INFLUENCE OF THE PHOTOSYNTHETICALLY ACTIVE RADIATION ON CROPS IN THE ROMANIAN COASTAL ZONE

INFLUENȚA RADIAȚIEI ACTIVE FOTOSINTETICE ASUPRA CULTURILOR AGRICOLE ÎN ZONA LITORALULUI ROMÂNESC

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Abstract: *Photosynthetically active radiation represents an ecological basis for determining the distribution of plants and favourable areas to different crops. The aim of this paper is to observe the direct influence of radiation on the development of crops. We used data on 25 years and calculation methods for the statistical knowledge of radiation and its distribution to specific hours. Here were performed on measurements of solar direct radiation and diffuse solar radiation, then we calculated the photosynthetically active radiation on basis of which we managed to make some estimation on the amount of energy that occurs in costal areas, how it is distributed over a period of one year and certain times characteristic. In this way we manage to make a concordance between the distribution of photosynthetically active radiation and the vegetation period of crops.*

Rezumat: *Radiația activă fotosintetică reprezintă un factor ecologic de bază care determină distribuția plantelor şi zonele favorabile pentru diferite culture. Scopul acestei lucrări este acela de a observa influența directă a radiației asupra dezvoltării culturilor agricole. S-au utilizat date meteorologice pe o perioadă de 25 de ani şi metode de calcul statistic pentru cunoaşterea valorilor radiației şi distribuția ei la ore caracteristice. Am efectuat măsurători asupra radiației solare directe şi difuze, pe baza cărora am calculat radiația activă fotosintetică pe un an şi la anumite ore caracteristice. În acest fel am reuşit să facem o concordanță între distribuția radiației active fotosintetice şi perioada de vegetație a culturilor.*

Key words: *Photosynthetically active radiation, solar direct radiation, active radiation, crops*
Cuvinte cheie: *radiație activă fotosintetică, rdiație directă, radiație difuză, culturi*

INTRODUCTION

The solar radiation flux has a very important role in the life of plants. The energy of the sunrays is turned into heat or consumed in different physical, chemical and biological processes. Solar radiation influences plant growth and development, the shape, position, colour and build of leaves, the chemical composition, the level and quality of the harvest, the formation of organs, the duration of the vegetation period and a large number of specific properties such as: resistance to disease and pests, to the unfavourable meteorological phenomena etc. Solar radiation influences the vegetation by duration and intensity of light, as well as by its spectral composition. Sun light conditions the growth and development of plants, it even represents a limitative factor to which the climate zone, altitude and latitude etc are added.

MATERIAL AND METHODS

The photosynthetically active radiation (PAR) can be determined by means of instruments such as: thermo- and photo-electrical phytoactinometers and phytopyranometers, which are not produced industrially. The photosynthetically active radiation (Q_{RAF}) may be calculated indirectly, based on the values of the direct radiation (I_m) and diffuse radiation (I_d):

$$Q_{RAF} = 0.43 I_m + 0.56 I_d$$

The values can be expressed in cal/(cm^2 ·min), J/(cm^2·min), erg/(cm^2·s) and Wm^{-2}.

The only radiometric station in the Romanian littoral is in Constanta. This is where measurements were taken of the direct solar radiation and diffuse solar radiation. Based on them, the photosynthetically active radiation was calculated. As a result of the measurements and calculations realized based on the formula presented above, we succeeded in making some appreciations on the energy quantities that are manifested in this littoral sector and on the way in which it is distributed over a year and at certain characteristic hours: 6, 9, 12, 15, 18.

RESULTS AND DISCUSSIONS

The growth and development processes of plants are influenced not only by the intensity and composition of light, but also by the time of plant exposure to light during the day. In certain plants like vegetables, the light requirements are different according to what is harvested. For example, in tomatoes and peppers, the fruit is harvested and intense light is essential. However, in those plants where only the vegetative part is consumed (cauliflower, cabbage), light is no longer that essential, a more marked nebulosity being more favourable to them. Different types of wheat can ripen very quickly at a light exposure of 13-15 hours or 15-18 hours, while others even at 24 hours.

Each cultivated plant has a number certain need for solar radiation in order to develop properly, in order to reach maturity and offer lucrative productions. The *photosynthetically active radiation* (PAR) in the field of visible spectrum (0.4 µm – 0.7 µm) has a major significance for the plant development processes. The assimilation of the radiant solar energy by the leaves is selective because it is realized by means of the chlorophyll. The leaves absorb the most intensely the radiations with a wavelength between 0.40 µm and 0.48µm (blue-violet) and 0.65 µm – 0.68 µm (red-orange). A minimum of absorption is observed in the wavelengths between 0.50 µm and 0.58 µm (long red).

Based on the results obtained after the calculation of the photosynthetically active radiation, it can be observed that it varies according to the characteristic hours when the measurements were taken, as well as over the years. The most significant observations are made for the warm season (July), for the cold season (December) and also the multiannual analysis of the values. (Tabel 1,2)

Table 1

The variations of photosynthetically active radiation Wm^{-2}, to Constanța in December (1965-2000)

Radiation/hour	9	12	15
I_m	405	621	349
I_d	48	105	45
Q_{RAF}	200	325	175

Table 2

The variations of photosynthetically active radiation Wm^{-2}, to Constanța in July (1965-2000)

Radiation/hour	6	9	12	15	18
I_m	335	733	796	712	265
I_d	98	223	258	216	84
Q_{RAF}	198	439	462	426	160

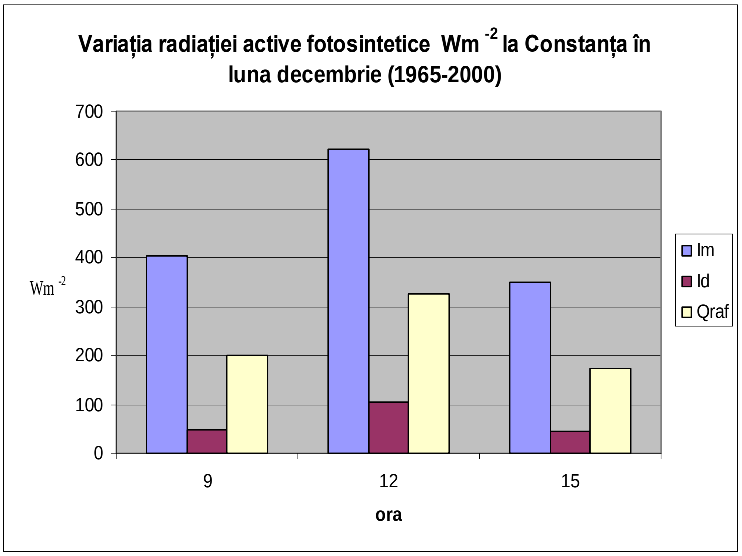

Figure 1. The variations of photosynthetically active radiation Wm^{-2}, to Constanța in December (1965-2000)

Table 3

The multi-annual average variations of photosynthetically active radiation Wm^{-2}, to Constanța (1965-2000)

Hour/ month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
6				82	165	198	140	119	61			
9	196	250	332	373	414	431	408	397	377	323	260	199
12	333	361	407	434	460	476	463	446	435	412	348	322
15	196	250	320	368	407	418	402	382	356	310	223	173
18				101	147	157	157	98	71			

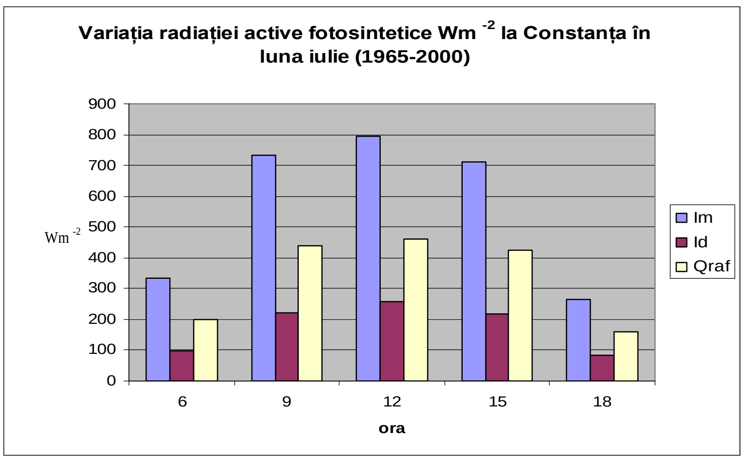

Figure 2. The variations of photosynthetically active radiation Wm^{-2}, to Constanța in July (1965-2000)

The daily regimen of the solar radiation on normal surface is symmetrical to the astronomical time of the zenith (12 o'clock) and to July, the summer solstice. The lowest levels of the photosynthetically active radiation are recorded at 6 p.m. in July and at 3 p.m. in December, while the maximal values can be reached at 12, both in July and December. Their variation is determined by the regimen of the clouds, fog and other phenomena that modify the atmospheric transparency.

During the clear sunny days, photosynthesis in the photophile plants, which are predominant in the littoral area, begins with low intensity in the morning and then increases with light intensity and temperature rise, reaching a maximum at noon. A declining process begins afterwards, as photosynthesis is reduced abruptly with the decrease in light intensity and temperature. Some plants reach a maximum of photosynthesis intensity before noon, by 12 o'clock, especially those that prefer shade, and it stops in the evening. The photosynthesis progress during the day is more irregular if the insolation is stronger, the air drier and the temperature higher. In most cases, photosynthesis registers a drop around noon due to the water deficit in the leaves, associated with a decrease in soil humidity. In this case, photosynthesis reaches a maximum quite early during the day, followed by a sudden decline.

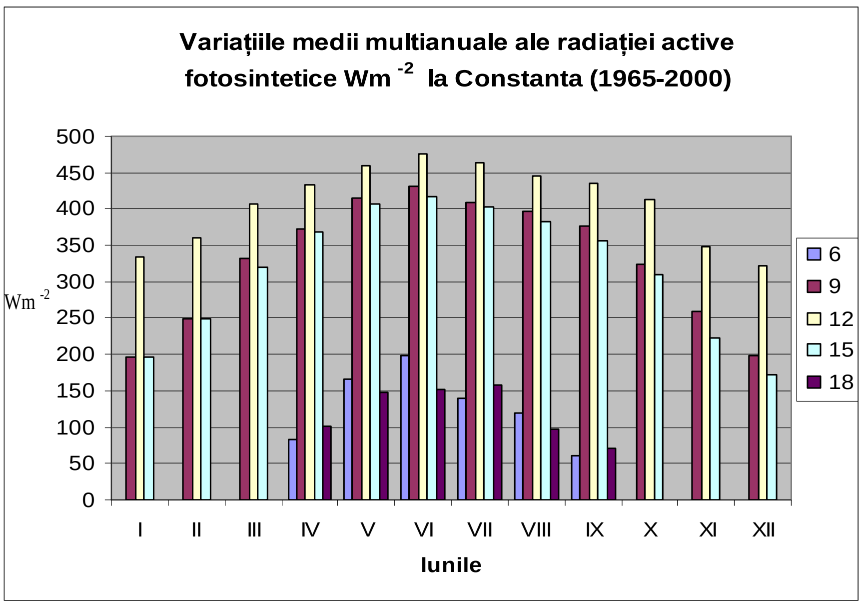

Figure 4. The multi-annual average variations of photosynthetically active radiation Wm^{-2}, to Constanța (1965-2000)

By analyzing the multi-annual average variations of the photosynthetically active radiation, it can be observed that it varies both according to hour and according to the year period. The highest values are registered between April-October, overlapping the entire vegetation period, when the photosynthesis process is most active. The rise of the photosynthesis process occurs by the blossoming period or fruit formation, which is why it can be said that photosynthesis reaches maximum intensity with the fruit formation. Photosynthesis intensity decreases in autumn when the plants prepare to enter vegetative rest with the decrease in the intensity of the photosynthetically active radiation.

The absorption and permeability to the photosynthetically active radiation (PAR) is different according to the geometrical structure (culture architecture), the size, and surface and plant inclination towards the solar rays.

CONCLUSIONS

Solar radiation is an essential factor for plant development. Agrometeorology has introduced new aspects which aid in connecting the photosynthetically active radiation to the development rhythm of crops. In the Romanian littoral, the sunlight duration is the highest and consequently, the values of the photosynthetically active radiation are similar, which determines the prolongation of the vegetation season, plants preparation for the cold season, the appearance of new plant varieties cultivated according to the climate requirements of the area.

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