SCHOOL OF CIVIL ENGINEERING

# JOINT HIGHWAY RESEARCH PROJECT

JHRP-75-14

## AN EVALUATION OF SEVERAL MULCH MATERIALS ON LANDSCAPE PLANT GROWTH, WEED CONTROL, SOIL TEMPERATURE AND SOIL MOISTURE

P. L. Carpenter


PURDUE UNIVERSITY
DIANA STATE HIGHWAY COMMISSION

Interim Report

# AN EVALUATION OF SEVERAL MULCH MATERIALS ON LANDSCAPE PLANT GROWTH, WEED CONTROL, SOIL TEMPERATURE AND SOIL MOISTURE

TO: J. F. McLaughlin, Director
Joint Highway Research Project

July 30, 1975

Project: C-36-48G

FROM: H. L. Michael, Associate Director
Joint Highway Research Project

File: 9-5-7

The attached Interim Report is submitted on the HPR Part II Research Study titled "Development of Techniques for Plant Establishment on the Roadside". The Report is titled "An Evaluation of Several Mulch Materials on Landscape Plant Growth, Weed Control, Soil Temperature and Soil Moisture". The title quite well summarizes the content of the brief report.

The Report is submitted as partial fulfillment of the objectives of this Study. It will also be forwarded to the ISHC and FHWA for review, comment and similar acceptance.

Respectfully submitted,

Harold L. Michael

Harold L. Michael
Associate Director

HLM:ms

cc:
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16. Abstract

The effectiveness of various materials as mulches for landscape sites was evaluated. Factors considered were weed control, effect on growth of landscape plants, and soil environment modification. The latter included measurements of soil temperatures and soil moistures. Mulches investigated were Douglas fir bark chips (2" dia), shredded hard wood bark, shredded scrap from rubber tires, and stone approximately 1.5" in diameter. Best weed control over a 2 year period was obtained with the Douglas fir bark chips with 2" mulch of shredded rubber tires being nearly as good. The best plant growth was obtained when the plants were mulched. Cotoneaster grew better when mulched with Douglas fir bark than any other mulch treatment except 2" of shredded rubber tires. This is probably due to a reduction in weed competition. The effect on growth of junipers was less pronounced.

Soil temperature and loss of soil moisture was reduced by all mulches tested. Stone by itself, however, was not as good as the others. The addition of plastic under stone was effective in increasing retention of soil moisture and compared favorably to the Douglas fir bark and shredded rubber tire mulches.

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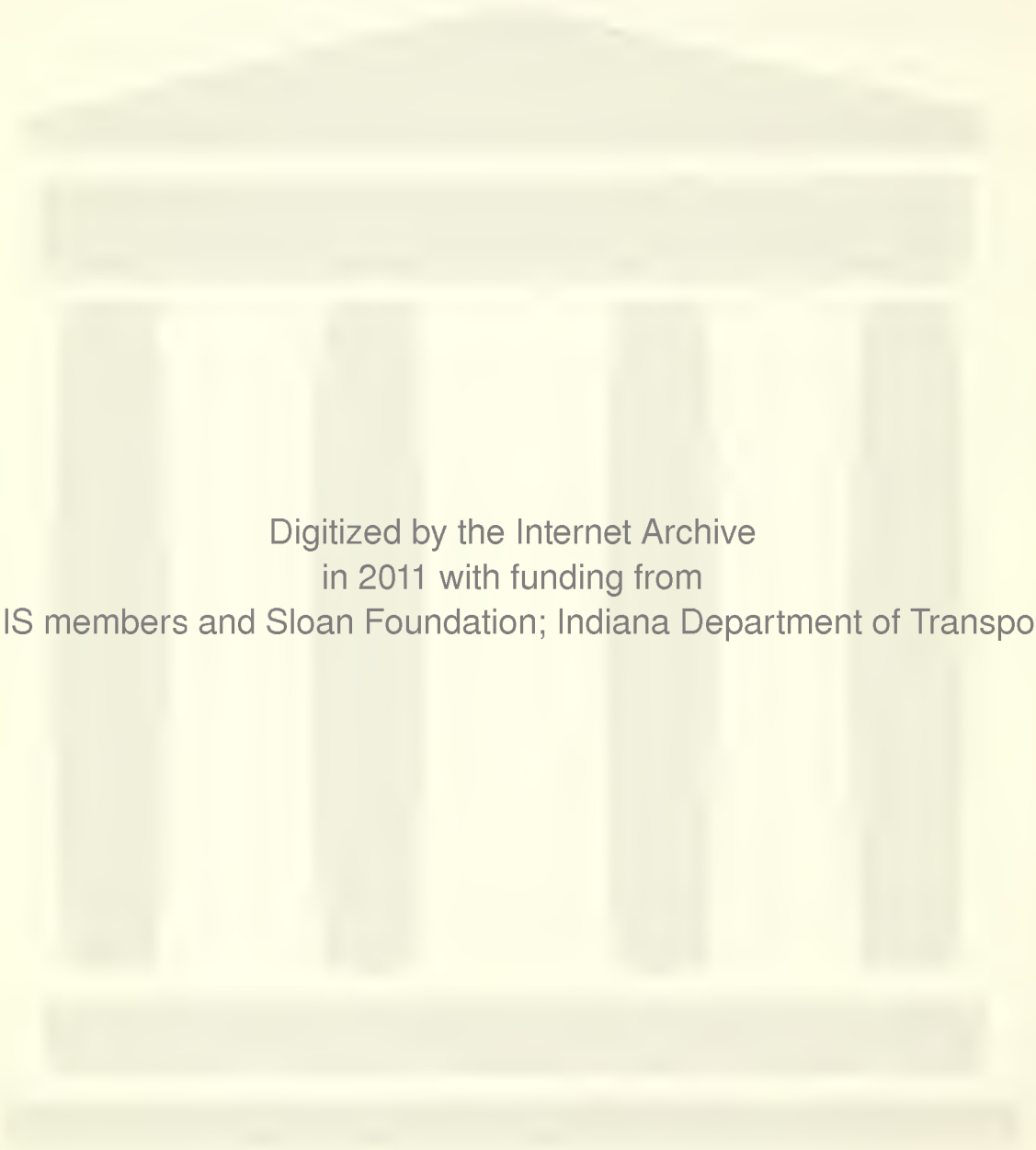

Interim Report

# AN EVALUATION OF SEVERAL MULCH MATERIALS ON LANDSCAPE PLANT GROWTH, WEED CONTROL, SOIL TEMPERATURE AND SOIL MOISTURE

by

P. L. Carpenter
Associate Professor of Horticulture
Department of Horticulture
School of Agriculture

Joint Highway Research Project

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Conducted by

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Engineering Experiment Station
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in cooperation with the

Indiana State Highway Commission

and the

U.S. Department of Transportation
Federal Highway Administration



Purdue University
West Lafayette, Indiana
July 30, 1975

## HIGHLIGHT SUMMARY

The effectiveness of various materials as mulches for landscape sites was evaluated. Factors considered were weed control, effect on growth of landscape plants, and soil environment modification. The latter included measurements of soil temperatures and soil moistures. Mulches investigated were Douglas fir bark chips (2" dia), shredded hard wood bark, shredded scrap from rubber tires, and stone approximately 1.5" in diameter. Best weed control over a 2 year period was obtained with the Douglas fir bark chips with 2" mulch of shredded rubber tires being nearly as good. The best plant growth was obtained when the plants were mulched. Cotoneaster grew better when mulched with Douglas fir bark than any other mulch treatment except 2" of shredded rubber tires. This is probably due to a reduction in weed competition. The effect on growth of junipers was less pronounced.

Soil temperature and loss of soil moisture was reduced by all mulches tested. Stone by itself, however, was not as good as the others. The addition of plastic under stone was effective in increasing retention of soil moisture and compared favorably to the Douglas fir bark and shredded rubber tire mulches.

# An Evaluation of Several Mulch Materials on Landscape Plant Growth, Weed Control, Soil Temperature and Soil Moisture

by P. L. Carpenter

## Introduction:

The effectiveness of various materials as mulches for landscape sites was evaluated. Factors considered were weed control, effect on growth of landscape plants, and soil environment modification. The latter includes measurements of soil temperatures and soil moisture. The effect of a mulch on soil temperature and moisture as well as weed control will, of course, have a marked effect on the growth of a landscape plant, but the effect of the mulch itself on plant growth should also be evaluated. This report will be divided into two sections, the first is on the effects of various mulches on the growth of landscape plants and on weed control, and the second section will cover the effects of mulches on the soil environment.

## I

## EFFECTS OF VARIOUS MULCHES ON THE GROWTH OF LANDSCAPE PLANTS AND CONTROL OF WEEDS IN THE LANDSCAPE BED

## Materials and Methods:

Eight treatments were established on a silt loam soil that had a history of minimum cultivation and a wide range of annual weeds. The treatments used for the evaluation were:

1. Check - no mulch or herbicide applied
2. Casoron at 4 #/A (herbicide)
3. 1" shredded hard wood bark
4. 2" shredded hard wood bark
5. 2" shredded hard wood bark + Casoron 4 #/A
6. 1" shredded rubber tire
7. 2" shredded rubber tire
8. 2" Douglas fir bark chips

All treatment plots were 6' x 6' and each treatment was replicated 4 times. The herbicide was incorporated in the bark mulch at the rate of 6 oz of 4G Casoron per cubic yard. The treatments were applied during mid-June 1973 except the Douglas fir bark which was applied 3 weeks later.

All mulches and herbicides were applied after the landscape plants were planted in the plots. The test plants used were:

Cotoneaster divaracata - Spreading cotoneaster

Juniperus chinensis 'pfitzeriana' - Pfitzer juniper

Three plants of each species were planted in each plot on 1 1/2' centers. Test plants were purchased from a commercial nursery as one gallon container grown plants. The soil type at the site was a loamy fine sand with a pH of 6.7 and organic matter content of 1.52%.

Data taken consisted of number of weeds per plot in 1973 and weight of weeds in the plots in 1974. Weeds were removed from the plots after data were taken in 1973. During 1973 the weeds were removed only once during the season to more closely relate to a highway roadside situation and a second application of the herbicide was not made. Weeds were neither removed

from the plots during 1974 nor was the herbicide applied at the beginning of the season.

Plant growth was recorded as fresh weight of the plant top (all above ground parts) and this data were collected at the end of the experiment (26 September 1974).

Results and Discussion:

Long lasting (2 growing seasons) weed control was achieved with 3 of the treatments. Best control was obtained using Douglas Fir bark a minimum of 2 inches deep. The control, however, was not significantly better than that achieved with shredded rubber 1" deep or 2" deep, 2" of bark mulch, or 2" of bark mulch plus Casoron during the first year. Second year control was good only in the two rubber treatments and the Douglas fir bark treatment (See Table 1). Weed control probably will not decline for several years when a shredded tire mulch is used 2 or more inches deep. The Douglas fir bark will decompose with time and weed control should be lost when this occurs.

Landscape plant growth was measured after two growing seasons. The growth of the junipers was significantly better than the check only with the Douglas fir mulch treatment. There was, however, no significant difference between any of the mulch treatments except that the Douglas fir bark treatment was better than the shredded 1" deep hardwood bark. Results obtained with the cotoneaster are somewhat more complex. Growth was better than the check though, when 2" of any mulch material was used. Growth in plots utilizing Douglas fir bark was significantly better than

that achieved with shredded hardwood bark, but it was not significantly better than that of the plants mulched with 2" of shredded rubber tires. (See Table 2).

There is no evidence that mulching with shredded rubber tires will reduce the growth of the landscape plants tested. The only injury noted occurred a few days after planting of the junipers. The plants were in a very active growth stage and the ends of the new shoots were "burned" when in contact with the rubber mulch, this was probably due to the high temperatures that occur on the surface of the rubber mulch on bright days. This injury neither persisted nor effected total growth of the plant. The better growth of the mulched plants was due, at least in part, to the reduction of weed competition. (Compare data in Tables 1 and 2).

Conclusions and Recommendations:

1. Mulches should be used a minimum of 2" deep for achieving best weed control.
2. Good weed control with the rubber mulch will be a minimum of two seasons and there is no reason to assume that it will not be semi permanent (several years).
3. Growth of landscape plants does not appear to be reduced with any mulch even on a sandy loam soil.
4. It is recommended that a large scale experiment be initiated at a newly landscaped highway site preferably utilizing shredded rubber tires as a mulch.

Table 1.

Weed control achieved using

different mulch materials

| Treatments | # Weeds/sq. ft.[1] | Fr. wt grams of weeds/sq.ft.[2] |
|---|---|---|
| Check | 163.9 | 458.7 |
| Casoron 4#/A | 37.3 | 375.7 |
| Bark Mulch 1" | 54.4 | 325.8 |
| Bark Mulch 2" | 6.7 | 285.0 |
| Rubber Mulch 1" | 23.3 | 80.3 |
| Rubber Mulch 2" | 1.3 | 66.2 |
| Bark 2" + Casoron 4#/A | 0.2 | 211.4 |
| Douglas Fir Bark 2" | 0.1 | 13.8 |
| LSD .05 | 33.0 | 175.6 |

[1]Data taken July 16, 1973.

[2]Data taken Sept. 26, 1974.

Table 2.

Growth of Juniperus chinensis 'pfitzeriana' and Cotoneaster divaracata when grown under different mulches.

| Treatments | Fr. wt./plant grams | |
|---|---|---|
| | Juniper | Cotoneaster |
| Check | 1832.75 | 211.25 |
| Casoron 4#/A | 1545.00 | 228.00 |
| Bark Mulch 1" | 1904.00 | 510.75 |
| Bark Mulch 2" | 2380.25 | 556.50 |
| Rubber Mulch 1" | 2263.50 | 454.25 |
| Rubber Mulch 2" | 2266.00 | 790.00 |
| Bark 2" + Casoron 4#/A | 2370.00 | 537.75 |
| Douglas Fir Bark 2" | 2514.00 | 957.25 |
| LSD .05 | 516.90 | 343.80 |

# II

# THE EFFECTS OF VARIOUS MULCHES ON SOIL TEMPERATURE AND SOIL WATER

Materials and Methods:

Five treatments consisting of 4 mulch materials and a bare soil check were established on a Warsaw silt loam soil located on the Purdue University campus. The mulches used were:

1. Check - bare soil
2. Shredded rubber tires - 3" deep
3. Rock - 1"-1 1/2" dia. - 3" deep
4. Rock - 1"-1 1/2" dia. - 3" deep over 4 mil black plastic
5. Douglas fir bark - 3" deep

Each plot size was 6' x 6' and each treatment was duplicated.

To determine soil moisture levels a 2" diameter aluminum irrigation pipe was installed in the center of each of the plots. A neutron probe was lowered in this pipe to determine soil moisture at depths of 0", 6", 12" and 18". Data obtained with the probe were converted to percent moisture by volume of soil. Readings were made once per week during the months of July, August, September, October, November 1973, and May and June 1974. Two readings were taken at each plot and an average was recorded for the day. All readings were taken in the afternoon.

Temperature sensing (thermisters) devices were installed on the soil surface and 6" deep in the soil in each plot. The mulch treatments were applied after the installation of these devices. Readings

were taken twice daily (8:30 am and 3:00 pm) from 29 May to 4 December 1973.

Results and Discussion:

Moisture determinations show that the moisture levels at the soil surface varied some from week to week with the moisture content being somewhat higher under the mulches (Table 3). At a soil depth of 6" the moisture level was highest with the stone over plastic treatment. There was, however, very little difference between that treatment and the shredded tire or Douglas fir bark treatments. These 3 treatments had noticeably higher soil moisture levels than either bare soil or soil covered with stone. At the 12" depth soil moisture was higher with the same 3 mulch treatments than bare soil and the moisture level under just stone was even lower than the bare soil treatment. The data obtained at 18" level show much the same results. With the exception of the plain stone mulch, there does not appear to be any difference between the mulches evaluated in terms of their effect on soil moisture. Perhaps the stone alone prevented some soil penetration of rainfall by absorbing some moisture that later evaporated. Also, the stone would not be as effective a barrier as other mulches to capillary movement of moisture to the surface and hence evaporation.

The temperature data collected indicate that the use of mulches modifies the soil temperature both at soil surface (under the mulch) and 6" below the soil surface. There are less drastic fluctuations in temperature on a daily basis when a mulch is used. It should also, be noted that soil temperatures remained above freezing by 2-4 $^{\circ}$C when a

mulch was used. There appears to be very little difference in mulches as far as their effect on soil temperature is concerned (Figures 1-8), although the lighter colored stone mulches appear to be slightly less effective at retaining soil heat at the low air temperatures. The soil under the darker colored mulches was found to be 1-2°C warmer.

Table 4 shows minimum soil temperatures at various soil depths. In certain winters, soil temperatures at an 8" depth dropped to lows that would be injurious to roots of some ornamental species. (Note the temperatures at 8" in Jan. 1966, '69, '71, and '72). In 4 out of 10 years, temperatures were low enough to injure sensitive, shallow rooted species. It should also be noted that under a turf cover, soil temperatures never reached an injurious level. Mulches likewise will help prevent extreme low soil temperatures at shallow depths (4" - 6"). Dark mulches will be heat absorbant and hence should help maintain a higher soil temperature. Warmer soil temperatures in the winter will reduce the chances of low temperature injury to sensitive species.

Conclusions:

1. Mulches do provide a modification in soil temperature fluctuations.
2. Mulches will help reduce the chance of low temperature injuries to plant roots.
3. Mulches will reduce loss of moisture by soil and this moisture can be utilized by plants on a highway landscape site.
4. Stone alone may not be an effective mulch material.

Table 3

Soil moisture at four soil depths

under different mulches

| Treatment | Soil Depth | % Moisture 7/25 | 8/29 | 9/25 | 5/8 |
|---|---|---|---|---|---|
| Bare Soil | 0" | 26.2 | 28.2 | 32.6 | 29.8 |
| | 6" | 35.9 | 35.0 | 35.4 | 35.2 |
| | 12" | 38.0 | 37.0 | 37.6 | 36.9 |
| | 18" | 36.4 | 36.5 | 35.7 | 36.3 |
| Rubber | 0" | 32.6 | 34.3 | 36.0 | 34.6 |
| | 6" | 41.1 | 40.8 | 41.2 | 40.7 |
| | 12" | 41.0 | 40.4 | 39.4 | 39.3 |
| | 18" | 39.8 | 39.2 | 36.8 | 37.8 |
| Bark | 0" | 36.2 | 35.1 | 37.2 | 36.2 |
| | 6" | 43.0 | 41.6 | 41.0 | 40.4 |
| | 12" | 40.4 | 39.2 | 38.0 | 38.8 |
| | 18" | 41.1 | 39.7 | 40.4 | 39.5 |
| Rock + Plastic | 0" | 33.8 | 38.4 | 36.3 | 38.3 |
| | 6" | 43.8 | 43.2 | 43.0 | 42.5 |
| | 12" | 41.4 | 39.8 | 39.8 | 39.4 |
| | 18" | 40.1 | 38.8 | 38.6 | 39.0 |
| Rock | 0" | 34.2 | 33.0 | 31.6 | 35.1 |
| | 6" | 37.5 | 36.6 | 36.5 | 36.7 |
| | 12" | 35.1 | 33.8 | 33.8 | 30.8 |
| | 18" | 28.6 | 28.3 | 28.4 | 31.2 |

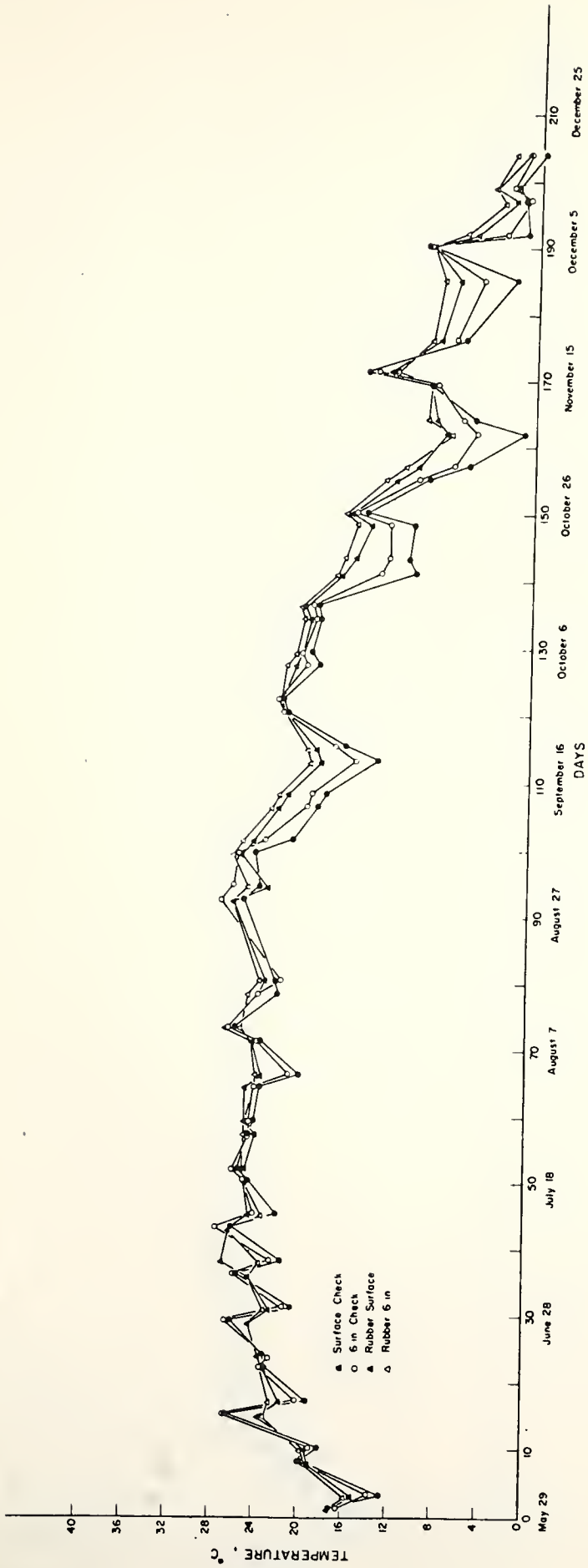


Figure 1. Comparison of temperatures of bare soil vs. soil under 3" rubber mulch. Temperature measurement at 8:30 a.m.

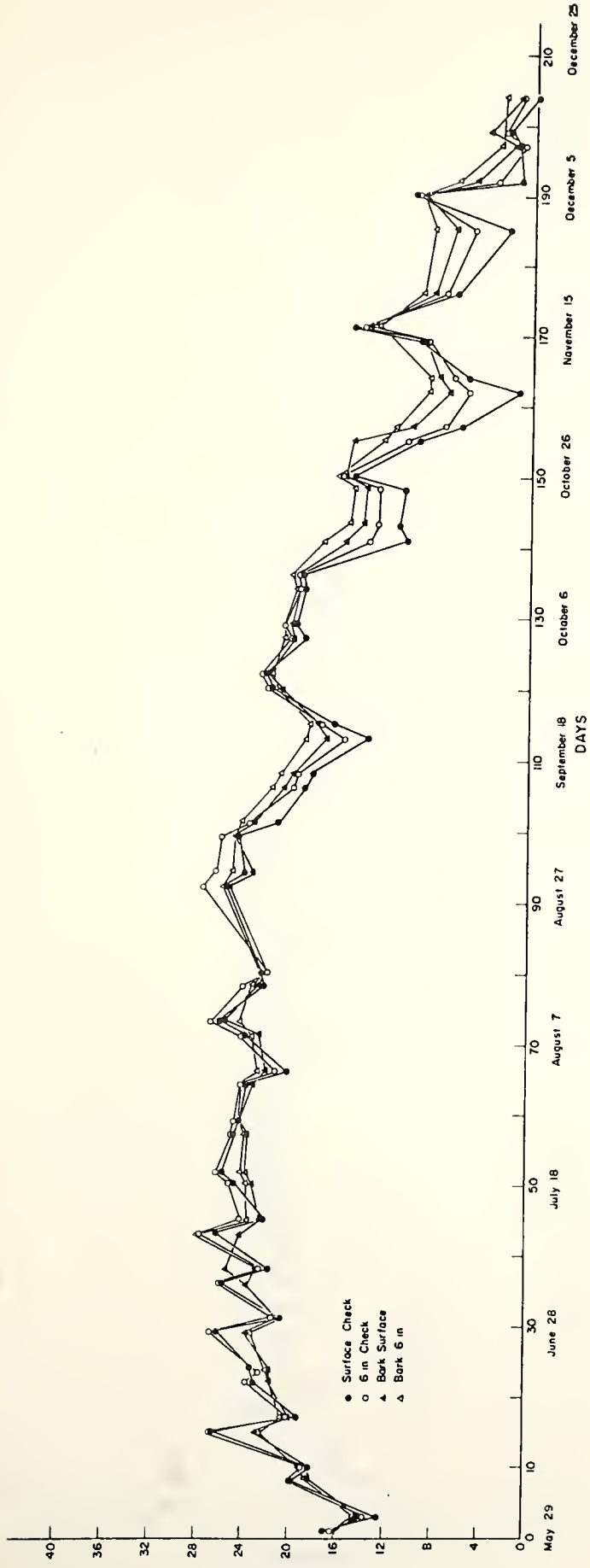


Figure 2. Comparison of temperatures of bare soil vs. soil under 3" Douglas Fir bark mulch. Temperature measurment at 8:30 a.m.

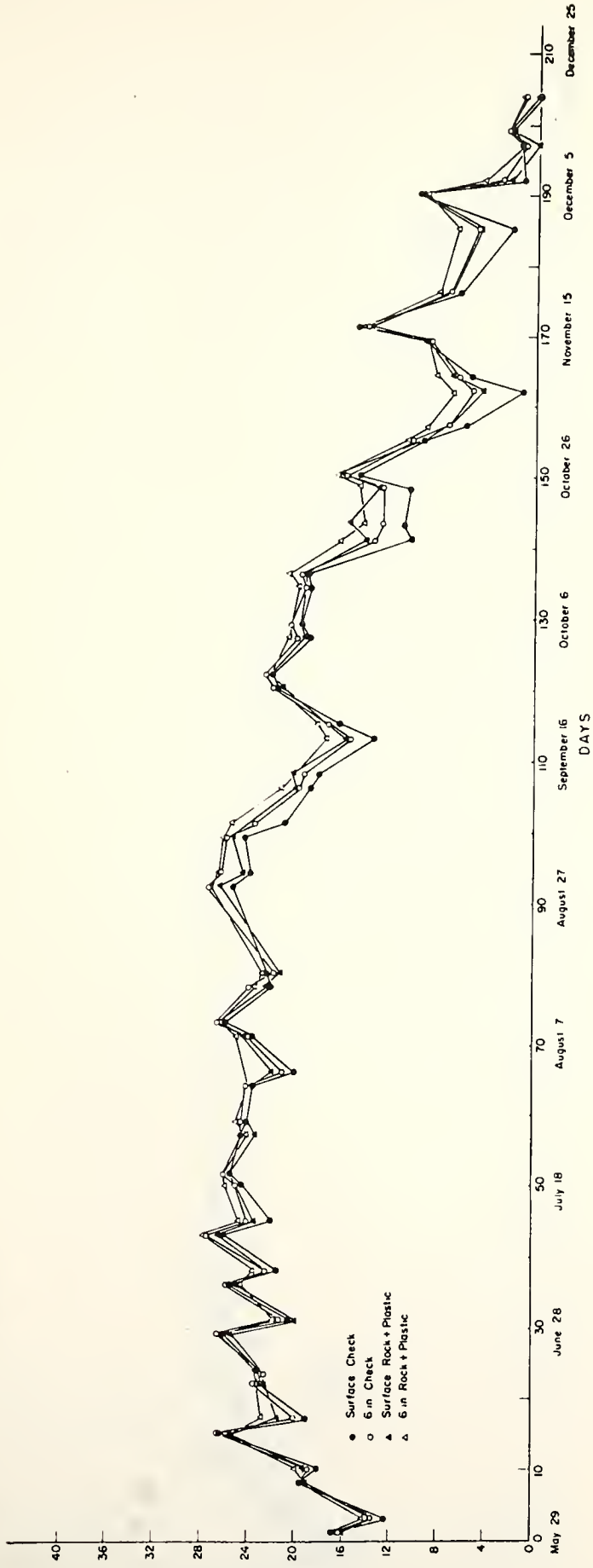


Figure 3. Comparison of temperatures of bare soil vs. soil under 3" rock mulch over plastic. Temperature measurement at 8:30 a.m.

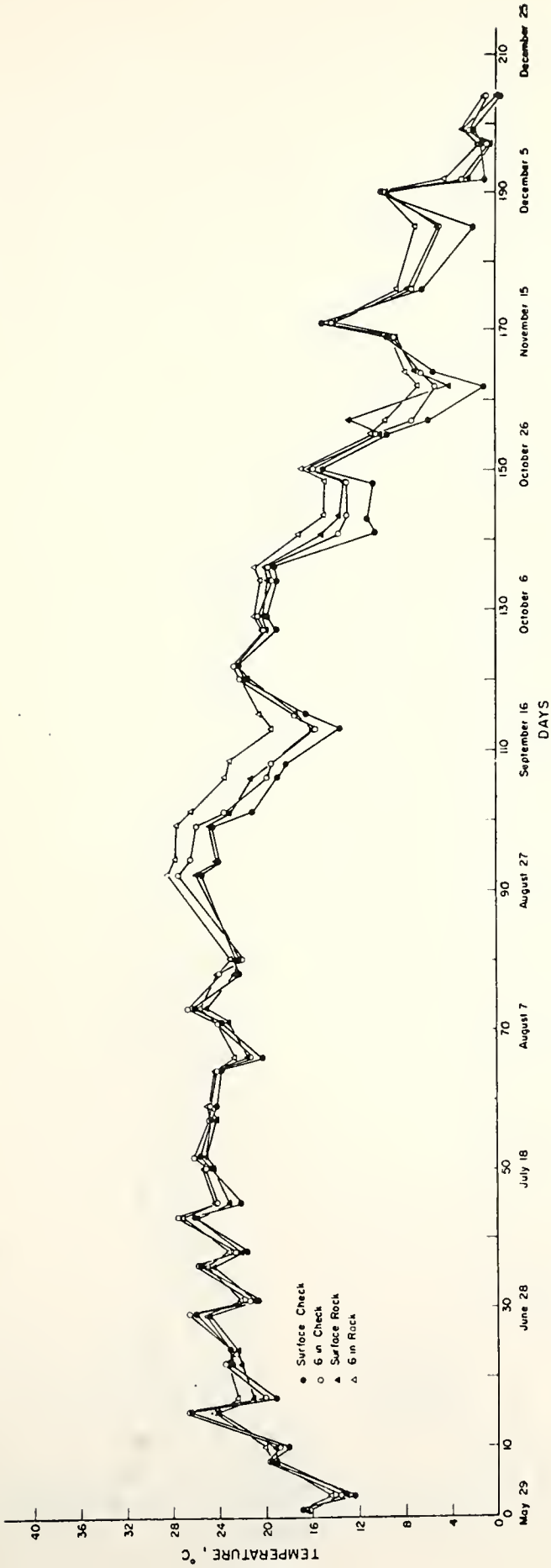


Figure 4. Comparison of temperatures of bare soil vs. soil under 3" rock mulch. Temperature measurement at 8:30 a.m.

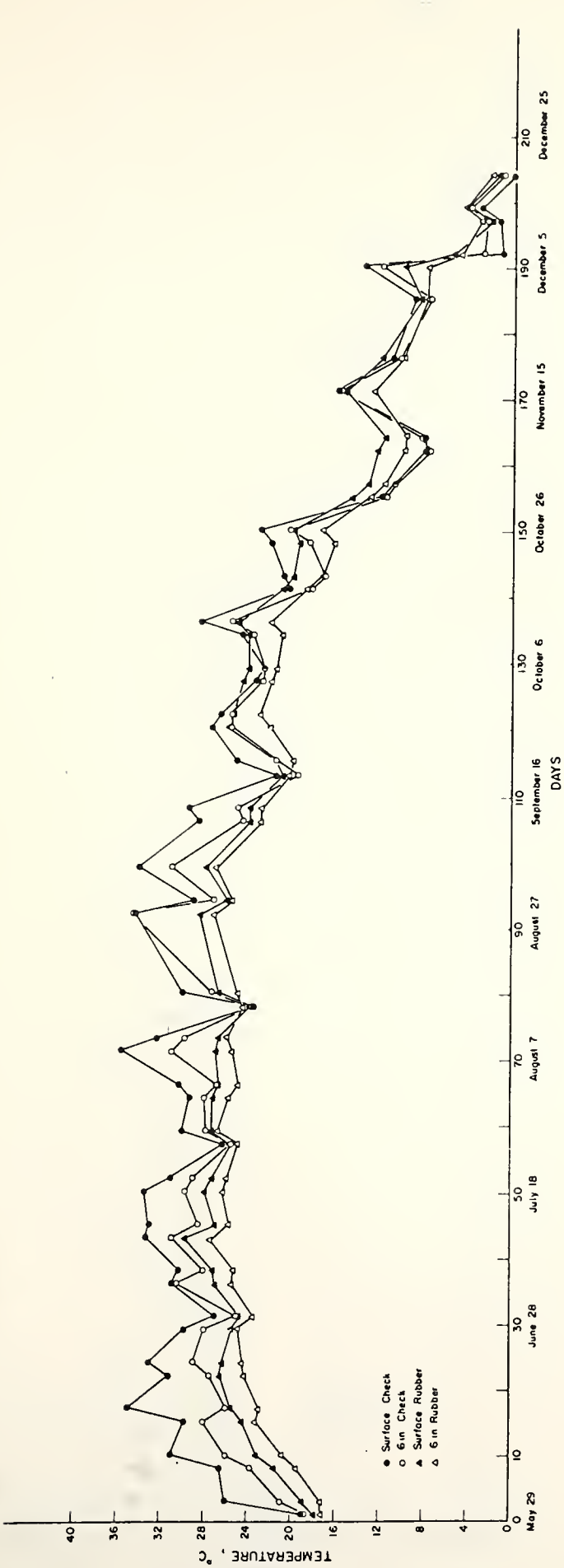


Figure 5. Comparison of temperatures of bare soil vs. soil under 3" rubber mulch. Temperature measurement at 3:30 p.m.

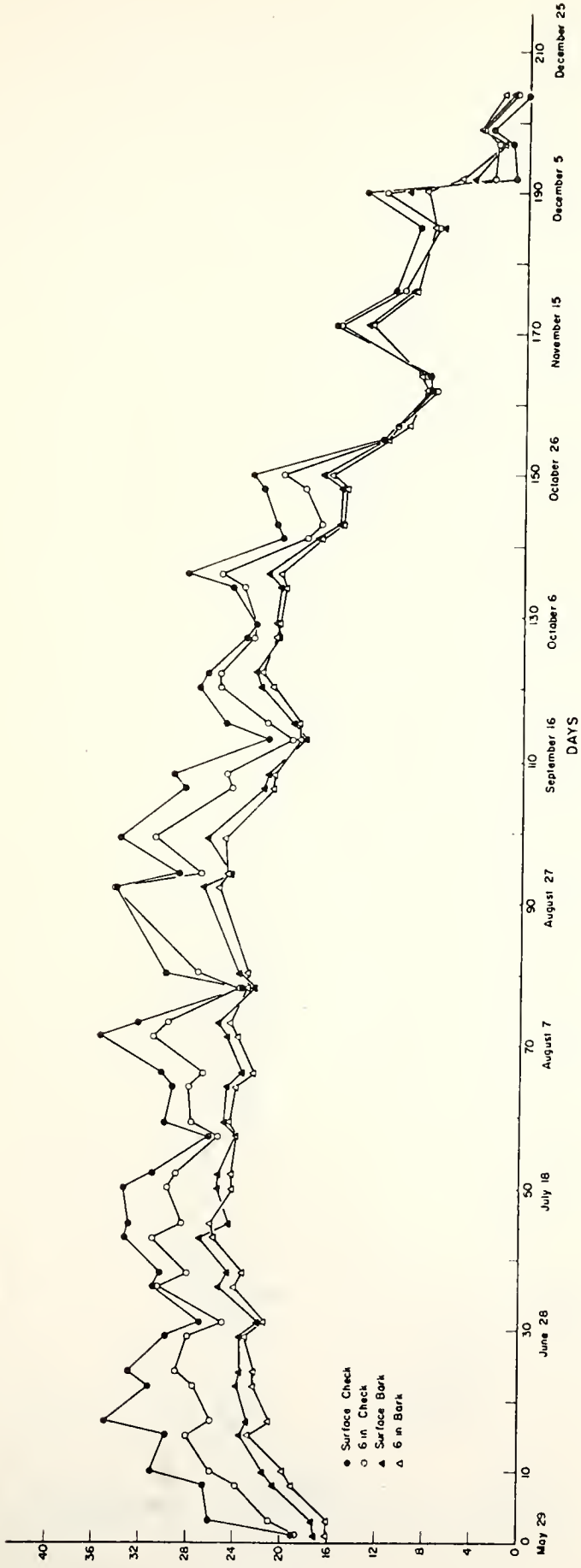


Figure 6. Comparison of temperatures of bare soil vs. soil under 3" Douglas Fir bark mulch. Temperature measurement at 3:30 a.m.

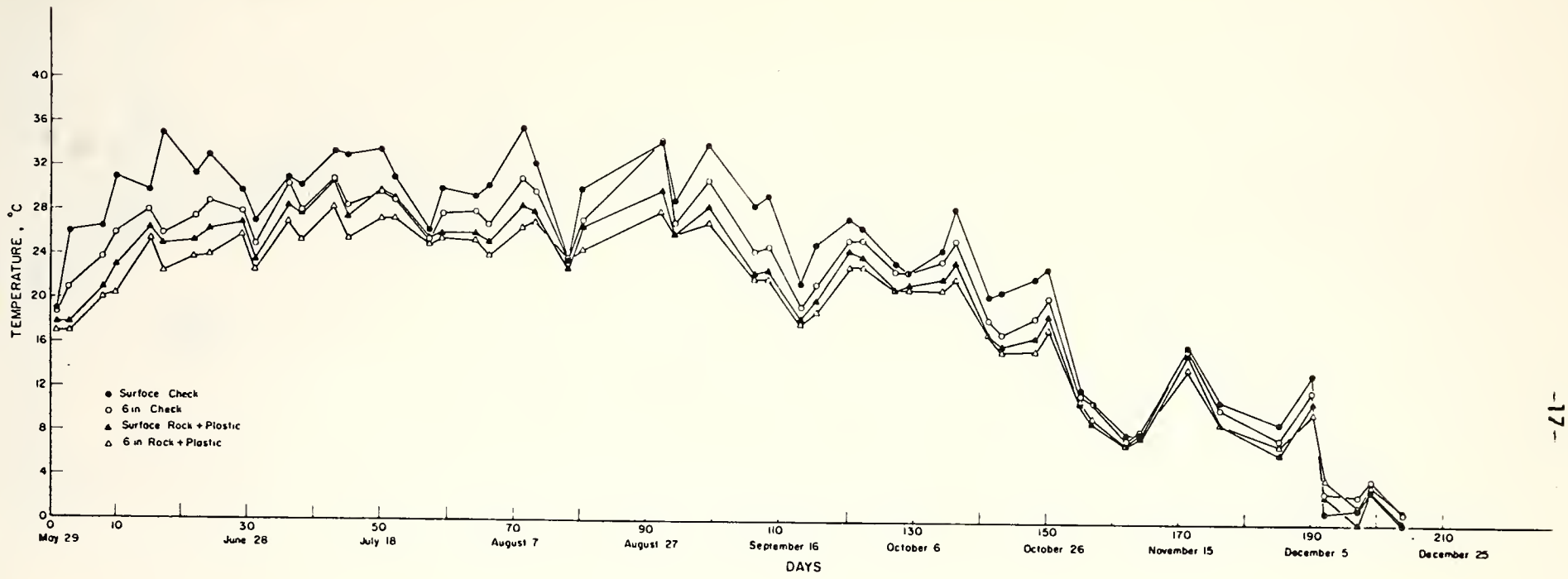




Figure 7. Comparison of temperature of bare soil vs. soil under 3" rock mulch over plastic. Temperature measurement at 3:30 a.m.

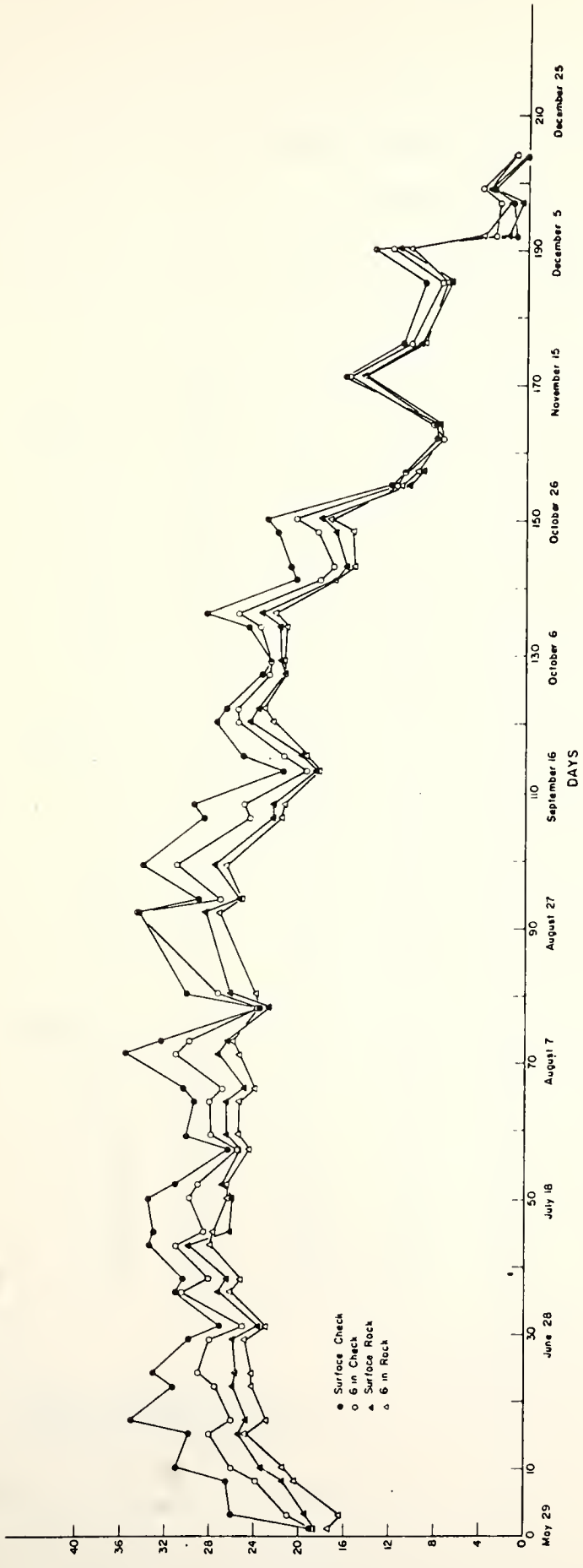


Figure 8. Comparison of temperatures of bare soil vs. soil under 3" rock mulch. Temperature measurement at 3:30 a.m.

Table 4.

Lowest minimum temperatures

Agronomy Farm

West Lafayette, Indiana

| | | Bare soil | | | | | Grass covered |
|---|---|---|---|---|---|---|---|
| | | 2" | 4" | 8" | 20" | 40" | 4" |
| Jan. | 74 | 32 | 32 | 34 | 36 | 44 | 33 |
| | 73 | 13 | 17 | 27 | 34 | 41 | 32 |
| | 72 | 8 | 15 | 20 | 37 | 43 | 34 |
| | 71 | 10 | 14 | 22 | 34 | 41 | 30 |
| | 70 | 29 | 29 | 32 | 38 | 41 | 34 |
| | 69 | 11 | 14 | 21 | 35 | 41 | 32 |
| | 68 | 29 | 34 | 33 | 38 | 42 | 38 |
| | 67 | 13 | 19 | 23 | 34 | 41 | 33 |
| | 66 | 7 | 11 | 16 | 32 | 41 | 26 |
| | 65 | 16 | 20 | 25 | 36 | 41 | 32 |
| Feb. | 74 | 23 | 24 | 33 | 35 | 42 | 33 |
| | 73 | 18 | 22 | 31 | 34 | 41 | 33 |
| | 72 | 22 | 25 | 29 | 37 | 41 | 33 |
| | 71 | 6 | 10 | 16 | 23 | 38 | 29 |
| | 70 | 19 | 22 | 30 | 37 | 41 | 33 |
| | 69 | 25 | 27 | 31 | 36 | 40 | 32 |
| | 68 | 15 | 23 | 26 | 35 | 40 | 34 |
| | 67 | 15 | 24 | 28 | 37 | 41 | 37 |
| | 66 | 12 | 16 | 18 | 31 | 39 | 26 |
| | 65 | 21 | 20 | 25 | 33 | 39 | 30 |
| March | 74 | 33 | 34 | 34 | 35 | 42 | 35 |
| | 73 | 32 | 31 | 32 | 34 | 41 | 33 |
| | 72 | 27 | 31 | 32 | 37 | 41 | 34 |
| | 71 | 29 | 32 | 32 | 35 | 38 | 32 |
| | 70 | 30 | 31 | 32 | 37 | 41 | 33 |
| | 69 | 31 | 32 | 32 | 36 | 40 | 34 |
| | 68 | 22 | 28 | 29 | 34 | 39 | 35 |
| | 67 | 30 | 33 | 30 | 36 | 39 | 37 |
| | 66 | 33 | 33 | 33 | 35 | 39 | 32 |
| | 65 | 26 | 31 | 33 | 35 | 40 | 32 |

*All temperatures in °F.

Lowest min. temp. Agronomy Farm (Cont'd).

| | | Bare soil | | | | | Grass covered |
|---|---|---|---|---|---|---|---|
| | | 2" | 4" | 8" | 20" | 40" | 4" |
| Dec. | 74 | | | | | | |
| | 73 | 32 | 32 | 33 | 37 | 46 | 32 |
| | 72 | 18 | 22 | 27 | 34 | 43 | 31 |
| | 71 | 29 | 32 | 35 | 41 | 48 | 37 |
| | 70 | 21 | 25 | 31 | 40 | 46 | 34 |
| | 69 | 27 | 28 | 32 | 40 | 45 | 35 |
| | 68 | 23 | 25 | 31 | 38 | 45 | 33 |
| | 67 | 32 | 35 | 35 | 41 | 46 | 38 |
| | 66 | 25 | 28 | 29 | 39 | 46 | 38 |
| | 65 | 32 | 35 | 35 | 40 | 47 | 36 |

COVER DESIGN BY ALDO GIORGINI