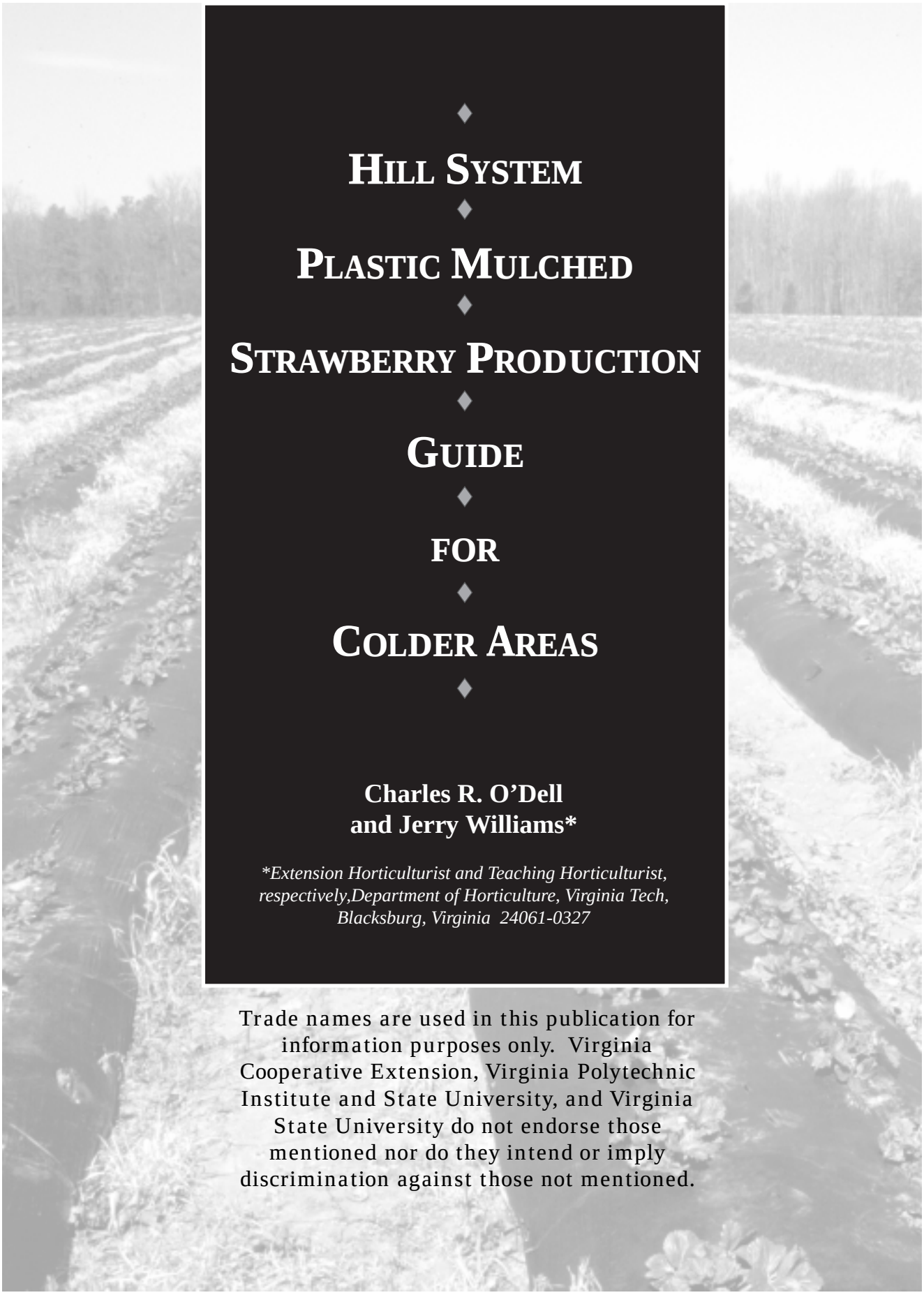


HILL SYSTEM
PLASTIC MULCHED
STRAWBERRY PRODUCTION
GUIDE
FOR
COLDER AREAS

Charles R. O'Dell
and Jerry Williams*

**Extension Horticulturist and Teaching Horticulturist, respectively,Department of Horticulture, Virginia Tech, Blacksburg, Virginia 24061-0327*

TABLE OF CONTENTS PAGE

TABLES

FOREWORD

This production guide was written to answer inquiries for information by many potential new strawberry growers in this region north of the Carolinas. The information presented herein was developed from our research results and field experience of several years with plasticulture strawberries at Kentland Agricultural Research Farm near Blacksburg, Virginia, at an elevation of approximately 2,400 feet above mean sea level.

Plasticulture strawberry production originally developed several years ago in California by University of California researchers who merged into a production system the technologies of (1) drip irrigation for supplying uniform, precise and steady amounts of water and nutrients; (2) raised row beds covered with plastic mulch film, either clear, black or white in color, depending on the production region within California and the desired harvest season of the year (year-round production is now practiced in California); (3) development of the variety Chandler by Dr. Victor Voth at the University of California that is highly suited to multi-row hill system culture on beds covered with plastic mulch and is winter hardy in much of the Eastern USA; (4) the availability of methyl bromide soil fumigant applied as a one-time pre-plant broad spectrum crop protectant only under the strips of film mulch (one-half the total field area) for preventative control of soil-borne strawberry diseases, root and stem feeding insects, parasitic nematodes, and most noxious weed seeds, all of which seriously impair the production of strawberries; and, (5) frost control by field crop covers or sprinkler irrigation, critically important with the earlier blooms on black plastic mulch. *Profitability with this production system, especially in this area of mountains and in northern areas subject to late spring frosts, will be in large measure directly proportional to growers' investment in and commitment to frost control during bloom and early fruit development each spring.*

We gratefully acknowledge the help and leadership of Dr. Barclay Poling, Extension Horticulturist and director of the Southeast Small Fruit Center at North Carolina State University, who, with his colleagues at North Carolina State University and the North Carolina Department of Agriculture, led the development of a plasticulture strawberry industry in the Southeast U.S., including development of information for profitable plantings in eastern and southern piedmont areas of Virginia.

Dr. Poling and his colleagues provided inspiration for us to intensify our strawberry research beginning in 1991 to further the knowledge of profitable strawberry production in shorter, colder growing season areas. Information in this publication has been developed, verified, or field proven at this colder location at Blacksburg, Virginia. Special thanks is given to: the Virginia Agricultural Council for funding assistance that helped make research possible for the information herein; to our secretarial/field support technician, Maura Wood, for helping compile this publication ; to Dr. Roger Harris, Associate Professor of Horticulture at Virginia Tech, for his help with statistical analysis of harvest data; to Davoncrest Farms who provided runner tips and plug transplants for this work; to Nourse Farms who provided dormant bare root plants for this work; and to our Horticulture Research Farm Manager, Mr. Jon Wooge, and his crew for their assistance with this project over several years.

PLANNING FOR THE ENTERPRISE

Why grow strawberries by this new, more expensive, plasticulture system when the time-honored, proven matted row production system continues to work in Virginia? The answer is simple once you compare the systems during harvest: Bigger berries throughout the harvest season; more berries per acre (when you invest in and master the system), earlier and longer harvest season (up to 10 days earlier, plus extending up to 10 days later compared to matted row culture); less fruit-protecting fungicides may be needed since fruit never touches or comes in contact with soil; much easier harvesting due to the even separation of individual plants (hill system) on black plastic mulch film creating visual contrast between ripe red fruit and black mulch film; and, excellent in-row weed control provided by the plastic mulch (especially when combined with row or strip soil fumigation). Collectively, these all add up to the advantage of high customer satisfaction as a U-Pick or fresh picked, wholesale marketed enterprise, compared to the matted row production system. In fact, once customers have experienced harvesting plasticulture system berries, they will not harvest matted row berries again on the same farm.

Put another way, once you have provided them the opportunity to harvest from this new production system, you can never go back again to the old system! Bear in mind that once you commit to production by the new system, you have but one option: Get good at it, or the economics of this high cost production system will drive you out of the berry business (as is also true in most businesses today).

What then are the disadvantages to you, the potential producer of plasticulture strawberries? Although the higher production costs per acre may actually be lower costs per pound, quart or gallon of berries only if you master the system, the higher costs per acre allow for a very small margin for error associated with plasticulture berry production. For success or profitability, this new production system requires close attention to detail. Do you have the time and management ability to do or to see that things are done right the first time? You cannot afford to make many mistakes once you financially commit to this production system! To maximize your initial success which protects your initial investment and reduces risks of subsequent investments in this new production system, you must study this system carefully. Plan to attend the SE Strawberry Expo or other regional educational seminars held on plasticulture strawberry production and take the time to visit with successful growers and university field days featuring this new production system before you invest and make your first planting of plasticulture strawberries. In other words, this system has the disadvantage to you of requiring more time before start-up and during the production cycle, a more management-intensive production system, which is not good if you do not have time for it. Know and understand your time, labor, financial, and family/emotional investments for this new production system!

For example, if you lose 40% of your matted row strawberry production to frost in your first year of berry production, you have lost only a relatively small investment and still may even make a small profit on that investment, but if you lose 40% of your plasticulture strawberry crop your first year of investment in this system, because of inadequate frost protection equipment and/or other needed requirement, you will lose money, possibly a significant amount! You would learn the hard (expensive) way that planning is a most important part of the strawberry business.

ACTUAL COST CONSIDERATIONS

Table 1 lists and totals most of the components needed for fall planted plasticulture strawberry production. Hopefully, you have on hand a sprinkler irrigation system normally not used in April and May, capable of solid-set covering your berry planting on a 60 X 60 foot staggered grid pattern over the entire berry field or fields for frost protection during bloom. If not, we have included a cost for crop covers to provide both winter protection in colder areas and for later use for spring frost protection, uv-treated to last for at least 4 years' use. During that time you may be able to locate a good buy in a used sprinkler irrigation system, or evaluate the continued use of crop covers for both winter protection and for frost control.

Your sprinkler irrigation system must be capable of providing 60 to 80 pounds of water pressure per square inch at the nozzle tips. For frost protection without applying excess water to waterlog your fields, plug by capping one end of each sprinkler, then replace the spreader/kicker arm nozzle tip with either a 1/8 or 9/64 inch tip to apply only 1/10 acre inch of water per hour. Under most of our spring season light frost conditions with expected lowest temperatures at strawberry plant level of 26 degrees F. or above, 1/10 inch of water per hour, about 2,800 gallons per acre per hour, will provide excellent frost control providing the system is previously in place and activated when temperatures and dew point indicate the need (see Tables 2 and 3 on frost control). The system must be operated continuously until all the ice is melted from berry plants (sometimes not until 9:30 or 10 AM or even later the following day).

On colder spring nights, also with very light winds and temperatures at berry plant level expected to drop into the very low twenty's F., and with low dew point, up to 2/10 inch of water per hour (5,600 gallons of water per acre per hour) or more may be needed for bloom protection, requiring larger nozzle tips be kept on hand for such conditions. For windy conditions and expected temperatures in the low to mid twenties F., especially with low dew points predicted, you are better off not trying to sprinkler irrigate for frost protection, since wind will disrupt your evenly applied water distribution pattern and actually create super-cooling, causing even worse bloom injury. Don't rush to push your plants into active growth by beginning spring drip irrigations/fertigations before your berry plants have resumed active growth on their own or you may be setting yourself up for early season frost damage in this colder region!

Excellent used sprinkler irrigation systems can often be found, including motors, pumps, suction line with strainer, main line and in-field lateral lines, elbows, T's, end plugs, risers and sprinklers. Generally, even with good used equipment, you can expect to spend several thousand dollars for a dependably good frost protection system. Remember, you will also need an adequate surface water supply, ponds or stream, capable of sustaining the considerable gallonage of water needed for several nights/mornings of irrigations for frost protection during the bloom/early fruiting period each spring. For example, in this area in recent springs, growers have had to frost protect against loss of buds and blooms from 4 to 22 times per 6 week spring bloom period, with each irrigation cycle running from 4 to 7 hours or longer (until all ice was melted from the berry plants).

TABLE 1

Production Costs and Projected Income at Low, Medium and High Yield, and at 3 Berry Pricing Levels for 1 Acre of U-Pick Plastic Mulched Strawberries

Expected Income (before deducting costs)			
Quantity (quart)	**Price/Quart $1.25**	**$1.50**	**$1.75**
8,712	$10,890	$13,068	$15,246
17,424	$21,780	$26,135	$30,492
26,136	$32,670	$39,204	$45,738

Management Information

- Stay off low, frost pocket, flood plain areas.
- Overhead sprinkler frost protection (or crop covers) are essential for frost protection. Drip irrigation is essential for supplying water and nutrients under plastic mulch.
- Use plug transplants, 15,000/A 14" in-row for Late Star, 17,424/A for Chandler 12" in-row spacing.
- Fine tune planting date depending on variety and area, to achieve 4-6 branch crowns before spring bloom. Too many branch crowns cause over-competition and small fruit size.
- Start out on a small scale. Over-planting for your market area, especially until consumers know you are in business, can produce a glut of berries resulting in over-ripe, rotting unpicked berries. Intensive, year-round management (field-work) is critical for a successful berry business.

Variable Costs:	**Units**	**Quantity**	**Price**	**Costs**
Annual ryegrass cover crop, row middles	bu	2	$24.00	$48.00
Plug Transplants, Latestar or Chandler	each	17,424	$0.15	$2,614.00
Pre-plant fertilizer by Soil Test				
N	lb	60	$0.30	$18.00
P	lb	120	$0.28	$33.60
K	lb	120	$0.20	$24.00
Soluble N, Spring Fertigations N	lb	40	$0.75	$30.00
Lime	Ton	1	$25.00	$25.00
Plastic Mulch, 4.5' x 2,400'	Roll	4	$65.00	$260.00
Custom Bedding/Strip Fumigation	Acre	1	$1,000.00	$1,000.00
Crop Protectant Spray Supplies	as needed		$141.00	$141.00
Drip Irrigation w/depreciation	first acre	1	3,000./20%	$600.00
Containers, plastic buckets (stay on farm)	4-5 Qt size	300	$0.60/25%	$45.00
Crop covers, 1.25 oz/sq. yard, 4 yr life	Acre	1 A	$2,000/25%	$500.00
Slant deer fence	Acre	1 A	$1,600/20%	$320.00
Machinery and Equip. (fuel, oil, maint)	$$	$68.06	$1.00	$68.06
Operating Interest	$$	$5,726.00	10%	$573.00
Operating Costs				**$6,299.00**
Fixed Costs:				
Labor	Hours	400	$6.00	$2,400.00
Total Fixed Machine Costs	$$	$173.20	$1.00	$173.20
Total Fixed Frost Control Costs	$$	$1,800.00	10.00%	$180.00
Land Charges	$$	$2,000.00	6.00%	$120.00
			Total Costs	**$9,172.20**
Total Costs/Quart, at 1/2 Quart yield per plant (8,712 Qts/Acre)				**$1.05**
at 1 Quart yield per plant (17,424 Qts/Acre)				**$0.53**
at 1.5 Quarts yield per plant (26,136 Qts/Acre)				**$0.35**

TABLE 2

Recommended Sprinkler Irrigation Starting Temperature for
Various Critical Temperatures and Dew Points

Critical Temperature (Wet Bulb)		Dew Point		Suggest Starting (Air) Temperatures	
˚F	˚C	˚F	˚C	˚F	˚C
32	0	32	0	34	1.1
32	0	31	-0.6	35	1.6
32	0	29	-1.7	36	2.2
32	0	28	-2.2	37	2.8
32	0	26	-3.3	38	3.3
32	0	24	-4.4	40	4.4
32	0	22	-5.6	41	5.0
32	0	20	-6.7	42	5.6
32	0	18	-7.9	43	6.1
30	-1.1	30	-1.1	32	0.0
30	-1.1	29	-1.7	33	0.6
30	-1.1	27	-2.8	34	1.1
30	-1.1	25	-3.8	35	1.6
30	-1.1	24	-4.4	37	2.8
30	-1.1	22	-5.6	38	3.3
30	-1.1	20	-6.7	39	3.9
30	-1.1	17	-8.3	40	4.4

TABLE 3

Application Rate Recommended for Sprinkler Irrigation Cold Protection
Under Different Wind and Temperature Conditions*

Minimum Temperature Expected	WIND SPEED IN M.P.H.		
	0 to 1	2 to 4	5 to 8
	Application Rate (inches/hour)		
27˚F	0.10	0.10	0.10
26˚F	0.10	0.10	0.14
24˚F	0.10	0.16	0.30
22˚F	0.12	0.24	0.50
20˚F	0.16	0.30	0.60
18˚F	0.20	0.40	0.70
15˚F	0.26	0.50	0.90

**Ext. Circular 287, Florida Agricultural Extension Service, by Gerber and Martsolf.*

TABLE 4

Equipment Needs and Labor Estimates by Season for 1 Acre of U-Pick Plastic Mulched Strawberries

Labor Required	Hours/Season
June 16 - 30 Land prep.	25
July 1 - Sept. 30 Planting	100
Oct. - November	10
December	10
Jan. - February	15
March 1 - 15	25
March 16 - 31	15
April 1 - 15	20
April 16 - 30	40
May 1 - 15	40
May 16 - 31	50
June 1 - 15	50
TOTAL	**400 Hours**

Machine Used	Total	Operating Costs Hours Used Per Hour	Operating Costs Total	Fixed Costs Per Hour	Fixed Costs Total
40 HP Tractor & Fertilizer Spreader	2	3.18	6.36	4.61	9.22
40 HP Tractor & Water Wheel Planter	8	3.81	30.48	11.29	90.32
40 HP Tractor & Sprayer	3	4.01	12.03	10.43	31.29
40 HP Tractor & Shielded Sprayer	3	4.01	12.03	10.43	31.29
40 HP Tractor & Rotary Mower	2	3.58	7.16	5.54	11.08
Totals	18		68.06		173.20
Total Machine Costs					241.26

One acre of berries receiving 1/10 acre inch of irrigation water per hour requires 2,800 gallons of water/hour X 7 hours = up to 19,600 gallons of water per acre or more for each frost event! Multiply that amount by our 1996 spring experience of 22 irrigations averaging 5 hours each: 2,800 X 5 X 22 = 308,000 gallons of water was needed, actual case scenario, to frost protect 1 acre of strawberries! Since there are 7 gallons of water per cubic foot, this example required 44,000 cubic feet of pond water, or a pond measuring 100 feet long X 75 feet wide X 5.87 feet average depth, if the pond is not easily refilled from springs, creeks or surface rainfall runoff. **Make certain you have adequate water on hand for frost protection before you invest in the sprinkler irrigation frost protection option.**

The bottom line: Look at all of your investment costs versus probable yields in Tables 2 and 3. One half quart of fruit per plant is average yield in this area when there is poor or no frost protection; 1 quart of fruit/plant is average where good management including good frost protection is practiced; and, 1 & 1/2 quarts of fruit per plant (or more) has been achieved with excellent management including excellent frost protection. What is your goal for yield/income? How serious are you about growing plasticulture strawberries? Do you have the time to do it right? Doing everything right is absolutely required to achieve success with plastic mulched strawberries.

Most of our new plasticulture berry growers have used the services of a custom applicator for their initial planting, so specialized equipment needs shown in Table 4 do not include the 5-jobs super bedder (instead, we used the custom work fee) which also shapes and beds the rows 6 to 10 inches high depending on grower preference.

Note: to use this machine on sloping land or with contoured rows requires building beds and charging them with fertilizer as a separate step before laying plastic mulch, drip irrigation lines, and soil fumigant simultaneously (jobs 2, 3 and 4).

Jobs 2, 3 and 4 are completed on the second pass over the beds previously made, applying fertilizer and lime before bedding land as job 1. Jobs 2, 3 and 4 require loading the bedder with black plastic mulch film, 1.25 to 1.50 mils thickness recommended, 1 cylinder of pressurized nitrogen gas propellant for dispersing methyl bromide fumigant normally gauge-nitrogen pressurized to 40 pounds p.s.i. and 1 to 2 cylinders of methyl bromide fumigant non-pressurized liquid, each 200 lbs. capacity. Growers use 1 cylinder, 200 lbs/acre in row strips, of the 98-02 formulation of methyl bromide/chloropicrin (tear gas leak indicator). Under severe soil disease pressure, formulation 67-33 may be plant pathologist-recommended since chloropicrin also has excellent activity against pathogenic soil fungi. **Make certain to check and clean daily the metal disk flow regulators found at the head of each discharge tube leading to each soil shank fumigant outlet.** Finally, the roll of drip irrigation tubing, 6,000 linear feet of 10 mil thickness or 7,200 feet of 8 mil thickness, is loaded onto the bedder to lay drip irrigation lines down the center of each bed 1 to 2" beneath the soil surface under the mulch film. While laying mulch and driplines, fumigant is injected 6 inches deep from 2 or more shanks into each bedded row.

TABLE 5-A *

Total first year and carry-over second year fresh weight harvested for nine cultivars of strawberry, planted bare-root dormant on 26 June 1997 (early) or by plugs on 21 August 1997 (late). Harvest was from 14 May to 5 June in 1998 and 19 May to 11 June 1999. 1 replication = 12 single plants. N = 4. 6 tons/acre poultry litter was broadcast on cover crop residue 1 year before planting.[5]

Variety	Total Season Fresh Weight			
	Early[z]		Late	
	1998	1999	1998	1999
Latestar	1.36a[1]	1.30a[2]	0.58a[3]	1.57a[4]
Marmalada	0.84b	0.73bc	0.38abc	0.46d
Honeoye	0.65bc	0.89b	0.56ab	0.90b
Primetime	0.53bcd	0.62bc	0.26c	0.79bc
Jewel	0.52bcd	0.54bc	0.37abc	0.75bcd
Northeaster	0.35cd	0.45bc	0.28bc	0.60bcd
Allstar	0.32cd	0.42c	0.39abc	0.56cd
Earliglow	0.31cd	0.39c	0.29abc	0.54cd
Delmarvel	0.21d	0.34c	0.25c	0.50cd

* Charlie O'Dell, Jerry Williams, and Roger Harris, VA Tech, Department of Horticulture, Blacksburg, VA.

[z] Mean separation within columns by Duncan's NMRT. P=0.05.

[Y] P>F for treatment within each cultivar for 1998 and 1999.

[1] 1.36 qts/plant @ 14" in-row spacing = 20,400 qts/acre, 1st year

[2] 1.30 qts/plant @ 14" in-row spacing = 19,500 qts/acre, 2nd year

[3] 0.58 qts/plant @ 14" in-row spacing = 8,700 qts/acre, 1st year

[4] 1.57 qts/plant @ 14" in-row spacing = 23,550 qts/acre, 2nd year

[5] 6 tons poultry litter/A supplied all nitrogen and phosphorus needs for 1st year crop, spring N fertigations at 5 lbs N/A/ week required for second year's crop, 50# N/A spring fertigations total.

TABLE 5-B

Total 1999 fruit weight (kg) and qts/plant of 'Cavendish,' 'Chandler,' and 'Jewel' plugs planted on 31 July (Early), 14 August (Mid-S) and 2 September 1998 (Late). One replication = 6 plants. n = 4.

MEAN FRESH FRUIT WEIGHT (KG/PLOTS) & QTS/PLANT

	Cavendish	Chandler	Jewel
Early[z]	(2.39a)	(2.07b)	(1.96a)
	0.58 qt	0.51 qt	0.48 qt
Mid-S	(2.23ab)	(2.53a)	(1.31b)
	0.55	0.62	0.32
Late	(1.59b)	(2.65a)	(1.37b)
	0.39	0.66	0.33

[z] Mean separation within columns by Duncan's NMRT.

$P < 0.05$.

TABLE 6-A*

Total first year and carry-over second year fresh berry weight harvested for nine cultivars of strawberry, planted bare-root dormant on 26 June 1997 (early) or by plugs on 21 August 1997 (late). Harvest was from 14 May to 5 June in 1998 and 19 May to 11 June 1999. 1 replication = 12 single plants. n = 4.

Variety	Fresh Weight Per Berry(g)			
	Early[z]		Late	
	1998	1999	1998	1999
Latestar	10.1ab	6.2ab	9.9cd	7.2abc
Marmalada	11.7a	6.5ab	12.5ab	7.5ab
Honeoye	11.7a	6.2ab	13.7a	6.5bc
Primetime	10.1ab	5.8b	11.6abc	6.1c
Jewel	9.1bc	6.5ab	11.0bc	7.1abc
Northeaster	10.9ab	6.9ab	10.3bcd	8.1a
Allstar	11.4a	7.1a	13.4a	7.1abc
Earliglow	7.8c	4.5c	8.5d	4.7d
Delmarvel	9.9ab	6.2ab	10.4bcd	6.4bc

[z] Mean separation within columns by Duncan's NMRT. P=0.05.

[Y] P>F for treatment within each cultivar for 1998 and 1999.

[*] Charlie O'Dell, Jerry Williams, and Roger Harris, VA Tech, Department of Horticulture, Blacksburg, VA.

TABLE 6-B

Total 1999 fresh weight (g) per berry of 'Cavendish,' 'Chandler,' and 'Jewel' plugs planted on 31 July (Early), 14 August (Mid-S) and 2 September 1998 (Late). One replication = 6 plants. n = 4.

MEAN FRESH WEIGHT (G) PER BERRY, 1ST YEAR

	Cavendish	Chandler	Jewel
Early[z]	8.8a	9.2a	10.6a
Mid-S	9.8a	10.1a	10.4a
Late	9.9a	9.9a	9.2a

[z]Mean separation within columns by Duncan's NMRT.
P < 0.05.

TABLE 7 *

First year number of berries, total seasonal fresh weight, and fresh weight per berry of 'Latestar' strawberries harvested in spring 1999 and transplanted bare-root or by plugs in early- (31 July), mid- (14 Aug), or late- (2 Sept.) season 1998. One replication = 12 plants. n=4. No poultry litter used prior to planting.7

	Plant type					
	Bare-root			Plug		
Planting time	Fruit number	Seasonal weight (qts/plant)	Weight per berry (g)	Fruit number	Seasonal weight (qts/plant)	Weight per berry (g)
Early 7/31	750.5a	0.911	10.0a	676.5b	0.764	9.2a
Mid 8/14	776.0a	0.932	10.0a	1102.8a	1.065	9.0a
Late 09/02	424.5b	0.513	9.8a	584.3b	0.626	8.0a

* Charlie O'Dell, Jerry Williams, and Roger Harris, VA Tech, Department of Horticulture, Blacksburg, VA.

Z Mean separation within columns by Duncan's NMRT. P=0.05.

Y P>F for treatment within each cultivar for 1998 and 1999.

1 0.91 qts/plant, 14" in-row spacing, 15,000 plants/A=13,650 qts/A.

2 0.93 qts/plant, 14" in-row spacing, 15,000 plants/A=13,950 qts/A.

3 0.51 qts/plant, 14" in-row spacing, 15,000 plants/A=7,650 qts/A.

4 0.76 qts/plant, 14" in-row spacing, 15,000 plants/A=11,400 qts/A.

5 1.06 qts/plant, 14" in-row spacing, 15,000 plants/A=15,900 qts/A.

6 0.62 qts/plant, 14" in-row spacing, 15,000 plants/A=9,300 qts/A.

7 Conventional granular fertilizers applied pre-plant based on soil tests; 60# N, 120# P205, 120#K2O/A, plus weekly spring fertigations totaling 40# N/A over 12 weeks time, early bloom to harvests.

Finally, still in this pass over each bed, the plastic mulch edges are covered by discs (job 5), sealing the mulch film tightly over the top and sides of the beds which are left undisturbed for 98-02 fumigant dispersion into the gas phase, preferably for 1 week in warm summer weather, up to 2 weeks under cool conditions when soil temperatures are below 60 degrees F. In this colder region, 67-33 MB fumigant requires a minimum of 3 weeks for fumigant dispersion before planting, even in the summer months.

Note: Do not apply fumigant when soils are cold, below 50 degrees F. within the beds, or fumigant will be poorly dispersed. Early spring soil fumigation is not recommended because it has generally always provided poor results, but should be completed the previous fall.

A minimum tractor horsepower of 50, preferably 60 HP, is required to operate the super bedder (for constructing the higher beds) as well as for operating a tractor powered take off-(pto) operated irrigation pump for proper high pressure sprinkler irrigation frost protection (or you may prefer to obtain and use a stand-alone diesel or gasoline-powered irrigation pump motor for sprinkler irrigation frost protection). Generally, the super bedder machines are difficult to locate as used equipment. You can expect to pay $5,000 and up for a new super bedder, depending on bed height and width desired, number of fumigant cylinders held, number of rolls of mulch film held, and any other desired features.

If you have a water source for both drip and frost protection sprinkler irrigation and are willing to invest in both types of irrigation systems necessary to succeed with plasticulture strawberries in this region, you may be able to hire custom fumigators in North Carolina who have assisted many Virginia growers before they purchased their own super bedders. To our knowledge, there are currently no custom strawberry strip soil fumigators in Virginia at the time this is written (fall, 1999).

Caution: *Soil fumigants are EPA-restricted pesticides requiring you to obtain a private applicator license that includes soil fumigation certification for you to use your super bedder on your farm for soil fumigation of your strawberry land. Should you wish to become a custom fumigator for others in Virginia and this region, perhaps to help pay for your bedder, you will be required to become a commercially certified applicator (subject to more stringent surveillance and reporting requirements).*

CHOOSING A SITE

Plasticulture strawberries perform well on a wide range of soil types ranging from sandy loams to heavier silt and clay loams. Sites just previously in cultivation may be more easily prepared, i.e., may not contain large amounts of undecayed plant residues and/or rocks which will hang up in the bedder. When using fallow land previously used for soil-building cover crops, always plow down these residues 2 to 3 months ahead of bedding the site for strawberries, to allow time for decomposition of organic residues.

Note: undecomposed fresh plant residues also absorb and hold soil fumigants, reducing their effectiveness.

Sites for any fruit planting, especially plasticulture strawberries which wake up to bloom earlier on the black plastic mulch compared to many other fruit, should offer excellent air drainage over and below the planting. Cold air is heavier, so during frost conditions on slopes that extend below the planting without any intervening trees or other impediments, frost can drain away, lessening potential frost damage. Sloping sites also are fine, even with drip irrigation use under the mulch film (for water and nutrients applications, not for frost protection), as long as rows are laid out and bedded on the contour as nearly level as possible by trained eye. No transient survey equipment is needed by careful, experienced bedder operators. Always place headers or manifold

supply lines for drip irrigation row tubing across the higher side of sloping land, then lay off rows on the contour, but with very slight down slope (less than 1% gradient) from row end hook-ons down to the far row ends. This will allow excess rainfall to gently "walk" out of row middles without causing erosion or ponding and possibly breaking over beds or washing out beds and plants in periods of heavy rain or melting snow in colder, hilly planting sites.

Note: Always try to learn to use new equipment, including bedders, on as level land as possible. **Be certain to tighten anti-sway chains or bars on the 3-point hitch; this is especially critical for bedder use when contouring rows on sloping land.**

For uniform drip irrigation flow to row beds, row lengths should not exceed 300 feet unless (a) larger diameter drip lines are used, or (b) the manifold or header line is placed down the center of the field, running drip lines in both directions from the header at each row, requiring twice the number of hook-on fittings (expensive). Also, for U-Pick fields, rows should not exceed 300 feet in length for best picking with minimum field supervision. Otherwise, with poor field supervision during U-Pick harvesting, distant portions of many rows may go unpicked, resulting in over-ripe, rotting fruit.

Even with the use of strip soil fumigation, strawberry planting sites should be rotated to lessen build-up of berry pests in untreated strips and to allow for soil-building or soil-sustaining cover crops to be used on old berry sites for at least 2 to 3 years between berry plantings. On heavily farmed old berry land, we found 6 tons of poultry litter per acre applied the previous summer before replanting to strawberries supplied 100% of the nitrogen and phosphate needed for the first year's harvest season. According to soil test needs of that site, extra potash was applied pre-bedding for the strawberry planting. Water holding capacity was also improved, requiring less frequent drip irrigation cycles according to soil moisture tensiometer readings. The slow-releasing nutrients in the 6 tons/acre rate of poultry litter also kept nitrogen within the plant tissue sufficiency levels for the entire first year harvest season without fertigations, providing us the highest yields to date at our research plots (see Tables 5 and 7). On second year carry-over beds of eastern varieties, we had to begin applying supplemental nitrogen fertigations midway through the second harvest season. Only at every second or third year should poultry litter be applied on the same site at the rate we used. Otherwise, over-applications of nitrogen and phosphate, above the uptake needs of the crop, could create nutrients pollution of surface and ground water.

FERTILIZER AND LIME USE CONSIDERATIONS

Inventory your soil nutrients and pH status before planting. Strawberries thrive, as opposed to merely surviving with lower yield potentials, at high soil levels of phosphate and potash and relatively low levels of preplant nitrogen at a pH of between 6.0 and 6.5. Add preplant phosphate and potash to bring levels to the high range by soil test report and add lime only if soil tests below pH of 6.0, again as recommended by soil test report. If soil has previously

been planted to a perennial legume cover crop, no preplant nitrogen may be needed. Otherwise, apply no more than 60 pounds of actual nitrogen per acre bedded preplant or at time of bedding rows. Research has shown that higher amounts of nitrogen applied before planting are not fully utilized by strawberry plants and may endanger pollution of surface or ground water with nitrates. Spring season fertilizer use and management through fertigations with the drip irrigation system are discussed later under spring management considerations. Then, you may wish to review again the information above on use of poultry litter as a viable, soil sustaining, alternative, fertility management strategy for strawberry production.

PLANTS, PLANTING AND CHOICE OF VARIETY OR CULTIVAR CONSIDERATIONS

For fall planting plasticulture strawberries in colder areas, 2 rows spaced 14 to 18 inches apart are planted on each 24 to 27 inch wide bed covered with black plastic mulch. Going down each double row per bed, plants are spaced in-row 12 to 14 inches apart according to variety used and grower preference, requiring 17,424 plants per acre on 5 foot bed centers with plants spaced 12 inches apart in-row (recommended for cv. Chandler), 14,550 plants per acre on 5 foot bed centers with plants spaced 14 inches apart in-row (recommended for the eastern U.S. variety Late Star).

To lessen plant loss and plant stress risk, we recommend new growers plant plug transplants, usually 50 per flat. Southern and California varieties are started from disease-free Canadian field runner tips. Eastern U.S. varieties are started from mid-Atlantic regional greenhouse runner tips from tissue cultured mother plants in order to have earlier plug transplants than are available from Canadian field runner tips production. Late July to mid-August is the ideal time slot for planting Late Star and other eastern varieties in our colder areas (see Table 5). Runner tips are transported by refrigerated truck from tip propagators and kept at 32 degrees F. until planting, planted into commercial potting soil mix, kept under near constant mist for the first 3 to 4 days, preferably in full sunlight after sticking tips. Let plants dry only at night to lessen favorable conditions for infection by foliage diseases, then flats are watered only as soil mix begins to dry for the following 3 weeks. By the fourth week from sticking runner tips in potting soil, plants are ready to plant on plastic mulch. New growers can purchase finished 4 week plug transplants from specialist commercial plug plant growers who are dealers for the originators of the plant runner tips, or, with eastern varieties, purchase plugs directly from the tip propagators who also are plug plant producers.

Experienced growers may also purchase runner tips from some tip propagators, or may purchase fresh dug whole bare root strawberry plants of southern and California varieties from Canadian sources. However, crop cooling overhead sprinkler irrigation plus the drip irrigation system will both need frequent operation (multi-daily use of crop cooling sprinklers) for a week or longer after planting, which can seriously waterlog the row middles in this region of sloping fields, so that if heavy rains occur during the week after planting, serious soil erosion is possible. **Plug plants are recommended over fresh dug bare root and dormant dug bare**

root plants of both eastern U.S. and California varieties for summer to early fall plantings on plastic mulch (proper time of planting depends on variety, see Table 5(A) and 5(B)) for this region.

The water punch wheel planter aid is most often used for assisting hand setting of transplant plugs on plastic mulched beds. We find that adding 2 seats behind the 2 front seats is a fine idea so that 2 people riding on each side of the bed can each plant every other planting hole to increase planting efficiency. In addition, a water barrel or barrels also should be used with the planting operation so that plants do not dry out quickly. Also, beds should be pre-wetted with the drip irrigation system before planting, then watered-in at planting. In very hot weather, the addition of crop-cooling sprinkler irrigation for brief periods for a few days after planting on the hot black plastic mulch will also enhance survival and early plant vegetative growth.

In this mountainous region and northward, the varieties Late Star (eastern U.S. variety) and Chandler (California variety) are recommended. At our 2,400' elevation here, Late Star has been a top performer for the past 2 years (see Table 5(A)). South of us Chandler also works well along with the earlier maturing Florida variety Sweet Charlie. In our research plots and grower experience in the mountains, Sweet Charlie is just too frost-prone, having a lower chilling requirement causing it to break into active growth and bloom in late winter at first false spring weather. We are test-planting new varieties as they become available; many new varieties are on the horizon, soon to be released for commercial use. The flavor of all varieties of strawberries is higher and more robust if allowed to fully ripen on the vine. This is not possible for shipping berries, but helps create the high consumer demand for flavor-packed, locally grown berries. If nitrogen levels are kept on the lower side of the sufficiency range, U-Pick customers and store buyers are very complimentary of locally-grown ripened-on-the-vine strawberries. On the other hand, we found that high nitrogen rates adversely affect flavor, creating a bland, less flavorful fruit in our variety tests that have included California, Florida and selected eastern varieties.

Based on our research experience in this area in the mountains and northward, we recommend planting Chandlers the first week of September. In later plantings running to late September and October here, we could increase yields by applying crop covers over the plantings in October to extend the fall growing season. We leave them on until late February in this region, then remove them until about April 1, then re-use them as needed for frost control through April and early May. We recommend extending the fall growing season by planting Chandlers earlier in this area then applying fall covers. We have not used fall covers on the hardy eastern varieties planted from late July through mid-August. Table 5(A) shows that Late Star and other eastern variety yields are decreased if plug transplants are planted after mid-August. If you cannot plant eastern varieties by mid-August, fall crop covers would likely improve yields the following spring. We, along with many growers in this region, have had very poor results planting dormant bare root eastern strawberry varieties on plastic mulch in the heat of summer. Planted earlier, survival of dormant bare root plants is much better, but excess branch crowns and runners adversely affect berry size and increase labor of transplanting and of cleaning off beds pre-harvest. We recommend setting plug plants of eastern varieties for summer plantings on plastic mulch.

South of this area, along the North Carolina border running from west to east, plantings of southern and California varieties are made from late September into October, depending on location. In that zone the variety Sweet Charlie also performs well. Grower experience there shows it should be planted 2 weeks earlier than Chandler since it makes slower fall growth with less branch crowns unless given more growing time in the fall for crown development.

FALL MANAGEMENT OF NEW PLANTINGS

If planting beds are properly pre-wetted with the drip irrigation system and plants are well watered at planting as described earlier, plug transplants will quickly root and begin new growth. High temperature, sunlight and wind, versus cool, cloudy or rainy weather, plus plug condition and size, all affect how often drip irrigation needs to be applied in the fall and spring. Generally, once plants have become rooted the first week after planting, you will need to operate the drip system **until you see or feel that beds are wet from shoulder to shoulder**, often once per week, 6 or more hours per cycle. **Never let the wetted zone fail to reach the strawberry root systems planted 8 to 9 inches on either side of the drip line on each bed. Your main fall management objective is to grow a fine, healthy, large, vegetative plant with about the same diameter as a large cantaloupe fruit (or adult human head) with 4 to 6 branch crowns.**

Where 60 pounds of actual nitrogen was applied per acre only in the beds, pre-plant at bed shaping, our research found no additional benefit from any fall-applied soluble nitrogen fertigations. Also, by Thanksgiving or earlier in the mountains here and northward, vegetative plant growth has about slowed to a stop for the fall, eliminating the need for further drip irrigation system operation until spring. At last fall drip irrigation and before hard freezes are expected, be certain to drain all layflat vinyl, PVC or aluminum alloy main and header lines above and below the soil surface plus pump and filters. In-row drip irrigation lines will self-drain.

SPRING MANAGEMENT CONSIDERATIONS

This is the exciting, intensive, dynamic (nail biting) season! You have the wind in your face (and sometimes your crop covers or the cold frost protection sprinkler water). Hope springs eternal, a good harvest is anticipated and is earned. You will either lose a lot of sleep getting up in the wee hours to check the thermometers **in the berry field and down at the pump (not on the back porch or just outside your bedroom window), or use a lot of energy pulling crop covers with extra help on the afternoons before frosts are expected.** An excellent and modest investment is an alarm wired to a specially built thermometer placed in the berry field that is set to trigger a bell to ring in your bedroom near your pillow when the field air temperature at berry plant level drops to 35 degrees F. Such an alarm system is available from local irrigation suppliers.

Before first blooms are visible or berry plants have resumed much new spring leaf growth, set up either your sprinkler frost control system and test that it will operate dependably later when it will be needed, or anchor your crop covers on the windward northwest side of your

fields so you can pull them with the wind, not against. Anchor the sides and ends with blocks or soil or with gravel-filled plastic mesh bags. Also, make certain you have purchased your soluble fertilizers for spring fertigations to be applied in this area beginning around April 1 and continuing through early June.

Table 8 helps describe our typical spring fertigation program in our research plots near Blacksburg. We believe that alternating liquid calcium nitrate, formulation 9-0-0-11(calcium) one week with urea solution, dissolved ammonium nitrate, 30% nitrogen liquid, or other soluble nitrogen sources the next week, improves berry flavor, hang time on the vine and shelf life, compared to the use of nitrogen sources without calcium. A Virginia supplier of liquid calcium nitrate exists to supply your needs. The technical greenhouse grades of prilled granular calcium nitrate are dependably free of anti-caking agents to prevent clogging your drip lines, filters and fertigator. Also, the greenhouse grade of granular calcium nitrate is very expensive per pound of nitrogen compared to the liquid formulation and is time consuming to dissolve into solution for fertigation use in the drip irrigation system.

Research has found no yield or quality increase from using phosphate and/or potash with nitrogen fertigated weekly in the spring, provided that phosphate and potash levels were brought to the high range by pre-plant field additions based on soil test report. However, growers have found through experience that where preplant fertilization levels were modest, perhaps insufficient to bring P and K levels to the high range, weekly fertigations using soluble 20-20-20 carefully dissolved into true solutions, alternated with calcium nitrate fertigations, have benefited their strawberry crops.

Our nitrogen fertigation research over 3 spring seasons on our heavy silt loam soil supported North Carolina's findings that the rate of 1/2 pound of actual nitrogen per acre per day, but applied only once per week (1/2 X 7 days = 3 and 1/2 pounds of actual nitrogen per acre per week, 40 lbs during spring season), is the ideal fertigation rate of nitrogen for plastic mulched strawberries for both top yields and best berry flavor. Our weekly samplings of petiole sap nitrogen also confirmed that higher weekly nitrogen fertigations increased nitrogen content within the berry plants to levels above sufficiency causing adverse heavy vegetative growth, bland berry flavor, and soft berries with poor hang time on the vine and poor shelf life off the vine. Tall, lush plants at harvest reduce harvest efficiency and berry visibility, important considerations especially for inexperienced U-Pick customers. Such large size plants also are slow to dry in wet weather helping create ideal conditions for development and spread of fruit rots.

In the spring your fertigation/drip irrigation management objective is to produce the maximum amount of highest quality fruit from the heavily crowned plants you produced the previous fall, with minimum excess new vegetative growth, requiring careful spring nitrogen management.

Fresh strawberry petiole plant sap nitrate nitrogen sufficiency levels have been determined by Dr. George Hochmuth and colleagues at the University of Florida for each stage of growth as shown in Table 9. Our appropriate fall and spring seasons are shown rather than for the late fall planting and winter harvest season in Florida.

TABLE 8

Weekly Spring 1994 Petiole Sap Levels in PPM of Fresh Plant Sap for Nitrogen and Potash1, April 1 - June 10, cv Chandler Strawberries, Kentland Research Farm, Va Tech, Blacksburg, Va.

	NO_3-N[1] (Ideal Range)[2]	**K^2O (Ideal Range)**
4/01	540 (600-800)	2500 (3000+ 1st blooms visible)
4/08	500 (300-500)	2400 (2500+)
4/15	450 (300-500)	2400 (2500+)
4/22	248 (200+)	2400 (2500+ 1st fruit visible)
4/29	250 (200+)	2300 (2500+)
5/06	217 (200+)	2300 (2000+)
5/13	215 (200+)	2200 (2000+ 1st fruit pinking)
5/20	200 (200+)	1900 (1800+ 1st harvests)
5/27	200 (200+)	1900 (1800+ harvesting)
6/3	190 (200+)	1800 (1500+ harvesting)
6/10	190 (200+)	1800 (1500+ harvesting)

[1] From in-field readings made with portable Cardy N and K Ion Meters, from Spectrum Technologies, Inc., 12010, So. Aero Drive, Plainfield, IL 60544.

[2] From George Hochmuth, 1993. Grower Guidelines: Hard Figures For Petiole Sap Testing, American Vegetable Grower, Meister Pub. Co., Willoughby, OH 44094, Vol. 41, No. 12, Dec., 1993, pp. 62-63.Research has found no yield or quality increase from using phosphate and/or potash with nitrogen fertigated weekly in the spring, provided that phosphate and potash levels were brought to the high range by pre-plant field additions based on soil test report.

TABLE 9

Sufficiency ranges for petiole sap N and K Concentrations for Strawberries (from Univ. of Florida Extension Circular 1141, 9/94, George Hochmuth and Earl Albregts)

Petiole Sap Nutrient Conc.(ppm)

Month(SW V a.)	No3-N	K
mid-October	800-900	3000-500
mid-November	600-800	3000-3500
mid-March	00-800	2500-3500
April 10	300-500	2000-2500
May 10	200-500	1800-2500
June 1	200-500	1500-2000

Petiole sap testing for nitrate nitrogen should be backed up by routine tissue analyses of whole leaves by a tissue testing laboratory. Sufficiency ranges for all plant nutrients in whole strawberry leaves are presented in Table 8.

TABLE 10

Sufficiency nutrient ranges in most-recently matured whole leaves (blade plus petioles) of strawberries, dry weight basis for laboratory tissue analysis.

Time of Sampling: early season, pre-harvest.

	Deficient	Adequate Range	High	Toxic
N	< 2.8 %	2.8 - 3.0	> 3.0	-
P	0.2	0.2 - 0.4	> 0.4	-
K	l.l	1.1 - 2.5	> 2.5	-
Ca	< 0.4	0.4 - 1.5	> 1.5	-
Mg	< 0.2	0.2 - 0.4	> 0.4	-
S	< 0.8	0.8 - 1.0	> 1.0	-
ppm				
Fe	< 50	50 - 100	>100	-
Mn	< 25	25 - 100	>100	800
Zn	< 20	20 - 40	>40	-
B	< 20	20 - 40	> 40	-
Cu	< 5	5 - 10	> 10	-
Mo	< 0.5	0.5 - 0.8	> 0.8	-

HARVEST CONSIDERATIONS

In the cooler, early season harvest periods of our mountain area, both Late Star and Chandler strawberries grown on black plastic mulch usually need to be picked only twice each week, with a 3-day interval between harvests. During hotter harvest weather, the same plants will need to be picked every other day. During cooler weather, for most U-Pick harvests in this colder region, picking may be done on Mondays and Fridays for a given field, on Tuesdays and Saturdays for another field, and on Wednesdays and Sunday afternoons for a third production field (where Sunday picking is acceptable). Several U-Pick operations in this region take Sundays off, closed to retail traffic in the berry fields. Their Wednesday berry picking area is next harvested either on Saturdays or Mondays, depending on the weather and speed of ripening, and provides, in effect, an overflow area for heavy Saturday or Monday U-Pick customer demand.

The early season 3-day harvest interval is made possible here in the mountains by the excellent ripe berry hang-time on the mulch film and by the cooler night temperatures here compared to lower elevations. A 3-day harvest interval allows for plenty of large, ripe berries to be present, visible to U-Pick customers or hired pickers.

Note: With the high financial costs of producing this premium berry, growers charge a premium price for the privilege of U-Pick harvesting on the plastic mulched raised beds. Grower prices should not be dictated by area prices being charged for matted row ground-grown berries. Also, some growers have stopped charging by the pound and are charging a set volume price per plastic bucket. They found that with less labor they could quickly count containers and also avoid long check-out lines when customers finish picking.

BENEFITS OF RECYCLING OLD PLANTINGS IN COLDER REGIONS

Starting with disease-free runner tips/transplant plugs planting stock for each planting, we have researched and successfully demonstrated (see Table 3) the financial and environmental benefits of recycling for a second U-Pick harvest year the original plants, the beds, the initial strip fumigation, the plastic mulch, the labor of establishing the planting, and the drip irrigation tubing, fittings and header lines.

Note: Conservation in the use of man-made methyl bromide plastic products, fertilizer nutrients and all pesticides are very important public and political issues. If recycling continues to be successful, it has the potential to effectively cut in half the amount of methyl bromide fumigant and plastic products we now use in our annual plantings. Coupled with the development of mulch films that are both longer lasting and more impervious to transmission of the gas phase of methyl bromide fumigant, significant reductions in agricultural use of methyl bromide could be accomplished. Such conservation might help delay final congressional/EPA removal of this broad-spectrum crop protectant from our industry (slated for removal in the year 2004).

Many producers of plasticulture strawberries in this colder region have inquired about specific recommendations by month for carrying over their berry fields for a second year. We have developed such recommendations (see Table 11) to minimize favorable conditions for

Strawberry Anthracnose and to increase second year yields and berry size. You should understand there is a risk involved from carrying over fields due to Anthracnose, a fungus disease attacking crowns, foliage, stems, flowers and fruit of most varieties. This disease devastated and nearly ruined the North Carolina strawberry industry a few years ago when they were propagating their own plants, including some that were infected possibly at planting. There are no highly effective preventative or chemotherapy fungicides labeled for control of Anthracnose on strawberries; the only cure is to avoid the pathogen. Only healthy fields should be retained for carry-over, destroying any that the University Plant Pathology Clinic has identified as having Anthracnose on the plant parts. There is a fruit infection form of Anthracnose that has been identified in this region during harvest, but so far has not attacked plants or caused plant injury.

Note: The Sweet Charlie variety is highly resistant to Strawberry Anthracnose, confirmed by Dr. Dan Legard, Strawberry Plant Pathologist at University of Florida's Dover Research Center where Sweet Charlie was bred by Dr. Craig Chandler. So, what are the risks of your Late Star or Chandler carry-over fields getting this disease now that the industry in this area starts each planting with Anthracnose-free runner tips and plug transplants? No one can say for certain; only time will tell.

Some good growers in this region have kept plantings over for the second year's crop and even for the third year's crop, following our renovation procedure shown in Table 9. They also report as good or even higher yields the second year, as we did in our research here. However, you may have more branch crowns on carry-over plants due to good management and favorable conditions for increased vegetative growth the previous fall and winter. Such plants need no additional branch crowns or many small berries will develop the second year! We have successfully crown-thinned with shielded sprayer and Gramoxone at renovation in late June to remove one-half of the old crown diameter growth, with no damage to the remaining unsprayed portion of the plants.

Excellent new research results by our colleagues confirm these observations. Such regional research results are presented annually at The Southeast Strawberry Expo at Raleigh, North Carolina, traditionally held in early November. We hope to see each of you at this annual conference. How can you afford not to go?

Growers not interested in carry-over of strawberries for the second harvest year may still be interested in other recycling double cropping possibilities: Desiccating the strawberry plants with Gramoxone after the harvest is complete, mowing off or pulling out the dead plants and replanting with vegetables such as fall pumpkins (which have been successfully field seeded and also transplanted onto the mulch film), fall tomatoes, fall cabbage, even fall cauliflower, fall broccoli, fall greens and oriental vegetables. Some successful growers have merely desiccated the old strawberry plants, mowed them down low, then planted in-between the old berry plants. Tomatoes, pumpkins and other cucurbits are planted as a single row slightly off-center to avoid hitting the drip irrigation tube. Most other vegetables are double-rowed on the old plastic mulch, either hand seeded and/or transplanted with mechanical vacuum planters and seeders developed to plant through plastic mulch. Several such planters are being used in Virginia to double crop old plastic mulched beds.

TABLE 11

Calendar of Jobs for Carry-Over Strawberries on Plastic Mulch

1. **July 1** - After harvest, by 7/01, broadcast spray 2,4-D amine, labeled formulation, 1.5 Qts/A. NOTE: If plant-killing diseases are present, destroy planting, do not carry-over.

2. **July 14** - 2 weeks after spraying 2,4-D mow berry plants 2" above plastic mulch.

3. **July 14** - After mowing off as above, if you have more than 5 branch crowns on average, set shielded sprayer so shields expose outer 1/2 of plants on each row on the beds, set shield height to just clear the crowns, spray with 2 pints/acre of Gramaxone and crop oil to thin crowns for better fruit size next year.

4. **July 15** - Drip irrigate to wet beds shoulder to shoulder (7 hours of drip @ 12" in-line emitters, beds on 5' centers = 1 acre inch to beds). No fertilizers in summer months. Goal: keep plants alive, but not fast-growing (controlled moisture stress).

5. **August 15** - Drip irr. beds as above. Goal: same as above.

6. **September 1** - Take plant tissue analysis or soil test the carry-over beds. Typically in this area, beds will test high in nitrogen, medium or medium-low in both phosphate and potash.

7. **September 15** - Drip irrigate to wet beds shoulder to shoulder, but this time at 2/3 of the way through the drip cycle, fertigate nutrients as per tests needs, typically may need to add 15-20 #/A of phosphate and potash, smaller amounts of nitrogen. One option is to fertigate with solubles such as 12-48-8 or 9-45-15 followed by 8-15-36. Mixing them can cause salting out or heavy fertigator-clogging precipitates, use in sequence. Other options are liquids such as 11-48-0 followed by 0-0-30. Note: see examples at end for calculating how much/acre to fertigate.

8. **September 20** - Spray row middles with Gramoxone, shielded sprayer as per VCE Pub. 456-420, for all vegetation including rooted berry runners filling row middles. If foxtail or other tall grasses have filled middles, use Poast, crop oil plus ammonium sulfate activator as per Poast label prior to use of Gramoxone in middles. Remove crop shields for Poast spray to cover grass over beds and raise spray boom to high position to completely spray overtop of grass in middles.

9. **October 1 and 15** - Last drip irrigations of the season, wet beds shoulder to shoulder. If you didn't pre-plant fumigate to kill soil insects in beds, field mice and voles may move into beds to feed on grubs and bugs or just to overwinter, even in fields that were fumigated, destroying drip tape and plants. Adults of the May Beetle family lay their eggs on sod. Their grub larvae devour strawberry roots, one of their favorite food host plants. They have nearly ruined some fields, so best to use a soil insecticide labeled for strawberries (VCE Pub. 456-420) or plan to bait beds with mouse poison placed under the plastic mulch. Injury has been most severe where strawberries rotate behind sod with no fumigation or soil insecticides.

10. **October 16** - Winterize and drain all drip components, filters, lines. Order winter/spring crop covers or obtain a frost control sprinkler system. Don't bet on another 'Carolina winter.'

11. **October 20 to December 1** - Apply crop covers if needed. Colder areas of the state generally apply crop covers in October. Warmer areas usually get by with no winter covers.

12. **Early February** - Remove winter crop covers, leave windward side secured to pull covers later when severe freeze events are expected, also later to re-pull for frosts during bloom.

13. **February** - (If you use sprinkler irrigation for frost control). Set up and test sprinkler system well ahead of expected bloom season.

14. **Early Feb. to early March** - As weather permits clean off dead runners plus dead leaves from each of the 2 rows per bed, back to original mother plants. Check out mechanical brushes and/or high-vacuum mowers to reduce hand labor of this chore. Dead leaves and runners are the primary source of spores of Gray Mold to infect new spring leaves and blooms.

15. **Late March - Early April,** depending on area and season - At first flush of new plant growth after cleaning beds, spray protective/preventative fungicides as per VCE Pub. 456-420 for prevention/management of Botrytis Gray Mold fruit rot as follows: 1st. spray before first bloom on new vegetative growth; 2nd spray at first to 10% bloom; 3rd spray at full bloom; 4th spray at final bloom. Gray Mold spores infect the blooms, then the fruit rot appears later on ripening fruit, especially following periods of wet weather during bloom and harvest. The preventative program of 4 sprays as above has allowed growers to make no further sprays during harvest season so there are no sprays on fruit or visible spray residues on plants for U-Pick.

16. **Early April through harvest season** - Every week, once per week or every 5 days in very dry, sunny, windy weather, drip irrigate beds to move water plus fertigations to rows, not just to wet the bed centers near the drip tape. Weekly spring months irrigations/ fertigations take at least 4 hours per cycle on our heavier silt loam soils in this area. Fertigate 3 lbs./acre of actual nitrogen, phosphate and potash per week on carry-over beds over a 12 to 14 week spring time period. Many growers either use 8-8-8 liquid fertilizer or soluble 20-20-20 dissolved in water for weekly fertigation of carry-over beds.

Fertilizer calculations: How much N, P and K are in a bag of 20-20-20 soluble fertilizer? Multiply 25 lbs per bag X .20 for 20% = 5 lbs. each of N, P and K. How much N, P and K are in a gallon of liquid 8-8-8? Check with your bulk supplier for the weight per gallon. For this example, let's use 12.5 lbs/gal. so multiply 12.5 X .08 for 8% = 1 lb of each major element/ gallon of 8-8-8. To apply 3 pounds of N, P and K/acre per week means you need 3 gallons/ acre per week of liquid 8-8-8. Let's go back to page 1 to the September fertigations of high phosphate and high potash fertilizers your beds may have needed: How much phosphate is in a 25 lb. bag of 12-48-8? Multiply 25 lbs X .48 = 12 lbs. of phosphate. To apply 15 lbs. P/acre means you will have to use 1.25 bags per acre. How much P in a gallon of 11-48-0? If it weighs 12.8 lbs/gal, multiply 12.8 X .48 for 48% P = 6.14 lbs. P per gallon. To apply 15 lbs. of P/acre in September means you need 15 divided by 6.14 = 2.44 or 2 and 1/2 gallons of 11-48-0 per acre. Since 1 gallon of 0-0-30 weighs 12.15 lbs/gal., how much 0-0-30 do you need per acre to supply 15 lbs. K/acre? Multiply 12.15 X .30 = 3.75 lbs. K/gallon. To apply 15 lbs. K/acre, divide 15 by 3.75 = 4 gallons of 0-0-30 per acre.

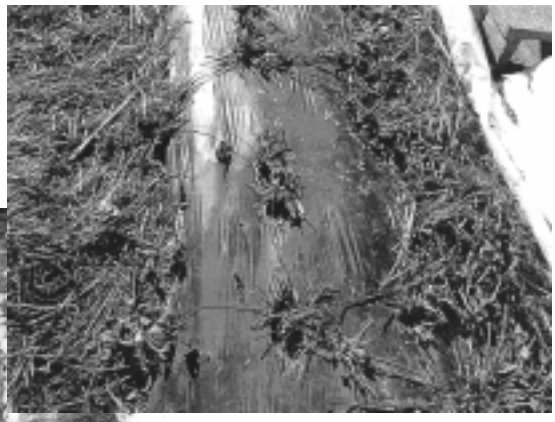
EARLY SPRING MECHANICAL CLEANING OF STRAWBERRY BEDS

Early spring is the time of year folks need to clean off strawberry beds, both matted row and on plastic mulch, to remove old dead leaves and last season's unrooted runners. Such old dead plant material is a huge source of latent infectious spores of Botrytis Gray Mold Fruit Rot that infects the blooms, but expresses in the fruit. Removing this inoculum before new spring leaves, buds and blooms really get going is a great help in controlling Gray Mold, along with fungicide crop protectant sprays during bloom.

Hand cleaning beds is a high-labor, bend-over, tough job, even on first year beds planted just last year. Getting the old dead plant debris off the fruiting beds in late February or early March means fruit does not develop in contact with this disease-carrying material, which also can infect fruit as a secondary inoculum in wet weather. During last spring's wet bloom and harvest season, many growers had to shut down their picking season 2 weeks early because of Gray Mold fruit rot. Beds may not have been cleaned nor fungicides applied during bloom season infection time.

To make such cleaning less of a hand labor chore, we have experimented with a mower set at its highest 3" height, plus welded a 31/2" protruding piece of flat steel on the back side opposite the 31/2" sharpened edge on both ends of the blade. The 31/2" long piece protrudes 1/2" beyond the blade, as shown on one of the images attached. Growers need to remember to balance the blade before re-installing it. The following photos show how well it works on our plots! Thanks for sharing this with your clients now.

Credit for this idea goes to Mike Smalley, a W. Va. grower who tried a hover-mower, and to Mr. Johnny Patterson of Lancaster Farms in SE Virginia. His talents include welding/metals fabrication. I saw how he modified 5 HP Honda mower deck blades, mounted 3 mowers on a frame, to top prune woody nursery plants and side-discharge the prunings away from the plants being pruned. Our research farm technician Romney Smith helped me make the "lift" idea work on a self-propelled 21" lawn mower for cleaning our strawberry plots, both the beds planted last summer and for old carry-over 2 & 3 year beds. The images attached are from the really thickly covered 2 year carry-over beds.



Second year carry-over beds before mechanical mowers cleaning (right) and after mowing (far right) in late February

Close-up view of mowed bed showing old runners and leaf growth has been lifted, cut and removed, late February (crop cover is shown on left)

For recycling old strawberry beds to fall tomatoes and species in the cabbage family, we recommend applying a pre-plant spray to the black mulch film of white latex paint (indoor or outdoor formulation), mixed with warm water at the rate of 1 part white latex paint to 3 parts of warm water. Stir in a mixing bucket then pour the premixed solution into a backpack sprayer with flat fan nozzle. Immediately after application, clean the sprayer with warm water containing dishwashing detergent, including running some cleaning solution through the sprayer nozzle, then rinse. The whitened mulch film will produce excellent fall tomatoes (preferably stringweave) and fall cabbage family species. Pumpkins and other cucurbits have done fine direct-seeded into the black mulch film without heat damage even in hot summer weather. Transplants of all vegetable species should always be toughened in full outdoor sunlight for several days after coming out of the greenhouse before setting them on black or even on whitened mulch film.

A final note on recycling the mulch film, the strip fumigation, the beds, the labor of planting, and the drip irrigation tubing/headers: Successful strawberry carry-over fields may also be recycled yet again for a third cropping cycle, by planting fall vegetables on the mulch film after the second berry crop. In both cases, whether after one or two strawberry cropping cycles, soil testing and fertigations for subsequent crops needs to be done according to the particular crop needs and timing for nutrients. These rates and timings are shown as sidedress rates and timings in VCE Pub. 456-420, Vegetable Production Guide for Virginia. We have found that the sidedress rates given in the publication for broadcast, full acre application, may be cut by one-half since you are fertigating only about one-half the acre, only the portion within the beds beneath the mulch film. By the end of a third cropping cycle, the mulch film has begun to break into pieces due to photo-degradation from sunlight. Ultraviolet (UV) inhibitor compounds are maximized in thicker films such as 1.25 to 1.50 mils thickness and greater, affording even longer recycling potentials. The drip tubes and beds are usually still intact after 3 cropping cycles; fertigation can be used to re-charge beds with needed nutrients for subsequent crops.

Close-up view of mower blade modification on back edges opposite sharpened blade edges.

STRAWBERRY POLLINATION CONSIDERATIONS

Did you know that often you can obtain up to a 20% yield increase from larger and more perfectly shaped berries by using one hive of bees per acre placed near the berry fields during bloom? What other simple practice could we so quickly and easily do that would have such a potential yield increase? Even if you have done everything right and are looking at a potentially great crop, lack of bee pollination could still prevent you from making as many deposit trips to the bank as you would hope!

Dr. Richard D. Fell, Entomologist at Virginia Tech, prepared the following information on using bees to pollinate strawberries. We are grateful to Dr. Fell for his help and expertise on this important topic.

"Most varieties of strawberry are self-fruitful with both the male (stamen) and female (pistil) parts of the flower located close together. This arrangement within the flower helps to insure that some berries will be produced. However, other factors can help improve pollination, resulting in an increase in both number and quality of the berries produced. Wind, for example, shakes the flowers and increases pollen transfer, but even wind and self-pollination cannot be relied upon to produce complete pollination of all pistils on a flower. Additional pollination by bees and other insects is often necessary, especially if one wants to insure maximum berry size and perfectly shaped fruit. Research studies show that 16 to 20 bee visits per blossom are needed for the best fruit development.

A number of studies have been made on strawberry pollination and indicate that many plantings could benefit from increased numbers of insect visitors. Studies in Michigan, for example, have shown that many large commercial berry fields have very low bee populations and hence poor insect pollination. These studies also indicate that a number of varieties benefit significantly from honey bee pollination, including such established older varieties in Michigan as Guardian, Surecrop, Redchief and Earlidawn. Good bee pollination can increase average berry size and quality by as much as 15 to 20% in some varieties. Making a recommendation for the use of bees for pollination is not easy, however, since varieties may vary considerably with regard to insect attractiveness. Some varieties have low nectar and/or pollen production and are not as attractive to honey bees, meaning that higher numbers of bee colonies are necessary if optimum pollination (yield) is to be obtained. With other plantings, the use of bee colonies for pollination may produce smaller increases in fruit quality.

Growers can get an idea of pollination needs by checking flowers at petal fall. Flowers should be examined in several areas of a field, especially toward the center areas where the poorest pollination is most likely to occur. Flowers that have been well pollinated have pistils that appear dark and shrunken in size. Pistils that were not pollinated appear yellow -green in color and very fresh in appearance. If poorly pollinated flowers are found in berry fields, efforts to increase the bee population will help improve berry quality and yields. High numbers of poorly shaped berries can also indicate a need for better pollination. Although such findings present little opportunity to correct the problem the current year on most varieties, the longer bloom period for Chandler suggests that quick action to place bees near the field will be worthwhile.

If pollination problems are apparent, the easiest method to solve such problems is to increase bee pollinations by renting hives of honey bees. Beekeepers with hives are often willing to rent colonies for the bloom period if they trust that the grower practices good insect pest management practices, is not an indiscriminate spray operator bent on killing all insects, including the beekeeper's bees and other beneficial insects. Their rental fee includes their bringing the hives to the field and picking them up at the end of bloom season. Recommendations for hive placement vary from a few hives in a field to as many as one colony per acre. A good starting point would be one colony per two acres. Colony numbers can then be increased or decreased in the future as needed. Beekeepers willing to rent bees can by located by contacting the regional Virginia Department of Agriculture and Consumer Services bee inspectors, obtainable from your Extension Agent or by calling the Richmond VDACS Apiarist at 804-786-3515".

OBSERVATIONS ON DEER CONTROL

Over the past several years deer have become the #1 pest of horticultural crops in Virginia as well as of home gardens and landscaped grounds in both suburban and rural communities. Countless types of repellents have been tried with varying degrees of short-term success, but excluding deer by fencing them out of plantings has been grower-proven to be the only successful method providing long-term deer control. However, construction costs for 8' or taller conventional woven wire fences are prohibitively high for most folks and for fencing larger agricultural fields and home grounds.

Virginia strawberry growers have suffered great losses to deer feeding on the green plants, especially growers in milder Virginia areas with southern strawberry varieties Chandler and Sweet Charlie that remain green all winter. Growers of hardy Eastern U.S. strawberry varieties with leaves that scenesce or die in dormancy have found their plants are more attractive to deer in spring, summer, and fall months. I cannot recommend commercial production of strawberries in most areas of Virginia unless an effective deer exclusion fence is constructed at the time of planting! Green strawberry leaves are known to be high in phyto-nutrients, a "5-A-Day salad browse" highly sought by deer who seem to "come out of the woods" to devour strawberry and other horticultural plantings.

A Low Cost Virginia Deer Control Success Story: In 1995 strawberry grower Hugh French in Cumberland County, Va., after repeatedly losing 3 acres or more of berry plants to deer feeding each winter for several years, constructed a 7-strand 5' height high tensile electrically charged slant deer fence. Fence design was developed by Gallagher Corporation, a New Zealand fence manufacturing company (with dealers worldwide) that first published this design back in 1984. For the past 3 years he has had 100% deer control with this slant fence that surrounds 12 acres of strawberries. Other growers are now beginning to enjoy similar success in deer control by building their own slant fences. Previous to Mr. French's fence construction, in efforts to reduce deer feeding, he had obtained state wildlife control permits allowing massive deer elimination by hunting each year. However, deer feeding damage to his strawberry plants seemed to increase as more animals were eliminated each year!

Apparently, the 3 dimensional effect of the slanting tier of wires confuses depth of field vision of deer so they will not jump by night or by day over the relatively short, 5' fence height. Normally a 5' fence height would offer absolutely no impediment to deer intent on devouring horticultural plants. Part of the slant fence's success also may be credited to the electrical fence charger designed by the Gallagher Corp. especially for deer conditioning/ control without harming them. When they approach the inwardly slanting fence and touch an outer top wire, the electrical jolt lets them know the fence is not deer-friendly, nor is it friendly to dogs or to children. Good neighbors will certainly post signs warning others not to touch or try to climb through the electrified slant fence. Otherwise, eager perpetrators of litigation may rush to "trip" or "fall" over your fence in their haste to serve you papers!

Small animal exclusion, such as for groundhogs, also can be attained by placing the lowest of the 7 electrified wire strands just a few inches off the ground. Normally the 7 wire strands are placed about 1 foot apart for the 6 strands up to the vertical line posts, with the 7th or top wire placed on the end of the slant posts protruding some 1 and 1/2 feet outward beyond each vertical post (see figure 1). Hunting house cats also may be excluded by well-placed lower wires electrified specifically 1) not to harm small animals or children other than the unpleasant jolt when the fence is touched, and 2) not to lose power with snow loads. After deer severely

damaged our summer, 1997 research planting of Eastern strawberries at our Kentland Research Farm near Blacksburg, we also constructed a slant fence. Unknown varmints, possibly groundhogs (or deer), also devoured several varieties of snap beans adjacent to our strawberry plots. When my prize experimental selections of half-runner bean plants were eaten nearly to the ground, that was my final wake-up call to action! We join Hugh French, Bernell Williams and others with slant fences, in looking forward to providing no more edible landscape for wildlife in our horticultural crops! We used 8' length treated landscape timbers for our line posts placed 2.5' in the ground with 5' height remaining above ground (some cut the posts back to 4' height), spaced every 30' along the perimeter of our plots. We bolted an 8' landscape timber to each line post at a slanting angle allowing the top end of each slant post to protrude outward from each line post so that top ends of slant posts were 5' above ground. The bottom end of each slant post rests on the ground and is not placed in the ground. For field equipment and personnel access to plots inside the fence, we used non-conducting plastic electric fence handles and tensioners to provide an 8' long access near one corner. We can take down each wire strand and move the strands to one side upon entering or exiting the plots.

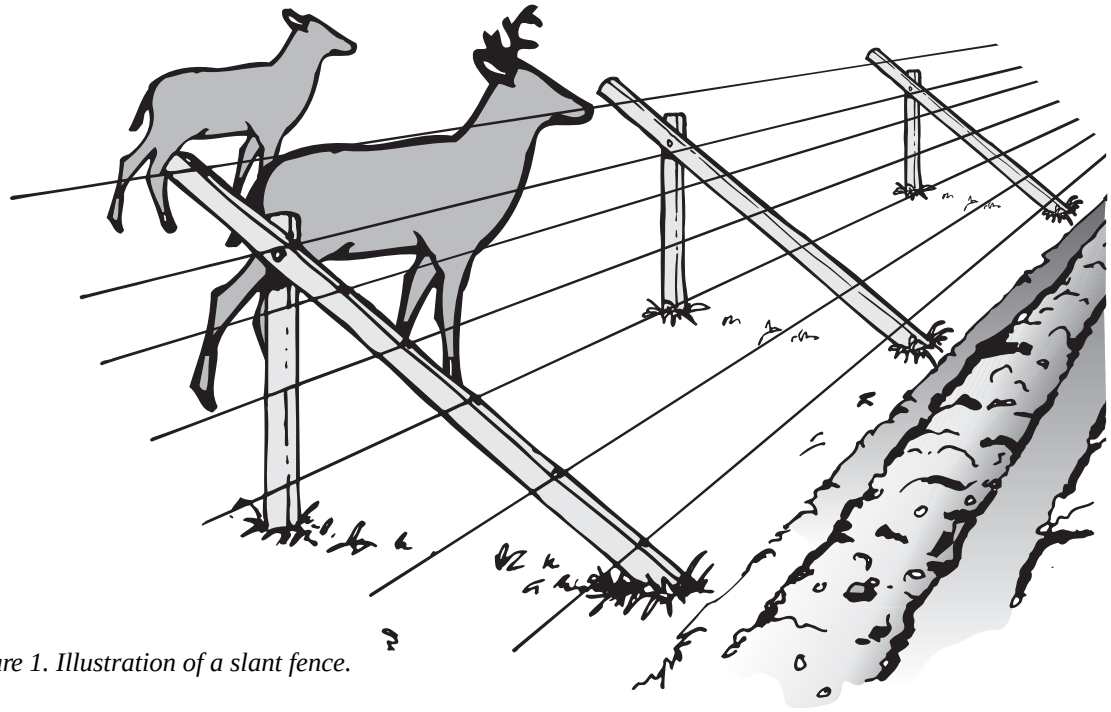


Figure 1. Illustration of a slant fence.

For under a dollar per running foot of fenced land perimeter for purchased supplies (not counting our labor), we believe this is the most economical, long-term solution to deer damage for our high value horticultural crops in Virginia. For larger fields of agronomic crops requiring thousands upon thousands of feet of perimeter fencing, cost of a fence for deer exclusion may be prohibitive, even for construction of a slant fence. For more information and equipment to construct the slant fence, please contact a Gallagher dealer in your area.

Special thanks to Mr. John Carden, Gallagher representative in Central Virginia, for his assistance to growers and to us in the construction of deer control slant fences; to Mr. Hugh French for first demonstrating this fence design and for his insight on the multi-years effectiveness of the slant fence in a very high pressure deer damage area; to our student Extension summer intern, Robyn Otto, for assistance in maintenance, even partial replanting

of damaged summer strawberry plots; and, to Mr. Jon Wooge, Mr. Buddy Poff and Horticultural farm technician crew for their rapid construction of our slant fence on short notice.

This wildlife control fence design uses flexible spring-loaded, 14-gauge high-tensile wire. The fence is designed to withstand the impact of deer, falling trees, thermal expansion and contraction, and snow/ice loading with minimal maintenance or repair.

Minimal weed control is necessary with high-power electrical energizers specifically designed for the slant fence. Growers may elect to use an industrial strength fence line or right-of-way herbicide application under the slant fence to provide multi-year vegetation control from one application. Do not use soil-persistent vegetation control herbicides near valuable shade trees or landscape plants. Heed and follow all instruction on product labels.

NOTE: Upright post in illustration above has been cut to 4' height. Top outer edge of slant post is at 5' height. Deer are spooked from jumping the fence by the slant or slope, not by fence height. Too much height causes too steep (more than 45 degrees) a slope or slant which will be ineffective.

LIST OF SUPPLIERS OF SPECIALIZED EQUIPMENT*

* Used for Plastic Mulched Hill System Strawberry Research at Va. Tech Horticulture by C.R. O'Dell and Jerry Williams, Dept. Hort., Va. Tech., Blacksburg, VA 24061-0327.

1. Super Bedder, Reddick, Inc. Williamston, NC, Victor Lilley or Mark Reddick, at 1-800-358-8837; also builds plastic mulch lifters and waterwheel transplanter aids; also Kennco Mfg., Inc. Ruskin, Fl. at 813-645-2591.

2. Shielded Row Crop Sprayer: H & H Farm Machinery Company, Mr. B.B. Haigler, Indian Trail, NC at 704-753-4919 or 1.800-735-1523.

3. Early Plug Plants from greenhouse propagation: A) Eastern and Southern varieties Plug Plants: Davon Crest Farms, David and Lance Lankford at 1-800-207-9862, also ph. and FAX @ 410-943-8792; We Gro-Rite, Allen and Lynda Williford @ 828-321—4371, FAX: 828-321-5255. B) Chandler & So. Varieties Plug Plants from Canadian field-grown tips, Aarons Creek Farms, Inc., Clarksville, Va. at 1-800-487-8502.

4. Custom Bedding, Mulch and Drip tape laying: Mr. Mitchell Wrenn, Zebulon, NC at 919-269-9781 (day) or 919-269-4993 (night).

5. Drip Irr. Supplies and Design: A) Johnson & Co., Advance, NC 910-998-5621. B) Berry Hill Irrigation Co., (Va.) 1-800-345-3747. C) Drip Irr. & Plastic Mulch Supplies Only: Reddick, Inc. (Reddick also has 1.5 mil maximum life black plastic mulch film in 4', 4.5', & 5' widths).

6. Frost control Sprinkler Irrigation Supplies and Design: Mid-Atlantic Irrigation Co. at Farmville, Va. at 804-392-3141.

7. Crop Covers, uv inhibited, a heavier Reemay type, multi-year use (our research suggests heavy 1.25 oz uv-treated covers may go up to 4 years' use): Ken-Bar Corporation at Reading Mass., 1-800-336-8882; also Hendricks and Dail, Inc. at Oxford, NC., Agrofabric crop covers at 1-800-662-4130.

8. Nitrate Nitrogen Petiole Sap Meter to Monitor Fertigation Needs: Cardy Nitrate Nitrogen Ion Meter, by Spectrum Technologies, Inc. Plainfield, Illinois at 1-800-248-8873, attn. Mr. Mike Thurow (also has Potash Petiole Sap Meter and soil pH meter).

9. Portable Irrometer, Model LT (low tension, very sensitive scale calibrated to read only from 0 to 40 centibars from soil moisture saturation): Irrometer Company, Riverside, California at 909-689-1701, attn Al, also has the hand-held vacuum pump service kit.

10. Liquid Calcium Nitrate 9-0-0-11 (each gallon has 1.1 lb. N & 1.4 lb. Ca.), from Burton and Puckett Inc., Scottsburg, (Halifax Co.) Va., Mr. Tom Burton at 804-454-6445, also custom blends, as liquid 8-8-8 with minor elements or other liquid analyses blends as per your leaf tissue or soil test needs.

11. Deer Exclusion Slant Fence Supplies: Gallagher Dealer: Mr. John Carden, Cumberland, Va. at 804-492-9617; 4-page Va. Coop. Extension leaflet describing slant fence, VCE Agents.

12. Clamshell Strawberry/Blueberry Pint and Quart Containers plus stackable master flats: Rockford Fruit Supply Company at 1-800-444-7225; UltraPak Corp. at 1-800-999-9001; also ExtraFresh Corp., Joel Kaufman at 413-567-8995. Joel also provides labels for your clamshells and UPC code, all applied at factory with your farm name/location; Clamshells and fiber pints and quart containers, Tenneco Packaging, Arlene Armstrong @ 540-434-0785, FAX: 540-434-2198, pager @ 540-981-6783.

13. 5 A DAY Promotional Products and Apparel, Remline Corp. at 1-800-555-6115; 5ADAY stick-ons and promotional products, Try-Foods International, Inc. at 1-800-421-8871.

CONSIDER EXTRA PLASTIC MULCH

Consider laying some extra rows of plastic mulch as you prepare land for fall planting of strawberry plug plants. Several growers do so, getting on their land in early spring for earlier vegetable plantings. They also find the wheel punches they use for strawberries are ideal for direct seeding early sweet corn, bean and other early veg. crops. Everything from peas to squash have been early produced by this technique. Personally, I feel it does a faster, better job as a seeding aid than wheel punches do as planting aids for strawberry plugs! With 4 seats on punchers, the front two people drop the seeds, the rear two “squinch” a bit of soil over and firm in the seed, planting a double-rowed bed 300' long in less than 12 minutes. I’ve seen 2 crops of strawberries, then a crop of fall pumpkins, then the following spring for the 4th crop on “recycled” mulch and drip lines, a final crop of double-rowed sweet corn. Let’s use it up and wear it out!

They also use their winter crop covers over these early seedings to get a bit of frost control and to exclude crows, other birds and insects from early plantings, removing the covers after 3 weeks or so from emergence. They gain faster growth under the covers after very uniform, rapid emergence leading to very uniform harvesting. Sweet corn growers report much better early season stands of all types of sweet corn, including the supersweets, with the combination seedings on raised beds covered with black plastic mulch plus the early use of crop covers.

Melon growers can also make such early direct seedings. Using the crop covers, they save the expensive use of transplant plug plants, offsetting the cost of crop covers (good covers last for several seasons). Remember how sweet (late) this past spring was, and remember, you cannot make use of these early planting potentials unless you make some extra beds and lay some extra plastic mulch with drip tape this fall! Use the same pre-beds application of fertilizer and lime you would use for fall-planted strawberries, then add extra nitrogen or nitro/potash during the crop cycle next year at normal sidedress timings for that enterprise. For berry growers in colder areas, laying some extra plastic now means you will be in a position to test-plant some plug plants of Late Star next summer that should be available from commercial greenhouse-grown mother plants producing greenhouse tips in June.

MINIMIZE STRAWBERRY GRAY MOLD FRUIT ROT NEXT SPRING

At the 1997 Southeast Strawberry Expo held annually at Raleigh, NC, in November, Laura Carver, a graduate student at NC State University's Department of Plant Pathology, presented an excellent paper on Gray Mold Development and Strawberry Plant Phenology Throughout The Southeastern Production Season, which we all need to study carefully before next spring's big rush! It is too late for controlling Gray Mold now, since plant diseases are only controlled by prevention. I highly recommend you order a copy of The Proceedings, 1997 SE Strawberry Expo from: NC Strawberry Association, 1138 Rock Rest Road, Pittsboro, NC 27312. Send a check for $10. made to NC Strawberry Association; I guarantee this one paper is worth far more to growers than the cost of the whole proceedings! I will attempt to provide a few highlights of this paper to whet your interest, but you need the entire work to plan your strategy for improved control of Gray Mold fruit rot next spring (especially if it's another wet spring such as we had in 1998).

Gray Mold, caused by the fungus Botrytis cinerea, has long been a problem in strawberry production systems, causing field and postharvest fruit rot. Maturing on dead or dying plant tissue, the Gray Mold fungus produces small structures termed conidiophores upon which thousands of microscopic spores are attached. These spores are spread by both wind and water movement, potentially landing on newly emerging fall and spring leaf tissue, establishing a latent, resting, grower-invisible infection in fall, winter or early spring, causing no damage at this point.

Once these leaves naturally senesce or turn brown and die, Gray Mold awakens in early spring with the advent of warmer temperatures and resumes growth and sporulates, just in time to infect the newly emerging leaves, then flowers, causing the subsequent development of Gray Mold on the berries. We should plan to spray during first spring season's plant growth flush, first bloom, main bloom and late bloom during spring. If rains of 1/2" or more occur, washing off protective fungicides for Gray Mold, reapply ASAP. Some said "it was too wet to spray." Our successful growers sprayed and resprayed during bloom; they found a way to get the job done between rains. Yes, they have a big fungicide bill, and a big $500. to $700./acre dead leaves/dead runners beds cleaning labor bill on carry-over fields, but they

have been picking beautiful berries and selling at premium prices this spring, thanks to El Nino Muy Grande in California.

The infection you see on berries during harvest occurs in the blooms and is expressed later in your developing and especially your ripening fruit. Virginia growers who attended the Strawberry Expo got this message; they are really making money this spring with almost no Gray Mold, enjoying this past week's wholesale price increase. I'm hearing $14, even $16 per single layer flat wholesale this week for strawberries! If you are throwing rotted berries out of your crop, there went your potential profit. We circulated this Gray Mold control strategy during our winter meetings, but no one realized back then what a problem Gray Mold would be this spring.

Typical management practices growers may use to control Gray Mold are definitely too late for effective control; the spores were spread onto new growth and blooms long before we may have thought about this disease. We don't see any symptoms until fruit development and ripening. We may have been applying up to 6 or more fungicide sprays for Gray Mold during harvest season, continuing periodically throughout all the harvest, with very little effect. This intense fungicide program is not only expensive, it is wasted and may assist the development of fungicide-resistant Botrytis strains. Sprays during harvest also can raise public health or food safety concerns of fungicide residues on the fruit (and plants customers must contact to harvest the fruit, especially at U-Pick farms).

Most research on Gray Mold, including its disease cycle, has been conducted in earlier years on the typical perennial matted row production system. In order to use more efficient management practices today, it is necessary to evaluate the biology of Botrytis to determine its relationship to strawberry growth and development in plasticulture systems of the Southeast. Grower and our research experience in Virginia, especially in multi-year plasticulture systems with southern and hardy Eastern U.S. varieties, is that Gray Mold can always have the potential to be worse on older carry-over fields, unless dead plant runner growth and old dead leaves were removed before the new spring flush of plant growth. No current strawberry varieties are resistant to Gray Mold disease!

The focus of Laura Carver and associates' study was to determine the primary source of inoculum for Gray Mold fruit rot in the spring, and secondly to document strawberry plant growth and development on the plastic mulch production system. Note: Gray Mold is generally worse in a wet spring on a plant-crowded or heavy foliage canopy, matted-row production system where fruit touches soil or wet, slow-drying straw or other organic mulches.

Two field experiments were conducted in NC, each with 3 treatments varying by source of transplant. In the first test, only the cultivar Chandler was used. Two treatments were planted from bare roots and obtained from 2 distinct regions of Canada; the third treatment was planted as a plug plant grown in NC (from Canadian-produced runner tips). For the second experiment, treatments varied by cultivar Camarosa, Chandler and Sweet Charlie, all obtained as bare root plants from a single source.

Three possible sources of primary inoculum were evaluated at each site: 1) native plant species that might potentially harbor Gray Mold mycelium or spores; 2) soil, a possible overwintering site for the sclerotial form; and, 3) transplants that may be capable of introducing latent infections into the field. On studying this paper, I was relieved to note they found no indication of Gray Mold on soils or on native plant material. However, when they incubated strawberry foliage from the newly set plots at time of transplanting, bingo! The percentage of latent infection being brought into the field ranged from 12 to 66% of all leaves sampled, plugs or bare roots made no difference. Thereafter, newly emerging leaves sampled monthly across the fall and early winter showed a very high percentage of infected leaves.

So now we know, we were loaded with Gray Mold infection long before bloom or fruit development in the spring! I expect our dormant-dug Eastern U.S. bare root plants would show similar results, since Gray Mold is found everywhere there are strawberries.

A very sustainable idea generated by this paper is that we CAN greatly reduce Gray Mold infection by removing all dead leaves and runner growth in late winter and early spring. Get the dead growth of old runners and old leaves off the plastic mulch even on new plantings where dead leaf growth is present (hopefully, fewer runners on new plantings).

Next on the Gray Mold control agenda, after dead leaves and runners removal, is to apply a thorough, tank-mix fungicide spray to the plants just as the new spring foliage growth flush occurs, coming usually by early March to warmer, lower elevation areas, usually about early April here. Don't wait until first bloom to begin, but complete perhaps 4 such combination tank-mix sprays before first fruit ripens. Waiting until you see Gray Mold developing on ripening fruit to apply later sprays during harvest season is a waste of money and your time! Combination tank-mix fungicides alternated as per our VCE Pub. 456-420 reduce single fungicide-resistant fungus "escapes." Check your annually updated Cooperative Extension fungicide recommendations as per VCE Pub. 456-420.

A big advantage to consumers by this approach is that we don't load ripening fruit and foliage with visible fungicides. Late winter plant cleaning plus four well-timed and early sprays, one at first growth flush after cleaning off dead plant growth from the raised, plastic-mulched beds, a second at first to 10% bloom, a third at full bloom, and a fourth at late or extended bloom, will, together with removal of dead plant material from the beds, reduce your former Gray Mold management program costs by 50% to 75% (from 6 to 8 wrongly timed sprays down to 4 properly timed sprays), provide much less Gray Mold, and provide clean fruit and harvesting environment with no spray residues! Good, strawberry-committed Virginia growers proved it again in our very wet bloom/harvest 1998 year! In visits to grower fields, we've noted great variation concerning grower successes and failures to control Gray Mold this spring. The consistent pattern was that where growers applied (and reapplied in wet weather) pre-bloom and bloom fungicide sprays, Gray Mold was effectively controlled. We CAN whip it!

Notes