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Apple growing potentials in Europe. 2. Flowering dates[1]

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Summary

A method of calculating flowering dates of apple in Europe is presented, based on dates of fulfilment of the cold requirement, temperature sums and minimum temperature per month. Calculated and reported dates were compared. With the exception of the most southern part of the growing area an acceptable agreement was found. Differences between both values were less than 5 days in 65 % of the cases, which is less than 5-2½ % of the duration of the period that apples are hanging on the trees.

Introduction

Production of apples occurs in a large part of Europe: from the highlands of Spain and the north of Italy in the south to Denmark and southern Sweden in the north. The possibilities of production are roughly determined by the fulfilment of the cold requirement in the south and the prevailing temperatures and the duration of the season — the period between blossoming and picking of the apples — in the north.

In a previous paper Kronenberg (1979) gave information on the southern border of the growing area. Kronenberg (1983) provided information on the relationship between temperatures in spring and the blooming dates of apple trees. The present and past information opens up possibilities to calculate flowering dates of apples in spring. It is necessary to try to calculate these dates, since phenologically determined dates are rather scarce. Only fruit-growing experimental stations nowadays gather this type of information, and it is a pity that in most cases these facts are available over only a rather short period.

This paper supplies a method of calculation of the beginning of apple blossoming based on a comparison between available phenological data and calculations.

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Method of approximation

The early-flowering cultivar 'Schone van Boskoop' and the late-flowering 'Golden Delicious' were chosen for this purpose.

All known fruit research stations in Europe were asked to provide information on flowering of both cultivars. Reactions are brought together in Table 1, the last column of which gives the names of meteorological stations used in calculating the temperature sums. The selection of these stations was based on:

— availability of truthworthy data
— distance to the fruit growing station
— situation with regard to this station and the nearby situated fruit growing area.

Data of the cultivars 'Schone van Boskoop' and 'Golden Delicious' were available from nearly all stations. However, different states of flowering, 5-80 % of open flowers were registered. To make a comparison possible, all reported dates were corrected to 20 % of open flowers (the Wilhelminadorp method) with a correction factor of 1 day per 10 % more or less open flowers. These data are brought together in Table 2, which shows that differences in days for Commentry and Ujfehérto are exceptionally large, without a possible explanation. For the rest it holds true that in

Table 1. Fruit growing research stations and nearby meteorological stations.

Country	Place	Cultivar	Number of years	Meteorological station (estimated distance in km from fruit growing station)
Denmark	Odense	Golden Delicious	6	Odense (5)
England	Long Ashton	Golden Delicious	5	Cardiff (68)
				Pershore (82)
	Faversham	Schone van Boskoop	10	Dungeness (44)
		Golden Delicious	10	Felixstone (78)
the Netherlands	Wilhelminadorp	Schone van Boskoop	10	Vlissingen(20)
		Golden Delicious	10	
West Germany	York	Schone van Boskoop	*	Bremen (90)
		Golden Delicious	*	Hamburg (20)
Belgium	St Truiden	Schone van Boskoop	39	Eindhoven (75)
		Golden Delicious	39	
France	Bordeaux	Schone van Boskoop	5-17	Bordeaux (5)
		Golden Delicious	5-17	Cognac (110)
	Commentry	Schone van Boskoop	15	Limoges (80)
		Golden Delicious	15	St Etienne (80)
West Germany	Bavendorf	Schone van Boskoop	20	Friedrichshafen (40)
		Golden Delicious	20	Zürich (80)
Hungary	Ujfehérto	Schone van Boskoop	5	Nylregheza (10)
		Golden Delicious	5	Debrecen (50)
Italy	Laimburg	Schone van Boskoop	7	Venezia (150)
		Golden Delicious	7	Padova (100)
	Bologna	Schone van Boskoop	*	Padova (80)
		Golden Delicious	*	Bologna (5)

* Not reported.

Table 2. Flowering dates (day/month) of the apple cultivars 'Schone van Boskoop' and 'Golden Delicious' in Europe (moment of 20 % of flowers open).

Place	Cultivar	Reported date (in some cases corrected)	Difference	Minimum temperature (°C)	Calculated date	Number of days that reported is	
						earlier	later
Odense	Golden Delicious	18/5		5.5	21/5	3	
Long Ashton	Golden Delicious	8/5		5.5	4/5		4
Faversham	Schone van Boskoop	3/5	5	4	22/4		12
	Golden Delicious	8/5		5.5	3/5		5
Wilhelminadorp	Schone van Boskoop	3/5	5	4	3/5		
	Golden Delicious	8/5		5.5	8/5		
York	Schone van Boskoop	12/5	1	4	7/5		5
	Golden Delicious	13/5		5.5	9/5		4
St Truiden	Schone van Boskoop	24/4	5	4	27/4	3	
	Golden Delicious	29/4		5.5	29/4	0	
Bordeaux	Schone van Boskoop	8/4	7	4	22/3		17
	Golden Delicious	15/4		5/5	29/3		17
Commentry	Schone van Boskoop	11/4	18	4	13/4	2	
	Golden Delicious	29/4		5.5	26/4		3
Bavendorf	Schone van Boskoop	6/5	4	4	4/5		2
	Golden Delicious	10/5		5.5	7/5		3
Ujfehérto	Schone van Boskoop	20/4	14	4	24/4	4	
	Golden Delicious	4/5		5.5	28/4		6
Laimburg	Schone van Boskoop	19/4	0	4	11/4		8
	Golden Delicious	19/4		5.5	11/4		8
Bologna	Schone van Boskoop	13/4	2	4	8/4		5
	Golden Delicious	15/4		5.5	8/4		7

the north and the middle of Europe 'Schone van Boskoop' flowers earlier than 'Golden Delicious' and in the southern part both cultivars flower nearly at the same time. This is in agreement with the fact that calculated minimum temperatures in 'Golden Delicious' are higher than in 'Schone van Boskoop' (Kronenberg, 1983).

A next step was to compare reported flowering and calculated dates. Calculation was based on the date of fulfilment of the cold requirement (Kronenberg, 1979) and the temperature sums of Wilhelminadorp (551 degree-days for 'Schone van Boskoop' and 612 degree-days for 'Golden Delicious'). Minimum temperatures were based on Kronenberg (1983). Temperatures were taken from Thran & Broekhuizen (1965). Temperatures of a certain station, however, were corrected if there was a difference between the situation above sea level of the fruit growing station and the meteorological station with 0.6 °C per 100 m difference. A further correction was used if data from more than one meteorological station were used. In that case an average value of both was taken. The results of these calculations are given in Table 2. 'Reported dates' are earlier than calculated in 4 cases and later in 15 cases, which means that minimums must be a bit higher than the values used. Data of four stations differ considerably: Faversham, Bordeaux, Laimburg and Bologna. The

Table 3. Observed and calculated dates of flowering (day/month) of apple cultivars 'Schone van Boskoop' and 'Golden Delicious' in Europe.

Place	Cultivar	Number of days between fulfilment of cold requirement and flowering	Reported flowering date	Calculated flowering date with 2 days correction	Number of days that reported is	
					earlier	later
Odense	Golden Delicious	138	18/5	23/5	5	
Long Ashton	Golden Delicious	106	8/5	6/5		2
Faversham	Schone van Boskoop	102	3/5	24/4		(10)
	Golden Delicious	107	8/5	5/5		3
York	Schone van Boskoop	131	12/5	9/5		3
	Golden Delicious	132	13/5	11/5		2
St Truiden	Schone van Boskoop	93	24/4	29/4	5	
	Golden Delicious	98	29/4	31/4	2	
Bordeaux	Schone van Boskoop	69	8/4	31/3*		7
	Golden Delicious	76	15/4	7/4*		7
Commentry	Schone van Boskoop	85	11/4	15/4	4	
	Golden Delicious	103	29/4	28/4		1
Bavendorf	Schone van Boskoop	124	6/5	6/5	0	
	Golden Delicious	128	10/5	9/5		1
Ujfehérto	Schone van Boskoop	110	20/4	26/4	6	
	Golden Delicious	124	4/5	30/4		4
Laimburg	Schone van Boskoop	51	19/4	21/4*	2	
	Golden Delicious	51	19/4	21/4*	2	
Bologna	Schone van Boskoop	80	13/4	18/4*	5	
	Golden Delicious	82	15/4	18/4*	3	

* Correction 10 days.

deviation reported by Faversham on 'Schone van Boskoop' is inexplicable. All three others have rather high temperatures in spring and periods between fulfilment of cold requirement and flowering of only 76, 51 and 82 days, which is rather short compared with the rest of Europe (98-138 days).

If calculated flowering dates in northern and central Europe are corrected with 2 days and in southern Europe with 10 days the best fit comes out. Table 3 gives the results of these corrections. The following example demonstrates the method of calculation in the case of 'Golden Delicious' in Odense. Temperature sum Wilhelminadorp 612 with a base temperature of 0 °C; with 5.5 °C the temperature sum is 133, calculated as follows:

Average montly temperature Vlissingen		With base temperature 5.5 °C
March	5.2	–
April	8.4	2.9
May	12.1	6.6

Temperature sum $30 \times 2.9 + 7 \times 6.6 = 133.2$

Odense: fulfilment of cold requirement 30/12 (Kronenberg, 1979).

Fig. 1. Calculated potential average flowering dates of the apple cultivator 'Schone van Boskoop'. Broken lines: supposed.

Average monthly temperature Odense (no corrections needed)		With base temperature 5.5 °C
December	1.8	–
January	0.2	–
February	0.2	–
March	2.0	–
April	6.0	0.5
May	11.2	5.7

$30 \times 0.5 + 20.7 \times 5.7 = 133$. The required temperature sum is reached at 21 May. Trees flower on 21 + 2 = 23 May.

A last step was to calculate for all places mentioned in Table 1 of Kronenberg, 1979, flowering dates of the cultivars 'Schone van Boskoop' and 'Golden Delicious'. If the number of days between fulfilment of cold and flowering was 90 or less, a correction of 10 days was applied; in all other cases only 2 days (Table 4).

Table 4. Dates on which 'Schone van Boskoop' (S.v.B.) and 'Golden Delicious' (G.D.) trees start flowering in 119 places in Europe.

Place	Date (day/month)		Place	Date (day/month)	
	S.v.B.	G.D.		S.v.B.	G.D.
Marseille	18/4	16/4	Odessa	17/5	19/5
Perpignan	14/4	8/4	Bukarest	27/4	26/4
Split	7/4	3/4	Limoges	23/4	22/4
Pescara	23/4	26/4	Edinburgh	19/5	28/5
Ancona	9/4	8/4	Claremorris	27/4	15/5
Biarritz	9/4	7/4	London	21/4	5/5
Cherbourg	5/5	17/5	Slåttersy	27/5	3/6
Brawdey	5/5	15/5	Stavanger	1/6	7/6
Cognac	11/4	12/4	Eelde	6/5	8/6
Dinard	25/4	8/5	Eindhoven	24/4	1/5
Brest	15/4	19/4	Trappes	24/4	1/5
Valley	27/4	13/5	Praga	7/5	7/5
Valentia observarory	17/4	28/4	Stornoway	10/5	6/5
Venezia	13/4	16/4	Chaermont	26/4	3/5
Mount Batten	21/4	5/5	Skagen	28/5	1/6
Carcassone	30/3	4/4	Karlsruhe	23/4	29/4
Stalin	23/4	26/4	West Raynham	2/5	15/5
Tiree	13/5	22/5	Wahnsdorf	14/5	15/5
Toulouse	3/4	11/4	Dublin	11/4	28/4
Nantes	16/4	24/4	Aberdeen	22/5	3/6
Poitiers	17/4	24/4	Oban	13/5	22/5
Bordeaux	1/4	9/4	Bremen	9/5	11/5
Felixstone	1/5	5/5	Trier	4/5	11/5
Rennes	17/4	27/4	Frankfurt a/M.	29/4	4/5
Shannon	28/4	10/5	Emden	12/5	14/5
Beograd	27/4	30/4	St Etienne B	28/4	5/5
Milano	18/4	18/4	Exeter	3/4	26/4
Cardiff	30/4	5/5	Hantsholm	25/5	30/5
Malin Head	25/4	14/5	Bydgoszer	18/5	12/5
Acklington	19/5	27/5	Nancy	28/4	4/5
Blackpool	3/5	14/5	Wick	15/5	24/5
Spurn Head	5/5	18/5	Kiel	20/5	24/5
Pershore	26/4	9/5	Friedrichshafen	5/5	9/5
Dungeness	25/4	5/5	Freistadt	8/5	8/5
Den Helder	4/5	7/5	Osnabrück	8/5	9/5
De Bilt	30/4	4/5	Caen	11/5	27/4
Valkenburg (Z.H.)	2/5	7/5	Hela	2/5	3/6
Zeebrugge	4/5	10/5	Stettin	14/5	16/5
Lille	29/4	6/5	Halle	7/5	8/5
Duinkerken	27/4	6/5	Göteborg	22/5	27/5
Ambérieu	26/4	2/5	Hamburg	12/5	13/5
Chatillon sur Seine	29/4	26/4	Potsdam	11/5	11/5
Köln	21/4	2/5	Byglandsfjord	29/5	2/6
Constanta	27/4	30/4	Odense	19/5	23/5

Table 4 (continued)

Place	Date (day/month) S.v.B.	G.D.	Place	Date (day/month) S.v.B.	G.D.
Lärwick	8/6	23/5	Zürich	6/5	9/5
Muhldorf	15/5	18/5	Kråkenesfyr	5/6	12/5
Warszawa	11/5	11/5	Uppsala	6/6	6/6
Karup	21/5	25/5	Turku	6/6	6/6
Allenstein	15/5	18/5	Tampere	6/6	7/6
Kiev	12/5	13/5	Gorky	26/5	23/5
Kironograd	11/5	12/5	Domnarvet	5/6	5/6
Brønnøsund	18/6	21/6	Voshiy Voloshek	30/5	28/5
Jönköping	5/6	5/6	Vallersud	11/6	12/6
Stockholm	6/6	6/6	Smolensk	25/5	23/5
Karlstad	3/6	2/6	Voronez	13/5	15/5
Riga	27/4	25/4	Nyland	16/6	18/6
Tallin	6/6	6/6	Lillehammer	4/6	4/6
Leningrad	6/6	6/6	Kajaaini	18/6	21/6
VelikieLuke	–	–	Gunnarn	23/6	24/6
Kwisk	20/5	20/5			

Places are given in the same sequence of Table 1 (Kronenberg, 1979). Plotting on a map of Europe results in Fig. 1.

Discussion and conclusions

Dates of Table 4 are based on phenological observations and calculations. It is a well known fact that registration of 20 % flowering may be 1-2 days in error. Furthermore, surveying Table 1, it is clear that number of years of observations differ between 5 and 39 and that differences between early- and late-flowering cultivars are sometimes inexplicably small or large. Different inexactitudes are therefore introduced in Tables 2 and 3. The introduction of a supplement of 2 or 10 days respectively is arbitrary and only done to get the best fit. The supplement of 2 days is acceptable in view of the rather extreme situation of Vlissingen compared with other places on the continent. A supplement of 10 days in the case of 3 rather southern situated stations can only be accepted because minimum temperatures as produced by Kronenberg (1983) do not hold quite near the 1000 hours under 7 °C line; apple trees there have a slower reaction than calculated. All the same, differences between reported and calculated date of flowering are less than 1 day in 5 % of the cases, less than 2 days in 15 %, less than 3 days in 40 %, less than 4 days in 55 %, less than 5 days in 65 %, and less than 6 days in 80 % of the cases.

It has to be remembered that the central purpose of this study was to fix the beginning of the period in which apples hang on the trees. The duration of this season differs roughly between 100 and 200 days and a misestimation of the beginning of the flowering with e.g. 5 days means errors between 5 and 2½ %.

The information used above is from 12 fruit growing stations scattered over Europe. In most apple growing areas there was a responding station, but there is an overrepresentation in the north (with about 5 % of the production) and an underrepresentation in the south (with about 35 % of the production). After all, results can be considered rather representative for Western Europe.

Conclusions from the above can be summarized as follows. It was possible to estimate date of flowering of apple trees based on calculation. Comparison with reported dates yielded a difference of less than 5 days in 65 % of the cases. Reported dates have normally an inexactness of ± 1 day. The beginning of the 'season' with a duration of 100-200 days could be calculated with a 5-2½ % aberration in 65 % of the cases. It became clear that minimum temperatures as reported by Kronenberg (1983) were of restricted value for areas near the southern border of the apple-growing area.

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