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Multibase and Multiemulsion Space Photos for Crops and Soils

They are about equally useful for discriminating crop and soil condition.

(*Abstract on next page*)

INTRODUCTION

ABOUT 95 percent of the land mass of the United States is occupied by farmland, forests, and rangelands. Space imagery of sufficient resolution should be extremely valuable for surveying and inventorying these resources.

Visual inspection of the Apollo 9 imagery indicated that the resolution of the space photography was sufficient to investigate the multispectral signature of individual fields as affected by crop cover and growing conditions. This article reports the results of a study to computerize the identification of crop species and soil conditions from film optical density differences where ground truth of fields was available.

PROCEDURE

The photography used was obtained from the SO-65 experiment "Multispectral Terrain Photography" conducted during the Apollo 9 mission. In this experiment a set of four Hasselblad cameras, each equipped with a different film-filter combination, obtained simultaneous imagery of the same area of the earth. The films and filters, the wavelength of peak or plateau film sensitivity and the bandpasses used were as shown in Table 1 (Mapping Sciences Laboratory, 1969):

The frame of imagery used is designated *AS-9-26L-3799* where the letter *L* refers to the magazine designating letters *A*, *B*, *C* or *D*. The view is of the Salton Sea and Imperial Valley of California. The imagery was obtained at 1628 hours Greenwich Mean Time on March 12, 1969, from an altitude of 129 nautical miles. The sun elevation was 30 degrees. The principal points are: latitude, 33°05′N and longitude, 115°18′W (Apollo 9 Preliminary Plotting and Indexing Report, 1969). A composite of the photography is displayed as Figure 1.

Immediately following the science screening of the imagery on April 2 and 3, 1969, duplicate 70-mm transparencies of each of the four images were requested from the National Aeronautics and Space Administration, Earth Resources Survey Division, Manned Spacecraft Center, Houston.

Optical mechanical scanner and ground truth (Spansail *et al.* 1969) data of the Imperial Valley were obtained by the University of Michigan during the Apollo 9 mission. A copy of the ground truth for line 15A, Dogwood Road, and a print of the scanner imagery simulating type 3400 film with 25A filter were obtained. Line 15A was 10.5 miles long, and the Michigan scanner which flew at 10,000 feet sensed 1 3/4 miles on each side of Dogwood Road. The ground-truth data furnished by Michigan listed 303 fields within this area.

In order to study the Imperial Valley flight line more intensively, an isodensitracing

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was prepared of the 1:3,000,000 scale, 2 mm×6 mm section covering line 15A in the duplicate 70-mm Ektachrome IR transparency. The scene was enlarged 100-fold to produce a facsimile image of the target scene to the same scale as the Michigan imagery (1:30,000). A red transmission filter was used in the approximately 60-micrometer diameter light beam of the microdensitometer to accent the film density difference between cropped areas, which develop red tones on Ektachrome IR film and hence have low optical density to red light, from noncropped areas characterized by blue tones. Both the University of Michigan imagery and the isodensitracing with fields located and enumerated are shown in Figure 2.

Over the area of the isodensitracing at the positions numbered in Figure 2, 18 microdensitometer scan lines, corresponding to 18 transects of the flight line, were chosen for quantification. These 18 lines were retraced without a filter and with blue (Wratten 94), green (Wratten 93), and red (Wratten 92)

ABSTRACT: *Kodak Ektachrome infrared Aero film SO 180 (multiemulsion) was compared with Panatomic-X exposed to green and red light, and black-and-white infrared films to discriminate crop species and soil conditions of 53 Imperial Valley, California, fields. Simultaneous imagery was obtained by the cluster of 4 Hasselblad cameras used in the Apollo 9 SO-65 experiment. Ground truth was used to establish the categories and to judge the accuracy of category classification.*

Film optical densities for the Ektachrome Infrared (IR) film were determined with no filter (white light) and with red, green, and blue filters in the light beam. For the black and white films, the optical densities were determined only to white light. The standard signature for each category was taken as the mean optical density difference among selected filter combinations for all fields in the category. The data were processed by a computer program that compared the signature of each field with all standard signatures. Each field was assigned to the category of the standard signature from which it deviated the least.

On the Ektachrome IR image 68 percent of the fields were correctly identified, whereas 72 percent were correctly identified on the combined data from the three black-and-white images. Most misidentifications were due to incorrectly identifying one crop as another. It is concluded that multibase and multiemulsion imagery are about equally useful for crop and soil condition discrimination using optical density differences and that spectral similarity among crops at the photographic wavelengths makes crop discrimination difficult.

TABLE 1. FILM AND FILTER CHARACTERISTICS

Film Magazine Resignation	*Film Type and Filter*	*Wavelength of Peak or Plateau Film Sensitivity*		*Nominal Filter Bandpass*
			nm	nm
A	SO 180, Ektachrome Infrared Aero; Photar 15	Green, Red, Infrared,	550 650 800[a]	510–890
B	3400, Panatomic X; Photar 58 B	Green,	525	470–610
C	SO 246, Black-and-white IR; Photar 89 B	Infrared,	800	680–890
D	3400, Panatomic X; Photar 25 A	Red,	645	590–715

[a] There is a small peak at 750 nm and a broad plateau beyond it.

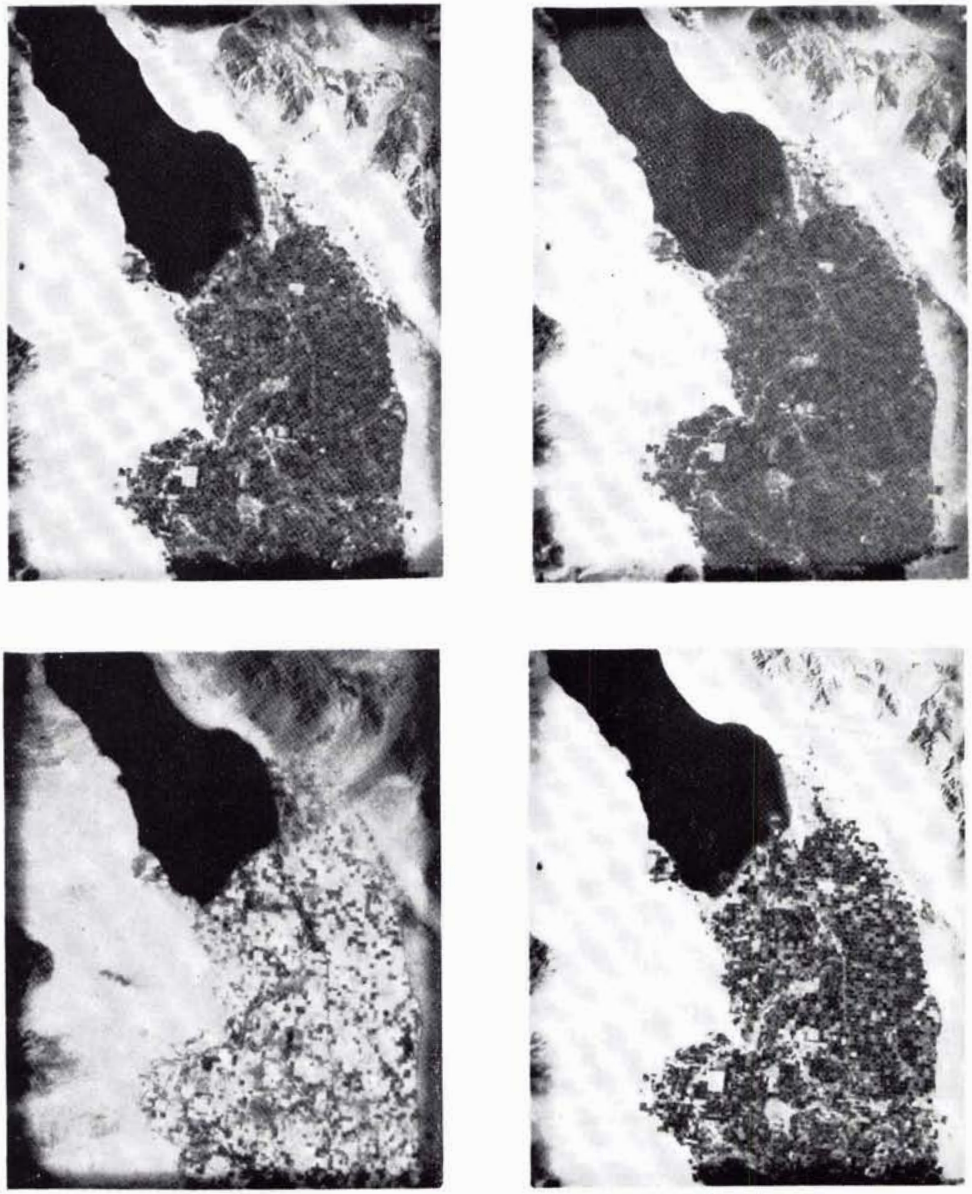

FIG. 1. Apollo 9 frame 3799 Ektachrome infrared (upper left), Panatomic X green band (upper right), black-and-white infrared (lower left), and Panatomic X red band (lower right) images of Imperial Valley and Salton Sea, California. Scale of the space photograph is approximately 1:3,000,000.

gelatin filters in the light beam, respectively. Microdensitometer tracings across these same fields were also obtained for each of the three black-and-white transparencies. For the black-and-white transparencies, however, the optical counts were obtained only to white light.

The optical counts (related to optical density by the relation, [(optical count − 30) (.0111) + .39 = optical density]) were recorded on punched paper tape simultaneously with their tracing. The paper-tape optical counts per scan line were listed by Flexowriter, matched to the corresponding fields, and the

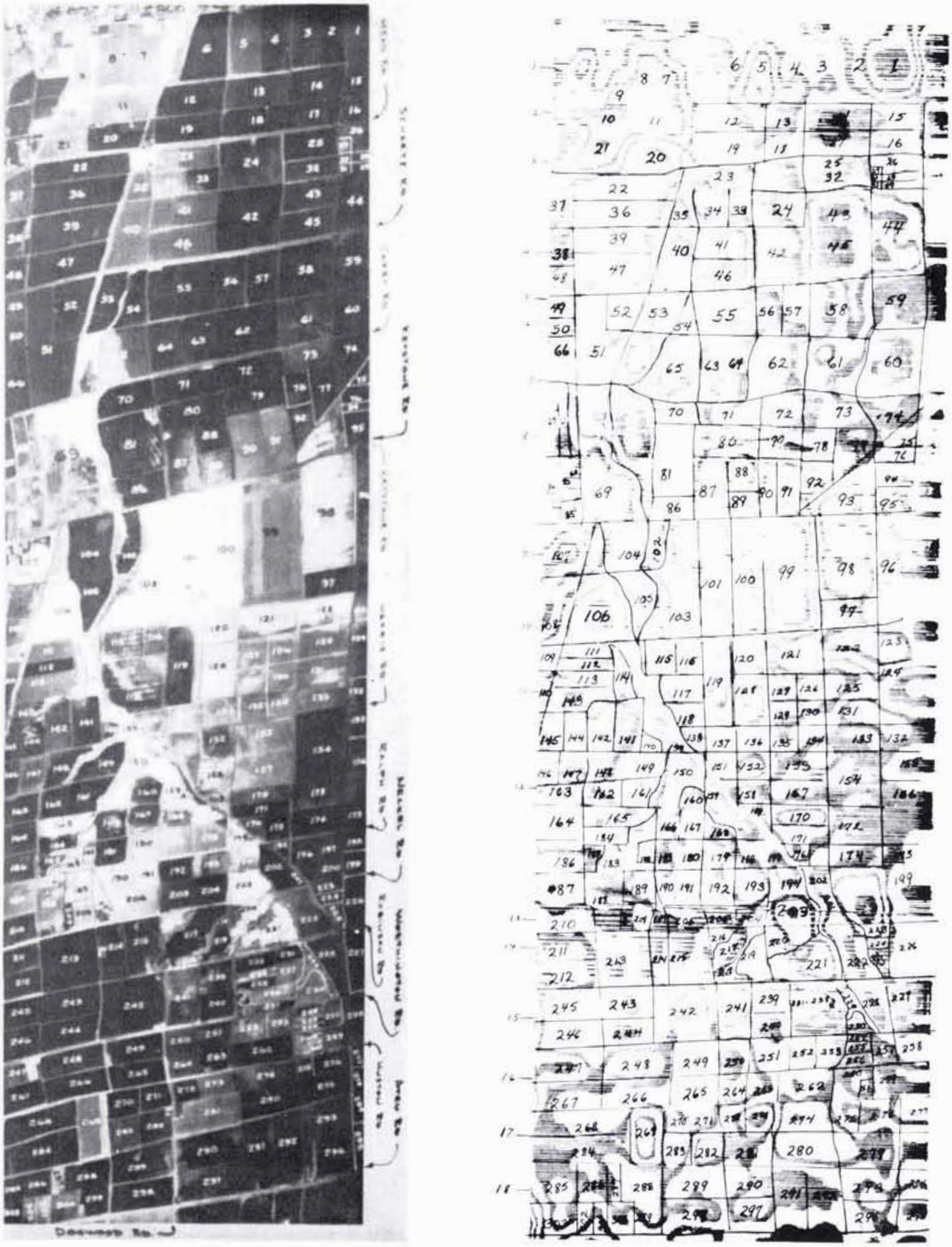

FIG. 2. University of Michigan optical mechanical scanner imagery simulating Panatomic X film with 25A filter obtained of Imperial Valley flight line 15A from 10,000 feet, and a 100-fold enlargement isodensitracing of the same flight line prepared from the space photograph. Numbers on the images are field designations. Scale of both is 1:30,000.

average optical count was determined. Taking the ground-truth data into account in sorting the fields into crop species and soil condition categories that were sufficiently replicated, 53 useable fields resulted. The 53 fields consisted of 10 sugarbeet, 10 alfalfa, 11 bare soil, 13 barley, and 9 salt-flat fields.

The analysis procedure was the following: The arithmetic mean of the optical count for each filter was used as the representative or standard signature for that field condition. The data were entered into a computer where the mean optical counts were converted to optical densities. Every optical density difference among the various filters was obtained for the standard signature of each category. For the Ektachrome Infrared image, the optical density differences corresponding to the following filters were taken: red minus blue, red minus no, blue minus no, red minus green, green minus blue, and green minus no. For the black-and-white transparencies, the following differences in optical density of the spectral bands with no filter in the light beam were taken: red band minus green band, red band minus infrared band, and green band minus infrared band. Algebraic signs of the differences were honored.

The deviation from each standard signature for every filter combination optical density difference of each individual field was taken, squared, and accumulated. The computer then identified the crop or field condition category that the field in question most closely resembled. This minimum distance to the mean procedure results in every field being unambiguously assigned an identification.

RESULTS

The crop and soil condition categories investigated from the Ektachrome Infrared transparency of the Imperial Valley were sugarbeets (*SB*), alfalfa (*A*), bare soil (*BS*), barley (*B*), and salt flat (*SF*). Table 2 identifies each field by number and crop species or soil condition category, presents the computer identification of each field for both the Ektachrome Infrared and black-and-white imagery, and states the ground truth for each test field. The ground-truth data show that the plant heights of each crop vary considerably. Crop height does not seem to be very closely related to proper identification. For example, of the three alfalfa fields improperly identified on Ektachrome Infrared film, ground truth plant height was 3 inches for one, 10 to 12 inches for the second, and 3 to 14 inches for the third.

Percent ground cover of row crops is usually overestimated by a ground observer, in our experience. It is difficult to visualize as similar ground cover percentages as are listed in Table 2 for a crop varying as much in height as the sugarbeets do; percent ground cover should increase as plant height increases if plant stands and soil conditions are similar.

The smallest field included in the analysis was 30 acres. As indicated in the isodensitracing of Figure 2, small fields are difficult to locate. The 36 fields properly identified on Ektachrome Infrared film averaged 107 acres compared with 70 acres for the 17 fields that were improperly identified.

Table 3 is a summary of the identifications and percentage identifications of the various crop and soil condition categories. The results indicate that Ektachrome Infrared film is generally superior for identifying crop categories and that the balck-and-white multispectral films are superior for identifying the bare soil and salt flat categories. The overall percentage of correct identifications is 68 percent for the multiemulsion film and 72 percent for the multibase black-and-white films.

On the Ektachrome Infrared film, 8 of the 10 misidentifications of alfalfa, barley, and sugarbeets were as one of the other of these crops; all sugarbeets misidentified were called barley. All four of the bare soil fields misidentified were called alfalfa. A total of eight fields were misidentified as alfalfa, indicating the similarity in optical signature of fields in other categories to the standard signature for alfalfa.

For the black-and-white multibase films, 10 of the 12 total misidentifications of alfalfa, barley, and sugarbeet fields were called one of the other of these crops. All five of the misidentified barley fields were designated sugarbeets by the computer.

Table 4 presents the mean optical density values, the standard error of the mean optical density and the coefficient of variation for each crop and soil condition category for each set of imagery. Relationships among optical density values may be used to classify soil and crop condition categories. However, color density of films is affected by conditions of storage, exposure, and processing. The numerical differences between the optical densities are more constant for crop and soil condition categories than are the optical densities *per se*.

The four optical densities measured on Ektachrome IR film can be expressed as six independent optical density differences. Figure 3 shows the optical density differences for both multiemulsion film and multibased films for each crop and soil condition category. The mean difference and one standard error each side of the mean are plotted.

The crop and soil condition categories can

TABLE 2. CROP AND SOIL CONDITION CATEGORIES, COMPUTER IDENTIFICATIONS, AND GROUND TRUTH OF EACH FIELD STUDIED TO EVALUATE IDENTIFICATION OF IMPERIAL VALLEY FIELDS ON EKTACHROME INFRARED AND MULTISPECTRAL (OR MULTIBASE) BLACK-AND-WHITE SPACE PHOTOGRAPHY

Crop	*Field No.*	*Computer Identification*		*Acres in Field*	*Plant ht., Inches*	*Ground Cover %*	*Comments*
		Ekta-chrome IB	*Multi-spectral Blk-&-Wht*				
Alfalfa, *A*	65	A	BS	133	2–6	80	Recently cut & irrigated
	167	A	BS	40	3–4	80	Recently cut
	274	A	A	62	3–5	90	Recently cut; light color
	293	SF	A	120	3	80–90	Pastured
	288	A	B	67	6–8	95	Pastured
	24	A	A	72	6–8	60	Irregular crop cover
	22	A	B	94	10–12	90	—
	39	B	B	140	10–12	85	—
	42	A	SB	165	10–12	70	—
	282	BS	A	42	3–14	80	Combining in progress
Barley, *B*	119	SB	SB	138	18–24	60	Variable cover; heading
	20	B	SB	55	24–30	90	—
	161	A	B	60	10–15	90	—
	60	B	B	—	12–16	95	Variable height
	192	B	SB	30	10–15	95	—
	213	B	B	139	18–24	95	—
	249	B	B	95	10–12	95	—
	36	B	SB	110	24–36	100	—
	47	B	B	104	24–30	100	—
	243	B	B	72	20–28	100	—
	144	B	B	80	15–18	100	—
	104	A	B	113	20–24	80	Light green mottling at NE. edge of field
	105	A	SB	57	20–24	95	
Sugar-beet, *SB*	62	SB	SB	138	6–8	80	—
	248	SB	SB	66	10–12	80	—
	242	B	A	155	8–20	80	5% weed cover
	205	SB	SB	37	13–18	80	Salt deposits along field edges
	52	B	SB	67	12–18	90	—
	53	B	SB	74	12–14	90	—
	77	SB	SB	65	12–15	90	—
	59	SB	SB	—	10–12	95	Yellow mottling
	51	SB	SB	215	12–18	95	do
	16	SB	SB	—	10–14	90	do
Bare soil, *BS*	1	BS	BS	—			Bedded EW[a] for cotton
	11	BS	BS	85			do
	41	A	BS	94			Bedded NS[a] for cotton
	44	BS	BS	—			Bedded EW for cotton
	46	BS	BS	91			Bedded NS for cotton
	73	A	BS	60			Bedded for cotton
	133	A	SF	56			Bedded NS for cotton
	269	BS	A	83			do
	34	A	BS	33			Plowed
	40	BS	BS	99			—
	61	BS	BS	115			Recently plowed & irrigated
Salt flat, *SF*	96	SF	SF	—			Sparse natural vegetation
	165	A	SF	45			Weedy; white salt deposits
	103	SF	A	288			—
	128	SF	SF	77			—
	131	SF	SF	72			—
	69	BS	SF	315			—
	120	BS	SF	45			—
	125	SF	SF	75			—
	100	SF	SF	187			Recently plowed

[a] EW designates rows planted in the east-west direction and NS designates rows running north and south.

TABLE 3. NUMBER AND PERCENTAGE OF CORRECT IDENTIFICATIONS BY CROP AND SOIL CATEGORIES USING BOTH MULTIEMULSION (EKTACHRONE IR) AND MULTIBASE (THREE DIFFERENT BLACK-AND-WHITE) IMAGES

Crop	No. of Fields	*Ektachrome Infrared*		*Black-and-White*	
		No. Identified	*Percent Identified*	*No. Identified*	*Percent Identified*
Alfalfa	10	7	70	4	40
Barley	13	9	69	8	62
Sugarbeet	10	7	70	9	90
Bare soil	11	7	64	9	72
Salt flats	9	6	67	8	89
Total	53	36		38	
Overall Pct.			68		72

TABLE 4. THE MEAN OPTICAL DENSITY, THE STANDARD ERROR OF THE MEAN, AND THE COEFFICIENT OF VARIATION OF OPTICAL DENSITY OF THE EKTACHROME INFRARED AND BLACK-AND-WHITE IMAGERY OF THE IMPERIAL VALLEY FIELDS FOR EACH FILTER USED IN THE MICRODENSITOMETER

Imagery	*Crop*	*No. of Fields*	*Bandpass Filter*	*Mean Optical Density*	*Standard Error of the Mean*	*Coefficient of Variation*
SO 180	Alfalfa	10	None	.5854	.0408	6.97
			Red	.4673	.0534	11.43
			Green	.7518	.0332	4.42
			Blue	.5083	.0436	8.58
3400, G band			None	.7820	.0491	.628
3400, R band			None	.8385	.0237	2.83
SO 246			None	.4892	.0139	2.84
SO 180	Barley	13	None	.6617	.0334	5.05
			Red	.3755	.0273	7.27
			Green	.8546	.0229	2.68
			Blue	.6523	.0349	5.35
3400, G band			None	.7836	.0569	7.26
3400, R band			None	.9583	.0090	0.94
SO 246			None	.4606	.0206	4.47
SO 180	Sugarbeet	10	None	.6395	.0242	3.78
			Red	.3320	.0155	4.67
			Green	.7650	.0195	2.55
			Blue	.5616	.0221	3.94
3400, G band			None	.7270	.0567	7.92
3400, R band			None	.9074	.0094	1.04
SO 246			None	.4572	.0113	2.47
SO 180	Bare soil	11	None	.6015	.0206	3.42
			Red	.6600	.0493	7.47
			Green	.7595	.0273	3.59
			Blue	.5069	.0201	3.97
3400, G band			None	.5719	.0360	6.29
3400, R band			None	.7031	.0123	1.75
SO 246			None	.6054	.0142	2.35
SO 180	Salt flats	9	None	.3405	.0471	13.83
			Red	.3621	.0458	12.65
			Green	.4381	.0497	11.34
			Blue	.2841	.0415	14.61
3400, G band			None	.3882	.0790	20.35
3400, R band			None	.5677	.0243	4.28
SO 246			None	.5895	.0241	4.09

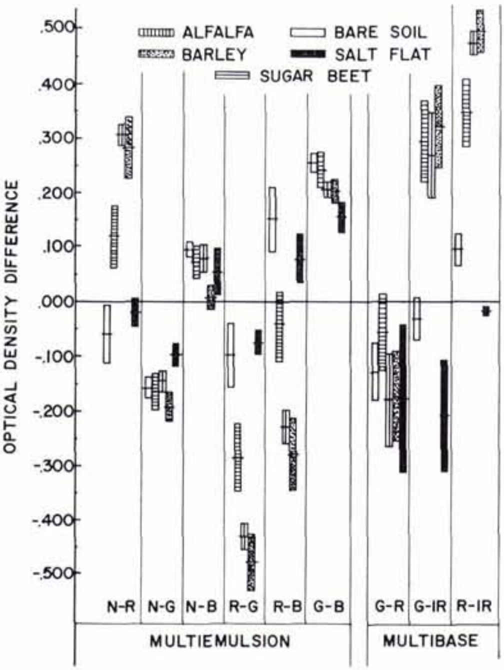

FIG. 3. Ranges of optical density differences of crop and soil condition categories on multiemulsion and multibased film.

most easily be identified on the multiemulsion Ektachrome IR film by using the no-minus-red, the red-minus-green, and the red-minus-blue differences. In each of these differences the barley and sugarbeets are separated from the bare soil and salt flat; alfalfa falls between with no overlapping of ranges of these three groups. The no-minus-green, the no-minus-blue, and the green-minus-blue differences aid little in separating the crop and soil categories used here.

For the multiemulsion image the differences involving optical density to red light are the ones useful in separating the cropped areas from the noncropped areas. The optical density of cropped areas to red light is low and to blue or green light is high. Areas of bare soil appear blue or green (depending mainly upon surface moisture condition). Optical density of images of bare soil is high to red light and low to blue.

The high reflectance of near infrared from plants is apparent in the multibase films by a low density in the SO 246 film. Separation of the categories is most distinct in the differences between the density of the red band image and the infrared. Both differences involving infrared images (red band-minus-infrared band and green band-minus infrared) adequately separate cropped areas from non-cropped areas. These differences are also the only ones in which the bare soil range does not overlap that from the salt flat category. The differences between optical densities of the red band image and the green band image are indistinctive. Over-exposure of the SO 246 film and the hazy appearance of the green band (see Figure 1) may have affected their usefulness in this study.

DISCUSSION

The area chosen for the study was dissected by the Rose Canal and the Southern Pacific Railroad. In addition, many of the fields were salt affected. Because the fields were not uniform, it was difficult to represent truly the fields in the ground truth and microdensitometer data obtained.

The photographic analysis approach also is severely limited by the narrow wavelength interval available for exploitation. Table 5 presents the single leaf reflectance and infinite reflectance (R_∞) data for mature leaves of nine different plant genera at the wavelengths of peak [or plateau] response of Ektachrome IR film. Both the single leaf and infinite reflectance data are unpublished absolute radiometric data furnished by A. J. Richardson and W. A. Allen of the Remote Sensing Investigations Group at Weslaco. Infinite reflectance is a theoretical quantity typifying the maximum reflectance each genera would have at an extremely dense leaf canopy (Allen and Richardson, 1968). The signature of a crop from space would range from a negligible response superimposed upon the soil background up to the infinite reflectance maximum depending upon maturity of the crop.

The data of Table 5 show that the reflectance from a horizontal layer of leaves one leaf in depth is very close to the infinite reflectance at both the 550 and 650 nanometer wavelengths. This means that as long as the plants just obscure the soil, the density of the plant canopy causes infinite reflectance in the signature of a given genera recorded on the green and red layers of the Ektachrome Infrared film. In the infrared, however, six to eight leaf layers are required to give the signature corresponding to the infinite reflectance (Allen and Richardson, 1968) so that differences in plant size, density, and vigor, and hence number of leaf layers, do affect the signature recorded on the emulsion sensitive to the 700 to 900 nanometer wavelength. Thus, on Ektachrome Infrared film we are dealing with weak signals in the green and red wavelengths and a strong signal in

TABLE 5. SINGLE LEAF AND INFINITE REFLECTANCE (R_∞) OF NINE CROP GENERA AT THE WAVELENGTHS OF PEAK [OR PLATEAU] RESPONSE OF EACH OF THE EMULSION LAYERS IN EKTACHROME INFRARED AERO FILM

Crop	*Wavelength, nanometers*			*Wavelength, nanometers*		
	550	*650*	*800*	*550*	*650*	*800*
	Single leaf reflectance, %			*Infinite reflectance, %*		
Sugarbeet	12.2	7.4	42.5	12.3	7.4	67.6
Alfalfa	10.4	9.0	45.2	10.5	9.0	53.5
Corn	15.0	8.4	41.9	15.3	8.4	73.0
Cotton	14.3	7.7	47.6	14.5	7.7	73.2
Potatoes	11.4	7.3	47.2	11.5	7.3	53.9
Tomatoes	11.4	7.4	46.3	11.4	7.4	61.1
Sorghum	18.1	11.4	48.7	18.2	11.4	69.1
Cabbage (purple)	14.5	13.0	48.3	14.5	13.0	62.6
Onion	13.6	7.9	58.5	13.7	7.9	64.4

the infrared. Strong exposure of the infrared-sensitive cyan layer results in a light-toned cyan image that allows the red color produced by combination of the yellow and magenta of the other two layers to predominate (Gausman *et al.*, 1970).

It is very likely that the variability in ground cover and height of the plants in the test fields of this study exceeded the differences among genera. Geometrical differences in plant height and row direction could have introduced additional nonuniformity within genera. Row direction effects could not be discerned in the discrimination results of Table 2, however.

Results of Richardson and Thomas (1969) show that the photographic wavelengths are not very useful for genera differentiation. Within the wavelength interval 500 to 2,500 nanometers, wavelengths between 1,300 and 2,400 nm are most useful. Information in this region, however, bears primarily on plant cell size and secondarily on genera (Gausman *et al.*, 1969).

CONCLUSIONS AND RECOMMENDATIONS

The use of film optical density differences of Apollo 9 SO 65 experiment photography to discriminate the crop and soil condition categories alfalfa, barley, sugarbeets, bare soil, and salt flat and auxiliary information on the reflectance of crop species reported in this article lead to the following conclusions:

- Multibase and multiemulsion photography are about equally useful for crop and soil condition discrimination.
- On the multiemulsion Ektachrome IR film the categories are most easily discriminated using the no-minus-red, the red-minus-green, and the red-minus-blue bandpass-filtered optical-density differences. For the three black-and-white films, the optical-density differences between the red band image and the infrared image were most useful to distinguish categories.
- The crop categories are more difficult to distinguish from each other than from the bare and salt flat soil conditions.
- Reflectance differs little in the green and red wavelengths among crop genera and does not increase with foliage density as occurs in the near infrared. Hence the spectral information content of photographs in the green and red wavelengths is limited; discrimination capability would be aided by characteristic plant geometry such as crown structure and shadow patterns which film also records.
- Suboptimal exposure of the photography used in similar studies can affect the discrimination results. As space photography exposure settings and emulsion formulations are improved, discrimination results should also improve.

The great quantity of photographic imagery that continues to be obtained justifies attempts at quantification and its application to answering specific questions. The data chosen for this study were at the resolution capability of the instrumentation used to study it. Therefore, it is recommended that comparisons be made among imagery differing in scale such as the medium- (10,000 ft) and high- (50,000 ft) altitude aircraft and spacecraft (100+ miles) imagery that were obtained over the same site during the Apollo 9 mission.

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References

Allen, W. A., and A. J. Richardson. Interaction of light with a plant canopy. *J. Opt. Soc. Am.* 58:1023–1028. 1968.

Gausman, H. W., W. A. Allen, R. Cardenas, and A. J. Richardson. Relation of light reflectance to cotton leaf maturity (*Gossypium hirsutum* L.). *Proc. 6th Intl. Symp. on Remote Sens. of Environ.*, Univ. of Michigan, Ann Arbor. II:1123–1141. 1969.

Gausman, H. W., W. A. Allen, V. I. Myers, R. Cardenas, and R. W. Leamer. Reflectance of single leaves and field plots of Cycocel-treated cotton (*Gossypium hirsutum* L.) in relation to structure. *Remote Sens. Environ.* 1(2):103–107. 1970.

Johnson, C. W., L. W. Bowden, and R. W. Pease. A system of regional agricultural land use mapping tested against small scale Apollo 9 color infrared photography of the Imperial Valley (California). *Tech. Rpt. V, Status Rpt. III*, Univ. of California (Dept. of Geography, Riverside). 96 p. Nov. 1969.

Mapping Sciences Laboratory, NASA, MSC, Houston. *Apollo 9 Preliminary Plotting and Indexing Report*. April 1, 1969.

Richardson, A. J., W. A. Allen, and J. R. Thomas. Discrimination of vegetation by multispectral reflectance measurements. *Proc. 6th Intl. Symp. on Remote Sens. of Environ.*, Univ. of Michigan, Ann Arbor. II:1143–1156. 1969.

Spansail, Norma *et al.* Imperial Valley Ground Truth for Apollo 9 Overflight of March 1969. Univ. of Michigan, Inst. Sci. & Tech., *Rpt. No. 2264-7-X*. May 1969.

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