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OPTICAL CHARACTERISTICS OF TROPICAL TREE-LEAVES

I. ANDIROBA (Carapa guianensis Aubl.) (*)

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The tree

Carapa guianensis Aubl. (Meliaceae), known all over Amazonia as Andiroba (U.S.A. : Brazilian Mahogany), is exploited because of its first-class lumber and the oil complex of its seeds. Phenotypically the tree is characterized by the outstanding size and pattern of its leaves. Andiroba has compound leaves with up to 19 opposite leaflets each, the latter being 10 to 60 cm in length and 5 to 30 cm in width. Detailed information about Andiroba is given in references Le Cointe (1947) and Loureiro + Freitas da Silva (1968).

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The site

At Reserva Florestal Ducke, a forest pilot scheme of the Instituto Nacional de Pesquisas da Amazônia, (I.N.P.A.), located at km 26 of the Manaus-Itacoatiara Road (AM-010) a 6-year-old Andiroba plantation was chosen for study. The site is approximately north exposed, i.e. insolation is lightly reduced. Soils are of the yellow latosolic complex. Vegetation cover was cut in advance of planting. Some general stand characteristics as stem height and stem diameter (DBH) are presented in figure 1.

Sampling

In 1969 almost every 3 months 20 Andiroba leaves, i.e. about 270 leaflets respectively, were collected, following general sampling principles. Young leaves (present growing period) and old leaves (earlier growing periods) were discriminated, matching Munsell Color Charts for Plant Tissue and according to personal experiences. Likewise sun-leaves and shadow-leaves were separated. All leaves were grouped after sampling, put carefully into nylonnet bags moistened and brought to the laboratory for study. Time delay was in the order of 2 hours at the maximum.

General comments

Structure, thickness, water content, exposure, chlorophyll and other color pigments cause a considerable individuality in leaf absorption, reflection and transmittancy pattern. Statistically this problem was solved by a great experimental data population. As stated by Dirmhirn (1964), the water content deviation in leaves influences transmittancy. Therefore the decrease of water content during transport was given fullest consideration. But laboratory as well as field study (portable battery-fed equipment) showed only little water loss during the first two hours. So no correction was carried out.

Although terrestrial plants are affected by radiation of wavelenths between 2 900 A and 100 000 A , the present study was undertaken at a spectral range from 3 500 A to 7 200 A approximately, i. e. the entire visible electromagnetic radiation spectrum including the chlorophyll absorption bands (see fig. 2).

As total incoming radiation is equal to total reflection (direct and scattered reflection) plus absorption plus transmittancy (scattered transmittancy) all members of the ratio were determined separately in per cent and plotted against total radiation input as 100 per cent.

Following the procedure stated above, 400 young and old leaflets were studied, i.e. 2 400 readings as a total.

Direct reflection (gloss)

Method

The direct reflection of Andiroba leaflets was studied by means of a gloss meter (120^{o} angle) and two colored glass filters (Schott-filter : VG 9 (range 4 420 A to 6 440 A); RG 2 (range 6 000 A to 7 500 A), th = 1 mm) over a black, polished glass standard (see fig. 2). The standard was calibrated to the scattered reflection normal stated below. Readings were done on a highly sensitive galvanometer.

Results

Mean gloss and standard deviation, considering normal light beam (normal), green (VG 9) and red (RG 2) filtered light, were calculated for young and old leaflets on both sides. The data are presented in table 1.

These data justify the following conclusions :

1.) Normal and spectral direct reflection of old and young leaflets on both sides is quite low.

2.) Normal and spectral direct reflection of old leaflets is fairly higher (about 5 to 10 %) than that of young leaflets considering both sides.

3.) Normal and spectral direct reflection of old and young leaflets (upper side) is considerably higher (about 25 to 30%) than that of young and old leaflets (lower side)

Scattered reflection

Method

Scattered reflection was recorded operating a reflection meter and a set of 2 colored glass filters (VG 9, RG 2, th = 1 mm) over a 99 % magnesia-white normal (see fig. 2). Readings were taken of a highly sensitive galvanometer.

Results

Mean scattered reflection and standard deviation regarding normal light beam (normal), green (VG 9) and red (RG 2) filtered light were computed for young and old leaflets on both sides. Data, given in table 2, may allow the subsequent statements :

1. Normal and spectral scattered reflection of old and young leaflets on both sides is considerably high.

2.) Red scattered reflection of old and young leaflets on both sides exceeds normal and green diffuse reflection (about 10 %).

3.) Normal and spectral scattered reflection of old leaflets is remarkably lower (about 20 to 30 %) than that of young leaflets on both sides.

4.) Normal and spectral scattered reflection of young and old leaflets (upper side) is much lower (about 25 to 35 %) than that of young and old leaflets (lower side).

Transmittancy

Method

Transmittancy was determined operating a reflection meter and 2 colored glass filters (VG 9; RG 2; th = 1 mm) over a white and black polished glass standard alternately. (see fig. 2). Extracting the root of the contrast, i.e. the difference of white and black standard values, and multiplying the result with 10, renders the computation of transmittancy.

Results

Mean transmittancy and standard deviation, regarding normal light beam (normal), green (VG 9) and red (RG 2) filtered light, were calculated for young and old leaflets on both sides. According to the data of table 3 it may be admitted that:

1.) Normal and spectral transmittancy of old leaflets is remarkably lower (about 35 to 50 %) than that of young leaflets on both sides.

2.) Red transmittancy of old and young leaflets is dominant on both sides over normal and green transmittancy. (about 10 %)

3.) Normal and spectral transmittancy of old and young leaflets (upper side) is similar to that of old and young leaflets (lower side).

Absorption

Method

Absorption was computed by the ratio:
Incoming radiation (100 %) = total reflection (direct and scattered) + absorption + transmittancy (scattered)

Results

The mean leaf absorption considering normal and spectral conditions (see fig. 2) for young and old leaflets on both sides is presented in table 4. Interpreting these data, the results are as follows :

1.) Normal and spectral absorption of old leaflets is higher (about 40 to 60 %) than that of young leaflets on both sides with a lower side absorption minimum at red-absorption.

2.) Normal and spectral absorption of old and young leaflets (upper side) is fairly higher (about 35 %) than that of old and young leaflets (lower side).

Conclusions

As shown above, direct reflection is rather negligible as an environmental factor. Transmittancy, although being an important factor in plant physiology, will but slightly increase the multiple reflection of the stand, occuring at wavelengths of about 6 000 A to 7 200 A (see fig. 2, tab. 3). Therefore, scattered reflection and absorption both closely interrelated, are the most important optical stand factors of an Andiroba plantation. While absorption, at wavelengths from 4 500 A to 6 000 A, is remarkably high (see tab. 4), the spectral range between 6 000 A and 7 200 A however, shows a considerable absorption lack, corresponding to the maximum scattered reflection values (see tab. 2).

With reference to Andiroba seedlings, high scattered reflection of young leaflets and high lower side reflection rates allow a deliberate site selection, if the best soil color reflection group is chosen (Brinkmann, 1970 b). The specific leaf-surface reduction system of Andiroba under full sun exposure will be of great additional help. On the other hand, increment of an Andiroba stand can be influenced by providing best scattered reflection-absorption conditions all over the stand, if only no vital plant growth factors are lacking.

Abstract

As incoming total radiation equals total reflection (direct and scattered) plus absorption plus transmittancy, all members of the ratio were calculated for both sides of Andiroba-leaflets with respect to different spectral conditions at wave-lengths from 3 500 A to 7 200 A approximately. The results can be summarized as follows :

1.) Direct reflection rates are negligible.

2.) Transmittancy, although important, is remarkably shadowed by multiple scattered reflection under natural conditions.

3.) Scattered reflection and absorption are the dominant optical stand factors.

4.) Scattered reflection and absorption data can be useful in plantation site selection.

RESUMO

Foi determinada a radiação total e os seus componentes : reflexão total (direta e difusa), absorção e tranmitância. Considerando a radiação total igual a 100%, cada um dos seus componentes foi avaliado em percentual do total, tendo sido feitas determinações em ambas as faces das folhas de Andiroba, considerando-se diferentes condições espectrais entre 3.500 e 7.200 Angstroms aproximadamente.

Os resultados podem ser resumidos como segue :

1 — Os valores da refleção direta são insignificantes.

2 — A transmitância, apesar de importante, é obscurecida pela reflexão difusa nas condições naturais.

3 — A reflexão difusa e a absorção são os fatores dominantes.

4 — O estudo da reflexão difusa e da absorção pode ser útil na seleção de locais para plantio.

References

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old leaflets

	upper side			lower side		
	normal	VG 9	RG 2	normal	VG 9	RG 2
mean (%)	3.0	2.9	3.6	2.4	1.7	2.9
standard deviation	0.96	0 74	0.73	0.52	0.96	0.50

young leaflets

	upper side			lower side		
	normal	VG 9	RG 2	normal	VG 9	RG 2
mean (%)	2.7	2.8	3.3	2.2	1.6	2.5
standard deviation	1.02	0.73	0.69	0.48	1.70	0.44

Tab. 1 Mean gloss and standard deviation of young and old Andiroba-leaflets on both sides with respect to different spectral conditions (size of sample = 800).

old leaflets

	upper side			lower side		
	normal	VG 9	RG 2	normal	VG 9	RG 2
mean (%)	26.4	19.4	35.4	39.9	34.1	45.2
standard deviation	2,14	0.31	0.44	1.92	0.77	0 94

young leaflets

	upper side			lower side		
	normal	VG 9	RG 2	normal	VG 9	RG 2
mean (%)	36.4	30.1	46.7	48.3	43.5	57.8
standard deviation	0.54	1.44	0.22	1.44	1.14	0.44

Tab. 2 Mean scattered reflection and standard deviation for young and old Andiroba-leaflets on both sides with reference to different spectral conditions (size of sample = 800).

old leaflets

	upper side			lower side		
	normal	VG 9	RG 2	normal	VG 9	RG 2
mean (%)	13.4	8.9	20.9	14.1	9.4	20.0
standard deviation	0.82	0.54	0.68	1.62	1.42	0.86

young leaflets

	upper side			lower side		
	normal	VG 9	RG 2	normal	VG 9	RG 2
mean (%)	18.1	14.8	26.0	18.1	13.4	25.8
standard deviation	0.64	0.48	0.65	1.70	1.60	0.54

Tab. 3 Mean transmittancy and standard deviation of young and old Andiroba-leaflets on both sides with respect to different spectral conditions (size of sample = 800)

	old leaflets					
	upper side			lower side		
	normal	VG 9	RG 2	normal	VG 9	RG 2
mean (%)	57.8	78.8	40.1	43.6	54.8	31.9
	young leaflets					
	upper side			lower side		
	normal	VG 9	RG 2	normal	VG 9	RG 2
mean (%)	42.8	52.3	24.0	31.4	41.5	13.9

Tab. 4 Mean absorption rates of young and old leaflets on both sides with regard to different spectral conditions.

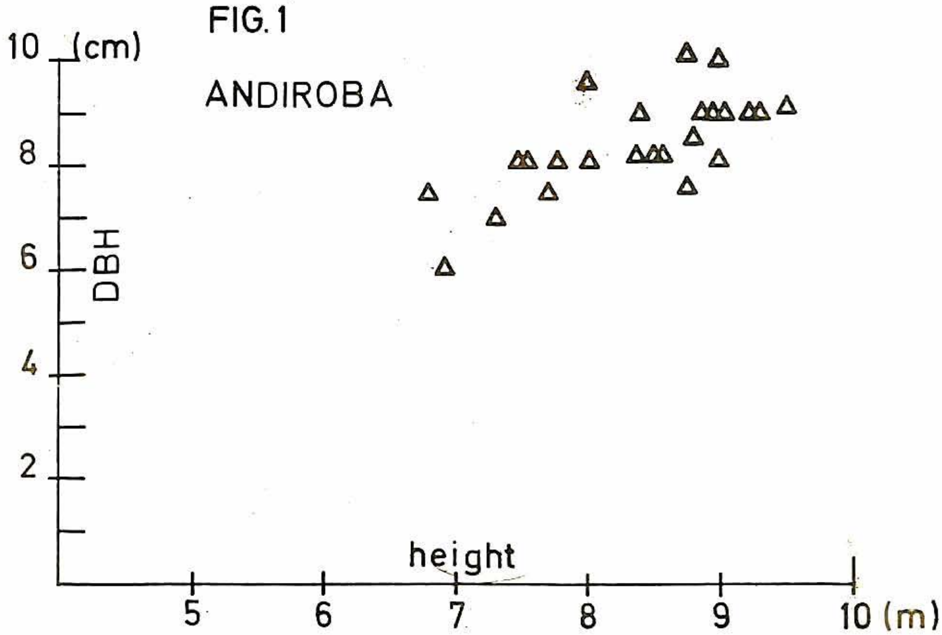

Fig. 1 Height/DBH (diameter breast high) relation of an Andiroba stand at Reserva Florestal Ducke (Data obtained from : Centro Pesquisas Florestais — I.N.P.A.)

FIG. 2

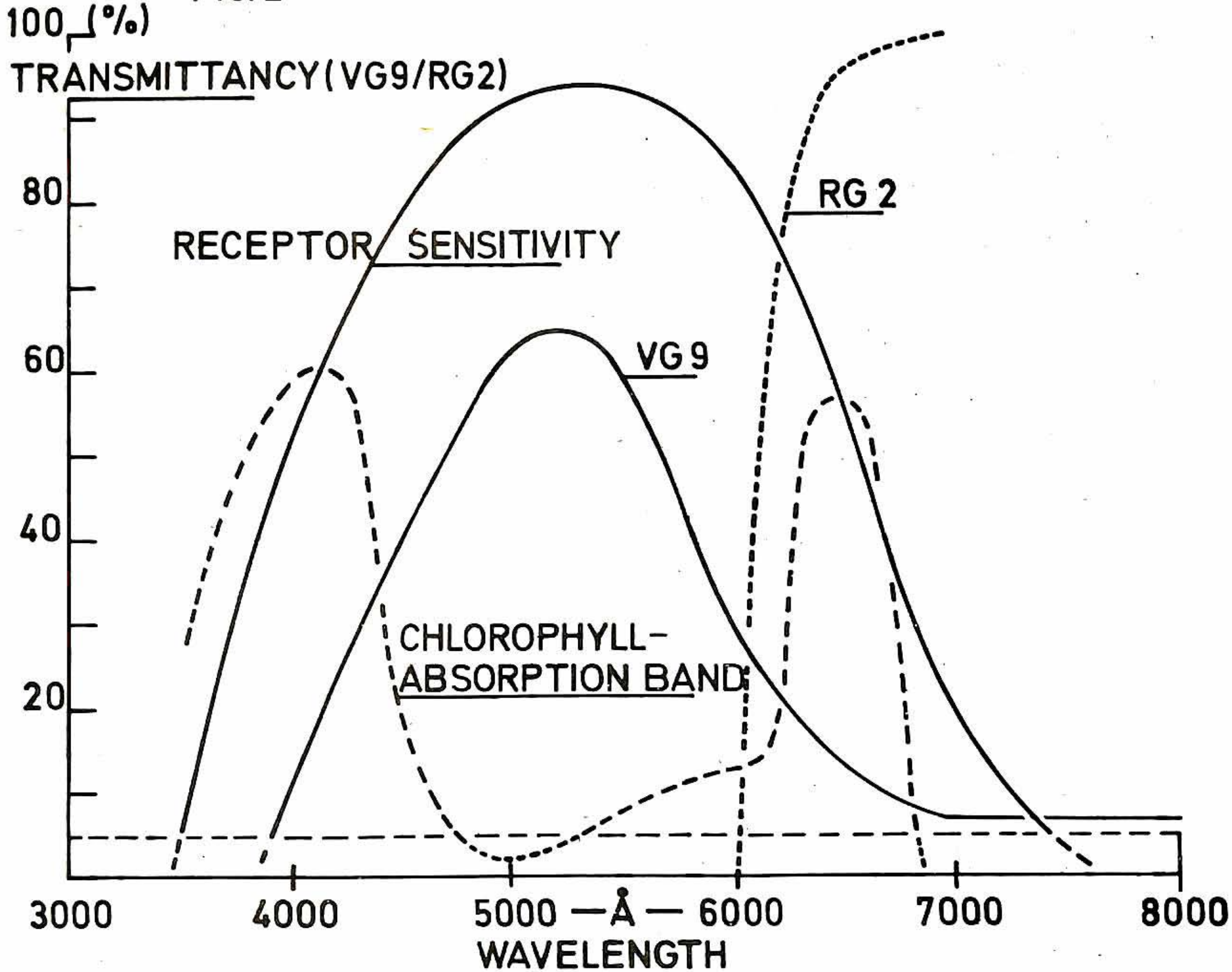

Fig. 2 Receptor sensitivity, chlorophyll absorption bands 1) and transmittancy curves of Schott-filt VG 9 and RG 2 (data from: 1) Dirmhirn, 1964, 2) Farb-und Filterglas, Schott & Gen., M Germany, 1962).

NOTA

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