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TITEL: Die daarstelling van vruggroei-kromme vir nuwe appel kultivars Pink Lady en Fuji

The Development of Fruit Growth Curves for Fuji and Pink Lady Apples under South African Conditions

Elmi Lötze & O. Bergh

Abstract

There is a worldwide increasing demand for fruit quality with fruit size being one of the quality parameters. For a good fruit size, fruit thinning of apples and pears is a common practice throughout the fruit industry. It can improve quality, control crop load, increase final fruit size and reduce alternate bearing (Bergh, O.,1984; Bramardi, Castro & Zanelli (1998), Zhang, (1997); Greybe, E., Bergh, O. & Ferreira, D.I., 1997).

In order to assist in fruit thinning, it is necessary to know the seasonal growth pattern and growth curve of the fruit. Williams et al. (1969) has shown that there is a relationship between fruit size during the growing season and the size reached at harvest. This enables one to relate the size of the fruit at harvest back to the size, for example at thinning time. It is thus possible to identify the small fruit that should be removed at hand thinning. According to literature, several factors influence fruit size including climate and orchard practices. This indicates that specific fruit growth curves are required according to specific climate, cultivar and orchard practices. Therefor, although several models have been developed for pome fruit growth around the world (Batjer, et al., 1975;Bramardi,et al., 1998; Ortega, et al., 1996; Ortega, et al., 1998; Williams, et al.,1969),no models for the new apple and pear varieties existed under South African conditions. Two varieties,'Pink Lady' and 'Fuji', were identified to be studied under field conditions to determine their growth curves. Results were to be used during hand thinning under local conditions.

During the 1999/2000 and 2000/01 seasons the diameters of different apple varieties were recorded on a weekly basis, from approximately 40 days from full bloom (dffb) until harvest. The objectives were i) to determine the growth curve for each variety under these conditions and thereafter ii) to develop an accurate tool (growth table) for determining which fruitlets to hand thin at 40 dffb.

Differences in fruit diameter were observed between the varieties and areas as early as 40 dffb. These differences were related to variations in seasonal temperature, hours of sunlight and crop load in the present as well as in previous seasons (Bergh, 1984). The differences, observed between the varieties, for fruitlets which had similar diameters at 40 dffb, showed that the varieties had inherently different growth rates, which have to be considered when determining the optimum thinning procedure. In all cultivars, mall fruit at 40 dffb remained small at harvest and could be accurately identified early in the season and eliminated.

Materials and Methods

The experimental sites were selected in commercial orchards in the two main apple-producing areas in the Western Cape, with different climatic conditions – Ceres and Elgin. Two to four young bearing trees on M793, representative of the orchard, were identified and 25 fruitlets on two opposite sides of the trees labelled for measurements at approximately 40 dffb. In total 100 fruitlets were labelled per experimental site for each year. Fruit diameters were recorded with an electronic Cranston gauge on a weekly basis and the data stored in a work sheet format. Measurements were discontinued for fruitlets which dropped during the season. The fruitlets kept their identity throughout the season.

The orchard details of two sites are summarized in Table 1. The differences in climate are summarized in table 2.

Growth curves of the fruit were compiled from this data for the appropriate seasons and a common or general growth curve per variety for the two seasons and two regions was calculated. A weekly average growth increment was then fitted on the same graph. The value of the x-axis was always taken as days from full bloom, to enable comparisons of phenological data across years and climate areas.

For future reference, hourly temperatures from nearby automatic weather stations were recorded for the growing period.

Results & discussion

The growth curves for the mentioned varieties are illustrated graphically in Figures 1 – 3 with the weekly increments in diameter given on the secondary y-axis. A mathematical equation was fitted to the data. It described the slope as being a logistic model, which in accordance with the findings of Ortega, et al., (1998). Although a similar good fit (r=0.99) was achieved with a MMF and polynomial fit, the end values were either under or over estimated. According to the well known fact that the growth curve is sigmoidal and assuming measurements were taken from full bloom until maturity, it made more sense to take the logical fit which proved more accurate in this case. Bramardi, et al. (1998) started his measuring later (60 dffb) and stopped with the early harvest (130 dffb) which explains his better fit with a linear curve. He only captured the linear phase of the sigmoidal curve, which can be used if one only needs to predict fruit growth within this limited growth period. As Bergh (1984) has pointed out though, the earlier hand thinning is done (close as possible to 42 dffb) the bigger the influence on the remaining fruit. Under our local

circumstances producers need fruit sizes often as early as 30 dffb, thus the preference to use the logistic fit as part of the sigmoidal curve.

$Y = a/(1+b^{\exp.(-cx)})$

a, b & c- constants
x - days from full bloom
y - fruit diameter

Figures 1 and 2 show the fit of the predicted average growth versus the actual growth for both varieties. With an r=0.99 in both cases, the mathematical equations for both are accepted as accurate and can be used for future predictions of fruit size with the dependent factor, days from full bloom. When the two varieties are compared to one another, as far as the predicted curves are concerned (Fig 3), there seems to be a similarity between the varieties. This will be quantified and compared with other existing curves to determine whether the same equation can in fact be used for all varieties or whether one will be sufficiently accurate for all apples, using the same constant values.

The average weekly increments as well as total growth of Fuji was higher than for Pink Lady (Fig 4). This can be attributed to various factors, e.g. tree size, crop and climate but it will not be discussed in this report. If it can be proved that the increments of Fuji are bigger with little effect form the mentioned factors, a possible conclusion would be that Fuji is a more aggressive grower and given similar growth conditions as Pink Lady as well as the same initial fruit size at 40 dffb, it will always reach a better fruit growth.

Figures 5 and 6 illustrate the accuracy of predicted growth curves for selected initial diameters derived from mathematical equations versus the actual average growth of the average fruit diameters for both varieties during the two seasons. The purpose behind using a mathematically derived table versus a table of actual values is the ability to accommodate intermediate diameters not specified in the actual table, as well as saving time and effort trying to and identify sufficient fruitlet samples for 1mm intervals early in the season to continue measurements until, eventually all possibilities are covered and summarized in a actual fruit growth table.

Conclusions

A growth table was constructed for 'Fuji' and 'Pink Lady', to be of practical use for the producer. This implies the grouping of fruit diameters into measurable entities at thinning and adjustment of the logical fit for each fruit entity or size category, to be able to elaborate fruit growth tables. It will be distributed by Hortec (Pty) Ltd.

Questions that were not answered in this report are i) do the curves vary significantly between seasons and regions or can one general curve be used to draw up a growth table ii) are the increments due to temperature changes or crop loads and iii) do we need different curves for different apple varieties as was implied by previous researchers. These issues will be addressed in future reports.

For the purpose of this study, the observed relationship between early- and final fruit size

for these two apple varieties can be employed (at 40 dffb) as an indicator of the likelihood of a 'small fruit year'. Once the growth tables are available, thinning procedures (hand thinning) may then be implemented in sufficient time to substantially improve fruit size distribution, fruit quality and income. The influence of crop load should always be kept in mind when implementing the table.

References

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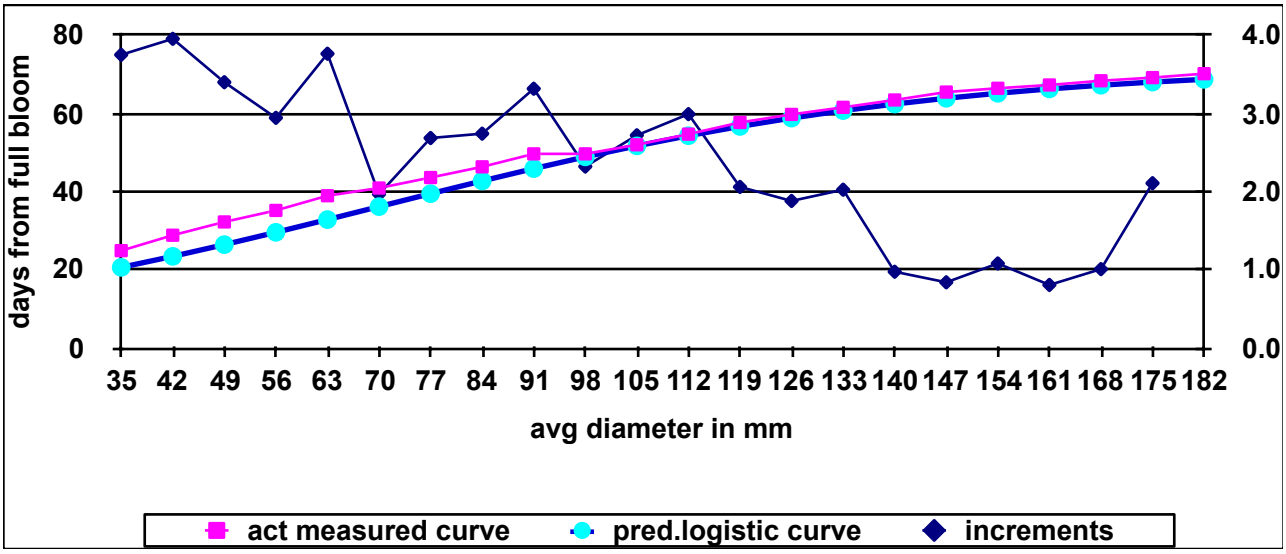

Figure 1 Fuji growth curve - actual measurements vs logistic prediction of average fruit diameters and average weekly increments for the actual measurements during 2000 and 2001.

Figure 2 Pink Lady growth curve - actual measurements vs logistic prediction of average fruit diameters and average weekly increments for the actual measurements during 2000 and 2001.

Figure 3 Comparison between the logistic prediction of average fruit diameters for Pink Lady and Fuji growth curves during 2000 and 2001.

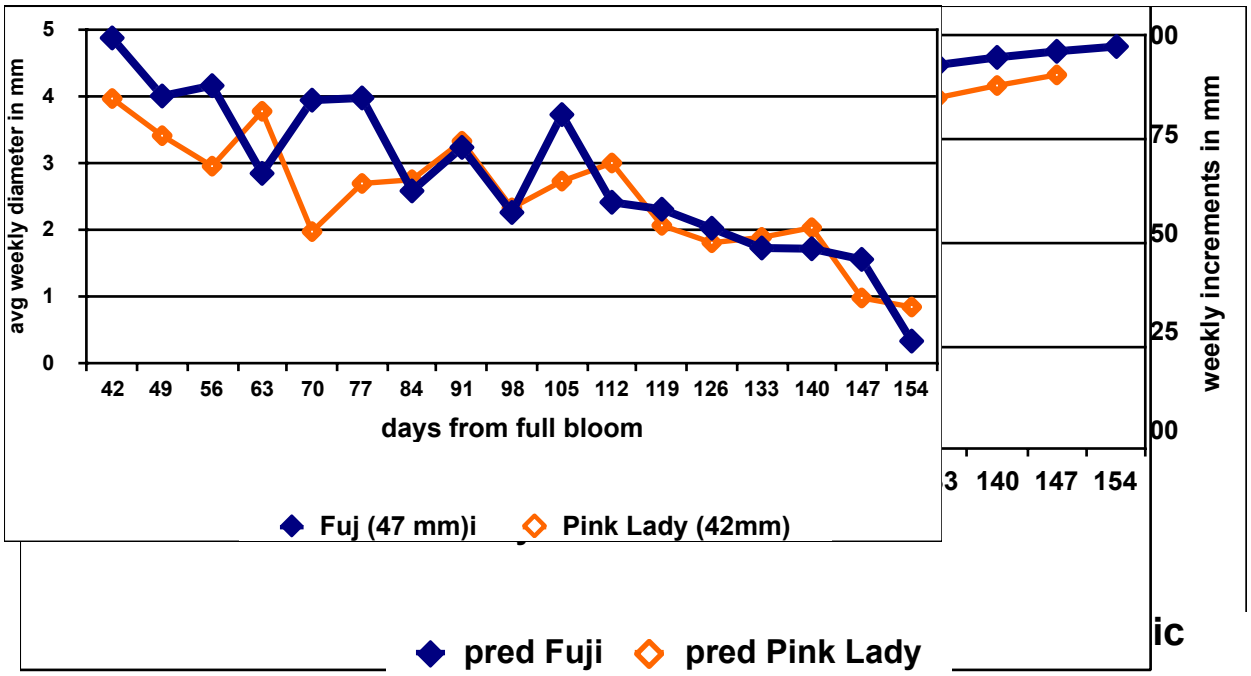

Figure 4 Comparison between the weekly increments for Pink Lady and Fuji with total average growth in parenthesis

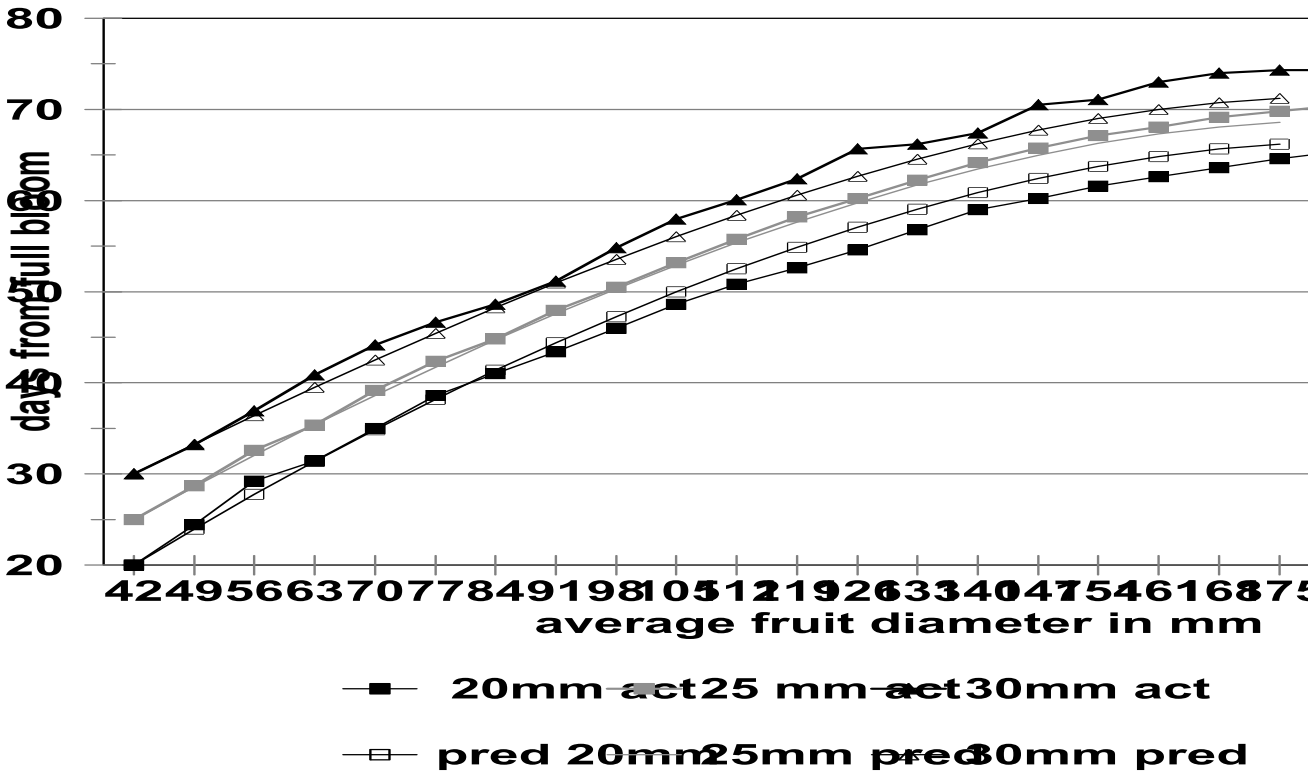

Figure 5 Comparison of predicted vs actual average diameter of Pink Lady from the growth table with fruitlets of similar initial diameter at 42 dffb.

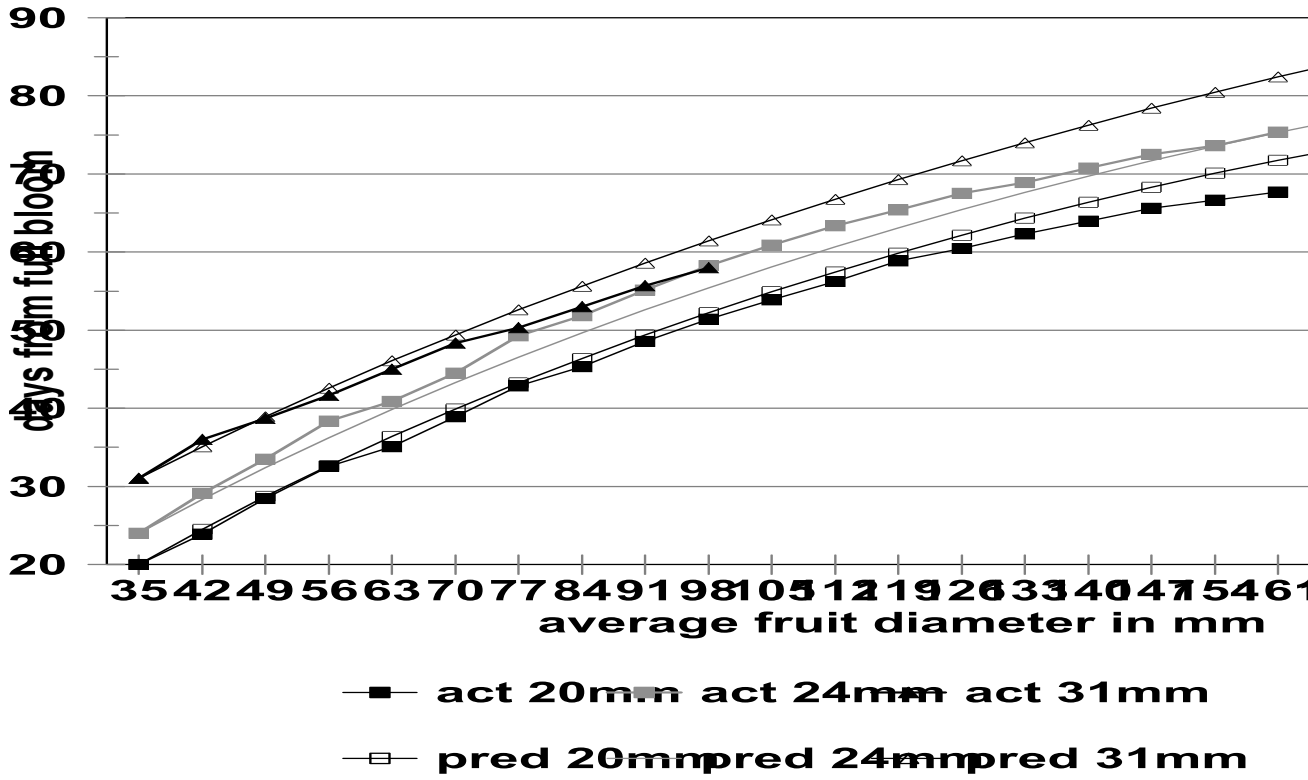

Figure 6 Comparison of predicted vs actual average diameter of Fuji from the growth table with fruitlets of similar initial diameter.

Table 1 The orchard details of the sites

Area	Site	Cultivar	Planted	Pl dist.	Rootstock	
Elgin	De Rust	Fuji	1993	4.5x 2.0	sdl	
		Pink Lady	1995	3.5x 1.0	M793	
Ceres	Esperanto	Pink Lady	1994	4.5x 1.5	M793	
	Nooitgedacht	Fuji	1995	3.5x1.0	M793	

Table 2 The differences in location and climate of the three areas.

Area	Longitude	Latitude	Altitude	Chilling
Elgin	3408	1902	305m	Medium
Ceres	3310	1902	1020m	High