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CONTENTS

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EFFECT OF MULCHES ON SOIL TEMPERATURES DURING THE WARMEST WEEK IN JULY, 1925

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Previous investigations[1, 2, 3] on the use of paper as a mulch in contrast to soil mulches have dealt mainly with the effect on crop growth and crop yields. Investigations are now under way regarding the effects of such paper covering on the temperature and moisture conditions of the soil, and also on the most desirable kind of paper to use with particular regard to color, weight, durability, and need for perforations.

By the use of an unperforated black paper mulch at Berkeley in 1924, Shaw[4] found that the soil at a depth of three inches averaged about 0.42° F warmer than at a similar depth in the soil-mulched plots. Hartung[2] in the pineapple fields of Hawaii obtained higher mean soil temperatures at a depth of three inches in areas covered with grayish brown paper mulches than in unprotected soil. In his summary he states that "paper mulch maintains a mean soil temperature in the upper 3-inch layer of soil during the cool season in the localities given, from 3 to 4.5 degrees Fahrenheit above that of non-paper covered soil; provided the mulch paper is dark, preferably black in color." Although the standard mulch paper which Hartung used presented a "greyish brown appearance," he nevertheless recommends black paper. Stewart[5] and his co-workers in Hawaii found that on clear days the areas covered with black paper were from 12° to 15° F warmer during the day, and from 4° to 5° F warmer during the night.

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Fig. 1.—Soil temperature plots at Davis, California, January, 1925.

METHODS

The experimental tract used in these experiments is an area of Yolo loam which had been summer fallowed in 1924. The surface soil to a depth of three feet is a fairly uniform loam on a subsoil of fine sandy loam with some minor variations of coarser texture. This soil is of recent alluvial deposition, is derived mainly from sedimentary rocks, and occupies a nearly flat topographic position. Sixteen plots, each five meters square, were arranged in this area, separated by paths two meters wide.

A sixteen-point recorder was installed in a one-story frame structure, 150 feet north of the experimental area, in January, 1925, with all connecting wires carried to the plots in overhead conduits as shown

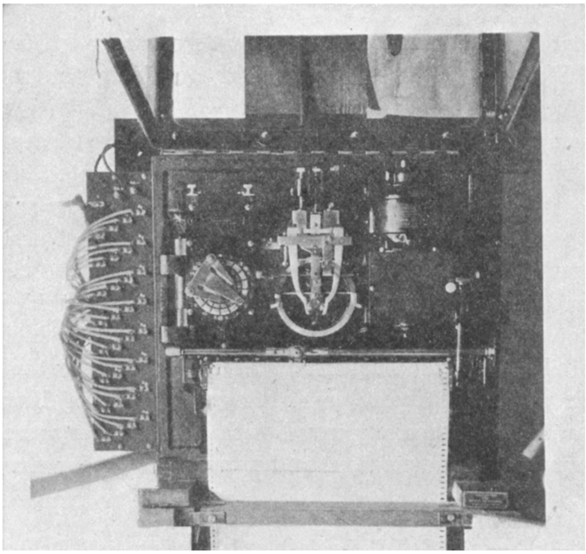

Fig. 2.—Automatic temperature recorder.

in figure 1. Sixteen resistance thermometers were carefully standardized against standard mercury thermometers and were placed in the soil at the center of only five of the plots at depths of from ½ inch to 36 inches. The least number of thermometers in any one plot was two and the most was six. In burying the thermometers, a hole of small diameter was dug, the soil of the various horizons being carefully laid aside. The thermometers were then inserted in the undisturbed soil on the north side of the holes, so that the resistance units or "bulbs" were at least eight inches from the excavation. The hole was then filled, the soil layers being put back in proper order and lightly tamped in order to attain the same degree of compactness as existed originally.

The temperature recorder (fig. 2), a Leeds & Northrup 16-point recorder, was adjusted so that the temperature of each individual thermometer was recorded every 15 minutes, giving 96 records in a 24-hour period or 10,752 records from the 16 thermometers in a period of 7 days. All temperatures herein reported are in degrees Fahrenheit.

A continuous record of the air temperature and humidity was obtained in a standard United States Weather Bureau shelter, located in the northeast corner of the area.

SURFACE TREATMENTS OF CERTAIN PLOTS IN 1925

Various treatments of the soil surface were under experiment in 1925, but only plots 6, 7, 10, 11 and 15, in which soil temperatures were taken, will be discussed in this paper. The surface treatments of these plots were as follows:

Plot 6—covered with Pabco Thermo-Gen 214, black on both sides and with large, irregularly triangular perforations 1¼ inches apart.

Plot 7—not covered with paper, cultivated 4 inches deep once a month.

Plot 10—covered with Moistite Thermo-Gen mulch paper, gray on both sides and with small triangular perforations ¾ of an inch apart.

Plot 11—covered with Thermo-Gen, black on both sides, but without perforations.

Plot 15—covered with Mulch Paper Plain, gray on both sides and without perforations.

Where the paper mulch was put on, it was laid in 36-inch strips running north and south. A lap of 3 inches was allowed and over this redwood battens were laid and stapled down with No. 6 iron wire.

These battens were $1\frac{1}{4}$ inches wide and $\frac{1}{4}$ inch thick (fig. 3). All plots were covered on May 1 and during the 1925 season no crop was grown on any of them.

A period of very high temperatures with clear weather occurred in California, centering around July 16–18, 1925. At some points in the state all previous maximum temperatures for July were equalled or exceeded. The discussion in this paper is confined to a consideration of the temperature changes recorded during this week, or from July 14 to July 21.

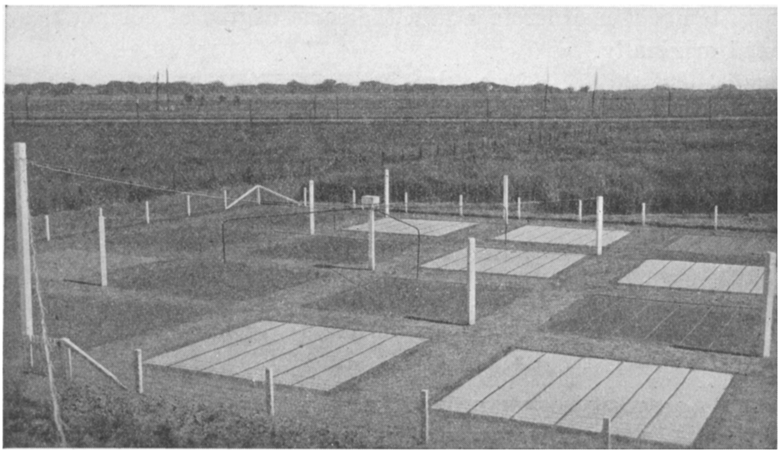

Fig. 3.—Paper mulch and bare plots, Davis, California, May, 1925.

EXPERIMENTAL RESULTS

In two plots (Nos. 6 and 7) temperatures were obtained at the depth of one-half inch. The average day temperature (sunrise to sunset) in the bare plot, No. 7, at this depth was 109°, and in plot 6, which was covered with black perforated paper, it was 99°, or 10 degrees colder. The night (sunset to sunrise) temperatures were reversed, however, the average of the bare plot being 81° and of the covered plot 86.6°, or a difference in favor of the covered plot of 5.6°. The highest soil temperature recorded in any of these plots in 1925 was 143° obtained at a depth of one-half inch in the bare plot (No. 7) on July 17.

At the six-inch depth in these same two plots the average day temperature was 91.3° for the bare plot and 90.4° for the covered plot, or a difference of only 0.9° in favor of the bare plot. At the same depth the average night temperature was slightly higher in both cases, it being 92.7° for the bare plot and 92.1° for the covered plot.

A more detailed study of the records from the bare plot at the various depths shows that the average day and night temperatures (fig. 4) to a depth of twelve inches during this warm period differ decidedly; but at greater depths little or no difference was noted. This is in full agreement with the records for any of the clear days in 1925 not herewith reported, as temperatures were obtained from February to October.

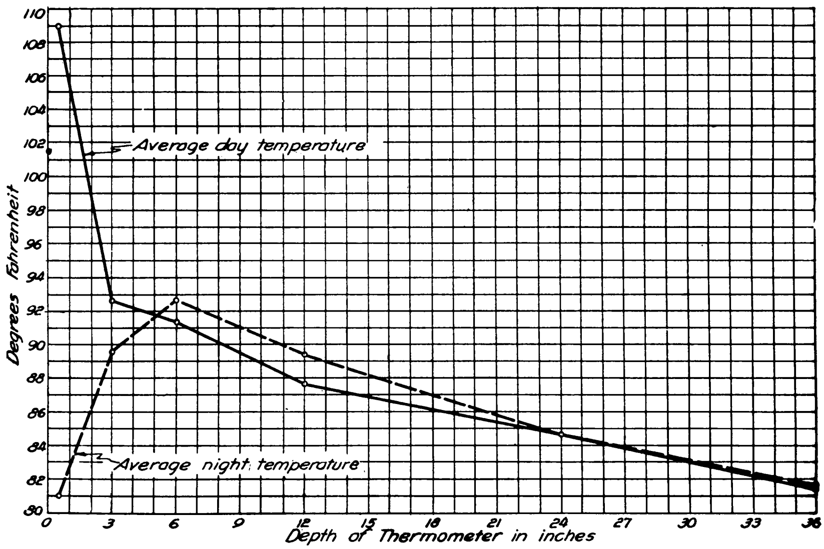

Fig. 4.—Temperature ranges in bare plot, July 14–21, 1925.

The average time of sunrise during the week of July 14–21 was 4:54, and for sunset it was 7:30. The time of occurrence of the maximum and minimum temperatures in the bare plot are shown in table 1. There was no diurnal effect below 12 inches, but there was a gradual increase in temperature, which at the 24-inch depth amounted during the week to four degrees. The maximum air temperature for the week occurred at approximately the same time as that at the one-half inch depth, while the minimum air temperature occurred 28 minutes earlier than the minimum at the one-half inch depth.

The rate at which the heat moved into the soil is shown graphically in figure 5 and the loss of heat from the soil is illustrated in figure 6.

TABLE 1

TIME OF OCCURRENCE OF MAXIMUMS AND MINIMUMS IN BARE PLOT

Depth	Time of maximum after sunrise	Time of minimum after sunset
½ inch	8 hours 51 minutes	8 hours 51 minutes
3 inches	11 hours	10 hours 43 minutes
6 inches	12 hours 17 minutes	11 hours 51 minutes
12 inches	16 hours 25 minutes	14 hours

The gradual increase in temperatures at depths below 12 inches shows that heat was not only lost by radiation from the soil to the atmosphere, but also by conduction downward.

The diurnal range in temperature in the bare plot for depths to 12 inches naturally varies inversely to the depth and is shown in figure 7.

When the temperatures at the 3 inch depth in all five plots are compared (figs. 8, 9), it is quite evident that different results were obtained.

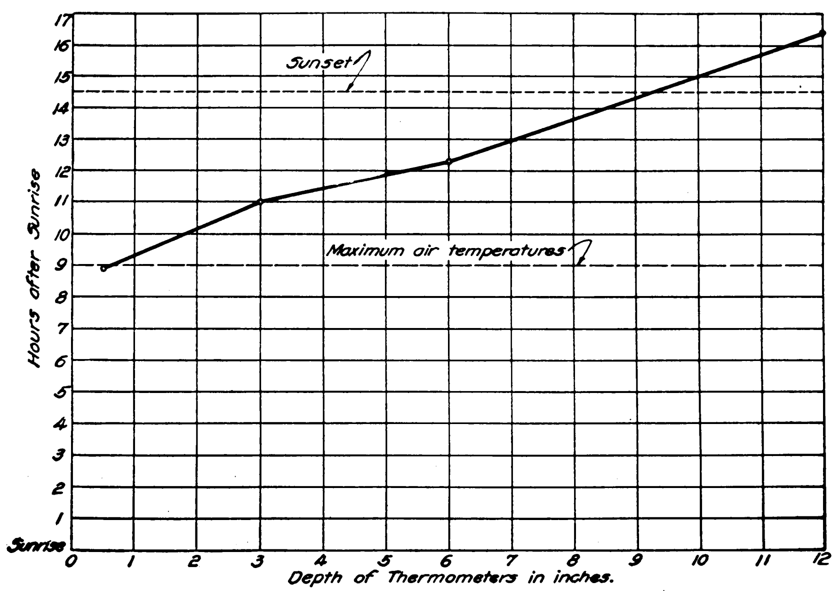

Fig. 5.—Maximum temperatures in bare plot: time of occurrence after sunrise. Average for the week of July 14–21, 1925.

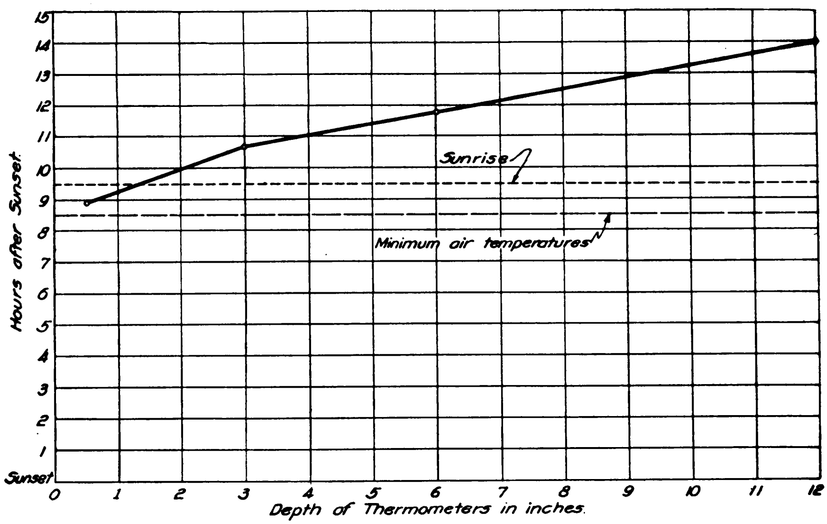

Fig. 6.—Minimum temperatures in bare plot: time of occurrence after sunset. Average for the week of July 14–21, 1925.

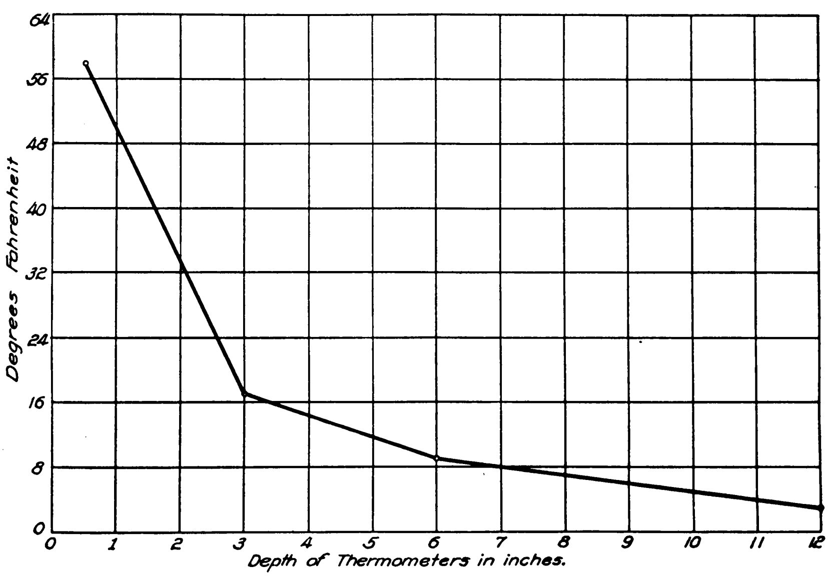

Fig. 7.—Average diurnal range for the week of July 14–21, 1925.

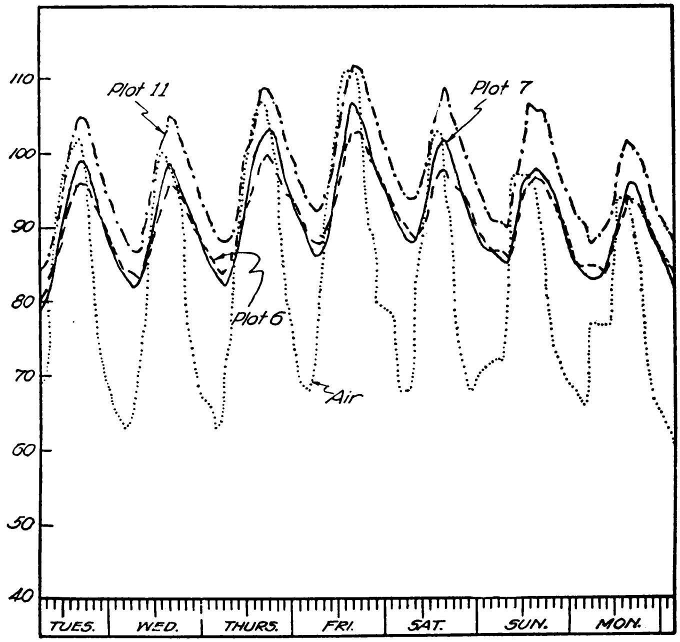

Fig. 8.—Temperatures at 3 inch depth in bare and covered plots and of air by two hour intervals. Week of July 14–21, 1925.

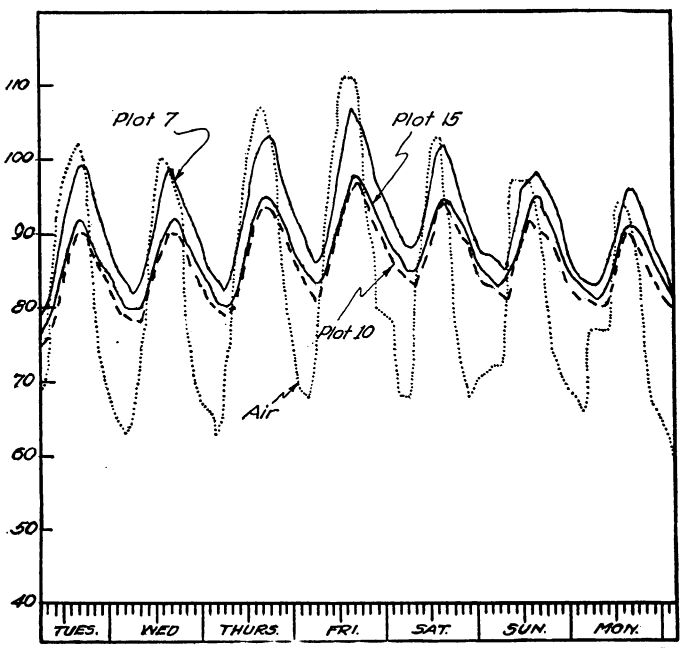

Fig. 9.—Temperatures at 3 inch depth in bare and covered plots and of air by two hour intervals. Week of July 14–21, 1925.

TABLE 2

AVERAGE TEMPERATURES AT THREE-INCH DEPTH, JULY 14–21, 1925

Plot	Cover	Day	Night	Maximum	Minimum
		° *F.*	° *F.*	° *F.*	° *F.*
11	Black solid paper	98.0	96.0	107.0	88.7
7	No paper—soil mulch	92.6	89.6	100.5	83.4
6	Black perforated paper	91.4	90.4	97.9	84.7
10	Gray perforated paper	86.3	85.0	92.4	79.4
15	Gray solid paper	88.0	86.0	94.0	81.3
Air				102.0	66.9

In table 2 the effect of the color of the paper mulch as well as the effect of perforations is shown. Plot 11, which was covered with black solid paper, was 5.4° warmer during the day and 6.4° warmer during the night than the bare plot (No. 7). Where the black perforated paper was used as a mulch (plot 6), the average day and night temperatures were about the same as in the bare plot, with slightly higher night temperatures in favor of the black perforated paper.

Plot 15, which was covered with gray solid paper, was 4.6° colder during the day and 3.6° colder during the night than the bare plot. The coldest of the five plots was number 10, where the average day temperature was 6.3° lower than in the bare plot (No. 7). As the color of the surface soil in these plots is brown, drying to a light brown, the plots covered with the light-colored or gray papers did not have the capacity to absorb as much heat as the bare plot, while those covered with black paper had an increased capacity for heat absorption.

The effect of perforating the mulch paper with large and frequent perforations (fig. 10) is to permit the circulation of air, which results in general in lower temperatures being recorded at the 3 inch depth in the plots covered with perforated paper than in those covered with the non-perforated paper. Plot 6, which was covered with black perforated paper, was on the average 1.2° colder during the day and slightly warmer during the night, as shown in table 2, than the bare plot. The gray perforated paper (plot 10) was the coldest of the five plots, both during the day and at night. Whatever heat is absorbed by the paper mulches during periods of sunlight is rapidly lost from the soil surface by conduction and radiation to the atmosphere when the papers are perforated.

The maximum temperatures in the five plots at the 3-inch depth occurred usually at about the same time, which was two hours after the maximum air temperature was reached. The average maximums

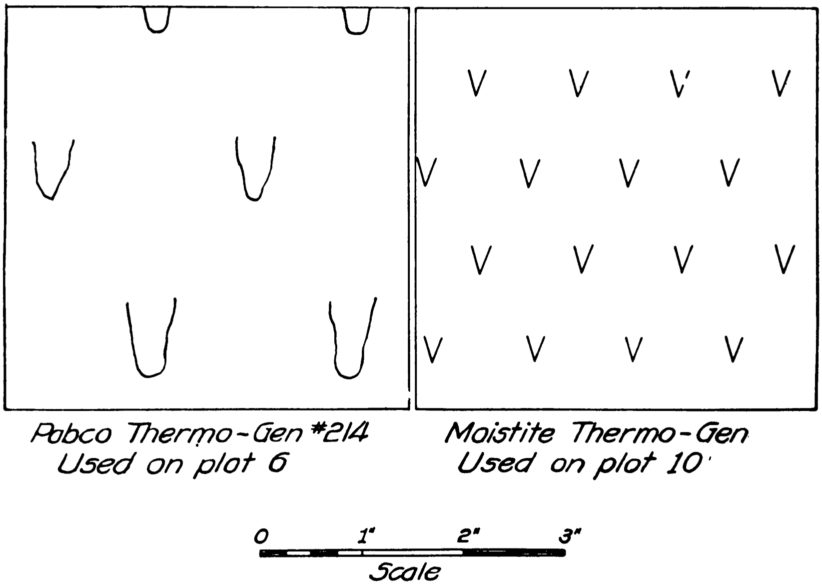

Fig. 10.—Types of perforated paper used.

of these plots as given in table 2 show the range of from 94° to 107°, or 13°. The minimum temperatures at the same depth occurred on the average 1 hour and 40 minutes after the minimum air temperature and showed a range from 81.3° to 88.7°, or 7.4°.

The changes in temperature which occurred at the 12 inch depth in these five plots are graphically shown in figures 11 and 12. The maximum temperatures occurred usually at about the same time, which was 8 hours after the maximum air temperature was reached, and showed a range of 11.6°. The minimums occurred, on the average, 6 hours after the minimum air temperatures and had a range of 10.6°. The results for the 12 inch depth are shown in table 3.

TABLE 3

Average Temperatures at Twelve-inch Depth, July 14–21, 1925

Plot	Day	Night	Maximum	Minimum
	° *F.*	° *F.*	° *F.*	° *F.*
11	93.1	95.4	96.0	92.6
7	87.6	89.4	90.3	86.4
6	88.6	90.0	90.6	87.7
10	82.7	84.0	84.4	82.0
15	84.0	85.0	85.6	83.0
Air	....	....	102.0	66.9

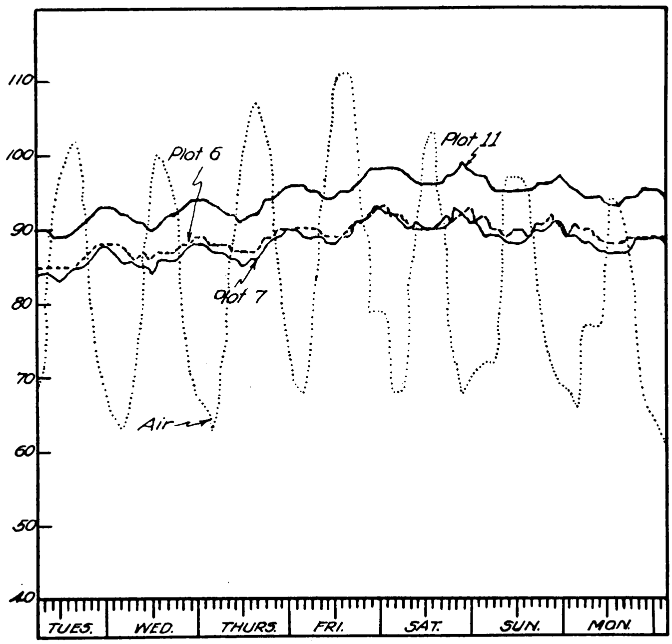

Fig. 11.—Temperatures at 12 inch depth in bare and covered plots and of air by two hour intervals. Week of July 14–21, 1925.

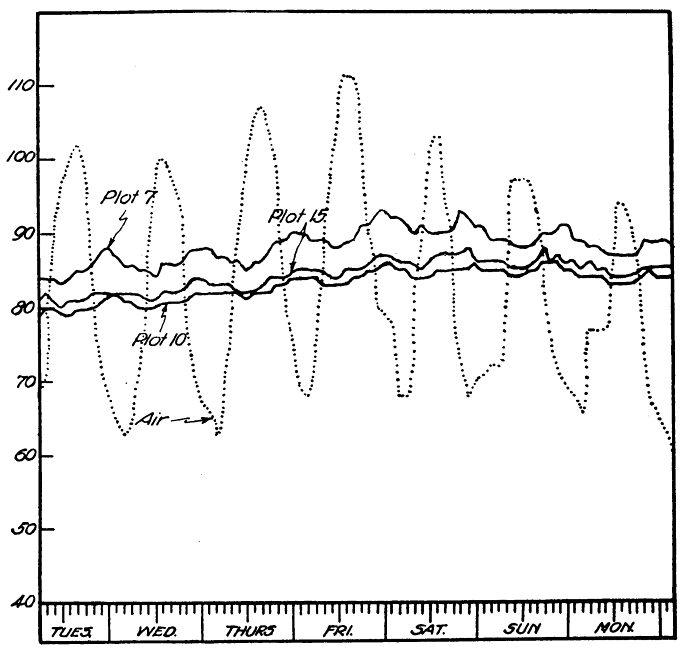

Fig. 12.—Temperatures at 12 inch depth in bare and covered plots and of air by two hour intervals. Week of July 14–21, 1925.

In general the effects of the various types of mulches were the same at a depth of 12 inches (table 3) as those at the 3 inch depth. Plot 11, covered with black solid paper, had the highest temperatures at the 12 inch depth. The average day temperature was 5.5°, and the average night temperature 6.0°, higher than in the bare plot. Plot 6, covered with black perforated paper, was slightly warmer at the 12 inch depth than the bare plot. The plots covered with gray paper mulches were the coldest at the 12 inch depth. Plot 15 covered with gray solid paper was 3.6° and 4.4° colder on the average during the day and night, respectively, than the bare plot (No. 7). Plot 10, covered with the gray perforated paper, was on the average during the day 4.9° and during the night 5.4° colder than the bare plot.

SUMMARY

The highest soil temperature found was in the bare plot, where on July 17, 1925, at a depth of one-half inch, 143° F was registered. Temperatures obtained at a depth of one-half inch showed that the bare plot averaged 10° warmer during the day and 5.6° cooler at night than the plot covered with perforated black paper. In the bare plot the average day temperature at the 6 inch depth for the week was 0.9° higher and the average night temperature was 0.6° higher than on the area covered with perforated black mulch paper.

In the bare plot, where temperatures were obtained at depths of ½, 3, 6, 12, 24, and 36 inches, decided differences were found between the night and day temperatures to a depth of 12 inches.

Temperatures taken at a depth of 3 inches in five plots, where different mulches were used, varied considerably. The warmest plot was that covered with solid black paper. Where the perforated black paper was used the temperatures were about the same as in the bare plot. The coldest plots were those covered with gray paper and in this case the perforated paper was again colder than the non-perforated. The maximum temperatures at the 3 inch depth occurred on the average 2 hours after the maximum air temperature and showed a range of 13°. The minimum temperatures at the 3 inch depth occurred on the average 1 hour and 40 minutes after the minimum air temperature and had a range of 7.4°.

Temperatures taken at a depth of 12 inches showed that the plot covered with the solid black paper was the warmest. The plot covered with perforated black paper was slightly warmer at the 12 inch depth than the bare plot. The coldest plot was that covered with gray perforated paper, while the gray solid paper was only slightly warmer than the gray perforated. The maximum temperatures at the 12 inch depth occurred usually about 8 hours after the maximum air temperature was reached and showed a range in the various plots of 11.6°. The minimum temperatures at the same depth occurred, on the average, 6 hours after the minimum air temperature and had a range of 10.6°.

The effect of the mulch paper was markedly influenced by variations in color and by the presence or absence of perforations. The warmest soil during this week was that covered with non-perforated black paper, and the coldest that covered with the gray perforated paper. Under the conditions of this experiment, the standard perforated mulch papers showed no material effect in increasing the soil temperatures.

These results are not given as indicating the possible effects which might occur when paper mulches are used in crop rows and are not to be taken as recommendations for the use of any particular type of paper mulch. Other work is in progress which will include the effects on crops. This will be reported later.

LITERATURE CITED

[1] ECKART, CHAS. F.

1923. How thermogen enhances the growth of plants 1–29. Published by author, San Francisco.

[2] HARTUNG, W. J.

1926. The functions of paper mulch in pineapple culture 1–31. Hawaiian Pineapple Co., Ltd., Honolulu.

[3] LYON, H. L., G. R. STEWART, and WALLACE MACFARLANE

1923. Univ. Hawaii, second annual short course in pineapple production: 36–39, 74–75, 143–144.

[4] SHAW, C. F.

1926. The effect of a paper mulch on soil temperature. Hilgardia 1: 341–365.

[5] STEWART, G. R., E. C. THOMAS, and JOHN HORNER

1926. Some effects of mulching paper on Hawaiian soils. Soil Sci. 22: 35–51.

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The titles of the Technical Papers of the California Agricultural Experiment Station, Nos. 1 to 20, which HILGARDIA replaces, and copies of which may be had on application to the Publication Secretary, Agricultural Experiment Station, Berkeley, are as follows:

1. The Removal of Sodium Carbonate from Soils, by Walter P. Kelley and Edward E. Thomas. January, 1923.
3. The Formation of Sodium Carbonate in Soils, by Arthur B. Cummins and Walter P. Kelley. March, 1923.
4. Effect of Sodium Chlorid and Calcium Chlorid upon the Growth and Composition of Young Orange Trees, by H. S. Reed and A. R. C. Haas. April, 1923.
5. Citrus Blast and Black Pit, by H. S. Fawcett, W. T. Horne, and A. F. Camp. May, 1923.
6. A Study of Deciduous Fruit Tree Rootstocks with Special Reference to Their Identification, by Myer J. Heppner. June, 1923.
7. A Study of the Darkening of Apple Tissue, by E. L. Overholser and W. V. Cruess. June, 1923.
8. Effect of Salts on the Intake of Inorganic Elements and on the Buffer System of the Plant, by D. R. Hoagland and J. C. Martin. July, 1923.
9. Experiments on the Reclamation of Alkali Soils by Leaching with Water and Gypsum, by P. L. Hibbard. August, 1923.
10. The Seasonal Variation of the Soil Moisture in a Walnut Grove in Relation to Hygroscopic Coefficient, by L. D. Batchelor and H. S. Reed. September, 1923.
11. Studies on the Effects of Sodium, Potassium, and Calcium on Young Orange Trees, by H. S. Reed and A. R. C. Haas. October, 1923.
12. The Effect of the Plant on the Reaction of the Culture Solution, by D. R. Hoagland. November, 1923.
13. Some Mutual Effects on Soil and Plant Induced by Added Solutes, by John S. Burd and J. C. Martin. December, 1923.
14. The Respiration of Potato Tubers in Relation to the Occurrence of Blackheart, by J. P. Bennett and E. T. Bartholomew. January, 1924.
15. Replaceable Bases in Soils, by Walter P. Kelley and S. Melvin Brown. February, 1924.
16. The Moisture Equivalent as Influenced by the Amount of Soil Used in its Determination, by F. J. Veihmeyer, O. W. Israelsen and J. P. Conrad. September, 1924.
17. Nutrient and Toxic Effects of Certain Ions on Citrus and Walnut Trees with Especial Reference to the Concentration and Ph of the Medium, by H. S. Reed and A. R. C. Haas. October, 1924.
18. Factors Influencing the Rate of Germination of Seed of Asparagus officinalis, by H. A. Borthwick. March, 1925.
19. The Relation of the Subcutaneous Administration of Living Bacterium abortum to the Immunity and Carrier Problem of Bovine Infectious Abortion, by George H. Hart and Jacob Traum. April, 1925.
20. A Study of the Conductive Tissues in Shoots of the Bartlett Pear and the Relationship of Food Movement to Dominance of the Apical Buds, by Frank E. Gardner. April, 1925.