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Controlling Soil Moisture for Vegetable Crops in Missouri

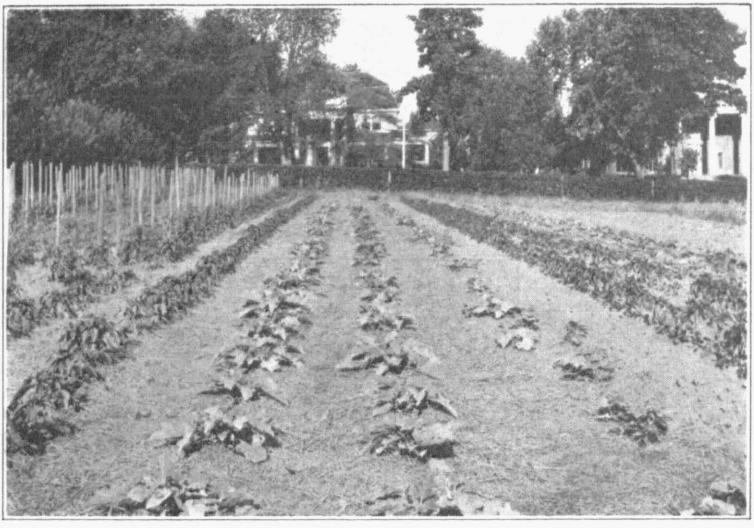

Fig. 1.—Straw mulch in use on vegetable crops.

COLUMBIA, MISSOURI
JUNE, 1923

TABLE 1.—RAINFALL* DURING THE GROWING SEASON OF THE YEARS IN WHICH IRRIGATION AND MULCH TESTS WERE CONDUCTED AT COLUMBIA, MO.

	1919 inches	1920 inches	1921 inches	1922 inches
May, 1st week	0.81	1.52	1.71	1.13
2nd week	.98	0.91	1.46	0.31
3rd week	2.83	1.36	0.00	0.67
4th week	.13	0.43	0.88	1.35
June, 1st week	3.89	6.19	0.14	0.98
2nd week	0.42	0.10	1.57	0.17
3rd week	0.38	0.00	0.00	0.02
4th week	0.73	0.50	1.08	0.71
5th week	.....	0.89	0.40	1.29
July, 1st week	0.00	0.10	0.84	0.16
2nd week	2.25	0.68	0.60	1.17
3rd week	0.22	0.00	0.00	0.31
4th week	0.05	0.30	1.04	0.69
August, 1st week	1.59	1.50	1.17	2.20
2nd week	0.05	0.14	3.04	0.07
3rd week	1.39	2.16	1.35	0.00
4th week	2.23	0.00	0.48	1.08
5th week	.....	.....	0.40	1.20
September, 1st week	0.11	1.20	3.51	1.64
2nd week	0.43	1.38	1.02	1.29
3rd week	1.51	1.52	3.75	0.58
4th week	1.24	0.13	.....	0.00

*From records of U. S. Weather Bureau Station at Columbia, through the courtesy of Mr. George H. Reeder, meteorologist.

TABLE 2.—RESULTS OF IRRIGATION TESTS.

Year	Yield—lbs. per acre		Gain from irrigation	
	Irrigated	Not irrigated	Lbs. per acre	% gain
Tomatoes, 1920	36,284	23,169	13,115	56.6
1921	27,972	15,898	12,078	76.0
1922	29,818	22,060	7,758	35.1
Average	31,358	20,375	10,982	54.0
Peppers, 1920	21,900	16,625	5,275	31.7
1921	26,500	23,400	3,100	13.5
1922	18,160	12,500	5,660	48.4
Average	22,187	17,508	4,679	26.8
Eggplants, 1920	27,438	20,900	6,538	31.45
1921	5,190	3,420	1,770	51.7
1922	21,600	11,010	10,590	96.1
Average	18,076	11,777	6,299	53.5
Cucumbers, 1920	87,350	43,000	44,350	103.0
1921	32,800	21,600	11,200	51.8
1922	22,950	26,647	7,610	49.6
Average	47,700	30,415	21,053	79.0
Snap Beans, 1920 (green)	10,062	5,656	4,406	80.0
1920 (wax)	9,940	5,029	4,911	97.7
1921	9,780	6,440	3,340	52.0
1922	7,980	5,320	2,660	50.0
Average	9,440	5,611	3,829	68.3

Controlling Soil Moisture for Vegetable Crops in Missouri

J. T. ROSA

Abstract.—The effects of irrigation and of mulching on yields of tomatoes, peppers, eggplants and cucumbers are shown. Increased yields from irrigation are thought to justify the use in Missouri of overhead irrigation for intensive cultivation of valuable crops. The proportion of early maturing fruit was not affected, but susceptibility to disease was increased. Mulching gave smaller increases which appeared the latter part of the season. During the first two weeks of harvest, tomato yields were greater on the unmulched plants. Hence the straw mulch is not recommended for crops grown for early market. The effects of the mulch are attributed to reduction of soil temperature and decrease in fluctuations of the soil moisture content.

Although the annual average rainfall in Missouri ranges from 36 to 40 inches, an amount ample for intensive truck crop production, the fact remains that lack of moisture in the soil prevails during more or less brief periods in almost every summer. In fact, this is one of the principal limitations on production of large yields of those vegetables which are grown during the midsummer season. The moisture deficiency is of course due to irregular distribution of rainfall through the year, and to the heavy demands made by plants for water during the summer season. Beginning in 1919, experiments were begun on the horticultural grounds of the Missouri Agricultural Experiment Station at Columbia to determine the practical value of well known methods of regulating the soil moisture for vegetable crops. The main object has been to measure the effect of such treatments on yield. The soil used in these experiments was black silt loam of medium fertility and quite retentive of moisture. It was underlaid at a depth of 8 to 10 inches by a tight subsoil which seems quite impervious to roots of tender plants. This limited the feeding range of the plants' roots, confining them to the comparatively thin layer of top-soil. Hence the results may have been more striking than they would have been if the tests had been conducted on a deeper soil. On the other hand, the distribution of rainfall was such during the four years of these tests that there were no prolonged droughts during the period of the tests; the last two years, 1921 and 1922, being especially favorable in regard to summer rainfall. The rainfall for the seasons concerned is given in Table 1.

EARLY PLANTING

One way to make the most of the natural moisture supply is to plant the crops as early in spring as possible, so that good growth is made in the early part of the season while moisture conditions are still favorable. This insures more or less complete development of the crop before the summer drought begins. Very striking increases in yield were obtained in compari-

sons of early versus late planting of Irish potatoes, sweet potatoes and tomatoes. The data on these were not sufficient, however, to warrant their inclusion here.

IRRIGATION

Several plots of the principal summer vegetable crops were irrigated and the yields compared with those of unirrigated plots which were handled in every way similar to the irrigated plots. The method of irrigation used was the overhead spray system. It should be said that this method of irrigation has been in successful use for many years on a fairly large scale by market gardeners in eastern and southern states; and some of the vegetable growers in Missouri also have been using it with good results. The yields obtained in the irrigation experiments at Columbia in 1920, 1921 and 1922 are given in Table 2. The three-year averages are also given for the different crops. In the first column is given the calculated total yield (in lbs. per acre) of the irrigated plots; in the second column is given the yield of the unirrigated plot; the third column gives the gain in yield, which may be attributed to irrigation, and the fourth gives the percentage gain.

Discussion of Results.—In the case of tomatoes, there was a large net gain in yield each year as a result of irrigation. A study of the daily harvest records shows that irrigation did not affect particularly the proportion of early maturing fruits; but late in the season there was a sharp falling off in yield from the irrigated plots. This was due to the plants being killed by the leaf-spot disease, which developed rapidly under the moister conditions in the irrigated plots, but made slower headway on the unirrigated plants. In no case were the tomato plants sprayed for the prevention of this disease, although such spraying would seem to be especially desirable on tomatoes irrigated by the overhead spray system.

Peppers (of the Ruby King variety) showed considerable gain in yield from irrigation. This gain was due to an increased number of fruits and larger fruits being produced on the irrigated plots during the midsummer period.

Eggplants gave large increases in yield, and in size and quality of fruits on the irrigated plots. As in the case of tomatoes, however, the irrigated eggplants were defoliated by disease (leaf blight and fruit spot) toward the end of the season.

Cucumbers of the White Spine variety gave very large increases in yield from irrigation. It is noticed in the table that yields of both irrigated and unirrigated plots fell off sharply in the three successive years of the experiment. This is due to the fact that the same plots had to be used for the tests each year; and that consequently in the second and third years, striped cucumber beetles and stalk-borers became so numerous that the crop was seriously damaged despite the application of careful control measures. We have here a striking demonstration of the necessity of crop rotation for the purpose of avoiding insect pests.

Snap beans gave substantial increases in yield with irrigation. The beans were grown as an early spring and summer crop. In 1920 duplicate plots of green-pod and wax-pod varieties were used—the latter giving the largest

percentage increase from irrigation. The yields of beans for the early portion of the season were very much higher on the irrigated plots, while the increase was much less on the latter part of the crop.

It is easily seen in the case of the five crops discussed above, that greatly increased yields resulted from irrigation. It is believed that these higher yields represent a net profit in favor of irrigation. The cost of the type of irrigation equipment used here would be about $200 per acre. This is a permanent fixture and should be considered as an additional charge on the value of the land. The amount of water used in these experiments was not measured; it was obtained through the city water system. The amount used would vary with the season, the kind of crop and the soil type. The plots were simply irrigated enough to saturate the surface soil whenever the condition of the crops and of the soil indicated that more moisture was needed. This was about every 8 or 10 days during the drier part of the summer. It need hardly be added that irrigation of this type would not likely prove practical for crops grown on an extensive or field scale, or for crops having a low acre-value. For the more intensive crops having a high value, overhead irrigation is profitable under Missouri conditions.

MULCHING

The use of a layer of straw, or other organic material spread over the surface of the soil to prevent evaporation of moisture is by no means a new practice. Its extensive use in Missouri, however, has been restricted mostly to the Irish potato crop. During the past four years, plots of tomatoes, peppers, eggplants, and cucumbers were mulched and the yields recorded from these and similar plots given ordinary clean cultivation. The material used for mulching was wheat straw of the previous year's crop, the depth being 4 to 6 inches and the rate of application about ten tons per acre. It was always applied as early as possible in the season, while the soil was still full of moisture, and before the plants had spread over the surface of the ground to any extent. About June 1 was the usual time of application. The straw was dumped between the rows and worked up close to the main stem of the plants with a fork. The results of the mulching tests, so far as total yields are concerned, are set forth in Table 3.

Effect of Straw Mulch on Yield.—It is seen at once upon inspection of Table 3 that the results in the different years are by no means uniform. Also there seems to be some difference in the effect of mulching upon different crops. Thus eggplants gave a very substantial gain in yield on the mulched plots every year, while peppers usually showed little benefit from mulching. In the case of tomatoes, the mulched plots gave a small to moderate increase in yield every year except the last, 1922. The explanation of the decreased yield of the mulched tomatoes in 1922 was obvious at the time. As will be shown later, mulching retards the maturing of the crop, and yields are usually heavier from unmulched plots in the early portion of the season. In 1922, a period of rainy weather set in the latter part of July and soon afterward the tomato plants in all plots died rapidly, due to an attack of leaf-spot disease. At this time, the unmulched plants had already passed the peak of their production, while the mulched plants had not yet reached

TABLE 3.—RESULTS OF MULCH TESTS.

Year	Yield—lbs. per acre		Gain from mulch	
	Mulched	Not mulched	Lbs. per acre	% gain
Peppers				
1919	18,800	10,800	8,000	74.1
1920	24,242	23,837	405	1.7
1921	51,300	47,500	3,800	8.0
1922	7,650	9,800	— 2,150	—22.0
Average	25,498	22,984	2,514	10.9
Cucumbers				
1921	27,300	23,500	3,800	11.35
1922	25,350	14,300	11,050	77.4
Average	26,325	18,900	7,425	39.3
Eggplants				
1918	42,480	35,100	7,380	21.0
1919	15,670	5,220	10,090	193.2
1921	9,200	5,300	3,900	73.6
1922	25,350	16,200	9,150	56.5
Average	23,175	15,455	7,720	50.0
Tomatoes				
1918 not staked	64,820	57,920	6,900	11.9
1919 staked	41,530	31,200	11,330	36.3
1919 not staked	40,400	36,400	4,000	11.0
1920 staked	38,490	31,140	7,350	23.6
1920 not staked	23,095	13,130	9,965	76.0*
1921 staked	22,700	18,440	4,260	23.1
1921 not staked	26,530	25,420	1,110	4.7
1922 staked	15,110	20,680	— 5,570	—27.0
1922 not staked	10,339	15,007	— 4,669	—31.0
Average	31,446	27,704	3,741	13.5

*In 1920 the "not staked" tomatoes were planted near a row of apple trees which probably explains the relatively low yield of both mulched and not mulched plots, as well as the abnormally large percentage increase in yield of the mulched plot.

their period of heaviest yield, hence the apparent decrease in yield on mulched plots because of the premature death of the plants caused by disease.

On the whole, it may be stated that use of a moderate straw mulch has proved profitable for the crops experimented upon, and such mulching may be expected to prove even more advantageous in seasons of severe drought. However, mulching has not given as large increases in yield as overhead irrigation, though the former practice may often be cheaper or more convenient on small acreages of intensively planted summer crops. The saving of labor in cultivation is also another considerable advantage of the straw mulch.

Effect of Straw Mulch on Season of Maturity.—It has already been indicated that tomato plants treated with straw mulch did not ripen as many early fruits as the unmulched plants. This effect appeared to be quite consistent with all of the crops tested, and occurred in the results every year.

An idea of the extent of this retarding effect upon maturity may be gained from an inspection of the average weekly harvests from mulched and unmulched tomatoes in 1921. These are shown graphically in figure 2. It is clearly shown that the harvest of fruit the first two weeks of the season was greater on the unmulched plants, while for the balance of the season the mulched plants were more productive—their advantage being greatest the last four weeks of the season. Apparently, then, straw mulch would be undesirable on crops being grown especially for early markets. This factor would not prevent the straw mulch from being very useful in the home garden, nor in the market garden for the medium or late crops.

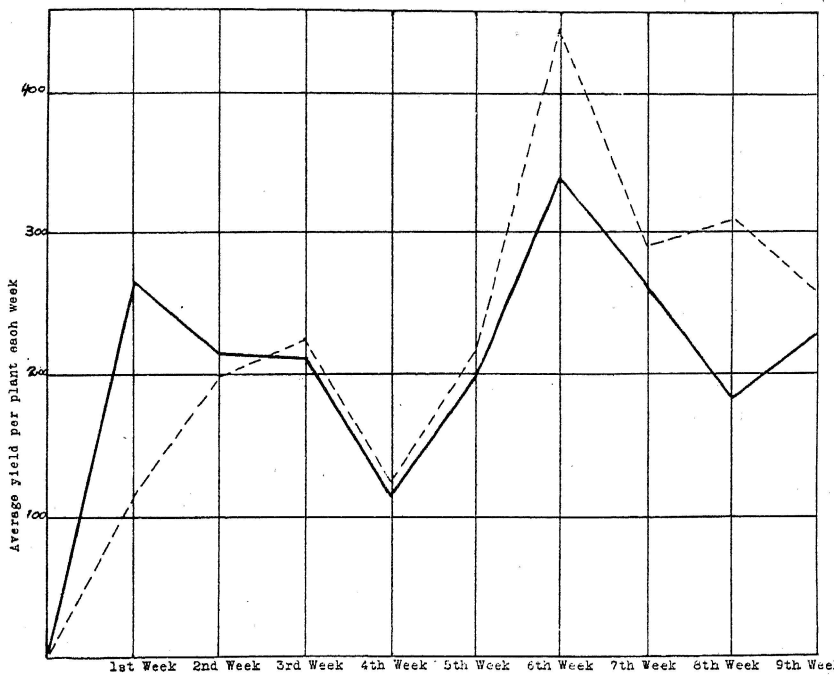

Fig. 2.—Rate of ripening of tomatoes as effected by straw mulch. Broken line indicates mulched plants. Solid line indicates clean cultivation.

Other investigations have shown that the straw mulch reduces the temperature of the soil 7 to 10 degrees Fahrenheit. Probably to this reduction in soil temperature may be ascribed the slower ripening of crops treated with the mulch.

Effect of Mulch on Retention of Moisture.—The straw mulch serves to increase soil moisture by increasing absorption through lessened run-off, as well as by preventing evaporation from the surface of the soil. In the present experiments, the effect of the mulch upon moisture content of the soil was measured in only one season, 1922. However, the moisture content of uncropped soils in mulched and cultivated plots on similar soil type located near those used for the vegetable experiments herein described, has

been determined by Dr. W. A. Albrecht* for a three-year period. His results show strikingly the efficiency of the straw mulch in moisture retention on uncropped soil. However, soil occupied by growing crops would be subject to greater variation in moisture content than fallow land.

During the 1922 season, soil samples were drawn each week from the mulched and unmulched plots. The samples were taken in triplicate, at points about 40 feet apart, about the center between the rows, always in the plots occupied by tomatoes. The top six inches of soil and the second six inches were sampled separately. The samples were dried in the usual way and the percentage of moisture determined on the dry weight basis. The results are shown graphically in figure 3.

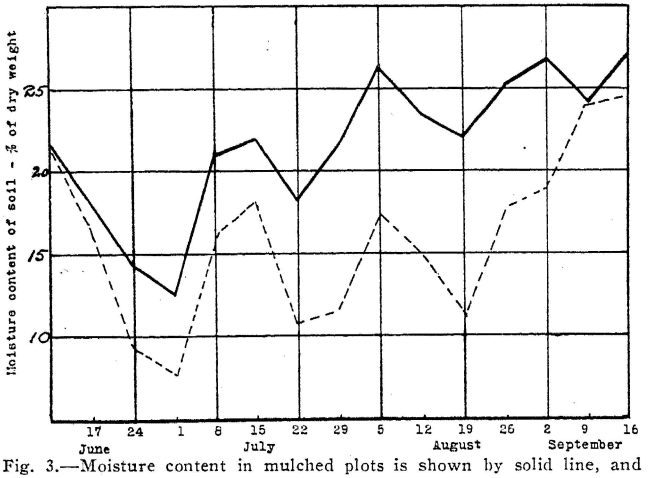

Fig. 3.—Moisture content in mulched plots is shown by solid line, and in unmulched plots by broken line.

From figure 3 it is seen that the fluctuations in moisture content of the top soil were considerable during the season, these differences being much greater in the unmulched soil. After application of the mulch (June 8) the moisture content of the unmulched soil declined rapidly, and it remained considerably below that of the mulched soil most of the summer. It may be noted here that the moisture content of the mulched plot during the early part of the season is considerably lower than the minimum of 19 per cent found by Albrecht in his mulched fallow plots. The medium moisture content of these mulched cropped plots proved at all times ample for the needs of the plant, and may be more favorable for the accumulation of nitrates in the soil than the higher moisture content of Albrecht's mulched fallow plots.

*Nitrate Accumulation Under Straw Mulch. Soil Science, Volume 14: pages 299-305, 1922. Dr. Albrecht is Associate Professor of Soils at the Missouri Agricultural Experiment Station.