	+	64	5.8	blush/striped)
Fuji 1/1	+	62	5.5	
Fuji spur	-	80	2.8	
Naga-fu 1	-	75	3.0	
Naga-fu 2	-	75	2.8	C
Kiku 6	-	70	2.0	(blush)
Kobayashi	-	64	3.3	
Kiku 3	-	60	5.0	
Kiku 2	-	60	3.7	
Ho-fu	-	55	3.0	

[z]Scoring: 1-4 = blush; 5-6 = blush/striped; 7-10 = striped.
[y]'+' equals positive; '-' equals negative.

Table 3. Results of fruit thinning on Fuji/M.9 (Vigl—Laimburg, 1996).

Treatment	Dose (g/1000 liter)	Time of spray	Fruits/ 100 flower clusters	Thinning effect %	Yield (kg/tree)	Fruit size (g/fruit)	Fruit color (%)	% flower buds 1997
1. Control	-	-	63	-	23.8	227	55	23
2. NAD	80	G[z]	65	-3	24.7	224	52	12
3. NAA + Carbaryl + Mineral oil	50+50+100	12 mm	50	21	19.4	251	57	46
4. Ethrel Carbaryl + Mineral oil	30 50+100	F[z] 15	49	22	20.6	266	54	42

[z]=F = beginning of flower time; G = 80% petal fall (according to Fleckinger).

Table 4. Influence of hand thinning on quality of Fuji/M.9 (Vigl—Laimburg, 1995).

Treatment	Time of spray	Thinning effect (%)	Hand thinning: no — Yield (kg/tree)	Hand thinning: no — Fruit size (g/fruit)	Hand thinning: yes — Yield (kg/tree)	Hand thinning: yes — Fruit size (g/fruit)	% flower buds, 1996: no	% flower buds, 1996: yes
1. Control untreated	--	--	39	158	27	217	10	13
2. NAD[z] + mineral oil (0.08% + 0.1%)	G[x]	5	34	149	27	226	7	18
3. Carbaryl + mineral oil (0.05% + 0.1%)	12 mm	9	37	163	27	215	16	30
4. NAA[y] + Carbaryl + mineral oil (0.05% + 0.05% + 0.1%)	12 mm	22	27	207	23	230	52	53

[z]Amid Thin W.
[y]Dirado.
[x]G = 80% petal fall.

Table 5. Influence of 1996 harvest date on starch decrease, firmness, soluble solids and titratable acidity of Fuji (ULO storage: 1% O_2 and 1% CO_2).

Harvest date	Starch (0-5)	Firmness (kg/cm^2): Harvest	Firmness (kg/cm^2): May 12, 1997	Firmness (kg/cm^2): May 26, 1997	° Brix: Harvest	° Brix: May 12, 1997	Titratable acids (g/liter): Harvest	Titratable acids (g/liter): May 12, 1997	Titratable acids (g/liter): May 26, 1997
Sept. 24	2.57	8.08	7.19	6.88	13.4	14.0	4.91	3.15	2.78
Oct. 1	2.90	7.83	7.02	6.83	13.8	13.9	5.07	2.84	2.49
Oct. 8	3.48	7.68	6.90	6.69	14.1	14.4	4.44	2.80	2.25
Oct. 15	4.08	7.45	6.61	6.68	14.3	14.2	4.42	2.50	2.14
Oct. 22	4.20	7.22	6.39	6.15	14.4	13.7	4.00	2.17	1.86

Table 6. Influence of the harvest date on scald incidence on Fuji/M.9, Laimburg, 1996.

	Scald (%) after storage in ULO	
Harvest date	May 12, 1997	After 14 days
September 24	17.0	80.0
October 1	0.0	13.0
October 8	0.0	0.0
October 15	0.0	0.0
October 22	0.0	0.0

Table 7. Sensory evaluation of different apple varieties.

Variety	Appearance[z]	Crispness[z]	Taste[z]
December 14, 1996, in Milano with 1000 participants			
Golden Delicious	2.72	3.03 b	3.10 a
Jonagold	3.37	2.75 c	2.76 b
Gala	3.30	2.80 c	2.77 b
Braeburn	2.95	3.12 a	2.78 b
Fuji	3.01	3.16 a	3.10 a
February 12, 1997, in Rimini with 250 participants			
Golden Delicious	2.29 b	2.84 b	2.94 b
Jonagold	3.51 a	2.52 b	2.82 b
Gala	3.07 b	2.44 b	2.62 b
Braeburn	2.78 b	3.20 a	2.90 b
Fuji	2.84 b	3.35 a	3.26 a

[z] Values followed by the same letter are not significantly different.

Table 8. Newly planted orchards of Fuji in Italy (COO, Ferrara).

	Area (ha)						
Region	1992	1993	1994	1995	1996	1997	Total ha
Emilia-Romagna	7	5	6	89	44	76	227
Veneto	4	2	0	6	12	8	32
Piemont	0	6	6	5	45	23	85
Total	11	13	12	100	101	107	344

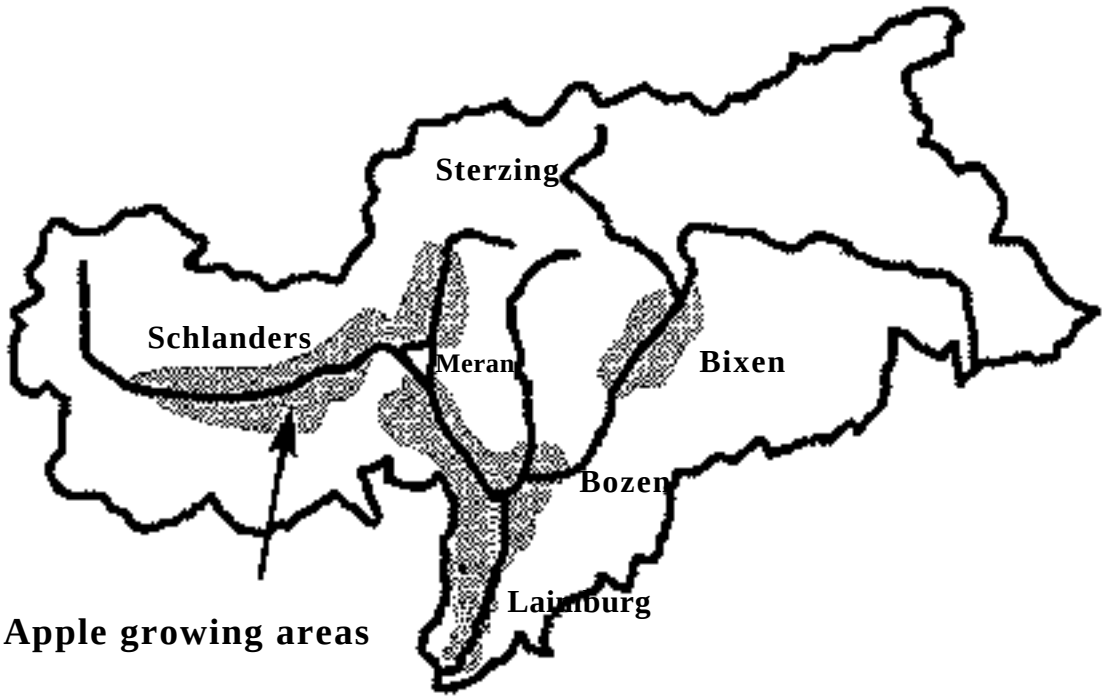

Figure 1. Apple growing areas in South Tyrol, Italy

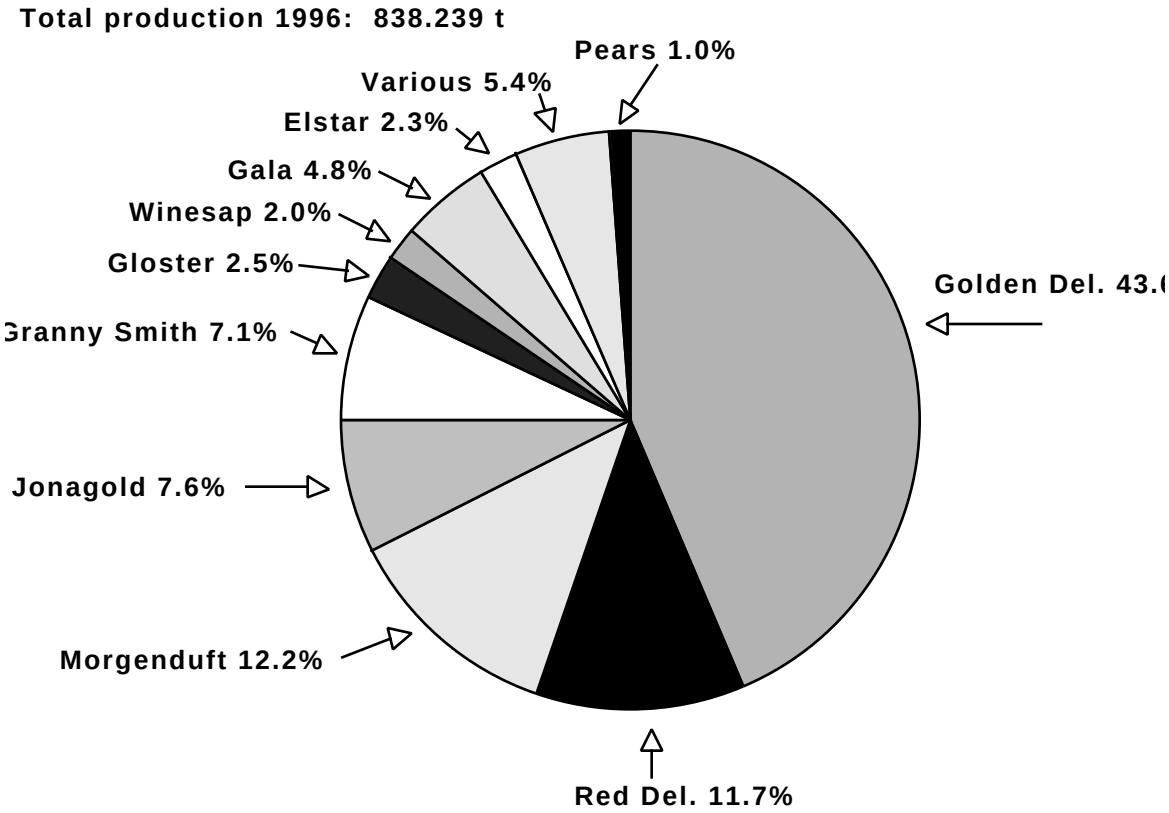

Figure 2. Production of apples and pears (%) 1996 in South Tyrol.

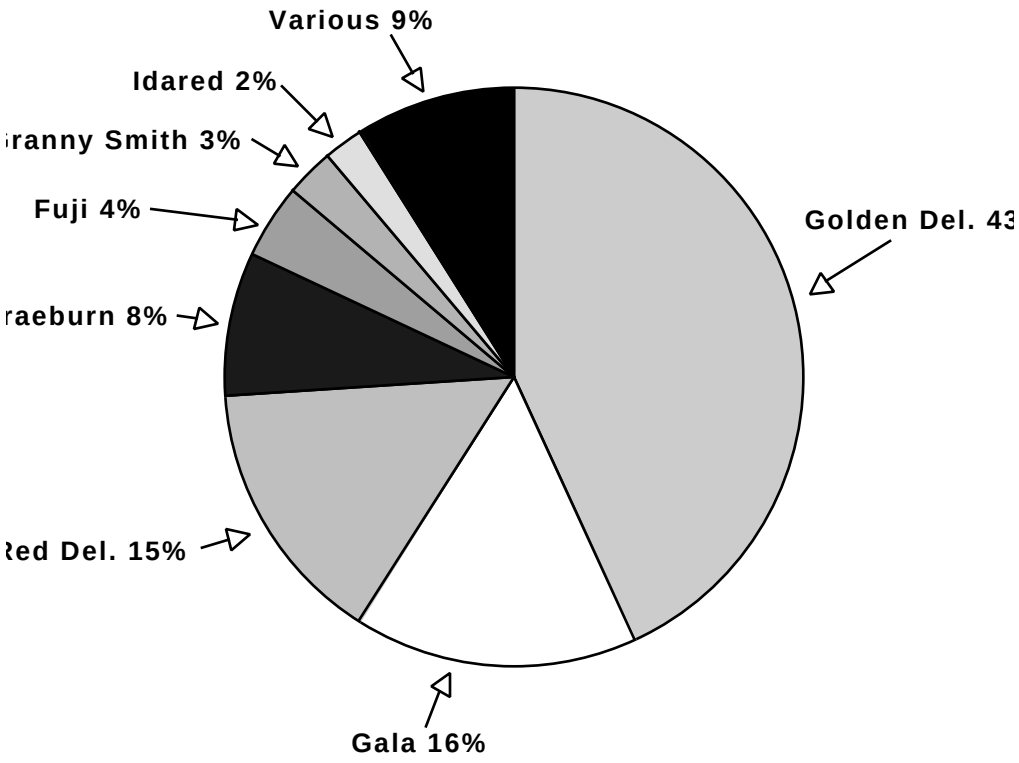

Figure 3. Production of young trees (%) in South Tyrolean nurseries, 1996/97.

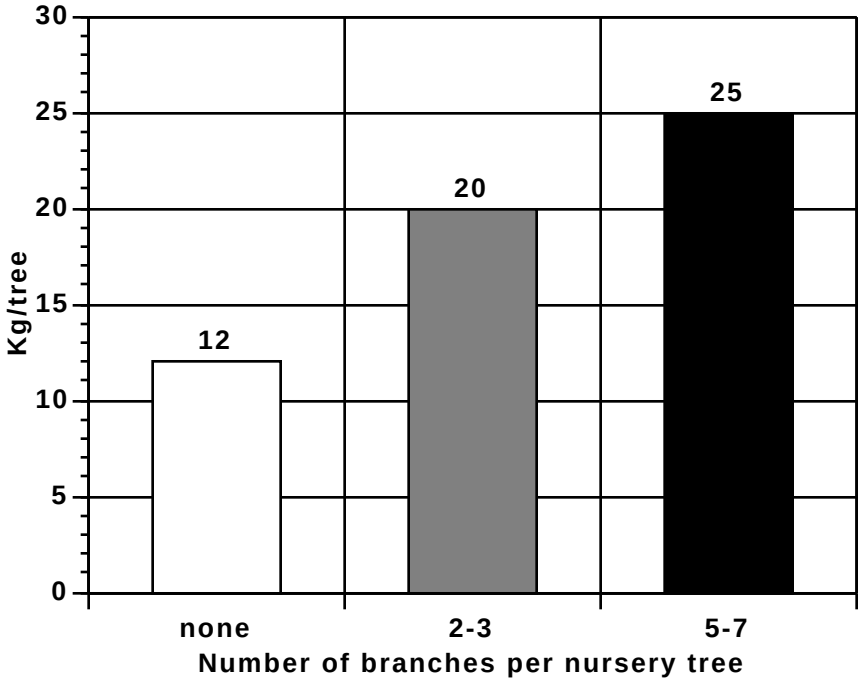

Figure 4. Cumulative yield (kg/tree) until 4th leaf with different planting material of Fuji/M.9.