FINAL REPORT
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Project Title: Development of cultivar-specific storage protocols utilizing 1-MCP

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Objectives:

1. Identify ranges of maturity 1-MCP can be successfully used for PNW apple cultivars. Successful use constitutes control or avoidance of physiological disorders and extension of storage life compared to non-treated controls.

2. Determine the range of temperature and CA gas composition over which apples treated with 1-MCP can be successfully stored.

3. Develop storage protocols that minimize the potential for CO_2 injury while maximizing the responses to 1-MCP, low temperature, and CA for long-term storage.

4. Identify factors contributing to development of CO_2 injury and how 1-MCP impacts that process.

5. Determine if 1-MCP impacts fruit susceptibility to lenticel breakdown after packing.

Significant Findings in 2002-05:

1. Storage of 1-MCP-treated Delicious, Gala, Golden Delicious, and Granny Smith apples at CA O_2 concentrations and temperatures higher than current recommendations for long-term CA was as effective as current low O_2 and temperature setpoints used with untreated fruit for maintenance of firmness and titratable acidity. (Argenta cooperation)

2. Incidence of bitter pit, shrivel and rough peel were not enhanced by 1-MCP treatment of any cultivar. Bitter pit lesion size may be larger in fruit treated with 1-MCP. (Argenta cooperation)

3. Retention of watercore in Delicious apples can be prolonged by 1-MCP treatment, however, this response is inconsistent between lots and seasons.

4. Delicious and Granny Smith apples harvested with minimal starch clearing (1-2) did not develop superficial scald through 6 months storage (RA or CA) when treated within 5 days of harvest with 1-MCP.

5. Efficacy of 1-MCP for scald control and quality maintenance of Granny Smith apples is not compromised by extended (2 months) storage in air following removal from CA.

6. Onset of Granny Smith delayed sunscald can be accelerated following 1-MCP treatment, however, this effect is lot specific. When fruit have been stored long enough for the disorder to develop on untreated fruit, incidence is similar between control and 1-MCP-treated fruit.

7. Granny Smith apples treated with 1-MCP within 10 days of harvest then stored in up to 5% O_2 (1% CO_2) at up to 41 ^oF did not develop superficial scald and developed less or did not develop internal disorders compared to untreated fruit. Retention of green peel color decreased as storage temperature increased regardless of 1-MCP treatment.

8. Incidence of diffuse skin browning (DSB) on Golden Delicious apples stored at 31 ^oF can be enhanced by 1-MCP treatment and/or storage in CA, particularly in high CO_2 (i.e. 3%). Development of DSB on 1-MCP-treated fruit can be reduced by delaying 1-MCP treatment 5-10 days after harvest.

9. (NC, WA) Golden Delicious maturity. NC: Fruit treated with 1-MCP had acceptable firmness after 5 months RA if firmness was ~15.5 lbs or above at the time of treatment. WA: Fruit stored in air had marginal quality after 3 months regardless of harvest maturity or 1-MCP treatment. The combination of 1-MCP followed by CA significantly improved quality, especially firmness and titratable acidity, compared to 1-MCP-treated fruit stored in air, or untreated fruit stored in CA. Storage in CA reduced development of bitter pit while effects of 1-MCP treatment on bitter pit were not apparent. Maturity at harvest and storage in CA impact peel color changes during storage more than 1-MCP treatment. No effects of storage CO_2 concentration were evident regardless of 1-MCP treatment, however, previous results indicate susceptibility of Golden Delicious apples to high CO_2-induced peel injury in some lots/seasons is not reduced by 1-MCP.

10. Fruit temperature at the time of 1-MCP treatment: The incidence of senescent scald and a disorder similar to delayed sunscald on Golden Delicious apples increased with fruit temperature imposed during a 5 minute exposure at up to 120 ^oF at harvest. Application of 1-MCP following high temperature treatments reduced but did not eliminate development of both disorders.

11. Increased susceptibility of Braeburn apples treated with 1-MCP to coreflush and core browning is not reduced by delaying 1-MCP treatment.

12. Delaying cooling (holding at 50-70 ^oF) of 1-MCP-treated Braeburn apples for 10 days followed by storage in air at 32 ^oF or 37 ^oF reduces but does not eliminate development of

core flush and core browning in all lots/seasons. This protocol does promote retention of quality compared to untreated fruit.

13. DPA applied to Braeburn apples previously treated with 1-MCP reduces but does not eliminate development of core flush or core browning in all lots/seasons.

14. Jonagold apples treated with 1-MCP at harvest then stored in CA with up to 3% CO_2 did not develop external or internal CO_2 injury, however, different responses to CO_2 related to lot/season were not evaluated.

15. (NC) Packing (trays, perforated poly liners, fiberboard box) did not reduce efficacy of 1-MCP for Delicious apples treated at harvest then stored in air at 32 ^{o}F. Liner thickness can reduce efficacy according to AgroFresh research.

16. Treatment of Gala apples with 1-MCP at harvest did not consistently increase development of lenticel breakdown after simulated packing. (Curry cooperator)

17. (NC) Gala apples receiving pre-harvest Retain treatments [1X (label rate), 2X (twice label rate), split application (1X twice)], with a postharvest 1-MCP treatment were firmer compared to fruit receiving either material used alone. Soluble solids were generally lower in fruit to which Retain was applied.

18. (NC) Gala apples harvested on 3 dates with firmness averages of 21, 19 and 17 lbs had acceptable (>14 lbs) firmness after storage for 6 months in air at 32 ^{o}F when treated with 1-MCP at harvest. Titratable acidity was the quality limiting factor after this storage duration. Similar results using Washington grown fruit have been observed previously.

19. Efficacy of post-storage 1-MCP treatment of Gala apples is dependent on storage duration, storage environment, maturity at harvest, fruit condition at the time of treatment, and duration in air after post-storage treatment.

20. Treatment of apples having optimal maturity with 1-MCP at harvest extends the period of acceptable quality when fruit are held for relatively short periods (less than 2 months) of cold storage followed by holding at 70 ^{o}F for up to 1 month. Holding 1-MCP-treated fruit at 70 ^{o}F accelerates starch loss compared to cold-stored apples. Apples treated with 1-MCP are less likely to exhibit excessive quality loss after experiencing suboptimal temperature management (i.e. unrefrigerated retail displays) after up to 2 months of RA storage.

21. 1-MCP treatment delay. **I. Golden Delicious** apples harvested at CA maturity were treated with 1-MCP: 1) at harvest then placed into CA (1.5% O_2, 3% CO_2) after 0, 2, 4 or 6 weeks at 33 ^{o}F; or 2) after 0, 5, 10 or 15 days followed by CA (1.5% O_2, 3% CO_2). Incidence of disorders was low and was not impacted by delays in CA or 1-MCP treatment. Effects of 1-MCP on firmness and titratable acidity decreased with increased delay of CA establishment after 1-MCP treatment, however, firmness of 1-MCP-treated fruit was higher compared to untreated fruit regardless of the duration of CA delay. Firmness and titratable acidity decreased with increased delay of 1-MCP treatment, however, values for 1-MCP-treated fruit were higher compared to non-treated fruit when treatment delays were 5 days or more. Peel color was yellower for untreated fruit with the longest delay (15 d) prior to establishment of CA conditions. Color of 1-MCP-treated fruit was similar regardless of treatment delay.
II. Cameo: 1-MCP treatments applied 0, 5, 10 or 15 days after harvest resulted in higher firmness and titratable acidity compared to non-treated fruit regardless of storage type (RA,

CA: 1.5% O_2, 2% CO_2). Delaying 1-MCP treatment up to 15 days did not impact firmness or titratable acidity when fruit were stored in RA. A 15 delay prior to 1-MCP treatment and establishment of CA reduced efficacy compared to fruit treated 10 or less days after harvest, however, fruit quality was still superior compared to untreated fruit. A peel disorder (radiant shape, rough texture, light brown color) similar to CO_2 injury developed on both 1-MCP-treated and non-treated fruit stored in CA. Incidence ranged from 6-22% and the disorder was present only in treatments where the delay in establishment of CA was 5 days or less. Subsequent research indicated development of rough peel on Cameo fruit stored in CA was not clearly associated with 1-MCP, CA delay or CA CO_2 concentration. A relationship between incidence of this disorder, maturity at harvest, and storage in CA was evident in 2004-05.

III. Fuji: Apples from 3 lots were used to evaluate delays up to 20 days in 1-MCP treatment and subsequent development of disorders and quality. Fruit exposed to 1-MCP 0, 10 or 20 days after arrival were stored at 37 ^oF for 17 days, then at 33 ^oF. Impacts of 1-MCP treatment and treatment delay were lot specific. All lots had ratable watercore at harvest and most of the watercore had cleared regardless of 1-MCP treatment and storage type (RA, CA) after 4 months. Storage type and duration of 1-MCP treatment delay were factors influencing peel background color. Treatment with 1-MCP then storage in CA slowed degreening unless the 1-MCP treatment delay was 20 days. Incidences of external and internal CO_2 injury were negligible for all lots in this trial.

IV. Braeburn: Apples from 3 lots were handled similarly as Fuji (III above). In two lots, treatment with 1-MCP increased incidence of core flush (light brown) and core browning regardless of treatment delay or subsequent storage environment (CA or RA). Incidence of internal browning in the cortex was low, often accompanied sunburn, and was not related to maturity at harvest, storage environment, or 1-MCP treatment. Firmness and titratable acidity of fruit treated with 1-MCP were superior compared to untreated fruit regardless of treatment delay. After 8 months, firmness and titratable acidity of 1-MCP-treated fruit stored in RA were superior to untreated fruit stored in RA or CA.

V. Granny Smith: Apples harvested on 3 dates (Sep. 18, Oct 9, 17) starting at starch 1.2, exposed to 1-MCP 0, 5 or 10 days after harvest, then stored at 33 ^oF in air or CA (1% O_2, 1% CO_2) did not develop superficial scald regardless of harvest date, treatment delay or storage environment. Development of superficial scald on untreated controls decreased with harvest date and increased with CA delay. Earlier onset (1 month RA) of delayed sunscald was observed on fruit harvested Sep 6 and treated with 1-MCP. However, no difference in incidence of delayed sunscald due to 1-MCP treatment was evident on this fruit evaluated after 3 months RA. All 1-MCP treatments resulted in enhanced firmness and titratable acidity compared to controls for fruit stored in RA. No consistent differences in firmness or TA were evident between 1-MCP-treated fruit stored RA or CA and untreated fruit stored in CA.

22. Fuji: CO_2 tolerance in a non-CA environment. Apples exposed to 1-MCP the day after harvest were stored at 33 ^oF in air then in up to 8% CO_2 beginning 0, 10 or 20 days after 1-MCP treatment. Incidence of internal browning decreased with increased delay in exposure to CO_2, and incidence was highest at 8% CO_2. A high incidence of injury was present after 1 month storage. Incidence of peel damage was not related to 1-MCP treatment. Peel damage increased with CO_2 concentration when fruit were exposed to CO_2 supplemented environments with no delay after harvest. Exposure to 8% CO_2 was necessary to induce peel injury if CO_2 exposure was delayed 10 or 20 days after harvest.

23. Analysis of DPA metabolites extracted from Granny Smith peel tissues confirmed the presence of 4-hydroxydiphenylamine (4-OHDPA) and smaller amounts of 2-hydroxy (2-

OHDPA), 3-hydroxy (3-OHDPA), and dihydroxydiphenylamine. These compounds along with nitrogenous DPA derivatives including n-nitrosodiphenylamine (NODPA), 2-nitrodiphenylamine (2-NO2DPA), and 4-nitrodiphenylamine (4-NO2DPA) as well as numerous other compounds were detected in multiple lots of Granny Smith apples obtained from commercial packers. These compounds were present in all lots tested but amounts varied widely between lots. None of these compounds were detected in any of the DPA EC formulations tested. The most abundant DPA derivative, 4-OHDPA appears immediately upon treatment of apple fruit with DPA and its abundance increases with harvest maturity and duration of cold storage in air or CA. One of the derivatives, 4-OHDPA, can prevent development of superficial scald when applied to susceptible fruit at harvest while other DPA derivatives (mentioned above) do not. The generation of nitrogenous DPA derivatives follows a different pattern and accumulation is inhibited by 1-MCP. Based on accumulation of DPA derivatives, including 4-hydroxy-DPA and *N*-nitroso-DPA, it is likely the mode of action of DPA in preventing scald development is by proton donation rather than by direct interaction and derivative formation with free radicals as occurs in non-biological materials including smokeless powders.

Results and Discussion

2004-05 Results

Golden Delicious diffuse skin browning (DSB)

Fruit was obtained at harvest from an orchard with a high incidence of DSB the previous year. Factors evaluated included 1-MCP treatment, delay of 1-MCP treatment, storage type (RA, CA) and CA CO_2 concentration. All fruit were stored at 31 ^{o}F in air or CA (1.5% O_2, 1,2 or 3% CO_2). Delayed 1-MCP treatments were applied to fruit in CA. The incidence of DSB was enhanced by storage in CA at 3% CO_2, and by treatment with 1-MCP for fruit stored in air or CA with 1% CO_2. Delaying 1-MCP treatment for 6 or 12 days after harvest reduced DSB incidence.

Table 1. Golden Delicious DSB after 2 months storage

Atmosphere	Treatment	1-MCP delay	DSB incidence
air	control	-	0%
	1-MCP	0 days	69
1.5% O_2, 1% CO_2	control	-	3
	1-MCP	0	19
		6	3
		12	3
1.5% O_2,2% CO_2	control	-	6
	1-MCP	0	3
		6	0
		12	0
1.5% O_2,3% CO_2	control	-	33
	1-MCP	0	36
		6	3
		12	0

Fruit were evaluated for DSB symptoms 0 and 7 days after removal from storage, results were combined and reported as incidence (%).

Granny Smith RA after CA

The impact of duration in RA after CA storage on scald control and fruit quality was evaluated using Granny Smith apples harvested at weekly intervals starting September 14, 2004. Apples were treated with 1-MCP the day after harvest, then stored in CA (1.5% O_2, 1% CO_2). After 4 months CA followed by 1 or 2 months RA plus 7 days at 68 ^oF , no scald developed on 1-MCP treated apples, while scald incidence for untreated controls was up to 80%. 1-MCP treatment effects on retention of firmness, titratable acidity, and peel color were dependent on harvest date and duration in RA after CA. Treatment differences when present were greater when fruit was stored 2 months in RA after CA.

Table 2. Granny Smith fruit quality after 4 months CA plus 1 or 2 months RA

Harvest	RA (months)	Treatmnt	Scald %	lbs	TA %	color 1-5
9-14	1	control	11	17.6	0.678	1.3
		1-MCP	0	18.1	0.760	1.1
	2	control	67	17.3	0.642	1.1
		1-MCP	0	18.3	0.698	1.0
9-21	1	control	0	18.1	0.611	1.6
		1-MCP	0	18.2	0.649	1.0
	2	control	56	16.3	0.596	1.6
		1-MCP	0	18.2	0.654	1.4
9-28	1	control	0	18.6	0.655	1.1
		1-MCP	0	18.6	0.628	1.0
	2	control	78	16.7	0.500	1.7
		1-MCP	0	18.2	0.657	1.0
		$LSD_{0.05}$		1.2	0.025	

TA: titratable acidity; LSD: least significant difference

Management of Delicious Watercore

Apples harvested with slight (orchard 1, starch 2.1) or moderate (orchard 2, starch 3.9) watercore were treated with 1-MCP then held at 32 ^oF in air for up to 21 days prior to establishment of CA (1.5% O_2, 1% CO_2). Through 5 months, firmness and titratable acidity of 1-MCP-treated fruit was not consistently altered by delayed CA after harvest. The presence of watercore after 5 months was not consistently higher in 1-MCP-treated fruit compared to untreated controls. The highest incidence of internal browning at 5 months was in orchard 2 fruit stored in air (control 22%, 1-MCP 50%). Consistent trends between development of internal disorders, 1-MCP treatment, and CA delay were not evident in this experiment.

Table 3. Delicious fruit quality after storage in air or 1.5% O_2, 1% CO_2.

Orchard	Storage/delay	treatment	lbs	TA	WC %	IB
1	air	control	10.1	0.202	6	0
		1-MCP	16.9	0.220	6	0
	CA: 0 days	control	11.0	0.215	6	6
		1-MCP	17.4	0.243	11	0
	7	control	12.7	0.212	6	0
		1-MCP	17.3	0.249	17	0
	14	control	11.8	0.184	22	11
		1-MCP	16.0	0.233	17	0
	21	control	10.6	0.178	11	22

		1-MCP	16.6	0.227	28	0
2	air	control	10.0	0.124	33	22
		1-MCP	14.4	0.170	28	50
	CA: 0 days	control	12.1	0.182	6	6
		1-MCP	16.0	0.202	22	6
	7	control	10.6	0.174	11	12
		1-MCP	15.6	0.182	6	0
	14	control	12.1	0.187	6	18
		1-MCP	16.2	0.206	39	6
	21	control	11.4	0.180	22	6
		1-MCP	15.9	0.193	0	6
		$LSD_{0.05}$	1.4	0.012		

TA: titratable acidity; WC: watercore; IB: internal browning; LSD: least significant difference

Interaction between Cameo maturity, 1-MCP treatment and storage environment.

Fruit was harvested from two orchards at weekly intervals beginning at commercial maturity (starch ~2.5, 16+lbs), stored at 33 ^{o}F for 5 days prior to 1-MCP treatment, then stored in air or CA (1.5 % O_2, 2% CO_2). Treatment with 1-MCP extended the storage life of fruit from all harvests stored in air, with the duration of acceptability for 1-MCP-treated fruit dependent on maturity at harvest and orchard source. Incidence of a peel disorder with a radiant, star-like pattern and rough texture was observed on both control and 1-MCP-treated fruit, particularly fruit from the first harvest if stored in CA, and the third harvest if stored in air. Storage in CA with or without prior 1-MCP treatment appeared to enhance incidence of this disorder. Incidence of internal browning in fruit from 1 orchard stored in air for 4 or 6 months was enhanced by late harvest and 1-MCP treatment.

Table 4. Cameo (Orchard 1) fruit quality after storage in air (RA) or 1.5% O_2, 2% CO_2 (CA)

Month/ storage type	Harvst	treatment	Lbs RA	Lbs CA	TA % RA	TA % CA	IB % RA	Peel inj. % RA	Peel inj. % CA
2 RA/3 CA	1	control	13.2	15.6	0.382	0.433	0	0	11
		1-MCP	17.1	16.6	0.472	0.462	0	0	17
	2	control	12.0	14.9	0.364	0.424	0	0	6
		1-MCP	16.4	16.7	0.394	0.426	0	0	0
	3	control	10.7	13.2	0.313	0.368	0	0	0
		1-MCP	14.1	15.6	0.390	0.365	0	0	0
4 RA	1	control	11.8		0.299		0	0	
		1-MCP	16.8		0.390		0	0	
	2	control	10.8		0.270		0	6	
		1-MCP	16.3		0.365		0	0	
	3	control	8.9		0.245		0	0	
		1-MCP	11.5		0.334		17	0	
6 RA/CA	1	control	11.2	13.6	0.222	0.420	0	0	6
		1-MCP	17.0	17.1	0.343	0.445	0	0	28
	2	control	10.3	13.7	0.218	0.398	0	0	11
		1-MCP	16.7	16.2	0.364	0.401	0	0	0
	3	control	8.8	11.9	0.177	0.345	6	0	0
		1-MCP	10.7	15.3	0.287	0.379	33	0	0

TA: titratable acidity; IB: internal browning; Peel inj.: peel injury
Fruit held 7 days at 68 ^{o}F after removal from storage.

Braeburn Internal Disorders

Fruit treated with 1-MCP the day after harvest were held in air at up to 70 ^oF for up to 50 days prior to transfer to 32 or 37 ^oF. After 3 and 6 months the combined incidence of core flush, core browning and internal browning was enhanced in 1-MCP-treated fruit held 30 days at 50 F then moved to 32 or 37 ^oF. At 6 months, no incidence of internal disorders was observed in fruit treated with 1-MCP at harvest, then held at 70 ^oF for 10 or more days prior to storage at 32 or 37 ^oF. Controls subjected to the same cooling delay had significant development of internal disorders. Impact of 1-MCP-treatment on fruit quality (firmness, acid retention) were not compromised by cooling delay of 10 or 30 days.

Table 5. Braeburn fruit quality after 6 months storage plus 7 days at 68 ^oF.

Delay (days)	^oF during delay	Final ^oF	Trtmnt	Int. Dis. %	lbs	TA
0		32	control	6	12.8	0.349%
			1-MCP	13	18.3	0.405
		37	control	33	11.7	0.345
			1-MCP	7	17.6	0.395
10	37	32	control	0	13.3	0.377
			1-MCP	16	18.3	0.393
	50		control	0	12.5	0.365
			1-MCP	11	19.3	0.432
	70		control	0	10.3	0.347
			1-MCP	17	17.7	0.419
	32	37	control	33	11.8	0.351
			1-MCP	11	18.9	0.413
	50		control	22	12.0	0.330
			1-MCP	22	16.5	0.399
	70		control	0	10.1	0.330
			1-MCP	0	17.3	0.404

Int. Dis.: internal disorders; TA: titratable acidity

Project Summary:

1-MCP/CA: For all cultivars evaluated, fruit treated with 1-MCP then stored in a CA regime at O_2 setpoints of 2-3% O_2 performed as well or better than fruit stored in close to 1% O_2. Fruit treated with 1-MCP also performed well in CA regimes where temperatures in the mid 30s were used. In a well managed storage facility, assuming apples are of good quality with a maturity suitable for long-term CA, higher O_2 and temperature may result in less risk of development of injury from low O_2 and/or low temperature while incurring operational savings from reduced energy costs. These results were consistently obtained in experiments where fruit was treated with 1-MCP soon after harvest then stored in small CA chambers. Under commercial conditions, the magnitude of 1-MCP-induced responses may vary due to room loading time, lot to lot differences in maturity, and operational differences between facilities. However, the physiological response of inhibition of ethylene action by 1-MCP may account for the quality differences obtained when untreated fruit from the same lot is stored in ultra low O_2 and temperatures near 32 ^oF compared to higher O_2 and 33-35 ^oF.

Disorders: While the use of 1-MCP, particularly for control of superficial scald, has proven to be commercially viable, questions remain regarding other problems including lenticel breakdown and internal browning. Lenticel breakdown has many causal factors as identified by Eric Curry over the past 4 years. With the exception of the cooperative project with Eric, the disorder has been relatively absent in our experiments. The lack of simulated packing in our experiments may have contributed to the near absence of lenticel breakdown in our results, and if so, points to a difficult resolution for this problem as while all warehouses pack fruit, procedures vary greatly between facilities. Some other factors identified by Eric, particularly maturity at harvest and storage duration can also be impacted by the use of 1-MCP. The effectiveness of 1-MCP in slowing ripening can allow fruit harvested at a maturity that used to be considered too mature for long-term CA to now be stored based on retention of firmness. Longer storage durations increase the risk of lenticel breakdown, and the question as to direct effects of reducing ethylene action on susceptibility to this disorder has not been fully answered. A similar situation exists for internal disorders, particularly those encountered in the 2004 crop. In general, internal browning and breakdown related to fruit senescence have been delayed or prevented by 1-MCP treatment in our studies, while problems related to CO_2 concentrations during storage can be exacerbated by the use of 1-MCP. It also appears that 1-MCP can enhance the low-temperature sensitivity in susceptible fruit, susceptible being the key as a means to define the lot to lot variability in this regard is unknown. As internal disorders can arise from a number of causes, it is critical to determine what factor is most likely responsible for initiating the disorder before a possible role of 1-MCP in enhancing or reducing fruit susceptibility can be identified.

The central role of ethylene in regulating apple fruit ripening has become even more apparent with the availability of 1-MCP. Experiments we have conducted have in some cases confirmed and in others identified new differences between specific cultivars. Apples for which firmness management has been the key to extending the marketing period have responded well in that regard to 1-MCP. For later cultivars which tend to retain firmness the benefits of 1-MCP are less clear or obviously still in doubt (i.e. Braeburn) due to other issues. For these cultivars, the primary benefits may exist for other quality components, particularly retention of titratable acidity, and/or storage in air rather than CA for at least part of the storage season.

CA rooms at the Stemilt RCA facility were used to conduct the 1-MCP delay trials for Braeburn and Fuji, and to store apples during the 2004-05 season.

Budget:

Project Title: Development of cultivar-specific storage protocols utilizing 1-MCP
PI: James P. Mattheis
Project duration: 2002-2004
Current year: 2004
Project Total (3years): $240,870
Current year request: 0

Year	**Year 1 (2002)**	**Year 2 (2003)**	**Year 3 (2004)**
Total	$130,840	$161,330	$66,500

Budget breakdown:

Salaries	$ 96,400	$ 102,781	$ 44,800
Benefits	$ 19,940	$ 44,049	$ 19,200
Wages	$ 7,000	$ 7,000	$ 0
Supplies	$ 7,500	$ 7,500	$ 2,500
Total	**$130,840**	**$161,330**	**$66,500**

2002-3 salaries included 1 post-doctoral research associate and 2 research technicians. Increase in 2003 benefits due to change in post-doc appointment administration due to visa status. 2004 salary for 1 research technician. Supply funds used for purchase of fruit and consumable supplies. Wages supported a student worker at NCSU (S. Blankenship).