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An Airphoto Key for Major Tropical Crops

Twenty-three stereoscopic photographs covering ten crops are included.

Introduction

The capacity to identify crops on aerial photographs supplies a base for accomplishing detailed land-use inventories as well as for assessing crop yields or stresses. Airphoto crop identification also provides a convenient means for developing or confirming interpretations from satellite data. In addition, it provides important, if not indispensable, input to studies that require pre-satellite data or data of a resolution exceeding that of available satellite sensors.

Earlier studies that have dealt with airphoto crop identification in the tropics are generally of limited availability and site specific, offering few keys for identifying crops elsewhere or even within the region studied (Cornell University Airphoto Interpretation Team, 1955; Liu, 1961; Organization of American States, 1969; Puerto Rico Dept. of Natural Resources and Cornell University, 1973; Sridas, 1966; U.S. Army Cold Regions Research and Engr. Lab., 1966; U.S. Geological Survey, 1944; U.S. Navy Dept., 1945). Of the more recent investigations of crop identification, the great majority have utilized satellite data (Bauer *et al.*, 1979). Although these data might be useful for analyzing agricultural systems in the tropics (Harnapp and Knight, 1971), their low spatial resolution causes the currently available satellite data to be of limited applicability for identifying most crops in most areas of the tropics. Similarly, although recent studies of crop identification have employed data acquired by aircraft multispectral scanner or other non-photographic sensors (Ayyanger, 1978; Ulaby et al., 1980), these data are generally expensive to collect and analyze, and their utilization can seldom be justified solely for the purpose of crop identification.

Airphoto Crop Key

In this paper, a key is presented for identifying selected major crops of the tropics through stereoscopic analysis of medium-scale (1:10,000 to 1:30,000) panchromatic aerial photographs. In order that the key would be of value to the widest possible audience, its development is based on representative photographs of crops as they occur throughout the tropics. The key is thus applicable by students as well as resource managers in either their first experience with airphoto crop identification or in providing the basis for developing more detailed regional keys.

Placing emphasis on panchromatic aerial photographs reflects the fact that black-and-white films are the most commonly used aerial film types, particularly in the tropics. Moreover, if a crop can be identified with black-and-white aerial photographs, its identification would normally be facilitated with color or other multispectral aircraft data. Placing emphasis on stereoscopic medium scale photography reflects the fact that a three-dimensional view is important for identifying or differentiating certain crops, while medium scale photography is the most commonly available. The key does not rely on temporal images of a crop over its growth stages (Goodman, 1959); time-sequential aircraft data are seldom available and costly to fly.

The key recognizes certain field, management, and crop features that are frequently associated with crop occurrence. A comprehensive treatment

Abstract: *A key for identifying selected major crops of the tropics on stereoscopic medium-scale panchromatic aerial photographs is presented. Crops considered include sugar cane, lowland rice, corn, tobacco, pineapple, banana, rubber, coconut, coffee and cacao.*

Photogrammetric Engineering and Remote Sensing,
Vol. 48, No. 2, February 1982, pp. 223-233.

0099-1112/82/4802-223$02.25/0

of these features can be found in an earlier paper (Philipson and Liang, 1975), which serves to characterize, but not develop an identification key for, the crops considered here.

As a final note, it is emphasized that *positive* crop identification normally requires ground verification. No matter how inclusive, airphoto keys provide no assurance that an observed crop is not some crop or type of vegetation which has not been considered by the keys. This latter possibility might be resolved by the analyst's familiarity with the study area (Miller, 1960). Just as the general key presented here provides a basis for developing regional keys, knowledge of the region under study is invaluable for crop identification and subsequent interpretations.

ACKNOWLEDGMENTS

The authors express their appreciation to the various agencies that supplied photographic examples. (*Photo credits:* Figure 1, Terra Surveys Ltd., Canada; Figure 5, Secretaria de Recursos Hidraulicos, Mexico; Figures 3, 5, and 14, U.S. Department of Agriculture; Figure 7, U.S. Geological Survey; all other figures from government or educational organizations of the respective countries.) The authors would also like to thank William L. Teng, for his helpful suggestions, and Sandra J. Matulonis and William S. Altman, for their assistance in preparing the photographic examples.

KEY FOR IDENTIFYING MAJOR CROPS OF THE TROPICS USING STEREOSCOPIC MEDIUM-SCALE PANCHROMATIC AERIAL PHOTOGRAPHS

A.1. Field under study appears to have one type of vegetation [most figures]* . . . *E*
A.2. Field under study appears to have more than one type of vegetation [Figures 17, 21-23] . . . *B*

B.1. Tallest vegetation consists of trees which appear to be for shade only [Figures 21-23] . . . *C*
B.2. Tallest vegetation appears to be for temporary shade or part of intercropping; consider each crop separately [Figure 17] . . . *E*

C.1. Regularly spaced, dark-toned, bush-like understory plants can be observed through gaps in the tree canopy [Figures 21-23] . . . *D*
C.2. No understory plants can be observed, or plants are not as described in C.1 . . . *crop unclassified, uncultivated or absent*

D.1. Altitude generally below 750 meters, with gentle to moderate slopes [Figures 22, 23] . . . *probably cacao, with or without banana; possibly coffee*
D.2. Altitude generally above 750 meters, with moderate to steep slopes [Figure 21] . . . *probably coffee, with or without banana; possibly cacao*

E.1. Plants are tree or bush-like [most fields in Figures 15-23] . . . *F*
E.2. Plants are not tree or bush-like, and individual plants are indiscernible [most fields, Figures 1-13] . . . *O*

F.1. Most individual plants are easily discernible [Figures 15, 19, 20, 21, 23] . . . *G*
F.2. Most individual plants are not easily discernible [top of Figure 15; B & R in Figure 16; R in Figure 18] . . . *L*

G.1. The foliage of the individual plants is relatively open or spreading and either jagged or star-like in outline [Figure 19; some B in Figure 16] . . . *H*
G.2. The foliage of the individual plants is relatively dense and generally circular in outline [Figures 21, 21, 23] . . . *I*

H.1. Plants are generally tall [Figure 19] . . . *probably coconut*
H.2. Plants are of medium height [Figure 15] . . . *probably banana, plantain, or abaca; possibly coconut*

I.1. Plants (trees) are generally very tall, with some or much overlap between adjacent trees, and with relatively dark-toned foliage [Figures 16-18] . . . *probably rubber, especially if distinct planting pattern; possibly unclassified or uncultivated tree*
I.2. Plants may be short or tall, with little or no overlap between adjacent plants [Figures 20, 21, 23] . . . *J*

* Photographic examples of features are listed in brackets.

J.1. Plants are spaced in regular pattern, and foliage is very dense and very dark-toned [Figures 20, 21, 23] . . . *K*
J.2. Plants are not as described in J.1 . . . *plants unclassified; if planting pattern discernible, possibly fruit crop*

K.1. Diameter of foliage is generally large [trees with B in Figure 17] . . . *probably mango*
K.2. Diameter of foliage is generally intermediate [Figure 20] . . . *probably citrus or other fruit*
K.3. Diameter of foliage is generally small to intermediate [Figure 20] . . . *probably coffee, cacao, citrus, or other fruit tree; see D if coffee or cacao*

L.1. Plants occur as plantation crop with a large area, many fields, or field subdivisions planted to same crop [Figure 15; R in Figures 16, 18] . . . *M*
L.2. Plants do not occur as plantation crop [B in Figure 16] . . . *various possible crops, including banana*

M.1. (see I.1)
M.2. Plants are not tall trees [Figure 15] . . . *N*

N.1. Texture of population is uniformly jagged or relatively coarse like sandpaper [Figure 15; B in Figure 16] . . . *probably banana*
N.2. Texture is not as described in N.1. [compare B & S in Figures 5, 14] . . . *crop unclassified; possibly sugar cane (for cane, continue with O)*

O.1. Relatively high number of fields in area appear to have the same crop, though possibly at different stages [Figures 1-4; P in Figure 6; Figures 8-11; M in Figure 12] . . . *P*
O.2. Relatively few fields in area appear to have the same crop [Figure 14] . . . *I*

P.1. Fields are relatively small with intensive irrigation/flood control through paddies [Figures 8-11] . . . *probably lowland rice*
P.2. Fields are relatively small without intensive network of paddies . . . *crop unclassified*
P.3. Fields are relatively large [Figures 1-4, 6; M in Figure 12; T in Figure 13; T in Figure 13] . . . *Q*

Q.1. Fields are subdivided [Figures 1-3, 6, 7; T in Figure 14] . . . *R*
Q.2. Fields are not subdivided . . . *S*

R.1. Crop height is medium, texture is smooth, and rows are indiscernible at maturity [Figures 2-4] . . . . *probably sugar cane*
R.2. Crop height is low; field subdivisions are very regular and tonally distinct [Figures 6, 7] . . . *probably pineapple*
R.3. Crop height is low, field subdivisions are not tonally distinct; curing barns or drying towers or racks are observed in area [Figure 14] . . . *probably tobacco*

S.1. (see R.1)
S.2. Crop height is low to medium, texture is smooth and rows are discernible [M in Figure 12] . . . *probably corn or other grain (e.g., sorghum or millet)*
S.3. Crop height is low [T in Figure 13] . . . *possibly tobacco, pineapple, or unclassified crop*

T.1. Field is subdivided . . . *U*
T.2. Field is not subdivided . . . *V*

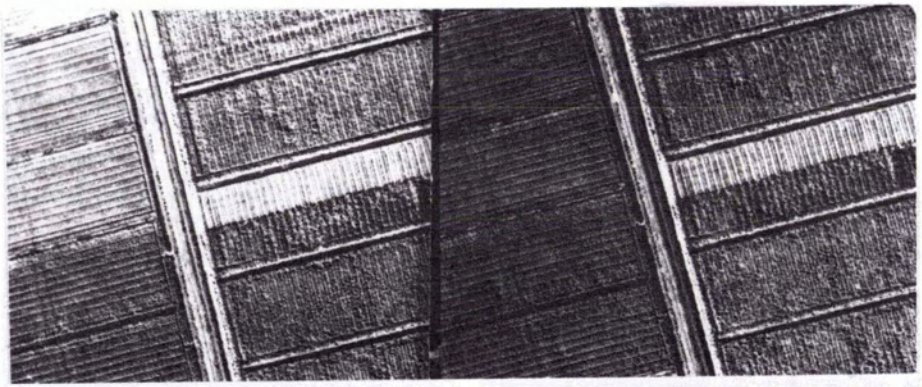
U.1. (see R.1)
U.2. (see R.3)

V.1. (see P.1)
V.2. Fields do not have irrigation/flood control through paddies . . . *W*

W.1. Crop height is low to medium . . . *X*
W.2. Crop height is low; rows are indiscernible . . . *possibly upland rice or uncultivated (e.g., pasture—most non-annotated fields in Figure 14); also, possibly tobacco, pineapple, vegetable, etc.*

X.1. (see S.2)
X.2. Rows of crop in field are indiscernible . . . *possibly pasture (i.e., grasses)*

Where necessary, the figures have been annotated, as follows: S-sugar cane, L-lowland rice, M-corn, T-tobacco, P-pineapple, B-banana or plantain, R-rubber, C-coconut, O-coffee and A-cacao.



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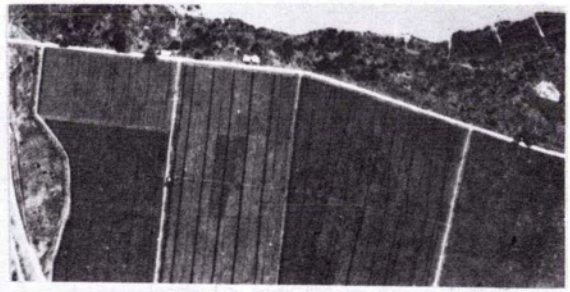

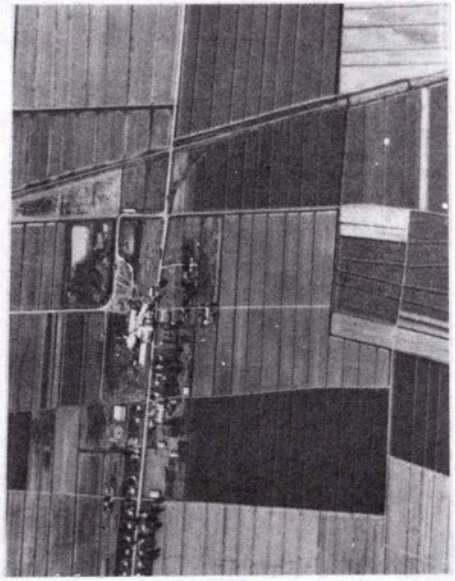

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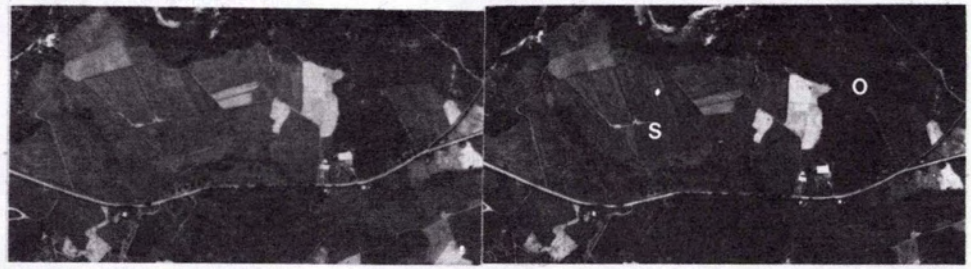

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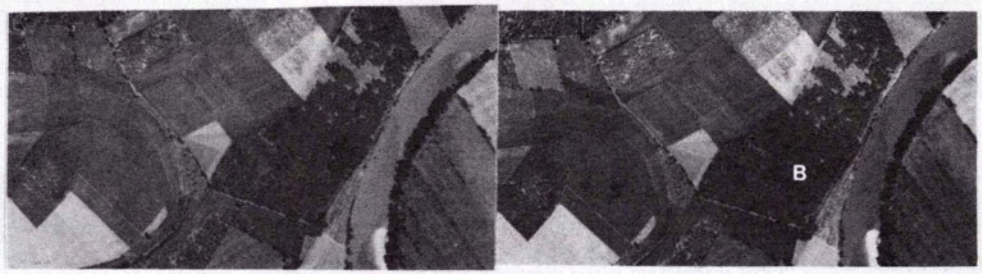

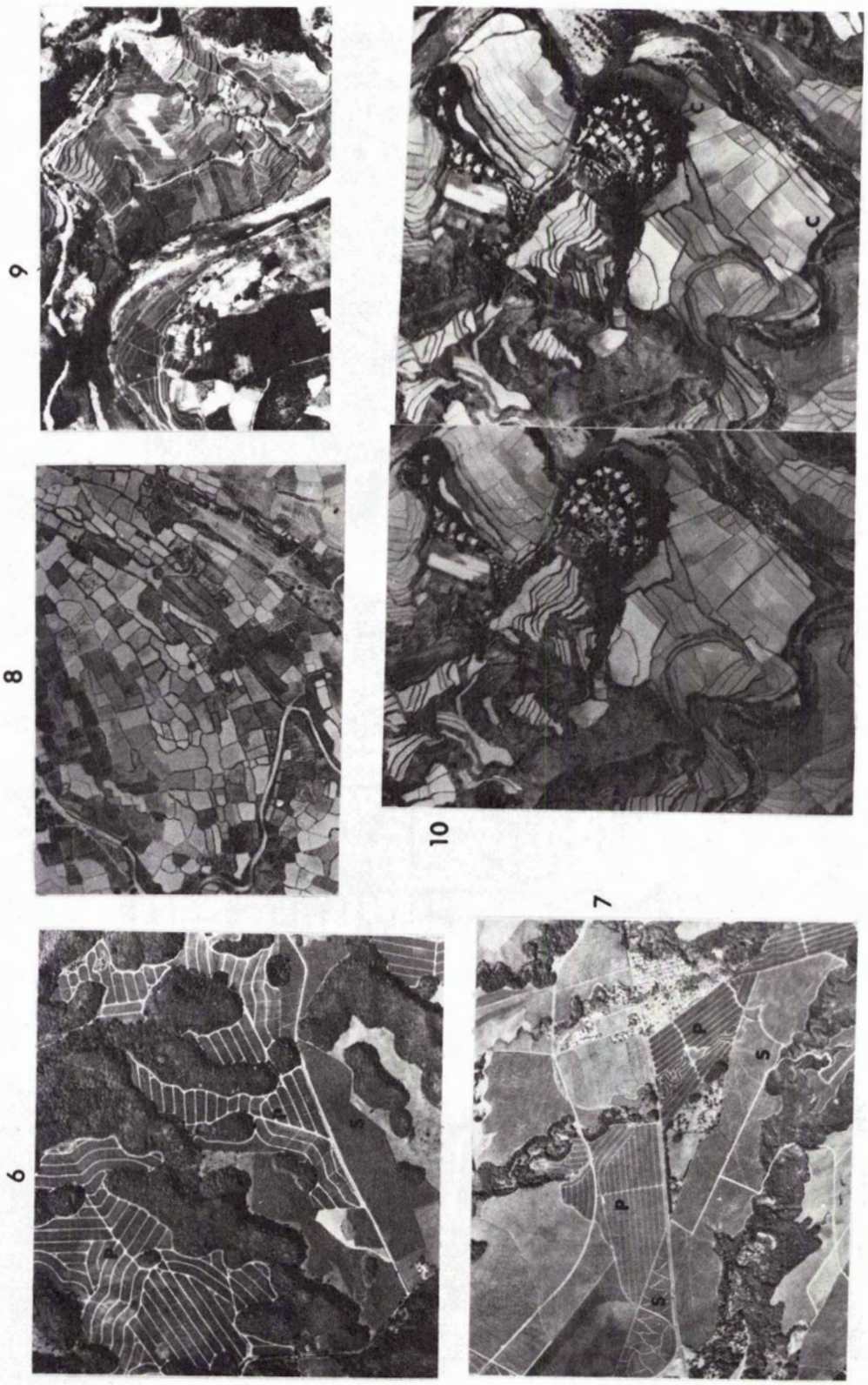
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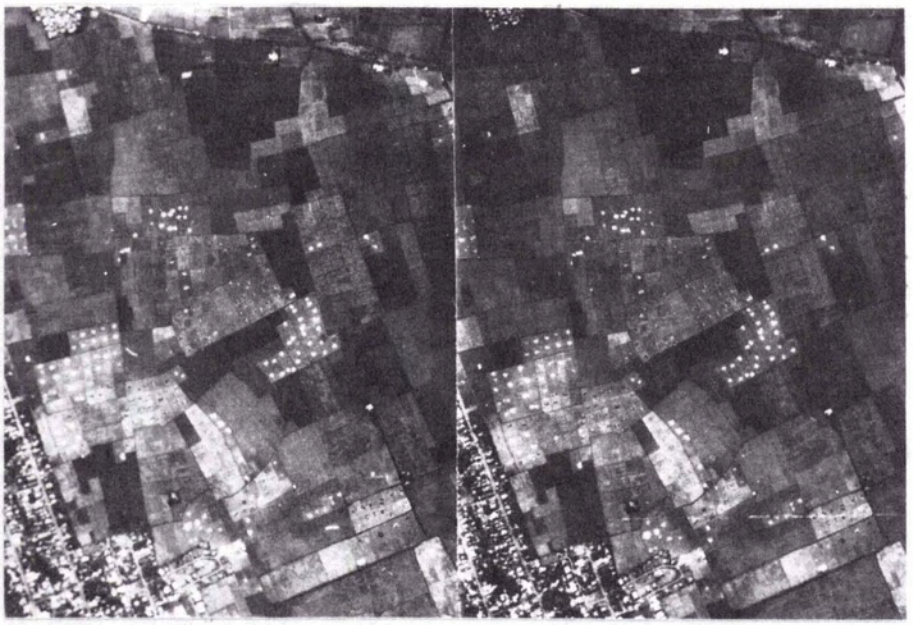

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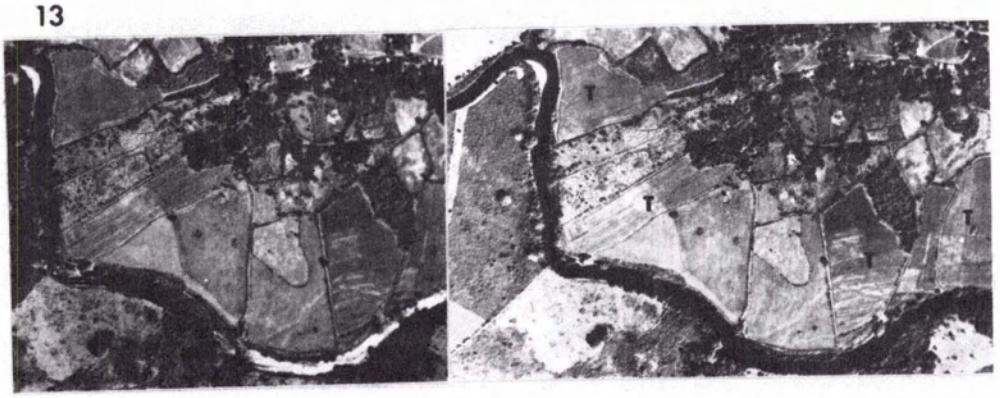

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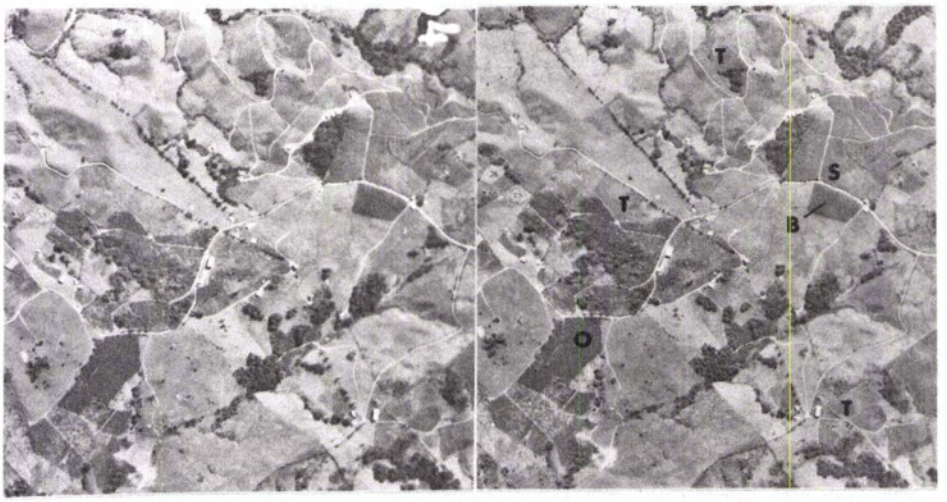

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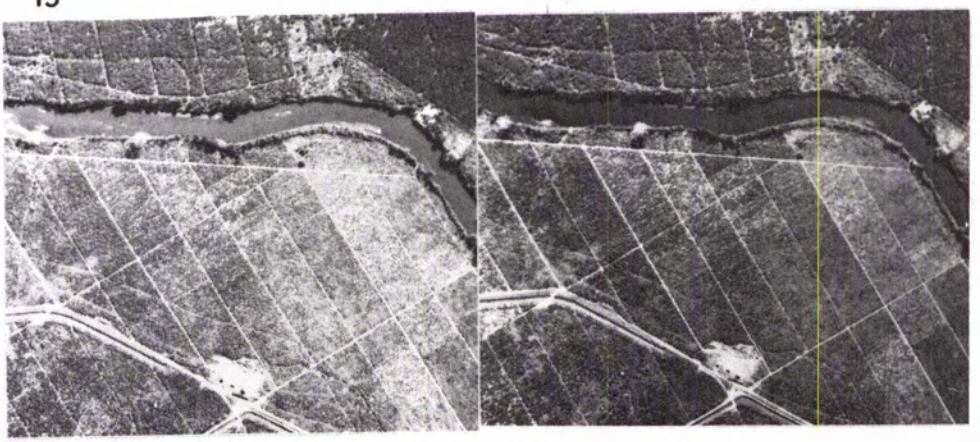

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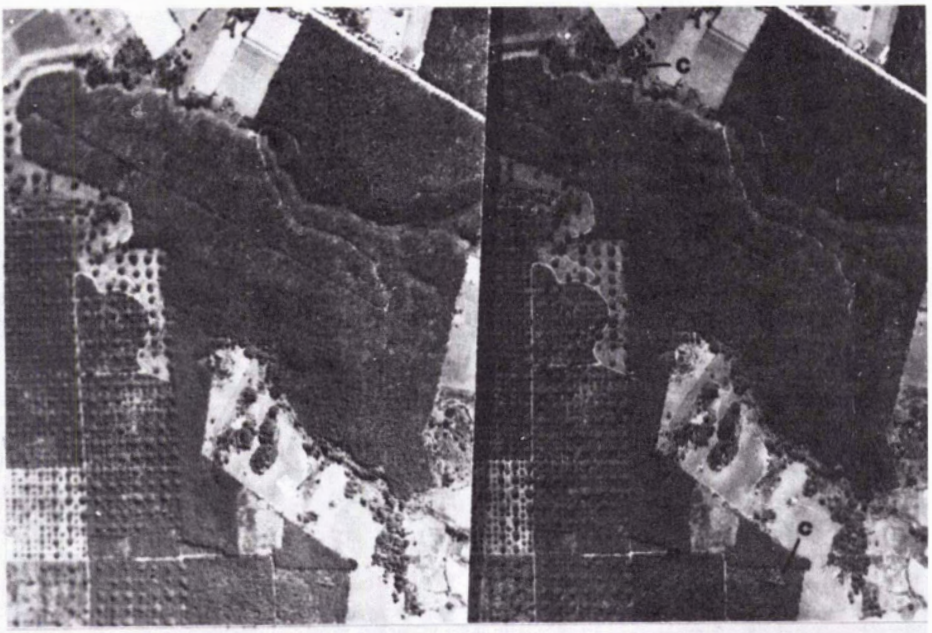

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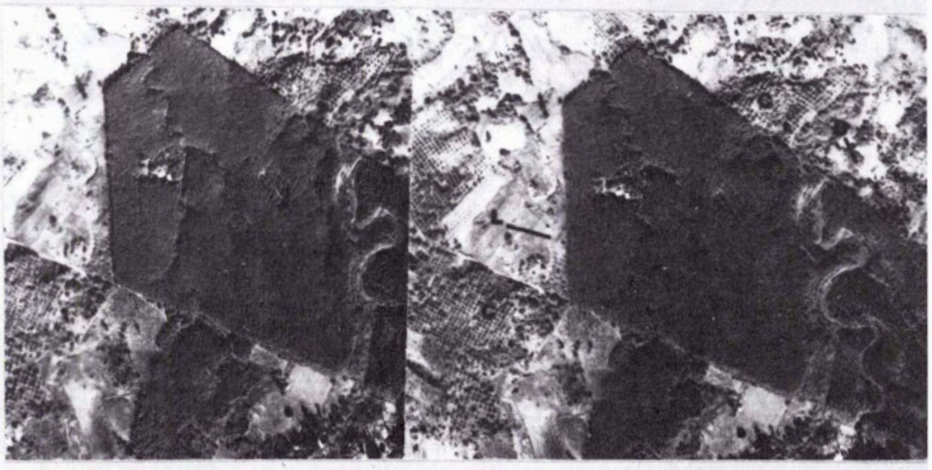

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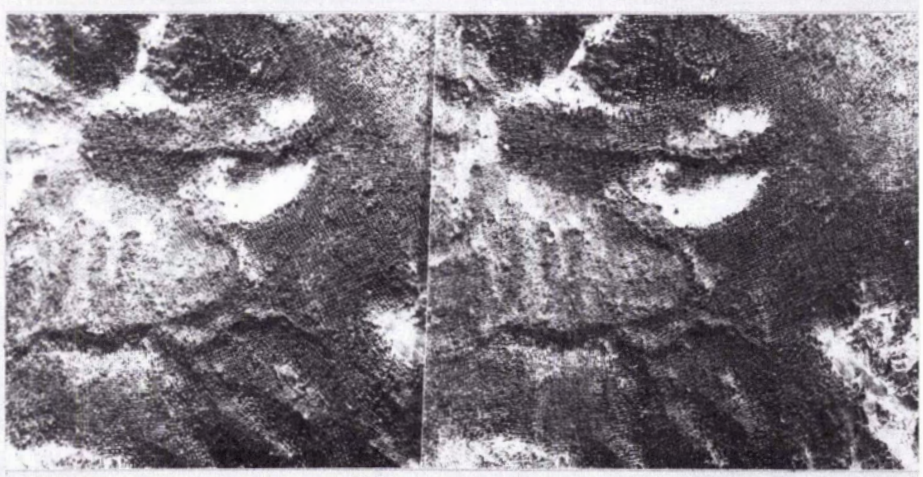

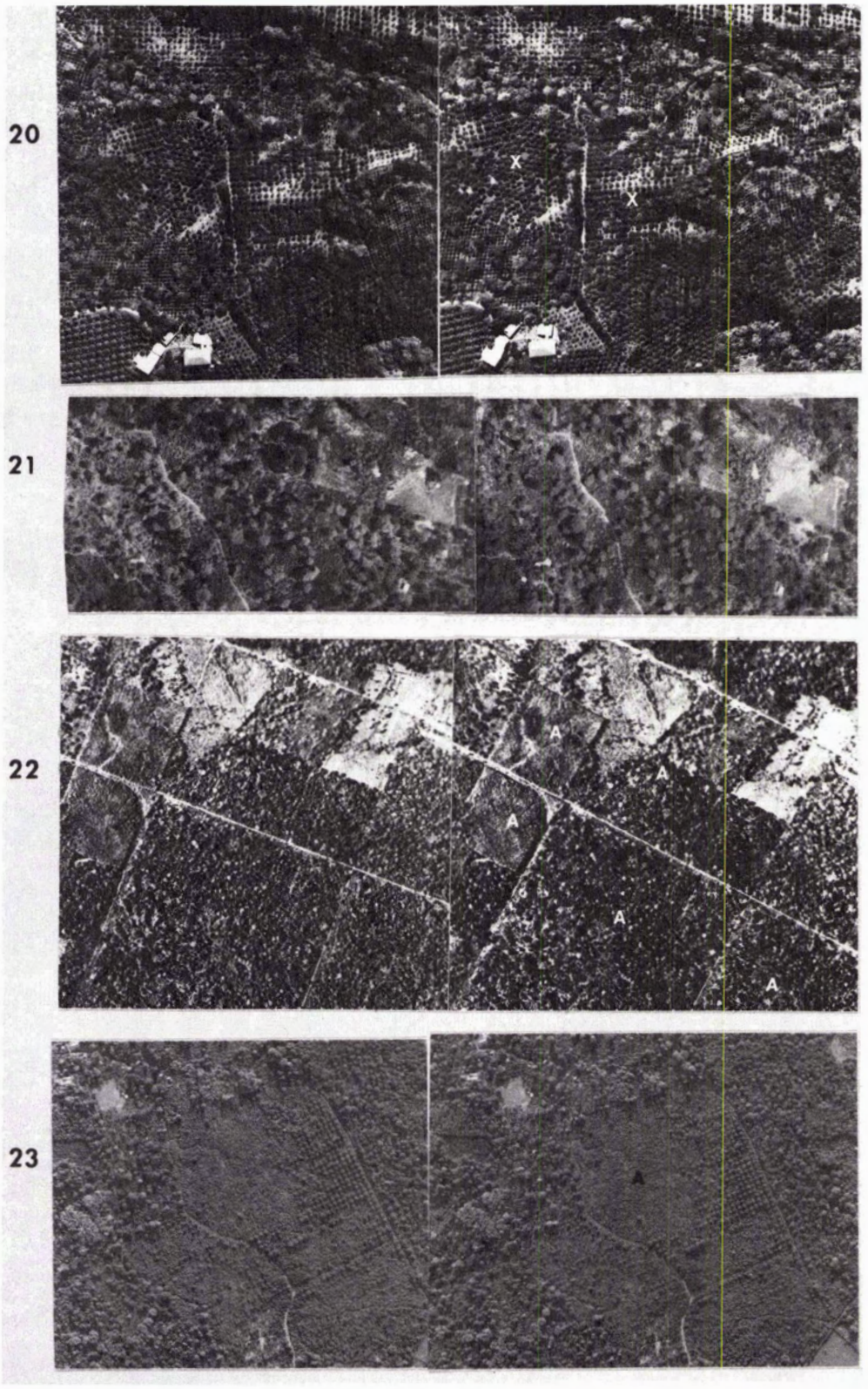
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FIG. 1. Sugar cane in Guyana; note deep furrows and irrigation canals.

FIG. 2. Sugar cane in Tanzania; note field subdivisions.

FIG. 3. Sugar cane in Louisiana; note mill and cane at different stages.

FIG. 4. Sugar cane and coffee (lightly shaded) in Costa Rica (*stereo*).

FIG. 5. Sugar cane and banana in Mexico (*stereo*).

FIG. 6. Pineapple and sugar cane in Puerto Rico; note pineapple field subdivisions.

FIG. 7. Pineapple and sugar cane in Hawaii.

FIG. 8. Lowland rice in Burma; note field density, size, shape and assemblage.

FIG. 9. Lowland rice in Taiwan; note terraced paddies.

FIG. 10. Lowland rice in Philippines; note scattered coconut (*stereo*).

FIG. 11. Lowland rice in Philippines; note various stages, recently harvested piles (many small light dots in certain paddies), and threshing sites or straw piles (large circular areas in certain paddies—light-toned or, if burned, black) (*stereo*).

FIG. 12. Corn and lowland rice in Philippines; note that rows of corn are discernible (*stereo*).

FIG. 13. Tobacco in Panama (*stereo*).

FIG. 14. Tobacco, coffee (unshaded), sugar cane and banana in Puerto Rico; note large tobacco curing barns (*stereo*).

FIG. 15. Banana (young and mature) in Panama (*stereo*).

FIG. 16. Rubber (young and mature), banana and lowland rice in Malaysia (*stereo*).

FIG. 17. Rubber and intercropped mango and banana in Philippines; note scattered coconut (*stereo*).

FIG. 18. Rubber and coconut in Philippines; note chain of rice paddies and clumps of banana (*stereo*).

FIG. 19. Coconut in Philippines (*stereo*).

FIG. 20. Coffee (unshaded to lightly shaded) and citrus (X) in Panama; note size of coffee vs citrus trees and intercropped area in lower left (*stereo*).

FIG. 21. Coffee (lightly shaded) in Colombia (*stereo*).

FIG. 22. Cacao (medium to heavy density shade) in Costa Rica; note that cacao is visible through gaps in shade (*stereo*).

FIG. 23. Cacao (unshaded to lightly shaded) in Ecuador (*stereo*).

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(Received 30 July 1980; revised and accepted 4 September 1981)