

## Determination of the optimum time for mechanical harvesting of strawberry (*Fragaria ananassa*)

Bestemmelse af optimalt høsttidspunkt for jordbær (*Fragaria ananassa*) til maskinhøst

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### Summary

With the aim of developing a method for the determination of the optimum time of once-over mechanical harvesting of strawberries several experiments were carried out.

In five fields one hundred plants were marked immediately before appearance of the first red strawberries. With intervals of one to four days the fruits of ten plants were harvested and the fruits above 10 mm were sorted out in: green, red green, red, and rotten.

During fruit development the yield and percentage (number) of green strawberries decreases,

while the yield and percentage of red fruits increases. The yield and percentage of red green fruits were at a very low level. By attack of *Botrytis cinerea* the yield of red fruits can be reduced in the last part of the harvesting period.

The optimum time of harvest of the varieties 'Sima' and 'Primek' was found to be at 25–30 per cent green fruits. At this percentage the highest yield of red fruits was obtained. If the changes in percentages of green fruits and yield of red fruits are followed closely, the determination of the optimum time of harvest of strawberries can be done precisely.

**Key words:** *Fragaria ananassa*, strawberries, time of harvest, machine harvest.

### Resumé

Der er blevet udført forsøg med henblik på at udvikle en metode til at bestemme det optimale høsttidspunkt for jordbær til maskinhøst. I forskellige marker blev alle jordbær på ti planter høstet med intervaller på en til fire dage.

Jordbær med diameter over 10 mm blev sorteret i: grønne, rødgrønne, røde og rådne. Under bærudviklingen aftager udbyttet af grønne bær, og der udvikles proportionalt hermed røde jord-

bær. Udbyttet af rødgrønne bær var forholdsvis lavt på alle høsttidspunkter. Hvis gråskimmelangreb kan holdes under kontrol, vil dette udviklingsmønster være karakteristisk. Ved angreb af gråskimmel vil nogle af de modne frugter blive ødelagt, og udbyttet vil blive reduceret sidst i høstperioden.

Resultaterne viste, at det optimale tidspunkt for høst af sorterne 'Sima' og 'Primek' var ved 25-

30 pct. grønne bær. Ved at følge ændringer i antalprocent og udbyttet pr. moderplante, er det muligt

at bestemme høsttidspunktet med rimelig sikkerhed.

**Nøgleord:** *Fragaria ananassa*, jordbær, høsttidspunkt, maskinhøst.

## Introduction

In Denmark several varieties of strawberries suitable for mechanical harvesting and a harvesting machine have been developed (1,2,3,4).

These have been used in 1989 and 1990 with great success by several growers.

Because of the introduction of once-over harvesting a method for the determination of the optimum time of harvesting is necessary for proper scheduling.

The aim of the research described has been to develop an applicable method for the determination of the optimum time of harvest of strawberries suitable for mechanical harvesting.

## Materials and methods

In 1989 and 1990 sampling was carried out in one field at the Department of Vegetables where the variety 'Sima' was grown in beds. To obtain better evaluation of the applicability of the method experiments was carried out in 1990 with the variety 'Primek', grown in small fields (0.5 to 2 ha) by different growers.

Shortly before the first red berries appeared 100 mother plants were marked in every field. The first harvesting days in 1989 and 1990 were 5 July and 21 June respectively.

The fruits with a diameter above 10 mm from each plant were separated in: green, red green,

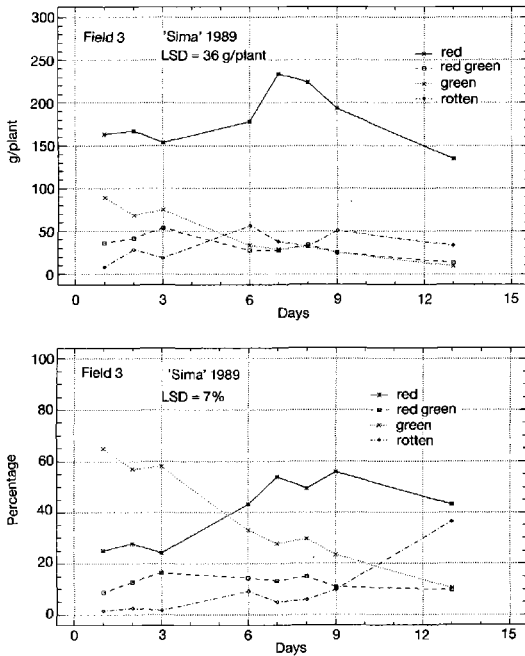


Fig. 1. Yield of fruits in grams per plant and number of fruits in percentage of total fruits for 'Sima' in 1989. Field number 3. First day of harvest 5 July.

Udbytte og procentfordeling af jordbær for 'Sima' i 1989. Mark 3. Første høstdag 5/7.

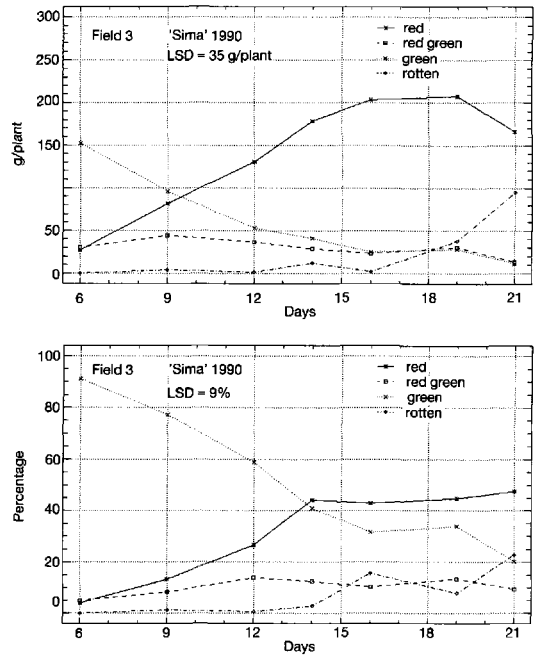


Fig. 2. Yield of fruits in grams per plant and number of fruits in percentage of total fruits for 'Sima' in 1990. Field number 3. First day of harvest 21 June.

Udbytte og procentfordeling af jordbær for 'Sima' i 1990. Mark 3. Første høstdag 21/6.

red, and rotten. The fruits of each category were counted and weighed so that the fruit development at each harvest time could be determined with an average of 10 replications.

In each field sampling was carried out with intervals of 1 to 4 days.

The data were treated by use of analysis of variance and least significant differences were applied to evaluate the average values of yield per plant and percentages (numbers) of the fruit categories.

## Results and discussion

The results from 'Sima' are shown in Fig. 1 and 2. In both years the yield of red fruits reached a maximum of about 200 g/plant at 25–30 per cent green fruits. A decrease in yield or percentage of green fruits and an increase of yield or percentage of red fruits could be expected. The yield of red green fruits or the percentage in this category remained almost constant during the harvesting period. The yield or percentage of rotten fruits increased in the last part of the harvesting period.

From these results it can be concluded that the optimum harvesting time was at 30 per cent green fruits. By later harvesting the yield of red fruits did not increase, but a decrease could occur if rotting occurred. Mechanical harvesting with machine was carried out on day 8 and 11 respectively.

For the variety 'Primek' grown in field 1 similar results were obtained. This is shown in Fig. 3. The yield of green fruits decreased from 320 to 15 g/plant, while the yield of red fruits increased from 20 to 430 g/plant. The changes in percentage green and red fruits were 90 to 25 and 10 to 60 respectively.

The yield and percentage red green fruits had a maximum on about day 8, while the yield of rotten fruits was low except at the latest harvest.

As shown in Fig. 4 the attack of *Botrytis cinerea* in field number 2 was uncontrolled with the result of development of unacceptable amounts of rotten fruits. Fruit dropping can be the explanation of decrease in yield of red and rotten fruits.

In Fig. 5 the results from sampling in field

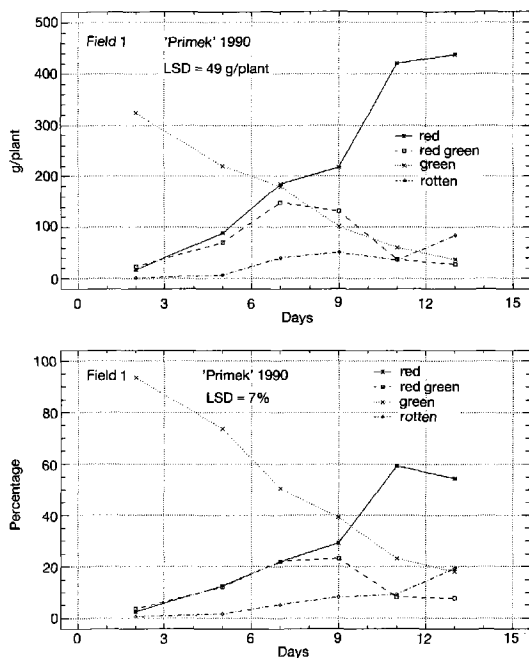


Fig. 3. Yield of fruits in grams per plant and number of fruits in percentage of total fruits for 'Primek' grown in field number 1 with first day of harvest 21 June.

Udbytte og procentfordeling af jordbær for 'Primek' på mark 1. Første høstdag 21/6.

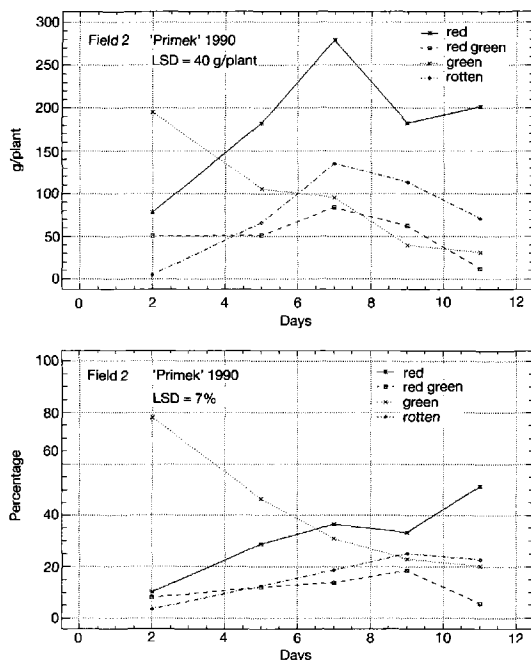


Fig. 4. Yield of fruits in grams per plant and number of fruits in percentage of total fruits for 'Primek' grown in field number 2.

Udbytte og procentfordeling af jordbær for 'Primek' på mark 2. Første høstdag 21/6.

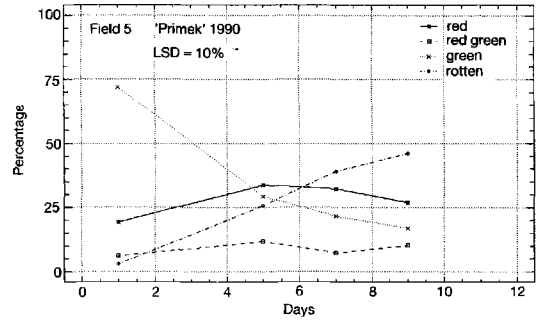
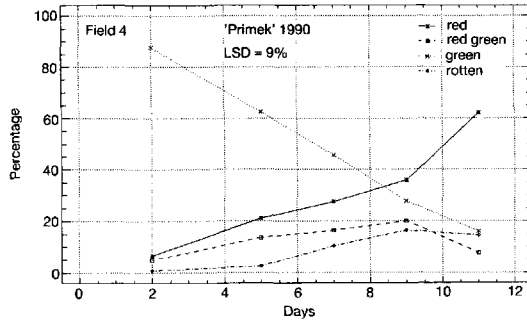
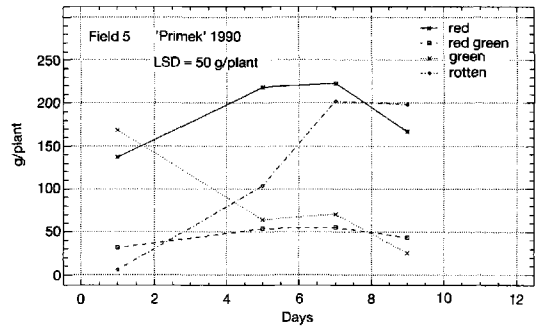
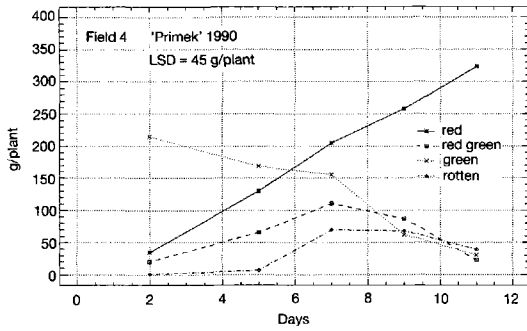


Fig. 5. Yield of fruits in grams per plant and number of fruits in percentage of total fruits for 'Primek' in field number 4.

Udbytte og procentfordeling af jordbær for 'Primek' på mark 4. Første høstdag 21/6.

Fig. 6. Yield of fruits in grams per plant and number of fruits in percentage of total fruits for 'Primek' grown in field number 5.

Udbytte og procentfordeling af jordbær for 'Primek' på mark 5. Første høstdag 20/6.

number four are shown. Percentage of green fruits changed from 90 to 15 and the percentage of red fruits from 10 to 60. From day 9 the percentage of rotten fruits increased considerably.

The optimum time of harvest was at a percentage of green fruits of 25–30 with an yield of red fruits of 320 g/plant. A maximum of red green fruits occurred and the yield of rotten fruits was very low.

Because of attack of *Botrytis cinerea* bad results were obtained in field number 5. This is shown in Fig. 6.

At a percentage of red fruits of 30 the yield of red fruits was 200 g/plant, but the yield of rotten fruits at this stage of development was 25 per cent and 100 g/plant respectively.

The decrease in yield or percentage of green fruits was not followed by development of red fruits because of attack of *Botrytis cinerea*.

## Conclusion

Development of a considerable number of red fruits should occur if the percentage of green or red green fruits is high and the number of rotten fruits in percentage of total is low. This theory has been proven in several cases if the attack of *Botrytis cinerea* was under control. Unless this is the case the red fruits obviously are rotting.

It is not possible to obtain 100 per cent red fruits. For the varieties 'Sima' and 'Primek' the optimum time of harvesting was estimated to be at a percentage of green fruits of 30. At this point the maximum yield of red fruits was obtained.

If *Botrytis cinerea* is kept under control 60 per cent red fruits can be obtained with the variety 'Primek'.

Normally a decrease of the percentage by number or yield in grams of green fruits is followed by development of red fruits. The percen-

tage or yield of red green fruits probably has a maximum value for 'Primek', while this was not shown for the variety 'Sima'.

By graphical tracking the changes in yield of red fruits and percentage green fruits can be followed by sampling each day in the period of harvesting.

In 1990 the method was used for determination of the time of harvest of strawberries at four growers in Denmark, but further work has to be done especially regarding the application of the method in greater fields where larger variation in the maturation of the strawberries can occur.

## References

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