STRAWBERRY GROWING MANUAL FOR SOUTH AFRICA

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Indemnity:

Please note that the contents of this manual are a mixture of information from the internet and learning's that I have gleaned from the years that I have been in the business. Please note that I have collated this information in order to assist the South African strawberry growers, so use this information at your discretion, as I cannot be held liable for any losses arising from the use thereof.

Foreword:

There has never been a better time to grow strawberries in South Africa than at present. We have some excellent varieties to choose from and the three current favorites, Festival, Honor and Albion, each from a different breeding program, give growers an extended season of excellent quality fruit. There are great varieties in the pipeline and the Cape Strawberry Growers Association is making great strides with plant certification, chemical registration and packaging. I hope that this booklet acts as a guide for improved performance. Remember that it is a work in progress and it will be continually updated.

CULTURAL PRACTICES FOR STRAWBERRIES

Handling Strawberry Transplants

Planting
Following recommended procedures for handling and planting the cultivars is essential for achieving optimum plant vigor. Good plant vigor increases yields and reduces the impact of pests.

Planting dates. The best time to plant depends on cultivar and location. Yield, quality, and earliness of production are affected by planting date. The correct planting date helps ensure vigorous growth, improves yields, and reduces pest problems. Planting too early reduces vigor and yield, may increase mite problems, and may result in a higher incidence of misshapen, small fruit. Planting too late causes excessive growth of foliage and runners, delays fruit production, and decreases yield.

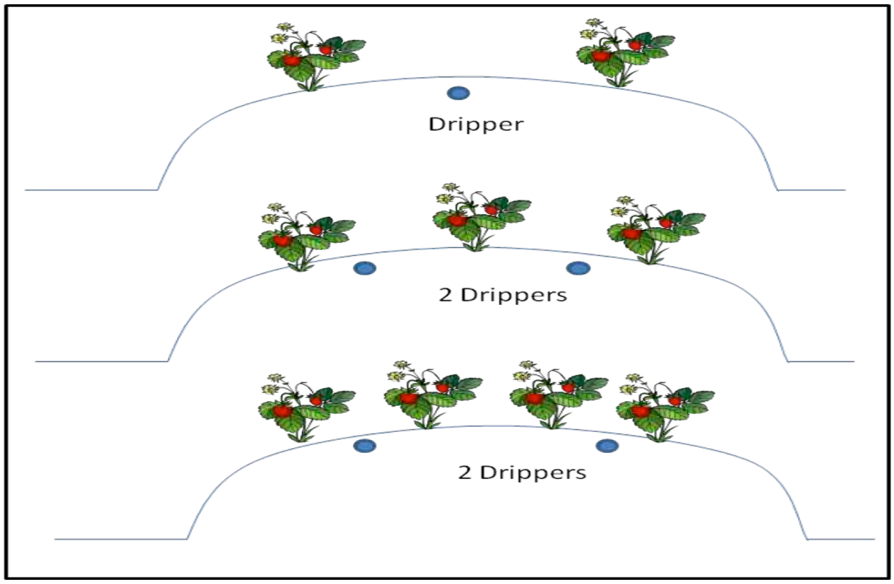
Handling transplants. Keep transplants protected during planting operations to prevent drying, and place them into beds with soil moisture near field capacity. T

ransplants usually are placed into holes punched into the tops of formed beds by machine after polyethylene mulch has been applied.

My call for planting dates and distances are as follows:

Variety	**Type**	**Planting date**	**Spacing (cm)**
Orly	Ultra SD	Feb/March	25
Festival	Short Day	Feb/March	25
Sabrosa	Short Day	March/April	25
Splendor	Short Day	March/April	30
Virtue	Short Day	March/April	30
Honor	Short Day	March/April	30
Promise	Day Neutral	March -Sep	30
Albion	Day Neutral	March -Sep	30
San Andreas	Day Neutral	March -Sep	30
Monterrey	Day Neutral	March -May	30
Portolas	Day Neutral	March -Sep	30

Beds and Mulching



Planting formats: 2, 3 & 4 row beds.

The standard planting system in S.A. is the 2 row bed with a single dripper in the middle of the bed. Make sure that the dripper line is pegged or buried a few cm deep so that it does not migrate off one side of the bed with expansion and contraction of the pipe, resulting in uneven watering. Pulsed irrigation (more frequent, short burst irrigations per day) will ensure better lateral spread of the irrigation water. Growers are using double dripper lines with 3 or 4 row beds and research with 2 dripper, three row beds have shown a doubling of production/ha (50% from the extra plants and 50% from the extra dripper line) Remember that you need to optimise plant numbers when using Spanish tunnels, and this is the most effective method. Extra labour will be needed to clean excess foliage and more attention needs to be given to harvest as the middle row fruit are not well exposed.


American style 4 row beds

Bed forming

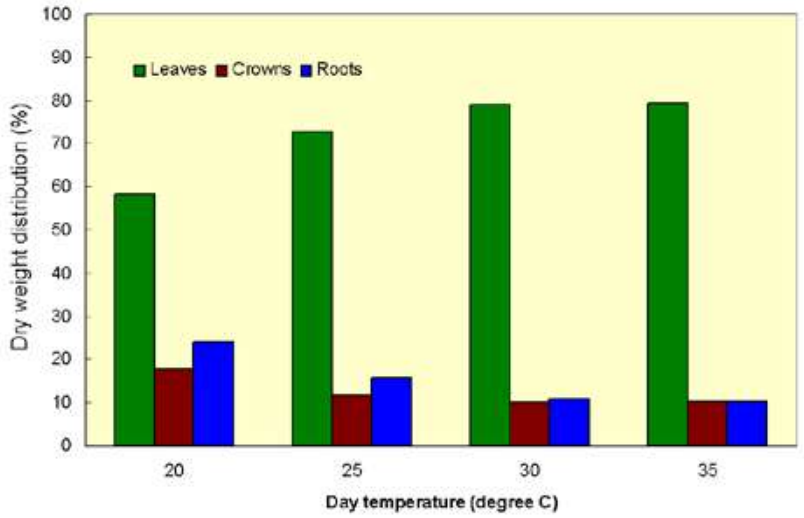
After plant material, planting technique and nutrition, the formation of the beds is crucial for optimizing production. Bed formers like the Cosmeco (below right) or Zuiderwint (below left), which work up the beds from the sides rather than scoop it through a mould, tend to give beds of even density. These formers are also height and width adjustable and can pull a plastic mulch and dripper layer.

http://www.cosmeco.it

'tjasse@zuiderwint.co.za'

Remember that the ridge needs to be well formed and compacted so that the mulch plastic is held tightly to the bed. This helps to transfer the heat from the black mulch to the soil and speeds up the plant and root growth in Autumn and also minimises wind lift. Round bar welded onto the outside of the ridger leaves grooves for permanent dripper line placement

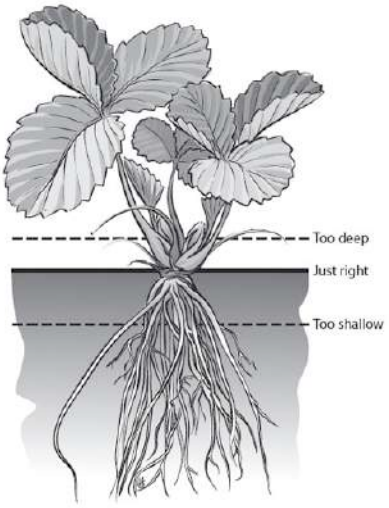
Soil temperature plays a huge role in determining time of commencement of harvest, yield and quality. For earliness it is vital to get the plants in the ground early enough to get sufficient vegetative growth before the winter sets in. Once you have a reasonable canopy of leaves, the roots will continue to grow throughout the winter months, and the leaves will produce reserves for supporting fruit production and developing the structure needed for the spring flush.



Effect of day temperature on root, leaf and crown development

As the temperature warms up in spring, crown and root growth slows down and leaf growth accelerates. Even on black plastic, larger plants will cover the black mulch sufficiently to shade and keep the soil temperatures from rising too high. Plants that develop poorly in winter will not give this effect and the black mulch will heat the soil so that mainly leaf growth takes place. The small roots and crown will not be able to support acceptable yields.

Proper placement of transplants is critical. For this reason, all transplants are planted by hand. Make sure that the crown is properly exposed after the soil is closed around the transplants. Plants die if placed too deep and grow poorly if placed too shallow. Roots should be vertical in the planting slot and not be allowed to form a 'J'. The 'J' root results in a pocket of air being trapped in the root area which dries out the root and encourages root rots If excessive root length interferes with proper planting, roots may be pruned, but should never be less than 10cm in length. Place transplants no farther than 15-20cm from a drip line.



Strawberry transplants should be planted so that the crown bud is above the soil line and all roots are below the soil line. Planting with the crown too high will dry out the new adventitious roots that develop from the crown area before they can reach the soil. Planting too deep allows rots to infect the crown. Remember that the strawberry plant has the ability to replace its root system from new roots originating just below the developing crown. Rather plant a little too deep than a little too shallow or these new roots will dry and die before reaching the ground and the plant will be "floppy''

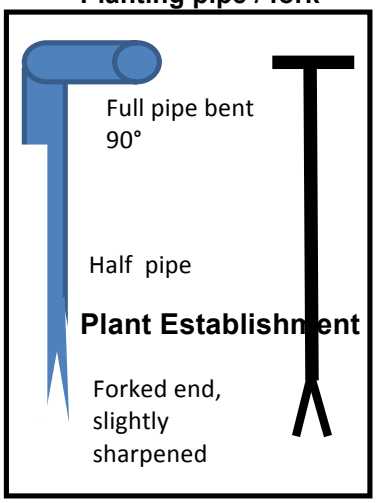
When make closed around in

planting bare-root strawberry transplants, sure the crown bud is exposed after soil is around each transplant. Compact the soil the crown to get rid of air spaces and water immediately

The roots of bare-root strawberry transplants may be trimmed to facilitate planting, but should never be shorter than 10cm. The best way to ensure no “J rooting” is to plant with a pronged fork or modified “pipe knife”. Hook the fork into the bottom quarter of the root. As the crown gets to the required depth, hold it tightly in position and push through with the fork beyond the root depth to straighten/ cut the root and ensure no “J” rooting.

Recommended planting densities vary with cultivar, nursery source and planting date, nitrogen fertilizer management, soil type, field location, and bed width. In all plantings, plants are staggered, placing them as far apart from each other as practical on the bed. This practice minimizes plant competition and improves spray coverage. Planting too closely reduces fruit size, makes picking inefficient, and increases problems with diseases, especially gray mold, and uneven coloring. Planting too far apart reduces yields. When planting under plastic or netting, try and maximize plant densities without overcrowding. This can only be done by fitting ridges closer together or planting 3 or 4 row beds

Planting pipe / fork



Sprinkler irrigation immediately after planting is the best way to establish transplants. Even if you are planting plugs, it is advisable to use at least a ½ cup of water per plant to set the plants and get rid of air around the roots. Newly developing roots are sensitive to dryness and salinity, so careful placement of fertilizer and frequent irrigation is needed to prevent reductions in growth and yield. Frequent irrigation is critical during the first 4 weeks after planting. Irrigate often enough to keep soil in the beds near field capacity (tensiometer readings of -5 to -10 kPa; 7 yellow discs on the G-Dot meters), but avoid standing water. Excessive irrigation encourages diseases. If drip irrigation is used to get plants established, lay the drip lines and mulch, then irrigate long enough to bring beds to field capacity before planting. Winter irrigation may be needed if the soil dries out.


G Dot and Tensiometer for soil moisture testing

Occasionally, strawberry plants form runners in fall after planting. Runners must be removed to encourage the formation of large, high-yielding plants. Have them removed as soon as enough runners are present to justify sending crews through the field. Runner removal may be combined with hand-weeding operations. Runners, unlike leaves, are difficult to remove by hand and should be trimmed mechanically. Excessive or old leaves, however, should be removed by hand using lateral clockwise or ant-clockwise movements so that the leaf tears off with the leaf base intact. Dried leaf bases are sources of botrytis once they die and dry out.

Nutrition

Before planting it is vital to make sure that the soils nutrients are in the correct balance. As a rule of thumb, the cations should have the following balance:

Nutrient	% of Cation Exchange Capacity
Calcium (Ca++)	70-75
Magnesium (Mg++)	15-20
Potassium (K+)	4-6
Sodium (Na+)	<1

Calcium gives the soil structure and is vital for producing firm fruit as it is used in the cell walls of the fruit. As a rule of thumb, always add 1t Gypsum/ha over and above the recommended lime requirement. The Gypsum ($CaSO_4$) will not raise the pH but will raise the

available calcium. It will also help to leach out and excess sodium in the soil (as ($NaSO_4$) The magnesium molecule has the same charge (binding force) as calcium, but is half the size. An excess of magnesium in the soil results in a tight compacted soil which will hold less water and free oxygen and so reduces productivity. There are now $CaCO_3$ and $CaSO_4$ products now available that can be injected into the dripper line without blocking and even a $CaCO_3$ product that can be mixed into the $CaNO_3$ tank

A typical irrigation program is shown in the table below. This program is available as an Excel spreadsheet on request. All that needs to be changed are the clear blocks: fertilizer tank size, injection rate and parts per million of the elements required. The program will then calculate the amount of fertilizer required per tank. Tank concentration remains the same except for one change in the Potassium tank, to raise the K level, change the injection rate to change concentrations. Try and stick to full bag additions (25kg) to simplify fertigation. REMEMBER TO INSERT YOUR IRRIGATION WATER ANALYSIS!

Commencement of nutrition depends on plant material type. Plug plants can be fertilized with a 50% strength dosage a day or two after planting, while for bare rooted plants wait a week with leaf-on and 2 weeks with leaf-off plants. Check for new root growth first. The vegetative mix depends on variety, soil fertility and pre-plant organics, but at this stage the emphasis is on encouraging root and leaf growth and so Nitrogen and Phosphates are all important. I am in favor of using $CaNO_3$ as the sole nitrogen source as it adds Calcium to the soil/medium.

My rule of thumb is to run with 100-120ppm N with every irrigation, until the plants are at least 70% of the required size on sandy, 60% on loamy and 50% on heavy soils. Thereafter cut the nitrogen in half to prevent the plants getting too big. I look at the new leaves emerging during the season, together with monthly leaf analysis results to determine whether to cut or raise nitrogen levels during the production period. Remember that Albion requires more N than other varieties.

Try to read the plants rather than the EC's. If you watch the new leaves emerging they will tell you what is happening in the plant. If they are getting bigger than the previous leaves and more than 1 leaf is emerging from the crown, then there is too much vigor and you need to cut Nitrogen. If the leaves are getting smaller, and they will as soon as you put on a load of fruit, then push up the nitrogen as well as the P, K and Mg. The developing fruit will canibalise the rest of the plant for nutrients (mainly K) if the roots cannot supply enough and the leaves and roots will lose condition so fast that it will take many weeks to recover!. REMEMBER that in winter, soil temperatures below 16°C will result in considerably reduced nitrogen uptake by the roots and smaller leaf size and shorter petioles. This is why you get a rosette of much smaller leaves in the winter. The only way to invigorate small plants under these conditions is with foliar sprays containing nitrogen (0.5% solutions are used) and KNO_3 is recommended as it also increases the leaf K)

SHORT DAY VARIETY FERTIGATION PROGRAM

PHC 2014 Vegetative program: Start-up: Commence 2 days after planting for 2 weeks for plugs & after 10 days for bare root plants

Tank	FERT	Element EC	Tank Volume	kg/L in Tank	kg/m^3	Stock tank EC	Injection rate (l/m^3)	EC	N	P	K	Ca	Mg	Cl	S	NO3
1	$CaNO_3$	1.29		350	140.1	180.8		0.5	54			**66.6**				**239**
1	$CaCl_2$	2.00	2500	0	0.0	0.0	2.5	0.0				0		0		
1	Omnispoor			10												
1	Fe EDTA		2500	5			2.5									
2	K_2SO_4	1.7		100	40.0	68.0		0.2			42				0.00	
3	MKP	0.70		50	20.0	14.0		0.1		23	28					
3	$MgSO_4$	1.00	2500	150	60.0	60.0	5	0.3					39		14.6	
	DAM															
	TOTAL							**1.0**	**54.3**	**22.5**	**70.4**	**66.6**	**39.0**	**0.0**	**14.6**	**238.9**

Vegetative program: to develop plants before allowing fruit to set (60-70% of required size)

Tank	FERT	Element EC	Tank Volume	kg/L in Tank	kg/m^3	Stock tank EC	Injection rate (l/m^3)	EC	N	P	K	Ca	Mg	Cl	S	NO3
1	$CaNO_3$	1.29		350	140.1	180.8		0.9	109			**133.1**				**478**
1	$CaCl_2$	2.00	2500	0	0.0	0.0	5	0.0				0		0		
1	Omnispoor			10												
1	Fe EDTA		2500	5			3									
2	K_2SO_4	1.7		100	40.1	68.1		0.2			51				0.00	
3	MKP	0.70		50	20.0	14.0		0.1		23	28					
3	$MgSO_4$	1.00	2500	150	60.0	60.0	5	0.3					39		14.6	
	DAM															
	TOTAL							**1.5**	**108.6**	**22.5**	**78.9**	**133.1**	**39.0**	**0.0**	**14.6**	**477.8**

Reproductive program: once you stop deflowering SD varieties

Tank	FERT	Element EC	Tank Volume	kg/L in Tank	kg/m^3	Stock tank EC	Injection rate (l/m^3)	EC	N	P	K	Ca	Mg	Cl	S	NO3
1	$CaNO_3$	1.29		350	140.1	180.8		0.5	54			**66.6**				**239**
1	$CaCl_2$	2.00	2500	0	0.0	0.0	2.5	0.0				0		0		
1	Omnispoor			10												
1	Fe EDTA		2500	5			5									
2	K_2SO_4	1.7		100	40.0	68.0		0.3			84				0.00	
3	MKP	0.70		50	20.0	14.0		0.1		23	28					
3	$MgSO_4$	1.00	2500	150	60.0	60.0	5	0.3					39		14.6	
	DAM															
	TOTAL							**1.2**	**54.3**	**22.5**	**112.4**	**66.6**	**39.0**	**0.0**	**14.6**	**238.9**

SD Reproductive program: Average of 2 trusses pushing

Tank	FERT	Element EC	Tank Volume	kg/L in Tank	kg/m^3	Stock tank EC	Injection rate (l/m^3)	EC	N	P	K	Ca	Mg	Cl	S	NO3
1	$CaNO_3$	1.29		350	140.0	180.6		0.5	65			**79.8**				**286**
1	$CaCl_2$	2.00	2500	0	0.0	0.0	3	0.0				0		0		
1	Omnispoor			10												
1	Fe EDTA		2500	5			5.5									
2	K_2SO_4	1.7		100	39.8	67.7		0.4			92				0.00	
3	MKP	0.70		50	20.0	14.0		0.1		23	28					
3	$MgSO_4$	1.00	2500	150	60.0	60.0	5	0.3					39		14.6	
	DAM															
	TOTAL							**1.3**	**65.1**	**22.5**	**120.4**	**79.8**	**39.0**	**0.0**	**14.6**	**286.4**

SD Reproductive program: Average of 3 trusses pushing

Tank	FERT	Element EC	Tank Volume	kg/L in Tank	kg/m^3	Stock tank EC	Injection rate (l/m^3)	EC	N	P	K	Ca	Mg	Cl	S	NO3
1	$CaNO_3$	1.29		350	140.0	180.6		0.7	87			**106.4**				**382**
1	$CaCl_2$	2.00	2500	0	0.0	0.0	4	0.0				0		0		
1	Omnispoor			10												
1	Fe EDTA		2500	5			6									
2	K_2SO_4	1.7		100	40.1	68.1		0.4			101				0.00	
3	MKP	0.70		50	20.0	14.0		0.1		23	28					
3	$MgSO_4$	1.00	2500	150	60.0	60.0	5	0.3					39		14.6	
	DAM															
	TOTAL							**1.5**	**86.8**	**22.5**	**129.4**	**106.4**	**39.0**	**0.0**	**14.6**	**381.9**

DAY NEUTRAL VARIETY FERTIGATION PROGRAM

PHC Vegetative programStart-up: Commence 2 days after planting for 2 weeks for plugs & after 10 days for bare root plants

Tank	FERT	Element EC	Tank Volume	kg/L in Tank	kg/m³	Stock tank EC	Injection rate (l/m³)	EC	N	P	K	Ca	Mg	Cl	S	NO3
1	$CaNO_3$	1.29		400	160.1	206.6	2.35	0.5	58			**71.3**				**256**
1	$CaCl_2$	2.00	2500	0	0.0	0.0		0.0				0		0		
2	K_2SO_4	1.7	2500	200	80.0	136.0	1.5	0.2			50				54.00	
3	MKP	0.70		50	20.0	14.0		0.1		18	23					
3	$MgSO_4$	1.00	2500	200	79.8	79.8	4	0.3					42		25.9	
3	Omnispoor			14												
3	Fe EDTA			8												
	DAM							0.1								
	TOTAL							**1.2**	**58.2**	**18.0**	**73.1**	**71.3**	**41.5**	**0.0**	**79.9**	**256.1**

Vegetative program: to develop plants before allowing fruit to set (60-70% of required size)

Tank	FERT	Element EC	Tank Volume	kg/L in Tank	kg/m³	Stock tank EC	Injection rate (l/m³)	EC	N	P	K	Ca	Mg	Cl	S	NO3
1	$CaNO_3$	1.29		400	160.0	206.4		1.0	124			**152.0**				**546**
1	$CaCl_2$	2.00	2500	0	0.0	0.0	5	0.0				0		0		
2	K_2SO_4	1.7	2500	200	80.2	136.3	3	0.4			101				108.21	
3	MKP	0.70		50	20.0	14.0		0.1		18	23					
3	$MgSO_4$	1.00	2500	200	79.8	79.8	4	0.3					42		25.9	
3	Omnispoor			14												
3	Fe EDTA			8												
	DAM							0.1								
	TOTAL							**1.9**	**124.0**	**18.0**	**123.7**	**152.0**	**41.5**	**0.0**	**134.2**	**545.6**

Reproductive program: once you stop deflowering DN varieties

Tank	FERT	Element EC	Tank Volume	kg/L in Tank	kg/m³	Stock tank EC	Injection rate (l/m³)	EC	N	P	K	Ca	Mg	Cl	S	NO3
1	$CaNO_3$	1.29		400	160.0	206.4		0.6	74			**91.2**				**327**
1	$CaCl_2$	2.00	2500	0	0.0	0.0	3	0.0				0		0		
2	K_2SO_4	1.7	2500	200	80.1	136.1	4	0.5			135				144.11	
3	MKP	0.70		50	20.0	14.0		0.1		18	23					
3	$MgSO_4$	1.00	2500	200	79.8	79.8	4	0.3					42		25.9	
3	Omnispoor			14												
3	Fe EDTA			8												
	DAM							0.1								
	TOTAL							**1.6**	**74.4**	**18.0**	**157.2**	**91.2**	**41.5**	**0.0**	**170.0**	**327.4**

DN Reproductive program: Average of <5 trusses/ plant pushing

Tank	FERT	Element EC	Tank Volume	kg/L in Tank	kg/m³	Stock tank EC	Injection rate (l/m³)	EC	N	P	K	Ca	Mg	Cl	S	NO3
1	$CaNO_3$	1.29		400	160.1	206.5		0.7	79			**97.3**				**349**
1	$CaCl_2$	2.00	2500	0	0.0	0.0	3.2	0.0				0		0		
2	K_2SO_4	1.7	2500	200	79.9	135.9	4.2	0.6			141				151.07	
3	MKP	0.70		50	20.0	14.0		0.1		18	23					
3	$MgSO_4$	1.00	2500	202	80.8	80.8	4	0.3					42		26.3	
3	Omnispoor			12												
3	Fe EDTA			7												
	DAM							0.1								
	TOTAL							**1.7**	**79.4**	**18.0**	**163.7**	**97.3**	**42.0**	**0.0**	**177.3**	**349.4**

DN Reproductive program: Average of >5 trusses pushing

Tank	FERT	Element EC	Tank Volume	kg/L in Tank	kg/m³	Stock tank EC	Injection rate (l/m³)	EC	N	P	K	Ca	Mg	Cl	S	NO3
1	$CaNO_3$	1.29		400	160.0	206.4		0.7	89			**109.5**				**393**
1	$CaCl_2$	2.00	2500	0	0.0	0.0	3.6	0.0				0		0		
2	K_2SO_4	1.7	2500	200	80.1	136.2	4.8	0.7			162				173.04	
3	MKP	0.70		50	20.0	14.0		0.1		18	23					
3	$MgSO_4$	1.00	2500	202	80.8	80.8	4	0.3					42		26.3	
3	Omnispoor			12												
3	Fe EDTA			7												
	DAM							0.1								
	TOTAL							**1.9**	**89.3**	**18.0**	**184.2**	**109.5**	**42.0**	**0.0**	**199.3**	**392.9**

DN Reproductive program: If plants look tired and leaf & fruit size dropping

Tank	FERT	Element EC	Tank Volume	kg/L in Tank	kg/m³	Stock tank EC	Injection rate (l/m³)	EC	N	P	K	Ca	Mg	Cl	S	NO3
1	$CaNO_3$	1.29		400	160.2	206.6		0.8	99			**121.7**				**437**
1	$CaCl_2$	2.00	2500	0	0.0	0.0	4	0.0				0		0		
2	K_2SO_4	1.7	2500	200	80.0	136.0	5	0.7			168				180.00	
3	MKP	0.70		50	20.0	14.0		0.1		18	23					
3	$MgSO_4$	1.00	2500	200	79.8	79.8	4	0.3					42		25.9	
3	Omnispoor			14												
3	Fe EDTA			8												
	DAM							0.3								
	TOTAL							**2.2**	**99.3**	**18.0**	**190.7**	**121.7**	**41.5**	**0.0**	**205.9**	**436.9**

Use refractometers to monitor the leaf brix on a weekly basis. Remember that the leaves are the factory that converts 6 water molecules and 6 carbon dioxide molecules plus sunlight into 1 molecule of glucose (sugar). If the leaf is short of water, nutrients and light the amount of sugar produced will decrease and so too will the supply into the roots and fruits. Read the leaf brix at the same location and same time each week, changing the day only if there is cloud cover (10-12am is a good time). You need to aim for 9-11% Brix before the plants are in production and try and keep them above 7 during production. Monitoring the leaf brix will enable you to see when the plants are under stress and this is the time to add foliar sprays of a balanced nutrition. There will be times when the fruit will require more nutrients than the roots can supply and that is when they canibalise the leaves and fruits. When the brix levels drop to 7 and below, check the nutritional status (LEAF SAMPLES PLEASE!) The problem is often only a trace element deficiency or poor water management.

Calcium nutrition remains a focus area for improving firmness and shelf life. The uptake of Ca is passive and it moves through actively growing root tips only, meaning that the more active the roots and the water the plant takes up, the more calcium goes with it. The problem is that the Ca is not mobile, so if the leaves are transpiring optimally, most of the Ca will land up in the leaves. Improving wind movement through the plants will increase Ca uptake. More wind = more evaporation by the leaves = more Ca uptake. The fruit do transpire when they are young and so this will have a positive effect on fruit Ca as well. One of the ways that Ca moves into non-transpiring parts like flowers, ripe fruits and furled young leaves is through root pressure generated at night. The little droplets of water (guttation) seen along the serrated edges of the leaves and petioles in the morning shows that there was positive root pressure the night before, pushing water (and calcium) into all parts of the plant – including fruit. Lower EC's favor positive root pressure and so fertigate in the morning and afternoon with 75% of the plants water needs and give the remaining 25% as pure water in the evening. When spraying Ca as a foliar spray, aim it at the fruit or you are wasting your time and money if you spray it on the leaves as it will not move to the fruit. Add Fulvic acid to improve uptake (35% improvement). The new microfine $CaCO_3$ and $CaSO_4$ products that can be put through the dripper line will go a long way to overcoming soil deficiencies if the liming was not up to standard.

Watch your phosphate levels. Many of our older fields have high P levels (>60ppm). High P levels will tie up trace elements like Mn and Zn as well as form insoluble calcium phosphate bonds. If the P is high you will have to encourage/add biologicals which will help break down the complexed nutrients. Added organics will supply soil life with the food they need to flourish. The coarser the organics the more the fungi will predominate and their mycelium web growth helps to prevent Calcium from leaching from the profile

Apply magnesium in cases where the soils or irrigation water do not contain optimal quantities.

Once the strawberries commence flowering it is vital to switch over to the reproductive mix which is high in potassium (K). Varieties like Festival and Albion need higher amounts than other varieties. If there is a large flush of flowers then fertilise with higher doses of K as the fruit will need more K that the roots can absorb and so the fruit will drain reserves from the leaves and roots, weakening the prospects of a prolonged, quality yield. When expecting a large flush make sure that the Leaf K levels are very high (2-3%) so that there is ample for the developing fruit. This is done by increasing the feed and foliar K. Failure to do so, or late

application (after flowering) results in smaller fruit, lower brix levels and a longer waiting period until the next flush emerges.

Leaf analysis norms are as follows:

Orchard	Date	N	P	K	Ca	Mg	Na	Mn	Fe	Cu	Zn	B
		%					mg/kg					
Low		3.0	0.3	1.6	0.8	0.3	0	50	75	5	25	25
High		4.5	0.6	3.0	1.5	0.6	2000	200	250	15	100	100

In many of our growing regions, N,K,Mn,Zn and Cu are deficient in winter. The Omnia product “Omnigreen” is excellent in alleviating all 5 deficiencies using a 0.5% solution.

PLANT DISEASES

Anthracnose: *Colletotrichum acutatum*

SYMPTOMS

The most obvious symptoms of anthracnose in the field are stem and fruit lesions. In some fields after planting, stunting and yellowing of plants may occur. Wilting and collapse of plants may occur but this is rare in California annual plantings. Stem lesions or characteristic crown symptoms usually precede the collapse of affected plants. Stem lesions appear as dark brown or black, lens-shaped, sunken spots on petioles and runners. Under warm, humid conditions, salmon-colored masses of spores may form on lesions.

Anthracnose crown discoloration

Identification tip: Red-brown discoloration in crown tissue of wilted plants.

When crown tissue is infected and becomes decayed, the entire plant may wilt and die. Like Phytophthora crown rot, the internal crown tissue is discolored, but with anthracnose the discolored tissue is cinnamon to red in color whereas Phytophthora-rotted tissue is more of a chocolate brown; in addition, stem and foliage lesions are not produced by Phytophthora spp.

Fruit decay caused by anthracnose is common in production areas. If infected plants are present, decay can develop following periods of warm, rainy weather. Fruit at any stage of ripeness can be affected. Small, sunken, oval-to-round brown spots (on green fruit) or black spots (red fruit) develop and may expand to cover most or all of the fruit surface. Under high humidity, salmon or orange-colored spores commonly occur on the lesions. Decayed tissue is firm and dry.

The pathogen that causes anthracnose can survive in soil for at least 9 months without host plants. In addition to strawberry, several weeds are known to host this. If strawberries are planted in infested soil, they become infected when soil containing spores is splashed onto crowns or stems by rain or irrigation water. In fields that have been fumigated, the disease usually originates on infected nursery stock or from volunteer strawberry plants in adjacent fields that were planted to strawberry. In addition, inoculum can come from contaminated soil on field equipment or be blown in from nearby weeds.

MANAGEMENT

Soil fumigation destroys most residual inoculum of *Colletotrichum* in the soil. Follow good cultural procedures to prevent disease inoculum from entering the field, and rotate to non-host crops where fumigation and solarization are not feasible. Fungicide dips (Azoxystrobin) can be used on transplants before planting in production fields. Foliar fungicides are available for use on plants when the disease is present and conditions are ideal for foliar and fruit disease development.

Scouting Notes
Scout for anthracnose when rain is followed by hot, humid conditions. Watch for brown dried up blooms and brown lesions on fruit. In late summer scout for runner lesions in both established and new plantings.

Spore germination and infections requires 100% relative humidity. Warm to hot temperatures (20-32°C) are optimum for disease development.

Thresholds: None established.

Treatment decisions are based on field history and weather conditions.

Management Notes

- Purchase plants from an accredited program.
- Remove infected fruit from the field during harvest.
- Work in infected fields last.
- Clean clothing and equipment after work in infested fields. Spores can survive for several weeks on clothing.
- Use straw mulch/wood chips/ dwarf grasses to reduce rain splash.
- Use of drip irrigation rather than overhead sprinklers can reduce disease spread.
- Clean up crop debris between crops.
- Vigorous plants high in nitrogen seem to be more susceptible this disease, so avoid over-use of nitrogen.
- Fungicides can be used to help manage this disease.
- Resistance has been incorporated into some varieties but most common varieties are susceptible.

Phytophthora Crown Rot: *Phytophthora cactorum,*

SYMPTOMS
Initially, symptoms typically include plant stunting and small leaves. As the season progresses, plant collapse may occur rapidly or slowly. When infected plants are cut open, a brown discoloration can be seen in the crown vascular tissue or throughout the crown tissue. The same *Phytophthora* species also attack roots, causing a brown to black root rot.

COMMENTS ON THE DISEASES
Of the *Phytophthora* species involved, *P. cactorum* is the most common; the others are much less prevalent on strawberry. *Phytophthora* is soil borne. When the soil becomes saturated with water, the pathogen can produce and release zoospores, which swim through water-filled pores to infect plant tissue. *Phytophthora* species also produce resilient spores (chlamydospores, oospores) that enable them to survive in soil for long periods without a host or under adverse conditions. Infections can occur during cool to moderate temperatures, which are typical throughout coastal fruit-production cycles.

MANAGEMENT
Soil fumigation and good cultural practices provide adequate control of *Phytophthora* in production fields. Good cultural practices include the use of certified transplants, avoiding poorly drained soils, and preparing fields to provide good soil drainage during wet weather. *Phytophthora* can be moved in water that has drained from infested fields, so avoid using runoff water for irrigation or for wetting down field roads for dust control. In fields that are prone to Phytophthora problems, you may want to plant less susceptible cultivars. Even with tolerant cultivars, however, it is important to follow good cultural practices.

Cultural Control

Use raised beds and carefully managed drip irrigation; plant in non-infested soils that have good drainage. Also, use clean plant stock and consult your farm advisor about cultivar susceptibility. 2 Ridomil Gold applications through the dripper are a must for Fortuna and Winter Star, followed by weekly foliar applied potassium phosphite applications.

Botrytis Fruit Rot: Botrytis cinerea

Botrytis early fruit lesion: Infection from colonized petal
Identification tip: **Light brown spots or patches on fruit, often near calyx.**

Botrytis blossom blast
Identification tip: **Brown, withered blossoms; gray tufts of pathogen spores.**

Botrytis sporulation (gray mold)

Identification tip: Velvety gray pathogen spores on surface of rotting fruit.

SYMPTOMS
The fungus that causes Botrytis fruit rot, also known as gray mold, is widespread in the environment. It can infect strawberry flowers when spores landing on them are exposed to free water and cool temperatures. Infections can either cause flowers to rot or Botrytis can become dormant in floral tissues. Dormant infections resume activity on the berry later in the season anytime before or after harvest when sugars increase and conditions become favorable to disease development.

Infections first appear as small brown lesions, often under the calyx. Lesions begin to sporulate within a day after resumption of activity, and spore structures appear under the calyx as tiny stalks with clusters of spores at their tips. Lesion size increases rapidly. Both green and red berries are susceptible. Infected

berries maintain their original shape and take on a velvety, gray-brown coat of mycelium and spores. Initially, rotted areas are soft and mushy, becoming leathery and dry in the absence of high humidity. Millions of spores are produced on each berry and become airborne at the slightest touch or breeze.

Direct infection of the berries also occurs if berries are exposed to free water. These infections develop in the same manner as flower-infected berries, but differ in that multiple initial lesions may appear anywhere on the berry's surface.

COMMENTS ON THE DISEASE

During the growing season, the fungus is constantly present and is often found in new plantings. Nothing can be done to escape the presence of this fungus, but the level of inoculum in a particular field can be reduced by removing dead leaves and infected fruit. After harvest, the fungus survives in the soil as small, black, inactive sclerotia on ploughed-in leaves and fruit. In addition, the fungus lives on decomposing, dead organic matter of many plant species in and around the growing area. Wet, cool weather is necessary for development of this disease. After transplant, the fungus colonizes the old dying leaves, producing spores that infect new leaves and early flowers and fruit. These spores will serve as the main sources of inoculum for the eventual infection that usually occurs during the main strawberry crop. Fruit infection may occur by two main routes. The most important is colonization of flower parts such petals and stamens .The other is by direct contact of healthy fruit with diseased fruit and dead leaves. Spore production and infection are promoted by temperatures between 16 and 25°C combined with long wet periods due to rain, fog, or heavy dew. Conditions like these during the bloom period could trigger an epidemic of Botrytis fruit rot when these fruit ripen. Such “epidemics” are actually the result of slowly progressing infections which start in the flowers and culminate in visible symptoms 2 to 4 weeks later on green fruit, ripening fruit, and harvested fruit in the cooler.

MANAGEMENT

To reduce losses to Botrytis, think FUNGICIDES and FLOWERS. If newly opened flowers are adequately protected from Botrytis, half the battle is won.
Presently, control of Botrytis fruit rot ranges from repetitive fungicide treatments with no cultural control to intensive cultural methods with no fungicide applications. Environmental conditions in various microclimates play an important role in determining control strategies. Planting in areas where wind can rapidly dry out the plants and interrupt disease progress helps to reduce disease incidence.

Powdery Mildew Pathogen: Sphaerotheca macularis

Powdery mildew damage

Identification tip: **Leaf edges curled upward; purple discoloration of leaf margins.**

Powdery mildew sporulation

Identification tip: **Powdery white patches on underside of leaves.**

SYMPTOMS
Leaves infected with powdery mildew initially have small, white powdery colonies on the undersides of leaves. These colonies

enlarge to cover the entire lower leaf surface, causing the edges of the leaves to roll up. Purple reddish blotches appear on the upper and lower surface of leaves. Infected flowers produce deformed fruit or no fruit at all. Severely infected flowers may be completely covered by mycelium and killed. Infected immature fruits become hardened and desiccated. Infected mature fruits become seedy in appearance and support spore-producing colonies that look powdery and white.

COMMENTS ON THE DISEASE

The disease overwinters as mycelium on leaves, so it is most likely introduced into the field through planting material or spores from neighboring fields. Spores are wind disseminated and short-lived. The pathogen also survives as mycelium and cleistothecia on plants coming from nurseries. Ideal conditions for infection are dry leaf surfaces, high relative humidity, and cool to warm air temperatures. Only immature, newly developing leaves and fruits are susceptible to Powdery Mildew, but thye symptoms only show when the leaves mature. Mature leaves are resistant to attack. When spraying, make sure that the chemicals get into the developing crown so that the new leaves are protected.

MANAGEMENT

To control powdery mildew, apply fungicides at the first sign of disease. This is especially important for protectants such as sulfur. During routine field surveys, watch for the leaf distortion and discoloration that are the first signs of powdery mildew, especially in fall and spring. Controlling powdery mildew in the fall reduces the amount of disease that develops the following spring, and controlling foliar disease helps prevent fruit infections. The standard practice of removing leaves from transplants during harvest and packing helps minimize introduction of the disease, although inoculum may still be present on crowns. Cultural practices are important in helping to prevent disease buildup.

Spider Mite: Two spotted spider mite: *Tetranychus urticae*

Two spotted spider mite damage

Identification tip: **Yellow stippling and discoloration of foliage. Infestations usually not heavy enough to cause visible symptoms.**

Two spotted spider mite adult

Identification tip: **Moving dots on the undersides of leaflets. With hand lens: yellowish, pale green, or orange; dark blotch on each side; two red eyespots on head; eggs spherical.**

DESCRIPTION

Red spider mite eggs are laid on the undersides of leaves and are spherical, clear, and colorless when laid but become pearly white as hatch approaches. Nymphs, adult males, and reproductive adult females are oval shaped and generally yellow or greenish in color. There are one or more dark spots on each side of their bodies, and the top of the abdomen is free of spots. Adult female Red spider mites may cease to reproduce during the coldest winter months in production areas of colder inland valleys. Diapause is indicated by a change in color to bright orange. In coastal growing areas it is rare to have a significant proportion of the population undergo diapause. Mating and egg laying typically occur year round in all coastal strawberry-growing regions.

DAMAGE

Red spider mite damage to strawberries appears as stippling, scarring, and bronzing of the leaves and calyx. Red spider mite feeding is particularly damaging during the first 2 to 5 months following transplanting in late summer or fall, and yield loss is detectable at all mite infestation levels exceeding one mite per leaflet. Mite feeding during this critical period of plant growth substantially reduces berry number per plant and overall plantation yield. Plants are less sensitive to mite feeding after initial berry set; substantial yield loss results from densities of 15 to 20 mites per mid-tier leaflet at this time. Plants that sustain infestations of greater than 75 mites per leaflet may become severely weakened and appear stunted, dry, and red in coloration. The highest red spider mite populations are often observed following the peak spring fruit harvest, and this peak is typically followed by a rapid, natural decline in mite density when the plant enters a vegetative growth cycle. Red spider mite densities may again increase later in summer as fruit production by day-neutral cultivars again increases.

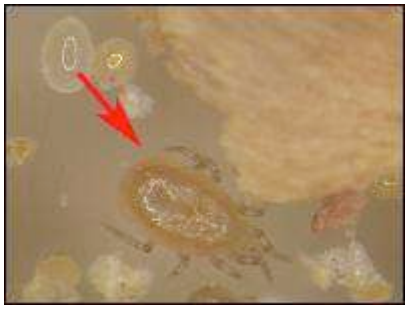
MANAGEMENT

Cultural practices that favor vigorous plants are key to minimizing damage from spider mites. In addition, protect populations of natural enemies as much as possible by choosing insecticides and miticides that are least harmful to beneficials. If necessary, populations of natural enemies can be supplemented with the release of predatory mites. When treating for mites, choose the most selective miticide and alternate it with a miticide of a different chemistry or mode of action to avoid the development of resistance.

Biological Control

Predator mites such as *Phytoseiulus persimilis*, *Amblyseius californicus* , and *Amblyseius swirkii* are commercially available for release. Of the commercially available predatory mites, *Phytoseiulus persimilis* is most commonly used for suppressing spider mite populations. It is an aggressive feeder, and it multiplies and spreads rapidly. They will leave the field, however, if spider mite densities become too low to sustain the predator population.

Phytoseiulus persimilis, predatory mite that feeds on the two spotted spider mite.



Neoseiulus californicus, predatory mite that feeds on the two spotted spider mite.

Applying a short-residual miticide to reduce spider mite densities before a predator release may improve biological control under

some conditions. Monitor fields on a regular basis to determine spider mite population densities.

Following releases of predator mites, it is important to monitor spider mite densities closely to evaluate the effectiveness of the predatory mites in maintaining the pest mites below economically injurious levels. A 1:10 ratio is generally sufficient for control. Insecticides, miticides, and fungicides that are not selective will kill the predators. Make releases only after residues are below lethal levels following any pesticide application. *Phytoseiulus persimilis* has become established in most coastal strawberry-growing areas, and naturally occurring populations often move into spider mite-infested fields on their own. *Amblyseius californicus* has also been found to naturally infest strawberry plantations in some growing areas and can effectively maintain spider mite densities that are below threshold levels. Another predator mite, *Phytoseiulus macropilus,* occasionally occurs in strawberries early in spring.

Other natural enemies include minute pirate bug *(Orius tristicolor)*, a small, black lady beetle *(Stethorus* spp.), a small, black rove beetle *(Oligota oviformis)*, bigeyed bugs *(Geocoris* spp.), brown lacewings *(Hemerobius* spp.), green lacewings *(Chrysopa* spp.),

Miticide Resistance

Twospotted spider mites have a history of rapidly developing resistance to miticides when a miticide is repeatedly applied to the same population. Alternating miticides that have different modes of action may reduce development of resistance to a specific miticide. Avoid unnecessary spraying and treat only infested portions of the plantation. Organophosphate, carbamate, and pyrethroid insecticide applications can induce twospotted spider mite outbreaks. If possible, avoid early season insecticide applications or apply insecticides that are less disruptive to beneficial arthropods. Careful selection and use of insecticides early in the season can potentially reduce the number of miticide applications.

Monitoring and Treatment Decisions

Vigorous plant growth during the first 4 months following fall transplant is a key factor in strawberry production. Monitor mid-tier leaves during this critical period when mite feeding is extremely damaging. Mid-tier leaflets can be monitored by examining the undersurface with a hand lens to count the number of mites or by using a mite-brushing machine. Randomly select 10 leaflets/acre in small fields and 5 leaflets/acre in larger fields The established economic threshold for this period is an average of five mites per mid-tier leaflet. Summer transplants have a higher threshold of an average of 10 mites per mid-tier leaflet during this same period. Once harvest begins, strawberries become more tolerant of mite feeding and treatment thresholds increase to an average of 15 to 20 mites per mid-tier leaflet. Treatment thresholds may vary somewhat depending on location, time of season, cultivar, overall plant vigor, yield potential, and the availability of an effective miticide.

Western Flower Thrips: *Frankliniella occidentalis*

DESCRIPTION OF THE PEST
Western flower thrips are slender, very small insects, about 0.8 mm long when mature. Adults have feathery wings and vary in color from yellow to dark brown; nymphs are white or yellowish with small dark eyes. In spring, flower thrips populations build up on alfalfa, weeds, ice plant, and other vegetation and move from these hosts when they are cut, stop flowering, or dry up.

Strawberry plantations often have a mixed population of thrips that includes a low percentage of the onion thrips, *Thrips tabaci.*

DAMAGE
Thrips feeding on strawberry blossoms causes the stigmas and anthers to turn brown and wither prematurely, but not before fertilization has occurred. Although often numerous on berries when cat-facing occurs, western flower thrips do not cause cat-facing, which is a result of other factors. As fruit develops, thrips feeding may cause a russeting of the fruit around the cap, but this injury is seldom economic. (Other types of bronzing are associated with phytotoxicity from sulfur and other types of sprays (Type II) and from plant physiological factors (Type III). The most severe bronzing that covers the entire fruit is believed to have a physiological cause that is associated with hot temperatures occurring from Oct through Dec.)

MANAGEMENT
Populations of the western flower thrips build up on a number of crops and weeds. They may migrate into strawberries when other crops are harvested, when second-year strawberries or other perennial hosts stop flowering, or when weeds dry up in spring. Control is not usually necessary because western flower thrips rarely cause economic damage at densities that typically occur in strawberry fields. Sprays applied to control thrips disrupt biological control of other pests such as twospotted spider mites, lygus bugs, whiteflies, and other insects. In addition, because western flower thrips feed on spider mite eggs, at low population levels they can be beneficial. If treatment is necessary, choose the least disruptive insecticide to preserve biological controls agents.

Biological Control

Naturally occurring minute pirate bugs *(Orius* spp.) feed on thrips. *Orius* are also available commercially, but release rates and timing have not been determined. *Amblyseius swirkii* is effective in controlling thrips and will control red spider mite as well. They can survive on pollen when there are no longer pests to eat.

Organically Acceptable Methods

Sprays of the Entrust formulation of spinosad are acceptable for use on organically certified strawberries.

Monitoring and Treatment Decisions

Consider treating only if populations reach 10 thrips per blossom when flowers are shaken onto a flat surface and thrips counted. A better way to sample thrips is to place randomly collected flower blossoms into a glass container with several drops of either ethyl acetate or methyl isobutyl ketone (or with a small amount of either of these materials soaked into cotton or other absorbent material). After at least one-half hour, count the thrips by removing the blossoms and shaking them onto black paper. Because more thrips will be found with this method, the treatment threshold is greater than that indicated for shaking flowers.

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Immature stages of thrips (nymphs).

Figure 23.

Thrips Damage

Control

Sample thrips by randomly collecting flower blossoms; then slap the blossoms onto white paper or blow on the flowers to cause the thrips to run bout. Flower thrips rarely cause economic damage at low population densities. Sprays (compatible and incompatible with biological control) are available to control excessive thrips (e.g. Spinosad). The predatory bug, *Orius* spp., can provide good control.

Orius spp, the insidious predatory flower bug.

Amblesius swirskii eating thrips nymph

Cyclamen Mite: ***Phytonemus pallidus***

Cyclamen mite damage

Identification tip: Stunting and distortion of new leaves; compact mass of crinkled leaves in center of plant. Cyclamen mite adults and eggs

Identification tip: Invisible to naked eye. With 20X hand lens: teardrop shaped; tiny legs toward one end; eggs oblong.

DESCRIPTION OF THE PEST

At low population densities, cyclamen mites (Family Tarsonemidae) are usually found along the mid-vein of young, unfolded leaves and under the calyx of newly emerged flower buds; when populations increase, these mites can be found anywhere on non-expanded plant tissue. They are not visible to the naked eye, and when mature, they measure only about 0.25mm long. Mature mites are pinkish orange and shiny. The hind legs are thread- or whip-like in the female and grasping or pincer-like in the male. Eggs are translucent and comparatively large.

Adult females lay about 90 eggs, 80% of which develop into females. During summer, newly hatched mites develop into mature adults within 2 weeks. Populations build rapidly soon after a field becomes infested. Cyclamen mites overwinter as adult females in the strawberry crown and can be present on transplants if the nursery field was infested.

Cyclamen mite can be distinguished under magnification from non-damaging tarsonimid mites in the genus *Tarsonemus* by examining the 4th femur of male mites. The cyclamen mite has a "flange" or distinct bulge present while the males of other *Tarsonemus* species do not.

DAMAGE

Cyclamen mites are primarily pests in autumn-planted and second-year plantings, but they can be transplanted into first-year fields and the damage symptoms become apparent on leaves as the season progresses. Leaves heavily infested with cyclamen mites become severely stunted and crinkled, resulting in a compact dark leaf mass in the center of the plant. Feeding on flowers can cause them to develop bronzing or even wither and die. Fruit on infested plants is dwarfed, and the seeds stand out on the hard brown flesh of the berry. When uncontrolled, this mite can prevent plants from producing fruit.

MANAGEMENT

Management of cyclamen mite requires carefully timed sprays of miticides that do not harm natural enemy populations. Prevent its introduction into strawberry fields by following good cultural practices. Propagating nursery stock free of cyclamen mites is essential to prevent introducing populations to fruit-producing fields. This mite may survive in furrows of fields that have been bed fumigated. Because other non-damaging tarsonemid mite species, including *Tarsonemus setifer* and *Tarsonemus confusus,* occur in strawberry fields and it is very difficult to distinguish one species from another, focus control efforts in those fields where damage symptoms occur.

Biological Control

Early season releases of the commercially available predatory mite, Amblyseius californicus, may be able to control this pest mite. Amblyseius cucumeris releases have not proven to be effective. Other common predatory mites will help to curb the spread of the pest but are too large to enter the crown area where the much smaller cyclamen mite thrive.

Cultural Control

Cyclamen mites can easily be transferred from one location to another by pickers, bees, birds, and harvesting equipment. Cyclamen mite are killed by the UV component of the sun's rays, so an effective control measure once infection is detected is to increase fertigation with high nitrogen to induce vigour. A vigorous crown will continually expose the mites to UV, predators and miticid es and not allow the build-up of damaging populations in the crown. ANY PLANT STRESS WILL CAUSE THE CROWN TO BECOME DORMANT AND CYCLAMEN MITES TO GET THE UPPER HAND!

Organically Acceptable Methods

Biological and cultural control methods are acceptable for use on organically certified strawberries.

Monitoring and Treatment Decisions

If any damage symptoms are observed, be sure to monitor the rest of the field carefully to determine the extent of the infestation. Monitor newly unfolding leaves and treat the area of the field believed to be infested when densities of one cyclamen mite in 10 leaves are found. To control cyclamen mites, a high rate of water per acre (300–500 gal) is necessary to soak the folded leaves and immature flower buds located in the crowns. Effective control requires a high rate of kill because populations of this mite can increase rapidly. Rogueing and treating infested hot spots with a hand-sprayer can be useful in suppressing infestations without having to treat the entire field. In nurseries, early season control before plant canopy closes over is critical.

Aphids: *Chaetosiphon fragaefolii*

DESCRIPTION OF THE PESTS

Strawberry aphid is pale green to yellowish in color. Both adults and nymphs appear to have transverse striations across the abdomen and are covered with knobbed hairs that are readily seen with a hand lens. These striations and hairs are not found on any of the other aphid species infesting strawberry.

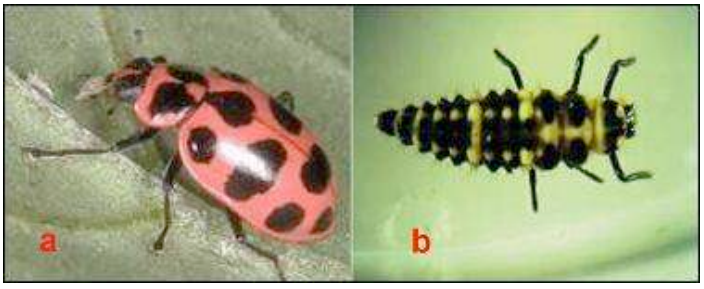
DAMAGE

Aphids transmit several viruses that can cause significant economic losses in strawberries if the planting remains in the field for several years. While not a serious problem in annual production plantings, aphid transmission of viruses is a major concern for nursery production.

MANAGEMENT

While biological control can help to keep aphid populations low, treatments may be necessary in southern California, and occasionally in Central Coast fields, if spring weather is conducive to their development. Treatments are also applied in strawberry nurseries to prevent aphid buildup and virus spread. In other strawberry fruit production areas, aphids rarely reach damaging levels and are not treated.

Biological control



Lady beetle adults (a) and larvae (b), , can control aphids.

Lacewing adults (a) and larvae (b), such as *Chrysoperla* spp., can control aphids.

Strawberry

Relative Toxicities of Insecticides and Miticides Used in Strawberries to Natural Enemies and Honey Bees

Common name (trade name)	Selectivity (affected groups)	Predatory mites	Gen. predators	Parasites	Honey bees	Duration of impact
abamectin (Agri-Mek)	moderate (mites, leafminers)	M	L	M/H	II	long on predatory mites and affected insects
azadirachtin (Neemix)	broad (insects, mites)	M	L/M	L/M	III	short
Bacillus thuringiensis ssp. aizawai	narrow (caterpillars)	L	L	L	IV	short
Bacillus thuringiensis ssp. *kurstaki*	narrow (caterpillars)	L	L	L	III	short
bifenazate (Acramite)	narrow (spider mites)	L	L	L	III	short
bifenthrin (Talstar)	broad (insects, mites)	H	H	H	I–III[8]	long
chlorpyrifos (Lorsban)	broad (insects, mites)	M	H	H	I[9]	moderate
fenbutatin oxide	narrow (pest mites)	L	L	L	IV	short
pyrethrins	broad (insects)	—	M	M	III	short
spinosad	narrow (caterpillars, thrips, whiteflies, fruit flies, leafminers)	L	M[15]	L/M	III	short to moderate
thiamethoxam (Actara)	narrow (sucking insects)	—	—	M	I	moderate

H = high M = moderate L = low — = no information

* I-Do not apply to blooming plants; II-Apply only during late evening; III-Apply only during late evening, night, or early morning; and IV-Apply at any time with reasonable safety to bees

Suggested spray chemical priority list for Powdery Mildew

Index	Disease pressure	Pathogen status	Suggested spray schedule			
			Biologicals[1]	Sulfur[2]	Sterol-inhibitors[3]	Strobilurins[4]
	low	present	7- to 14-day interval	14- to 21-day interval	21-day interval or label interval	21-day interval or label interval
	intermediate	reproduces every 15 days	7-day interval	10- to 17-day interval	21-day interval	21-day interval
	high	reproduces every 5 days	use not recommended	7-day interval	10- to 14-day interval	14-day interval

[1] *Bacillus subtilis*
[2] Soft chems MKP, Potassium Bicarbonate, Sulfur
[3] Quinoxifen (Legend)
[4] pyraclostrobin/boscalid (Bellis), azoxystrobin (Quadris, Ortiva, Amistar)

Suggested spray chemical priority list for Botrytis

Index	Disease pressure	Flowering status	Suggested spray schedule			
			Biologicals[1]	Captan[2]	Prodione[3]	Switch, Bellis[4]
	low	Pre Bloom Period	7- to 14-day interval	14- to 21-day intervals	21-day interval or label interval	21-day interval or label interval
	intermediate	10% flowering, low incidence	7-day interval	10- to 17-day intervals	21-day intervals	21-day intervals
	high	Flowering, rainy weather	use not recommended	5 to 7-day intervals	10- to 14-day intervals	14-day intervals

[1] *Tricoderma Herzianum, Tricoderma asperellum* and *Bacillus subtilis*
[2] Soft chems: Captan
[3] Regulars:, Prodione
[4] Big guns: Switch, Bellis

Suggested spray chemical priority list for Black Spot (Anthracnose)

Index	Disease pressure	Pathogen status	Suggested spray schedule			
			Biologicals[1]	Captan[2]	Switch, Prodione, Legend	Strobilurins[4] Quadris, Bellis, Amistar, Ortiva
	low	present	7- to 14-day interval	14- to 21-day interval	21-day interval or label interval	21-day interval or label interval
	intermediate	Some disease present, occasional rain	7-day interval	10- to 17-day interval	21-day interval	21-day interval
	high	Disease present, rainy weather	use not recommended	5 to 7-day interval	10- to 14-day interval	14-day interval

[1] *Tricoderma Herzianum, Tricoderma asperellum* and *Bacillus subtilis*

Availability of Biopesticides:

POWDERY MILDEW

Potassium Bicarbonate (Agricure @2.5kg/ha) Johnatan Edrington 041 5017407

Bacillus subtilis @ 1liter/ha & R300/Liter RealIPM: Jean Kuiper 0833028911; jean@realipm.co.za

BOTRYTUS & BLACK SPOT

Tricoderma Herzianum, Various agents
Tricoderma asperellum @ 1liter/ha RealIPM: Jean Kuiper 0833028911; jean@realipm.co.za

Bacillus subtilis @ 1liter/ha RealIPM: Jean Kuiper 0833028911; jean@realipm.co.za

INSECTS

Metorisium @ 200ml/ha Real IPM: Jean Kuiper 0833028911; jean@realipm.co.za

Can be tank-mixed with soft insecticides for Symbiotic effect
Amblyseius swirskii Effective on thrips, whitefly and mites Koppert product available from Hygrotech

MITES

Phytoseulius persimilis RealIPM: Jean Kuiper 0833028911; jean@realipm.co.za
Neoseiulus cucumeris RealIPM E.Cape: Rick: 0832687838

Phytoseulius persimilis Dudu-tech: Richard Gillies 031 7054660 Neoseiulus cucumeris richard.gillies@nashuaisp.co.za
Amblyseius californicus

Registered Crop Protection Products Strawberries 2016

	Disease/ Pest	Chemical	Active ingrdient	Registration No's.	Cc	Pre harvest Interval	Spider Mite	Cyclamen Mite	Aphids	Bollworm	White Fly	Thrips	Fruit Fly	Bees 4 = toxic		Precautions	EU MRL	SA MRL	Woolies MRL	Dose/ha	Rate of application (l or kg/100l)
Insecticides	Aphids	Aphox	Pirimicarb	L3428	2	2											3	2		0.125	
		Danadim Progress/ Deus 400/ Dimethoate 400/ Dimethoate EC/ Dimeto 40 EC/ Fetron 400 EC/ Genoate 400 EC/ Rogor EC	Dimethoate	L8868, 7610, 8455, 5367, 7940, 1042, 3253, 8195, 4257		14											0.02	0.5	0.01		0.125
		Actara	Thiametoxam	?	25%	3										bee toxin	0.5				
		Pugar 932	Piperonyl butoxide, pyrethrins, canola & garlic oil	L7145																	
	Thrips	Chess	Pymetrone	L8104		7											0.3	0.5			
	Fruit Fly	Avi Guard	Mercaptothion	L216												Bait	0.02	10			
		Chempac ME lure/ Invader Lure/ Invader B Lok	Methyl Eugenol/ Methyl Eugenol + Mercaptothion	L8569, 8584, 8585		10										Bait					
		Static Spinosad ME	spinosad + Methyl Eugenol	L9074		14											0.3				
		Lok-Lure	Protein Hydrolisate	L8162		10										Bait					
	Weavils	Cryptonem	Heterohabtis bacteriophora	L9251																	
	Bollw orm	Proclaim	Emmamectin	L7581		7											0.05	0.04	0.01		
		Boldex/ Graboll/ Helocovir	Helicoverpa armigera nucleopolyhedrovirus	L8895, 9295, 8484		0												0			
		GF 120 NF/ Tracer	spinosad	L7331/ 6557	480g/l	14								3			0.3	0.3	0.01		0.02
		Prev-Am	Borax/ orange oil		10g/ 50g	0											na	na	na		0.4
		Boudica	Boudica																		
		Delegate	Spinetoram	L8392		7										Max = 4	0.02	0.01			
		Beauvaria bassiana	Beauvaria spp														0.01				
		BeTaPro/ Dipel	Bacillus Thuringiensis	L8834, 6441		0								3		Spray late / night	na	na	na		0.05
	Spider / Cyclamen Mite	Abalone 18,/ Abamec plus/ Agrimec 018/ Agrimec gold/ Agromectin/ Avermit/ Biomectin/ Makhromectin/ Mecti/ Sanamectin 18/ Unimectin 18/ Zero 36	Abamectin	L7458, 5888, 3209, 9235, 6248, 7783, 7979, 7941, 7008, 5928, 7978, 8712	18g/l	3								2		Spray w hen w arm	0.1	0.01	0.01		0.06
		Cytow et/ Orasorb	Citrus oil		500ml												0.01				0.05
		Beauvaria bassiana	Beauvaria spp	L8270													0.02	0.01			
		Milbinock	Milbimectin	L6654		1															
		Kangar 931	Canola & Garlic oil	L7145																	
		Omite	Propargite	L1578		3											0.01	3			

	Disease/ Pest	Chemical	Active ingrdient		Cc	PHI	Powdery	Anthractnose	Phytophthora	Botrytus	Leaf Blight	Leaf Scorch	Leaf Spot	Angular leaf spot	Precautions	UK MRL	SA MRL mg/kg	Woolies MRL	Dose/ha	Rate of application (l or kg/100l)	
Fungicides		Sw itch	cyprodinil	?	375g/kg	3										5		0.1		0.04	9
			fludioxonil	?	250g/kg											4		0.5			12
		Bellis	Boscalid	L7817	252g/l	7										10		5		0.06	7
			Pyraclostrobin		128g/l	7										0.5		0.1			11
		Captab/ Thor/	captab	L6758, 7691	500g/l	10										3	15	3	420g	0.1	M4
		Bacillus subtilis	Bacillus subtilis													0.01					
		Lunar Privlege	Fluopyram	L8997		1										2	1				7
		Mycobacterium marytipicum	Mycobacterium marytipicum																		
		Tricoderma Harzianum	Trichoderma spp.													0.01					
	Pow dery Mildew	Amistar top	Azoxystrobin/ Difenoconazole	L7897	500g/kg	1										10 & 0.4				0.04	11&3
		Amistar/ Ortiva	Azoxystrobin	L7897, 5968		1										10	5	0.01			11
		Legend 250 SC	Quinoxifen	L6840	250g/l	3										0.3		0.5		0.03	13
		Agricure	Potassium Bicarbonate																		NC
		Sulfostar	sulphur		800g/l	0												50	10	0.4	M2
		Coprox	Copper Oxychloride	L5408, 4720	180g/l	14										5	20	20	10	0.35	M1
		Nordox 86% 86% WG/ WP	Coprous oxide	L8077, 8078		14										5	20				M1
		MKP	Monopotassium phosphate			1										75				1	
		Quatrokill	Ammonium chloride		120g/l	0														0.4	
	Phytophthora	Ridomil Gold	Mefenoxan	?		7										0.5					4
		Fighter	Potassiumm. Phosphite		386g/l	0										75			5000g	0.035	33

		Chemical	Active ingrdient		Cc	PHI	Fungi	Weeds	Nematodes						Precautions	UK MRL	SA MRL	Woolies MRL	Dose/ha	Rate of application (l or kg/100l)	
Fumigants		Telopic	1,3 dichloropropene +chloropicrin	L7164												0.05					
		Basamid granular	Dazomet	L0277												0.02					
		Protect	Furfural	L7534												1					
Herbicides		Dacthal	Chlorthal- dimethyl	L1372												0.01					
		Sharda Glyphosate	Glyphosate	L8900												0.01					
		Sequal 240/ Series240	Clethodim	L8912, 8913		28										0.5					
Bioregulators		Chemical	Active ingrdient		Cc	PHI									Precautions	UK MRL	SA MRL	Woolies MRL	Dose/ha	Rate of application (l or kg/100l)	
		Designer	Synthetic Latex + organosilicone												sticker/ w etter						
		Kelpak	Auxins + Cytokinins	L 2414												0.01					

Effect of Insecticides on beneficial insects (check out the www.koppert.com website)

Legend close

Natural enemies

- 1 Harmless < 25% reduction
- 2 Slightly harmful 25 - 50% reduction
- 3 Moderately harmful 50 - 75% reduction
- 4 Very harmful > 75% reduction
- ? Effect/persistence unknown

Persistence is indicated in number of **weeks**!

Bumblebees

- O No action
- Cover
- Remove
- Incompatible
- ? Effect/persistence unknown

Persistence is indicated in number of **days**!

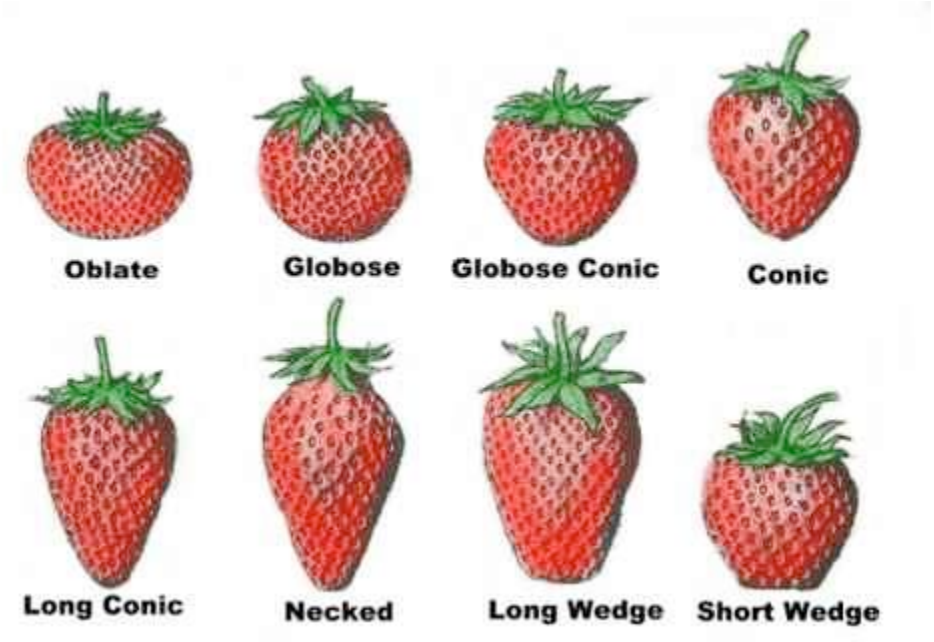
Application methods

HVS = high volume spray; DR = drench; DUS = dust; FOG = fog; GRA = granulate; LVM = low volume method; O = various; PA = paint; SM = smoke; SPK = sprinkle; TMX = tankmix

		abamectin		bifenazate		emamectin	fenbutatin oxide		indoxacarb			spinosad			spirodiclofen
		HVS	TMX	HVS	TMX	HVS	HVS	TMX	HVS	FOG	TMX	HVS	DR	TMX	HVS
Amblyseius californicus	population														
	egg			1			1								
	larva														
	nymph			1			1					1			
	adult	4		1			1					1			2
	persistence	1 - 2		0			0					0			?
Orius laevigatus	population														
	larva														
	nymph	4					1					4			
	adult	4		1			1		3			4	1		
	persistence	6		0			0		> 2			1 - 2	0		

		abamectin		bifenazate		emamectin	fenbutatin oxide		indoxacarb			spinosad			spirodiclofen
		HVS	TMX	HVS	TMX	HVS	HVS	TMX	HVS	FOG	TMX	HVS	DR	TMX	HVS
Amblyseius cucumeris	population														
	egg						1								
	nymph	4					1								
	adult	4		1			1					4			
	persistence	2		0			0					1 - 2			
Phytoseiulus persimilis	population														
	egg						1								
	larva														
	nymph	4					1					2			
	adult	4		3			1		1			2			2
	persistence	1 - 2		> 1			0		?			1			2 - 3

Strawberry Shapes



Precooling Strawberries[1]

Strawberries are one of the most delicate and highly perishable fruits. Their nonclimacteric physiological characteristics dictate that they must be harvested in an essentially ripe condition. The quality of fresh strawberries depends on their maturity and appearance (red color intensity and distribution, fruit size and shape, freedom from defects and decay), firmness, and flavor (determined by amounts of sugars, organic acids, phenolics, and characteristic aroma volatiles). The principal decays likely to affect strawberries are gray-mold and Rhizopus rots. Even a small amount of infestation can quickly spread throughout an entire package.

The most important factors in attaining and maintaining good quality are harvesting at the fully-ripe stage, avoiding physical injuries during all handling steps, enforcing strict quality control procedures, prompt precooling, and providing proper temperature and relative humidity during transport and handling at destination.

Loss of strawberry quality is not acceptable to consumers. The parameters which largely determine quality cause the quality to decrease rapidly at ambient temperatures; therefore, proper temperature management is important. Proper temperature management of strawberries begins with precooling (rapid removal of field heat) from field temperatures which can be > 30°C .Rapid removal of field heat is critical to retard deterioration of strawberries. The recommendation for maximum quality retention of strawberries is precooling to near 0°C within 1 hour of harvest and maintaining at 0°C throughout the marketing channels.

Cooling methods

The selection of a particular precooling method is determined by several factors, including: the rate of cooling required, compatibility of the method with the commodities to be cooled, subsequent storage and shipping conditions, and equipment and operating costs.

During precooling, the sensible heat (or field heat) from the product is transferred to the ambient cooling air. The rate of heat transfer, or cooling rate, is critical for the efficient removal of field heat and is dependent upon three factors: time, temperature, and contact. In order to achieve maximum cooling, the product must remain in the precooler for sufficient time to remove the heat (7/8-cooling time). This is particularly important during busy periods when it may be tempting to "push" product through the pre-cooler. A correctly sized precooler should have sufficient capacity so as to provide adequate resident time for precooling, while at the same time not slowing subsequent packing and/or handling operations. The cooling air must be maintained at a constant temperature throughout the cooling period. If the refrigeration system is undersized for the capacity of product requiring precooling, the temperature of the air will increase over time. The cooling air must also have intimate contact with the surfaces of the strawberry. Inappropriately-designed containers can markedly reduce flow of the cooling air.

The cooling rate is not only dependent upon time, temperature, and contact with the commodity; it is also dependent on the cooling method employed. As noted above, most strawberries in Florida are forced-air cooled. Hydrocooling (showering or immersion in chilled water) is not recommended because wet berries are much more susceptible to decay. Cooling with crushed or slush ice is even worse because the berries are likely to sustain physical damage. Vacuum-cooling would produce critical moisture loss and procedures using water spray could not be used. **Room-cooling of strawberries is not an acceptable precooling method nor is reliance on refrigerated trucks during transit**.

Forced-air cooling (pressure cooling)

Forced-air cooling, which has been described in detail in various publications, can solve many difficult cooling problems because it provides for cold air movement through, rather than around, containers. The system, which creates a slight pressure gradient to cause air to flow through container vents, achieves rapid cooling as a result of the direct contact between cold air and warm product. With proper design, fast, uniform cooling can be achieved through unitized pallet loads of containers. Various cooler designs can be used, depending on specific needs. Converting existing cooling facilities to forced-air cooling is often simple and inexpensive, provided sufficient refrigeration capacity and cooling surfaces (evaporator coils) are available. Some variations in forced-air cooler design are described here.

Forced-air tunnel

This is the more traditional forced-air cooling system. Essentially, two rows of pelletized containers or bins are placed on either side of an exhaust fan, leaving an aisle between rows. The aisle and the open end are then covered to create an air plenum tunnel (Figure 1). With the exhaust fan operating, a slight negative

air pressure is created within the plenum tunnel. Cold air from the room then moves through any openings in or between containers toward the low-pressure zone, cooling the product as it moves. The exhaust fan can be a portable unit that is placed to direct the warm exhaust air toward the air return of the cold room, or it can be a permanent unit which also circulates the air over the cooling surface and returns it to the cold room (Figure 2).

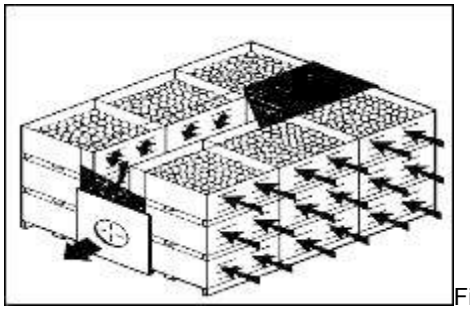


Figure 1.

Forced-air tunnel with portable exhaust fan.

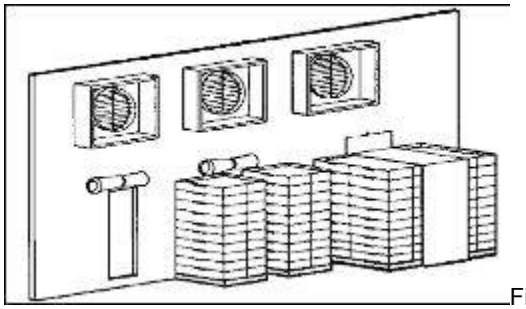


Figure 2.

Forced-air cooler with permanent constructed air plenum