Using Color Infrared Aerial Photography to Study Cotton Fields Infested with *Meloidogyne incognita*

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ABSTRACT

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Color infrared photographs of fields of cotton during three successive years of growth were used as a technique in a survey to detect areas infested with the root-knot nematode *Meloidogyne incognita*. On the photographs, nematode infestation appeared as irregular areas characterized by exposed soil and dense weed vegetation. The center of a highly nematode-infested area was characterized by lack of vegetation or by thin rows of cotton, which could also be seen along the margins of the area. Photographs taken at the end of the cotton-growing season gave a better image of the infested area than photographs taken earlier in the season. The rate of nematode spread according to the photographs averaged 25–50%/yr.

Cotton (*Gossypium hirsutum* and *G. barbadense*) has been cultivated in Israel for more than 20 yr. During the last decade, it has become the most important industrial crop in that country, with a total area of about 70,000 ha. Although cotton has been known as a host of the root-knot nematode *Meloidogyne incognita* (Kofoid & White) Chitwood for almost a century (8), no plants were found to be infected in Israel until more than a year ago. In an inoculation trial with a local population of *M. incognita*, none of the *G. hirsutum* cv. Acala 4-42 seedlings were infected, although the same cultivar is susceptible to *M. incognita* in the United States (6). We concluded that the local population of *M. incognita* was unable to parasitize cotton and that the Israeli and U.S. populations may be different races within the same species. Root-knot nematode races differing in host range have been characterized by Sasser (9).

In 1979, a cotton plant (*G. hirsutum* cv. SJ.2) with galled roots growing in the drained Hula swamp area was found to be infected with *M. incognita*. Following this finding, a method of surveying large cotton fields was needed; the most promising and available technique was color infrared (CIR) aerial photography. This technique has had a broad spectrum of uses in agriculture, particularly in cotton, in the United States and Israel (1–4,7).

Limited information is available on the use of aerial photography to locate nematode infestation. Norman and Fritz (5) located *Radopholus similis* infestation of citrus trees and Heald et al (2) detected *Rotylenchulus reniformis* infestation of cotton by this method. The purpose of the present work was to study and characterize *M. incognita* infestation in cotton fields by means of CIR photography as a practical tool for surveying and identifying fields infested with root-knot nematodes.

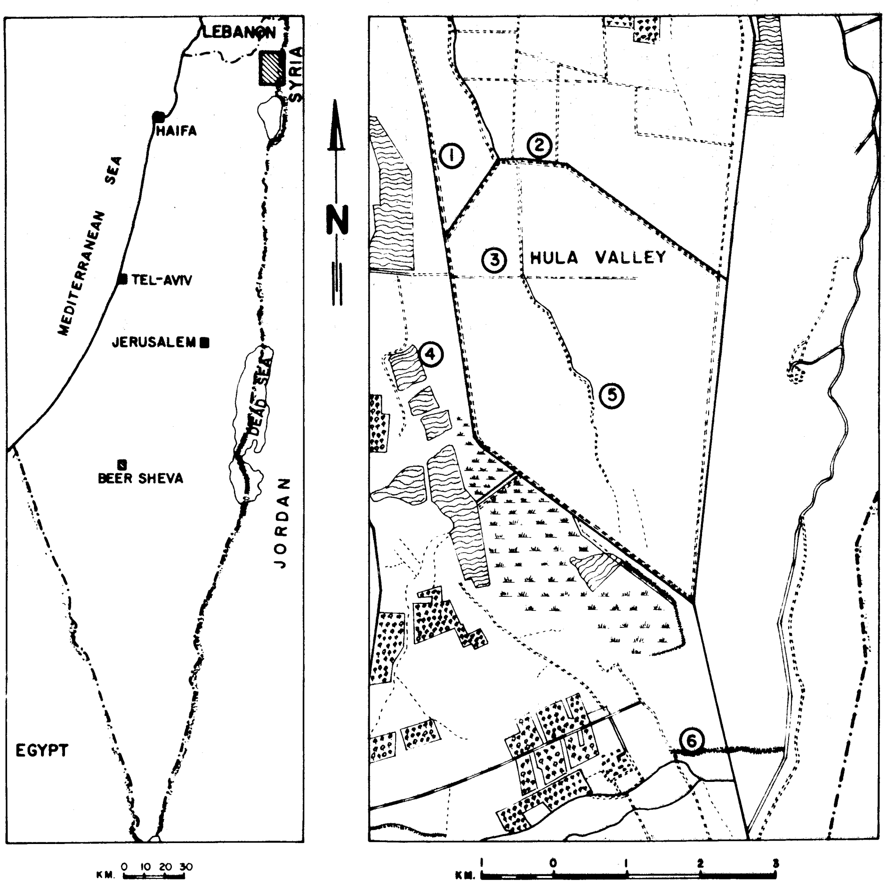

Fig. 1. Location of six *Meloidogyne incognita*-infested cotton fields studied by color infrared photography. Map of Israel (**left**) with shading to indicate Hula Valley; detailed map (**right**) of Hula Valley.

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MATERIALS AND METHODS

Six cotton fields infected with *M. incognita* were located in the Hula Valley area by conventional examination of root galling in suspected stunted areas (Fig. 1). Aerial CIR photographs of these areas were taken in September 1980 using Kodak Aerochrome 2443 film to produce format transparencies measuring 23 × 23 at a scale of about 1:10,000. Photographs taken in 1978, 1979, and 1980 of the same sites were studied and compared in this study. The photographs were taken either in June about 8 wk after the start of the cotton growing season or in September at the end of the season. The transparencies were interpreted by means of a light table, magnifying lens, and mirror stereoscope.

RESULTS

In the CIR photographs taken in three successive years, infestation with the root-knot nematode appeared as irregular areas of various sizes from 500 to 42,500 m^2. In June, the photographs of the infested areas were characterized by dark or green areas within areas having thin red lines, which were a reflection of the exposed soil. The difference in color depended on the soil properties. Various hues of pink of irregular shape, interrupting the rows of cotton, were an indication of various weed species. The cotton rows near the periphery of the infested areas were thinner and brighter in color than the healthy cotton, which had a deep and even red appearance.

In photographs taken in September, the center of the infested areas appeared as a mixture of bright areas and various light red hues, a reflection of the exposed soil and the dense weed vegetation. The rows were barely distinguishable because of missing cotton plants and dominating weeds. The margins of the infested area were clearly indicated by the thin rows, which contrasted with the completely covered, red areas of the healthy adjacent cotton. CIR photographs of an area infested by *M. incognita* taken in September are shown in Figures 2 and 3.

In 2–3 yr, *M. incognita* infestation spread about 25% a year in two fields (Fig. 4). At this alarming rate of spread, the entire Hula Valley area would be infested with *M. incognita* within 10–15 yr. The center of the infested area was expanding as well, an indication that dense inoculum had accumulated during the previous year and devastated the growing cotton seedlings.

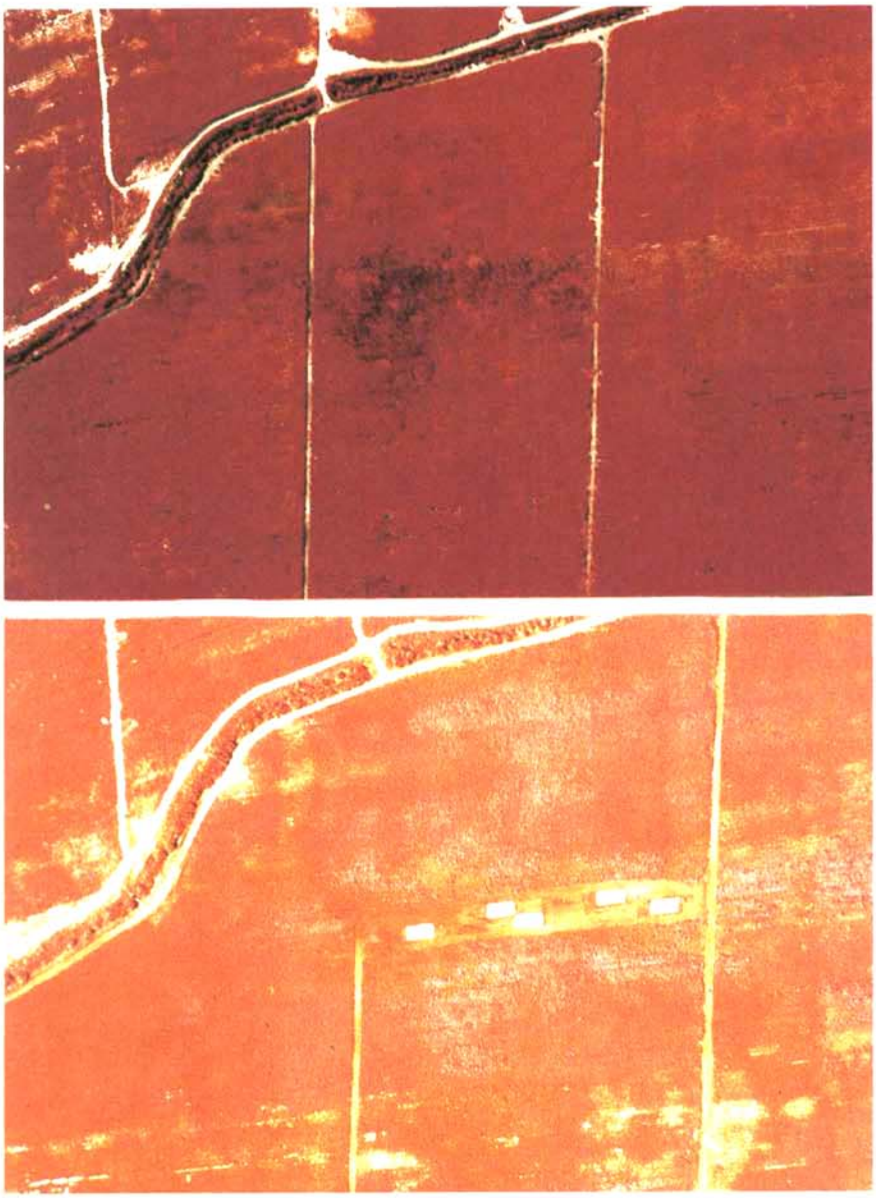

Fig. 2. Color infrared photographs of *Meloidogyne incognita*-infestation of cotton fields taken at location 4 (see Fig. 1) in September 1978 (**top**) and September 1980 (**bottom**).

DISCUSSION

The present work provides descriptive data, using CIR aerial photography, of the appearance of areas infested by *M. incognita*. Although heavily infested areas can be easily detected without using aerial photography, the CIR photographs clearly indicated the edges and borders of the infested areas, as well as light infestations that are difficult to define by conventional surveys. The difference between the center and the periphery of infected areas (Figs. 2 and 3) indicated the intensity of the nematode population. Very light infestation at the periphery of the infested area did not differ in the CIR photographs from healthy cotton areas.

Photographs taken at the end of the growing season gave clearer information about the size of the infested area than those taken earlier, probably because of the continuous damage caused to the plants during their growth. Study of photographs taken during successive years provided an accurate tool for ascertaining infection and measuring nematode spread in fields.

This work is one of the first to introduce CIR in nematode research. The technique has many additional advantages in the study of various aspects of nematode infestation under field conditions, such as the effect of crop rotation, fallow, and soil treatments, as well as crop loss estimation. To obtain more accurate information on root-knot nematodes and other soilborne pathogens, researchers should investigate the effect of these agents on the wavelength reflected from the cotton foliage.

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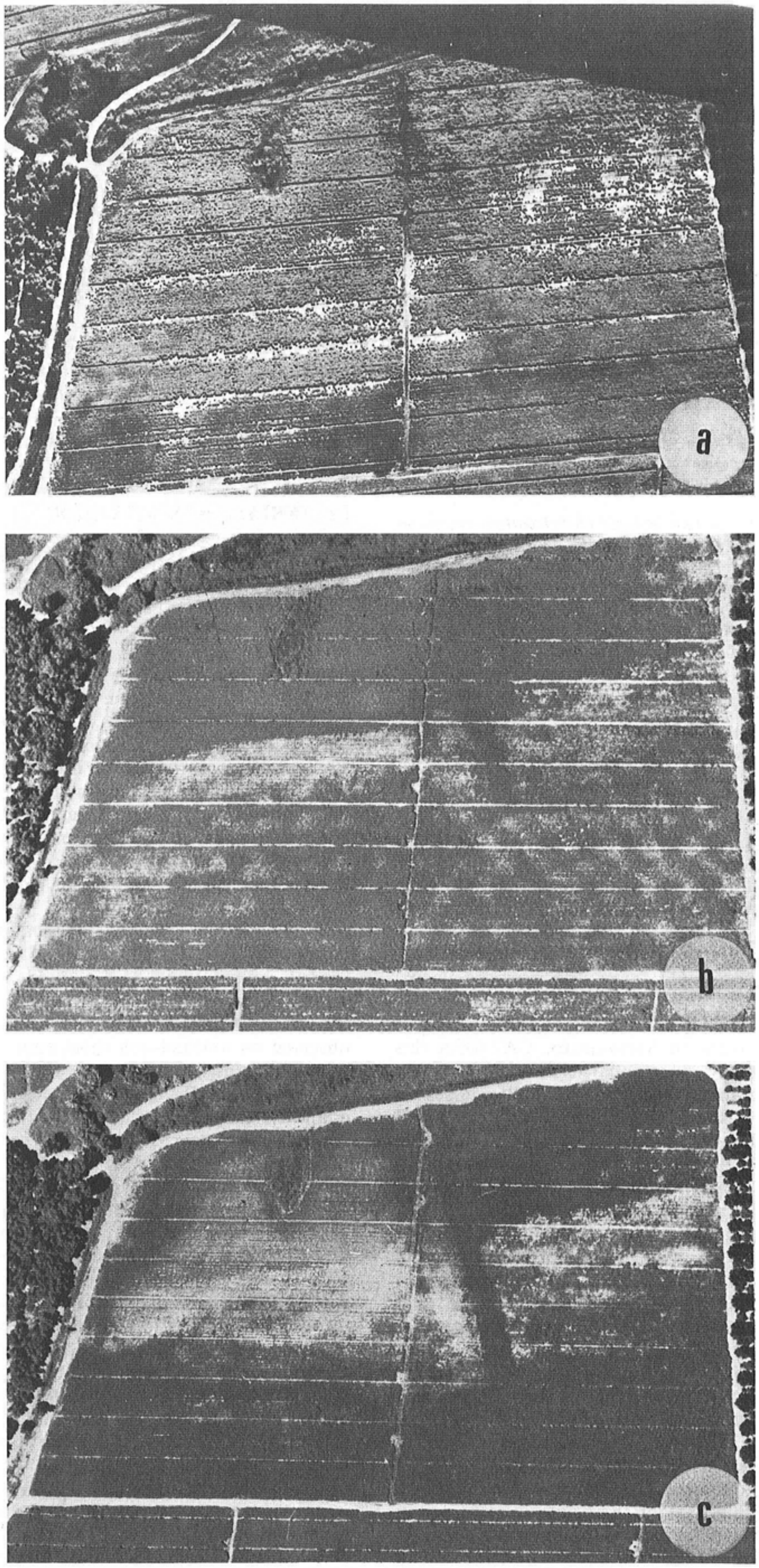

Fig. 3. Black and white prints of color infrared photographs of a *Meloidogyne incognita*-infested cotton field taken at location 6 in three successive years: (**A**) 1978, (**B**) 1979, and (**C**) 1980.

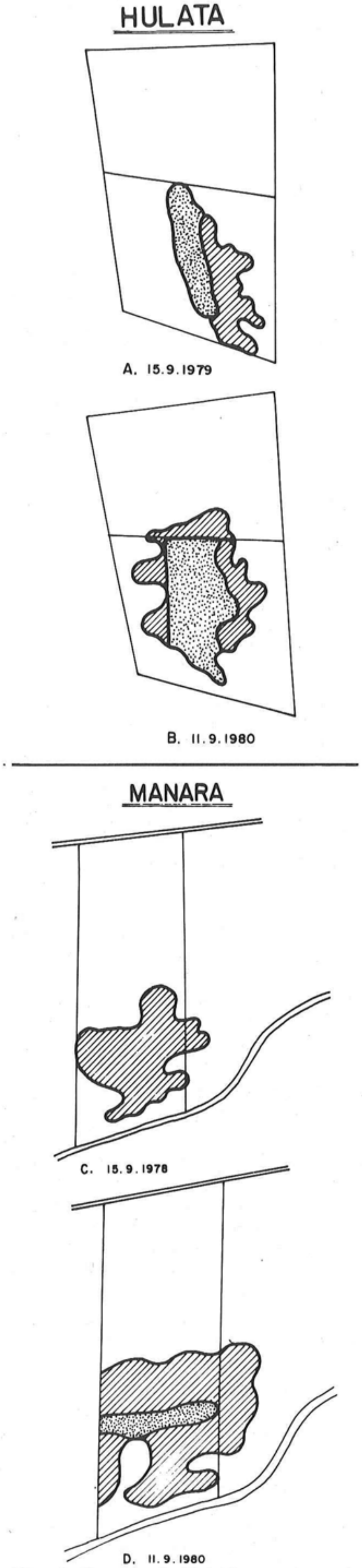

Fig. 4. Spread of *Meloidogyne incognita* infestation in two cotton fields. Dotted area indicates the highly infested center of the fields.

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