

## Effect of flower bud position on fruit set and fruit size in apple

*Betydning af blomsterknoppens placering på frugtsætning og frugtstørrelse hos æble*

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### Summary

The apple cultivars 'Boskoop', 'Cox's Orange', 'Discovery', 'Elstar', 'Gloster', 'Golden Delicious', 'Ingrid Marie', 'Jonagold' and 'Summerred' were investigated for their flowering and fruiting habit. The most pronounced spur flowering cultivars are 'Boskoop', 'Cox' and 'Ingrid Marie', however 'Discovery' and 'Gloster' also have the main flowering on spurs.

'Jonagold', 'Golden Delicious', and 'Summerred' are typical shoot flowering cultivars. All cul-

tivars flowered on extension shoots, but on 'Cox' and 'Boskoop' this was negligible.

Fruit set is generally best on brindles and poorest on shoots. There are great differences in the fruit set level between the cultivars. Fruit size is not influenced by position for 'Summerred', 'Cox' and 'Elstar', while the other cultivars have smaller fruits on shoots.

'Jonagold' is the only cultivar that may bear as much as half of the fruit on shoots.

**Key words:** Apple, flower position, fruit set, fruit size.

### Resumé

Æblesorterne 'Boskoop', 'Cox's Orange', 'Discovery', 'Elstar', 'Gloster', 'Golden Delicious', 'Ingrid Marie', 'Jonagold' og 'Summerred' er undersøgt for deres blomstrings- og frugtsætningsmønster. Sorterne 'Boskoop', 'Cox' og 'Ingrid Marie' er typisk sporebærende, men også 'Discovery' og 'Gloster' bærer en stor del af blomsterne og frugterne på sporer.

'Jonagold', 'Summerred', 'Golden Delicious'

og 'Elstar' bærer typisk mange blomster på årsskuddene fra foregående år. For alle sorter er der fundet blomstring på årsskuddene, men hos 'Boskoop' og 'Cox' var denne blomsterplacering dog ubetydelig.

Frugtsætningen er generelt bedst på langsporer og dårligst på årsskuddene og med kortsporer næsten på højde med langsporerne. Der er fundet store forskelle i frugtsætning mellem sorter og år.

Frugstørrelsen på de tre skudtyper var ens for 'Elstar', 'Summerred' og 'Cox', mens frugter på årsskuddene var mindre end på kortsporer og langsporer hos de øvrige sorter. Frugtprodukti-

onen på årsskuddene udgør en stor andel hos 'Jonagold', 'Summerred', 'Elstar' og 'Golden Delicious'. For 'Jonagold' blev op mod halvdelen af frugterne båret på årsskud.

**Nøgleord:** Æble, blomsterkvalitet, frugtsætning, sorter, frugstørrelse.

## Introduction

Flowers on apple trees are normally formed on spurs, as terminal or lateral buds on brindles and as lateral or terminal buds on the annual shoots.

It has been known for long time that flower buds on spurs and extension shoots may not give the same fruit quality. *Blank et al.* (1) consider flowers on extension shoots of 'Golden Delicious' as inferior. On the other hand *Ferree* (3) points out that old spurs result in reduced fruit size. For 'Cox' *Jackson* (4) has shown that there seems to be an optimum branch age of four years to give the biggest fruit size. *Goldwin* (5) found that terminal flowers had better fruit set and fruit size than lateral flowers on the same shoot types. Inside the cluster competition occurs, and *Lakso* and *Goffinet* (7) have shown that the king flowers are more dominating than the laterals. As shown by *Edminster* (2) branch angle can influence flower bud formation.

The aim of this investigation was to elucidate if old and new cultivars show different patterns in the flowering on shoot types, in fruit set, and fruit size.

## Materials and methods

This investigation was carried out on single branches. Each year 20 branches per cultivar were selected on spindle trees planted in spring 1983. The investigation was conducted in 1985, 1986 and 1987. The selected branches were 2 or 3 years old. As an attempt to exclude branch angle influence on the results, all selected branches were near to horizontal. Every branch was divided into spurs, brindles, and shoots.

As the trees were trained as spindle trees, the branches may be pruned. Pruning will remove vertical shoots, which will cause a reduction in the number of shoots. A spur is defined as a shoot of less than 5 cm, a brindle is a shoot from the preceding year with a length between 5 and 20 cm and typically with a well developed terminal flower bud. A shoot is defined as an extension shoot

from the preceding year, one branch may have a terminal and some lateral extension shoots.

The number of spurs, brindles, and shoots were counted as well as the number of flower clusters and later the number of fruits. Fruit size was also determined.

Flower distribution and flower intensity on shoot types was calculated as p.c. on the single branches and the statistical analysis were performed on the p.c. figures. Using this method calculations across tables cannot be done.

The statistical analysis were made with the General Linear Model Procedure (GLM) in the PC-SAS (Statistical Analysis System).

## Results

For all cultivars the three shoot types were present on the branches selected, Table 1. Over the

**Table 1.** Number of the three shoot types per branch. Antal kortsporer, langsporer og årsskud pr. gren. Gns. af tre år.

Cultivar (Mean of years)	Spurs <i>Kortsporer</i>	Brindles <i>Langsporer</i>	Shoots <i>Årsskud</i>
'Boskoop'	15.5	3.6	1.4
'Cox's Orange'	16.3	2.6	2.4
'Discovery'	8.6	2.7	1.9
'Elstar'	11.4	4.4	2.3
'Gloster'	9.1	2.7	1.6
'Golden Delicious'	7.9	2.2	1.7
'Ingrid Marie'	8.9	4.0	2.3
'Jonagold'	8.9	2.4	2.4
'Summerred'	12.2	2.3	2.2
Mean	11.0	3.0	2.0
LSD	1.2	0.6	0.4
Year (Mean of cultivars)			
1985	8.7	2.8	2.2
1986	10.1	3.6	2.0
1987	14.0	2.5	1.7
LSD	0.7	0.4	0.2

three years the number of spurs per branch increased, while the number of brindles and shoots decreases slightly.

As mean of the nine cultivars 44 p.c. of the flowers were on spurs, but for 'Cox's Orange', 'Ingrid Marie' and 'Boskoop' more than half of the flowers were on spurs, while 'Jonagold' only had 17 p.c., Table 2. 'Discovery' and 'Gloster' also had a large number of flowers on spurs. All cultivars had about 20–30 p.c. of the flowers on brindles, 'Boskoop' and 'Elstar' having the largest number, Table 2.

Flowering on shoots was found in all nine cultivars, but the differences were great. 'Boskoop' had very few and 'Jonagold' had most of the flowers on shoots. 'Golden Delicious' and 'Summerred' are also typical shoot flowering cultivars, while 'Discovery', 'Elstar' and 'Gloster' are intermediate.

Table 3 shows the frequency of flowering on the different positions for the nine cultivars. All cultivars except 'Boskoop' had flowering on more than half of the spurs. Most cultivars had more than one cluster on each brindle, indicating lateral flowering on the brindles.

Although all cultivars flowered on shoots, 'Cox's Orange' and 'Boskoop' as mean had only

**Table 2.** Flower distribution on shoot types. P.c. of total. *Fordeling af blomsterklaser på skudtyper. Gns. af tre år og årsforskelle. Pct. af totalantal.*

Cultivar (Mean of years)	Spurs	Brindles	Shoots
'Boskoop'	58	34	8
'Cox's Orange'	66	17	17
'Discovery'	46	21	33
'Elstar'	39	28	32
'Gloster'	47	21	31
'Golden Delicious'	30	21	49
'Ingrid Marie'	54	19	27
'Jonagold'	17	20	62
'Summerred'	40	15	45
Mean	44	22	34
LSD	5.7	4.9	5.8
Year (Mean of cultivars)			
1985	26	22	52
1986	41	28	32
1987	63	17	21
LSD	3.3	2.8	3.4

**Table 3.** Flower clusters per shoot for each shoot type. Mean of three years.

*Blomsterklase frekvens på skudtyper. Gns. af tre år. Klaser pr. skud.*

Cultivar (Mean of years)	Spurs	Brindles	Shoots
'Boskoop'	0.4	1.2	1.0
'Cox's Orange'	0.6	0.9	1.2
'Discovery'	0.8	1.2	3.0
'Elstar'	0.6	1.1	3.5
'Gloster'	0.7	1.0	3.1
'Golden Delicious'	0.7	1.8	6.2
'Ingrid Marie'	0.7	0.8	2.0
'Jonagold'	0.6	2.9	9.3
'Summerred'	0.6	1.2	4.8

one cluster per shoot, Table 3. The other cultivars had some clusters per shoot.

In Table 2 it can be seen that the ratio of flowering on the different positions changes through the three years. The number of flowers on spurs increased as the trees grew older, and flowering on shoots decreased relatively.

However, 'Jonagold', 'Golden Delicious', 'Summerred' and 'Elstar' maintain a very high ratio of flowering on shoots. (Data not shown).

Fruit set is shown in Table 4. Generally considerable differences were found between the cultivars.

'Gloster' and 'Summerred' had the highest fruit set. 'Elstar' also had a high fruit set. In 'Discovery' and 'Golden Delicious' no differences were seen in fruit set, in the different positions. All other cultivars showed significant differences.

The general tendency was that brindles had the highest fruit set. It was only significantly higher for 'Summerred'. For 'Ingrid Marie' it was significantly higher than spurs, while for 'Jonagold' it was significantly lower. For 'Summerred', 'Cox's Orange', 'Ingrid Marie', 'Elstar', 'Boskoop', and 'Gloster' fruit set was markedly lower on shoots than on spurs and brindles.

Table 5 shows the number of fruits per branch and the distribution. For most cultivars spurs are the dominating fruit position, but for 'Summerred', 'Jonagold' and 'Golden Delicious' the extension shoots are responsible for much of the fruit due to heavy flowering here, Table 2. For 'Jonagold' as much as half of the fruit was produced on shoots.

**Table 4.** Fruit set expressed as fruit per 100 flower clusters.

*Frugtsætning som frugter pr. 100 klaser. Gns. af tre år og årsforskelle.*

Cultivar (Mean of years)	Spurs	Brindles	Shoots	LSD
'Boskoop'	37	33	5	15
'Cox's Orange'	80	109	18	30
'Discovery'	42	58	45	n.s.
'Elstar'	98	117	59	30
'Gloster'	121	104	52	26
'Golden Delicious'	53	42	47	n.s.
'Ingrid Marie'	59	92	45	24
'Jonagold'	99	30	29	19
'Summerred'	115	161	98	41
LSD	20.5	26.3	21.7	
Year (Mean of cultivars)				
1985 mean	85	74	23	
1986 mean	58	70	45	
1987 mean	97	107	83	
LSD	12.0	15.4	12.4	

Fruit size was about the same on brindles and spurs, but significantly smaller on shoots for all cultivars except 'Summerred', 'Cox's Orange' and 'Elstar', which did not show significant differences between the positions, Table 6. With the exception of 'Jonagold' and 'Boskoop' the other cultivars had significantly different fruit size over the three years.

## Discussion

Distribution of flowers between shoot types is characteristic for the cultivars, but also the tree age will influence the distribution with older trees having more spurs with flowers.

It is here shown that the flower quality is differing between positions, and it is mainly shoot flowers, which has a poor fruit set and fruit quality in some cultivars. Not only the amount of flowers is important, but also the differences in fruit set between flower position and cultivars result in the amount of fruit produced on different shoot types.

**Table 5.** Number of fruits produced on the different positions per branch.

*Antal frugter pr. gren fordelt på de tre positioner. Gns. af tre år og årsforskelle.*

Cultivar (Mean of years)	Branch	Spurs	Brindles	Shoots
'Boskoop'	3.3	2.2	1.1	0.1
'Cox's Orange'	10.3	7.4	2.6	0.3
'Discovery'	7.4	2.9	1.8	1.7
'Elstar'	12.7	5.5	4.8	2.4
'Gloster'	11.2	6.4	2.8	2.0
'Golden Del.'	8.4	3.1	1.4	3.9
'Ingrid Marie'	8.0	3.7	2.6	1.7
'Jonagold'	12.4	4.4	1.9	6.1
'Summerred'	17.5	7.7	3.5	6.3
Mean		4.8	2.5	2.7
LSD		1.4	1.0	1.1
Year (Mean of cultivars)				
1985	8.7	3.8	2.1	2.8
1986	9.1	3.8	2.7	2.6
1987	12.0	6.8	2.6	2.6
LSD		0.8	0.6	0.6

It is obvious that the growth habit of the cultivars is different and that pruning therefore must differ.

In spur bearing cultivars as 'Boskoop' and 'Cox's Orange' branches may be left for many years, saving as many spurs as possible. However, as pointed out by Jackson (4), old branches may produce fruit of reduced size. This could also be a result of shading as discussed by Ferree (3), Jackson (4), and Verheij and Verwer (9).

The pruning of typical spur bearing cultivars should concentrate on branch thinning and removal of extension shoots, but always leaving one shoot per branch to prevent too much annual growth. Renewing branches on such cultivars takes three years and should therefore only be done, if fruit size decreases.

This investigation does not primarily deal with age of wood as a possible reason for reduced fruit size, but there was a reduction in fruit size as the trees grew older. This reduction could also be caused by a higher number of fruits, Table 5 and 6.

**Table 6.** Fruit size on the different positions. g/fruit.  
*Frugtstørrelse afhængig af frugtposition. Gns. af tre år og årsforskelle.*

Cultivar (Mean of years)	Spurs	Brindles	Shoots	LSD 1	LSD 2
'Boskoop'	165	162	116	11.5*	n.s.
'Cox's Orange'	91	85	99	n.s.	***
'Discovery'	99	104	92	6.5***	***
'Elstar'	114	108	112	n.s.	***
'Gloster'	137	134	118	10.4***	***
'Golden Delicious'	121	117	102	9.9***	***
'Ingrid Marie'	122	114	97	10.4***	***
'Jonagold'	152	150	135	9.4***	n.s.
'Summerred'	105	111	107	n.s.	***
Mean	123	119	110		
LSD	8.0	9.6	9.9		
Year (Mean of cultivars)					
1985	132	133	122		
1986	129	122	108		
1987	111	103	100		
LSD	4.7	5.5	5.7		

LSD 1 is difference between fruit position. LSD 2 is difference in fruit size between years.

However, this investigation shows reduced fruit size on one year old wood, compared with two or three year wood, which is in agreement with *Blank et al.* (1) and *Silbereisen* (8) who report the same for 'Golden Delicious'.

For other cultivars, which flower and set fruit on shoots, in the second year, renewing of branches only take one year and may therefore take place continuously to avoid shaded parts of the canopy. If fruit size is too small on the young shoots, cutting back one year old wood could be a method of improving fruit size, and a useful strategy for shoot bearing cultivars as 'Golden Delicious', 'Jonagold', 'Summerred' and 'Elstar'.

The results in this investigation show that the fruit size for most cultivars is smaller on shoots than on spurs. For such cultivars fruit on shoots should be avoided if there are size problems in the orchard.

But for a big fruited cultivar as 'Jonagold' the size reduction may not be a problem and shoots can be intensively used. The same may be the case

for 'Summerred' and 'Elstar' as their fruit is of comparable size on spurs and on shoots. However, in the case of very heavy fruiting, growth may be checked too much as mentioned by *Grunow* (6) for 'Jonagold'. In such situations the use of too many shoots for fruit production may result in bent branches due to the thin shoots and the heavy fruit load.

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