Commercialising Australian bred strawberry varieties in Western Australia - better berries WA

Dennis Phillips
Department of Agriculture
Western Australia

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Horticulture Australia Ltd
Level 1
50 Carrington Street
Sydney NSW 2000
Telephone: (02) 8295 2300
Fax: (02) 8295 2399
E-Mail: horticulture@horticulture.com.au

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COMMERCIALISING AUSTRALIAN BRED STRAWBERRY VARIETIES IN WESTERN AUSTRALIA

Dennis Phillips *et al.*
DEPARTMENT OF AGRICULTURE
WESTERN AUSTRALIA

HORTICULTURE AUSTRALIA
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PURPOSE

This publication report is intended to meet the commitment to the industry funding providers: Horticulture Australia Limited, the Strawberry Industry of W.A. and the Department of Agriculture Western Australia, to report the findings of research to industry and the scientific community.

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DISCLAIMER

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1. MEDIA SUMMARY

A protocol was developed to facilitate effective adoption of new varieties from an Australian breeding program into commercial cultivation. A promising, selection first identified in 'small plot' trials and later named 'Kiewa' was chosen to test the protocol.

Four lines of investigation were explored in this project. These included:

1. Production of sufficient 'non virus indexed' runners to enable semi-commercial evaluations of the selection alongside commercial crops.
2. Fertiliser and irrigation research to develop a recommended practice, that would optimise marketable yield and fruit quality.
3. Consumer studies of the new selection compared to existing cultivars in widespread commercial cultivation, using a sensory laboratory and informal methods of evaluation.
4. Exploration of the potential of using fruit brix as a surrogate for flavour in a planned marketing strategy based on consumer recognition.

The methods proved the marketability of the new selection and created a demand among growers for commercial runners when it was released as a named cultivar. Kiewa proved to be well adapted to a range of field chilling conditions, and compared favourably with the industry standard varieties, Camarosa and Gaviota.

Kiewa was highly responsive to nitrogen fertiliser applied after planting, but fruit flavour became increasingly worse with increasing nitrogen rates. A compromise nitrogen rate was identified that would give the grower good yields while not overly disaffecting flavour. A procedure to test plant sap to verify that nitrogen was within guidelines was devised. Standards for quality marketing of the cultivar using fruit brix as a surrogate for flavour were derived based on simple on-farm tests.

The methods tested in this project did create a demand for Kiewa among growers but did not prove sufficient to bring the variety into widespread cultivation in the three year timeframe. This was due to insufficient commercial runners being made available in time. This is an issue that must be addressed by the Australian industry if it is to derive maximum value from its investment in breeding in Australia.

The project showed that there is great potential to increase per capita consumption of strawberries in Australia if consumer expectations for flavour can be met. This project proved that Kiewa can satisfy these requirements if properly managed and marketed by growers, and still give the grower high yields and a good dollar return.

2. TECHNICAL SUMMARY

The climate in the south of Western Australia is essentially 'mediterranean' and strawberry production is centred at two locations, latitude 32°S and 35°S.

This western seaboard location is sufficiently similar to that of California, so that varieties bred in that part of the United States are also reasonably well adapted to our conditions and have been are the mainstay of our domestic industry. Despite this, there is a need for varieties that are better adapted to these conditions.

A publicly funded breeding program for Southern Australia has been underway in Victoria since the early 1990's and Western Australia has been an evaluation and selection site to develop new varieties since then. Many promising 'short day' selections have been identified that are adapted to the climate in Western Australia but none have become major commercial successes. One of the reasons for this was that Australian bred varieties have no 'track record' of commercial success in other places when they are released, and growers have no personal experience of growing the variety(ies) in marketable quantities.

The objective of this project was to give growers and the market this essential personal experience with a promising new Australian bred selection (95-041-19 - Kiewa) while it was being named and licensed, so that when it was released to the market, there would be 'seamless' adoption. The lessons learnt from commercialising Kiewa could then be applied to future selections from the Australian breeding program.

Four lines of investigation were explored in this project. These included:

1. Production of sufficient 'non virus indexed' runners to enable semi-commercial evaluations of the selection alongside commercial crops. Approximately 60,000 runners from three runner production locations with different levels of 'in-field' chilling, times of runner digging and replanting were compared in up to 10 commercial strawberry crops over three consecutive years.
2. Fertiliser and irrigation research to develop a recommended practice, that would optimise marketable yield and fruit quality. Two replicated field experiments were conducted at the Department of Agriculture's Medina Research Station in 2001 and 2002 testing the fruit yield and quality response to nitrogen, phosphorus and potassium fertilisers at a range of rates. Irrigation scheduling was practiced and the effects monitored. The effects of nitrogen on fruit quality were evaluated in a sensory laboratory in replicated experiments.
3. Consumer studies of the new selection compared to existing varieties in widespread commercial cultivation, using sensory laboratory and informal methods of evaluation. Kiewa, Camarosa and Gaviota from different field management regimes were compared for flavour and other sensory attributes in fully replicated trials in three sensory laboratories in Australia.
4. Evaluation of the potential for planned marketing based on measurement of fruit quality and flavour. The 'total soluble solids' (Brix) content of fruit grown under different management regimes from research station trials and commercial crops was tested. From these tests, a Brix threshold and fruit sampling procedure that would ensure a high probability of consumer satisfaction with the flavour and fruit quality was proposed.

Kiewa proved to be well adapted to runner production over a range of field chilling conditions from 40 to 400 hours at or below 7°C. Field performance of the variety was more affected by grower management than field chilling of runners. Kiewa had higher yields at 35°S latitude than at 32°S latitude but was well adapted to both locations.

Fruit production in Kiewa responded strongly to increasing rates of nitrogen applied after planting, but not before, and although significant increases in marketable yield could not be demonstrated beyond 600 kg/ha N for the season, the increase in yield above that rate was linear. Nitrogen fertiliser application greater than 450 kg/ha N for the season on sandy soils resulted in increasingly poorer fruit flavour and consumer acceptance.

Fruit flavour in Kiewa was positively correlated with fruit brix percentage, but this attribute in strawberries was found to be highly variable between individual fruits grown with the same management. This simple objective measure of fruit flavour offers potential for planned fruit marketing based on a guarantee of flavour.

In conclusion, the methods tested in this project did create a demand for Kiewa among growers but did not prove sufficient to bring the variety into widespread cultivation in the three year timeframe. This was due to insufficient commercial runners being made available in time. Careful management of nitrogen nutrition by growers is essential to produce fruit that will satisfy consumers flavour requirements and failure to do so has probably already resulted in significant loss of sales. Routine 'on farm' tests of fruit for brix and plant sap for nitrogen using simple and cheap technology have the potential to greatly improve the yield and flavour of fruit marketed, and reverse this trend.

3. GENERAL INTRODUCTION

The aim of this project from its inception was to develop a methodology for bridging the gap between experimental evaluation of promising Australian bred strawberry breeding lines, and adoption of these as named varieties into full commercial production in Western Australia (W.A.).

The problem that existed prior to commencement of the project was that Australian strawberry growers and state Departments of Agriculture had funded two breeding programs in Australia for more than a decade with only limited uptake of varieties bred by them.

One of the breeding programs was run by the Department of Primary Industries in Queensland, and the other by Agriculture Victoria. The former program is focussed on producing varieties suitable for sub tropical production in winter, and the latter the more traditional temperate production employing 'short day' and 'day neutral' types for spring and summer production respectively.

Western Australian growers and the Department of Agriculture had participated in the temperate program for more than a decade at an estimated cumulative cost of around $1 million of a total program cost of $4.5 million. There had been little commercial 'payoff' for the stakeholders in that time and it was imperative for the future of the program and the industry that a methodology was developed to ensure commercial adoption in Western Australia.

The sub-tropical program had achieved higher levels of adoption of it's varieties into commercial cultivation than the temperate program, but only in Queensland. At the same time, the temperate program had achieved moderate levels of commercial adoption in Victoria but very little in the other Australian states that actively participated in the program, i.e. Western Australia and South Australia. The reasons for this are complex, but there were some fundamental differences between the two programs that facilitated more rapid uptake of new varieties in Queensland than other States.

The sub-tropical program included components of breeding and selection as well as development of production protocols, commercial propagation and consumer evaluation, which could not be accommodated within the budget of the larger temperate program. It was considered that these components assisted in more rapid and complete adoption of new varieties, but these strategies needed to be enacted in the physical and market environment where the varieties were to be grown to be effective.

This project was born to add some of these 'commercialisation components' to the existing selection activities conducted in W.A. for a promising 'short day' selection that had been identified in W.A. in 1998. The selection was supplied as a breeding line numbered (95-041-19), and during the course of the project, it was named and licensed by Agriculture Victoria under the name ***'Kiewa'***. This name will be used to identify the selection throughout this report to avoid confusion.

Kiewa was identified as being both high yielding and having excellent flavour in screening plots in 1998 and 1999. We did not know how robust it would be when grown on a larger semi-commercial scale and we needed to know more about its cultural requirements to fully capitalise on its attributes. The logistics of naming, virus indexing, licensing and propagating a new Australian bred selection suitable for the W.A. environment needed to be identified and tested. This project set out to do that in 'real time' to establish a logistics framework for rapid and effective adoption of future selections. To this end, Kiewa was used as the 'vehicle' for the study.

This report describes the work done by the project team to propagate sufficient quantities of the new selection to allow meaningful semi-commercial evaluation, the selection's response to fertilisers and irrigation, comparative consumer preferences for the selection, market research and physiological responses of the selection to environment.

Selection of advanced breeding lines continued in parallel with this work, and the process of identifying and evaluating the next group of selections to submit to the commercialisation protocol is reported on.

The remaining two aspects of the project were ensuring that the prerequisites that underpin commercialisation of the selection were done within the lifespan of the project and informing industry of the results of the project in appropriate forums. The prerequisites included, virus indexing, virus elimination as well as the mechanics of appointing licencees for the variety and providing mother stock for commercial scale propagation. Dr Bruce Morrison from Agriculture Victoria took responsibility for the prerequisites.

4. COMMERCIAL EVALUATION AND DEVELOPMENT OF KIEWA

Dennis Phillips

4.1 INTRODUCTION

The process of breeding and selecting new strawberry cultivars in Australia is lengthy and time consuming because the crop has an annual growth cycle and is propagated vegetatively from season to season. The time from selection of suitable parents to full commercialisation can be nine years or longer depending on the intensity of selection and evaluation required. The bio-security aspect of runner propagation to protect the planting material from infection by viruses and other pathogens, while necessary, adds time and complexity to the commercialisation cycle. Time can also be lost in the logistics of enacting 'plant breeders' rights' and licensing runner propagators.

The temperate breeding program had developed efficient and effective methods for the technical aspects of plant crossing, propagation and selection in three States of Australia during its evolution throughout the 1990's. However, our experience in Western Australia before 2000 was that the process of taking promising selections from small plot trials to semi-commercial size evaluation, by a number of growers, was always limited by the availability of sufficient planting material.

One of the identified problems was caused by the need to propagate runners in cool climate regions in eastern Australia (in this case Tasmania) at the same time that selections were being evaluated in each of the southern States participating in the program. For example, mother plants for production of trial runners for the 2001 fruit production season needed to be planted no later than September 2000. Fruit from selection trials in Western Australia would have only commenced picking by September and results of the year 2000 trials would not be known until December 2000. This effectively meant that semi-commercial quantities of runners of selections made in 2000 would not be available for planting until 2002 at the earliest. This timeline was also subject to sufficient mother plants of the selected lines being available in 2001 to produce the number of runners required for 2002. The propagation process was complicated further by the fact that planting material at this early stage of selection was not virus indexed and could not be grown by certified runner growers. This further limited the runner production potential.

To break this deadlock, it was decided to explore the runner production potential of a 'greenfield site' in alpine Victoria, with the specific aim of bridging this gap in the development cycle more quickly. The site chosen by Dr Bruce Morrison was a research station at Ovens in Victoria (Ovens) that had specialised in tobacco research in the past and had no history of strawberry runner production. The W.A. strawberry industry commissioned the production of 50,000 runners of Kiewa by Ovens, grown from 'non virus indexed' mother plants in each of the 2001 and 2002 production seasons in W.A.. The runners produced were paid for by the Strawberry Growers' Association of W.A. as a service to their members, and distributed by them on a pro-rata basis to ten participating growers.

Runners from Ovens were dug and delivered to W.A. on four dates in the 2001 production season from mother plants supplied to Ovens by Dr Morrison. In addition, a supply of runners was also available from the regular collaborating propagator in Tasmania (Tasmanian Highland Runner Growers) at one date of digging. A small number of runners were also dug from a year 2000 trial plot grown by a fruit grower at Mt Barker in W.A. to broaden the spread of 'field chilling' levels.

In 2002, runners from Ovens were supplied to eight growers at two dates of digging and delivery and eight growers were supplied with runners from Tasmania.

In 2003, the contract with Ovens was discontinued and runners were supplied from two propagators in Tasmania to six growers at two delivery dates.

The aims of these evaluations were to:

- Familiarise a significant proportion of growers with the attributes and cultural requirements of Kiewa and to elicit feedback on its market potential.

- To better define the 'chilling' requirement of Kiewa and its optimum planting date(s) in two production regions, Perth metropolitan (32° South latitude) and Great Southern (35° South latitude).
- To provide a 'market pull' incentive for Kiewa to be named and licensed for propagation at the earliest possible date.
- To test this method of achieving rapid commercialisation of a new Australian bred selection.

The results of those evaluations and an assessment of the merit of this method to facilitate commercialisation are described in this chapter.

4.2 MATERIAL AND METHODS

Field plantings of runners from the different sources and times described above are presented in Tables 4.1, 4.3 and 4.4 for the three years 2001, 2002 and 2003 respectively. All of these plantings were made within the respective growers' commercial crops and were subjected to the same management as the surrounding crop. Yield data was collected at some of the sites but for most, the assessment was largely subjective.

Estimates of chilling hours in the runner beds at each site and in the field at selected sites after planting were made from Cox® temperature loggers placed at ground level in the crop (shaded) and in one case from records taken from a Stephenson screen in 2001.

Table 4.1 Kiewa runner distribution and plantings 2001 - numbers of runners

Digging date	Planting date W.A.	Grower	Location*	Ovens	Tasmania	Great Southern W.A.
17 April	1 May	Langlands	Neerabup	3000	0	0
		Verheyen	Jandabup	1000	0	0
		Bolsenbroek	Jandabup	1000	0	0
		Tweedie	Wanneroo	500	0	0
		Ivankovic	Carabooda	7500	0	0
		Handasyde Neil	Albany	500	0	0
30 April - 2 May	8 May	Langlands	Neerabup	1000	300	
		Verheyen	Jandabup	2500	300	80
		Bolsenbroek	Jandabup	2250	300	100
		Tweedie	Wanneroo	100	300	150
		Ivankovic	Carabooda	3000	300	174
		Handasyde Neil	Albany	500	300	200
		Tweedie	Albany	8650	300	100
		Chi	Landsdale	500	0	0
		Yewers	Bullsbrook	1250	200	63
		Dept of Agriculture	Medina		2000	0
4 May	23 May#	Langlands	Neerabup	1750	0	100
		Verheyen	Jandabup	500	0	100
		Bolsenbroek	Jandabup	500	0	100
		Tweedie	Wanneroo	100	0	100
		Ivankovic	Carabooda	5560	0	148
		Handasyde Neil	Albany	500	0	125
		Tweedie	Albany	3000	0	125
		Wilkinson	Albany	0	0	125

Table 4.1 Continued

Digging date	Planting date W.A.	Grower	Location*	Ovens	Tasmania	Great Southern W.A.
11 May	May 23 -26!	Langlands	Neerabup	500	0	50
		Verheyen	Jandabup	500	0	90
		Bolsenbroek	Jandabup	600	0	50
		Tweedie	Wanneroo	100	0	50
		Ivankovic	Carabooda	5100	0	51
		Handasyde Neil	Albany	500	0	50
		Tweedie	Albany	1000	0	50
		Wilkinson	Albany	0	0	110
Totals				**53,960**	**4310**	**2391**

* Neerabup, Jandabup, Landsdale, Carabooda, Wanneroo and Bullsbrook are all within 50 km north of Perth. Albany is on the south coast, 450 km from Perth.

Planting of these was delayed by 14 days due to an interstate quarantine problem. Runners remained in coolstorage for the period.

! Planting of these was delayed by approximately seven days due to an interstate quarantine problem. Runners remained in coolstorage for the period.

Sub plots of between 10 and 35 plants each were marked out within these trial plantings on six farms. These sub plots were harvested twice per week throughout the cropping season from August to November in Perth districts and October to January in Albany. Marketable weight and marketable fruit number were recorded at all dates and a cumulative record of yield was compiled. Plant numbers harvested are shown in Table 4.2.

Table 4.2 Harvest plot sizes for the six grower sites in the Perth region and at Albany in 2001

Runner source	Digging date	No. of plants - Perth	No. of plants - Albany	
		Sites A, B, C, D	Site E	Site F
Ovens	1; 2; 3; 4	20; 20; 20; 20	10	20
Great Southern W.A.	1; 2; 3	20; 15; 20	10	20
Tasmania		35	10	20

Table 4.3 Kiewa runner distribution and plantings 2002 - numbers of runners

Digging date	Planting date W.A.	Grower	Location*	Ovens	Tasmania
7 April	12 April	Langlands	Neerabup	0	500
7 April	12 April	Verheyen	Jandabup	0	140
26 April - 2 May	3-6 May	Langlands	Neerabup	1000	1000
		Verheyen	Jandabup	0	8000
		Bolsenbroek	Jandabup	0	7000
		Ivankovic	Carabooda	5000	1500
		Yewers	Bullsbrook	0	500
		Handasyde Neil	Albany	3000	4500
		Handasyde Norm	Mt Barker	0	500
		Tweedie	Albany	2500	7500
		Dept of Agriculture	Medina	0	3000

Table 4.3 Continued

Digging date	Planting date W.A.	Grower	Location*	Ovens	Tasmania
9 May	13 May	Verheyen	Jandabup	2000	0
		Bolsenbroek	Jandabup	2000	0
		Ivankovic	Carabooda	7190	0
		Handasyde Neil	Albany	2500	0
		Wilkinson	Albany	4750	0
		Zabaznow	Busselton	500	0
Totals				**30,440**	**37,500**

* Mt Barker is in the Great Southern approximately 35 km north of Albany.

Table 4.4 Kiewa runner distribution and plantings 2003 - numbers of runners

Approximate digging date	Planting date W.A.	Grower	Location	Bignell Tasmania	Cox Tasmania
8 - 12 May	16 - 19 May	Langlands	Neerabup	2000	3000
		Verheyen	Jandabup	500	1350
		Ivankovic	Carabooda	2000	3000
		Handasyde Neil	Albany	1500	3500
		Wilkinson	Albany	1500	1500
		Tweedie	Albany	1500	4000
		Langlands	Neerabup	0	1730
		Verheyen	Jandabup	0	5000
Total				**9,000**	**23,080**

4.3 RESULTS

Chilling records 2001

Estimates of 'chilling hours', at or below 7°C at ground level, in the runner production beds for the three sources of runners used for planting are shown in Table 4.5. The results show that relatively large amounts of chilling were received by runners grown in Tasmania compared to the other two sites.

Table 4.5 Approximate chilling hours for strawberry runners grown at three locations used for fruit production trials in Western Australia in 2001

Runner digging date	Tasmania	Ovens	Great Southern W.A.
17 April		49 (35.5)*	
30 April - 2 May	353 - 400	59	37
4 May		66	39
11 May		137	43

* An independent measure of field chilling was collected from a weather station at Ovens from temperature records taken in a Stephenson screen at 1.5 m height above the ground. The figure of 35.5 hours <= 7°C was from these data records taken between 1 March and 4 April 2001.

A measurement of 'in-field' chilling after planting was made at one site (Ivankovic, Carabooda) for the period 25 June to 9 August. It was found that the growing crop was exposed to significant levels of chilling during this period compared to those experienced in the runner beds. The aggregate chilling for this interval was a further 186 hours.

Runner production at Ovens Research Station, Victoria.

Yield and quality 2001

Aggregate yield records are presented in Table 4.6. The six grower sites are represented as A, B, C, D, E and F. Sites A-D were in the Perth region and sites E and F were at Albany. The results show that for the four Perth sites, runners of Kiewa sourced from Tasmania outyielded those sourced from the Great Southern in W.A. The yield differences were not large except at the highest yielding site (A).

The runners sourced from Ovens mostly yielded equal to or less than those sourced from Tasmania in the Perth region. The second digging of runners from Ovens on 30 April was the highest yielding in Perth at the three sites where it was planted. Three of the four growers in Perth achieved relatively low yields overall compared to the best yielding site (A), and yields for Perth were in most cases less than half those achieved at the highest yielding site in Albany (E).

Runners dug at Ovens on 4 May yielded best overall at the two Albany sites (E and F) closely followed by the Ovens runners dug on 11 May. The runners from Tasmania performed best at site F but were the lowest yielding at site E.

Semi commercial trial block of 'Ovens' Kiewa, Wanneroo, September 2001.

Control varieties bred in California were compared to Kiewa as controls at sites D, E and F. Gaviota was used as the control at site D in Perth and site F in Albany, while Camarosa was used at site E in Albany. These control varieties only outyielded Kiewa at site D, and were average yielders at the other two sites.

The relatively good performance of the two Ovens selections at Albany was surprising because delivery of runners for both plantings was delayed by an interstate quarantine problem prior to planting. Runners from the 4 May digging were held in coolstore for an extra 14 days before planting and the 11 May runners were held for an extra seven days compared to the earlier diggings. It was notable that the 4 May runners that had been held in coolstore longest after digging produced the largest mean berry weights at four of the five sites where it was tested.

Table 4.6 Yield estimates (per plant) from six of the grower evaluation sites for Kiewa from three runner sources and with different levels of field chilling

Runner source and digging date	Market weight (grams per plant)						Number of marketable berries						Mean berry weight (grams)					
	Grower						Grower						Grower					
	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F
Ovens: 17 April	403	116		281	1375		17	4		14	70		24	31		21	28	
Ovens: 30 April	667	214		302	1460	629	27	7		12	74	30	24	32		26	25	21
Ovens: 4 May	449	162		227	1875	716	17	4		6	88	34	27	43		37	33	21
Ovens: 11 May	545	96		260	1547	726	21	3		10	74	28	26	31		27	30	26
Tasmania: 30 April	701	209	165	282	1098	876	31	6	10	12	53	39	23	34	17	23	25	23
Tasmania: 8 May				316						15						20		
Gt. Sthn W.A.: 8 May	547	163	150	254	1265	571	26	6	9	10	66	28	21	27	16	26	28	20
Gt. Sthn W.A.: 16 May	488	166	176	251	1273	462	20	6	10	9	65	24	24	29	17	27	27	20
Gt. Sthn W.A.: 23 May	370	140	149	206	1393	655	16	5	8	9	71	31	23	29	18	23	24	21
Camarosa: E/April				389						22						18		
Camarosa: E/May					1309						82						17	
Gaviota: E/May				466		638				17		31				26		21

A detailed analysis of the monthly harvest data for all runner sources at all locations is presented in Tables 4.7 and 4.8. At most locations in Perth, runners sourced from Tasmania produced higher yields of early fruit in August. Yields were progressively delayed by later planting of the Ovens and W.A. runners. Berry weights were inconsistent between runner sources and the properties in Perth. At site D, Camarosa and Gaviota produced greater early fruit yields than all the Kiewa lines.

Table 4.7 Monthly yield estimates (per plant) from four grower evaluation sites in Perth for Kiewa from three runner sources with different digging dates

Grower	Runner and digging date	Marketable yield (grams per plant)			Mean berry weight (grams)		
		August	September	October	August	September	October
A	Ovens April 17	23	97	196	28	25	25
	Ovens April 30	19	163	324	25	30	23
	Ovens May 4	0	88	288		28	28
	Ovens May 11	0	123	295		26	26
	Tasmania April 30	95	172	288	29	33	20
	W.A. May 8	60	125	232	20	26	20
	W.A. May 16	29	103	239	24	26	25
	W.A. May 23	26	76	189	22	22	25
B	Ovens April 17	8	69	39	26	37	24
	Ovens April 30	18	112	84	27	37	29
	Ovens May 4	0	86	76		49	37
	Ovens May 11	3	50	44	25	31	31
	Tasmania April 30	35	94	80	37	46	26
	W.A. May 8	20	82	61	25	25	30
	W.A. May 16	23	102	40	27	30	25
	W.A. May 23	8	77	54	28	29	28
C	Tasmania April 30		27	80		18	19
	W.A. May 8		39	51		16	20
	W.A. May 16		41	71		18	22
	W.A. May 23		44	52		17	23
D	Ovens April 17	5	81	195	21	34	18
	Ovens April 30	5	84	213	25	30	25
	Ovens May 4	0	53	174		31	39
	Ovens May 11	0	54	206		28	27
	Tasmania April 30	3	64	215	33	36	21
	Tasmania May 8	0	96	220		29	18
	W.A. May 8	6	85	163	20	23	27
	W.A. May 16	5	81	165	18	25	27
	W.A. May 23	1	63	142	12	20	25
	Camarosa E/April	52	138	199	29	20	15
	Gaviota E/May	24	179	263	24	35	22

Harvesting Kiewa 'semi commercial' trial plots, Wanneroo 2001.

At Albany, the Kiewa runners from Tasmania tended to produce more early fruit (October) than the other sources of Kiewa at both sites. Camarosa commenced harvest later than the Kiewa lines at site E, while Gaviota gave similar early yields to the best Kiewa lines. Fruit size for all lines and varieties declined rapidly after October. The fruit size of all the W.A. Kiewa lines was smaller than the other runner sources at site F.

Table 4.8 Monthly yield estimates (per plant) from the two grower evaluation sites in Albany for Kiewa from three runner sources with different digging dates

Grower	Runner source and digging date	Marketable yield (grams per plant)				Mean berry weight (grams)			
		Oct	Nov	Dec	Jan	Oct	Nov	Dec	Jan
E	Ovens 17 April	206	485	357	326	43	21	16	15
	Ovens 30 April	152	600	446	262	39	25	16	14
	Ovens 4 May	136	612	700	428	38	31	19	15
	Ovens 11 May	162	476	530	379	35	31	19	14
	Tasmania 30 April	245	457	229	167	44	23	14	15
	W.A. 8 May	144	452	409	259	37	26	16	14
	W.A. 16 May	123	446	421	283	35	28	16	14
	W.A. 23 May	65	473	519	336	25	30	18	15
	Camarosa	0	535	461	314		21	15	12

Table 4.8 Continued

Grower	Runner source and digging date	Marketable yield (grams per plant)				Mean berry weight (grams)			
		Oct	Nov	Dec	Jan	Oct	Nov	Dec	Jan
F	Ovens 30 April	127	66	110		32	18	18	
	Ovens 4 May	54	62	7		37	28	22	
	Ovens 11 May	146	62	96		39	23	22	
	Tasmania 30 April	147	110	82		35	20	29	
	W.A. 8 May	106	80	129		25	20	19	
	W.A. 16 May	99	54	125		26	18	18	
	W.A. 23 May	48	90	141		20	26	21	
	Gaviota	130	76	148		28	18	20	

The cumulative yield profiles of runners from all sources and growers is presented in Figures 4.1a and 4.1b.

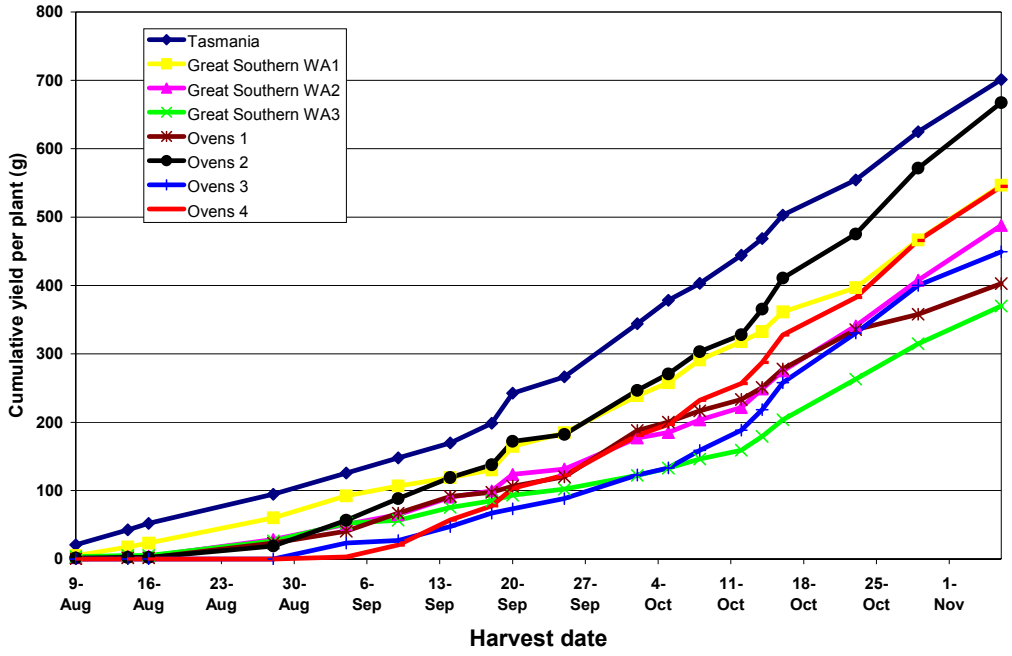

Figure 4.1 Cumulative increase in marketable yield of strawberry fruit grown at the highest yielding site in Perth (A) from runners of different origins and digging dates.

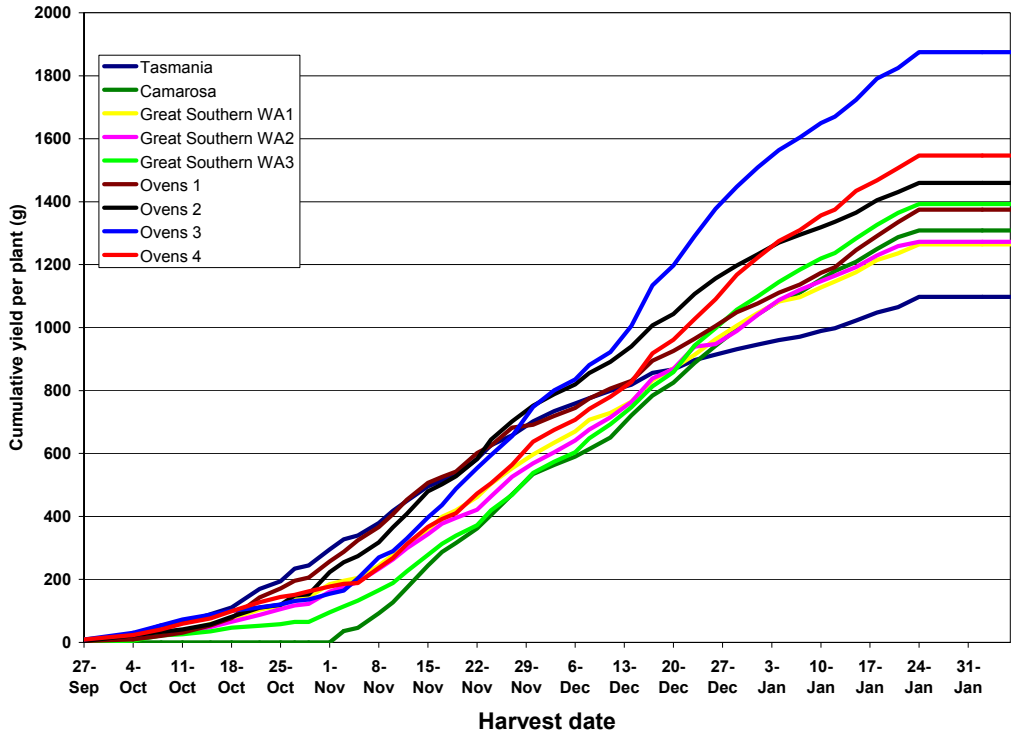

Figure 4.2 Cumulative increase in marketable yield of strawberry fruit grown at the highest yielding site in Albany (E) from runners of different origins and digging dates.

Marketable percentage

The percentage of marketable fruit by weight was calculated at two sites, D and F, in Perth and Albany. The percentage ranged from 54.3% to 61.1% for all Kiewa runner sources in Perth, while Gaviota had 76.6% marketable at the same time. Total yields for Kiewa and Gaviota were similar, but the greater marketable percentage of Gaviota led to higher marketable yields than Kiewa.

At Albany, the result was different, with all the Kiewa lines and Gaviota recording marketable percentages between 90.9% and 99.7%. Consequently, Gaviota showed no yield advantage over Kiewa.

Fruit quality

The fruit at site D was rated for flavour and appearance on a number of occasions throughout the harvest season and fruit brix was measured with a hand held refractometer in September and October. The results of those assessments are presented in Table 4.9. The flavour and brix tests were conducted on individual fruits at each time however, results need to be treated with caution because strawberry flavour can vary considerably from berry to berry taken from any one plant at the same time of harvest.

The best overall flavour score was recorded by Kiewa from Tasmania (30 April). Ovens 30 April and Gaviota performed relatively poorly for flavour, overall. Kiewa from Tasmania (30 April) and Gaviota had the best appearance scores of the group.

The brix levels recorded were generally higher in October than September and all levels would be expected to be associated with good flavour except Gaviota in September and Ovens (17 April).

Table 4.9 Quality parameters for eight runner sources of Kiewa and a control plot of Gaviota from grower site D

Runner source and digging date	Mean flavour score 1-9	Number of times tasted	Mean appearance score 1-9	Number of times scored for appearance	Brix 25 September	Brix 29 October
Ovens: 17 April	6.0	3	6.0	4	6	11
Ovens: 30 April	5.0	3	5.8	4	7.7	9.2
Ovens: 4 May	6.3	3	5.8	4	9.4	11
Ovens: 11 May	6.0	3	5.3	4	7.5	9.2
Tasmania: 30 April	7.0	3	6.3	4	7.5	12
Tasmania: 8 May	5.7	3	5.8	4	11	9.5
Gt. Sthn W.A.: 8 May	5.7	3	5.8	4	8.6	13.2
Gt. Sthn W.A.: 16 May	5.7	3	5.5	4	8.8	13.1
Gt. Sthn W.A. 23 May	6.3	3	5.8	4	10	9.2
Gaviota	5.7	3	6.5	4	5	10

The fruit was given a subjective rating at site F at each harvest date, with appearance and flavour (infrequently) being rated as poor, average, good and very good. The following is an overall summation of those ratings:

Tasmania 30 April	Mostly good - sometimes average appearance and flavour
Ovens 30 April	Average to good appearance
Ovens 4 May	Average to good appearance
Ovens 11 May	Average to good appearance
W.A. 23 May	Started poor appearance later good
Gaviota	Good to very good appearance early but average to good only in Nov and Dec
W.A. 8 May	Good to average appearance throughout
W.A. 16 May	Good to average appearance throughout

Chilling records 2002

Estimates of 'chilling hours', at or below 7°C at ground level, in the runner production beds in the 2002 season were recorded at Ovens and in Tasmania. Transport and cool storage temperatures were also recorded after runner lifting and an estimate of non-field chilling hours was also made. Results of these measurements are presented in Table 4.10.

Table 4.10 Chilling hours received by runners from two sources in the 2002 production season

Runner location and digging	Chilling hours = < 7°C	Post digging chilling hours
Ovens Dig 1: 26 April	16	
Ovens Dig 2: 3 May	47	245
Tasmania: 26 April	233	

The chilling hours recorded at Ovens by the time of the first digging were extremely low at 16 hours compared to Tasmania at 233 hours. By digging 2, the Ovens plants had received levels of chilling similar to those recorded for the Great Southern runners in 2001 but well below those received at Ovens in 2001.

Yield and quality 2002

In the 2002 season the Ovens runners performed very poorly with significant deaths within weeks of planting out in Perth. The situation was similar at one of the sites in Albany and better at the other. Runners from the second digging at Ovens performed much better, but were still not up to the standard achieved in 2001. Runners from Tasmania established well with almost no deaths at any of the sites.

It was thought that the most likely cause of deaths was the immaturity of the Ovens runners which was caused by low levels of chilling in the runner beds, combined with an arduous road trip to Perth of more than seven days duration. This effect would have led to insufficient starch reserves in the roots of runners to allow them to establish well after transplanting in the field.

Due to the poor establishment of the Ovens runners, yield data was only collected at one of the ten sites where runners were planted. Results of this assessment for grower site E (Albany) are shown in Table 4.11.

Table 4.11 Yield estimates for runners of Kiewa from the two diggings at Ovens compared to runners from Tasmania and commercial crop varieties of US origin at site E in Albany

Runner source and digging date	Planting date	Market weight (grams per plant)	Number of marketable berries	Mean berry weight (grams)
Tasmania: (approx. 2 May)	10 May	410.1	210	15.6
Ovens: April 26	9 May	344.3	197	15.7
Ovens: May 9 (rep 1)	16 May	597.8	380	17.3
Ovens: May 9 (rep 2)	16 May	690.3	319	17.3
Camarosa 1	9 May	468.8	245	17.2
Camarosa 2	16 May	736.7	435	16.9
Gaviota	16May	448.0	309	14.5

The results presented in Table 4.11 show that acceptable yields were achieved from the 9 May dug runners from Ovens and the 16 May planting of Camarosa. The poor performance of the early dug runners from Ovens was to be expected from the similar result at other sites, but the relatively poor result from the Tasmania Kiewa runners, Gaviota and Camarosa planted on 9 May could not be so easily explained.

The marketable yield and berry size distribution for each month of harvesting differed between some of the Kiewa lines and the control varieties. These differences are shown in Table 4.12.

Table 4.12 Monthly marketable yield and berry size for the Kiewa lines and control varieties of US origin grown at site E in Albany

Cultivar	Marketable yield (g/plant)							Mean market berry weight (g)					
	Oct	Nov	Dec	Jan	Feb	Mar	Tot.	Oct	Nov	Dec	Jan	Feb	Mar
Tasmania: (approx. 2 May)	2	113	230	46	19	1	411	18	21	17	10	8	7
Ovens: 26 April	4	69	196	65	10	1	345	12	21	18	11	11	6
Ovens: 9 May (rep 1)	23	200	266	67	30	13	599	18	28	17	10	9	12
Ovens: 9 May (rep 2)	8	182	348	93	52	8	691	9	27	19	10	13	11
Camarosa 1	27	150	217	46	19	10	469	16	28	18	10	10	7
Camarosa 2	38	249	277	108	53	11	736	21	26	16	13	11	11
Gaviota	2	168	191	34	43	9	447	9	22	15	7	10	8

The harvest results by month in Table 4.12 show that all Kiewa lines and the control varieties peaked in fruit production in November and December. Kiewa picked more fruit than Camarosa and Gaviota in December while the second planting of Camarosa did best in November. Fruit size for the two high yielding lines of Kiewa was similar to Camarosa but Gaviota generally had smaller fruit.

All of the work described above was conducted with planting material that had not been virus indexed. The process of eliminating any virus, or similar pathogen from the mother stock was commenced in 2001 by Agriculture Victoria at Knoxfield research station. Clonal material that had been heat treated and subsequently meristem cultured became available in the 2002 season and 10 clones of 30 plants each were planted alongside the untreated plants at site D (Wanneroo) to assess their trueness to type. The results of harvests for these clones are presented in Table 4.13.

Table 4.13 Monthly total and marketable yield, and berry size of Kiewa clonal selections, Wanneroo 2002

Clone	Total yield (g/plant)					Marketable yield (g/plant)					Market berry weight (g)			
	Aug	Sep	Oct	Nov	Tot.	Aug	Sep	Oct	Nov	Total (% market)	Aug	Sep	Oct	Nov
025	98	221	207	95	625	73	188	114	67	446 (71.4)	19	28	15	10
026	50	172	241	117	579	7	128	99	50	284 (49.0)	18	24	15	9
027	86	266	201	91	644	55	217	145	60	476 (73.9)	22	25	15	10
028	144	216	150	107	619	96	181	113	83	475 (76.7)	19	23	14	10
030	75	157	116	47	397	53	131	82	37	303 (76.3)	15	18	11	8
031	117	263	164	116	661	64	202	103	82	452 (68.4)	19	23	14	11
033	111	232	165	96	605	67	195	111	66	439 (72.6)	19	26	14	10
034	118	209	130	58	520	78	173	98	39	390 (75.0)	18	21	12	8
035	99	236	124	73	531	67	198	88	53	405 (76.3)	20	23	13	11
036	103	209	166	116	594	56	169	118	83	426 (71.7)	19	21	17	11

All of the meristem cultured clones flowered more prolifically than would normally be expected from 'non-meristem cultured' Kiewa and consequently, the mean berry weight was less than would normally be expected. Most clones produced acceptable percentages of marketable fruit, but the reason for rejection of fruit was too often poor fruit shape. If fruit size had been included as a criterion for rejection, the percentage reject would have been much larger than shown in Table 4.13.

It was decided to make subjective assessments of plant health and fruit quality attributes by comparing the clones against each other within the group (of 10 clonal plots) and also with a nearby commercial crop of Kiewa sourced from Ovens Research Station (2nd dig, 3 May 2002). Visual assessments were made for plant habit, plant vigour, foliage colour, fruit colour, fruit number, fruit size, fruit shape, fruit uniformity, rain damage, aroma, flavour and calyx conformation.

All clonal plots were comparatively assessed 11 times from 2 August to 4 December. During this period it became apparent that of the twelve criteria used for assessment, only four criteria were displaying marked differences between the individual clones and with the nearby commercial crop of Kiewa. These were plant vigour, fruit number, fruit size and fruit shape. Other assessments such as plant habit and fruit colour produced only minor variations that could be considered normal or due to meristem culture effects. A monthly summary of clonal performance against the four critical criteria is presented in Table 4.14.

Three of the clones were assessed as being of uncertain quality (or not true to type) taking into account the objective data, subjective data and critical comments. They were: 026, 030 and 035.

- 026 was a low yielder and produced small poorly shaped fruit.
- 030 had low plant vigour, low yields and produced small poorly shaped fruit.
- 035 had low plant vigour, poorly shaped fruit and produced too few fruit in October and November.

Table 4.14 Monthly performance of ten Kiewa clones against four critical subjective criteria

Clone	August		September		October		November	
	+	-	+	-	+	-	+	-
025		s	👍	vv			👍👍	
026		zs		sss		ss	👍	zxz
027		sv	👍👍	vsv			👍	z
028		zs	👍	vv			👍	zzx
030		vzsvzsvzs		vzsvsvs		vzsvzs		vzvzxsz
031	👍👍	s	👍	vs	👍	s	👍👍	z
033	👍👍		👍👍	sz		s	👍	zv
034	👍		👍	zvs	👍	v	👍	vzv
035	👍	vs	👍	vs		vs		vxvz
036	👍👍	v	👍	sz	👍		👍👍👍	

Positive attribute:

👍 = positive attribute, e.g. good fruit size, good fruit uniformity, good plant vigour.

Negative attributes:

s = shape (atypical shape); v = vigour (low vigour); z = size (poor fruit size); x = few fruit.

Yield and quality 2003

In the 2003 season, the Strawberry Growers Association of W.A. did not enter into a contract with Ovens Research Station in Victoria to produce Kiewa runners for semi-commercial evaluation. Instead, runners grown from non-virus indexed mother plants were supplied by two commercial runner producers in Tasmania, designated as Tas A and Tas B. These were compared with commercial certified runners of industry standard varieties, Camarosa and Gaviota sourced from Toolangi in Victoria. The Kiewa runners were purchased by the Growers Association, for trial by their members. The distribution of those runners is shown in Table 4.4.

Yield and quality data was only systematically collected from one of the grower's sites at Wanneroo. This was the same grower (D) as reported in 2001 and 2002 but a different property to that where plants were grown in 2002. Yield results from those plots are reported in Table 4.15. All results presented in the table are for bare rooted runners and repeat plots (reps) of Camarosa and Gaviota were compared. For the Kiewa runners from runner grower A (Tas A), plots of large and small runners were compared.

Table 4.15 Monthly total and marketable yield of Kiewa from two commercial runner sources compared to control varieties, Camarosa and Gaviota

Cultivar	Total yield (g/plant)					Market yield (g/plant)					Yield	Berry size (g)		
	Aug	Sep	Oct	Nov	Tot.	Aug	Sep	Oct	Nov	Tot.	%	Sep	Oct	Nov
Camarosa (rep 1)	11	131	375	110	616	8	101	326	108	543	88	35	26	24
Camarosa (rep 2)	9	113	258	42	413	8	96	216	37	357	86	36	23	15
Gaviota (rep 1)	0	114	344	74	533	0	102	310	63	476	89	44	23	15
Gaviota (rep 2)	5	76	283	45	404	0	59	240	40	339	84	37	23	14
Kiewa (Tas A small)	11	85	381	80	546	9	62	316	72	459	84	35	27	17
Kiewa (Tas A large)	17	99	307	52	459	12	84	268	44	408	89	30	27	15
Kiewa (Tas B)	10	154	249	51	454	8	122	211	44	386	85	28	25	15

The results presented in Table 4.15 show that greater differences existed between reps of the control varieties than between Kiewa and the controls, suggesting that Kiewa had at least equivalent yield potential to Camarosa and Gaviota. The yield for runners from the two sources were of a similar order and all varieties had similar marketable percentages. Kiewa from both runner sources held its fruit size better than Gaviota, particularly in October, but was not as good as the best plot of Camarosa.

Fruit quality of the Kiewa and control varieties was measured six times during the course of the season using a 3-point rating scale where:

1 = poor
2 = acceptable
3 = excellent

The results of those assessments were averaged for each month of harvesting and those average scores are presented in Tables 4.16 and 4.17.

Table 4.16 Mean monthly quality scores for fruit colour, uniformity and fruit size for Kiewa and the control varieties

Cultivar	Fruit colour			Colour uniformity			Size uniformity		
	Sep	Oct	Nov	Sep	Oct	Nov	Sep	Oct	Nov
Camarosa (rep 1)	2.0	2.0	2.0	2.5	2.0	2.5	3.0	2.5	2.5
Gaviota (rep 1)	2.5	2.5	2.5	2.0	2.5	2.5	2.5	2.5	2.0
Kiewa (Tas A small)	2.0	1.2	2.0	2.5	1.5	2.0	3.0	2.0	1.5
Kiewa (Tas A large)	2.0	2.0	2.0	2.5	2.0	2.0	2.5	2.0	2.5
Kiewa (Tas B)	2.0	2.0	2.0	2.0	2.0	2.0	3.0	2.5	1.0

Table 4.17 Mean monthly quality scores for appearance and flavour for Kiewa and the control varieties

Cultivar	Appearance of ripe fruit			Flavour		
	Sep	Oct	Nov	Sep	Oct	Nov
Camarosa (rep 1)	2.0	2.0	2.0	2.0	2.0	2.0
Gaviota (rep 1)	2.0	3.0	2.5	2.0	2.0	2.5
Kiewa (Tas A small)	2.0	1.5	2.0	2.5	2.0	2.0
Kiewa (Tas A large)	2.0	2.0	2.0	2.5	2.5	2.0
Kiewa (Tas B)	2.0	2.0	2.0	2.5	2.5	2.0

The tables show that Kiewa from the two runner sources scored better for flavour in September and October than the control varieties, while Gaviota was better in November. Kiewa was comparable to Camarosa in appearance, but Gaviota was better than both in October and November.

Kiewa and Camarosa were similar for fruit colour, but Gaviota rated better than both. Overall, Camarosa and Gaviota rated slightly better for fruit colour uniformity than Kiewa, while size uniformity was similar for all varieties.

4.4 DISCUSSION

The attempt to fast track the commercial adoption of Kiewa by contracting the production of semi-commercial quantities of runners to Ovens Research Station in Alpine Victoria was only partially successful.

In 2001, the runners from this source were of a good commercial standard despite being produced from non-indexed mother plants and this being the first attempt at runner production by Ovens staff.

In 2002, the first digging of runners at Ovens resulted in a high level of plant deaths in Perth when these runners were planted in the field. This result suggested that runners from this source were insufficiently mature in a season where chilling levels were low. When chilling levels of around 40 hours or more were received by the runners prior to digging, plant establishment and subsequent fruit production were satisfactory in both Perth and Albany.

The harvest results for the two years suggested that chilling levels prior to digging runners of the order of 50 hours or more was sufficient for Kiewa to produce good quality fruit when planted in Perth districts. The best planting time in Perth was in the first week of May.

It was difficult to draw a conclusion about planting later than this in Perth because these two plantings were delayed by a quarantine issue which caused them to be left in cool store receiving more post-digging chilling than they would normally get. This extra chilling appeared to make the plants more vegetative as they matured in the field, resulting in fewer fruit of a larger size where the extra chilling extended to 14 days.

The level of pre-digging chilling received by the runners from Tasmania in 2001, in excess of 350 hours did not adversely effect Kiewa and these plants were among the highest yielding at all of the Perth sites.

Overall, the practice of producing runners for semi-commercial evaluation at Ovens was more successful when these runners were replanted in Albany than in Perth, possibly due to the effects of more in-field chilling and a later start to harvesting.

Production of runners in W.A. for this phase of the selection and evaluation process proved feasible and effective despite the relatively low levels of pre-digging chilling. The advantage that this location compared to Eastern Australia was that runners could be quickly replanted after digging, minimising any adverse effects of runner immaturity.

Kiewa compared favourably to commercial control varieties from overseas breeding programs, for yield and fruit quality characteristics, but the data suggested that Gaviota may give better marketable percentages and yields in Perth.

5. FERTILISER AND IRRIGATION RESEARCH

Kelly Hulcup

5.1 2001 TRIAL - MEDINA RESEARCH STATION

5.1.1 Summary

The aim of this work was to develop an understanding of the fertiliser requirements of the new strawberry variety Kiewa (*Fragaria* x *ananassa*). Nine rates of nitrogen (N), three rates of phosphorus (P) and three rates of potassium (K) were applied to a field trial of fertigated plants grown in sandy soil. The effect of each fertiliser regime was measured in terms of crop production, plant nutrient analysis and fruit quality.

Nitrogen fertiliser gave significant increases in marketable yield and berry size proportional to fertigation rate applied and the pre-plant use of fowl manure. Sap nitrate (NO_3) levels were also related to the rate of nitrogen fertigated. On the basis of the yield data, the suggested desired range for sap NO_3 is 1500-2000 mg/L. High nitrogen fertiliser rates were associated with reduced sugar content in the berries.

Yield was also proportional to the rate of phosphorus fertiliser with the application of 150 kg/ha P required to maximise yields. Adequate phosphorus was also important to fruit quality with higher sugar and lower acid concentrations in fruit.

Kiewa was sensitive to potassium fertiliser rates. The application of 225 kg/ha or less suppressed yields and reduced berry size. Plant analysis of these treatments revealed low sap nitrate concentrations and very low manganese levels in the leaves. Potassium fertiliser increased the sugar content of berries.

5.1.2 Introduction

A balanced supply of nutrients is critical to strawberry production. Strawberry plants require nitrogen in relatively large amounts. Without adequate nitrogen the leaves are pale green and plant growth, fruit production and fruit size are reduced. Severe deficiencies can lead to the older leaves becoming red and the younger leaves, pale with shortened petioles. Excessive nitrogen is associated with increased *Botrytis cinerea* and a reduction in fruit quality.

Demand for phosphorus in strawberry plants tends to be low but phosphorus deficiency can lead to reduced growth, dark green leaves and a small root system. Excess P fertilisation can cause micro-nutrient deficiencies.

Strawberries have a high requirement for potassium with deficiency occurring in the older leaves first, resulting in marginal necrosis. Potassium is a major component of the fruit and often the amount of potassium in leaves decreases as crop load increases.

Kiewa is an Australian bred variety that is likely to become commercialised but the nutritional requirements of this new cultivar are unknown. This research project aimed to define its nutritional requirements as a precursor to future commercial development. The experiment described here had three components designed to assess the requirements of Kiewa for nitrogen, phosphorus and potassium. The effect of N, P and K application rates on fruit production and quality were studied as well as the relationship between fertiliser application and plant analysis.

5.1.3 Materials and methods

Strawberry plants (*Fragaria annanasa*, cv. Kiewa) were planted at the Medina Research Centre on 7 May 2001. The source of the 'bare root' runners was a commercial runner producer in Tasmania (Tasmanian Highland Runner Growers). The runners were not grown from virus indexed mother plants for reasons already described, but they were essentially 'virus free' from field observation. Runners were graded before planting to remove those smaller than 10 mm crown diameter and larger than 40 mm.

Beds, 10 cm high were formed 1.2 m wide and covered by polyethylene (50 μm) mulch, with a distance of 80 cm between beds. Plants were set 30 cm apart within four staggered rows spaced 30 cm from each other.

The total length of each plot was 2.6 m, with unplanted buffer areas between consecutive plots, down the row of 1 m. Each plot consisted of 20 harvest plants and 16 buffer plants. The effective plant population (including pathways) was 70,175 plants per hectare, but for the purpose of interpreting graphs and tables in this report, one hectare of plastic excluding pathways with plants at the 30 cm spacing would accommodate 111,111 plants. Rates of fertigation per hectare in the report are the quantities that would be applied to 111,111 plants.

Following crop establishment with overhead irrigation, water was applied through a drip irrigation system (Netafim Streamline 80®) with a flow rate of 0.98 l/hr. Two laterals per bed were installed with emitters spaced every 25 cm. Irrigation was applied daily at 9 a.m., based on the mean daily evaporation for each month (Table 5.1.) calculated from long-term (26 years) evaporation pan (Epan) data collected at the Meteorology unit at the Medina Research Centre from an Australian 'Class A' pan evaporimeter. Overhead irrigation was used to cool the trial area when air temperatures exceeded 25°C.

Table 5.1 Medina average daily evaporation (mm)

Month	Mean daily Epan (mm)
July	1.76
August	2.22
September	3.10
October	4.55
November	6.19
December	7.81

A soil sample was taken prior to the application of the fertiliser treatments to the trial area to measure the pH as well as the NPK status of the soil. The alkaline soil was found to contain relatively low levels of nitrogen, phosphorus and potassium (Table 5.2).

Table 5.2 Pre-trial soil analysis

pH	P	K	N	N
($CaCl_2$)	(HCO_3)	(HCO_3)	(NH_4)	(NO_3)
	mg/kg	mg/kg	mg/kg	mg/kg
6.6	55	19	2	4

The trial area was divided into three sub-sections for the N, P and K components of the experiment. Within each sub-section a randomised complete block design was used to compare the treatments imposed on four replicates.

Treatments

Nitrogen

Before planting a fertiliser blend of Superphosphate®, Hi Trace® and magnesium sulphate was broadcast and incorporated seven days before bed formation and planting (Table 5.3). Fertiliser was also applied through the dripper tape immediately before planting. Potassium was applied at 100 kg/ha as potassium sulphate and ammonium nitrate was used as a source of nitrogen as per treatment schedule (Table 5.4). Fertigation was carried out during the trial with each irrigation event. Potassium sulphate, ammonium nitrate, calcium nitrate, magnesium nitrate and magnesium sulphate were used to create the nutrient solution. While the amount of nitrogen differed for each treatment, the season target for potassium was 350 kg/ha (K) and 35 kg/ha for calcium (Ca) and magnesium Mg.

Table 5.3 Pre-plant broadcast fertiliser applied (kg/ha)

N	P	K	S	Ca	Mg	Zn	Mn	Cu	B	Fe	Mo	Co
0	150	0	230	10	25	9	10	2	1.2	0.5	0.01	0.005

A range of nitrogen rates were applied to study the relationship between the rate of N applied and timing of application on the yield and fruit quality of Kiewa. The following nine treatments were applied:

Table 5.4 Nitrogen treatments applied (kg/ha)

Treatment	Pre-plant nitrogen (N)	Fertigation nitrogen (N)
1	150	50
2	400	50
3	150	150
4	300	150
5	150	300
6	0	450
7	150	450
8	450	450
9	874 as fowl manure @ 50 m^3	450

Fowl manure was applied before planting to one of the treatments. A sample of the manure was analysed to determine its composition and was found to contain 4% N (dry weight basis), which when applied at the rate 50m^3/ha, provided the treatment with 874 kg/ha N (Table 5.5).

Table 5.5 Composition of fowl manure applied (kg/ha)

N	P	K	S	Ca	Mg	Zn	Mn	Cu	Fe	Na
874	260	260	100	520	80	7	14	2.4	16	80

Phosphorus

A pre-plant broadcast fertiliser blend of Hi Trace® and magnesium sulphate was incorporated seven days before bed formation and planting (Table 5.6.). Fertiliser was also applied through the dripper tape immediately before planting. Nitrogen was applied this way at 450 kg/ha as ammonium nitrate and 100 kg/ha of potassium as potassium sulphate.

Fertigation was carried out during the trial with each irrigation event. Potassium sulphate, ammonium nitrate, calcium nitrate, magnesium nitrate and magnesium sulphate were used to create the nutrient solution. The season target for fertigated nitrogen was 450 kg/ha, potassium 350 kg/ha, and 35 kg/ha for Ca and Mg. The total N applied for the life of the crop, including pre planting was thus 900 kg/ha N. Similarly the total K application for its full life was 450 kg/ha K.

Table 5.6 Pre-plant broadcast fertiliser applied to phosphorus trial (kg/ha)

N	P	K	S	Ca	Mg	Zn	Mn	Cu	B	Fe	Mo	Co
0	0	0	57	10	25	9	10	2	1.2	0.5	0.01	0.005

Three phosphorus rates were applied to study the relationship between the rate of P applied on the yield and fruit quality of Kiewa. Phosphorus as Superphosphate® was broadcast by hand and incorporated seven days before planting. The following treatments were applied:

Table 5.7 Phosphorus treatments applied

Treatment	Pre-plant phosphorus
1	0
2	75
3	150

Potassium

A fertiliser mix of Superphosphate®, Hi Trace® and magnesium sulphate was broadcast and incorporated seven days before bed formation and planting (see Table 5.3). Fertiliser was also applied through the dripper tape immediately before planting. Nitrogen was applied at 450 kg/ha as ammonium nitrate, and potassium sulphate was used as a source of potassium as per the treatment schedule (Table 5.8).

Fertigation was carried out during the trial with each irrigation event. Potassium sulphate, ammonium nitrate, calcium nitrate, magnesium nitrate and magnesium sulphate were used to create the nutrient solution. Whilst the amount of potassium differed for each treatment, the season target for fertigated nitrogen was 450 kg/ha (N) and 35 kg/ha for Ca and Mg. The total N applied for the life of the crop, including pre planting was thus 900 kg/ha N.

Table 5.8 Potassium treatments applied (kg/ha)

Treatment	Pre-plant potassium	Fertigation potassium
1	0	0
2	50	175
3	100	350

Data recording

Fruit were picked and graded twice a week to determine yields and average fruit size for each treatment. Small berries (< 10 g) and inferior fruit were discarded. The harvest period was from 27 August until 27 November, 2001.

Petiole sap samples of the youngest fully expanded leaf from buffer plants in each treatment were analysed for NO_3-N, PO_4 and K content during the trial. Sap was extracted from petioles and tested using a Merck RQFlex reflectometer with Merck Reflectoquant® Nitrate (NO_3^-), Phosphate (PO_4^{3-}) and Potassium (K^+) strips. Leaf samples were analysed on a dry basis (% db, ppm) for N(NO_3), N, P, K, Na, Ca, Mg, S, B, Cu, Fe, Mn and Zn using ICP - AES, and a colourimetric autoanalyser for nitrates and total nitrogen.

Fruit quality was measured in terms of sugar (% Brix) and citric acid content. Twenty randomly selected berries of even maturity were tested individually for sugar levels by squeezing juice onto a hand-held refractometer (Atago). The results were averaged for each treatment and standard errors calculated. The berries were then crushed and passed through a sieve to remove seeds and pulp. The citric acid content was measured by titration of 10 mL of juice with NaOH. The titration was repeated three times.

Data were compared using the statistical program package Genstat 5. Differences in the parameters studied were evaluated by analysis of variance procedures and significance was determined by p values ≤ 0.05.

Year 2

At the completion of the spring fruiting season, all plots were retained and irrigation and fertigation was continued over the summer.

The following regime was applied during this period:

> Thirty minutes of irrigation at each of 8:00 and 14:00 (60 minutes per day total) with fertigation during each cycle (10 minutes). An additional 20 minutes of overhead irrigation at midday each day for cooling.

The following fertiliser program was followed over summer:

Weekly fertigation totals (11 treatments x 4 reps):

Calcium nitrate	610g
Magnesium nitrate	128g
Ammonium nitrate	525g
Potassium sulphate	312g

By the end of summer, there was a high incidence of plant death in many of the treatments. The lowest death rate was consistently found in the two highest nitrogen treatments, 450 N and 450 N + 50 FM.

All four replicates of these two treatments were retained to assess Kiewa's potential to produce an autumn crop. The original 36 plant plots were 'cut back' and had dead leaf matter removed on 14 March 2002.

The following fertiliser program was applied to these eight plots:

Post Planting Fertiliser (fertigated daily through drip - weekdays)

Duration: 15 April - 30 June 30

Fertiliser	Rate per week (Total for eight weeks)
Calcium nitrate	10.6 g
Magnesium nitrate	22.2 g
Ammonium sulphate	164.8 g
Potassium sulphate	72.8 g

The irrigation schedule below was followed:

April - June

Month	April	May	June
Epan (mm)	3.9	2.3	1.7
% applied	100	100	100
Total drip time: 8 a.m.	20 minutes	10 minutes	10 minutes
Fertigation time: 8 a.m.	5 minutes	5 minutes	5 minutes
Total drip time: 2 p.m.	20 minutes	10 minutes	10 minutes
Fertigation time: 2 p.m.	5 minutes	5 minutes	5 minutes

Output Rate: 6.2 mm/hr (bed area)

5.1.4 Results

Yields

Nitrogen trial

Nitrogen fertiliser affected the yield of Kiewa with total and marketable yields significantly increased by high nitrogen fertigation rates (450 kg/ha N) and the use of pre-plant fowl manure (Figure 5.1). The application of fowl manure plus 450 kg/ha N during the season resulted in the production of over 800 g of marketable fruit per plant. With the exception of the fowl manure + 450 regime, yields were not related to pre-plant treatments or the total amount of nitrogen applied, but to fertigation rates alone (Table 5.9).

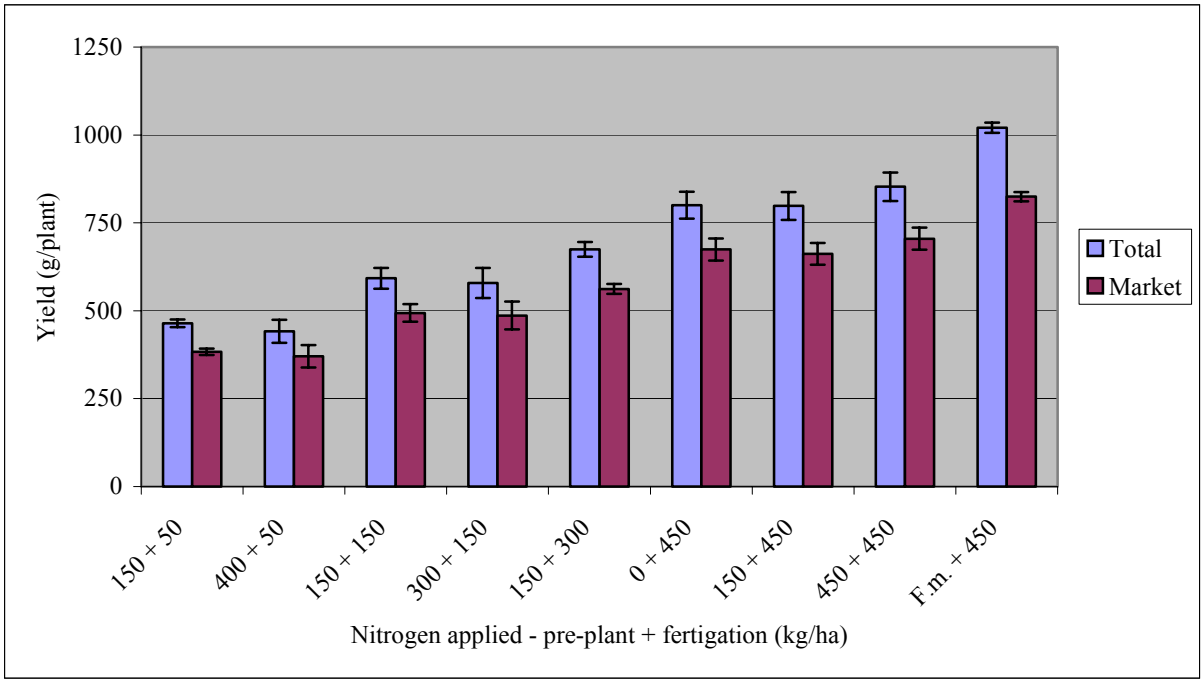

Figure 5.1 Effect of nitrogen rate and timing of application on the total and marketable yield of Kiewa. Bars indicate s.e.

Table 5.9 Effect of nitrogen treatments on Total and Marketable yield (g/plant)

Nitrogen treatment (kg/ha)		Total yield		Marketable yield	
1	150 + 50	464	e	384	d
2	400 + 50	442	e	371	d
3	150 + 150	592	dc	494	c
4	300 + 150	579	d	486	c
5	150 + 300	675	c	562	c
6	0 + 450	800	b	674	b
7	150 + 450	798	b	662	b
8	450 + 450	853	b	705	b
9	Fowl manure + 450	1021	a	825	a
	l.s.d.	93.3		78.47	

The average size of fruit from the nitrogen trial was significantly larger for treatments that received 450 kg/ha N as fertigation, despite the heavier crop loads of these treatments (Figure 5.2). Low nitrogen fertigation rates (50, 150 kg/ha) produced smaller berries but the fruit size was still relatively large at over 20 g/berry (Table 5.10).

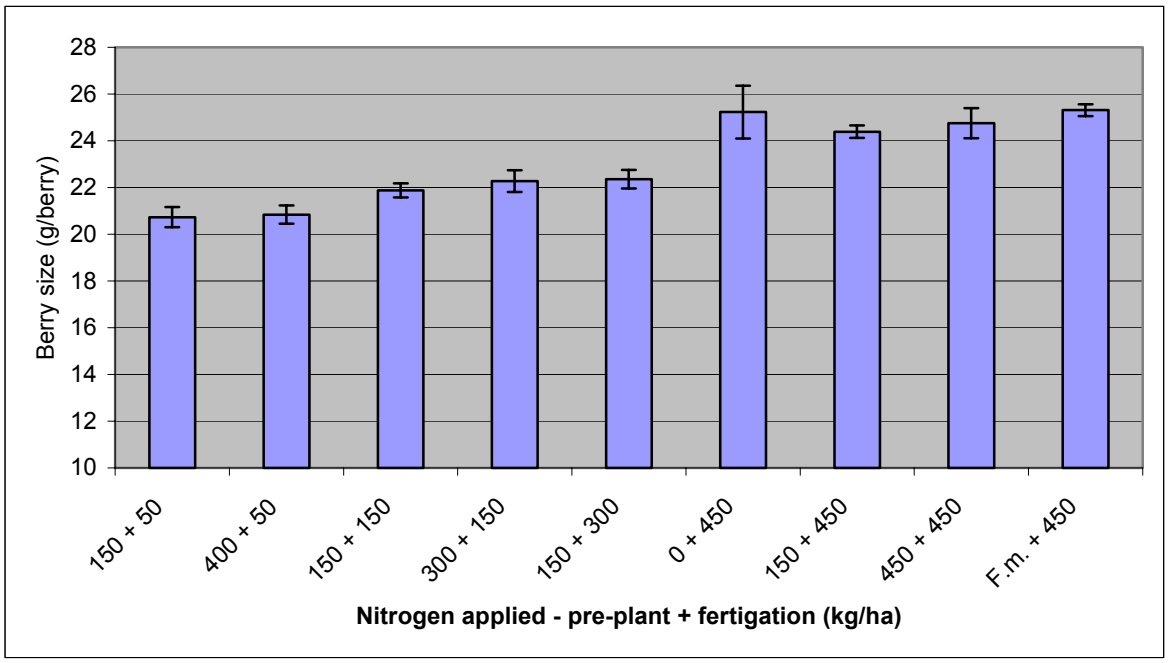

Figure 5.2 Effect of nitrogen rate and timing of application on average marketable fruit berry size of Kiewa. Bars indicate s.e.

Table 5.10 Effect of nitrogen treatments on average marketable fruit size (g/berry)

Nitrogen treatment (kg/ha)		Berry size	
1	150 + 50	20.73	c
2	400 + 50	20.84	bc
3	150 + 150	21.88	bc
4	300 + 150	22.27	bc
5	150 + 300	22.36	b
6	0 + 450	25.23	a
7	150 + 450	24.39	a
8	450 + 450	24.75	a
9	Fowl manure + 450	25.31	a
	l.s.d.	1.57	

High N plus fowl manure (foreground); low N (background) at Medina, October 2001.

Phosphorus trial

Yield was proportional to the rate of phosphorus fertiliser broadcast before planting (Figure 5.3). Despite the low native phosphorus levels in the soil, plants that did not receive any phosphate fertiliser still produced 583 g of marketable fruit per plant. The application of 150 kg/ha P however significantly increased yields by 20%.

The average berry size was not affected by the rate of phosphorus fertiliser (Table 5.11). Over the season all treatments produced large fruit that averaged over 24 g/berry.

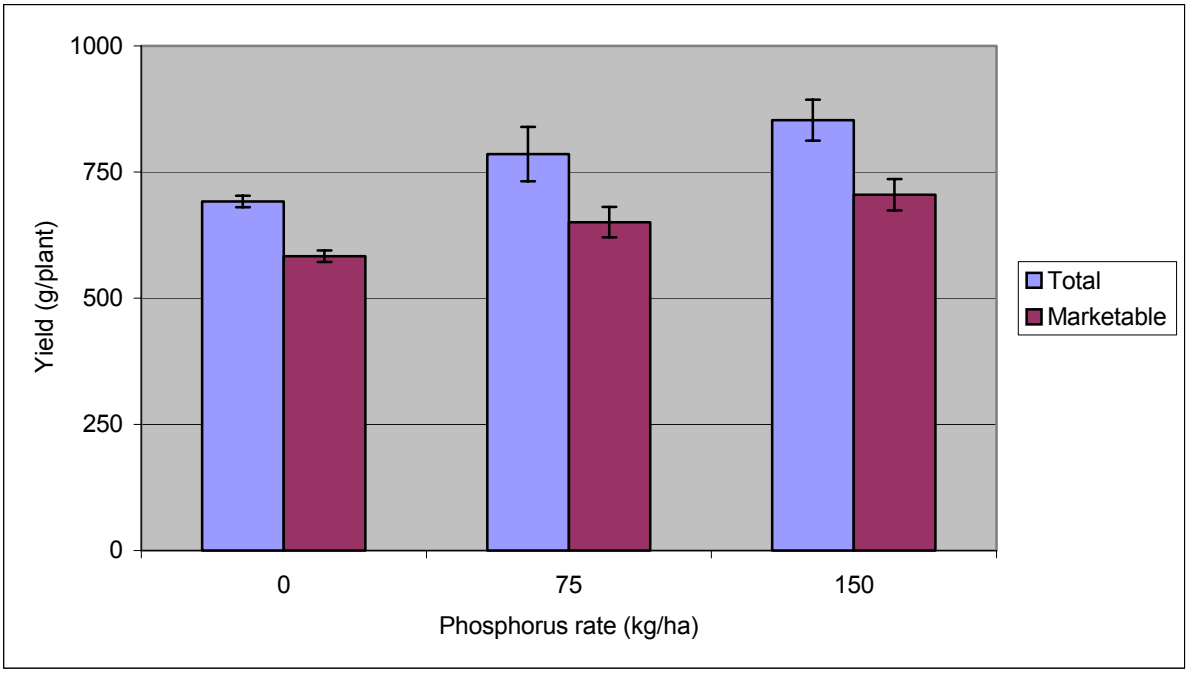

Figure 5.3 Effect of phosphorus rate on the total and marketable yield of Kiewa. Bars indicate s.e.

Table 5.11 Average berry size significance table (g/berry)

Phosphorus treatment (kg/ha)		Berry size	
1	0	24.5	a
2	75	25.3	a
3	150	24.7	a
	l.s.d.	2.14	

Potassium trial

The yield of Kiewa was sensitive to potassium fertiliser (Figure 5.4). The application of 100 kg/ha K pre-plant and a further 350 kg/ha after planting resulted in a significantly higher marketable yield of 881 g/plant. The application of 225 kg/ha K or less suppressed the yield by 25%.

Potassium fertiliser rates also had implications for berry size. The highest rate of potassium fertiliser, 100 + 350 produced larger berries than the 50 + 175 K rate (Table 5.12). However the average size of berries was large for all the treatments at over 22 g/berry.

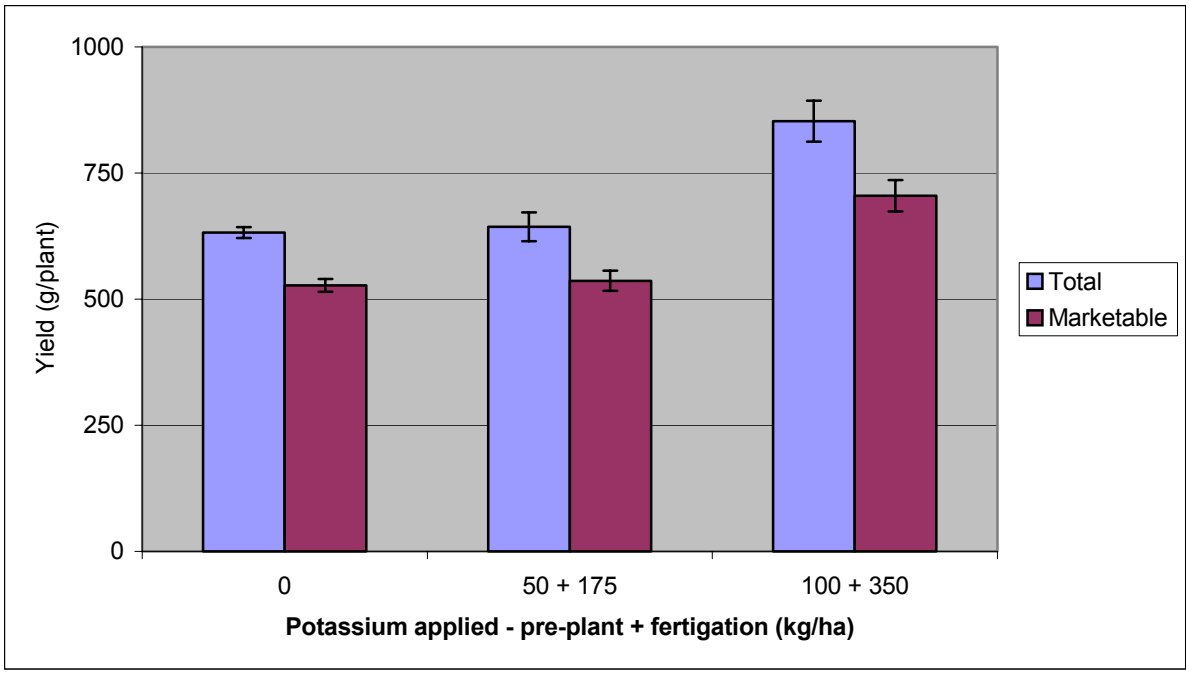

Figure 5.4 Effect of potassium rate on the total and marketable yield of Kiewa. Bars indicate s.e

Table 5.12 Average berry size significance table (g/berry)

Treatment		Berry size	
1	0	23.71	ab
2	50 + 175	22.44	b
3	100 + 350	24.75	a
	l.s.d.	1.70	

Uptake of nutrients

Nitrogen trial

The optimum sap nitrate levels for strawberries is dependent on the variety. For example, the desirable sap nitrate range for Chandler (a parent of Kiewa) is 800-1200 mg/L, while Parker (also used in the parentage of Kiewa) has a higher range of 1500-2000 mg/L (Vock and Greer, 1997). Leaf nitrogen levels should be greater than 2.7% d.b.

Sap nitrate levels of Kiewa increased during the season before peaking in early November (Figure 5.5). Low nitrogen fertigation treatments tended to have lower nitrate levels. The 50 kg/ha N fertigation treatments consistently had the lowest sap nitrate levels while the 450 kg/ha N fertigation treated plots typically contained the highest concentration. The fowl manure + 450 kg/ha N treatment maintained highest NO^-_3 levels throughout the season.

Based on the sap nitrate results, a suggested desirable sap NO^-_3 range for Kiewa during peak harvest periods would be 1500-2000 mg/L. The 50 kg/ha N fertigation treatments peaked at only 625 mg/L. The reduced yields of these treatments and the slight yellowing of the older leaves of the plants indicated that these treatments were nitrogen deficient.

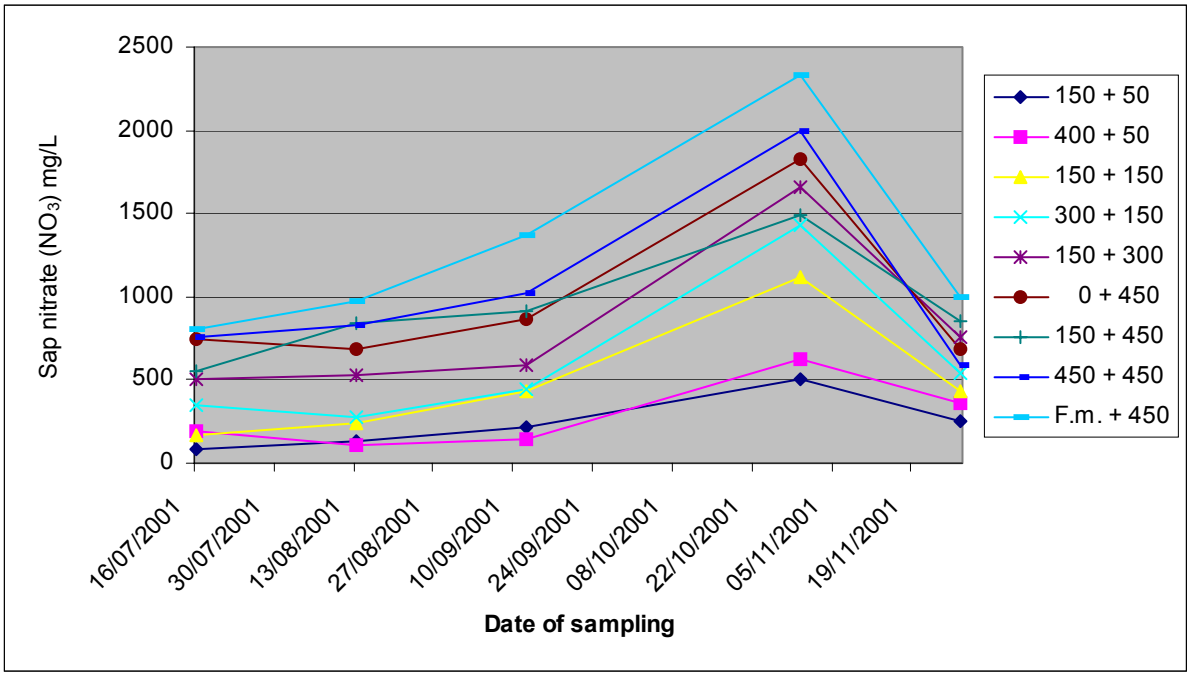

Figure 5.5 Effect of nitrogen fertiliser on sap nitrate (NO_3) cv. Kiewa.

Nitrogen fertiliser treatments did not effect the sap phosphate levels, which fluctuated considerably between treatments (Figure 5.6). Good fruit yields were obtained from the 0 + 450 treatment and its sap phosphate levels were mostly around 150 mg/L.

The fowl manure treatment tended to have the highest P levels, reflecting the high phosphorus content of this fertiliser and the extra phosphorus it added compared to the other treatments. This extra phosphorus supplied may have been the factor resulting in higher yields achieved with this treatment, compared to the mineral fertiliser treatments.

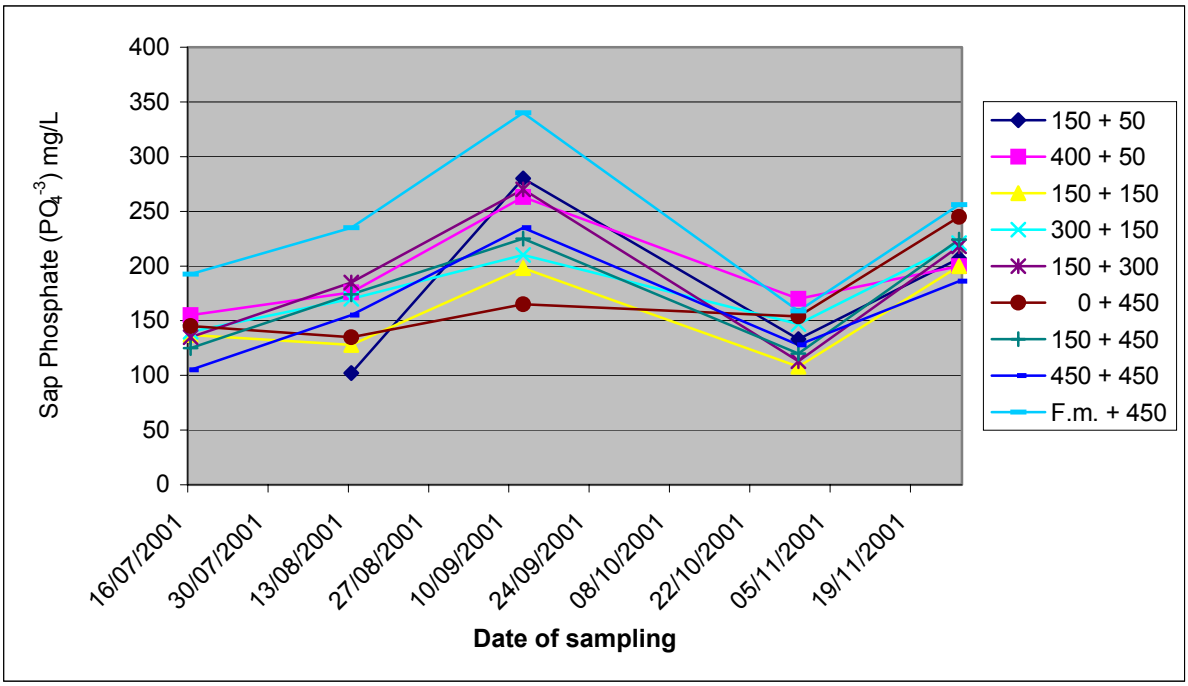

Figure 5.6 Effect of nitrogen fertiliser on sap phosphate (PO_4^{-3}) cv. Kiewa.

The potassium sap levels were not affected by nitrogen rates except in early November (Figure 5.7). Treatments receiving the 450 kg/ha N fertigation rate had lower potassium levels at this time. This is most likely due to the greater demand for potassium from the heavier crop load of these treatments.

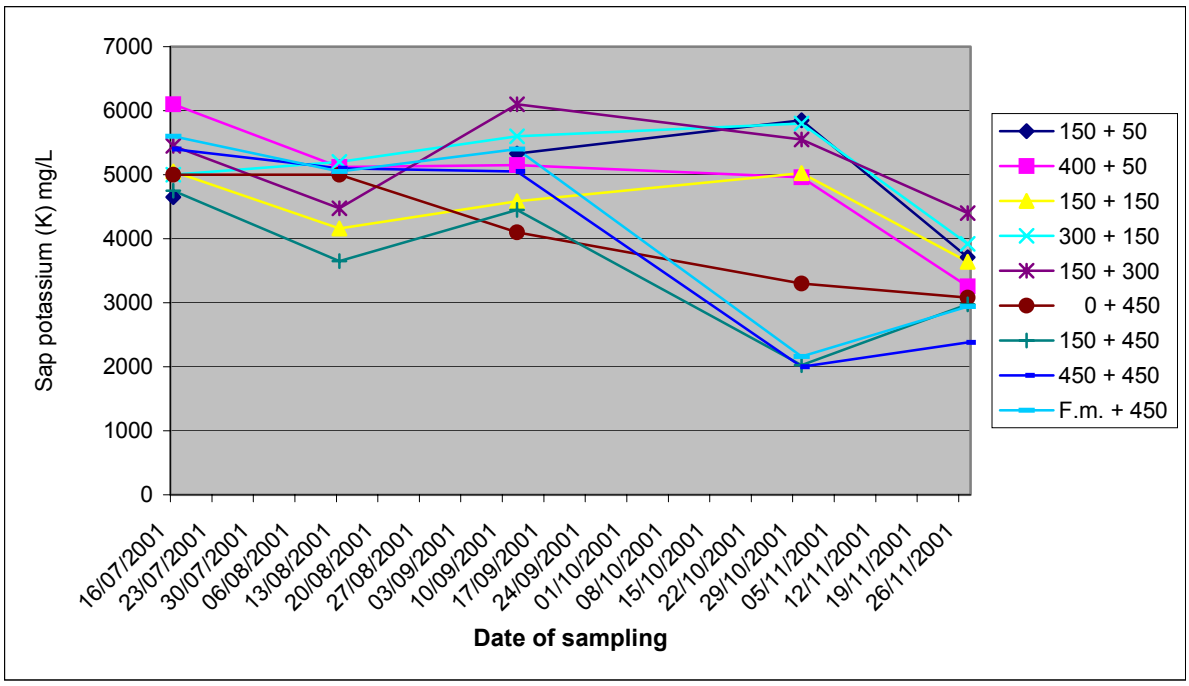

Figure 5.7 Effect of nitrogen fertiliser on sap potassium (K) cv. Kiewa.

Phosphorus trial

The sap phosphate (PO_4^{-3}) levels for all three treatments were within the desired sap PO_4^{-3} range of 100-250 mg/L (Figure 5.8). The lowest rate, 0 kg/ha P and the highest rate, 150 kg/ha P followed a similar pattern, peaking at 235 mg/L in mid-September. The 75 kg/ha P rate deviated slightly from the other two treatments but not by more than 100 mg/L. Trial plots treated with the lower rates of phosphorus displayed mild symptoms of phosphorus deficiency. Plants in these plots tended to be slower growing dark green plants with smaller leaves.

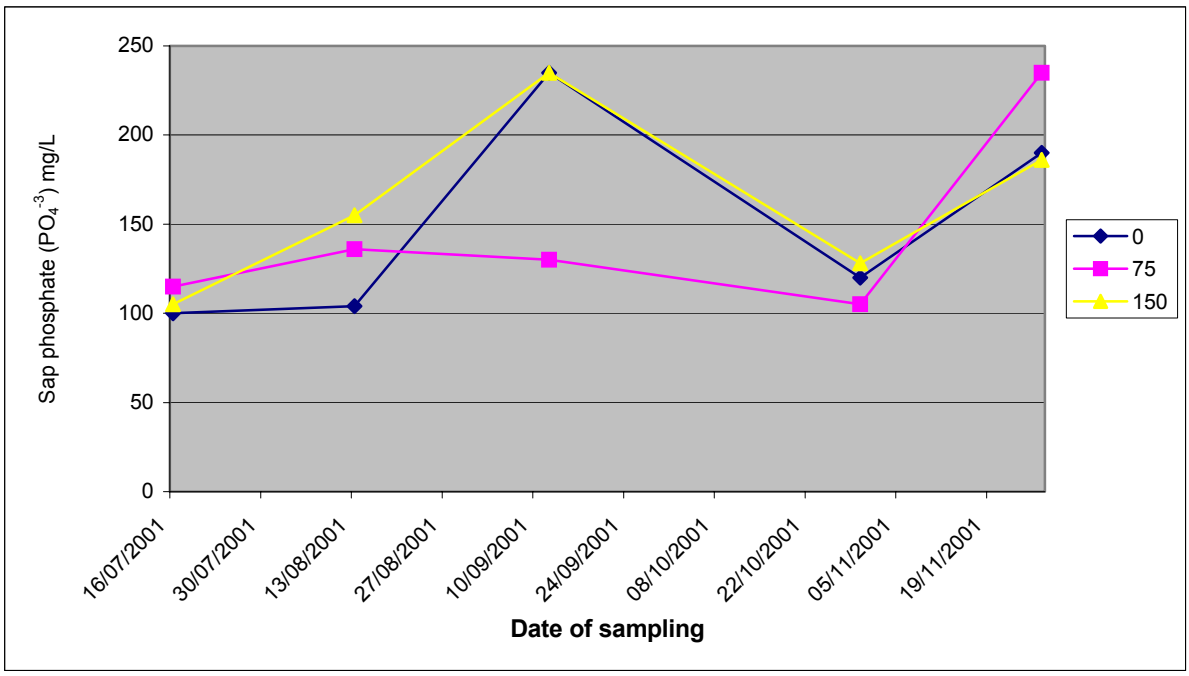

Figure 5.8 Effect of phosphorus fertiliser on sap phosphate (PO_4^{-3}) cv. Kiewa.

Measurements of sap nutrient found few differences in N, P or K levels between phosphorus treatments. Phosphorus fertiliser application rate had no effect on sap nitrate (Figure 5.9) or potassium (Figure 5.10).

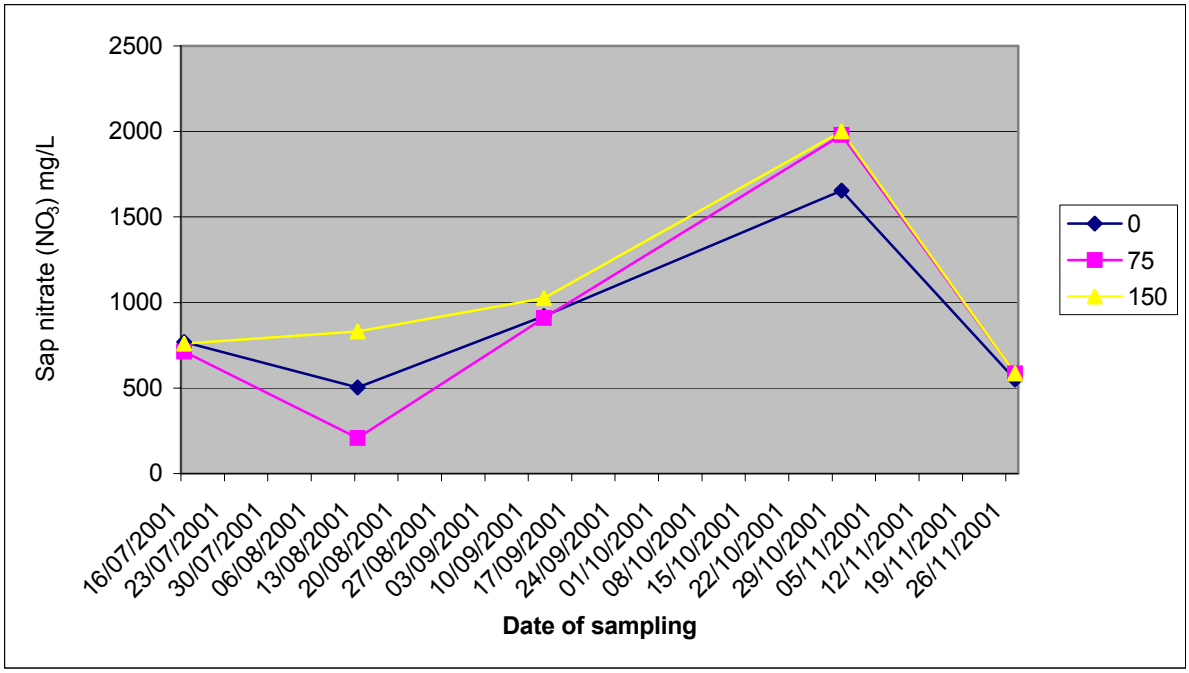

Figure 5.9 Effect of phosphorus fertiliser on sap nitrate (NO^-_3) cv. Kiewa.

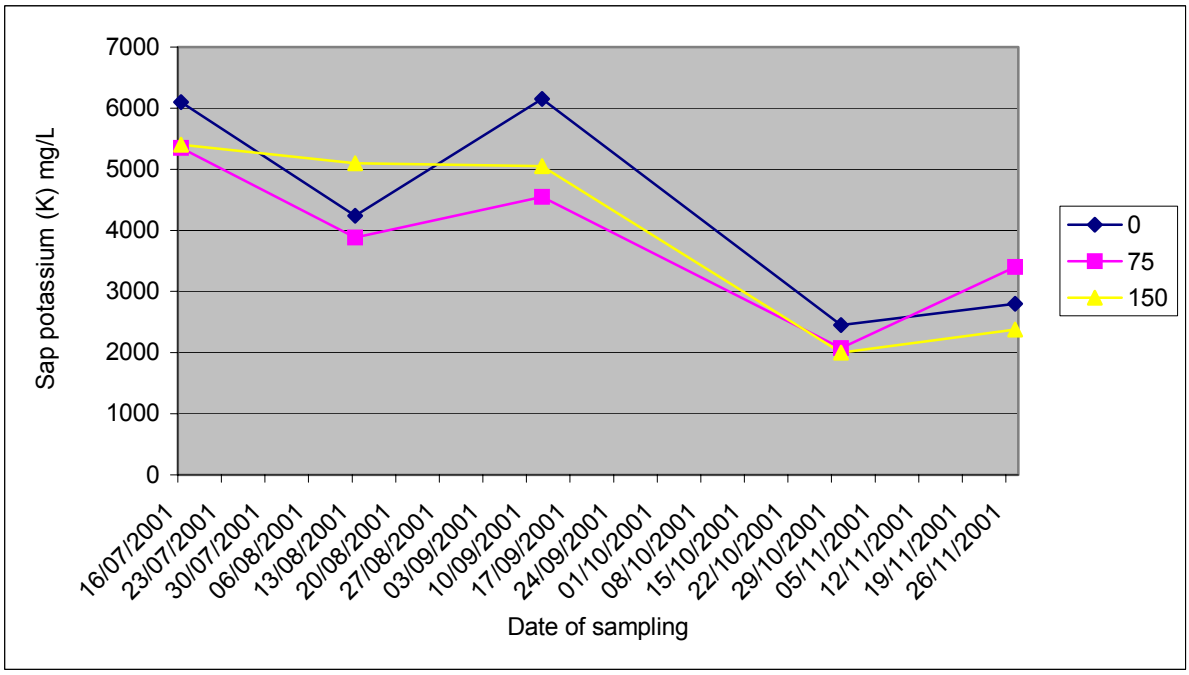

Figure 5.10 Effect of phosphorus fertiliser on sap potassium (K) cv. Kiewa.

At the end of the trial, leaf samples from each treatment were tested and the concentration of P in the leaves was found to be proportional to the rate of phosphorus fertiliser applied (Table 5.13). Phosphorus fertiliser rate also influenced the concentrations of other nutrients with the application of 150 kg/ha P resulting in higher N, Ca, Mg, B, and manganese levels.

Table 5.13 Effect of phosphorus fertiliser on leaf nutrients cv. Kiewa

P rate	N	P	K	Na	Ca	Mg	S	B	Cu	Fe	Mn	Zn
(kg/ha)	%db	%db	%db	%db	%db	%db	%db	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
0	1.90	0.27	1.20	0.04	1.26	0.42	0.16	38	3.5	140	39	16
75	1.88	0.28	1.12	0.03	1.23	0.42	0.16	37	3.1	150	36	15
150	2.04	0.32	0.99	0.03	1.54	0.54	0.17	44	3.2	150	44	13

Potassium trial

Despite a range of potassium fertiliser treatments from 0 to 450 kg/ha, the concentration of K in the sap was not effected by the rate of potassium applied (Figure 5.11). The consistent effect for all treatments was, for the sap levels to fall dramatically as the crop carried a progressively higher fruit load, from August to November.

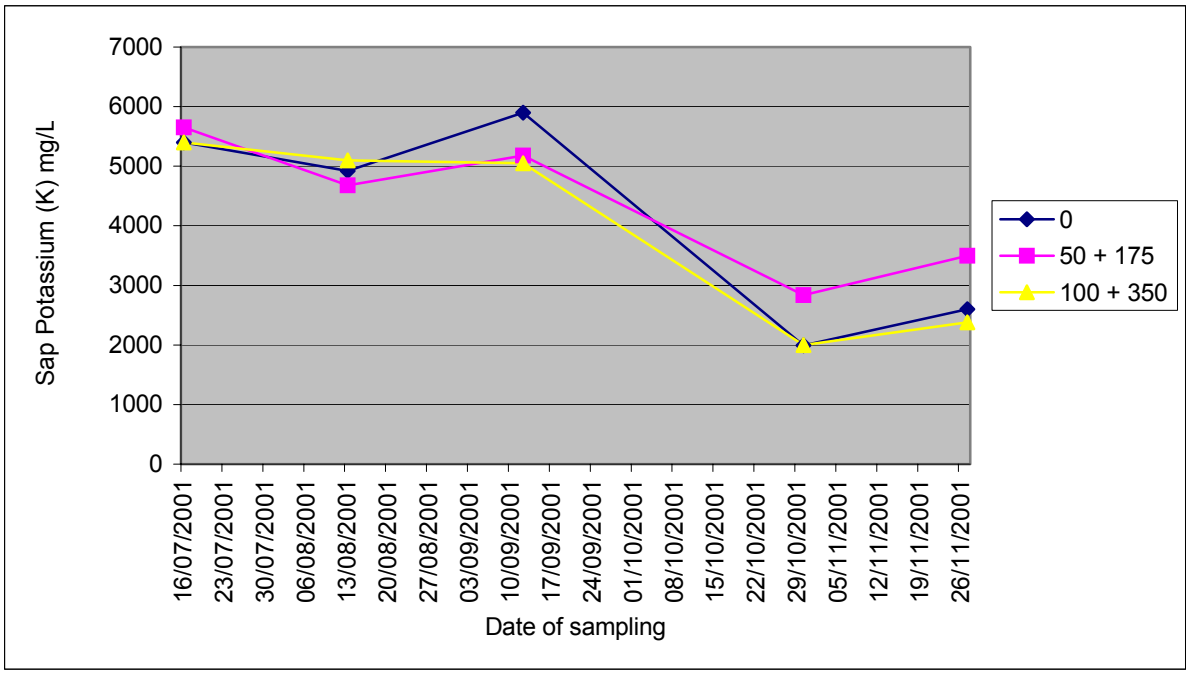

Figure 5.11 Effect of potassium fertiliser on sap potassium (K) cv. Kiewa.

Increasing applications of potassium did not increase the plant tissue levels of potassium in a sample collected in early September 2001 (Table 5.14). If anything, increasing potassium fertiliser applications reduced plant tissue levels of potassium. The test result shown in Table 5.14 was taken before fruit harvesting commenced in earnest, by which time, potassium levels for foliage growth may have been adequate, even where it had not been applied.

Plants in the 0 and 50 + 175 kg/ha K treatments were visibly affected by the low potassium rates before the leaf sample was taken. However the symptoms were not typical of K deficiency, beginning with the yellowing of young developing leaves. The main veins remained green as the interveinal regions gradually lightened to a very pale yellow. There was no necrosis.

While sap and leaf analyses of NPK did not explain the leaf symptoms, analysis of micro-nutrients indicated that the deficiency was most likely manganese. Leaves from the full rate of K, 100 + 350 contained almost 10 times as much Mn as the lower potassium treatments (Table 5.14). A foliar application of micro-nutrients including manganese was applied to the trial on two occasions, but this did not relieve the symptoms. After the conclusion of the trial, the leaves appeared to recover from the deficiency when the rate of potassium fertiliser applied to the 0 and 50 + 175 kg/ha K treatments was increased to that of the 100 + 350 kg/ha rate.

The explanation for this may be that manganese was made more available in the alkaline soil by the local acidifying effect of potassium sulphate. In those treatments where no potassium sulphate or low levels were applied, manganese deficiency expressed itself.

Table 5.14 Effect of potassium fertiliser on leaf nutrients cv. Kiewa

K rate	N	P	K	Na	Ca	Mg	S	B	Cu	Fe	Mn	Zn
(kg/ha)	%db	%db	%db	%db	%db	%db	%db	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
0	3.42	0.59	2.13	0.01	1.32	0.57	0.22	53	4.3	150	33	20
50 + 175	3.29	0.53	2.11	< 0.01	1.39	0.56	.21	46	4.7	210	45	15
100 + 350	3.61	0.69	2.03	0.01	1.4	0.55	0.24	46	4.6	210	370	21

Induced manganese deficiency symptoms in low K plot, Medina, October 2001 (note leaf yellowing).

Low rates of K fertiliser resulted in lower sap nitrate concentrations (Figure 5.12). The sap NO_3 concentration of the 0 and 50 + 175 kg/ha K treatments were suppressed compared to the 100 + 350 kg/ha rate, particularly in early November, despite the treatments receiving the same nitrogen fertiliser program. It may have been that the apparent manganese deficiency in these plants inhibited nitrate uptake.

Potassium fertiliser did not affect phosphate concentrations in the sap (Figure 5.13).

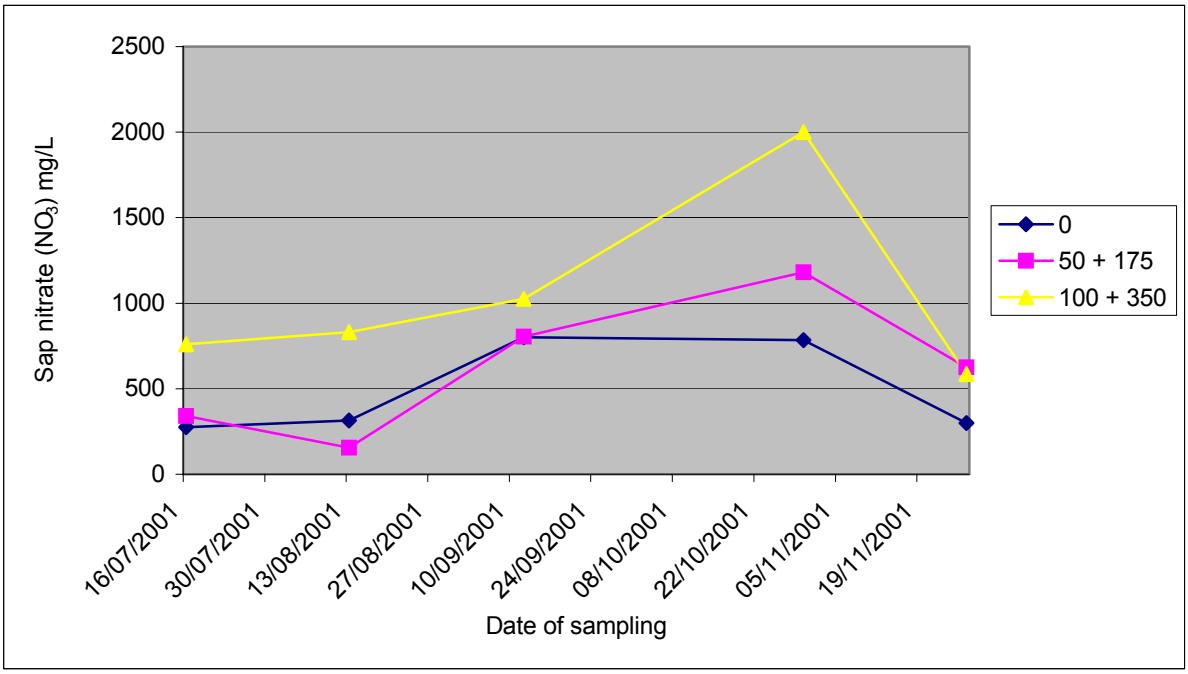

Figure 5.12 Effect of potassium fertiliser on sap nitrate (NO_3) cv. Kiewa.

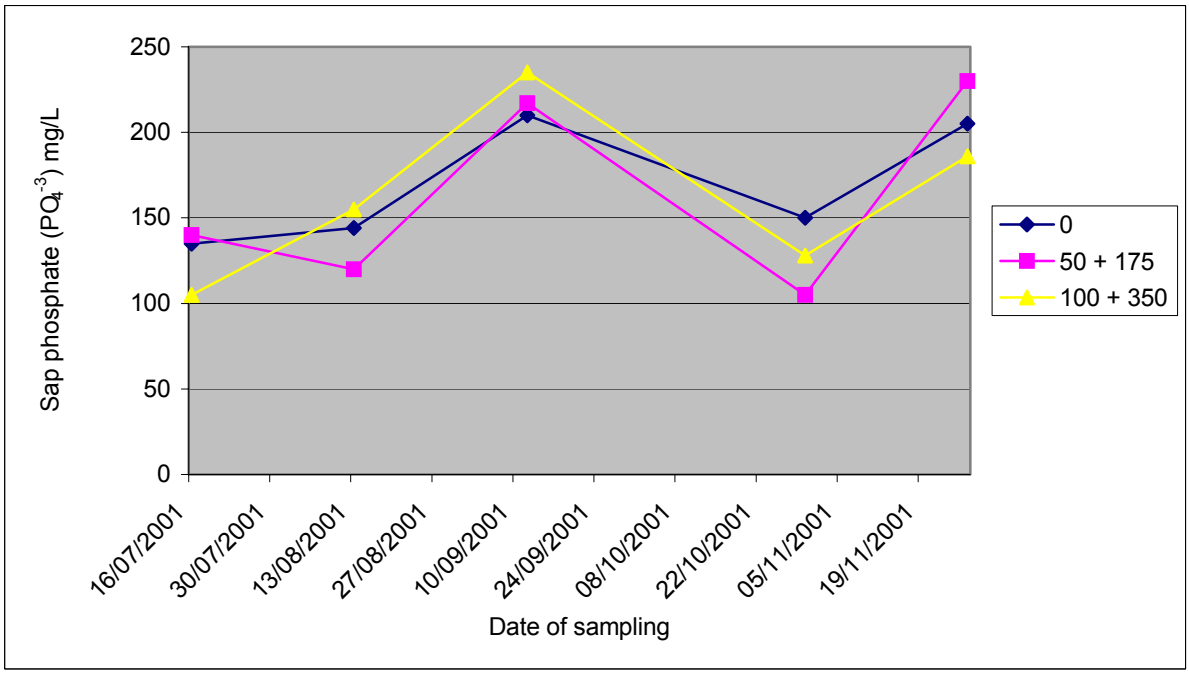

Figure 5.13 Effect of potassium fertiliser on sap phosphate (PO_4^{-3}) cv. Kiewa.

Fruit quality

Nitrogen trial

Nitrogen fertiliser affected the sugar content of fruit. (Figure 5.14). Generally as the rate of total N applied increased, the % Brix dropped. This was more evident at the end of the season. Fruit from the fowl manure + 450 treated plots consistently had the lowest % Brix. Mid season the difference between fowl manure and the other treatments ranged from 1.5 to 3% Brix. The 150 + 150 kg/ha N treatment produced the sweetest fruit. The relationship between nitrogen fertiliser and fruit sugar may be linked to differences in crop load between treatments. There was no apparent trend between nitrogen fertiliser and acid levels.

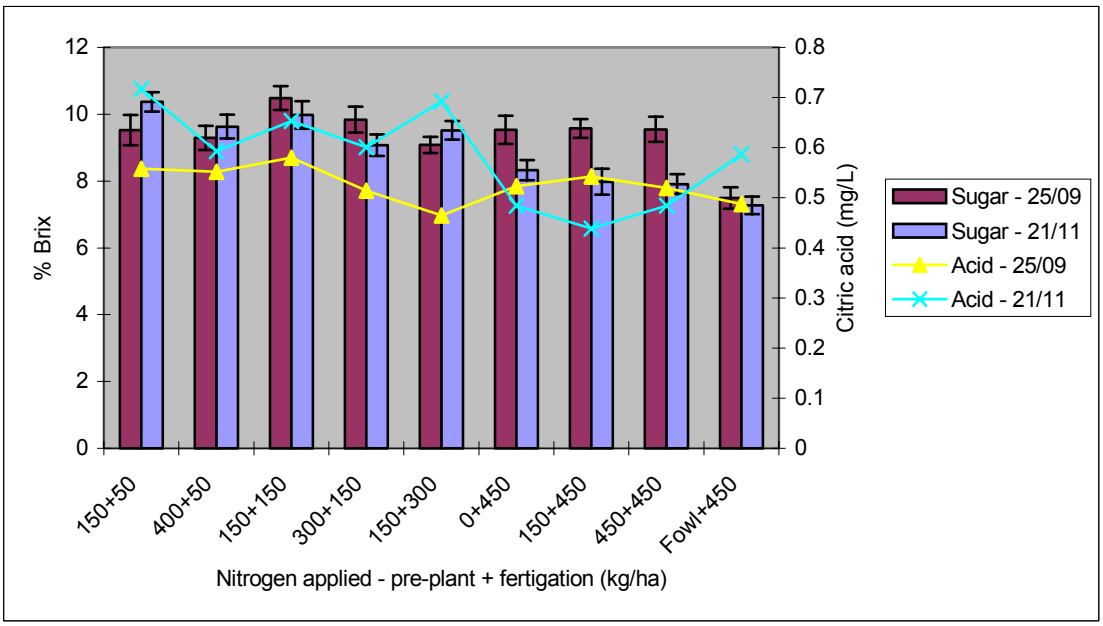

Figure 5.14 Effect of nitrogen fertiliser on fruit sugar and acid levels.

Phosphorus trial

The rate of phosphorus applied influenced the sugar levels of berries mid season (Figure 5.15). As the phosphorus rate increased from 0 to 150 kg/ha the % Brix increased by 1.5. The application of no phosphorus fertiliser increased the concentration of citric acid in fruit. This combination of lower sugar and higher acid would greatly reduce the eating quality of berries from this treatment compared to the 150 kg/ha P treatment.

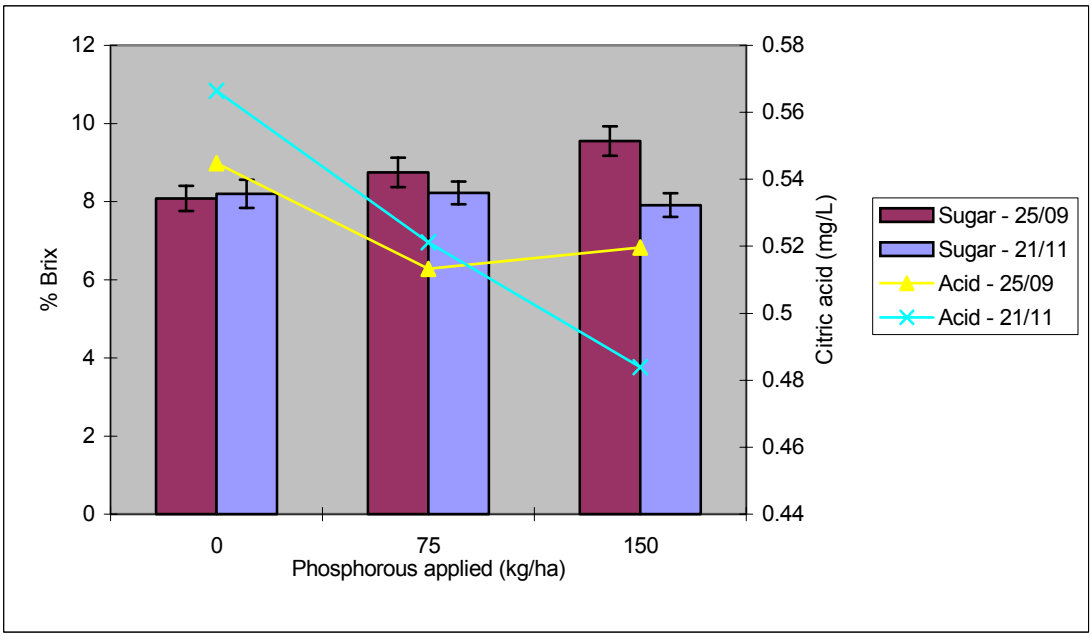

Figure 5.15 Effect of phosphorus fertiliser on fruit sugar and acid levels.

Potassium trial

Under the heavy crop load at the end of September, increased rates of potassium fertiliser tended to result in higher sugar levels whilst citric acid levels were not influenced by potassium rate (Figure 5.16.). At the end of the season, the sugar levels dropped and no relationship between potassium fertiliser and % Brix or acid levels was evident.

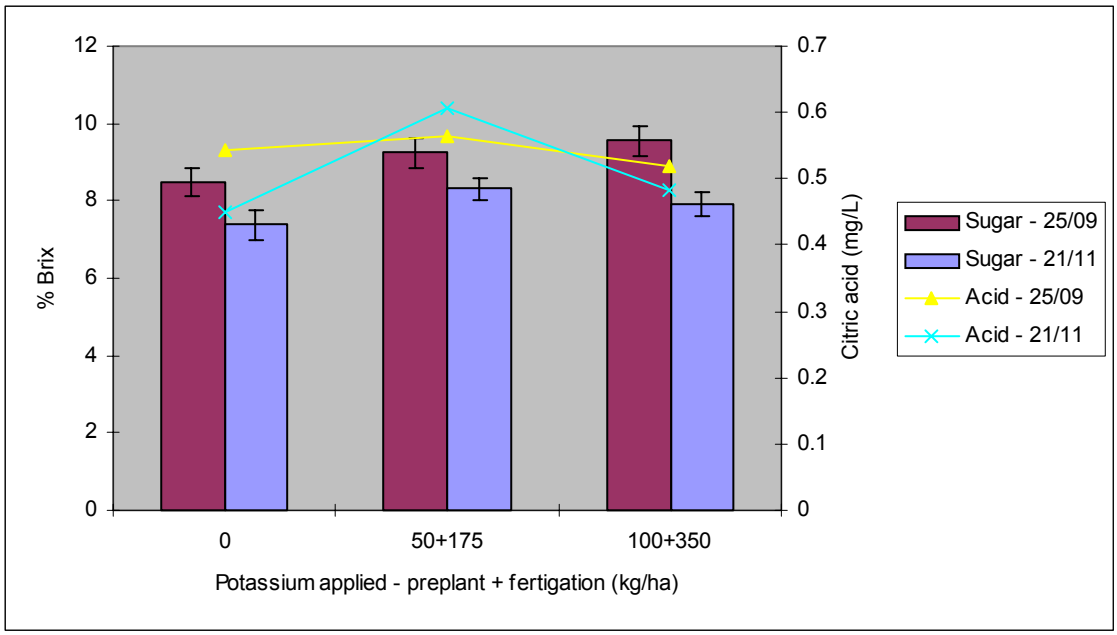

Figure 5.16 Effect of potassium fertiliser on fruit sugar and acid levels.

Nitrate leaching

Lysimeters were used to collect water that had leached below the root zone of all trial plots in one of the four replicates. The concentration of NO_3 in the leachate was used to estimate the loss of nitrogen from each treatment regime. These results need to be interpreted with caution because they were not replicated, however they do show that nitrogen readily leached below all treatments on these sandy soils.

Increased total nitrogen application generally resulted in higher levels of nitrogen leached (Figure 5.17.). For example, the fowl manure treatment received over 1200 kg/ha of nitrogen of which 550 kg/ha was estimated to have been leached. Despite the heavy loss of nitrogen from the fowl manure treatment, it was not the most inefficient. The percentage of nitrogen fertiliser remaining in the root zone ranged from just 19% (0 + 450) to over 70% (300 + 150) but typically around 50% of the total nitrogen applied could not be recovered in the leachate.

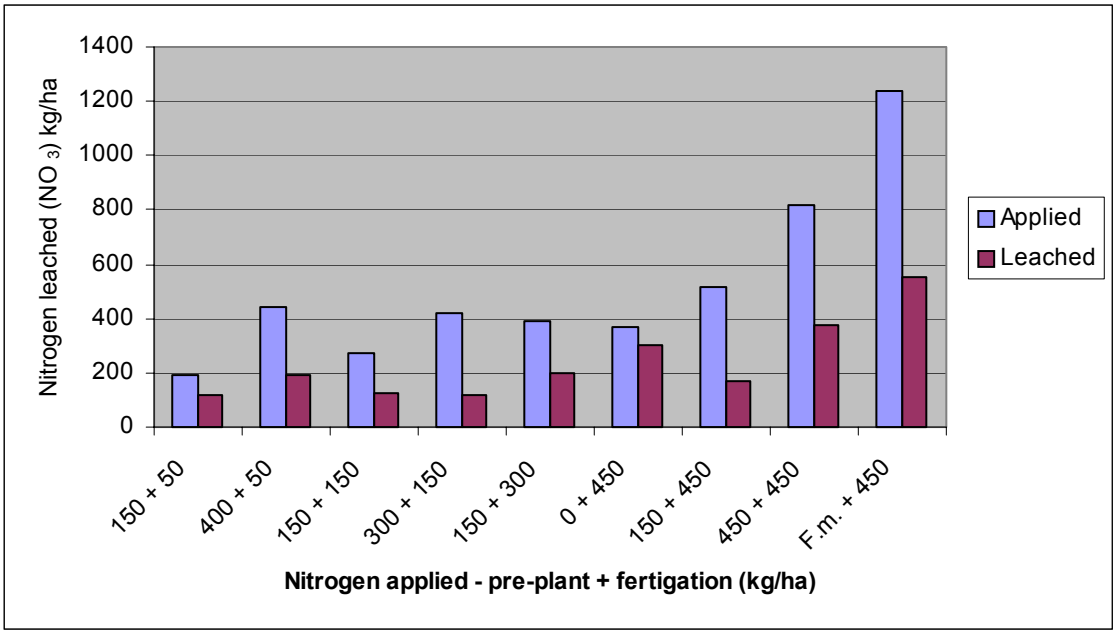

Figure 5.17 Comparison of total nitrogen applied to nitrogen leached.

Year 2

Both treatments retained for an autumn crop produced large marketable fruit, but most of that fruit was badly damaged by an uncontrollable infestation of plague thrips. This was despite covering all the plots with low plastic cloches for rain protection in mid May. The exercise proved that Kiewa would produce a 'ratoon crop' in the autumn, but the survival of plants over summer was dependent on high foliage vigour being retained to shade black plastic mulch from sunlight. It was considered that high soil temperatures resulting from exposed black plastic in the low nitrogen treatments was the cause of most of the summer plant death in these treatments.

Second year Kiewa plot at Medina, May 2002.

5.1.5 Discussion

Kiewa proved to be sensitive to nitrogen fertiliser with progressive increases in yield being achieved with increasing rates up to 450 kg/ha (N). There was no measurable yield benefit from applying nitrogen to these sandy soils before planting, but there was a trend to increased sap nitrate levels in comparable treatments where pre planting applications had been made. However, the practice could not be recommended because most of the fertiliser applied was wasted and had the potential to leach into groundwater.

Fertigation by contrast was a relatively effective method of applying nitrogen fertiliser. Fertigation with mineral fertilisers alone could not be shown to produce the same yields as fertigation plus fowl manure application. The differences in yield were small at the 450 kg/ha nitrogen rate but the potential waste of nutrients from the pre planting fowl manure was too large to justify on environmental grounds. The reason for the difference between mineral fertiliser alone and mineral fertiliser plus fowl manure may be the extra nitrogen supplied by fowl manure, other nutrients in fowl manure, physical factors, or all three.

On the basis of the results achieved from these trials, the following interim recommendation for producing good yields of high quality Kiewa on these soils can be made (Table 5.15).

5.1.6 Recommendations

Table 5.15 Interim fertiliser recommendation for Kiewa

Pre-plant	Rate
Phosphorus	150 kg/ha
Potassium	100 kg/ha
Fowl manure*	50 m^3
During crop growth	
Nitrogen	450 kg/ha
Potassium	350 kg/ha

* Subject to health regulations on use of animal manures on food crops.

5.2 2002 TRIAL MEDINA RESEARCH STATION

Dennis Phillips

5.2.1 Summary

The aim of this work was to develop an understanding of the fertiliser requirements of the new strawberry variety Kiewa (*Fragaria* x *ananassa*). In 2002, an experiment was conducted at the Department of Agriculture's Medina Research Station to compare seven rates of fertigated nitrogen and a control treatment of nitrogen plus pre planting fowl manure. The range of fertigated nitrogen treatments extended beyond the maximum rate used in the 2001 trial in an attempt to reach the point of yield maximisation for Kiewa and bridge the yield gap between mineral fertilisers and mineral fertilisers plus fowl manure. The effect of each fertiliser regime was measured in terms of crop production, plant nutrient analysis and fruit quality.

Fertigated mineral nitrogen fertiliser gave a linear increase in marketable yield and berry size proportional to nitrogen rate up to 900 kg/ha (N) for the life of the crop. Yields from a combination of 450 kg/ha (N) fertigated plus 50 cubic metres per hectare fowl manure broadcast before planting exceeded those from the highest rate of mineral nitrogen by a small margin. Eating quality of the fruit declined in direct proportion to the rate of mineral nitrogen applied, and it was at its worst where fowl manure and mineral nitrogen were applied together. Fruit brix level also declined in proportion to the decline in flavour of the fruit with increasing nitrogen rate.

Sap nitrate levels increased with increasing rate of fertigated nitrogen. On the basis of the yield data, the suggested range for sap NO_3 that would maximise yield was confirmed at 1500-2000 mg/L (NO_3) during fruit picking from September to November.

5.2.2 Introduction

The results of the field trial with Kiewa from 2001 left a number of unanswered questions, including :

- What is the yield maximising rate of fertigated nitrogen on these sandy soils?
- Will fertigated mineral fertilisers fully substitute for the pre planting fowl manure dressing if the rate is high enough?
- What is the effect of increasing nitrogen rates on fruit flavour and other quality characteristics?
- Is there a compromise rate of fertigated nitrogen that will give acceptable fruit yields without compromising flavour and quality too much?
- Is there a compromise rate of fertigated nitrogen that will give acceptable fruit yields without excessive nitrate leaching and consequent damage to shallow groundwater?

In 2002, we set out to answer some of these questions by extending the maximum rate of fertigated nitrogen applied to 900 kg/ha (N). We measured fruit yield, as well as nitrate leaching below the root system of the crop and evaluated fruit flavour in formal and informal taste panel tests.

5.2.3 Materials and methods

Strawberry plants (*Fragaria annanasa*, cv. Kiewa) were planted at the Medina Research Centre on 8 May 2002. The source of the 'bare root' runners was a commercial runner producer in Tasmania (Tasmanian Highland Runner Growers) as was the case in 2001. The runners were grown from non-virus indexed mother plants for reasons already described, but they were essentially 'virus free' from field observation. Runners were graded before planting to remove those smaller than 10mm crown diameter and larger than 40 mm.

Beds, 10 cm high were formed 1.2 m wide and covered by polyethylene (50 μm) mulch, with a distance of 70 cm between beds (picking pathways). Plants were set 30 cm apart within four staggered rows spaced 30 cm from each other. The total length of each plot was 5.4 m, with unplanted buffer areas between consecutive plots, down the row of 1 m. Each plot consisted of 24 harvest plants and 48 buffer plants. The buffers were used later in the life of the crop to supply fruit for sensory evaluation tests at Curtin University. All buffers received the same fertiliser treatment as the 24 plants used for continuous yield assessment.

The effective plant population of the trial plot (including pathways) was 70,175 plants per hectare, but for the purpose of interpreting graphs and tables in this report, one hectare of plastic at the 30 cm x 30 cm spacing would accommodate 111,111 plants. Rates of fertigation per hectare in the report are the quantities that would be applied to 111,111 plants.

Following crop establishment with overhead irrigation, water was applied through a drip irrigation system (Netafim Streamline 80®) with a flow rate of 0.98 l/hr. Two laterals per bed were installed below ground with emitters spaced every 25 cm. Irrigation was applied twice daily at 8 a.m. and 2 p.m., based on a percentage of the monthly average of the daily evaporation as set out below (Table 5.16.) calculated from long-term (26 years) evaporation pan (Epan) data collected at the Meteorology unit at the Medina Research Centre from an Australian 'Class A' pan evaporimeter. Overhead irrigation was used to cool the trial area when temperatures exceeded 25°C.

Each of the eight treatments (all four replicates) was irrigated by its own solenoid valve with a water meter (accuracy ± 2%) to record water use. The aim was to monitor the flow from each valve and adjust the duration of each irrigation block as required, so that each treatment received the same amount of irrigation. The duration of irrigation events was adjusted at 14 day intervals to achieve the target schedule shown in Table 5.16, over the life of the crop.

Table 5.16 Long term pan evaporation for Medina and irrigation schedule (including and excluding rainfall) for the duration of the 2002 experiment

Irrigation schedule	May	June	July	August		September		October		November		December	
				1st ½	2nd ½	1st ½	2nd ½	1st ½	2nd ½	1st ½	2nd ½	1st ½	2nd ½
Epan mm daily	2.6	1.7	1.7	2.2	2.6	3.0	4.0	4.4	5.0	6.1	7.0	7.6	9.0
Target % applied	100	50	50	60	60	70	70	80	80	90	90	100	100
Actual % applied with rainfall	140	85	85	100	65	80	110	96	110	80	51	52	
Actual % applied without rainfall	140	85	85	100	65	75	60	75	74	61	51	52	
Actual minutes applied daily (am and pm)	15 x 2	9 x 2	9 x 2	12 x 2	9 x 2	11 x 2	11 x 2	12 x 2	14 x 2	17 x 2	19 x 2	20 x 2	

Treatments

Before planting a fertiliser blend of Superphosphate® (2000 kg/ha), Hi Trace® (100 kg/ha) and K-Mag® (550 kg/ha) was broadcast and incorporated seven days before bed formation and planting (Table 5.17). Deep litter fowl manure at a rate of 50 cubic meters per hectare was broadcast and incorporated into the soil in the control treatment (T8) on 19 April 2002.

Fertigation was carried out during the trial with each irrigation event. Potassium sulphate, ammonium nitrate, calcium nitrate and magnesium nitrate were used to create two nutrient solutions for morning and afternoon application. While the amount of nitrogen differed for each treatment, the fertigation season target for potassium was 350 kg/ha (K) and 25 kg/ha for Ca and Mg. Fertilisers were dissolved in two buckets of water and one bucket of each was injected into the irrigation stream during the irrigation cycle.

Fertiliser injection was done using an automatic injection pump (Acromet®) coupled into the water supply line. The length of time over which fertiliser was injected was controlled by an electronic irrigation controller. The duration of an irrigation event was at least two minutes greater than the fertiliser injection time to allow drip lines to fill and be flushed before and after fertilisers. The fertigation time remained constant throughout the trial period but the total irrigation time increased according to the schedule shown in Table 5.16.

Ammonium nitrate and potassium sulphate were dissolved in one of the two buckets and applied in the morning irrigation cycle and magnesium and calcium nitrate were applied from the second bucket in the afternoon.

The target fertiliser schedules (kg/ha) for each of the eight treatments are shown in Table 5.18 and the actual fertigation schedule used to deliver it month by month (per 10,000 plants equivalent) is shown in Table 5.19.

Table 5.17 Pre-plant broadcast fertiliser applied to all treatments (kg/ha)

N	P	K	S	Ca	Mg	Zn	Mn	Cu	B	Fe	Mo	Co
0	180	100	341	410	72	9	10	2	1.2	0.5	0.01	0.005

Table 5.18 Fertiliser rates applied to each of the eight nitrogen treatments (kg/ha)

Treatments	Pre-plant (NPK)	Fertigation (NPK)
T1	0:180:100	50:0:350
T2	0:180:100	150:0:350
T3	0:180:100	300:0:350
T4	0:180:100	450:0:350
T5	0:180:100	600:0:350
T6	0:180:100	750:0:350
T7	0:180:100	900:0:350
T8	FM @ 50 m^3	450:0:350
T8	0:180:100	

Table 5.19 Daily fertigation schedules used to supply each of the eight nitrogen treatments (grams per 10,000 plants equivalent)

Month	Fertiliser	Treatment in trial							
		1	2	3	4	5	6	7	8
May	Calcium nitrate	54.4	54.4	54.4	54.4	54.4	54.4	54.4	54.4
	Magnesium nitrate	114.6	114.6	114.6	114.6	114.6	114.6	114.6	114.6
	Ammonium nitrate	2.3	129.6	320.6	511.6	703.7	893.5	1085.6	511.6
	Potassium sulphate	365.7	365.7	365.7	365.7	365.7	365.7	365.7	365.7
June	Calcium nitrate	49.8	49.8	49.8	49.8	49.8	49.8	49.8	49.8
	Magnesium nitrate	105.3	105.3	105.3	105.3	105.3	105.3	105.3	105.3
	Ammonium nitrate	2.3	119.2	296.3	472.2	649.3	825.2	1002.3	472.2
	Potassium sulphate	338.0	338.0	338.0	338.0	338.0	338.0	338.0	338.0
July	Calcium nitrate	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3
	Magnesium nitrate	96.1	96.1	96.1	96.1	96.1	96.1	96.1	96.1
	Ammonium nitrate	1.2	108.8	272.0	432.9	594.9	756.9	919.0	432.9
	Potassium sulphate	309.0	309.0	309.0	309.0	309.0	309.0	309.0	309.0
August	Calcium nitrate	54.4	54.4	54.4	54.4	54.4	54.4	54.4	54.4
	Magnesium nitrate	114.6	114.6	114.6	114.6	114.6	114.6	114.6	114.6
	Ammonium nitrate	2.3	129.6	320.6	511.6	703.7	893.5	1085.6	511.6
	Potassium sulphate	365.7	365.7	365.7	365.7	365.7	365.7	365.7	365.7
September	Calcium nitrate	54.4	54.4	54.4	54.4	54.4	54.4	54.4	54.4
	Magnesium nitrate	114.6	114.6	114.6	114.6	114.6	114.6	114.6	114.6
	Ammonium nitrate	2.3	129.6	320.6	511.6	703.7	893.5	1085.6	511.6
	Potassium sulphate	365.7	365.7	365.7	365.7	365.7	365.7	365.7	365.7
October	Calcium nitrate	57.9	57.9	57.9	57.9	57.9	57.9	57.9	57.9
	Magnesium nitrate	122.7	122.7	122.7	122.7	122.7	122.7	122.7	122.7
	Ammonium nitrate	2.3	138.9	346.1	550.9	756.9	963.0	1169.0	550.9
	Potassium sulphate	393.5	393.5	393.5	393.5	393.5	393.5	393.5	393.5
November	Calcium nitrate	57.9	57.9	57.9	57.9	57.9	57.9	57.9	57.9
	Magnesium nitrate	122.7	122.7	122.7	122.7	122.7	122.7	122.7	122.7
	Ammonium nitrate	2.3	138.9	346.1	550.9	756.9	963.0	1169.0	550.9
	Potassium sulphate	393.5	393.5	393.5	393.5	393.5	393.5	393.5	393.5

Data recording

Fruit were picked and graded twice a week to determine yields and average fruit size for each treatment from 24 plants per plot. Small berries (< 10 g) and inferior fruit were discarded. The harvest period was from 6 August until 28 November 2002.

Petiole sap samples of the youngest fully expanded leaf from buffer plants in each treatment were analysed for NO_3-N, PO_4 and K content during the trial. Sap was extracted from petioles and tested using a Merck RQFlex reflectometer with Merck Reflectoquant® Nitrate (NO_3^-), Phosphate (PO_4^{3-}) and Potassium (K^+) strips. Sampling was undertaken at monthly intervals during the harvest period.

Drainage lysimeters with surface dimensions of 40 cm x 40 cm were dug into the soil below each of the eight treatments (40 cm) in one replicate of the trial before planting. They were pumped weekly for the duration of the trial to estimate water and nutrient losses from leaching. Nitrate levels were measured using Merckoquant® test strips together with an RQflex® digital meter.

To monitor water use, two low-tension tensiometers, equipped with pressure transducers, were installed in four plots in Treatments 1, 4, 7 and 8. These recorded centibars of suction at 15 and 30 cm depth and were recorded at 15 minute intervals by a Unidata 8-channel logger. The results of this continuous soil moisture monitoring were plotted onto a chart record for interpretation of the effects of the irrigation schedule on soil wetness.

Fruit quality was measured in terms of Total Soluble Solids (% Brix) and citric acid content on a weekly basis from the commencement of harvesting in August. Twenty randomly selected berries of even maturity from each plot were bulked together and pressed in a plastic bag to extract a composite sample of juice. The fruit was picked from the 'buffer area' of each treatment (48 plants per plot) so as not to interfere with yield assessments from the harvest plots. Uniformly mixed samples of seived and settled juice from each plot were measured for total soluble solids using a hand-held refractometer (Atago®). The results were averaged for each treatment. A sample of the juice was then passed through a sieve to remove seeds and pulp and stood for 20 minutes to allow suspended solids to settle. The titratable acidity (TA) was measured by titration of 10 mL of juice with 0.1 N (NaOH). From this result, the citric acid content was calculated as TA x 0.64 = grams/litre of citric acid.

Brix testing of individual berries was conducted on two occasions when fruit was submitted to the Curtin University sensory laboratory for consumer evaluation. On these occasions, a longitudinal sliver through each berry submitted for tasting was tested using the refractometer method. Up to 40 individual berries from each plot were tested by this method. On one occasion, fruit tip and calyx brix was compared for individual berries from selected treatments. This was done to check that a composite whole berry sample was a representative method of measuring brix.

5.2.4 Results

Yields

Fruit yields, both total weight and number as well as marketable weight and number were recorded twice per week throughout the harvest period from August to late November. The data was partitioned into yields per month of the picking season and cumulative yield was calculated to the end of each calendar month. The results of this analysis for marketable fruit yield is shown in Table 5.20.

The quantities of fruit harvested to the end of August were relatively small, but an analysis of variance showed that the 300, 600 and 900 N treatments gave higher marketable weight yields than other treatments.

The data became more reliable by the end of September, and a significant ($p <= 0.05$) positive linear trend with increasing nitrogen rate up to the maximum rate (900 N) was observed. This significant trend continued for the October and November data. Attempts to fit quadratic and plateau functions to the data to determine the yield maximising rate for each month proved unsuccessful due to the strong linear relationship.

It could be inferred that the yield maximising rate of nitrogen may have been greater than 900 N. However, analysis of variance of the data showed that this rate did not give statistically significant yield increases over rates of 450 N and above in September or 600 N in October and November. It could thus be inferred that 600 N for the life of the crop is a sufficient rate to maximise marketable yield.

Table 5.20 Cumulative mean marketable fruit weight (grams per plant) for the eight nitrogen treatments. Coloured cells are not significantly different (p < = 0.05) from the highest yielding treatment in each month

Harvest Duration	50 N	150 N	300 N	450 N	600 N	750 N	900 N	450 N + 50 FM
End of August	66.4	78.7	87.0	77.1	89.0	80.0	89.9	66.8
End of September	152.0	191.3	191.7	205.5	225.3	215.4	233.1	180.3
End of October	299.3	370.8	349.5	409.3	439.5	464.4	482.4	417.5
End of November	450.1	535.7	560.5	623.6	690.7	737.9	753.1	719.5

The yield increase at higher rates of nitrogen was not solely caused by increasing berry weight. Total and marketable berry number also increased, while berry weight remained relatively stable for most nitrogen rates. Table 5.21 shows that the range in berry weight from the lowest nitrogen rate to the highest was never more than about 15%. Significant differences were found between the treatments, but they would have been barely visible to the naked eye in most cases, and unlikely to affect marketability of the fruit greatly. Despite this, the largest fruit was consistently produced in all months by the three highest nitrogen rates, including the fowl manure treatment. Table 5.21 shows these significant effects as red cells.

Table 5.21 Cumulative mean marketable berry weight (grams per fruit) for the eight nitrogen treatments. Coloured cells are not significantly different (p < = 0.05) from the highest yielding treatment in each month

Harvest duration	50 N	150 N	300 N	450 N	600 N	750 N	900 N	450 N + 50 FM
End of August	29.2	28.7	29.9	30.8	28.9	30.0	31.0	31.4
End of September	27.0	27.8	28.3	28.8	29.1	30.0	30.3	30.1
End of October	24.2	26.4	25.6	26.6	26.4	27.8	27.6	28.9
End of November	21.7	23.2	22.7	23.4	23.3	24.1	23.8	24.2

High nitrogen treatment (right) compared to low nitrogen treatment (left) Medina, December 2002.

Marketable fruit yields for the nitrogen rates of 450 N and above were comparable throughout the harvest period as discussed earlier, as shown in Figure 5.18. Yields progressively fell behind at the lower N rates as illustrated in Figure 5.18 by the lower yields recorded for the 50 N rate.

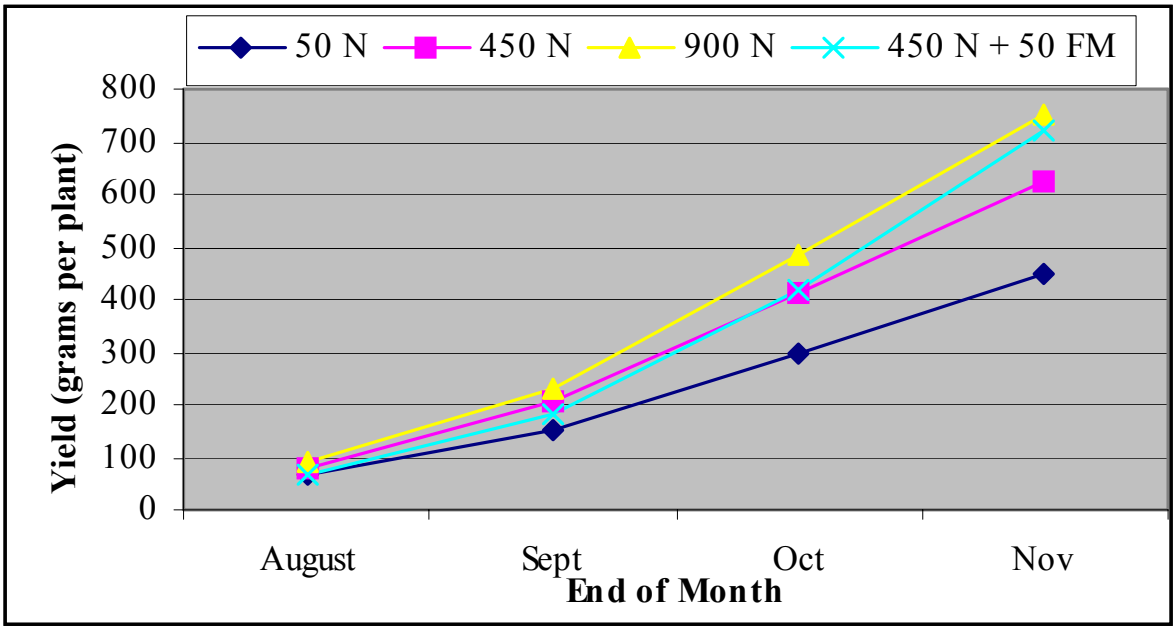

Figure 5.18 Cumulative marketable fruit weight yields for four of the eight nitrogen treatments, spanning the range of rates compared at Medina in 2002.

Another illustration of the progressive response to nitrogen with increasing rate of nitrogen is shown in Figure 5.19 for total and marketable fruit weight to the end of the harvest period in late November. Despite the apparent linear trend with increasing nitrogen rate, statistically no difference in yield could be demonstrated above the 600 N rate.

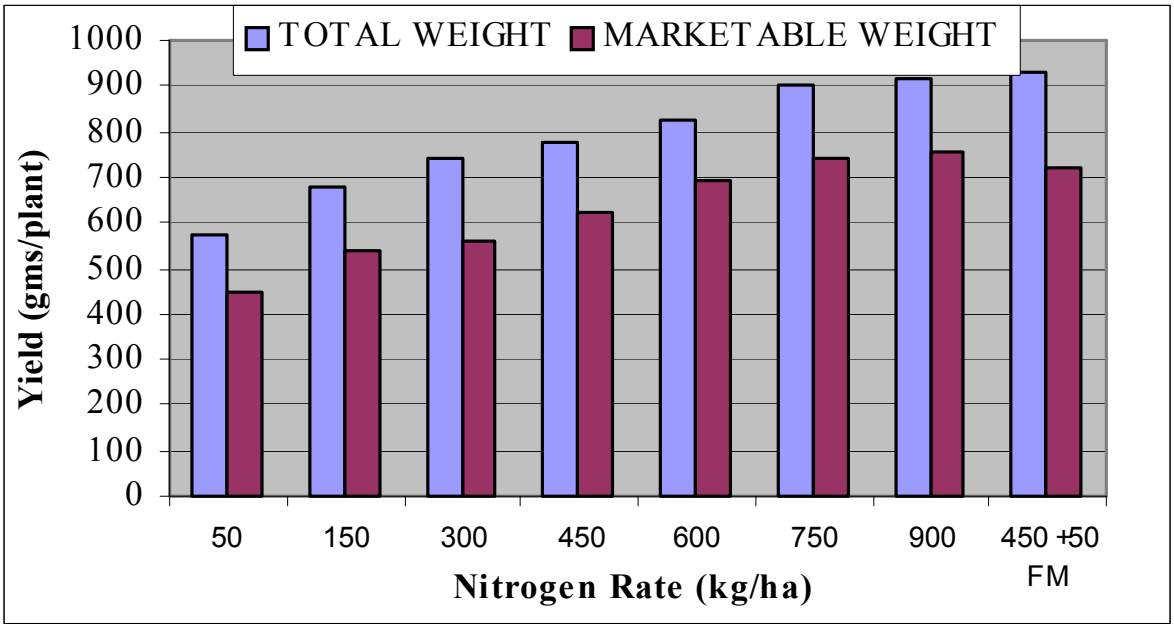

Figure 5.19 Cumulative total and marketable weight yield of fruit to the end of November for the eight nitrogen fertiliser treatments compared at Medina in 2002.

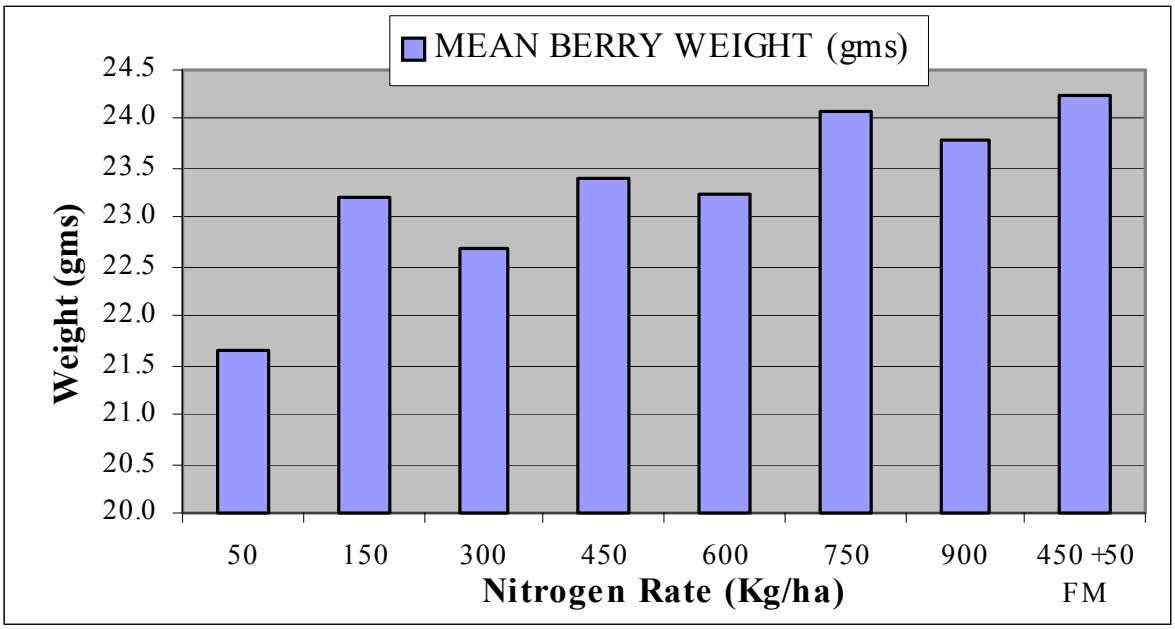

Figure 5.20 Cumulative mean individual berry weight of fruit to the end of November for the eight nitrogen fertiliser treatments compared at Medina in 2002.

Figure 5.20 shows the relatively small effect of nitrogen rate on mean fruit size to the end of November. Only the lowest nitrogen rate (50 N) produced fruit that were visually smaller than the other treatments.

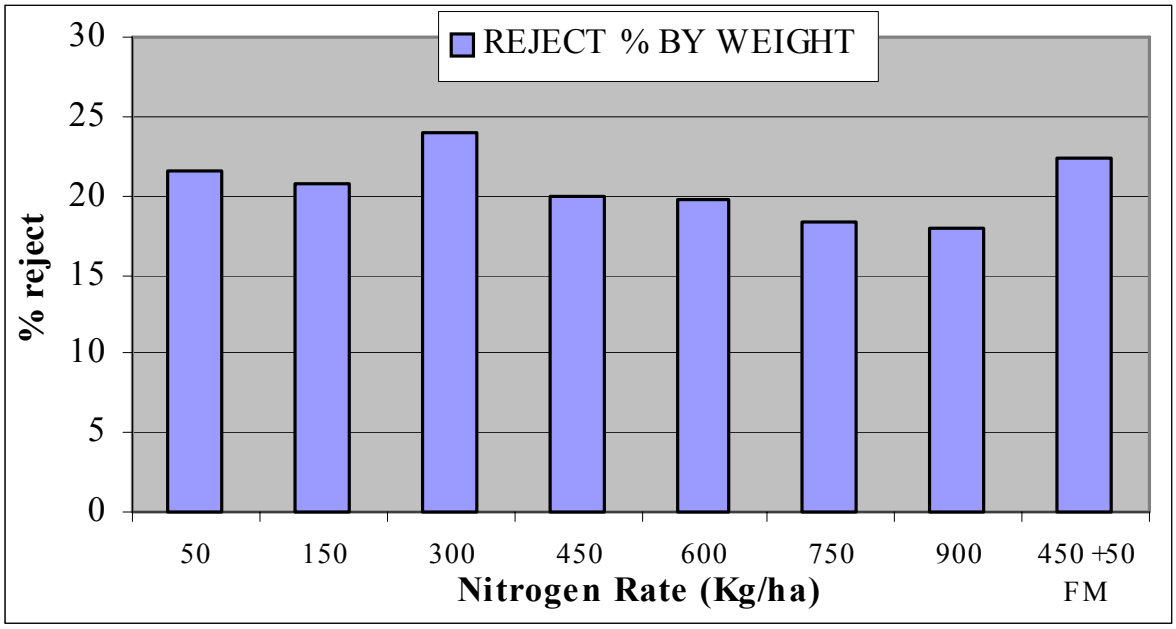

Figure 5.21 Cumulative reject percentage of fruit by weight to the end of November for the eight nitrogen fertiliser treatments compared at Medina in 2002.

The percentage of reject fruit recorded for the life of the crop was relatively high around 20%. The higher nitrogen treatments tended to have lower percentages of reject by weight as shown in Figure 5.21, except for the treatment which included fowl manure where the total weight of reject fruit was the second highest of any treatment and rejection rates were high.

Much of the reject fruit in October was from fungal disease, *Botrytis* and *Phytophthora cactorum*, but later it was misshapen or poorly set fruit and small fruit. Treatments which produced high foliage vigour such as the fowl manure treatment recorded higher levels of loss from *botrytis.*

Irrigation

A subsidiary aim of this study was to test and monitor the effects of an irrigation schedule derived from past research at Medina for other commercial varieties, such as Camarosa, on Kiewa. The results of continuous monitoring of irrigation levels applied, rainfall and evaporation is reported here together with the results of soil moisture monitoring.

The scheduled irrigation method based on long term pan evaporation and crop factors as shown in Table 5.21 was largely successful, but in some weeks, the actual evaporation replacement levels deviated sharply from the planned levels. For some of the period, a shortfall in irrigation water applied was probably made up by rainfall in late October and early November (Table 5.22). The consequences of this were not serious for any treatments until mid November when the 900 kg/ha rate treatment began to show water stress in the replicate that was monitored.

The reasons for the actual irrigation application drifting from the planned schedule could not be determined, but Table 5.23 shows that there was generally good conformity between the long term evaporation data used to schedule irrigation and actual evaporation when taken over a seven day period.

The trends in Table 5.21 show that there was a general trend to ‘over irrigate’ all plots compared to the planned schedule in August. In September and October, the schedule was mostly met except for a moderate degree of under-watering in the last two weeks of September and the first week of October. Soil moisture monitoring showed that none of these events resulted in water stress to the plants.

Actual irrigation fell significantly below the schedule for all of November until completion of harvest. This was offset to some degree by rainfall in the first week of November, but it did lead to water stress in some plots by late November. The net effect of the irrigation scheduling was that all plots received an average irrigation rate of

between 277 mL and 315 mL per plant per day from early August to early December. On a per hectare basis, this approximated 3900 kL of irrigation for the period.

Table 5.21 Evaporation replacement (crop factor) percentage for the duration of the experiment excluding rainfall

Week from	Treat 1	Treat 2	Treat 3	Treat 4 and 8	Treat 5	Treat 6	Treat 7	Required %	Trend
8 August	105.08	103.26	118.01	94.61	102.16	120.56	110.54	60	Over
to 15 August	105.08	103.26	118.01	94.61	102.16	120.56	110.54	60	Over
22 August	141.04	136.61	158.16	123.01	134.19	135.60	128.55	60	Over
29 August	86.18	98.40	94.00	87.48	83.57	86.98	89.79	60	Over
5 September	67.90	72.90	85.23	64.59	75.04	74.33	75.94	70	OK
12 September	71.31	81.27	89.27	68.64	78.78	78.25	79.14	70	OK
19 September	55.18	61.89	69.20	52.87	60.70	61.14	61.14	70	Under
26 September	49.74	56.08	64.03	49.20	58.37	55.81	68.88	70	Under
3 October	46.81	47.84	56.46	44.14	50.20	49.17	47.94	80	Under
10 October	72.50	71.34	85.05	65.94	74.01	73.55	75.18	80	OK
17 October	75.88	75.51	84.60	71.59	81.06	77.02	78.16	80	OK
24 October	75.40	74.21	80.28	75.88	86.48	76.95	78.38	80	OK
31 October	68.82	68.49	74.33	69.76	79.28	60.23	71.68	80	OK
7 November	59.50	58.64	64.28	60.41	68.68	61.60	62.56	90	Under
14 November	59.24	58.24	63.16	59.28	67.83	62.24	60.74	90	Under
21 November	47.61	48.67	48.67	48.90	54.83	49.93	48.81	90	Under
28 November	51.63	52.81	52.74	53.05	59.03	54.74	53.02	90	Under
5 December	49.99	51.53	51.13	51.53	57.29	53.74	52.00	100	Under

Figure 5.22 Evaporation replacement (crop factor) percentage for the duration of the experiment, including rainfall

Week from	Treat 1	Treat 2	Treat 3	Treat 4 and 8	Treat 5	Treat 6	Treat 7	Required %	Trend
to 8 August									
15 August	339.69	337.87	352.62	329.22	336.78	355.17	345.16	60	Over
22 August	141.04	136.61	158.16	123.01	134.19	135.60	128.55	60	Over
29 August	143.32	155.55	151.14	144.62	140.72	144.12	146.93	60	Over
5 September	204.69	209.69	222.02	201.38	211.84	211.12	212.73	60	Over
12 September	74.60	84.56	92.56	71.93	82.07	81.53	82.42	70	Over
19 September	106.36	113.07	120.38	104.05	111.88	112.32	112.32	70	Over
26 September	106.68	113.02	120.97	106.14	115.31	112.75	125.82	70	Over
3 October	46.81	47.84	56.46	44.14	50.20	49.17	47.94	70	Under
10 October	143.06	141.89	155.61	136.49	144.57	144.10	145.73	80	Over
17 October	77.22	76.84	85.93	72.92	82.39	78.35	79.49	80	OK
24 October	140.81	139.62	145.69	141.29	151.89	142.36	143.79	80	Over
31 October	82.77	82.44	88.28	83.71	93.23	74.19	85.64	80	OK
7 November	95.86	95.00	100.64	96.77	105.04	97.96	98.92	90	Over
14 November	59.24	58.24	63.16	59.28	67.83	62.24	60.74	90	Under
21 November	47.61	48.67	48.67	48.90	54.83	49.93	48.81	90	Under
28 November	52.36	53.54	53.47	53.78	59.76	55.47	53.75	90	Under
5 December	49.99	51.53	51.13	51.53	57.29	53.74	52.00	100	Under

Table 5.23 Actual evaporation for the trial period compared to the long term average figures used to schedule irrigation

Week from	Actual rainfall	Long term average evaporation	Actual evaporation
8 August			
15 August	48.8	15.4	20.8
22 August	0	18.2	18.8
29 August	10.8	18.2	18.9
5 September	29	21	21.2
12 September	0.7	21	21.3
19 September	13	28	25.4
26 September	16	28	28.1
3 October	0	30.8	36.9
10 October	23	30.8	32.6
17 October	0.4	35	30
24 October	20.8	35	31.8
31 October	4.8	35	34.4
7 November	14.4	42.7	39.6
14 November	0	42.7	45.4
21 November	0	49	57.2
28 November	0.4	49	54.8
5 December	0	53.2	56.6

The consequences of the irrigation schedule on soil moisture levels at 15 cm and 30 cm depth below the crop are shown in Figures 5.22 to 5.25, which are tensiometer traces for selected weeks during the crop cycle.

Figure 5.22 shows a typical soil moisture trace in a week when the actual irrigation approximated the schedule for all treatments at the 15 cm depth. At this depth, a soil moisture tension of between -3 and -5 centibars is considered saturated, and levels up to -10 centibars will not cause water stress to the plants. In the week commencing 18 October, only treatment seven (900 kg/ha) showed any significant drying in the root zone.

The drying effect was more pronounced at 30 cm depth for treatments 1 and 7, but the levels were not considered to be harmful (Figure 5.23).

By the week commencing 15 November, treatments 1, 4 and 8 appeared to be unaffected by a period of under-watering compared to the plan, but treatment 7 showed a marked drying trend early in the week at 15 cm depth (Figure 5.24). This trend progressively reversed after 16 November despite no rain falling. The trend at 30 cm depth mirrored that at 15 cm in this period (Figure 5.25).

It is expected that the plants in treatment 7 ‘shut down’ after the period of irrigation deficiency which commenced on 25 October and the apparent recovery in soil moisture tension was the result of reduced uptake by the plants. The effect was noted to a lesser extent in the other three treatments also. Soon after this event, it was noticeable that this plot ceased flowering and produced little more fruit to the end of the season.

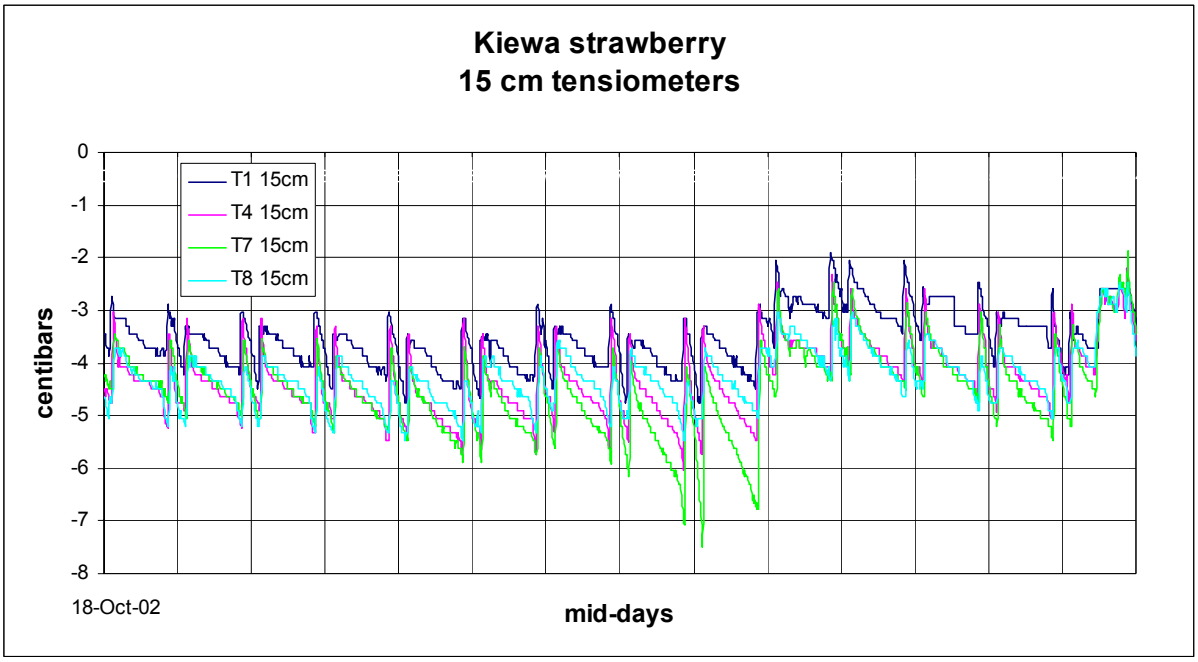

Figure 5.22 Soil moisture tension at 15 cm below four nitrogen treatments as measured by tensiometers in October.

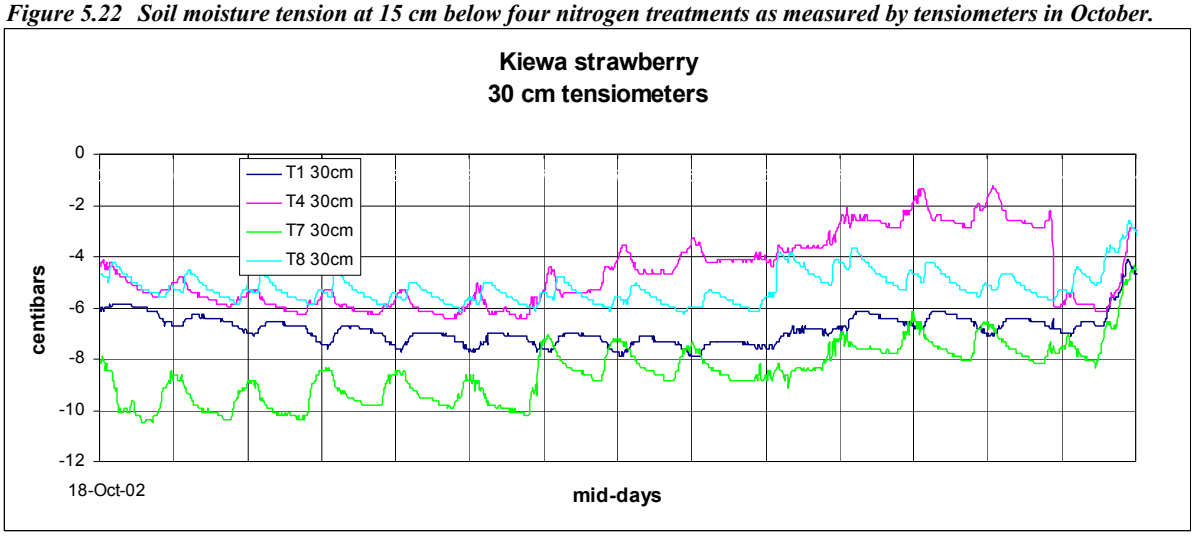

Figure 5.23 Soil moisture tension at 30 cm below four nitrogen treatments as measured by tensiometers in October.

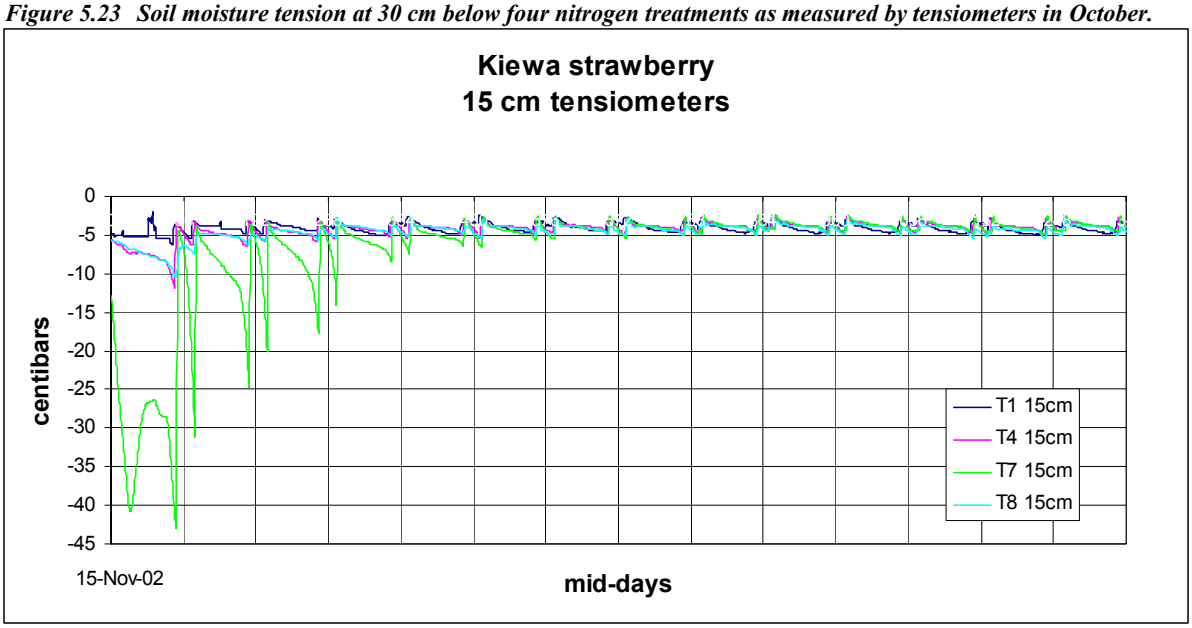

Figure 5.24 Soil moisture tension at 15 cm below four nitrogen treatments as measured by tensiometers in November

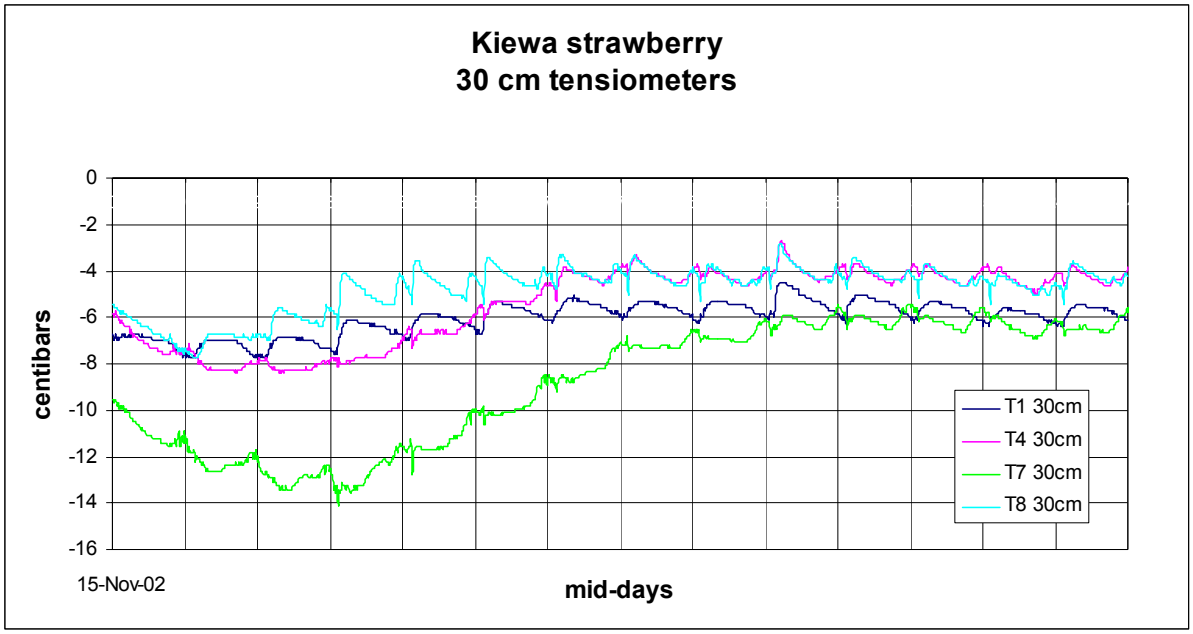

Figure 5.25 Soil moisture tension at 30 cm below four nitrogen treatments as measured by tensiometers in November

Low nitrogen plot showing tensiometer monitoring sites and lysimeter tubes (right) Medina, September 2002

Nitrate leaching

The drainage lysimeters placed under replicate 1 of each of the eight treatments were pumped at regular intervals to determine the level of nutrient leaching. The results of tests for nitrate in the drainage water for four of the treatments is shown in Figure 5.26. Treatment 8 that was 450 kg/ha of fertigated N plus a pre planting application of fowl manure at 50 cubic meters per hectare resulted in by far the highest nitrate concentration in the drainage water below the crop.

The concentration of nitrate was more than four times that of the equivalent treatment which did not include the fowl manure application (T4). The conclusion that could be drawn from this was that most of the nitrate loss below the crop resulted from the fowl manure application.

There was little discernable difference between nitrate concentrations from the 50 kg/ha N rate (T1) and the 450 kg/ha rate (T4). At the highest fertigated rate, 900 kg/ha N (T7), the concentration of nitrate was up to double that found below the two lower fertigated rates (T1 and T4).

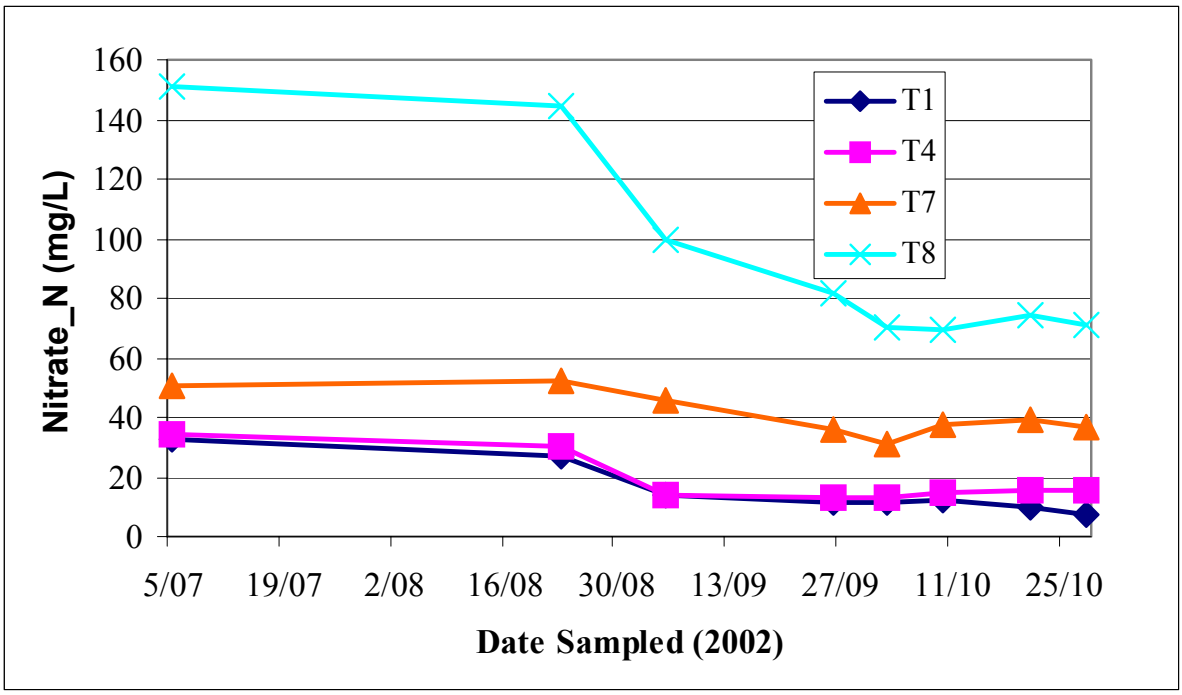

Figure 5.26 Nitrate nitrogen content of drainage water collected below four nitrogen treatments in 2002.

Fruit quality

The surrogate measures of fruit flavour, brix level and citric acid content were measured weekly throughout the life of the crop. The data for the eight treatments is presented in two groups in Figures 5.27 and 5.28, those that were used for sensory testing (5.27), and the remainder (5.28). Figures 5.27 and 5.28 show that the brix content of the fruit declined in direct proportion to the rate of nitrogen applied, and was consistently at its lowest level where nitrogen plus fowl manure had been applied to the crop.

The brix level for any individual treatment was relatively constant throughout the harvest season, but began to decline after mid October, only to rise again through November. It was considered that the falling trend was to be expected with more fruits available to partition sugars amongst, but the rise in November may have been a consequence of management. Tensiometer results presented earlier showed that the crop became water stressed in early November and this caused a dramatic reduction in flowering and fruit production. This may have resulted in rising sugar levels per fruit.

The citric acid content followed a similar trend to brix with lower lower levels recorded as the nitrogen rate increased (Figure 5.29). There was also a seasonal downward trend for all treatments which was reversed in November as described for brix. The reasons for this may have been the same as those hypothesised for brix.

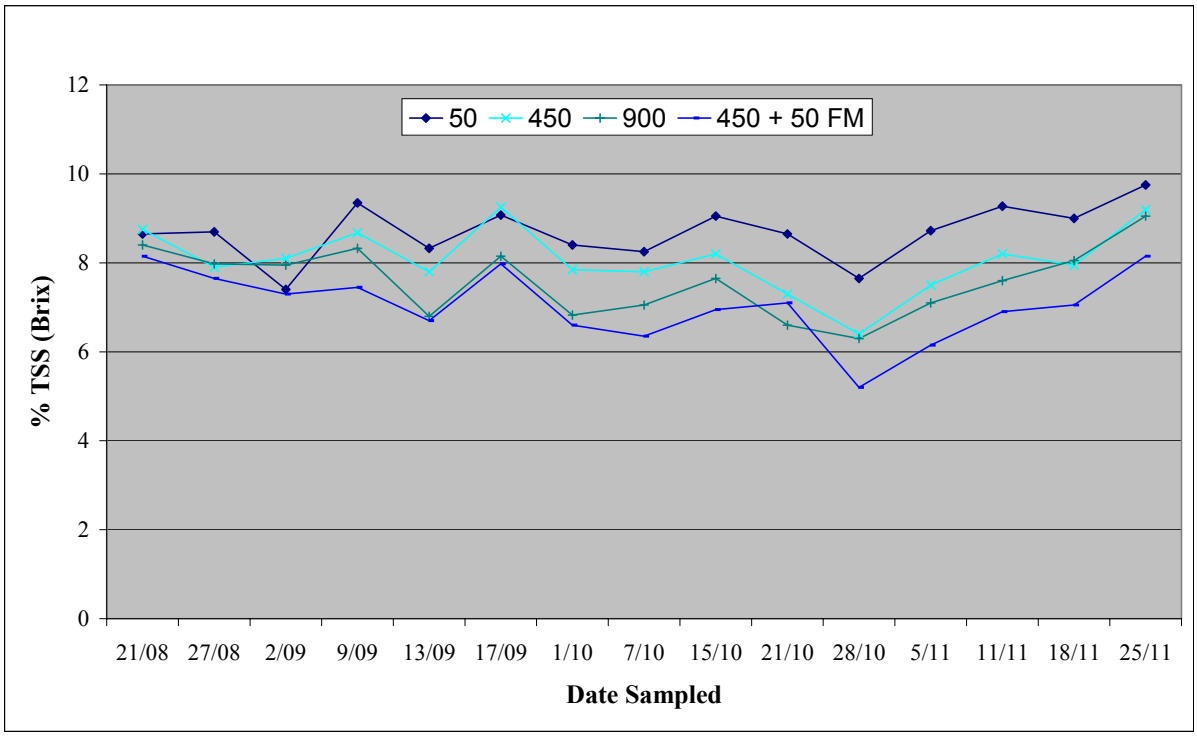

Figure5.27 Total soluble solids (Brix) content of fruit response to the four nitrogen treatments used for sensory testing.

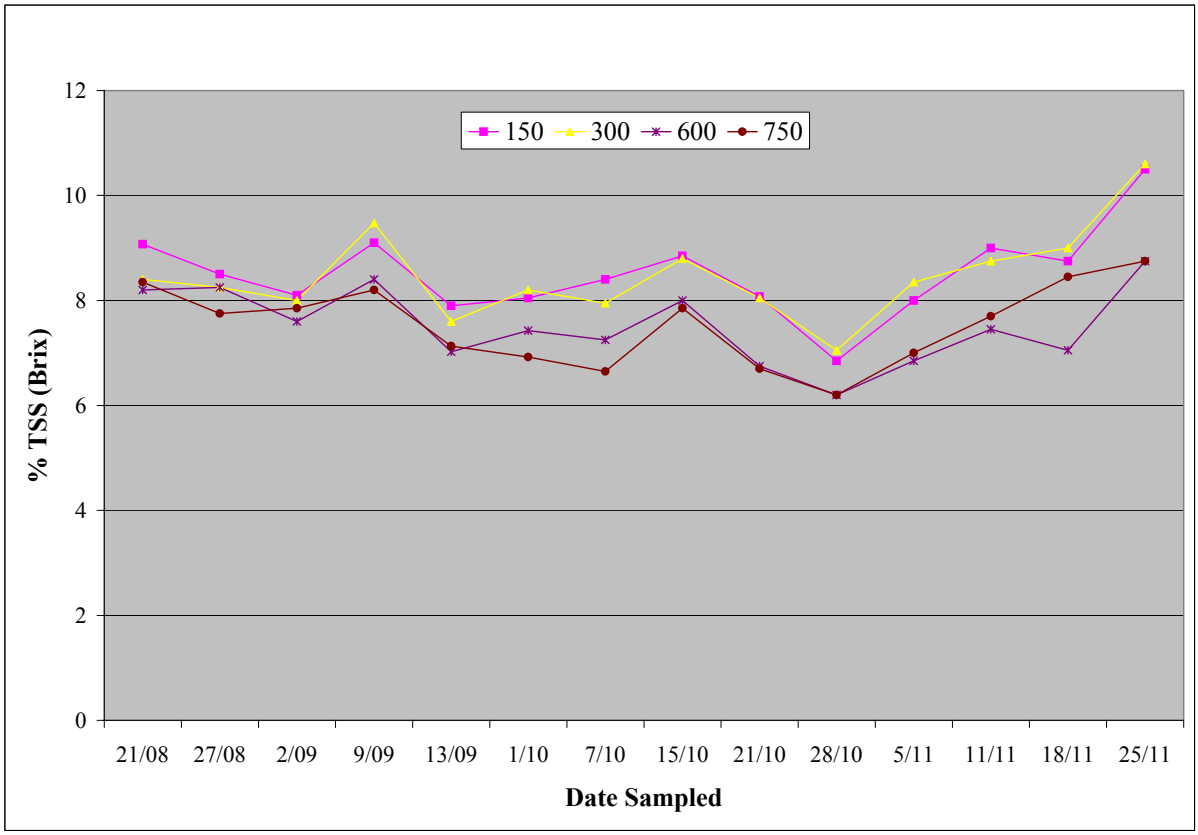

Figure 5.28 Total soluble solids (Brix) content of fruit response to the four nitrogen treatments which were not used for sensory testing.

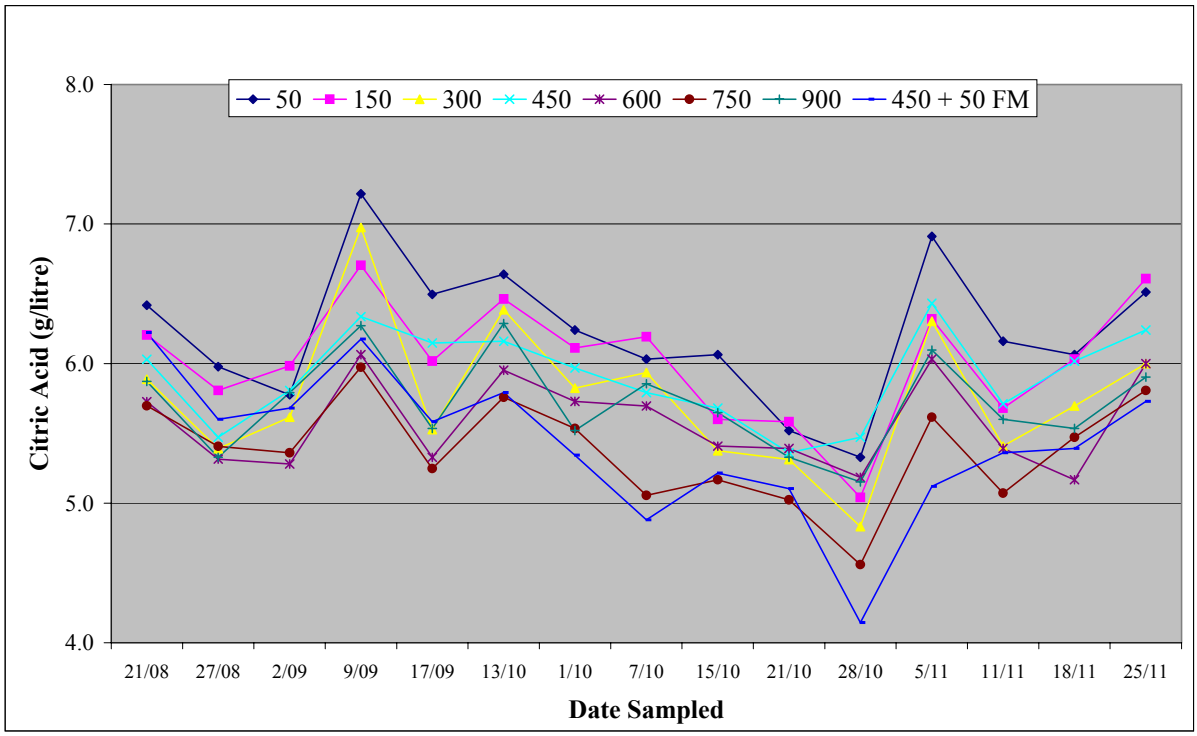

Figure 5.29 Mean Citric acid content (grams per litre of juice) of fruit from the eight nitrogen treatments for the duration of the harvest period.

Statistical analysis of the data for replicated brix tests at each date of collection are depicted in Table 5.24. The overwhelming trend from this analysis was that the frequency of occurrence of significantly higher brix levels was greatest for the three lowest nitrogen rates. Treatments which were not significantly different from the highest brix level at each date are coloured in Table 5.24. There was a notable drop in frequency of non significance at rates of N of 450 and above.

The tend for citric acid was similar, but a high frequency of non significant difference extended to the 450 kg/ha N rate in this case. (Table 5.25).

Table 5.24 Fruit brix vs nitrogen treatment sampled at 15 dates through the season together with the number of times each treatment was not significantly different from the highest level recorded at each date

Date sampled	50 N	150 N	300 N	450 N	600 N	750 N	900 N	450 N + 50 FM
21 August	8.65	9.08	8.40	8.75	8.2	8.35	8.40	8.15
27 August	8.70	8.50	8.25	7.9	8.25	7.75	7.98	7.65
2 September	7.4	8.1	8.0	8.1	7.6	7.85	7.95	7.3
9 September	9.35	9.1	9.48	8.68	8.4	8.2	8.33	7.45
13 September	8.33	7.9	7.67	7.69	7.03	7.2	6.8	6.7
17 September	9.08	8.61	8.61	9.25	8.61	8.61	8.15	7.98
1 September	8.4	8.05	8.2	7.85	7.43	6.93	6.83	6.6
7 September	8.25	8.4	7.95	7.8	7.25	6.65	7.05	6.35
15 September	9.05	8.85	8.8	8.2	8.0	7.85	7.65	6.95
21 September	8.65	8.08	8.05	7.3	6.75	6.7	6.6	7.1
28 September	7.65	6.85	7.05	6.4	6.2	6.2	6.3	5.2
6 November	8.72	8.0	8.35	7.5	6.85	7.0	7.1	6.15
11 November	9.28	9.0	8.75	8.2	7.45	7.7	7.5	6.9
18 November	9.0	8.75	9.0	7.95	7.05	8.45	8.05	7.05
25 November	9.75	10.5	10.6	9.2	8.75	8.75	9.05	8.15
Number of times	14	12	12	5	3	3	1	0

Shaded cells are those which are not significantly different from the highest level at each date of sampling p<= 0.05.

Table 5.25 Citric acid content of fruit (g/l) vs nitrogen treatment sampled at 15 dates through the season together with the number of times each treatment was not significantly different from the highest level recorded at each date.

Date sampled	50 N	150 N	300 N	450 N	600 N	750 N	900 N	450 N + 50 FM
21 August	6.42	6.21	5.89	6.03	5.73	5.70	5 .87	6.22
27 August	5.98	5.81	5.39	5.47	5.32	5.41	5.33	5.6
2 September	5.78	5.99	5.62	5.81	5.28	5.36	5.79	5.68
9 September	7.22	6.71	6.98	6.34	6.06	5.98	6.28	6.18
13 September	6.5	6.02	5.46	6.13	5.33	5.18	5.54	5.59
17 September	6.64	6.46	6.39	6.16	5.95	5.76	6.29	5.79
1 October	6.24	6.11	5.83	5.97	5.73	5.54	5.52	5.35
7 October	6.03	6.19	5.94	5.79	5.70	5.05	5.86	4.88
15 October	6.07	5.6	5.38	5.68	5.41	5.17	5.65	5.22
21 October	5.52	5.58	5.31	5.36	5.39	5.02	5.33	5.1
28 October	5.33	5.04	4.83	5.47	5.19	4.56	5.15	4.14
5 November	6.91	6.32	6.31	6.43	6.03	5.62	6.10	5.12
11 November	6.16	5.68	5.41	5.71	5.39	5.07	5.6	5.36
18 November	6.06	6.03	5.70	6.02	5.17	5.47	5.54	5.39
25 November	6.51	6.61	6.0	5.24	6.0	5.81	5.91	5.73
Number of times	15	13	10	11	5	2	7	4

Plant uptake

Sap nitrate test results for the eight nitrogen rates are shown in Figure 5.30. The results are consistent with those recorded in the 2001 trial, with rising levels during August and a relative plateau from August to November. The higher yielding treatments (above 450 N) were all above 1500 mg/l NO_3 from mid September onwards. The highest rates were generally above 1750 mg/l and at times approached 2000 mg/l.

The lower nitrogen rates showed much more volatility in the sap nitrate levels, with rapid increases in November evident for the two lowest nitrogen treatments. It is thought that for these treatments, sap nitrate may have increased late in the season because they were not carrying a heavy fruit load.

Sap phosphate (PO_4) levels rose to a peak exceeding 300 mg/l in September and declined thereafter for all treatments (Figure 5.31). The lower nitrogen treatments tended to have lower sap phosphate early in the season than other treatments, while the fowl manure treatment sustained higher phosphorus levels than other treatments later in the season. This is not surprising because fowl manure supplied extra phosphorus as well as nitrogen compared to all other treatments.

Sap potassium levels exceeded 4000 mg/l K for most of the season for all treatments, but the order of level was the inverse of that found for nitrogen (Figure 5.32). It was not surprising that sap levels of K for high rates of nitrogen were lower than those for low rates of nitrogen, because the rate of K applied for all treatments (except T8) was fixed, and crop removal of K would have been greater for the higher yielding treatments.

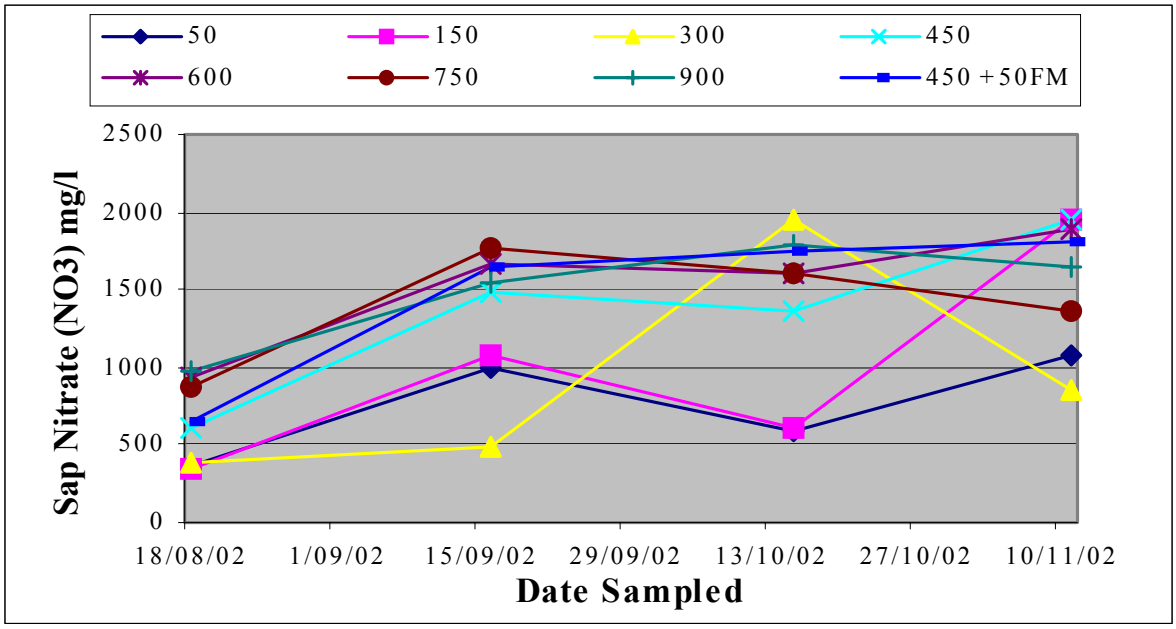

Figure 5.30 Sap nitrate levels recorded from the eight nitrogen treatments for the duration of the harvest period.

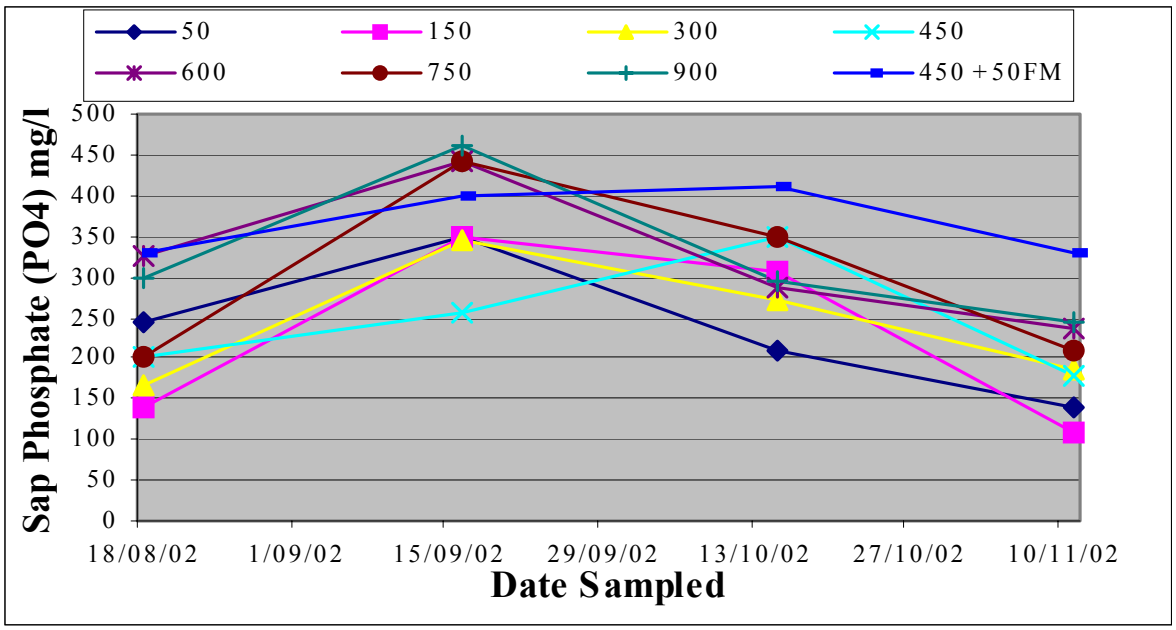

Figure 5.31 Sap phosphate levels recorded from the eight nitrogen treatments for the duration of the harvest period.

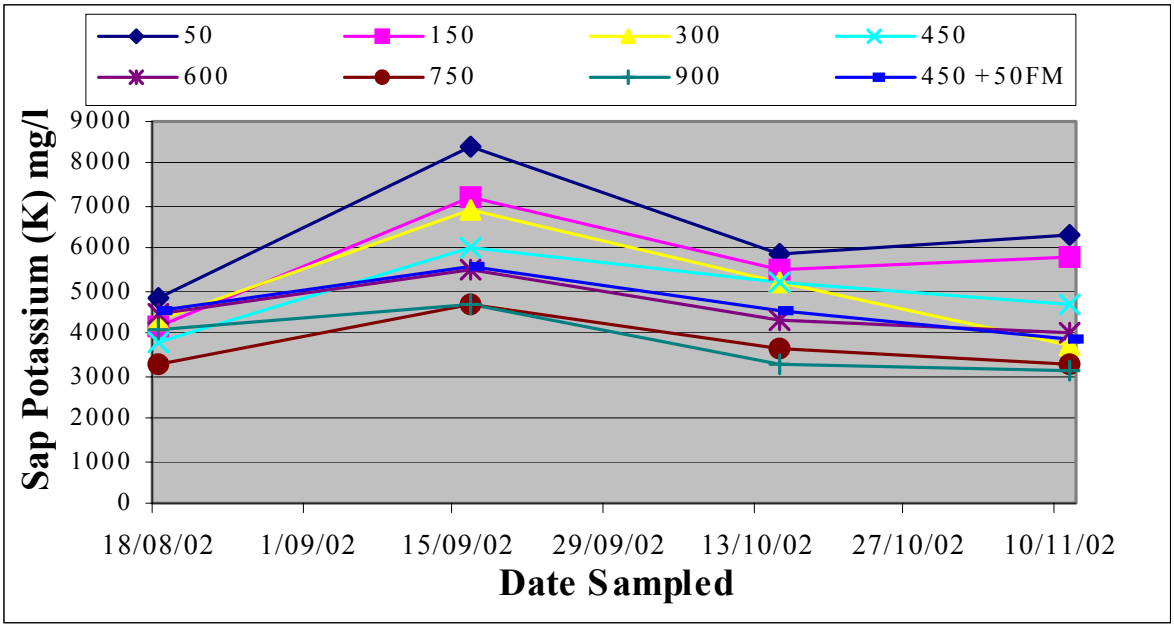

Figure 5.32 Sap potassium levels recorded from the eight nitrogen treatments for the duration of the harvest period.

5.2.5 Discussion

Strawberry fruit yields increased linearly with increasing rate of nitrogen, but fruit quality as measured by the total soluble solids content (brix) fell in direct proportion. When choosing a fertiliser program for strawberries, consideration must be given to not only the yield maximising rate but also the rate that maintains acceptable eating quality of the fruit. Another consideration is choosing a rate that will minimise nutrient loss to the environment.

This study suggests that a first approximation to this compromise rate is between 450 kg/ha N and 600 kg/ha N for the life of the crop on sandy soils of the Swan Coastal Plain.

Conformity with such a fertiliser program can be monitored using sap testing. During the main harvest period from September to November, a sap nitrate (NO_3) level in excess of 1500 mg/litre is desirable for high yield.

Sap phosphate (PO_4) levels in excess of 300 mg/L and potassium (K) levels greater than 4000 mg/L are also considered desirable.

A successful strawberry crop can be grown with as little as 4000 kL per hectare of irrigation through drip irrigation on sandy soils at this time of year, but great care must be taken to avoid water stress. The consequences of this happening late in the season in warming weather is a cessation of flowering and a consequent loss of fruit production. Tensiometers are a good measure of soil moisture status and can act as a warning signal for drought stress, if read at least once daily. Tensiometer readings must be plotted daily or more often to show dangerous drying trends in the soil, and remedial action taken.

6. CONSUMER AND MARKET RESEARCH

INTRODUCTION

The preceding two chapters have described two aspects of the commercialisation process for Kiewa, semi commercial production and 'best practice' nutrition and irrigation. Both of these aspects identified practices that were important to achieving high yields, high fruit quality and maximising returns to growers.

The other key component to making Kiewa a commercial success is consumer satisfaction with the product which leads to increased purchases. The third key component of this project was therefore to measure consumer satisfaction with Kiewa, in terms of comparative fruit flavour and fruit appearance. We also set out to identify management practices which would improve the eating quality of the fruit and ensure that consumers could identify Kiewa in the market place and demand it. The aim was ultimately to create consumer demand for Kiewa leading to growth in sales through 'market pull' rather than the more traditional 'production push'.

This chapter reports on a number of approaches to consumer and market evaluation of Kiewa undertaken during the 2001, 2002 and 2003 seasons, with the help of project partners, 'Fresh Finesse' and Curtin University. The work includes flavour and quality evaluation of Kiewa against commercial standard varieties conducted in sensory laboratories in NSW, Queensland and WA as well as a consumer 'focus group session' conducted by Fresh Finesse and consumer evaluations at retail outlets and regional fairs. Reports on each of these studies are compiled in this chapter.

6.1 2001 RESEARCH

6.1.1 Aims

The initial aims of the work were to:

- Compare fruit of Kiewa with the industry standard 'short day' variety at the time, Camarosa, in formal taste panel tests conducted in sensory laboratories in Eastern Australia to determine Kiewa's comparative market potential.
- Assess the potential for building future sales of Kiewa by conducting informal taste testing and consumer surveys at selected retail outlets.

6.1.2 Materials and methods

Fruit from the semi commercial trial plots described in Chapter 4 were collected from two participating growers' crops on 6 November 2001. Fruit from these two growers was chosen because they both had the industry standard Camarosa, as well as Kiewa, and their production methods reflected two contrasting styles. One was described as a 'high input' site and the other 'low input'. The 'high input' grower's objective was primarily to achieve high yields for domestic marketing, while the 'low input' grower's objective was high quality fruit for export.

The fruit collected was of a uniform size and ripeness (fully ripe) from both sites, and it was despatched the next day by air to both laboratories after pre cooling overnight. The final reports of those two evaluations follow.

Fruit from the semi commercial plots was also used for consumer evaluations at selected fresh market outlets during the Spring of 2001. Fully ripe fruit was delivered to the chosen retail outlet and project staff supervised a tasting and evaluation, together with a professional 'fresh produce demonstrator' engaged by Fresh Finesse at each session. Fresh Finesse provided the demonstration booth and strawberry industry promotional material was used to identify it to consumers. The booth was sited in each case near a display of strawberries for sale, and Thursday, Friday or Saturday was chosen for the tests to ensure sufficient customers. Surveys usually lasted one to two hours. The results of those studies are also reported below.

6.1.3 Results 1 - Food Science Australia Report

FOOD SCIENCE AUSTRALIA
A JOINT VENTURE OF CSIRO AND AFISC

CSIRO AFISC Australian Food Industry Science Centre

ABN: 78 695 101 514

FEE FOR SERVICE REPORT

CLIENT:	**Agriculture Western Australia**
CONTACT:	Dennis Phillips
ADDRESS:	36 Railway Parade MIDLAND WA 6056
PHONE:	08 9250 9432
FAX	08 9250 1859
SERVICE:	STRAWBERRY TESTING - TRIAL 2
REF NUMBER:	104907
PREPARED BY:	Dr Irene Baxter
DATE:	09 November 2001

SAMPLES TESTED: Strawberries:

Camarosa high input reps 1-3;
Camarosa low input reps 1-3;
Kiewa high input reps 1-3;
Kiewa low input reps 1-3

The fruit arrived at Food Science Australia's North Ryde laboratory in good condition on Thursday 8th November 2001; having been air freighted overnight from Perth WA.

DATE OF TESTING: 8th and 9th November 2001.

METHODS:

Twenty consumers who all liked strawberries and regularly consumed them were recruited from the Food Science Australia database. A further eight consumers from the staff at Food Science Australia also participated in the testing which took place over two consecutive days.

The samples required for each day's testing were kept at room temperature to maximise the volatiles and flavour. Those samples not required on Thursday 8th were stored in a cool room at 4ºC, but were brought up to room temperature prior to sampling. All fruit were washed in cool water and dried on absorbent kitchen paper prior to serving. Samples were served in transparent plastic odour-free containers (lidded) labelled with a 3-digit blinding code. Initially two berries per serving were given, but after the first session (six consumers), consumers commented that it was too confusing as there were differences between the 'same' strawberries for some attributes (e.g. acidity levels). With the availability of more fruit, more consumers were recruited, this time among the Food Science Australia staff (excluding staff involved in horticulture).

The evaluation of the samples took place in accordance with International Standards on Sensory Evaluation. As the total number of samples (n=12) was too great to be evaluated in one session, a balanced incomplete block design was used whereby each consumer evaluated six samples per session with a break after the third sample to prevent fatigue. Two samples were evaluated in triplicate on each day (to allow for the possibility of consumers

being unable to attend on both days). The sample presentation order was balanced across all consumers within each session.

The evaluation took place in the sensory booths at Food Science Australia's North Ryde sensory facility. Compusense™ version 5 (a computerised data capture system for sensory analysis) was used to present the scoresheets to the consumers. Consumers rated each samples in turn for:

- **Ripeness** using a 'just about right' scale

not ripe enough		just right		much too ripe
☐	☐	☐	☐	☐

- **Appearance**: overall liking for appearance using a 9-point hedonic scale (1 = dislike extremely; 9 = like extremely).
- **Aroma:** overall liking for the aroma using a 9-point hedonic scale.
- **Sweetness** using a 'just about right scale from 'not sweet enough' to 'much too sweet'.
- **Acidity** using a 'just about right' scale from 'not acidic enough' to 'much too acidic'.
- **Flavour**: overall liking for the flavour using a 9-point hedonic scale.
- **Firmness** using a 'just about right' scale from 'not firm enough' to 'much too firm'.
- **Juiciness** using a 'just about right scale' from 'not juicy enough' to 'much too juicy'.
- **Texture**: overall liking for the texture using a 9-point hedonic scale.
- **Overall acceptability**: using a 9-point hedonic scale.

After each sample there was a 60 second enforced break during which time consumers were instructed to drink water to cleanse their palate.

Data were analysed using one-way analysis of variance and Fisher's multiple comparison test (Minitab release 12.1). The replicates were treated as separate samples for the purpose of analysis.

RESULTS:

There were significant differences between the samples for all attributes with the exception of acidity.

The mean scores for each attribute can be seen in Table 1 (See Appendix 1). Table 2 (Appendix 1) shows the mean scores per sample where replicates were consolidated prior to ANOVA. This may make interpretation of the results simpler. Appendix 2 is a summary of the results of the consolidated replicate analysis.

Ripeness

The mean scores for ripeness show that in general:

- *Camarosa* high input samples are 'just about right'
- *Camarosa* low input samples are slightly too ripe
- *Kiewa* high input samples are 'just about right'
- *Kiewa* low input samples are just about right (although rep 2 is slightly under-ripe)

ANOVA was significant ($p \leq 0.001$) and Fisher's test showed significant differences (refer to Table 1 for the direction of the difference) between the following samples:

- *Camarosa* low input rep 1 and all *Camarosa* high input reps 1-3
- *Camarosa* low input rep 3 and *Camarosa* high input rep 3
- *Kiewa* low input reps 1 & 2 and *Camarosa* low input reps 1-3
- *Kiewa* low input rep 3 and *Camarosa* low input rep 1
- *Kiewa* high input rep 1 and *Camarosa* low input rep 1
- *Kiewa* high input reps 2 & 3 and *Camarosa* low input reps 1-3
- *Kiewa* high input rep 1 and *Kiewa* low input rep 2

Overall liking for appearance

The mean scores show that the appearance of all the samples except the *Camarosa* low input samples were liked (scores ≥ 6 on a 9-point hedonic scale). ANOVA of the mean scores showed significant differences between samples ($p \leq 0.001$) and Fisher's test showed significant differences between the following samples:

- *Camarosa* low input (reps 1-3) and all the other samples.

Overall liking for aroma

The mean scores show that consumers preferred the aroma of *Kiewa* high input and *Camarosa* high input to the aroma of the low input samples. In general, the aromas of all the samples were liked. ANOVA of the mean scores showed significant differences between samples ($p \leq 0.001$) and Fisher's test showed significant differences between the following samples:

- *Camarosa* high input rep 1 and all *Camarosa* low input samples, and all 95-0Kiewa low input samples.
- *Kiewa* high input reps 1& 2 were liked more than all *Camarosa* low input samples.
- *Kiewa* high input reps 1& 2 were liked more than all 95-0Kiewa low input samples.

Sweetness

The mean scores for sweetness show that the low input samples (both varieties) were not at all sweet enough for consumers liking, while the *Camarosa* high input samples were just about right and the *Kiewa* high input samples were perceived to be almost sweet enough. ANOVA of the mean scores showed significant differences between samples ($p \leq 0.001$) and Fisher's test showed significant differences between the following samples:

- *Camarosa* high input samples (reps 1-3) and all the low input samples (both varieties).
- *Kiewa* high input rep 1 and *Kiewa* low input (all reps).
- *Kiewa* high input rep 1 and *Kiewa* high input rep 2.
- *Kiewa* high input rep 2 and *Kiewa* low input rep 2.
- *Kiewa* high input rep 3 and *Kiewa* high input rep 1 and *Kiewa* low input rep 1.

Acidity

The acidity of all the samples tested was perceived to be just about right (mean scores of 3 on a 5-point 'just about right' scale). ANOVA of the mean scores showed no significant differences between samples ($p = .155$).

Overall flavour liking

The flavours of the high input samples (both varieties) were liked more than the low input samples. ANOVA of the mean scores showed significant differences between samples ($p \leq 0.001$) and Fisher's test showed significant differences between the following samples:

- *Camarosa* high input (all reps) and *Camarosa* low input (all reps).
- *Camarosa* high input (all reps) and *Kiewa* low input (reps 2 & 3).
- *Kiewa* high input (all reps) and *Kiewa* low input (all reps).
- *Kiewa* high input (reps 1 & 2) and *Camarosa* low input (all reps).
- *Kiewa* high input (rep 3) and *Kiewa* low input (reps 2 & 3).

Softness

The mean scores show that sample *Kiewa* high input (all reps) and *Camarosa* high input (all reps) were perceived to be just right in terms of firmness/softness. The low input samples (both varieties) were found to be slightly too firm. ANOVA of the mean scores showed significant differences between samples ($p \leq 0.001$) and Fisher's test showed significant differences between the following samples:

- *Camarosa* high input (all reps) and *Camarosa* low input (all reps).
- *Camarosa* high input (all reps) and *Kiewa* low input (reps 2 and 3).
- *Kiewa* high input (all reps) and *Camarosa* low input (all reps).
- *Kiewa* high input (all reps) and *Kiewa* low input (all reps).
- *Kiewa* low input rep 1 and *Kiewa* low input reps 2 and 3.

Juiciness

The mean scores show that the high input samples (both varieties) were perceived to be perfectly juicy while the low input samples (again, both varieties) were slightly too dry. ANOVA of the mean scores showed significant differences between samples ($p \leq 0.001$) and Fisher's test showed significant differences between the following samples:

- *Camarosa* high input (all reps) and *Camarosa* low input (all reps).
- *Camarosa* high input (all reps) and *Kiewa* low input (all reps).
- *Kiewa* high input (all reps) and *Camarosa* low input (all reps).
- *Kiewa* high input (reps 2 & 3) and *Kiewa* low input (reps 1 and 3).
- *Kiewa* high input rep 1 and *Kiewa* low input rep 3.

Overall texture liking

The mean scores show that the texture of all samples were liked more than that of the *Camarosa* low input (all reps) which was 'neither liked nor disliked' (score of 5 on a 9-point hedonic scale). The scores for the texture of the high input samples (both varieties) were overall higher than those for the *Kiewa* low input sample (all reps).

ANOVA of the mean scores showed significant differences between samples ($p \leq 0.001$) and Fisher's test showed significant differences between the following samples:

- *Camarosa* high input (all reps) and *Camarosa* low input (all reps)
- *Camarosa* low input (all reps) and *Kiewa* low input (rep 1)
- *Kiewa* high input (all reps) and *Camarosa* low input (all reps)
- *Kiewa* high input (all reps) and *Camarosa* high input (reps 2 & 3)

Overall liking for samples

The mean scores for the samples show that the high input samples (both varieties) were liked more than the low input samples when all sensory attributes were considered by the consumer. ANOVA of the mean scores showed significant differences between samples ($p \leq 0.001$) and Fisher's test showed significant differences between the following samples:

- *Camarosa* high input (all reps) and both low input samples (all reps).
- *Kiewa* high input (all reps) and *Camarosa* low input (all reps).
- *Kiewa* high input (rep 1) and *Kiewa* low input (all reps).
- *Kiewa* high input (reps 2 & 3) and *Kiewa* low input (reps 2 and 3).

DISCUSSION

The high input samples of both the *Camarosa* variety and *Kiewa* variety were liked more than the low input varieties. Neither the *Camarosa* high input nor the *Kiewa* high input samples emerged as a clear favourite.

The low input samples were perceived to be slightly over-ripe in appearance, lacking in sweetness, too firm and too dry (non-juicy). The low input variety of *Kiewa* was liked more than the low input *Camarosa* in terms of its appearance and texture. However, in terms of overall liking, there were no significant differences between the *Camarosa* low input samples and the low input samples of *Kiewa*.

AUTHORISED BY:

Dr Irene Baxter
Sensory Scientist

APPENDIX 1

TABLE 1: MEAN SCORES FOR STRAWBERRIES - CONSUMER TESTING NOVEMBER 2001

Sample	Ripeness (JAR)	Overall appearance (hedonic)	Aroma (hedonic)	Sweetness (JAR)	Acidity (JAR)
Significant difference between samples	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	Non-significant
Camarosa high input r1	2.964	6.893	7.214	2.607	3.179
Camarosa high input r2	3.000	6.429	6.250	2.571	3.286
Camarosa high input r3	2.929	6.750	6.857	2.750	3.179
Camarosa low input r1	3.821	5.071	5.929	1.964	3.571
Camarosa low input r2	3.357	5.393	6.107	1.964	3.250
Camarosa low input r3	3.429	5.214	5.786	2.071	3.250
Kiewa high input r1	3.179	7.000	7.143	2.964	3.000
Kiewa high input r2	2.821	6.536	7.107	2.357	3.250
Kiewa high input r3	2.857	6.893	6.393	2.286	3.143
Kiewa low input r1	2.821	6.857	6.071	2.071	3.429
Kiewa low input r2	2.607	6.786	5.929	1.643	3.571
Kiewa low input r3	3.000	6.821	5.750	1.929	2.964
Sample	**Overall flavour (hedonic)**	**Softness (JAR)**	**Juiciness (JAR)**	**Overall texture (hedonic)**	**Overall liking**
Significant difference between samples	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
Camarosa high input r1	7.000	2.929	2.857	7.143	7.036
Camarosa high input r2	6.500	2.964	3.000	6.571	6.607
Camarosa high input r3	6.643	2.893	2.893	6.643	6.786
Camarosa low input r1	5.000	2.429	2.214	5.429	4.929
Camarosa low input r2	5.464	2.357	2.464	5.536	5.571
Camarosa low input r3	5.250	2.143	2.536	5.286	5.071
Kiewa high input r1	7.250	3.143	2.893	7.250	7.250
Kiewa high input r2	6.714	3.071	2.929	6.929	6.714
Kiewa high input r3	6.500	3.071	3.071	7.143	6.321
Kiewa low input r1	5.714	2.679	2.536	6.429	5.821
Kiewa low input r2	5.107	2.286	2.714	6.036	5.000
Kiewa low input r3	5.286	2.214	2.429	6.071	5.286

NOTE:

'Just about right' (JAR) scales are 5-point scales where 1 = 'not enough…' 3 = 'just right', 5 = 'too much…'

not ripe enough ☐ ☐ just right ☐ ☐ much too ripe ☐

Hedonic scales are 9-point scales where 1 = 'dislike extremely', 5 = 'neither like nor dislike', 9 = 'like extremely'

(Scores between 1-4 represent dislike for the attribute, 6-9 represent liking)

TABLE 2: MEAN SCORES FOR STRAWBERRIES - CONSUMER TESTING NOVEMBER 2001

(Replicate scores merged to form one sample)

Sample	Ripeness (JAR)	Overall appearance (hedonic)	Aroma (hedonic)	Sweetness (JAR)	Acidity (JAR)
Significant difference between samples	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	Non-significant
Camarosa high input	2.988	6.635	6.765	2.600	3.212
Camarosa low input	3.536	5.226	5.940	2.000	3.357
Kiewa high input	2.952	6.810	6.881	2.536	3.131
Kiewa low input	2.810	6.821	5.917	1.881	3.321
Sample	**Overall flavour (hedonic)**	**Softness (JAR)**	**Juiciness (JAR)**	**Overall texture (hedonic)**	**Overall liking**
Significant difference between samples	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
Camarosa high input	6.635	2.953	2.918	6.706	6.729
Camarosa low input	5.238	2.310	2.381	5.417	5.190
Kiewa high input	6.821	3.100	2.964	7.107	6.762
Kiewa low input	5.369	2.393	2.560	6.179	5.369

NOTE:

'Just about right' (JAR) scales are 5-point scales where 1 = 'not enough…' 3 = 'just right', 5 = 'too much…'

not ripe enough ☐ ☐ just right ☐ ☐ much too ripe ☐

Hedonic scales are 9-point scales where 1 = 'dislike extremely', 5 = 'neither like nor dislike', 9 = 'like extremely'

(Scores between 1-4 represent dislike for the attribute, 6-9 represent liking)

APPENDIX 2

SUMMARY OF RESULTS FROM CONSUMER TESTING OF STRAWBERRIES

(Replicates consolidated into one result per sample)

NOTE: Refer to Table 2 (Appendix 1) for mean scores.

RIPENESS

A one-way ANOVA showed there were significant differences between the samples ($p \leq 0.001$). Fisher's test found significant differences between the following samples:

- Camarosa high input and Camarosa low input
- Camarosa low input and Kiewa low input
- Camarosa low input and Kiewa high input

LIKING FOR APPEARANCE

A one-way ANOVA showed there were significant differences between the samples ($p \leq 0.001$). Fisher's test found significant differences between the following samples:

- Camarosa high input and Camarosa low input
- Camarosa low input and Kiewa low input
- Camarosa low input and Kiewa high input

Aroma liking, Sweetness, Overall flavour liking, Softness, Juiciness, Overall acceptability.

The samples were found to differ significantly (all at $p \leq 0.001$) with respect to all of the above attributes. Fisher's tests found that the samples which significantly differed for each of these attributes were the following:

- Camarosa high input and Camarosa low input
- Camarosa high input and Kiewa low input
- Camarosa low input and Kiewa high input
- Kiewa low input and Kiewa high input

TEXTURE LIKING

The samples differed significantly for overall texture acceptability. Fisher's test showed that the following samples were significantly different:

- Camarosa high input and Camarosa low input
- Camarosa high input and Kiewa low input
- Camarosa low input and Kiewa low input
- Camarosa low input and Kiewa high input
- Kiewa low input and Kiewa high input

6.1.4 Results 2 - 'Centre for Food Technology' Report

CENTRE FOR FOOD TECHNOLOGY

Consumer assessment of strawberry varieties from different farm management plans

Prepared by the

Sensory and Consumer Science Unit

November 2001

Commissioned by:
Dennis Phillips
Agriculture Western Australia

SEN2002/1003779359

Queensland Government
Department of Primary Industries

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Consumer assessment of strawberry varieties from different farm management plans

November 2001

SENSORY AND CONSUMER SCIENCE UNIT

Members of the Sensory and Consumer Science team are listed below and all are available to discuss project possibilities as well as project results.

Stephen Nottingham
Senior Research Scientist

Claire Reid
Food Scientist – Sensory Project Leader

Gwen Bell
Food Scientist

Christine Gore
Asst Senior Sensory Technician

Any of the above may be contacted at:

The Centre for Food Technology
19 Hercules Street
Hamilton
Brisbane QLD 4007

Telephone (07) 3406 8555
Fax 3406 8665
E-mail cft@dpi.qld.gov.au

EXECUTIVE SUMMARY

On the 8 and 9 November 2001, an average of 18 pseudo-consumer panellists (over 3 sessions) from the Centre for Food Technology, Brisbane evaluated four strawberry samples from Agriculture Western Australia. The four strawberry samples were two different varieties (Kiewa and Camarosa) from two different farm management plans (low input and high input). The strawberry samples were evaluated on hedonic and just right line scales according to the Australian Standard AS2542.2.3, 1988. The data collected was analysed statistically using analysis of variance.

Significant differences ($P < 0.05$) were found between the samples for the hedonic line scale attributes appearance, overall, texture and flavour. The appearance of the Kiewa high input, Camarosa high input and Kiewa low input strawberry samples was liked significantly more ($P < 0.05$) than the appearance of the Camarosa low input sample. For texture and flavour as well as overall, both the Kiewa high input and Camarosa high input samples were liked significantly more ($P < 0.05$) than the Kiewa low input and Camarosa low input samples. No significant differences ($P > 0.05$) were found between the likeability of the samples for the attributes odour and shape.

Significant differences ($P < 0.05$) were found between the samples for most of the "just right" line scale attributes. Both the Kiewa high input and Camarosa high input samples were significantly different ($P < 0.05$) to the Kiewa low input and Camarosa low input samples for firmness, sweetness and ripeness. For the attribute juiciness, the Kiewa high input, Camarosa high input and Kiewa low input samples were all significantly different ($P < 0.05$) to the Camarosa low input sample. The mean sensory scores for the Kiewa low input and Camarosa low input samples indicated that they were perceived to be slightly too firm and below "ideal" towards under-ripe. The Camarosa low input sample was also perceived to be slightly not juicy enough and all four samples were slightly not sweet enough. There was no significant difference ($P > 0.05$) between the samples for acidity.

A factorial analysis showed significant differences ($P < 0.05$) between high input and low input farm management plans. The high input samples were liked significantly more ($P < 0.05$) than the low input samples for the attributes odour, appearance, overall, texture and flavour. Significant differences ($P < 0.05$) were also found between the high and low farm management plans for firmness, juiciness, sweetness and ripeness. No significant differences ($P > 0.05$) were found between high and low input farm management plans for shape and acidity.

The comparison of the Kiewa and Camarosa varieties showed that in terms of likeability, the appearance, overall, texture and flavour of the Kiewa variety was liked significantly more ($P < 0.05$) than the Camarosa variety. Significant differences ($P < 0.05$) were also found between the varieties for firmness and juiciness. No significant differences ($P > 0.05$) were found between the Kiewa and Camarosa varieties for the attributes odour, shape, sweetness, acidity or ripeness.

METHODOLOGY

SESSIONS AND SAMPLES

The strawberry samples were collected from Australian Air Express Pty Ltd, Brisbane Domestic Airport on 8 November 2001 at approximately 9.30am and transported directly to the Centre for Food Technology (CFT).

On arrival at CFT, the samples from replicates one and two were retained at room temperature (approximately 22°C). The samples for assessment on 9 November 2001 (replicate three) were stored at 2°C. All samples were kept in their original packaging materials prior to sample preparation.

Table 1 Strawberry assessments completed November 2001

	Session date, time, number and replicate		
	8 November		9 November
Sample (and blinding codes)	2.00pm Session 1 Replicate 1	3.15pm Session 2 Replicate 2	10.00am Session 3 Replicate 3
Kiewa - High Input Farm (117, 635, 128)	✓	✓	✓
Camarosa - High Input Farm (283, 720, 487)	✓	✓	✓
Kiewa - Low Input Farm (906, 189, 604)	✓	✓	✓
Camarosa - Low Input Farm (564, 441, 359)	✓	✓	✓

SAMPLE PREPARATION

One hour before the scheduled session was due to commence, 40-50 strawberries, from each of the four strawberry samples, were selected for assessment. The sample selected did not include any berries that were damaged, bruised or misshapen. At this stage, the sample was labelled with the appropriate 3-digit code that was used to identify the sample throughout the preparation process.

The 40-50 strawberries were then placed into a plastic colander and immersed into cold water for 4-5secs. To avoid bruising, one hand was placed carefully over the strawberries to stop them from falling out of the colander. The sample was then gently tipped onto an aluminium tray that had been lined with paper towels. Any excess water was dried off immediately with additional paper towels. The sample was then left at room temperature.

Thirty minutes before the session was due to commence, two strawberries of approximately equal size and ripeness were placed into individual 3-digit pre-coded containers and sealed with lids. The 300ml round containers were made of opaque polypropylene. A range of strawberry sizes were selected from small to medium to large so that they were representative of the sample sent to CFT.

SENSORY EVALUATION

Four strawberry samples were assessed in each session. In each session, each pseudo-consumer panellist was provided with samples of approximately equal size i.e. all small, all medium or all large. The panellists were supplied with room temperature filtered water for palate cleansing between samples within a session.

The samples were presented to the panellists on white plastic trays. Assessments were carried out in individual booths illuminated with white light (day light equivalent). Within a session, the four samples were assessed in a randomised order, balanced as much as possible.

On average, 18 pseudo-consumer panellists evaluated the strawberry samples over the three sessions conducted on the 8 and 9 November 2001. The pseudo-consumer panellists were recruited from CFT on the basis that they liked and consumed strawberries.

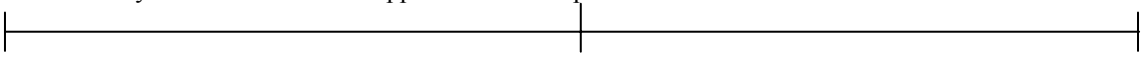
The panellists assessed the samples using a standard rating test (AS2542.2.3, 1988). The line scales were anchored with verbal anchors where the left-hand end was equivalent to 0 and the right-hand end was equivalent to 100 (see Figure 1a and 1b). Therefore, a mean sensory score of 50 represents the mid-point on the line scale.

Each sample was assessed using the following line scales:

- Odour - dislike extremely (0), neither like nor dislike (50), like extremely (100)
- Appearance - dislike extremely (0), neither like nor dislike (50), like extremely (100)
- Shape - dislike extremely (0), neither like nor dislike (50), like extremely (100)
- Overall - dislike extremely (0), neither like nor dislike (50), like extremely (100)
- Texture - dislike extremely (0), neither like nor dislike (50), like extremely (100)
- Flavour - dislike extremely (0), neither like nor dislike (50), like extremely (100)
- Firmness - not firm enough (0), just right (50), too firm (100)
- Juiciness - not juicy enough (0), just right (50), too juicy (100)
- Sweetness - not sweet enough (0), just right (50), too sweet (100)
- Acidity - not acid enough (0), just right (50), too acid (100)
- Ripeness – under ripe (0), ideal (50), over ripe (100)

Figure 1a) Example of a hedonic line scale used for the assessment of strawberries

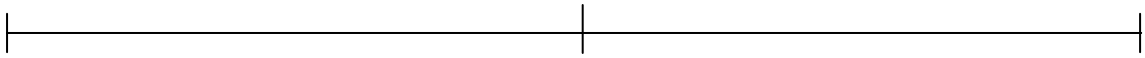
How much do you like or dislike the appearance of sample 117?



Dislike extremely	Neither like nor dislike	Like extremely
(0)	(50)	(100)

Figure 1b) Example of a just right line scale used for the assessment of strawberries

Firmness



Not firm enough	Just right	Too firm
(0)	(50)	(100)

NOTE: The panellists only see the verbal anchors, not the numerical values.

Panellists could also add odour and appearance comments as well as general comments relevant to the sample.

Data was collected directly into computers using an integrated software package, Compusense five ver. 4.0 (Compusense® Inc, Canada).

STATISTICAL ANALYSIS

Initially, the individual pseudo-consumer panellist scores across all four samples for each attribute evaluated were graphically represented in a histogram to check that the data resembled a normal-like distribution. These graphs are not included in this report.

Panel scores were averaged prior to a randomised block factorial analysis of variance. The factorial analysis was completed to look at the effect of the variety (Kiewa and Camarosa) and farm management plan (high input and low input) and the interaction between them. The replications as identified on the samples on arrival at CFT were used as blocks as the fruit from all varieties within each block were assessed within one session. Therefore, blocks were aligned with sessions. The analysis was completed using Genstat (Genstat Committee of the Statistics Department, IACR-Rothamsted, 2000).

RESULTS AND DISCUSSION

For the strawberry assessments completed 8 and 9 November 2001, the mean sensory scores for the four samples are presented in tables 2 and 3. The results from the factorial breakdown are presented in tables 4, 5, 6 and 7.

The mean panel data from the three replicates can be found in Appendix 1. The odour and appearance as well as the general comments can be found in Appendix 2.

Table 2 Hedonic line scale mean sensory scores for strawberry samples assessed 8 and 9 November 2001

Sample	Odour$^{\infty NS}$	Appearance$^{\infty}$	Shape$^{\infty NS}$	Overall$^{\infty}$	Texture$^{\infty}$	Flavour$^{\infty}$
Kiewa High Input	66	66c	66	64c	68c	62c
Camarosa High Input	56	61bc	67	63c	66c	62c
Kiewa Low Input	52	56b	63	49b	53b	47b
Camarosa Low Input	50	47a	65	40a	41a	39a
2-way interaction P value	0.316	0.360	0.603	0.035	0.011	0.036
LSD (5%)	12.5	7.6	7.0	4.9	4.4	5.3

Scale: Dislike extremely (0), Neither like nor dislike (50), Like extremely (100).
abc: Means within a column followed by a common letter are not significantly different ($P > 0.05$).
NS: Not significant ($P > 0.05$) and LSD is presented as a measure of variability.

For the assessments completed using hedonic line scales (Table 2), significant differences ($P < 0.05$) were found between the samples for the appearance, overall, texture and flavour attributes. In addition, significant interactions ($P < 0.05$) were found between farm management plan and variety for the overall, texture and flavour attributes.

The appearance of the strawberry samples Kiewa high input, Camarosa high input and Kiewa low input was liked significantly more ($P < 0.05$) than the appearance of the Camarosa low input sample. Although significantly different ($P < 0.05$) to each other, both the Kiewa low input and the Camarosa low input samples had mean sensory scores close to 'neither like or dislike' of 56 and 47 respectively. There was no significant interaction ($P > 0.05$) between farm management plan and variety for appearance. However, for the high input

plan there was no significant difference ($P > 0.05$) in appearance between varieties while for the low input plan the appearance of the Kiewa variety was liked significantly more ($P < 0.05$) than the Camarosa variety. Similar trends were found for the overall, texture and flavour attributes. For these attributes the interaction was significant ($P < 0.05$).

Overall, both the Kiewa high input and Camarosa high input samples were liked significantly more ($P < 0.05$) than the Kiewa low input and Camarosa low input samples. The Kiewa low input sample was liked significantly more ($P < 0.05$) than the Camarosa low input sample, but the Kiewa low input sample was liked significantly less ($P < 0.05$) than both the Kiewa high input and Camarosa high input samples. With a mean sensory score of 40, the Camarosa low input sample was slightly lower than 'neither like nor dislike' on the overall line scale.

The texture of both the Kiewa high input and Camarosa high input samples was liked significantly more ($P < 0.05$) than the texture of the Kiewa low input and Camarosa low input samples. However, the texture of the Kiewa low input sample was liked significantly more ($P < 0.05$) than the Camarosa low input but was liked significantly less ($P < 0.05$) than the texture of the Kiewa high input and the Camarosa high input samples.

The flavour of both the Kiewa high input and Camarosa high input samples was liked significantly more ($P < 0.05$) than the flavour of the Kiewa low input and Camarosa low input samples. The flavour of the Kiewa low input sample was liked significantly more ($P < 0.05$) than the flavour of the Camarosa low input sample. However, the flavour of the Kiewa low input sample was liked significantly less ($P < 0.05$) than that of the Kiewa high input and Camarosa high input samples.

There were no significant differences ($P > 0.05$) between the four samples assessed for the attributes odour acceptability and shape acceptability (Table 2).

Table 3 Just right line scale mean sensory scores for strawberry samples assessed 8 and 9 November 2001

Sample	Firmness^	Juiciness^	Sweetness^	Acidity^NS	Ripesness#
Kiewa High Input	47a	53c	42b	51	52c
Camarosa High Input	50a	52bc	44b	54	53c
Kiewa Low Input	58b	48b	33a	54	45b
Camarosa Low Input	66c	38a	29a	57	40a
2-way interaction P value	0.244	0.014	0.077	0.900	0.057
LSD (5%)	6.4	4.4	4.4	6.0	4.5

^ Scale: Not enough of named attribute (0), Just right (50), Too much of named attribute (100).
# Scale: Under ripe (0), Ideal (50), Overripe (100).
abc: Means within a column followed by a common letter are not significantly different ($P > 0.05$).
NS: Not significant ($P > 0.05$) and LSD is presented as a measure of variability.

Significant differences ($P > 0.05$) were found between the four test samples for the 'just right' line scale attributes of firmness, juiciness, sweetness and ripeness assessed in November 2001 (Table 3). However, a significant interaction ($P > 0.05$) was found only for juiciness.

For the attribute firmness, both the Kiewa high input and Camarosa high input samples were significantly different ($P > 0.05$) to the Kiewa low input and Camarosa low input samples. The Kiewa low input sample was significantly different ($P > 0.05$) to the Kiewa high input and the Camarosa high input samples as well as the Camarosa low input sample. With mean sensory scores of 47 and 50 respectively (where a score of 50 is equivalent to 'just right'), the Kiewa high input and Camarosa high input samples were both close to 'just right'

in terms of firmness. However, the Kiewa low input sample and Camarosa low input sample would be considered to be slightly too firm.

In terms of juiciness, the Kiewa high input, Camarosa high input and Kiewa low input samples were significantly different (P > 0.05) to the Camarosa low input sample. The Kiewa high input, Camarosa high input and Kiewa low input samples had mean sensory scores all close to 'just right' for juiciness (range 48 to 53). However, the Camarosa low input sample had a mean sensory score of 38 below 'just right' for juiciness indicating that it was perceived to be slightly not juicy enough. For juiciness, the Kiewa high input and Camarosa high input samples were not significantly different (P > 0.05). However, the Camarosa low input and Kiewa low input samples were significantly different (P > 0.05) in terms of juiciness.

For the attribute sweetness, the Kiewa high input and Camarosa high input samples were both significantly different (P > 0.05) to the Kiewa low input and Camarosa low input samples. With mean sensory scores ranging from 29 to 44, all samples would be considered to be slightly not sweet enough.

Both the Kiewa high input and Camarosa high input samples were significantly different (P > 0.05) to the Kiewa low input and Camarosa low input samples in terms of ripeness. The Kiewa low input sample was significantly different (P > 0.05) to the Kiewa high input, Camarosa high input and Camarosa low input samples. With mean sensory scores of 52 and 53 respectively, the Kiewa high input and Camarosa high input samples were close to 'ideal' for ripeness. However, the Kiewa low input sample and Camarosa low input sample were rated below 'ideal' towards the 'under-ripe' end of the line scale.

No significant differences (P > 0.05) were found between the four samples assessed for the attribute acidity (Table 3).

Table 4 Mean sensory scores for high input and low input farm management plan strawberries assessed on hedonic line scale 8 and 9 November 2001

Sample	Odour$^{\infty NS}$	Appearance$^{\infty}$	Shape$^{\infty NS}$	Overall$^{\infty}$	Texture$^{\infty}$	Flavour$^{\infty}$
High Input	61 b	64b	67	63b	67b	62b
Low Input	51a	52a	64	44a	47a	43a
P value	0.043	0.001	0.225	0.001	0.001	0.001
LSD (5%)	8.8	5.4	4.9	3.5	3.1	3.8

Scale: Dislike extremely (0), Neither like nor dislike (50), Like extremely (100).
abc: Means within a column followed by a common letter are not significantly different (P > 0.05).
NS: Not significant (P > 0.05) and LSD is presented as a measure of variability.

Table 5 Mean sensory scores for high input and low input farm management plan strawberries assessed on just right line scales 8 and 9 November 2001

Sample	Firmness^	Juiciness^	Sweetness^	Acidity$^{\wedge NS}$	Ripesness$^{\#}$
High Input	49a	53b	43b	53	52b
Low Input	62b	43a	31a	56	42A
P value	0.001	0.001	0.001	0.139	0.001
LSD (5%)	4.6	3.1	3.1	4.3	3.2

^ Scale: Not enough of named attribute (0), Just right (50), Too much of named attribute (100).
\# Scale: Under ripe (0), Ideal (50), Overripe (100).
abc: Means within a column followed by a common letter are not significantly different (P > 0.05).
NS: Not significant (P > 0.05) and LSD is presented as a measure of variability.

Table 4 presents the results of the comparison between a high input (Kiewa and Camarosa) and a low input (Kiewa and Camarosa) farm management plan measured by the assessments completed on hedonic and 'just right' line scales.

Significant differences (P > 0.05) were found between the high input and low input farm management plans for the attributes odour, appearance, overall, texture and flavour rated on hedonic line scales (Table 4).

Where significant differences (P > 0.05) were found, samples from the high input plan were consistently liked more than samples from the low input management plan. This indicates that the high input farm management plan results in strawberry samples that are liked significantly more (P > 0.05) than samples from the low input farm management plan in terms of odour, appearance, overall, texture and flavour.

No significant difference (P > 0.05) was found between the high and low input farm management plans for the attribute shape rated on a hedonic line scale. This indicates that regardless of the farm management plan the likeability of the shape of the strawberry samples is not significantly affected.

From the factorial two-way analysis of variance, significant differences (P > 0.05) were found between the high input and low input farm management plans for the 'just right' attributes firmness, juiciness, sweetness and ripeness (Table 5).

A significant difference (P > 0.05) was found for the attribute firmness, where the high input farm had a mean sensory score of 49 close to 'just right' at 50. However, the mean sensory score for the low input farm was 62 indicating that the strawberry samples from a low input farm were slightly too firm.

A significant difference (P > 0.05) was found between the high and low farm management plans for juiciness. The high input plan had a mean sensory score of 53 close to 'just right'. However, the low input plan had a mean sensory score of 43 indicating the strawberry samples were slightly not juicy enough.

For sweetness, a significant difference (P > 0.05) was found between the high input and low input farm management plans with mean sensory scores of 43 and 31 respectively. These mean sensory scores indicate that both the high input and low input farm management plan strawberry samples were perceived to be slightly not sweet enough.

For the attribute ripeness, a significant difference (P > 0.05) was found between the high and low input management plans. The low input plan strawberry samples were perceived to be slightly under-ripe.

No significant difference (P > 0.05) was found between the high input and low input farm management plans for the attribute acidity (Table 5). This indicates that the farm management input does not affect the perceived levels of acidity as measured by the pseudo-consumer panellists.

Table 6 Mean sensory scores for Kiewa and Camarosa variety strawberries assessed on hedonic line scale 8 and 9 November 2001

Sample	Odour$^{\infty NS}$	Appearance$^{\infty}$	Shape$^{\infty NS}$	Overall$^{\infty}$	Texture$^{\infty}$	Flavour$^{\infty}$
Kiewa	59	61b	64	56b	60b	54b
Camarosa	53	54a	66	51a	64a	50a
P value	0.156	0.014	0.505	0.011	0.002	0.043
LSD (5%)	8.8	5.4	4.9	3.5	3.1	3.8

$^{\infty}$Scale: Dislike extremely (0), Neither like nor dislike (50), Like extremely (100).
abc: Means within a column followed by a common letter are not significantly different (P > 0.05).
NS: Not significant (P > 0.05) and LSD is presented as a measure of variability.

Table 7 Mean sensory scores for Kiewa and Camarosa variety strawberries assessed on just right line scales 8 and 9 November 2001

Sample	Firmness^	Juiciness^	Sweetness^	Acidity^NS	Ripesness#
Kiewa	53a	50b	38	53	49
Camarosa	58b	45a	37	56	46
P value	0.031	0.008	0.528	0.154	0.094
LSD (5%)	4.6	3.1	3.1	4.3	3.2

^ Scale: Not enough of named attribute (0), Just right (50), Too much of named attribute (100).
# Scale: Under ripe (0), Ideal (50), Overripe (100).
abc: Means within a column followed by a common letter are not significantly different (P > 0.05).
NS: Not significant (P > 0.05) and LSD is presented as a measure of variability.

Significant differences (P > 0.05) were found between the Kiewa and Camarosa strawberry varieties for the hedonic line scale attributes appearance, overall, texture and flavour (Table 6).

For appearance, texture and flavour as well as overall, as measured by hedonic line scales, the Kiewa strawberry variety was liked significantly more (P > 0.05) than the Camarosa variety. This indicates that the Kiewa strawberry variety is associated with higher likeability scores for appearance, texture, flavour and overall compared to the Camarosa variety.

There were no significant differences (P > 0.05) between the Kiewa and Camarosa varieties as measured by factorial analysis for the hedonic line scale attributes odour and shape (Table 6). This indicates that the strawberry variety (Kiewa or Camarosa) does not have a significant effect on the likeability of the odour or shape.

Significant differences (P > 0.05) were found between the Kiewa and Camarosa strawberry varieties for the 'just right' attributes firmness and juiciness (Table 7).

A significant difference (P > 0.05) was found between the two strawberry varieties for the attribute firmness. The Camarosa variety would be considered to be slightly too firm.

For the attribute juiciness, although a significant difference (P > 0.05) was found between the Kiewa and Camarosa samples, both had mean sensory scores close or equal to 'just right'.

There were no significant differences (P > 0.05) between the two strawberry varieties for the attributes sweetness, acidity and ripeness (Table 7). This indicates that the strawberry variety (Kiewa or Camarosa) does not have a significant effect on the perceived sweetness, acidity or ripeness as measures by pseudo-consumer panellists.

APPENDIX ONE - MEAN DATA FOR STRAWBERRY SAMPLES ACROSS REPLICATES

Mean sensory scores for Kiewa and Camarosa variety strawberries assessed on hedonic line scale 8 and 9 November 2001

Sample	Replicate	Odour[∞]	Appearance[∞]	Shape[∞]	Overall[∞]	Texture[∞]	Flavour[∞]
Kiewa High Input	1	66	66	65	69	66	68
	2	67	70	68	63	71	60
	3	66	64	66	59	67	58
Camarosa High Input	1	66	61	63	65	64	63
	2	59	61	68	64	68	64
	3	43	61	69	60	65	60
Kiewa Low Input	1	50	59	66	51	55	49
	2	52	53	59	46	51	44
	3	55	58	63	49	53	47
Camarosa High Input	1	55	53	70	46	40	41
	2	58	41	63	37	40	38
	3	43	47	62	37	43	37

[∞]Scale: Dislike extremely (0), Neither like nor dislike (50), Like extremely (100).

Just right line scale data for strawberry varieties assessed on 8 and 9 November 2001

Sample	Replicate	Firmness[^]	Juiciness[^]	Sweetness[^]	Acidity[^]	Ripeness[#]
Kiewa High Input	1	48	53	43	52	52
	2	46	50	43	50	50
	3	48	56	41	52	54
Camarosa High Input	1	51	54	46	53	56
	2	50	53	46	54	52
	3	50	50	41	55	50
Kiewa Low Input	1	62	49	31	53	45
	2	55	47	31	55	46
	3	59	47	35	54	46
Camarosa High Input	1	70	39	31	64	41
	2	68	36	28	56	40
	3	59	40	28	52	38

[^] Scale: Too little of named attributed (0), Just right (50), Too much of named attribute (100).
[#] Scale: Under ripe (0), Ideal (50), Overripe (100).

APPENDIX TWO - COMMENTS

Odour and appearance comments for strawberry samples assessed 8 and 9 November 2001

Session	Kiewa High Input
8 November Rep 1	• deep red in colour • fine • just average • looked hard and compressed - uneven colouring • not really a nice rounded shape - quite bumpy • quite large - probably joined • the appearance is very appealing because of its rich colour • very good appearance, average size • very good • very little odour, good sized strawberry although oddly shaped
8 November Rep 2	• a bit too dark in colour • bit discoloured and a bit deformed and leaves folding back again - otherwise looks good • looks and smells good • nicely rounded • quite average • smallish • smell good but not very strong, look pretty good • the shape makes it easiest to take a bite of all of the strawberry because of the long stem
9 November Rep 3	• appears to be a little overripe • colour a bit uneven, otherwise good • didn't like odour and colour not very good • leaves don't sit flat, and shape is bumpy • one sample was rounded on the end the other pointed, prefer pointed shape • quite large, uniform colour • slightly unusual shape around the leaves • strong strawberry flavour • weak typical odour plus moderate green odour

Odour and appearance comments for strawberry samples assessed 8 and 9 November 2001 continued

Session	Camarosa High Input
8 November Rep 1	• almost perfect size and shape • also perfect looking • average size, quite good colour, doesn't have particularly strong odour either way • looks and smells ripe • odour just a bit too strong • the ends are square rather than pointed • the shapes are a bit odd • these look very dark or over ripe, they have a very estery odour that is too intense • this sample seems to be quite good and I should say this is the best of the lot till now • too dark • uneven colouring and some seeds were black
8 November Rep 2	• cheesy odour • colour was appealing • don't like dark colour • lack typical odour and have a green/straw/hay type odour - look very good • over ripe smell • shape, odour and appearance is quite appealing • smells and looks ok • two different shapes so difficult to comment. size good • variation in colour and leaves fold back from fruit
9 November Rep 3	• dirty odour • good size, looks and smells nice • odour a bit too strong and colour not very appealing • slight mouldy odour • square ended rather than nice curved tips • stinky (wet wash cloth, fertiliser poo, yucky) odour, look very good • the shape and appearance I can say is normal • too dark

Odour and appearance comments for strawberry samples assessed 8 and 9 November 2001 continued

Session	Kiewa Low Input
8 November Rep 1	• bruised • good colour and shape - little small • it doesn't look fresh, the shape and size are good and even • low odour, colour and shape good • no odour - especially not a strawberry odour - maybe chemical • these smell like green bananas, they look a bit over ripe and have a slightly rough shape • this sample is also quite hard to bite • very little odour and appearance is a bit too red for my liking
8 November Rep 2	• a bit dark and dull • colour too dark • good but like the leaves too wrapped around the fruit • good to look but normal to taste • leaf material on strawberries are brown in colour - strawberries didn't look nice at all • leafy part too small • plastic odour • small, but look and smell ok • smallish • these look very dark or over ripe, they have a green/sappy type of odour which isn't very strong • too dark
9 November Rep 3	• didn't like the odour very much and colour not very good • dirty odour • good size, smells ok • surface was quite bumpy • too dark • very dull odour, not appealing or fresh

Odour and appearance comments for strawberry samples assessed 8 and 9 November 2001 continued

Session	Camarosa Low Input
8 November Rep 1	• a bit too dark and dull • bit hard to bite and just ok, but quite juicy • don't like the dark colour • look a little too small and dark • nice rounded shape and pointed tip • perfect looking • slightly dark • small in size, but looks and smells fine • the colour looks a bit patchy • these look very dark or over ripe, otherwise smell good and have good shape • too dark - leaves dead • too dark in colour so not very appealing • very dark red, looked a bit old & tired
8 November Rep 2	• colour too dark • dark • dark in colour • don't like dark colour, it looks as though strawberries are old and bruised • it looks very dry • no sweet odour at all, looked a little small and hard • old & tired looking dark red colour • there was no odour and the appearance was very poor • these look over ripe and are a little small • too dark • too dark and old - leaves look dead • too dark in colour- looks old • too small and flat • very small
9 November Rep 3	• colour not very good • good size • lacked fresh odour, sun burnt appearance dark uncharacteristic colour • look like they have been in cold storage for years - leaves browning and strawberries are dull and dark • odour so strong did not taste • small • smells and looks good, uniform in colour • too dark • very dark strawberries • very poor stinky type odour, look over ripe/very dark

General comments on strawberry samples assessed 8 and 9 November 2001

Session	Kiewa High Input
8 November Rep 1	• fantastic- where can I buy strawberries like this ? • felt funny in the mouth • one was tasteless and one was very sweet • very nice taste. ripe and juicy • these strawberries were perfect in my opinion • not much flavour • again, very tasteless
8 Nov Rep 2	• lacked flavour and sweetness • one had no flavour at all and one was sweet • slightly over-ripe, but good taste • not the best but ok • delicious • hardly any taste • not bad but lacking sweetness, overall appearance good • very tasteless and watery- like normal shop strawberries
9 Nov Rep 3	• not much flavour - very bland, not sweet enough • one was too acidic and one was beautiful • tasted okay but outside seemed a bit rough in texture • strawberry flavour overall was too bland • a little over-ripe, but nice taste • not sweet at all but quite juicy, but furry feeling in the mouth • the best of the 4 but still lacking a little sweetness

General comments on strawberry samples assessed 8 and 9 November 2001

Session	Camarosa High Input
8 November Rep 1	• perfect all round • not particularly flavoursome • one was a bit sour, the other tasted good • not much flavour and the acidity was not to my liking • these were very sweet, some may say too sweet but I actually like them like this - very strong full flavour but just lacks a little acidity • this sample is good • one was a bit tart and hard- the other soft and juicy • bitter
8 November Rep 2	• a slight dirty background flavour • could have been a bit sweeter • this sample had the right texture and felt quite good in the mouth • good taste and texture • a damn good strawberry • very nice - looked good and tasted even better • not sweet and very acidic • strange flavour in one of the samples • the two strawberries were completely different, one over ripe the other under ripe
9 November Rep 3	• seeds too hard, dirty flavour • slightly over-ripe, acidic • tasted better than it looked • good colour but slightly under ripe taste • very intense concentrated strawberry flavour and some bad stinky type flavours • overall it was ok but could have been a little bit more sweet • little bit acidic, not sweet enough • one strawberry in particular was very acidic • one sweeter - one more acidic and both hollow in the middle but tasted quite good • quite reasonable

General comments on strawberry samples assessed 8 and 9 November 2001

Session	Kiewa Low Input
8 November Rep 1	• very bland taste, no sweetness • bland taste, under-ripe • left a furry feeling inside my mouth - no flavour or smell – yuk • one sample was much worse than the other but the overall average is still pretty bad. I don't like this sample, poor flavour, texture and mouth feel • did not like the taste of the sample • lacked flavour • quite astringent • very low on taste
8 November Rep 2	• lacked flavour and sweetness • one sweet - one sour - had a bug crawled out of it • very, very average • lack flavour • slightly under-ripe • very seedy and gritty • looks ok but disappointing in terms of flavour, lacking sweetness • tasteless and a little gritty • watery hardly any taste
9 November Rep 3	• didn't like this strawberry at all • seeds very prominent, unclean flavour • slightly acidic • not good, lacked flavour and appeal • no taste - very bland • overall average but should have been a little bit more sweet • slightly gritty seeds, slightly lacks sweetness, fairly tart otherwise very good • they look really ripe but tasted under ripe

General comments on strawberry samples assessed 8 and 9 November 2001

Session	Camarosa Low Input
8 November Rep 1	• outside was a bit too gritty • overall it is ok • lacking sweetness, also has floury texture, not particularly appealing • hollow in the centre • too under-ripe, bland taste • terrible • these were way too firm and had lots of very hard seeds that were very coarse to chew • left an aftertaste in my mouth- sort of furry • didn't like this strawberry at all • appeared ripe but when you take a bite of the strawberry they are firm and have a strange flavour • these two samples were quite different to each other
8 November Rep 2	• not very good • it left you with a funny taste • not a good eating experience, not sweet at all • very poor taste, disliked the most • terrible - too hard, tart and no flavour and looks awful • gritty • the surface had a bit of a strange feel, maybe because of an unusually high number of pips • very similar to sample 189 - leaf material not bright green in colour - very acidic
9 November Rep 3	• lacked flavour, juiciness and sweetness • surprising, had some flavour but lacked required sweetness, slight green taste • slightly deformed, uneven colour and hollow in the middle • odour so strong did not taste • under-ripe, lacks flavour • very tart and floury mouth feel, concentrated and intense strawberry flavour and also some bad/yucky type flavours • this sample was too sour and hard to bite, I don't like when it is too sour • too gritty

6.1.5 Results 3 – Report on consumer evaluations at fresh retail outlets

Dennis Phillips, Kelly Hulcup and Geraldine Pasqual

Introduction

A new strawberry variety Kiewa (previously 95-041-19) bred in Victoria has been selected and commercialised in WA.

If Kiewa is competitive in flavour and appearance during the season compared with traditional varieties then growers would be more confident to:

- fast-track the commercialisation of the variety; and
- ensure that it was differentiated in the market place so that customers could identify it.

Aim

To conduct preliminary assessments from September to December of consumer preference for Kiewa compared with traditional varieties (Camarosa/Selva) in terms of taste and appearance.

Methodology

Customers of fruit and vegetable specialty shops were asked which strawberry variety they preferred on the basis of taste and looks about every two weeks from September to December 2001:

Location	Dates
Fresh Today	September 21-22, 2001
Fresh Today	October 4-6, 2001
Karrinyup Fresh	October 18-19
Herdsman Fresh, Wembley	November 1-2, 2001
Boatshed Market	November 22-23, 2001
Midland Fresh	December 6-7, 2001

Consumers were surveyed for their preferences in:

- Taste - consumers tasted non-labelled, cut fruit samples of Kiewa and a traditional variety (Camarosa or Selva)
- Appearance - consumers looked at non-labelled whole fruit samples of Kiewa and a traditional variety (Camarosa or Selva).

Post November 1, 2001 customers were also asked which variety they would buy.

Fruit for each survey session were provided by one grower and therefore could be assumed grown under similar conditions.

These trials were not designed for statistical evaluation but represent a first attempt to address the issue of consumer response to a new variety.

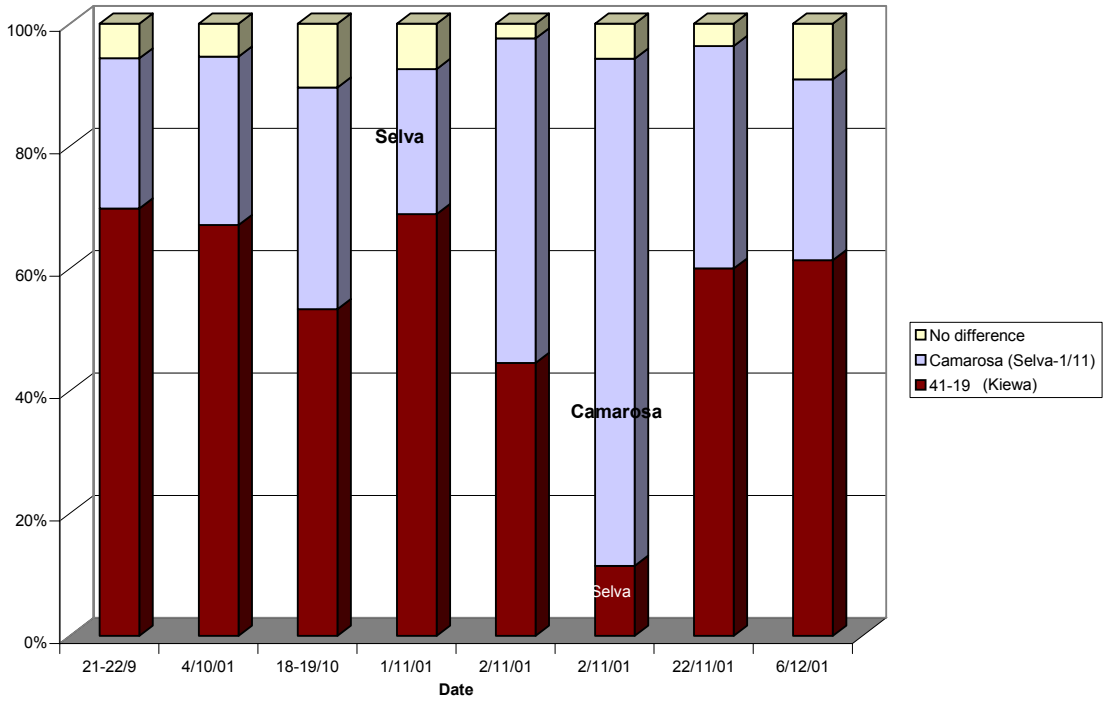
Results

Taste preference

- Kiewa outperformed Camarosa and Selva (1/11/01) consistently from September to December - with higher preference for Camarosa only on 2/11/01.

- Kiewa taste preference showed a downward trend from 21/9/01 to 2/11/01, which may reflect detrimental effects of climate on fruit quality during the season.

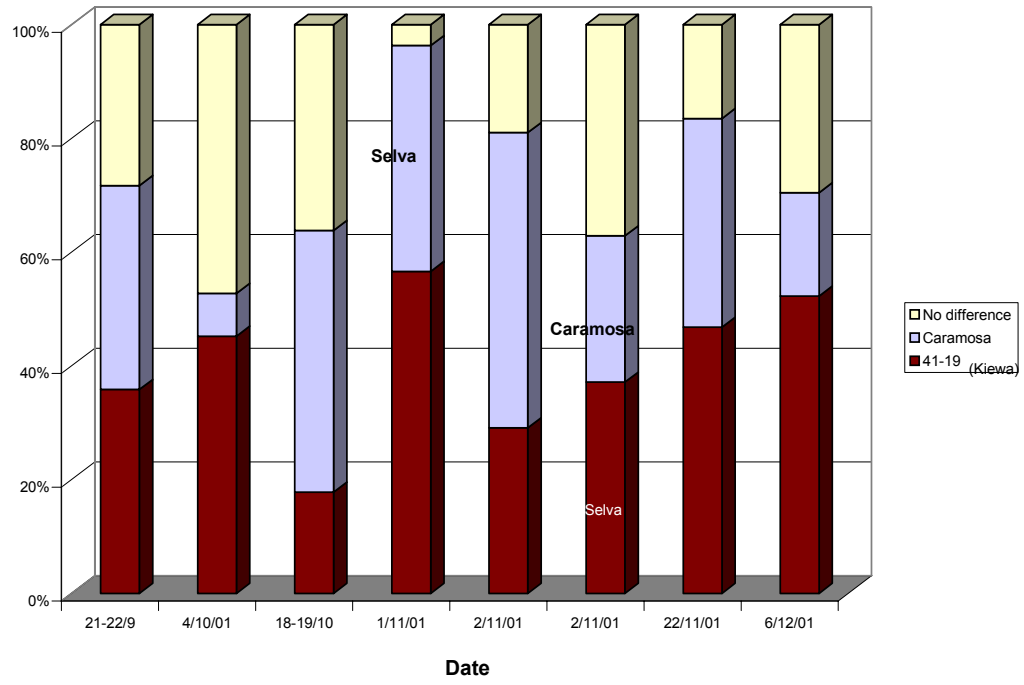
Figure 1: Consumer Taste Preference



Appearance preference

- Results are variable - consumers often unable to offer a preference on the basis of looks. Kiewa outperformed Camarosa or Selva on 5 of 7 dates.

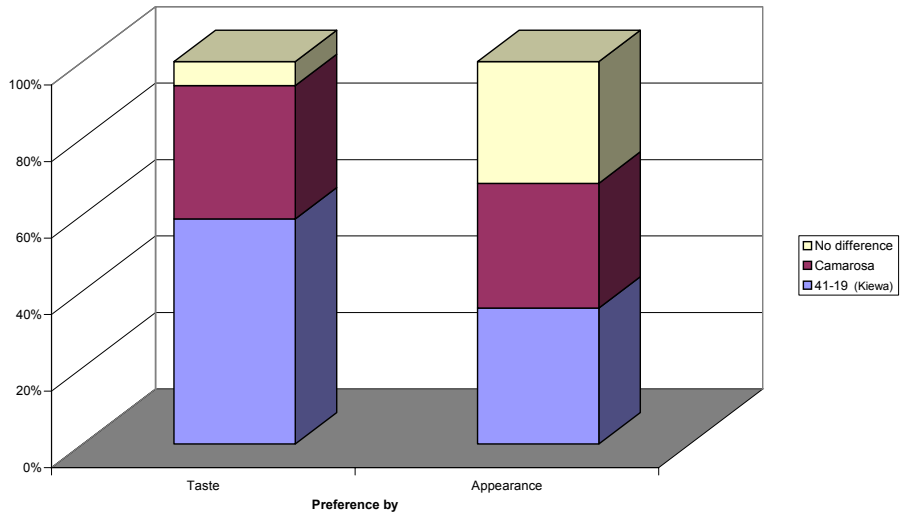
Figure 2: Appearance Preference



Overall preference

- More consumers preferred the taste of Kiewa compared with Camarosa over all dates and survey locations.
- Over all dates and survey locations, one third of consumers preferred the looks of Kiewa, another third preferred Camarosa and the final third could not find a difference in appearance to make a decision.

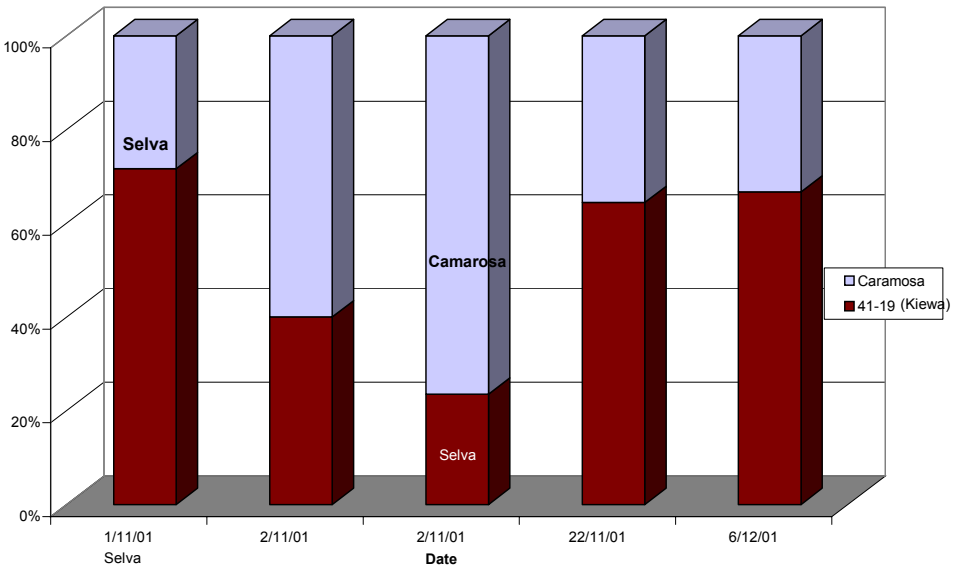
Figure 3: Overall consumer preference



Preference to buy

- Comparing the results depicted in Figures 1 and 2 with that in Figure 4 it is evident that the propensity to buy a particular variety is linked strongly to its taste rather than appearance. For example Kiewa is greatly preferred by taste over Selva on 1/11/01 and this is reflected by a strong inclination to buy Kiewa ever though preference by appearance was not strong.

Figure 4: Buy preference



Conclusions

- Kiewa is competitive in flavour and appearance from September to December compared with Camarosa (and with Selva at one date).
- It is difficult for consumers to make a preferential decision based on appearance of Kiewa and Camarosa.
- Consumers are more inclined to buy based on taste rather than looks.
- More consumers preferred the taste of Kiewa compared with Camarosa over all dates and survey locations so it is important that they are able to easily identify Kiewa in the marketplace.

Acknowledgments

Participating retailers for surveying opportunities and Strawberry Growers Association for organising fruit supply.

6.2 2002 RESEARCH

6.2.1 Introduction

The results of the work in 2001 convinced us that Kiewa was competitive in yield and consumer appeal to the best alternative in the market at the time ie Camarosa. The focus of the work in 2002 changed to identifying the effects of plant nutrition on fruit flavour and consumer appeal using fruit from the Medina trial (Chapter 5) and getting consumer feedback on how best to market the variety. The results of three consumer evaluations of fruit from the nutrition trials at the Curtin University sensory laboratory in Perth are reported on here, together with the results of a 'consumer focus group session' mediated by Fresh Finesse.

6.2.2 Aims

The aims in 2002 were:

- To identify the effects of nitrogen fertiliser practice on fruit flavour and quality through sensory laboratory tests.
- To get consumer feedback on how best to position Kiewa in the market after its release and widespread availability to consumers through a 'focus group' session.

6.2.3 Materials and methods - Field and laboratory

Fully ripe fruit was harvested from four of the eight treatments in the fertiliser trial at Medina Research Station on three dates for sensory testing at Curtin University's sensory laboratory. The treatments chosen spanned the range of nitrogen rates tested in the trial, including 50N, 450N, 900N and 450N + 50FM as described in chapter 5. Approximately 50 ripe fruit of uniform size was harvested from each of the four replicates of these four treatments from within the 48 plant buffer area of each treatment, so as not to disrupt yield assessments from the trial. The dates of harvest were September 16, October 14 and November 11 and 14.

Fruit was transported direct to the Curtin laboratory in the afternoon of harvest and coolstored overnight for testing the following day or the day after depending on the availability of tasters. All taste panel tests were conducted on consecutive days at each time except for the test in November that was done on two dates in the same week, November 12 and November 15 with two replicates from the trial tested on each date. The fruit for the tests on November 12 was harvested on November 11 and that for the two replicates on November 15 was harvested on November 14.

For all sensory tests, tastings were divided into four sessions, AM and PM on two days as described above. For the September tests, all four replicates of each of the four treatments were tasted at each session ie everyone tasted four replicates of treatment 1in the morning and returned for the afternoon session taste all four replicates of treatment 2 etc. In October and November, one replicate of all four treatments was tasted at each session.

In September, all fruit was cut in half prior to tasting, and each taster tested one half and another taster the other half. A longditudinal sliver was cut from the middle of each berry for brix testing in September only. By

November, there was enough fruit available for all tasters to taste whole fruit instead of cut pieces as for the earlier months.

On October 6 2002, a consumer focus group session was convened by Shane Dodd from Fresh Finesse on behalf of the project. The session was attended by eight female consumers ranging in age from early twenties to fifties. The group discussed various aspects of strawberry purchasing and preferences, with the aim of developing a future marketing strategy for Kiewa when it becomes more widely available, and for better strawberry marketing practices generally.

Detailed methods used in the sensory laboratory together with the results of each of the three tests and the 'focus group' session are documented in the following reports:

6.2.4 Results 1 – Report on Sensory Testing at Curtin University September 2002

REPORT OF STRAWBERRY TASTING CURTIN UNIVERSITY SENSORY LABORATORY - TEST 1

SUBMITTED TO

DENNIS PHILLIPS

DEPARTMENT OF AGRICULTURE WESTERN AUSTRALIA

BY

VIJAY JAYASENA

CURTIN UNIVERSITY OF TECHNOLOGY

TESTS CONDUCTED SEPTEMBER 17 AND 18, 2002

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1. MATERIALS AND METHODS

1.1 Samples

Strawberry samples, grown at Medina Research Station in WA, were supplied for tasting by Dennis Phillips at the Department of Agriculture of Western Australia (DAWA). A total of 16 samples (4 treatments x 4 replicates) were evaluated (Table 1).

Table 1. Treatment details

Treatment code	Replicates	Pre-plant NPK	Fertigation NPK	Fowl manure
T1	R1, R2, R3, R4	0:180:100	50:0:350	No
T4	R1, R2, R3, R4	0:180:100	450:0:350	No
T7	R1, R2, R3, R4	0:180:100	900:0:350	No
T8	R1, R2, R3, R4	0:180:100	450:0:350	Yes (50 m3/ha)

1.2 Venue and dates

The sensory evaluation was conducted at the Department of Food Science & Technology at Curtin University of Technology in 4 sessions. Details of the sessions are given in Table 2.

Table 2. Session details

Session	Date	Time
1	Tue, 17 Sep 2002	10:00 - 11:00 am
2	Tue, 17 Sep 2002	3:00 - 4:00 pm
3	Wed, 18 Sep 2002	10:00 - 11:00 am
4	Wed, 18 Sep 2002	3:00 - 4:00 pm

1.3 Number of participants

The agreement was to conduct the sensory evaluation trial with 30 participants. However, a total of 40 participants, who like strawberries and consumed regularly, were recruited for the study.

1.4 Method of sensory evaluation

1. The samples were stored in a cool room at 8ºC.
2. The samples were taken out from the cool room 2 hours before tasting and kept at the room temperature.
3. Strawberries were washed and dried on absorbent kitchen paper prior to serving.
4. Samples were identified by a 3-digit random number for the tasting.
5. Strawberries were cut into halves and each panelist received approximately 1/2 of a fruit for tasting.
6. Small slice of each fruit was collected for the determination of brix value.
7. Each panelist evaluated 4 strawberry samples during one session.
8. The colour of the samples was masked using coloured lighting.
9. The evaluation of the samples took place in accordance with International Standards on Sensory Evaluation.
10. The samples were evaluated using the '9-Point Hedonic Scale' and 'just about right scale' as requested by WADA (A sample questionnaire is attached).

11. Panelists were asked to take a bite of a cracker and a sip of water 'to cleanse their palate' before tasting each sample.

12. Attributes used for the study were:
    - **Ripeness:** 'Just about right' scale from 'not ripe' to 'too ripe'
    - **Sweetness:** 'Just about right scale from 'not sweet enough' to 'much too sweet'
    - **Acidity:** 'Just about right' scale from 'not acidic enough' to 'much too acidic'
    - **Juiciness:** 'Just about right scale' from 'not juicy enough' to 'much too juicy'
    - **Firmness:** 'Just about right' scale from 'not firm enough' to 'much too firm'
    - **Texture:** Nine-Point Hedonic scale from 'dislike extremely' to 'like extremely'
    - **Aroma:** Nine-Point Hedonic scale from 'dislike extremely' to 'like extremely'
    - **Flavour:** Nine-Point Hedonic scale from 'dislike extremely' to 'like extremely'
    - **Overall acceptability:** Nine-Point Hedonic scale from 'dislike extremely' to 'like extremely'

1.5 Ideal strawberry

One section of the questionnaire refereed to ideal strawberries, strawberries that may not exist now, but the strawberries that participants would like to have. Nine-point Hedonic scale was used with sweetness, acidity/sourness, juiciness and firmness/hardness as attributes.

1.6 Data analysis

Excel for data tabulation and SPSS statistical package for data analysis were used. Duncan Multiple Range Test (DMRT) was used for treatment means comparison.

Preparing fruit for sensory testing at curtin university september 2002.

2. RESULTS

2.1 Demographic data

2.1.1 Gender

The total number of participants was 37 with 32 % males and 68 % females (Table 2.1).

Table 2.1. Gender

	No. of Participants	%
Male	12	32.4
Female	25	67.6
Total	37	100

2.1.2 Age group

Table 2.2 shows that 24 % of the participants were in the age group of 18-25 years, 19 % of the participants were between the age group of 26-35 years, 32 % in the age group of 36-45 years and 22 % in the age group of 46-55 years. Only 3 % of the participants were in the age group of 56-65 years.

Table 2.2. Age group

Age group	No. of Participants	%
18 – 25	9	24.3
26 – 35	7	18.9
36 – 45	12	32.4
46 – 55	8	21.6
56 – 65	1	2.7
Total	37	100

2.1.3 How often participants consume strawberries

It was found that 57 % of the participants consume strawberries once a week and 22 % of the participants consumed 2-4 strawberries a week. About 14 % consume 5-8 strawberries a week and 8 % of the participants consume more than 8 strawberries a week (Table 2.3).

Table 2.3. Frequency of strawberry consumption

Frequency	No. of Participants	%
Once a week	21	56.8
2-4 strawberries a week	8	21.6
5-8 strawberries a week	5	13.5
More than 8 strawberries a week	3	8.1
Total	37	100

2.1.4 Why strawberries are usually consumed

Participants were asked to select more than one option if appropriate. It was found that the flavour is the main reason for strawberry consumption. As illustrated in the Table 2.4, 89 % of the participants reported that they consume strawberries due to the flavour.

Nutritional benefits and texture also play an important role in strawberry consumption. The result showed that 54 % consumed strawberries for the nutritional benefits.

Table 2.4. Reasons for eating strawberries

	No. of Participants	% answered
Flavour	33	89.2
Texture	20	54.1
Nutritional benefits	20	54.1
Appearance	18	48.6
Inexpensive/Best value	6	16.2
Other	0	0.0

2.1.5 Different ways of consuming strawberries

Depending on consumer's preferences, there are different ways by which strawberries can be consumed. Fresh strawberry seems to be the most common way of strawberry consumption. All participants consume fresh strawberries (Table 2.5). Only a small percentage of participants consume strawberries in various other forms.

Table 2.5. Different ways of consuming strawberries

	No. of Participants	% answered
Fresh	37	100
Cooked/processed	3	8.1
Fresh and cooked	2	5.4
Juiced	3	8.1

2.2 Ideal strawberry

The participants were asked to rate their ideal strawberry according to sweetness, acidity, juiciness and firmness.

2.2.1 Sweetness

The result showed that the consumers prefer sweet strawberries (Table 2.6). None of the participants would like to have less sweet strawberries.

Table 2.6 Sweetness

Scale	No. of responses	%
1 - Not sweet	0	0.0
2	0	0.0
3	0	0.0
4	0	0.0
5	0	0.0
6	7	21.9
7	12	37.5
8	6	18.8
9 - Very Sweet	7	21.9
Total	32	100

2.2.2 Acidity

The majority of the participants indicated that they like less sour strawberries (Table 2.7). However, 38% of the participants like the strawberries to be a little acidic. It seems like sweet-sour taste is the consumer preference for strawberries. Almost 90% of the participants prefer less acidic strawberries.

Table 2.7 Acidity

Scale	No. of responses	%
1 - Not sour	6	18.8
2	2	6.3
3	6	18.8
4	3	9.4
5	12	37.5
6	2	6.3
7	1	3.1
8	0	0.0
9 - Very sour	0	0.0
Total	32	100

2.2.3 Juiciness

Almost 1/3 of the panelists recorded that they would like to have very juicy strawberries (rated 9/ 9). None of the participants prefer less juicy strawberries (Table 2.8).

Table 2.8 Juiciness

Scale	No. of responses	%
1 - Not juicy	0	0.0
2	0	0.0
3	0	0.0
4	0	0.0
5	7	21.9
6	7	21.9
7	6	18.8
8	2	6.3
9 - Very juicy	10	31.3
Total	32	100

2.2.4 Firmness

For the firmness of their ideal strawberry, most of the participants like the strawberries to be ‘not too soft’ (Table 2.9).

Table 2.9 Firmness

Scale	No. of responses	%
1 - Very soft	0	0.0
2	2	6.3
3	4	12.5
4	3	9.4
5	11	34.4
6	6	18.8
7	5	15.6
8	1	3.1
9 - Very hard	0	0.0
Total	32	100

2.3 Results of sensory evaluation

2.3.1 Ripeness - Just about right scale

There was no significant difference between T1, T4 and T7 (Table 2.10). Ripeness rating for T8 was significantly lower than T1 and T4.

Table 2.10 Treatment, means and 95% Confidence Intervals for ripeness

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	5.014 a	0.062	4.875	5.154
T4	5.042 a	0.062	4.902	5.182
T7	4.905 ab	0.062	4.765	5.045
T8	4.715 b	0.062	4.575	4.855

Means with same letters are not significantly different ($\alpha = 0.05$)

2.3.2 Sweetness - Just about right scale

There was no significant difference between T1, T4 and T7 (Table 2.11). Sweetness of T1 was significantly higher that that of T8. Sample T8 was rated as the least sweet sample.

Table 2.11 Treatment, means and 95% Confidence Intervals for sweetness

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	4.604 a	0.139	4.290	4.918
T4	4.236 ab	0.139	3.922	4.550
T7	4.182 ab	0.139	3.869	4.496
T8	4.027 b	0.139	3.713	4.341

Mean with same letters are not significantly different ($\alpha = 0.05$)

2.3.3 Acidity - Just about right scale

There was no significant difference between treatments (Table 2.12).

Table 2.12 Treatment, means and 95% Confidence Intervals for acidity

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	5.181 a	0.091	4.975	5.386
T4	5.215 a	0.091	5.009	5.420
T7	5.156 a	0.091	4.950	5.361
T8	5.394 a	0.091	5.188	5.599

Means with same letters are not significantly different ($\alpha = 0.05$)

2.3.4 Juiciness - Just about right scale

There was no significant difference in juiciness between treatments (Table 2.12).

Table 2.13 Treatment, mean and 95% Confidence Interval for juiciness

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	4.817 a	0.081	4.633	5.001
T4	4.778 a	0.081	4.593	4.962
T7	4.689 a	0.081	4.505	4.873
T8	4.736 a	0.081	4.551	4.920

Means with same letters are not significantly different ($\alpha = 0.05$)

2.3.5 Firmness - Just about right scale

There was no significant difference in firmness between treatments (Table 2.14). Firmness was just about right for all samples.

Table 2.14 Treatment, means and 95% Confidence Intervals for firmness

Treatment	Mean	Std. error	95% Confidence Interval	
			Lower Bound	Upper Bound
T1	5.050 a	0.063	4.906	5.193
T4	4.958 a	0.063	4.815	5.102
T7	5.162 a	0.063	5.019	5.306
T8	4.986 a	0.063	4.843	5.130

Means with same letters are not significantly different ($\alpha = 0.05$)

2.3.6 Texture - Nine point hedonic scale

Texture rating for T1 and T4 were significantly better than T7 and T8. T1 was rated as the best and T8 as the worst according to the texture profile (Table 2.15).

Table 2.15 Treatment, means and 95% confidence intervals for texture

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	6.833 a	0.090	6.629	7.038
T4	6.806 a	0.090	6.601	7.010
T7	6.345 b	0.090	6.140	6.549
T8	6.089 b	0.090	5.884	6.293

Means with same letters are not significantly different ($\alpha = 0.05$)

2.3.7 Aroma - Nine point hedonic scale

Results showed T1 was significantly better than T7 and T8 (Table 2.16) according to the aroma profile. Sample T1 had the best and T8 had the worst aroma profile.

Table 2.16 Treatment, means and 95% confidence intervals for aroma

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	6.660 a	.099	6.436	6.883
T4	6.361 ab	.099	6.138	6.585
T7	6.270 b	.099	6.047	6.494
T8	6.108 b	.099	5.885	6.332

Means with same letters are not significantly different ($\alpha = 0.05$)

2.3.8 Flavour - Nine point hedonic scale

Flavour profiles of samples were similar to aroma profiles. T1 was rated as the best and T8 as the worst (Table 2.17).

Table 2.7 Treatment, mean and 95% confidence interval for flavour

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	6.681 a	.153	6.335	7.026
T4	6.514 a	.153	6.168	6.860
T7	6.270 ab	.153	5.925	6.616
T8	5.831 b	.153	5.485	6.177

Means with same letters are not significantly different ($\alpha = 0.05$)

2.3.9 Overall acceptability- Nine point hedonic scale

Results showed that samples T1, T4 and T7 were equally acceptable with no significant difference between samples. Sample T8 was rated significantly lower than the other three samples (Table 2.18).

Table 2.18 Treatment, means and 95% confidence intervals for overall acceptability

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	6.673 a	.086	6.479	6.868
T4	6.611 a	.086	6.417	6.806
T7	6.426 a	.086	6.231	6.620
T8	5.682 b	.086	5.488	5.877

Means with same letters are not significantly different ($\alpha = 0.05$)

2.4 Brix value

Treatments T1 and T4 had significantly higher brix values than T7 and T8. There was no significant difference between T1 and T4. Brix value of T7 was similar to T8 (Table 2.19).

Table 2.19 Treatment, means and 95% confidence intervals for brix value

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	9.182 a	.222	8.679	9.685
T4	9.275 a	.222	8.772	9.778
T7	8.153 b	.222	7.650	8.656
T8	7.959 b	.222	7.456	8.462

Means with same letters are not significantly different ($\alpha = 0.05$)

2.5 Relationships between Brix value and sensory attributes

- Poor correlation ($R^2 = 0.52$) was observed between the brix value and overall acceptability (Figure 1).

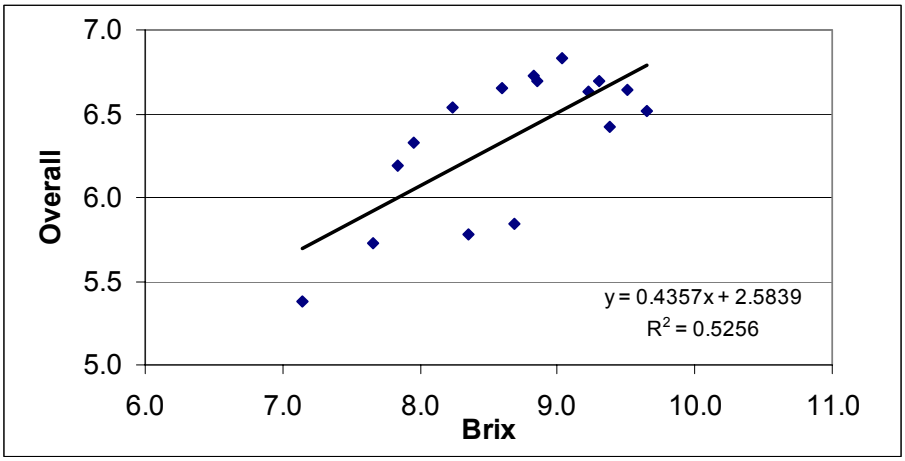


Figure 1. Correlation between Brix level of fruit and overall acceptability of fruit.

- Poor correlation ($R^2 = 0.45$) was observed between the brix value and sweetness (Figure 2).

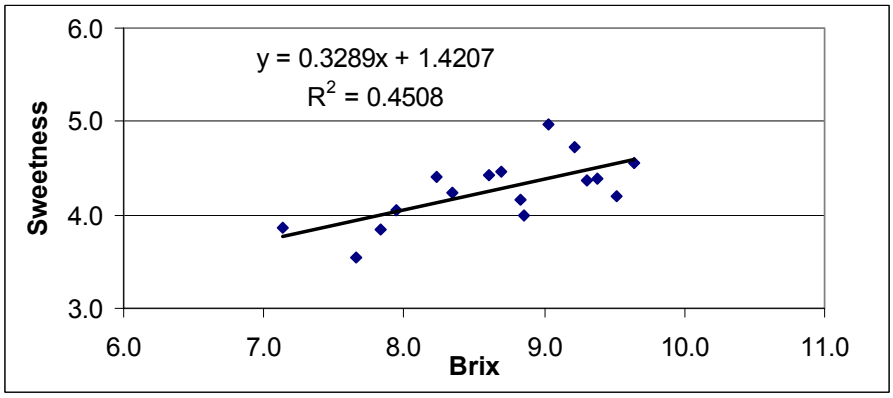


Figure 2. Correlation between Brix level and sweetness of fruit

- Better, but not strong, correlation ($R^2 = 0.66$) was observed between the brix value and flavour (Figure 3).

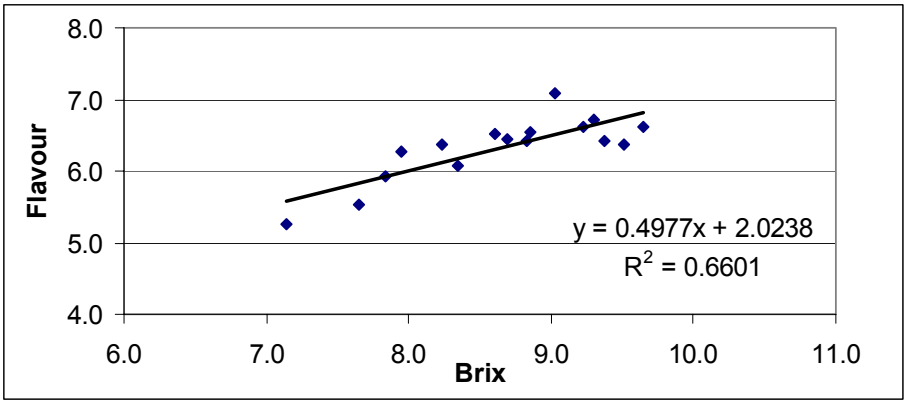


Figure 3. Correlation between Brix level and flavour of fruit

- All other attributes showed poor correlation with the brix value.

3. CONCLUSIONS

- Treatments showed significant differences in all attributes tested except acidity, juiciness and firmness.
- Treatments T1 and T4 were rated as the best 2 samples according to the consumer acceptability.
- Consumers rated T8 as the least acceptable sample.
- The brix value was not correlated to any of the attributes except the flavour.
- Very sweet, less acidic and very juicy strawberries are the most preferred strawberries.

Brix value - refractometer

6.2.5 Results 1 - Report on Sensory Testing at Curtin University October 2002

REPORT OF STRAWBERRY TASTING CURTIN UNIVERSITY SENSORY LABORATORY - TEST 2

SUBMITTED TO

DENNIS PHILLIPS

DEPARTMENT OF AGRICULTURE WESTERN AUSTRALIA

BY

VIJAY JAYASENA

CURTIN UNIVERSITY OF TECHNOLOGY

TESTS CONDUCTED OCTOBER 16 AND 17, 2002

TABLE OF CONTENTS

1. MATERIALS AND METHODS

1.1 Samples

Strawberry samples, grown at Medina Research Station in WA, were supplied for tasting by Dennis Phillips at the Department of Agriculture of Western Australia (DAWA). A total of 16 samples (4 treatments x 4 replicates) were evaluated (Table 1).

Table 1. Treatment details

Treatment code	Replicates	Pre-plant NPK	Fertigation NPK	Fowl manure
T1	R1, R2, R3, R4	0:180:100	50:0:350	No
T4	R1, R2, R3, R4	0:180:100	450:0:350	No
T7	R1, R2, R3, R4	0:180:100	900:0:350	No
T8	R1, R2, R3, R4	0:180:100	450:0:350	Yes

1.2 Venue and dates

The sensory evaluation was conducted at the Department of Food Science & Technology at Curtin University of Technology in 4 sessions. Details of the sessions are given in Table 2.

Table 2. Session details

Session	Date	Time
1	Wed, 16 October 2002	10:00 - 11:00 am
2	Wed, 16 October 2002	3:00 - 4:00 pm
3	Thu, 17 October 2002	10:00 - 11:00 am
4	Thu, 17 October 2002	3:00 - 4:00 pm

1.3 Number of participants

The agreement was to conduct the sensory evaluation trial with 30 participants. However, a total of 36 participants, who like strawberries and consumed regularly, were recruited for the study.

1.4 Method of sensory evaluation

1. The samples were stored in a cool room at 8ºC.
2. The samples were taken out from the cool room 2 hours before tasting and kept at the room temperature.
3. Strawberries were washed and dried on absorbent kitchen paper prior to serving.
4. Samples were identified by a 3-digit random number for the tasting.
5. Strawberries were cut into halves and each panelist received approximately 1/2 of a fruit for tasting.
6. Small slice of each fruit was collected for the determination of brix value.
7. Each panelist evaluated 4 strawberry samples during one session.
8. The colour of the samples was masked using coloured lighting.
9. The evaluation of the samples took place in accordance with International Standards on Sensory Evaluation.
10. Panelists were asked to take a bite of a cracker and a sip of water ‘to cleanse their palate’ before tasting each sample.

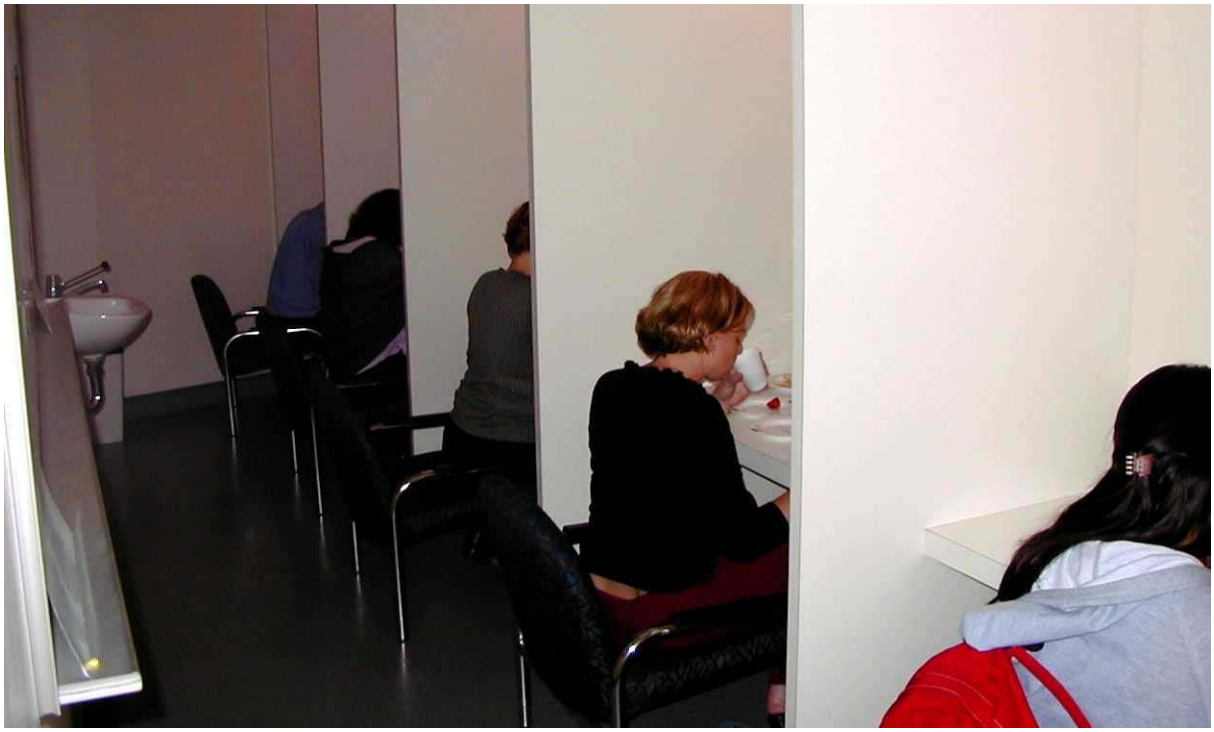
11. The following attributes were use for the study with 9-Point hedonic scale ('dislike extremely' to 'like extremely'):
    - Sweetness
    - Acidity/sourness
    - Juiciness
    - Texture
    - Flavour/aroma
    - Overall acceptability

1.5 Ideal strawberry

One section of the questionnaire refereed to ideal strawberries, strawberries that may not exist now, but the strawberries that participants would like to have. Nine-point Hedonic scale was used with sweetness, acidity/sourness, juiciness and firmness/hardness as attributes.

1.6 Data analysis

Excel for data tabulation and SPSS statistical package for data analysis were used. Duncan Multiple Range Test (DMRT) was used for treatment means comparison.



Tasting Kiewa fruit at Curtin University Sensory Laboratory, October 2002.

2. RESULTS

2.1 Demographic data

2.1.1 Gender

The total number of participants was 33 with 27% males and 73% females (Table 2.1).

Table 2.1. Gender

	No. of Participants	%
Male	9	27.3
Female	24	72.7
Total	**33**	**100**

2.1.2 Age group

Table 2.2 shows that 33% of the participants were in the age group of 18-25 years, 18% of the participants were between the age group of 26-35 years, 18% in the age group of 36-45 years and 27% in the age group of 46-55 years. Only 3% of the participants were in the age group of 56-65 years.

Table 2.2. Age group

Age group	No. of Participants	%
18 – 25	11	33.3
26 – 35	6	18.2
36 – 45	6	18.2
46 – 55	9	27.3
56 – 65	1	3.0
Total	**33**	**100**

2.1.3 How often participants consume strawberries

It was found that 42% of the participants consume strawberries once a week and 32% of the participants consumed two strawberries a week (Table 2.3).

Table 2.3. Frequency of strawberry consumption

Frequency	No. of Participants	%
Once a week	14	42.4
2 times a week	11	33.3
More than two strawberries a week	8	24.3
Total	**33**	**100**

2.1.4 Why strawberries are usually consumed

For this question, participants were asked to select more than one option if appropriate. It was found that the flavour is the main reason for strawberry consumption. As illustrated in the Table 2.4, 88% of the participants reported that they consume strawberries due to the flavour.

Texture and nutritional benefits also play an important role in strawberry consumption. The result showed that 55% consumed strawberries for the nutritional benefits.

Table 2.4. Reasons for eating strawberries

	No. of Participants	% answered
Flavour	29	87.9
Texture	21	63.6
Appearance	18	54.5
Inexpensive/Best value	6	18.2
Nutritional benefits	16	48.5
Other	0	0.0

2.1.5 Different ways of consuming strawberries

Depending on the consumers, there are different ways by which strawberries can be consumed. Fresh strawberry seems to be the most common way of strawberry consumption. All participants consume fresh strawberries (Table 2.5). Only a small percentage of participants consume strawberries in various other forms.

Table 2.5. Different ways of consuming strawberries

	No. of Participants	% answered
Fresh	29	87.9
Fresh with another desert	15	45.5
Cooked/processed	0	0
Both fresh and cooked	4	12.1
Juiced	2	6.1

2.2 Ideal strawberry

The participants were asked to rate their ideal strawberry according to sweetness, acidity, juiciness and firmness.

2.2.1 Sweetness

The result showed that the consumers prefer sweet strawberries (Table 2.6). None of the participants would like to have less sweet strawberries.

Table 2.6 Sweetness

Scale	No. of responses	%
1 - Not sweet	0	0.0
2	0	0.0
3	0	0.0
4	0	0.0
5	1	3.0
6	2	6.1
7	10	30.3
8	10	30.3
9 - Very Sweet	10	30.3
Total	**33**	**100**

2.2.2 Acidity

The majority of the participants indicated that they like less sour strawberries (Table 2.7). However, 38% of the participants like the strawberries to be a little acidic. It seems like sweet-sour taste is the consumer preference for strawberries. Almost 90% of the participants prefer less acidic strawberries.

Table 2.7 Acidity

Scale	No. of responses	%
1 - Not sour	5	15.2
2	5	15.2
3	6	18.2
4	3	9.1
5	5	15.2
6	5	15.2
7	3	9.1
8	1	3.0
9 - Very sour	0	0.0
Total	**33**	**100**

2.2.3 Juiciness

Almost 1/3 of the panelists recorded that they would like to have very juicy strawberries (rated 9/ 9). More than 80% prefer juicy strawberries (Table 2.8).

Table 2.8 Juiciness

Scale	No. of responses	%
1 - Not juicy	0	0.0
2	0	0.0
3	0	0.0
4	0	0.0
5	1	3.0
6	2	6.1
7	11	33.3
8	9	27.3
9 - Very juicy	9	27.3
Total	32	100

2.2.4 Firmness

For the firmness of their ideal strawberry, only 12% of the participants like the strawberries to be a bit soft and 65% like their strawberries to be a little hard (Table 2.9).

Table 2.9 Firmness

Scale	No. of responses	%
1 - Very soft	1	3.0
2	1	3.0
3	0	0.0
4	2	6.1
5	8	24.2
6	10	30.3
7	7	21.2
8	4	12.1
9 - Very hard	0	0.0
Total	**33**	**100**

2.3 Results of sensory evaluation

2.3.1 Sweetness

There was no significant difference between T1 and T4 (Table 2.10). Sweetness rating for T1 was significantly higher than T7 and T8. Sample T8 was rated as the least sweet sample.

Table 2.10 Treatment, means and 95% confidence intervals for sweetness

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	7.369 a	.121	7.095	7.643
T4	7.082 ab	.121	6.808	7.356
T7	6.725 bc	.121	6.451	6.999
T8	6.460 c	.121	6.186	6.735

Means with same letters are not significantly different ($\alpha = 0.05$)

2.3.2 Acidity/sourness

No significant difference was observed between T1 and T4. The difference between T7 and T8 was also not significant (Table 2.11).

Table 2.11 Treatment, means and 95% confidence intervals for acidity

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	6.725 a	.112	6.471	6.979
T4	6.639 ab	.112	6.385	6.893
T7	6.331 bc	.112	6.077	6.585
T8	6.068 c	.112	5.814	6.322

Mean with same letters are not significantly different ($\alpha = 0.05$)

2.3.3 Juiciness

There was no significant difference in juiciness between treatments (Table 2.12). All samples were rated very good for the juiciness.

Table 2.12 Treatment, means and 95% confidence intervals for juiciness

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	7.140 a	.108	6.895	7.385
T4	7.174 a	.108	6.929	7.418
T7	7.184 a	.108	6.940	7.429
T8	7.037 a	.108	6.793	7.282

Means with same letters are not significantly different ($\alpha = 0.05$)

2.3.4 Texture

There was no significant difference in texture between treatments (Table 2.12). All samples were recorded as good for the texture attribute.

Table 2.13 Treatment, mean and 95% confidence interval for texture

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	7.014 a	.113	6.758	7.269
T4	7.045 a	.113	6.789	7.301
T7	6.724 a	.113	6.469	6.980
T8	6.675 a	.113	6.419	6.930

Means with same letters are not significantly different ($\alpha = 0.05$)

2.3.5 Flavour

Treatments T1, T4 and T7 showed similar flavour profiles. Sample T8 had significantly lower flavour profile compared to samples T1 and T4. However, all treatments had acceptable flavour profiles (Table 2.14).

Table 2.14 Treatment, means and 95% confidence intervals for flavour

Treatment	Mean	Std. error	95% Confidence Interval	
			Lower bound	Upper bound
T1	7.043 a	.095	6.827	7.258
T4	6.948 a	.095	6.733	7.163
T7	6.763 ab	.095	6.548	6.978
T8	6.563 b	0.95	6.348	6.778

Means with same letters are not significantly different ($\alpha = 0.05$)

2.3.6 Overall acceptability

Results showed that overall acceptability of T1 and T4 were significantly higher than that of T7 and T8. However, the results also indicate that all four samples are acceptable (Table 2.15).

Table 2.15 Treatment, means and 95% confidence intervals for texture

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	7.169 a	.118	6.901	7.436
T4	7.127 a	.118	6.860	7.395
T7	6.741 b	.118	6.474	7.008
T8	6.491 b	.118	6.223	6.758

Means with same letters are not significantly different ($\alpha = 0.05$)

2.4 Brix value

All four samples were significantly different according to the brix value (Table 2.19). Samples T1 and T8 recorded the highest and the lowest brix values respectively.

Table 2.19 Treatment, means and 95% confidence intervals for brix value

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	10.150 a	.186	9.729	10.571
T4	9.100 b	.186	8.679	9.521
T7	8.225 c	.186	7.804	8.646
T8	7.625 d	.186	7.204	8.046

Means with same letters are not significantly different ($\alpha = 0.05$)

2.5 Relationships between Brix value and sensory attributes

- Good correlation ($R^2 = 0.75$) was observed between the brix value and sweetness (Figure 1).

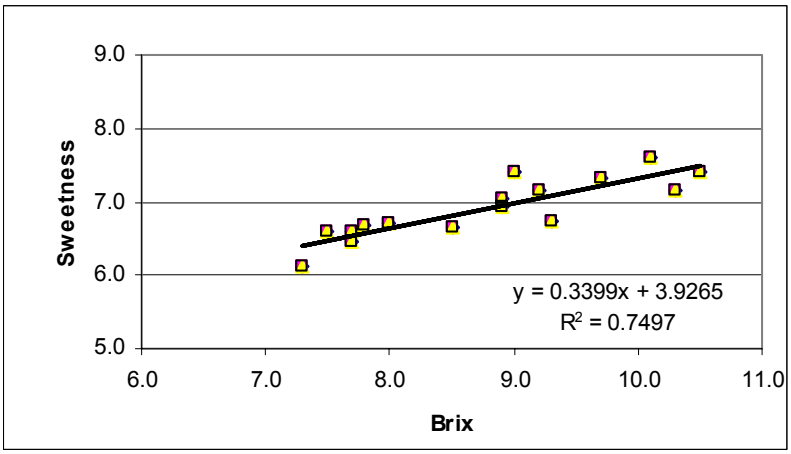


Figure 1. Correlation between Brix level of fruit and sweetness of fruit.

- Reasonable correlation ($R^2 = 0.63$) was observed between the brix value and overall acceptibility (Figure 2).

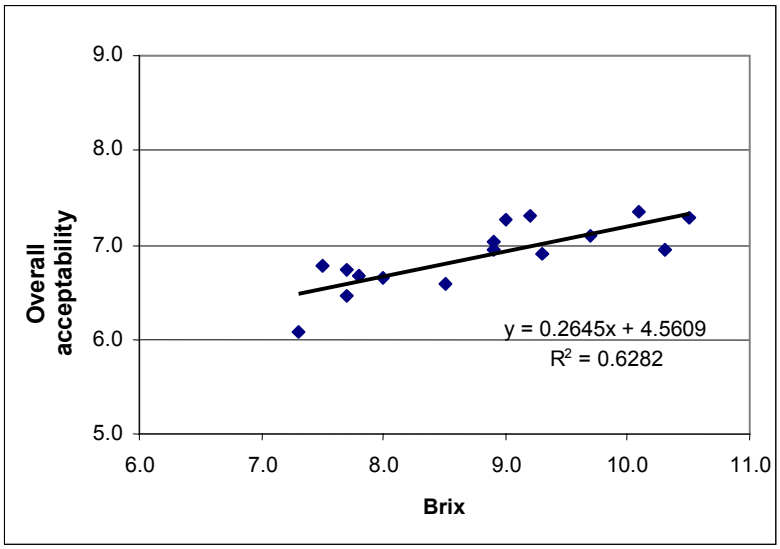


Figure 2. Correlation between Brix level and acceptibility of fruit.

2.6 Relationships between sensory attributes

- As illustrated in the Figure 2, sweetness and overall acceptibility showed very strong correlation ($R^2 = 0.89$).

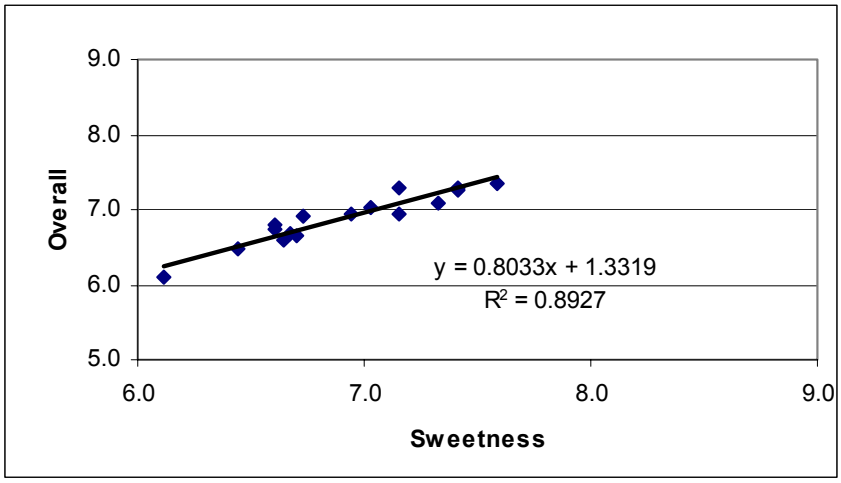


Figure 2. Correlation between sweetness and overall acceptibility of fruit.

- Reasonable correlation (R2 = 0.70) between overall acceptability and acidity.
- Reasonable correlation (R2 = 0.67) between flavour and overall acceptability.

3. CONCLUSIONS

- Treatments showed significant differences in all attributes tested except for the texture and juiciness.
- Treatments T1 and T4 were rated as the best 2 samples according to the consumer acceptability.
- Consumers rated T8 as the least acceptable sample among 4 samples.
- All 4 samples were rated as acceptable.
- The brix value was correlated to sweetness.
- Sweetness was strongly correlate to overall acceptability.
- Very sweet, less acidic and very juicy strawberries are the most preferred strawberries.

6.2.6 Results 3 – Report on Sensory Testing at Curtin University November 2002

REPORT OF STRAWBERRY TASTING CURTIN UNIVERSITY SENSORY LABORATORY - TEST 3

SUBMITTED TO

DENNIS PHILLIPS

DEPARTMENT OF AGRICULTURE WESTERN AUSTRALIA

BY

VIJAY JAYASENA

CURTIN UNIVERSITY OF TECHNOLOGY

TESTS CONDUCTED NOVEMBER 12 AND 15, 2002

TABLE OF CONTENTS

1. MATERIALS AND METHODS

1.1 Samples

Strawberry samples, grown at Medina Research Station in WA, were supplied for tasting by Dennis Phillips at the Department of Agriculture of Western Australia (DAWA). A total of 16 samples (4 treatments x 4 replicates) were evaluated (Table 1).

Table 1. Treatment details

Treatment code	Replicates	Pre-plant NPK	Fertigation NPK	Fowl manure
T1	R1, R2, R3, R4	0:180:100	50:0:350	No
T4	R1, R2, R3, R4	0:180:100	450:0:350	No
T7	R1, R2, R3, R4	0:180:100	900:0:350	No
T8	R1, R2, R3, R4	0:180:100	450:0:350	Yes

1.2 Venue and dates

The sensory evaluation was conducted at the Department of Food Science & Technology at Curtin University of Technology in 4 sessions. Details of the sessions are given in Table 2.

Table 2. Session details

Session	Date	Time
1	Tues, 12 November 2002	10:00 - 11:00 am
2	Tues, 12 November 2002	3:00 - 4:00 pm
3	Fri, 15 November 2002	10:00 - 11:00 am
4	Fri, 15 November 2002	3:00 - 4:00 pm

1.3 Number of participants

The agreement was to conduct the sensory evaluation trial with 30 participants. However, a total of 37 participants, who like strawberries and consumed regularly, were recruited for the study.

1.4 Method of sensory evaluation

1. The samples were stored in a cool room at 8ºC.
2. The samples were taken out from the cool room 2 hours before tasting and kept at the room temperature.
3. Strawberries were washed and dried on absorbent kitchen paper prior to serving.
4. Samples were identified by a 3-digit random number for the tasting.
5. Strawberries were served as whole fruits tasting.
6. Samples were not collected for the testing of brix value.
7. Each panelist evaluated 4 strawberry samples during one session.
8. The colour of the samples was masked using coloured lighting.
9. The evaluation of the samples took place in accordance with International Standards on Sensory Evaluation.
10. Panelists were asked to take a bite of a cracker and a sip of water ‘to cleanse their palate’ before tasting each sample.

11. The following attributes were use for the study with 9-Point hedonic scale ('dislike extremely' to 'like extremely'):
    - Sweetness
    - Acidity/sourness
    - Juiciness
    - Texture
    - Flavour/aroma
    - Overall acceptability

1.5 Ideal strawberry

One section of the questionnaire refereed to ideal strawberries, strawberries that may not exist now, but the strawberries that participants would like to have. Nine-point Hedonic scale was used with sweetness, acidity/sourness, juiciness and firmness/hardness as attributes.

1.6 Data analysis

Excel for data tabulation and SPSS statistical package for data analysis were used. Duncan Multiple Range Test (DMRT) was used for treatment means comparison.

2. RESULTS

2.1 Demographic data

2.1.1 Gender

The total number of participants was 30 (37 recruited) with 20% males and 80% females (Table 2.1).

Table 2.1. Gender

	No. of Participants	%
Male	6	20
Female	24	80
Total	**33**	**100**

2.1.2 Age group

Table 2.2 shows that 403% of the participants were in the age group of 18-25 years, 20% of the participants were between the age group of 26-35 years, 7% in the age group of 36-45 years and 30% in the age group of 46-55 years.

Table 2.2. Age group

Age group	No. of Participants	%
18 – 25	12	40.0
26 – 35	6	20.0
36 – 45	2	6.7
46 – 55	9	30.0
56 – 65	1	3.3
Total	**30**	**100**

2.1.3 How often participants consume strawberries

It was found that 28% of the participants consume strawberries once a week and 17% of the participants consumed two times a week (Table 2.3).

Table 2.3. Frequency of strawberry consumption

Frequency	No. of Participants	%
Less than once a week	12	40.0
Once a week	8	26.7
Two times a week	5	16.7
More than two strawberries a week	5	16.7
Total	**30**	**100**

2.1.4 Why strawberries are usually consumed

For this question, participants were asked to select more than one option if appropriate. It was found that the flavour is the main reason for strawberry consumption. As illustrated in the Table 2.4, 83% of the participants reported that they consume strawberries due to the flavour.

Texture and nutritional benefits also play an important role in strawberry consumption. The result showed that 50% consumed strawberries for the nutritional benefits.

Table 2.4. Reasons for eating strawberries

	No. of Participants	% answered
Flavour	25	83.3
Texture	16	53.3
Appearance	16	53.3
Inexpensive/Best value	3	10.0
Nutritional benefits	15	50.0
Other	0	0.0

2.1.5 Different ways of consuming strawberries

Depending on the consumers, there are different ways by which strawberries can be consumed. Fresh strawberry seems to be the most common way of strawberry consumption. As shown in Table 2.5, 83% of participants consume fresh strawberries.

Table 2.5. Different ways of consuming strawberries

	No. of Participants	% answered
Fresh	25	83.3
Fresh with another desert	11	36.7
Cooked/processed	1	3.3
Both fresh and cooked	4	13.3
Juiced	4	13.3

2.2 Ideal strawberry

The participants were asked to rate their ideal strawberry according to sweetness, acidity, juiciness and firmness.

2.2.1 Sweetness

The result showed that the consumers prefer sweet strawberries (Table 2.6). None of the participants would like to have less sweet strawberries.

Table 2.6 Sweetness

Scale	No. of responses	%
1 - Not sweet	0	0.0
2	0	0.0
3	0	0.0
4	0	0.0
5	0	0.0
6	1	3.3
7	7	23.3
8	11	36.7
9 - Very Sweet	11	36.7
Total	**30**	**100**

2.2.2 Acidity

Forty three per cent of the participants indicated that they like less sour strawberries (Table 2.7). However, 40% of the participants reported that they like the strawberries to be a little acidic.

Table 2.7 Acidity

Scale	No. of responses	%
1 - Not sour	4	13.3
2	8	26.7
3	0	0.0
4	1	3.3
5	5	16.7
6	8	26.7
7	3	10.0
8	1	3.3
9 - Very sour	0	0.0
Total	**30**	**100**

2.2.3 Juiciness

Almost 1/3 of the panelists recorded that they would like to have very juicy strawberries (rated 9/ 9). More than 90% prefer juicy strawberries (Table 2.8).

Table 2.8 Juiciness

Scale	No. of responses	%
1 - Not juicy	0	0.0
2	0	0.0
3	0	0.0
4	1	3.3
5	0	0.0
6	3	10.0
7	9	30.0
8	9	30.0
9 - Very juicy	8	26.7
Total	**30**	**100**

2.2.4 Firmness

For the firmness of their ideal strawberry, only 13% of the participants like the strawberries to be a bit soft and 53% like their strawberries to be a little hard (Table 2.9). It was also noted that 1/3 of the participants prefer not soft and not hard strawberries.

Table 2.9 Firmness

Scale	No. of responses	%
1 - Very soft	0	0.0
2	0	0.0
3	1	3.3
4	3	10.0
5	10	33.3
6	4	13.3
7	6	20.0
8	5	16.7
9 - Very hard	1	3.3
Total	**30**	**100**

2.3 Results of sensory evaluation

2.3.1 Sweetness

There was no significant difference between T1, T4 and T7 (Table 2.10). Sweentess rating for T1 was significantly higher than that of T8. Sample T8 was rated as the least sweet sample.

Table 2.10 Treatment, means and 95% Confidence Intervals for sweetness

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	7.300 a	.246	6.743	7.857
T4	6.750 ab	.246	6.193	7,.307
T7	7.150 a	.246	6.593	7.707
T8	6.325 b	.246	5.768	6.882

Means with same letters are not significantly different ($\alpha = 0.05$)

2.3.2 Acidity/sourness

No significant difference was observed between T1, T4 and T7. The differences between T4, T7 and T8 were also not significant (Table 2.11).

Table 2.11 Treatment, means and 95% Confidence Intervals for acidity

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	6.600 a	.183	6.187	7.013
T4	6.225 ab	.183	5.812	6.638
T7	6.450 ab	.183	6.027	6.863
T8	5.925 b	.183	5.512	6.338

Mean with same letters are not significantly different ($\alpha = 0.05$)

2.3.4 Juiciness

There was no significant difference in juiciness between treatments (Table 2.12). All samples were rated very good for the juiciness.

Table 2.12 Treatment, means and 95% Confidence Intervals for juiciness

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	7.425 a	.246	6.868	7.982
T4	7.150 a	.246	6.593	7.707
T7	7.375 a	.246	6.818	7.932
T8	7.425 a	.246	6.868	7.982

Means with same letters are not significantly different ($\alpha = 0.05$)

2.3.4 Texture

There was no significant difference in texture between treatments (Table 2.12). All samples were recorded as good for the texture attribute.

Table 2.13 Treatment, mean and 95% confidence interval for texture

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	7.275a	.161	6.910	7.640
T4	6.900 a	.161	6.525	7.265
T7	7.000 a	.161	6.635	7.365
T8	6.750 a	.161	6.385	7.115

Means with same letters are not significantly different ($\alpha = 0.05$)

2.3.5 Flavour

There was no significant difference in flavour between samples (table 2.14). All samples were recorded as good for the flavour attribute.

Table 2.14 Treatment, means and 95% confidence intervals for flavour

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	7.100 a	.168	6.719	7.481
T4	6.650 a	.168	6.269	7.031
T7	6.850 a	.168	6.469	7.231
T8	6.575 a	.168	6.194	6.956

Means with same letters are not significantly different ($\alpha = 0.05$)

2.3.6 Overall acceptability

The results showed that the sample T1 had the highest and the sample T8 had the lowest overall acceptability rating. There were no significant differences among samples T1, T4 and T7 (Table 2.15).

Table 2.15 Treatment, means and 95% confidence intervals for overall acceptability

Treatment	Mean	Std. error	95% confidence interval	
			Lower bound	Upper bound
T1	7.200 a	.202	6.743	7.657
T4	6.700 ab	.202	6.243	7.157
T7	7.025 ab	.202	6.568	7.482
T8	6.400 b	.202	5.943	6.857

Means with same letters are not significantly different ($\alpha = 0.05$)

2.4 Relationships between sensory attributes

- Sweet and overall acceptability showed very strong correlation (Table 2.16).
- Flavour and overall acceptability showed very strong correlation (Table 2.16).

Sensory attribute	R-value
Sweetness and overall	0.97
Acidity and overall	0.91
Juiciness and overall	0.47
Texture and overall	0.80
Flavour and overall	0.93
Sweetness and flavour	0.89

3. CONCLUSIONS

- Treatment T1 rates as the best sample according to the consumer acceptability.
- Treatment T8 was the least acceptable.
- Treatments showed no significant differences in texture, flavour and juiciness.
- Sweetness and flavour were strongly correlated to overall acceptability.
- Very sweet, less acidic and very juicy strawberries are the most preferred strawberries.

6.2.7 Consumer Focus Group - "Fresh Finesse" Report

Focus Group Report on

Strawberry Consumption and Consumer Demands

Conducted in Western Australia
for

Department of Agriculture

Oct-Nov 2002

Fresh Finesse

Fresh Food Promotions

Suite 29, Crossways Centre 180 Rokeby Road SUBIACO WA 6008
Phone: 9388 2775 Fax: 9388 2925

Executive Summary

The Australian strawberry industry is dominated by varieties bred in California or Israel and sold in Australia under license. Royalties payable overseas may be as high as $1 million annually for the whole industry.

Australian growers have funded two breeding programs in Australia for more than a decade in order to give themselves more choice and to reduce their dependence on imported varieties. The Western Australian industry have participated in these breeding programs throughout the period by conducting regional selection to identify breeding lines adapted to the WA climate and conditions.

A promising selection first identified in WA in 1998 has reached the semi-commercial development phase after four seasons of trialling and has now been named Kiewa and licensed for cultivation. The WA strawberry industry in partnership with the Department of Agriculture WA and Horticulture Australia Ltd have funded a two year project to develop production guidelines for the variety, together with market research to assist future marketing plans for the fruit. This study of consumer attitudes to strawberry marketing and Kiewa is intended to satisfy some of these marketing requirements.

A focus group meeting was conducted with seven female strawberry consumers on October 9th 2002 to provide insights into consumer attitudes. The group identified the following important issues relevant to strawberry marketing.

Consumers testing Kiewa fruit at "Fresh Finesse" Focus Group Session, October 2002.

1.0 Introduction

Until recently, strawberries grown in Australia under license have been originally bred in California and Israel, meaning royalties of up to one million dollars a year are paid overseas. This study aims to test and elicit ideas for future marketing of strawberries and the variety Kiewa in particular by discussing strawberry retail presentation and marketing with a typical group of consumers.

1. Ideas were obtained on the following topics and the Kiewa variety in particular. This was achieved through discussion of strawberry retail presentation, marketing and consumer patterns with a typical group of consumers.

- Marketing names
- Labeling
- Price
- The perfect strawberry, including fruit size, colour, shape and appearance
- Packaging types and sizes
- Consumption patterns
- In-store displays
- Product information
- Product promotion
- The current market and marketing situation

2. Information on consumers understanding of descriptors for strawberries used in sensory evaluation such as texture, sweetness etc to be collected to assist in future sensory evaluation work with strawberries using Kiewa fruit as a prompt.

3. Information on specific preferences for Kiewa by testing sample fruit in three size ranges.

2.0 Strawberry Consumption Patterns

Strawberry consumption patterns varied from every day to once a week and appeared to be influenced by additional factors such as price and nutrition. Some commented, “I eat them every day...I find them really filling and you don’t put on any weight,” whereas others were more influenced by the price of strawberries, responding, “I bought some last week because they were only $1.49”. Some consumers mentioned they bought a punnet to last over the course of a week, saying, “We had strawberries last week, but they’re just about all gone. My lot loves them straight out of the fridge, or with ice-cream.”

Whilst some consumers ate strawberries on their own or with ice cream, others commented, “I like them with custard or yoghurt or put with melted chocolate. One of my mum’s friends, they mix it and put it into the bubble tea.” “My husband likes them with lots and lots of sugar on it. It doesn’t matter how sweet it is…” Whether eaten on their own or with an accompaniment, some confessed, “I mostly take the tops off before I serve them” whilst others opposed such action, commenting, “I don’t like to cut the tops off because I think it wastes such a lot.” Such responses indicate the diversity of strawberry consumption and possible avenues for recipe marketing and serving suggestions.

3.0 Describing the Perfect Strawberry

When asked to choose the two characteristics, which were most important for strawberries, “Sweet and succulent,” were offered by some, whilst others commented, “I like it sweet and sour, with a really nice taste.” One consumer expressed, “Juicy, and I like it to taste like strawberry” whilst another felt it was important for the strawberry to be “medium size and red and juicy,” continuing, “if they’re too big they tend to be a little bit tasteless.” Consumers seemed to find it difficult to choose only two characteristics with some opting for three. “They must be red and sweet and succulent.”

4.0 Colour

When prompted with a red colour chart (see Appendix III) participants were asked to discuss their preference for strawberry colour. The colour represented by D was chosen by all participants with one respondent indicating, "(the colour is) very important for me." With shade D being the darkest on the chart, consumers were asked if they would like to go darker than D. Some merely responded "no" whilst others expanded saying darker would be, "Too ripe and soggy" and "Any darker than that is slush."

Upon indicating where the shoulder region of the strawberry was located, consumers were in general agreement that they "prefer to have not too much white shoulder" commenting that it was "sour…unripe and hard to bite." General agreement was made in response to the comment that "consumers would be more inclined to buy strawberries with a smaller white shoulder."

5.0 Designing the Perfect Strawberry

When designing an ideal, perfect strawberry, consumers were asked to take into consideration size, colour and flavour. The colour represented by D on the provided colour chart was collectively decided as optimal. General disproval was expressed for strawberries with any degree of white on the shoulder with one participant saying, "I don't like them."

When commenting on sweetness, some replied, "Medium, so that you wouldn't really have to put sugar on it" which was supported by other comments like, "You shouldn't have to and that is really important for slimming. You can really fill yourself up on strawberries but it's completely deceiving if you have to put sugar on them."

Consumers had a specific idea of the size they most preferred when it came to strawberries however this altered from person to person. Some preferred the size of H on the size chart whilst others opted for I or J. It is interesting to note that these three preferences were consecutive, which provides a valuable size range for strawberry growers.

6.0 Purchasing

6.1 Form

The question of how consumers prefer to buy strawberries was presented with prompts for 250g punnets, 500g punnets or loose. Some preferred to buy 250g punnets for everyday consumption whilst others would buy "a lot," saying, "Usually I buy the big tray or sometimes a box because there's a lot." "The bigger punnet" weighing 500g was preferred by some also.

The issue of the white shoulder, as mentioned in sections 4.0 and 5.0, was raised to be influential on the buyer with the comment, "For me it would depend on the shoulder. Sometimes if you're looking at the bigger ones, you seem to get a lot with the whiter shoulder so I wouldn't buy the big punnet, I'd sooner buy the smaller ones that are all red."

6.2 Packaging and Storage

Participants were in general approval of punnets with plastic wrap saying, "If they're not wrapped you may as well go and buy them loose anyway and put them in a plastic bag." Others continued by saying, "Then they don't fall out when you pack them up" and "It's heaps easier getting them home like that without being squashed." Some expressed health concerns for loose, unwrapped strawberries by saying, "I don't like the flies" and "…if there's lots of people touching them, testing them…All sorts of things fly into the shops," whilst others were not phased commenting, "We always wash the fruit anyway so…"

Some consumers wanted their strawberries to last one week in the refrigerator whilst others commented, "No, they definitely wouldn't last. I would think probably only about three days." Difficulty in storing was expressed due to varied levels of ripening. "(There's) too much variation because some of those are ready and others you

couldn't possibly eat." Similar comments indicated, "If you buy them too ripe, one is not right. If you eat it in a day, yeah, but in a couple of days…"

6.3 Display

Participants in this study bought their strawberries from either the supermarket or the fruit and vegetable market. In-store displays were mentioned to be important as consumers are suggested to have become de-sensitized to many visual triggers. "Even having their own big stand with one big background. …You go into the shopping centre and they've just got them all up the wall and you don't really notice them unless you actually look for them." Others reinforced this by saying "(It's) something you don't see but I like the idea of strawberries in a cart, a big white cart…ooh that would be lovely."

6.4 Price

In response to how much consumers would be prepared to pay for a 250g punnet of red, sweet strawberries, some commented, "I like to pay one fifty" whilst others confessed, "I pay up to one ninety-nine. If it's good, no worries because we love it so much." As for the 500g punnets, "four to five (dollars)" was the preferred amount for some participants whilst others responded, "two ninety-nine."

Quality was influential for some consumers on the price they would pay, supported by the comment, "If it's really good, I don't mind paying for it" whilst others refused to pay more for a punnet of smaller, redder strawberries than an ordinary punnet of equal weight. This represents the high expectation of consumers to receive a top quality product at a competitive price. Some indicated that the price was about right but the product was generally failing in quality. "I'd be expecting to pay the same price for the same weight."

Consumers acknowledged that two punnets of equal weight could pose different labour costs to the supplier if one were filled with smaller berries and another with fewer, larger berries. Some consumers agreed they were deterred by having fewer berries in a punnet, even if the weight is uniform but would not be prepared to pay more to have a punnet of smaller strawberries.

6.5 Sampling

Strong approval was voiced for in-store sampling, particularly due to the surprise response to the flavour of the large Kiewa strawberry. "It would be good for people to try it because I know that those who did try them would be really surprised. Normally you would think if something is larger than it traditionally is, it immediately loses its taste. I think most people think that." Others maintained similar opinions, saying, "They like to sample before they buy."

7.0 Today's Strawberry Market

Today's strawberry market was said to be failing in a number of areas. Issues raised include size variation, ripeness and packing. "I think in many ways (it's) the size variation. …That's the first thing people notice, the variation in size. It would be preferable if they were all medium but they're all different sizes." This was expressed to be the case across the board as well as within the punnets consumers were purchasing. "We're not stupid…"

Some consumers felt like they were being deceived with comments such as, "They're usually putting the smaller ones on the bottom anyway and the larger ones on the top," and "All the squashy ones (go) on the bottom." This follows on to the issue of ripeness with one participant mentioning, "…Sometimes I think they pick them a bit too early because they're a bit firm and have a lot more white shoulder."

General agreement was met that consumers in this study were purchasing less strawberries because they could not purchase a satisfying product. "So often I'm dissatisfied at the flavour of the strawberry that, I'll give it a go and then I think, oh, it's not right."

8.0 Naming Kiewa

"Succulent," "Sweet," and "Juicy" were the words chosen to present a 'luxurious' image for Kiewa and the word *plump* also received positive response. Consumers responded well to names that included colours and/or flavours such as *Ruby Sweet* and *Crimson Delight* saying, "Ruby is lovely because it's a rounded word."

Alcohol was a point of repeated referral with some making comments such as, "I would go for Champagne Quality," voicing approval for "Ruby Champagne." Discussion surrounded the consumption of strawberries with champagne and also strawberry flavoured champagne. "They make a strawberry champagne in Margaret River, made just from strawberry, there's no grapes in it at all."

Strong disproval was expressed for names with any sexual connotation. In response to prompts such as *passion* and *desire*, one respondent said, "Women shoppers are too discerning for that crap, they really are. It's silly," and was met with general agreement from other participants.

9.0 Labelling

9.1 Size and Recollection

Whilst labeling was mentioned to be extremely important for strawberries, some consumers had little recollection of existing labels whilst others complained the label sometimes obstructs vision of the strawberries. "I don't think you ever see (them). I pick up a punnet and it's like…I hardly ever see a sticker on it." In response to this, others commented, "…I've never bought a punnet of strawberries that hasn't had a sticker on (it)." When asked if labeling needs to be bigger, one participant indicated, "No, I want to see the strawberries that (I'm) actually buying in the punnet."

9.2 Colours and Images

Comments were also offered around the colours and images most appropriate for strawberry stickers. Some stated, "A sticker with a picture on (it) is always better" and "a heart shape" or "a strawberry shape" were welcomed. Images of a sun were also met with positive response. "The old sun in the corner, with the sticks coming out of it always gets you going. Strawberries and sun (represent) the traditional warm strawberry straight from the plant."

Bright colours were recommended, with some saying, "They need to be dressed up," and "I'd go for an iridescent colour, …a bright, iridescent colour. Fluoro colour." This was suggested to be the first factor in gaining the consumers attention. "It's got to be something catchy. It needs something bright to catch your attention. You look at it and then you tend to read what the label is. If it's just a quiet, dull label, it's not interesting." Others commented, "It needs to be simple, I think those (sample pictures) are too complicated."

9.3 Product Information

Some consumers wanted strawberry labeling that informed, "Where they're from and where they're grown, WA" with supporting statements from others saying, "In big letters. People really do want to know. They do." Strong opinions were held by one participant who suggested, "For people these days, the most critical piece of information would be that it's grown healthily and it hasn't got anything…" Supporting statements offered, "No pesticides or whatever you use…and then WA."

It was also expressed that having the variety name was important because "…You want to know what to look for next time." Strong approval was expressed for words such as *organic* along with the phrase *not genetically modified*. When asked if either of these would be important for strawberry labeling, response indicated, "It would these days" particularly if they were of larger size. "I think it's important that for the big ones, they don't put any hormones to make it big. Some people think, 'oh, it's really big…"

10.0 Evaluation of Kiewa

10.1 Size and Colour

On visual inspection, consumers had ranging preferences for the plate of Kiewa that were small to those that were medium size. Some participants were influenced by the colour and ripeness whilst others were concerned with the amount of strawberry they were getting from each berry. "They've got less white shoulder on this plate (small) than the others." Other participants offered, "I would personally go for this size (small) but depending on how they looked I could even go to the medium because then they're big enough to chop in half and you'll still get a reasonable mouthful."

For some people, the purpose for the strawberries would determine the size they opted for. " If you're cooking, you don't want them really big because it takes more preparation in getting them smaller." Others commented, "Everyday I would still go for that smaller size, if it was that size. For entertaining, I would probably size up" and "If you're dishing it out, people see much more it if. Just for the eyesight, you know, 'I've got more'. Somehow (it) just satisfies you more. If you've got children especially."

Those who were primarily influenced by ripeness stated, "I would usually go for that size (medium) but when I look at it I'd immediately go for those (small) ones. They look more juicy and ripe and the others have just got all the white around them." People in this study clearly indicated that they would not compromise on colour and ripeness but would alter their choice in size to ensure these qualities were fulfilled.

10.2 Taste

Upon tasting the three different sizes of Kiewa strawberry consumers had different views on which strawberry they preferred. "I enjoyed the really big one" was supported by other statements including, "Yeah, I liked the flavour of the big one," "I go for the big one. You can really have a really big bite" and "I enjoyed the big one because I could smell the smell." Some were still in favour of the smaller size after tasting, saying, "I liked the big one and the small one. Really ripe and smell nice" and "I think that the small ones win but it's a close second with the large ones."

Discussing the quality of larger strawberries available on the market today, consumers quoted, "They're tasteless," "They're hard," and "They've got a hole in the middle." Once respondent communicated surprise for the taste of the large Kiewa by saying, "These are luscious," and was supported by others who offered, "and these are very juicy. Beautiful. Very nice."

10.3 Written Evaluation

10.3.1 Colour

With the continuum labelled *pale* to the left and *red* to the right, some indicated that the colour of the small Kiewa was lighter than desirable, but still far from pale. Responses ranged from the centre of the continuum to the far right labelled *red.* Others felt the small Kiewa was the ideal colour or very close. It is important to consider colour variation evident within the samples. No respondents indicated that the colour was darker than their ideal.

Response to the medium sized Kiewa suggested that there was great difference between the real and ideal colour. Some indicated towards the centre of the continuum, with their ideal to the far right, labeled *red.* Others evaluated the medium Kiewa to the right of the continuum, close to their ideal. This size would clearly be identified as lighter in colour to the smaller strawberry.

The largest of the Kiewa samples was rated best for colour and had the highest rates for real and ideal colour being evaluated equal. Some placed their ideal colour at the right extreme, labelled *red*, whereas others identified their ideal at approximately 3/4 along the continuum. One respondent indicated that this size was darker than their ideal colour.

10.3.2 Shape and Size

With the ideal size for Kiewa indicated with a cross in the centre of the continuum, extremes were labelled *too small* and *too big.* Some felt the small Kiewa was the ideal size whilst others indicated that they would like a slightly larger strawberry. Shape was considered favourable by some and ideal by others, with no one indicating dislike for the shape.

Shape and size for the medium Kiewa received the highest rate for real and ideal being equal. Some liked the shape but felt the size was slightly *too big* whilst others neither liked nor disliked the shape but felt the strawberry was slightly too big. No respondents indicated the size was too small nor did any responses for shape fall below the centre of the continuum.

Respondents indicated that the largest of the Kiewa samples was slightly larger than ideal but no respondents indicated that it was *too big.* All responses fell between the centre of the continuum (perceived as ideal) and the third quarter. Some felt the shape and size of the larger strawberry were ideal whereas others had no opinion of the shape and preferred a smaller strawberry.

10.3.3 Smell

Categories for evaluating Kiewa on smell included *sugar sweet*, *earthy*, *berry sweet*, *no smell and other*. The small sample of Kiewa was thought to be *berry sweet* by some and have no smell by others. Some preferred their strawberry to smell sugar sweet and some failed to indicate what their ideal would be. This size had the highest rate for real and ideal being equal at *berry sweet.*

No smell was the most common response to the medium Kiewa with some indicating the smell was only faint and some thinking it to be *sugar sweet*. Some participants failed to indicate their ideal smell however it would be hoped that this would be uniform from previous evaluation sheets. Others indicated their ideal to be either *berry sweet* or *sugar sweet*.

Smell for the large Kiewa was indicated by some to be *berry sweet*, with an ideal of *sugar sweet* whereas others thought it to have a *sugar sweet* smell with an ideal of *berry sweet*. Some indicated real and ideal smell to be equal for the large Kiewa however, failure to indicate an ideal smell was again evident.

10.3.4 Flavour

A continuum for flavour had extremes labelled *sour* to the left and *sweet* to the right. In response to the small sample of Kiewa, some felt the strawberry was *sweet* and their ideal flavour whilst others indicated that the flavour to be not sweet enough, represented with a cross at the centre of the continuum, still far from sour. A response at the border of the first and second quarter of the continuum indicated the small Kiewa to be slightly sour.

The medium Kiewa was evaluated to be *sweet* by some with high rates of real and ideal flavour being equal to the sweeter end of the continuum. Some however felt that the flavour was slightly sour and preferred a sweeter taste.

Responses to flavour for the large Kiewa strawberry ranged from the second quarter of the continuum to the extreme sweet end. This size had the highest rates for real and ideal flavour being equal though this ideal was at different points on the continuum for different respondents and not strictly at the sweetest end. Some failed to indicate their ideal flavour however no one indicated the large Kiewa to be sweeter than ideal.

10.3.5 Texture

Prompts of *firm*, *soft*, *grainy* and *just right* were offered for consumers to evaluate the texture of the small, medium and large sizes of Kiewa. All consumers in this study indicated *just right* to be the ideal texture for their strawberry. Responses ranged from *soft* to *firm* with some indicating the texture to be *just right.* Variation in texture may be evident within this category and should be taken into account.

Medium sized strawberries were evaluated as *grainy* by some and *firm* by others. Interestingly, of those who responded *firm* in response to Kiewa, one participant also saw this as their ideal texture. With *just right* being recorded by others as ideal, some felt this was the texture of the medium Kiewa.

The large Kiewa strawberry had the highest rates for real and ideal being equal at *just right.* Some participants indicated however that the larger strawberry was soft in texture.

10.3.6 Aftertaste

Consumers were given a line to indicate how their mouth felt after eating each of the three sizes of Kiewa strawberry. Responses to the small size included, "It was not sweet enough," "A bit sourer than I expected," "Grainy, starchy and very watery" and "Berry was too soft and watery in flavour." Others however made positive comments saying, "Fresh" or "Refreshing" along with statements like, "I had a sweet taste left in my mouth."

For the medium Kiewa, some felt the aftertaste to be "Gritty, starchy and acidic," supported by other participants who wrote, "An acidic taste (was) left in my mouth."

Certain consumers chose to compare to the previous smaller strawberry saying their mouth had a "less strawberry feeling" Others felt they were influenced by eating the white shoulder last and this affected their evaluation. "Sensational" was the response given by one consumer with other positive comments including, "Texture was ideal and flavour was good."

"No grit or grains" was written to be the aftertaste for the large Kiewa with others saying it had an "Earthy" aftertaste. Other terms used include, "Fresh," "Slightly tart," "Acidic" and "Just right." Some chose to compare this size to the smaller Kiewa saying it was "Not as crisp and clean" whilst others contrasted texture and flavour with, "Texture was slightly too soft, flavour was good."

11.0 Conclusion

- Purchasing frequency and method of preparation of strawberries for consumption varied widely within the group.
- No single major consumption method stood out. The main message which can be taken from this is that strawberries are a versatile fruit which can be eaten in many ways. This is the direction that future marketing should take.
- Strawberries are most appealing to consumers if they are fully red, sweet and succulent. Growers and marketers should pay attention to marketing fully ripe fruit in future without any obvious white flesh.
- Sweetness and juiciness should be the basis of future promotion and advertising for Kiewa, to tap into consumer desires.
- Large fruit is viewed with suspicion by consumers and expectations are that it will be tasteless, hard and dry and probably has been exposed to hormones and chemicals to make it that large.
- In-store demonstrations and tastings, coupled with point-of-sale information and education could rectify these misconceptions.
- Medium size fruit ~20-25grams is preferred.
- A deep red fruit colour (crimson) is preferred but there is a point (deep crimson) beyond which consumers are turned off and become suspicious of flavour and texture. Fully ripe Kiewa did not reach this point.
- Punnet sizes of 250g and 500g are equally acceptable to consumers.
- Clear plastic punnets and plastic wraps are preferred and considered convenient. This packaging should be continued as consumers like to see all fruit through the packaging.
- Food safety and hygiene concerns were expressed about loose strawberries and this method of presentation should be reviewed.
- Uniformity of fruit maturity and flavour are important and these are aspects where the industry is considered to be performing badly at present.

- In-store displays and posters are of little value and hardly ever noticed, Special purpose display stands for superior fruit such as a white cart are considered a better marketing tactic.
- Consumers are price sensitive with barriers to purchase being $1.99 for 250g punnets and $2.99 for 500g punnets.
- They will not pay more for small fruit but prefer it, while conceding that it probably costs more to produce. More berries per punnet goes further with a family.
- Succulent, luscious and juicy are words that conjure up the right images for strawberries and should used in future marketing.
- If marketing names are to be used, those with sexual connotations such as passion and desire should not be used because they insult the female purchaser's intelligence.
- Women prefer more descriptive names such as Ruby Sweet and Crimson Delight. References to champagne were also well received.
- Labelling is important but it should be fluoro in colour, small and shaped (heart, sun, strawberry etc.) but unobtrusive. Images of the sun represent freshness.
- Consumers need to know where the fruit comes from (in bold letters) and that it is safe.
- The variety name is important so that the consumer can find the exact same product in future.

Kiewa

- Consumers like the flavour, juiciness and aroma and were surprised how nice the fruit was, particularly the larger fruit.
- Kiewa fruit was not considered too dark by anyone when fully ripe and the colour is acceptable.
- Medium size fruit (20-25g) was considered ideal but larger fruit (30g) was not too big.
- Aroma did not come through strongly for Kiewa in this setting, however this is not considered one of the most important factors for sale as consumers would not normally smell fruit before purchase.
- Larger fruit gave the best overall ratings for flavour and texture when it was tasted, with many rating it close to ideal.
- Some disliked the aftertaste from Kiewa and this may be due to the crunchiness of seeds. Consumers expressed strong dislike for too many seeds on strawberries. Kiewa did not have too many seeds.

Camarosa

A commercial line of Camarosa was available for compariason with the fully ripe Kiewa. The following themes emerged:

- Camarosa has too much white flesh, which is too hard and has an unpleasant taste.
- Camarosa strawberries have a hole in the middle.
- Kiewa smells nicer.
- Fruit is seedy and grainy.
- Has a nice uniform shape.

APPENDIX I - TRANSCRIPT

Code	Name
A	Amber Cook
C	Cherry
D	Dennis Phillips (Observer)
F	Florence Kartawinata
J	Julianna Duro
L	Linda Charteris
M	Monica Morroccoli
O	Christine Simpson (Scribe)
S	Shane Dodd (Facilitator)
W	Lindy Westwood

S: If I could start by getting you all to start talking about the last time, how recently, you had strawberries. If you've had any interesting strawberry recipes, any that you've tried recently…

J: I've been having strawberries nearly every day

S: Every day?

J: Yes, we buy them off the grocery shop, the Chinese people. They sell it very cheap too and I tend to just whiz it up...

S: Smoothies?

J: Smoothies, yeah.

C: I bought some last week because they were only $1.49. I took them home because I find them really filling and I you don't put on any weight. We sat and wolfed them without any guilt.

W: Well we had strawberries last week but they're just about all gone. My lot love them any way, straight out of the fridge or with ice cream.

M: Yeah, I love them. I have them every day. I usually have them with yoghurt…or just on it's own.

F: I like them with custard or yoghurt. Or people do them with melted chocolate… One of my mums friends, they mix it and put it into the bubble tea.

L: Melville Fresh have strawberries in these packs where they're marinated in a strawberry juice so you can really, really taste it. So they're the last lot of strawberries I've had.

C: Has anybody tried that strawberry champagne? They get the glass of champagne and they drop the strawberry into the middle.

A: They make a strawberry champagne in Margaret River, made just from strawberry. There's no grapes in it at all.

S: So would you say that generally you eat your strawberries straight from the punnet, with the caps still on, or do you chop them off…? Or would you put them with something?

W: Mostly take the tops off before I serve them.

C: Depends a lot on the time of day. If it's lunchtime, I don't bother to take the tops off I just rinse them, holding the top. If it's evening I'll probably hull them and maybe put them with some ice cream or something.

D: Would you cut the tops off?

C: I don't like cutting the tops off because I think it wastes such a lot. I usually get my thumbnail and dig it off.

J: I always cut it. My husband loves them with lots and lots of sugar on it. It doesn't matter how sweet it is. …Because we buy a lot smaller size; let it stand a few minutes.

S: Okay, so going around the group I want you to pick two words to describe your ultimate, perfect strawberry. It's okay if words are repeated.

A: Sweet, succulent (not firm and not soft).

J: I like when it's sweet and sour, with a really nice, tingly taste.

C: Fragrant. Fragrant, with a strawberry taste.

W: Medium size and red and juicy. If they're too big they tend to be a little bit tasteless.

S: There's ten.

M: Yeah, same here, I like them medium size and sweet.

F: They must be red, sweet and succulent.

L: Sweet and tasting like a strawberry

S: Okay, so we've got sweet, we've got medium size coming through a couple of times there. So what if it was sweet and juicy but it was green?

W: I'd try it to give it a go. You have to be game to do anything once.

L: If it tastes like a strawberry I think the publics going to enjoy it but…yeah; it would have to have the flavour.

S: How important is the colour?

J: Very important for me

S: Just going by this chart here, (See Prop 1) if you could just go around and pick which colour you would prefer them to be.

A: D

J: D

C: D

W: D

M: D

F: D

L: D

S: So everyone is happy with D there?

D: What about darker than D?

C: No.

W: Too ripe and soggy.

C: Any darker than that is slush.

A: Oh, I hate that. Overripe.

S: So a bit too overripe?

C: I reckon, yeah.

W: Yeah, getting a bit soft.

S: What influence does the size of the white shoulder have, just between the red and the green cap?

W: Prefer to have not too much white shoulder.

(General agreement)

M: I try to eat off it.

C: Sometimes it's sour…and sometimes it's hard. Unripe and hard to bite.

S: So you would be more inclined to buy ones with a smaller white shoulder.

(General agreement)

S: So, now as a group, I'd like to design the perfect strawberry, taking into account the size and the colour…the shape, everything. I'll pass these around for you, to have an idea to pick your (size). Obviously it's been decided that D is going to be the colour of it.

W: Design a strawberry summing up have we?

S: How sweet would it be? Some people like it a little bit sour…

W: Medium. So that you wouldn't really have to put sugar on it.

C: You shouldn't really have to and that's very important for slimming. You can really fill yourself up with strawberries as they're filling but its completely deceiving if you have to put sugar on them.

S: Some of them have almost a fibrous, grainy texture inside... Do you have an opinion on that?

C: Don't like them.

(General disproval)

W: It's the size.

S: Even if you go around and pick the size that you most prefer.

L: I like a J

S: So, how many picked H? One…two…three? Two. And I? Three on I. J? Two.

Now, how would you like to buy your strawberries, in a punnet, a 250g punnet, 500g punnet, a tray? By weight even?

J: I buy a lot. Usually I buy in the big tray or sometimes in a box because there's a lot.

A: The bigger punnet.

S: 500g

C: Depends on what I wanted to do with them. If I wanted them to be part of a really swish…if I'm going to be entertaining I'd do a fresh fruit salad, I'd probably buy them loose. I'd probably buy large ones loose so people could look at it.

S: Just for your normal everyday consumption.

C: For everyday consumption I'd buy this one.

S: Two hundred and fifty gram punnet.

W: If I did that I would have to buy two, otherwise the bigger one. For me it would depend on the shoulder. Sometimes if you're looking at the bigger ones you seem to get a lot with the whiter shoulder so I wouldn't buy the big punnet, I'd sooner get two smaller ones that are all red.

M: I'd get this one.

S: Two hundred and fifty grams, yeah?

F: Yeah.

L: Yeah.

S: So, how much would you be prepared to pay for this strawberry you've designed, for a two hundred and fifty gram punnet. It's about medium size, it tastes like a strawberry, it's sweet…How much do you think a 250g punnet should cost.

C: I like to pay one fifty.

J: Yeah I pay a dollar ninety-nine if it's good, no worries, because we love it so much.

S: What about the five hundred gram punnet?

L: Three

A: Four to five.

S: Four to five dollars, you wouldn't mind paying that?

J: Two ninety-nine.

S: Two ninety-nine. Okay your thinking one fifty and double that?

J: Well, double the size, but if it's really good, I don't mind paying for it.

D: What do you think of wrapped versus unwrapped.

W: Oh, wrapped. Wrapped.

(General agreement)

D: Why do you think that?

W: Then they don't fall out when you pack them up.

C: It's heaps easier getting them home like that without being squashed.

W: If they're not wrapped you may as well go and buy them loose anyway and put them in a plastic bag.

D: Does anybody have any health concerns related to that? Not being wrapped?

C: No. Because we wash them... Always wash fruit anyway so…

F: I don't like the flies.

J: Or if there's lots of people, you know, touching them, testing them or whatever. All sorts of things fly into the shops.

S: Where are you most likely to buy your strawberries from? The supermarket or the growers market.

A: I buy from the markets.

M: Yeah, from the markets.

J: From the market for the fruit and veggies, or the supermarket.

C: I go to the market or the supermarket.

W: Yeah, the market or the supermarket.

F: Same.

L: Melville fresh or supermarket

S: So, how would you say the strawberries that are out there today in the market or the supermarket today are different from your ideal strawberry that you designed just a minute ago? The strawberries that are out there now, how are they failing?

C: I think in many ways in the size variation. I don't mind that, but when you talking about wanting to be all ideal, that's the first thing people notice the variation in size. There's the medium ones, it would be preferable if they were all medium but they're all different sizes. Also the white shoulder…

D: Are you saying there's variation within the punnet or sometimes you go in and they're all small or sometimes you go in and they're all big?

C: Well you can get either or can't you? Quite often there's a variation in the punnet there.

J: They're usually putting the smaller ones on the bottom anyway and the larger ones on the top

C: All the squashy ones on the bottom.

W: And then sometimes I think they pick them a bit too early because they're a bit firm and have a lot more white shoulder.

S: Would you say you eat a lot less strawberries because you find the taste is not close enough to your ideal?

(General agreement)

L: So often I'm dissatisfied at the flavour of the strawberry that I'll give it a go and then I think oh, it's not right.

S: Okay, so what words do you think are most appealing or appetising when describing a strawberry? So if we're aiming for a luxurious image, how would we describe it?

J: Succulent.

A: Sweet.

F: Juicy.

W: Sweet.

S: Words that get your taste buds going.

L: Juicy.

S: Plump?

(General agreement)

S: Okay, what could we call a strawberry that was everything you wanted it to be? What would be a good name for it? We've got some examples like Crimson Delight, Magnum, Ruby Sweet…

C: Mmm, a Ruby Sweet.

(General approval)

L: Yeah, very nice.

S: So, something that is matching the colour and the flavour

(General agreement)

W: I would go for Champagne Quality.

(Laughs)

C: Ruby Champagne.

(Laughs)

S: Words like passion or desire…? Anything like that?

(Strong disagreement)

C: Women shoppers are too discerning for that crap. They really are. It's silly.

S: But the colour sets a visual image?

C: Ruby is lovely because it's a rounded word.

S: Rolls off the tongue.

D: And the words are short.

C: Ruby Berries.

S: Okay so how do you think the name should be displayed for the strawberries, if they were sold like that and then they had a little leaflet with it or little stickers on the packet…or even just a coloured dot or something.

C: A sticker with a picture on is always better.

S: A sticker and a picture?

C: A sticker with a picture and the name.

S: What shapes or pictures do you think would go best with strawberries?

C: A strawberry shape.

W: A heart shaped sticker.

C: But so that it showed up you'd have to put a background behind it, perhaps yellow or something. So it shows up because if it's the same colour as the strawberry it's not going to show.

W: I'd go for an iridescent colour; I wouldn't necessarily have red if I had a heart sticker on there. I'd go for a bright iridescent colour that's all the go these days. Fluoro colour.

S: To get their attention

W: Yeah.

S: Pictures like flowers or sunshine?

C: The old sun in the corner, with the sticks coming out of it always gets you going. Strawberries and sun is the traditional warm strawberries straight from the plant.

D: What about water, or waterfalls?

C: No, water damages strawberries.

(Laughs)

C: The summer theme. A smiley face.

S: A smiley face on the sun? Well we've got a love heart or a strawberry shape...

C: Well looking back we've got the sound of the heart strawberry like that and in the left hand corner I see the sticks coming out and the sun.

S: Even the old Strawberry Shortcake? A character or something like that? (No real response) Would you say you pay much attention to the labels or is it mainly just the strawberries?

W: Oh, it's got to be something catchy. It needs something bright to catch your attention. You look at it and then you tend to read what the label is. If it's just a quiet dull label it's not interesting

L: It needs to be a fairly simple; I think those are a bit too complicated.

C: Could I just ask something, why are the strawberries on all these cards you've shown, why are they brown?

S: Oh that's just from the printer, the colour.

C: This picture is okay, maybe without the leaves…and the flowers definitely shouldn't be blue.

S: So the most important thing is a nice bright colour?

(General agreement)

S: So then once you're looking at the label, what do you want to see on the label?

W: Where they're grown and where they're from, WA.

(General agreement)

C: ...in big letters. People really do want to know, they do.

D: Are you interested in the name of the variety?

W: A lot of people are interested in the names of the products?

C: Yes. Definitely.

D: I've just stolen Shane's thunder…

C: Because you want to know what to look for next time. Without all the leaves around it, I think the French heart looks great. Slightly, sort of, lop-sided.

S: Curly.

W: A characteristic heart.

A: Even having their own big stand with one big background. You know how you go into the shopping centre and they've just got them all up the wall and you don't really notice them unless you actually look for them.

S: Or even their own little cart?

C: That would be nice, yeah. That's something you don't see but I like the idea of strawberries in a cart. A big white cart, ooh…

(Laughs)

S: With the vine and the flowers, a bright sun in the corner.

(Laughs)

C: Oh that would be lovely.

S: Do words such as organic have an effect?

(Strong agreement)

W: That is something you need to have on your label because if they're going to be organically grown, a lot of people tend to go for that sort of thing because there's no pesticides and things. So that we on your label with your name, the variety…where they're grown.

S: Would it have any difference if it had 'not genetically modified'?

W: It would these days.

C: Definitely

(General agreement)

S: So you would definitely like it to say that it's local and made in WA?

(General agreement)

S: Just now, looking at the strawberries we've got on the table, at the far end we've got the small platter, the smaller size. The mediums ones are in the middle and the large are up this end. Just looking at them, which would you more inclined to say were the best. I'll go around and you can each say your own opinion.

J: I like the middle one.

C: When you say the best, do you mean overall?

S: Yeah, just looking at them.

C: Definitely this plate.

S: The small plate.

C: They've got less white shoulder on this plate than the others.

W: I would personally go for this size but depending on how they looked I could even go to the medium because then they're big enough to chop in half and you'll still get a reasonable mouthful.

M: I would usually go for that size (med) but when I look at it I'd immediately go for those (small) ones. They look more juicy and ripe and the others have just got all the white around them.

F: That's quite ripe. If that was more the size I would go to that one. But it the ripeness, I go towards the ripeness.

L: I usually choose the small varieties, there's more flavour.

A: The small ones, I like the colour of them. That size is pretty good as well if you wanted to decorate.

S: So you like the darker colour but you would like a bit more of the strawberry there?

(General agreement)

S: Do you think there should be any difference in the prices between these three strawberries?

W: I think you should have them in the punnets because if you get the large ones you're getting two fifty grams anyway and if you get the smaller ones you still get the two fifty grams so that shouldn't really make any difference weight wise.

S: Let's say for example you had two, two hundred and fifty gram punnets and one was of large strawberries and one was of small strawberries. Would you pay slightly more to have the smaller, redder strawberries?

C: Ooh, what a question.
(Laughs)

S: For the equal amounts of strawberries, how much more would you be expecting to pay?

W: I'd be expecting to pay the same for the same weight.

C: Yes I think so too.

S: Well, we've got three tasting sheets for you. The first one is for the smaller strawberries up that end and then you've got medium and large. The blue pens are used to respond to the Kiewa strawberry and you can use red to indicate what your ideal would be. So if you'd like to have a bit of a move around and have a taste, fill out the three different response forms.

C: So, what do we do?

S: So basically, firstly you're just going on the colour…your first whole sheet is just for the small strawberries. So looking at the small strawberries, first rate them on colour, put a cross in the blue pen along the line…on how good you think their colour is.

C: Where do we put the cross, is that significant?

S: Yeah, along the line. If you think those strawberries are pale you put your cross towards the left and if you think they are about right, you put your cross toward the right, in the blue pen.

J: So we're putting a cross.

W: A sliding scale.

C: When do we get to taste them? That's what I want.

S: Yeah, just further down where it says flavour.

(Laughs)

C: I'm drooling over here. So where it says size, if I put my cross right in the middle, does that mean I've said it's perfect.

S: Yes. But if you would like them slightly bigger, then you would place your cross slightly to the left.

S: If you think they should be more towards the middle size, then you should say you think they are a bit too small.

C: You're too slow. You're going to get your strawberry last.

L: Those are nice…

C: That one is a bit grainy.

S: When you've finished that one feel free to move on the medium size tray.

W: So do I do anything with the red pen on this now?

S: Yes, with the red pen you go back and indicate where your ideal strawberry would've been. So we get an idea of what you were expecting.

J: Sorry, the red for what?

S: Your ideal strawberry, how red would it be, how big would it be? The shape one isn't relevant.

J: Are we doing the second one now?

S: Yes. Feel free to make any comments on the sheet, to clarify.

D: Does anyone know what the normal strawberry season is?

J: No.

W: Summer?

D: Are we in season yet?

J: Yeah, I think we are, you see so many around now. And in the season they get sweeter.

W: ...And cheaper.

J: It's not so bad the price, but it definitely gets cheaper in the season.

A: What's the feeling, how do you describe when you get a starchy feeling like after eating an apple or fresh apple juice?

S: Starchy

L: It's like an acidic feeling. Like it's broken down all the saliva.

S: Acidic

J: Oh, this is beautiful. I love these.

(Laughs)

D: What do you people think about the juiciness?

(General approval)

J: This is beautiful.

W: Just like me to go for the biggest one.

D: You were supposed to go for the smallest one.

W: I wanted to go for the other end of the scale.

S: You all seem a little surprised…

(Strong agreement)

S: I think maybe you've come to expect the bigger ones to be a little tasteless. When you get a big one that has all the positive attributes…

C: …and what do you call that bit?

D: Calix.

C: C-a-l-l…

D: Shoulder…When we do tastings we just taste a longitudinal section.

C: So, if they had started at that end and finished at that end they would be left with a different after taste.

O: That is a sweet strawberry.

C: What is the best way to keep strawberries out of the punnet as soon as you get home. You can take this off? Do they dry out?

D: If you take the plastic off, yeah, they do. It's better to leave it on.

C: I'm a great believer in brown paper bags. I tend to put most of my stuff in brown paper bags. Do you think that's reasonable?

D: I'd think they'd dehydrate. The wrap keeps the moisture in. It's dual purpose. You can actually see them and it also keeps the moisture in.

D: Brown paper bags are better for other things.

W: What's that?

D: Somebody got the big one.

C: Somebody got there first.

W: I did.

C: You did?

W: I had to have the big one so I could go both ends of the scale.

C: Well, Lindy took the big one so I can't really tell you…

W: Well it was *very* nice.

(Laughs)

O: Tragic.

D: Tragic… We do have a Berry Sweet, that's a brand.

C: Can I try from the other another way?

D: Better ask Shane. She's the boss…

S: Please, keep trying. Start all over again with a new one.

C: Except you look at that, look at the size. What's that called?

O: Core, that's what I call it.

W: So, can I ask where these were actually grown?

D: Yeah, they're grown at Medina.

W: Medina.

C: Where's Medina

D: South of Perth, Kwinana. Can I just get back to that question about the price that you pay, would you think it would cost the grower's more to pack and present a punnet of small strawberries than a punnet of big strawberries?

M: Yeah.

C: For the labour.

(General agreement)

D: But even though you know that, you're not prepared to pay more for it?

C: No.

(Laughs)

D: That might be why you don't get it very often.

J: We're not stupid either.

(Laughs)

S: Does anyone ever think, when they're really big, you don't really get as many in the punnet?

J: Yes.

L: Yeah.

(General agreement)

D: So, you can understand why the grower might be doing that though? Wanting to sell you more big ones than small ones…because he's got labour costs.

S: Is everyone finished? So, overall in the beginning it was the first tray of smaller ones that probably won out in the beginning. They had the best colour but tray two was better for size. Now that you've tasted them, which tray would you say you overall, enjoyed the most?

W: I enjoyed the really big one.

S: Okay, go around, each person.

M: Yeah, I liked the flavour of the big one.

F: I liked the big one and the small one. Really ripe and smell nice.

L: I think that the small ones win but it's a close second with the large ones.

A: I enjoyed the bigger one because I could smell the smell. The other ones didn't seem to have much flavour.

J: I do go for the big one. You can really (have) a really big bite.

(Laughs)

S: So we've got a surprise.

L: Definitely.

S: The big one, how's the big one different from the big ones you've got in the shop at the moment?

L: They're tasteless.

S: You're obviously surprised.

M: They're hard…

J: In the shop now, a lot of them…

D: Got a hole in the middle?

J: Yeah, yeah, yeah.

C: These are luscious.

J: …and these are very, very juicy. Beautiful. Very nice.

S: So, if you knew they were going to be nice and sweet all the way through, you would actually want a bigger strawberry?

L: For certain occasions.

W: Yes.

L: Sometimes if you're cooking, you don't want them really big because it takes more preparation in getting them smaller…

W: Everyday I would still go for that smaller size, if it was that size. For entertaining, I would probably size up but for every day…

J: If you're dishing it out, people see much more of it. Just for the eyesight, you know, 'I've got more'. Somehow just satisfies you more. If you've got children especially.

F: I think it's important that for the big ones, they don't put any hormones to make it big. Some people think, 'oh, it's really big…'

S: So if you see a really big one you'd assume that they'd done something to it to make it really big?

F: Yes, if it's bigger than normal size…

A: Like chickens.

(Laughs, general agreement)

F: We have to promote…

S: Maybe having samples where you buy them so you can have a quick taste first.

C: I think variety is the…yeah, definitely.

J: Oh they like to sample before they buy.

Break in taping

C: It would be good for people to try it because I know that those who did try them would be really surprised. Normally you would think if something is larger than it traditionally is, it immediately loses its taste. I think most people think that.

S: As Amber has just said, there's this whole surprise coming through. That could be used in the marketing… A Ruby Surprise, Berry Surprise…

W: Savour the flavour. Try the berry!

D: Did anybody get tripped up by texture? What we mean when we asked for texture?

C: Not really because it's been written underneath, you get a choice.

D: If we hadn't said that, what would you have thought texture meant?

W: Whether it's floury or soft. Sometimes it can be a bit…

D: Could it mean hard?

M: Sort of in between. One was not hard and not too soft.

O: Can I ask if anyone has noticed any other brand of strawberries. If there is anything about the branding that makes them know that they can go to that existing brand and guarantee a sweet, juicy, red, ripe strawberry?

C: I don't think you ever see; pick up a punnet and it's like that…I hardly ever see a sticker on it. Somewhere like the Melville Fresh might have a label on it but in the supermarket I can't say I've noticed anything…

O: …not a sticker at all?

W: I don't read it because I don't have my glasses on…

O: So, you're saying you want branding but I guess you're saying you never see the branding but I reckon I've never bought a punnet of strawberries that hasn't had a sticker on…

J: I have.

L: Oh, yeah.

D: Do you think we could do without it?

L:I think it's good for where it's come from and I guess us lot up here are going to be a lot more discerning…

J: They need to be dressed up.

O: So what you're saying is that the label needs to be a lot more obvious. In fact what appears to have happened, as with that one is that it is so insignificant that you're not actually noticing it.

L: No, I want to see the strawberries that you're actually buying in the punnet so…

D: What if we give you more information? We got some of that out. What would be the absolutely most important things, when we're talking about the label, that you want to know?

L: I think bright

W: For people these days, the most critical piece of information would be that it's grown healthily and it hasn't got anything…

(Strong agreement)

W: No pesticides or whatever you use…and then WA.

D: That it's grown here…

W: Yeah.

(General agreement)

C: But also the name so if you do like it you know what to look for next time. I just want to say something about that, if you're not going to put stickers actually on the punnet, the difficulty then is with the store staff because, oh, they just don't label things. Either they don't bother or they stick it in and it gets knocked over by somebody…nobody knows even if they like the strawberry what it is.

L: If the sticker was sort of like, there, rather than there…

D: Not in the middle...

C: Even on that side.

L: Yeah, just slightly coming over the top but there rather than there.

D: Of those Camarosa packs, what do you think of the ripeness of those.

L: Not ripeness.

D: Not ripe enough?

L: No.

(General agreement)

L: That one is a bit better.

W: They look like they'd be too seedy.

L: Yeah, seedy. You can see that on that one there.

C: With too much variation because some of those are ready and others you couldn't possibly eat.

D: Shane, could we taste those?

S: Certainly.

D: If anybody wants them.

S: So when you get them home and put them in your fridge, given that they're not eaten, how long do you want them to last in the fridge?

C: A week.

L: Week.

(General agreement)

S: A week?

(Laughs)

S: But they've got to be ripe right now?

C: No they definitely wouldn't last. I would think probably only about three days, I don't know.

J: If you buy them too ripe, one is not right. If you eat it in a day, yeah, but in the next couple of days…

C: If I wanted them to last, I think I'd take them home and I'd take them out of this. I wouldn't put them in the brown paper bag but instead wash them and I'd probably put them, spread them out in a Tupperware thing or…

J: On a tray...

W: Sounds like too much hard work.

C: Then they'd last longer and you've got the flavour of them.

W: Oh, I wouldn't go beyond a couple of days anyway.

C: The thing is you've probably ate them haven't you? Have you got more in your family?

W: Five.

S: Are you eager to have a try of these Camarosas…Keep in mind the categories that were on your other evaluation sheet and we'll just go around and I'll get you to say a couple of words about how this compares to the other one.

D: Have a look at those as well, at the shape of those. What do you feel about, is there anything about the shape of those that you notice?

W: They're a bit more consistent with their overall shape whereas some of these are…waver around.

D: Do you have a preference or…

S: I'll just go around one at a time, for you to say for the tape, what your individual preference is. Amber?

A: They're (Camarosa) a lot harder and sour. You can only feel the seeds on your tongue when you put it in your mouth. It just feels grainy.

C: Yeah, grainy.

J: Yeah.

(General agreement)

J: There's just so much seeds.

C: That's what I think too.

W: The Kiewa ones smell a lot nicer…

L: Yeah, a there's no smell for these Camarosa ones.

W: …and I think they taste a lot better, the Kiewa.

L: Do you want us to try the big ones as well?

S: Yes, try both.

M: They're lacking in flavour. This one's too hard in texture.

F: This one is sour, less sweet and…a big gap.

(Laughs)

C: What do you call it?

D: The whole.

(Laughs)

S: You would know now if you were able to go to a strawberry that was like the Kiewa and you had the Camarosa there as well… You would feel more confident going to buy that other brand.

W: Definitely.

S: So in that case the label would be very important.

W: …and you do need the label because if you get a punnet like that, you think maybe the grocery store has got boxes of them from out in the bush and then packaged up their own. So you do need a label. Even if it's just on the corner... To cover the little corner better... You don't want a huge label but something, fluoro, iridescent to catch the eye.

(Laughs)

J: And you go back for what you bought before.

W: A bright label.

J: Yeah.

D: If Kiewa didn't have a name on the label, what would you look for to try and identify it?

L: The shape.

J: Yeah, the shape and try and see the colour

(General agreement)

W: Yes but then I'm sure you're not going to always get the Kiewa strawberries exactly the same as that in every punnet. It just depends when they pick them so, it does need a label so that you've got Kiewa written on the label and you don't have to spend time checking out that punnet to the other one. You just want to see Kiewa, pick it up and go…

D: Could we use something else, that's always on it, like 'luscious'?

W: Yeah, you need a label to relate to.

S: Thankyou all for coming, that's great. Please feel free to have some more coffee and more strawberries.

APPENDIX II - SENSORY EVALUATION RESPONSE SHEET

So What Do You Think?

(Place your response to Kiewa with a blue cross and your ideal with a red cross on the continuum.)

Colour:

Pale……Red

Shape:

Dislike……Like

Size:

Too small……Too big

Smell: (please circle one)

Sugar sweet Earthy Berry Sweet No Small Other _____

Flavour:

Sour……Sweet

Texture: (please circle)

Firm Soft Grainy Just right

After Taste (How does your mouth feel?)

6.3 2003 RESEARCH

6.3.1 Introduction

Results of the research conducted in 2001 and 2002 showed that Kiewa was market competitive and its flavour and consumer appeal could be improved by controlled production practices. During the life of the project from 2001 to 2003, a new 'short day' variety bred in California had become available to growers. This variety, Gaviota occupied approximately the same harvest window as Kiewa and could in future become a competitor for grower runner purchases. The project commenced with a comparison between Kiewa and Camarosa, and it seemed appropriate that it should end with a sensory comparison of Kiewa and Gaviota.

6.3.2 Aims

The aims in 2003 were:

- Compare fruit of Kiewa with the new 'short day' variety competitor, Gaviota in formal taste panel tests conducted in sensory laboratory at Curtin University to re-assess Kiewa's comparative future market potential.

6.3.3 Materials and methods - Field and laboratory

Fully ripe fruit was harvested from two growers' Camarosa crops as it was in the 2001 study on November 10, 2003. Uniform size fruit of both varieties, representative of the respective varieties was harvested at both sites on the same day and coolstored overnight at the sensory laboratory for tasting the following day.

6.3.4 Results - Report on Sensory Testing at Curtin University November 2003

Results of the sensory tests are shown in the following report. The results of this test need to be treated with some caution, because the day chosen (in advance) for harvesting fruit for the sensory test was the second day of an unseasonal heat wave. The temperatures damaged fruit at the medium input site more than the high input site because the former crop had less foliage cover to protect it from the sun. Kiewa was proportionately worse affected by the heat than Gaviota at both sites.

6.3.5 Results 4 – Report of Strawberry testing - Kiewa and Gaviota

REPORT OF STRAWBERRY TASTING - KIEWA AND GAVIOTA

SUBMITTED TO

DENNIS PHILLIPS

DEPARTMENT OF AGRICULTURE WESTERN AUSTRALIA

BY

VIJAY JAYASENA

CURTIN UNIVERSITY OF TECHNOLOGY

TESTS CONDUCTED NOVEMBER 12 AND 15, 2003

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1. MATERIALS AND METHODS

1.1 Samples

Strawberry samples were supplied for tasting by Dennis Phillips at the Department of Agriculture of Western Australia (DAWA). A total of 16 samples (2 varieties X 2 growers X 4 replicates) were evaluated (Table 1).

Table 1. Treatment details

Varieties	Growers
1. Kiewa	1. Medium input
2. Gaviota	2. High input

1.2 Venue and dates

The sensory evaluation was conducted at the Department of Food Science & Technology at Curtin University of Technology in 4 sessions. Details of the sessions are given in Table 2.

Table 2. Session details

Session	Date	Time
1	11 November 2003	10:00 - 11:00 am
2	11 November 2003	3:00 - 4:00 pm
3	12 November 2003	10:00 - 11:00 am
4	12 November 2003	3:00 - 4:00 pm

1.3 Number of participants

A total of 40 participants, who like strawberries and consumed regularly, were recruited for the study.

1.4 Method of sensory evaluation

1. The samples were stored in a cool room at 8ºC.
2. The samples were taken out from the cool room 2 hours before tasting and kept at the room temperature.
3. Visual evaluation was conducted separately using a few bunches for each sample.
4. Strawberries were washed and dried on abosorbent kitchen paper prior to serving.
4. Samples were identified by a 3-digit random number.
5. Strawberries were served as whole fruits tasting.
6. Each panelist evaluated 4 strawberry samples during one session.
7. The colour of the samples was masked using coloured lighting.
8. The evaluation of the samples took place in accordance with International Standards on Sensory Evaluation.
9. Panelists were asked to take a bite of a cracker and a sip of water ‘to cleanse their palate’ before tasting each sample.

10. The following attributes were used for the study with 9-Point hedonic scale ('dislike extremely' to 'like extremely'):
    - Sweetness
    - Acidity/sourness
    - Juiciness
    - Firmness
    - Overall acceptability

1.5 Data analysis

Excel for data tabulation and SPSS statistical package for data analysis were used.

2. RESULTS

2.1 Demographic data

2.1.1 Gender

The total number of participants was 37 with 27% males and 73% females (Table 2.1).

Table 2.1. Gender

	No. of Participants	**%**
Male	10	27
Female	27	73
Total	**37**	**100**

2.1.2 Age group

Table 2.2 shows that 16% of the participants were in the age group of 18-25 years, 27% of the participants were between the age group of 26-35 years, 27% in the age group of 36-45 years and 24% in the age group of 46-55 years.

Table 2.2. Age group

Age group	**%**
18 – 25	16
26 – 35	27
36 – 45	27
46 – 55	24
56 – 65	6
Total	**100**

2.2 Results of sensory evaluation

2.2.1 Variety

Ratings of Gaviota were significantly higher than the ratings for Kiewa for all sensory parameters tested (Table 27). However, data showed that both varieties are highly accpetable according to the sensory qualities of berries.

Table 2.10 Sensory ratings of variety

Variety	Sweetness	Acidity	Juiciness	Firmness	Overall acceptability
Kiewa	6.6 a	6.3 a	7.2 a	7.1 a	6.7 qa
Gaviota	7.4 b	6.9 b	7.6 b	7.3 b	7.4 b

Means with same letters are not significantly different ($\alpha = 0.05$)

2.2.2 Grower

Grower (location) showed no significant effect on sensory qualities (Table 2.11).

Table 2.11 Sensory ratings according to the grower

Grower	Sweetness	Acidity	Juiciness	Firmness	Overall acceptability
'Medium input'	6.9 a	6.5 a	7.3 a	7.2 a	7.0 a
'High input'	7.1 a	6.9 a	7.5 b	7.3 a	7.2 a

Mean with same letters are not significantly different ($\alpha = 0.05$)

2.2.3 Aroma visual observations

There was no significant difference in aroma between treatments (Table 2.12). All samples recorded very good ratings for the aroma.

Kiewa variety grown by 'High Input' received the best rating for the berry shape. All other samples received similar ratings for the shape.

A significantly lower rating for the colour was recorded for Gaviota grown by 'High Input'. (Note: Staff members who conducted the sensory evaluation had noticed the dark red colour (over-ripe appearance) of Gaviota samples grown by 'High Input').

Ratings for overall appearance showed similar pattern to that of the berry shape (Table 7). Kiewa grown by 'Medium Input' recorded a significantly higher rating than all other samples. However, all samples rated as very good according to the overall appearance.

Table 2.12 Results of aroma and visual observations

Variety	Grower	Aroma	Shape	Colour	Overall acceptability
Kiewa	'Medium input'	7.0 a	7.2 a	7.3 a	7.2 a
Kiewa	'Medium input'	6.9 a	7.9 b	7.6 a	7.7 b
Gaviota	'High input'	7.0 a	6.9 a	7.1 a	7. 1 a
Gaviota	'High input'	7.3 a	7.1 a	6.4 b	6.8 a

Means with same letters are not significantly different ($\alpha = 0.05$).

Gaviota fruit at Wanneroo.

3. Conclusions

- Both Kiewa and Gaviota varieties showed very good ratings for sensory qualities and visual observation.
- Gaviota rated better than Kiewa in tasting.
- Grower had no significant effect on tasting parameters, except on the juiciness.
- Grower had a significant effect on the parameters of visual observation. Kiewa grown by 'Medium Input' showed the best shape and overall appearance.

7. NEW SELECTIONS

David Gatter

7.1 INTRODUCTION

The fourth aspect of this project as originally proposed was to prepare for the next selection to be commercialised. Kiewa was first selected in WA as a breeding line in the 1998 season and was from a cross conducted in 1995. Many more selections, both short day and day neutral from crosses made after 1995 have been evaluated since and continued to be evaluated during the course of the course of this project from 2001 to 2003.

The national breeding project does not fund evaluation of preferred selections beyond the first four years after crossing. In this case, selections made in WA from crosses made from or before 1997 to 1999, were the responsibility of the WA industry to evaluate in large trial plots.

New crosses received for selection each year are described in the national temperate breeding project as 'Stage 4', once selected material is 'Stage 5' and more than once selected is 'Stage 6 and beyond'. This activity in the project is concerned with the latter category and these will be called 'Advanced' selections in this report.

The Department of Agriculture has a suitable location with sandy soils to conduct plant nutrition studies for new varieties and selections near Perth, but does not have a similar facility at Albany. A possible location with a similar climate to the Albany district is Manjiump Horticultural Research Centre. Day neutral strawberry varieties had not been grown commercially in Manjimup, and we planned to explore the potential of this site for future research work with 'day neutrals'.

7.2 AIM

- To identify and get commercial grower feedback on the next promising selections (short day and or day neutral) considered worthy of future commercialisation.
- To test Manjimup Research Centre in the lower south west of WA as a secure location for future nutrition work with day neutral varieties.

7.3 MATERIALS AND METHODS

During the life of this project, advanced selections were tested each year on one property at Wanneroo (latitude 32°S) and at another property near Albany (latitude 34°S). Short Day selections were always tested at Wanneroo and mostly Day Neutral selections were tested at Albany.

Planting material for these trials was supplied annually by Dr Bruce Morrison, the runners were always non-virus indexed and their origin was Tasmanian Highland Runner growers. This origin ensured that they would get adequate pre planting chilling and that propagation methods were typical of those they may expect when fully commercialised.

The same grower hosted the trials at Wanneroo and two different growers hosted the work at Albany during the period. All management practices applied by both growers were the same as those applied to their commercial crops that surrounded the trial plots. Typically, at Wanneroo, the soil type was Karrakatta sand with poor water and nutrient retention characteristics. The trial was planted into 120 cm wide black plastic covered beds. The selections were planted in twin rows 20 cm apart, two pairs of rows per 120 cm bed with 28 cm spacing within rows and irrigated at the same time as the surrounding commercial crop with overhead sprinklers. Fertiliser was applied every second or third day.

Typically at Albany, the soil type was peaty sand in a low lying site. Trials were planted into black plastic covered raised beds within a commercial crop. Beds were planted with two rows of plants with 28 cm spacing along the rows and irrigated at the same time as the surrounding commercial crop with trickle irrigation.

Selection criteria changed over the period from a system where the following ranking applied in 2001/02:

- monthly and season yield;
- fruit quality characteristics;
- absence of serious faults;
- berry size; and

to one where the order of importance changed to the following by 2003/04:

Selection criteria (both subjective and objective) were ranked in the following order:

- flavour score;
- fruit appearance;
- yield and fruit size;
- ease of harvest; and
- absence of serious faults.

A range of subjective criteria were measured on a regular basis from 2002/03 as follows:

Characteristics of plant vigour and fruit quality were recorded during the season with attributes rated on a scale from 1-3; 1 = poor, 2 = acceptable and 3 = excellent. (Note: a plant vigour score of 3 = very vigorous and is not necessarily desirable.)

Manjimup

An observation plot of 1000 Selva plants (ex: Toolangi Runner Growers Co-op.) was planted on the 8 June 2001 at Manjimup Horticultural Research Centre to familiarise staff with production practices for the crop. The following management practices were employed for the planting:

- Layout: Twin rows of plants at 40 cm x 30 cm staggered on black plastic mulched beds 1200 mm wide plastic giving a 900 mm wide bed.
- Pre planting: Strip incorporated Superspud at 1.5 t/ha in the bed before bed forming and plastic laying. Plus HiTrace 100 kg/ha, Magnesium Sulphate 150 kg/ha.
- Irrigation: Netafim Streamline 80 with 300 mm emitters was laid under the plastic, with a strip of irrigation tape between the pair of rows about 5 cm below soil surface. Flow rate 1.11/hr @ 10 m head pressure (id 16.0 mm; wt 0.25 mm). Irrigation was applied daily at 100% Epan. After mid November this was supplemented with overhead irrigation to keep the crop cool when day max exceeded 30°C (15-20 mins) or to settle dust.
- Post planting: Potassium nitrate and Ammonium nitrate were injected through the Netafim tape at least once per week from planting for the eight month cropping cycle at a weekly rate of 15 kg/ha KNO_3 plus 21.5 kg/ha NH_4NO_3.

Harvests were conducted twice weekly on this plot commencing on 8 October 2001 and ending on 7 June 2002.

Various management techniques were tested on these plants, including two different times of cutting back the plants after summer. Half of the plot was cut back at each of 5 March and the other half on 14 March 2002. The earlier date was intended to simulate a common practice on the south coast at Albany while the later date was more typical of the cutting back time at Busselton on the west coast for the variety Selva. After this, the plants recovered in the autumn and produced an autumn crop, after a period of low fruit production in mid summer.

7.4 RESULTS

Selections were made progressively in each of the three seasons and a number of breeding lines were rejected over the period and a few were retained. We started with 17 advanced short day selections in 2001/02 and 33 day neutrals at Albany. The year of crossing for these ranged from 1992 to 1998 and the size of plots was from 5 to 30 plants.

By 2002/03, a list of 18 short days remained representing crosses from 1992 to 1999 in plots ranging from five to 300 plants each. The day neutrals at Albany had been reduced to 22 selections representing crosses from 1993 to 1999 with plot sizes from four to 82 plants each by the 2002/03 season.

By the end of the project life, the short day selections had been reduced to seven selections of 1994 to 1999 origin and eight day neutrals of 1997 and 1998 origin. Plot sizes ranged from five to 100 plants each.

Progress was generally better with the 'short day' selections than the 'day neutrals' and by the end of the 2003/04 season, seven advanced numbered selections 94-099-143, 97-022-121, 98-030-3, 98-031-70, 98-049-119, 99-041-85, and 99-047-26 were recommended to be tested again in small semi-commercial sized blocks. Comparative yield and quality data for these selections is shown in tables 7.1 7.2 and 7.3.

Table 7.1 Monthly total and marketable yield, and berry size of advanced 'short day' selections, Wanneroo 2003/04

Selection	Total yield (g/plant)					Market yield (g/plant)					Yield	Berry size (g)		
	Aug	Sep	Oct	Nov	Tot.	Aug	Sep	Oct	Nov	Tot.	%	Sep	Oct	Nov
94-099-143	16	121	278	78	477	13	110	250	72	445	93	18	20	14
97-022-121	19	80	213	67	389	16	56	165	57	311	80	23	28	20
98-030-3	4	83	127	33	243	3	52	109	31	195	80	16	18	15
98-031-70	5	121	240	67	428	3	88	217	58	366	85	27	20	15
98-049-119	5	63	120	22	233	3	34	95	20	169	73	19	21	16
99-041-85	20	195	370	64	629	15	118	317	38	488	78	40	30	20
99-047-26	8	158	274	60	492	6	107	187	54	354	72	33	29	19

Table 7.2 Mean monthly fruit quality characteristics of colour, uniformity and size, Wanneroo 2003/04

Selection	Fruit colour			Colour uniformity			Size uniformity		
	Sep	Oct	Nov	Sep	Oct	Nov	Sep	Oct	Nov
94-099-143	2.0	2.0	2.0	2.0	2.0	2.0	2.5	3.0	2.0
97-022-121	2.0	2.0	2.0	2.5	2.0	2.0	2.0	2.5	2.5
98-030-3	2.0	2.5	2.5	2.0	2.0	2.5	2.5	2.0	2.5
98-031-70	2.0	2.5	2.5	2.0	3.0	2.5	2.0	2.5	2.5
98-049-119	2.5	2.5	2.0	2.0	1.5	2.0	2.0	1.5	2.0
99-041-85	1.0	2.0	2.0	1.5	2.0	1.5	3.0	3.0	2.5
99-047-26	2.0	2.0	2.0	1.5	2.0	2.5	2.5	3.0	2.5

Table 7.3 Mean monthly fruit quality characteristics of appearance, flavour and brix, Wanneroo 2003/04

Selection	Appearance of ripe fruit			Flavour			Brix (whole fruit)	
	Sep	Oct	Nov	Sep	Oct	Nov	2/10/03	16/10/03
94-099-143	2.5	2.0	2.0	2.0	2.0	2.0	6.5	
97-022-121	1.5	2.0	1.5	2.5	2.0	2.0		
98-030-3	2.0	2.5	2.5	2.0	2.5	2.5		7.6
98-031-70	2.0	2.0	2.0	2.5	2.5	3.0		7.0
98-049-119	2.0	2.0	2.0	2.0	2.0	2.0		
99-041-85	1.5	2.5	2.0	1.5	2.0	1.5		
99-047-26	1.5	2.0	2.0	3.0	2.0	2.5		

Growers taste testing new selections at a field day.

At Albany, many of the day neutrals performed poorly and only two were selected for further evaluation, and full commercialisation was considered premature on the basis of results achieved by the end of 2002. Comparative results for the selections in 2002/03 are shown in tables 7.4, 7.5 and 7.6.

Table 7.4 Monthly marketable yield, and berry size of Advanced 'day neutral' selections, Albany 2002/03

Selection	Marketable yield (g/plant)								Market berry size (g)						
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Tot.	Sep	Oct	Nov	Dec	Jan	Feb	Mar
93-015-245	2	57	216	274	158	129	38	873	23	23	27	20	12	12	9
95-027-3	1	19	14						14	15	20				
95-032-27	5	58	233	420	91	109	53	971	18	19	23	16	11	11	10
96-026-47	4	86	249	304	117	92	38	889	18	24	24	16	12	11	14
97-101-75		53	254	375	172	180	48	1081		19	19	15	11	9	8
97-101-89		63	321	469	276	254	50	1433		20	27	18	14	11	8
97-101-125	13	163	339	432	191	255	72	1465	23	23	25	16	13	10	9
98-047-1		59	225	388	198	126	50	1047		18	20	15	9	9	7
98-049-185		37	274	382	140	229	54	1116		23	35	22	12	14	10
98-051-113	4	52	249	432	191	120	51	1100	15	20	27	16	10	9	7
98-054-208		94	179	284	276	270	59	1162		22	10	20	12	11	9

Table 7.4 (Continued)

98-055-46		153	298	449	246	303	38	1486		32	32	21	15	13	8
98-055-55		12	308	444	264	244	43	1314		16	27	16	12	11	9
98-055-174		68	475	471	248	220	15	1496		23	23	15	11	10	6
98-082-43		52	219	233	120	138	32	792		20	24	16	12	10	9
98-083-28		160	316	419	104	59	43	1100		16	20	13	7	7	7
99-056-137	6	100	291	346	153	202	29	1127	25	14	17	12	8	9	6
99-067-47		57	363	712	286	248	83	1750		24	31	16	11	9	7
99-070-55		62	273	307	89	169	14	914		18	26	15	10	10	7
99-073-6		9	37	116	96	138	10	404		12	13	18	11	11	8
99-089-84		19	116	175	31	231	81	653		11	20	12	8	12	10
99-094-46		86	468	681	191	171	74	1671		23	36	19	11	11	9

A promising day neutral selection at Albany, 2003.

Table 7.5 Fruit quality characteristics of advanced selections, Albany 2002/03 (grower assessments)

Selection	Taste 1-9 (where 9 = excellent)	Appearance 1-9 (where 9 = excellent)
93-015-245	5.6	6.3
95-027-3		
95-032-27	6.1	6.1
96-026-47	6.3	5.7
97-101-75	6.2	6.8
97-101-89	6.1	6.4
97-101-125	5.7	6.3
98-047-1	5.7	6.8
98-049-185	5.7	6.4
98-051-113	6.4	6.6
98-054-208	5.8	6.8
98-055-46	5.3	6.5
98-055-55	6.0	6.6
98-055-174	5.5	6.5
98-082-43	6.4	6.3
98-083-28	6.4	6.4
99-056-137	7.1	6.5
99-067-47	6.0	6.5
99-070-55	6.1	6.1
99-073-6	5.3	5.5
99-089-84	6.0	6.4
99-094-46	6.0	6.4

Note: The fruit taste and appearance scores are a mean of 47 observations.

Table 7.6 Monthly (October, November, December, February) observations of fruit quality characteristics (1-3), advanced selections, 2002/03 Albany

Selection	Fruit colour				Colour uniformity				Size uniformity				Appearance score				Taste score				Brix
	Oct	Nov	Dec	Feb	Oct	Nov	Dec	Feb	Oct	Nov	Dec	Feb	Oct	Nov	Dec	Feb	Oct	Nov	Dec	Feb	
93-015-245	1	1	3	2	2	1	2	2	3	2	2	1	2	1	2	2	2	1	1	1	
95-027-3																					
95-032-27	3	3	3	2	3	2	2	1	2	2	2	1	3	1	2	1	2	1	1	1	8.2
96-026-47	2	2	2	1	2	2	2	1	2	2	2	1	3	1	2	1	2	2	3	1	8.2
97-101-75	3	3	3	2	2	2	2	1	2	2	2	1	3	1	2	1	2	2	3	1	8.2
97-101-89	2	3	3	2	2	2	2	2	3	2	3	2	2	3	3	1	1	1	1	1	6.0
97-101-125	3		3	2	2		2	1	2		2	1	3		2	1	1		2	1	7.4
98-047-1	2	3	3	2	2	2	1	1	3	2	1	1	2	2	3	1	2	1	1	1	8.0
98-049-185		2	2	2		2	2	1		2	2	1		2	2	2		1	2	1	
98-051-113	2	1	2	1	2	2	1	1	2	2	2	1	2	2	2	1	2	2	2	1	8.0
98-054-208		1	3	2		1	3	2		2	2	1		2	3	1			2	1	
98-055-46		2	3	1		2	3	1		1	2	1		2	3	1		1	1	1	
98-055-55		2	3	1	1	2	3	1		2	2	1		2	3	1		1	1	1	
98-055-174	2	3	3	1	2	2	2	1	2	2	1	2		3	2	1	1	1	2	1	
98-082-43	2	2	3	2	2	1	2	1	3	2	2	1	2	2	1	1	2	2	1	1	8.4
98-082-43	2	2	3	1	3	2	3	1	1	2	2	1	2	3	3	1	2	2	3	1	8.4
99-056-137	2	2	3	1	2	2	3	1	2	1	1	1	2	2	3	1	2	1	2	1	
99-067-47	2	1	2	1	2	1	1	1	2	2	1	1	2	1	2	1	2		1	1	
99-070-55	2	2	3	1	2	1	1	1	3	2	1	1	2	1	1	1	2	1	2	2	
99-073-6		2	3	2		2	2	2		2	1	1		1	2	1		2	1	2	
99-089-84	2	1	1		3	1	1		3	1	1		2	2	1		2		1		
99-094-46	1	1	3	1	1	1	2	1	2	2	2	1	2	1	2	1			2	1	

Manjimup

The harvest profile for Selva grown at Manjimup from October to February is shown in Figure 7.1. The pattern of harvest was similar to that expected at Albany. Fruit production in the autumn was relatively light compared to spring production as shown in the accompanying photo, but cutting back earlier on March 7 gave earlier fruit production than cutting back a week later.

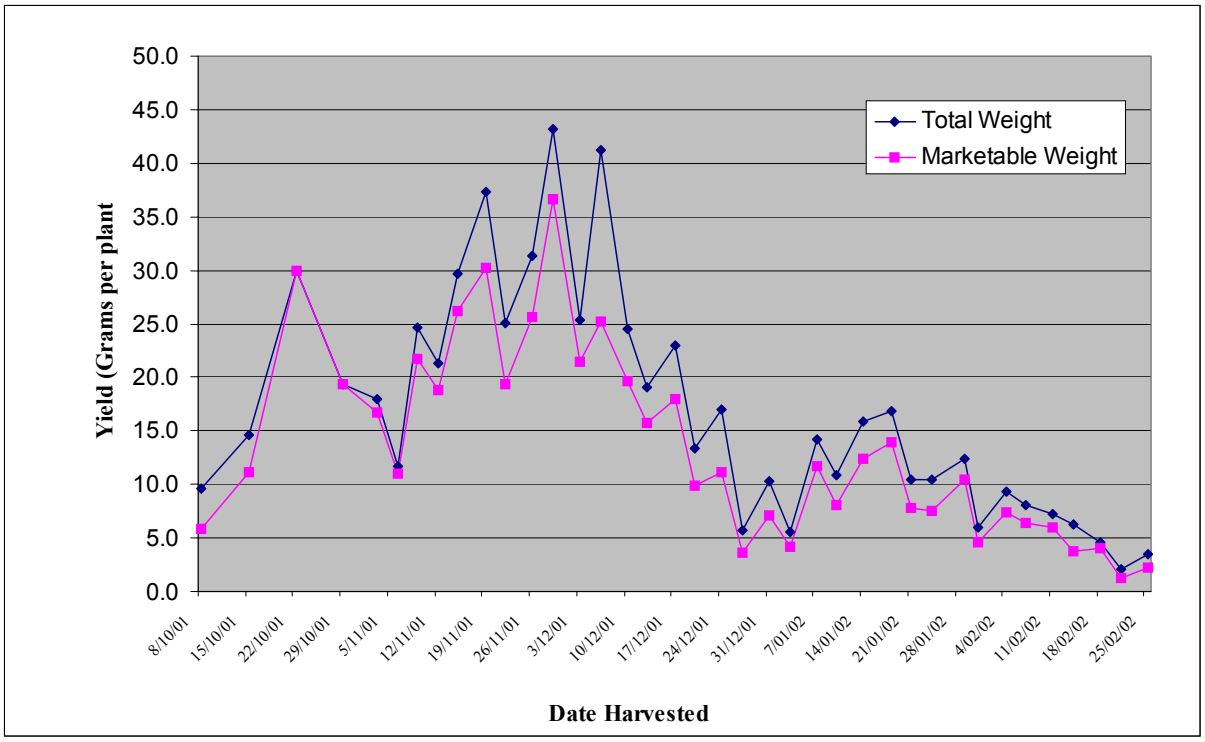

Figure 7.1 Spring harvest profile for Selva grown at Manjimup Horticultural Research Centre in 2001/02

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Selva growing at Manjimup, May 2002

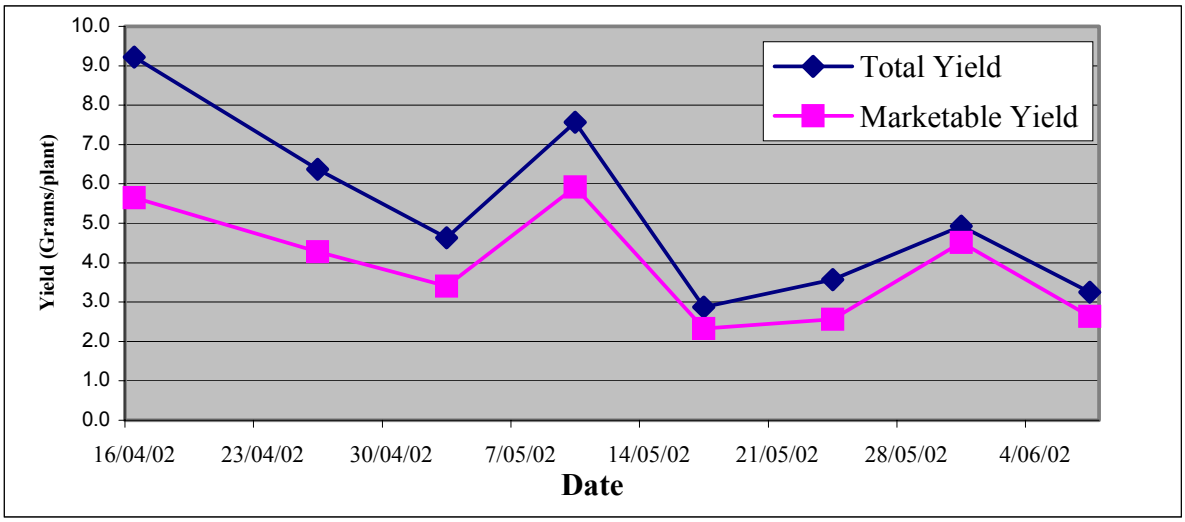


Figure 7.2 Autumn harvest profile from March 7 cut back plants at Manjimup 2002.

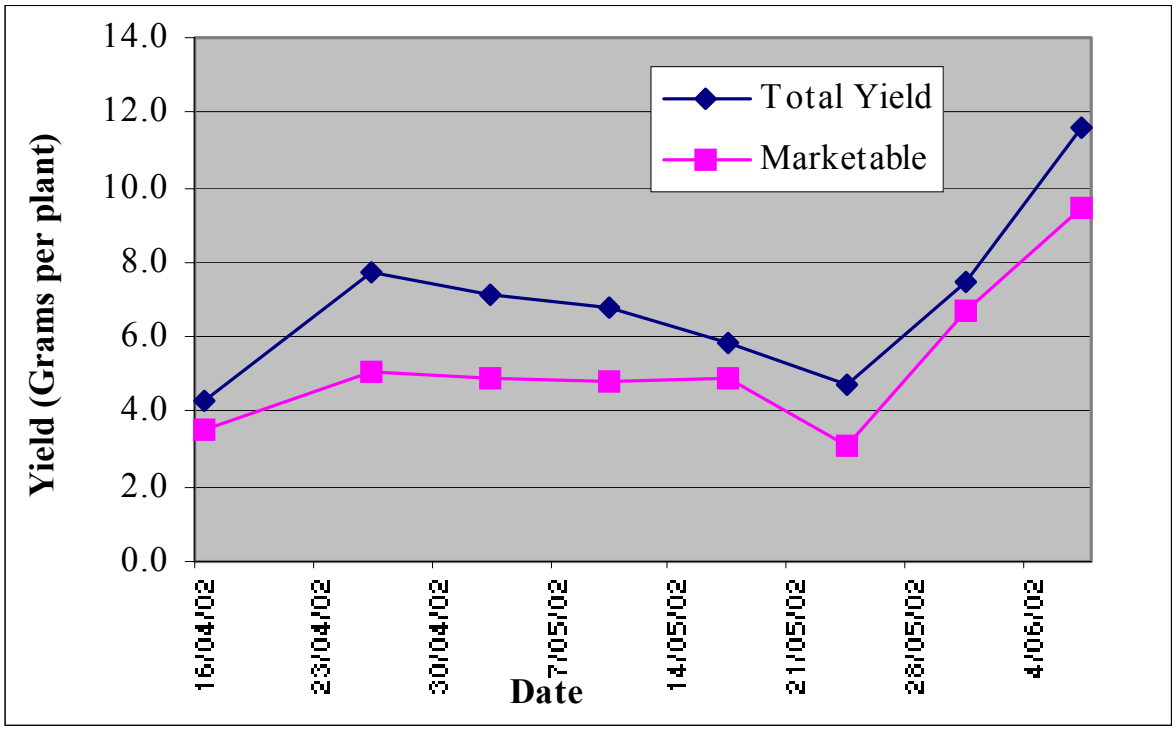


Figure 7.3 Autumn harvest profile from March 14 cut back plants at Manjimup 2002.

7.5 Conclusions

'Short Day' selections, 98-030-3, 98-049-119 and 99-041-85 are worthy of further evaluation by a number of growers in visible sized plots of up to 100 plants each before any decision to bulk up large semi-commercial quantities of runners.

Day neutral selections had not reached this stage of confidence by the end of the 2002/03 season, but further evaluation is warranted for selections 97-101-75 and 98-083-28.

8. MARKETING

8.1 INTRODUCTION

When the project proposal was written in 2001, it was envisaged that test marketing of Kiewa fruit using some form of varietal labelling to identify the variety to consumers may be possible within the life of the project. Time did not permit this within the original two year time frame of the project. An extension of the project for an additional year was sought to explore some of these possibilities, and an additional eight months was granted. Two aspects of Kiewa marketing which needed to be investigated in the market place, flowing on from the consumer studies conducted earlier in the project included:

1. Commercial testing of labelling and quality testing ideas as components of the future marketing package for Kiewa.
2. Assessing market and consumer reaction to 'brix tested' fruit in the marketplace following an accepted testing protocol.

Consumer research done by the project team showed that consumers want to be told what they are buying and to gain confidence in it through a series of positive experiences. They also have strong loyalty for products produced in WA.

The work also showed that 'Total Soluble Solids' of fruit (Brix) was well correlated with consumer perceptions of flavour, and a simple test on-farm using a hand held refractometer could be used by growers to test the brix level of their fruit before marketing.

The plan for this phase of the work was to coordinate the supply of Kiewa fruit to the market from the six growers in WA who were growing it. The growers agreed to test all Kiewa fruit for sugar (brix) prior to sale and apply an identifying sticker to punnets of fruit that meet an agreed minimum standard. The sticker will incorporate the essential information which consumers requested during the market research phase of this project. That is:

- The product comes from WA;
- it is guaranteed to have good flavour; and
- they can easily identify this fruit in the market place next time they purchase.

An agreed sticker for punnets was produced and a sampling kit for brix was supplied to growers, but as the season unfolded, it became obvious that more work needed to be done on a reliable and practical method of sampling fruit for brix on-farm. Licensing and propagation problems with the variety also meant that there was insufficient Kiewa fruit available for a meaningful marketing plan to be enacted.

The spring of 2003 did not prove conducive to high brix levels and good fruit flavour, so we confined our activity to development of a reliable fruit sampling method for brix. We needed to estimate a threshold brix level above which, consumer satisfaction was likely to be improved compared to untested fruit, before any attempt at market testing was possible.

8.2 MATERIALS AND METHODS

Brix data from fruit used for the sensory tests conducted at Curtin University in 2002 was re-analysed to help determine the number of fruit which would reliably estimate the whole population and the sampling intensity required. Brix results from the treatment which gave the best consumer flavour scores in September (i.e. 50 N) was manipulated to determine the probability of brix levels falling below various threshold levels.

8.3 RESULTS

8.3.1 Derivation of threshold brix for quality marketing

Individual fruit brix tests from the September 2002 harvested fruit used for sensory testing at Curtin University were partitioned into quantils to determine the probability of any individual fruit falling below a pre determined brix level. The distribution of fruit brix levels in this sample is shown in Table 8.1 and the quantil distribution in Table 8.2.

Table 8.1 Distribution of fruit brix levels from 72-80 individual fruits from September and October harvests in 2002 (treatments tested in Curtin sensory laboratory)

Treatment/ month	Mean Brix	Standard dev'n	Number of samples	Std error of mean	95% C.I. lower	95% C.I. upper	Coeff't of variation
50N Sept 02	9.074	1.509	80	0.1688	8.736	9.411	16.63
450 N Sept 02	9.197	1.555	72	0.1833	8.831	9.564	16.91
900 N Sept 02	8.151	1.641	76	0.1882	7.775	8.528	20.13
450 N + 50FM Sept 02	7.983	1.660	76	0.1905	7.602	8.364	20.79
50 N Oct 02	10.17	1.443	72	0.1700	9.827	10.51	14.19
450 N Oct 02	9.106	1.422	72	0.1676	8.770	9.441	15.62
900 N Oct 02	8.214	1.399	72	0.1648	7.884	8.544	17.03
450 N + 50 FM Oct 02	7.6	1.227	72	0.1446	7.311	7.889	16.14

The results from the three sensory tests conducted at Curtin University in September, October and November 2002 showed that nitrogen fertiliser treatments 50 N and 450 N always produced fruit that satisfied consumers, while 900 N sometimes did.

The two better treatments gave mean brix levels greater than 9.0 in September and October with coefficients of variation of around 17%. It was hypothesised that this was a profile for strawberry fruit that could be used as a target in a planned marketing campaign.

The effect on the distribution of 10 fruit in a punnet for each of these treatments is shown in Table 8.2. The data shows that for the two best treatments, only 2 out 10 fruits in a punnet would be expected to have a brix level of 7.5 or less in September or October.

Table 8.2 Segmentation (quantil) of the population of recorded fruit brix levels from samples of 72-80 individual fruits from September and October harvests in 2002 (treatments tested in Curtin sensory lab)

Quantil/ treatment	0.0	0.05	0.1	0.2	0.25	0.5	0.75	0.9	0.95	1.0
50 N Sept 02	6.6	6.9	7.25	7.5	7.8	8.95	10.4	11.0	11.1	13.0
450 N Sept 02	6.2	7.0	7.2	7.6	8.1	9.2	10.0	11.2	11.8	13.8
900 N Sept 02	4.8	5.0	6.2	7.0	7.0	8.0	9.2	10.2	11.0	13.5
450 N + 50 FM Sept 02	5.0	5.3	5.8	6.5	6.7	8.0	9.0	10.2	11.0	11.8
50 N Oct 02	6.8	7.8	8.4	9.0	9.2	10.2	11.0	12.6	12.8	13.0
450 N Oct 02	5.8	6.6	7.0	8.0	8.3	9.0	10.1	11.0	11.2	12.0
900 N Oct 02	5.8	6.0	6.6	7.0	7.1	8.0	9.3	10.0	10.8	11.2
450 N + 50 FM Oct 02	5.0	6.0	6.0	6.6	6.9	7.6	8.5	9.2	9.6	10.6

It was proposed that a standard that could be set for a fruit test which would ensure customer satisfaction was as follows:

if (mean > = 9 and CV < 20%) - accept fruit for quality marketing

if (mean between 8-9 and CV < 15%) - accept fruit for quality marketing

if (mean < 8 and CV > 15%) - do not accept fruit for quality marketing

if (Mean < 8) no sweet sticker - do not accept fruit for quality marketing

8.3.2 Derivation of a reliable fruit sampling method and testing procedure

We set out to test this proposed standard by harvesting batches of 10 fruits at a time from commercial growers crops in 2003 and comparing means derived from individual fruit measurements with composite samples.

Three batches of 10 fruits each collected from the same crop on the same day of uniform size, shape and apparent ripeness were tested for brix individually and a composite sample. This first sample was collected on 3 September 2003. Results of this tests are presented in Table 8.3.

Table 8.3 Comparison between estimating mean fruit brix from a composite sample of juice from 10 and 30 berries and calculating a mean from three batches of 10 individually tested fruits

	Batch 1	Batch 2	Batch 3	Grand mean
Arithmetic mean of 10 fruits	8.64	8.93	9.14	8.9
Composite of 10 fruits	8.6	8.6	8.8	
Composite of 30 fruits				8.6

Table 8.3 shows that there was little difference in the result obtained by collecting the juice from 10 or 30 berries and combining it for a single test, and measuring the individual results for all 30 berries. From this result it could be inferred that collecting 30 uniform berries from a crop and testing three composite samples of juice from batches of 10 fruit each is a satisfactory way of estimating the brix in a harvest of uniformly ripe fruit. The coefficient of variation of these batches of fruit were around 14%, so this sample would have met our previously described criteria for quality marketing.

8.3.3 Testing the sampling procedure and threshold in a commercial crop

Samples of uniformly ripe fruit were collected on a randomly selected harvest day on 17 September 2003 to test the proposed sampling procedure and threshold brix. The results were disappointing , in that the acceptable threshold was not reached, but the sampling technique was confirmed as reliable and the coefficients of variation were in a similar range to previous samples, as shown in Table 8.4.

Table 8.4 Results of a random test of commercial fruit on 17 September 2003 to test the sampling methods and brix thresholds achievable in a commercial crop

	Batch 1	Batch 2	Batch 3	Grand mean
Arithmetic mean of 10 fruits	6.88	6.96	7.2	7.01
Composite of 10 fruits	6.8	6.8	7.0	
Coefficient of variation	15.76	17.23	11.42	
Composite of 30 fruits				7.0

Growers were left with the sampling instructions and sampling kit for the remainder of the season but none marketed fruit using the sticker or following the testing procedure outlined. It was inferred that Kiewa fruit did not reach the required brix threshold often enough to permit quality marketing based on brix tested fruit.

8.4 DISCUSSION AND CONCLUSION

The sampling procedure proposed for commercial testing of strawberry fruit for flavour based marketing is practical, but the required brix threshold of 8.5-9.0 which would ensure customer satisfaction could not be reached often enough in the 2003 season to make the marketing method possible.

9. EXTENSION AND TECHNOLOGY TRANSFER

9.1 INTRODUCTION

The extension component of the project was limited by the time frame of the project to three field days for growers and marketers, in each of the three years spanned by the project. The field day activities included inspection of the advanced breeding lines at the grower site in Wanneroo, a talk on the results of the previous season's research each time and inspection of the field plots at Medina research station in 2001 and 2002. Other activities included an article in the national strawberry industry newsletter (yet to be published).

An attempt was made to monitor the irrigation practice and the recommended fertiliser program on a grower's property in 2001, but difficulties were encountered that led us to the conclusion that this type of work needed to be done in a separate project after the research had been completed and appropriate extension materials had been written.

9.2 RESULTS

FIELD DAY 2001

The following field day notes relevant to this project and report were distributed to approximately 20 interested growers at the field day in August 2001.

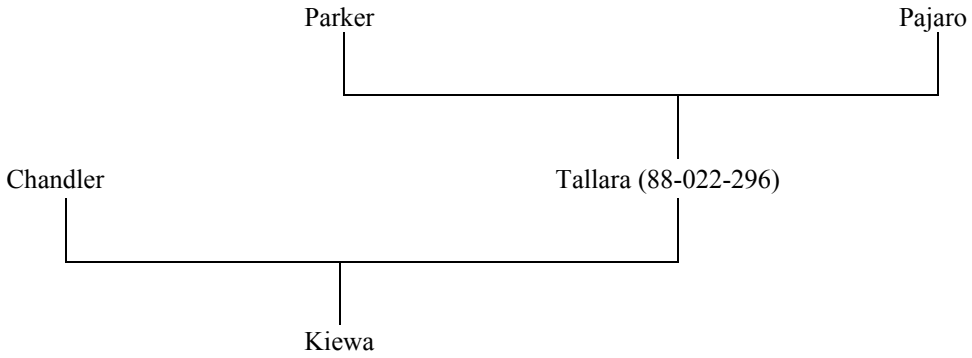
Field day group at a grower site in Wanneroo, 2001.

STRAWBERRY FIELD DAY, 31 AUGUST 2001

KIEWA

ORIGIN

Kiewa is a short day cultivar selected from a cross between the Californian cultivar Chandler, and Tallara made in 1995 by Dr Bruce Morrison at Agriculture Victoria's Institute for Horticultural Development, Knoxfield.



AGRONOMY SUMMARY

Kiewa produces vigorous, medium dense plants with medium green leaves. It is highly productive and fruit are produced on single stems which are easy to find and pick.

Kiewa was first selected in Victoria and trialed in non Methyl Bromide fumigated soil, without the use of fungicides. Since 1998, it has been trialed in Western Australia under standard grower conditions. Kiewa has not shown any particular susceptibility to pests, or leaf and fruit diseases. While not susceptible to two spotted mites, the positioning of lower leaves flat against the ground may make adequate application of miticides difficult.

Nutrient requirements are currently being studied at Medina. Preliminary results suggest that Kiewa does not have a heavy nitrogen demand.

Kiewa is suitable for a wide range of growing conditions, performing well in both Wanneroo and Albany trials.

FRUIT QUALITY SUMMARY

Kiewa produces attractive bright red fruit of superior flavour. The fruit are easily identified by the calyx, which at the final stage of maturity reflexes, bending back towards the stem.

The uniform shape is similar to Chandler. The flesh is medium red and moderately firm, but juicy. The skin is rain resistant and not easily damaged by picking and packing.

Shelf life and consumer acceptability of Kiewa are still to be determined but consumer acceptability is expected to be substantially better than cultivars currently grown due to its enhanced flavour and aroma.

WANNEROO

9.3 YIELDS

Kiewa produces very high yields, especially mid season (October). It has consistently yielded better than Chandler and Camarosa (Figure 9.2.1). It can also produce an autumn crop (no data available).

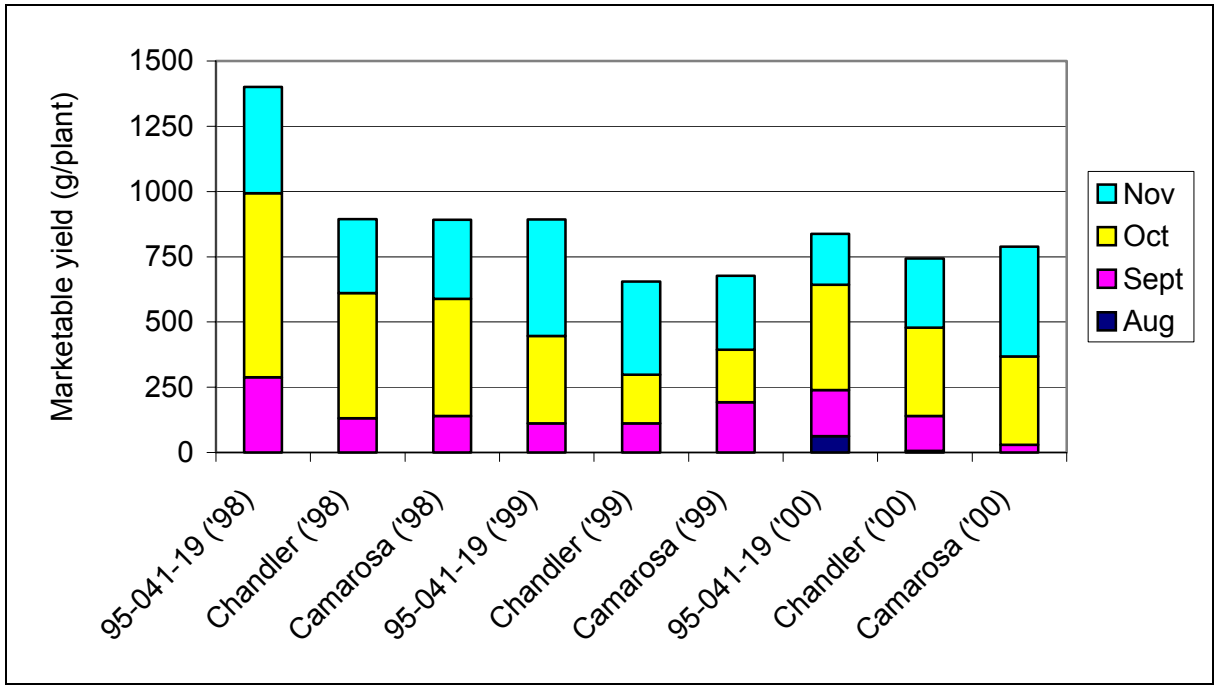


Figure 9.2.1 Marketable yield performance of Kiewa (95-041-19) at Wanneroo, 1998-2000.

FRUIT QUALITY

Kiewa fruit is 20% larger than Chandler and 5% larger than Camarosa (Table 1).

Table 9.2.1 Fruit size at Wanneroo (g)

	Kiewa	Chandler	Camarosa
1998	18.6	15.3	18.1
1999	23.1	17.9	20.9
2000	21.2	19.1	21.1
Mean	21.0	17.4	20.0

Table 9.2.2 Appearance of Kiewa at Wanneroo (score 1-9)

	Kiewa	Chandler	Camarosa
1998	6.3 (16)	5.9 (63)	6.4 (30)
1999	6.8 (4)	6.3 (4)	7.0 (4)
2000	5.3 (3)	5.3 (3)	7.0 (3)
Mean	6.1	5.8	6.8

(n) = number of times appearance was rated during season.

ALBANY

Yield

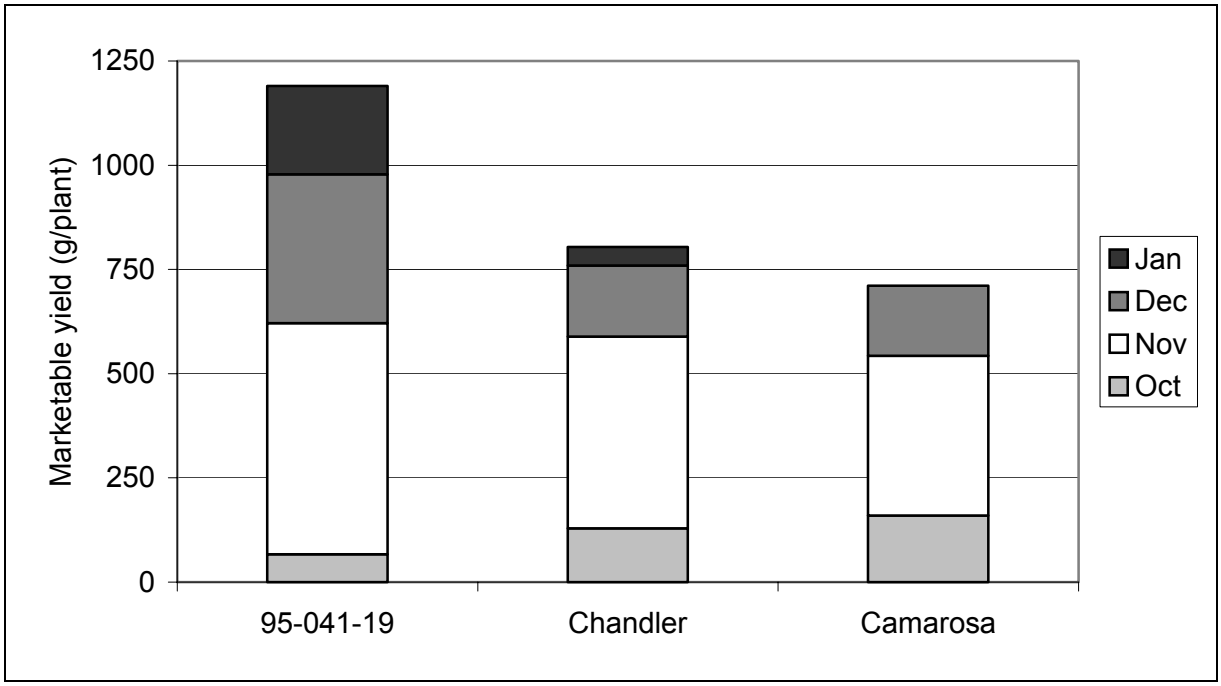


Figure 9.2.2 Marketable yield of Kiewa (95-041-19) at Albany, 2000/01.

FRUIT QUALITY

Table 4. Fruit size at Albany, 2000/01 (g)

	Kiewa	*Chandler*	*Camarosa*
size	18.1	12.3	18.1

Table 5. Fruit quality of Kiewa at Albany, 2000/01

Score (1-9)	*Kiewa*	*Chandler*	*Camarosa*
Appearance	5.8 (9)	5.2 (6)	6.2 (5)
Taste	6.8 (16)	6.5 (14)	7.5 (10)

(n)= number of times rated during season

Table 9.2.3 Fruit size at Albany, 2000/01 (g)

	Kiewa	**Chandler**	**Camarosa**
Size	18.1	12.3	18.1

Table 9.2.4 Appearance of Kiewa at Albany (2000/01)

	Kiewa	Chandler	Camarosa
Appearance	5.8 (9)	5.2 (63)	6.2 (5)
Taste	6.8 (16)	6.5 (14)	7.5 (10)

(n) = number of times appearance was rated during season.

BUSSELTON

Kiewa produced twice as much fruit as Selva from September to the end of December.

Table 9.2.5 Marketable yield of Kiewa at Busselton (2000)

Variety	Maretable yield (g/plant)
Kiewa	1258
Selva	614

WHEN SHOULD KIEWA BE PLANTED AND HOW MUCH CHILL DOES IT NEED ???

This year we have planted runners from three sources with up to four digging dates to test the response to eight different 'chill' treatments. Since planting, the plants have also received significant chilling in the field. For example, during July and August 186 hrs were recorded at I. Ivanokovic's Carabooda farm.

Table 9.2.6 Chilling hours required by runners

Digging date	Source	Chill hours (< 7°C)
17 April	Ovens	49
30 April	Tasmania	353
30 April	Ovens	59
4 May*	Ovens	66 (+ 168)
8 May	Mt Barker	37
11 May	Ovens	137
16 May	Mt Barker	39
23 May	Mt Barker	43

*held in cool room for at least one week before planted.

KIEWA REPORT CARD

	August	September	October	Final Grade	
Picking and Packing	**%**	**%**	**%**	**%**	
Plant size	86	70	76	77	A
Display of fruit	78	71	78	76	A
Ease of picking	83	71	63	72	B+
Fruit shape	67	74	81	80	A+
Fruit size	86	80	78	81	A+
Uniformity of size	67	69	78	71	B+
Tolerance to rain		74	81	78	A
Resistance to bruising	67	80	83	77	A
Marketability					
Attractiveness of fruit	56	75	80	70	B+
Colour - external	67	68	81	72	B+
Colour - internal	67	73	78	72	B+
Flavour	67	73	72	71	B+
Shelf life			74	76	A
Cultural					
Berry rot tolerance	67	73	78	72	B+
Leaf disease tolerance	72	86	80	77	A
Mite tolerance		73	80	77	A

COMMENTS

Best features: rain tolerance, plant vigour, yield, fruit size and colour, not too early, shape appearance; fruit size and quality, adaptability, fruit display.

Worst features: calyx, too bushy, susceptible to gnomonia; fruit display, decreased plant vigour.

FIELD DAY 2002

The following notes were distributed to those attending the 2002 field day.

STRAWBERRY FIELD DAY, MEDINA NUTRITION TRIAL - 24 AUGUST 2002

Project Objective: To supply growers with a production guide to maximise yield and quality from Kiewa

AIMS

- To assess the effects of nitrogen fertiliser application on yield and quality of Kiewa.
- To develop a fertiliser program for Kiewa based on mineral fertiliser only.
- To confirm sap nitrate guidelines for Kiewa.

TRIAL DETAILS

Planting date: 8/05/2002 *Kiewa* (Bignell)

Spacing: 30 x 30 cm in four row beds

Irrigation system: Netafim Streamline 80 with 250 mm emitters. Flow rate 0.98 L/hour

Irrigation schedule: Dripper twice daily (8 a.m. and 2 p.m.), based on a percentage of the monthly average of the daily evaporation as set out below. Overhead irrigation used for cooling only.

Irrigation schedule	May	June	July	August		September		October		November		December	
				1st ½	2nd ½	1st ½	2nd ½	1st ½	2nd ½	1st ½	2nd ½	1st ½	2nd ½
Epan mm daily	2.6	1.7	1.7	2.2	2.6	3.0	4.0	4.4	5.0	6.1	7.0	7.6	9.0
Target % applied	100	50	50	60	60	70	70	80	80	90	90	100	100
Actual % applied	140	85	85	100	65	-	-	-	-	-	-	-	-
Actual mins applied daily (a.m. and p.m.)	15 x 2	9 x 2	9 x 2	12 x 2	9 x 2	-	-	-	-	-	-	-	-

Treatments: Two schedules of pre-plant fertiliser with seven rates of fertigation superimposed, giving a total of eight treatments (see table below).

Treatment	Pre-plant fertiliser (NPK) (kg/ha)	Fertigation (NPK) (kg/ha)
T1	0:180:100	50:0:350
T2	0:180:100	150:0:350
T3	0:180:100	300:0:350
T4	0:180:100	450:0:350
T5	0:180:100	600:0:350
T6	0:180:100	750:0:350
T7	0:180:100	900:0:350
T8	0:180:100 + fowl manure @ 50m^3	450:0:350

Superphosphate (2000 kg/ha), HiTrace (100 kg/ha), and K-Mag (550 kg/ha) were incorporated into the entire trial area. Fowl manure treatment applied (19/04/2002) to trial four to five days before laying plastic.

ACTUAL FERTILISER RATES PER 10,000 PLANTS PER DAY

MEDINA STRAWBERRY (KIEWA) FERTILISER (FERTIGATION) SCHEDULE 2002									
Fertiliser rates grams per day per 10,000 plants for each designated month									
Month	Fertiliser	Treatment number in trial							
		1	2	3	4	5	6	7	8
May	Calcium nitrate	54.4	54.4	54.4	54.4	54.4	54.4	54.4	54.4
	Magnesium nitrate	114.6	114.6	114.6	114.6	114.6	114.6	114.6	114.6
	Ammonium nitrate	2.3	129.6	320.6	511.6	703.7	893.5	1085.6	511.6
	Potassium sulphate	365.7	365.7	365.7	365.7	365.7	365.7	365.7	365.7
June	Calcium nitrate	49.8	49.8	49.8	49.8	49.8	49.8	49.8	49.8
	Magnesium nitrate	105.3	105.3	105.3	105.3	105.3	105.3	105.3	105.3
	Ammonium nitrate	2.3	119.2	296.3	472.2	649.3	825.2	1002.3	472.2
	Potassium sulphate	338.0	338.0	338.0	338.0	338.0	338.0	338.0	338.0
July	Calcium nitrate	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3
	Magnesium nitrate	96.1	96.1	96.1	96.1	96.1	96.1	96.1	96.1
	Ammonium nitrate	1.2	108.8	272.0	432.9	594.9	756.9	919.0	432.9
	Potassium sulphate	309.0	309.0	309.0	309.0	309.0	309.0	309.0	309.0
August	Calcium nitrate	54.4	54.4	54.4	54.4	54.4	54.4	54.4	54.4
	Magnesium nitrate	114.6	114.6	114.6	114.6	114.6	114.6	114.6	114.6
	Ammonium nitrate	2.3	129.6	320.6	511.6	703.7	893.5	1085.6	511.6
	Potassium sulphate	365.7	365.7	365.7	365.7	365.7	365.7	365.7	365.7
September	Calcium nitrate	54.4	54.4	54.4	54.4	54.4	54.4	54.4	54.4
	Magnesium nitrate	114.6	114.6	114.6	114.6	114.6	114.6	114.6	114.6
	Ammonium nitrate	2.3	129.6	320.6	511.6	703.7	893.5	1085.6	511.6
	Potassium sulphate	365.7	365.7	365.7	365.7	365.7	365.7	365.7	365.7
October	Calcium nitrate	57.9	57.9	57.9	57.9	57.9	57.9	57.9	57.9
	Magnesium nitrate	122.7	122.7	122.7	122.7	122.7	122.7	122.7	122.7
	Ammonium nitrate	2.3	138.9	346.1	550.9	756.9	963.0	1169.0	550.9
	Potassium sulphate	393.5	393.5	393.5	393.5	393.5	393.5	393.5	393.5
November	Calcium nitrate	57.9	57.9	57.9	57.9	57.9	57.9	57.9	57.9
	Magnesium nitrate	122.7	122.7	122.7	122.7	122.7	122.7	122.7	122.7
	Ammonium nitrate	2.3	138.9	346.1	550.9	756.9	963.0	1169.0	550.9
	Potassium sulphate	393.5	393.5	393.5	393.5	393.5	393.5	393.5	393.5

NOTE: Potassium sulphate cannot be mixed with calcium nitrate and magnesium nitrate (a precipitate is formed). The fertigation applications are split into two applications: ammonium nitrate and potassium sulphate are applied a.m. and calcium nitrate plus magnesium nitrate are applied p.m.

Potassium sulphate is used at Medina to correct soil pH.

MEASUREMENTS

Yields: Total weight
Marketable weight
Number of berries

Quality: Brix and Acid at weekly intervals from end of August to mid December.
Sensory panel evaluation at three dates (monthly).

RESULTS SO FAR

Lysimeter: Lysimeter readings (mg/L) 5/07/2002

	NO_3	NO_3-N
T3	150	34
T7	225	51
T1	146	33
T5	240	54
T4	150	34
T8	670	151
T2	170	38
T6	154	35

Yields:

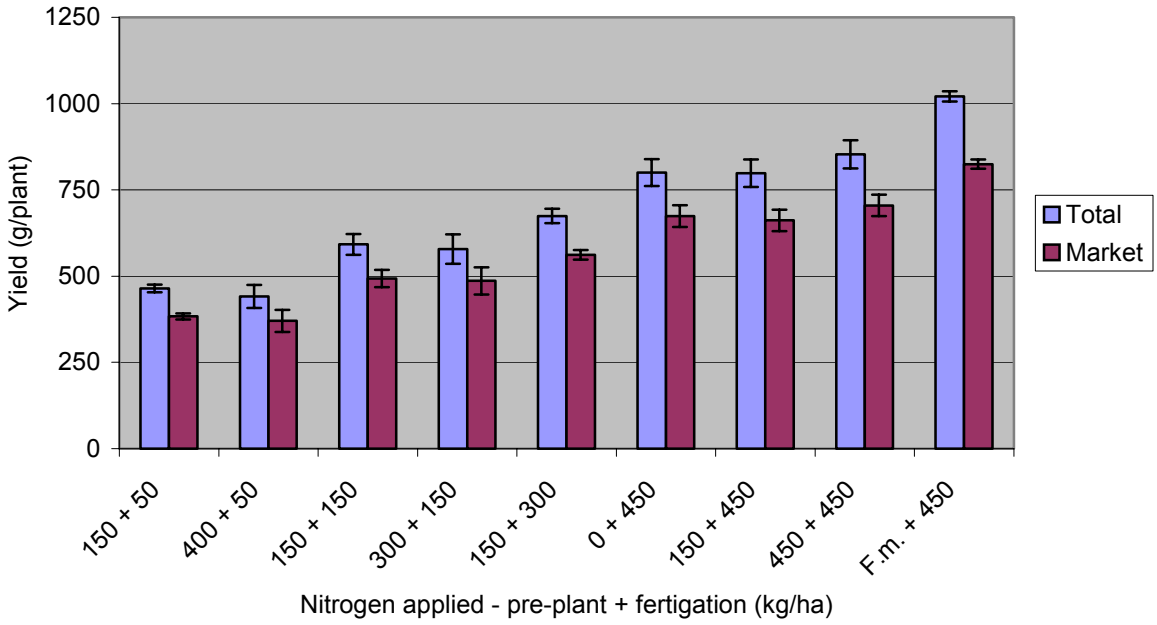
Marketable yields for August in grams per plant			
Treatment	**13/08/2002**	**16/08/2002**	**20/08/2002**
1	24.1	26.8	42.1
2	32.7	33.3	45.9
3	34.2	38.7	55.4
4	26.8	30.3	36.5
5	31.9	49.3	48.6
6	26.8	41.3	56.5
7	37.3	41.5	55.1
8	27.1	19.7	30.3

Quality:

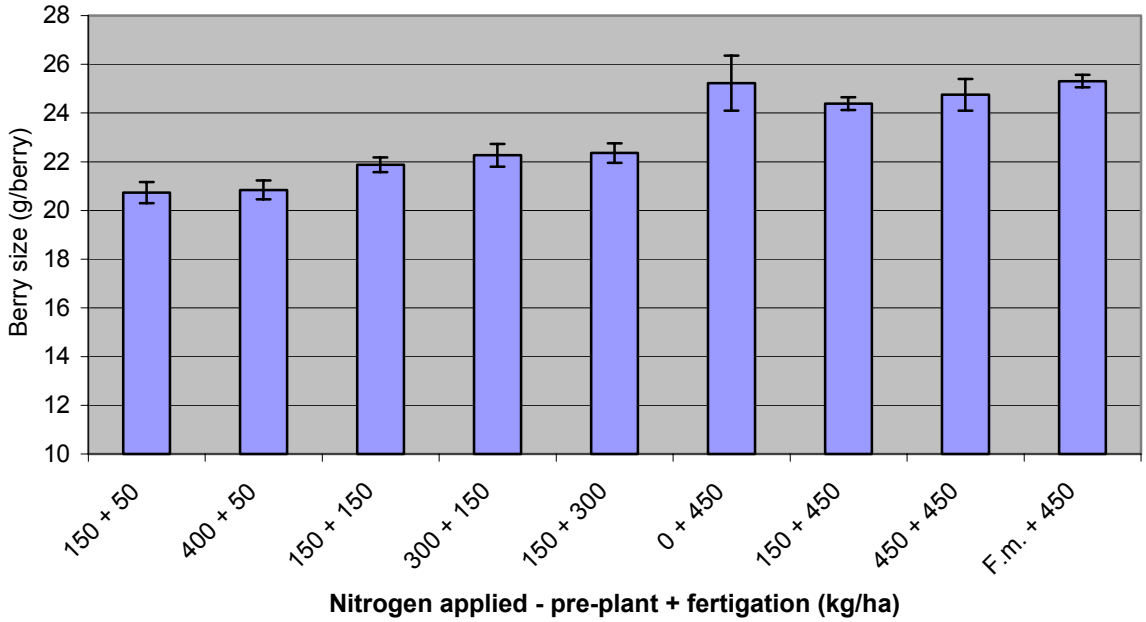
Brix and acid readings from first sampling.

21/08/2002		
Treatment	**BRIX° (mean of 4 reps)**	**Citric acid g/l**
1	8.65	6.42
2	9.08	6.21
3	8.40	5.89
4	8.75	6.03
5	8.20	5.73
6	8.35	5.70
7	8.40	5.87
8	8.15	6.22

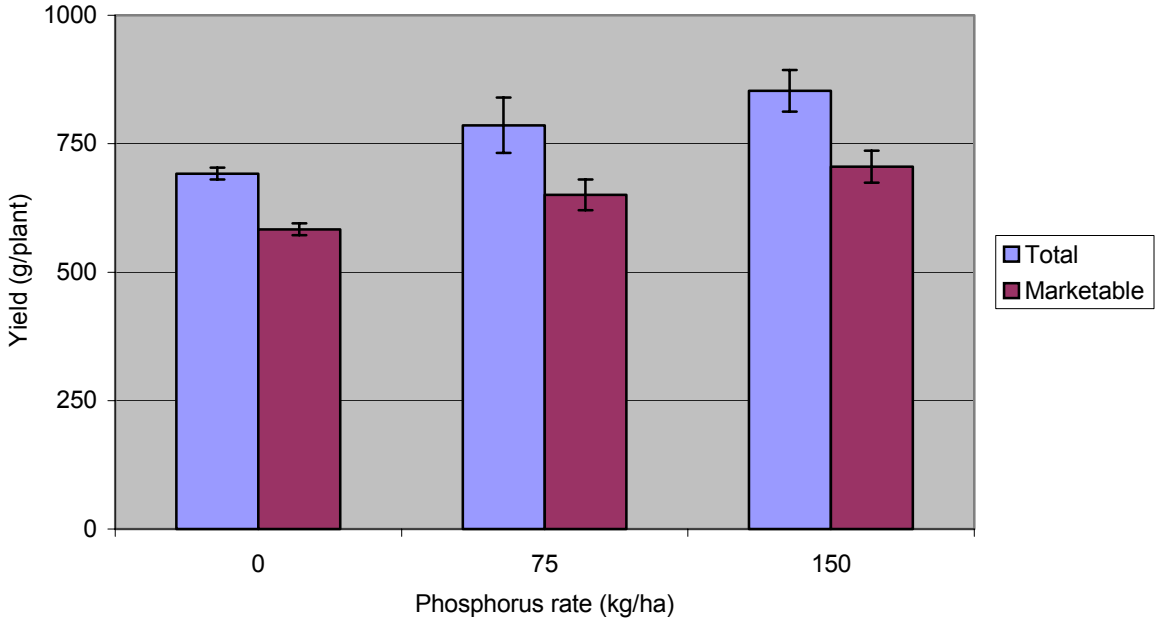
RESULTS FROM 2001



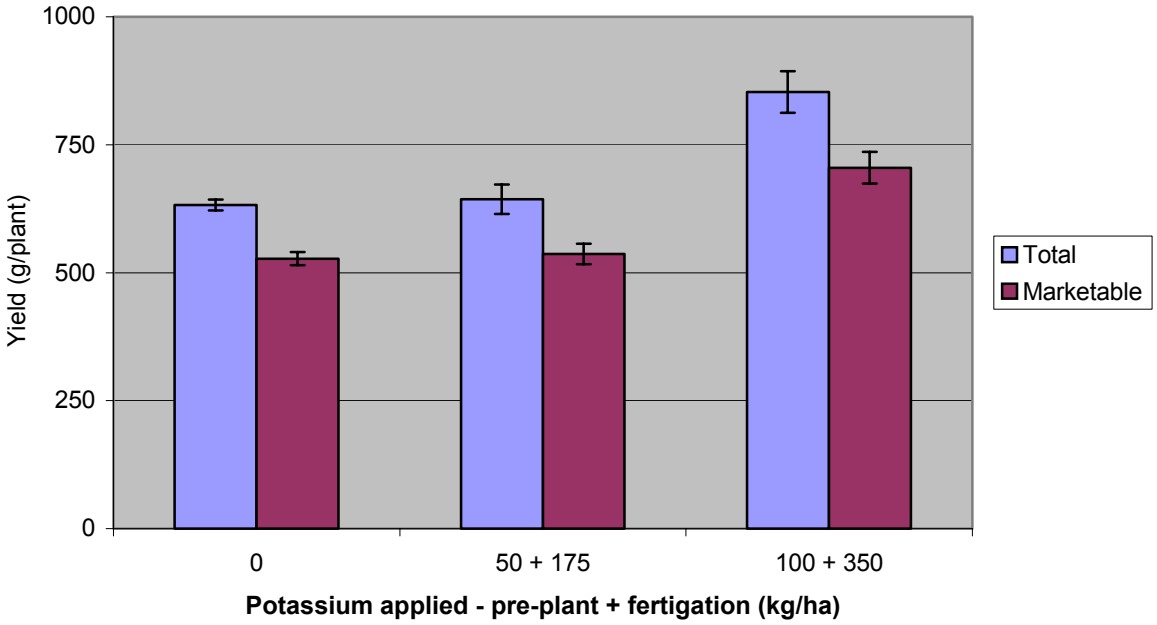
Effect of N rate and timing on total and marketable yield of Kiewa.



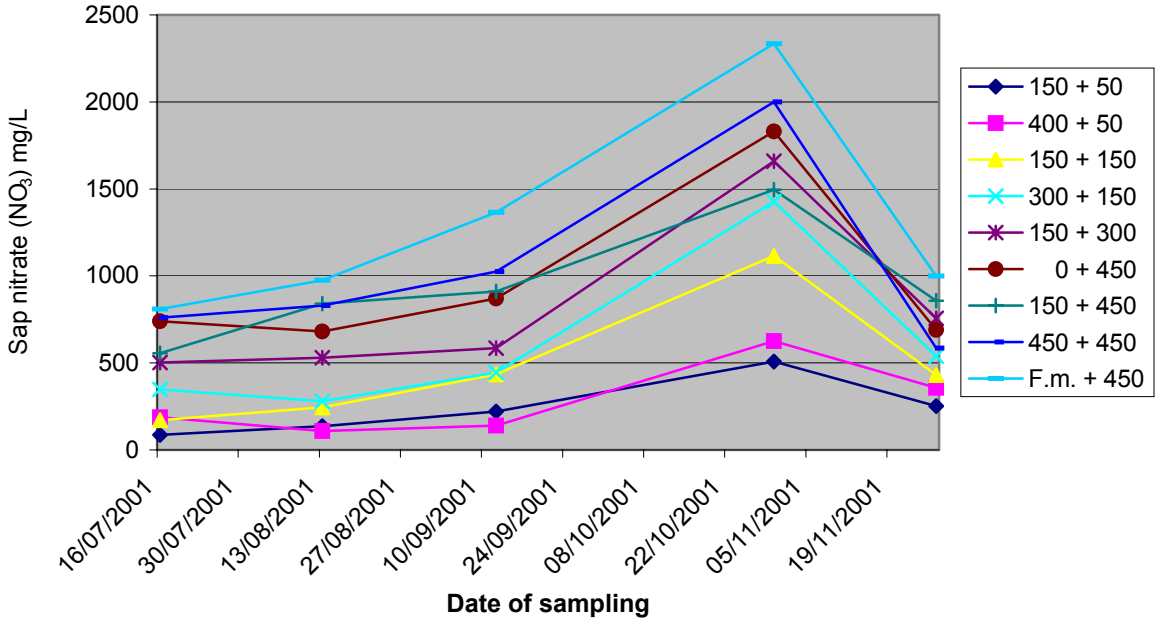
Effect of N rate and timing on average marketable berry size of Kiewa.



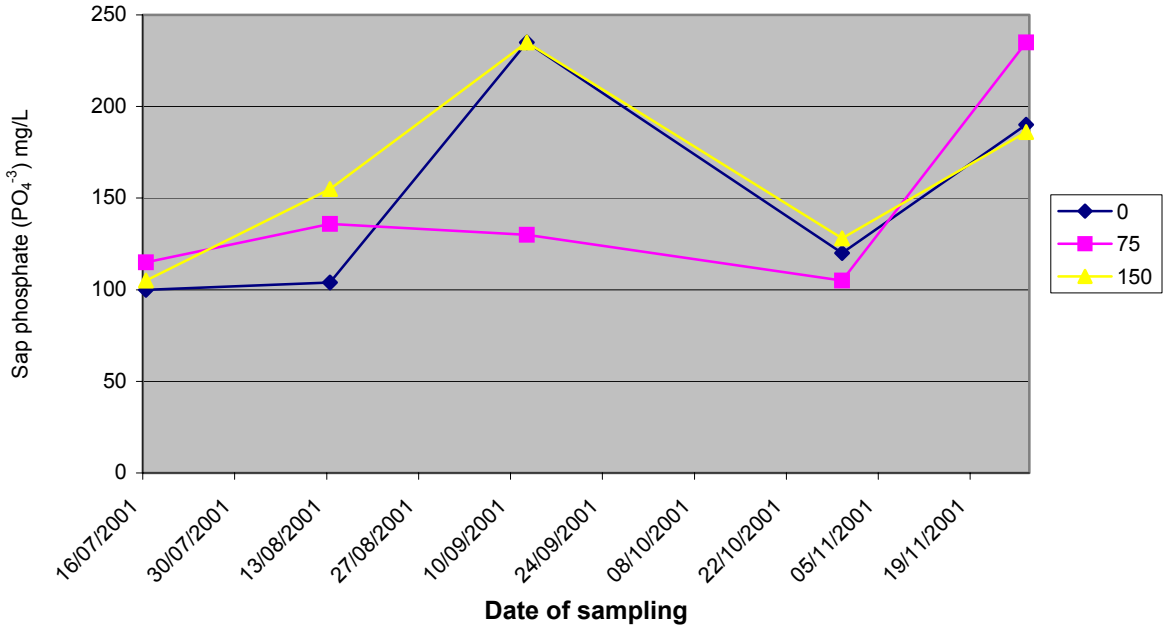
Effect of P rate on the total and marketable yield of Kiewa.



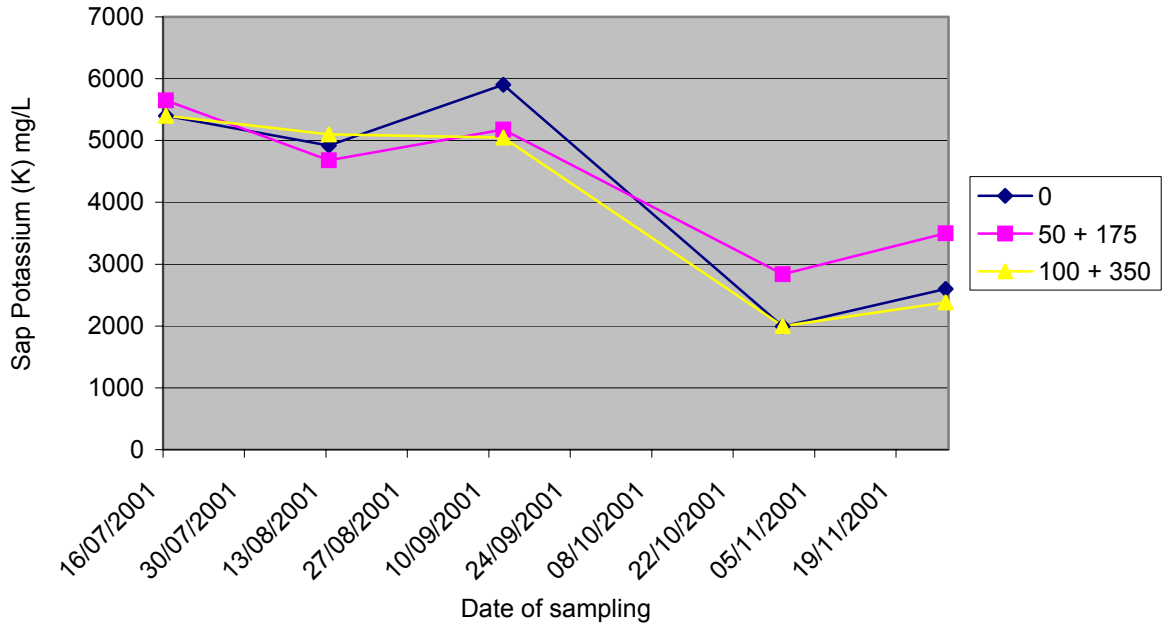
Effect of K rate on the total and marketable yield of Kiewa.



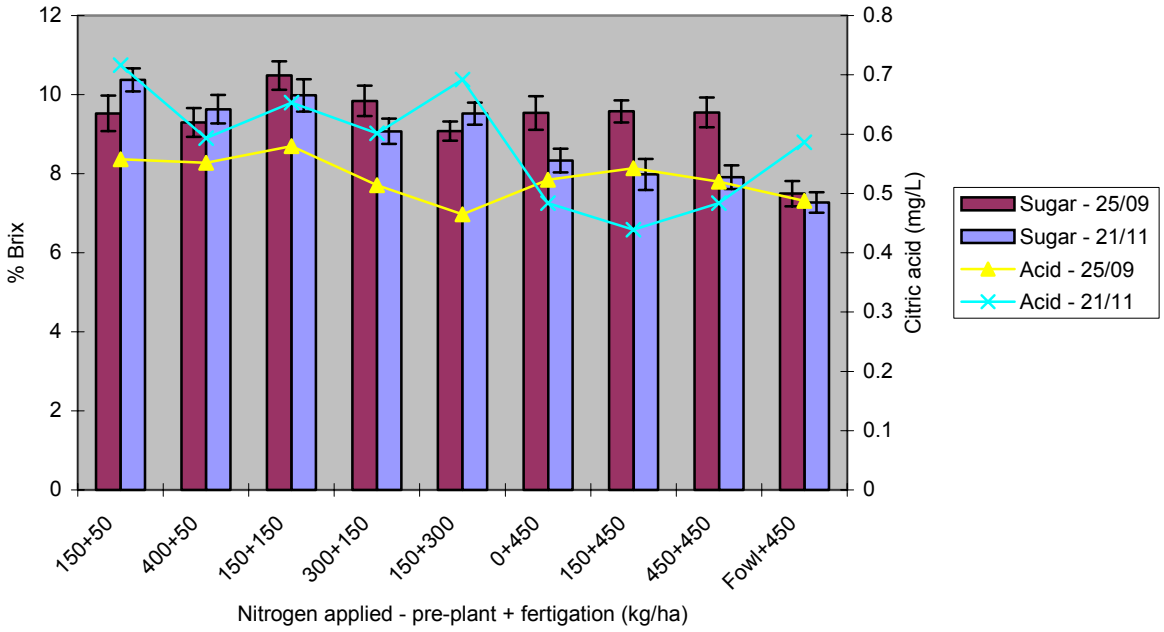
Effect of nitrogen fertiliser on sap nitrate (NO^-_3) cv. Kiewa.



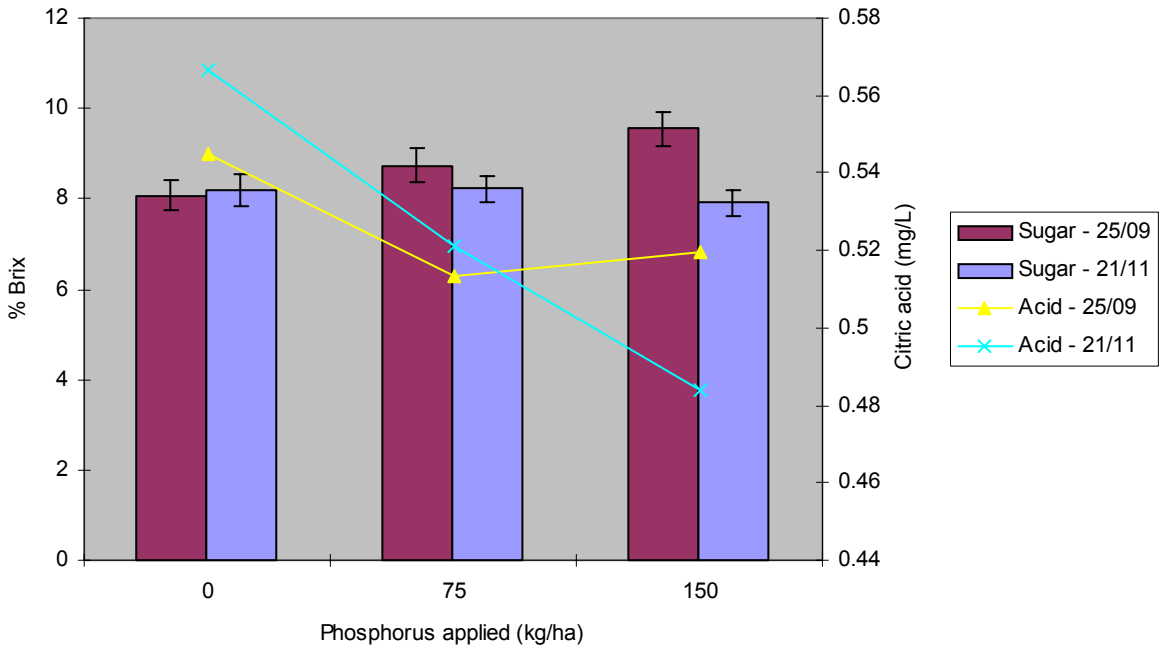
Effect of nitrogen fertiliser on sap nitrate (NO^-_3) cv. Kiewa.



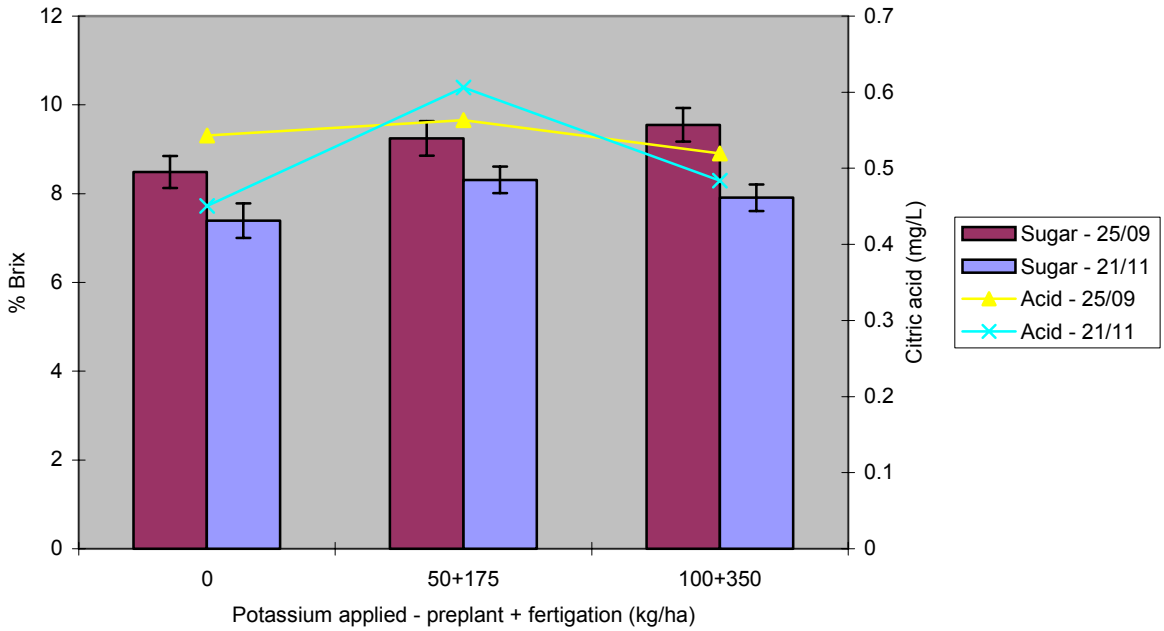
Effect of potassium fertiliser on sap potassium (K) cv. Kiewa.



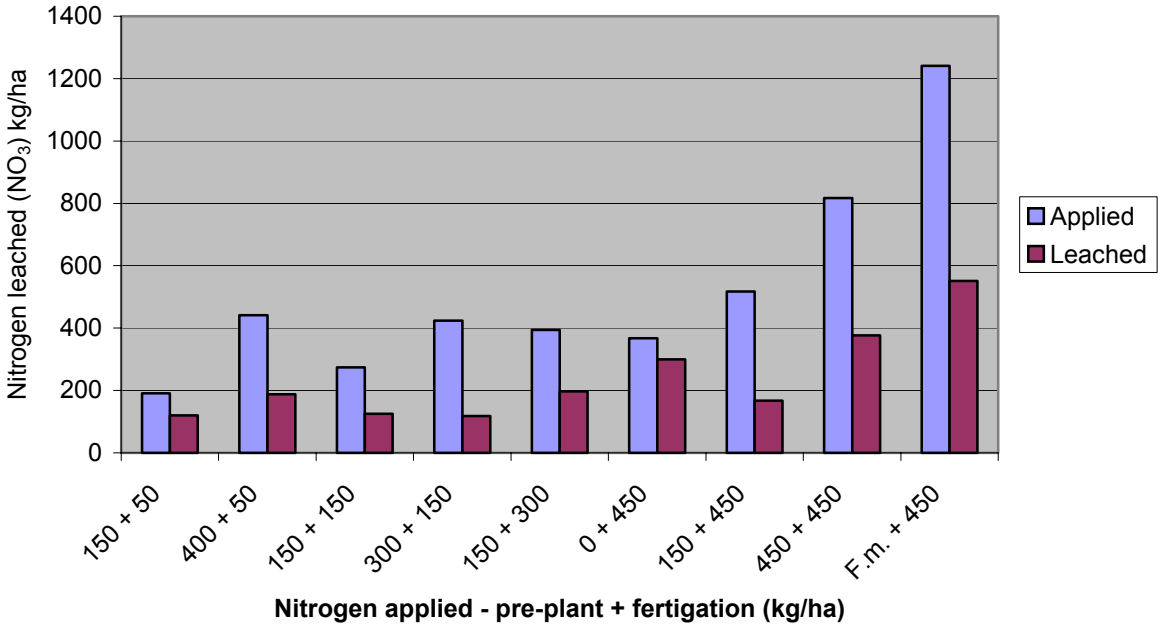
Effect of nitrogen fertiliser on fruit sugar and acid levels.



Effect of phosphorus fertiliser on fruit sugar and acid levels.



Effect of potassium fertiliser on fruit sugar and acid levels.



Comparison of total nitrogen applied to nitrogen leached.

Pre-plant	**Rate**
Phosphorus	150 kg/ha
Potassium	100 kg/ha
Fowl manure*	50 m^3
During crop growth	
Nitrogen	450 kg/ha
Potassium	350 kg/ha

* Subject to health regulations

Fertiliser recommendation for Kiewa.

FIELD DAY 2003

The following notes were distributed to those attending the 2003 field day.

STRAWBERRY FIELD DAY, MEDINA TRIAL MANAGEMENT PRACTICES - 22 AUGUST 2003

Project Objective: To supply growers with a production guide to maximise yield and quality from Kiewa

AIMS

- To assess the effects of nitrogen fertiliser application on yield and quality of Kiewa.
- To develop a fertiliser program for Kiewa based on mineral fertiliser only.
- To confirm sap nitrate guidelines for Kiewa.

TRIAL DETAILS

Planting date: 8/05/2002 *Kiewa* (Bignell)

Spacing: 30 x 30 cm in four row beds

Irrigation system: Netafim Streamline 80 with 250 mm emitters. Flow rate 0.98 L/hour

Irrigation schedule: Dripper twice daily (8 a.m. and 2 p.m.), based on a percentage of the monthly average of the daily evaporation as set out below. Overhead irrigation used for cooling only.

Applied irrigation:

Irrigation schedule	May	June	July	August		September		October		November		December	
				1st ½	2nd ½	1st ½	2nd ½	1st ½	2nd ½	1st ½	2nd ½	1st ½	2nd ½
Epan mm daily	2.6	1.7	1.7	2.2	2.6	3.0	4.0	4.4	5.0	6.1	7.0	7.6	9.0
Target % applied	100	50	50	60	60	70	70	80	80	90	90	100	100
Actual % applied	140	85	85	100	65	75	60	75	74	61	51	52	
Actual mins applied daily (a.m. and p.m.)	15 x 2	9 x 2	9 x 2	12 x 2	9 x 2	11 x 2	11 x 2	12 x 2	14 x 2	17 x 2	19 x 2	20 x 2	

Irrigation plus rainfall:

Irrigation schedule	May	June	July	August		September		October		November		December	
				1st ½	2nd ½	1st ½	2nd ½	1st ½	2nd ½	1st ½	2nd ½	1st ½	2nd ½
Epan mm daily	2.6	1.7	1.7	2.2	2.6	3.0	4.0	4.4	5.0	6.1	7.0	7.6	9.0
Target % applied	100	50	50	60	60	70	70	80	80	90	90	100	100
Actual % applied	140	85	85	100	65	75	60	75	74	61	51	52	
Actual mins applied daily (a.m. and p.m.)	15 x 2	9 x 2	9 x 2	12 x 2	9 x 2	11 x 2	11 x 2	12 x 2	14 x 2	17 x 2	19 x 2	20 x 2	

Treatments: Two schedules of pre-plant fertiliser with seven rates of fertigation superimposed, giving a total of eight treatments (see table below).

Treatment	Pre-plant fertiliser (NPK) (kg/ha)	Fertigation (NPK) (kg/ha)
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T4	0:180:100	450:0:350
T5	0:180:100	600:0:350
T6	0:180:100	750:0:350
T7	0:180:100	900:0:350
T8	0:180:100 + fowl manure @ 50m^3	450:0:350

Superphosphate (2000 kg/ha), HiTrace (100 kg/ha), and K-Mag (550 kg/ha) were incorporated into the entire trial area. Fowl manure treatment applied (19/04/2002) to trial four to five days before laying plastic.

ACTUAL FERTILISER RATES PER 10,000 PLANTS PER DAY

MEDINA STRAWBERRY (KIEWA) FERTILISER (FERTIGATION) SCHEDULE 2002									
Fertiliser rates grams per day per 10,000 plants for each designated month									
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	Ammonium nitrate	2.3	129.6	320.6	511.6	703.7	893.5	1085.6	511.6
	Potassium sulphate	365.7	365.7	365.7	365.7	365.7	365.7	365.7	365.7
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	Magnesium nitrate	105.3	105.3	105.3	105.3	105.3	105.3	105.3	105.3
	Ammonium nitrate	2.3	119.2	296.3	472.2	649.3	825.2	1002.3	472.2
	Potassium sulphate	338.0	338.0	338.0	338.0	338.0	338.0	338.0	338.0
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	Magnesium nitrate	114.6	114.6	114.6	114.6	114.6	114.6	114.6	114.6
	Ammonium nitrate	2.3	129.6	320.6	511.6	703.7	893.5	1085.6	511.6
	Potassium sulphate	365.7	365.7	365.7	365.7	365.7	365.7	365.7	365.7
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	Magnesium nitrate	114.6	114.6	114.6	114.6	114.6	114.6	114.6	114.6
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	Magnesium nitrate	122.7	122.7	122.7	122.7	122.7	122.7	122.7	122.7
	Ammonium nitrate	2.3	138.9	346.1	550.9	756.9	963.0	1169.0	550.9
	Potassium sulphate	393.5	393.5	393.5	393.5	393.5	393.5	393.5	393.5
November	Calcium nitrate	57.9	57.9	57.9	57.9	57.9	57.9	57.9	57.9
	Magnesium nitrate	122.7	122.7	122.7	122.7	122.7	122.7	122.7	122.7
	Ammonium nitrate	2.3	138.9	346.1	550.9	756.9	963.0	1169.0	550.9
	Potassium sulphate	393.5	393.5	393.5	393.5	393.5	393.5	393.5	393.5

NOTE: Potassium sulphate cannot be mixed with calcium nitrate and magnesium nitrate (a precipitate is formed). The fertigation applications are split into two applications: ammonium nitrate and potassium sulphate are applied a.m. and calcium nitrate plus magnesium nitrate are applied p.m.