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Short-wave albedo of soil and jowar crop

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सार – 1970 की खरीफ की फसल के दौरान ज्वार की धवलता की माप की गई। आकाश की विभिन्न दशाओं में फसल की धवलता के दैनिक विचरण का वर्णन किया गया है। 11 प्रतिशत मृदा धवलता की तुलना में ज्वार की औसत मध्याह्न धवलता 22 प्रतिशत थी। आकाश स्वच्छ होने पर फसल की धवलता सूर्य के उन्नयन कोण पर काफी निर्भर रहती है, परन्तु मेघाच्छादन में इस पर अपेक्षतया कम निर्भर करती है। मेघों के छाये रहने से दिन की मध्याह्न फसल धवलता के मानों में कोई विशेष परिवर्तन नहीं होता है।

ज्वार की दोपहर की धवलता की ऋतुनिष्ठ प्रवृत्ति फसल की बढ़वार के साथ-साथ धवलता में वृद्धि दर्शाती है। यह वृद्धि 25% तक पहुंचती है और उस समय तक फसल 55 दिन की हो जाती है, इसके बाद 15 दिन एक जैसी रहती है और बाद में धीरे-धीरे कम होती हुई फसल के पकने तक 18% रह जाती है।

ABSTRACT. Measurements of albedo of jowar were made during the kharif season of 1970. The diurnal variation of crop albedo under different sky conditions is discussed. The average noontime albedo of jowar was 22 per cent compared to the soil albedo of 11 per cent. There is a strong dependence of crop albedo on solar elevation under clear sky conditions; the dependence is relatively weak under cloudy conditions. The midday crop albedo values do not change significantly with cloudiness.

The seasonal trend of midday albedo of jowar shows an increase of albedo with crop growth, till it reaches 25 per cent when the crop was 55 days old, remains steady for 15 days, and decreases gradually thereafter to about 18 per cent as the crop matures.

1. Introduction

Albedo is an important parameter in radiation balance studies. It is defined as the ratio of radiation reflected by a surface to the total incoming radiation and is expressed as a percentage. Measurements of crop albedo are sparse in tropical areas. For a country of India's size, and diversity of crops and cropping patterns, studies of crop albedo are meagre, the main constraint being the lack of radiation instruments at the agrometeorological observatories. Knowledge of the reflective characteristics of crops is also necessary in interpreting and processing data from remote sensing which is gaining importance as a technique in crop yield estimates and identification of crop conditions over large areas.

Quite a good number of studies on albedo of soil, field crops and forests have been made in middle and higher latitudes (Rusin 1958, Monteith 1959, Monteith and Szeicz 1961, Graham and King 1966, Stanhill *et al.* 1966, Fritschen 1967, Piggin and Schwerdtfeger 1973 — for field crops and Stewart 1971, Mukammal 1971 and De Wallae and Mc Guire 1973 — for forests).

In the tropics, Chang (1961) studied the albedo of sugarcane in Hawaii. Subramanyam and Ratnam (1969) conducted albedo studies in sugarcane field at Anakapalle, India. Mani *et al.* (1975) while discussing aircraft measurements of albedo over India have reported ground observations of albedo of grass and crops like sugarcane and groundnut.

The results of short-wave albedo observations of bare soil and jowar crop at Pune are discussed in this paper.

2. Site and instrumentation

Continuous recording of incoming short-wave radiation was made by Molls solarimeter, kept on the terrace of the laboratory building of the Central Agrometeorological Observatory at Pune (Lat. 18 deg. 32′ N, Long, 73 deg. 51′ E).

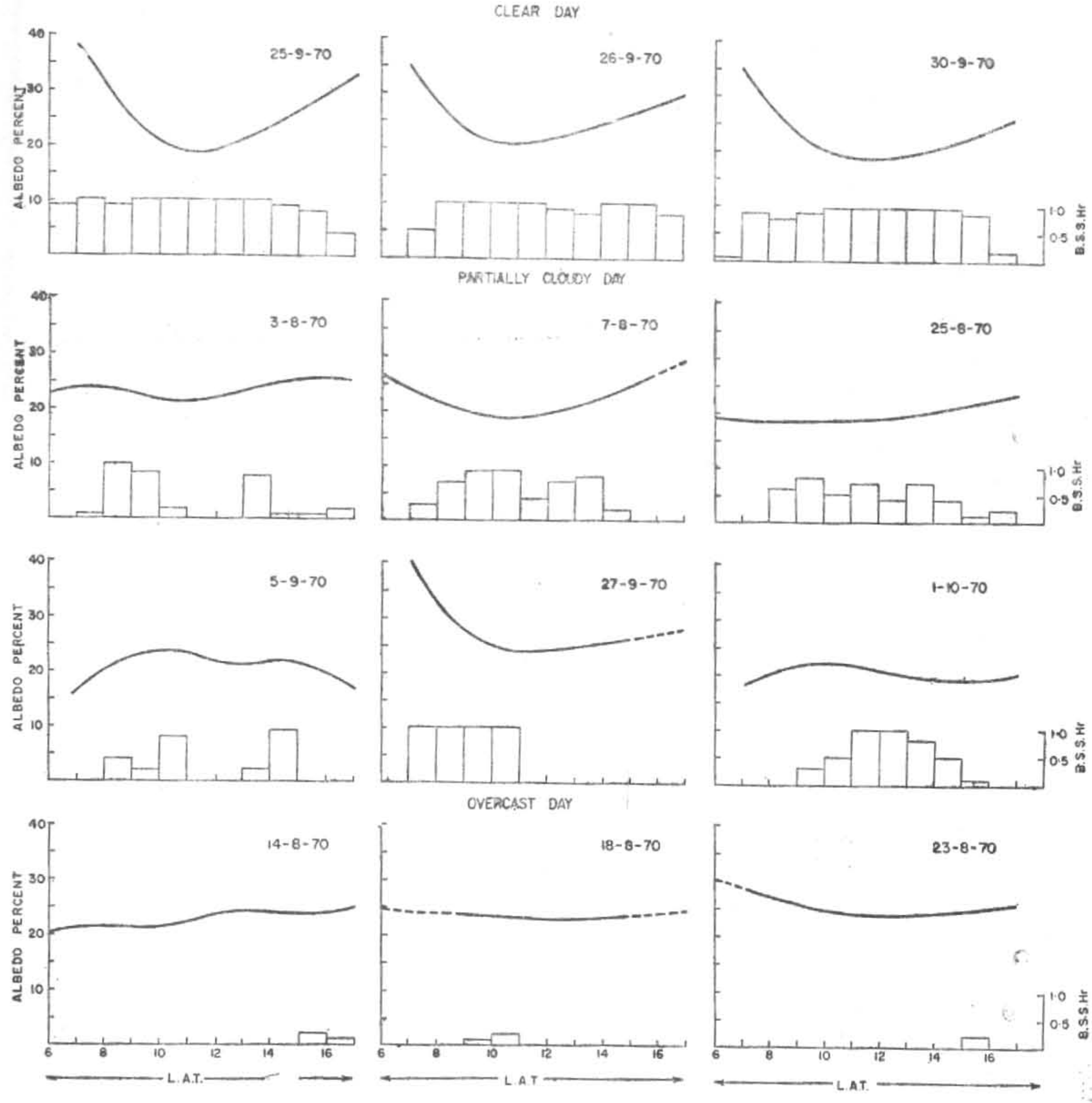

Fig. 1. Diurnal variation of albedo of jowar

Continuous recording of reflected short-wave radiation from the bare soil was obtained from an inverted Molls solarimeter which was mounted at a height of 1.5 m above the ground in the observatory enclosure. Instantaneous values of reflected short-wave radiation in a jowar field (50 m from the observatory enclosure) were measured by using an inverted Eppley Pyrheliometer which was mounted on a cross-bar one metre above the crop canopy.

The jowar crop was sown on 19 June 1970 and harvested in November 1970. The season was normal in respect of crop-growth. The rows were running east-west. The distance between plants was 15 cm and the row spacing was 45 cm. It is black cotton soil both in the observatory enclosure and the field.

From measured instantaneous outputs of pyrheliometer at 12 L.A.T. and the corresponding values of incoming radiation picked from the records of the Molls solarimeter and those of reflected radiation from the bare soil picked from the records of the inverted Molls solarimeter, the noon albedos of crop and soil were calculated from 31 July to 7 October 1970.

In addition, a total of about 100 hourly values of crop albedo were obtained on some selected days during the period from 3 August 1970 to 1 October 1970.

3. Discussion

3.1. *Diurnal variation of albedo of jowar*

The albedo of a crop surface depends on solar elevation besides crop factors like colour, moisture conditions, density of crop cover and leaf geometry. The average albedo of jowar in the 70-day period under study was 22 per cent, at 12 L.A.T. The corresponding value of the bare soil was 11 per cent. The soil albedo varied between 13 and 10 per cent depending upon the moisture conditions. The solar elevation at 12 L.A.T. changed from 89 deg. to 66 deg. during this period.

The diurnal variation of albedo is presented in Fig. 1 for three clear days, three overcast days and six partly cloudy days along with hourly values of bright sunshine (B.S.S.). The shape of the curves on clear days is nearly parabolic, with some asymmetry between forenoon and afternoon parts, the rate of change of crop albedo being greater in the forenoon than in the afternoon. The reason for this asymmetry in jowar albedo is not clear.

Mukammal (1971) noticed a similar behaviour in a pine forest and attributed the increased albedo in the forenoon to increased reflection as a result of trees at the west side of the forest being higher and more irregular in height than on the east side.

The diurnal variation which is seen prominently on clear days, almost disappears on overcast days. The curves tend to become flat due to a significant decrease of crop albedo in the morning and evening under cloudy conditions. The midday values however do not change significantly with cloudiness. On partially cloudy days, there is no definite pattern of diurnal variation.

3.2. *Dependence of albedo of jowar on solar elevation*

In Fig. 2 the available hourly crop albedo values have been plotted against solar elevation under (*a*) mainly clear sky coditions (*i.e.*, hourly B.S.S. 0.8 to 1.0) and (*b*) nearly overcast conditions (*i.e.*, hourly B.S.S. 0.0 to 0.2). Under clear day conditions, the scatter of points is less than under overcast conditions. There is an increasing trend of albedo with decreasing solar elevation. This trend is more prominent under clear sky than under overcast sky conditions. The rate of albedo increase is insignificant upto about 45 deg. to 50 deg. and progressively increases at lower elevations. Subramanyam and Ratnam (1969) found sugarcane albedos remained steady between 21 and 25 per cent for solar elevations greater than 40 deg.

Monteith and Szeicz (1961) observed that reflection by grass and bare soil was least at midday and increased almost linearly with decreasing solar elevation, more rapidly over grass than over soil.

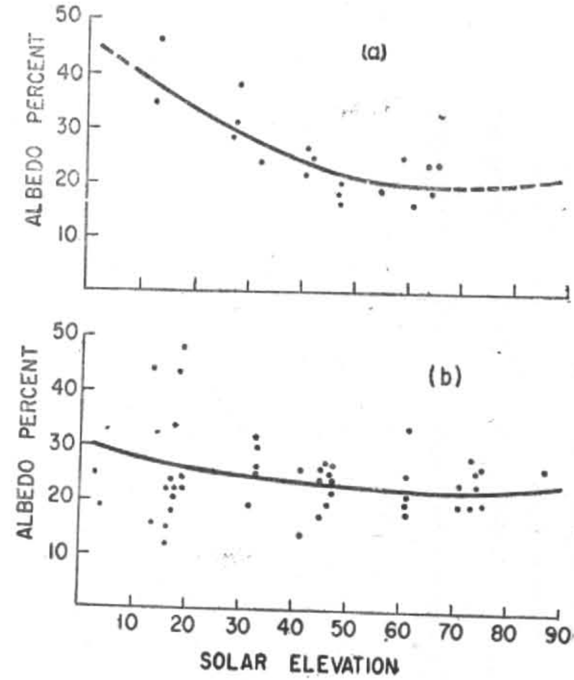

Fig. 2. Variation of albedo with solar elevation for jowar under (a) clear and (b) overcast sky

Graham and King (1961) found a similar dependence of albedo of maize on solar elevation and suggested that the lower albedo at high solar elevations is caused by trapping of radiation beneath the canopy and the effect would be reduced at small solar elevations since the direct solar radiation would not penetrate to such an extent. According to Rosenberg (1974) major cause of parabolic relationship is probably the fact that most natural surfaces reflect specularly rather than diffusively particularly under low sun angle.

Stewart (1971) found a pronounced dependence of albedo of pine forest on solar zenith angle on cloudless days while on cloudy days there was little variation. Stanhill *et al.* (1966) could find the trend of increasing albedo with decreasing solar altitude only in three out of the eleven natural vegetation and agricultural surfaces, studied by them. These three surfaces, *viz.*, fish pond, orange orchard and evergreen maquis forest, showed greater reflection coefficient when solar altitude was below 30 deg. The degree of cloud cover had no discernible influence on the values of albedo measured for any of the surfaces.

The results of present study in respect of the differences in patterns of diurnal variation of albedo of jowar under different sky conditions are quite similar to those of Piggin and Schewerdtfeger (1973) for wheat and barley.

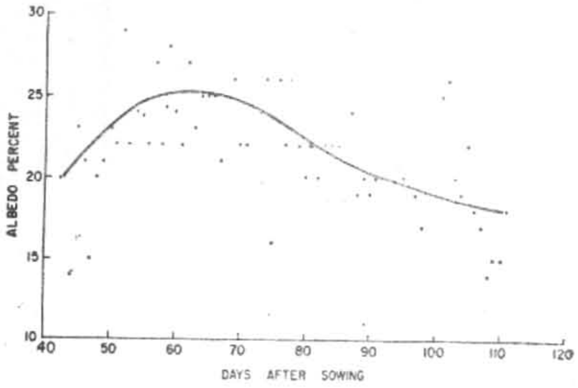

Fig. 3. Seasonal trend of 12 L.A.T. albedo of jowar

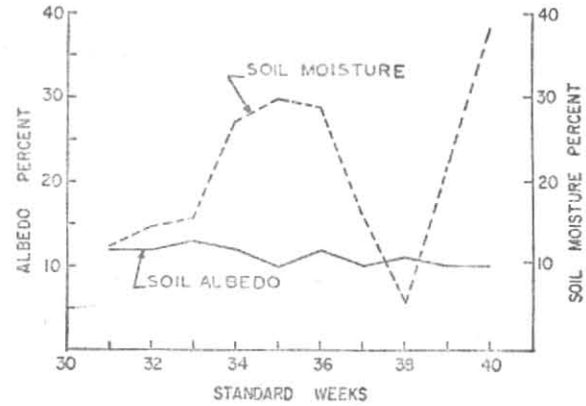

Fig. 4. Variation of soil albedo and surface soil moisture

According to them, the differences in the angular distribution of incoming radiation in the presence of clouds cause the difference in the daily pattern. On clear days the incoming radiation is predominantly a point source and varies diurnally in both direction and intensity. Under overcast sky, the radiation is substantially isotropic and unvarying throughout the day. Scattered cloud radiation would be intermediate between these two types. They also mentioned that effective mean solar elevation on a overcast day is 40 deg. to 50 deg. It is of interest to note that the dependence of jowar albedo on solar elevation has been found in this study, to be prominent at elevations below 45 deg. to 50 deg. as mentioned earlier.

3.3. *Seasonal trend of albedo of jowar*

The seasonal trend of jowar albedo is depicted in Fig. 3 where 12 L.A.T. values of albedo are plotted against the days after sowing. The 12 L.A.T. albedo values are chosen for the purpose because they do not change significantly, as already stated, with sky conditions. The measured albedo in the crop field can be considered as a composite of the albedos of the crop and the underlying soil surface.

On the day of the first observation on 31 July 1970 the crop had not fully covered the ground. The albedo then was 20 per cent. Before 31 July 1970 it may be inferred that the albedo increased from about 12 per cent, which is value of soil albedo, to 20 per cent with the increase of vegetative growth. With further growth of the crop, the albedo increased to 25 per cent when the crop was 55 days old by which time the crop had reached almost full cover. The albedo levelled off at 25 per cent and remained so for another 15 days. This corresponds to the *"albedo plateau"* at full crop cover found by Piggin and Schwerdtfeger (1973) for wheat and barley. The flag leaf stage of jowar was reached during the plateau period. Thereafter, the curve showed a gradual decline in the albedo, reaching a value of 18 per cent when the crop was about 110 days old. This decrease can be attributed to the gradual drying of lower leaves and consequent greater exposure of oil as the crop approached maturity.

Fig. 4 depicts the weekly average values of 12 L.A.T. bare soil albedo and surface soil moisture values measured in the observatory enclosure. The inverse relationship of soil albedo with soil moisture content can be seen from the figure.

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