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Administration and Management of Citrus Groves with Aerial Color Infra-Red Photography Using Low-Cost Microprocessors

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FINAL SCIENTIFIC REPORT

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ADMINISTRATION AND MANAGEMENT OF CITRUS GROVES

WITH AERIAL COLOR INFRARED PHOTOGRAPHY

USING LOW-COST MICROPROCESSORS

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III ABSTRACT

An Aerial Color Infrared (ACIR) photographic experiment was conducted in Israel to test the adaptation of a grid/cell system developed in Florida for tree registration and compatability with microprocessor computer programs. Photointerpretation of (ACIR) transparencies was modified to Israeli conditions for storage and analysis with microprocessors. Three aerial photographic flights with ACIR were flown over four test sites in citrus producing areas of Israel, two during the spring seasons of 1981 and 1983 and one in the summer of 1982. Photointerpretation of the transparencies indicated that citrus tree conditions observed in Israel were quite similar to those observed in Florida. The most prevalent anomalies observed in transparencies were chlorosis of citrus trees, and sooty mold. Image analysis of the transparencies were successful in measuring different density levels that were more accurate than visual interpretations in measuring tree conditions. Measurements were done by visual selection and manually at first, shortly afterwards by visual selection and a computer program, and lastly with a standard formula for consistently selecting density levels for analysis with a computer program. Two microprocessor computer programs were written, one in Florida, and one in Israel, that were complimentary, allowing greater choice of analysis for growers. An inexpensive microprocessor system was developed for field surveys and simple tree inventories. Preliminary work was done with avocado and avocado interpretations.

IV FINAL REPORT

Administration and Management of Citrus Groves
with Aerial Color Infrared Photography
Using Low Cost Microprocessors

BARD NO. US-193-80

PREFACE

Progress in the electronic and microprocessor fields has been astounding in the past three years, beyond the expectations of the electronic industry, creating such revolutionary changes as inexpensive digitizers, image analysis consoles, video to computer interphases, electronic pencils, graphics tablets, telecommunication equipment over regular telephone lines, electronic mail, music and voice synthesizers, but most of all a dramatic reduction in prices of microprocessors and associated hardware. As an example, the BARD project US-193-80 originally required the purchase of a \$6000 dollar microprocessor which can now be purchased for \$2000. These rapid changes have forced considerable revisions to incorporate part of the new technology into the research plan and modify it sufficiently to enhance the research objectives as much as possible.

Image Analysis, an almost new computer field, has also benefited tremendously from the recent electronic advances, making possible new breakthroughs in damage assesment of agricultural crops. At the present time damage assessment is not always consistent. This is partly due to excessive dependence on arbitrary rating bias of evaluators and inexact systems. Arbitrary rating systems have had a

considerable margin of error because the inconsistent boundary limits of each class of damage, and the inability of evaluators to accurately measure each class. Image Analysis, may prove to be an extremely useful tool in repeatedly making precise and consistent measurements on damaged plant parts or on images (photographic or video) of the damaged plant parts.

All of the above technology have been studied and taken into consideration while conducting the main objectives of the US-193-80 BARD grant, which were to test the Florida system of photographing citrus groves with aerial color infrared color film to inventory and estimate damage assesment of citrus groves with low cost microprocessors.

Efforts were made to concentrate on the main objectives, while maximizing on potential spin-off benefits, in delineating the expensive photographic flights. While the main crop to be photographed in the project was citrus, efforts were made to look at other agricultural crops, or other fields of endeavor in Israel where the use of aerial color infrared photography would be of considerable benefit.

Preliminary tests were made with avocado groves, where there is a need to relate flowering dates with size and yield, as well as with damage due to soil conditions or deficiencies.

INTRODUCTION:

Progress in the use of aerial photography in citriculture in Florida and Israel has more or less followed parallel lines although the objectives used by the agencies doing the photography cannot be accurately compared.

Aerial photography of citrus groves in Israel was initiated in 1971, and has continued to date using Aerial Color Infrared (ACIR) film Aerochrome 2443. Hand processing of the film is an outstanding feature of the Israeli work, since the manufacturer does not recommend it, and suggests instead machine processing.

Colwell, 1956, first pioneered the use of ACIR in cereal disease detection, Manzer and Cooper worked on potato disease detection with ACIR in 1976,

ACIR has been used in Israel to pin-point large areas where problems exist (sooty mold, chlorosis, deficient soil moisture, soil alkalinity, etc.) rather than the individual status of health of individual trees (Hochberg et al, 1974). This was quite logical since individual tree losses are not as significant in Israel as they are in Florida.

Kadman et al, 1975, developed a system for measuring avocado tree canopies from ACIR and Black and White (B & W) photography.

Considerable work with ACIR film was done in Florida in the (Norman and Fritz, 1965) period 1962 through 1968 by Mr. Gerald Norman of the Florida Department of Agriculture, but his work was changed somewhat with the shift by the manufacturer of the film from a hand process film to machine processing. This change and the continuous problems of ACIR with sun angle (excessive shadows), change in color balance between frames, and the effect of flight direction on sides of the frames, discouraged other potential users from working with ACIR film in Florida.

About the same time the Florida Livestock and Crop Reporting Service (A combined effort of the U.S.D.A. Statistical Reporting Service, and the University of Florida's Extension Service) decided to use aerial photography to survey all of the citrus groves being planted in Florida (McGreggor, 1976). After considerable investigations they opted to use B & W Panchromatic film because they were interested in determining the acreages planted in each variety of citrus and grove changes, rather than emphasizing individual tree conditions (Todd, 1971).

The uses of ACIR in Israel and of B & W in Florida are somewhat similar, except that Blight (a disease of undetermined origin) causes severe tree losses in Florida, ranging from 15% to 20% per year of the planted acreage. This high rate of loss creates a need to have individual tree information (dead, missing and replacement trees), to conduct management practices involved in the purchase of new trees, grove depreciation and revenue loss, as well as tax credit. Without such a disease there is less need for information of individual trees (Abbitt, 1977).

Photointerpretation of aerial photographs either singly or in stereo-pairs has been done both in Israel and in Florida by visual observation aided by microscopes or viewers. Photointerpreters have estimated changes by arbitrary decisions based on intuitible knowledge, or by planimeters (not always precisely calibrated), aided sometimes with mathematical formulas (Edwards et al, 1976).

ACIR investigation were made in Israel in nematode surveys on Cotton by Orion et al in 1982.

Horticulturists have become increasingly aware of the importance of grove mapping (Abbitt, 1977) and they are developing a different approach such as the one used by East Germany (Wolff, 1976).

Photointerpretations conducted in this fashion have two major flaws; (1) Accuracy of the interpreter decreases with fatigue within two hours of working, (2) Arbitrary decisions are not always consistent from day to day, nor between different interpreters, (Murtha, 1978).

Early in 1973, the National Space and Aeronautics Administration initiated a number of projects that would ultimately be oriented to the use of satellite imagery from their newly launched "Landsat" program.

At the John F. Kennedy Space Center in Florida, an office was established by NASA to deal with Earth Resources (satellite acquired data), and to initiate investigations with potential users of the technology.

One of the projects initiated involved the testing of a Daedalus mechanical scanner to acquire images of citrus groves that could be processed by an Image-100 image analyzer. Conceivably, use of the scanner would expedite image acquisition and eliminate the inherent problems of ACIR film. Use of the Image-100 image analyzer would do away with photointerpreters, so that images could rapidly and consistently be analyzed for long periods of time and in addition any one image could be accurately compared with another. Computer printouts of tree counts and health status could be rapidly obtained from the Image-100 (Edwards, et al, 1976).

The KSC project was successful in a number of tests, but due to resolution limitations of the scanner, it could not be flown at altitudes higher than 900 meters. the Image-100 analyzer was not totally free of the problems of ACIR, since it could not distinguish sick trees from shadows or dark soil. Visually, operators could distinguish the trees, but the computer could not (Blazquez, unpublished reports).

An ACIR supportive project was initiated to develop a mapping system for the project that might help solve some of the problems. The ACIR project was very successful, and did help to solve some tree registration problems of the Daeadalus Image-/651100 project (Blazquez and Horn, 1980)

Unfortunately, one year after the BARD US-193-80 was initiated, the KSC project was discontinued and all NASA remote sensing work cancelled.

It was possible to relocate most of the Image-100 image analyzer equipment at the Remote Sensing Facility in the main campus of the University of Florida, but the Image-100 was not made operational soon enough to assist in the BARD project.

During this period of transition, a Linear Measuring System (LMS) was acquired by the Agricultural Research and Education Center in Lake Alfred. The LMS is an inexpensive image analyzer able to distinguish 24 shades of gray and accurately measure the areas of each shade of gray. It is an Apple II+ (microprocessor) driven image analyzer, quite suitable to the needs in ACIR photography.

This unexpected equipment allowed additional analysis

of the Israeli ACIR photographs, greatly enhancing the results obtained with the BARD US 193-90 Grant.

During the three years of the grant, other changes not directly related to the objectives had a considerable effect on the scheduling of the project goals. The most significant change was the termination of Remote Sensing as a main task at the National Space and Aeronautical Administration's Kennedy Space Center, thus closing the Data Analysis Facility.

A second important change occurred at Agricultural Research and Education Center, where a move was required to expand the Remote Sensing Laboratory (plagued by a number of significant delays in installation).

Regrettably, we lost our technical assistance while finalizing the results of the entire project, an event further delaying progress until a new assistant could be obtained on University funds.

METHODS

An aerial color infrared (ACIR) photographic system developed through cooperative work between the National Aeronautical and Space Administration, Kennedy Space Center, Florida and the University of Florida, Lake Alfred, Florida (Blazquez & Horn, 1980) was tested and modified for use in Israel under Binational Agricultural Research Development (BARD) Grant US-193-80. The system included a rapid photointerpretation grid/cell registration method and an interactive computer program for inputting information extracted from aerial photographs into a microprocessor for analysis and storage of the information on diskettes

(floppy disks). Ground surveys of selected areas of the test sites were made to verify the interpretation of the ACIR photographs.

Three representative citrus growing areas of Israel with a large range of planting distances and a large selection of the main varieties of Israel were taken into consideration in selecting the three test sites:

- a. Northern - Tahanahim
- b. Central - Gush Tel Mond
- c. Southern - Hevel Habesor

From these three areas, three sites each were selected for accurate assessment and tree counts. In the Gush Tel Mond area, an additional three sites were selected to insure adequate representation of grove types. ACIR photography was acquired April 11, 1981, June 20, 1982 and May 22, 1983. The Tahanahim area was photographed August 4 and May 22, 1982 for sequential comparisons within a growing year.

The archeological richness of Israel encouraged the testing of photography in potentially interesting sites with ACIR as a side project with the cooperation of Dr. Yval Portugali of the Hebrew University in Jerusalem. Special efforts were made in the Jezreel Valley area to photograph sites close to citrus areas.

The citrus sites photographed the first two years were interpreted in Florida and input into a General Automation SPC 16/65 minicomputer using the first computer program to be developed for citrus grove mapping, written in Fortran (Blazquez & Edwards, 1978). This program proved difficult

to handle except by experienced operators and the accessibility of a minicomputer to the growers would be problematic. A program written in BASIC was developed in 1982-1983 by Tomer Computers, Ltd. (unpublished data) for use in an Apple II microprocessor to input data from plots and make rapid analysis of any special pattern of distribution of a problem within a grove. A third program, also in BASIC was developed by Applied Computer Software, Inc. in 1983 (unpublished data) for use in the Apple II+ microprocessor to input the data onto 5-1/4" floppy disks and make rapid analysis of the grove information. This latter program was designed to compare four sets of information concerning individual cells and/or blocks of trees and the sums thereof at one time with the option of printing any part of the program. Comparisons of the three programs were made to determine the best feature of each (Table 1).

A fourth computer program was developed early in 1983 for use with a very inexpensive microprocessor that could be taken into the field to summarize data from field surveys. The program was based on the grid/cell system, and was designed to run with a cassette recorder, rather than a disk drive. It performed very well. (Barros et al 1983) and was most useful in the field, unfortunately it was only tested in Florida's groves.

Experimental results indicated the Florida Citrus Grove Management system with ACIR was successful in Israel and could be used immediately to inventory tree stands and detect levels of stress, deficiencies and diseases.

Transparencies of all the photographic data were photointerpreted in Israel and input into a computer with the Tomer Computers, Ltd. program. In groves where tree canopies could not be distinguished from each other, special magnification techniques were developed to locate and identify individual trees.

Efforts were made during the duration of the Grant to incorporate as many advances in image analysis, interpretation systems and software development as possible. The use of aerial color infrared photography would be encouraged, made easier and have greater cost benefits in both Israel and Florida. Image analysis of the ACIR photographs of the experimental sites were done in Florida with a Linear Measuring Set System (LMS) manufactured by Measurronics Corporation of Great Falls, Montana.

Photographs were scanned and separated into different density levels to determine if changes in color on the transparencies could be associated with differences in plant health or levels of disease as well as measurements made of each area. Simple enlargement techniques were also investigated to aid in adapting the procedures to the grower level of work.

The comprehensive description of the research plan outlined in the initial proposal was followed and modified only when it was necessary to improve the final results of the research.

EXPERIMENTAL APPROACH

- 1) A background information survey of the best citrus areas where specified sites would be representative and

give a serious test of the grid/cell mapping system of ACIR was made in Israel in 1981.

- 2) A review of existing photography at the Division of Remote Sensing, Jaffa, was made to assemble a profile of the candidate test sites including: (a) Universal Transverse Mercator (UTM) map (scale 1:50,000) (b) A Citrus survey map showing numbers and classes of helkas (scale 1:10,000) and (c) a high altitude (1:10,000) black and white print (Fig. 1,2,3,37,38,39).
- 3) Field surveys were made of candidate test sites with photography and each site delineated on all available photography and maps.
- 4) Preliminary surveys were made of potential computer software programmers who might be available for adapting the desired programs for storage and analysis of the photointerpreted data.
- 5) ACIR photography was obtained during three consecutive years - 1981, 1982 and 1983 - as described in the project plan of the initial proposal.

TEST SITES

Planting distances and a large selection of the main varieties in Israel, were considered in picking the representative citrus groves for sequential photography. Previous aerial photographs were used to select groves showing special conditions or patterns of problems that could be easier to pinpoint with ACIR than by ground surveys. Topography, where some sites were on small hills and others on completely flat areas, was also considered in making the selection of test areas (Table IV).

Location: Grove sites were located in three citrus producing areas of Israel:

a. Tahanahim	SITE	AREA	GROVE
	1	1108	5,10
	2	1108	36
	3	1108	43
b. Gush Tel Mond	Nir Elihau		
	1	0808	18
	2	0808	13
	3	0808	20
	Gan Efraim		
	4	9920	131
	5	9920	160
	6	9920	150
c. Hevel Habesor	1	5404	74
	2	1051	115
	3	5406	140

ARCHEOLOGICAL TEST SITES:

Archeological test sites selected were located in the jezreel valley, the tests were:

- a. Yoqne'am
- b. Qashish
- c. Shimrom

Each site was located on the Israeli Citrus Survey and the UTM maps available at the Division of Remote Sensing, Jaffa, Israel and given an identification number for each helka and group of helkas. (Grove Profile, Table IV).

PHOTOGRAPHY

The three annual aerial photographic missions were made according to project plans in the early spring/summer seasons of 1981, 1982 and 1983 as closely as possible to the after-bloom period of each area. In 1982, two additional missions were conducted August and September to determine if it might be advantageous to photograph during late summer (Table II).

Contracts were awarded to Ofek, Inc. of Tel Aviv, Israel. Photography was done with a modified Fairchild K-24, 23 cm X 23 cm aerial camera using 30 cm focal length apochromatic (without aberration lens.) The camera was connected to a Zeiss Model ICC/NSI intervalometer powered by the electrical system of the Cessna 172 aircraft. Photographs were taken 1219 m (scale 1:4000) through the three annual photographic missions and from 3000 m (scale of 1:10,000) the first year for orientation and site registration purposes. A forward lap of 60% and side lap of 30% was maintained.

Film Used: Aerial photography was accomplished with Kodak's aerochrome no, 2443 Estar base ACIR film for machine processing.

Processing: The ACIR film was processed into positive transparencies with the required chemicals by an Ofek hand processing system at the Ofek Laboratories in Tel Aviv. Rolls of film were taken to the Division of Remote Sensing at Jaffa for evaluation, acceptance and use.

Ground Photography: A Cannon A-1, 25 mm single lens reflex camera was used to take ground photographs of trees at the test sites. Photographs of trees in varying degrees

of stress, with apparent problems and diseases were taken with Ektachrome 64 color film for comparison with conditions identified in the aerial photography.

PHOTOINTERPRETATION

The terms "transparency" and "photograph" are used interchangeably throughout the manuscript. ACIR transparencies were photointerpreted at AREC, Lake Alfred and the Division of Remote Sensing, Israel, by different interpreters with varying degrees of expertise and the results compared to field surveys for accuracy.

Several types of magnification systems were evaluated including an Omega projection enlarger and Bausch and Lomb microscope which proved too tedious for any large quantities of interpretation.

In Israel, the microview-280 transparency enlarger assembled locally was used primarily to photointerpret. The bulk of the work at Lake Alfred was accomplished using a modified DL-2 Dokumator microfilm reader manufactured by Jena Optik, Jena, Germany H., which had four magnifications (6.5, 9, 13 and 17.5) diopers, and a Panasonic PK-700 video camera projected through a Sony 13 in (33cm) color monitor. Grid cell markings were made on the film protectors over the transparencies with the aid of a large 4-diopter rectangular double lens magnifying glass manufactured by Stocker and Yale, Beverly, Massachusetts.

The light tables used were described in NASA Reference Publication 1067 (Blazquez and Horn, 1980).

TEST SITE PROFILE:

A profile of each test site was assembled in a folder including all maps, high altitude (small scale) photography,

contact prints and respective ACIR transparencies as well as computer printouts from the three computer programs (Table I). A number of test sites were photointerpreted by more than one interpreter making it possible to compare errors of omission and commission and using ground verification to determine the most probable tree condition.

Damage assessment of each tree was determined on the basis of degree of stress, disease or condition (25%, 50%, 75% and 100%) present (Table III) and if healthy, the size of the tree (large, medium, young, and replacement).

Grid cells of each test site were marked on the transparent plastic protector of each transparency and appropriately marked according to NASA Reference Publication 1067 (Blazquez and Horn, 1980). Whenever necessary, more than one transparency was used in completing the site analysis for input into the microprocessor system.

The Omega enlarger was tested on the early transparencies made of Nir Elihau and Tahanahim test sites which were badly shadowed and difficult to interpret but it was not readily adaptable (Fig. 40).

Transparencies were rapidly scanned three times prior to interpreting individual trees and assigning damage or stress values. Repeated comparisons were made between trees considered healthy and those being evaluated to avoid possible errors of omission or commission.

FIELD SURVEYS:

Field surveys were made of each experimental site to observe grove conditions that might influence the

photography or interpretation, such as nearby vegetation, presence or absence of grass, vines, and other weeds which might show through the tree canopies. Also observed and recorded were topographic differences in the sites which could assist in the location or registration of a particular area of the site such as hills, large ditches and wet areas.

An enlargement of the site was used as a map or guide to select potential areas where damage assessment might be difficult and a high altitude print helped locate the best approaches to roads and in determining the easiest access to the sites. The enlargements were also used to design the best fit for the grid/cell.

IMAGE ANALYSIS:

The Remote Sensing laboratory at AREC, Lake Alfred acquired a Linear Measuring Set System (LMS) image analyzer, after the BARD US-193-80 Grant was awarded. The LMS is capable of detecting up to 24 shades of gray on any type of image whether print, transparency, video tape or any object. This capability makes the LMS an extremely useful tool in measuring areas and shades of color from healthy and diseased leaves and roots to quantify levels of damage by associating color with disease.

Test site transparencies of Tahanahim Site 1 and Nir Elihau Sites 2 and 3, from photographic flights on May 11, 1981, June 20, 1982 and May 22, 1983 were processed through the LMS's first system which involved manual interpolation and recording of the density levels, area and shapes, (Figs. 10,11,49,50) . A more sophisticated version delivered at a later time eliminated the manual inputs and did all the processing through a computer program. In early

investigations with both the manual and computer analysis of density levels, the density levels were selected visually from observations in the monitor. Later in the program density levels were selected by the following formula:

$$1) \frac{(HDL-LBL)}{nDL} = \text{Increment Number}$$

(HDL) Highest Darkness Level

(LBL) Lowest Brightness Level

(nDL) Number of desired density levels

The Increment number was used to increase Darkness Level at an assigned value, thus eliminating arbitrary selections of brightness levels. Thus it would be possible for other researchers to duplicate the image analysis. (Figs. 18,19,20,21,22,23,24,25,26,27,28,29,30).

The same images from Tahanahim and Nir Elihau were again processed and additional visually selected density slice maps made, as well as histograms (Figs.12,14,16). A formula was developed for systematic incrementing of density levels in order to reduce arbitrary errors made in visual density level selection (Figs. 18,22,27).

The concept of calibration trees (standard) (Blazquez and Horn, 1980) was used throughout the photointerpretation process as well as the degree of damage, stages of health and tree size.

Efforts were made initially to use a tree size template made in Israel (Kadman et al, 1975) for avocado tree photointerpretation, but the process slowed work considerably and was only used to establish the range of sizes in each grove, rather than to move the template over each tree to be interpreted.

The use of letters in early investigations was shifted to numbers so that a key pad could be substituted. This would accelerate the input of data by an interpreter into a computer (Table III).

The Aerial Color Infrared Photographic system developed for Florida was easily adapted for photographing citrus groves in Israel. The simple magnifying equipment used in the system worked well at the large scale (1219 m) used in the photography. Color video cameras worked well when used to magnify images from the large scale as well as from smaller scale photography (2440 m).

A DL-2 Dokumator used in Florida was also a versatile system for image interpretation being capable of projecting images on a wall. A Microview 280 used in Israel, a transparency enlarger, was also quite versatile and made photointerpretation easy. Initially two person teams were used, one to interpret and one to record, but as interpreters acquired proficiency they were able to do both tasks.

Smaller scale photography (3408 m) was most useful to study the relationship between the sites selected, and helped a great deal in orientation during the field surveys. The 3048 m photographs, along with the area and helka designations used by the Remote Sensing Division, were combined with the transparencies from the three years of photography and prints to form what became designated as a "Grove Profile".

All things considered, the ACIR photography from 1219 m was good, and made it possible to detect different levels of stress, insect damage, soil problems and mineral

deficiencies. This scale of photography was best adapted to detail surveys that individual growers or companies could use. The 1219 m scale revealed a great deal that was not readily apparent with inexpensive interpretation equipment. Use of a closed circuit color video system (video camera to monitor) made it possible to enlarge images with greater ease and more vivid details, that could also be observed in smaller scale photography taken from an altitude (2440 m),

Automated computer controlled image analysis of the three overflights did not differ greatly in the amount of canopy (tree crowns), indicating a good consistency in LMS's area measuring ability. Differences between the overflights in shadows and soil areas were dependant on the time of photography, as the LMS can only measure black pixels (picture elements) and cannot determine whether they are due to visible soil or shadows (Fig.11).

COMPUTER ANALYSIS (METHODS)

While the main goal of BARD's US-193-80 grant was to show that low cost microprocessors were useful in the administration and management of citrus groves, the initial test work at AREC Lake Alfred was done on a General Automation SPC 16/65 minicomputer, because a microprocessor program was not available.

Initial tests with available microprocessors at NASA's Kennedy Space Center indicated that the best candidate for use in the project was the Apple 11+ microprocessor because its ease of operation and considerable software support by the manufacturer.

Two identical Apple II+ microprocessors were used in the project, although the one in Israel had to have a

somewhat different configuration than the one in Florida.

A basic computer program developed to demonstrate the concept of microprocessor use with the grid cell system previously developed (Blazquez and Horn, 1980), could not be adapted to summarize and inventory. Consequently bids were submitted to three computer programmers in Florida and one in Israel to develop useful programs in Florida following two different complimentary approaches.

The Florida program was based on the premise that computer printouts would not be used for comparisons with ACIR transparencies, and that speed in retrieval of cell data was most important. It was also designed for rapid comparison in the computer on a cell and block data for four different sets of information (aerial photographs or field surveys). The Florida program was designed to display from one to four cells in the video screen with cell totals (both spaces entered and numbers per class). Although four computer programmers submitted bids for the work in Florida, only Applied Computer Software of Satellite Beach, Florida, completed an interactive and useful program called "Grove Management Program".

In Israel, a different approach was used in developing an interactive program. Because of the low rate of change in citrus production, a program was designed to display an entire helka, or major portions of it, on the video screen or printout instead of individual cells. It would then be possible to compare at a glance the data photointerpreted with the ACIR transparency, particularly if a closed circuit video system was used. Due to the influence of soil types in Israel, a section of the program was written to classify

each cell by soil type and by canopy density. Canopy density can be a good indicator of the need to hedge a grove and this is of particular importance in Israel due to the close planting of most citrus groves. Tomer Computers Ltd. of Haifa, Israel, developed a Basic program called "Orchards Management System". The program includes a section for rating trees on chlorosis and alkalinity with a separate printout option. It can print out entire helka maps, of either all classes or each class of tree separately, with the appropriate descriptions and classifications. The only disadvantage of the program is it's relative slowness in processing the data.

TIMEX FIELD PROGRAM METHODS

The Timex/Sinclair system was tested under a configuration designed to compare it with the standard method of recording data in the field. The entire system (for the test only), was checked simultaneously with manual recording by an experienced team of scribe and field surveyors who rated the trees according to the system described previously (Barros et al, 1983).

The system was designed to fit in the cab of a pickup, but for the test it was carried in the back to accomodate both the manual recording scribe and the system.

DATA PROCESSING METHODS:

The FORTRAN computer program previously used in Florida research (Blazquez and Horn, 1980) was used in summarizing and analyzing the data photointerpreted from the May 11, 1983 and June 20, 1983 photographic missions, until a microprocessor computer program was developed.

The facilities at AREC, Lake Alfred, where the General Automation SPC 16/65 is located in one building and the Remote Sensing laboratory with all the photointerpretation equipment in another building, did not allow the development of an interactive system, making it necessary to input the data into properly marked graph paper and then copying it into the computer. This double recording required considerable time and effort with a greater potential for making errors.

Although it was initially thought that the program would produce a printout that could be used as a map, this was only possible in groves that had been planted in squares, rectangles or any shape that could be fitted into these two geometric patterns. In the case of Israeli groves this was not always possible, so while the data could be recorded, the computer printout was not always a close duplicate of the photographic image.

AERIAL PHOTOGRAPHY RESULTS:

The three planned ACIR photographic missions in 1981, 1982 and 1983, plus the two additional tests carried out in 1982, were taken by Ofek, Inc. and hand processed. A developing method not recommended by the Kodak Company, manufacturers of the Aerochrome # 2443 ACIR film, and only done in the U. S. by the Remote Sensing laboratory (USDA) at Weslaco, Texas (personal communication with Mr. Ron Bowen).

All of the aerial photography taken in Florida was processed by Precision Photo Labs of Dayton, Ohio with a Kodak Versamat processor.

Comparisons of photography between Precision Photo and Ofek, Inc. were made with a number of transparencies of similar groves from Israel and Florida. The only detectable differences between the various flights in Israel and Florida were usual changes in color balance between the batches of film and time of photography.

The late afternoon photography taken in one mission June 20, 1982 did suggest that the different sun angle encountered in Israel's latitude yielded much less light than the same hour in Florida. This factor should be taken into consideration in future photography.

Considerable adaptations had to be made to the grid/cell system in using it with transparencies from Israeli citrus groves. It was possible to use it, although computer printouts could not always be matched to the configurations of the groves (Fig. 42))

The close plantings used in Israel had both favorable and unfavorable effects in photointerpretation. The relative low rate of missing or diseased trees (when compared with Florida's groves) made it very easy to detect these type of trees, however, it was much harder to correctly register and locate them. Once these trees were located, it was much easier to determine their rate of disease increase, since their numbers were relatively low (Fig. 45)

All of the types of damage detected in Florida were observed in Israeli transparencies without much difficulty. Vines, (Fig. 8B) weeds, patches of grass, groves with mixed varieties (Fig. 8A) could also be detected. Abandoned groves and groves with cultivation were easily observed when located next to well groomed groves.

Soil moisture levels were as easily observed in Israeli transparencies as in Florida's (Fig.47C). Groves with sprinkler irrigation systems could be distinguished from those with micro-jets or other low volume irrigation systems (Fig.47D). Watered and unwatered reset trees were observed easily. Variations of soil moisture in groves could be observed in some cases by the different rate of tree growth of a single variety of citrus.

The overall results of the three years of photographic surveys in Israel suggested the ACIR film could capture the same information previously observed in Florida's images, in addition some conditions not found in Florida.

Photointerpretation results of transparencies from the three-year photographic survey in Tahanahim, Gush Tel Mond, and Hevel Habesor were in many respects quite similar, although the same conditions or stress did not occur in every test site. Three of the best test site examples of results obtained were selected for in depth reporting and comparisons to avoid redundancy.

The test sites selected for in depth comparisons were Tahanahim 1 and Nir Elihau 2 and 3. Tahanahim 1 was chosen because it was a difficult site requiring a great deal of photographic enlarging and accurate mapping techniques to fit the grid/cell system to the site's configuration and tree planting. Nir Elihau 2 had an irregular planting configuration but was not a difficult site to fit to the grid/cell system. Nir Elihau 3 also had a complex planting configuration, but was studied because part of the trees were cut down one and two days prior to photography and would offer a rare opportunity to study changes in

reflectance of trees, one and two days after being cut down.

AERIAL PHOTOGRAPHY RESULTS

IN DEPTH COMPARISON SITES

TAHANAHIM 1 -Site 1 was selected as an example of the types of grove configurations due to tree planting found more frequently in Israel than in Florida. Site 1 is identified as Helka 5 of Area 1108 in the Branch Citrus Inventory Map (1:10,000).

Trees in the site were not planted perpendicularly to form rows at a 90 degree angle, but instead were planted at a 70 degree angle to fit the natural contours of the land. Other groves in the area were planted in contour plantings indicating that elevation is of importance in the area. While most of the rows in Site 1 were planted in a straight line, rows 14 to 24 have a bend on one end, making it necessary to ignore such changes in the tree inventory and computer printouts (Figs.4,9)

Tree counts were difficult to make in the first ACIR transparencies because the photography was done in the afternoon, later in the day than was desirable. Shadows of wind-break trees covered the first row of trees (Fig.4A) but not in subsequent photography which was done at a more appropriate time in the morning (Figs.4B,C,D). Tree counts were further complicated by the fact that a seven-tree wide strip was planted at a later time from rows 24 to the end of the sate at row 68. This strip was clearly visible in the transparencies of June 20 (Fig. 4B) and August 4, 1982, and is indicated in the Inventory map (1:10.000) where Site 1 is Helka 5 and the seven-tree strip is considered to be Helka 10 of the same Area. This size difference is not as

obvious in any other photography (Figs.4C,4D).

CHLOROSIS:

Whitish (chlorotic) foliage was observed from the middle of the Helka (rows 21 to 41) toward the center of the rows in irregular patterns in transparencies of May 11, 1981, June 20, 1982 and May 22, 1983. Both the intensity of the chlorosis and the number of trees showing it increased considerably during the three years of photography.

Chlorosis was severe enough to suggest considerable loss of foliage in trees located in the center of rows 31 through 34 in the May 22, 1983 transparency (Fig.5A,B,C). Irregular chlorotic areas were observed in the southern part of the Helka beginning with rows 57 to 61, with some trees showing loss of foliage in cells 71 and 72 of row 57 (Fig.5D).

Progressive foliage loss was detected in tree 4 of row 32 (Fig. 6A) until observed missing in the May 22, 1983 transparencies (Fig.6D). Chlorotic discolorations were not observed as clearly as the transparencies of June 20, 1982 (Fig.6B) or September 10, 1982 (Fig.6C).

In Helka 11 of Area 1110 (Fig.8A) trees at the ends of rows close to Site 2 (Helka 36, Area 1108) by a ditch were observed to have severe chlorosis in both transparencies of August 4 and September 10, 1982 with additional trees scattered throughout the Helka showing various degrees of chlorosis (Fig. 8A,B).

A curious anomaly was observed on a Pride of India (*Melia saderach* L. (Fig. 7) growing in the middle of Row 10 of Helka 4, east of Site 1 and in the same area, was observed to have normal foliage in photographs taken during

the months of May 1981 and 1983 and June 1982, However, on the transparency taken in September 10, 1982, the tree showed severe chlorosis on the upper foliage. In most of the photographs observed, citrus trees were observed to show chlorosis in the months of May through June, decreasing in September, which is the opposite of this tree.

Photointerpretation of the transparencies taken during the three years indicated a very low rate of tree mortality, as was the case in the other sites photographed.

SOOTY MOLD:

South of Site 1, in Helka 2 of Area 1108, where tree rows were planted in a 60 degree angle, a very heavy concentration of sooty mold (Hochberg et al, 1974) was observed on the western end of the helka. Sequential photographs taken on August 4 and September 10, 1982 indicated that the fungus was decreasing. On the May 22, 1983 transparency, no sooty mold was detected in any part of the helka, suggesting that complete control was obtained (Fig.9D).

Observations of Helka 40, Area 1108, near Site 3 in Tahanahim (Figs.8C, and 8D) indicated that the helka had been roto-tilled shortly before the August 4, 1982 photography was taken. Two grapefruit interplants can be clearly distinguished in row 5 (from the south border), trees 8 and 10 as well as row 4, tree 9. Differences in soil moisture between the roto-tilled soil and the soil between the trees can be easily distinguished. This transparency has more of a reddish color balance, but good enough to distinguish the grapefruit interplants from the Shamuti oranges. A

subsequent transparency taken on September 10, of the same year, showed that the shallow furrows of the roto-tilled soil were still visible, although not as distinctly as on August 4. The magenta color balance of this transparency made it difficult to separate the grapefruit resets from the Shamuti oranges (Fig.8D).

NIR ELIAHU 2

The Nir Eliahu Site 2 (Helka 20, Area 0808) was selected because it is an excellent example of a healthy mature grapefruit tree grove. The trees were vigorous and well developed although closely planted. Throughout the three photographic missions (May 11, 1981, (Fig.45A); June 20, 1982 (Fig.45B) and May 22, 1983 (Fig.45C) very slight differences in health could be detected; in fact only five trees indicated some slight leaf loss, but since these difference were not consistent they were ignored.

Tree canopies were easily distinguished so that no difficulty was encountered in adapting the grid/cell system and using the first FORTRAN computer program in the General Automation SPC 16/65 computer (Fig.51). With a uniform stand of trees, Site 2 was rapidly counted and analyzed.

Site 2 was tested with the modified Omega Projection Enlarger and the resulting schematic figure analyzed to see how well canopies could be separated (Fig.40) The work was laborious and not accurate enough to warrant spending additional effort in outlining individual canopies; however, it was possible to do so. Shadows were not a problem as all three photographic flights were taken at a desirable sun angle. Interpretation with the closed video system was excellent and was done very rapidly, although the planting configuration was not the standard block type.

Site 2 has straight rows, with the exception of one end where they curve slightly and the tree-row alignment is not quite perpendicular (it's 110 degrees) which poses no problems if fitting a grid/cell overlay.

Both in-depth sites were interpreted in Florida and Israel and the results compared. In general, interpretations agreed and the only significant differences were between persons of different training, they were not sufficient enough to warrant serious investigations, but will be assembled for further analysis.

NIR ELIHAU 3

Grapefruit trees in this helka (Helka 13, Area 0808) were planted in a complex configuration, as the majority of the rows were planted in a negative 32 degree configuration to the north-south boundaries of the helka, with the last 4 rows planted in a negative 120 degrees, making a difficult grid pattern (Fig.41). ACIR photography of June 20, 1982 was taken very late in the afternoon, giving heavy shadows to the tree.

Observations of grapefruit trees cut down two and one days before the photography was taken indicated that very little change in reflectance has occurred within the lapse of 48 and 24 hours of photography when compared to standing trees (Fig.46). Closeup photography of either end of the rows and the centers did not differ greatly in reflectance (Fig.47A,B).

FIELD SURVEYS - RESULTS

Field surveys of each experimental site were made during the two visits to Israel (1981 and 1983) by the Principal Investigator (Table VI). Surveys were made using

all the maps and aerial photographs described under grove profile . Enlargements of each respective site were used to select candidate rows to walk through and estimate visually any degree of damage as described previously (Table VI).

Field survey estimates were checked with photointerpretation ratings and did not differ greatly. The most consistent difference between visual observations and photointerpretation of the same tree was a tendency in visual observations to assign lower ratings of damage (1-25% and 2-50% diseased) than in photointerpretation.

Surveys of the test sites during the 3 years of the grant revealed no major changes in the plots selected for photointerpretation with the exception of of Site 2 at Nir Elihau, Gush Tel Mond which was half cut down when the last ACIR photograph was taken.

Development of the Grove Profile was most helpful for field trips in assembling all data from a specific site in a group, making possible the comparison of various sets of transparencies and maps with the same system. The twelve sites selected for the BARD US-193-80 Grant constitute a considerable amount of maps, ACIR transparencies and prints, B&W prints and enlargements, as well as numerous computer printouts which if included in this report would constitute a massive volume of data.

GROUND PHOTOGRAPHY - RESULTS

Ground photographs with Ektachrome color film (ASA 64) were taken of trees at specific sites to compare the condition of trees on the ground with ACIR photographs and

for use at demonstrations of the results at grower workshops and scientific meetings.

IMAGE ANALYSIS

Although image analysis was not an integral goal of the original plan of work, considerable efforts were carried out to use the Linear Measuring System (LMS) in doing image analysis of all twelve test sites in the project. The amount of data obtained was considerable, although in many cases quite similar, so in order to avoid duplication, the results of image analysis will deal primarily with the two in-depth sites, Tahanahim 1 and Nir Eliahu 2.

During the first year of operation the LMS required a number of manual operations to record the intensity of light digitized (image changed from analog signal to digital-number-signal) and the ratio of light to dark numerical readings for maximum and minimum amount of light. It was also necessary to record the total area digitized (Figs.10,49).

Operation of the LMS was expedited considerably by the development of a computer program to automatically record all of the above parameters, as well as to display a histogram comparing all of the gray levels detected in the image. This new procedure is most useful, as it allows investigators to easily compare gray levels from one image to another, and then select the best option on a numerical basis of intensity.

Tananahim 1

Image analysis of the entire site was done from the May 11, 1981 ACIR photography with the Manual System of the LMS. The image was separated on the basis of four gray levels of intensity which matched quite well two types of foliage

(dark and light) a dark area of the site, and the total area encompassed by the entire helka (Fig.10). At this magnification it was not possible to detect any level of stress or diseased condition of individual trees.

After the upgrading of the LMS, transparency of June 20, 1982 was processed through. In this second analysis, six gray levels were chosen for the entire helka. Results indicated that both the dark, light and chlorotic foliage patterns compared well with observations of the transparency, but again it was not possible to distinguish individual trees (Fig.11). But was very useful in detecting and accurately measuring canopy density in the various transparencies (Fig.13).

Image analysis of the entire helka from the ACIR transparency taken on May 22, 1983 was based on six gray levels. The results were quite good, as the levels separated by the LMS corresponded well with dark and light foliage, and the severe chlorosis in two areas of the helka observed in the transparency.

Comparisons of entire helka images from the three photographic flights suggested that chlorotic areas were increasing in size and intensity in the helka, with additional rows of trees in other areas also showing chlorosis for the first time. These comparisons are important, not only because they pin-point a specific problem occurring in successive years, but because they demonstrate the capability of the LMS in delineating the area and giving an accurate percentage of the part of the helka under stress.

The chlorotic areas observed in the transparencies from rows 21 to 47 of the helka were analyzed with the LMS to determine if a clear separation of gray level was possible. LMS comparisons with visual ratings were positive in all of the photographs taken (Table V).

Gray level separation in the May 11, 1981 transparency was not as distinct as the ones from the June 20, 1982, or the one from May 22, 1983. Separations from the two later flights were better, but the computer printouts of each gray level were not as satisfactory as those from separations of the whole helka. Specific levels of gray were much more distinct in image analysis of the entire helka. (Fig.11).

Analysis of rows 21 to 47 degraded the images and did not allow single tree examination. Differences in canopy density and tree health or light were much better observed in the whole helka separations (Figs.12,13,14,15,16,17).

Experiments with different enlarging lenses were done to determine the resolution of the LMS. Analysis of sections of the Tahanahim 1 helka were more successful when the number of gray levels were decreased as magnification was increased. When only three levels were chosen (soil, crowns, and shadow), it was possible to obtain a fairly good printout (Fig.11).

An effort to enlarge images to the maximum capability of the LMS did not help single tree observation. although the differences were clearly distinct in visually (Figs.12,13,14,15,16,17).

Filter enhancement of the images were not very successful, although the technique may improve with the use

of narrow band filters, which were not tested.

Nir Elihau 2

The excellent health of the grapefruit trees in Site 2 precluded any image analysis of problems or diseases. In the Manual LMS System, four gray levels were used to analyze the May 11, 1981 ACIR image of the Nir Elihau 2 helka. Gray level separation was good, as the gray levels assigned to middles, tree crowns, and shadows corresponded well with visual interpretation (Fig.11).

Photography of May 11, 1981 had a somewhat red color balance, although the grapefruit could be distinguished well from the adjacent Shamuti orange helka, no specific problems were observed as all the trees were healthy (Fig. 45A).

The June 20, 1982 photography was taken late in the afternoon when light is less available and tree shadows increase difficulties in photointerpretation. this transparency is quite darker than others and has an excessive red color balance, so that it is much harder to distinguish the grapefruit trees from the Shamuti oranges than in other transparencies (Fig.45B).

Photography from the last test flight on May 22, 1983 was quite good, although somewhat overexposed. However, the color balance was good and the differences between the grapefruit trees and the Shamuti oranges was quite distinct (Fig.45C). The photographic plane had arrived at Sites 2 and 3 after grove crews had finished cutting down trees in rows 25,26,and 27. Visual comparisons between the trees cut down the day prior to the photography, the day of the

photography and the standing trees indicated a very slight change in reflectance between the three different kinds of trees, a somewhat unexpected bluish appearance when in stress or when they are dead.

IRRIGATION EXAMPLES:

In Helka 40, Area 1108, adjacent to Sites 2 and 3, it was possible to observe different type of irrigation on photography taken in June 20, 1982 and May 22, 1983. In the June 20, 1982, a sprinkler type of irrigation was observed on a helka planted east of Site 2 (Fig. 47C), and on the transparency taken on May 22, 1983, single tree emitter type of irrigation was observed on a helka west of Site 3 (Fig. 47D). Central and main drain pipes were easily observed as well as different levels of moisture in the adjacent areas.

AVOCADOS:

An avocado helka (Helka 21, Area 0808), east of site 2 in Nir Eliahu was photographed on the same dates as site 2. on the May 11, 1981 transparency, the heavy red color balance makes it very difficult to see differences between the grapefruit trees in sites 2 and 3 and the avocado trees in the adjacent helka (Fig. 48) the photography of June 20, 1980 was taken late in the afternoon, making it a very dark transparency, considerably underexposed, with heavy tree shadows. The very heavy red color balance of this transparency makes it difficult to distinguish grapefruit trees from avocado trees, but they can be distinguished slightly easier than in the 1981 transparency (Fig. 45B). The best color balance was obtained in the May 22, 1983

photography, although somewhat overexposed, but it was excellent for distinctly observing the differences between the avocado and Shamuti orange trees (Fig.45C).

There were no particular problems observed in the avocado helka, as the trees were observed to develop and grow well.

In a different helka, considerably south of Sites 2 and 3, avocado trees were observed to have some chlorotic foliage in the May 22, 1983 transparency (Fig.48D). Unfortunately this avocado helka was not photographed in previous test flights.

ARCHEOLOGICAL SITES:

Preliminary photographic studies were made of the ACIR transparencies of May 11, 1981 to detect differences in vegetation on Tel Yogne'Am and species distribution in regard to specific evacuation dates. ACIR photography suggested that specific vegetation may be associated with types of debris found at the tel. Additional photointerpretation and image analysis studies will have to be made to confirm this.

Scanning of the transparencies also suggested that periodic photography should be used to study patterns of moisture that may help to detect "shelved structures" of each Tel.

Regrettably, not enough time was available to conduct in-depth photointerpretations.

DATA PROCESSING

Availability of both the Florida and the Israeli computer programs were delayed considerably by modifications.

Although simple programs were designed at first, continued meetings with the programmers revealed that refinements could be made to both programs, making them much more user friendly than the Fortran program for the minicomputer. Thus it was decided to proceed with the modifications so that the final results would be smooth working and versatile programs.

Late delivery of both of the above programs only allowed time to input the data of the May 22, 1983 for all twelve sites with the Applied Computer Software Program in Florida. The Israeli program, written in Basic, has both English and Hebrew commands and the instruction handbook is written in both languages. The Florida program was written in Basic, but the commands and the instruction handbook are all in English, without Hebrew translations.

In Florida, the May 11, 1981 and June 20, 1982 data was entered into the Fortran program of the General Automation SPC 16/65 computer. Due to the premature loss of the technical assistant, only the May 22, 1983 data was entered into the Florida program. In Israel only the data from May 11, 1981 and June 20, 1982 were entered into the Israeli program due to the late delivery of both programs and because the May 22, 1983 imagery was being evaluated in Florida. The condition can well be observed in comparing two computer printouts made with the Israeli program, showing the number of healthy trees (Fig.34) and the number of trees with chlorosis (cloroza) (Fig.35). A third

computer printout shows the soil type and canopy density on a cell by cell basis for Site 1 in Tahanahim (Fig. 36).
FLORIDA COMPUTER PROGRAM (GROVE MANAGEMENT PROGRAM).

The Applied Computer Software, Inc. program has two major sub-programs that can be used, once data has been input into the main program. These sub-programs are: (1) Class separation and (2) Histogram class display. Operation of the program was done by booting the computer with the program diskette in disk drive 1, and then substituting the program diskette by either a blank diskette for data input or a data diskette for viewing, modification or comparison.

The main program has three modules:

1. Data Input
2. Data Modification
3. Data Display

1. Data Input - there are a number of options to allow initial file creation, a subsequent input option (of similar data), and auto-incrementation.

The most important considerations in the program dealt with the grove architecture (the number blocks per grove and the total number of trees in a block). These parameters were fundamental in understanding of the program, as they limited the amount of auto-incrementation possible.

Auto-incrementation was included in the design of the program, making it possible to move from the lowest cell number to the highest cell number in increments of one cell, simply by pressing the space bar in the computer.

This automatic feature did allow to rapidly review data from four different dates (on a cell by cell basis, or block by block basis). In the cell by cell search of data

Auto-incrementation revealed both the location of the trees in the cells as well as the total numbers of each class, and the total number of tree spaces in the cell. In block by block search, only the total numbers per class, and the total number of spaces per block were displaced for all four sets of data (Figs.32,33).

The program does have options to input and extract data without the Auto-incrementation feature.

2. Data Modification was a very convenient module to have, as it allowed correction and modification of data in the program with subsequent modification in the permanent set of data in the diskette.

3. Data Display allowed the viewing of any of the data in a single diskette (single photograph) or from many, up to four, however, it is necessary to have the data in separate diskettes in separate drives. This hardware constriction means that for each set of data it is necessary to have a disk drive.

A useful part of the program is the ability to select a printout in any of the three modules of the program, so that any data displayed on the video screen can be printed.

Tahanahim 1 - In the course of photointerpretation of the May 11, 1981 and June 20, 1982 a decision was made to consider foliar discoloration as diseases, since in Florida, chlorosis due to iron deficiency is a very minor problem and seldom observed in the intensity detected in the May 22, 1983 transparency. Having considered chlorosis a disease previously, it was included in the classes of 1 to 4, rather than in a special number by itself (9), which is generally allocated to special conditions. So in Florida we show

chlorosis as disease, rather than a deficiency. With the exception of this confounding situation, no problems were encountered with the computer program, once the fundamental architecture of the program was written down.

Nir Elihau 2 - No difficulties were encountered this site, since all of the trees were healthy. No additional observations were recorded.

ISRAELI COMPUTER PROGRAM (ORCHARD MANAGEMENT PROGRAM).

The Orchard Management Program was designed to emphasize whole site display on the video screen, and production of a computer printout of a site.

The architecture of the program is user friendly, as it is not necessary to include it in the data record. The terms PLOT, HELKA, and BLOCK are synonymous, although PLOT is used consistently in the program to mean either/or the two other terms.

The program was written so that Plot drawings in a color monitor are displayed in orange color, and as soon as data is input the orange lines change to green. In the Plot orientation section, the arrows indicating the direction of North are displayed in blue, clearly standing out in the entire Plot display. The program was written so that it can be copied easily at the beginning of an initialized diskette, and is not necessary to change diskettes for data input. This also means that only one disk drive is necessary for the entire operation. The only additional hardware required is a wide printer with a driver card on slot 5 of the Apple microprocessor.

There are three main sections in the body of the program

1. Creating and Retrieving Plot.
2. Creating and Retrieving Cell.
3. Printing Reports.

The Creating and Retrieving PLOT options section is further subdivided into:

1. New Plot Creation
2. View Plot.
3. Plot Deletion.
4. Present Existing Plots.
5. Information About a Plot.
6. Updating Plot.

The Creating and Retrieving CELL option section is subdivided into:

1. Input cell.
2. View cell.
3. Cell deletion.
4. Updating cell.

The Printing Reports section is further subdivided into:

0. Back to the main menu.
1. Printing statistical data.
2. Graphic display of trees.
3. Graphic display of soil type and tree density.
4. Print all cell data.
5. Graphic display of tree type.
6. Exit.

The input of photointerpretation data into the Israeli program is a simple process, if the transparencies have been properly divided into the grid/cell system and preparations previously mentioned in methods (photography) are done.

Display of the entire helka while data input allows the interpreter to know exactly what data has been stored in the microprocessor and reduces the possibility of error or mis-identification of cell.

The display of a grid showing an entire helka indicated how data has been entered, reduced the possibility of mistaken registration, and simplified data input.

It is quite easy to determine what data was recorded in the diskette by using the option; "information about a plot option".

Input errors were easily corrected by using the updating plot and updating cell options.

Special features of the new plot creation were (1) Orientation feature, whereby it is possible to record the position of the helka in relation to North. (2) Soil type and (3) Canopy density found in the individual cell.

Both the helka (plot) and cell viewing options were excellent, although independent of each other. It was possible to determine the status of the entire helka before viewing the individual cell. Information about a cell shows the number of trees in each class, including chlorosis, while the option of viewing an individual cell also shows soil type and canopy density.

Tahanahim 1 - As it was the case with the Florida program, the actual planting configuration of the grove was ignored, and the rows were considered to be planted perpendicularly to the roads, and parallel to each other, this means that a visual adjustment has to be made in comparing the computer printouts of the program with the actual 70 degree angle to the road that the rows are

planted. No distinction was made between the two dates of planting recorded in the entire area map (1:10,000) (Fig.3).

The special class of chlorosis was extremely useful in the case of Site 1, as it was described previously, there was an increasing occurrence of the deficiency as observed in the transparencies from May 11, 1981 through the May 22, 1983 transparency.

DISCUSSION:

Aerial Color Infrared (ACIR) photography of citrus groves in Israel was successful using the methods developed in Florida. As it was expected, some adaptations were necessary due to the different horticultural practices and needs of the growers.

The original goals of BARD Grant US 193-80 were completed and expanded to include recent advances in image analysis with microprocessors. Results of the aerial photography were good and yielded a great deal of information that will help to better understand some of the problems encountered in working with ACIR photography.

The Florida ACIR system was carried out in Israel with the first photographic mission (May 11, 1981). The second photographic mission (June 20, 1982) as well as the other test missions were done by the Israeli cooperators. The third photographic mission was carried out entirely by the Israeli cooperators and once the Tomer Computer Ltd. computer program was delivered, all of the photointerpretation was done by Israeli cooperators.

Results of the three photographic flights indicated that sequential flights over the same area yield greater

benefits than a single flight. In the Tahanahim area sequential flights carried out in the spring-early summer showed increasing severity of a chlorotic condition of the central rows of Site 1 (Fig.5). In one instance a tree that appeared deficient in the first overflight of May 11, 1981, was dead when the May 22, 1983 photography was taken (Fig.6).

Visual of chlorosis ratings made from enlarged transparencies of all three flights May 11, 1981, June 20, 1982 and May 22, 1983 compared well with density levels obtained with the LMS (Table V). Soil analysis of the sites were not made so no correlation could be determined with iron deficiency quantities on the tree.

It was possible to observe in sequential photographs that a Pride of India (Melia saderach L.) growing in the middle of a chlorotic citrus row did not show any chlorosis during the spring-summer (May-June) but did show it in Fall (September) photography (Figs.7A,B,C,D). In Tahanahim, a group of trees, as severely chlorotic as those of Site 1, was observed in an area adjacent to test site 2, (Fig.8A).

In a helka adjacent to Site 3 in Tahanahim, an excellent example of differences in soil moisture between roto-tilled soil shortly before the August 4 photography was taken and moisture changes a month later when another photograph was taken on September 10, 1982. While the tiller tracks could be observed in the second photographs, the moisture levels were not as distinct as in the August 1982 photographs (Figs 8C,D).

Differences in irrigation systems were as easily observed in the previous Florida photography (Blazquez and Horn, 1980).

It was possible to determine in Site 3 of Nir Elihau, that grapefruit trees cut down 48 and 24 hours prior to ACIR photography do not change their characteristic reflectance when compared with living trees. It appears that a longer period of time will have to elapse before they acquire the typical bluish discoloration on the ACIR transparencies (Figs.47A,47B).

The avocado helka adjacent to Sites 2 and 3 in Nir Elihau was observed in the three different test flights made. The helka was quite healthy and growth development appeared to be normal. The branch development could be followed, suggesting that it might be feasible to trace each tree with large scale photography (Figs.48A,B,C).

In the May 11, 1983 transparency, chlorotic foliage was observed in avocado trees growing in a helka far south of Sites 2 and 3. Unfortunately, the helka was not photographed in any other photographic test flight (Fig.48D).

It was confirmed that the best color balance for observation of stress or disease in ACIR was a bluish one so that the difference in color between red and magenta could be detected easily such as in the May 22, 1983 photography (Fig.45C). There is no doubt that the color balances of the transparencies of May 11, 1981 and June 20, 1982 were

marginal for photointerpretation, as the differences between avocado grapefruit, and orange trees were difficult to observe, thus increasing difficulties in photointerpretation and slowing down the process (Figs.45A,B).

Regrettably, not enough time was available to properly photointerpret ACIR transparencies of the archeological test sites, and only preliminary scanning of the photographs was made. Although three field trips were made to some of the sites, it will be necessary to omit from this report any serious results. There are indications that sequential photography would be of considerable benefit, as it might show changes in vegetation due to soil moisture and structures under ground. The preliminary studies were very encouraging, and definite efforts will be made to fully analyze the transparencies obtained to date. Dr. Portugali, Hebrew University, is most encouraged, and will cooperate whenever it is possible (Portugali, 1982).

Image analysis, a new electronic process that was adapted to microprocessors after initiation of the grant, was used extensively with the ACIR transparencies of Israeli groves in attempts to measure health status of the groves with the images in the transparencies. Results obtained with the Linear Measuring System (LMS) of Israeli transparencies suggested that it would be a most useful tool, since many of the problems detected were helka wide and not found on only one tree. Image analysis of transparencies was a good procedure to consistently measure stress or changes as indicated by the various shades of (gray) color in the transparencies. It was particularly useful in accurately measuring canopy density since it

involves area measurement, which is the specialty of the LMS.

Image analysis may be an excellent tool to solve one of the basic problems of ACIR photography which is the consistent transfer of the data acquired in the image to recorded data. Until recently photographs have had to be photointerpreted to determine what levels of damage are present in the image. This procedure required arbitrary decisions by the photointerpreter in separating classes of level of damage on the basis of his intuitive knowledge. Unfortunately, not all photointerpreters selected the same levels or classes, so that little or no consistency has been available to obtain similar results of photointerpretation.

Another aspect of photointerpretation, which was the same in Israel as it was in Florida, was the duration of each photointerpretation session, and the considerable decrease in accuracy by the photointerpreter as the period of the session increased.

The amount of data collected during the experiment will require additional time to completely analyze it and assemble it for publication. It will be necessary to have additional reviews between the Florida and Israeli cooperators on how to best present all of the results obtained, particularly since the image analysis data will suggest a different approach to analysis.

A number of studies were made with aerial photographs of avocado groves, in an attempt to design a system to separate tree canopies, but the limited efforts yielded no significant results, and indicated that additional efforts will have to be made to separate.

Computer programs developed for summarizing and analyzing the data from photointerpretation were useful, interactive, and will allow users of ACIR photography to rapidly compile most of the information recorded in the transparencies.

Two different approaches were used in selecting the criteria for the programs. In Israeli, because the emphasis of interpretation is on the individual helka (with minimal tree loss), program requirements were made to display an entire helka on the screen for rapid viewing. In Florida, where individual tree loss is far more severe, emphasis was placed on extracting data about the individual tree.

Both computer programs can be used in either location, as both are user friendly, giving the user-grower a good choice of programs. The Timex program is basically a combination of both, but because of memory restrictions it cannot handle an entire helka, and instead is reduced to storing 20 cells. However, it must be remembered that Timex program is fundamentally for field use only.

Similar requirements in need of citrus grove information in Israel and Florida by various state, federal agencies, and citrus investigators, would suggest a feasibility study to determine the capability of new image analysis systems that could be used in extracting data from ACIR photography.

There are computer systems that can be structured for small users at low costs, but can be expanded to large complex multi-users according to desirable plans.

New breakthroughs in computer graphics, video interphasing with digitizers, and electronic communication

would suggest that a desirable system could be assembled with little difficulty.

Such a system would be very desirable in Florida, as the ACIR photography acquired by Property Appraisers could conceivably be used by other agencies, such as County Extension Agents, Agricultural investigators, and Water Management Districts to develop area profiles and have an excellent source of data on vegetation and water relationships in relation to agricultural production.

In Israeli, an image analysis system would make available citrus and agricultural area information to users in the various agencies in Kibbutzim, Extension Service Offices, and Commercial Companies without having to visit the Ministry of Agriculture's Remote Sensing Division in Tel Aviv.

The benefits of being able to analyze images of one's own grove at will without having to travel, would be most beneficial, and in all probability encourage a greater number of users of both the ACIR system and computer analysis.

Although Florida's citrus grove information is acquired from aerial photography by many agencies, and Israel's grove information is obtained primarily by one agency. The information requirements are similar in both countries so that the results of the project and similar requirements suggest that a multi-purpose image analysis system could be developed for use in both countries. Such a system should have different levels of sophistication, that could be structured to set up a simple system for single unit use, but with the capability for increase in data acquisition and

the number of users. New breakthroughs in video, microprocessors, and communication suggest that the hardware is available but what is now needed is a project to select and assemble the potential system.

Regrettably not enough time was available to properly photointerpret ACIR transparencies of the archeological test sites, and only preliminary scanning of the photographs was made. Although three field trips were made to some of the sites, it will be necessary to omit from this report any serious results. There are indications that sequential photography would be of considerable benefit, as it might show changes in vegetation due to soil moisture and structures under ground. The very preliminary studies were very encouraging, and definite efforts will be made to fully analyze the transparencies obtained to date. Dr. Portugali, Hebrew University, is most encouraged, and will cooperate whenever it is possible.

CONCLUSIONS

The principal goals of the BARD US 193-80 Grant were met.

The ACIR Florida System was tested one year in Israel by the Florida team, the second year the work was done in cooperation with the Israeli Investigators, and the third year the research was successfully done by the Israeli Investigators.

The advantages of ACIR photography and the grid/cell system were confirmed in the Israeli work.

The best approach for Israeli interpretation appeared to be on the basis of individual helkas, in addition to the individual tree analysis as it is done in Florida.

All of the field conditions of trees and detection of stress and health levels observed in Florida transparencies were also observed in photographs of Israeli groves.

The most striking tree changes observed in Israeli transparencies were tree chlorosis and sooty mold infestations.

Low tree mortality in Israeli groves suggested a stronger potential use of entire helka image analysis, than it is in Florida.

Soil moisture differences observed in Florida transparencies were also detected in Israeli photographs. These differences could be detected in bare fields as well as in groves under irrigation. Different types of irrigation systems could be detected in the Israeli transparencies.

Image analysis of entire helkas was more accurate, reliable and faster than photointerpretation in area measurement and separation of damage levels. The LMS system was particularly useful in accurately measuring canopy density in the Israeli grove, and proved to be potentially useful in Israeli transparencies.

The computer programs developed in Florida and Israel were complimentary, easy to manipulate and save accurate reports of tree and helka conditions. The use of microprocessors was encouraged, particularly with the decreasing purchase costs and potential for image analysis.

An inexpensive portable Timex/Sinclair microprocessor system was developed for rapidly summarizing data in field surveys of citrus groves. The computer program is user friendly and very easy to manage. Needs for rapid citrus grove information in Florida and in Israel, suggest that

research should be done to select the best image analysis system that can rapidly extract information from ACIR photography tabulate it and analyze it for planning and management uses.

Photointerpretation of avocado transparencies during a three year period indicate that it may be possible to identify branches of trees although it will not be an easy task and will require sophisticated image analysis equipment. The equipment is available for microprocessors like the Apple II and others.

First observations of ACIR transparencies from archeological test sites in the Jezreel Valley suggest that ACIR is an excellent potential tool for archeological investigations

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TABLE 1. Comparisons of three computer programs:(1)
 Fortran Program for use in General Automation
 SPC 16/65 minicomputer and BASIC programs for use in an
 Apple II+ microprocessor by (II) Applied Computer Software,
 Inc. and (III) Tomer Computer Ltd. for citrus
 grove inventory and Management. Programs were developed to
 be complementary to each other rather than competitive.

(I) FORTRAN

(II) APPLIED COMPUTER

(III) TOMER COMPUTERS LTD.

	(I)	(II)	(III)
Interactiveness	No	Highly	Good
Printout at any section of program	No	Yes	Partially
Comparison of data with data from other overflights	No	Yes	No
Number of cells displayed on screen at one time	1	4	10
Speed in adding grove totals	Slow	Rapid	Very slow
Speed in adding cell totals	Slow	Rapid	Very slow
Search of individual classes	Slow	Rapid	Fast
Histogram of a class	No	Yes	No

TABLE II. Dates of Aerial Color Infrared (ACIR)

Photographic Missions over citrus test sites in north, central and southern Israel. ACIR photographs were taken with a modified Fairchild K-24 camera through a 30 cm focal length lens and yellow No. 12 Wratten filter. Kodak Aerochrome 2443 film was used and hand processed by Ofek, Inc. of Tel Aviv, Israel.

SITE	1981	1982	1983

Tahanahim			
1.	May 11 (1615:30)	June 20	May 22

2.	May 11	June 20	May 22

3.	May 11	June 20	May 22

Gush Tel Mond

Nir Elihau

1.	May 11 (14:10)	June 20	May 22

2.	May 11	June 20	May 22

3.	May 11	June 20	May 22

Gan Efraim

4.	May 11	June 20	May 22

5.	May 11	June 20	May 20

6.	May 11	June 20	May 22

Hevel Habesor

1.	May 18	June 20	May 22

2.	May 18	June 20	May 22

3.	May 18	June 20	May 22

TABLE III. Numerical Rating System of Classification Used in Evaluating Tree Health and Disease.

ORIGINAL SYSTEM		TREE SPACE	NEW SYSTEM	
CLASS		STATUS	CLASS	
COMPUTER	WRITTEN		WRITTEN	COMPUTER
	.	HEALTHY, MATURE		.
M	^	MEDIUM	9	9
Y	-	YOUNG	8	8
R	R	REPLACEMENT	7	7
X	X	REMOVED (MISSING)	6	6
1	1	DECLINE-SLIGHT (25%)	1	1
2	2	DECLINE-MODERATE (50%)	2	2
3	3	DECLINE-SEVERE (75%)	3	3
4	4	DEAD (100%)	4	4
N/A	N/A	OTHER CONDITION-A	5	5
N/A	N/A	OTHER CONDITION-B	-	-

TABLE IV. List of Maps, Aerial Photographs, Computer Printouts and Drawings Useful in Grove Profile-found in Grove Profile

Israeli Map - Universal Transverse Mercator
(UTM)-1:50,000 scale

Israeli Citrus Helka Map - 1:10,000 scale

Color Contact Print - 23 cm x cm of Aerial CIR Photograph
1:10,000 scale

Color Contact Print - 23 cm x cm of Aerial CIR photograph
1:4,000 scale

Black & White enlargement of test site, 20 cm x cm at
1:30 scale (suitable for field survey - scale may vary)

Manual Canopy Drawing with LMS

Manual Canopy Drawing the enlarger (Nir Elihau only)

Computer printout - General Automation SPC 16/65

Computer printout - Apple II+

Orchard Management Program (Tomer Computers) Israel

Grove Management Program (Applied Computer) Florida

TABLE V. Comparison of Visual Iron Deficiency Ratings and Percent LMS Gray Levels in Aerial Color Infrared

Transparencies of Tahanahim Site 1 taken May 11, 1981, June 20, 1982 and May 22, 1983. Visual ratings were made over an area where 0 = healthy and 4 = 100% iron deficient canopy

GRAY LEVELS	ENLARGED		ENLARGED		ENLARGED		ENLARGED	
	5-11-81		6-20-82		6-20-82		5-22-83	
	LMS %	VR	LMS %	VR	LMS %	VR	LMS %	VR
1.	0.7	3	3.6	0	0.0	0	4.7	4
2.	5.0	2	9.9	3	0.7	2	12.5	3
3.	10.3	1	19.3	1	10.5	1	19.0	2
4.	15.3	0	26.0	0	40.7	0	19.2	1
5.	20.7	0	24.4	0	40.5	0	14.9	0
6.	20.8	0	12.9	0	0.0	0	14.0	0
7.	17.4	0	4.3	0	6.2	0	11.5	0
8.	8.6	0	1.2	0	0.0	0	2.7	0
9.	1.0	0	0.2	0	0.0	0	0.8	0
Other	0.0	0	0.0	0	1.2	0	0.5	0

TABLE VI. Field Survey Dates of Experimental Test Sites in
Aerial Color Infrared Photographic Experiment.

1981

Tahanahim Sites 1, 2 and 3 May 12

Gush Tel Mond

Gan Efraim May 15

Nir Elihau May 17

Hevel Habesor May 20

1983

Tahanahim Sites 1, 2 and 3 May 13

Gush Tel Mond

Gan Efraim May 18

Nir Elihau May 18

Hevel Habesor May 17

TAHANAHIM

ג'י'ן 6-1, II

ג'י'ן-ש'א'ן

1:50,000

רשת בינלאומית של פרקטור דומי (UTM)
איזור 36

Fig. 1. Universal Transverse Mercator map of the Tahanahim Region in Israel at the scale of 1:50,000 showing the location of the three citrus grove test sites selected for Aerial Color Infrared (ACIR) photography.

Fig. 3. Black and White copy of an Aerial Color Infrared photograph of the Tahanahim area taken at the scale of 1:10,000 showing the location of the test sites in relation to the rest of the citrus growing area. The sites selected were appropriately marked Sites 1 through 3.

Fig. 4. Color print enlargements of Aerial Color Infrared (ACIR) photographs of rows 23 through 48 of the Tahanahim Test Site 1 showing the increase and severity in chlorosis of the trees. The photographs were taken on: A) May 11, 1981; B) June 20, 1982; C) September 10, 1982; and D) May 22, 1983.

Fig. 5. Closeup Color print enlargements of Aerial Color Infrared ACIR photographs of row centers from rows 33 through 38 of Site 1 in Tahanahim indicating the most severe areas of tree chlorosis in photographs taken on: A) May 11, 1981; B) June 20, 1982; C) September 10, 1982; and D) May 22, 1983.

Fig. 6. Closeup Color print enlargements of Aerial Color Infrared (ACIR) photographs of the western ends of rows 33 through 38, Site 1 in Tahanahim, showing the progressive defoliation of a single tree (arrow) in photographs taken on: A) May 11, 1981; B) June 20, 1982; September 10, 1982; and May 22, 1983.

Fig. 7. Closeup Color print enlargements of Aerial Color Infrared (ACIR) photographs of Helka 4 Area 1108 adjacent to Site 1 in Thanahim showing the normal foliage of a Pride of India (Melia aderach L) tree during spring and summer (May '81 and '83 and summer (June '82), and the chlorotic appearance observed on a September 10, 1982 transparency.

Fig. 8. Very close print enlargement of Aerial Color Infrared (ACIR) transparency of Helka 11 in Area 1110 illustrating: A) chlorosis in trees by ditch, B) dying chlorotic trees with vines on top, C) soil moisture difference between roto-tilled middles and between trees, D) soil moisture changes a month later. Differences in reflectance between grapefruit resets and Shamuti oranges were visible in the previous month, but not in this September 10 transparency.

Fig. 9. Color print enlargements of Aerial Color Infrared (ACIR) transparencies on the western part of Helka 2, Area 1110 did show orange trees severely infested with sooty mold (*Capnodium citri*.(Berk. & Desm.)). The June 20 through September 10, 1982 (A,B,C) transparencies showed decreasing incidence of sooty mold. The May 22, 1983 transparency showed no sooty mold.

GROVE NAME Tahanahim I
 ALTITUDE 1,219.2 LENS 12" SCALE 30.48 = 40 M
 FRAME NO 6432 FLIGHT LINE _____ FLIGHT DATE 5/11/81
 TREE PLANTING DISTANCE _____ X _____

L M S

	DIGITIZE		SCENE	
	NO. 1	NO. 2	No. 3	No. 4
TV CAMERA HEIGHT <u>18</u> SUPPLEMENTAL LENS <u>4</u>	LT/DK AREA	LT/DK AREA	LT/DK AREA	LT/DK AREA
AREA DISTANCE <u>37</u>	<u>7/55</u>	<u>39/48</u>	<u>18/40</u>	<u>36/62</u>
*SCALE <u>2cm</u> <u>80</u>	<u>entire</u>	<u>foliage</u>	<u>foliage</u>	<u>dark</u>
DISTANCE CONSTANT <u>4628</u>	<u>area</u>			<u>area</u>
CLEAR (c)				
AREA CONSTANT <u>214</u>				
ERASE GRAPHICS				
ON VDR - NEW SCENE				
APPLE COMPUTER - PADDLE LEVEL 2 - - -				
AREA DISTANCE **				
MEASURE/DIVIDE BY (CONSTANT) _____	<u>4.811</u>	<u>.547</u>	<u>2.09</u>	<u>2.43</u>
= AREA	A	B	C	D

CONSTANTS: **

10,000 IF IN METRIC = HECTERS
 43,560 IF IN FEET = ACRES
 107,640 IF IN FEET = HECTERS

SCALE * FOR 12 INCH LENS (30.47 cm.) AND ALTITUDE OF 4,000 FT. (1,219.2M)

4,000 / 12 = 333 FT / INCH ON FILM

1,219.2 / 30.48 = 40 M / CM ON FILM

OPERATOR gr

DATE 7/9/82

Fig. 10 Form used for visually selecting density levels of brightness and darkness from a May 11, 1981 ACIR transparency of Tahanahim and manually recording the percent area in hectares: A) entire area of helka B) light foliage C) dark foliage and D) dark areas (shadows and soil)

Fig. 11 Visually selected density levels of brightness and darkness, and percent area in hectares from an ACIR transparency of Tahanahim 1 taken on May 11, 1981 showing: A) total area- 4.811 ha, B) light foliage-0.547 ha, C) dark foliage- 2.09, D) dark areas (shadows and soil) - 2.43 ha.

LABEL	LIMITS		PERCENT of TOTAL SCENE
	BRIGHT	DARK	
	143	162	00.71
2	143	170	05.00
3	143	178	10.30
4	143	186	15.30
5	143	194	20.70
6	143	202	20.80
7	143	210	17.40
8	143	218	08.59
9	143	227	01.01
OTHER			00.00
TOTALS			100.00

Fig. 12. Visually selected density levels of brightness and darkness from an ACIR transparency of Tahanahim 1 taken on May 11, 1981, displayed in table and histogram forms prepared by a computer program.

Fig. 13. Density levels of image analysis data from an ACIR transparency of Tahanahim 1 taken on May 11, 1981 showing density levels of brightness of 143 to a darkness level of 227 with the percent of total area involved.

LABEL	LIMITS		PERCENT OF TOTAL SCENE
	BRIGHT	DARK	
1	75	151	3.63
2	75	161	9.88
3	75	171	19.30
4	75	181	26.00
5	75	191	22.40
6	75	201	12.90
7	75	211	4.27
8	75	221	1.18
9	75	231	0.23
OTHER			0.00
TOTALS			100.00

Fig. 14. Visually selected density levels of brightness and darkness from an ACIR transparency of Tahanahim 1 taken on June 20, 1982, displayed in table and histogram forms prepared by a computer program.

Fig. 15. Density levels of image analysis data from an ACIR transparency of Tahanahim 1 taken on June 20, 1982 showing density levels of brightness of 75 to a darkness level of 231 with the percent of total area involved.

LEVEL	LIMITS		PERCENT OF	
	BRIGHT	DARK	TOTAL	SCENE
1	80	146	4.7	%
2	80	158	12.5	%
3	80	168	19.0	%
4	80	179	19.2	%
5	80	190	14.9	%
6	80	201	14.0	%
7	80	212	11.5	%
8	80	223	2.7	%
9	80	235	0.8	%
OTHER			0.4	%
-----TOTALS				
100.0			%

Fig. 16. Visually selected density levels of brightness and darkness from an ACIR transparency of Tahannahim 1 taken on May 22, 1983, displayed in table and histogram forms prepared by a computer program.

Fig. 17. Density levels of image analysis data from an ACIR transparency of Tahanahim 1 taken on May 22, 1983 showing density levels of brightness of 80 to a darkness level of 235 with the percent of total are involved.

LEVEL	LIMITS		PERCENT OF
	BRIGHT	DARK	TOTAL SCENE
1	70	86	2.0
2	70	102	16.0
3	70	113	23.6
4	70	133	17.6
5	70	150	14.8
6	70	166	12.2
7	70	182	10.3
8&9	70	190	3.2
OTHER			00.00
TOTALS			100.00

Fig. 18. Formula (1) selected Density Levels of brightness and darkness from an ACIR transparency of Tahanahim 1 taken on May 11, 1981, displayed in table and histogram forms prepared by a computer program.

Fig. 19. Formula (1) selected Density Levels from a May 11, 1981 Tahanahim ACIR transparency. A) Level 2-Brightness 70-Darkness 102 / 16.0% Total area, B) Level 3-Brightness 70-Darkness 113 / 23% Total area.

A

B

Fig. 20. Formula (1) selected Density Levels from a May 11, 1981 Tahanahim ACIR transparency. A) Level 4-Brightness 70-Darkness 133 / 17.6% Total area, B) Level 15-Brightness 70-Darkness 150 / 14.8% Total area.

A

B

Fig. 21. Formula (1) selected Density Levels from a May 11, 1981 Tahanahim ACIR transparency. a) Level 6-brightness 70-Darkness 166 / 12.2% Total area, B) Level 7-Brightness 70-Darkness 182 / 10.3% Total area.

LEVEL SCENE	LIMITS		PERCENT OF
	BRIGHT	DARK	TOTAL
1	77	96	0.2 %
2	77	115	8.4 %
3	77	134	22.7 %
4	77	153	23.7 %
5	77	172	21.8 %
6	77	191	16.7 %
7	77	210	5.1 %
8	77	229	1.1 %
Other			00.00
Totals			100.00

Fig. 22. Formula (1) selected density levels of brightness and darkness from an ACIR transparency of Tahanahim 1 taken on June 20, 1982, displayed in table and histogram forms prepared by a computer program.

A

B

Fig. 23. Formula (1) selected Density Levels from a June 20, 1982 ACIR transparency. A) Level 1, Brightness 45-Darkness-62 / 2.3% Total area, B) Level 2, Brightness 45-Darkness 79 / 19.4% Total area.

Fig. 24. Formula (1) selected Density Levels from a June 20, 1982 Tahanahim 1 ACIR transparency. A) Level 3, Brightness 45-Darkness 96 / 10.0% Total area, B) Level 4, Brightness 45-Darkness 113 / 31.9% Total area.

Fig. 25 Formula (1) selected Density Levels from a June 20, 1982 ACIR transparency. A) Level 5, 5-Brightness 45-Darkness 130 / 21.3% Total area, B) Level 6, Brightness 45- Darkness 147 / 8.7 Total area.

Fig. 26. Formula (1) selected Density Levels from a June 20, 1982 Tahanahim ACIR transparency. A) Level 8, Brightness-45-Darkness 181 / 7.4% Total area, B) Level 9, Brightness 45-Darkness 198 / 0.7% Total area.

LEVEL SCENE	LIMITS		PERCENT OF
	BRIGHT	DARK	TOTAL
1	77	96	0.2 %
2	77	115	8.4 %
3	77	134	22.7 %
4	77	153	23.7 %
5	77	172	21.8 %
6	77	191	16.7 %
7	77	210	5.1 %
8	77	229	1.1 %
Other			00.00
Totals			100.00

Fig. 27 Table and histogram of image analysis data from an ACIR transparency of Tahana Him 1 taken on May 22, 1983, showing density levels selected according to formula " 1 " , and a histogram computer program.

A

B

Fig. 28. Formula (1) selected Density Levels from a May 22, 1983 Tahanahim ACIR transparency. A) Level 2, Brightness 77-Darkness 115 / 8.4% Total area, B) Level 3, Brightness 77-Darkness 134 / 22.7% Total area.

A

B

Fig. 29. Formula (1) selected Density Levels from a May 22, 1983 Tahanaah m.1 ACIR transparency. A) Level 4, Brightness-77-Darkness 153/ 23.7% Total area, B) Level 5, Brightness 77-Darkness 172 / 21.8% Total area.

Fig. 30. Formula (1) selected Density Levels from a May 22, 1983 Tahanahim 1 ACIR transparency. A) Level 6, Brightness-77-Darkness 191 / 16.7% Total area. B Level 7, Brightness 77-Darkness 210 / 5.1% Total area.

	LIMITS		PERCENT	AREA
LABEL	BR	DK	OF TOTAL	METERS
SOIL-	67	138	9.01%	1843.63643
CRWNS	67	158	83.3%	17028.9665
SHADOW	67	183	7.66%	1567.06979
OTHER			0.00%	0
TOTALS			100 %	20439.6725

T22

T22

Fig. 31. Image analysis computer printout of the May 11, 1981 Aeria Color Infrared (ACIR) photograph showing crown density in the center of rows 2 to 6 of Site 1 in Tahanahim.

TAHANAHIM 1
 TAHANAHIM 1
 5-11-81
 5-22-83

FILE DATA THROUGH
 FILE DATA THROUGH
 BLOCK: 2
 BLOCK: 2
 CELL: 4
 CELL: 4

DATA ON DISK

SUMMARY
 SUMMARY
 TOTAL NR: 2392
 TOTAL NR: 2395
 TYPE ., SUM: 1718
 TYPE ., SUM: 1498
 TYPE 1, SUM: 251
 TYPE 1, SUM: 263
 TYPE 2, SUM: 31
 TYPE 2, SUM: 200
 TYPE 3, SUM: 2
 TYPE 3, SUM: 52
 TYPE 4, SUM: 13

TAHANAHIM 1
 5-11-81
 FILE DATA THROUGH
 BLOCK: 2
 CELL: 4

SUMMARY
 TOTAL NR: 2392
 TYPE ., SUM: 1718
 TYPE 1, SUM: 251
 TYPE 2, SUM: 31
 TYPE 3, SUM: 2
 TYPE 4, SUM: 13
 TYPE 5, SUM: 0
 TYPE 6, SUM: 153
 TYPE 7, SUM: 24
 TYPE 8, SUM: 81
 TYPE 9, SUM: 139
 TYPE -, SUM: 0

TYPE 4, SUM: 14
 TYPE 5, SUM: 0
 TYPE 5, SUM: 5
 TYPE 6, SUM: 153
 TYPE 6, SUM: 175
 TYPE 7, SUM: 24
 TYPE 7, SUM: 24
 TYPE 8, SUM: 61
 TYPE 8, SUM: 53
~~TYPE 9, SUM: 139~~
 TYPE 9, SUM: 111
 TYPE -, SUM: 0
 TYPE -, SUM: 0

TAHANAHIM 1
 5-22-83

FILE DATA THROUGH
 BLOCK: 2
 CELL: 4

SUMMARY
 TOTAL NR: 2395
 TYPE ., SUM: 1498
 TYPE 1, SUM: 263
 TYPE 2, SUM: 200
 TYPE 3, SUM: 52
 TYPE 4, SUM: 14
 TYPE 5, SUM: 5
 TYPE 6, SUM: 175
 TYPE 7, SUM: 24
 TYPE 8, SUM: 53
 TYPE 9, SUM: 111
 TYPE -, SUM: 0

Fig. 32. Photointerpretation Comparisons of Site Totals of
 Tahanahim 1 ACIR photography from May 11, 1981 and May 22, 1983
 using the Applied Computer Software Program.

Fig. 35. Photographic print of a comparison between the Tomer Computers Ltd. computer printouts of healthy (O) and chlorotic (C) trees observed on an Aerial Color Infrared (ACIR) transparency of Tahanahim 1 taken on June 6, 1982. Notice that the printouts complement each other.

GRAPHIC DISPLAY OF SOIL TYPE AND TREE DENSITY

20/6/82 TAMA 1 5 TAHANAHIM

	1	2	3	4	5	6
10	E 16 D 3	E 16 D 3	E 16 D 3	E 16 D 3	E 19 D 3	
20	G 9 D 3	G 12 D 3	G 12 D 3	G 12 D 3	G 12 D 3	
30	G 9 D 3	G 12 D 3	G 12 D 3	G 12 D 3	G 12 D 3	
40	G 12 D 3	G 12 D 3	G 12 D 3	E 13 D 3	E 13 D 3	
50	G 9 D 3	G 12 D 3	G 12 D 3	E 13 D 3	E 13 D 3	
60	E 9 D 3	G 12 D 3	E 13 D 3	E 13 D 3	E 13 D 3	
70	G 9 D 3	G 12 D 3	E 13 D 3	E 13 D 3	E 16 D 3	
80	G 9 D 3	G 9 D 3	G 12 D 3	E 14 D 3	E 13 D 3	
90	G 9 D 3	G 9 D 3	G 12 D 3	E 13 D 3	E 13 D 3	
100	G 9 D 3	G 9 D 3	G 12 D 3	E 13 D 3	E 13 D 3	
110	G 9 D 3	E 13 D 3	E 13 D 3	E 13 D 3	E 14 D 3	
120	G 9 D 3	E 13 D 3	E 13 D 3	E 13 D 3	E 14 D 3	
130	E 13 D 3	E 13 D 3	E 14 D 3	E 14 D 3	E 14 D 3	
140	E 13 D 3	E 13 D 3	E 14 D 3	E 14 D 3	E 14 D 3	
150	E 14 D 3	E 14 D 3	E 14 D 3	E 14 D 3	E 14 D 3	
160	E 14 D 3	E 14 D 3	E 14 D 3	E 14 D 3	E 14 D 3	
170	E 14 D 3	E 14 D 3	E 14 D 3	E 14 D 3		

Fig. 36. Photographic print of a Tomer Computer Ltd. computer printout of photointerpreted soil type and tree density observed in an Aerial Color Infrared (ACIR) transparency of Tahanahim 1 taken on June 20, 1982.

NIR ELIAUH

SOUTH SABA

כפר-סבא

רשת פרקטור רוחבית ב
רשת ישראל
איזור 86

Fig. 37. Universal Transverse Mercator map of the Nir Elihau region of Israel at the scale of 1:50,000 showing the location of the three citrus grove test sites of the Aerial Color Infrared photographic project.

BARD

NIR ELIAHU

Fig. 38. Citrus Grove Survey Map of the Nir Eliahu Region of Israel, with the three Aerial Color Infrared Photographic project three test sites marked. The sites selected were: Site 1 - Helka 18, Site 2 - Helka 20, and Site 3 - Helka 13, all of Area 0808.

Fig. 39. Black and White contact print of an aerial photograph at the scale of 1:10,000 of the Nir Elihau region showing the location of the test sites to the rest of the citrus producing area.

Fig. 40. Projected individual tree outlines made from the May 11, 1981 Aerial Color Infrared transparency of Nir Elihau with an Omega enlarger. Crown density was difficult to delineate.

Fig. 41. Photostatic copy of a negative print of Site 2 of Nir Elihau made from an enlargement of an Aerial Color Infrared transparency. The process did not improve the separation of tree density from shadows and soil.

Fig. 42 Black and white copy of May 11, 1981 Aerial Color Infrared transparency of Nir Elihau. Shadows between the rows are distinct but cover a major portion of the space between rows. Trees in the avocado tree planting on the upper right hand corner (arrow) could be easily distinguished from each other.

Fig. 43. Black and white copy of the June, 20, 1982 Aerial Color Infrared transparency of Nir Eliahau. The photography was done late in the afternoon, so that the print shows considerable underexposure, and excessive tree shadows which can also be observed from avocado trees on the upper right hand corner (arrow). Shadows from the tree suggest that their canopy was larger than it really was.

Fig.44. Black and white copy of the May 22, 1983 Aerial Color Infrared transparency of Nir Elihau. The photograph was taken near midday, with a considerable reduction in tree shadows of the citrus and avocado trees in the upper right hand corner (arrow).

Fig. 45. Color prints of enlargements from Aerial Color Infrared (ACIR) transparencies of Site 2 Nir Elihau taken on: A) May 11, 1981, B) June 20, 1982, C) May 22, 1983 showing the even growth and development of the grapefruit trees. D) A closeup enlargement of adjacent trees indicating the more magenta color of grapefruit trees and more reddish color of orange trees.

Fig. 46. Color prints of enlargements from Aerial Color Infrared (ACIR) transparencies of Site 3 at Nir Elihau taken on: A) May 11, 81, B) June 20, 1982 showing the different color balance and degrees of shadows in relation to planting orientation, C) May 22, 1983 photograph taken 48 hrs after first rows of the helka were cut down, d) Northern rows of Helka 3 with a different orientation showing excessive shadow effect.

Fig. 47. Color prints of enlargements from Aerial Color Infrared (ACIR) transparencies of Site 3 at Nir Elihau taken on May 22, 1983 illustrating differences in reflectance between healthy trees (A) and cut down trees (B), with sprinler type of irrigation (C) and single emitter type (D).

Fig. 48. Color prints of enlargements from Aerial Color Infrared (ACIR) transparencies of Sites 2 and 3 at Nir Elihau on (A) May 11, 1981, (B) June 20, 1982, and (C) May 22, 1983. (D) Avocado trees planted north of Site 2 in Helka 21, were observed to have some chlorotic leaves which appear white in the enlargement of the ACIR transparency

GROVE NAME Nir Eliahu 2
 ALTITUDE 1,219.2 LENS 12" SCALE 30.48 = 40 M
 FRAME NO 6386 FLIGHT LINE _____ FLIGHT DATE 5/11/81
 TREE PLANTING DISTANCE _____ X _____ Gr. p. fruit

L M S

	DIGITIZE		SCENE	
	NO. 1 LT/DK AREA	NO. 2 LT/DK AREA	NO. 3 LT/DK AREA	NO. 4 LT/DK AREA
TV CAMERA HEIGHT <u>18</u> SUPPLEMENTAL LENS <u>4</u>	<u>27/61</u>	<u>47/59</u>	<u>19/52</u>	
AREA DISTANCE <u>88</u>	<u>entire area</u>			
*SCALE <u>(2cm x 40) = 80</u>		<u>middle</u>	<u>crowns</u>	
DISTANCE CONSTANT <u>1.1</u>				
CLEAR (c)				
AREA CONSTANT <u>1.21</u>				
ERASE GRAPHICS				
ON VDR - NEW SCENE				
APPLE COMPUTER - PADDLE LEVEL 2 - - -				
AREA DISTANCE				
MEASURE/DIVIDE BY (CONSTANT) <u>10,000</u>	<u>1.306</u>	<u>0.205</u>	<u>0.772</u>	
= AREA <u>14.1 Ha.</u>				

CONSTANTS: **

10,000 IF IN METRIC = HECTERS
 43,560 IF IN FEET = ACRES
 107,640 IF IN FEET = HECTERS

1.306
1.942
3.648

SCALE * FOR 12 INCH LENS (30.47 cm.) AND ALTITUDE OF 4,000 FT. (1,219.2M)

4,000 / 12 = 333 FT / INCH ON FILM

1,219.2 / 30.48 = 40 M / CM ON FILM

OPERATOR JR

DATE 7/8/81

Fig. 49. Form used for visually selecting density levels of brightness and darkness from a May 11, 1981 ACIR transparency of Nir Eliahu, and manually recording the percent area in hectares. A) entire area of helka, B) light foliage, C) dark foliage, D) dark areas of transparency.

Fig. 50. Manually selected density levels of the May11, 1981 Aerial Color Infrared transparency of the Nir Elihau Site 2. Four density levels of brightness (b) and darkness (d) were visually selected: A) Total area of the helka/ b-27/d-61; B) Middles between rows/ b-47/d-19; C) Tree crowns/ b-19/d-52; D) Shadows/ b-36/d-45.

SITE NE2 FL CB 5/11/81

TREES WITH SLIGHT DECLINE

CATEGORY	TOTAL
YOUNG....	3
MEDIUM....	17
REPLACEMENTS....	0
MISSING....	0
HEALTHY....	336
SLIGHT DECLINE....	5
MODERATE DECLINE....	0
SEVERE DECLINE....	0
DEAD....	0

SITE NE2 FL CB 5/11/81

TREES WITH SLIGHT DECLINE

ROW TREE

8	17
8	27
16	14
16	15
20	25

Fig. 51. Computer map of Nir Elihau Site 2 made with the Lake Alfred Fortran program for the General Automation SPC 16/65 minicomputer.

V EVALUATION OF RESEARCH ACHIEVEMENT

The original objectives of the project were to test an aerial photographic system, using microprocessors for data extraction, under Israeli conditions and transfer the capability to Israeli cooperators.

The three planned photographic flights of the designated citrus growing areas in Israel were successful and more than enough information was acquired to reveal the potential of the system when combined with the use of microprocessors.

The two additional photographic flights were most helpful in adding information on citrus tree reflectance that would help guide investigators on future photographic decisions.

The incorporation of a new electronic tool of image analysis to the project, made it possible to augment considerably, the value of the information already acquired from the photography. The LMS capability accelerated photointerpretation, reduced subjectivity of the operator and made it possible to interpret images for longer periods of time.

The photographic images were analyzed by separating them into specific density levels that could be measured, and these levels were associated in some cases with degrees of stress on the trees.

While the feasibility of the technology was demonstrated, it was not possible to conduct an accurate test of the use of image analysis on a timely basis to

measure and solve a problem, since such a capability was not part of the original experimental design.

The Aerial Color Infrared (ACIR) flights were successfully performed by the Israeli cooperators and analyzed with an Israeli and Florida microprocessor programs. In addition to these results, a great deal of information on grove changes and anomalies were detected, generally confirming previous ACIR work, and expanding knowledge of the groves to a greater degree.

Preliminary studies with another crop, avocado, indicated that ACIR could also be used with great advantage to detect changes and indicate potential areas of stress. It is believed that it could also be valuable in selecting trees that have high yield and are smaller than others, as well as detecting potential areas of stress and disease.

The photographic flights should be considered survey flights that gathered new publishable information, that will be beneficial not only to the participating citrus growing regions, but that could be applied to other citrus growing regions of the world as well.

Results of the project have also shown that a small microprocessor driven system has a tremendous capability in analyzing photographic information, without the considerable costs usually associated with mini or main frame computers.

The cooperative efforts of both institutions made it possible to acquire a great deal of knowledge that would not have been possible to obtain by each individual organization.

VI DESCRIPTION AND RESULTS OF COOPERATION.

Cooperation between the Remote Sensing Laboratory at AREC, Lake Alfred and the Division of Remote Sensing of Israel's Ministry of Agriculture was excellent throughout the duration of the project, and allowed the frank and productive exchange of information between the two parties.

Differences in citrus horticultural practices between Florida and Israel were determined and taken into consideration in the design of the photographic experiment and the architecture of the computer programs. A basic understanding of the problems was due to the cooperative efforts made by participating investigators and assistants.

Primary objectives of the grant were achieved without difficulty, so that additional efforts not originally planned within the scope of the grant, were carried out, thanks to the extra additional efforts made by cooperating parties both in Israel and Lake Alfred.

Efforts were made throughout the three years to expand and improve the capability of both agencies by searching within the industry for the best and most economical computer system that would be suitable to both facilities. The free flow of information between the parties made it possible to go beyond the original plans and become involved in the image analysis of the data collected.

Two complimentary computer programs were developed (one in Israel and one in Florida) to give citrus growers different options in selecting a program suitable to their

needs, but versatile enough to be used with aerial color infrared photographs of avocado groves, or any other orchard crop.

Additional contacts were made with the plant pathology group at the Volcani Institute, where some potential cooperative projects were discussed involving basic research in spectral reflectance and use of video and image analysis as it relates to damage assessment.

Excellent cooperative work was done with the Haders Extension Service group, particularly with Dr. Avraham Ben Ya'acov of the Volcani's Center Regional office who is investigating propagation and rootstocks of avocados.

Dr. Ben Ya'acov is quite interested in using ACIR to separate avocado crowns so that he can continue to study the relationship of canopy development in flowering to yield. An interactive image analysis system controlled by a microprocessor would be ideal to his needs.

The versatility of ACIR was demonstrated in the cooperative effort established with Dr. Yval Portugali, of the Hebrew University at Jerusalem (currently with the Geography Department of Tel Aviv University), in photographing ancient archeological ruins at three Tels in the Jezreel Valley. Efforts will be made to continue this project beyond the termination of the grant, since ACIR photography can be of considerable use to Dr. Portugali.

VII THESIS

NONE

VIII BENEFITS TO AGRICULTURE

Aerial photography with Color Infrared (ACIR) film was done over 25 years ago by photographic pioneers like Dr. Colwell, Mr. Norman, and Drs. Manzer and Cooper, and yet general use and application of the technology has had very little acceptance in US agriculture when compared with the meteoric rise of computer technology and its uses in many aspects of modern farming.

A similar comparison can be made with the more flamboyant cousins of ACIR, the massively supported Remote Sensing. Although the National Aeronautical and Space Administration of the U. S. has supported the development and introduction of satellite image acquisition and mainframe computer analysis (principal components of Remote Sensing), the acceptance of the technology has been made primarily by the U.S. Federal Agencies in the cartographic and geological surveys field, and some branches of the Department of Agriculture.

It is believed that the new breakthroughs in electronic technology such as image analysis and the video disk) and the plummeting costs of microprocessors and their components will greatly accelerate the use of ACIR because it will make agricultural scientists and growers aware that arbitrary assessments previously done from photographs can now be done accurately and consistently with image analysis. Parallel development in video cameras, and video cassette recorders, as well as digitizers, will make it possible to interphase all of these components into an overall

integrated system, which could have as its base ACIR photography, since it is a mapping tool as well as a damage assessment method.

The results of the BARD project will have to be published in basic research journals as well as in applied publications and popular agricultural magazines, before the major benefits of the project will become known.

Without a doubt, a considerable amount of expertise was obtained by both the Florida and the Israeli cooperators.

IX INVENTIONS

NONE