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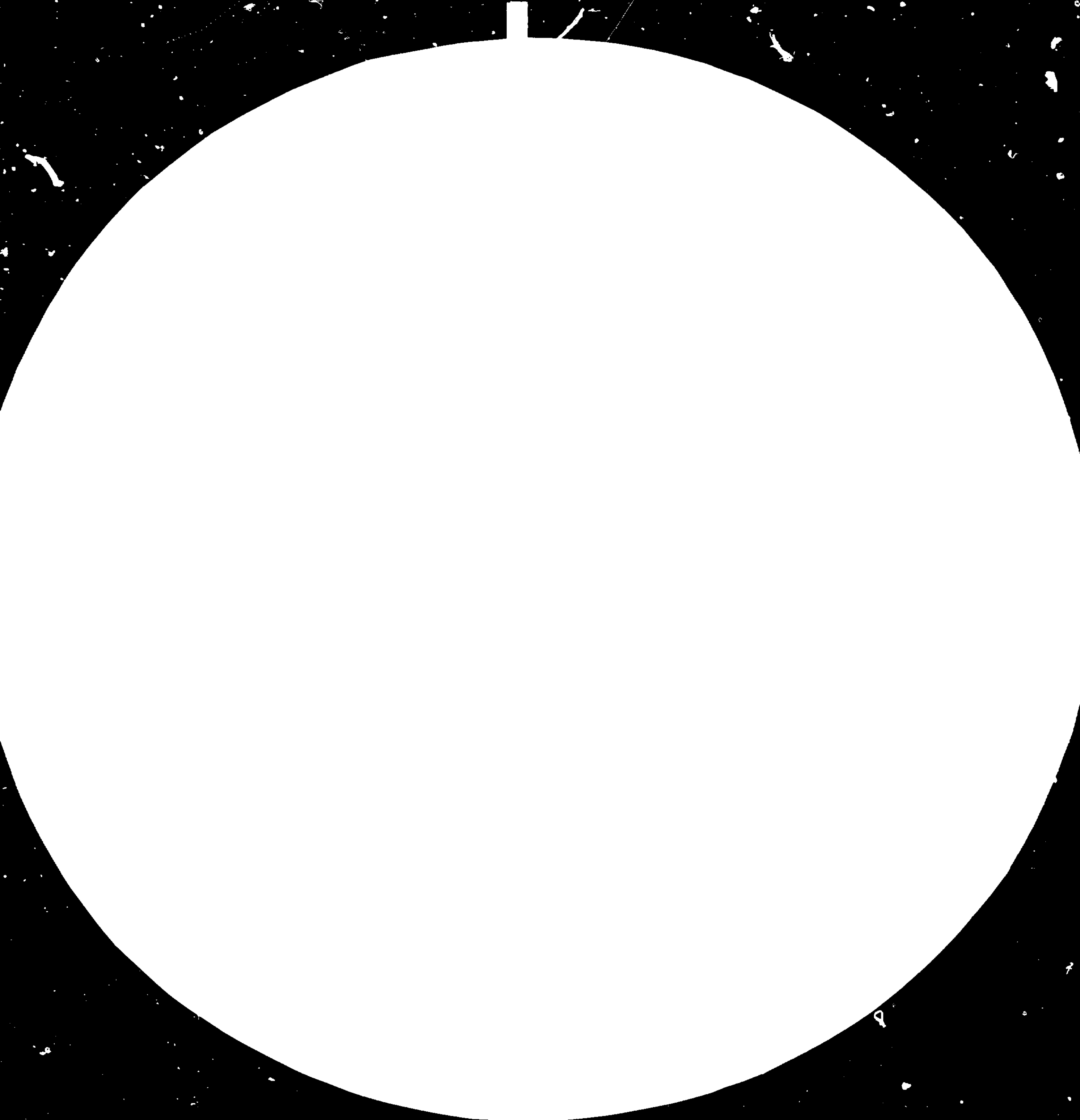

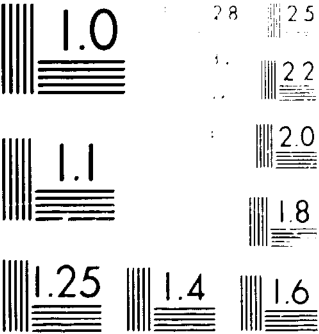

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# THE SOLAR-ENERGY-POWERED THERMOREGULATION CUSHION: AN ORIGINAL DEVICE FOR PROMOTING THE EARLY MATURITY OF MELONS AND WATERMELONS*

by

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* The views expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been translated from an unedited original.

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As a result of the dramatically threatening crisis in the world's oil supply situation, intensive efforts must be made to find alternative energy sources.

One of the areas of research that has received most attention is the area concerned with the maximum possible use of solar radiation. Research in this direction is already being very actively pursued in the agricultural sector as well. The expectation is that, within a relatively short time, the use of solar energy on an economically sound basis will become commonplace in a number of agricultural activities.

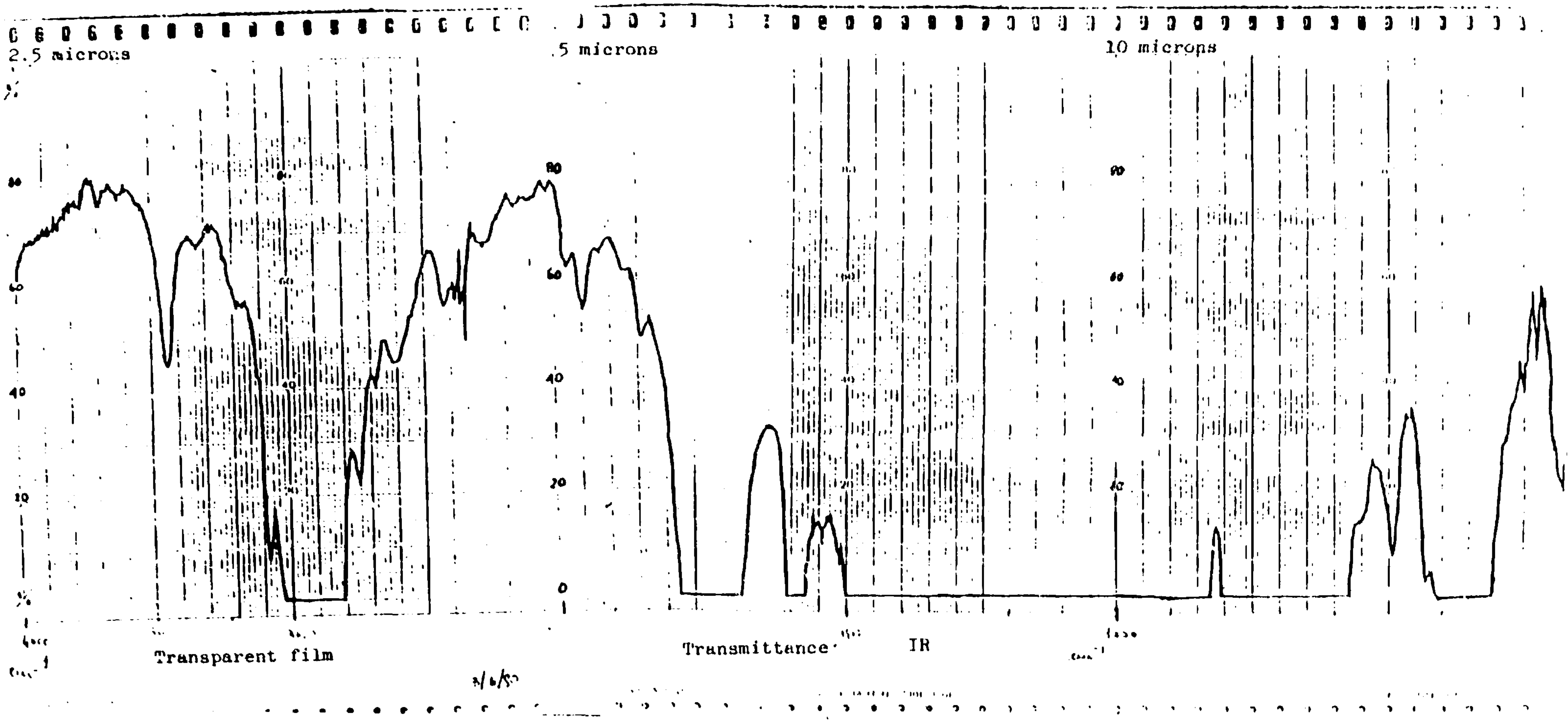
Already such structures as greenhouses, large and small tunnels, and crop-protection shelters in general may be regarded as solar collectors operating on the basis of the so-called greenhouse effect, i.e. the retention of the medium- to long-wave infra-red radiation emitted by soil previously heated by solar radiation.

Another device based on the use of solar energy has been developed and patented by the Montedison Agricultural Technology Centre, Servizi Agricoltura S.p.A., at Mantua. This new technological development is based on the fact that water has a higher heat-insulating capacity than soil. This explains why, although it takes longer to heat, water also releases its heat more slowly.

This realization led to the idea of surrounding the plant with a certain quantity of water in order that it might benefit from this characteristic. About ten kilograms of water was confined inside a cushion consisting of two square sheets, 50 x 50 cm, one of them black and the other transparent (or both transparent), heat-sealed at the edges, with a valve-equipped neck for the introduction of the liquid and a hole in the centre, likewise welded around the edges, for the passage of the plant material.

Graph No. 1 indicates the infra-red transmission beginning at 2.5 microns. It will be seen that good transmission in the solar IR is followed by considerable impermeability in the infra-red re-radiated by the soil. As a result, the cushion, once it has been filled with water, becomes a genuine solar collector, storing heat during the hours of sunshine and releasing it very slowly during the night.

GRAPH No. 1


2.5 microns
5 microns
10 microns
Transparent film
Transmittance
IR

The transparent PVC forming the upper wall of the cushion permits passage of the short-wave infra-red radiation, which is absorbed by the water and by the lower wall. In turn, this lower wall transmits by contact to the soil only a portion of the stored heat, and does so in quantities which remain more or less constant during both the day and night.

Because of the transparent polyvinyl chloride's high degree of impermeability to the transmission of the longer infra-red radiation, which would otherwise tend to pass from the cushion into the environment, the release of the heat is slow and gradual, with the result that at dawn, when the danger of frost is greatest, there is still some heat in reserve to protect the plants.

The accumulation and slow release of the heat can even be enhanced through the careful addition to the water of glycols, alcohols, or diathermic oils, which have the effect of heightening precisely these characteristics.

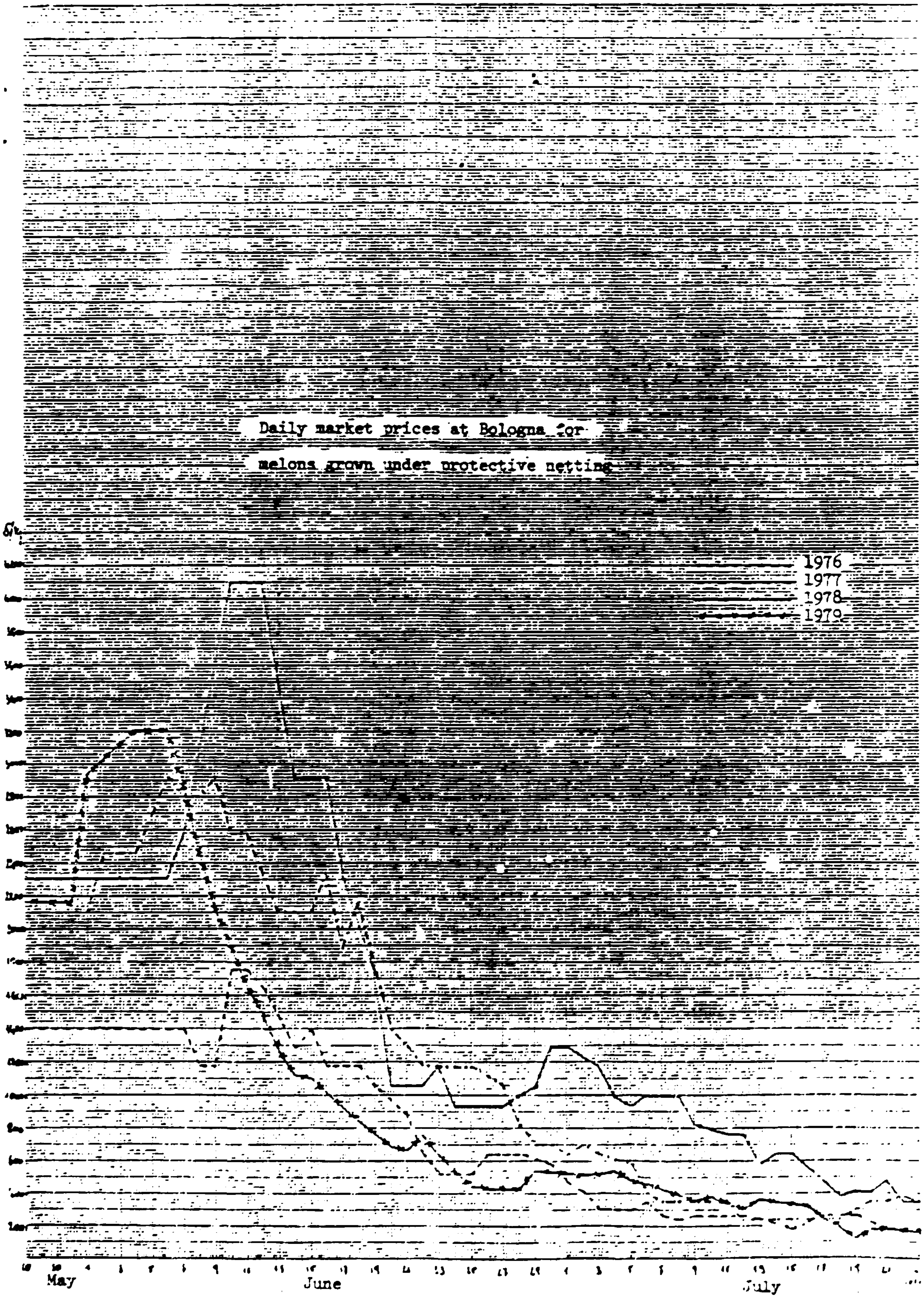
During the hours of sunshine, the absorbed heat is partially carried off into the environment and thus to the plant, which in this way is protected against temperature extremes of the kind that might stunt its growth. At night, the heat absorbed during the sunlight hours is slowly released into the soil and environment. As a result, the heat reaches the root system and aerial portion of the plant, which thus enjoys continued protection against interrupted development because of the relatively low night-time temperatures and the occasional killing morning frosts.

This system, using variously shaped cushions, can be used with the different species of vegetables most commonly grown out of season. The most important crop, however, to which it may be applied is the melon.

The selling price of melons grown under protected, non-heated shelters declines rapidly from the last ten-day period of May to the second ten-day period of June, whereafter it steadies during July at a level which, considering the high costs of the labour and materials needed for this crop, places a severe strain on the grower.

From Graph No. 2, where we have traced melon prices during the last four years on the Bologna fruit and vegetable market, one can arrive at a number of fairly significant observations indicating the sales advantages to be gained through the earliest possible production of this crop.

GRAPH No. 2


Daily market prices at Bologna for
melons grown under protective netting
1976
1977
1978
1979
May
June
July

During the four years studied, melons fetched the highest selling prices during the first ten-day period of June (1977 and 1979) or during the first days of the second ten-day period (1976 and 1978).

Specifically:

- In 1976, the highest market prices were paid from 10 to 11 June, after which the price fell off rapidly until it reached the first low beginning on 23 June. In 17 market days the price fell 1,230 lire per kg, corresponding to 137 lire per kg per market day.
- In 1977, the maximum price was reached on 6 and 9 June and the minimum on 29 June, with a loss of 2,200 lire per kg over 17 market days, representing an average decline of 130 lire per kg per day.
- In 1978, melons brought their highest price on 10 and 12 June, with the minimum price representing a loss of 3,165 lire per kg in 11 market days, for a mean drop of 280 lire per kg per day.
- In 1979, the maximum price was paid on 4 and 6 June, the first minimum occurring on 26 June. In 15 market days the price dropped by 2,780 lire per kg, representing a mean decrease in the selling price of 185 lire per kg per market day.

These results, based on a theoretical approach to the problem, show the importance of moving forward melon production, if only by a few days.

Accordingly, our experimentation programme, now in its sixth year, has focused principally on the melon, where the result has been increasingly early production, with respect either to the initial harvesting date or the concentration of the bulk of production during the first period. This can be seen in the successful setting of fruit from the flowers of the first tertiary branches, which do not normally produce. In the case of certain melon varieties, following the harvest of the first fruits there may be a second setting of fruit from an equal number of flowers on the most distant tertiary branches. As a result, there is a possibility of obtaining an abundant late harvest after good initial yields.

In the case of mulched and forced crops, a synergistic effect can be observed in the interaction of the three factors: forcing, mulching, and the use of the cushion.

The most dramatic effects of early maturity occur in the case of crops grown under the protection of greenhouses and large tunnels, particularly when polyvinyl chloride is employed as the covering material. For these protected crops. the quantitative behaviour of the product by harvest can be described by a curve which rises rapidly during the first 12-15 days and then falls equally rapidly during the next 6-8 days, with a decrease of about one half every other day from the production obtained the previous two days, after which it stabilizes at fairly low levels until the end of the production cycle (see Graph No. 3).

The early production promoted by the use of the cushion during the first harvests has consistently resulted in a substantial increase in the gross saleable product. This increase has considerably over-compensated for the higher costs arising from the use and depreciation of the cushion, even when late production has been poor or non-existent (very likely as a result of the poor fertility of the land or technical errors in irrigation and/or manuring).

During the period from 15 April to 31 May 1980 observations were conducted in order to determine the following values:

1. The temperature of the air measured at the height of the leaves of melons growing at the centre of a 60-metre-long tunnel covered by a double sheet of polyvinyl chloride 0.15 mm thick and polyethylene 0.10 mm thick and without ventilation (so as to simulate the higher temperatures typical of Southern Italy);

2. The temperature of the soil at a depth of 10 cm under a transparent cover of PE film 0.07 mm thick;

3. The temperature of the water within a cushion consisting of two transparent sheets and placed under a transparent cover as described under point 2 above;

4. The temperature of the water within a cushion consisting of an upper transparent sheet and a lower black sheet and placed under a transparent cover as described under point 2 above;

5. The temperature of the soil at a depth of 10 cm, as under point 2 above, under a cushion consisting of two transparent sheets;

6. The temperature of the soil at a depth of 10 cm, as under point 2 above, under a cushion the upper portion of which is transparent and the lower black.

The thermometer readings are given in table 1. These readings suggest the following conclusions:

## GRAPH No. 3

Yields: ten-day and continuous    with cushion (solid line)    without cushion (dashed line)

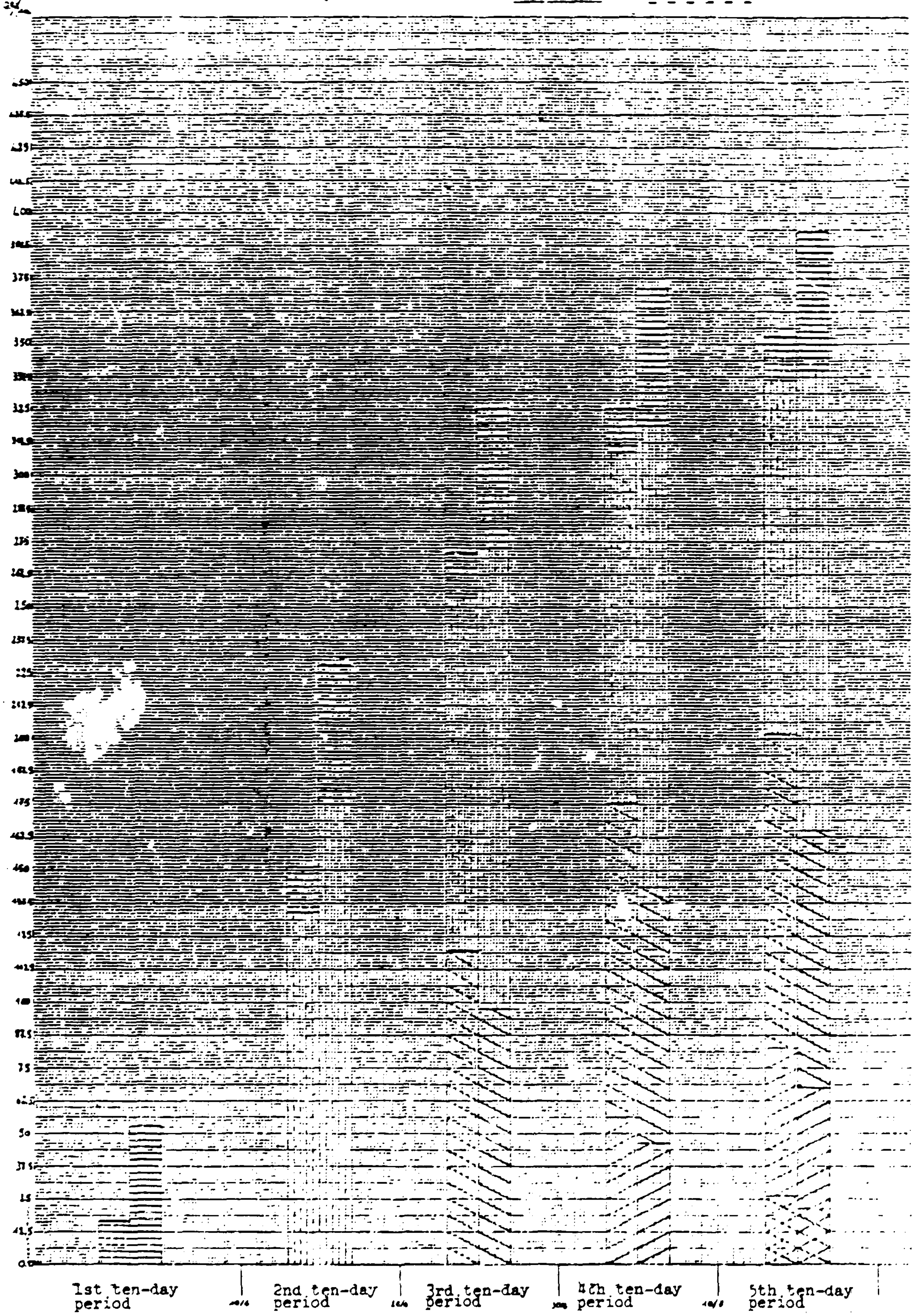


Table 1

| Date | Air | | | Soil at a depth of 10 cm | | | Cushion with both sides transparent: Water | | | Cushion with both sides transparent: Soil | | | Cushion with one transparent side and one black side: Water | | | Cushion with one transparent side and one black side: Soil | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | min. | max | range | min. | max | range | min. | max | range | min. | max | range | min. | max | range | min. | max | range |
| 15/4 | 9.5 | 35.0 | 25.5 | 19.7 | 25.5 | 5.1 | 17.5 | 28.5 | 11.0 | 19.7 | 23.8 | 4. | 17.3 | 31.7 | 14.4 | 18.0 | 22.2 | 3.2 |
| 16 | 12.0 | 36.0 | 24.0 | 20.0 | 23.7 | 3.7 | 18.0 | 25.0 | 7.0 | 19.8 | 22.1 | 2.3 | 18.2 | 28.6 | 10.4 | 18.8 | 22.2 | 3.4 |
| 17 | 12.0 | 45.0 | 33.0 | 19.2 | 29.0 | 9.8 | 17.6 | 30.1 | 12.5 | 18.8 | 23.7 | 4.9 | 17.3 | 35.0 | 17.7 | 17.9 | 24.3 | 6.4 |
| 18 | 9.2 | 45.2 | 35.0 | 19.0 | 29.0 | 10.0 | 19.2 | 32.2 | 13.0 | 19.0 | 24.7 | 5.7 | 18.8 | 36.2 | 17.4 | 18.3 | 25.6 | 7.3 |
| 19 | 11.6 | 38.8 | 27.2 | 20.5 | 25.1 | 4.6 | 15.0 | 25.1 | 10.1 | 19.2 | 24.0 | 4.8 | 17.8 | 31.0 | 13.2 | 19.8 | 24.2 | 4.4 |
| 20 | 9.8 | 25.0 | 15.2 | 17.4 | 21.2 | 3.8 | 16.5 | 21.3 | 4.8 | 18.0 | 20.4 | 2.4 | 15.0 | 22.2 | 7.2 | 16.6 | 20.0 | 3.4 |
| 21 | 5.5 | 31.5 | 26.0 | 15.8 | 23.1 | 7.3 | 13.5 | 25.4 | 11.9 | 16.1 | 21.2 | 5.1 | 12.2 | 29.8 | 17.6 | 14.4 | 22.1 | 7.7 |
| 22 | 5.0 | 41.4 | 36.4 | 16.9 | 25.0 | 8.1 | 12.5 | 25.6 | 13.3 | 17.0 | 22.5 | 5.5 | 14.2 | 33.5 | 19.3 | 16.2 | 24.0 | 7.8 |
| 23 | 6.5 | 40.0 | 33.5 | 17.9 | 25.1 | 7.2 | 17.0 | 28.5 | 11.5 | 18.3 | 23.0 | 4.7 | 17.0 | 33.0 | 16.0 | 18.0 | 24.0 | 6.0 |
| 24 | - | - | - | 18.0 | 24.1 | 6.1 | 16.7 | 27.6 | 10.9 | 18.4 | 22.0 | 3.6 | 16.5 | 32.0 | 15.2 | 18.0 | 23.4 | 5.4 |
| 25 | - | - | - | 17.9 | 24.9 | 7.0 | 17.0 | 27.4 | 10.4 | 18.4 | 22.6 | 4.2 | 17.0 | 31.2 | 14.2 | 18.1 | 23.5 | 5.7 |
| 26 | - | - | - | 18.8 | 24.0 | 5.2 | 18.0 | 25.0 | 7.0 | 19.0 | 22.0 | 3.0 | 18.0 | 28.5 | 10.5 | 18.8 | 22.1 | 3.3 |
| 27 | - | - | - | 17.9 | 22.2 | 4.3 | 17.3 | 23.1 | 5.8 | 18.8 | 20.6 | 1.8 | 17.0 | 26.0 | 9.0 | 17.9 | 20.4 | 2.5 |
| 28 | - | 39.0 | - | 17.0 | 23.2 | 6.2 | 16.5 | 24.5 | 8.3 | 17.9 | 21.0 | 3.1 | 15.8 | 25.4 | 12.6 | 16.9 | 22.2 | 5.3 |
| 29 | 5.6 | 42.6 | 36.9 | 17.0 | 25.6 | 8.6 | 16.6 | 28.2 | 11.6 | 18.0 | 23.0 | 5.0 | 17.0 | 32.6 | 15.6 | 17.9 | 24.3 | 6.4 |
| 30 | 7.0 | 40.6 | 33.6 | 18.7 | 25.2 | 6.5 | 18.4 | 27.0 | 8.6 | 19.5 | 23.0 | 3.5 | 19.2 | 30.5 | 11.3 | 19.7 | 24.0 | 4.3 |
| 1/5 | 11.0 | 27.0 | 16.0 | 19.8 | 22.9 | 3.1 | 19.8 | 22.0 | 2.2 | 20.0 | 21.0 | 1.0 | 26.0 | 23.6 | 3.0 | 20.0 | 21.2 | 1.2 |
| 2 | 13.2 | 42.8 | 29.6 | 18.9 | 23.9 | 5.0 | 18.5 | 24.9 | 6.1 | 19.1 | 22.0 | 2.9 | 19.6 | 23.0 | 3.4 | 19.2 | 23.0 | 3.8 |
| 3 | 10.0 | 43.0 | 33.0 | 18.2 | 25.8 | 7.6 | 18.5 | 27.6 | 9.1 | 19.2 | 23.7 | 4.5 | 19.2 | 31.4 | 12.2 | 19.6 | 25.0 | 5.4 |
| 4 | - | - | - | 20.0 | 21.3 | 1.3 | 20.0 | 21.2 | 1.2 | 20.1 | 21.0 | 0.9 | 20.8 | 25.2 | 4.4 | 20.4 | 23.2 | 2.8 |
| 5 | - | - | - | 18.3 | 19.7 | 1.4 | 18.0 | - | - | 19.0 | 20.2 | 1.2 | 19.0 | - | - | 18.9 | 20.4 | 1.5 |
| 6 | - | 43.4 | - | 17.2 | 26.0 | 8.5 | 17.0 | 25.6 | 8.6 | 17.9 | 21.9 | 4.0 | 17.2 | 29.0 | 11.8 | 18.9 | 22.8 | 3.9 |
| 7 | 12.9 | 43.0 | 30.1 | 20.3 | 27.0 | 6.7 | 19.9 | 26.6 | 6.7 | 20.0 | 22.8 | 2.8 | 20.6 | 31.0 | 10.4 | 20.0 | 24.0 | 4.0 |
| 8 | 9.8 | 42.0 | 32.2 | 20.0 | 25.1 | 5.1 | 19.2 | 22.6 | 3.4 | 19.9 | 23.5 | 3.6 | 20.2 | 31.5 | 11.3 | 20.1 | 24.8 | 4.7 |
| 9 | 13.4 | 42.5 | 29.1 | 21.1 | 27.9 | 6.8 | 20.4 | 27.3 | 6.9 | 20.9 | 23.7 | 2.8 | 21.6 | 31.0 | 9.4 | 21.0 | 24.5 | 3.5 |
| 10 | 13.0 | 43.5 | 30.5 | 20.9 | 28.2 | 7.3 | 20.0 | 32.2 | 12.2 | 20.6 | 26.1 | 5.5 | 21.0 | 38.0 | 17.0 | 20.8 | 28.2 | 7.4 |
| 11 | 14.9 | 42.0 | 27.1 | 22.1 | 29.1 | 7.0 | 22.2 | 33.0 | 10.8 | 22.3 | 27.0 | 4.7 | 23.5 | 39.5 | 16.0 | 23.0 | 29.9 | 6.9 |
| 12 | 11.8 | 50.2 | 38.4 | 21.8 | 31.9 | 10.1 | 21.5 | 30.6 | 8.5 | 22.[illegible] | 28.9 | 6.7 | 23.0 | 43.8 | 20.8 | 23.1 | 31.9 | 8.8 |
| 13 | 11.6 | 49.4 | 37.8 | 22.6 | 31.0 | 8.4 | 22.0 | 34.0 | 12.0 | 22.8 | 28.8 | 6.0 | 23.0 | 40.6 | 17.6 | 23.0 | 30.7 | 7.7 |
| 14 | 16.5 | 31.0 | 14.5 | 23.0 | 25.6 | 2.6 | 23.0 | 26.0 | 3.0 | 23.9 | 24.3 | 0.9 | 23.3 | 28.5 | 5.3 | 22.8 | 25.0 | 2.2 |
| 15 | 13.5 | 33.5 | 20.0 | 21.4 | 24.6 | 3.2 | 20.0 | 25.0 | 5.0 | 21.0 | 23.1 | 2.1 | 20.6 | 28.0 | 7.4 | 21.0 | 23.7 | 2.7 |
| 16 | 12.5 | 29.5 | 17.0 | 19.7 | 22.2 | 2.5 | 18.4 | 22.0 | 3.6 | 19.3 | 21.1 | 1.8 | 18.5 | 24.0 | 5.5 | 19.2 | 21.3 | 2.1 |
| 17 | 11.5 | 32.5 | 21.0 | 18.6 | 22.1 | 3.5 | 16.8 | 21.8 | 5.0 | 18.0 | 20.7 | 2.7 | 16.8 | 24.5 | 7.7 | 18.8 | 21.0 | 2.2 |
| 18 | 12.0 | 48.0 | 36.0 | 18.3 | 26.8 | 8.5 | 17.0 | 30.8 | 13.8 | 18.1 | 25.7 | 7.6 | 17.0 | 38.2 | 21.2 | 17.7 | 26.7 | 9.0 |
| 19 | 14.2 | 47.5 | 33.3 | 20.0 | 28.2 | 8.2 | 20.0 | 32.6 | 12.6 | 20.7 | 27.0 | 6.3 | 21.2 | 38.8 | 17.6 | 21.0 | 28.6 | 7.6 |
| 20 | 11.5 | 51.2 | 39.7 | 20.7 | 23.0 | 2.3 | 20.6 | 31.0 | 10.4 | 21.0 | 26.2 | 5.2 | 21.0 | 38.0 | 17.0 | 21.2 | 27.1 | 5.9 |
| 21 | 12.0 | 44.2 | 32.2 | 20.8 | 28.7 | 7.9 | 20.4 | 35.2 | 14.8 | 21.0 | 27.7 | 6.7 | 20.6 | 43.5 | 22.9 | 20.8 | 30.1 | 9.3 |
| 22 | 11.5 | 45.5 | 34.0 | 21.9 | 29.0 | 7.1 | 21.6 | 34.2 | 12.6 | 22.2 | 27.9 | 5.7 | 22.5 | 41.0 | 18.5 | 22.6 | 30.0 | 7.4 |
| 23 | 13.5 | 25.0 | 11.5 | 21.8 | 23.6 | 1.8 | 20.5 | 27.0 | 6.5 | 21.0 | 25.1 | 4.1 | 26.0 | 28.5 | 2.5 | 21.3 | 26.3 | 5.0 |
| 24 | 12.8 | 41.8 | 29.0 | 20.7 | 26.1 | 5.4 | 18.4 | 28.4 | 10.0 | 19.8 | 25.0 | 5.2 | 18.8 | 33.0 | 14.2 | 19.8 | 26.2 | 6.4 |
| 25 | 11.0 | 46.5 | 35.5 | 20.6 | 30.0 | 9.4 | 19.0 | 36.4 | 17.4 | 20.1 | 29.0 | 8.9 | 19.0 | 44.4 | 25.4 | 20.2 | 31.1 | 10.9 |
| 26 | 15.0 | 45.0 | 30.0 | 22.9 | 31.8 | 8.9 | 22.0 | 34.0 | 12.0 | 22.9 | 31.2 | 8.3 | 22.6 | 44.0 | 21.4 | 23.2 | 30.6 | 7.4 |
| 27 | 15.0 | 35.0 | 20.0 | 23.0 | 25.6 | 2.6 | 20.6 | 26.0 | 5.4 | 22.3 | 24.2 | 1.9 | 22.3 | 29.6 | 6.8 | 21.0 | 25.0 | 4.0 |
| 28 | 13.6 | 42.0 | 28.4 | 20.9 | 26.0 | 5.1 | 19.0 | 29.0 | 10.0 | 20.2 | 24.5 | 4.3 | 19.3 | 34.2 | 14.9 | 20.0 | 25.7 | 5.7 |
| 29 | 13.0 | 43.0 | 30.0 | 21.3 | 27.0 | 5.7 | 19.5 | 30.5 | 11.0 | 20.9 | 26.0 | 5.1 | 20.5 | 36.1 | 15.6 | 21.0 | 27.3 | 6.3 |
| 30 | 10.6 | 49.2 | 38.6 | 21.0 | 28.0 | 7.0 | 19.3 | 32.0 | 12.7 | 20.8 | 26.6 | 5.8 | 19.8 | 37.0 | 17.2 | 21.0 | 26.5 | 5.5 |
| 31 | 12.0 | 45.5 | 36.5 | 20.9 | 30.1 | 9.2 | 19.0 | 37.0 | 18.0 | 20.3 | 29.2 | 8.9 | 19.3 | 43.5 | 24.3 | 20.2 | 31.0 | 10.8 |
| Aver. | 11.5 | 40.5 | 29.3 | 19.8 | 25.9 | 6.1 | 18.8 | 28.2 | 9.4 | 19.9 | 24.2 | 4.3 | 19.3 | 32.9 | 13.6 | 19.7 | 25.2 | 5.5 |
| Maximum deviations from the mean | -5.0<br>+6.5 | -15.5<br>+10.4 | -17.5<br>+10.4 | -2.7<br>+3.4 | -[illegible]<br>+6.0 | -4.8<br>+4.0 | -5.3<br>+4.2 | -7.0<br>+8.8 | -8.2<br>+8.0 | -3.8<br>+4.0 | -4.0<br>+7.0 | -3.4<br>+4.6 | -7.1<br>+6.7 | -10.7<br>+11.5 | -11.1<br>+11.8 | -5.3<br>+3.5 | -5.2<br>+6.7 | -4.3<br>+5.4 |

1. The average minimum water temperature is on the average higher than the average air temperature read at the same height by about 7.3° C (18.8° C as opposed to 11.5° C) with respect to the average minimum temperatures in the two cushions both of whose walls are transparent, and by about 7.8° C (19.3° C as opposed to 11.5° C) with respect to the average minimum temperatures in the cushions whose upper wall is transparent and whose lower wall is black. This prevents excessively low temperatures from stunting the development of the plants.

Thus, corresponding to the minimum air temperature of 5.0° C on 22 April 1980, a minimum of 14.8° C was recorded in the completely transparent cushion and 14.2° C in the transparent-and-black cushion, i.e. 9-10° C more than the ambiental temperature. This factor is of even greater value when one considers that these minimum temperatures occur during the first period following the pricking out of the plants, when the young plant is still under-developed and completely surrounded by the cushion.

2. The water temperature is on the average lower than the air temperature at the same height by 12.6° C with respect to the average maximum temperature in the two transparent-walled cushions (40.8° C as opposed to 28.2° C) and by 7.9° C for the cushions with a lower black wall (40.3° C as opposed to 32.9° C). Apparently, the lower black wall attracts and stores more heat in the water, without however holding it longer since the minimum temperatures are, in general, only slightly higher than those found in the all-transparent cushions (a difference of about 0.5° C).

This fact might suggest that the all-transparent cushion should be preferred, particularly in Central and Southern Italy where the reduction of the higher temperatures is a serious problem. For example, when (on 20 May) a maximum air temperature reading of 51.2° C was obtained, the maximum in the transparent cushion was 31.0° C (20.2° less), whereas in the cushion with a lower black wall the maximum was 38° C (13.2° C less).

Moreover, while during the period in question the maximum temperature of the water in the all-transparent cushion was 37.0° C (31 May), in the black-bottomed cushion it reached 44.4° C (25 May). A temperature this high can disturb the plant's normal growth.

3. The day-time temperature spread, as recorded in air of between 11.5° C and 39.7° C (average: 29.3° C), averaged 9.4° C in the water within the all-transparent cushions and 13.6° C in the water contained in the black-bottomed cushions, with a maximum deviation of +8.0° C in the transparent cushions and 11.8° C in the black-bottomed cushions.

4. In mulched soil, at a depth of 10 cm, the differences are not so considerable and the effect of the cushion is less pronounced than when it is above the soil, particularly with regard to the minimum readings.

On the other hand, there is a small decrease (0.7° C) in the average maximum temperature for the black-bottomed cushions (from 25.9° C to 25.2° C) and a slightly larger decrese (1.7° C) for the all-transparent cushions (from 25.9° C to 24.2° C).

Even the temperature spread decreases from 6.1° C to 5.5° C (-0.6° C) when using black-bottomed cushions, and to 4.3° C when using transparent cushions.

A number of readings taken at a depth of 5 cm in the soil, under an organic mulch and under the cushions (unfortunately, it was not possible to take readings during the entire period in question because of instrument malfunction) furnished intermediate values between the temperatures above the ground and those recorded at a depth of 10 cm. It has been possible to carry out these heat-measurement tests only this year, whereas the most varied testing, carried out over a period of five years with different types of mulching and cushions (with PE and PVC and with different shapes and colours), has consistently shown that the use of the cushions leads to positive results in respect of production and early maturity. On the basis of this testing, two PVC cushion types (all-transparent and transparent with black bottom) were selected and tested this year using continuous-reading recording thermometers capable of continuously monitoring temperature changes.

In addition, tests on watermelons in the Valle dell'Oro near Palermo had earlier been carried out by Professor Caruso of the Horticultural Institute of the University of Palermo in Sicily.

In these tests the following techniques were compared:

1. Mulching with transparent PE;
2. Mulching with black PE;

3. Cushions of transparent PVC under transparent mulch;
4. Cushions of transparent PVC under black mulch;
5. Cushions of transparent PVC on top of transparent mulch;
6. Cushions of transparent PVC on top of black mulch;
7. Control growing (without mulching or cushions).

We reproduce below Prof. Caruso's summary of his findings.

The crop observations were concerned with yields, in quintals per hectare, the average weight of the fruit, the number of days elapsed from the time of sowing to the emergence of the small plant, and the length of the stalk on the 37th day after sowing. In addition, the temperature was monitored near the plants and at different depths in the soil during the months of May, June, and July. Near the plants the temperature was measured by means of an alcohol thermometer at soil level, in the control plot, and among the plants where the covering used consisted of transparent or black plastic. In the plots where the "cushions" were installed, the thermometers were placed inside the cushions for the observations.

The readings were taken at 7 a.m., at noon, and at 6 p.m. The data obtained indicate clearly the effect of the thermoregulation of the water in the cushions. This effect was more pronounced in the plots using transparent mulching. For example, average temperature at 7 a.m. amidst the cushioned crops almost always exceeded by several degrees the temperature in the control plot. The most significant differences were recorded at 6 p.m. in May, when in the growing areas using cushions above and below the mulching the temperatures observed exceeded by nearly 8-10° C the temperatures of the control and black-mulch areas.

At noon, on the other hand, the presence of the cushions prevented the rise in temperature observed among the plants mulched with transparent plastic (46-50° C). For these same plants, the temperatures observed at noon and 6 p.m., in areas where the use of cushions was generally provided, kept to very close values (about 35° C), there being no sign of the 8-10° C spread encountered in the control plots and where black mulching was used.

For the soil temperature measurements it was necessary to take readings at three different depths - 5, 10, and 18 cm - always at the hours already mentioned. As expected, the 7 a.m. readings showed an increasing temperature spread from the surface to the lower layers of the soil, whereas the opposite effect was noted at noon and at 6 p.m. The most obvious differences among the plants were observed at 7 a.m. and 6 p.m. Thus, regardless of the depth of the reading, the temperatures of plants provided with cushions and transparent mulching was higher than those recorded in the control plots and in the growing areas with black mulching only. At noon the differences were less pronounced or non-existent.

The yield results are shown in table 2.

Summing up then, the following conclusions may be drawn:

1. The temperature readings confirm the thermoregulatory effect of the water.

2. This effect reduces considerably the day-time temperature range by contracting the interval between maximum and minimum temperatures, the result being the establishment of a microclimate around each plant to promote more balanced and consistent growth.

3. Because of the favourable environment created in this way, the plant is capable of the early production of perfectly formed flowers from as early a stage as the first tertiary branches, and provided the season continues in such a way as to permit visits by bees and other pollinating insects and the configuration of the shelter does not prevent these visits, the flowers will be regularly and successfully impregnated. If, on the other hand, the season is a poor one, it will be necessary to use artificial means to ensure the successful impregnation of the flowers by resorting to the appropriate hormonal treatments (2-naphthoxy-acetic acid and others) in dosages proportional to the state of health of the plant, bearing in mind that these treatments cause a certain stress, which, within limits, promotes impregnation.

4. The lowering of the peak temperatures promotes the normal development of the fruits and eliminates periods of arrested growth. Provided there is proper irrigation and manuring, the result will be more abundant yields despite the earlier maturity of the crop.

5. The harmonious development of the plant will make possible a second impregnation followed by the normal development of additional fruits when the first harvest is beginning. This will provide a second, late, and occasionally less abundant, yield, the income from which, once the costs of harvesting and marketing have been deducted, represents a net gain.

Table 2

Watermelons, Palermo 1979

| Readings<br>Coverings | Total watermelon yield quintals/hectare | Average weight of melons grams | Days elapsed from sowing to emergence of small plant | Length of principal stalk 37 days after planting (cm) |
|---|---|---|---|---|
| Transparent mulch | 407 | 6 506.6 | 8.6 | 36.6 |
| Black mulch | 226.9 | 5 902 | 10.6 | 7.7 |
| Cushions below transparent mulch | 527.1 | 6 077.6 | 7 | 71.1 |
| Cushions below black mulch | 373.3 | 5 891.6 | 8.6 | 23.6 |
| Cushions on top of transparent mulch | 421.5 | 5 827.3 | 6 | 52.9 |
| Cushions on top of black mulch | 351.3 | 5 554.6 | 10 | 28.6 |
| Control plot (no mulch or cushions) | 289.6 | 5 720 | 12.3 | 12.9 |