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Color & Color-IR Films for Soil Identification[2]

An evaluation for 12 soils shows that they can be divided into two groups using aerial photographs.

INTRODUCTION

THE OBJECTIVES of this study were to evaluate the influence of soil hues on the optical densities of Kodak Ektachrome[3] Aero 8442 (*CC*) and Kodak Ektachrome Infrared Aero 8443 (*EIR*) Films, and to determine which of the above films is best suited for use in soil identification.

Anson (1966, 1968) reported that *CC* film was better than *EIR* film for identifying soils with dry surfaces. However, *EIR* film was better for identifying freshly cultivated soils with a moist surface.

To date researchers have attempted to differentiate between soil types by visually comparing aerial photographs but the procedure is slow, tedious, and somewhat inconsistent. The inconsistency arises from differences among photo interpreters in identifying targets and in color-observing capacity.

CC and *EIR* films are well adapted to automatic analysis because they record in three parameters; *CC* film records three parts of the 400- to 700-nm wavelength interval, and *EIR* film with a G 15 filter records three parts of the 500- to 1000-nm wavelength interval. Optical density can be converted to electronic signals that can be used to determine hues (type of color), values (darkness or brightness), and chromas (color saturation) of soils for their identification. Therefore, a statistical comparison between *CC* and *EIR* films is clearly needed.

ABSTRACT: *Ektachrome Infrared Aero Film 8443* (EIR) *and Kodak Ektachrome Aero Film 8442* (CC) *were tested for use in identifying soil types. Twelve air-dried soils, differing in Munsell color designations, were photographed with the* CC *and* EIR *films. Optical density measurements were made on film transparencies with a densitometer using red-, green-, blue-, and white-light band-pass filters. Duncan's statistical test indicates that the soils can be separated into two groups: soils with a low chroma (soils grey or neutral in color), which are distinguished best with* EIR *film, and soils with high chroma (soils with high color), which are distinguished easiest with* CC *film. Optical densities measured using red filters discriminated best among low chroma soils, while optical densities obtained with blue filters discriminated best among the high chroma soils.*

DESIGN OF STUDY

Twelve soils of different colors were sampled, oven-dried, and passed through a 2-mm sieve. The particle size distribution of the 2-mm fraction was made according to the Bouyou-

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[3] Use of a Company or Product name by the Department does not imply approval or recommendation of the product to the exclusion of others which may also be suitable.

cos method (1936). Sieved oven-dried soils were placed in 1×11×16-inch black-coated pans, leveled with a straight edge, and the pans with soils were randomly assigned to approximately square blocks of a randomized complete block design. One of the three replications of the 12 soils is depicted in Plate 1. Numbers beneath each soil refer to their numbers and description in Table 1.

A 6-inch space was left between pans in both the horizontal and vertical directions. The pans were placed on an 8×8-foot square of sheetrock that had been painted with non-reflective black paint to remove background interference.

Photographs of the soils were taken at 1157, 1210, and 1228 hours, central standard time, July 23, 1969. The times correspond to replications one, two, and three, respectively. Photographs were taken with two synchronized, tandem-mounted Hasselblad cameras equipped with 50-mm focal length lenses. One camera contained 70-mm *CC* film and the other contained 70-mm *EIR* film. A 15 G filter (approximately 100 percent absorption edge at 500 nanometers) was used with the *EIR* film. Photographs were taken with the camera lenses 12 feet above the soils. Cameras were randomly assigned positions for each replication. Each replication (12 pans of soil) was taken on a single exposure. Exposure for each replication was conducted at three *f*-stops—above, at, and below that indicated by a Weston light meter. The best exposure was selected for each replication for microdensitometry by a consensus of five observers. The films were developed according to Kodak recommendations (1967).

Optical density measurements were made with a Joyce-Loebl microdensitometer using four filters [red (Wratten 92), green (Wratten 93), blue (Wratten 94), and white (optical clear glass)] in random order on each soil sample within each replication (time of exposure) for both *CC* and *EIR* films.

Results and Discussion

The 12 soils are considered below in the following two significantly different ($p=0.05$) groups: (1) seven soils giving the highest optical densities with a red filter placed between the densitometer's light source and *EIR* film transparencies (Figure 1), and (2) five soils giving the highest optical densities with a blue band-pass filter and *CC* film transparencies (Figure 2). For comparative purposes, however, optical density values for *CC* and *EIR* films are included in both Figures 1 and 2.

Differences among soils showing the highest optical densities with a red filter and *EIR* transparencies are portrayed in Figure 2. Values on the ordinate (*y*-axis) are optical densities ($\log_{10}$) (1/transmission); color band pass filters and soil types are given on the X_1 and X_2 axes, respectively. The red filter gave the significantly highest densities ($p=0.05$) for soils 1 to 6 and soil 12 for *EIR* film transparencies compared with the lower densities for the *CC* film transparencies. The soils with the highest densities on *EIR* film arranged from lowest to highest values are

Table 1. Description of Soils Used. Soil Number Corresponds to to those Given in the Soil Photograph, Plate 1

Soil Number	*Soil Series*	*Soil Type*	*Munsell Color*[a] *(dry soil)*		*Location*[b]
1	Reynosa	Silty clay loam	10YR	7/2	L 12 F 2
2	Reynosa	Silty clay loam	10YR	5.5/1	L 12 F 15
3	Harlingen	Clay	10YR	6/2	L 12 F 42
4	Harlingen	Silty clay	10YR	5/2	L 12 F 63
5	Hidalgo	Sandy clay loam	10YR	4/2	L 12 F 66
6	Raymondville	Sandy clay loam	10YR	5/2	L 11 F 4
7	Delmita	Fine sandy loam	7.5YR	4/4	Delmita, Tx.
8	Delmita	Fine sandy loam	5YR	5/6	Delmita, Tx.
9	Delmita	Fine sandy loam	5YR	4/6	Delmita, Tx.
10	McAllen	Fine sandy loam	7.5YR	6/4	E. McCook
11	McAllen	Fine sandy loam	7.5YR	8/2	E. Harlingen Arroyo
12	Romodero	Sandy clay loam	5YR	6/1	La Feria, Tx.

[a] Munsell color data taken from Munsell Soil Color Charts, Munsell Color Company, Inc., 1954 Edition. YR = hue, number preceding / is value (brightness); number following / is chroma (color saturation).

[b] *L* is flight line number; *F* is field number; Delmita soil and those below it in the table are not on a flight line.

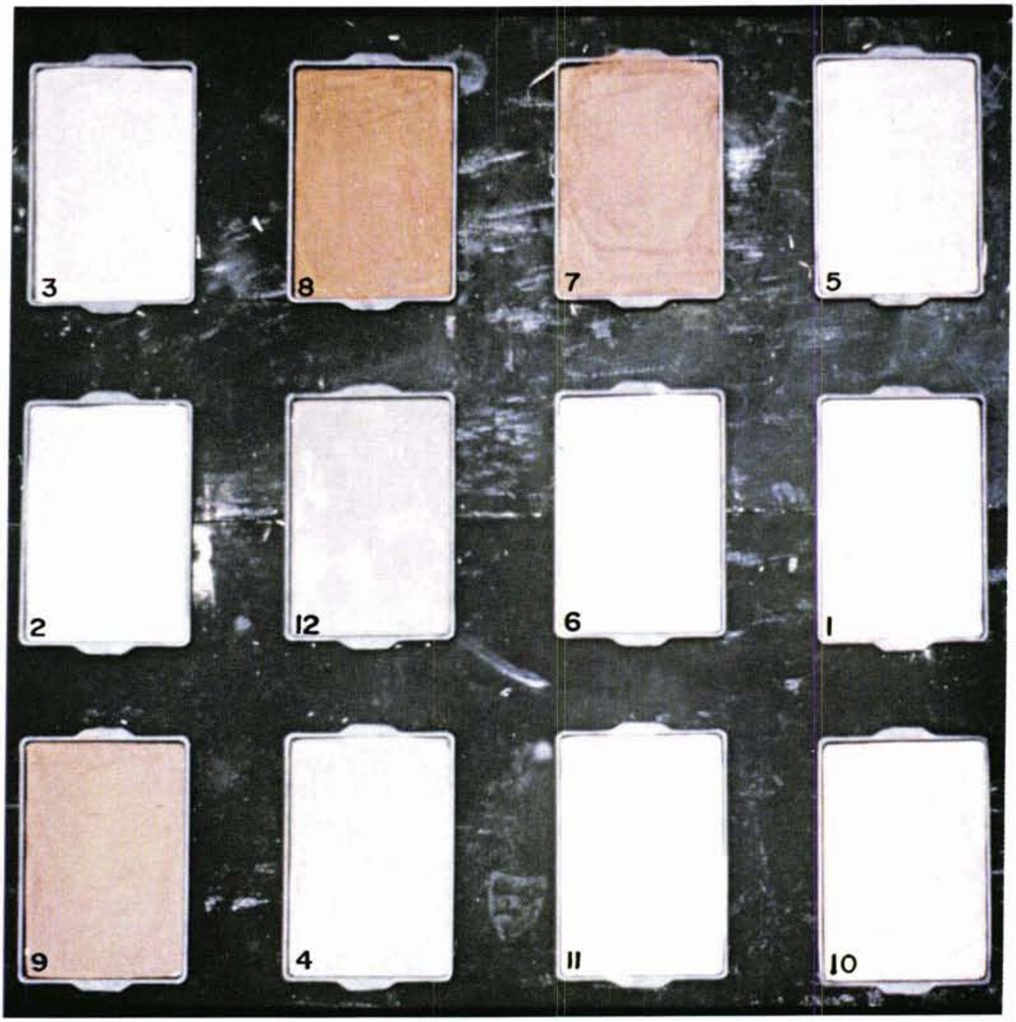

PLATE 1. One replication of the 12 soils showing color differences on *CC* film. Numbers refer to the numbered soil series and types in Table 1 with Munsell color data.

1, 5, 6, 2, 3, 4, and 12. Comparisons (Duncan's multiple range test, $p=0.05$) among soils of mean density values obtained with the red filter indicate that soils 2, 5, and 6 were alike and soils 2, 3, and 6 were alike. All other comparisons among soils were statistically significant. Careful examination indicates that these soils were affected by hue (type of color) or value (brightness). For example, in terms of hue (Table 1), soils 12 and 4 had Munsell hues (color) of 5YR and 10YR, respectively. Soil 12, therefore, was more red than soil 4 (Plate 1), and was better distinguished with *EIR* than with *CC* film. For comparions of values, soils 5 and 1 had comparable Munsell hues of 10YR, but their values (brightness) were 4 and 7, respectively. Soil 5, therefore, was darker than soil 1; it was better distinguished with *EIR* film. Even though these comparisons have been based on hue and value, this group of soils (1 to 6 and 12, Figure 1) had low chroma (color saturation), and they were grey or neutral in color (Plate 1).

Figure 2 shows results for soils giving the highest optical densities with a blue band-pass filter and *CC* film transparencies. In this respect, soils 7, 8, 9, 10, and 11 had significantly ($p=0.05$) higher optical density values for *CC* compared with *EIR* film transparencies. All comparisons among soils using

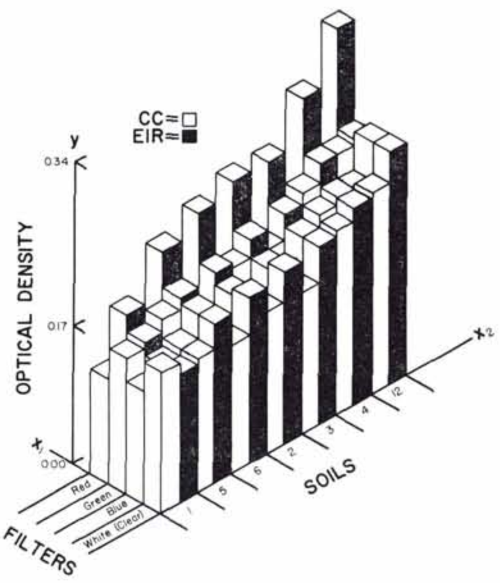

FIG. 1. The optical density for each filter used on both films for the group of seven soils giving the highest optical densities with a red filter placed between the densitometer's light source and Ektachrome Infrared Aero (EIR) Film transparencies.

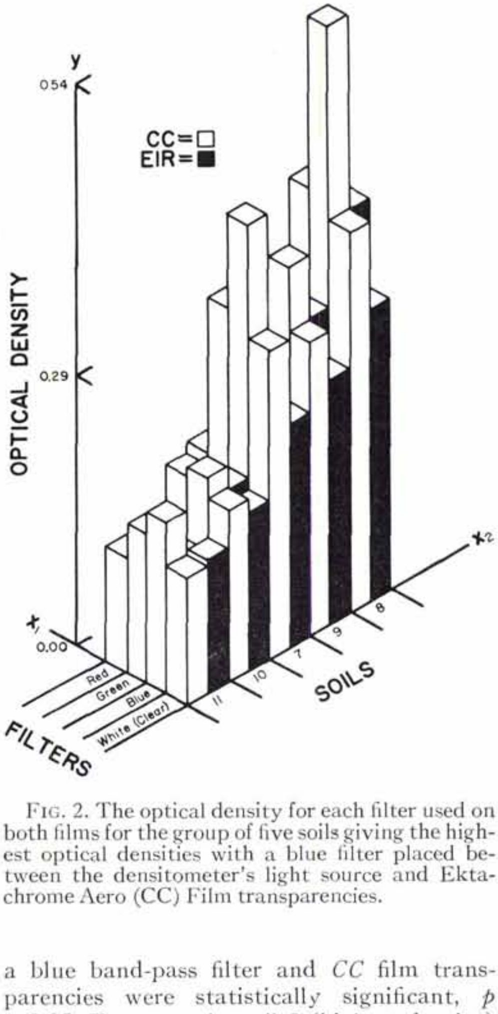

FIG. 2. The optical density for each filter used on both films for the group of five soils giving the highest optical densities with a blue filter placed between the densitometer's light source and Ektachrome Aero (CC) Film transparencies.

a blue band-pass filter and *CC* film transparencies were statistically significant, $p=0.05$. For example, soil 8 (highest density) and soil 11 (lowest density), Table 1, had Munsell hues of 5YR and 7.5YR, and different values of 5 and 8, respectively. Soil 8 was more color saturated (high chroma) than soil 11, (Plate 1), and was best distinguished with *CC* compared with *EIR* film. Soils in this group with high chroma (No. 7 through 10) were best distinguished with *CC* film.

Results for the two films show that the 12 soils considered here can be divided into two groups for soil identification with aerial photographs. First, measurements of optical densities on *EIR* film transparencies using a red band-pass filter are best to distinguish soils with low chroma (soils grey or neutral in color). Secondly, measurements of optical densities on *CC* film transparencies using a blue band-pass filter are best to distinguish soils with a high chroma (soils with a high color). Several soils within each group (*CC* vs. *EIR* film) can be further identified by differences in hues (color) or values (brightness) on the films.

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