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MULCH PAPER IN VEGETABLE PRODUCTION

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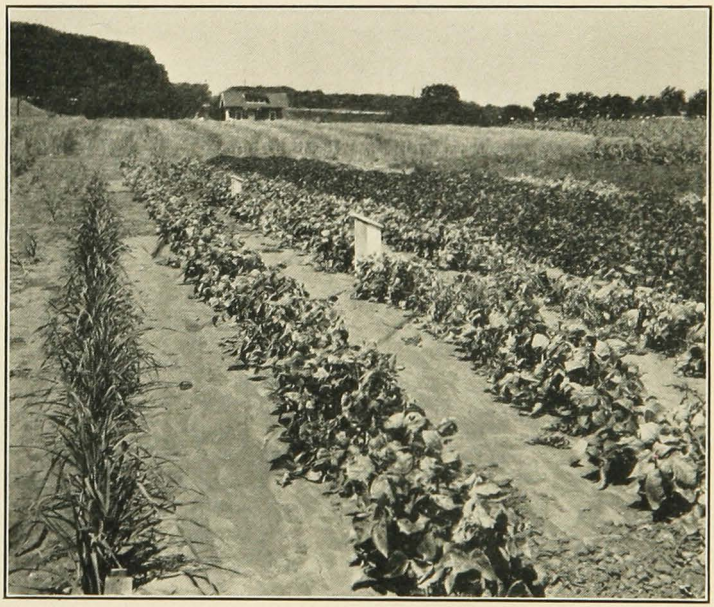

UNIVERSITY FARM, ST. PAUL

MULCH PAPER IN VEGETABLE PRODUCTION

A. E. HUTCHINS

The idea of using mulches in the production of crops is not a new one. Various types of mulches, such as soil, straw, or refuse, have been used for many years. However, the use of paper is a comparatively recent innovation.

One of the first to record the use of paper for mulching was Mrs. E. W. Berger, of Florida (1). She used the newspapers and wrapping paper that accumulated about the house for mulching roses and found them very effective, especially in controlling weeds and in decreasing the amount of labor required for proper culture.

C. F. Eckart (2) is usually given credit for developing the use of an impervious asphalt paper as a mulch. Eckart, the manager of a sugar plantation in Hawaii, was interested principally in finding a method of weed control that would be successful under the warm and very humid conditions existing in that country. In 1914, he started experiments in which a cheap asphalt paper was laid between the rows of cane. Altho this was found to be fairly successful, the weeds within the rows still remained and much labor was required to remove them. In 1916, an impervious asphalt paper was laid directly on the rows. This method proved satisfactory in the control of weeds and it was noted also that the plants in the mulched sections showed an increase in growth over those in the unmulched areas.

Encouraged by the results obtained in the sugar industry, the Hawaiian pineapple growers took up the use of paper in 1919 (6)(7). It proved so effective that about 90 per cent of the pineapple crop was grown in this manner in 1927.

With such outstanding results reported from Hawaii, it was inevitable that experiments would be undertaken in regard to the effectiveness of paper mulch in other parts of the world and with many other crops. Investigations have been made in many foreign countries, in Canada, and in the United States. Most of these experiments have been conducted with vegetables.

The first experiments of any consequence in the United States were conducted by L. H. Flint, of the United States Department of Agriculture (4)(5). He found that paper mulch was advantageous in vegetable production under the conditions of his investigations, as it:

1. Increased the yields for most crops tested.
2. Eliminated a large part of the weeding and cultivation.
3. Hastened the maturity of some crops.
4. Increased the germination in some cases.
5. Gave a product superior in size, quality, and cleanliness in certain crops.

The general beneficial results obtained in these investigations naturally led to many other experiments along similar lines. Mulch paper trials have been conducted at the Ohio (10)(11)(12), Michigan (3), Cornell (13)(14)(15), and many other state agricultural experiment stations and also in Canada (8)(9).

The results obtained by various workers indicate that mulch paper may affect the growth of plants by its influence on several environmental factors. Moisture may be conserved directly by the prevention of evaporation and indirectly by the elmination of weeds. Soil fertility is conserved by the elimination of weeds and several investigators have observed increased nitrification under the paper (11, 15, 17). Increased soil temperatures under the paper have also been reported (11, 15, 18). These are probably the main factors influenced, but other things such as soil texture and soil flora may be affected also.

Yields produced in these trials have been highly variable. Certain crops showed an increase under the paper treatment in some investigations; in others there were no benefits and, in some cases, there was an actual decrease in yield. While the majority of the trials reported show that some beneficial effect is exerted by the paper on plant growth and production, the increase in yield is often insufficient to pay for the additional expense incurred. Therefore, the value of a paper mulch in the production of vegetable crops is still an open question. It is a question of considerable interest among market and home gardeners. To obtain additional information in this respect, investigations with mulch paper were begun at University Farm in 1929 and continued in 1930 and 1931.

OBJECTS OF THE EXPERIMENT

The main objects of the experiment were to determine the effect of mulch paper on the yield and maturity of the vegetable crops grown in this region. In addition, attempts were made to determine a practical method of keeping the paper in place after planting.

PROCEDURE AND METHODS

The plots utilized for the experiment were on Hempstead silt loam that was highly fertile and retentive of moisture. In all cases, treatment of the plants on the mulched and unmulched plots was as nearly identical as possible with the exception that the unmulched plots were kept

clean cultivated by ordinary cultivation methods while the mulched plots were hand weeded when necessary.

In 1929, 28 species of vegetables, including 40 varieties, were tested. This included most of the important vegetable crops grown in this section and several of lesser importance. Early and late varieties of some of the more important crops were tested. These were planted in rows 132 feet long. In most cases, three rows of each of the more important crops were planted and data were taken on the central row at harvesting time. Usually only a single row of each of the crops of lesser importance was grown. The rows were divided into plots two rods long. Thus four plots were obtained, the first and third of which were mulched and the second and fourth clean cultivated. At harvest time, data were taken on the central rod of each two-rod plot. In a few instances, some variations were made in the number of plots, rows per plot, and plants per hill. More than one planting was made of certain rapidly maturing crops, such as radish, lettuce, and spinach.

In 1930, the number of species was reduced to sixteen. Many of the minor crops were dropped unless, for some particular reason, it was thought desirable to have a check on the results of the previous season. The experiment was laid out in a manner similar to that of 1929, except that the 132-foot rows were divided into six plots, each 22 feet long. Plots one, three, and five were mulched, and plots two, four, and six were clean cultivated. When more than one variety of a species was used, the varieties within the species were systematically distributed.

In 1931, only seven species were planted—cabbages, carrots, beets, cucumbers, potatoes, sweet corn, and tomatoes. These crops were selected to include both cool- and warm-season plants and hill and drilled crops. Most of these produce crops of fairly high value per acre. The reduction in number was made with the idea of growing each crop in the test more extensively with a corresponding increase in the accuracy of the results. The number of plants, rows, and plots was increased for each crop to such an extent as to make the experiment somewhat larger than in 1929 when more crops were grown.

Uniform planting distances and cultural practices were followed for the mulched and the cultivated areas in all three years. With crops that are drilled, 18-inch strips of paper were used. A strip was laid and the seed sown as close to its edge as possible. Then another strip was laid and the process repeated. Transplanted and hill crops were planted through the paper, the plants or seeds being placed at the proper distance in the row in the center of 36-inch strips.

In all cases, Type A Gator Hide mulch paper was used. This is a light weight, black, impervious, asphalt paper that has been much used

for annual crops. The paper was put in place and the crops planted as soon as it was possible to get on the soil after a rain. The 36-inch paper was laid with a machine (Fig. 1) especially designed for the purpose; the 18-inch paper was laid by hand.

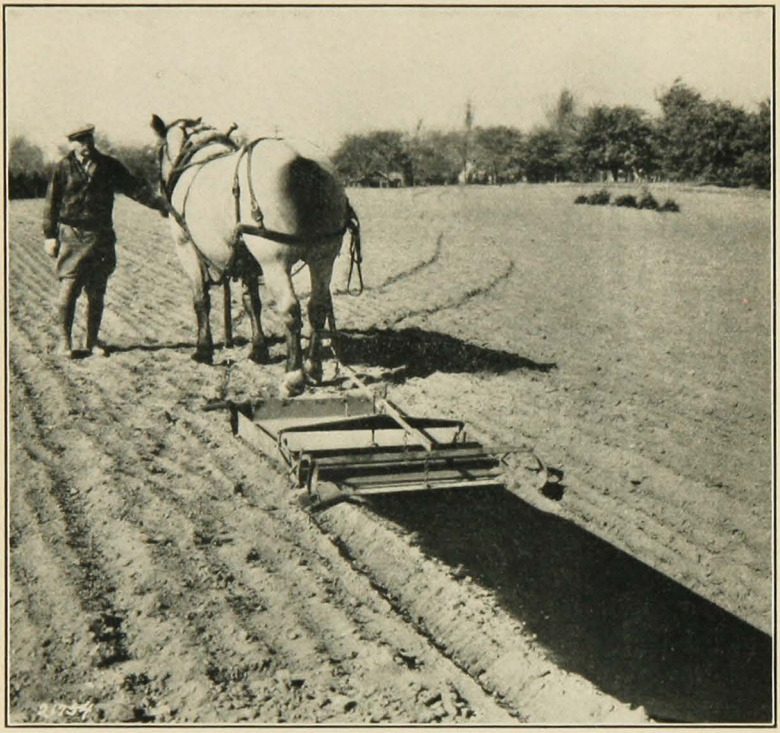

Fig. 1. Machine Designed for Smoothing and Packing the Soil, Forming the Plant Bed, Laying the Paper, and Covering the Edges with Soil in One Operation

WEATHER CONDITIONS

In Figure 2, it is noticeable that 1929 more nearly approached the normal in temperature and precipitation than did the seasons of 1930 and 1931. This is especially true for the months of June and July, when vegetable growth should be at its maximum. The years 1930 and 1931 were characterized by high temperatures and both were low in precipitation, especially 1931. In addition to this, Weather Bureau reports show that from January, 1929, to September, 1931, inclusive, there was a cumulative deficiency of precipitation of 15.88 inches as compared to the normal annual rainfall of 27.11 inches. Of this deficiency 6.10 inches occurred from January 1 to October 1, 1931. Weather conditions were fairly favorable for vegetable production at

University Farm in 1929, but owing to the combination of high temperatures and low precipitation were unfavorable in 1930 and 1931.

EFFECT OF PAPER ON TOTAL YIELDS

The per cent increase or decrease in total yield for the various crops in 1929, 1930, and 1931 is given in Table 1. In this table, a minus sign indicates that there was a lower yield on the mulched plots than on the corresponding cultivated plots. All other figures show an increase in favor of the paper.

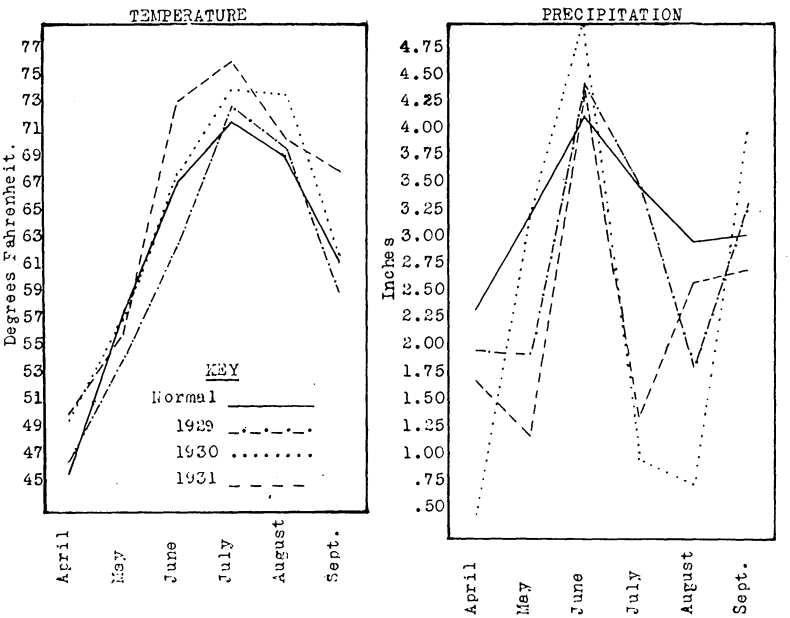

Fig. 2. Mean Monthly Temperature and Total Monthly Precipitation from April to September, Inclusive, 1929, 1930, and 1931, as Compared to Normal for Those Months, 1871-1931

Temperatures and normal precipitation from U.S.D.A. weather reports, St. Paul station; from monthly precipitation reports of Division of Soils, University of Minnesota.

The results obtained at University Farm as to total yield have been rather variable, particularly in 1929. Where paper was used in 1929, 59 per cent of the crops grown showed an increase and 41 per cent showed a decrease. Of the crops tested in both 1929 and 1930, 50 per cent gave increases and 13 per cent decreases in both years; 29 per cent gave an increase in one year and a decrease in the other; and 8 per cent showed no effect in 1930. Of those that were under observation throughout the entire experiment, 69 per cent gave increases or showed no decreases in all years; 16 per cent gave increases in two years; and 15 per cent gave increases in only one year.

Table 1

Per Cent Increase or Decrease in Total Yield of Vegetable Crops Produced with Mulch Paper as Compared with Those Produced under Cultivation

Crop	Variety	1929	1930	1931	Av. per year
Beans	Bush Lima	21.4			
Celery	Golden Self Blanching	14.9			
Celeriac	Turnip Rooted	18.4			
Garlic	Bavarian Selected	—26.7†			
Kohl-rabi	Early White	— 7.1			
Komatsuma	Chinese	47.5			
Lettuce	Grand Rapids (Leaf)	47.4			
Leek	American Flag	22.6			
Onion	Yellow Globe	—54.3			
Onion	Prizetaker	—41.9			
Parsnip	Guernsey	9.5			
Pumpkin	Fort Berthold	— 1.3			
Salsify	Sandwich Island	29.4			
Squash	Kitchenette	— 7.3			
Tomato	Golden Husk	55.4			
Beans	Improved Golden Wax	23.7	—38.5	....	— 1.6
Beans	Late Refugee	— 4.1	00.0	....	— 3.3
Eggplant	Black Beauty	—21.6	— 7.6	....	—14.9
Peas	Little Marvel	9.7	33.3	....	13.5
Peas	Telephone	77.8	40.0	....	64.3
Pepper	Ruby King	—13.8	59.1	....	25.0
Radish	Scarlet Globe	33.3	33.3	....	33.3
Rutabaga	Large White	—25.3	14.7	....	—14.7
Chard	Giant Lucullus	— 9.4	5.6	....	— 5.4
Spinach	New Zealand	95.3	20.6	....	44.9
Turnip	White Globe	—27.1	20.0	....	—17.6
Cabbage	Early Jersey Wakefield	— 7.2	5.9	27.9	3.7
Cabbage	Danish Ballhead	4.8	3.7	16.3	7.3
Carrot	Coreless	16.7	0.0	20.0	9.1
Beet	Detroit Dark Red	9.6	29.0	27.3	19.0
Cucumber	Arlington White Spine	15.1	47.4	109.4	46.1
Potato	Triumph	11.5	7.9	28.4	14.1
Potato	Irish Cobbler	15.9	3.3	23.9	13.7
Potato	Rural New Yorker	....	50.0	21.9	35.3
Sweet Corn	Golden Bantam	23.9	5.0	5.3	17.4
Sweet Corn	Golden Sunshine	— 3.5	10.0	15.8	2.7
Sweet Corn	Country Gentleman	20.8	15.5	00.0	17.9
Tomato	Red River	00.5	19.3	18.1	8.0
Tomato	Bonny Best	—19.1	— 2.0	9.3	—11.5
Tomato	Stone	—26.8	—10.6	14.8	—19.4

* For more detailed data, see Tables 4 and 5.

† A minus sign indicates a lower yield on the mulched plots than on the corresponding cultivated plots.

Noting the crops that were grown throughout the three years of the experiment, it is apparent that there was, in general, a wide variation in the results obtained for each of the three years, altho the effects of the paper were beneficial in most cases. This may be due, at least partly, to the difference in the amount of rainfall in the different seasons and to the probability that one of the reasons for the beneficial effects of the paper is that it aids in the conservation of moisture. If this is so, it is to be expected that there would be a large amount of

variability in the results obtained in 1929 and such was the case. Decreases were obtained with several crops and increases were not very high in most others. Figure 2 shows that the rainfall for May and June, 1930, was also fairly high; therefore the various crops received an even better early supply of moisture than in 1929. This gave the plants a good start but because of moisture deficiency later in the season they did not maintain this growth, and the paper could conserve the moisture to the advantage of the plants only as long as there was a sufficient moisture supply in the soil for normal growth. This may account for the fact that, while the results of the paper treatment were more uniformly beneficial in 1930 than in 1929, the actual percentage increase was lower in several cases. In 1931, there was a deficiency of moisture throughout the season, except in June, in addition to the accumulated deficiency of the previous years. The yields and the growth of various crops were poor on both the mulched and the cultivated plots. The mulched plots, however, showed a higher and more uniform increase, in general, than in either of the other years, which may be due, in part, to the ability of the paper to conserve moisture.

As can be seen in Table 1, there was a decided preponderance in the number of beneficial results obtained on the paper. However, the increases in many of these crops were not sufficient to pay for the additional expense incurred. With salsify, New Zealand spinach, turnips, rutabagas, cabbages, potatoes, and others, the economic value is so low that a very large increase in yield would be necessary to make the use of the paper profitable. On the basis of total yields, the conclusion that the increase in yield would not support the use of the paper appears to be justified for a majority of the crops tested.

In vegetable production, however, there is another phase which, in many cases, is perhaps more important than total yield, especially from the market gardener's viewpoint. That is earliness of maturity. For example, the production of ripe tomatoes a few days earlier in the season may mean the difference between profit and loss.

EFFECT OF MULCH PAPER ON EARLINESS

In Figures 3 to 7, inclusive, some data are given as to the effect of mulch paper on earliness of maturity. The broken curves represent the cumulative increase or decrease in yield in bushels per acre, for the given years, of the mulch-paper plots as compared to the yield of the cultivated plots, which is represented by the straight line, 0. In other words, the total increase or decrease in yield of the mulch paper plots, up to any date during the period of the experiment, may be read directly from the figures by taking the yield, as represented by the broken lines, on that date.

Figures 3, 4, and 5 give the results obtained with the three varieties of tomatoes tested. Red River is an early variety; Bonny Best, a medium early or all-season variety; and Stone, a late variety.

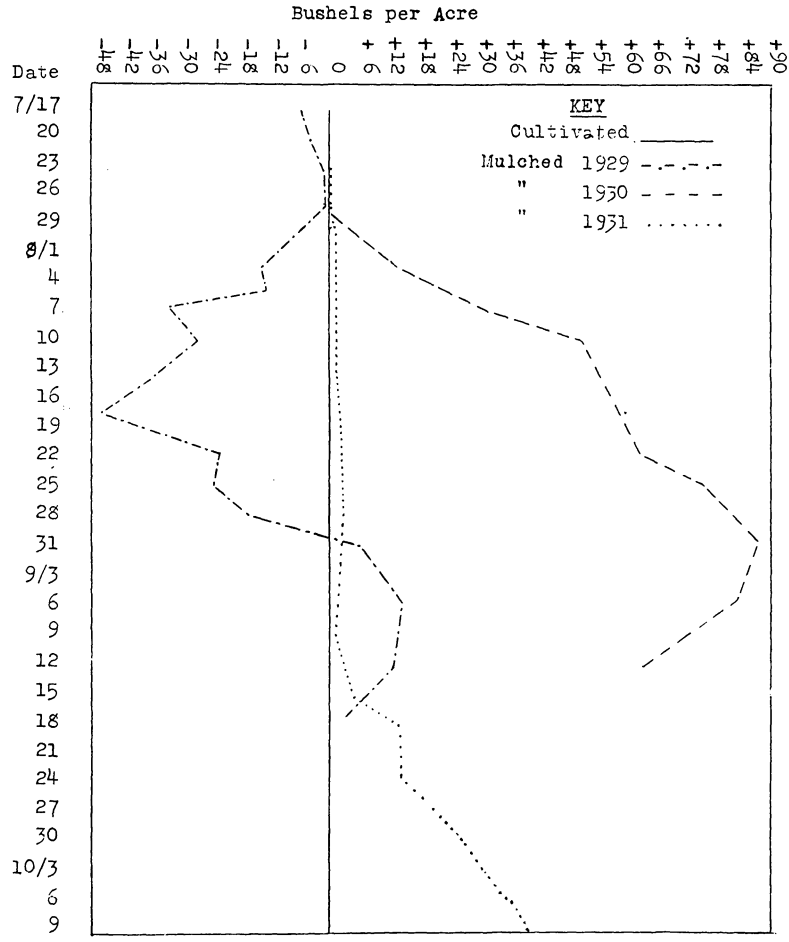

Fig. 3. Cumulative Increase or Decrease in Yield of Mature Fruit of Red River Tomatoes Grown with Mulch Paper Over Those Grown on Cultivated Plots, 1929-31

As previously stated, very early tomatoes usually command a high price on the market in this region. From Figures 3, 4, and 5 it can be seen that, in most cases, there was an increase in yield in favor of the paper during the early part of the season. Here again, however, the results are very variable. In 1929, the Red River variety showed a decrease throughout the early part of the season while Bonny Best and Stone both gave comparatively slight increases in favor of the paper. In 1930, Red River produced very favorable results on the mulch paper.

Bonny Best fairly favorable, and Stone somewhat less favorable than either of the other varieties. It is to be noted, also, that the total increase in yield on the mulched plots was rather small in several cases and that a decrease was often shown. In general, the data obtained in this part of the experiment show that the paper has some beneficial effect on the early yield of the tomato varieties tested but that, in most cases, the increases in yield obtained were not sufficient to make its use profitable.

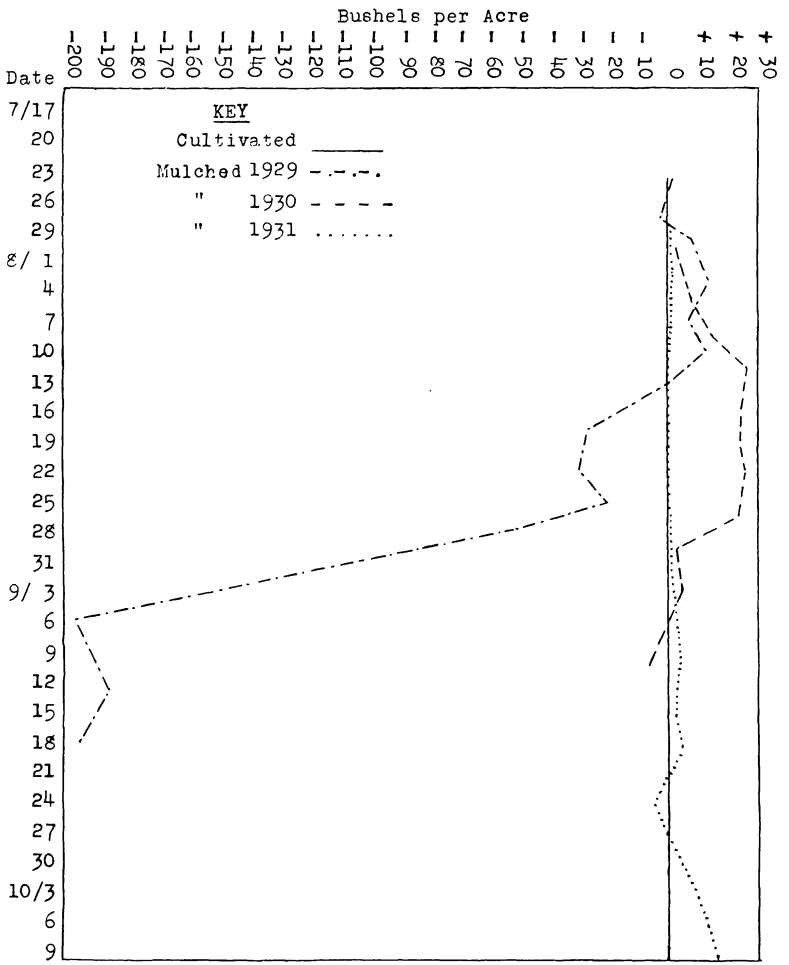

Fig. 4. Cumulative Increase or Decrease in Yield of Mature Fruit of Bonny Best Tomatoes Grown with Mulch Paper Over Those Grown on Cultivated Plots, 1929-31

Figure 6 gives the results obtained with cucumbers during the three-year period. The variety used was Arlington White Spine, which is one of the most commonly grown slicing varieties in this region.

It can be readily seen from Figure 6 that a very marked increase in early yield was obtained in each of the three years. The difference in yield also increased throughout each season with the exception of the latter part of 1929. There was also a marked difference in total yield in all three years in favor of the paper. On the whole, the results obtained with cucumbers were very favorable on the mulch-paper areas.

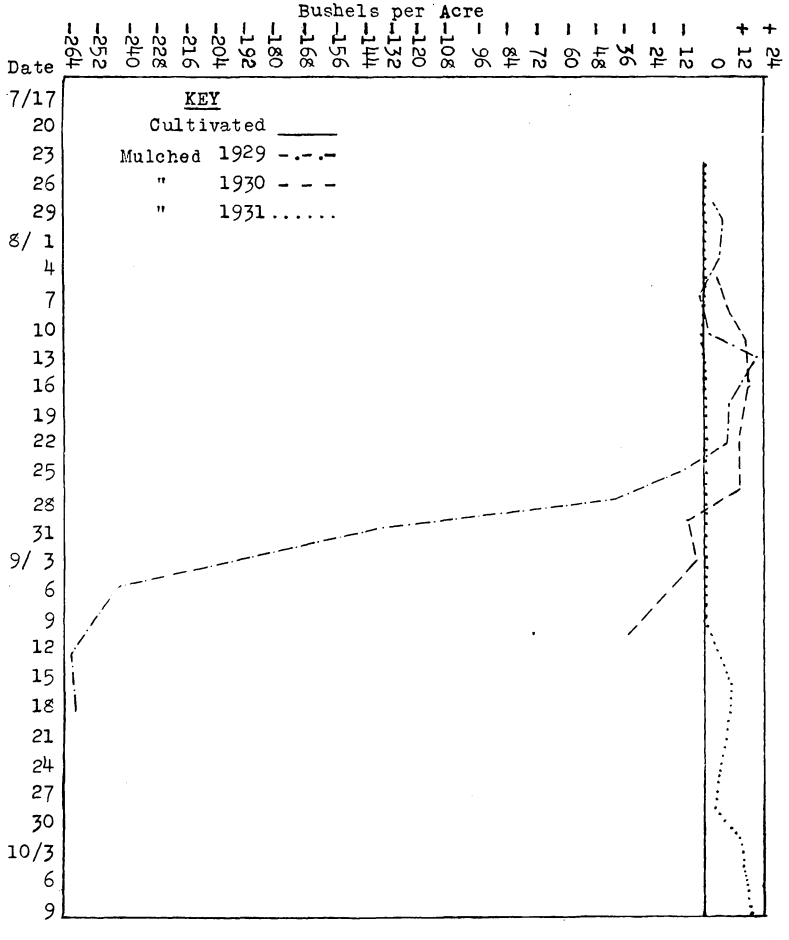

Fig. 5. Cumulative Increase or Decrease in Yield of Mature Fruit of Stone Tomatoes Grown with Mulch Paper Over Those Grown on Cultivated Plots, 1929-31

In Figure 7 and Table 2, data on earliness are given for three varieties of sweet corn—Golden Bantam, Golden Sunshine, and Country Gentleman. Bantam and Sunshine are early and Country Gentleman is a late variety. In 1931, the yield of sweet corn was very poor probably because of unfavorable moisture conditions throughout the season and

to high temperatures at time of pollination. For this reason the 1931 yields are not shown in the graphs; they are given in Tables 4 and 5.

Table 2 illustrates the effect of the paper on earliness of sweet corn in 1931 as indicated by the time of silking. In this table the ratio, M to C, gives the number of plants silking on the mulched plots to one plant silking on the cultivated plots. For example, on July 7, 1931, 8.2 plants of Golden Bantam were silking on the mulched plots for every one that was silking on the cultivated plots.

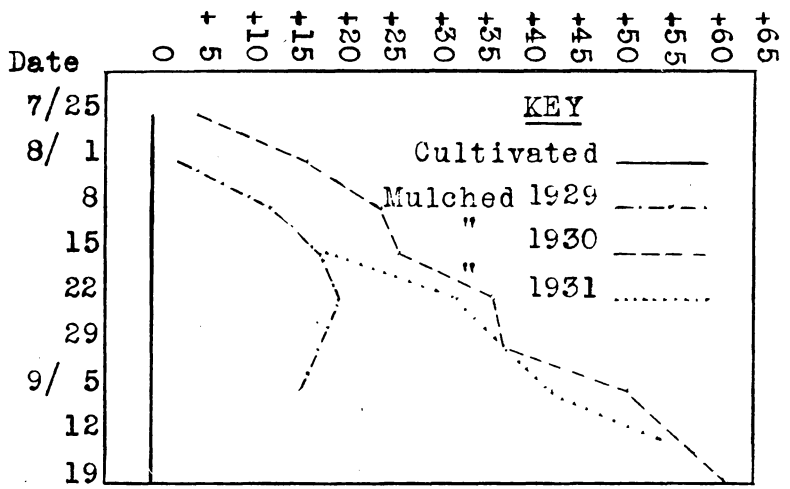

Fig. 6. Cumulative Increase or Decrease in Yield of Arlington White Spine Cucumbers Grown with Mulch Paper Over Those Grown on Cultivated Plots, 1929-31

Table 2

Increase or Decrease in Earliness of Sweet Corn Grown on Mulch Paper Over That Grown on Cultivated Plots as Indicated by the Date of Silking, 1931

Date	Golden Bantam		Golden Sunshine		Country Gentleman	
	No. of plants	Ratio M to C	No. of plants	Ratio M to C	No. of plants	Ratio M to C
7/ 7.....	654	8.2:1	550	15.4:1		
11.....	...	1.9:1	...	2.7:1		
15.....	...	1.1:1	...	1.3:1		
20.....	...	1.0:1	...	1.1:1		
24.....	...	1.0:1	...	1.0:1		
28.....	...	1.0:1	...	1.0:1	520	2.1:1
8/ 1.....	...	....	...	....	...	1.6:1
5.....	...	....	...	....	...	1.1:1
11.....	...	....	...	....	...	1.2:1
18.....	...	....	...	....	...	1.0:1

Figure 7 indicates that there was an appreciable increase in early yield in all varieties on the mulch paper in 1929. The increases during the period of early production in 1930, however, were negligible in all cases. Table 2 indicates a pronounced increase in earliness of silking

in 1931. This is especially noticeable in the Golden Sunshine and Golden Bantam varieties and possibly would have resulted in increased early yields under more favorable growing conditions.

Table 3 presents a summary of the yields obtained with peppers in 1929 and 1930. The data are given on a cumulative basis and the differences in yield between the two treatments are shown in pounds and in percentage.

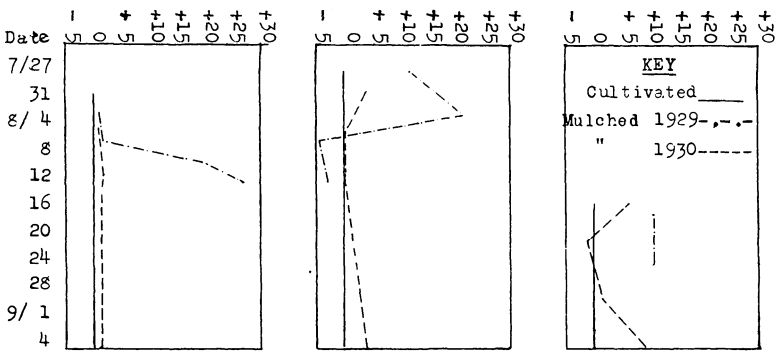

Fig. 7. Cumulative Increase or Decrease in Yield of Sweet Corn Grown with Mulch Paper Over That Grown on Cultivated Plots, 1929-30

Table 3

Cumulative Increase or Decrease in Yield of Ruby King Peppers Grown on Mulch-Paper Plots as Compared to Those Grown on Cultivated Plots, 1929-30

Date	Av. yield per plant, lb.		Difference	
	Mulched	Cultivated	Pounds	Per cent
8/21/29	0.05	0.07	−0.02	−29
27	.15	.12	+ .03	+25
30	.27	.25	+ .02	+ 8
9/12	.37	.50	− .13	−26
17	.50	.58	− .08	−14
8/18/30	.45	.29	+ .16	+55
9/ 2	.66	.42	+ .24	+57
10	0.91	.54	+ .37	+69
19	1.05	0.66	+0.39	+59

Here again, the results obtained in the two years are very variable. Pronounced increases were obtained in 1930. In 1929, taking the first three harvests as an indication of earliness, some hastening of the time of fruit maturity is shown, altho the mulched plots show a decrease in total yield over the cultivated plots.

In these experiments, the most pronounced indications of an increase in earliness in the mulched plots was obtained with vegetables that are classified as warm season crops. As previously stated, several investigators have reported increased soil temperatures under the paper. It has also been found, in some cases, that the soil cools off more slowly at night in the mulched areas. In other words, a black paper not only

increases the absorption of heat by the soil but also retards its loss by radiation from the surface. Optimum growing conditions for these crops would necessitate a higher temperature for both soil and air than is usually prevalent during May and June in this region. Assuming that the soil temperature is increased under the paper, such increases might have a sufficient beneficial effect to account, at least in part, for some of the results in regard to increasing earliness of maturity.

OBSERVATIONAL NOTES ON EARLINESS

In observations made during the early growth period, several items of interest were noted. Altho no conclusive data were taken, there was an indication that the paper had a tendency to hasten the germination of some vegetables. With such crops as sweet corn, carrots, radishes, potatoes, cucumbers, and New Zealand spinach, the first plants appeared in the mulched areas and the plants on these plots maintained their advantage for a short period during early growth. Beets, rutabagas, turnips, and beans, on the other hand, appeared to germinate more quickly on cultivated areas. With other crops tested, there was no apparent advantage for either treatment so far as germination was concerned.

It was also noted that potatoes, tomatoes, sweet corn, eggplants, peppers, radishes, and carrots showed a decided difference in vegetative development in favor of the paper in the period of early growth. Not only were the plants larger on the paper plots but they were darker green, and, in several cases, flowered and set fruit earlier. Later, however, the plants on the cultivated plots apparently caught up with them and there was very little, if any, visible difference between them from a vegetative standpoint.

METHODS OF ANCHORING THE PAPER

One of the greatest difficulties in the use of mulch paper is keeping it in place after it is laid. This difficulty was very serious in 1929, and in 1930 and 1931 to a considerable extent. The paper consistently rotted off along the edges where it was covered with soil. In numerous cases, the strips were blown away before the damage could be repaired and several times young plants were seriously injured or even carried away with the paper. This necessitated much additional labor and expense in relaying the old paper, in laying new strips where the old strips were too much damaged for further use, and in loss and injury to the growing plants. Many of the commercial vegetable gardeners have had the same trouble and some have discontinued the use of the paper largely for this reason.

In an attempt to find a more satisfactory method of laying the paper than covering the edges with soil, several schemes were tried out in 1930 and 1931 with varying degrees of success. These methods are

illustrated in Figure 8 as used with paper 36 inches wide. Similar investigations were conducted with the 18-inch paper.

Enumerating from left to right in Figure 8, the various methods are: (1) Covering the edges of the paper with soil; (2) Running laths lengthwise of the paper with spaces 18 to 24 inches long between the ends of the laths; (3) Running the laths crosswise of the paper at three-foot intervals; (4) Running steel rods, ¼ inch in diameter, crosswise of the paper at three-foot intervals; and (5) Running wires lengthwise of the paper along each edge stapled down at three-foot intervals.

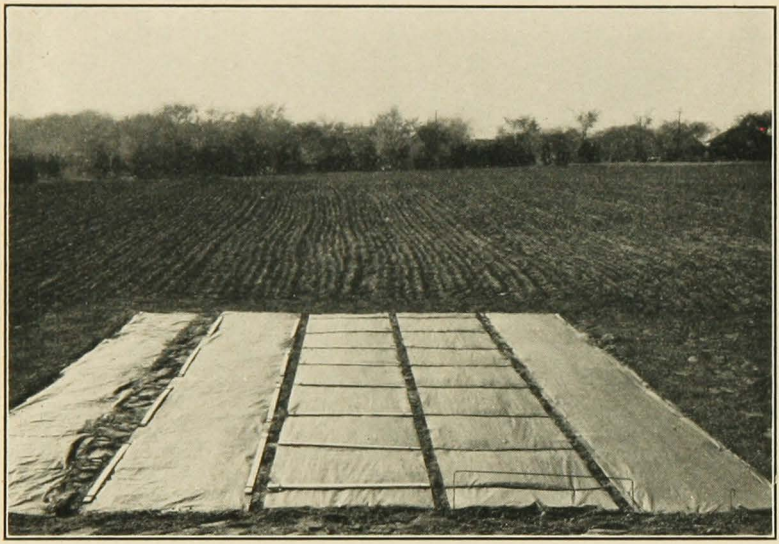

Fig. 8. Methods of Anchoring Mulch Paper

None of the methods used was entirely successful under the conditions of the experiment. In method 1, the paper rotted off in about three weeks where the soil covered the edges. A similar condition prevailed in methods 2 and 3. The paper rotted completely under the laths but the time required for rotting was about one week longer than in method 1. In method 5, the wind got under the edges of the paper and, in some cases, tore it up within a day or two after it was laid. Method 4 proved the most effective—no rotting occurred and only an occasional strip of paper blew away.

From a practical standpoint, method 1, in spite of the rotting, is probably the most effective and certainly the cheapest when fairly large areas are to be covered. This is especially true if a machine is used in the laying process. Several machines, are now being produced commercially but, in most cases, are rather expensive for the small grower. One of the machines is shown in Figure 1. Some growers have suc-

ceeded in devising home-made machines at rather low cost that do the work fairly effiiciently.

Methods 2, 3, 4, and 5 are rather expensive as to the materials used and the labor required and are not practical on a large scale. All the laying operations must be performed by hand. These methods, however, may have some application for home and small commercial gardeners. The initial cost of the staples used in method 4 is high but they are comparatively easy to put in place and can be used for several years. After two years' use in these experiments, only a slight corrosion was noted on the ends buried in the soil.

Numerous other methods have been tried on a small scale but with no better success and the matter of anchorage is still, in this area, an important item to be considered if the paper is to be used economically. Under the conditions of these experiments, the costs of laying, relaying, and reanchoring the paper plus the actual weeding that is necessary on the mulch plots appears to more than offset the gain accrued through the lesser amount of cultivation required.

CONCLUSIONS

The value of mulch paper in vegetable production is debatable. However, several conclusions may be drawn in regard to its use.

1. A beneficial effect appears to be exerted by the paper. In the experiments conducted at University Farm, the increases obtained do not, in most cases, appear to pay for the additional cost incurred.

2. Mulch paper seems most beneficial with warm-season crops.

3. Mulch paper apparently hastens the maturity of certain vegetables and may be profitable with crops that have a relatively high market value early in the season.

4. It also appears to be most beneficial under conditions that are unfavorable to the optimum development of the crop such as poor soil, deficient precipitation, and low temperature. Since there is no precise way in which climatic conditions can be predicted in a given locality, the value of the paper from this standpoint can be determined only after the growing season is past. Under favorable growing conditions, often very little beneficial and sometimes a detrimental effect is produced.

5. The effect of the paper varies not only with local climatic conditions but also with each crop grown and, to some extent, with different varieties of the same crop. Therefore each grower must determine the value of the paper for his particular crops and for his local conditions.

6. Warm-season crops of high acre value and yield that are grown intensively are most likely to give the best results.

7. The paper should not be used on a low value crop.

8. The paper eliminates the weeds in the covered area to a large extent and this conserves the moisture and fertility that would be used

by them. It also cuts down the cost of cultivation but, in these experiments, this effect was offset to a large extent by the added cost of laying and caring for the paper and by the additional labor involved in planting and transplanting when it was used.

9. Mulch paper may have a special value to the home garden enthusiast who is not particularly interested in the economic aspects. Slight increases in earliness and quality and reduction of the amount of labor necessary for cultivation, which is usually done by hand under such conditions, often appeals to such a gardener. The weed control aspect may also have a special value to him, for the paper will retard the weeds for a few days or weeks when the gardener is on his vacation or is busy with other work.

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Table 4.—Percentage Increase or Decrease in Average Total Yield per Plant of Vegetable Crops Produced with Mulch Paper as Compared to Those Produced Under Clean Cultivation, 1929-31

Crop	Variety	1929				1930				1931			
		No. of plants*	Av. yield per plant, lb. Mulched	Av. yield per plant, lb. Cultivated	Difference, per cent†	No. of plants	Av. yield per plant, lb. Mulched	Av. yield per plant, lb. Cultivated	Difference, per cent	No. of plants	Av. yield per plant, lb. Mulched	Av. yield per plant, lb. Cultivated	Difference, per cent
Beans	Bush Lima	64	0.17	0.14	21								
Celery	Golden Self Blanching	132	1.93	1.68	15								
Celeriac	Turnip Rooted	80	1.61	1.36	18								
Garlic	Bavarian Selected	40	0.11	0.15	—27								
Kohl-rabi	Early White Vienna	40	1.58	1.70	— 7								
Komatsuma	Chinese	132	0.90	0.61	48								
Leek	American Flag	40	0.65	0.53	23								
Lettuce	Grand Rapids (Leaf)	88	0.28	0.19	47								
Onion	Yellow Globe	320	0.16	0.35	—54								
Onion	Prizetaker	320	0.25	0.43	—42								
Parsnip	Guernsey	244	0.69	0.63	10								
Pumpkin	Fort Berthold	36	10.59	10.73	— 1								
Salsify	Sandwich Island	400	0.22	0.17	29								
Squash	Kitchenette	36	14.44	15.57	— 7								
Tomato	Golden Husk	24	3.45	2.22	55								
Beans	Improved Golden Wax	80	0.47	0.38	24	70	0.16	0.26	—39				
Beans	Late Refugee	80	0.47	0.49	— 4	70	0.11	0.11	00				
Eggplant	Black Beauty	26	2.03	2.59	—22	62	2.19	2.37	— 8				
Peas	Little Marvel	80	0.34	0.31	10	224	0.08	0.06	33				
Peas	Telephone	80	0.16	0.09	78	136	0.07	0.05	40				
Pepper	Ruby King	26	0.50	0.58	—14	62	1.05	0.66	59				
Radish	Scarlet Globe	400	0.04	0.03	33	304	0.04	0.03	33				
Rutabaga	Large White	184	0.71	0.95	—25	234	0.39	0.34	15				
Chard	Giant Lucullus	80	1.35	1.49	— 9	92	0.57	0.54	6				
Spinach	New Zealand	40	3.34	1.71	95	132	4.28	3.55	21				
Turnip	White Globe	76	0.43	0.59	—27	276	0.18	0.15	20				
Cabbage	Early Jersey Wakefield	48	3.33	3.59	— 7	118	1.99	1.88	6	337	1.88	1.47	28
Cabbage	Danish Ballhead	160	4.57	4.36	5	122	2.24	2.16	4	336	2.42	2.08	16
Carrot	Coreless	540	0.14	0.12	17	176	0.16	0.16	00	3,549	0.06	0.05	20
Beet	Detroit Dark Red	316	0.57	0.52	10	302	0.40	0.31	29	2,010	0.28	0.22	27
Cucumber	Arlington White Spine	80	3.43	2.98	15	104	5.35	3.63	47	484	2.89	1.38	109
Potato	Triumph	132	2.81	2.52	12	266	1.09	1.01	8	240	1.13	0.88	28
Potato	Irish Cobbler	136	2.40	2.07	16	270	1.57	1.52	3	234	1.35	1.09	24
Potato	Rural New Yorker	..	....	....	..	150	0.99	0.66	50	226	0.89	0.73	22
Sweet Corn	Golden Bantam	80	1.40	1.13	24	430	0.42	0.40	5	654	0.20	0.19	5
Sweet Corn	Golden Sunshine	132	0.82	0.85	— 4	390	0.44	0.40	10	550	0.22	0.19	16
Sweet Corn	Country Gentleman	126	0.64	0.53	21	202	0.67	0.58	16	520	0.01	0.01	00
Tomato	Red River	24	22.00	21.90	1	98	10.82	9.07	19	130	7.10	6.01	18
Tomato	Bonny Best	24	22.78	28.15	—19	92	10.18	10.39	— 2	132	6.11	5.59	9
Tomato	Stone	24	19.71	26.92	—27	96	7.98	8.93	—11	130	4.03	3.51	15

* Number of plants = Total number in experiment for given year. One-half or, in some cases, approximately one-half of this number gives the number in each treatment.

† Percentage difference: Minus sign indicates a decrease in yield with the paper mulch. All other differences show an increase in favor of the paper mulch.

Table 5.—Estimated Acre Yield, in Pounds, of Vegetable Crops Grown with Mulch Paper as Compared to Those Produced Under Clean Cultivation, 1929-31

Crop	Variety	Planting distance, ft., between		Yield per acre in pounds									Average difference	
				1929			1930			1931			Per year	
		Rows	Plants in row	Mulched	Cultivated	Difference*	Mulched	Cultivated	Difference	Mulched	Cultivated	Difference	Pounds	Per cent
Beans	Bush Lima	3.0	0.33	7,480	6,160	1,320								21
Celery	Golden Self Blanching	1.5	0.50	11,209	9,757	1,452								15
Celeriac	Turnip Rooted	1.5	0.50	9,351	7,899	1,452								18
Garlic	Bavarian Selected	1.5	0.25	12,778	17,424	— 4,646								—27
Kohl-rabi	Early White Vienna	1.5	1.00	45,883	49,368	— 3,485								— 7
Komatsuma	Chinese	1.5	0.25	104,544	70,858	33,686								48
Leek	American Flag	1.5	0.33	57,200	46,640	10,560								23
Lettuce	Grand Rapids (Leaf)	1.5	0.50	16,262	11,035	5,227								47
Onion	Yellow Globe	1.5	0.25	18,586	40,656	—22,070								—54
Onion	Prizetaker	1.5	0.25	29,040	49,949	—20,909								—42
Parsnip	Guernsey	1.5	0.33	60,720	55,440	5,280								10
Pumpkin	Fort Berthold	6.0	6.00	12,814	12,983	— 169								— 1
Salsify	Sandwich Island	1.5	0.33	19,360	14,960	4,400								29
Squash	Kitchenette	6.0	6.00	17,472	18,840	— 1,368								— 7
Tomato	Golden Husk	6.0	4.00	6,262	4,029	2,233								55
Beans	Improved Golden Wax	3.0	0.33	20,680	16,720	3,960	7,040	11,440	—4,400				— 220	— 2
Beans	Late Refugee	3.0	0.33	20,680	21,560	— 880	4,840	4,840	0,000				— 440	— 3
Eggplant	Black Beauty	3.0	2.00	14,738	18,803	— 4,065	15,899	17,206	—1,307				—2,686	—15
Peas	Little Marvel	3.0	0.17	29,040	26,478	2,562	6,833	5,125	1,708				2,135	14
Peas	Telephone	3.0	0.17	13,666	7,687	5,979	5,979	4,271	1,708				3,844	64
Pepper	Ruby King	3.0	2.00	3,630	4,211	— 581	7,623	4,792	2,851				1,125	25
Radish	Scarlet Globe	1.5	0.09	1,331	998	333	1,331	998	333				333	33
Rutabaga	Large White	1.5	0.50	41,237	55,176	—13,939	22,651	19,747	2,904				—5,518	—15
Chard	Giant Lucullus	1.5	0.50	78,408	86,539	— 8,131	33,106	31,363	1,743				—3,194	— 5
Spinach	New Zealand	3.0	1.00	48,497	24,839	23,658	62,146	51,546	10,600				17,129	45
Turnip	White Globe	1.5	0.33	37,840	51,920	—14,080	15,840	13,200	2,640				—5,720	—18
Cabbage	Early Jersey Wakefield	3.0	2.00	24,176	26,063	— 1,887	14,447	13,649	798	13,649	10,672	2,977	629	4
Cabbage	Danish Ballhead	3.0	2.00	33,178	31,654	1,524	16,262	15,682	580	17,569	15,101	2,468	1,524	7
Carrot	Coreless	1.5	0.10	40,656	34,848	5,808	46,464	46,464	0,000	17,424	14,520	2,904	2,904	9
Beet	Detroit Dark Red	1.5	0.33	50,160	45,760	4,400	35,200	27,280	7,920	24,640	19,360	5,280	5,867	19
Cucumber	Arlington White Spine	6.0	4.00	6,225	5,408	817	9,710	6,588	3,122	5,245	2,505	2,740	2,226	46
Potato	Triumph	3.0	1.50	27,201	24,394	2,807	10,551	9,777	774	10,938	8,518	2,420	2,000	14
Potato	Irish Cobbler	3.0	1.50	23,232	20,038	3,194	15,198	14,714	484	13,068	10,551	2,517	2,065	14
Potato	Rural New Yorker	3.0	1.50	.....	.....	.....	9,583	6,389	3,194	8,615	7,066	1,549	2,372	35
Sweet Corn	Golden Bantam	3.0	1.50	13,552	10,938	2,614	4,066	3,872	194	1,936	1,839	97	968	17
Sweet Corn	Golden Sunshine	3.0	1.50	7,938	8,228	— 290	4,259	3,872	387	2,130	1,839	291	129	3
Sweet Corn	Country Gentleman	3.0	1.50	6,195	5,130	1,065	6,486	5,614	872	97	97	0,000	646	18
Tomato	Red River	6.0	4.00	39,930	39,749	181	19,638	16,462	3,176	12,887	10,908	1,979	1,778	8
Tomato	Bonny Best	6.0	4.00	41,346	51,092	— 9,747	18,477	18,858	— 381	11,090	10,146	944	—3,061	—12
Tomato	Stone	6.0	4.00	35,774	48,860	—13,086	14,484	16,208	—1,724	7,314	6,371	943	—4,622	—19

* Minus sign indicates a decrease in yield with the paper mulch. All other differences show an increase in favor of the paper mulch.