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EVALUATION OF REMOTE SENSING IN CONTROL OF PINK BOLLWORM IN COTTON[1]

Virginia B. Coleman, Claude W. Johnson and Lowell N. Lewis, *Citrus Research Center/ Agricultural Experiment Station, Department of Geography, and Citrus Research Center/ Agricultural Experiment Station, University of California, Riverside, California 92502*

ABSTRACT

The purpose of our project is to identify and map cotton fields in the southern deserts of California. Cotton in the Imperial, Coachella, and Palo Verde Valleys is heavily infested by the pink bollworm which affects both the quantity and quality of the cotton produced. The California State Department of Agriculture, therefore, has regulated the growing season of cotton by establishing planting and plowdown dates. These procedures ensure that the larvae, whose diapause or resting period occurs during the winter months, will have no plant material on which to feed, thus inhibiting spring moth emergence.

There are approximately 800,000 acres of cotton in California and they are mapped yearly by ground survey teams. A more practical means of accomplishing that objective seemed necessary and satellite data from ERTS-1 was considered a viable alternative.

The underflight data from the U-2 aircraft has shown that we can detect the differences between a growing, a defoliated, and a plowed down field providing that we know where the fields are. The ERTS-1 multispectral scanner (MSS) data are being analyzed using an I^2S (International Imaging Systems) optical color combiner to determine which combinations of dates and colors will identify cotton fields and thus provide the data needed to produce maps of the fields for the forthcoming cotton season.

1. BACKGROUND

Our study sites, the Imperial, Coachella, and Palo Verde Valleys, are heavily infested with pink bollworm (Fig. 1 and 2). The pest affects both the quantity and quality of cotton produced by boring into the cotton boll and consuming the cotton seed, thus allowing other pests and diseases to enter the boll and either destroy the cotton fiber or prevent the boll from opening. Research is continuing on chemical and biological controls, but a satisfactory system has not been found. At present, the

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Fig. 1. The Coachella Valley north of the Salton Sea, and the Imperial Valley south of the Salton Sea in southern California.

Fig. 2. The Palo Verde Valley along the Colorado River in southern California

only effective means of control appears to be the plowdown procedure. This method provides that the pink bollworm larvae are allowed no plant material on which to feed during the diapause or resting period in the winter months. The California State Department of Agriculture has, therefore, established host-free periods for all the cotton districts in California. Cotton may not be planted until a given date and it must be picked, the remaining plant material shredded and plowed underground, and all gin trash disposed of by a certain date. Thus, the pink bollworm larvae are deprived of food during the diapause stage and spring moth emergence should be greatly reduced.

There are approximately 800,000 acres of cotton grown annually in the State of California. All the fields are mapped by ground survey teams and then monitored throughout the season to ensure compliance with state law. This procedure is extremely time consuming and therefore restricts or prevents the performance of other tasks vital to the rest of California's agriculture.

The pink bollworm has not yet become a problem in the San Joaquin Valley where 90% of California's cotton is grown, but there are indications that the pest may soon become a major problem. A more efficient means of monitoring cotton fields than ground survey is needed in order to prevent the spread of the pink bollworm. The use of satellite data appears to be the only feasible alternative at this time.

2. METHODS OF INVESTIGATION

Two methods of investigation are being employed to identify and map cotton fields. The first method involves the use of the crop calendar. Claude Johnson (Department of Geography, University of California at Riverside) is using this procedure to identify and map all crops in the Imperial Valley.

Essentially, the procedure is to map the status of each field, i.e., bare, wet, cropped, plowed, or harvested, from ERTS-1 imagery. A statistical analysis is then performed by computer to establish the probability of a given crop in a given field at a given time. For example, fields that are bare in August, in vegetative crop by September and October, and are not harvested until June and July are sugar beet fields. Cotton, because of its state regulated season which is coincident with no other crop, is considered to be easily identifiable.

The second method, which is being used for the Coachella and Palo Verde Valleys, relies principally on all bare fields evident in January and February photography. All fields which are bare at these times could potentially be cotton fields (Fig. 3). Cotton cannot be planted in the Coachella or Palo Verde Valleys until February 28, thus any crops appearing prior to that date in any of the bare fields are not likely to be cotton. Bare fields which begin to show crops in late March and early

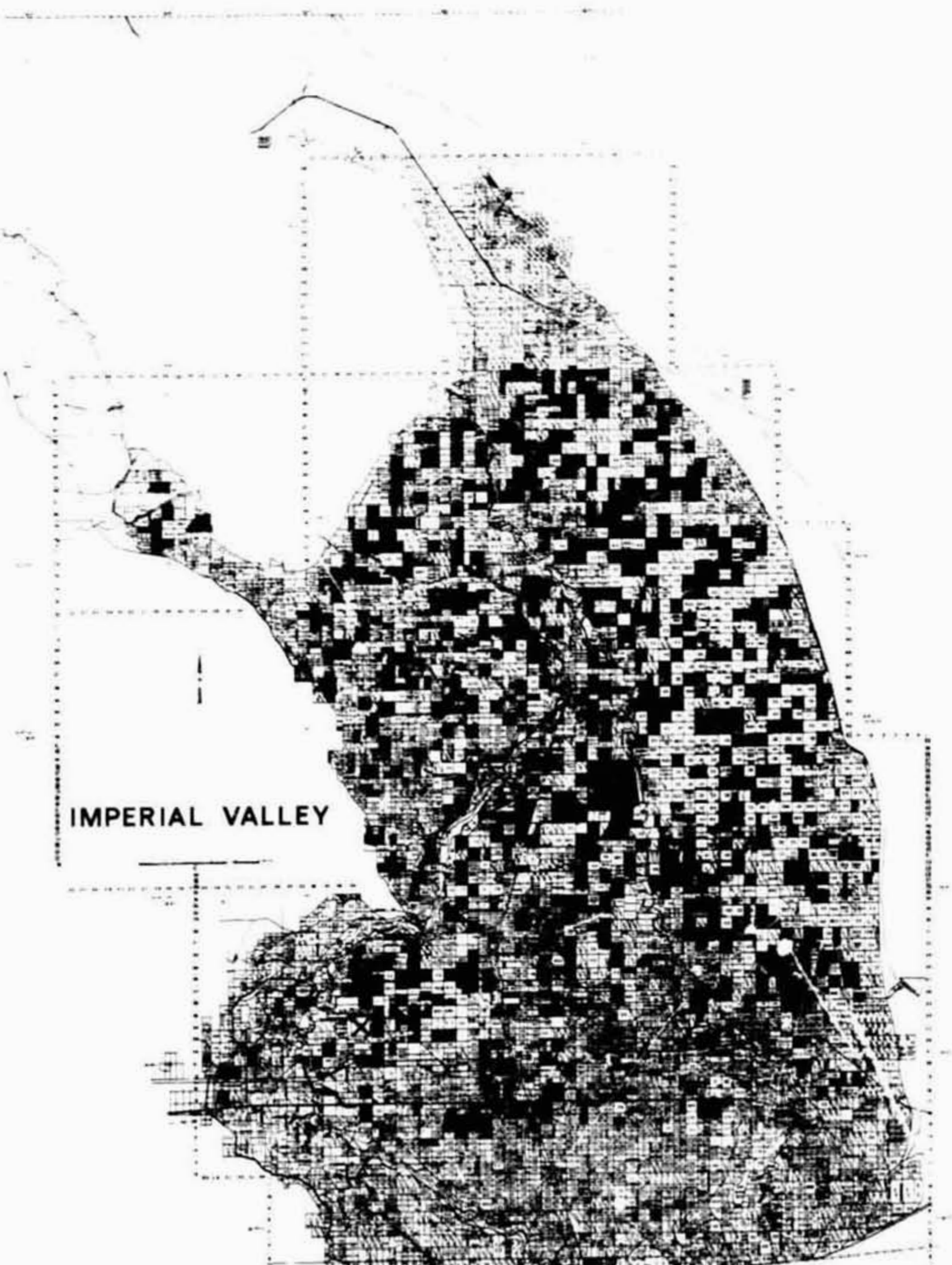

Fig. 3. Potential cotton fields mapped from ERTS-1 imagery, Dec. 30, 1972.

April are most likely to be cotton. Only minimal field checking would be necessary for fields less than forty acres since cotton is not usually planted in smaller acreages.

The plowdown date, December 15 in all three valleys, is, of course, the most critical date. The various stages of cotton harvesting, defoliation, picking, and shredding, are discernible on the U-2 underflight photography but are not identifiable on ERTS-1 imagery. However, once the location of all cotton fields is known, it is possible to tell whether or not a field is bare on December 15 because a plowed field can be easily identified on ERTS-1 imagery.

3. IMAGERY

The U-2 underflight photography and the ERTS-1 data have been very complementary. The U-2 color infrared (CIR) photography taken from the RC-10 camera has been particularly useful for updating base maps and for identifying the various stages of cotton harvesting: lavendar for defoliated and picked fields, pinkish brown for shredded fields, and dark grey for plowed fields. The photography also provides a check or ERTS-1 imagery interpretation to ensure accuracy of the status of a given field.

Color combining of ERTS-1 data is considered essential to this project. The 9" x 9" positive transparencies are color combined using the Diazochrome process. In this method, bands 4, 5, and 7 are exposed respectively to yellow, magenta, and cyan Diazochrome acetate sheets, then developed in ammonia vapor. The sheets are then superimposed and a simulated CIR transparency is produced. The second method uses the I^2S (Internation Imaging Systems) optical color combiner. Bands 4, 5, and 7 from the 70 mm positive transparencies are superimposed optically to provide simulated color infrared.

The ERTS-1 data in addition to being color combined to simulate CIR can also be combined in other ways to give additional information. For instance, if the percentage of change from cropped to harvested fields between one month and another is needed, the following procedure can be used. Band 7 from two different months, in this case September and December, are color combined in green and red, respectively. The combined product gives the following results: bright green fields has crops in September, but not in December; bright red fields - crops in December but not September; light colored fields indicate a crop in the field at both times, but there has been a change in status, i.e., a crop is beginning to emerge or has recently been harvested; dark colored fields indicate either no change in the status of a crop or that a field has been fallow for the entire period.

4. RESULTS

Although complete results will not be available until the March and April imagery have been analyzed, we are expecting to achieve 80-90% accuracy in identifying cotton fields for the coming season. Maps showing the location of cotton fields in each of the three valleys will be produced in late April or early May and distributed to each agricultural commissioner. The reliability of the satellite maps will be tested by their ground survey teams and if the accuracy is considered tolerable, the commissioners will consider satellite mapping to be an efficient alternative to their present methods and would consider using this method on a regular basis.

The real test of these techniques will come when they are tested in an area such as the San Joaquin Valley which, like many places in the world, is not uniquely cloud-free as are the deserts of southern California. If these techniques, the use of satellite data with minimal underflight and ground survey support, can be used reliably in the San Joaquin Valley, then the use of satellite data for agricultural management programs becomes a practical tool for the user and releases a great deal of manpower needed for other tasks.

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