REFLECTED RADIATION FROM A BARLEY CROP

SHAHARUDDIN B. AHMAD

SINOPSIS

Pembalikan bahangan atau albedo dari tanaman barli telah dikira dari bulan April hingga September 1978 dengan menggunakan dua solarimeter jenis Kipp dan Zonen dan dua jenis Thermometer Infrared. Nilai min albedo musiman 23.4 peratus telah didapati dengan nilai maximum bulanan terdapat ketika tanaman menutup bumi sepenuhnya, iaitu bulan Jun. Persamaan-persamaan linear regrasi berkaitan dengan hubungan antara normalized albedo dan litupan bumi, suhu daun, kandungan air daun telah didapti. Meskipun perhubungan positif yang baik didapati bagi litupan bumi, dua parameter tanaman yang lain menampakkan ada pengaruhnya ke atas normalized albedo dalam bentuk perhubungan-perhubungan yang negatif.

SYNOPSIS

Reflected radiation or albedo from a barley crop was measured from April till September 1978, using two Kipp and Zonen solarimeters and two types of Infrared Thermometers. Seasonal mean value of albedo 23.4 percent was obtained with maximum monthly value established during full ground cover i.e., in June. Linear regression equations relating measurements of normalized albedo on ground cover, leaf temperature, leaf water content respectively, were obtained. Although the better positive correlation was calculated for ground cover, the other two crop parameters seemed to have influenced on the normalized albedo in the form of negative correlations.

INTRODUCTION

Reflected radiation or albedo, expressed as a percentage, is defined by the equation

$$A = \frac{I_r}{I_o} \times 100$$

where I_r is the solar energy reflected by the surface and I_o is the solar energy incident on the same surface for wave lengths in the region of 0.3 to 4.0 μ. Accurate information on the albedo of natural surfaces, including agricultural fields, and on the influence of agronomic treatments and management practices on reflection is needed to advance our understanding of the radiation and energy balances of these surfaces.

Reflected radiation is the upward part of complementary radiation which depends on the absorption coefficient and the scattering function of leaves, on their orientation, on the ground cover, on the architecture and the depth of the stand, on the geometry and the spectral distribution of incident radiation and on cloud condition. In most agricultural crops, the albedo decreases with increasing solar zenith angle of the sun under cloudless condition. (Monteith and Szeicz, 1961; Rijks, 1967; Blad et al., 1972; Kalma et al., 1972; Piggin et al., 1973; Cesareni et al., 1976). Therefore, albedo is generally highest in the early morning and late evening and lowest at mid-day.

The other factor that plays an important part in determining the crops' albedo is ground cover. Average albedo values for several crops under different stages of ground cover are given by Monteith (1959), Lykowski (1970), Blad et al (1972) and Shaharuddin Ahmad (1978). Furthermore, the average albedo values for several crops in the whole of growing season have already been obtained by Budyko (1958), Monteith (1959), Monteith et al., (1961), Graham et. al (1961b), Chang (1961) and Ekern (1965b).

Although the above factors are mainly determined the albedo values of the agricultural crops, the leaf water content, leaf temperature and leaf structure are the other by-factors that may determine the albedo values. These factors have studied by several researchers including Pearman (1966), Thomas et. al., (1967, 1977), Gausman (1969) and Carlson et. al. (1971).

In this present paper, it is, therefore, some of the factors mentioned above, such as seasonal albedo values, ground cover effects, leaf temperature, and leaf water content that will be studied and determined by using barley as a studied crop.

MATERIALS AND METHODS

Barley (Hassan) was sown in the second week of April 1978 growing season. The physiographic region of the experimental site is the Pennine Foothills which are covered by superficial deposits on solid geology of upper carboniferous age, consists of Millstone Grit Series. Soil of the experimental site is mainly non-clacareous surface-water gley soils group. The parent material is clay or sandy clay.

Ground cover is defined as the percentage of bare soil that is covered by crops or plants. The method that employed in this present paper was by using photographs.Two or three photographs were taken vertically about one and a half meter above random sites for each day of measurement. A quadrant of 2352 square cm (56 cm x 42 cm) was placed between the crops at the ground level where photographs were taken. By using planimeter, the ground cover was determined from each photograph. The average was taken to represent the percentage of ground cover for a particular day of measurement.

Two Kipp and Zonen solarimeters were used in order to measure incoming short-wave radiation and reflected radiation from the crops. Incoming and reflected radiations were recorded by two portable high-speed chart recorders.

Leaf temperatures were determined by using a Barnes Infrared Thermometer during early observations and an Infrared Radiation Thermometer KT13 for the later part of the observations. This KT13 is a Heimann Bolometer and sensitive in the spectral range form 0.6 to 35 microns, or from 0.6 to 5.5 microns. Leaf water content measurement was started when the barley crop produced its second leaf from the apex and stopped when the leaves were fully dried. A few first and second leaves were taken from random samples of barley crop and placed in the weighted plastic bags. They were then sealed and taken to the laboratory. They were weighed and dried in an oven at 100°C to expel the water. In every 3 hours, the leaves were taken out of oven and then reweighed. This experiment was carried out until the dried weight showed the constant value. The leaf water content is expressed in terms of percentage of dry weight.

RESULTS AND DISCUSSIONS

a) Seasonal albedo values

Figure 1 gives the value of seasonal and monthly mean of albedo for barley crop in the 1978 growing season. It is clearly indicated that the maximum monthly means value of albedo was attained during the month of June, 26.7 percent. This coincided with the fact that the full ground cover was measured during this month. The lowest albedo was measured in the earlier observations. This revealed the effect of bare soil rather than of the crop. However, the albedo seemed to decrease again after its maximum value in June. The possible explanation of this phenomenon is that the effect of translocation of stored carbohydrates from leaves to ears was observed after heading stages, which began around late July. It seemed that at this stage, the leaves turned yellow and gradually became more drier and wilter. As a consequence, the leaf area index dropped sharply and exposed some bare soil to the radiant energy. Therefore, the albedo decreased to some extent at this stage.

After harvesting period in the second week of September, the trend seemed to increase again to some extent. The increase of the albedo may be explained in terms of the effect of vigorous weed growth which had completely covered the ground. Besides, the corn crop stubble probably is responsible for the slight increase in the abledo (Shaharuddin, 1978).

b) Ground cover, leaf temperature and leaf water content.

To relate albedo solely to ground cover as well as crop parameters, it is necessary to remove zenith angle effects. The raw data of albedo was normalized by using normalizing function (as previously described by Shaharuddin, et al. 1979). The final normalized albedo was obtained from an average value of normalized albedo of that particular day.

Figure 2 shows the relationship between normalized albedo and ground cover for the 1978 growing season. In the early observation it seemed that the albedo was less dependence on ground cover. However, the general trend showed that with increasing ground cover, the albedo tended to increase to some extent. At full ground cover, it was observed that the value of around 26.0 percent was established. The further observation of ground cover after this stage showed a declining trend. As a consequence, a fall in the albedo from its maximum value occured after this state. The last ground cover measurement of 80.0 percent was associated with the albedo of 20.0 percent. The regression equation was calculated as Y = 12.75 + 0.13 x with correlation coefficient, r, 0.89. This regression equation predicts that for every 10.0 percent increase in ground cover there is an increase of the albedo of about 1.8 percent. The fit of the data along the regression line suggest the possibility of determining barley crop cover rapidly and quite accurately from albedo measurement, especially if the soil surface conditions remain reasonably uniform.

Further relationships were obtained between leaf temperature, leaf water content and albedo, respectively, Figure 3 and 4 illustrate the relationships between these crop parameters and albedo. It is important to note that leaf temperatures were taken at different times throughout the observations. The measurements were taken three to four times a day; 9.00 am, 1130 am, 1300 pm, and 1700 pm. The measurements were stopped when the leaves at their fully dried condition.

The negative trends observed for barley crop indicated that with increasing leaf temperature and leaf water content, the albedo tended to decrease to some extent. Leaf temperatures measured, varied within the range of 12.5°C and 20.5°C whereas the leaf water contents varied within the range of 62.5 percent and 80.2 percent. The range of values revealed that considerably constant leaf temperatures and leaf water contents existed over barley. This is shown by the points that lay around the equation lines. Regression equations predict that for every 10.0°C increase in leaf temperature and in every 10.0 percent increase in leaf water content there is a decrease of the albedo of approximately 6.2 percent and 1.0 percent, respectively. In general, the two crop parameters, leaf temperature and leaf water content, play a minor part in determining the albedo of the crop, particularly leaf water content.

SUMMARY AND CONCLUSIONS

The seasonal trend of albedo showed that the two minimum values of albedo existed during the early and before harvesting periods, with this maximum value during full ground cover. The lowest value in the early period indicated the value of bare soil rather than the crop value whereas the later revealed the effect of wilting leaves as well as the exposure of some bare soil to the radiant energy.

A positive correlation was observed between albedo and ground cover; indicating that an increase in ground cover was followed by an increase in albedo values. During full ground cover, the albedo value of around 26.0 percent was measured. However, a negative correlation was observed between leaf respectively.

Albedo values are required for studying the energy and water balances of any agricultural crop. Seasonal values will be useful in determining these such objectives with regard to seasonal energy and water balances of vegetative surface. The correlations between crop parameters and albedo will be first to be considered in order to fulfil the requirement of studying the daily energy and water balances.

ACKNOWLEDGEMENTS

I would like to express my thanks to the Head, Geography Department, Leeds University for providing all the instruments, Encik Ismail Ahmad for his comments on my first draft of this papaer and the Cartographers, Geography Department, Universiti Kebangsaan Malaysia for drawing the diagrams.

REFERENCES

Blad, B.L. and Baker, D.G. 1972. Reflected radiation form a Soybean crop. *Agronomy* Journal, 64: p.277–280.

Budyko, M.I. 1958. *The Heat balance of the earth's surface* (Translated by N.A. Stepanova). U.S. Dept. Commerce, Weather Bureau, Washington.

Carlson, R.E., YARGER, D.N., and SHAW, R.H. 1971. Factors affecting the properties of leaves with special emphasis on leaf water status. *Agronomy Journal*, 63: p.486–489.

Cesapeni, G., and LANNUCCI, C. 1976. Diurnal Variation of corn crop albedo. Oecologia Plantanum, 11(3): p.257–265.

Chang, Jen-Hu, 1961. Microclimate of sugar cane. *Hawaiian Planters' Record* 56: p.195–223.

Ekern, P.C. 1965b. The fraction of sunlight retained as net radiation in Hawaii. *Journal of Geophysical Research*, 70(4): p.785–792.

Gausman, H.W., Allen, W.A., and CARDENAS, R. 1969. Reflectance of cotton leaves and their structure. *Remote sinsing and Environment*, 1(1): p.19–22.

Graham, W.E., and King, K.M. 1961b. Short-wave reflection coefficient for a field of Maize. *Quarterly Journal of Royal Meteorological Society*, 87: p.425–428.

Kalma, J.D., and Badham, R. 1972. The radiation balance of a tropical pasture. I. the reflection of short-wave radiation. *Agricultural Meteorology*, 10: p. 251–259.

Lykowski, B. 1970. Reflection of solar radiation by vegetation. *Ekologia Polska*, 18(8): p.211–222.

Monteith, J.L. 1959. The reflection of short-wave radiation by vegetation. *Quarterly Journal of Royal Meteorological Society*, 85, p. 386–392.

Monteith, J.L., and Szeicz, G, 1961. The radiation balance of bare Soil and vegetation. *Querterly Journal of Royal Meteorological Society*, 87: p.157–170.
Pearman, G.I. 1966. The reflection of visible radiation from leaves of some Western Australian Species. *Australian Journal of biological Sciences*, 19: p.97–103.
Piggin, I., Schwerdtfeger, S. 1973. Variation in the albedo of wheat and barley crops. *Archiv fur Meteorologie, Geophysik und Bioklimatologie*, Ser. B, 21: p.365–391.
Rijiks, D.A. 1967. Water use by irrigated cotton in Sudan. I. Reflection of short-wave ra radiation. *Journal of Applied* Ecology, 4(2): p.561–568.
Shaharuddin b. Ahmad 1978. Variations in Albedo over several cultivated crops in the Leeds Area. *Journal Ilmu Alam* bil. 7: p.37–51.
, and Lockwood, J.G. 1979. Albedo. *Progress in Physical Geography*, vol 3(4) p.510–543.
Thomas, J.R., Weigand, C.L. and Myer, V.I. 1967. Reflectance of cotton leaves and its relation to yield. *Agronomy Journal*, 59(11–12): p.551–554.
, and Gausman, H.W. 1977. Leaf reflectance vs leafchlorophyll and carotenoid concentrations for eight crops. *Agronomy Journal*, 69(5): p. 799–802.