discussion paper no. 7

Apple Monitoring in Germany & The Netherlands

A Whole Systems Approach to Grower Education & Research

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Foreword

This discussion paper is based on research work conducted by G.F. Thiele while on sabbatical leave at the University of Hannover.

The extension of the New Zealand apple monitoring work commenced in 1987 by Thiele and Zaprzalek, a Post Doctoral Fellow from Poland, to the European environment has provided a valuable addition to the international information on biological, economic, and technical aspects of the apple tree system.

Subsequently Zhang, a Chinese Ph.D student at Lincoln University, has developed an apple tree model which can be used by growers to manipulate their management practices under a range of climatic conditions.

The fact that data from a wide range of soil and climatic conditions, incorporating a range of management practices, can be effectively sampled and analysed to reliably identify significant differences, is a unique development in fruit tree research. Furthermore the recognition that scientific research must incorporate economic analysis as well to provide realistic, practical conclusions of use to growers is extremely important.

Although growers sometimes have a tendency to leave data recording to scientists, this work shows how much growers can learn by being involved and by comparing with other growers.

There are still gaps in our knowledge associated with the range of cultivars, and some data on, for example, harvesting and marketing costs is still suspect. The more data incorporated into the management information system the more reliable will be our practical decision making. This, obviously applies to a wide range of horticultural crops.

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Abstract

Twenty one Jonagold orchards in three regions of Germany and one in The Netherlands were monitored during the 1989 season for a range of biological, economic and management factors. Most orchards were 8 years old on MIX stock. Tree numbers varied between 1250 - 3472/ha and the selected orchards covered single and double row planting as well as 4, 5 and 6 row beds.

Flower numbers varied between 0.95m and 5.27m/ha but often orchards with high flower numbers set a lower percentage of fruit. Fruit set varied between 7.5 and 34.1%. Average fruit number/tree varied between 105 and 330. Average fruit weight on an orchard basis varied between 140 and 280g. Highest extrapolated yield was 92.2t/ha and the lowest 19t/ha.

Gross margins varied markedly between districts mainly because of average price. The highest gross margin recorded was DM 62,000 per ha and the lowest DM 9800. Harvesting and marketing costs represented about 20% of total returns but chemical costs were less significant in the range 3.0 - 3.3% of total returns. Market prices on average were highest in the south of Germany (DM 0.82/kg) and lowest in The Netherlands (DM 0.48/kg).

Detailed appendices are included setting out individual grower's spray and fertiliser programmes and labour and machinery inputs.

Data is recorded on a per tree basis with the trees divided into 3 levels. The harvest data includes yield, fruit size, fruit colour, and rejects. Some data is supplied on terminal and lateral positions of the flower buds and subsequent fruiting.

Analyses is given of various relationships, such as fruit number versus fruit size, and reasons for differences identified. The paper provides a basis for further development of this monitoring work to allow growers to improve their profitability by making management changes. It also identifies areas of research which are still needed to allow reliable predictive and explanatory apple tree models to be developed.

1. Introduction

The concept of horticultural crop monitoring involves growers, advisors and researchers understanding the crop production system as a whole. It is not just data recording for the sake of recording. It recognises that data can be recorded and mathematically analysed by comparison of trees growing in widely different situations involving widely different management methods and practices. It provides the basis for management support systems.

The method is based on the TEU (growers organisation), BET (biological, economic and technical) programme which has been in operation in Sweden for some time (Carlsson *et al.*, 1979) involving mainly greenhouse crops. Similar programmes have been initiated in New Zealand with blackcurrants, kiwifruit, peaches and nectarines and apples. For 3 seasons, a New Zealand apple monitoring system has been in operation with Gala apples. Five growers in each of 3 districts (a total of fifteen growers) have had their trees and orchard operations monitored, analysed and compared. The growers have been involved with the recordings, and they meet to compare and discuss all the results with a view to changing management practices. These growers have decided that high yield does not necessarily maximise profit. Quality, price and the cost of material, labour and machinery inputs can vary significantly in maximising that yield. Apple trees cannot be grown by a set of rules. Research results cannot be produced under controlled conditions in one situation and be applied to all situations. Variations in tree performance result from different spacing, tree training, and climatic and soil conditions. Variety, tree age and a wide range of cultural practices such as fertilisers, sprays, irrigation and pruning also have an effect.

All these varying factors must be incorporated into a fruit tree system so that the change in one factor can be related to the effect on all the other parts of the system. For instance, if fruit number is increased how does this affect ultimate fruit size? If fruit size is altered how does this affect returns? The cost of altering the fruit number by thinning must be taken into account and altering fruit size and number will affect the cost of harvesting and marketing. Dealing with a perennial plant complicates the system still further. Heavy crop loading (high fruit numbers) in one season will affect flower development for next season's crop. But growers' management can control flower numbers to some extent by fertilisers, irrigation, thinning and pruning practices. There is also the question of the quality of the flower, the inherent potential of the flower to produce a particular sized fruit and the affect of flower quality on setting potential. The fruit tree system also involves vegetative growth and requires an in depth knowledge of the processes involved to allow the grower to produce the optimum balance between growth and fruiting. The extent of growth can affect fruit quality which in turn affects returns (both colour and taste aspects).

A full discussion of the fruit tree as a system is given in Zapzralek and Thiele (1987) and Thiele and Zapzralek (1987). These publications also set out the detailed results of the first year of Gala apple monitoring in New Zealand. The results of the second year have been collated by Zhang (1988).

Having worked originally with Carlsson in Sweden in 1980 studying the monitoring of mainly annual greenhouse crops, the author concentrated on extending the concept to outdoor perennial fruit crops in New Zealand. Although it was clearly established that valuable information could be analysed from the data collected and that growers could profitably make changes to their management practices, it was still of major concern, that a realistic fruit tree model capable of being manipulated for realistic practical application had not been formulated. Hence the author went to the Horticultural Economics Institute at the University of Hannover, Germany in 1989 to benefit from their expertise in horticultural modelling and systems analyses.

At the same time it was decided to test the monitoring system with some German and Netherlands apple growers. It would have been ideal to use the same apple variety in Europe as was used for the monitoring work in New Zealand, namely Royal Gala, but there were insufficient European growers with Royal Gala trees of a similar age. Because it is a widely planted, newer variety, Jonagold was chosen. This publication summarises the results of the monitoring and analyses conducted during the European 1989 season using a total of 21 Jonagold growers in 3 districts of Germany and 1 district in The Netherlands. It was the intention of the author to incorporate orchards in the Dresden area of East Germany as well, but the political system at the time did not allow scientific and economic cooperation.

One of the key factors realised very early by Carlsson and the Swedish TEU personnel in their work with growers was that growers have as much to contribute to scientific and economic knowledge of the various horticultural production systems as do scientists, advisers, and academics, maybe more. Growers do not respond well to the imposition of recording systems and research directed from "above", without understanding the concepts through consultation. To contribute to the work they must feel that the cost/benefit of their time and money will be positive. On the other hand, if they do not contribute, they cannot benefit. The author believes strongly that the education concept goes hand in hand with the monitoring (comparative) approach. Therefore growers must assist with both the recording and the interpretation of the comparisons in order to benefit both themselves and others. Furthermore, such monitoring must be dynamic. What is recorded one year may have to be modified the next, in order to progressively solve the interractions of the fruit tree system as they affect management decision making, which presumably is aimed at perfecting the net output from the system. Anything less than perfection has an element of inefficiency, which must be dissatisfying as far as it is under the grower's control. Growers, and those servicing them, will not learn and be made to think by being provided with a recipe. The infinite variation between orchards and management practices makes growing by recipe a nonsense. Therefore, the grower must know his/her trees and all the interractions associated with them. Hence, comparative monitoring work will not work unless growers are interested in improving their knowledge and ability. The author cannot see any point in wasting time and money dealing with growers, advisers and scientists who are not interested in learning. The selection of participants is very important.

2. Method

As far as possible, growers with mature Jonagold trees at least 7 years from planting were selected. Fruitgrowing areas representing North (Jork), Central (Bonn) and Southern (Bodensee) were selected in Germany and one area in The Netherlands (South West near Goes). All trees had MIX as the rootstock except Grower 4 in the South of Germany (S4) who had trees on M2.

Planting details are given in Table 1.

Table 1. Planting system - all growers

Grower	Tree Age (years)	Row Systems	Spacing (m)	Trees/ha
Jork (J)				
J1	7	Single	1.35 x 3.60	2057
J2	7	"	1.66 x 3.80	1582
J3	7	"	1.50 x 3.65	1826
J4	7	"	1.78 x 3.60	1560
J5	6	"	1.60 x 4.50	1389
Bonn (B)				
B1	7	Single	1.50 x 3.50	1905
B2	6	"	1.20 x 3.00	2779
B3	8	"	1.50 x 3.50	1905
B4	6	"	1.50 x 3.50	1905
B5	8	"	1.50 x 3.50	1905
B6	8	"	1.50 x 3.50	1905
Bodensee (S)				
S1	8	Single	1.50 x 4.50	1667
S2	7	2 row	1.80 + 3.00 x 0.70	3003
S3	7	Single	1.57 x 3.55	1794
S4	8	"	1.65 x 4.00	1515
S5	9	"	2.00 x 4.00	1250
Netherlands (N)				
N1	7	Single	1.50 x 3.50	1905
N2	7	5 Row	1.25 + 3.25 x 1.75	3463
N3	8	6 Row	1.20 + 3.60 x 1.80	3472
N4	7	Single	1.25 x 3.25	2461
N5	7	4 Row	1.27 + 3.40 x 1.80	3082

2.1 Tree Size

Some assessment was taken of tree size (Table 2) by measuring the width of trees across the rows and the length along the rows to the extremity of growth and the height from ground level to the top of the leader growth. Although tree volume calculated from these figures does not give a true measurement of fruiting volume the comparison between growers is still valid as a relative measurement of tree size. Cross sectional area of the trunk was measured at 25 cm above ground level.

Table 2. Measurements of Tree Size taken in early spring (Average for 5 trees)

		Height (m)	Length (m)	Breadth (m)	Volume (m^3)	Trunk x.s.a (cm^2)
Jork	1	2.5	1.4	1.5	5.2	26.6
	2	2.3	2.0	2.0	9.1	45.8
	3	2.4	1.3	1.5	4.7	35.7
	4	2.3	1.3	1.3	4.1	30.4
	5	1.9	1.2	1.3	3.3	17.8
	Av.	2.3	1.4	1.5	5.2	31.3
Bonn	1	1.6	1.4	1.2	2.7	22.2
	2	1.4	1.5	1.5	3.2	11.2
	3	1.4	1.3	1.3	2.4	37.8
	4	1.5	1.7	1.4	3.6	16.5
	5	1.6	1.6	1.5	3.8	45.7
	6	1.8	1.6	1.5	4.3	25.3
	Av.	1.6	1.5	1.4	3.3	26.4
Bodensee	1	2.6	1.6	1.8	7.3	31.8
	2	1.9	1.3	1.1	2.6	33.9
	3	2.3	1.3	1.4	4.2	39.2
	4	2.6	1.6	1.9	8.0	56.2
	5	2.6	2.0	2.1	11.4	41.8
	Av.	2.6	1.6	1.7	6.7	42.5
Netherlands	1	2.0	1.7	1.9	6.5	30.3
	2	1.9	1.1	1.7	3.6	16.1
	3	2.0	1.3	1.2	3.1	26.8
	4	2.0	1.3	1.3	3.4	20.4
	5	2.1	1.3	1.4	3.8	34.8
	Av.	2.0	1.3	1.5	3.9	25.7
Overall average		2.1	1.5	1.5	4.8	31.5

2.2 Data recorded

Five trees on each property were selected as being representative of the block. Each tree was divided into three, 0 - 80 cm from ground level, 80 - 160 cm and above 160 cm. Flower and fruit number were recorded at each level and will be presented on a per level basis if applicable. Because of the larger size of the trees on MM106 in New Zealand, considerable difficulty was experienced in deciding on a sampling policy which would reliably represent the whole tree. One fruiting arm for each level was recorded in New Zealand. In the European work it was considered the smaller tree sizes in most instances allowed the whole trees to be recorded.

The following data was recorded for all orchards:

Biological factors.
- Flower number (terminal and lateral)
- Fruit number before and after thinning
- Fruit number at harvest
- Fruit size and weight at harvest
- Colour grade of fruit at harvest
- Defects at harvest

Management factors.
- Spray materials, fertilisers, herbicides
- Cultural practices - time taken pruning, mowing, thinning, spraying, irrigating, harvesting, sorting

Economic factors.
- Cost of materials
- Cost of labour
- Cost of machinery
- Fruit value less cost of marketing

2.3 Personnel involved

Overall coordinator:	G.F. Thiele (author)
District coordinators	
Jork	Matthias Georgeus graduate student, University of Hannover
Bonn (Meckenheim)	Achim Kunz Obstversuchsaulage, Klein-Altendorf, Rheinbach
Bodensee	Werner Baumann Berater im Landratsamt Bodenseekreis, Tettnang
The Netherlands	J. Goedegebure and M.L. Joossee Gartenbauokonomen der Proefstation voor de Fruitfeelt, Wilhelminadorp.

Others involved with advice and support include:

The advisory service in Jork
Prof Dr Bünemann)
Prof Dr Berg) University of Hannover
Prof Dr Storck)
Dr W. Bokelmann)
Prof Dr F. Lenz, Friedrich-Wilhelms Universitat, Bonn
Dr G. Engel, Obstversuchsaulage, Klein-Altendorf, Rheinbach
Prof Dr F. Winter, Forschungsstation, für Obstbau, Schumacherhof, Universitat Hohenheim

Dr S. Wertheim) Proefstation voor de Fruitfeelt
Ms P. Wagenmakers) Wilhelminadorp

Numerous others at all the institutions named kindly provided advice and assistance and are gratefully acknowledged.

Results were distributed to growers and coordinators on a regular basis during the season. The objective in New Zealand is to have at least one meeting of growers before the commencement of harvest when growers have an opportunity to visit the other orchards in the same district and to discuss the data collated to date. A further meeting is held in each district when all the results for the season are finalised. The attitude of European growers has been quite variable. An excellent pre harvest meeting of The Netherlands growers was held. Jork and Bodensee growers also met in the presence of the district co-ordinators during the season. The Jork growers considered that the work was so valuable it should continue but in the event research money was not available. The critical test of the value of the work is whether or not growers will fund the monitoring. In the case of Jork a post harvest meeting to consider the full season's results was held in the presence of Professor Storck, Dr Bokelmann and Mr Georgeus.

3. Results

The data from 21 growers is extensive and will be included in the appendices. Summarised data will be included in tables and figures in the text. In most instances averages for the five trees on each property will be given.

3.1 Flower numbers

Summarised flower numbers are given in Table 3 expressed on a per tree, per hectare and per trunk cross sectional area basis. Details of flower numbers at terminal and lateral bud sites where available and on the 3 levels of the tree are given in Appendix 1. Flowers per ha are presented graphically for all growers in Figure 1.

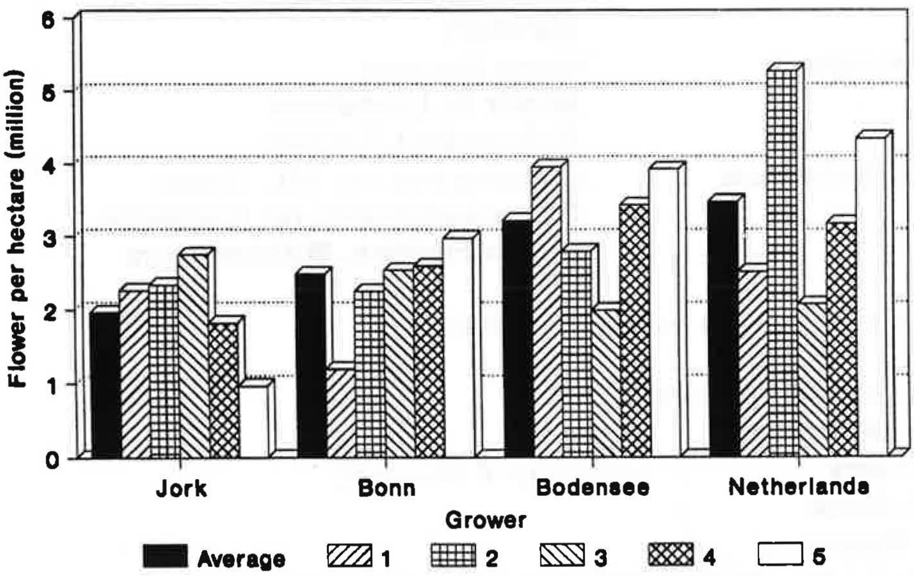

Figure 1. Flowers per hectare (million): for all districts.

Table 3. Flower Numbers - all Growers

		Flowers/Tree	Flowers/Ha (million)	Flowers/cm^2 trunk cross sectional area
Jork	1	1166	2.26	44
	2	1477	2.34	32
	3	1503	2.75	42
	4	1167	1.82	38
	5	688	0.96	39
	Av.	1201	1.96	38
Bonn	1	621	1.18	28
	2	809	2.25	72
	3	1332	2.54	35
	4	1332	2.60	81
	5	1566	2.98	34
	Av.	1240	2.49	47
Bodensee	1	2387	3.96	75
	2	932	2.80	28
	3	1108	1.99	28
	4	2267	3.44	40
	5	3141	3.93	61
	Av.	1967	3.22	48
Netherlands	1	1324	2.52	44
	2	1523	5.27	95
	3	597	2.07	22
	4	1292	3.18	63
	5	1410	4.35	40
	Av.	1229	3.48	48

Flower numbers/tree varied between 597 (N3) and 3141 (S5). No measure was made of flower and bud quality although the setting percentages reported in the next section suggest that low flower numbers can lead to a higher percentage set. Counts were made on average flower number per bud but the results were very consistent. They varied from 5.1 flowers/bud for grower S1 to 5.9 flowers/bud for growers N2 and N5. Overall the Netherlands had the highest average at 5.8 flowers/bud followed by Bonn 5.6 flowers/bud, Jork 5.5 flowers/bud and Bodensee 5.2 flowers/bud. The question of flower and bud quality as it relates to setting and ultimate fruit size needs to be addressed in more detail.

To include monitoring of flower and fruit according to the terminal or lateral position proved too complicated for this type of work at harvesting. The percentage of terminal flower buds varied quite widely between districts and between growers (Table 4). Data from the Netherlands was not recorded in this case.

Table 4. Percentage terminal flower buds

	High	Low	District Average
Jork	97 (J2)	68 (J5)	87a
Bonn	56 (B3)	21 (B1)	39c
Bodensee	75 (S3)	62 (S4)	67b

The hypothesis is that the average size of fruit is higher from terminal flower buds than from lateral ones but this has not been proven due to lack of harvest data on fruit positions. Furthermore, fruit number/tree and cultural practices can complicate the interpretation of results.

Regressing flowers/tree against cross sectional area of the trunk does not produce a very good fit ($r^2 = 0.18$, $y = 661 + 24x$) and even after thinning, to theoretically correct crop loading according to the capacity of the tree, fruit numbers regressed against cross sectional area of the trunk still does not give a high r value ($r^2 = 0.34$, $y = 73 + 3.4x$).

3.2 Fruit set

Fruit set for all growers is given in Figure 2 and detailed data in Appendix 2. Fruit numbers were counted before hand thinning and were recorded according to the terminal or lateral position of the fruit. Counts were taken during the period 28 June to 7 July 1989 after the finish of the natural June drop.

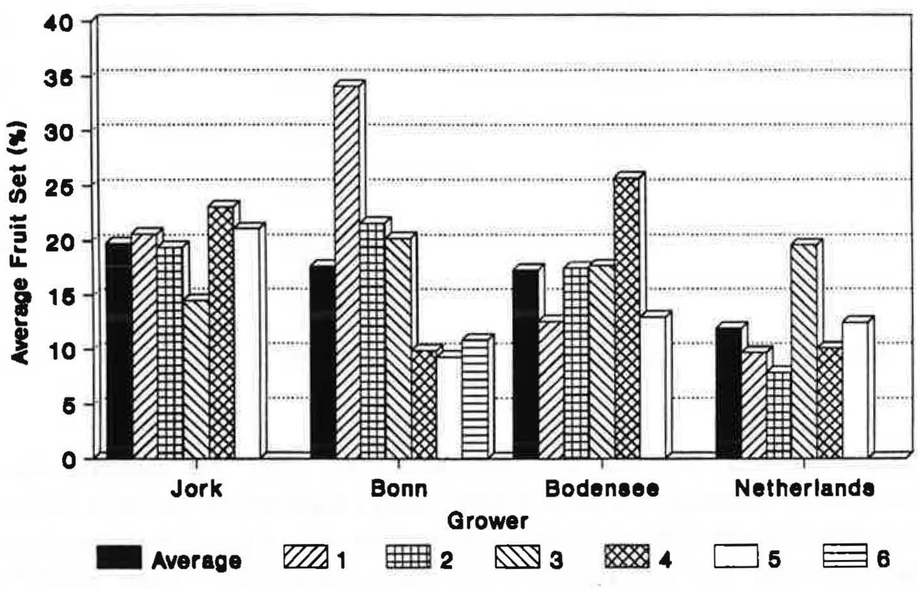

Figure 2. Average fruit set (%): all growers.

There are a number of difficulties in accepting and interpreting the data. Small green fruit at the end of June is extremely difficult to count accurately and the ability of the personnel in the various districts in this regard was variable. Ideally each count should have been checked by another counter. Growers were invited to do this but most of them declined. Errors appeared when some fruit numbers after thinning were recorded as higher than before thinning. Mostly the differences were small but nevertheless figures for percentage set cannot be taken as 100% accurate.

Another complication was created by five growers admitting to using "Amidthin" for chemical thinning. These were J2, J3, S1, S2, and S5 so that the percentage set in these cases does not reflect the level of natural set. Figure 2 shows that the percentage set for growers S1 (12.6%) and S5 (13.0%) was lower as the result of chemical thinning. It appears that S2 (17.5%) did not achieve the same effect from applying Amidthin. Grower S4 set an average 582 fruits/tree (25.7% set) and involved extra costs with hand thinning. There is no clear evidence that Grower J2 achieved much affect from the use of Amidthin with 17.4% set compared with the district average of 19.6% set, but J3 with 14.5% set, the lowest for the district, may have been more successful. Percentage fruit set varied overall between 7.9% (N2) and 34.2% (B1).

Weather conditions, time of flowering, site, pollinating cultivars, bee activity, flower quality and tree condition can all impact on setting (as well as the use of chemical thinning agents).

Cultivars neighbouring the Jonagold block being monitored are given for each grower in Appendix 3 (as far as is known).

Netherlands grower N2 with the lowest percentage set (7.9%) had the highest number of flowers per tree and per hectare while grower N3 (19.6% set) had the lowest number of flowers per tree and per hectare in the Netherlands. The implication here is that flower quality was better in the case of N3. Another possibility is that bee numbers per flower were higher for grower N3. Grower B1 also had low flower numbers per tree and per hectare and achieved the highest percentage set for the Bonn district (34.2%). This theory does not apply to S4 with 25.6% set, but the different rootstock (M2) in this case, producing a more robust tree, could be a complicating factor as far as flower quality and fruit set are concerned.

From a district point of view Jork averaged the highest percentage set (19.6%) and had the best weather conditions with later flowering than the Bonn or Bodensee districts. The Netherlands suffered most from weather conditions during flowering with a low average set of 10.7%. Some growers also suffered frost damage. One grower close to the Rhine had trees flowering earlier than the rest of the district and also caught the cold weather conditions experienced in Europe at that time (B4 = 9.7% set). Grower B5 with 9.5% set had buds weakened by powdery mildew which could explain the low set. Grower B6 also had a low set (10.9%) but clearly had the highest number of flowers/hectare for the district (compare B6; 3.4 million flowers/ha with B1; 1.2 million flowers/ha and 34.2% set).

Whether or not these explanations are accurate is open to argument and certainly needs more investigation. The variations are clearly very important from a management point of view and have major effects on both costs and returns. In normal commercial production it is difficult to relate flower bud quality to eventual fruit numbers per tree and to fruit size because of the influence of management practices, such as thinning, on the final outcome. It is, though, a very poorly researched area of fruit production, weakening knowledge on the fruit tree system as a whole. The initial size of the receptacle in the flower, cell numbers and the "strength" of the flower in terms of setting potential, and the effect of temperature on various cultivars are all part of this subsystem. They all appear to have an important effect on final fruit numbers and fruit size and on the economic outcome.

3.3 Thinning

Only 9 of the 21 growers carried out substantial hand thinning. Details of fruit per tree before and after hand thinning are given in Table 5. Growers who hand thinned are shown with an asterisk and those who applied Amidthin with a '+'. Significant differences (P < 0.05) between growers are given with lower case letters and between districts with upper case letters.

Table 5. Average fruit/tree before and after thinning.

District	Grower	Fruit/tree before hand thinning	Fruit/tree after thinning	% Fruit thinned	Fruit/tree at harvest
Jork	1	249	154*	38	142cd
	2	289+	194*	33	192bc
	3	218+	174*	20	158cd
	4	270	246	9	212bc
	5	145	132	9	130d
	Av.	234AB	180AB	22	167B
Bonn	1	212	162*	24	158cd
	2	175	117*	33	116d
	3	269	186*	31	180c
	4	132	132	0	119d
	5	145	144	<1	105d
	6	194	180	7	176c
	Av.	188AB	154B		142BC
Bodensee	1	301+	259*	14	171c
	2	163+	181	0 (E)	177c
	3	196	194	1	175c
	4	582	409*	30	330a
	5	409+	241*	40	224b
	Av.	330A	257A		215A
Netherlands	1	129	109	15	109d
	2	120	123	0 (E)	120d
	3	117	119	0 (E)	106d
	4	130	135	0 (E)	133d
	5	154	137	11	124d
	Av.	130B	125B		118C

(E = possible error, + = chemically thinned, * = hand thinned)

Final fruit/tree figures at harvest given in Table 5 indicate in some cases substantial loss of fruit between completion of thinning and harvesting. Natural drop is responsible for some of this loss. In other instances it is likely that growers have lightly rethinned or removed some lower grade fruit.

The rate of fruit loss between thinning and harvest can have an important influence on fruit growth curves. In formulating accurate predictive models it will be important to have reliable information on this effect in the decision support system.

To calculate the cost of thinning growers were asked to estimate the number of hours spent hand thinning. The cost of thinning 1000 fruits has been estimated in Table 6 for the Jork and Bonn growers who hand thinned. Although there is considerable variation in growers' estimates, a reasonable assumption is that the average cost of thinning 1000 fruits is in the vicinity of D.M. 7 to 7.5/1000 fruits.

There seems some variation in the estimated cost of applying Amidthin. The Jork grower estimated the material cost at D.M. 124/ha. but Bodensee growers claim only D.M. 23 - 30/ha.

Theoretically grower S1 removed about 400,000 - 500,000 fruits/ha with chemical thinning. Even if labour, machinery and material costs were D.M. 200/ha the cost per 1000 fruits removed would be only D.M. 0.4 - 0.5, a substantial saving compared with hand thinning. The benefit to fruit size of early thinning must be taken into account also. However, chemical thinning agents are being banned by some countries.

Table 6. Cost of Hand Thinning (1 hr = D.M. 12)

	Cost/ha(D.M.)	Fruits removed/hr	Cost/1000 fruit (D.M.)
J1*	360	6500	1.8
2	960	1620	7.4
3	756	1275	9.4
B1	720	1600	7.5
2	984	1900	6.3
3	1952	1650	7.3

* The figures here appear suspicious. It is likely the grower has underestimated the time spent thinning.

3.4 Fruit growth

Some fruit size measurements were taken during the growing period. At the time when pre thinning counts were being taken about the end of June, 30 fruits at each level on each monitored tree were randomly selected for size measurement (fruit diameter). As these measurements were taken over a period of about 14 days it is not valid to compare the relative fruit size between districts except that the Netherlands and Bonn fruit was all measured within a 2 day period. Comparison between growers within districts is valid.

It is also possible to attempt correlation between fruit size in June with that at harvest, to determine the validity of forecasting ultimate fruit size more than 3 months before harvest.

In the case of one grower, J1, 25 fruits on each tree were measured at 14 day intervals from

June until harvesting to develop growth curves.

3.4.1 Average fruit size before thinning (end of July)

Recordings for 3 districts are given in Table 7 and average fruit size at harvest is also listed. A size rating for each district is included for each set of measurements with 1 the largest and 5 (or 6) the smallest. Measurements in June-July are given as diameter in centimetres and those at harvest as grams/fruit.

The average diameter for The Netherlands fruit on 27 June 1989 was 4.35 cm, 7.14% larger than the Bonn fruit (4.06 cm diameter). Grower B4 had an average fruit diameter of 4.77 cm which can be explained by earlier flowering closer to the Rhine and earlier harvesting. Nevertheless the advantage was carried through to harvest. The Netherlands fruit, averaging 250.7g/fruit at harvest, was 41.3% heavier than the Bonn fruit 177.4g.

Grower B6 had an average fruit diameter of 4.33 cm on 29 June but this cannot be explained by earlier flowering nor number of fruits per tree.

Overall, the fruit diameter at the end of June was related to the fruit size at harvest. Regressing mean fruit weight at harvest with mean diameter at the end of June gives an r value of 0.68 (Figure 3).

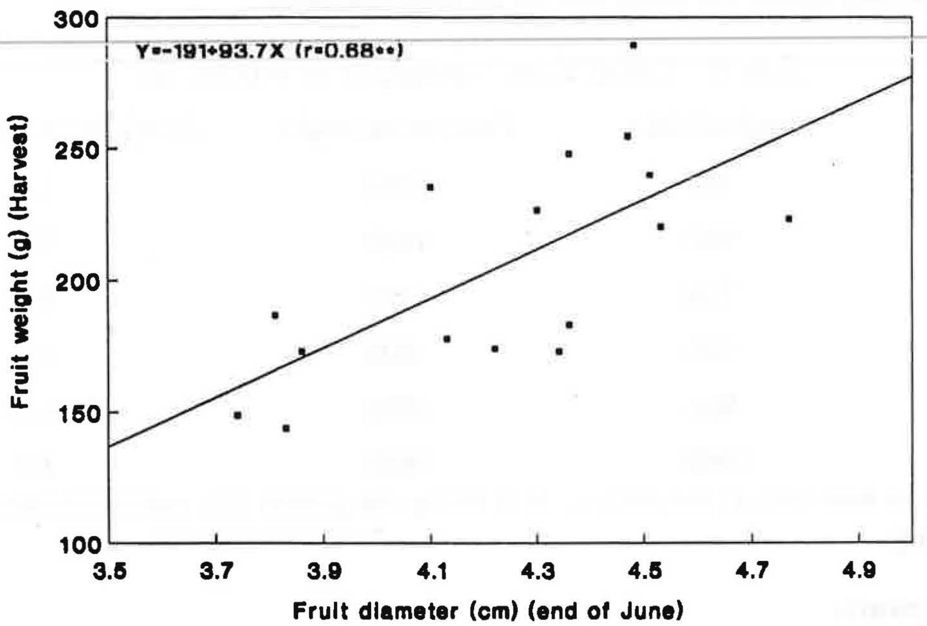

Figure 3. Fruit diameter in June vs fruit weight at harvest.

Table 7. Average fruit diameter before thinning (cm) and average fruit weight at harvest (g).

	Grower	Average Diameter June/July (cm)	Ranking June/July	Average Fruit Weight (g) at Harvest	Ranking at Harvest
Jork	1	4.22	4	174.0	4
(6 July 89)	2	4.51	2	239.7	1
	3	4.53	1	220.1	2
	4	4.34	3	173.0	5
	5	4.13	5	177.7	3
	Av.	4.35		196.9	
Bonn	1	3.86	3	172.7	4
(29 June 89)	2	3.74	6	148.9	6
	3	3.81	5	186.6	3
	4	4.77	1	223.0	1
	5	3.83	4	143.7	5
	6	4.36	2	189.6	2
	Av.	4.06		177.4	
Netherlands	1	4.48	1	289.5	1
(27 June 89)	2	4.30	4	226.4	5
	3	4.36	3	248.0	3
	4	4.47	2	254.7	2
	5	4.10	5	235.1	4
	Av.	4.35		250.7	

3.4.2 Fruit growth measurements Grower J1

Figure 4 shows fruit growth measurements on the 5 monitored trees for grower J1 taken from 68 days after full bloom at approximately 14 day intervals until harvest. Each point on the graph represents the average diameter of 25 fruits.

The average fruit size at the commencement of measurements, between trees, has been maintained until harvest. There is no reason for the fruit on tree 1 being markedly larger than that on the other trees. Tree 5 appeared to be in poorer health and less vigorous and had smaller fruits on average. Tree 1 in fact had the greatest number of fruits per tree (272) at the commencement of the measurements and Tree 5 the fewest (200). Again bud (flower) quality could have a bearing.

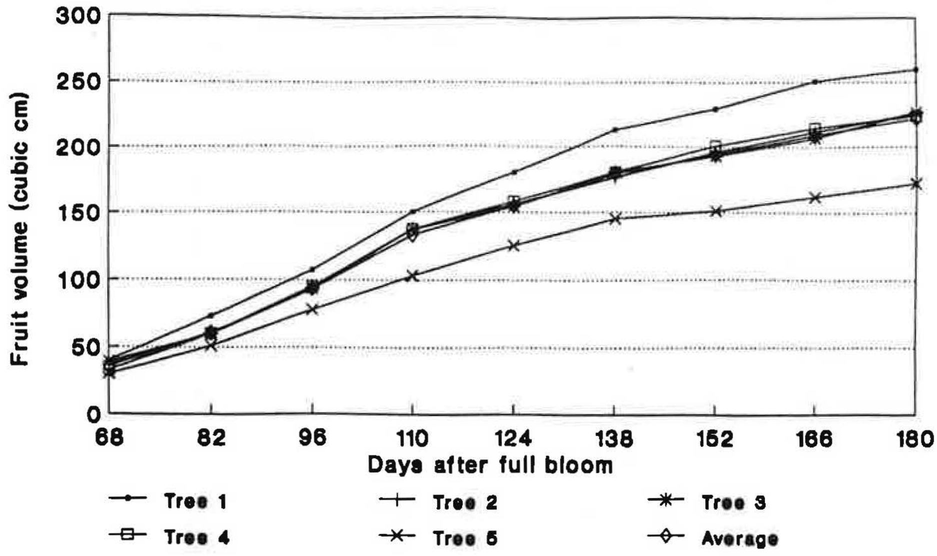

Figure 4. Fruit growth curve for 5 trees: Grower J1

4. Harvest Measurements

Fruit on the monitored trees was harvested according to growers' instructions at the same time as the rest of the block was being harvested. Each fruit was either weighed or measured using sizing rings. When sizing rings were used average weight of individual fruits was determined for each grade by weighing samples of 20 - 25 fruits. Each fruit was also graded for colour into >30%, 10 - 30%, <10% colour. In the case of rejects the reason for rejection was classified into insect, black spot, russet and other.

The author attempted to standardise the various coordinators in the district on grading methods but invariably variation in experience led to variation in severity of grading. The Netherlands figures are likely to be slightly biased towards severe grading and those in the Bodensee region towards liberal grading. Grading within each district was consistent and comparisons within districts are valid.

One grower, B4, did not protect the monitored trees from being picked by his casual workers on two occasions and his figures have had to be extrapolated from pre harvest fruit numbers using grades and sizes from the legitimate harvests and from the rest of the block.

Yield before and after rejects, fruit numbers, and fruit weights are given for each district in Appendix 4. These will now be considered separately for all growers.

4.1 Gross Yield

Gross yield/ha for all growers is given in Figure 5.

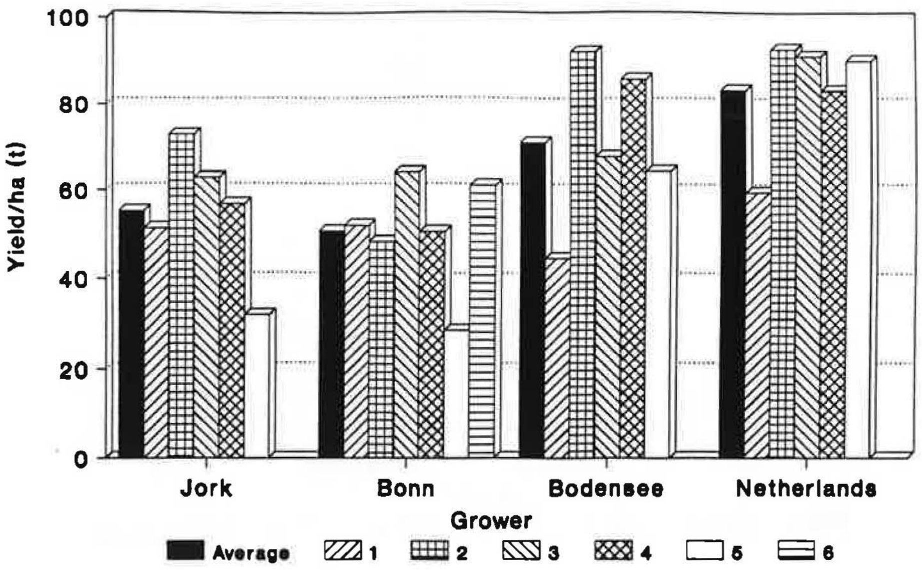

Figure 5. Gross yield per hectare (t): all growers.

Three of the five growers in The Netherlands achieved a gross yield in excess of 90 t/ha (N2, N3 and N5). Only grower N1 in The Netherlands had a gross yield significantly lower at 59.5 t/ha. This grower had the lowest number of trees/ha of the five growers and insufficient fruit to compensate. The average fruit weight in the case of N1 was 285g and this also affected total return per ha with large fruit earning less per kg.

Averaging district yields with a sample of only five growers per district is not realistic but clearly average total yield for The Netherlands at approximately 82 t/ha was well above the Bodensee area (71 t/ha) and Jork and Bonn (50 t/ha).

One Jork grower with acknowledged experience and expertise achieved a yield of 75 t/ha and another Jork grower with poorer trees on light soil harvested only 19 t/ha. One grower in the Bonn district achieved a higher yield at 64 t/ha than 4 other growers in the district who each harvested about 50 t/ha and another who only achieved 28 t/ha. Grower B5 had trees in poor condition with poor mildew control and also had the smallest fruit on average of any grower (140 g).

Extrapolation of yield to a per hectare basis from yields of monitored trees has possibly produced higher yields per hectare than would be expected in Europe. Nevertheless comparisons between growers and the reasons for the differences are valid. An attempt was made post-harvest to obtain a more accurate yield for each block from the growers but in most cases growers had not taken sufficiently accurate records.

4.2 Net Yield

Total rejects for Bonn, Bodensee and The Netherlands growers in tonnes/ha are given in Figure 6 and the detailed reasons for rejection in each case listed in Table 8. Some explanatory points for growers in each district follow.

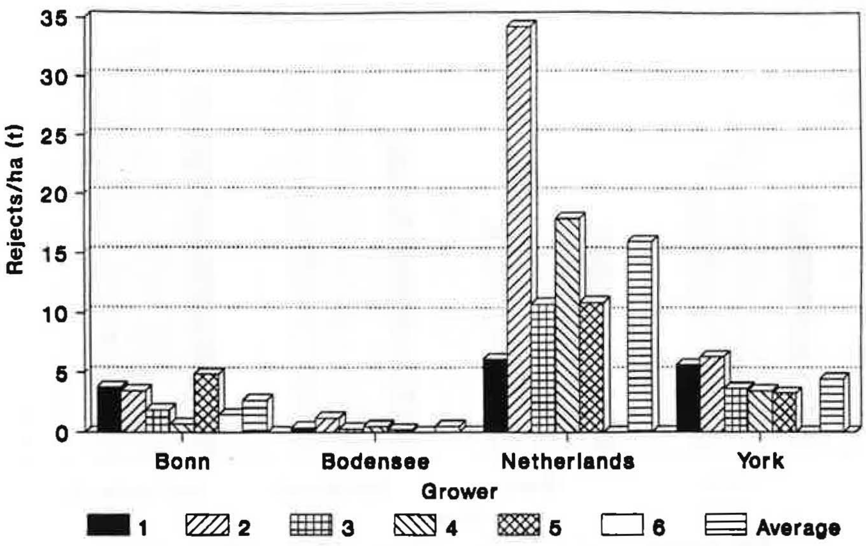

Figure 6. Reject yield per hectare (t): all growers.

Table 8. Rejects

		Total /tree (kg)	Total /tree (no)	Insect (kg/tree)	Blackspot (kg/tree)	Russet (kg/tree)	Other (kg/tree)	Rejects (t/ha)
Jork	1	2.8	16.6	-	-	-	2.8	5.7
	2	4.0	17.2	-	-	-	4.0	6.4
	3	2.0	10.2	-	-	-	2.0	3.7
	4	2.3	14.4	-	-	-	2.3	3.5
	5	2.3	13.4	-	-	-	2.3	3.3
Bonn	1	2.0	12.0	1.71	0.50	1.04		3.8
	2	1.3	8.6	-	-	1.07	0.17	3.5
	3	0.9	5.2	-	-	0.14	0.76	1.9
	4	0.4	1.9	-	-	0.04	0.32	1.0
	5	2.6	19.0	0.07	-	2.31	0.19	4.9
	6	0.8	4.4	0.16	-	0.33	0.31	1.5
Bodensee	1	0.4	2.8	0.34	-	-	0.06	0.4
	2	0.5	2.6	0.12	-	0.31	0.08	1.2
	3	0.2	0.8	-	-	0.15	0.05	0.3
	4	0.3	1.8	0.13	-	-	0.17	0.5
	5	0.2	0.8	0.05	-	0.10	0.05	0.2
Netherlands	1	3.3	12.6	1.71	0.16	1.11	0.26	6.2
	2	9.9	44.8	3.34	-	1.36	5.20	34.3
	3	3.1	14.2	1.34	0.06	0.83	0.89	10.8
	4	7.3	30.4	5.42	-	1.75	0.09	17.9
	5	3.6	15.8	1.19	-	1.71	0.67	10.9

Netherlands.

In general, the grading was more rigorous (severe) than in other districts and comparisons between districts could be misleading. Within the district, growers N1, N3 and N5 had relatively low numbers of rejects at about 13 - 16 fruits/tree.

All Netherland growers had some insect damage, mainly of the leaf roller type. Grower N4, in particular and N2 to a lesser extent, need to look at their spray programmes to determine the cause. There could be development of resistant strains.

Growers N1 and N3 had a very minor amount of blackspot. With N1, the crop load was low and the trees were growing vigorously possibly preventing adequate spray coverage and causing a microclimate within the tree conducive to blackspot development.

The Netherlands experienced low temperatures at flowering with some damage to the fruit from frost and hence the higher than normal incidence of russet. Grower N2 had fruit down graded for hail damage. All but a few fruits in the 'O' (other) category were rejected for hail marking.

Apart from an occasional wind rub the fruit in the 'O' category for N3 was rejected for spray damage. He applied 10 applications of calcium chloride during the period mid June until the end of August at a rate of 7 kg/ha (higher than the normal 5 kg/ha). The damage showed, usually on apples exposed to the sun, as smooth, light brown markings.

In the case of N5 the 'O' category contained a range of defects; wind rub, some hail and spray damage (calcium chloride). The rate for the 14 applications only twice reached 7 kg/ha.

The number of rejects recorded for The Netherlands growers had a major effect on profitability and, along with lower prices for larger than normal fruit, resulted in the district with the highest gross yields being the lowest profitability district overall.

Bonn.

The average loss from rejects in the district was 2.7 t/ha. Grower B5 had considerably higher incidence of russet than other growers mainly due to heavy mildew infection of the trees.

The district also recorded low temperatures during flowering and russet levels were high, possibly as a result of the low temperatures. Some of the fruits in the 'O' category for B1 and B2 have been recorded as frost damage but it is clear that some of the russet recorded fruit also resulted from the low temperatures at flowering (not just frost).

Information supplied by grower B6 indicated he applied Ethrel 250 ml/ha together with Amidthin 480 ml/ha on 30 September. He had applied an Amidthin 480 ml/ha alone 3 days before on 27 September. Details of these have not been included in Appendix 9b as the spray programme supplied was not detailed fully. There was a strong wind prior to the third and final harvest on 25 October and most of the remaining apples dropped to the ground. They were graded and recorded as though they were still on the tree although the true effect on eventual returns is not known. The explanation for the drop is that the Ethrel was applied too late. A total of 355 apples from the 5 monitored trees dropped to the ground prior to the final pick (ie 70% of the 3rd harvest fruits). Another grower B3 also used Ethrel with good results but he applied the last application on 4 September, 26 days earlier than B6. Both these growers have poor coloured selections of Jonagold and need to use Ethrel to enhance colour. B2 applied Alar, improving colour markedly.

Bodensee.

Very few rejects were recorded by Bodensee growers with 4 of the 5 having less than 1 ton/ha rejected. S1 had some insect damage, mainly leaf roller type, accounting for 85% of the rejects on that orchard and 66% of the rejects on orchard S4 were of a similar type. In both cases the incidence was only about 2 - 3 fruits/tree. Two orchards recorded some eye-rot, S2 and S4 although the incidence averaged less than 1 per tree. Grower S2 had more russet than the other growers but the reason for this is not clear.

Jork.

No details are available on the reasons for rejects for the Jork district. Total rejects are listed as other in Table 8.

4.3 Colour distribution

Colour distribution for each grower is shown in Figure 7 and a summary is given in Table 9. The lower case letters show significant differences ($P < 0.05$) for the 30% colour category between growers and upper case letters show similar differences between districts.

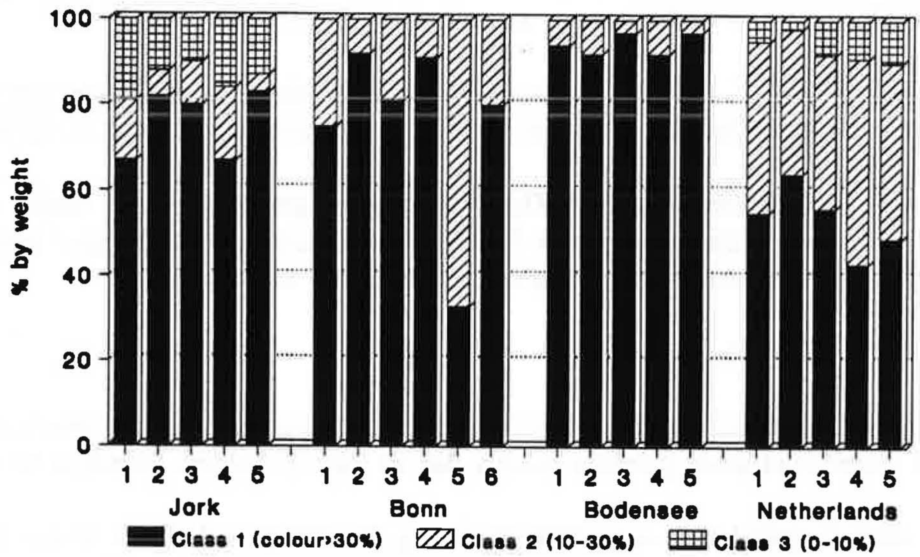

Figure 7. Colour distribution for each orchard

Table 9. Colour Distribution (%)

		>30% Colour	10-30% Colour	<10% Colour
Jork	1	67.0c	12.9	8.4
	2	82.6b	5.4	3.0
	3	77.6bc	11.3	4.5
	4	66.3c	16.9	9.9
	5	82.4b	3.9	3.4
District Average		75.2B	10.1	5.8
Bonn	1	74.0bc	19.8	6.2
	2	91.9ab	8.1	0.0
	3	80.7bc	12.9	6.4
	4	89.3ab	7.4	3.3
	5	30.8e	25.2	43.9
	6	78.7bc	17.1	4.2
District Average		74.2B	18.1	10.7
Bodensee	1	93.1ab	6.9	0.0
	2	89.9ab	10.1	0.0
	3	96.6a	3.4	0.0
	4	91.0ab	8.9	0.1
	5	96.9a	3.1	0.0
District Average		93.3A	6.5	0.0
Netherlands	1	54.2cd	40.1	5.7
	2	62.4c	35.1	2.5
	3	55.8cd	35.4	8.8
	4	42.0de	48.6	9.4
	5	51.3d	40.3	8.4
District Average		53.1C	39.9	7.0

The only growers to use any ripening/colouring sprays were B2, B3 and B6 as outlined in section 4.2. The growers claimed to have poor coloured strains of Jonagold.

Judging by the relative colour appearance of the fruit at harvest time it appears that the application of the grade standards between the 3 classes has been more severe in The Netherlands than the other districts.

Also, because details have not been recorded separately for reject fruit in Jork, it appears that rejects could have been included in Class 3 making the percentages in that category higher than expected. For analyses of colour differences it is best to compare within districts rather than between districts.

There are no clearly identifiable reasons for the colour differences in The Netherlands. Growers N2 and N3 have the highest tree densities/ha (3463 and 3472 respectively) but they have the highest (N2) and second highest (N3) percentage fruit in the >30% colour grade. Being more closely spaced the trees are also more severely pruned into a pillar shape and possibly let in more light. Two orchards with single rows and with more vegetative vigour than other orchards have a lower number of fruits in the >30% colour group. These orchards are N1 and N4. Colour grading was recorded on the 3 levels of the tree and, as would be expected, the upper third of the tree (level 3) had the highest percentage of Class 1 fruit (Table 10). In The Netherlands 4 grade categories were distinguished although for uniformity the 10 - 20%, and 20 - 30% colour groups have been combined in Table 9.

Table 10. Colour distribution on three levels of the tree in The Netherlands (fruit numbers/5 trees)

Grower	Level	<10% Colour	10-20% Colour	20-30% Colour	>30% Colour	Total
1	1	24	38	100	79	241
	2	6	13	47	98	164
	3	1	1	19	118	139
	Total	31	52	166	295	544
2	1	14	41	69	122	246
	2	1	21	57	160	239
	3	0	6	16	91	113
	Total	15	68	142	373	598
3	1	32	25	39	42	138
	2	14	31	73	146	264
	3	0	0	17	104	121
	Total	46	56	129	292	523
4	1	37	39	47	26	149
	2	22	44	142	162	370
	3	4	6	46	92	148
	Total	63	89	235	280	667
5	1	30	31	43	26	130
	2	26	23	64	79	192
	3	2	22	70	206	300
	Total	58	76	177	311	622

Of all the fruits harvested from the 5 growers from the upper level 3, 86.6% were in the >30% colour category. From level 2 the corresponding figure is 52.5% and for level 3, 32.5% of the fruit was in the >30% colour category.

On the same basis, for grower N2 alone, 80.5% of the fruit from level 3, 66.9% from level 2 and 49.6% from level 3 was greater than 30% colour.

For grower N4 the equivalent figures are 62.2% for level 3, 43.8% for level 2 and 17.4% for level 3. It would seem that grower N4 is losing most of the colour at level 3 but the colour overall would still be lower than grower 2 even if the colour level was lifted to the 49.6% level recorded at level 1 by grower N2.

This analysis is not very convincing. It is clear there are differences but the reasons for the differences are not clear and need further study in another season. It is recognised that the colour potential of the strain planted could vary between growers.

Grower N4 harvested on 4 occasions, 2 October, 13 October, 25 October and 2 November. Grower N2 harvested on 3 occasions, 12 October, 25 October and 2 November. This means that 11.3% of grower N4's crop was harvested 10 days before grower N2 started harvesting. It is significant that grower N4 harvested only 44% of the fruit at the first harvest on 2 October in the >30% colour grade. Theoretically the first harvest should be aimed at harvesting only those fruits in Class 1 for colour (as well as watching size).

Bonn

Growers B3 and B6 used Ethryl to enhance colour. There was an obvious effect to the eye but both growers recorded lower percentages in the >30% category than did B2 and B4. B2 used Alar 1.2 l/ha on 20 August and achieved the best colour in the district at 91.9% in the >30% colour category. B3 also used Alar (1.5 l/ha) on 15 August along with 3 applications of Ethryl but colour in this orchard was only average.

The most notable figures in the Bonn orchards were those for B5. This grower had only 30.8% of fruit in the >30% category the lowest by more than 10% of any of the 21 growers. This grower had 43.9% of fruit in the <10% colour grade far more than grower N4 with 9.4% in this low colour grade. B5's trees were "hard" and slow growing and certainly had no problem with light penetration to the fruit. Clearly the mildew problem referred to earlier under russet rejects has affected colour as well.

4.4 Fruit size

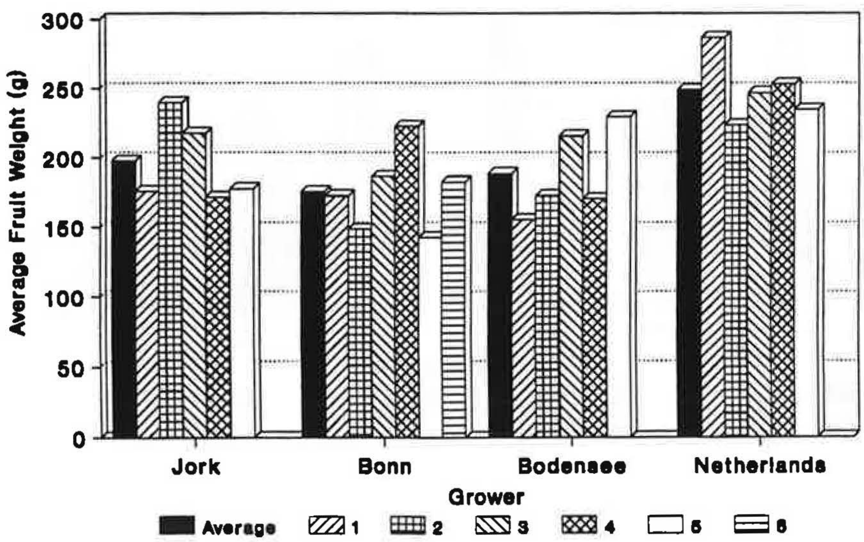

Figure 8. Average fruit weight (g): all growers.

Figure 8 shows average fruit weight for all growers together with district averages. Fruit size distribution for each grower is illustrated in Figures 9a - 9d on a district basis. Clearly The Netherlands fruit was too large, averaging 250g/fruit, compared with the other three district averages in the range 175-200 g. Details of average fruit weight on a per tree basis for each level are given in Appendix 5. With a total of 21 growers x 5 trees = 105 trees monitored for fruit size, fruit number and total fruit weight, it is possible to regress fruit weight to fruit number (Figure 10).

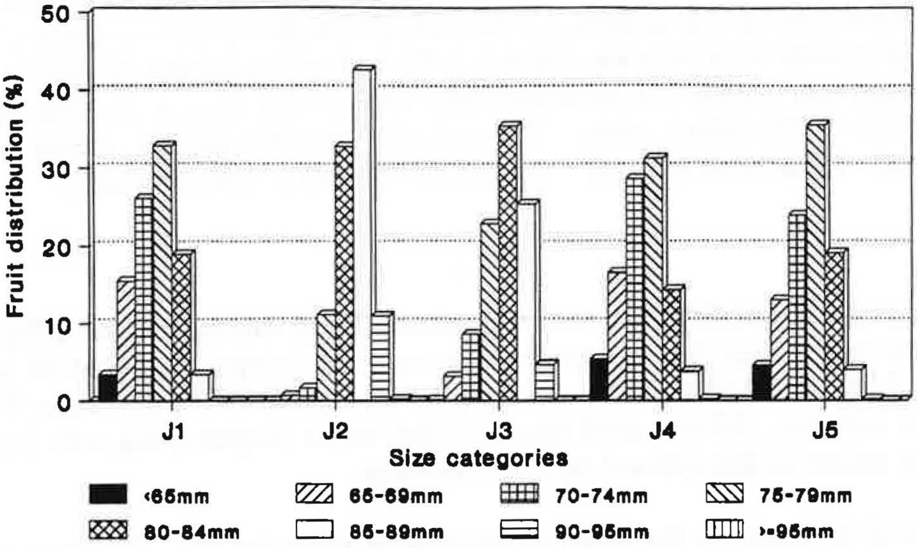

Figure 9a. Fruit size distribution for Jork

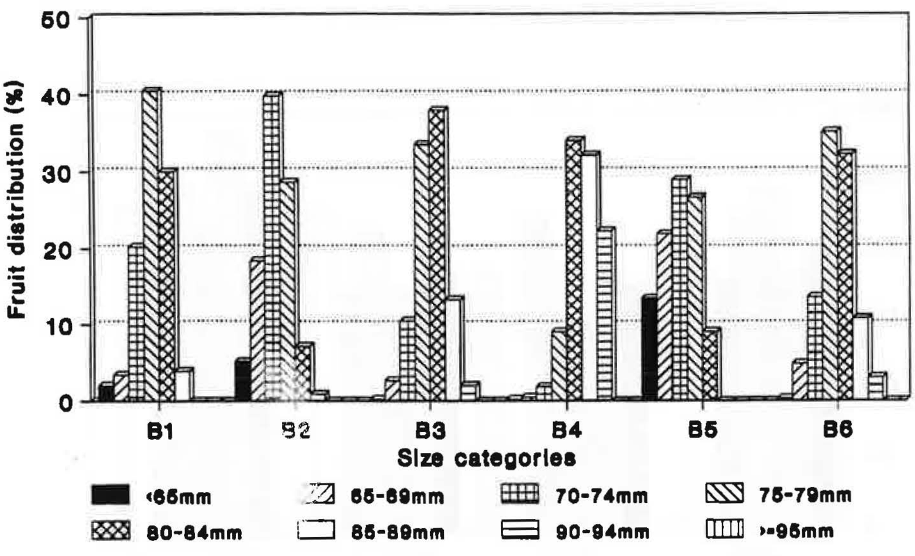

Figure 9b. Fruit size distribution for Bonn

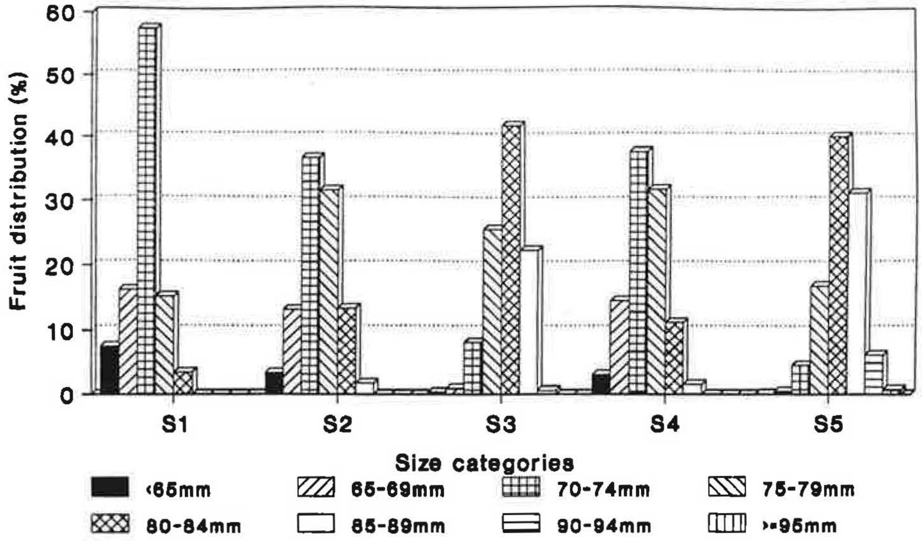

Figure 9c. Fruit size distribution for Bodensee

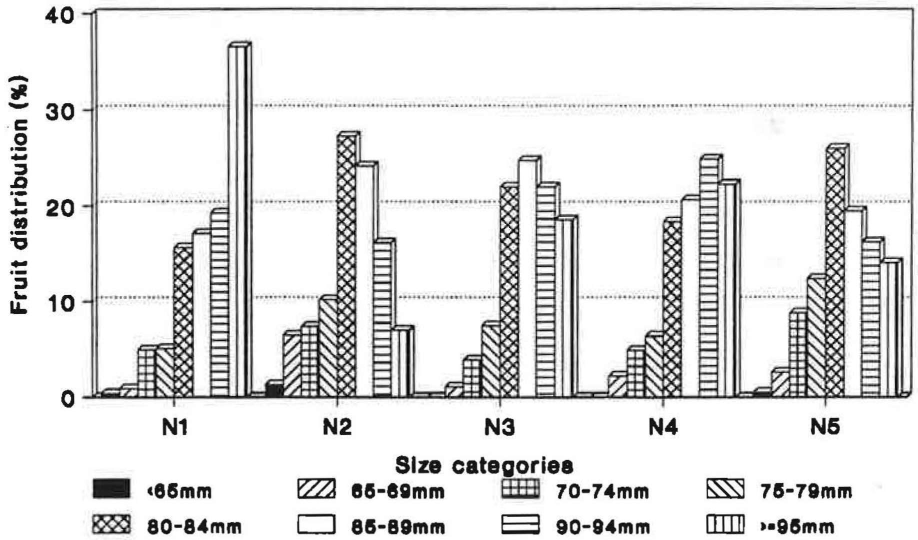

Figure 9d. Fruit size distribution for Netherlands

Average fruit weight on each level of the tree is given in Table 11, with significant differences ($P < 0.05$) indicated between growers and between districts indicated by the letters in the column for "all levels".

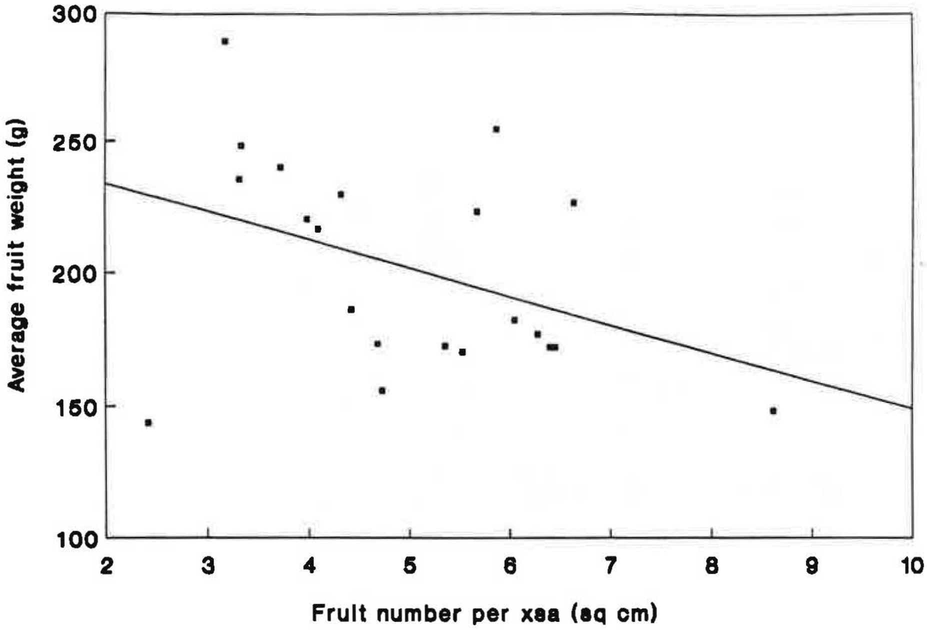

Figure 10. Relationship between fruit weight and fruit no per xsa

It is difficult to explain variation in fruit size on various levels of the tree. It could be expected that smaller fruit on average would be carried on the lower third of the trees where light might be lower and photosynthesis not as effective. In fact, in The Netherlands, the reverse was the case. For all Netherlands growers the average fruit size on level 1 (the lower level) was 259.4g, for level 2, 251g and for level 3, 234.7g. The highest difference was for grower N2 who had an average weight for level 1 fruit of 236.5g and for level 3, 201.1g. In some districts initial flower and setting counts differentiated between terminal and lateral buds but this was not the case in The Netherlands. It is suggested that the later flowering lateral buds produce smaller fruit on average but there is no correlation for this concept in other districts where there was differentiated recording. The effect of low temperatures and some frost at flowering in The Netherlands could have had some influence on selecting potentially larger fruits at the lower level where theoretically temperatures during a radiation frost would be slightly lower.

In other districts fruit size tended to be evenly distributed over the tree.

Table 11. Average individual fruit weight (g) on three levels.

		Level 1	Level 2	Level 3	All Levels
Jork	1	175.3	172.6	174.4	174.0de
	2	243.0	238.1	239.1	239.7bc
	3	214.7	217.9	228.4	220.1c
	4	168.1	172.8	177.6	173.0de
	5	174.5	180.3	179.3	177.7de
	Av.	195.1	196.3	199.8	196.9B
Bonn	1	173.7	172.8	170.6	172.8de
	2	152.7	148.3	133.3	148.9e
	3	191.8	184.1	188.3	186.6d
	4	206.0	227.6	221.1	228.0bc
	5	142.5	137.8	153.1	143.7e
	6	179.1	183.9	189.6	183.1de
	Av.	174.3	175.8	176.0	177.2B
Bodensee	1	157.2	159.7	147.0	156.2e
	2	162.0	173.6	177.8	173.0de
	3	211.6	216.7	220.1	216.4c
	4	175.7	166.7	173.0	171.2de
	5	227.0	228.3	234.1	230.0bc
	Av.	186.7	189.0	190.4	189.4B
Netherlands	1	297.3	289.3	265.6	289.5a
	2	236.5	221.7	201.1	226.4bc
	3	262.1	247.3	231.3	248.0b
	4	258.3	251.5	252.2	254.7b
	5	245.0	245.4	223.4	235.1bc
	Av.	259.4	251.0	234.7	250.7A

4.5 Yield per tree on each of three levels

Total yield of fruit on the three levels of the trees varied considerably between growers as shown in Table 12 and also presented in Figure 11 (Figures are averages of 5 trees). Significant differences ($P < 0.05$) are indicated by the letters in the "all levels" column. Details on a per tree basis are given in Appendix 6.

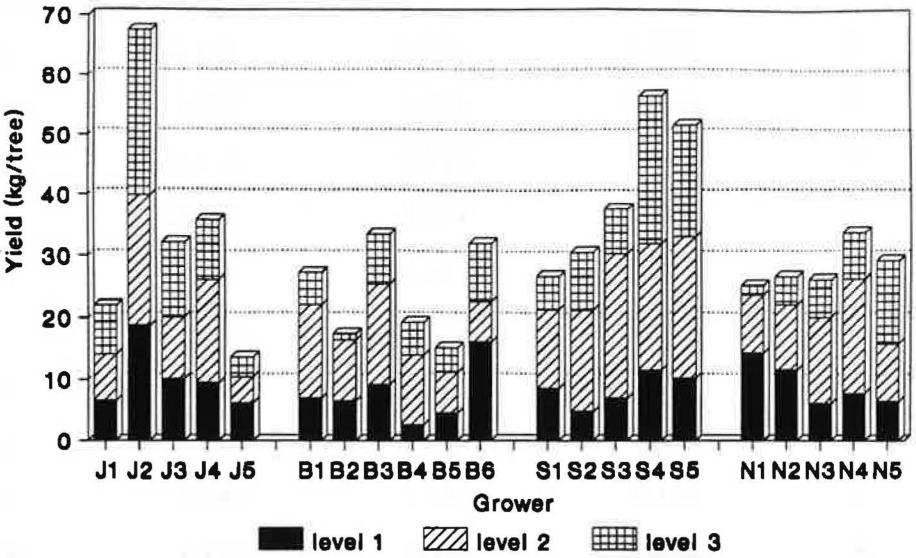

Figure 11. Yield per tree on each level: all growers

The distribution of fruit on the tree as measured by the three levels shows differences between districts and inefficiency of tree use by some growers. Bodensee growers tend to be using the centre of their trees effectively but have less weight on the upper and lower levels. Both S4 and S5 have good fruit distribution but both growers have taller trees. The Netherlands growers have a lower percentage yield on the top level although N5 is an exception. This is to be expected with the smaller trees. The Jork grower (J2) with the highest yield for that district is a good example of even fruit distribution and efficient use of the overall tree.

Apart from grower B6 in the Bonn district the highest percentage of fruit is carried on level 2 with B1 (58%), B2 (57%) and B4 (59%). This indicates there is a possibility for improving fruit numbers and hence yield over the full tree by better fruit distribution.

Some highly significant facts emerge by relating yield/tree to the number of trees/ha (Figure 12). Yields on The Netherlands trees varied over a very narrow range from 26 to 33 kg/tree inspite of a variation from 1905 to 3472 trees/ha. This infers that yield/ha can be increased by increasing the number of trees, particularly in cooler districts where growth rate is slower and where trees may take a longer time to mature. This is the case with New Zealand recordings where the more southern district, Canterbury, has smaller trees and lower yields/tree than the northern district of Hawkes Bay.

Table 12. Average yield of fruit/tree (kg) at each of 3 levels (% at each level in brackets)

		Level 1	Level 2	Level 3	All Levels
Jork	1	7.4 (30)	8.6 (35)	8.9 (35)	24.9d
	2	15.5 (35)	17.5 (38)	12.6 (28)	46.1b
	3	10.4 (31)	10.6 (32)	13.3 (38)	34.3cd
	4	9.2 (24)	17.1 (48)	10.1 (28)	36.3b
	5	10.0 (46)	7.5 (31)	5.6 (23)	23.0d
Bonn	1	6.9 (25)	15.2 (56)	5.2 (19)	27.3d
	2	6.4 (37)	10.0 (57)	1.0 (6)	17.3e
	3	9.1 (27)	16.4 (49)	8.1 (24)	33.6cd
	4	2.6 (14)	11.3 (59)	5.3 (27)	26.5d
	5	4.4 (29)	6.7 (45)	4.0 (27)	15.0e
	6	16.1 (51)	6.6 (20)	9.5 (29)	32.1cd
Bodensee	1	8.5 (32)	12.9 (48)	5.4 (20)	26.8d
	2	4.7 (15)	16.6 (55)	9.4 (31)	30.7cd
	3	6.9 (19)	23.6 (62)	7.3 (20)	37.8c
	4	11.5 (20)	20.6 (37)	24.4 (43)	56.6a
	5	10.2 (19)	23.1 (45)	18.3 (36)	51.6ab
Netherlands	1	14.3 (45)	9.5 (31)	7.4 (24)	31.2cd
	2	11.6 (43)	10.6 (40)	4.5 (17)	26.7d
	3	6.1 (23)	14.1 (54)	6.0 (23)	26.2d
	4	7.7 (23)	18.6 (55)	7.5 (22)	33.8cd
	5	6.4 (22)	9.4 (32)	13.4 (46)	29.2d

On the other hand Jork, Bonn and the Bodensee areas exhibited a more vertical yield distribution, indicating the ability of some growers in each district to mature heavier crops than other growers with similar spacings. Five growers in Bonn, for example, had 1905 trees/ha and their yields varied between 15 and 34 kg/tree.

In Europe it is common to predict yield based on tree fruiting volume in association with an estimate of fruit numbers and distribution (Winter 1979). In the monitoring work in New Zealand the trunk cross sectional area basis of comparison is considered by scientists to be only effective for trees which have not reached full maturity. Figures 13a and 13b use the two comparative methods, tree volume and cross sectional area, to test the European data. In neither case is the 'r' value high; cross sectional area of trunk versus yield/tree, $r = 0.731$ and tree volume versus yield/tree, $r = 0.696$. In both cases the poor performance of one or two growers (eg B5) is affecting the 'r' values. Tree volumes, although high by Winter's method of measurement, are nonetheless proportional. Clearly with both methods, at least one third of the growers are not utilising their trees to their full potential.

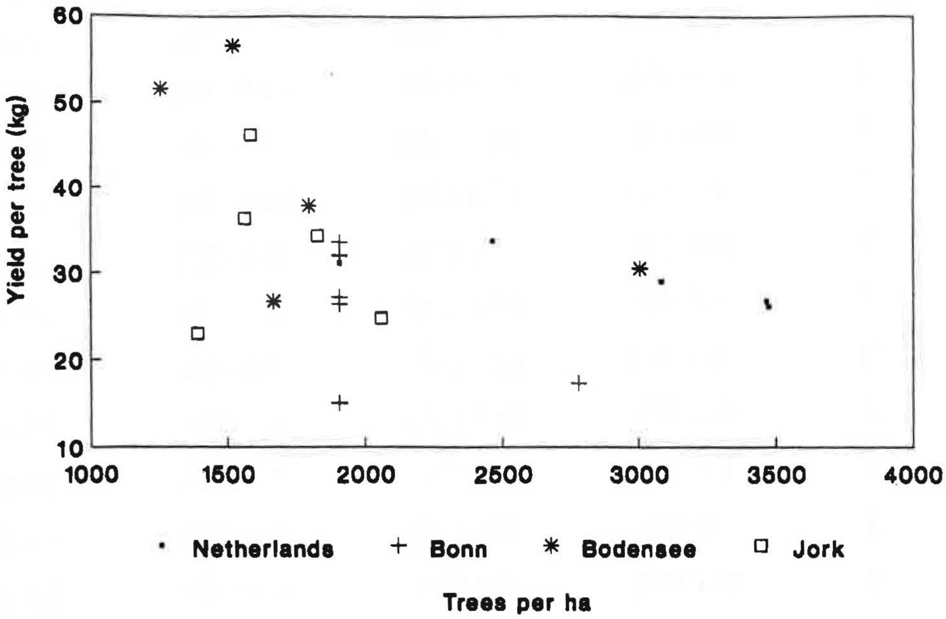

Figure 12. Trees per hectare vs yield per tree

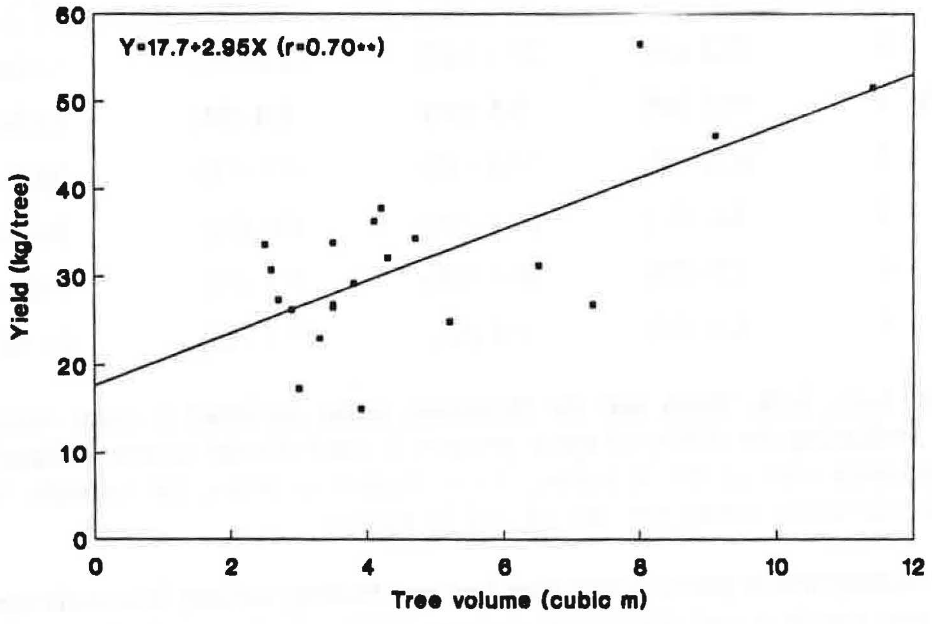

Figure 13a. Tree yield vs tree size: volume

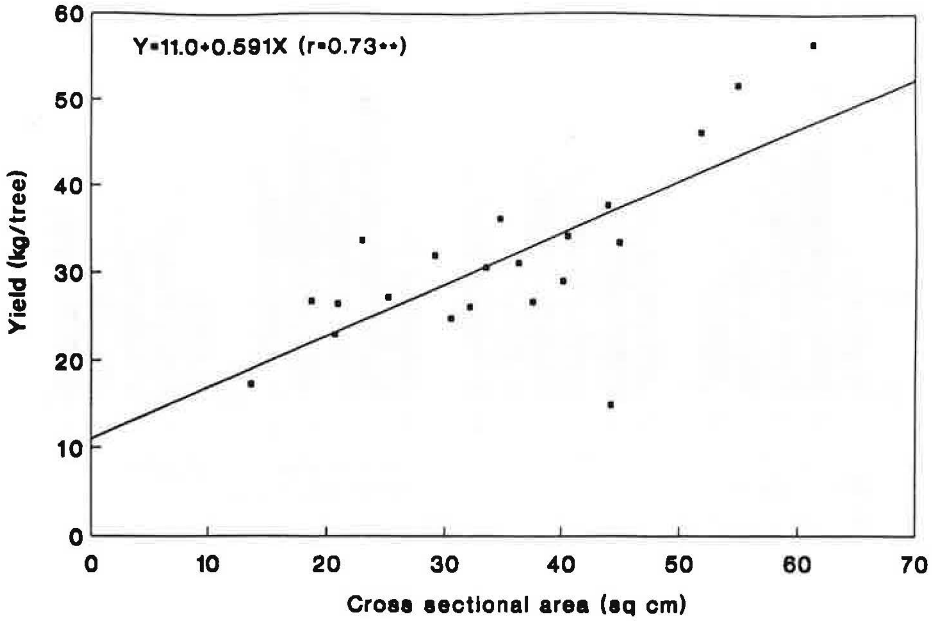

Figure 13b. Tree yield vs tree size: trunk cross sectional area

5. Economic Assessment

Estimated gross margins per hectare for all growers are given in Figure 14. Machinery costs/ha are minimal and do not show clearly in the figure. Total return represents market return after deducting commission and box charges. Labour costs were allocated at an average rate of DM 12/hour. Tractor hours were assessed at DM 10/hour, a sprayer at DM 3/hour and a mower DM 2/hour. Estimated machine and production labour hours are given in Appendix 7a and 7b. The gross margin was calculated by deducting direct costs from net market returns. No allowance has been made for overheads. Total costs/ha for each category for each grower are given in Appendix 8a and allocated on a per kilogram basis (Appendix 8b). To allow comparison, Dutch Florins have been converted to German Deutschmarks.

This was the most difficult section of the work and is likely to be the least accurate. Problems were experienced in gaining specific details from growers. The two key items were the harvesting and packing labour cost and the returns for the various classes of fruit.

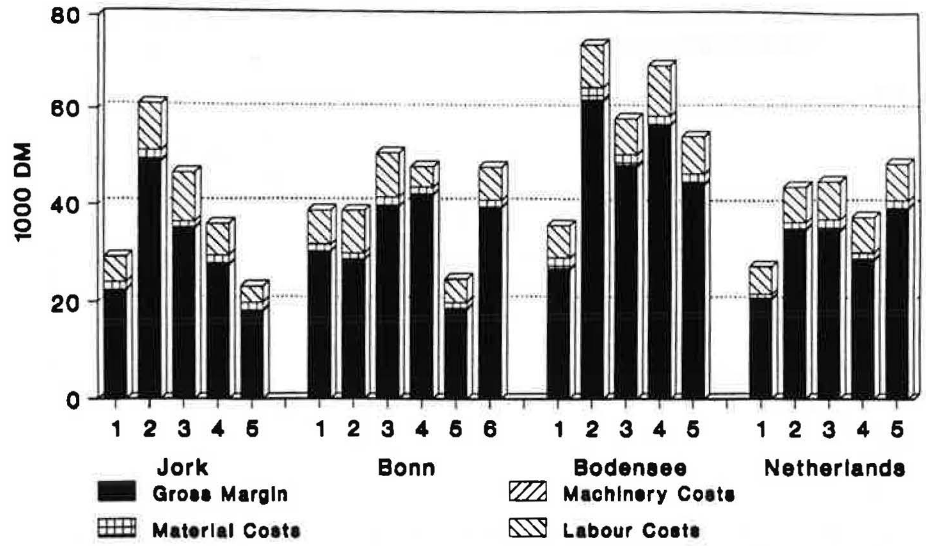

Figure 14. Gross margins and profitability: all growers

5.1 Costs

Considerable difficulty was experienced in getting accurate spray, fertiliser and herbicide programmes from the growers. Details are given in Appendices 9a - 9d grouped according to districts. In some instances, rates per hectare may be inaccurate, particularly in terms of level of concentration of the chemicals in the spray tank and the volume of dilute spray applied per hectare. Pricing of the chemicals may be variable between districts as well. Costs per kilogram or per litre were difficult to determine because of the size of chemical pack purchased by the individual growers. As far as possible, tax has been included in the price used but there could be inaccuracies in this aspect as well, because of doubt amongst individuals quoting the prices. Nevertheless the detail presented may form the basis for comparison and discussion and provide the opportunity to refine and standardise the method of presentation.

Table 13 shows a break down of costs as a percentage of returns for each district. The costs are remarkably similar within each category and in total fall within a narrow range between 26.8 - 30.9% of total returns. Harvesting labour and marketing costs together make up almost two-thirds of total costs. There is considerable variation between growers; for example, material costs per ha range from DM 890 (N1) to 2.569 (S2) but most fall in the DM 1500 - 2000 range. One grower in The Netherlands (N1) sprayed only 12 times at a material cost of DM 550 per ha and another grower, in the same district, sprayed 36 times at a material cost of DM 1240 per ha. There was no major difference in disease and pest control between the two properties. Similar variation was noted in the costs of herbicides and fertiliser. For example, average herbicide cost/grower in the Bodensee area was DM 745/ha but in The Netherlands it was only DM 167/ha. But the Bodensee area used very little fertiliser (DM 35/ha/grower) whereas Bonn used DM 288/ha/grower. Although district and soil type has some influence, there is clearly room for discussion and rationalisation between growers and districts in material useage.

Table 13. Average Direct Costs for Each District as a Percentage of Average Returns

	Jork	Bonn	Bodensee	Netherlands
Materials	3.9	3.0	3.3	3.3
Machinery	0.4	0.5	0.5	0.6
Production Labour	4.8	3.9	3.0	3.0
Harvesting Labour	11.5	11.2	9.9	11.7
Marketing	10.3	8.9	10.2	7.1
Gross Margin	69.1	72.5	73.2	72.6

Theoretically, lower harvesting costs/kg result from large fruit, good colour, small trees and fewer harvests. It was a disappointing part of the work that most growers were not prepared to record or even think about the cost of harvesting. Growers estimated it cost between DM 0.05 - 0.09/kg to harvest and between 0.01 - 0.05/kg to sort and pack. Clearly such wide ranging estimates are quite unsatisfactory for this type of work but there was no other alternative. Total harvesting and sorting costs had a range of DM 1615 - 7772/ha which to some extent depended on the yield but it was obvious in some cases that there was room for efficiency studies.

5.2 Returns

Total returns per planted hectare ranged from DM 74092 (S1) to DM 13741 (J5). Prices for the fruit were taken from market returns for the harvesting period assuming all fruit was marketed as it was harvested and packed. No account was taken of individual storage strategies. Some Jork growers sold some fruit at the gate and one Bonn grower B5 sold all fruit through a roadside shop. Another grower B4, close to the Rhine, harvested approximately 10 days ahead of other growers and benefitted from higher early market prices.

It was extremely difficult to obtain accurate market prices for each grower. It was necessary to rely on the district co-ordinators to supply prices and in some instances these were distinctly suspect. Bodensee growers were credited with the highest average return/kg (for fruit supplied to the market) but these figures are likely to be an overestimate. Conversely, The Netherlands growers had the lowest average returns, partly due to the large fruit and partly due to rigorous grading standards set by the co-ordinator. Average returns net of marketing costs for all growers are given in Table 14.

Table 14. Average Return DM/kg : All growers (net of marketing costs)

Grower	Jork	Bonn	Bodensee	Netherlands
1	0.65	0.75	0.80	0.46
2	0.81	0.80	0.80	0.47
3	0.79	0.80	0.86	0.49
4	0.64	0.95	0.81	0.45
5	0.72	1.16	0.85	0.54
6		0.78		
Average	0.72	0.87	0.82	0.48

5.3 Profitability

The suspect nature of harvesting costs and market returns, together with a possible overestimate of yields resulting from extrapolition from the monitored trees to a per planted hectare basis produce gross margin figures likely to be excessive in reality. Nevertheless, comparisons within districts are likely to be valid and at least will form the basis for analyses and discussion. The gross margins for all growers summarised in Table 15 show a wide range between D.M. 62072/ha to D.M. 18164/ha. Because of the overall variability the district averages quoted cannot be realistically compared.

Table 15. Gross Margin D.M./ha for all growers

Grower	Jork	Bonn	Bodensee	Netherlands
1	22414	30201	26423	20670
2	49134	28625	62072	35033
3	35095	39444	48171	34733
4	27578	41977	56948	28709
5	18164	18492	44467	39256
6		39221		
Average	30477	32993	47616	31682

Clearly yield for the top grower (S2) has been the dominating factor (92.1 t/ha). Grower N2 achieved a similar yield (92.7 t/ha) but the average price per kg credited to these two growers (S2 = DM 0.80 and N2 = DM 0.47) has had a major effect on profitability. If the figures are accurate The Netherlands growers have to look closely at their marketing strategies. If the figures are incorrect then it is obvious that more careful recording and analyses is warranted.

6. Discussion

The approach adopted in this research was based on the premise that decisions can be made by comparing production, economic and marketing data obtained from orchardists producing the same apple cultivar under a range of conditions. Normally, research is conducted under controlled conditions where any variations introduced for testing are replicated in such a way that they can be statistically analysed. The problem with this formal research approach is that the variables that can be tested are limited and as soon as results are implemented commercially another range of conditions often make the optimum results obtained under trial conditions invalid. An example would be an apple spacing trial where a particular tree density per hectare is determined to give the highest yield expressed in tonnes per hectare. It is clear that on a different soil type under different weather conditions the results of such a trial could well be different. Furthermore, various tree densities per hectare require that the trees be managed in a variety of ways. Density may well affect the pattern of yield over time and hence the time value of money must be considered. Tree spacing may also affect the quality of fruit, in that light levels and/or tree competition may affect fruit colour or fruit size. In this case, gross return would be important and to express results in yield terms may give a completely different optimum result. More trees per hectare could well mean more production costs but smaller trees could reduce costs/tree such as pruning. Another factor is that the perennial nature of a fruit tree means that interactions between seasons must be considered. There are many more factors to be considered in the apple tree or in the orchard system. The system is so complex in fact that the simple apple spacing trial based on determination of the best yield becomes almost a waste of time and money.

Another premise of this work is that there is a lot to learn by orchardists from their own orchards and that the development of a simple data base allowing comparisons between orchards can provide a sound platform for informed management decisions. To benefit to the fullest extent, growers need to be involved with the monitoring of their trees. Growers were selected on this basis, on the understanding that they were interested in the concept and that they were prepared to share their data with others, albeit on an anonymous basis. In selecting the properties, another objective was to provide a range of growing and management conditions to provide the opportunity to analyse these differences. The selection of orchards in northern, central and southern Germany and in south west Netherlands, allowed district differences to be identified but it would have been even better to have incorporated orchards near Dresden, Eastern Germany, Poland and Italy.

A major disappointment of this work was the lack of interest and involvement of some of the growers. In several instances, a lack of responsibility was revealed through failure to protect the trees being recorded. In some instances the author did not really discuss the results with the orchardist at all although comparative data was supplied to growers throughout the season and discussion invited. Meetings were held with the growers and co-ordinators in some districts, notably Jork and The Netherlands, and, as a result, the system of growers discussing the results and making decisions themselves worked very well.

Another disappointment was the difficulty encountered in gathering basic data on spray, herbicide and fertiliser programmes and costs associated with labour inputs into operations such as pruning,thinning, harvesting and packing. Because of this, some of the economic calculations are suspect and should be used only as a basis for improvement if growers consider it worthwhile. If there are errors in any of the recorded facts the author apologises for the difficulty experienced in verifying the calculations from the other side of the world.

Another difficulty experienced was in the standardisation of the key co-ordinators in the various districts inspite of at least four, and sometimes five, visits to each district and orchard during the season. Nevertheless the coordinators in each district played an extremely important role and without them this type of work would have been impossible.

Colour and reject grading at harvest was the most difficult to co-ordinate. Comparisons on fruit sizes are valid due to accurate weighing or use of fruit sizing rings.

The combination of the quality factors of size, colour and defects together with the time, place and method of selling made it almost impossible to stipulate fruit prices accurately for each orchardist. A difference between growers of more than 100% in the final average price allocated (compare N4 D.M. 0.45 and B5 D.M. 1.16) emphasises how critical fruit price is to the final gross margin. The importance of the need for detailed work in the area of costs of harvesting and marketing, quality and price cannot be overemphasised.

Although no attempt has been made to formulate the figures from this work into a fruit tree model for predictive or explanatory purposes, the New Zealand work has been processed into a practical planning model. The papers explaining this by Zhang and Thiele (1992) and Thiele and Zhang (1992) at the 3nd International Symposium on Computer Modelling in Fruit Research and Orchard Management are to appear in an Acta publication covering the symposium.

7. References

Carlsson, M., Christensen, I., Nilsson, C. 1979. B.E.T. analysis in Swedish Horticultural firms. *Acta Horticulturae* 97 : 33-43.

Thiele, G.F. 1989. The fruit tree as a system : Grower comparison in the German and Netherlands apple industries. *Obstbau* 8 : 208-210.

Thiele, G.F. 1990. Apple monitoring : A whole system approach to grower education and research : Germany and The Netherlands. *Acta Horticulturae* 295 : 39-46.

Thiele, G.F. and Zaprzalek, P.J. 1987. The apple tree system : a district and grower comparison. *Acta Horticulturae* 223 : 245-253.

Thiele, G.F. and Zhang, J. 1992. The dynamic apple tree system: relationships to aid management strategies. *Acta Horticulturae* (in print).

Winter, F. 1979. Frupro 1, a dynamic model connecting biological and economic elements of orchard management. *Acta Horticulturae* 97 : 423-425.

Zaprzalek, P.J. and Thiele, G.F. 1987. The apple tree system : a district and grower comparison 1986/87. *Discussion paper No. 6, Department of Horticulture and Landscape, Lincoln College, New Zealand* 103 pp.

Zhang, J., 1988. The systems analysis of apple tree production. *Postgraduate diploma dissertation, Department of Horticulture and Landscape, Lincoln University*, 54 pp.

Zhang, J. and Thiele, G.F. 1992. The dynamic apple system: pomological and climatic relationships. *Acta Horticulturae* (in print).

8. Acknowledgements

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List of Appendices

Appendix 1. Terminal flower buds as a percentage of total flower buds at each level

		Grower					
	level	1	2	3	4	5	6
Jork	1	97	94	90	88	74	
	2	95	96	96	89	71	
	3	93	100	89	77	58	
	av.	95	97	92	85	68	
Bonn	1						
	2			not recorded			
	3						
	av.	21	30	56	22	45	47
Bodensee	1	77	70	78	62	56	
	2	74	72	77	60	54	
	3	60	67	71	65	60	
	av.	70	70	75	62	57	
Netherlands	1						
	2			not recorded			
	3						
	av.						

Appendix 2. Details on fruit set (%)

		Grower					
district	average	1	2	3	4	5	6
Jork	19.7	20.6	19.4	14.5	23.1	21.1	
Bonn	17.7	34.1	21.6	20.2	9.9	9.3	10.9
Bodensee	17.3	12.6	17.5	17.7	25.7	13.0	
Netherlands	12.0	9.7	7.9	19.6	10.1	12.5	

Appendix 3. Cultivars neighbouring the Jonagold block (possible pollinators)

J1	Not known
J2	Elstar
J3	Gravenstein
J4	Not known
B1	C.O.P. Elstar
B2	C.O.P. Gloster
B3	Boskoop Jamba
B4	Elstar C.O.P.
B5	Kent Gloster
B6	C.O.P. , Every 11th tree "wild apple"
S1	Gloster
S2	Not known
S3	Idared Boskoop
S4	McIntosh
N1	All Jonagold
N2	Gloster
N3	Alkmene
N4	Not known
N5	Not known

Appendix 4. Yield before and after rejects, fruit numbers and fruit weights

District	Grower	Yield/ha (t)	Net yield/ha (t)	Fruit No/ha	Average fruit weight (g)
Jork	1	51.3	45.56	291271	174.0
	2	72.9	66.52	304060	239.7
	3	62.7	59.00	287778	220.1
	4	56.7	53.18	330096	173.0
	5	32.0	28.75	180014	177.7
	av	55.1	50.60	278644	196.9
Bonn	1	52.0	48.19	301371	172.8
	2	48.1	44.56	322804	148.9
	3	64.0	62.17	342138	186.6
	4	50.5	49.52	226314	223.0
	5	28.6	23.77	200406	143.7
	6	61.2	59.72	334518	183.1
	av	50.7	47.99	287925	176.4
Bodensee	1	44.6	44.27	285724	156.2
	2	92.1	90.92	532732	173.4
	3	67.9	67.57	313591	216.6
	4	85.7	85.16	500556	171.3
	5	64.5	64.29	280500	229.6
	av	71.0	70.44	382621	189.4
Netherlands	1	59.4	53.24	207264	289.5
	2	92.7	58.43	414175	226.4
	3	91.1	80.31	369421	248.0
	4	83.1	65.22	328297	254.7
	5	90.0	79.08	383401	235.1
	av	83.3	67.26	340512	250.7

Appendix 5. Mean individual fruit weight on each of 3 levels (g)

District	Grower	Tree	Level 1	Level 2	Level 3	Tree average
Jork	1	1	203.5	200.8	197.7	200.6
	1	2	191.6	184.1	190.0	187.2
	1	3	173.2	167.2	168.8	170.2
	1	4	170.0	176.0	179.0	175.4
	1	5	138.5	134.8	136.4	136.5
	2	1	246.1	238.9	248.2	243.2
	2	2	249.1	237.9	239.8	242.0
	2	3	238.3	240.8	245.3	241.4
	2	4	242.5	238.5	231.6	237.3
	2	5	239.2	234.2	230.6	234.8
	3	1	254.7	243.7	222.3	239.1
	3	2	196.7	218.9	224.1	213.4
	3	3	214.2	222.3	236.8	223.4
	3	4	210.4	207.8	225.1	216.3
	3	5	197.5	196.7	233.9	208.1
	4	1	166.1	161.4	157.6	161.9
	4	2	157.5	165.4	171.8	165.7
	4	3	177.4	181.8	190.8	184.3
	4	4	189.8	194.0	195.6	193.5
	4	5	149.6	161.6	172.4	159.8
	5	1	177.7	189.7	191.1	186.6
	5	2	190.7	183.7	191.1	188.2
	5	3	169.9	180.1	181.8	176.5
	5	4	186.4	189.6	182.3	186.5
	5	5	147.8	158.4	150.1	150.7
Bonn	1	1	185.7	183.8	176.8	182.3
	1	2	170.4	166.4	174.3	169.0
	1	3	168.3	165.1	164.2	165.8
	1	4	177.1	170.7	181.5	172.7
	1	5	177.4	175.8	154.1	174.2
	2	1	152.2	148.7	144.2	150.0
	2	2	153.0	145.3	123.3	146.4
	2	3	148.2	139.7	122.5	141.6
	2	4	155.2	157.2	145.7	156.1
	2	5	154.4	151.3	137.0	150.2
	3	1	195.7	177.3	179.9	180.6
	3	2	205.8	194.2	187.3	193.6
	3	3	200.0	190.9	197.1	195.1
	3	4	189.4	184.7	187.9	187.4
	3	5	176.0	173.1	182.9	176.4
	4	1	203.6	210.2	207.1	207.2
	4	2	175.8	211.9	215.8	210.9
	4	3	237.3	244.8	246.2	244.8
	4	4	251.3	244.5	229.0	239.7
	4	5	118.5	247.6	227.7	237.5
	5	1	152.5	147.6	172.4	156.8
	5	2	144.1	144.4	149.2	145.5
	5	3	150.1	131.5	157.0	139.9
	5	4	133.2	146.0	140.7	141.3
	5	5	129.5	130.9	148.6	134.8
	6	1	177.7	178.0	183.5	179.1
	6	2	176.5	179.3	180.3	178.2
	6	3	177.4	195.4	202.9	188.5

	6	4	182.3	188.2	193.5	187.3
	6	5	181.5	184.6	182.5	182.4
Bodensee	1	1	137.4	153.2	119.3	137.8
	1	2	161.0	159.7	159.7	160.1
	1	3	165.7	156.3	158.8	159.7
	1	4	158.7	161.0	139.8	157.0
	1	5	164.2	165.4	175.9	166.5
	2	1	173.4	170.2	165.6	169.8
	2	2	151.1	173.1	177.2	170.7
	2	3	173.5	167.5	189.5	174.8
	2	4	149.3	182.4	185.1	180.1
	2	5	159.8	175.4	173.1	171.4
	3	1	223.4	217.0	216.5	217.2
	3	2	203.7	209.7	238.5	209.4
	3	3	230.7	234.2	238.9	234.2
	3	4	195.9	199.9	211.3	201.3
	3	5	227.2	221.2	217.2	220.7
	4	1	175.3	175.0	178.0	176.5
	4	2	191.8	184.7	185.3	187.5
	4	3	180.4	163.8	172.2	170.1
	4	4	152.5	157.2	154.9	155.7
	4	5	152.8	164.9	172.4	166.8
	5	1	231.8	230.7	230.3	230.9
	5	2	221.4	221.6	222.1	221.6
	5	3	222.9	235.2	223.6	228.7
	5	4	220.7	223.7	232.5	227.8
	5	5	230.7	232.2	250.8	239.1
Netherlands	1	1	299.9	255.1	248.2	271.9
	1	2	318.3	325.3	299.3	313.8
	1	3	264.1	290.0	249.3	269.7
	1	4	318.4	329.8	295.2	317.4
	1	5	296.4	266.2	252.1	274.9
	2	1	246.0	231.4	228.9	237.0
	2	2	238.3	228.1	209.9	230.2
	2	3	212.3	212.8	157.3	196.1
	2	4	220.8	192.4	218.3	205.5
	2	5	269.4	255.2	280.2	262.8
	3	1	237.9	234.8	230.9	233.8
	3	2	274.3	249.1	200.9	249.5
	3	3	268.5	257.3	277.9	264.3
	3	4	269.7	267.6	221.8	256.8
	3	5	225.2	240.8	229.0	235.8
	4	1	257.5	255.2	245.5	252.9
	4	2	272.0	283.6	301.9	283.0
	4	3	263.5	247.3	269.7	253.3
	4	4	235.8	229.8	230.8	231.2
	4	5	258.1	261.5	232.1	253.0
	5	1	271.3	241.9	201.1	238.7
	5	2	250.5	242.8	211.1	229.5
	5	3	219.5	275.3	251.5	250.5
	5	4	254.4	235.4	227.7	232.7
	5	5	238.2	235.3	218.3	223.9

Appendix 6. Yield per tree on each of 3 levels (kg)

			Level 1		Level 2		Level 3		Tree
District	Grower	Tree	Yield	%	Yield	%	Yield	%	Yield
Jork	1	1	11.4	37.1	7.4	24.2	11.9	38.7	30.7
	1	2	4.4	16.1	13.8	50.5	9.1	33.4	27.3
	1	3	10.4	38.9	3.7	13.8	12.7	47.4	26.7
	1	4	5.4	22.0	12.7	51.2	6.6	26.8	24.7
	1	5	5.3	34.7	5.5	36.5	4.4	28.8	15.2
	2	1	18.7	36.3	23.4	45.4	9.4	18.3	51.5
	2	2	15.7	33.6	20.9	44.8	10.1	21.6	46.7
	2	3	16.0	38.0	11.3	26.9	14.7	35.0	42.0
	2	4	14.8	30.6	17.6	36.4	16.0	33.0	48.4
	2	5	14.6	34.9	14.3	34.2	12.9	30.9	41.8
	3	1	5.9	26.1	9.5	42.3	7.1	31.6	22.5
	3	2	12.2	31.1	11.2	28.4	15.9	40.5	39.3
	3	3	13.1	43.3	6.4	21.4	10.7	35.3	30.2
	3	4	8.6	20.4	13.3	31.5	20.3	48.0	42.2
	3	5	12.1	32.2	12.8	34.1	12.6	33.7	37.5
	4	1	16.4	35.8	16.6	36.1	12.9	28.1	46.0
	4	2	4.6	15.1	18.0	59.8	7.6	25.1	30.2
	4	3	5.9	18.8	13.3	42.6	12.0	38.6	31.1
	4	4	8.0	20.3	21.5	54.8	9.8	24.9	39.3
	4	5	11.2	31.9	15.8	45.0	8.1	23.0	35.2
	5	1	8.9	27.8	13.3	41.6	9.7	30.5	31.9
	5	2	10.7	43.7	8.8	36.0	5.0	20.3	24.5
	5	3	9.0	38.9	6.8	29.6	7.3	31.5	23.1
	5	4	10.6	64.0	3.6	21.7	2.4	14.3	16.6
	5	5	10.9	57.1	4.8	24.8	3.5	18.0	19.1
Bonn	1	1	6.1	21.7	14.7	52.0	7.4	26.3	28.3
	1	2	13.3	43.7	13.8	45.4	3.3	10.9	30.4
	1	3	8.4	30.9	9.6	35.2	9.2	33.8	27.2
	1	4	1.6	6.4	19.3	77.5	4.0	16.1	24.9
	1	5	5.1	20.0	18.6	72.3	2.0	7.8	25.8
	2	1	6.9	40.8	9.5	56.6	0.4	2.6	16.8
	2	2	5.4	29.3	12.2	66.7	0.7	4.0	18.3
	2	3	5.8	36.5	9.2	58.1	0.9	5.4	15.9
	2	4	7.1	38.1	11.2	59.6	0.4	2.3	18.7
	2	5	6.6	39.5	7.7	45.9	2.5	14.7	16.8
	3	1	5.3	17.8	21.5	72.4	2.9	9.7	29.6
	3	2	5.1	15.0	18.1	52.7	11.0	32.3	34.3
	3	3	12.2	30.2	18.3	45.4	9.9	24.4	40.4
	3	4	14.0	39.8	11.6	33.0	9.6	27.2	35.2
	3	5	8.6	30.2	12.6	44.2	7.3	25.6	28.6
	4	1	9.4	32.7	12.4	43.4	6.8	23.9	28.6
	4	2	1.1	4.8	15.0	68.0	6.0	27.3	22.1
	4	3	0.5	3.1	12.0	79.0	2.7	17.8	15.2
	4	4	1.8	11.3	8.6	54.9	5.3	33.8	15.6
	4	5	0.1	0.8	8.7	60.8	5.5	38.3	14.3
	5	1	4.4	36.2	3.8	31.4	4.0	32.4	12.2
	5	2	8.8	51.6	3.6	21.2	4.6	27.2	17.0
	5	3	2.3	14.4	9.3	59.6	4.1	26.0	15.7
	5	4	4.1	25.9	8.3	52.1	3.5	22.0	16.0
	5	5	2.2	15.4	8.4	58.6	3.7	26.0	14.3
	6	1	14.2	62.0	3.2	14.0	5.5	24.0	22.9
	6	2	15.7	45.2	11.5	33.0	7.6	21.8	34.8

	6	3	16.7	49.7	4.1	12.2	12.8	38.1	33.6
	6	4	12.6	44.5	5.8	20.6	9.9	34.9	28.3
	6	5	21.2	51.5	8.3	20.2	11.7	28.3	41.2
Bodensee	1	1	7.7	30.2	10.9	42.7	6.9	27.2	25.5
	1	2	7.6	28.1	12.3	45.7	7.0	26.1	26.9
	1	3	8.1	31.8	12.2	47.7	5.2	20.5	25.5
	1	4	8.7	38.6	10.9	48.4	2.9	13.0	22.6
	1	5	10.2	30.6	18.2	54.6	4.9	14.8	33.3
	2	1	8.1	22.4	19.7	54.3	8.4	23.2	36.3
	2	2	5.4	16.4	13.7	41.3	14.0	42.3	33.1
	2	3	1.9	7.0	16.1	59.0	9.3	34.0	27.3
	2	4	2.1	7.5	18.1	64.7	7.8	27.8	27.9
	2	5	5.9	20.5	15.3	53.0	7.6	26.5	28.8
	3	1	1.8	4.4	30.6	74.9	8.4	20.7	40.8
	3	2	11.6	30.1	24.5	63.7	2.4	6.2	38.5
	3	3	7.2	18.2	26.7	67.9	5.5	14.0	39.3
	3	4	8.0	23.6	18.6	54.7	7.4	21.7	34.0
	3	5	5.9	16.2	17.7	48.6	12.8	35.2	36.4
	4	1	14.4	23.7	17.1	28.3	29.0	47.9	60.5
	4	2	21.3	36.4	14.2	24.3	23.0	39.3	58.5
	4	3	8.7	15.9	20.5	37.5	25.5	46.7	54.6
	4	4	7.2	14.1	25.3	49.9	18.3	36.0	50.8
	4	5	6.0	10.2	26.1	44.6	26.4	45.2	58.4
	5	1	16.2	27.9	22.4	38.5	19.6	33.6	58.2
	5	2	11.3	22.1	30.4	59.3	9.6	18.7	51.2
	5	3	7.6	17.7	20.0	46.7	15.2	35.5	42.8
	5	4	4.0	9.3	17.0	39.9	21.6	50.8	42.6
	5	5	11.8	18.6	26.0	41.0	25.6	40.4	63.3
Netherlands	1	1	15.6	47.4	6.6	20.2	10.7	32.4	32.9
	1	2	7.0	27.6	9.4	37.1	9.0	35.3	25.4
	1	3	14.5	49.0	10.2	34.2	5.0	16.8	29.7
	1	4	19.1	60.2	7.9	24.9	4.7	14.9	31.7
	1	5	15.4	42.5	13.3	36.7	7.6	20.8	36.3
	2	1	12.1	43.8	9.7	35.3	5.7	20.8	27.5
	2	2	11.7	50.7	8.0	34.7	3.4	14.6	23.0
	2	3	12.7	48.1	7.4	28.1	6.3	23.8	26.5
	2	4	9.1	31.5	14.0	48.8	5.7	19.7	28.8
	2	5	12.7	45.0	13.8	49.0	1.7	6.0	28.1
	3	1	2.9	8.5	19.7	59.0	10.9	32.5	33.4
	3	2	8.2	34.7	12.5	52.6	3.0	12.7	23.7
	3	3	5.9	26.3	11.8	52.7	4.7	21.0	22.5
	3	4	10.5	36.9	11.8	41.3	6.2	21.8	28.5
	3	5	3.2	13.6	14.7	63.6	5.3	22.8	23.1
	4	1	5.2	16.2	18.1	56.9	8.6	27.0	31.9
	4	2	12.2	39.7	11.1	35.9	7.5	24.5	30.8
	4	3	4.2	13.5	21.3	68.3	5.7	18.2	31.2
	4	4	7.1	21.1	20.9	62.4	5.5	16.5	33.5
	4	5	9.8	23.6	21.7	52.3	10.0	24.1	41.5
	5	1	6.0	21.6	16.7	60.3	5.0	18.2	27.7
	5	2	10.8	36.7	5.1	17.4	13.5	46.0	29.4
	5	3	6.1	21.7	9.1	32.1	13.1	46.2	28.3
	5	4	2.3	6.9	14.6	43.9	16.4	49.3	33.3
	5	5	6.7	24.4	1.6	6.0	19.0	69.5	27.3

Appendix 7a Machine Hours/ha (T = Tractor, S = Sprayer, M = Mower)

Bodensee	S1	S2	S3	S4	S5
Fertiliser Application	T2	T2	-	T2	T2
Spraying	T10	T11	T16	T12	T7
	S10	S11	S16	S12	S7
Herbicide Application	T4	T2	T4	T4	T2
	S4	S2	S4	S4	S2
Mowing	T5	T7	T5	T6	T4
	M5	M7	M5	T6	T4
Harvesting	T4	T7	T6	T6	T2

Bonn	B1	B2	B3	B4	B5	B6
Fertiliser Application	T2	T2	T2	T2	T2	T2
Spraying	T7	T13	T14	T8	T8	T7
	S7	S13	S14	S8	S8	S7
Herbicide Application	T2	T2	T2	T2	T2	T2
	S2	S2	S2	S2	S2	S2
Mowing	T3	-	-	T4	T5	T2
	M3	-	-	M4	M5	M2
Harvesting	T5	T5	T6	T4	T3	T6

Netherlands	N1	N2	N3	N4	N5
Fertiliser Application	T3	T3	T3	T3	T3
Spraying	T6	T8	T12	T12	T15
	S6	S8	S12	S12	S12
Herbicide Application	T3	T1	T1	T2	T1
	S3	S1	S1	S2	S1
Mowing	T4	-	-	-	-
	M4	-	-	-	-
Harvesting	T8	T8	T8	T8	T8

<u>Jork</u> Not available in detail

Appendix 7b Production labour hours/ha

Bodensee	S1	S2	S3	S4	S5
Pruning					
Winter	--	45	60	80	80
Summer	70	--	35	35	20
Thinning	130	1	--	105	50
Fertiliser and Chemical Application	16	15	20	18	11
Mowing	5	7	5	6	4
Other	20				

Bonn	B1	B2	B3	B4	B5	B6
Pruning						
Winter	45	45	25	40	55	50
Summer	13	20	10	10	10	20
Thinning	60	84	96	--	45	--
Fertiliser and Chemical Application	9	15	16	10	10	9
Mowing	3	*	*	4	5	2
Irrigation	--	--	--	2	2	--

Netherlands	N1	N2	N3	N4	N5
Pruning					
Winter	70	50	80	80	70
Summer	30	--	20	10	20
Thinning	--	4	--	10	8
Fertiliser and Chemical Application	15	13	17	19	20
Mowing	4	--	--	--	--
Irrigation	--	--	4	2	2

Jork	J1	J2	J3	J4	J5
Pruning					
Winter	60	60	85	73	25
Summer	50	80	60	39	--
Thinning	30	80	63	--	--
Fertiliser and Chemical Application	8	20	16	8	17
Other	12	33			

Appendix 8a. Summarised costs D.M./ha

Grower	Gross Margin	Machinery	Material	Total Labour	Growing Labour	Harvesting Labour
Jork						
1	22414	84	1575	5182	2016	3168
2	49134	221	2022	9817	3270	6547
3	35095	163	1224	10353	2682	7670
4	27578	99	1807	6480	1440	5040
5	18164	172	1582	3224	504	2720
Bonn						
1	30201	193	1368	7000	1800	5200
2	28625	226	1074	8730	1968	6762
3	39444	248	1736	9444	1764	7680
4	41977	208	1457	4327	792	3535
5	18492	211	1253	4657	1500	3157
6	39221	190	1386	7072	972	6100
Bodensee						
1	26423	293	2187	6687	2664	4023
2	62072	337	2569	9114	816	8298
3	48171	365	2191	7542	1440	6102
4	56948	345	1653	10750	2928	7722
5	44467	200	2070	7797	1992	5805
Netherlands						
1	20670	250	890	5593	1428	4165
2	35033	218	1360	7300	804	6496
3	34743	266	2108	7836	1452	6384
4	28709	278	1324	7269	1452	5817
5	39256	302	1498	7747	1440	6307

Appendix 8b. Summarised costs D.M./kg

Grower	GM/kg	Machinery /kg	Material /kg	Labour /kg	Growing Lb/kg	Harvest Lb/kg
Jork						
1	0.437	0.002	0.031	0.101	0.039	0.062
2	0.674	0.003	0.028	0.135	0.045	0.090
3	0.560	0.003	0.020	0.165	0.043	0.122
4	0.486	0.002	0.032	0.114	0.025	0.089
5	0.568	0.005	0.049	0.101	0.016	0.085
Bonn						
1	0.581	0.004	0.026	0.135	0.035	0.100
2	0.595	0.005	0.022	0.181	0.041	0.141
3	0.616	0.004	0.027	0.148	0.028	0.120
4	0.831	0.004	0.029	0.086	0.016	0.070
5	0.647	0.007	0.044	0.163	0.052	0.110
6	0.641	0.003	0.023	0.116	0.016	0.100
Bodensee						
1	0.592	0.007	0.049	0.150	0.060	0.090
2	0.674	0.004	0.028	0.099	0.009	0.090
3	0.709	0.005	0.032	0.111	0.021	0.090
4	0.665	0.004	0.019	0.125	0.034	0.090
5	0.689	0.003	0.032	0.121	0.031	0.090
Netherlands						
1	0.348	0.004	0.015	0.094	0.024	0.070
2	0.378	0.002	0.015	0.079	0.009	0.070
3	0.381	0.003	0.023	0.086	0.016	0.070
4	0.345	0.003	0.016	0.087	0.017	0.070
5	0.436	0.003	0.017	0.086	0.016	0.070

Appendix 9a Jork Materials

Jork : Herbicides : 1989

	Material	Rate/Ha (l or kg)	Cost/Ha (D.M.)	
Grower 1				
	Ustinex G.L.	10	512.00	
				512.00
Grower 2				
	Ustinex K.R.	10	512.00	
	D.P.D.	3	30.00	
	M.C.P.A.	2	12.90	
	Roundup	4	199.80	
	Schwefel	10	6.00	
				760.70
Grower 3				
	Roundup	5	249.75	
	Basta	5	200.25	
				450.00
Grower 4				
	Basta	5	200.25	
				200.25
Grower 5				
	Roundup	3	149.85	
	Basta	5	200.25	
	Schwefel	10	6.00	
				356.10

Jork : Fertilisers : 1989

	Material	Rate/Ha (l or kg)	Cost/Ha (D.M.)
Grower 1			
	Kalkamonsalpeter	140	42
Grower 2			
	Harnstoff	80	31
Grower 3			
	Kalkamonsalpeter	80	24
Grower 4			
	Kalkamonsalpeter	80	24
Grower 5			
(March)	Kalkamonsalpeter	80	
(May)	Kalkamonsalpeter	80	
(June)	Kalkamonsalpeter	80	72

Grower J1 : Spray Programmes : 1989

Date	Material	Rate/Ha (l oir kg)	Cost/Ha (D.M.)
20 March	Captan	2.0	20.00
27 March	Captan	2.0	20.00
	E 605	0.5	15.00
14 April	Apollo	0.5	186.50
	Baycor	0.75	37.50
	Captan	1.50	15.00
21 April	Benocap	0.75	44.13
	Captan	1.50	15.00
	Netzschwefel	2.50	15.00
5 May	Dithane U	3.0	30.00
	Netzschwefel	2.0	12.00
	Decis	0.45	49.25
14 May	Omnex	0.375	25.90
	Dithane U	1.50	15.00
	Netzschwefel	2.50	15.00
17 May	Cercobin fl.	1.0	34.00
	Dimithoat	1.50	29.95
6 June	Omnex	0.375	25.90
	Dithane U	1.50	15.00
13 June	Omnex	0.375	25.90
	Dithane U	1.5	15.10
3 July	Dithane U	3.0	30.10
	Kalksalpeter	7.5	3.60
20 July	Captan	2.0	20.00
	Kalksalpeter	7.5	3.60
31 July	Captan	2.0	20.00
	Kalksalpeter	7.5	3.60
15 August	Captan	2.0	20.00
	Kalksalpeter	7.5	3.60
28 August	Torque	0.75	91.80
6 September	Euparen	2.25	58.35
	Calcium Chloride	7.5	1.50
20 September	Cercobin fl.	1.0	34.00
	Calcium Chloride	7.5	1.50
	Total Cost		952.78

Grower J2 : Spray Programmes : 1989

Date	Material	Rate/Ha (l or kg)	Cost/Ha (D.M.)
5 February	Kupfer	3.0	13.80
7 March	Kupfer	3.0	13.80
16 March	Antracol	1.5	17.35
22 March	Antracol	1.5	17.35
28 March	Antracol	1.5	17.35
8 April	Apollo	0.5	186.50
	E 605	0.5	15.00
	Netzschwefel	2.0	12.00
13 April	Delan	3.0	187.20
	Baycor	0.75	37.50
20 April	Delan (alt)	8.0	180.00
	Baycor	0.75	37.50
28 April	Baycor	0.5	25.00
	Delan	1.5	93.60
	Netzschwefel	1.0	6.00
4 May	Captan	1.5	15.00
	Netzschwefel	2.0	12.00
	Thiodan	2.0	76.00
12 May	Euparen	1.5	38.90
	Netzschwefel	1.5	9.00
15 May	Amidthin	1.05	124.50
30 May	Captan	1.2	12.00
	Dithane U	1.0	10.00
	Morestan	0.7	39.30
5 June	Captan	1.2	12.00
	Dithane U	1.0	10.00
	Morestan	0.7	39.30
24 June	Folpet	1.0	16.50
	Afugan	0.8	22.40
	Kalksalpeter	7.0	3.36
8 July	Dithane U	1.0	10.00
	Orthocit	1.2	7.20
	Netzschwefel	0.7	4.20
	Kalksalpeter	7.0	3.36
22 July	Folpet	1.0	16.50
	Afugan	0.8	22.40
	E 605	0.5	15.00
	Netzschwefel	0.7	4.20
	Kalksalpeter	7.0	3.36

5 August	Orthocit	1.5	9.00
	Nimrod	0.5	23.50
	E 605	0.5	15.00
	Calcim chloride	5.0	1.00
6 August	Ethrel	0.15	14.10
19 August	Benomyl	0.35	25.55
	Nimrod	0.5	23.50
	Calcium chloride	5.0	1.00
	E 605	0.5	15.00
29 August	Ethrel	0.15	14.10
2 September	Calcium chloride	5.0	1.00
	Benomyl	0.5	36.50
	Captan	1.5	15.00
	Total Cost		1585.28

Grower J3 : Spray Programmes : 1989

Date	Material	Rate/Ha (l or kg)	Cost/Ha (D.M.)
10 March	Kupfer	3.0	13.80
22 March	Delan SC	0.3	19.80
28 March	Delan SC	0.3	19.80
9 April	Apollo	0.6	223.80
	Delan Fl	3.0	48.00
22 April	Benocap	0.1	44.13
	E 605	0.4	12.00
	Dithane U	1.5	15.00
13 May	Amidthin	1.05	124.50
17 May	Dithane U	2.0	20.00
	Benocap	0.1	44.13
	Bayleton	0.1	36.90
	Netzschwefel	1.5	9.00
27 May	Benocap	0.1	44.13
	Bayleton	1.0	36.90
	Dithane U	2.0	20.00
	Netzschwefel	1.5	9.00
31 May	Benocap	0.1	44.13
	Bayleton	1.0	36.90
	Dithane U	2.0	20.00
	Netzschwefel	1.5	9.00
6 June	Dithane U	2.0	20.00
	Benocap	0.15	66.20
15 June	Benocap	0.15	66.20
	Dithane U	1.5	15.00

28 June	Dithane U	2.0	20.00
	Bayleton	0.75	27.66
	Kalsalpeter	6.0	2.88
10 July	Dithane U	1.5	15.00
	Omnex	0.2	13.80
5 August	Euparen	2.0	51.86
	Kalksalpeter	7.0	2.36
14 August	Euparen	2.0	51.86
	Kalksalpeter	7.0	3.36
29 August	Euparen	2.0	51.86
	Calcium chloride	7.0	7.00
13 September	Cercobin Fl.	1.3	44.20
	Calcium chloride	7.5	7.50
		Total Cost	1289.86

Grower J4 : Spray Programme : 1989

Date	Material	Rate/Ha (l or kg)	Cost/Ha (D.M.)
26 March	Baycor	1.5	75.00
	Dithane U	0.75	7.50
9 April	Delan	0.75	46.80
10 April	Apollo	0.5	186.50
	Netzschwefel	1.5	9.00
20 April	Benocap	0.15	66.20
	Dithane U	1.5	15.00
25 April	Captan	3.0	30.00
	Netzschwefel	2.0	12.00
9 May	Dithane U	3.0	30.00
	Wuxal	6.0	40.80
26 May	Captan	1.2	12.00
	Dithane U	1.0	10.00
	Wuxal	6.0	40.80
30 May	Captan	1.2	12.00
	Dithane U	1.0	10.00
	Bayleton	0.75	22.50
6 June	Omnex	0.375	25.90
	Dithane U	1.5	10.00

21 June	Captan	1.2	12.00
	Dithane U	1.0	10.00
	Bayleton	0.75	22.50
	Kalksalpeter	7.5	3.60
3 July	Captan	1.2	12.00
	Dithane U	1.0	10.00
	Kalksalpeter	7.5	3.60
6 August	Captan	1.2	12.00
	Bayleton	0.75	22.50
	Kalksalpeter	7.5	3.60
26 August	Folpet	1.0	16.50
	Calcium chloride	7.0	7.00
25 September	Benomyl	0.45	32.85
	Total Cost		830.15

Grower J5 : Spray Programme : 1989

Date	Material	Rate/Ha (l or kg)	Cost/Ha (D.M.)
6 March	Kupfer	4.5	20.49
16 March	Delan SC	0.75	49.50
23 March	Delan SC	0.40	26.40
3 April	Delan SC	0.75	49.50
10 April	Delan SC	0.75	49.50
13 April	Apollo	0.50	186.50
21 April	Baycor	0.75	37.50
	Delan SC	0.40	26.40
	Netzschwefel	2.0	12.00
	E 605	0.50	15.00
27 April	Baycor	0.75	37.50
	Delan SC	0.40	26.40
4 May	Polyram Combi	2.25	25.50
	Netzschwefel	2.25	13.50
14 May	Baycor	0.75	37.50
	Netzschwefel	2.0	12.00
	Phytox Super	1.5	17.00
29 May	Polyram Combi	3.0	34.00
	Metasystox	0.50	18.35
6 June	Benocap	0.15	66.20
	Polyram Combi	1.50	17.00
10 June	Dithane U	2.25	22.50

27 June	Dithane U	2.0	20.00
	Kalksalpeter	5.0	2.40
12 July	Dithane U	1.7	17.00
	Netzshwefel	2.0	12.00
	Kalksalpeter	5.0	2.40
25 July	Euparen	1.7	44.10
	Kalksalpeter	5.0	2.40
19 August	Euparen	1.7	44.10
	Kalksalpeter	5.0	2.40
8 September	Euparen	1.7	44.10
	Kalksalpeter	5.0	2.40
20 September	Euparen	2.25	58.34
	Calcium chloride	5.0	5.00
4 October	Cercobin	1.3	44.20
	Total Cost		1101.08

Appendix 9b Bonn Materials

Bonn : Herbicides : 1989

	Material	Rate/Ha (l or kg)	Cost/Ha (D.M.)	
Grower 1	Ustinex G1	3.4	210	
				210
Grower 2	Ustinex KR	5.0	200	
				200
Grower 3	Roundup	3.0	121	
	Simazine	2.0	44	
	Schwefel	5.0	8	
				173
Grower 4	Simazine	1.5	33	
	Ustinex KR	3.3	153	
				186
Grower 5	Roundup	3.0	121	
	Simazine	3.0	66	
	Schwefel	10.0	16	
				203
Grower 6	Domatol	8.0	272	
				272

Bonn : Fertilisers : 1989

	Material	Rate/Ha (l or kg)	Cost/Ha (D.M.)	
Grower 1	Simalith	1000	90	
				90
Grower 2	Fertiliser Mixture 12:12:17:2	400	250	
	Wuxal 12:4:6	17	120	370
Grower 3	Huttenkalk	2000	160	
	Superphosphate	400	140	
	Kalimagnesia	400	168	
	Blankorn	200	76	
				544
Grower 4	Granular Nitrogen	45	245	
				245

Grower 5	Huttenkalk	1600	128	
	Harnstoff	8	80	
				208
Grower 6	Huttenkalk	1400	112	
	Nitrophoska	400	160	
				272

Grower B1 : Spray Programme : 1989

Date	Material	Rate/Ha (l or kg)	Cost/Ha (D.M.)
20 March	Delan Fl	3.0	48
30 March	Ambush	0.3	38
11 April	Delan Fl	0.7	46
	Apollo	0.45	168
18 April	Delan Fl	3.0	48
	Kumulan	2.2	22
27 April	Elithal	0.45	68
	Dithane U	2.0	20
11 May	Dithane U	3.0	30
	Kumulan	2.2	22
29 May	Pallinal	3.0	48
7 June	Dithane U	3.0	30
	Bayleton	0.75	23
	Perfection	1.5	36
23 June	Dithane U	3.0	30
	Bayleton	0.75	23
5 July	Netzschwefel	0.4	3
24 July	Pallinal	2.0	32
9 August	Benomyl	0.5	37
	Total Cost		772

Grower B2 : Spray Programme : 1989

Date	Material	Rate/Ha (l or kg)	Cost/Ha (D.M.)
28 March	Delan	0.1	6.50
4 April	Delan	0.1	6.50
	Bayleton	0.1	3.00
	Harnstoff	1.4	0.55
8 April	Apollo	.06	22.38
15 April	Delan	0.1	6.50
	Bayleton	0.1	3.00
	Harnstoff	1.4	0.55
22 April	Captan	0.3	3.00
	Bayleton	0.1	3.00
	Wuxal	2.0	13.60
29 April	Pallinal	0.4	6.40
	Wuxal	2.0	13.60
13 May	Baycor	0.12	6.00
	Bayleton	0.1	3.00
	Dithane	0.2	2.00
20 May	Gusthion	0.4	9.60
27 May	Pallinal	0.4	6.40
	Wuxal	2.0	13.60
9 June	Dithane	0.4	6.40
	Kumulan	0.3	3.00
19 June	Pallinal	0.4	6.40
	Wuxal	2.0	13.60
1 July	Pallinal	0.4	6.40
	Decis	0.06	4.20
14 July	Captan	0.3	3.00
	Afugan	0.06	1.68
28 July	Dithane	0.4	4.00
	Bayleton	0.1	3.00
3 August	Mitac	3.0	102.00
11 August	Elital	0.06	9.00
20 August	Alar	1.2	64.80
	24a	0.12	11.28
24 August	Tutan TMTD	0.4	6.80
25 August	E605 forte	0.1	3.00
8 September	Tutan TMTD	0.4	6.80

22 September	Cercobin	0.14	4.76
	Total Cost		389.30

B3 : Spray Programmes : 1989

Date	Material	Rate/Ha (l or kg)	Cost/Ha (D.M.)
1 April	Delan	0.5	33.00
	Netzschwefel	4.0	24.00
11 April	Delan	0.5	33.00
	Netzschwefel	4.0	24.00
18 April	Rubigan	0.3	50.00
	Dithane U	1.0	10.00
25 April	Rubigan	0.3	50.00
	Dithane U	1.0	10.00
6 May	Delan	0.5	33.00
	Bayleton	0.5	15.00
13 May	Baycor	0.5	25.00
	Bayleton	0.5	15.00
23 May	Pallinal	2.0	32.00
	Peropal	1.0	83.00
6 June	Benocap	0.1	31.00
	Dithane U	1.0	10.00
	Rogor	1.0	13.50
24 June	Pallinal	2.0	32.00
	Rogor	1.0	13.50
8 July	Baycor	0.5	25.00
	Bayleton	0.5	15.00
24 July	Pallinal	2.0	32.00
5 August	Pomarsol	1.25	15.00
15 August	Alar	1.5	81.00
	Ethrel	0.25	23.50
18 August	Pomarsol	1.25	15.00
24 August	Ethrel	0.25	23.50
29 August	Cercobin	0.7	21.00
4 September	Ethrel	0.25	23.50
8 September	Benomyl	0.3	21.90
	Total Cost		833.40

Grower B4 : Spray Programme : 1989

Date	Material	Rate/Ha (l or kg)	Cost/Ha (D.M.)
25 March	Delan fl.	2.0	32
30 March	Apollo	0.3	112
	Netzschwefel	7.0	42
	Thiodan	1.0	38
8 April	Delan fl.	2.0	32
18 April	Delan fl.	2.0	32
	Netzschwefel	5.0	30
25 April	Rubigan	0.2	30
	Dithane U	1.0	10
6 May	Delan fl.	2.0	32
	Kumulan	2.0	20
13 May	Delan fl.	2.0	32
	Kumulan	2.0	20
24 May	Kumulan	2.0	20
	Dungal	3.0	18
5 June	Dithane U	2.0	20
	Nimrod	0.4	19
	Dungal	3.0	18
19 June	Dithane U	2.0	20
	Nimrod	0.4	19
	Dungal	3.0	18
July-August	Not supplied (estimate only)		256
	Total Cost		870

Grower B5 : Spray Programmes : 1989

	Material	Rate/Ha (l or kg)	Cost/Ha (D.M.)
Late March	Apollo	0.2	74.60
Before Blossom	Netzschwefel	4.0	24.00
	Insegar	0.4	59.00
During Blossom	Euparen	1.2	31.12
	Bayleton	0.3	9.00
During Blossom	Delan SC	0.8	52.80

Post Blossom	Delan SC	0.8	52.80
	Harnstoff	1.0	0.39
May	Nimrod	0.64	30.08
	Harnstoff	1.0	0.39
May	Insegar	0.4	59.00
	Harnstoff	1.0	0.39
June	Delan SC	0.8	52.80
	Bayleton	0.3	
	Harnstoff	1.0	0.39
June	Elital	0.2	30.00
	Harnstoff	1.0	0.39
June	Elital	0.2	30.00
	Harnstoff	1.0	0.39
July	Thiodan	1.6	60.80
	Dithane	3.2	32.00
	Afugan	0.8	22.40
	Harnstoff	1.0	0.39
	Cercobin	1.2	40.80
July	Kalksalpeter	5.0	2.00
	Harnstoff	1.0	0.39
August	Cercobin	1.2	40.80
	Kalksalpeter	5.0	2.00
	Total Cost		714.92

Grower B6 : Spray Programme : 1989

Date	Material	Rate/Ha (l or kg)	Cost/Ha (D.M.)
No details on dates of application supplied by the grower	Delan fl	3.0	48
	Delan fl	3.0	48
	Pallinal	3.0	48
	Pallinal	3.0	48
	Rubigan	0.45	68
	Pallinal	3.0	48
	Pomarsol	3.0	36
	Pomarsol	3.0	36
	Benomyl	0.5	37
	Benomyl	0.5	37
	E 605 forte	0.525	16
	Apollo	0.6	224
	Total Cost		694

Appendix 9c Bodensee Materials

Bodensee (South) : Herbicides : 1989

	Material	Rate/Ha (l or kg)	Cost/Ha (D.M.)	
Grower 1				
25 April	Roundup	3	117	
	SSA	10	6	
	Karmex	4	228	
20 July	V46 fluid	3	24	
	MCPA	6	48	
				423
Grower 2				
Spring	Basta	5	200	
	Roundup	3	117	
	Karmex	5	285	
	Shwefels Am	10	6	
				608
Grower 3				
Spring	Domatol Sp	15	718	
Summer	Domatol Sp	15	718	
				1436
Grower 4				
Spring	Roundup	3	117	
	Domatol Sp	15	718	
				835
Grower 5				
mid May	Domatol Sp	15	718	
				718

Bodensee (South) : Fertilisers : 1989

	Material	Rate/Ha (kg)	Cost/Ha (D.M.)	
Grower 1				
	Kalimagnesium	200	74	
				74
Grower 2				
	Nil			
Grower 3				
	Nil			
Grower 4				
	Kalimagnesium	150	55	
		30	10	
				65
Grower 5				
	Kalkamonsalpeter	100	34	
				34

Grower S1 : Spray Programme : 1989

Date	Material	Rate/Ha (l or kg)	Cost/Ha (D.M.)
11 March	Kumph	4.0	18.40
20 March	Delan SC	0.8	52.80
	Topas	0.2	25.48
28 March	Delan SC	0.8	52.80
	Netzschwefel	2.0	12.00
1 April	Apollo	0.4	149.20
	Telmion	0.5	5.02
3 April	Delan SC	0.8	52.80
	Benocap	0.1	31.00
	Netzschwefel	3.0	18.00
12 April	Delan SC	0.8	52.80
	Netzschwefel	2.0	12.00
18 April	Delan SC	0.8	52.80
	Netzschwefel	2.0	12.00
	Benocap	0.1	31.00
	Insegar	0.5	73.86
25 April	Delan SC	0.8	52.80
	Netzschwefel	2.0	12.00

2 May	Pomarsol	2.0	24.00
10 May	Amidthin	0.28	22.96
12 May	Delan SC	0.8	52.80
	Benocap	0.15	46.50
	Euparen	1.0	25.93
	Pirimor	0.2	24.83
	Insegar	0.5	73.86
27 May	Delan SC	0.8	52.80
	Nimrod	0.6	28.20
	Benocap	0.15	46.50
24 June	Delan SC	0.5	33.00
	Nimrod	0.6	28.20
	Benocap	0.15	46.50
	Dolomit C	0.6	1.00
13 July	Delan SC	0.5	33.00
	Benocap	0.1	31.00
	Dolomit C	0.5	1.00
3 August	Euparen	1.5	38.90
	Calcium chloride	2.0	1.10
11 August	Euparen	1.25	32.41
	Torque	1.0	122.40
	Calcium chloride	2.0	1.10
31 August	Euparen	1.0	25.93
	Calcium chloride	2.0	1.10
	Total Cost		1511.78

Grower S2 : Spray Programme : 1989

Date	Material	Rate/Ha x 5 (l or kg)	Cost/Ha (D.M.)
11 March	Delan SC	0.075	4.95
20 March	Delan SC	0.075	4.95
29 March	Delan SC	0.075	4.95
	Netzschwefel	0.45	2.70
1 April	Apollo	0.09	33.57
	Delan SC	0.075	4.95
10 April	Delan SC	0.075	4.95
	Netzschwefel	0.45	2.70
18 April	Delan SC	0.075	4.95
	Netzschwefel	0.45	2.70

25 April	Delan SC	0.075	4.95
	Netzschwefel	0.45	2.70
	Rubigan	0.045	6.75
2 May	Pomarsol	0.3	3.60
	Netzschwefel	0.45	2.70
13 May	Delan SC	0.075	4.95
	Pirimor	0.075	18.35
	Benocap	0.023	7.13
	Netzschwefel	0.45	2.70
26 May	Delan SC	0.075	4.95
	Netzschwefel	0.45	2.70
6 June	Delan SC	0.075	4.95
23 June	Delan SC	0.075	4.95
	Benocap	0.023	7.13
4 July	Delan SC	0.075	4.95
14 July	Delan SC	0.075	4.95
	Rubigan	0.045	6.75
22 July	Pomarsol	0.3	3.60
	Torque	0.075	9.18
8 August	Euparen	0.23	6.00
17 August	Euparen	0.23	6.00
31 August	Cercobin	0.10	3.40
7 September	Cercobin	0.10	3.40
Before Blossom	Insegar	0.045	5.50
After Blossom	Insegar	0.045	5.50
Thinning Spray	Amidthin	0.105	8.61
	Attraco	3.00	21.00
	Total Cost		1704.80

Grower S3 : Spray Programme : 1989

Date	Material	Rate/Ha x 2 (l or kg)	Cost/Ha (D.M.)
11 March	Delan SC	0.25	16.50
20 March	Dithane U	1.00	10.00
29 March	Dithane U	1.00	10.00
1 April	Telmion	5.00	50.00

3.April	Dithane U	1.00	10.00
10 April	Dithane U	1.00	10.00
	Netzschwefel	1.50	9.00
15 April	Dithane U	1.00	10.00
	Netzschwefel	1.50	9.00
20 April	Dithane U	1.00	10.00
	Netzschwefel	1.50	9.00
25 April	Dithane U	1.00	10.00
	Netzschwefel	1.50	9.00
29 April	Dithane U	1.00	10.00
	Netzschwefel	1.50	9.00
9 May	Dithane U	1.00	10.00
	Netzschwefel	0.50	3.00
13 May	Dithane U	1.00	10.00
	Rubitox	0.75	21.88
21 May	Dithane U	1.00	10.00
5 June	Dithane U	1.00	10.00
23 June	Polyram	1.00	11.00
	Peropal	0.5	41.50
30 June	Polyram	1.00	11.00
	Pirimor	0.15	18.62
5 July	Polyram	1.00	11.00
22 July	Polyram	1.00	11.00
7 August	Delan SC	0.25	16.50
17 August	Euparen	0.75	19.45
26 August	Euparen	0.75	19.45
7 September	Euparen	0.75	19.45
	Insegar	0.15	22.16
	Insegar	0.15	22.16
	Total Cost		490.67

Grower S4 : Spray Programme : 1989

Date	Material	Rate/Ha x 2 (l or kg)	Cost/Ha (D.M.)
14 March	Delan SC	0.25	16.50
	Netzschwefel	2.50	15.00
22 March	Delan SC	0.25	16.50
30 March	Delan SC	0.25	16.50
	Apollo	0.15	55.95
	Netzschwefel	2.25	13.50
5 April	Delan SC	0.25	16.50
	Benocap	0.125	38.75
	Netzschwefel	2.25	13.50
24 April	Delan SC	0.25	16.50
	Baycor	0.25	12.50
	Netzschwefel	1.00	6.00
2 May	Delan SC	0.25	16.50
	Netzschwefel	0.75	4.50
	Wuxal	1.00	6.80
9 May	Delan SC	0.25	16.50
	Netzschwefel	0.75	4.50
	Wuxal	1.00	6.80
16 May	Polyram	1.00	11.00
	Baycor	0.25	12.50
	Wuxal	1.00	6.80
26 May	Polyram	1.00	11.00
	Rogor	0.50	6.75
	Dimilin	0.15	36.60
2 June	Polyram	1.00	11.00
6 June	Polyram	1.00	11.00
24 June	Polyram	1.00	11.00
	Dursban	0.50	19.10
4 July	Polyram	1.00	11.00
	Salut	0.75	38.60
14 July	Polyram	0.75	8.25
28 July	Pomarsol	1.00	12.00
10 August	Pomarsol	1.00	12.00
	Peropal	0.50	41.50
24 August	Cercobin	0.35	11.90
7 September	Cercobin	0.35	11.90
	Total Cost		570.45

Grower S5 : Spray Programme : 1989

Date	Material	Rate/Ha (l or kg)	Cost/Ha (D.M.)
17 March	Delan SC	0.6	39.6
30 March	Delan SC	0.75	49.5
	Netzschwefel	3.75	22.5
6 April	Delan SC	0.5	33.0
	Netzschwefel	2.5	15.0
15 April	Delan SC	0.5	33.0
	Baycor	0.5	25.0
	Insegar	0.6	88.6
20 April	Delan SC	0.6	39.6
	Baycor	0.42	21.0
26 April	Dithane	3.2	32.0
11 May	Dithane	3.2	32.0
	Baycor	0.8	40.0
17 May	Polyram	2.6	28.6
	Insegar	0.65	96.0
30 May	Benocap	0.13	40.3
	Polyram	1.3	14.3
16 June	Polyram	2.6	28.6
	Rubitox	1.95	68.5
	Torque	0.65	79.3
22 June	Rubigan	0.24	36.0
	Polyram	2.40	26.4
5 July	Baycor	0.5	25.0
	Thiram	1.0	17.0
13 July	Thiram	2.4	40.8
	Baycor	0.6	30.0
	Pomarsol	2.4	28.8
2 August	Baycor	0.6	30.0
	Pomarsol	2.4	28.8
18 August	Thiram	1.5	25.5
	Adhasit	0.5	6.0
Thinning Spray	Amidthin	0.36	29.5
	Total Cost		1150.20

Appendix 9d Netherlands Materials

Netherlands : Herbicides : 1989

Grower 1	Material	Rate/Ha (l or kg)	Cost/Ha (D.Fl.)	
1 May	Finale	4	135.60	
	Simazine	1.5	13.58	
	Diuron	1.5	31.74	
6 June	MCPA	0.8	2.40	
	MCPP	1.6	8.51	
	24D	0.4	2.09	
10 October	Simazine	1.0	9.05	
	Amitrol	12.0	87.96	
				290.93
Grower 2				
October	Amitrol	3.0	21.99	
	Gramoxone	1.5	37.20	
	Simazine	3.0	18.10	
	Diuron	3.0	63.48	
				140.77
Grower 3				
April	Gramoxone	4.0	99.20	
	Simazine	3.0	27.15	
	Diuron	3.0	63.48	
				189.83
Grower 4				
April	Diuron	2.0	42.32	
	Simazine	2.0	18.10	
	Weedazol	8.0	58.64	
	(Spot)			119.06
Grower 5				
April	Diuron	3.0	63.48	
	Simazine	2.0	18.10	
	Casoron	1.0	11.90	
				93.48

Netherlands : Fertilisers : 1989

	Material	Rate/ha (l or kg)	Cost/Ha (D.Fl.)	
Grower 1	KAS (Ammonium Nitrate Limestone)	225	72.90	72.90
Grower 2	Mengmist 20:10:10	350	152.25	152.25
Grower 3	Mengmist 12:10:10	333	133.20	
	Kristallon 19:6:6	160	168.00	301.20
Grower 4	KAS 27%	300	97.20	97.20
Grower 5	Mengmist 23:16:0	260	78.00	
	Kristallon 19:6:6 (through trickle)	125	131.25	209.25

Grower NL1 : Spray Programme : 1989

Date	Material	Rate/Ha (l or kg)	Cost/Ha (D.Fl)
17 March	Baycor	1.0	55.74
	Captan	1.0	11.28
13 April	Baycor	1.0	55.74
18 April	Insegar	0.4	65.88
	Maneb	0.15	0.92
24 April	Baycor	1.0	55.74
	Nimrod	0.6	27.09
23 May	Topaz sp	1.2	30.47
	Maneb	0.15	0.92
6 June	Topaz sp	1.2	30.47
	Maneb	0.15	0.92
23 June	Pirimor	0.6	55.26
	Topaz sp	1.2	30.47
	Calcium nitrate	8.0	3.84
4 July	Captan	1.4	15.79
	Nimrod	0.6	27.09
16 August	Captan	1.5	16.92
30 August	Captan	1.5	16.92
27 September	TMTD	2.5	14.88
28 November	Captan	3.0	33.84
	Total Cost		550.18

Grower NL2 : Spray Programme : 1989

Date	Material	Rate/Ha (l or kg)	Cost/Ha (D.Fl)
4 April	Captan	2.25	25.38
	Baycor	1.0	55.74
23 April	Captan	2.25	25.38
	Alar	0.6	98.44
29 April	Captan	2.5	28.20
	Wuchsal	4.0	2.60
8 May	Pallinal	2.5	39.83
	Wuchsal	4.0	2.60
	Captan	1.5	16.92
18 May	Neoron	2.0	104.46
	Captan	1.5	16.92
	Pallinal	2.5	39.83
28 May	Captan	1.5	16.92
	Pallinal	3.0	47.79
	Wuchsal	4.0	2.60
10 June	Cymbush	0.6	30.31
	Captan	1.5	16.92
	Pallinal	3.0	47.79
	Wuchsal	4.0	2.60
27 June	Captan	1.5	16.92
	Pallinal	3.0	47.79
	Wuchsal	4.0	2.60
	Calcium Chloride	5.0	3.05
After 27 June			
2x	Pallinal	2.5	79.65
3x	Captan	1.8	60.91
1x	Neoron	2.0	104.46
6x	Calcium Chloride	5.0	18.30
2x	Topsin	1.5	88.65
2x	TMTD	2.5	29.75
1x	Cymbush	0.6	30.03
	Total Cost		1103.34

Grower NL3 : Spray Programme : 1989

Date	Material	Rate/Ha (l or kg)	Cost/Ha (D.Fl)
25 March	Topaz M	3.0	76.17
beg. April	Topaz M	3.0	76.17
mid April	Topaz M	3.0	76.17
25 April	Captan	2.25	25.38
	Neoron	2.0	104.46
5 May	Captan	2.25	25.38
	Cyhexatin	1.1	179.03
	Neoron	2.0	104.46
mid May	Pallinal	3.0	47.79
end May	Pallinal	3.0	47.79
	Ultracid	1.1	49.39
beg. June	Pallinal	3.0	47.79
	Decis	0.3	28.29
mid June	Pallinal	3.0	47.79
	Ultracid	1.1	49.39
	Captan	2.25	25.38
	Nissorum	0.6	174.15
mid June to end August (x10)	Captan	2.25 (x10)	253.80
	Calcium Chloride	7.0 (x10)	42.70
September	Topsin	1.5	44.33
September	Captan	2.25	25.38
September	TMTD	2.5	14.88
October	Captan	2.25	25.38
October	TMTD	2.5	14.88
October	Topsin	1.5	44.33
November	Captan	2.25	25.38
November	Captan	2.25	25.38
	Total Cost		**1698.32**

Grower NL4 : Spray Programme : 1989

Date	Material	Rate/Ha (l or kg)	Cost/Ha (D. Fl)
19 March	Captan	1.0	11.28
	Baycor	1.0	55.74
28 March	Captan	1.5	16.92
6 April	Captan	1.5	16.92
15 April	Captan	1.5	16.92
19 April	Kilval	1.9	76.19
24 April	Captan	1.0	11.28
28 April	Nissorun	0.6	174.15
5 May	Captan	1.5	16.92
17 May	Captan	1.0	11.28
27 May	Pallinal	2.0	31.86
6 June	Pallinal	3.5	55.76
18 June	Pallinal	3.2	50.98
28 June	Pallinal	3.5	55.76
8 July	Pallinal	3.5	55.76
18 July	Pallinal	3.5	55.76
	Calcium Chloride	6.0	3.66
20 July	Neoron	1.9	99.24
27 July	Pallinal	3.5	55.76
	Calcium Chloride	6.0	3.66
7 August	Pallinal	3.5	55.76
	Calcium Chloride	6.0	3.66
17 August	Pallinal	3.5	55.76
	Calcium Chloride	6.0	3.66
4 September	TMTD	3.0	17.85
	Bavistin	0.75	20.33
	Calcium Chloride	6.0	3.66
14 September	TMTD	3.0	17.85
	Calcium Chloride	6.0	3.66
28 September	TMTD	3.0	17.85
	Bavistin	0.75	20.33
	Calcium Chloride	6.0	3.66

12 October	TMTD	3.0	17.85
	Calcium Chloride	6.0	3.66
26 October	TMTD	3.0	17.85
	Calcium Chloride	6.0	3.66
	Total Cost		1142.66

Grower NL5 : Spray Programme : 1989

Date	Material	Rathe/Ha (l or kg)	Cost/Ha (D. Fl)
25 March	Captan	0.7	7.90
	Baycor	0.7	39.02
11 April	Dorado	0.2	38.04
	Ureum	2.0	0.96
	Captan	1.2	13.54
15 April	Dimethoate	0.5	4.07
	Captan	1.2	13.54
	Dorado	0.2	38.04
	Ureum	3.5	1.68
22 April	Topas	0.5	12.70
	Captan	0.5	5.64
	Ureum	3.0	1.44
28 April	Captan	1.2	13.54
	Ureum	3.0	1.44
8 May	Nissorum	0.5	145.13
11 May	Captan	1.3	14.66
18 May	Pallicap	1.4	16.74
23 May	Pallicap	1.4	16.74
29 May	Pallicap	1.4	16.74
5 June	Pallinal	1.7	27.08
8 June	Ekatin	1.0	54.00
12 June	Pallinal	2.0	31.86
13 June	Decis	0.2	18.86
19 June	Pallinal	2.0	31.86
20 June	Cyhexatin	1.1	179.03
4 July	Euparen	1.0	34.75
	Calcium Chloride	2.0	1.22

11 July	Euparen	1.0	34.75
	Calcium Chloride	3.0	1.83
17 July	Euparen	1.0	34.75
	Calcium Chloride	4.0	2.44
25 July	Euparen	1.0	34.75
	Calcium Chloride	4.0	2.44
28 July	Neoron	1.8	97.01
	Calcium Chloride	3.5	2.14
2 August	Pallicap	0.5	5.98
	Captan	1.1	12.41
	Calcium Chloride	3.0	1.83
9 August	Neoron	1.8	94.01
12 August	Captan	1.4	15.79
	Calcium Chloride	4.0	2.44
17 August	Calcium Chloride	5.5	2.44
23 August	Benomyl	0.8	35.88
	Captan	1.1	12.41
	Dolomite	0.8	
1 September	Captan	1.1	12.41
	Calcium Chloride	5.0	3.05
	Dolomite	0.6	6.00
5 September	Captan	0.5	5.64
	Dolomite	0.5	5.00
	Calcium Chloride	6.0	3.66
9 September	Calcium Chloride	6.5	3.97
	Dolomite	0.5	5.00
19 September	Calcium Chloride	5.5	3.36
	Dolomite	0.4	4.00
	Captan	0.5	5.64
	Bavistin	0.4	10.84
23 September	Calcium Chloride	7.0	4.27
30 September	Calcium Chloride	6.5	3.97
4 October	Aperdex	10 tablets	12.60
5 October	Calcium Chloride	7.0	4.27
November			
2x	Captan	2.2	49.63
1x	Copperoxychloride	2.7	13.64
	Total Cost		1236.46