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Improving the Efficiency of Mechanical Olive Harvest

Evaluation of fruit loosening agents

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Improving the Efficiency of Mechanical Olive Harvesting:

Evaluation of fruit loosening agents

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Mechanical Olive Harvesting*: Evaluation of Fruit Loosening Agents*

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Foreword

Mechanisation in agriculture can be a key driver of productivity growth. RIRDC is working with Australia's rapidly growing olive industry to enhance its productivity, and competitiveness. The forces that lead to mechanization in agriculture are clear: high cost and availability of manual labour. For some crops, these economic forces have led to rapid adoption of mechanization, for others, like olives in the Mediterranean basin; the pressure for mechanization has been growing at a much slower pace.

The emerging Australian olive industry needs to be extremely cost effective. The mechanization of harvesting is the most important factor affecting cost competitiveness. There is no doubt that Australian growers have made significant progress in these areas and are generating and evaluating technology without precedent in the world olive industry. The improvement is rapid - current technology was successful in harvesting and processing more than 50,000 tonnes of fruit in 2006 and almost 60,000 tonnes in 2007.

Poor harvesting efficiency is probably one of the Australian industry's worst hidden costs. A careful analysis of harvesters' performances indicates that fruit losses during the 2005-07 seasons clearly exceeded AU$5,000,000 in any of those seasons, an extremely high figure for an emerging industry.

Overseas research in chemical loosening agents has led this research work to be undertaken in Australia with most data in this report gathered at two of the largest irrigated commercial olive groves in the country. These trials evaluated the effect of foliar treatments in weakening the Fruit Retention Force (FRF) and improving mechanical harvesting efficiency and economics. The advantages of products increasing fruit abscission would be of value for an earlier harvest, with the consequent improvement in oil quality, reduction of biannual bearing and increased efficiency of mechanical harvesting. All these improvements would be beneficial for the entire Australian olive industry.

The results presented here show that fruit loosening agents increase harvest efficiency.

This project was funded from industry revenue which is matched by funds provided by the Australian Government.

This report, an addition to RIRDC's diverse range of over 1800 research publications, forms part of our New Plant Products R&D program, which aims to facilitate the development of new rural industries based on plants or plant products that have commercial potential for Australia.

Most of our publications are available for viewing, downloading or purchasing online through our website:

- downloads at www.rirdc.gov.au/fullreports/index.html
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Abbreviations

FLA: Fruit Loosening Agent.
FRF: Fruit Retention Force.
HE: Harvest Efficiency.
MKP: Mono Potassium Phosphate.
BBE: Boundary Bend Estate.
BOE: Boort Estate.

Contents

Executive Summary

What the report is about
Outlined in this report are the findings of a two year trial that set out to evaluate the currently available fruit loosening agents under Australian conditions in order to determine their cost effectiveness and conditions for their commercial use.

Who the report is targeted at
This report will be very useful for Australian olive growers and will provide supporting information to assist registration with the APVMA to enable legitimate use of this chemical in Australian conditions.

Background
Overseas research in chemical loosening agents has led to several trials undertaken in Australia and data in this report were gathered at two irrigated commercial olive groves. These trials evaluated the effect of foliar treatments in weakening the FRF (Fruit Retention Force) and improving mechanical harvesting efficiency and economics. The advantages of products increasing fruit abscission would be of value for an earlier harvest, with the consequent improvement in oil quality, reduction of biannual bearing and increased efficiency of mechanical harvesting.

Methods used
In total, seven different fruit loosening treatments were applied to Barnea, Frantoio, Picual and Minerva (Leccino clone) olive varieties, grown at two irrigated commercial olive groves, Boundary Bend Estate and Timbercorp Boort Olive Grove in Victoria. Smaller replicates of these trials were performed at Coonalpyn Olives in South Australia and Olive West in Western Australia to confirm obtained observation under different environmental conditions.

The fruit retention force (FRF) was measured twice weekly with a dynamometer for 30 fruits per 6 trees per treatment, per variety during 4 to 5 weeks. Before, during and after harvest assessments on leaf and fruit abscission were performed by counting fruit and leaf numbers on four labelled branches on 3 trees per treatment per variety. Efficiency of mechanical harvest was determined as a percentage of fruit weight (mechanically harvested fruit weight x 100 / total harvested fruit weight). The remaining fruit after harvest was picked by hand. Three separation zones were defined based on Weis et al. (1988): (3) Peduncle – branch, (2) Pedicel – rachis/peduncle and (1) Fruit – pedicel.

Results/Key findings
Statistical analysis of fruit retention force reveals there were significant differences between the treatments. Seven days after their application, all chemical treatments showed a clear decrease in the fruit retention force in comparison with the non treated trees. Untreated olive fruit showed a slower decrease in the fruit retention force than treated olives. The chemicals used were effective in reducing fruit retention force from application time to harvest. The maximum effect of agents occurred, in general, between two to three weeks after application.

Fruit separation was apparent in all three zones but abscission was predominant in zone 1. Fruit and leaf drop, after three counts over the trial period, resulted in no substantial losses in either fruit or leaf in 2006. In 2007, the Boort grove had an increased level of leaf drop on trees receiving higher rates of loosening agents as a result of those higher rates and due to the fact that the grove received less than full irrigation water levels as a consequence of water restrictions. Leaf losses showed significant differences between treated and not treated trees but in most cases they were below acceptable limits. It is important to highlight that we have received reports of severe defoliation (> 25% leaf drop) from groves where ethephon has been applied at higher than recommended concentrations or on severely stressed trees.

Harvest efficiency was measured according to the percentage of fruit mechanically removed, knowing the actual yield before harvest and then hand harvesting and weighing the remaining fruit in the tree. The number of kilograms of remaining olives proved slightly higher in the control blocks. As an example, Boundary Bend Estate offered harvest efficiency for the Barnea trees in treatment 2 of 96.64%, whereas the control resulted in only 89.29% despite the harvester being set at a constant

ground speed. Checking the speed of the harvester while trying to maintain a constant harvesting efficiency, variations from 31 to 40 seconds/tree have been observed.

Implications for relevant stakeholders for:

The following table provides a breakdown of costs involved and the benefits for one of the trials as an example. The table shows the treatments, the cost of agents and their application, the yield increase as a result of a greater harvest efficiency discounting any additional fruit losses and the income increase per hectare as a result of increased yield harvested. Calculations take into account that on average, crop levels were 12 tonne to the hectare, the percentage of oil on average at the time of crushing in the Barnea was 18.00% and the price of a litre of oil at $4.30/litre for not considering the marginal crushing costs of the additional fruit. Taking all these factors into consideration it can be seen that treatments 2, 3, 4 and 6 could have given additional benefits between $740.00 and $860.00/ha. Those treatments providing a larger benefit are based on larger quantities of ethephon increasing the risk of undesirable fruit and leaf drop.

Cost Efficiency Analysis for Barnea @ Boort Estate

Treatment	Agent	Yields (Tn/ha)	Efficiency	Fruit Losses (%)	Application cost ($/ha)*	Extra Yield (Lts/ha)**	Extra Income ($/ha)***	Difference ($/ha)
Treatment 1	MKP @ 3.0%	12.0	86.4%	0.0%	$65.07	136.1	$585.14	**$520.07**
Treatment 2	MKP @ 3.0% + Ethephon @ 0.05%	12.0	89.1%	0.0%	$74.05	194.4	$835.92	**$761.87**
Treatment 3	HarvestVant® @ 3.0%	12.0	90.3%	0.0%	$202.86	220.3	$947.38	**$744.52**
Treatment 4	Ethephon @ 0.1%	12.0	89.3%	1.2%	$44.42	196.3	$844.24	**$799.82**
Treatment 5	Ethephon @ 0.2%	12.0	84.9%	6.3%	$62.38	97.1	$417.74	**$355.36**
Treatment 6	MKP @ 4.0% + Ethephon @ 0.07%	12.0	90.4%	0.7%	$90.51	220.9	$949.97	**$859.46**
Treatment 7	Control	12.0	80.1%	0.0%	$0.00	0.0	$0.00	**$0.00**

* Includes all agents and application costs.

** Extra yields for increased efficiency - additional fruit losses @ 18.0% oil yields w/w.

*** Oil prices at AU$ 4.30/litre (It does not include the marginal expenses of crushing).

If we consider that most commercial groves in Australia (Approx. 20,000 ha) decide to apply these agents to approximately 25% of their crop (Mainly early harvest and difficult varieties), the potential benefits for the industry could reach values between AU$ 3,700,000 and AU$4,300,000/year. The preliminary results obtained from the first year of this research as well as our extensive bibliographic research was utilised by the Australian Olive Association to obtain an off-label permit for ethephon. Being a fertiliser, MKP did not need a permit to be applied.

Recommendations

The evaluated fruit loosening agents, when applied at correct rates, times and conditions, show a positive effect on decreasing the fruit retention force and on increasing harvest efficiency. This efficiency is reflected in larger fruit removal percentages and the possibility of harvesting faster reducing the length of harvest, its costs and risks associated with late harvest (Frost damage, biannual bearing).

Fruit loosening application is a potential aid in the harvesting of olives, especially at times of high cropping levels, or when harvesting greener fruit earlier in the season, or to lower the FRF on certain varieties that prove difficult to harvest, for example Frantoio, Koroneiki and Arbequina.

Being a hormonal product, there is always a potential risk of undesirable fruit losses and/or defoliation. Consequently, growers' education as regards to the use of this tool will be absolutely essential to avoid negative effects.

Fruit loosening agents are one of several tools to improve harvesting efficiency, and a general approach should be taken in order to achieve the best possible results, including other aspects such as training growers on optimal harvesting periods, harvesting technologies, tree training for mechanical or manual harvesting, quality control of the harvesting operations, etc. The publication of a small booklet covering all these aspects related to harvesting efficiency could be of interest to the industry.

Discussion with other growers has lead to the belief that the fruit loosening agents are causing an increase in acidity levels in the fruit and the oils produced from those olives. We could not confirm this negative effect during the trial. However, a specific assessment on this should be advisable. This final report should be utilised to support a registration of ethephon for its permanent permit in olives.

Introduction

The forces that lead to mechanization in agriculture are clear: high cost and availability of manual labour. For some crops these economic forces have led to rapid adoption of mechanization, for others like olives in the Mediterranean countries, the pressure for mechanization has been growing at a much slower pace.

This situation is rapidly changing. The new emerging Australian olive industry needs to be extremely cost effective. The harvesting mechanization is the most important factor affecting cost competitiveness. There is no doubt that Australian growers have made significant progress in these areas and nowadays we are generating and evaluating technology without precedent in the world olive industry. Even when we are still far from solving all our problems related to grove mechanization, our current technology was good to harvest and process more than 50,000 tonnes of fruit in 2006 and almost 60,000 tonnes in 2007.

Poor harvesting efficiency is probably one of our worst hidden costs. A careful analysis of harvesters' performances indicates that fruit losses during the 2005-07 seasons clearly exceeded AU$5,000,000 in any of those seasons. An extremely high figure for a competitive industry.

Objectives

Evaluation of the currently available fruit loosening agents under Australian conditions in order to determine their cost effectiveness and conditions for their commercial use. If one or more of the evaluated products demonstrate that its application is cost effective and safe, it could increase significantly the harvest efficiency of the Australian olive industry.

The advantages of having commercially evaluated products increasing olive fruit abscission would be of value for an earlier harvest, with the consequent improvement in oil quality, decrease of biannual bearing and increased efficiency of mechanical harvesting. All these combined benefits would represent a significant reduction in the current production costs increasing the competitiveness of the Australian olive industry in the world context.

Methodology

Field trials were conducted from April until May, in 2006 and 2007. The two largest commercial groves in Australia were utilised as the main sites for this trial. They are located at Boort (36º N) and Boundary Bend (34º N) in Victoria, Australia. Minor replicates of the trials were conducted in two other modern olive groves at Coonalpyn in South Australia (35ºN) and Gingin in Western Australia (31º N).

Treatments

The treatments involved the use of two main chemicals: 2-chloroethane phosphoric acid (Common name: ethephon 48%), which is a synthetic plant growth regulator that promotes the release of ethylene. Ethylene induces abscission as it weakens the stalk of the fruit. The second product was mono potassium phosphate (Common fertiliser and soluble salt).

Other agents included: HarvestVant®, which is a commercial product from Israel containing the previously described products coated with a special adjuvant. The percentage of the active ingredient, ethephon in the formulation is lower compared to commercial ethephon based products. Agral 60®, a non-ionic spray additive, was utilised to increase wetting and to improve spray coverage. All treatments were applied by foliar spray with a Silvan® sprayer at a rate of 1,000 L/Ha. Four treatments and a control were applied during the first year, while two more treatments were added in the second year of the trials.

The following treatments were applied.

In year 2006:

Treatment 1: MKP (3.0%) with wetting agent Agral 60 (0.1%).
Treatment 2: MKP (3.0%) with ethephon (0.05%) and wetting agent Agral 60 (0.1%).
Treatment 3: HarvestVant® (3.0%).
Treatment 4: Ethephon (0.1%) with wetting agent Agral 60 (0.1%).
Treatment 5: Control with no treatment.

All treatments were mechanically harvested by a Colossus® over the row harvester.

In year 2007:

Treatment 1: MKP (3.0%) with wetting agent Agral 60 (0.1%).
Treatment 2: MKP (3.0%) with ethephon (0.05%) and wetting agent Agral 60 (0.1%).
Treatment 3: HarvestVant® (3.0%).
Treatment 4: Ethephon (0.1%) with wetting agent Agral 60 (0.1%).
Treatment 5: Ethephon (0.2%) with wetting agent Agral 60 (0.1%).
Treatment 6: MKP (4.0%) with ethephon (0.07%) and wetting agent Agral 60 (0.1%).
Treatment 7: Control with no treatment.

All treatments were mechanically harvested by a Colossus® over the row harvester.

Figure 1. Foliar application of fruit loosening agents by Silvan® sprayer.

Figure 2. Trials being harvested by the Colossus® over-the-row harvester.

Trial Measurements

The fruit retention force (FRF) was measured twice weekly with a dynamometer in 30 fruits per tree and 6 trees per treatment and per variety during 3 - 5 weeks. Before, during and after harvest assessments on leaf and fruit abscission were performed by counting fruit and leaf numbers on four labelled branches on 3 trees per treatment and per variety. Efficiency of mechanical harvest was determined as percentages of fruit weight (mechanically harvested fruit weight x 100/total harvested fruit weight). The remaining fruit after harvest was picked by hand. The abscission zones were determined by counting the number of fruit removed in the three possible separation zones defined by Weis et al. (1988): (3) Peduncle – branch, (2) Pedicel – rachis/peduncle and (1) Fruit – pedicel (Fig. 1)

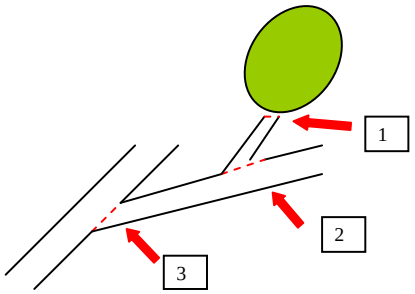

Figure 3. Diagram of the fruit separation zones: (1) Fruit – pedicel, (2) Peduncle – rachis/peduncle, (3) Peduncle – branch. Weis et al. (1988).

Olive samples were collected from each treatment and processed to produce oil with an Abencor® equipment. MRL laboratory analysis was performed on the oil by AMAL Analytical. The data obtained from field measurements were statistically analysed by ANOVA and post test analysis.

Figure 4. Dynamometer measuring fruit retention force.

Flower density measurements were performed in spring 2006 for the treated areas in order to determine if there was any significant difference between the treatments and flower differentiation and/or yield potential between the different treatments.

Fruit Retention Forces

The following tables (Tables 1 – 8) summarise the average FRF values (in grams) for all treatments and varieties at both sites during 2006 and 2007. After that, the statistical analysis of those values is presented in the Tables 9 – 16.

Fruit Loosening Agent Trials - Boundary Bend Estate & Boort Estate - Fruit Retention Forces - Summary Page 2006

Table N° 1: Fruit Retention Forces in Barnea at Boundary Bend Estate 2006

N°	Treatment	17-Apr	21-Apr	25-Apr	28-Apr	3-May	5-May	9-May	12-May
1	MKP 3%	317.2	368.4	365.7	420.5	293.3	355.1	319.9	347.1
2	MKP 3% + Ethephon	302.4	327.2	294.9	384.5	257.0	281.6	279.3	322.8
3	HarvestVant	380.3	383.3	370.3	402.9	256.1	323.5	295.8	349.0
4	Ethephon 0.1%	345.5	354.8	437.1	455.1	306.4	338.4	300.3	352.1
5	Control	427.3	456.8	516.4	559.3	403.9	420.7	389.8	389.1

Table N° 2: Fruit Retention Forces in Picual at Boundary Bend Estate 2006

N°	Treatment	17-Apr	21-Apr	25-Apr	28-Apr	3-May	5-May	9-May	12-May
1	MKP 3%	456.5	487.7	485.4	513.9	368.3	404.8	384.7	374.9
2	MKP 3% + Ethephon	461.1	493.0	480.2	524.3	348.5	381.3	368.6	420.6
3	HarvestVant	465.6	476.4	456.9	506.1	344.5	429.6	365.9	411.8
4	Ethephon 0.1%	457.4	482.5	501.1	552.6	348.3	361.7	392.3	417.3
5	Control	479.1	503.7	534.2	598.5	400.6	440.3	404.3	448.2

Table N° 3: Fruit Retention Forces in Barnea at Boort Estate 2006

N°	Treatment	19-Apr	24-Apr	27-Apr	1-May	4-May	8-May	11-May	15-May
1	MKP 3%	386.6	383.0	373.5	473.9	343.6	352.5	359.9	324.6
2	MKP 3% + Ethephon	380.8	335.5	363.7	381.7	293.9	349.3	335.1	342.7
3	HarvestVant	388.5	348.1	374.7	368.1	297.3	308.9	334.3	319.6
4	Ethephon 0.1%	403.7	365.5	381.1	417.6	301.5	318.9	322.9	322.8
5	Control	483.6	549.1	520.0	557.8	453.0	428.1	425.1	434.9

Table N° 4: Fruit Retention Forces in Frantoio at Boort Estate 2006

N°	Treatment	19-Apr	24-Apr	27-Apr	1-May	4-May	8-May	11-May	15-May
1	MKP 3%	554.8	568.6	565.7	595.8	425.2	Harvested	Harvested	Harvested
2	MKP 3% + Ethephon	532.2	509.7	447.9	559.5	362.7	Harvested	Harvested	Harvested
3	HarvestVant	518.2	576.4	441.9	504.7	333.3	Harvested	Harvested	Harvested
4	Ethephon 0.1%	525.2	496.6	507.6	543.9	447.1	Harvested	Harvested	Harvested
5	Control	667.8	645.7	611.0	651.7	571.1	Harvested	Harvested	Harvested

Fruit Loosening Agent Trials - Boundary Bend Estate & Boort Estate - Fruit Retention Forces - Summary Page 2007

Table N° 5: Fruit Retention Forces in Barnea at Boundary Bend Estate 2007

N°	Treatment	17-Apr	20-Apr	24-Apr	1-May	4-May	8-May	11-May
1	MKP 3%	557.8	466.4	463.7	443.9	Harvested	Harvested	Harvested
2	MKP 3% + Ethephon	435.4	490.2	430.1	340.2	Harvested	Harvested	Harvested
3	HarvestVant	453.0	491.1	390.8	401.4	Harvested	Harvested	Harvested
4	Ethephon 0.1%	408.3	456.6	382.3	356.3	Harvested	Harvested	Harvested
5	Ethephon 0.2%	376.9	463.6	358.4	318.4	Harvested	Harvested	Harvested
6	MKP 4% + Ethephon	387.6	427.2	380.7	372.2	Harvested	Harvested	Harvested
7	Control	453.3	404.7	375.3	400.9	Harvested	Harvested	Harvested

Table N° 6: Fruit Retention Forces in Minerva at Boundary Bend Estate 2007

N°	Treatment	17-Apr	20-Apr	24-Apr	1-May	4-May	8-May	11-May
1	MKP 3%	546.5	493.7	504.0	546.7	Harvested	Harvested	Harvested
2	MKP 3% + Ethephon	355.7	414.1	475.3	433.6	Harvested	Harvested	Harvested
3	HarvestVant	325.6	310.4	338.0	325.9	Harvested	Harvested	Harvested
4	Ethephon 0.1%	408.3	353.3	344.3	303.0	Harvested	Harvested	Harvested
5	Ethephon 0.2%	373.9	355.6	325.2	407.2	Harvested	Harvested	Harvested
6	MKP 4% + Ethephon	494.4	530.8	495.0	514.5	Harvested	Harvested	Harvested
7	Control	570.0	503.0	531.0	522.0	Harvested	Harvested	Harvested

Table N° 7: Fruit Retention Forces in Barnea at Boort Estate 2007

N°	Treatment	10-Apr	13-Apr	16-Apr	19-Apr	23-Apr	26-Apr	30-Apr	3-May	7-May	10-May
1	MKP 3%	418.3	415.5	446.3	333.5	349.5	333.8	367.7	287.5	347.2	356.9
2	MKP 3% + Ethephon	417.0	380.6	454.3	344.4	323.7	343.4	344.1	282.4	323.5	302.9
3	HarvestVant	445.9	427.8	419.3	329.9	354.0	350.4	289.9	277.4	344.6	318.5
4	Ethephon 0.1%	408.2	359.5	332.5	324.9	321.9	320.4	309.3	246.0	318.7	286.9
5	Ethephon 0.2%	259.9	240.1	224.7	198.5	Harvested	Harvested	Harvested	Harvested	Harvested	Harvested
6	MKP 4% + Ethephon	428.8	408.3	396.5	348.4	300.7	319.5	289.0	223.8	278.2	260.7
7	Control	495.8	458.7	445.9	369.8	367.1	406.2	375.4	383.5	391.1	338.3

Table N° 8: Fruit Retention Forces in Frantoio at Boort Estate 2007

N°	Treatment	10-Apr	13-Apr	16-Apr	19-Apr	23-Apr	26-Apr	30-Apr	3-May	7-May	10-May
1	MKP 3%	502.5	472.7	481.9	411.7	415.8	393.7	411.0	341.6	384.2	394.4
2	MKP 3% + Ethephon	464.7	415.0	433.5	371.2	373.8	378.2	356.0	289.6	339.9	338.6
3	HarvestVant	470.4	352.0	393.5	371.8	388.1	351.7	334.4	289.8	369.4	354.9
4	Ethephon 0.1%	377.8	388.5	392.4	342.9	328.6	348.3	333.9	282.3	343.0	324.2
5	Ethephon 0.2%	142.3	151.6	170.5	142.8	Harvested	Harvested	Harvested	Harvested	Harvested	Harvested
6	MKP 4% + Ethephon	425.1	365.2	340.3	339.6	329.6	305.3	303.8	188.1	298.8	269.6
7	Control	546.0	533.7	505.5	415.2	419.2	427.5	429.4	413.1	414.0	413.2

Table 9: FRF Barnea BBE Statistical Analysis 2006

Week 1				Week 2						Week 3				Week 4		
Treatment 2	a			Treatment 2	a					Treatment 3	a			Treatment 2	a	
Treatment 1	a	b		Treatment 1		b				Treatment 2	a			Treatment 3	a	
Treatment 4	a	b		Treatment 3		b	c			Treatment 1	a			Treatment 4	a	
Treatment 3		b	c	Treatment 4				d		Treatment 4	a			Treatment 1	a	
Treatment 5			c	Treatment 5					e	Treatment 5		b		Treatment 5		b

Table 10: FRF Picual BBE Statistical Analysis 2006

Week 1				Week 2				Week 3				Week 4		
Treatment 1	a			Treatment 3	a			Treatment 3	a			Treatment 3	a	
Treatment 4	a			Treatment 2	a	b		Treatment 4	a			Treatment 2	a	
Treatment 2	a			Treatment 1	a	b		Treatment 2	a	b		Treatment 1	a	
Treatment 3	a			Treatment 4	a	b		Treatment 1	a	b	c	Treatment 4	a	
Treatment 5	a			Treatment 5		b		Treatment 5			c	Treatment 5	a	

Table 11: FRF Barnea BOE Statistical Analysis 2006

Week 1			Week 2				Week 3				Week 4		
Treatment 2	a		Treatment 2	a			Treatment 3	a			Treatment 3	a	
Treatment 1	a		Treatment 3	a			Treatment 2	a			Treatment 4	a	
Treatment 3	a		Treatment 4	a			Treatment 4	a	b		Treatment 2	a	
Treatment 4	a		Treatment 1	a			Treatment 1		b		Treatment 1	a	
Treatment 5		b	Treatment 5		b		Treatment 5			c	Treatment 5		b

Table 12: FRF Frantoio BOE Statistical Analysis 2006

Week 1			Week 2				Week 3				Week 4
Treatment 3	a		Treatment 4	a			Treatment 3	a			Harvested
Treatment 4	a		Treatment 2	a			Treatment 4	a	b		Harvested
Treatment 2	a		Treatment 1	a	b	c	Treatment 2	a	b		Harvested
Treatment 1	a		Treatment 3	a	b	c	Treatment 1	a	b		Harvested
Treatment 5		b	Treatment 5			c	Treatment 5		b		Harvested

Table 13: FRF Barnea BBE Statistical Analysis 2007

Week 1			Week 2				Week 3					
Treatment 5	a		Treatment 5	a			Treatment 5	a				
Treatment 6	a		Treatment 7	a			Treatment 2	a	b			
Treatment 4	a		Treatment 6	a			Treatment 4	a	b	c		
Treatment 2	a		Treatment 4	a			Treatment 6	a	b	c	d	
Treatment 3	a		Treatment 3	a			Treatment 7	a	b	c	d	e
Treatment 7	a		Treatment 2	a	b		Treatment 3		b	c	d	e
Treatment 1		b	Treatment 1		b		Treatment 1					e

Table 14: FRF Mimerva BBE Statistical Analysis 2007

Week 1				Week 2				Week 3				
Treatment 3	a			Treatment 5	a			Treatment 4	a			
Treatment 2	a	b		Treatment 3	a	b		Treatment 3	a	b		
Treatment 5	a	b		Treatment 4	a	b		Treatment 5		b	c	
Treatment 4		b	c	Treatment 2			c	Treatment 2			c	d
Treatment 6			d	Treatment 6			c	Treatment 6			d	e
Treatment 1			d	Treatment 1			c	Treatment 7				e
Treatment 7			e	Treatment 7			c	Treatment 1				e

Table 15: FRF Barnea BOE Statistical Analysis 2007

Week 1					Week 2					Week 3			Week 4				Week 5			
Treatment 5	a				Treatment 5	a				Treatment 6	a		Treatment 6	a			Treatment 6	a		
Treatment 4		b			Treatment 4		b			Treatment 4	a		Treatment 3	a	b		Treatment 4	a	b	
Treatment 2		b	c		Treatment 6			c		Treatment 2	a		Treatment 4	a	b	c	Treatment 2	a	b	
Treatment 1		b	c	d	Treatment 3			c	d	Treatment 1	a		Treatment 2	a	b	c	d	Treatment 3		b	c
Treatment 6		b	c	d	e	Treatment 7				d	Treatment 3	a	Treatment 1			c	d	Treatment 1		b	c
Treatment 3		b	c	d	e	Treatment 1				d	Treatment 7		b	Treatment 7			d	Treatment 7			c
Treatment 7					e	Treatment 2				d										

Table 16: FRF Frantoio BOE Statistical Analysis 2007

Week 1						Week 2						Week 3					Week 4					Week 5				
Treatment 5	a					Treatment 5	a					Treatment 4	a				Treatment 6	a				Treatment 6	a			
Treatment 4		b				Treatment 6		b				Treatment 6	a	b			Treatment 4	a	b			Treatment 2	a	b		
Treatment 6		b	c			Treatment 4		b	c			Treatment 2	a	b	c		Treatment 3	a	b	c		Treatment 4	a	b		
Treatment 2			c	d		Treatment 3		b	c	d		Treatment 3	a	b	c		Treatment 2	a	b	c	d	Treatment 3	a	b		
Treatment 3			c	d	e	Treatment 2			c	d	e	Treatment 1			c		Treatment 1				d	e	Treatment 1		b	
Treatment 1				d	e	f	Treatment 1				e	Treatment 7			c		Treatment 7					e	Treatment 7		b	
Treatment 7						f	Treatment 7				e															

Fruit and Leaf Drop

The following tables summarise all measurements done as regards to fruit and leaf drop during both seasons as well as their statistical analysis.

Fruit and Leaf Losses

Boundary Bend Estate 2006 — Results after 1 month

Trial 1 - MKP @ 3.0% + Wetting agent @ 0.10%

Variety	North				South				East				West			
	N° Fruits		Dif.	N° Leaves		Dif.	N° Fruits		Dif.	N° Leaves		Dif.	N° Fruits		Dif.	N° Leaves		Dif.	N° Fruits		Dif.	N° Leaves		Dif.
Barnea	15	15	0	42	42	0	13	13	0	24	24	0	14	14	0	42	42	0	21	21	0	36	36	0
Barnea	20	20	0	46	46	0	12	12	0	28	28	0	8	8	0	38	38	0	20	20	0	36	36	0
Barnea	11	11	0	40	40	0	6	6	0	20	20	0	15	15	0	26	26	0	13	13	0	38	38	0
Picual	12	12	0	32	32	0	13	13	0	22	22	0	9	9	0	16	16	0	8	8	0	22	22	0
Picual	8	8	0	18	18	0	7	7	0	36	36	0	16	16	0	18	18	0	9	9	0	32	32	0
Picual	12	12	0	40	40	0	19	17	2	26	24	2	16	16	0	14	14	0	7	7	0	34	34	0

Trial 2 - MKP @ 3.0% + ethephon @ 0.05% + Wetting agent @ 0/10%

Variety	North				South				East				West			
	N° Fruits		Dif.	N° Leaves		Dif.	N° Fruits		Dif.	N° Leaves		Dif.	N° Fruits		Dif.	N° Leaves		Dif.	N° Fruits		Dif.	N° Leaves		Dif.
Barnea	22	22	0	52	52	0	8	8	0	24	24	0	20	20	0	46	46	0	14	14	0	32	32	0
Barnea	11	11	0	34	34	0	12	11	1	32	32	0	22	22	0	34	34	0	12	12	0	30	30	0
Barnea	19	19	0	32	32	0	8	8	0	38	37	1	11	11	0	42	42	0	12	12	0	30	30	0
Picual	10	10	0	34	34	0	9	6	3	28	22	6	10	10	0	24	24	0	14	14	0	38	38	0
Picual	13	13	0	36	34	2	14	14	0	26	26	0	11	11	0	30	30	0	10	10	0	30	30	0
Picual	14	14	0	24	24	0	14	14	0	32	30	2	11	11	0	34	34	0	13	13	0	26	26	0

Trial 3 - HarvestVant @ 3.0 %

Variety	North				South				East				West			
	N° Fruits		Dif.	N° Leaves		Dif.	N° Fruits		Dif.	N° Leaves		Dif.	N° Fruits		Dif.	N° Leaves		Dif.	N° Fruits		Dif.	N° Leaves		Dif.
Barnea	15	15	0	54	54	0	12	11	1	48	48	0	15	15	0	40	40	0	26	26	0	46	46	0
Barnea	10	10	0	48	48	0	7	7	0	52	52	0	7	7		44	44	0	9	9	0	24	24	0
Barnea	13	13	0	48	48	0	7	7	0	20	20	0	8	8		20	20	0	7	7	0	30	30	0
Picual	16	16	0	42	42	0	15	15	0	40	39	1	9	9		34	33	1	9	9	0	32	32	0
Picual	12	12	0	44	43	1	17	17	0	52	51	1	17	17		44	44	0	11	11	0	26	26	0
Picual	14	14	0	34	34	0	12	12	0	38	38	0	9	9		22	22	0	20	20	0	36	36	0

Trial 4 - Ethephon @ 0.10% + Wetting agent @ 0.10%

Variety	North				South				East				West			
	N° Fruits		Dif.	N° Leaves		Dif.	N° Fruits		Dif.	N° Leaves		Dif.	N° Fruits		Dif.	N° Leaves		Dif.	N° Fruits		Dif.	N° Leaves		Dif.
Barnea	14	14	0	44	44	0	10	10	0	44	44	0	13	13	0	28	28	0	9	9	0	20	20	0
Barnea	11	11	0	34	34	0	13	13	0	56	56	0	16	16	0	44	44	0	17	17	0	50	50	0
Barnea	12	12	0	50	50	0	5	5	0	28	28	0	9	9	0	26	26	0	13	13	0	30	30	0
Picual	13	13	0	22	22	0	10	10	0	46	46	0	17	17	0	34	34	0	6	6	0	26	26	0
Picual	16	16	0	50	50	0	9	9	0	18	18	0	18	18	0	32	32	0	15	15	0	28	28	0
Picual	11	11	0	40	40	0	10	10	0	24	24	0	8	8	0	30	30		8	8	0	30	30	0

Trial 5 - No Foliar Treatment

Variety	North				South				East				West			
	N° Fruits		Dif.	N° Leaves		Dif.	N° Fruits		Dif.	N° Leaves		Dif.	N° Fruits		Dif.	N° Leaves		Dif.	N° Fruits		Dif.	N° Leaves		Dif.
Barnea	8	8	0	36	36	0	7	7	0	22	22	0	18	18	0	46	46	0	7	7	0	42	42	0
Barnea	14	14	0	50	50	0	9	9	0	40	40	0	10	10	0	36	36	0	10	10	0	32	32	0
Barnea	7	7	0	32	32	0	8	8	0	30	30	0	11	10	1	42	41	1	19	19	0	40	40	0
Picual	7	7	0	28	28	0	8	8	0	26	26	0	11	11	0	30	30	0	6	6	0	34	34	0
Picual	9	9	0	42	42	0	8	8	0	30	30	0	16	16	0	16	16	0	4	4	0	18	18	0
Picual	10	10	0	22	22	0	19	19	0	54	54	0	10	10	0	34	34	0	7	7	0	18	18	0

Fruit and Leaf Losses

Boort Estate 2007

Results before application
Results after 3 weeks
Results after harvest

Trial 1 . MKP @ 3.0% + Wetting agent @ 0.10%

Variety	North							South							East							West						
	N° Fruits		Dif.	N° Leaves			Dif.	N° Fruits		Dif.	N° Leaves			Dif.	N° Fruits		Dif.	N° Leaves			Dif.	N° Fruits		Dif.	N° Leaves			Dif.
Barnea	13	13	0	34	34	34	0	16	16	0	32	32	32	0	29	29	0	64	64	62	0	16	16	0	34	34	33	1
Barnea	31	31	0	36	36		0	10	10	0	16	16		0	33	33	0	42	40		2	8	8	0	32	32		0
Barnea	13	13	0	32	32		0	4	4	0	28	28		0	22	22	0	36	36		0	8	8	0	48	48		0
Frantoio	17	17	0	26	26	26	0	5	5	0	18	18	18	0	24	14	10	28	28	28	0	9	9	0	22	22	20	0
Frantoio	19	19	0	24	24		0	30	30	0	32	32		0	15	15	0	48	48		0	11	11	0	22	22		0
Frantoio	4	4	0	18	18		0	15	15	0	24	24		0	22	21	1	32	18		14	14	14	0	22	22		0

Trial 2 . MKP @ 3.0% + ethephon @ 0.05% + Wetting agent @ 0/10%

Variety	North							South							East							West						
	N° Fruits		Dif.	N° Leaves			Dif.	N° Fruits		Dif.	N° Leaves			Dif.	N° Fruits		Dif.	N° Leaves			Dif.	N° Fruits		Dif.	N° Leaves			Dif.
Barnea	10	10	0	26	26		0	15	15	0	42	42		0	20	20	0	40	40		0	17	17	0	38	38		0
Barnea	19	19	0	24	24	24	0	8	8	0	56	56	48	0	12	12	0	46	46	45	0	17	17	0	36	36	36	0
Barnea	34	24	10	32	32		0	10	10	0	22	22		0	21	21	0	30	30		0	10	10	0	38	38		0
Frantoio	4	4	0	14	14		0	7	7	0	12	12		0	19	19	0	14	14		0	17	17	0	24	24		0
Frantoio	12	12	0	18	18		0	22	21	1	24	24		0	8	8	0	18	18		0	5	5	0	16	16		0
Frantoio	5	5	0	48	48	47	0	17	17	0	20	20	20	0	18	18	0	30	30	30	0	23	23	0	40	40	40	0

Trial 3 . Harvest/Vant @ 3.0 %

Variety	North							South							East							West						
	N° Fruits		Dif.	N° Leaves			Dif.	N° Fruits		Dif.	N° Leaves			Dif.	N° Fruits		Dif.	N° Leaves			Dif.	N° Fruits		Dif.	N° Leaves			Dif.
Barnea	5	5	0	32	32		0	7	7	0	26	26		0	15	15	0	32	30		2	5	5	0	40	40		0
Barnea	13	13	0	42	40		2	10	10	0	14	14		0	32	32	0	38	38		0	25	25	0	34	34		0
Barnea	27	27	0	34	34	32	2	10	10	0	60	58	52	6	25	24	1	42	42	40	2	22	22	0	36	36	36	0
Frantoio	12	12	0	28	28		0	13	13	0	14	14		0	14	14	0	40	40		0	11	10	1	32	32		0
Frantoio	16	15	1	24	24		0	19	19	0	32	32		0	5	4	1	24	24		0	14	14	0	16	16		0
Frantoio	12	12	0	36	36	36	0	8	8	0	16	16	16	0	8	8	0	28	28	28	0	16	15	1	20	20	20	0

Trial 4 . Ethephon @ 0.10% + Wetting agent @ 0.10%

Variety	North							South							East							West						
	N° Fruits		Dif.	N° Leaves			Dif.	N° Fruits		Dif.	N° Leaves			Dif.	N° Fruits		Dif.	N° Leaves			Dif.	N° Fruits		Dif.	N° Leaves			Dif.
Barnea	33	33	0	54	54	53	1	7	7	0	56	56	51	5	8	7	1	26	26	26	0	16	16	0	60	60	60	0
Barnea	13	12	1	44	44		0	3	3	0	46	46		0	19	19	0	28	28		0	15	15	0	38	37		1
Barnea	17	17	0	44	43		1	10	10	0	48	48		0	9	9	0	46	46		0	24	24	0	36	36		0
Frantoio	18	18	0	26	26		0	22	22	0	32	32		0	19	18	1	22	22		0	11	11	0	22	22		0
Frantoio	18	18	0	40	40	37	3	7	7	0	26	26	24	2	13	13	0	24	24	23	1	5	5	0	20	20	19	1
Frantoio	10	10	0	14	14		0	4	4	0	20	20		0	25	25	0	34	33		1	7	7	0	14	14		0

Trial 5 . No Foliar Treatment

Variety	North							South							East							West						
	N° Fruits		Dif.	N° Leaves			Dif.	N° Fruits		Dif.	N° Leaves			Dif.	N° Fruits		Dif.	N° Leaves			Dif.	N° Fruits		Dif.	N° Leaves			Dif.
Barnea	14	14	0	56	56		0	7	7	0	38	38		0	8	8	0	46	46		0	11	11	0	42	42		0
Barnea	35	35	0	62	62	62	0	17	17	0	26	26	25	1	6	5	1	34	33	33	1	6	6	0	32	32	32	0
Barnea	11	11	0	62	62		0	11	11	0	52	51		1	22	22	0	70	70		0	8	8	0	44	44		0
Frantoio	21	20	1	24	24		0	13	13	0	24	24		0	7	7	0	26	26		0	8	8	0	12	12		0
Frantoio	6	6	0	44	42		2	1	1	0	14	14		0	5	5	0	26	26		0	18	18	0	20	20		0
Frantoio	12	12	0	28	28	mis.	0	3	3	0	18	18	17	1	5	5	0	20	20	20	0	3	3	0	18	18	18	0

Fruit and Leaf Losses

Boundary Bend Estate 2007

Results before application
Results after 3 weeks (1st May 2007)
Results after harvest (8th May 2007)
Final assessment

Trial 1 - MKP @ 3.0% + Wetting agent @ 0.10%

Variety	North							South							East							West						
	N° Fruits				Dif.	N° Leaves				Dif.	N° Fruits				Dif.	N° Leaves				Dif.	N° Fruits				Dif.	N° Leaves				Dif.
Barnes	14	14	1		0	60	60	60		0	10	10	0		0	34	33	30		4	17	17	0		17	46	46	46		0
Barnes	9	9	0		0	56	54	54		2	6	6	0		0	35	32	32		0	10	10	0		10	31	31	24		7
Barnes	12	12	0		0	57	57	55		2	9	9	0		0	54	54	54		0	26	26	0		25	50	50	49		1
Minerva	13	13	0		0	42	42	40		2	9	9	0		0	40	40	40		0	10	10	0		10	33	33	27		2
Minerva	11	11	0		0	30	30	28		2	9	9	0		0	30	30	30		0	14	14	0		14	42	42	38		4
Minerva	11	11	0		0	39	39	38		0	9	9	0		0	36	36	34		1	10	10	0		10	33	33	33		0

Trial 2 - MKP @ 3.0% + ethephon @ 0.05% + Wetting agent @ 0.10%

Variety	North							South							East							West						
	N° Fruits				Dif.	N° Leaves				Dif.	N° Fruits				Dif.	N° Leaves				Dif.	N° Fruits				Dif.	N° Leaves				Dif.
Barnes	10	10	0	0	21	19	18		3	5	4	0	1	60	47	37		23	15	12	0		3	39	39	36		3
Barnes	16	16	0	0	29	27	26		3	10	10	0	0	49	49	46		3	10	10	0	0	63	63	63		4	13
Barnes	9	8	2		28	28	28		0	7	7	0	0	40	37	33		3	15	13	0		1	63	62	62		1	12
Minerva	10	10	0	0	62	62	62		0	10	10	0	0	58	54	50		3	12	12	0	0	41	41	41		0	7
Minerva	14	14	0	0	41	41	40		1	8	8	0	0	36	36	34		2	9	9	0	0	36	36	36		0	7
Minerva	6	6	0	1	34	34	33		1	11	11	0	0	66	66	60		6	8	8	0		1	36	36	36		0	9

Trial 3 - HarvestVent @ 3.0 %

Variety	North							South							East							West						
	N° Fruits				Dif.	N° Leaves				Dif.	N° Fruits				Dif.	N° Leaves				Dif.	N° Fruits				Dif.	N° Leaves				Dif.
Barnes	10	9	1		0	61	61	61		0	13	13	0	0	48	48	48		3	7	7	1		0	47	44	44		1	0
Barnes	8	8	0	0	44	44	40		4	10	10	0	0	56	53	46		7	11	11	0	0	59	57	54		4	8
Barnes	10	10	0	0	46	46	45		1	9	9	0	0	66	62	60		6	8	8	0	0	37	37	34		3	8
Minerva	14	14	0	0	59	59	57		1	8	8	0	0	42	42	39		3	10	10	0	0	38	38	38		0	8
Minerva	7	7	0	0	34	34	33		1	8	8	0	0	38	38	33		5	9	8	0		1	43	41	38		4	7
Minerva	11	10	0	1	49	47	41		6	9	9	0	0	69	69	60		9	10	9	0		1	50	50	46		4	1

Trial 4 - Ethephon @ 0.10% + Wetting agent @ 0.10%

Variety	North							South							East							West						
	N° Fruits				Dif.	N° Leaves				Dif.	N° Fruits				Dif.	N° Leaves				Dif.	N° Fruits				Dif.	N° Leaves				Dif.
Barnes	14	14	0	0	49	47	46		2	12	11	0	1	45	44	42		2	11	11	0	0	29	29	29		0	9
Barnes	18	16	0	2	36	36	32		4	12	10	0	2	42	41	38		4	15	14	0	1	34	34	34		0	3
Barnes	9	9	0	0	52	46	39		13	11	11	11		30	26	23		7	8	8	0	0	54	54	53		1	12
Minerva	9	9	1		34	34	34		0	7	7	0	0	36	36	36		1	9	9	0	0	34	34	33		1	8
Minerva	7	7	0	0	50	50	45		5	8	8	0	0	50	50	50		0	10	10	0	0	34	34	34		0	14
Minerva	12	12	0	0	44	44	32		12	10	6	0	4	49	47	41		6	12	12	0	0	36	34	34		1	12

Trial 5 - Ethephon @ 0.20% + Wetting agent @ 0.10%

Variety	North							South							East							West						
	N° Fruits				Dif.	N° Leaves				Dif.	N° Fruits				Dif.	N° Leaves				Dif.	N° Fruits				Dif.	N° Leaves				Dif.
Barnes	16	16	0	0	57	47	42		15	12	12	0	0	26	26	26		0	16	16	16		44	44	41		3	14
Barnes	9	9	0	0	26	24	23		1	11	11	0	0	39	39	32		7	11	11	0	0	36	31	25		6	8
Barnes	8	8	2		35	35	35		0	10	10	1	0	46	44	44		2	8	8	8		28	28	28		0	8
Minerva	9	9	0	0	37	37	37		0	9	9	0	0	26	26	26		1	9	9	0	0	36	36	31		5	10
Minerva	8	8	0	0	33	30	30		0	12	11	1	0	56	56	55		1	15	15	0	0	46	46	44		1	6
Minerva	12	12	0	0	40	40	34		6	12	12	0	0	42	42	40		2	8	8	0	0	34	34	34		0	9

Trial 6 - MKP @ 4.0% + ethephon @ 0.07% + Wetting agent @ 0.10%

Variety	North							South							East							West						
	N° Fruits				Dif.	N° Leaves				Dif.	N° Fruits				Dif.	N° Leaves				Dif.	N° Fruits				Dif.	N° Leaves				Dif.
Barnes	17	17	1		0	35	35	35		0	26	26	0	0	61	61	61		0	30	30	0	0	54	54	48		6	20
Barnes	15	15	1		0	44	44	44		0	14	14	0	0	36	36	36		0	15	15	0	0	49	49	48		1	16
Barnes	19	19	0	0	41	41	35		6	12	12	1	0	31	30	24		6	17	17	0	0	26	26	24		0	15
Minerva	9	9	0	0	69	69	67		2	9	9	1	0	38	38	37		1	9	9	0	0	54	54	47		2	11
Minerva	11	11	0	0	39	39	39		0	13	13	0	0	54	54	51		3	10	10	0	0	39	39	38		1	10
Minerva	10	10	0	0	42	41	38		3	11	11	1	0	52	52	48		3	9	9	0	0	49	49	41		2	7

Trial 7 - No Treatment

Variety	North							South							East							West						
	N° Fruits				Dif.	N° Leaves				Dif.	N° Fruits				Dif.	N° Leaves				Dif.	N° Fruits				Dif.	N° Leaves				Dif.
Barnes	7	7	1		0	26	26	26		0	9	9	0	0	28	27	27		1	16	16	0	0	39	39	36		3	17
Barnes	9	9	0	0	29	29	29		0	4	4	0	0	35	34	33		1	14	14	0	0	31	31	30		1	8
Barnes	12	12	6		24	24	24		0	12	12	8	4	46	46	46		0	16	16	0	0	27	27	26		1	8
Minerva	14	14	8		41	41	41		0	7	7	0	0	33	33	30		3	10	10	0	0	39	39	38		1	7
Minerva	12	12	0	0	42	42	41		1	14	13	0	1	49	48	42		6	10	10	0	0	50	50	48		2	13
Minerva	19	18	1		54	54	54		0	11	11	0	0	52	52	46		6	10	10	9		0	50	50	43		7	11

Fruit and Leaf Losses

Boort Estate 2007

Results before application
Results after 3 weeks (1st May 2007)
Results after harvest (8th May 2007)
Final assessment

Trial 1 - MKP @ 3.0% + Wetting agent @ 0.10%

Variety	North								South								East								West							
	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.
Barnea	14	14	0	0	38	38	33	5	6	6	0	0	56	56	56	0	17	17	0	0	35	35	34	1	9	9	0	0	23	23	23	0
Barnea	22	22	0	0	42	42	41	1	11	11	0	0	32	32	30	2	21	21	0	0	66	66	66	0	11	11	0	0	54	54	41	13
Barnea	14	14	0	0	46	46	44	1	12	12	0	0	31	31	31	0	15	15	0	0	66	64	58	6	11	11	0	0	40	40	33	7
Frantoio	9	9	0	[illegible]	39	39	39	0	6	6	0	[illegible]	30	30	29	1	14	14	mins	N/D	28	28	mins	N/D	12	12	0	0	28	28	28	0
Frantoio	14	14	7	[illegible]	22	22	22	0	13	13	0	0	27	27	26	1	16	16	0	0	39	39	38	1	6	6	0	0	38	38	37	1
Frantoio	13	13	7	[illegible]	27	27	23	0	29	29	0	0	36	33	27	9	16	16	mins	N/D	41	41	mins	N/D	10	10	0	0	24	24	21	3

Trial 2 - MKP @ 3.0% + ethephon @ 0.05% + Wetting agent @ 0.10%

Variety	North								South								East								West							
	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.
Barnea	11	11	0	0	29	29	29	0	6	6	0	0	66	60	62	3	22	22	mins	N/D	39	39	mins	N/D	12	12	0	0	48	47	38	9
Barnea	19	19	0	0	66	66	66	7	10	10	0	0	56	56	54	2	16	16	0	0	37	37	33	5	14	14	0	0	51	51	45	6
Barnea	16	16	0	0	39	39	35	4	10	10	0	0	71	61	53	10	15	15	0	[illegible]	41	41	37	4	20	20	0	0	47	46	42	4
Frantoio	10	10	mins	N/D	44	44	mins	N/D	9	9	0	[illegible]	46	46	46	0	16	16	0	0	42	42	34	8	13	13	0	0	47	47	37	10
Frantoio	9	9	0	0	21	21	16	5	19	19	0	0	41	41	37	4	14	14	0	0	28	28	27	1	12	12	mins	N/D	28	28	mins	N/D
Frantoio	10	10	1	[illegible]	26	26	26	0	6	6	1	[illegible]	26	26	24	2	21	21	0	0	42	42	41	1	9	9	0	[illegible]	18	18	17	1

Trial 3 - Harvest/Vent @ 3.0 %

Variety	North								South								East								West							
	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.
Barnea	11	11	0	0	55	54	52	3	11	11	0	0	27	27	26	1	10	10	0	0	46	46	45	1	11	11	0	0	30	30	27	3
Barnea	19	19	0	0	47	47	45	2	12	12	0	0	33	33	32	1	15	15	0	0	43	43	41	2	11	11	0	0	30	30	30	0
Barnea	19	19	0	0	38	38	38	0	7	7	0	0	36	36	35	1	9	9	mins	N/D	29	29	mins	N/D	7	7	0	0	39	39	32	7
Frantoio	9	9	0	0	26	26	25	1	9	9	mins	N/D	16	16	mins	N/D	11	11	mins	N/D	25	25	mins	N/D	11	11	0	0	40	40	33	7
Frantoio	12	12	0	0	30	30	25	5	17	17	0	[illegible]	43	41	41	2	9	9	0	0	27	27	26	1	8	8	0	0	26	26	26	0
Frantoio	9	9	0	0	26	26	24	2	13	13	0	0	23	23	20	3	17	17	0	0	23	23	22	1	16	16	0	0	17	17	16	1

Trial 4 - Ethephon @ 0.10% + Wetting agent @ 0.10%

Variety	North								South								East								West							
	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.
Barnea	8	8	0	0	33	33	30	3	10	10	0	0	30	30	29	1	8	8	0	0	46	46	45	1	12	12	0	0	36	31	29	6
Barnea	14	14	0	0	33	33	32	1	10	10	0	0	63	63	59	4	33	33	0	0	66	58	52	6	23	23	0	0	36	36	36	0
Barnea	15	15	0	0	63	63	61	2	11	11	0	0	54	49	47	7	16	16	0	0	29	29	29	0	17	17	0	0	67	55	43	14
Frantoio	10	10	1	[illegible]	27	27	25	2	11	11	0	0	23	23	22	1	13	13	0	0	20	20	19	1	11	11	0	0	30	30	24	6
Frantoio	10	8	0	2	29	31	26	3	11	11	0	0	29	29	29	0	12	12	0	0	36	34	29	7	13	13	0	0	19	19	16	3
Frantoio	21	21	0	0	49	49	44	5	14	14	0	0	20	20	20	0	14	14	0	0	36	36	33	3	10	8	0	2	36	36	36	0

Trial 5 - Ethephon @ 0.20% + Wetting agent @ 0.10%

Variety	North								South								East								West							
	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.
Barnea	14	14	0	0	29	29	24	5	9	9	0	0	21	16	14	7	12	12	0	0	49	49	46	3	14	14	0	0	31	31	31	0
Barnea	9	9	0	0	32	32	31	1	9	9	0	0	29	26	15	11	13	13	0	0	32	32	31	1	15	14	0	1	44	44	37	7
Barnea	10	10	0	0	45	45	45	0	8	8	0	0	36	36	36	0	34	34	0	0	66	66	60	6	10	10	0	0	47	47	36	11
Frantoio	10	8	0	4	28	28	27	1	9	9	0	0	36	36	36	0	9	9	0	[illegible]	16	16	16	0	11	11	0	0	24	24	23	1
Frantoio	9	9	0	0	29	29	28	0	10	7	0	3	22	21	20	2	9	9	0	1	22	21	19	3	14	14	0	0	39	39	38	1
Frantoio	14	14	0	0	18	18	17	1	10	8	0	2	35	32	30	2	13	12	11	[illegible]	29	29	29	0	9	7	mins	N/D	31	31	mins	N/D

Trial 6 - MKP @ 4.0% + ethephon @ 0.01% + Wetting agent @ 0.10%

Variety	North								South								East								West							
	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.
Barnea	11	11	0	0	41	41	37	4	9	9	0	0	34	34	31	3	31	30	0	1	46	44	40	5	11	11	0	0	32	32	30	2
Barnea	9	9	0	0	23	23	23	0	9	9	0	0	53	53	46	7	7	7	0	0	40	35	31	9	17	17	0	0	39	39	36	3
Barnea	11	11	0	0	42	40	35	7	9	9	0	0	34	34	28	6	12	12	0	0	27	27	27	0	8	8	0	0	34	33	28	6
Frantoio	11	11	0	0	12	12	12	0	7	7	0	0	36	36	27	9	16	16	0	0	34	34	30	4	8	8	0	[illegible]	17	16	14	2
Frantoio	16	16	0	0	34	33	32	2	21	20	0	1	28	24	18	6	9	9	0	0	20	20	14	6	14	14	0	0	36	36	36	0
Frantoio	17	17	0	0	21	21	21	0	8	8	0	0	33	30	26	4	14	14	0	0	36	36	35	1	6	6	0	0	29	29	29	0

Trial 7 - No Treatment

Variety	North								South								East								West							
	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.	N° Fruits			Dif.	N° Leaves			Dif.
Barnea	21	21	0	0	40	40	40	0	21	21	0	0	52	52	48	4	19	19	0	0	42	42	40	2	8	8	0	0	33	33	33	0
Barnea	9	9	0	0	37	37	37	0	11	11	0	0	51	51	48	3	16	16	mins	N/D	30	30	mins	N/D	10	10	0	0	32	32	32	0
Barnea	24	24	0	0	49	49	49	0	13	13	0	0	60	52	49	3	16	16	0	0	51	51	46	5	12	12	0	0	42	42	42	0
Frantoio	12	12	0	0	22	22	20	2	8	8	0	0	34	34	33	1	10	10	0	0	28	28	27	1	6	6	0	0	31	31	25	6
Frantoio	16	16	0	0	33	33	33	1	13	13	0	0	33	32	31	1	17	17	0	0	36	36	35	1	12	12	0	0	27	27	26	1
Frantoio	10	10	0	0	30	30	29	1	8	8	0	0	36	36	36	0	11	11	0	0	19	19	19	0	9	9	mins	N/D	36	36	mins	N/D

Fruit and Leaf Drop in Barnea BOE 2006 - Statistical Analysis

Fruit Drop Before Harvest				Leaf Drop Before Harvest				Leaf Drop After Harvest			
Treatment 1	a			Treatment 1	a			Treatment 1	a		
Treatment 3	a			Treatment 2	a			Treatment 5	a	b	
Treatment 5		b		Treatment 4	a			Treatment 3	a	b	
Treatment 2		b		Treatment 5	a			Treatment 2		b	c
Treatment 4			c	Treatment 3		b		Treatment 4			c

Fruit and Leaf Drop in Frantoio BOE 2006 - Statistical Analysis

Fruit Drop Before Harvest				Leaf Drop Before Harvest				Leaf Drop After Harvest			
Treatment 3	a			Treatment 2	a			Treatment 2	a		
Treatment 2	a			Treatment 3	a			Treatment 3	a		
Treatment 1	a			Treatment 4	a			Treatment 4		b	
Treatment 5	a			Treatment 5	a			Treatment 1		b	
Treatment 4	a			Treatment 1		b		Treatment 5			c

Fruit and Leaf Drop in Barnea BOE 2007 - Statistical Analysis

Fruit Drop Before Harvest				Leaf Drop Before Harvest				Leaf Drop After Harvest					
Treatment 1	a			Treatment 7	a			Treatment 6	a				
Treatment 2	a			Treatment 6	a			Treatment 5	a	b			
Treatment 3	a			Treatment 3	a			Treatment 7	a	b	c		
Treatment 4	a			Treatment 2	a			Treatment 3			c	d	
Treatment 7	a			Treatment 5	a			Treatment 1				d	e
Treatment 6	a	b		Treatment 4	a			Treatment 4					e
Treatment 5		b		Treatment 1		b		Treatment 2					f

Fruit and leaf Drop in Frantoio BOE 2007 - Statistical Analysis

Fruit Drop Before Harvest						Leaf Drop Before Harvest						Leaf Drop After Harvest					
Treatment 1	a					Treatment 2	a					Treatment 6	a				
Treatment 2	a	b				Treatment 3	a	b				Treatment 5		b			
Treatment 3	a	b	c			Treatment 6	a	b	c			Treatment 7		b	c		
Treatment 7	a	b	c	d		Treatment 7			c			Treatment 1		b	c	d	
Treatment 5	a	b	c	d		Treatment 1						Treatment 3		b	c	d	e
Treatment 4					e	Treatment 5				d		Treatment 2			c	d	e
Treatment 6					e	Treatment 4				d		Treatment 4					e

Fruit and Leaf Drop in Barnea BBE 2007 - Statistical Analysis

Fruit Drop Before Harvest						Leaf Drop Before Harvest						Leaf Drop After Harvest					
Treatment 1	a					Treatment 3	a					Treatment 4	a				
Treatment 5	a	b				Treatment 5	a	b				Treatment 2	a	b			
Treatment 6	a	b	c			Treatment 4		b	c			Treatment 7	a	b	c		
Treatment 7	a	b	c			Treatment 2			c			Treatment 1			c	d	
Treatment 4			c	d		Treatment 1				d		Treatment 6			c	d	
Treatment 2				d		Treatment 7				d	e	Treatment 5				d	
Treatment 3				d		Treatment 6					e	Treatment 3				d	

Fruit and leaf Drop in Minerva BBE 2007 - Statistical Analysis

Fruit Drop Before Harvest						Leaf Drop Before Harvest						Leaf Drop After Harvest					
Treatment 1	a					Treatment 7	a					Treatment 1	a				
Treatment 6	a	b				Treatment 5	a	b				Treatment 6	a	b			
Treatment 7	a	b				Treatment 2	a	b	c			Treatment 2	a	b	c		
Treatment 4			c			Treatment 6	a	b	c	d		Treatment 5			c	d	
Treatment 2			c			Treatment 1	a	b	c	d		Treatment 7			c	d	
Treatment 5				d		Treatment 4					e	Treatment 4				d	
Treatment 3				d		Treatment 3					e	Treatment 3				d	

Abscission Zones

The following tables summarise the results obtained measuring the percentage of occurrence of abscission in the different zones of the fruit presented in the previous paragraphs.

Fruit Abscission Zones - Boundary Bend Estate Barnea 2006

Abs. Zones	T1	T2	T3	T4	T5
1	96.0%	96.0%	86.0%	88.0%	92.0%
2	4.0%	4.0%	14.0%	12.0%	8.0%
3	0.0%	0.0%	0.0%	0.0%	0.0%

Fruit Abscission Zones - Boundary Bend Estate Picual 2006

Abs. Zones	T1	T2	T3	T4	T5
1	97.0%	94.0%	93.0%	99.0%	99.0%
2	3.0%	6.0%	7.0%	1.0%	1.0%
3	0.0%	0.0%	0.0%	0.0%	0.0%

Fruit Abscission Zones - Boort Estate Barnea 2006

Abs. Zones	T1	T2	T3	T4	T5
1	98.0%	96.0%	97.0%	98.0%	100.0%
2	2.0%	4.0%	3.0%	2.0%	0.0%
3	0.0%	0.0%	0.0%	0.0%	0.0%

Fruit Abscission Zones - Boort Estate Frantoio 2006

Abs. Zones	T1	T2	T3	T4	T5
1	86.0%	76.0%	80.0%	87.0%	88.0%
2	13.0%	24.0%	20.0%	13.0%	12.0%
3	1.0%	0.0%	0.0%	0.0%	0.0%

Fruit Abscission Zones - Boundary Bend Estate Barnea 2007

Abs. Zones	T1	T2	T3	T4	T5	T6	T7
1	90.6%	81.7%	87.2%	92.2%	92.8%	92.8%	95.6%
2	8.9%	16.1%	12.2%	7.8%	6.1%	7.2%	3.9%
3	0.6%	2.2%	0.6%	0.0%	1.1%	0.0%	0.6%

Fruit Abscission Zones - Boundary Bend Estate Minerva 2007

Abs. Zones	T1	T2	T3	T4	T5	T6	T7
1	93.9%	89.4%	83.9%	80.6%	77.2%	93.3%	93.3%
2	1.7%	5.6%	11.1%	8.3%	20.0%	3.9%	3.3%
3	4.4%	5.0%	5.0%	11.1%	2.8%	2.8%	3.3%

Fruit Abscission Zones - Boort Estate Barnea 2007

Abs. Zones	T1	T2	T3	T4	T5	T6	T7
1	98.3%	78.3%	82.2%	87.8%	73.3%	85.6%	88.9%
2	1.7%	19.4%	16.1%	11.1%	12.2%	11.7%	10.0%
3	0.0%	2.2%	1.7%	1.1%	14.4%	2.8%	1.1%

Fruit Abscission Zones - Boort Estate Frantoio 2007

Abs. Zones	T1	T2	T3	T4	T5	T6	T7
1	55.0%	68.3%	56.7%	60.6%	66.7%	41.1%	68.3%
2	42.8%	31.1%	41.7%	37.2%	18.9%	50.6%	29.4%
3	2.2%	0.6%	1.7%	2.2%	14.4%	8.3%	2.2%

Harvesting Efficiency

The following tables summarise the average harvesting efficiencies obtained for the different treatments and the statistical significance of those differences.

BBE 2006 - Harvest Efficiency

Treatment	T 1	T 2	T 3	T 4	T 5
Efficiency	91.6%	94.5%	89.4%	90.1%	89.0%

BOE 2006 - Harvest Efficiency

Treatment	T 1	T 2	T 3	T 4	T 5
Efficiency	90.7%	93.3%	92.5%	95.1%	90.3%

BBE 2007 - Harvest Efficiency

Treatment	T 1	T 2	T 3	T 4	T 5	T 6	T 7
Efficiency	78.8%	69.4%	91.8%	85.1%	79.2%	86.4%	80.7%

BOE 2007 - Harvest Efficiency

Treatment	T 1	T 2	T 3	T 4	T 5	T 6	T 7
Efficiency	84.4%	89.1%	87.6%	86.8%	76.5%	94.5%	79.5%

Harvest Efficiency 2006 - Statistical Analysis

BBE		BOORT	
Treatment 2	a	Treatment 4	a
Treatment 1	a	Treatment 2	a
Treatment 4	a	Treatment 3	a
Treatment 3	a	Treatment 1	a
Treatment 5	a	Treatment 5	a

Harvest Efficiency of Barnea Boort 2007

Treatment 6	a			
Treatment 2	a	b		
Treatment 3	a	b		
Treatment 4	a	b		
Treatment 1	a	b		
Treatment 7	a	b		
Treatment 5		b		

Harvest Efficiency of Frantoio Boort 2007

Treatment 3	a			
Treatment 6	a	b		
Treatment 5	a	b	c	
Treatment 4	a	b	c	d
Treatment 1	a	b	c	d
Treatment 7	a	b	c	d
Treatment 2				d

Harvert Efficiency of Barnea BBE 2007

Treatment 1	a		
Treatment 6	a	b	
Treatment 5	a	b	
Treatment 2	a	b	
Treatment 3	a	b	
Treatment 4	a	b	
Treatment 7		b	

Harvest Efficiency of Minerva BBE 2007

Treatment 7	a		
Treatment 4	a	b	
Treatment 6	a	b	
Treatment 3	a	b	
Treatment 5	a	b	
Treatment 2	a	b	
Treatment 1		b	

Discussion of Results

All data collated from the trial were averaged over the two years to observe comparisons. Table 17 is a complete summary of statistical data. Treatments have been rated from 1 to 7, with 1 indicating the best result and 7 indicating the worst outcome. The table tries to provide an overall rating of the treatments.

Treatment	FRF	Leaf Drop	Fruit Drop	Harvest Efficiency	Cost/Ha
1	3	2	1	2	4
2	2	2	2	1	5
3	2	2	2	1	7
4	2	2	3	1	2
5	1	2	3	2*	3
6	2	1	2	1	6
7	4	1	1	3	1

Table 17. Summary of statistical analysis of results, rating the treatments from 1-7.

* Treatment 5 could have had a lower harvesting efficiency as the trees were harvested three weeks earlier than the rest of the treatments. This was due to the levels of fruit drop occurring on fruit on the outside of the tree.

The statistical analysis of fruit retention force values reveals that there were significant differences between the treatments. Seven days after their application, all chemical treatments in 2006 showed an average 25% decrease in the fruit retention force in comparison with the non treated trees. Untreated olive fruit showed a slower decrease in the fruit retention force than treated olives (Fig. 5 and 6). The chemicals used were effective to reduce fruit retention force from application time to harvest. Maximum effect of agents occurred, in general, between two to three weeks after application.

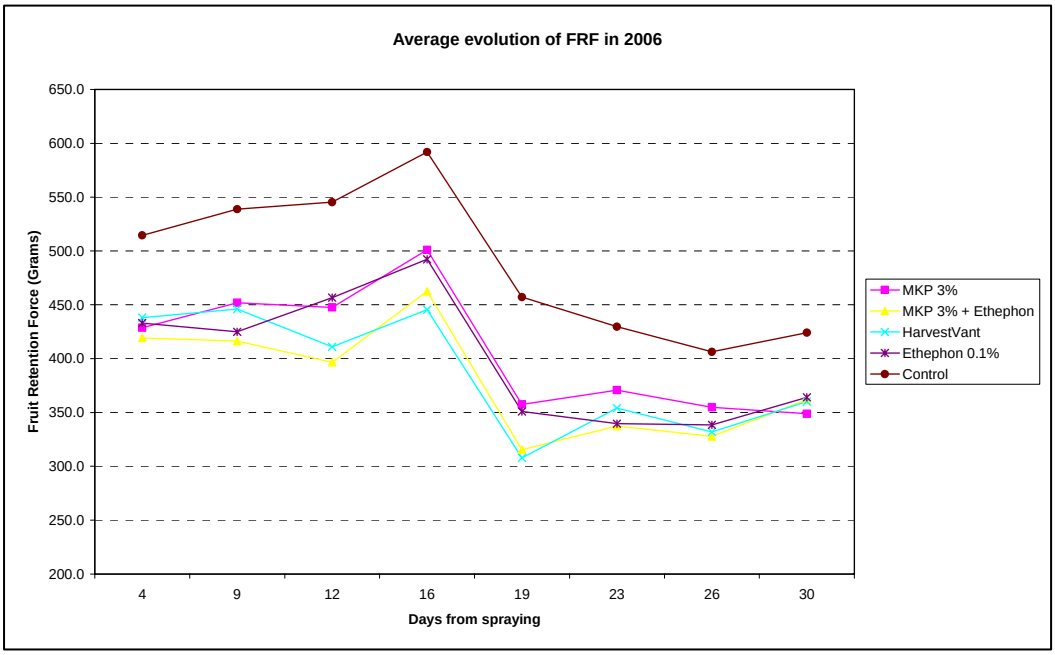

Fig. 5. Evolution of average fruit retention force in 2006

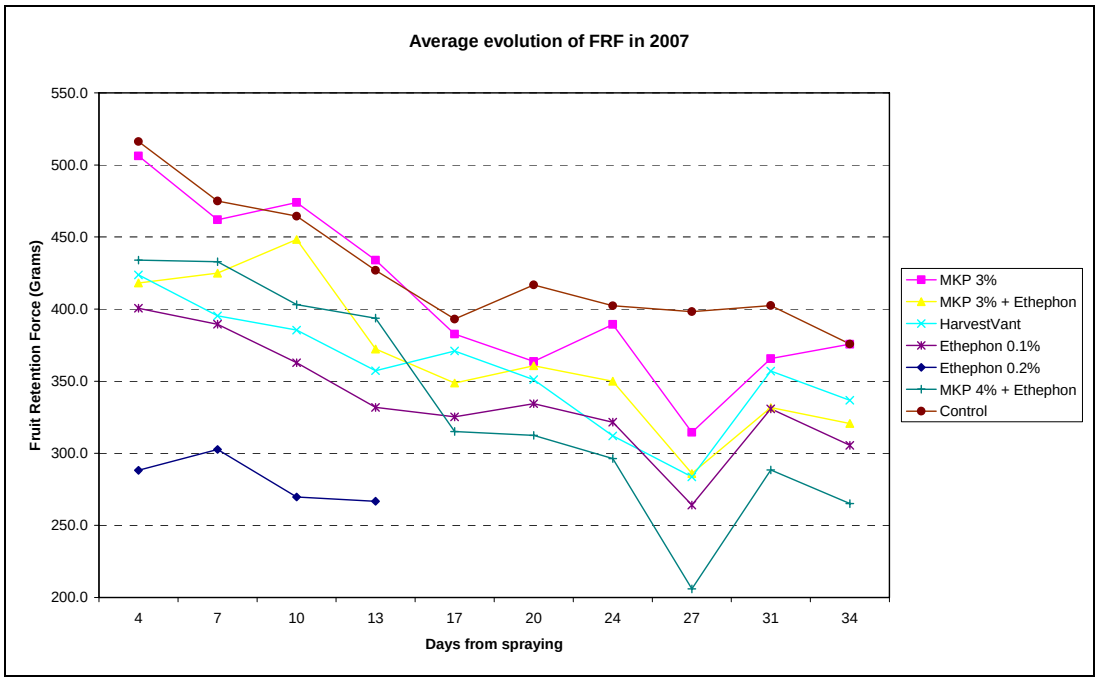

Fig. 6. Evolution of average fruit retention force in 2007

In relation to the above graphs, they illustrate that even within the first week after spraying, it is possible to notice the agents lowering the FRF in the fruit. The graph's general trend indicates that throughout the trial period the control on average, maintains a higher fruit retention force then treated trees. The uneven evolution of the FRF values throughout both seasons is quite characteristic from the olive tree and it has been described in other scientific papers (Porras Piedra, 1994).

As a general reference, it is recommended that when using the shaker harvester, the fruit retention force should be around 300 grams or less. Control fruit has never reached these values of FRF despite the fact that they reached their maximum oil content just a week after the treatments.

Fruit separation was monitored over two days, when pulling fruit off with dynameter, observing where abscission occurred. Fruit separation was apparent in all three zones but abscission was predominant in zone 1 (Fig. 7).

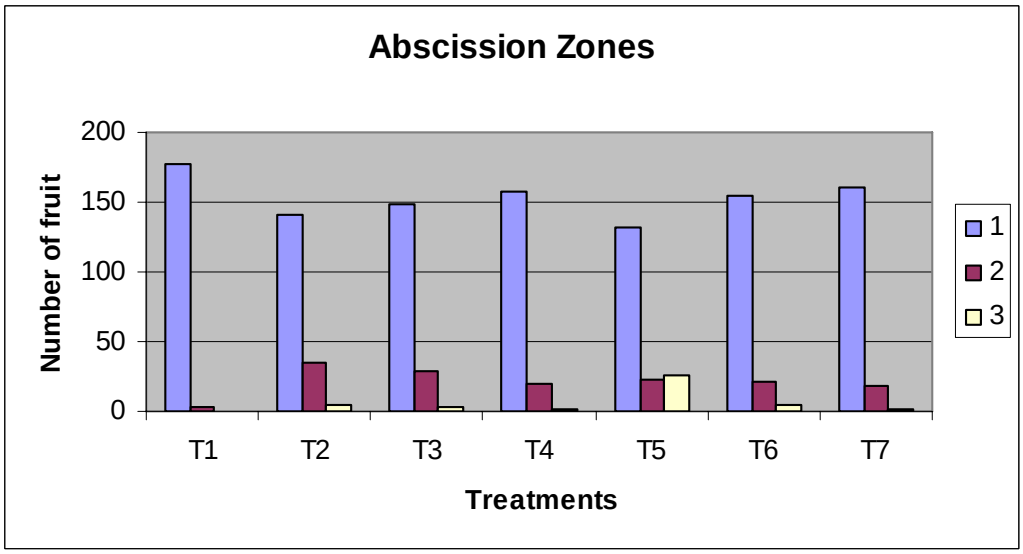

Figure 7 Abscission zones trends over the treatments.

During the maturity process, the attachment force of the olive fruit to the shoots gradually decreases by the formation of the abscission zone in a particular point of the peduncle, leading to fruit abscission. The different patterns for the separation zone distribution may indicate that ethephon may differ in its mode of action on the abscission zones but in the majority of cases abscission occurred in all zones across the treatments.

Fruit and leaf drop, after three counts over the trail period, resulted in no substantial losses in either fruit or leaf in 2006. In 2007, the trees at Boort were under slight stress as a consequence of water restrictions (78% of full irrigation), which could have been an important contributing factor to the higher levels of leaf and fruit losses (Tables 18 & 19).

Table 18: Average Losses 2006

Losses	T1	T2	T3	T4	T5
Fruit	1.8%	2.2%	0.9%	0.5%	0.6%
Leaf	1.2%	0.7%	0.6%	0.2%	0.3%

Table 19: Average Losses 2007

Losses	T1	T2	T3	T4	T5	T6	T7
Fruit	0.0%	2.1%	1.9%	2.8%	3.4%	0.4%	0.0%
Leaf	0.5%	2.2%	0.7%	2.3%	1.5%	1.0%	0.2%

Leaf losses showed significant differences between treated and not treated trees but in all cases they were under 4% in 2006 across all treatments, which is well below the maximum acceptable limits of approximately 10.0%. Leaf drop levels in 2007 reached higher values, particularly after harvest, but still within acceptable limits. It is important to highlight that we have received reports of severe defoliation (> 25% leaf drop) from groves where ethephon has been applied at higher than recommended concentrations or on more severely stressed trees. Final leaf drop figures were recorded after harvest, and although the harvest process involves some leaf removal, other reasons for leaf abscission can also be contributed to natural abscission of mature leaves.

Fruit drop across the majority of treatments was under 5% in 2006 and 2007, with the exception of treatment 5 in 2007, where levels reached more than 6%. Even when the water restrictions could have contributed to this, ethephon in this treatment was applied at twice the recommended rate. The high percentages of fruit drop resulted in the trial plot being harvested 3 weeks earlier, which also may have impacted the harvest efficiency results, as it was observed fruit on the outer sides of the tree were more influenced by the loosening agents than fruit inside the tree canopy and at the top of the tree.

Harvest efficiency was measured according to the percentage of fruit mechanically removed, knowing the actual yield before harvest and then hand harvesting and weighing the remaining fruit in the tree. The number of kilograms of remaining olives proved slightly higher in the control blocks. As an example, Boundary Bend Management Boort offered harvest efficiency for the Barnea trees in treatment 6 of 94.46%, whereas the control resulted in only 79.55% (Fig. 7) despite the harvester being set at a constant ground speed.

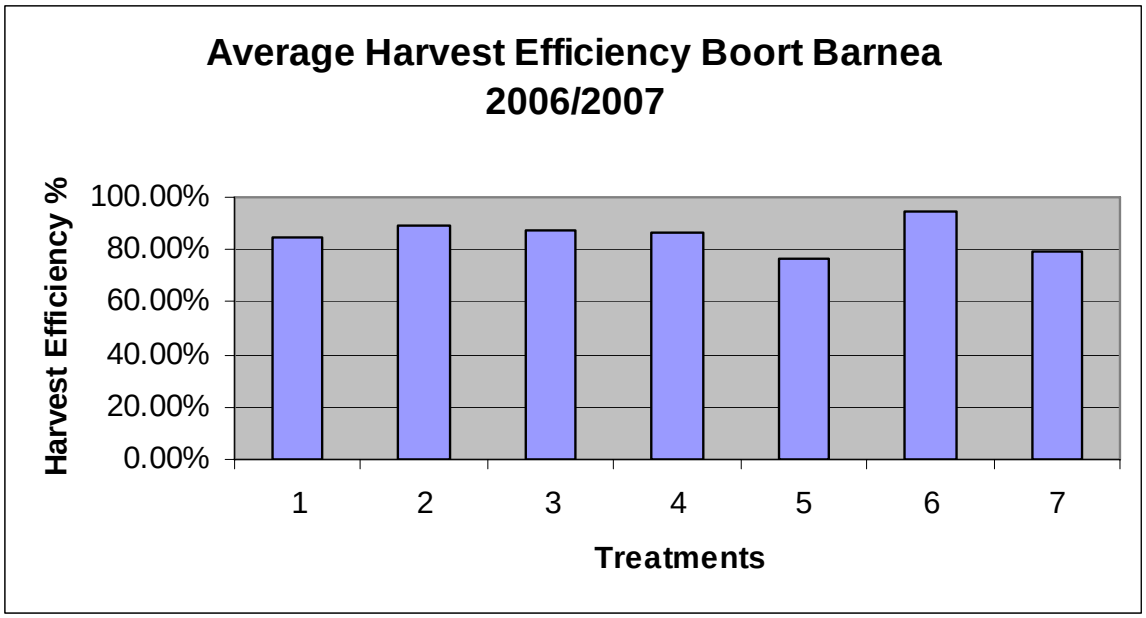

Figure 8 Average harvest efficiency of Barnea at Boort across the seven treatments.

Even when, statistical differences between harvesting efficiencies were not commonly determined as a consequence of large variations between trees, a clear pattern of increasing negative correlation between FRF and HE from week 1 to week 5 was observed. Figure 8 shows an example of a -91.33% negative correlation, indicating that as the grams of force required to remove an olive from the tree increases, the percent of harvest efficiency decreases almost in a direct proportion.

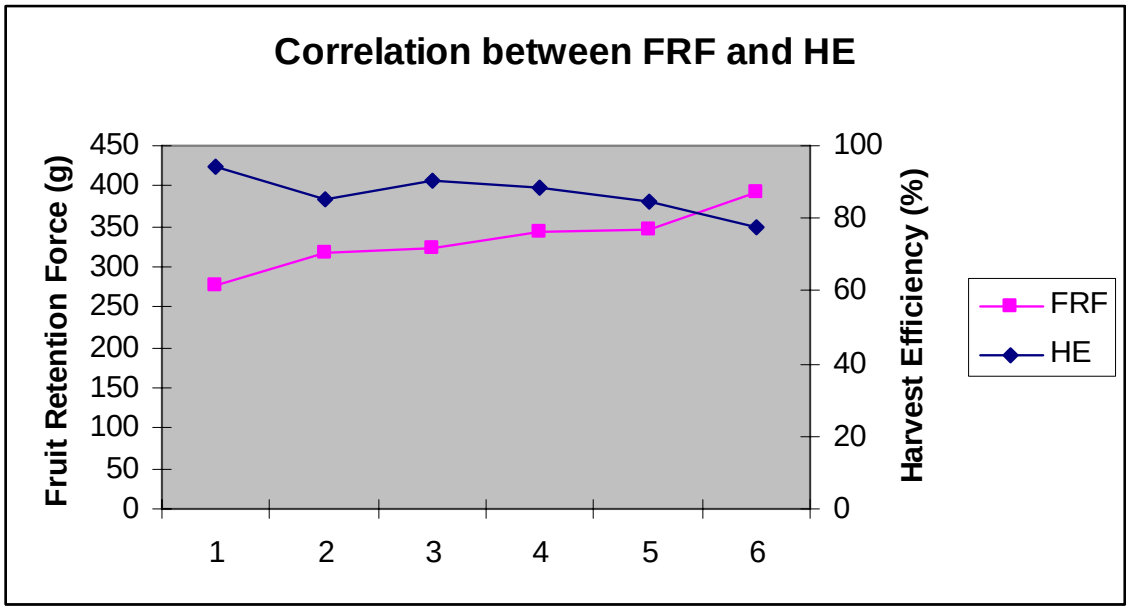

Figure 9 Negative correlation between fruit retention force and harvest efficiency.

Minimal residue limits chemical analysis (MRL) of all oil samples over the two years of the trials returned results of 0.05% for ethephon.

The evaluated fruit loosening agents, when applied at correct rates, times and conditions, show a positive effect on decreasing the fruit retention force and on increasing harvest efficiency. This efficiency is reflected in larger fruit removal percentages and the possibility of harvesting faster reducing the length of harvest, its costs and risks associated with late harvest (Frost damage, biannual bearing).

Fruit loosening application is a potential aid in the harvesting of olives, especially at times of high cropping levels, or when harvesting greener fruit earlier in the season, or to lower the FRF on certain varieties that prove difficult to harvest, for example Frantoio, Koroneiki and Arbequina. Fruit loosening agents will help to minimise the fruit left on the tree which results in less lost income for the current crop and reducing the affect on flowering and fruiting for the next year's crop.

From the results of the trial, several technical observations have arisen. In all cases, any treatment proved more effective than no treatment in weakening the fruit retention force. It was noted that, during stressing conditions (e.g. water restrictions), the effect of the FLAs could be more intense resulting in a higher percentage of leaf and fruit drop. Treatment 1 overall was not as effective as other treatments in regards to consistently lowering the FRF, although the percentage of fruit and leaf drop were minimal. Other treatments resulted in higher harvest efficiencies.

Trees should be receiving full foliar spray coverage. Do not spray in rainy conditions or when the trees are under stress. Biological variability and climatic uncertainties mitigate against uniform conditions for treatment application.

Monitoring of the fruit retention force will enable the grower to assess if the application of FLA would be required and for the most appropriate time to begin harvest, which is when the fruit decreases to approximately 300 grams of force. Results of fruit retention force monitoring indicated that the fruit loosening agents should be ideally applied 14-21 days prior to harvest to ensure an adequate decrease of FRF.

In conclusion, foliar treatments with the evaluated fruit loosening agents were found to be effective in weakening the stalk of the fruit and improving efficiency of mechanical harvesting. There was no significant fruit or leaf drop, although there was a higher rate of leaf drop in 2007 compared to 2006, due to the trees being under a larger level of water stress. All treatments were cost effective due to the increase of fruit removed from the tree. There was no detection of ethephon in oil samples across the treatments. The use of fruit loosening agents can be used as a management tool to improve harvest efficiencies.

The combination of MKP at 3.0% and ethephon at 0.05% as well as HarvestVant® at 3% or ethephon at 0.1% seems to be the safest options for FLA. A higher concentration of these solutions (e.g. MKP at 4.0% and ethephon at 0.07% or HarvestVant® at 4.0%) has proven more effective but they should be used much more carefully, with non stressed trees and for particularly difficult conditions (Initial FRF above 500 grams, small fruits, early harvest or heavy crops). Higher concentrations of ethephon are not recommended due to the risks associated with undesirable levels of fruit and leaf drop.

Implications

The following table provides a breakdown of costs involved and the benefits for one of the trials as an example. The table shows the treatments, the cost of agents and their application, the yield increase as a result of a greater harvest efficiency discounting any additional fruit losses and the income increase per hectare as a result of increased yield harvested. Calculations take into account that on average, crop levels were 12 tonne to the hectare, the percentage of oil on average at the time of crushing in the Barnea was 18.00% and the price of a litre of oil at $4.30/litre for not considering the marginal crushing costs of the additional fruit. Taking all these factors into consideration it can be seen that treatments 2, 3, 4 and 6 could have given additional benefits between $740.00 and $860.00/ha. Those treatments providing a larger benefit are based on larger quantities of ethephon increasing the risk of undesirable fruit and leaf drop.

Cost Efficiency Analysis for Barnea @ Boort Estate

Treatment	Agent	Yields (Tn/ha)	Efficiency	Fruit Losses (%)	Application cost ($/ha)*	Extra Yield (Lts/ha)**	Extra Income ($/ha)***	Difference ($/ha)
Treatment 1	MKP @ 3.0%	12.0	86.4%	0.0%	$65.07	136.1	$585.14	**$520.07**
Treatment 2	MKP @ 3.0% + Ethephon @ 0.05%	12.0	89.1%	0.0%	$74.05	194.4	$835.92	**$761.87**
Treatment 3	HarvestVant® @ 3.0%	12.0	90.3%	0.0%	$202.86	220.3	$947.38	**$744.52**
Treatment 4	Ethephon @ 0.1%	12.0	89.3%	1.2%	$44.42	196.3	$844.24	**$799.82**
Treatment 5	Ethephon @ 0.2%	12.0	84.9%	6.3%	$62.38	97.1	$417.74	**$355.36**
Treatment 6	MKP @ 4.0% + Ethephon @ 0.07%	12.0	90.4%	0.7%	$90.51	220.9	$949.97	**$859.46**
Treatment 7	Control	12.0	80.1%	0.0%	$0.00	0.0	$0.00	**$0.00**

* Includes all agents and application costs.
** Extra yields for increased efficiency - additional fruit losses @ 18.0% oil yields w/w.
*** Oil prices at AU$ 4.30/litre (It does not include the marginal expenses of crushing).

If we consider that most commercial groves in Australia (Approx. 20,000 ha) decide to apply these agents to approximately 25% of their crop (Mainly early harvest and difficult varieties), the potential benefits for the industry could reach values between AU$ 3,700,000 and AU$4,300,000/year. The preliminary results obtained from the first year of this research as well as our extensive bibliographic research was utilised by the Australian Olive Association to obtain an off-label permit for ethephon. Being a fertiliser, MKP did not need a permit to be applied.

Recommendations

The evaluated fruit loosening agents, when applied at correct rates, times and conditions, show a positive effect on decreasing the fruit retention force and on increasing harvest efficiency. This efficiency is reflected in larger fruit removal percentages and the possibility of harvesting faster reducing the length of harvest, its costs and risks associated with late harvest (Frost damage, biannual bearing).

Fruit loosening application is a potential aid in the harvesting of olives, especially at times of high cropping levels, or when harvesting greener fruit earlier in the season, or to lower the FRF on certain varieties that prove difficult to harvest, for example Frantoio, Koroneiki and Arbequina.

Being a hormonal product, there is always a potential risk of undesirable fruit losses and/or defoliation. Consequently, growers' education as regards to the use of this tool will be absolutely essential to avoid negative effects.

Fruit loosening agents are just one more tool in order to improve harvesting efficiency and a general approach should be taken in order to achieve the best possible results including other aspects such as training growers on optimal harvesting periods, harvesting technologies, tree training for mechanical or manual harvesting, quality control of the harvesting operations, etc. The publication of a small booklet covering all these aspects related to harvesting efficiency could be of interest for the industry.

Discussion with other growers has lead to the belief that the fruit loosening agents are causing an increase in acidity levels in the fruit and the oils produced from those olives. We could not determine this negative effect during the trial. However, a specific assessment on this should be advisable.

This final report should be utilised to support a registration of ethephon for its permanent permit in olives.

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Improving the Efficiency of Mechanical Olive Harvest

Evalulation of fruit loosening agents

RIRDC Publication No. 08/052

Mechanisation in agriculture can be a key driver of productivity growth. RIRDC is working with Australia's rapidly growing olive industry to enhance its productivity, and competitiveness. The forces that lead to mechanization in agriculture are clear: high cost and availability of manual labour. For some crops, these economic forces have led to rapid adoption of mechanization, for others, like olives in the Mediterranean basin; the pressure for mechanization has been growing at a much slower pace.

Outlined in this report are the findings of a two year trial that set out to evaluate the currently available fruit loosening agents under Australian conditions in order to determine their cost effectiveness and conditions for their commercial use.

This report will be useful for Australian olive growers and will provide supporting information to support registration with the APVMA to enable legitimate use of this chemical in Australian conditions.

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Cover photos: Front - Trials being harvested by the Colossus® over-the-row harvester. Back: Foliar application of fruit loosening agents by Silvan® sprayer.