E83-10049

EW-U2-04351

JSC-18563

CR-169565

AgRISTARS

A Joint Program for Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing

Early Warning and Crop Condition Assessment

SEPTEMBER 1982

USE OF NEAR-INFRARED VIDEO RECORDING SYSTEM FOR THE DETECTION OF FREEZE-DAMAGED CITRUS LEAVES

D. E. ESCOBAR, R. L. BOWEN,
H. W. GAUSMAN, AND G. COOPER

(E83-10049) USE OF NEAR-INFRARED VIDEO RECORDING SYSTEM FOR THE DETECTION OF FREEZE DAMAGED CITRUS LEAVES (Agricultural Research Service) 12 p HC A02/MF A01 CSCL 02C

N83-14558

Unclas

G3/43 00049

USDA/ARS
WESLACO, TEXAS 78596

Lyndon B. Johnson Space Center
Houston, Texas 77058

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
EW-U2-04351, JSC-18563		

4. Title and Subtitle
Use of Near-Infrared Video Recording System for the Detection of Freeze-Damaged Citrus Leaves

5. Report Date
September 1982

6. Performing Organization Code

7. Author(s)
D. E. Escobar, R. L. Bowen, H. W. Gausman, and G. Cooper

8. Performing Organization Report No.

9. Performing Organization Name and Address
USDA/ARS
Weslaco, TX 78596

10. Work Unit No.

11. Contract or Grant No.

12. Sponsoring Agency Name and Address
USDA/SRS
Johnson Space Center/SK
Houston, TX 77058

13. Type of Report and Period Covered

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract
A video recording system with a visible light blocking filter to give sensitivity in the 0.78 to 1.1 m waveband detected freeze-damaged citrus leaves rapidly. With this technique, the time to analyze images can be decreased from about one day for conventional photography to less than one hour for video recording.

17. Key Words (Suggested by Author(s))	18. Distribution Statement

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclass.	Unclass.	10	

*For sale by the National Technical Information Service, Springfield, Virginia 22161

Use of a Near-Infrared Video Recording System for the Detection of Freeze-Damaged Citrus Leaves

D. E. Escobar, R. L. Bowen, H. W. Gausman,
and G. Cooper
Biological Technician, Photographer, Plant Physiologist,
and Emeritus Professor, respectively,
Remote Sensing Research Unit,
Oklahoma-Texas Area, Southern Region,
ARS, USDA, Weslaco, TX 78596,
and
University of Maine, Orono, Maine 04469

ABSTRACT

A video recording system with a visible light blocking filter to give sensitivity in the 0.78 to 1.1 μm waveband detected freeze-damaged citrus leaves rapidly. With this technique, the time to analyze images can be decreased from about one day for conventional photography to less than one hour for video recording.

Reflectance measurements detected freeze-damaged citrus (Citrus aurantium Linn.) leaves within 5 hours after freezing temperatures; infrared and conventional color photography did not detect the damage for about 30 hours (3, 7, 8). The usefulness of reflectance for leaf freeze detection was further substantiated in studies with the cotton (Gossypium hirsutum L.) plant (5, 6). However, the use of narrow-band photography on citrus plants for leaf freeze detection warrants further investigation (2).

Our objective was to test a video recording system with a visible light blocking filter to give sensitivity in the 0.78 to 1.1 μm near-infrared waveband to quickly detect citrus leaf freeze damage. We wanted to decrease the time to analyze images from about one day for conventional photography to less than one hour by video recording.

MATERIALS AND METHODS

One-year-old sour orange seedlings (Citrus aurantium Linn.) were grown in pots in an unshaded greenhouse that was cooled with air circulated through moist pads. Temperatures ranged from 23.9 to 35.0 C, and humidity ranged from 70 to 95%. Ten plants were transferred to a freezing chamber (frozen), and 10 plants were left in the greenhouse (nonfrozen). The temperature regime was 4.4 C for 1 hour after which it was decreased at a rate of 1.1 C/hour until it reached -7.8 C, where it remained for 4 hours. The temperature was then increased to 4.4 C at a rate of 1.1 C/hour.

Reflectance measurements were made in less than 10 minutes on leaves collected from each frozen and nonfrozen plant held in the dark at 4.4 C. The leaves were taken from about 25 cm below the plants' apex.

A Beckman Model DK-2A spectrophotometer, equipped with a reflectance attachment, was used to measure total diffuse reflectance on upper (adaxial) surfaces of single leaves over the 0.5 to 2.5 μm waveband (WB). (Mention of company name or trademark is for the readers' benefit and does not constitute endorsement of a particular product by the U.S. Department of Agriculture over others that may be commercially available.) Data were corrected for decay of the barium sulfate standard to give absolute radiometric data (1).

Leaf thickness was measured with a linear-displacement transducer and digital voltmeter (4). Water content of the leaves was determined by oven-drying at 68 C for 48 hours, cooling in a desiccator, and weighing.

Twenty-four hours after completing spectral measurements, the frozen and nonfrozen plants were removed from the chamber and the greenhouse, respectively, and transferred to an automobile parking lot in juxtaposition for video recording. At that time, frozen plant leaves had no external evidence of freeze damage. The day was sunny and slightly windy with a temperature of about 25 C.

Nonfrozen and frozen plants were video recorded at a distance of about 6 m above their tops with a Sony Portable Video camera AVC-3450 modified with RCA Ultricon™ 4875/U camera tube to increase the near-infrared sensitivity from the 0.95-µm upper limit for infrared photography to 1.1 µm. A Kodak Wratten Filter No. 87C was used with the video camera to block the visible light and to allow transmittance of light from the 0.78 to 1.1 µm WB (Fig. 1).

The video camera was connected to a Betamax portable video cassette recorder, Model SLO-340. Immediately after video recording plants, the taped were played back in a Betamax video cassette player, Model SLP-303, that was connected to a Panasonic Video Monitor, Model CT 1910M. The recorded imagery was analyzed visually in about 5 minutes. Video images were photographed from the video monitor, using Kodak panchromatic B&W film.

RESULTS AND DISCUSSION

Reflectances for frozen and nonfrozen citrus leaves over the 0.5 to 2.5 µm (WB) are shown in Fig. 2. Frozen leaf reflectances were significantly lower ($p = 0.01$) than those of nonfrozen leaves over the entire WB. However, the largest differences between them occurred within the 0.75- to 1.35-µm WB. The frozen and nonfrozen leaves that were used for the spectral measurements had essentially similar water contents, 65.1 to 64.9%, respectively. Frozen leaves, however, were significantly ($p = 0.01$) thinner (0.128 mm) than nonfrozen leaves (0.156 mm). Apparently, frozen leaf cells collapsed, and leaf turgidity was decreased (3).

A photograph of the frozen (upper-right-hand cluster) and nonfrozen (lower-left-hand cluster) citrus plants from a video recording is shown in Fig. 3. The whitish appearance of the nonfrozen plant cluster resulted from high near-infrared light reflectance; whereas, the opaque appearance of the frozen plant cluster was caused by lower near-infrared light reflectance. Although a few frozen leaves had lost their water-soaked appearance at the time of video recording, the imagery still distinguished them from the nonfrozen leaves because of their low light reflectance (7). Therefore, the effectiveness of this video system with the visible light blocking filter was caused by the higher reflectance of nonfrozen leaves than that of frozen leaves over the 0.78 to 1.1 µm WB (Fig. 2).

We concluded that the use of the video recording system described in this paper with a visible light blocking filter can detect freeze-damaged citrus leaves rapidly over the 0.78 to 1.1 µm WB, and that the time to analyze images can be decreased from about one day for conventional photography to less than one hour for video recording. This system, therefore, is superior to conventional photography to detect the freeze damage of citrus plants.

LITERATURE CITED

1. Allen, W. A., and A. J. Richardson. 1971. Calibration of a laboratory spectrophotometer for specular light by means of stacked glass plates. Rev. Sc. Instrum. 42:1813-1817.

2. Escobar, D. E., R. L. Bowen, and H. W. Gausman. 1977. Infrared color film exposed with red light shown to be best for distinguishing yellow fruit of orange trees from green leaves. J. Rio Grande Valley Hort. Soc. 31:135-138.

3. Gausman, H. W., A. Peynado, D. E. Escobar, R. R. Rodriguez, and R. L. Bowen. 1977. Comparison of reflectance measurements with photographs for early freeze detection of sour orange plants. J. Rio Grande Valley Hort. Soc. 31:129-133.

4. Heilman, M. D., C. L. Gonzalez, W. A. Swanson, and W. J. Rippert. 1968. Adaptation of a linear transducer for measuring leaf thickness. Agron. J. 60:578-579.

5. Huang, S. Y., and H. W. Gausman. 1982. Ultrastructural observations on increase of cold tolerance in cotton plants (Gossypium hirsutum L.) by mepiquat chloride. J. Rio Grande Valley Hort. Soc. 35:35-41.

6. ______________________, F. R. Rittig, D. E. Escobar, and R. R. Rodriguez. 1981. Increase of cold tolerance in cotton with mepiquat chloride. Proc. 8th Plant Growth Regulator Working Group, St. Petersburg Beach, FL, pp. 240-246.

7. Peynado, A., H. W. Gausman, D. E. Escobar, R. R. Rodriguez, and M. V. Garza. 1979. Evidence of cell membrane injury detected by reflectance measurements. Cryobiology 16:63-68.

8. Young, R., and A. Peynado. 1967. Freezing and water-soaking in citrus leaves. Proc. Amer. Soc. Hort. Sci. 91:157-162.

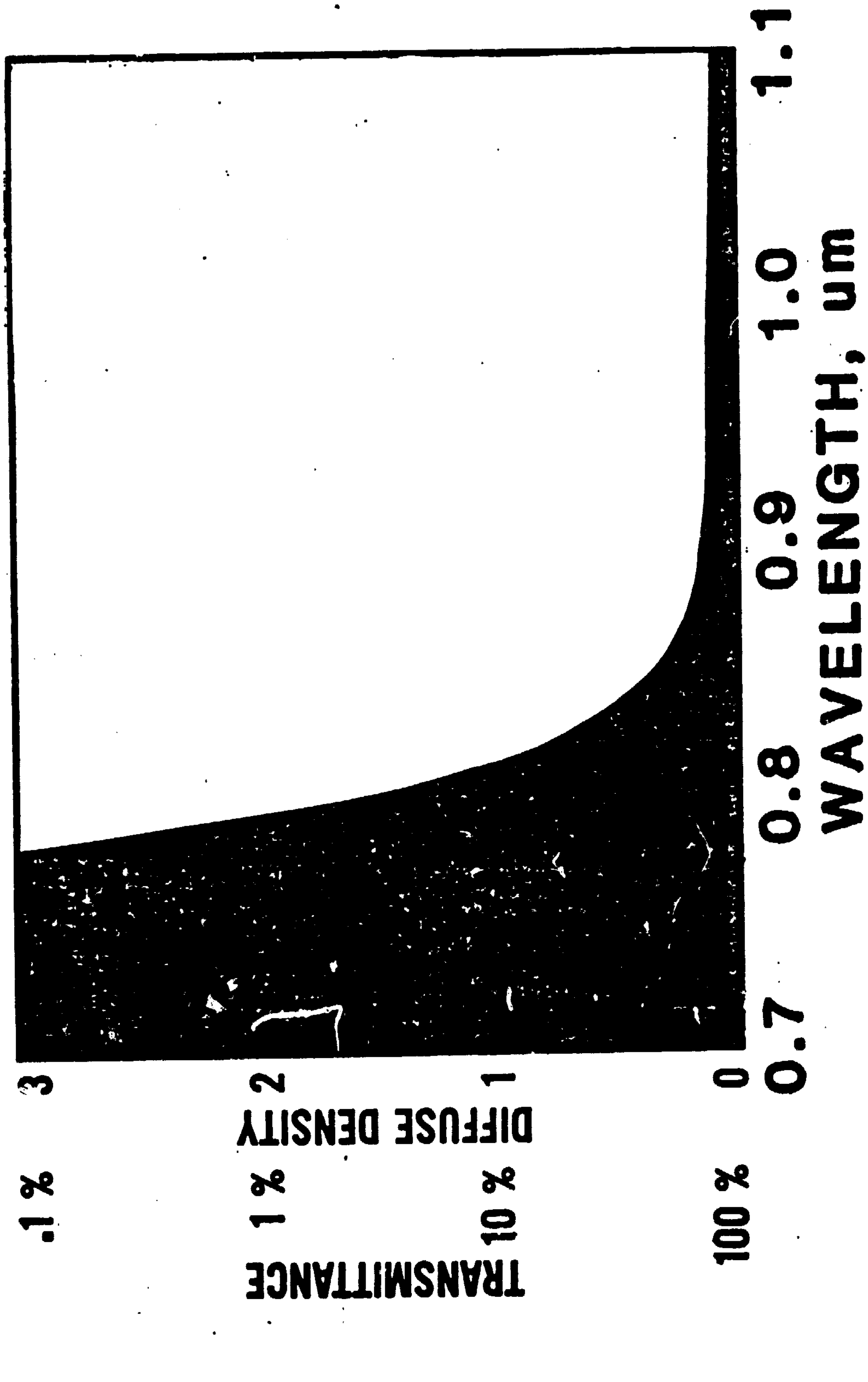
FIGURE CAPTIONS

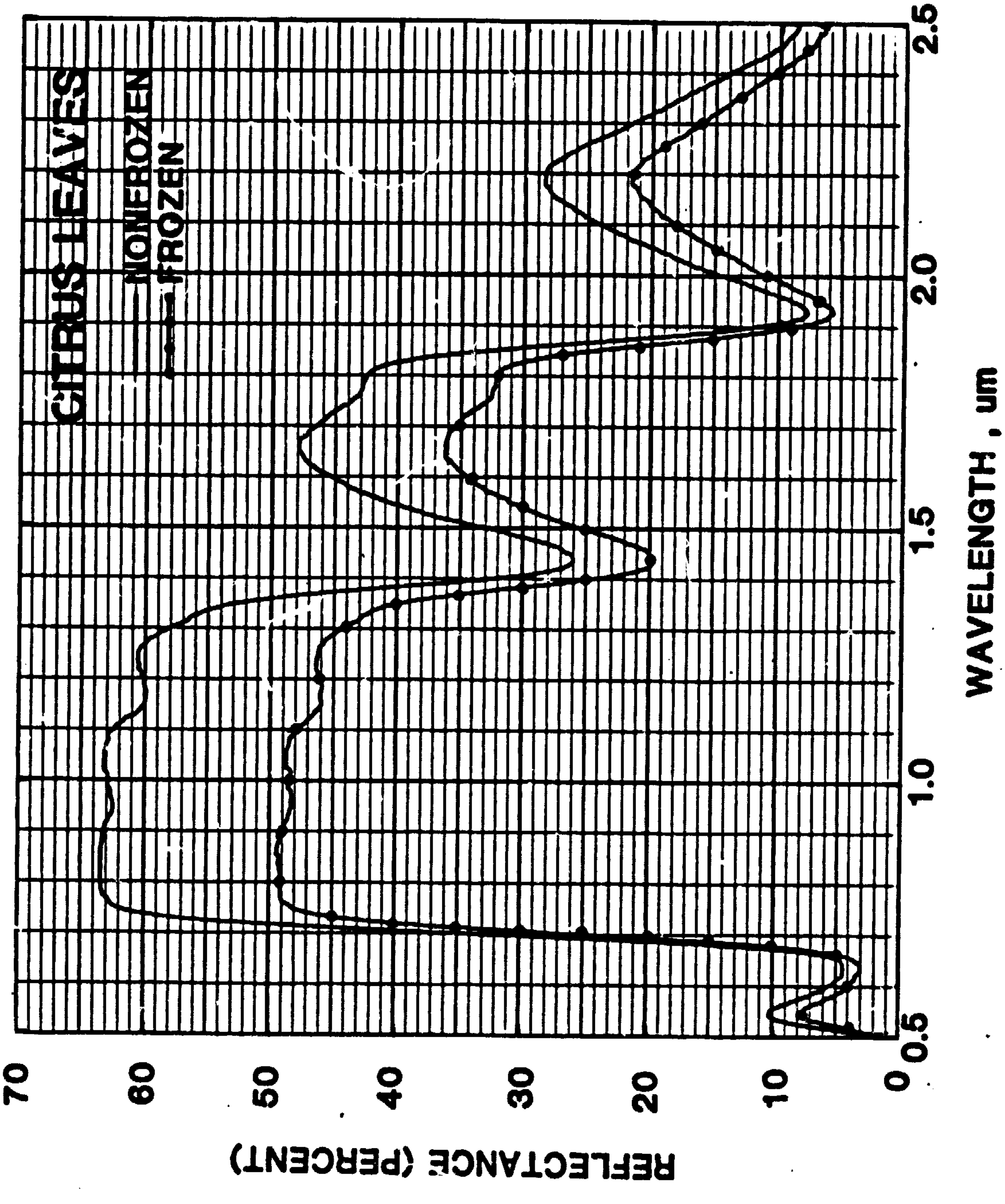
Fig. 1. The light transmittance for the Kodak Wratten Filter No. 87C.

Fig. 2. Light reflectances for frozen and nonfrozen citrus leaves over the 0.5 to 2.5 µm WB.

Fig. 3. A photograph of the frozen (upper-right-hand cluster) and nonfrozen (lower-left-hand cluster) citrus plants.

ORIGINAL PAGE IS
OF POOR QUALITY





ORIGINAL PAGE IS
OF POOR QUALITY

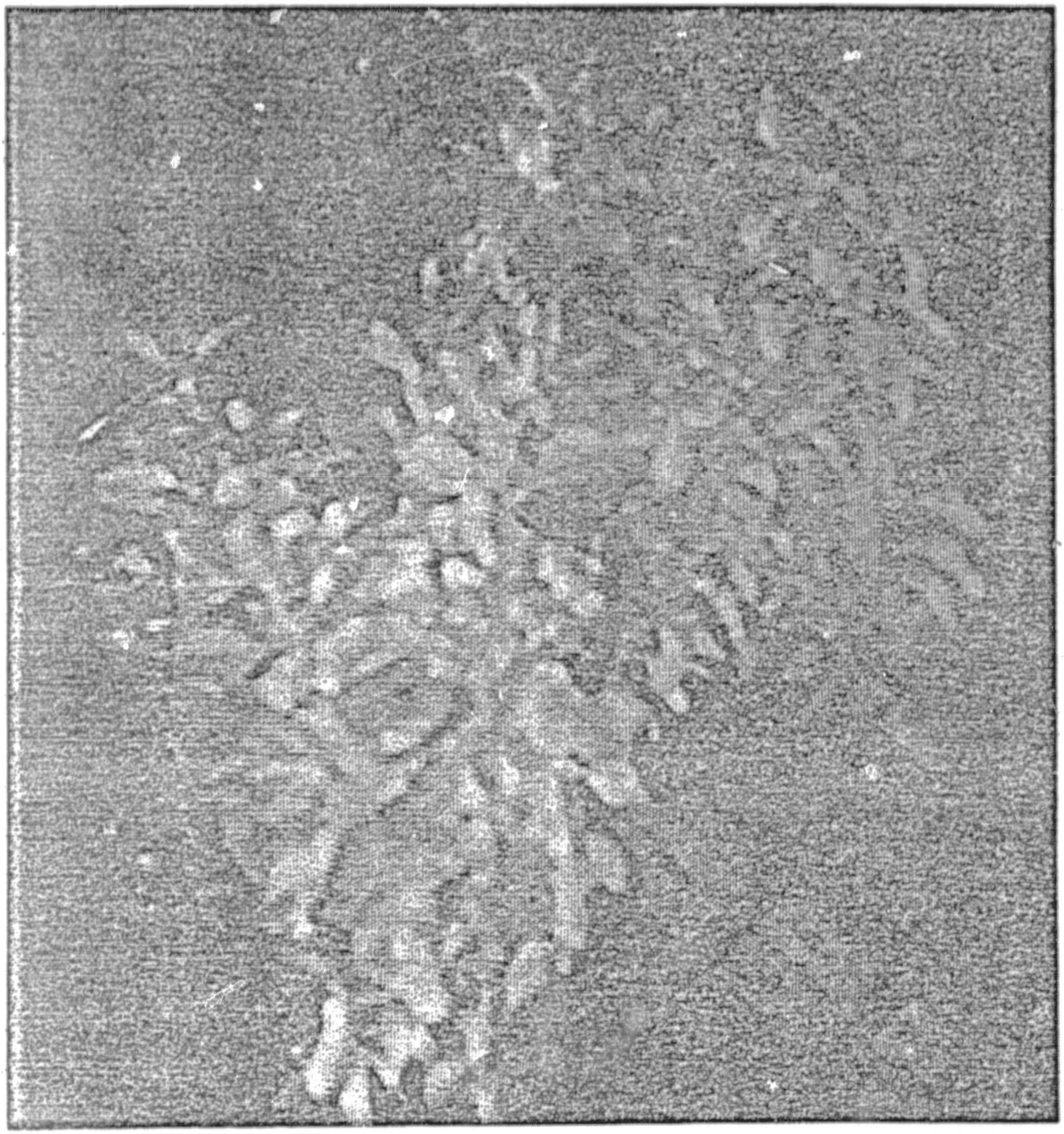


Fig. 3