Distribution of the incident light intensities on over the apple-fruit surface during some days of its growing period in the orchard

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INTRODUCTION

The present author in his earlier publications (ref. 1 and 5) has described a model of the ascorbic acid distribution in the apple-fruit, and then defined a relationship (ref. 2) existing between the distribution gradient of ascorbic acid and the penetration rate of the ascorbinogenic rays coming into the fruit. The relationship between the irradiance intensities and the efficiencies of the ascorbic acid synthesis in apple tissues seems to be even supported by the known fact, that the more irradiated fruit side is normally richer in ascorbic acid while comparing with the other sides, and especially with the opposite side to the first one.

To define more exactly the irradiance intensity distribution on over the fruit surface during its last growing period, special measurements were achieved by the present author and the results are presented in this paper.

METHODS

An apple-fruit, immovably suspended during its growing period on the tree, is — as it is known — periodically irradiated by the sun rays, which incident on it with altering angle degrees, and with the seasonal limit changes. Therefore such a fruit will be taken here analogically as the globe sphere was taken by the astronomers some centuries ago, before the Copernicus time. An apple-globe standard model, covered by the net of meridians and parallels of latitude, is presented on the Fig. 1. As it is seen, both: „southern", and „northern" meridians were in their middles (that is in the points, where the equator-line passes) joined by the so called „diametral line of the apple-fruit", a line being the mean mark in the present author's studies on the ascorbic acid distribution, and this mark was ofted utilized in his earlier reports.

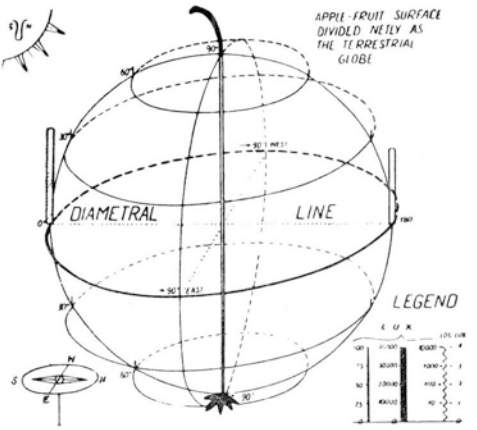
APPLE-FRUIT SURFACE
DIVIDED NETLY AS
THE TERRESTRIAL
GLOBE
DIAMETRAL
LINE
LEGEND
LUX

Fig. 1

Phot. 1

On such an adopted net were introduced the results of the irradiance intensity measurements, which are achieved by means of the photometer „Metrafot-2" (Number 108059, produced by the Metrawatt AG, Nuremberg-German Federal Republic) in the Polish Central Pomological Orchard at Skierniewice, that is in the locality having the following characteristics: $\varphi = 52°$, $\lambda = 20°$, $h = 130$ m.

The photometer was installed on the stand 1 meter high, remote from the neighbour trees on the standard distance (Phot. 1). The horizontality was insured by the libella, the inclination angle by a goniometer, and the orientation towards the cardinal points of the ceiling by a compass. All measurements were achieved with the opalescent screen put upon the photometer, evening even with the amplificator put.

The measurements were achieved in 1960 during the period comprising two last months of growing of the apple-fruits on the trees, that is when the fruit size is yet almost analogous to this in the date of picking. During this period, different kinds of weather were taken into consideration. The measurement terms (during the „Polish summer time") were mots often chosen as follow:

at morning: 9 o'oclock (moderate irradiance)

at noon: 12,30 o'clock (much intensive irradiance)

at evening: 19 o'clock (before the sun set- a very little irradiance intensity)

Figures, representing the distribution of the irradiance intensities, show the measurement terms in GMT units, that is after the deduction of 2 hours from the measurement terms in September, or only 1 hour from the measurement terms in October.

RESULTS

Results are presented * in lux units, or in the logarithms of them on the figures $2 \div 10$. Figures: 2, 3, 4 are showing the distribution of the incident light intensities when the sky was cloudy, namely in the mornings of Sept. 21^{th}, and Sept. 29^{th}, and in the noon of Oct. 8^{th}. Figures 5, 6, 7 show this distribution for the three terms of Sept. 14^{th}, when the sky was blue: in the morning, in the noon, and before the sun set. The logarithms of irradiance levels for the corresponding apple-meridians during the Sept. 14^{th}, 1960 are presented in two figures: Fig. 8-representing results lengthwise the northern meridians, and Fig. 9-lengthwise the southern ones.

Such a logarithmic presentation of results was necessary for the comparison of all measurements achieved within one day on one figure,

* For the legend see again Fig. 1.

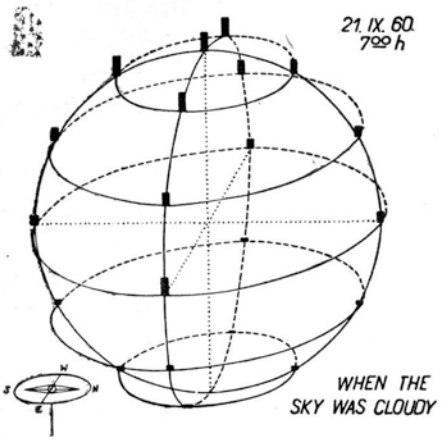

Fig. 2

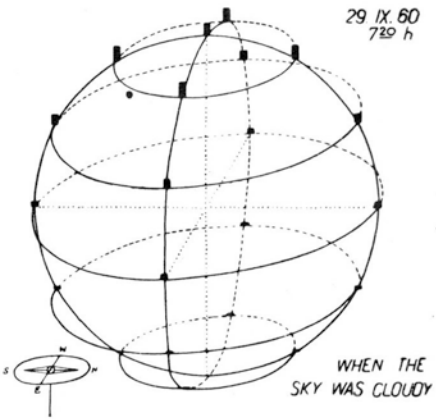

Fig. 3

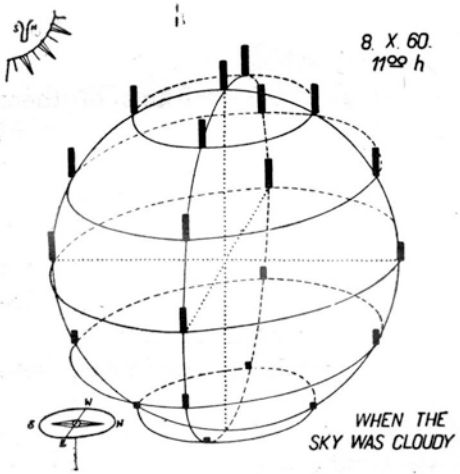

Fig. 4

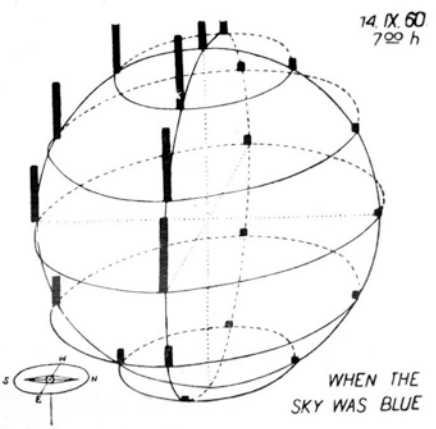

Fig. 5

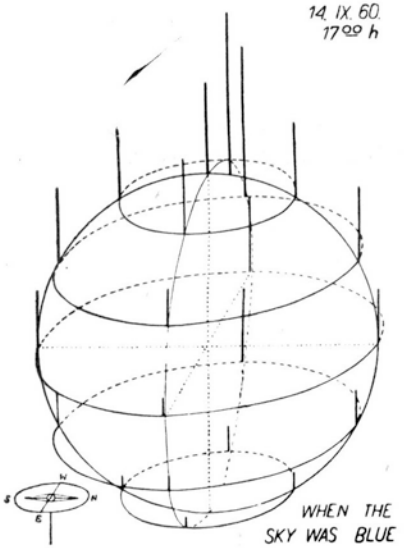

Fig. 6

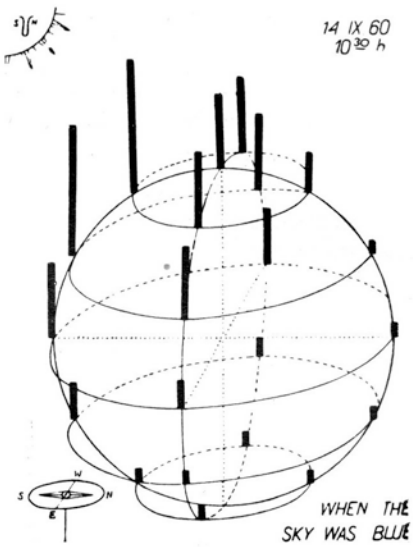

Fig. 7

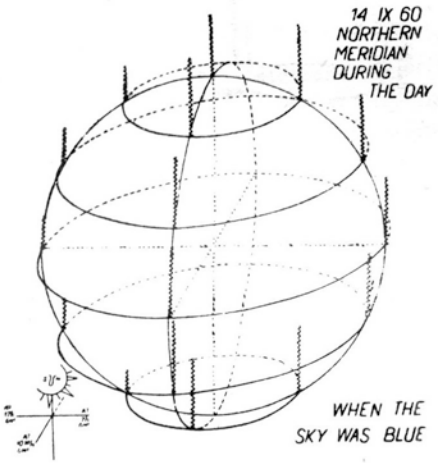

Fig. 8

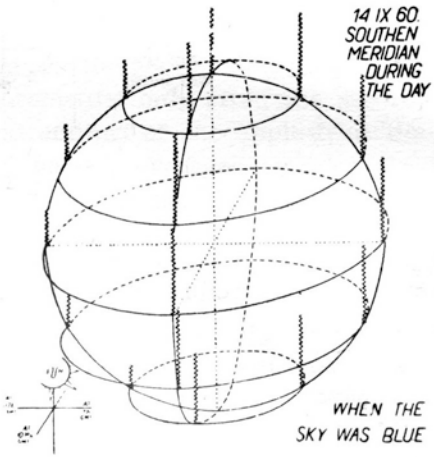

Fig. 9

included the results obtained just before the sun set, which are relatively very low.

It is to remark, that in the evening, before the sun set (see Fig. 7 for the evening Sept. 14th, 1960), the greater incident light intensities are localised in the topic zone of the sphere. It derives from the fact, that the dispersed light comes from the zenithal sky zone. It is visible in some other figures too, that the topic zone of apple is relatively stronger irradiated. This zone — corresponding in the nature to the

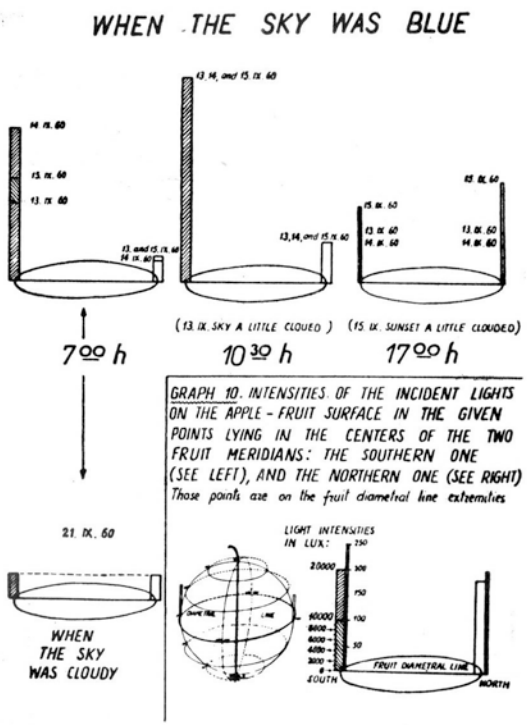

Fig. 10

apple stalk position — is generally covered with the branch and the leaves and therefore in practice some correction should be introduced here.

The most interesting is the distribution model of the light irradiance on over the both extremities of the apple-fruit diametral line, and namely for the interpretation of the irradiance ratio between the two extreme line points: the southern one (left), and the northern one (right); see Fig. 10.

DISCUSSION

As it is shown on Fig. 10, the intensity ratio between the two opposite fruit sides (namely between the „southern" and the „northern" one) is not so big, as it could seem without measurements. Only when the sky is blue, the ratio is important, but even in such a weather at evening the ratio diminishes, and can be sometimes even converted (so that the irradiance levels lengthwise the southern meridian are lower than those lengthwise the northern one).

When comparing the ratios found in this study with the level ratios of the ascorbic acid content in apple-fruit lengthwise the fruit diametral line on its southern (continuous line) run, and northern one (broken line), a strong similarity is obvious. Fig. 11 represents the average

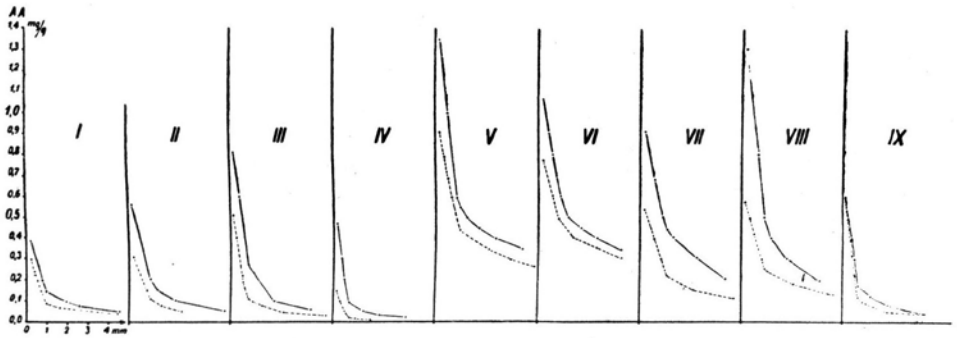

Fig. 11

data for the nine apple varieties from an earlier work (ref. 3) of the present author and his co-worker. The incident light intensity ratios were there deduced (without any measurements) only from the ascorbic acid distribution in the two opposite extremities of the apple-fruit diameter line, and are in average 63%. All variety averages are comprised between the two following values: 32% (for the Kitajka variety), and 100% (for the Starking variety).

The irradiance measurements included only the visual sun spectrum. It can be defined by the spectrogram presented on Fig. 12 (M i c h a r d R. 1960, Personal communication in November 7th), valid for the upper atmospheric zone of globe, that is excluding any interference caused by the ray absorption in the atmosphere of earth.

When the sun target approaches to the horison line, the sun rays must penetrate thicker zone of atmosphere, and therefore the target is submitted to some discolouration phenomenons presented in Fig. 13

(for the irradiance measurements achieved in Skierniewice). As it is known, the red light is the most transparent one, and finally the target seems to be red. In an earlier report of the present author and his co-worker (ref. 4) data were presented concerning the transparence of the different apple-tissues to the sun spectrum rays, with a conclusion that the red rays are penetrating best through the parenchyme layers,

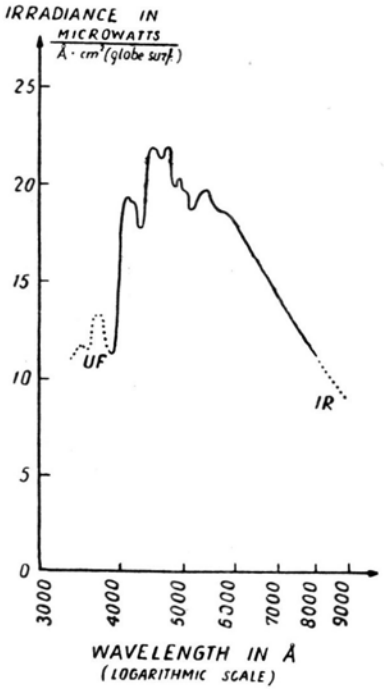

Fig. 12

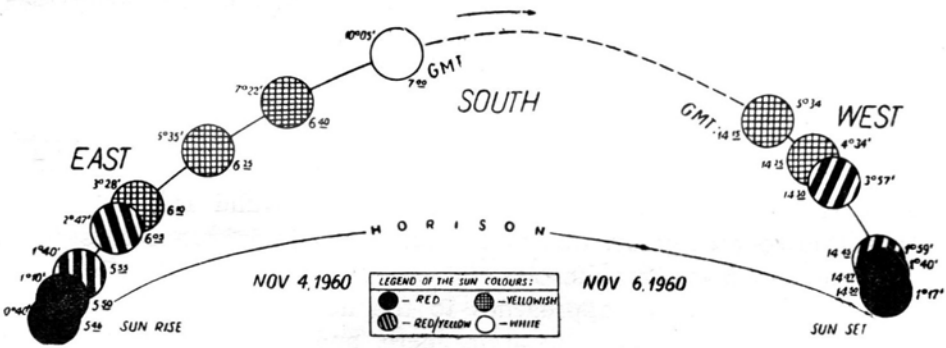

Fig. 13

and almost exclusively through the red coloured skin, which occures normally where the bigest is the incident light intensity.

Therefore it is very comprehensible why the red rays could be considered as the most important in the activation of the ascorbic acid biosynthesis in plants, and that the plants, which grow in mountains or under the greater geographical latitudes — both factors favouring greater red rays participation in the incident sun light — are generally considered as being relatively richer in ascorbic acid content.

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STRESZCZENIE

Określono rozkład natężeń irradiacji słonecznej na powierzchni modelowego jabłka w warunkach sadu jabłoniowego w czasie ostatnich miesięcy przed zbiorem. Wskazania luxometru — orientowanego zarówno w płaszczyźnie pionowej (kątomierzem), jak i poziomej (wobec róży wiatrów) — pozwoliły na wykreślenie typowych konfiguracji poziomów świateł padających jako funkcji pory dnia przy różnych pogodach: słonecznej i pełnym zachmurzeniu.

Relacja sumarycznych intensywności natężeń świateł padających na szczyty tzw. „linii średnicowej jabłka" (linii N—S), wykazuje podobieństwa rzędu wielkości do relacji poziomów zawartości kwasu askorbinowego w odnośnych rejonach owocu, tzn. relacji jaka została już określona dla dziewięciu odmian jabłek w poprzedniej pracy autora i wsp.

Dyskutowane jest znaczenie promieni czerwonych w biosyntezie kwasu askorbinowego z uwagi na ich specyficzne właściwości przenikania.

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