Comission nº VII/6
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PHOTO INTERPRETATION OF THE VEGETATION THROUGH DENSITOMETRY

1. ABSTRACT

The photo interpretatives parameters are very subjective, because each photo interpretater has his own criterion. The objective of the present work is to evidence the utilization of the densitometry in the interpretation of vegetation.

In the study, were used aerial color photographs (transparences 23 x 23 cm) in the scale 1:6.000. The utilized color film was the Kodak Ektachrome MS Aerographic Film 2448.

Because of the scale size, was very easy to identify the natural and cultural vegetation. Each type of vegetation was classified by Munsell denotation.

The optical density was measured through a WESTON transmission microdensitometer, model 877. For each type of identified vegetation were made densitometric measurements, for later comparation.

The obtained data were utilized in the evaluation of the importance of densitometric readings. For the utilized photographs, the main conclusions are: a)the densitometric measurements showed best results comparatively with the convencional photo interpretation; b)the utilization of the color infrared film suggests the possibility of an increase in the importance of the densitometric readings.

2. INTRODUCTION

The aerial photography seems to be the only instrument able to represent the forms and special arrangements of the plants, individually or in associations. According to SPURR (1960) the photo interpretation of the vegetation requires basically the knowledge of the most common species of the flora, its representation in aerial photographies and the types of plants that are generally associated with.

In regard to the characteristics of the vegetation, GATES (1970), comments the appearance of the plants and their surfaces - depend upon its interaction with the radiation, being influenced by the geometry of the leaves, morphology, physiology, chemical composition, soil and climate.

According to SIMONTACCHI _et al_. (1955), what is important is the elaboration of classification keyes, which can be of selection or elimination. The selection would be organized in such a way that the photo-interpreter selects the corresponding example to the image that he would be trying to identify. The elimination key is organized in a way that the photo interpreter accompanies a pre-determined sequence, eliminating all the items with the exception of that one which is intended the identification. The method of recognition is in part based on the study of tonality, texture, degree of shadow, form and dimension.

Even if one associates the color to these parameters, the photo interpretative criteria are rather subjective, varying according to the photo interpreter. The optical density in this case is important, since it is a high repetitive parameter.

The instruments that measure the optical density are called densitometers. A transmission densitometer is used to measure the quantity of light that crosses the film, while a reflection densitometer measures the quantity of light that is reflected from the surface of a photographic print (Kodak Company, 1972).

The densitometry has been successfully used by various authors. This way, MANZER and COOPER (1967) stated that it was possible to evaluate the severity of scorching of a potato crop through the densitometric measures in infrared colored transparencies. MURTHA (1969) comments that it was possible to detect physiologic damages in coniferous through the densitometric measures in infrared colored transparencies. JACKSON et al. (1971) obtained a high correlation when they related densitometric measures of a potato crop with different degrees of infestation by scirching, and infestation degrees obtained by pathologist for the same beds, evidencing the utility of this method.

This work intends to emphasize the use of the densitometry as an aid to photo interpretation of the vegetation.

3. MATERIAL AND METHODS

In this study it was used colored aerial photographies (transparencies 23 x 23 cm) in the scale 1:6.000. The colored film used it was KODAK Ektachrome medium speed, reversible, with an excellent definition and a good quality of image. It is used for mapping and reconnaissance for low and medium altitudes.

Since the photographies were in a large scale, it was very easy to identify the crops existing in the area, as well as the natural vegetation. Each category of vegetation was classified by MUNSELL (1966) notation.

The optical density was measured by a WESTON transmission microdensitometer model 877, with 0,8 mm aperture. Figure 1 shows the design of the instrument which was classified by BLANC and al (1966) as being of calibrated answer or direct reading.

For each item identified in the photographies, ten readings of optical density for further comparison were made.

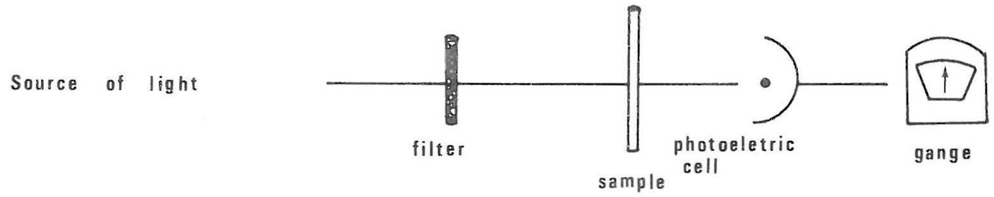

FIGURE 1 — Design of a Transmission densitometer

4. RESULTS AND DISCUSSION

Table 1 shows the results obtained. One can see that both MUNSELL's notation as the characterization of color are not so elucidative as the optical density values, which enable us to separate numerically the different categories of vegetation because these densitometric readings do not originate from a personal criterion, they can be reproduced any time, since perfectly calibrated densitometers are used.

By Table 1 one can also see that there are very close and similar readings as in the case of sugarcane and eucalyptus. This is due to the fact that the plants in the visible region show a low reflectivity not differentiated, growing as the wavelenght increases and showing now in the band belonging to infrared a clear distinction (GATES, 1970). Therefore using colored infrared images as MANZER and COOPER (1967), MURTHA (1969) and JACKSON and al (1971) did, in association with the usual colored pictures, the possibility of photo interpretation significantly increases, mainly when densitometry is used.

It is known that the difficulties of the photo interpretation increase as the photographic scale decreases.

One can say that with the reliability that it offers that the importance of the densiometry increases as the photographic scale decreases.

5. CONCLUSIONS

5.1. The densitometric measures offer more consistent results than the ones obtained by conventional photo interpretation.

5.2. The use of colored infrared film suggests the possibility to amplify the answer to the densitometric readings.

TABLE 1 - Colors and optical density for different types of vegetation

Categories	MUNSELL	Color	Optical density
Deep jungle	5,7 GY 3,6/4,8	Dark green	1,15-1,20
	8,0 GY 2,2/3,6		
Low cerrado	5,7 GY 3,6/4,8	Dark green	1,10
Cleared land	4,8 GY 6,0/5,0	Yellowish green	0,88
	4,8 GY 6,0/5,0	Yellowish green	0,90
Coffee	5,1 G 3,0/8,1	Dark green	1,08
Eucalyptus	5,7 GY 3,6/4,8	Dark green	1,04
Pastures	4,8 GY 6,0/5,0	Dark green	0,96
Sugar-cane	5,7 GY 3,6/4,8	Dark green	1,04

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YIELD ESTIMATES FOR CORN CROP THROUGH THE COLORED INFRARED FILM

1. ABSTRACT

The traditional system of yield forecasting utilizes technical reports from different resources. The collect of informations begins before the planting period and the estimatives are adjusted during the development of the cultures. The present work intends to show the possibilities of the color infrared film in the yield forecasting of the corn. The quantitatives informations was obtained through the transmission density.

The work was conducted in São Manuel Experimental Farm of the Faculdade de Ciências Agronômicas - Campus de Botucatu - UNESP.

The six trials consisted in different manure quantities, with probable yield differences. The culture was photographed with color film (Kodak Ektachrome 64 ASA) and color infrared film (Kodak Ektachrome Infrared Film) and the optical density was measured with a transmission microdensitometer, Weston, 877 model with an aperture of 0,8 mm.

The interaction between Yield and Optical Density was analysed through correlation and linear regression. The analysis of the results led to the following main conclusions:

a) after the necessary calibrations, the color infrared film can be used in the yield forecasting on the corn;

b) the quantitative interpretation of the results, through transmission density, suggest the apllication of this method in other types of cultures.

2. INTRODUCTION

The traditional system for yield estimation make use of technical reports based on information supplied by farmers, rural credit Department of the banks, technical assistance institutions, etc. The data collection begins before the planting time and so the estimates are being adjusted according to the development of the crops. Although more sophisticated the yield estimate through remote sensory has as its main advantage to get the information quickly, besides reducing substantially the data volume. For our present conditions, perhaps an intermediary phase is the use of remote sensory in order to evaluate crop problems in micro regions due to frosts, droughts, floods, pests, diseases, etc.

According to COLWELL (1970) the most simple procedure in this case would be to measure the output per unit area of different parcels and to have these crops related with photogrametric measures.

There are, however, several variables affecting this relationship. GATES (1970) reports that the appearance with radiation and it is influenced by the geometry of the leaves, morphology, physiology chemical composition, soil and climate. SPURR (1960) cites that the "coriaceous" leaves reflect less than the succulent leaves and that among the internal factors affecting the reflection are: variation in the pigmentation; and variation in the epidermis of the leaves. GATES (1970) yet comments that in the visible region the leaves of the different species show a low reflectivity not differentiated, which grows with the wavelenght increase and now showing in the band that belongs to the infrared a clear distinction. This distinction in the infrared region of the specter is due to the quantity of chlorophyll, so that it evidences the use of different types of films additional possibilities to the analyst.

According to FRITZ (1967) Kodak Ektachrome infrared film is suitable among other purposes, for the identification of pests and diseases in forests, orchards and cereal crops; identification of plant species and in the study of the condition of the soil. SCHULTE (1956) comments that the technique employed to photography with infrared film does not differ much from doing so with regular film. However, two steps are necessary to be taken; the first one refers to the use of appropriate lens, since the lens of the conventional cameras are rectified, so that the violet and yellow wavelenghts are both in focus in the same plan. If the camera is not equipped with a rectifying device which is proper for infrared films an approximate rectification must be made, varying the focal distance in 0,25%. The second refers to the use of filters and as is recommended by Kodak Company (1972) a yellow (wratten no. 12) must be necessarily used. Such filter blocks the blue light in such a way that only green, red and infrared reach the emulsion. NORMAN and FRITZ (1965), MEYER and FRENCH (1967), MEYER and COLPOUZOS (1968), PHILPOTTS and WALLEN (1969) using the colored infrared film obtained consistent results in the detection of diseases in different plant species. GARCIA and MARCHETTI (1976) report the relevance of the information obtained through the use of a colored infrared film in the early diagnosis of the defficiency of nitrogen in the tomato plants. Three treatments duly repeated became the differential doses of nitrogen. At 30, 50 and 70 days after the transplant, colored and infrared photographies of each parcel were obtained at the same time, this way one could conclude that the colored infrared film registered with approximately 15 days ahead of time the plants that would further show visual symptoms of difficiency.

Although the relevance of the infrared film is evidenced, the qualitative interpretation of the photographies suggests the need for numerical data, which are able to be obtained through densitometers,which measure the optical density. According to KODAK Company (1972), the transmission densitometer is used to measure the quantity of light that crosses the film, while the reflection densitometer measures the light that is reflected from the surface of a color print.

The densitometry has been used successifully by several authors. MANZER and COOPER (1967) report that it was possible to evaluate the severity of the sequence in a potato crop through the densitometric measures in colored infrared transfers, MURTHA (1969) comments that it was possible to detect photographies, too. VACKSON et al

(1971) obtained a high correlation when they related densitometric measures of a potato crop with different degrees of infestation obtained by pathologists for the same parcels in the field, so that the utility of this method was evident.

This present work intends to show the yield estimates for corn crop. In this case, the conventional colored film is the witness itself. The qualitative data should be obtained by transmission densitometry.

3. MATERIAL AND METHODS

3.1. Material

The work was conducted in São Manuel Experimental Farm of the Faculdade de Ciências Agronômicas - Botucatu, Campus of the São Paulo State University "Julio de Mesquita Filho".

The variety of corn planted it was HMD 7974 screen no. 20, in dark red latosol - sandy phase.

The six trials consisted of differential doses of fertilizers for the purpose of evidencing differences in the output already found in previous trials in the corn crop. Each trial was made out of four repetitions with 60 m^2 each.

In order to obtain the photographies two cameras Exacta Varex with 50 mm Tessar lens, were used. One of the cameras had a color film and the other one an infrared one together with a Kodak filter wratten no. 12. The films that were used are commercially produced by Eastman Kodak Company. The colored film used it was Kodak Ektachrome 64 ASA and the infrared one it was Kodak Ektachrome infrared, both in 35 mm. The platform used it was as singlemotor airplane Paulistinha Type belonging to Botucatu Air Club.

The optical density was measured by a Weston Transmission micro densitometer 877 model, 0,8 mm aperture and source of light of 50w.

3.2. Method

90 Days after the sowing, a flight over this site was made when the trial with the two different types of films was photographed. The most suitable height of the flight was already known and it was

approximately 130 meters (400 feet). The photographies were taken at 10:00 hours and 10:30 hours always from the same angle.

After the films were developed they were analyzed in the micro densitometer duly calibrated. Sento puntual (sic) was able to carry out several densitometric readings each 60 m^2 repetition in such a way that the final reading represented the average of the various partial readings.

To evaluate the interaction between production and optical density the analysis of correlation and linear regression for each film was used. The relevance of the correlation and angular coefficients were obtained by the application of tests "F" and "t", respectively. For the statistical analysis PIMENTEL GOMES's (1970) observations were observed.

4. RESULTS AND DISCUSSION

The output values by trial and parcel for each film, as well as the respective readings of optical density are shown in TABLE 1. The results concerning the correlation and regression analysis are found in TABLE 2, which the respective adjusted straight lines are found in TABLE 1.

For the colored infrared film the correlation coefficient was 0,86 with the significance level of 1% of probability. By regression the equation $y = 0{,}4894 + 0{,}0682x$ with significant angular coefficient at the level of 1% of probability, was obtained.

For the conventional colored film the correlation coefficient was of 0,77 with the significance level of 1% of probability. By regression, the equation $y = 0{,}8212 + 0{,}223x$ with the significant angular coefficient at the level of 1% of probability, was obtained.

In regard to the regression analysis, although in both the angular coefficients are significative one can see by TABLE 1 that there is an interdependence of data for the colored infrared film.

Analysis made with a small number of data and the least amplitude of variation were significant for the colored infrared film and not significant for the regular colored film so evidencing the superiority of the former.

TABLE 1 - Corn output and optical density of the colored and colored infrared films.

Trial	Parcels	Output (kg)	Optical Density	
			Infrared	Colored
0	1	8,00	1,02	1,00
	2	7,50	1,00	0,96
	3	8,80	1,02	1,02
	4	9,60	9,60	1,02
1	1	10,00	1,19	1,04
	2	11,50	1,22	1,08
	3	9,80	1,18	0,98
	4	9,30	1,15	1,04
2	1	9,50	1,14	1,00
	2	9,80	1,16	1,04
	3	10,00	1,16	1,02
	4	8,80	1,12	1,00
3	1	9,20	1,10	1,01
	2	9,00	1,10	1,01
	3	8,70	0,90	1,00
	4	9,70	1,20	1,03
4	1	10,50	1,26	1,10
	2	10,40	1,24	1,09
	3	9,80	1,23	1,09
	4	10,30	1,24	1,08
5	1	6,50	0,95	1,00
	2	7,00	0,98	0,98
	3	6,00	0,94	0,97
	4	6,90	0,97	0,98

TABLE 2 - Correlation and regression analysis between corn output by parcel and respective optical densities

Type of Film						
Colored infrared	0,4894	0,0682	0,8641**	0,7467	8,0636*	64,8612
Colored	0,8212	0,0223	0,7656**	0,5861	5,5823*	31,1623

** Significance at the level of 1% of probability

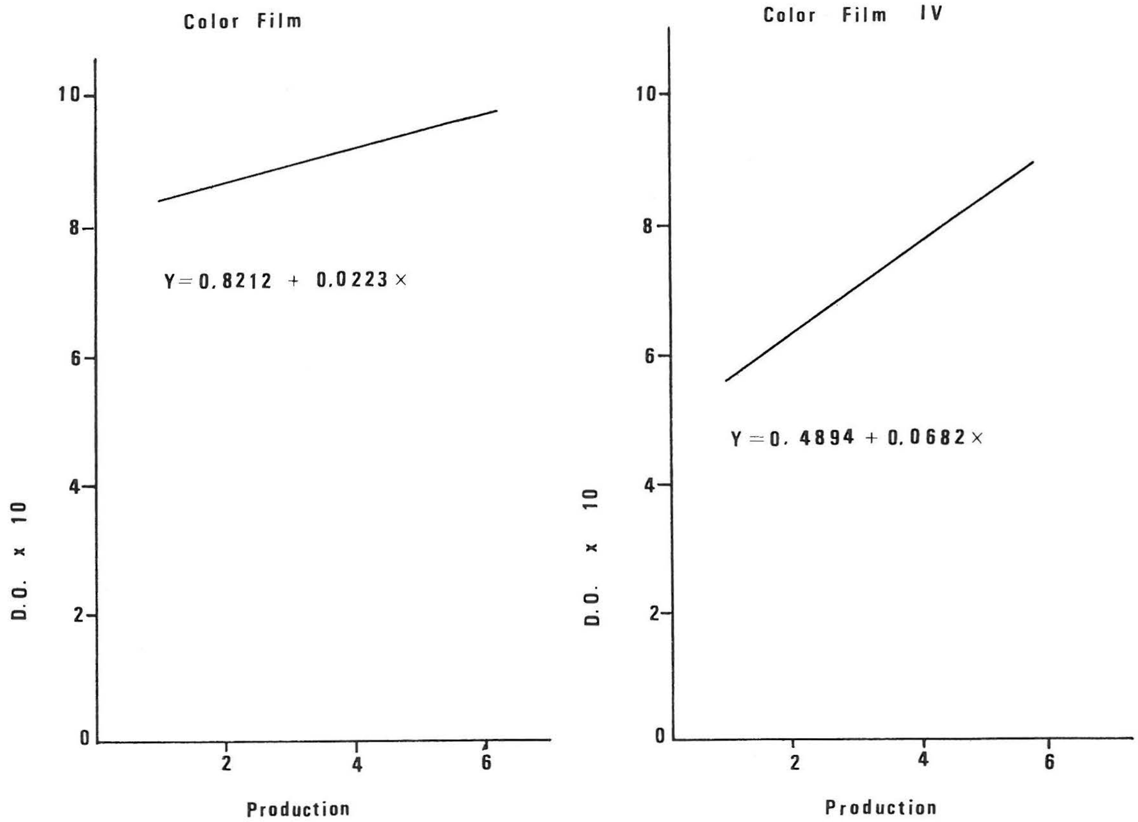

FIGURE 1 - Regration between production and optical density of color and infrared films

The results obtained concur with GATES (1970) in what it concerns the greater sensibility of the measures taken in the infrared region of the specter.

Specifically as to the use of the transmission densitometry this method proved valid concurring with MANZER and COOPER (1967), MURTHA (1969) and VACKSON et al. (1971), although these have studied plant diseases. However in both situations, the nutritional umbalances are present, which allow differentiations in the spectral register in different types of films. This way duly calibrated the densitometers can furnish highly repetitively values avoiding results outcoming from personal criterion.

5. CONCLUSIONS

In regard to the conditions studied one can come the following conclusions:

a) Since the necessaru calibrations are made the infrared film can be used in the yield estimated for corn crop.

b) The use of transmission densitometer for the quantitative interpretation of the results was important and it suggested the application of this method in other crops.

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