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# Study of solar radiation over cowpea

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सार — भारत में धारवाड़ (15° 26′ उ०, 75° 06′ पू०, सतह से 678 मी०) में लोबिया (विग्ना अन्गुक्यूलिट सखर युक्त (L.वाल्प) की फसल की तीन अवस्थाओं में घन्टेवार विकिरण संतुलन का अध्ययन किया गया था। दैनिक-तौर पर उपयोग किया गया विकिरण बीज जमने तथा पकने की अवस्था में पुष्पण तथा कटाई की अवस्थाओं की अपेक्षा अधिकतम था। घंटेवार अध्ययन के आधार पर प्रयुक्त विकिरण की प्रतिशतता प्रातः तथा सायं काल अधिकतम तथा दोपहर के समय न्यूनतम पाई गई।

ABSTRACT. Hourly radiation balance, at three phenophases of cowpea (*Vigna unguiculata* (*L.* Walp) crop was studied at Dharwad (15°26′ N, 75° 06′ E, 678 m a.s.l.) in India. On daily basis, the radiation utilized was maximum at the seed-setting and maturity stage, followed by the flowering and harvesting stages. On hourly basis, the percentage of radiation utilized was found to be maximum during the morning and the evening and minimum in the noon.

## 1. Introduction

Several scientists studied the solar radiation over field crops [Monteith and Szeicz 1961, Fritschen 1967, Ling & Robertson 1982, Pereira *et al.* 1982 and Andre & Viswanatham 1983]. In India Subrahmanyam and Ratnam (1969), Murthy & Rao (1982) and Kumar (1985) carried out studies on this field.

## 2. Material and methods

The radiation observations were made by using a pyranometer (National Instruments, Calcutta, India). The output was measured on a millivoltmeter and energy in cal/cm²/min was obtained by multiplying with the factory supplied by the firm. The cowpea was sown on 18 Feb 1985 in a plot size of 2.5 × 2.5 m with a spacing of 40 × 10 cm. The observations were made at fortnightly interval on hourly basis from 0800 IST to 1700 IST at flowering, seed-setting and maturity and the harvesting stages. As the leaf area developed slowly during the vegetative phase, the radiation observations were started at flowering stage. The incoming solar radiation, the reflected solar radiation from the crop and the solar radiation at the ground level of the crop were measured. The first two components were measured at a height of 1 metre above the canopy at the centre of the plot, keeping the pyranometer on an iron stand. The solar radiation utilized by the crop was obtained by subtracting the radiation reflected and transmitted from the incident radiation. The percentage of different radiation components were also computed. Total radiation of different components between 0800 and 1700 IST was obtained for different stages.

## 3. Results and discussion

### 3.1. *Incident, reflected, transmitted and utilized solar radiation*

The values of different components of solar radiation in cal/cm²/min were plotted against the time (in IST), for the three days of observation at fortnightly interval. The date of observation, stage and height of the crop are also shown in Fig. 1. As it was summer, large quantity of radiation was incident at the top of the canopy. There is no much variation at different periods of study. On the first day of observation, the maximum incoming radiation is observed at 1400 IST instead of noon due to cloudiness. On the remaining two days the curve is nearly bell-shaped. The maximum incoming solar radiation was around 1.3 cal/cm²/min. Subrahmanyam and Ratnam (1969) also reported that the hourly variation of incoming solar radiation followed a bell-shape with a peak at noon of around 1.2 cal/cm²/min at Anakapalle in December.

The reflected radiation is more at the seed-setting and maturity stage compared to the other two stages, because of higher reflectivity by beans, matured foliage and relatively less internal water content at maturity and low chlorophyll content. However, the difference is small.

The transmitted energy is large at the harvesting stage on account of dry and matured foliage. It is the least in the middle stage.

The energy utilised is maximum at the seed-setting and maturity stage and minimum at the harvesting stage, which are active growth and senescence stages respectively.

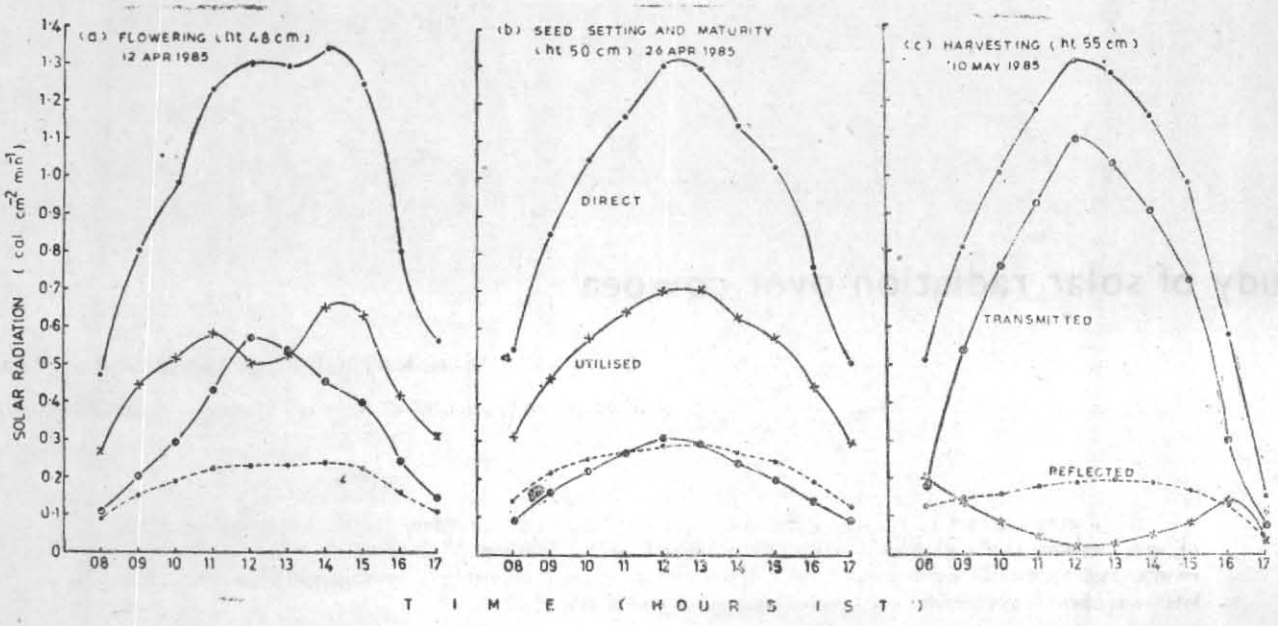


Fig. 1. Solar radiation components in cowpea at Dharwad, India

At the flowering stage, the utilized solar radiation is the maximum followed by transmission and reflection. At the seed-setting and maturity stage, the utilized component is the maximum followed by reflection and transmission. However, at the harvesting stage the transmitted radiation is the maximum followed by reflection and utilized radiation.

In a day, the maximum transmission is observed at noon time, at all the stages on account of the near-normal rays. Reflected radiation follows the same pattern on all the observed days, being the maximum at noon and minimum during the morning and evening. The utilization curve is similar to the incident radiation at the first two stages, with the maximum at the time of the highest incoming radiation. At the harvesting stage, the utilization is the minimum at noon and maximum at the morning and evening.

### 3.2. *Percentage of reflected, transmitted and utilized radiation*

In Fig. 2, the percentages of reflected, transmitted and utilized radiation components with respect to the incident radiation are drawn against time in IST for all the observed days.

The average daily albedo was 19,25 and 17 per cent at the flowering, seed-setting and maturity and harvesting stages respectively. The maximum percentage of reflection is at the seed-setting and maturity stage because of the foliage characteristics, the colour, internal water content and crop geometry. Among the stages the albedo is the lowest at the harvesting stage due to the old and withered leaves. Kumar (1985) reported the albedo values of 16 and 19 per cent at the initial and middle stages of the season for a finger millet crop. In a day the albedo is more in the morning and evening on account of the oblique rays, with the minimum occurring at noon. At the harvesting stage, the maximum diurnal variation was found, the range being 15 to 25 per cent. Similar pattern of diurnal variation of albedo (20 to 45 per cent) was reported for sugarcane by Subrahmanyam and Ratnam (1969) and for jowar (20 to 45 per cent) by Murthy and Rao (1982). Both the minimum and the maximum values were higher for sugarcane and jowar compared to cowpea, because of the higher height and leaf area.

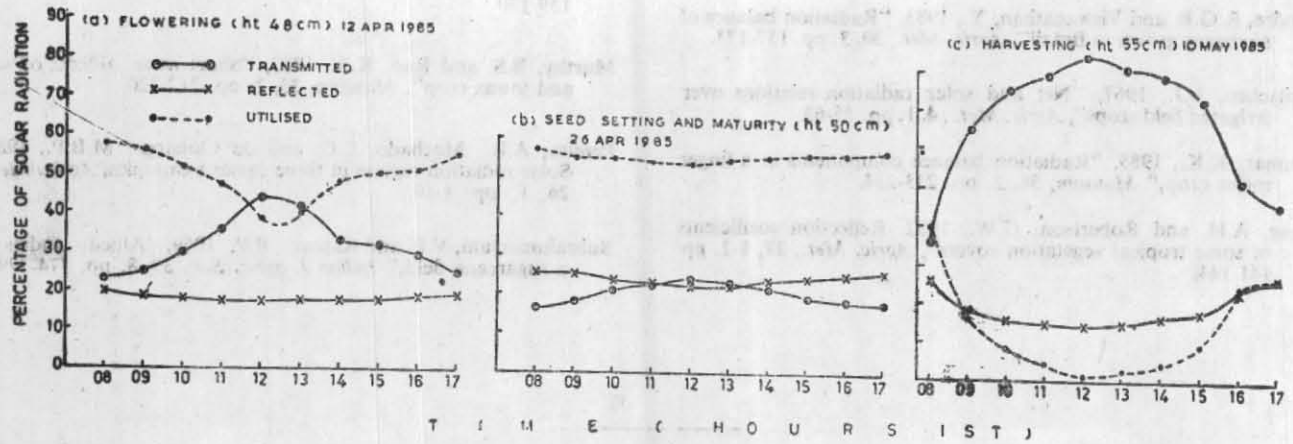


Fig. 2. Percentage of solar radiation components in cowpea at Dharwad, India

**TABLE 1**

**Total energy in cal/cm² at different stages of cowpea between 0800 and 1700 IST at Dharwad, India**

| | Direct | Trans-mitted | Reflect-ed | Utilised |
|---|---|---|---|---|
| Flowering (12 Apr 1985) | 580.2 | 197.6 (34.0) | 109.4 (18.9) | 273.2 (47.1) |
| Seed-setting and Maturity (26 Apr 1985) | 554.4 | 117.6 (21.2) | 135.6 (24.5) | 301.2 (54.3) |
| Harvesting (10 May 1985) | 525.0 | 388.8 (74.1) | 88.2 (16.8) | 48.0 (9.1) |

The percentage of transmission is the maximum at the harvesting stage due to less leaf area. It is the minimum at the seed-setting and maturity stage because of dense foliage. It is the maximum at the noon due to the near-normal rays of sun. It is less in the morning and evening.

The percentage of utilization is the highest at the seed-setting and maturity stage due to the best interception of radiation by leaves and it is the minimum at the harvesting stage. It is maximum during the morning and evening and the minimum at the noon.

Table 1 shows the total amount of the radiation components for all the observed days, between 0800 IST and 17.00 (IST). The values shown in brackets represent the percentage of the total amount of radiation components with respect to incident radiation. At the flowering and the seed-setting and maturity stages, the percentage of utilization is found to be the maximum and at the harvesting stage, the percentage of transmission is the maximum followed by the reflection and the transmission.

#### 4. Conclusions

The radiation utilized on a daily basis was maximum (301.2 cal/cm²) during the seed-setting and maturity stage, followed by the flowering (273.2 cal/cm²) and the harvesting stages (48.0 cal/cm²). The total reflected radiation also follows the above pattern. The total transmitted radiation was the maximum (388.8 cal/cm²) during the harvesting stage, followed by the flowering (197.6 cal/cm²) and the seed-setting and maturity stages (117.6 cal/cm²), the order being the opposite to the above two components.

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