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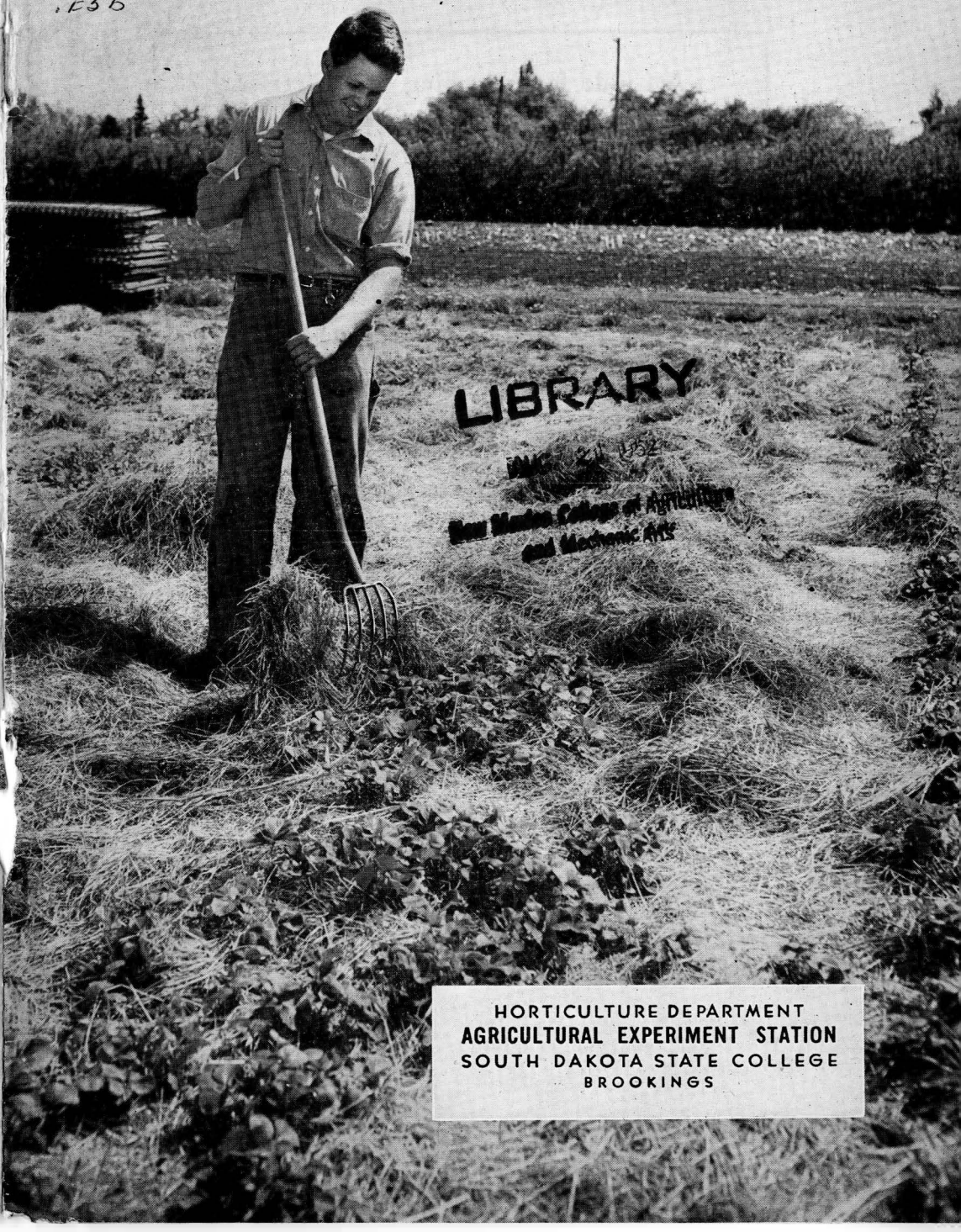
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# *Mulching* STRAWBERRY PLANTS 420 *for Winter Protection*

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BROOKINGS

## **A Guide for Mulching Strawberries**

As most strawberry plants suffer losses during the severe South Dakota winters, the practice of mulching is advisable.

**What to use for mulch:** Straw and hay are good mulches. To rely on a snow cover is not satisfactory. A supply of straw or hay should be readily on hand in fall so as to insure the proper covering at the right time.

**When to apply the mulch:** Two factors are of importance in determining at what time mulch should be applied: (a) varieties differ in their ability to prepare themselves for winter. This is called development of hardiness. (b) weather conditions have to be considered. Cool and sunny weather checks plant growth and develops hardiness. A short period of warm weather may cause the plant to lose its hardiness. Mulch should be applied after a week or more of near freezing temperatures. As weather conditions vary, plants will not harden at the same calendar date each year. Therefore weather reports will have to be watched so as to be able to apply the mulch at the correct time.

**Thickness of mulch needed:** The thickness of the mulch should not exceed 2 inches. In heavier mulch ice may form more easily and this will reduce the mulch's effectiveness.



Influence of mulching dates on plant survival for different varieties of strawberry plants

## MULCHING STRAWBERRY PLANTS FOR WINTER PROTECTION

S. A. McCrory and WILLIAM LAZARUK<sup>1</sup>

Mulching strawberries as a winter protective measure is of considerable interest to South Dakota strawberry growers, as the plants that are not protected incur great losses during the severe winters. It is known that strawberry varieties differ in their ability to withstand the cold weather and some develop greater hardiness than others, but there does not seem to be a variety hardy enough to withstand all winter conditions without some loss.

Though the practice of mulching with hay and straw is an old one, and has in many instances proved to be successful, this type of protection is a controversial issue among strawberry growers, as the same practice

that will afford good protection one year will fail to do so another year.

In order to find out why the mulching practices are so unreliable, a research project was undertaken and the results are given in this bulletin. The first part of the bulletin deals with field mulching practices, in particular with the influence of mulching date and thickness of mulch on plant survival. The second part investigates plant response to climatic conditions, in particular, plant food reserves in their relation to hardiness.

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After four years of mulching on October 26, most of the plants to the left are killed. On the right, plants were mulched later and have maintained a good row

## Field Mulching

As the practice of mulching has proved successful in some years, the first step in this experiment was to find out what possible influence the time of mulching could have on the ability of the plant to survive the winter. Therefore, mulching dates were selected without regard to the weather or condition of the plants. The second step was to measure the protection afforded by different thicknesses of mulch.

### Mulching Dates Influence Plant Survival and Yield

In the spring of 1945 the varieties Senator Dunlap, Premier, Aberdeen and Fairfax were planted in adjacent rows where good growing conditions could be provided. Rows were spaced 4 feet apart with plants spaced 18 inches in the row. By the end of the growing season a matted row, approximately 2 feet wide, had been developed from runners. Units 33 feet in length were selected for replications. These replications ex-

tended across the planting and included all four varieties. Three replications for each treatment were used.

On October 26 the first group was covered with 2 inches of marsh hay. Group two received a similar covering on November 10, and group three was mulched on December 1. Three replications were left unmulched. In early May the mulch was removed, leaving only enough to keep the fruit clean. The unmulched or check plots were then provided with mulch equal to that

left over the other plots. At the end of the fruiting season the rows were cultivated and conditions were made favorable for new runners to set plants. By this method the same row was maintained for four years with the above described mulching treatment being repeated each year. In 1946 the variety Burgundy was added as a new row.

Originally, the plan was to measure the yield from each plot for comparison. The great variation in the number of plants per plot made this an inaccurate means. Since it was necessary to count the plants to determine survival, it was decided to measure yield on a plant basis. Results are shown in Table 1.

Senator Dunlap has long been considered a dependable variety. It is interesting to note that for the 4-year period the greatest yield for that variety was from the latest

mulched plot, December 1. Aberdeen appears to benefit from an earlier mulching in two of the four years tested. Premier and Fairfax were favored by earlier mulching, but for some years during the test they were favored by late mulching. Neither Premier nor Fairfax is considered dependable by local growers. These varieties may require such specific conditions to induce hardiness that they may seldom be ready for winter.

By combining the average for the four years, the yield in quarts per acre is expressed in Fig. 1.

Since the varieties Premier and Fairfax suffered great winter loss the first year, another variety, Burgundy, was added the second year. With hardy varieties such as Senator Dunlap and Burgundy, few plants were killed when protected by mulch. Fairfax and Premier were

Table 1. Number of Berries per Plant as Influenced by Mulching Date.  
Average of Three Replications

Variety	Year	Oct. 26	Nov. 10	Dec. 1	Check
Senator Dunlap .....	1945	4.60	5.01	7.30	5.40
	1946	1.08	1.38	1.73	.55
	1947	2.44	2.87	3.24	2.67
	1948	.22	.45	.93	.17
	<b>Average</b>	<b>2.08</b>	<b>2.43</b>	<b>3.30</b>	<b>2.19</b>
Aberdeen .....	1945	4.09	5.05	4.66	2.78
	1946	1.91	2.75	2.97	.75
	1947	3.27	5.05	4.67	2.77
	1948	.16	.36	.93	.44
	<b>Average</b>	<b>2.36</b>	<b>3.30</b>	<b>3.31</b>	<b>1.69</b>
Premier .....	1945	5.05	4.69	2.12	2.11
	1946	1.07	1.13	.29	.43
	1947	4.52	5.04	2.94	2.86
	1948	.65	.64	.92	.15
	<b>Average</b>	<b>2.82</b>	<b>2.87</b>	<b>1.58</b>	<b>1.39</b>
Fairfax .....	1945	2.82	3.03	5.13	1.76
	1946	2.11	2.32	1.60	.67
	1947	3.25	1.68	2.48	.37
	1948	.00	.20	.35	.00
	<b>Average</b>	<b>2.04</b>	<b>1.81</b>	<b>2.39</b>	<b>.70</b>



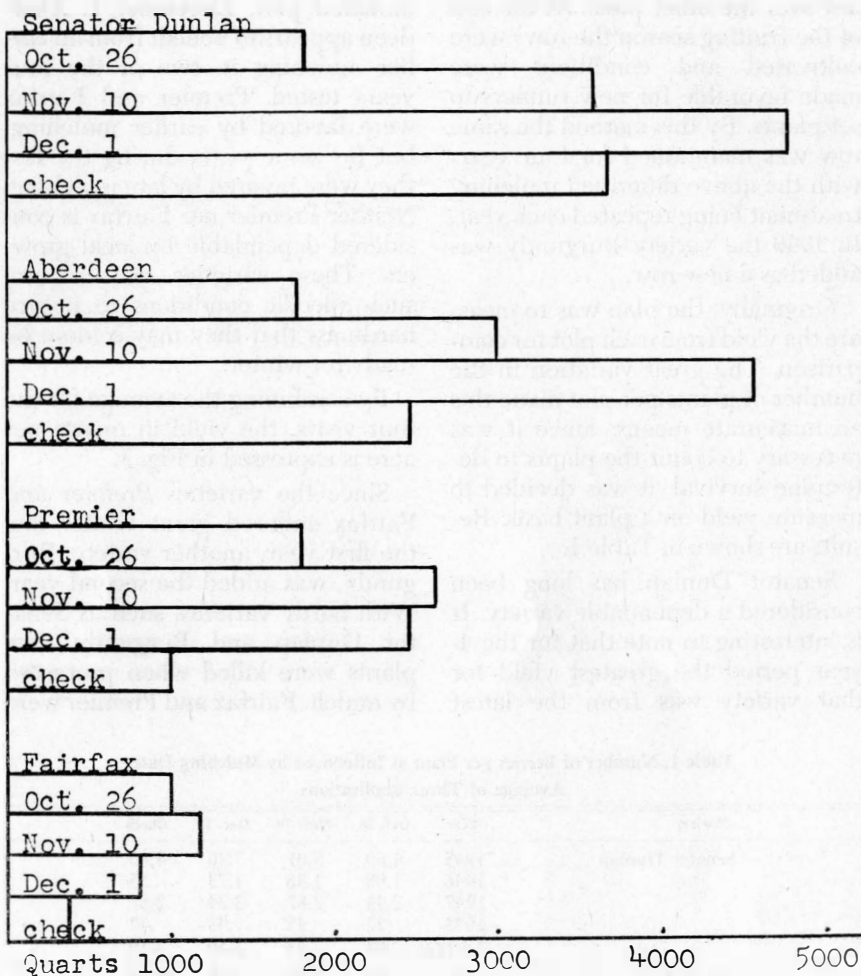


Fig. 1. Average number of quarts per acre annually (1945-48) when mulched at three different dates

less dependable, as shown in Table 2. The loss was generally associated with old plants and may have been influenced by disease. Since the planting was retained for the four years of study, the plant loss became increasingly greater. For that reason, data are not presented after the second year. On a basis of plant sur-

vival, it appears that there are great differences between varieties in their reaction to mulching dates.

### Early Mulching Resulted in Earlier Blossoming

The blossom buds of the strawberry are formed in late summer and spend the winter in the crown

of the plant. The vegetative part of the plant appears to tolerate a lower temperature than do the flower buds. Data in Table 3 were collected to see if mulching date was responsible for cull fruit. It was observed that the date of flowering was from one to four days earlier with plants mulched October 26 than for those mulched December 1. This influenced pollination and sometimes resulted in frost injury. These were the principal factors contributing to cull fruit. Premier is

an early flowering variety and appears to suffer most. However, the amount of cull fruit a plant produced did not show correlation with the mulching date.

### Thickness of Mulch Needed

Material for mulching strawberries is generally difficult to obtain, which may lead to inadequate coverage. An attempt was made to measure the protection afforded by 1, 2, and 4 inches of mulch. Accurate

Table 2. Plant Loss When Mulched at Different Dates

	1946 Plants		1947 Plants	
	Live No.	Dead %	Live No.	Dead %
<b>Senator Dunlap</b>				
10/26 .....	99	3.3	151	4.1
11/10 .....	132	2.3	149	3.2
12/1 .....	119	2.9	142	3.4
Check .....	107	2.3	139	5.0
<b>Aberdeen</b>				
10/26 .....	91	6.0*	82	6.8
11/10 .....	111	1.5	103	4.8
12/1 .....	85	2.5	88	6.4
Check .....	85	2.3	82	6.8
<b>Premier</b>				
10/26 .....	74	5.5	65	12.3
11/10 .....	67	10.3*	71	11.6
12/1 .....	54	5.9	85	10.6
Check .....	90	9.3*	72	15.6
<b>Fairfax</b>				
10/26 .....	67	6.6*	39	12.1
11/10 .....	85	4.6	43	41.0*
12/1 .....	59	3.8	46	15.0
Check .....	56	7.1*	33	63.0*
<b>Burgundy</b>				
10/26 .....	105	1.3	143	6.9*
11/10 .....	104	.0	136	7.1*
12/1 .....	107	.3	134	3.2
Check .....	119	.6	131	3.3

\*Indicates statistical significance for date of mulching.



measurement is difficult, and results should be considered as preliminary. A temperature recording instrument was placed in the field when the mulch was applied. The minimum and maximum temperatures recorded for a 24-hour period at weekly intervals are presented in Table 4. It is appreciated that absence of replications reduce the validity of data. The instrument was accurate to within two degrees.

The lowest temperatures during January, February and March were more frequently found to be under the greatest thickness of mulch. Since this is contrary to what one

would expect, some explanation appears in order. A snow in December covered the field and sifted into the straw covering. Subsequent warmer weather caused thawing. With the thicker mulch, ice was formed over the ground and through the mulch. The lighter mulch permitted complete thawing of snow.

Yield data are presented in Table 5. Although not statistically significant, there was a trend toward increased yield when 2 inches of mulch was applied. The temperature under 1 inch of marsh grass was never so low but that it could be tolerated by strawberry plants, as indicated by later tests.

Snow does not thaw fast in a mulch. The thicker the mulch the slower the rate of thawing. The area in the foreground of the picture was left bare. Note how the snow has melted in this part of the field. In the background of the picture, the field was covered with a mulch and the snow has not melted



Table 3. Influence of Mulching Date on the Percent of Cull Fruit

Variety	Year	Percent of Cull Fruit			
		Oct. 26 %	Nov. 10 %	Dec. 1 %	Check %
Senator Dunlap .....	1945	12.0	9.7	7.7	14.8
	1946	13.8	34.9	30.0	47.6
	1947	34.5	34.8	33.4	42.0
	1948	68.0	43.0	40.7	41.3
	<b>Average</b>	<b>32.0</b>	<b>30.6</b>	<b>27.9</b>	<b>36.4</b>
Aberdeen .....	1945	16.2	12.7	13.1	16.0
	1946	25.0	22.5	28.5	36.4
	1947	40.9	33.5	35.4	45.4
	1948	71.9	55.5	37.5	51.0
	<b>Average</b>	<b>38.5</b>	<b>31.0</b>	<b>28.6</b>	<b>37.2</b>
Premier .....	1945	18.0	11.6	30.1	9.8
	1946	19.5	22.6	17.1	27.1
	1947	30.9	33.8	28.2	37.0
	1948	59.6	51.8	42.1	61.5
	<b>Average</b>	<b>32.0</b>	<b>29.9</b>	<b>29.3</b>	<b>33.8</b>
Fairfax .....	1945	15.5	16.2	14.3	18.1
	1946	11.6	20.8	19.0	39.0
	1947	29.3	40.8	29.1	52.5
	1948	0	55.5	57.3	0
	<b>Average</b>	<b>18.8</b>	<b>33.3</b>	<b>29.9</b>	<b>36.5</b>

Table 4. Minimum and Maximum Temperatures Recorded Under Different Thicknesses of Mulch During January, February, and March, 1947. Readings for 24-hour Period, Made at Weekly Intervals

Date	4" Mulch		2" Mulch		1" Mulch	
	Min. °F.	Max. °F.	Min. °F.	Max. °F.	Min. °F.	Max. °F.
1/12 .....	12	20	12	22	16	23
1/18 .....	9	20	16	25	22	25
1/24 .....	23	34	24	32	24	25
1/30 .....	14	20	15	20	16	21
<b>Average</b> .....	<b>14.5</b>	<b>23.5</b>	<b>16.75</b>	<b>24.75</b>	<b>19.5</b>	<b>23.5</b>
2/6 .....	4	16	3	16	15	17
2/13 .....	20	33	20	35	23	30
2/20 .....	10	20	14	22	15	20
2/27 .....	9	22	11	22	12	22
<b>Average</b> .....	<b>10.75</b>	<b>22.75</b>	<b>12.0</b>	<b>23.75</b>	<b>16.25</b>	<b>22.25</b>
3/6 .....	23	26	16	26	17	18
3/13 .....	4	26	1	26	18	24
3/20 .....	16	24	18	26	22	23
3/27 .....	15	40	14	38	22	24
<b>Average</b> .....	<b>14.5</b>	<b>29.0</b>	<b>12.25</b>	<b>29.0</b>	<b>19.75</b>	<b>22.25</b>

Table 5. Marketable Berries per Plant When Four Varieties Were Mulched at Depths of 1, 2, and 4 Inches. Average of Three Replications

Variety	4" Mulch	2" Mulch	1" Mulch	Check
Aberdeen .....	6.52	6.16	5.87	4.12
Pathfinder .....	2.72	4.41	2.59	3.39
Premier .....	4.87	5.42	6.36	6.86
Fairfax .....	5.38	5.70	5.68	2.98
<b>Average</b> .....	<b>4.87</b>	<b>5.42</b>	<b>5.12</b>	<b>4.34</b>

## Plant Response to Climatic Conditions

From the data collected over a 4-year period, it is apparent that strawberry plants cannot be mulched at any particular calendar date with reasonable assurance that they will survive the winter well. Since the results varied for different years and different varieties, it seems that knowledge of plant behavior is essential for the establishment of a successful mulching program.

### Hardiness Is Associated With Plant Food Reserves

It is known that the carbohydrate content has some relation to the hardiness of plants. For example, the carbohydrate content in cabbage plants increases when they are "hardened" in preparation for transplanting. Therefore, the carbohydrate accumulation in strawberry plants was studied. Plant carbohydrates may be in the form of starch or sugars. In this report reference is made to total sugars. Both quantitative and qualitative data were collected.

Senator Dunlap plants from a 1-

year-old planting were used for this part of the study. The sugar content of the leaves, weather conditions and growth behavior were recorded at weekly intervals through the growing period (Table 6). It is to be noted that the sugar content is reduced following hot dry weather and during periods of growth. The greatest increase in sugar content occurred following cool weather but dropped quickly after a week of warm weather (Table 6, data for November 12 and Fig. 2).

Field-grown plants were studied from October 1 to December 9. Leaf samples were collected at bi-

Table 6. The Sugar Content of Senator Dunlap Strawberry Leaves During the Growing Season, May 17 to December 9, 1949

Date of Sample Collection	Total Sugars Mg./G.	Growing Conditions	Description of Growth
5/17 .....	56.9	Good	Early flowering
6/10 .....	46.7	Good	Green fruit
6/24 .....	54.8	Good	After fruiting
7/1 .....	68.5	Hot	Little growth
7/7 .....	56.2	Hot and dry	No growth
7/18 .....	37.0	Hot and dry	No growth
8/1 .....	36.6	Hot and dry	No growth
9/26 .....	59.1	Fair	Runner growth
10/1 .....	63.6	Good	Runner growth
10/15 .....	70.6	Fair	Few runners
10/28 .....	85.3	Cool	Few runners
11/4 .....	124.7	Cold	No growth
11/12 .....	69.9	Warmer	Some growth
11/18 .....	107.7	Cold	No growth
11/25 .....	114.62	Cold	No growth
12/2 .....	151.6	Cold	No growth
12/9 .....	160.4	Cold	No growth

Table 7. Sugar Content of Six Varieties of Strawberry Plants During the Hardening Period, October 1 to December 9, 1949

Date of Sampling	Senator Dunlap	Burgundy	Premier	Fairfax	Gem	Streamliner
10/1	63.6	59.0	42.2	70.4	61.4	63.4
10/15	70.6	78.7	84.4	71.6	60.5	45.8
10/28	85.3	99.8	85.0	81.8	74.8	59.4
11/4	124.7	112.0	92.4	132.7	107.2	115.1
11/12	69.9	67.3	62.6	81.7	70.3	54.1
11/18	107.7	120.3	126.4	120.5	107.4	143.5
11/25	114.6	151.9	141.8	126.3	119.8	143.2
12/2	151.6	137.2	133.8	138.4	117.0	144.9
12/9	160.4	138.0	146.7	139.5	127.8	138.9
Average	134.5	136.8	137.1	131.1	118.0	142.6

weekly intervals thereafter. Six varieties were included in the report, of which two were everbearing.

While it cannot be said with certainty that accumulation of carbohydrates is proof of winter hardiness, there is a parallel between the sugar content and hardiness in the variety Senator Dunlap (Table 7). Premier shows the fastest rate of

sugar accumulation while Senator Dunlap does not respond so rapidly. The two everbearing varieties show a loss in sugar content through most of October.

Premier, which earlier studies show benefits by an early mulch, responds rapidly to a few days of cool weather (Tables 7 and 8). Samples collected November 12 had been ex-

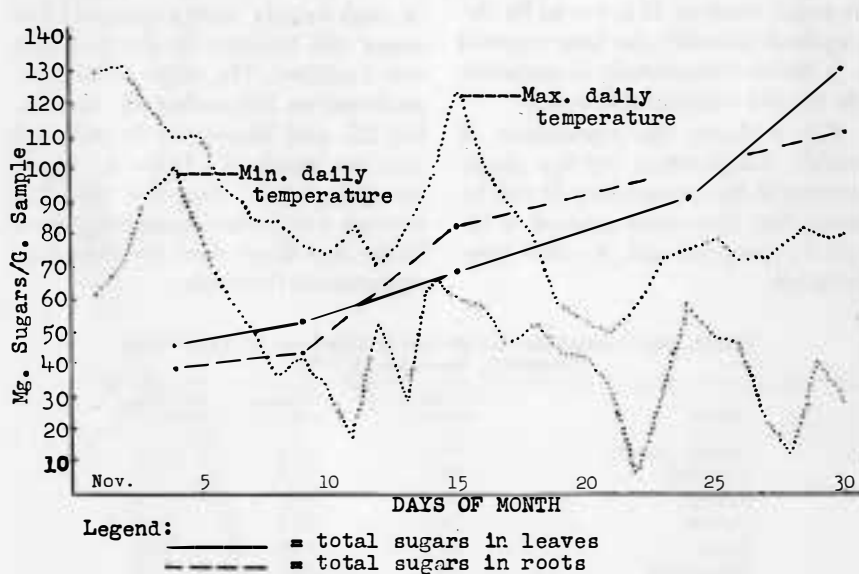


Fig. 2. Effects of temperature on sugar content of strawberry plants, Nov. 1948

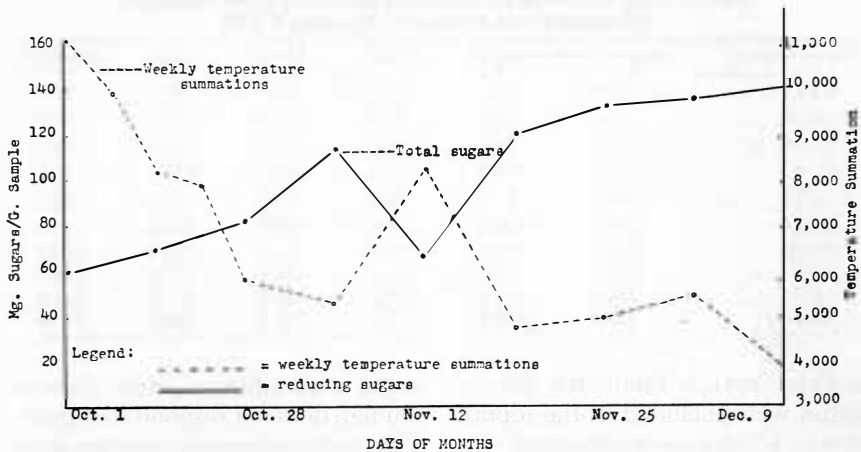


Fig. 3. Effects of changes in temperature, during the fall of 1949, on the average sugar content of the six varieties of strawberry plants

posed to a week of warm weather, and the sugar content was low. The following week was cool, and all varieties showed a marked increase in sugar content. Premier doubled its sugar content. It is yet to be determined whether the time interval or a lower temperature is responsible for this varietal difference.

Fig. 3 shows the correlation of weekly temperature on the sugar content of the six varieties. It will be noted that the sugar content is inversely proportional to the temperature.

### Early Mulched Plants Have Low Sugar Content

Units of 50 plants of each of the six varieties were set up. Ten plants of each variety were replicated five times. On October 28 the first unit was mulched. The other units were mulched on November 12, November 25, and December 9; one unit was not mulched (Table 8). Snow covering made data for the December 9 and check mulching unreliable and these data are therefore not given in the table.

Table 8. Sugar Content Mg/G of the Leaf Samples From the Three Mulch Treatments, November 25, 1949

Variety	Total Sugars October 28	Total Sugars November 12	Total Sugars November 25
Senator Dunlap .....	60.5	93.6	124.0
Burgundy .....	109.1	124.4	153.8
Premier .....	61.3	97.8	137.5
Fairfax .....	59.6	68.2	124.8
Gem .....	69.8	70.8	98.1
Streamliner .....	59.4	100.9	139.2
<b>Average</b> .....	<b>70.0</b>	<b>93.0</b>	<b>130.0</b>

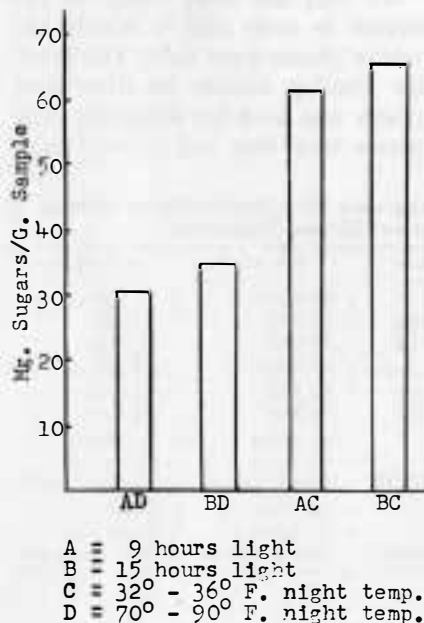
Table 9. Sugar Content of Leaf Samples of Fairfax Strawberries Receiving Different Temperature and Light Treatments (Mg/G)

Treatments	Total Sugar
9 hours daylight 70° to 90° F. ....	30.47
16 hours daylight 70° to 90° F. ....	34.49
9 hours daylight 32° to 90° F.* .....	61.46
16 hours daylight 32° to 90° F.* .....	65.81

\*Plants were placed in the refrigerator every third night for the first week, then every second night for a week, and every night thereafter for 30 days.

On November 25, just before the third mulching date, leaf samples were collected from all varieties of each of the three treatments. The amount of sugar extracted from the leaves is shown in Table 8. A marked increase of sugar in Treatment 3 over those mulched earlier is undoubtedly associated with a longer exposure to light. Since plants

Fig. 4. Effects of pre-cooling and controlled light treatments (July 6 to August 20, 1949) on sugar content of the Fairfax strawberry plants



under a mulch receive but little light, they cannot synthesize carbohydrates at as great a rate as those exposed to light.

The general trend of the increase of the sugars is the same for every variety, although varietal differences are present.

Strawberries mulched as late as November 12 showed a significant decrease in rate of sugar accumulation.

The early mulching of plants prevented maximum hardening, which better enables the plants to survive the low winter temperatures. Low temperature alone does not appear to be sufficient to induce similar increases in sugar as occurred in the unmulched treatments.

### Cool Weather and Sunshine Cause Sugar Accumulation

To measure the influence of temperature on sugar accumulation in strawberry leaves, 16 plants of the Fairfax variety were potted in 6-inch flower pots and grown outside. On July 6 these were divided into four groups for different treatments. Results are shown in Table 9 and Fig. 4.

From these data it is evident that a temperature slightly above the

freezing point will induce sugar accumulation in the strawberry leaf even in mid-summer. The length of day did not appear to influence the sugar content materially. Early fall weather will provide conditions similar to those found most advantageous for maximum sugar accumulation. When nature offers such conditions, plants harden themselves well and will frequently survive winter without mulch protection.

### Hardiness Is Related To Sugar Content

Potted Fairfax plants described above were placed in a refrigerator at below freezing temperatures to measure their tolerance of cold. This was in early August and plants had been outside except for those chilled overnight for a 30-day period. The temperature of the refrigerator remained constant at 14° F., and plants were removed after 2, 4, 8, and 10 hours of exposure. Results are shown in Table 10.

This appears to be the answer as to why strawberries die when mulched prematurely or when warm fall weather is followed by severe cold weather. From data in Tables 9 and 10, there appears to be an association between sugar content and ability to tolerate low temperature.

Freezing tests over 2, 4, 8, and 10 hours were conducted and plants from each treatment were tested at all freezing periods. It was noticed that at the end of every freezing period the leaves and the soil were frozen solid. After each freezing treatment the plants were returned to the cold frames (Table 10).

### Analysis of Roots and Leaves for Sugar Content

To find the relationship of the sugars in roots and in leaves, the whole plants were used. The Senator Dunlap variety of strawberry plants was used for this study. The plants were dug and washed thor-

Table 10. Injury Observed in Leaves of Plants Subjected to 14° F. Freezing Tests After Being Subjected to Different Day Length and Different Temperature

Treatments	2-hr. period	4-hr. period	8-hr. period	10-hr. period
Short day	a.* Slight wilt	a. Slight wilt	a. All wilted	a. All wilted
normal night	b.† Margins dead	b. Margins dead	b. All dead	b. All dead
temp.	c.‡ Margins dead	c. Margins dead	c. All dead	c. All dead
Long day	a. Margins wilted	a. Margins wilted	a. All wilted	a. All wilted
normal night	b. Margins dry	b. Margins dead	b. All dead	b. All dead
temp.	c. Margins dead	c. Margins dead	c. All dead	c. All dead
Short day	a. No injury	a. No injury	a. No injury	a. No injury
low night	b. No injury	b. No injury	b. No injury	b. No injury
temp.	c. Normal growth	c. Normal growth	c. Normal growth	c. Normal growth
Long day	a. No injury	a. No injury	a. No injury	a. No injury
low night	b. No. injury	b. No injury	b. No injury	b. No injury
temp.	c. Normal growth	c. Normal growth	c. Normal growth	c. Normal growth

\*a. Observation made 6 hours after freezing test.

†b. Observation made 2 days after freezing test.

‡c. Observation made 10 days after freezing test.





Late mulching resulted in plant loss (in front of the hand). From that point on plants survived well due to earlier mulching. Senator Dunlap to the right survived well under both conditions

oughly, the leaves separated from the roots and dried. Weekly samples were collected as shown in Table 11. The first samples of roots and leaves were collected November 4, 1948, and the other samples on November 9, 15, and 30, except for the sample on November 24 when only the leaf sample was obtained. The ground was frozen too hard at the time to permit digging of roots. After extracting, the amount of sugars per gram sample of material (air dry) was determined. Table 11 shows the variation in sugar content for the different dates of sampling.

The leaves of the plant appear to provide as accurate a means for measuring the sugar content as do the roots.

At intervals during the winter potted plants, described earlier and

Table 11. Sugar Content in Mg./G Sample (Air Dry) of Strawberry Plants, November, 1948

Date of Sample Collection	Root	Leaf
	Total Sugars	Total Sugars
11/4 .....	39.12	46.44
11/9 .....	43.30	53.07
11/15 .....	82.84	68.64
11/24 .....		90.72
11/30 .....	111.34	131.25

used for data in Table 12, were removed from under the mulch and placed on the ground near the frame. This gave full exposure to winter conditions, and since they were in pots the roots may have suffered more than if they were in the ground.

On December 2, eight pots from each mulching treatment were removed and exposed for 20 hours. During that time the temperature dropped to the following levels:

Below 21° F.....	19 hours
Below 10° F.....	16 hours
Below 0° F.....	8 hours
Below -2° F.....	4 hours

After exposure these plants were transferred to a greenhouse where the temperature was 62° F. There was no evidence of freezing injury after one week, and normal growth developed. The plants blossomed freely and produced fruit.

On December 20, twelve plants were removed from under each mulching treatment and placed beside the frame. These were exposed for 20 days. Temperatures were:

32° F. to 10° F.....	110 hours
20° F. to 10° F.....	95 hours
10° F. to 0° F.....	64 hours
0° F. to -5° F.....	73 hours
-5° F. to -10° F.....	39 hours
-10° F. to -14° F.....	15 hours

At the end of this exposure period the plants were transferred to the greenhouse (Table 12).

The first four days the plants were in the greenhouse the leaves showed no sign of injury. By removing the plant from the pot, some root surface could be examined. By the third day much browning of roots was in evidence. Leaf wilting started after one week in the greenhouse. This was first noticeable on plants from the October 28 mulching and appeared last on late mulched plants. In all cases, wilting and later killing appeared to be associated with root injury. As stated above, this was abnormal exposure. It is surprising that any plants survived as this was more severe exposure than would be experienced under natural conditions. Most potted

Plants in front were mulched November 10. Those beyond the men were mulched October 26





Applying mulch to strawberries

plants develop many roots around the inside of the pot. This subjected them to exposure to which field grown plants are not subjected. The fact that the only survival was with the last mulching, or with no mulch-

ing protection, suggests that the plants continue to harden well into the winter. It may also explain why unmulched plants sometimes survive the winter better than those that are mulched.

Table 12. Survival of Plants Mulched at Different Dates and Then Exposed to Outdoor Temperatures for 20 Days; Dec. 20, 1949 to Jan. 9, 1950

Date of Mulching	Survival of Plants After Exposure			
	1 Week	2 Weeks	3 Weeks	16 Weeks
10/28 .....	Wilted	All dead	All dead	All dead
11/12 .....	Wilted	All dead	All dead	All dead
11/25 .....	Some wilted	Badly wilted	All dead	All dead
12/9 .....	Wilted	8 plants wilted	4 plants alive	2 plants alive
Check .....	No injury	No injury	No injury	11 plants alive

## Summary

In the absence of a strawberry variety hardy enough to tolerate all winter conditions without loss, the practice of mulching for winter protection is desirable.

So far, mulching has not proved entirely satisfactory, as the same practice that offered good protec-

tion one year failed to do so in another year.

In an attempt to find out what causes the mulching to be so undependable, the study was undertaken and the following facts were brought out.

1. Marsh hay or straw is satisfac-

tory as a mulch. Snow covering alone is not dependable.

2. The thickness of the mulch should not exceed 2 inches. Heavier covering is conducive to ice formation in the mulch; the ice layer tends to lower the temperature under the mulch cover and by doing so defeats the purpose of the mulch.

3. The time of mulching is of the greatest importance to insure maximum plant survival. No definite date can be given. Different varieties respond to different mulching dates. In this connection it should be remembered that the ability of plants to prepare themselves for winter is associated with weather conditions. Hardiness in turn is in-

fluenced by the accumulation of plant carbohydrates.

4. The weather plays an important part in inducing the plants to store carbohydrates. The experiment showed that cool and sunny weather checks plant growth and is conducive to the development of hardiness. On the other hand, a short period of warm weather may cause a plant to lose its hardiness. Therefore mulch should be applied after a week or more of near freezing temperatures, and not after a few days of warm weather.

By watching the weather reports and having the mulch readily on hand, a planting can generally be covered in time to prevent injury.

A fine strawberry planting, belonging to Georgia Dillon, Tripp County

