Letters to the Editor

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RADIATION BALANCE COMPONENTS IN SUMMAR MOONG (VIGNA RADIATA L. WIL CZEK) CROP

1. Plants respond to instantaneous values of incident solar radiation. Incident solar radiation influences plant temperatures directly which in turn govern the rates of biochemical process within the plants. Albedo is of much importance in determining the radiation balance of a crop stand. Apart from determining the amount of solar radiation absorbed by the crop, it also influences the temperature of the crop surface. Net radiation is the main parameter in several methods of estimating evapotranspiration. Detailed information regarding the radiation balance components can be of more help in understanding the various physical and physiological processes taking place in a crop stand. However, not all incoming radiation is absorbed by the vegetation even though most of it is trapped (absorbed and transmitted). Radiation is dependent on several physical and biological factors such as solar position, plant structure, leaf geometry, angle, size, anatomy, age, arrangement of plants in the field, height of plants etc. Several workers studied the solar radiation over field crops (Monteith and Sziecz 1961, Fritschen 1967, Pereira et al. 1982 and Andre and Viswanathan 1983). In India Subrahmanyanam and Ratnam (1969), Murthy and Rao (1982) and Kumar (1985) carried out studies in this field.

2. Material and method — The experiment was conducted at the Experimental Farm of Haryana Agricultural University, Hisar (29° 10’ N; 75° 46’ E; 215.2 m.a.s.l.) during summer season of 1989 to study the radiation balance of moong (var. K-851) under normal sowing in flat beds with a spacing of 30 cm x 10 cm. The crop was sown on 6 April 1989 and harvesting was completed on 10 June 1989.

Diurnal observations from 0700 to 1700 IST on net radiation ($R_n$), incoming shortwave radiation ($R_s$) and reflected radiation ($R_f$) were made at one metre height above the crop canopy and dry and wet bulb temperatures were measured within and above the crop canopy at different heights at vegetative (40 days after sowing), flowering (48 days after sowing), pod formation (56 days after sowing) and maturity (65 days after sowing) stages. All inputs were supplied as per package of practices recommended for summer moong. Net radiometer (for $R_n$), albedometer (for $R_f$) and soil heat flux plates (for $G$) of Medoes and Co., Australia were used. The dry and wet bulb air temperature were measured by Assmann psychrometer. The data were analysed for the energy balance by Bowen’s ratio method with the help of following equations:

$$R_n = G + A + LE + P + M$$  \hspace{1cm} (1)

where,

- $R_n$ — Net radiation (mw/cm²),
- $G$ — Soil heat flux (mw/cm²),
- $A$ — Sensible heat flux (mw/cm²),
- $LE$ — Latent heat flux (mw/cm²),
- $P$ — Photosynthesis,
- $M$ — Miscellaneous exchanges.

The sum of $P$ and $M$ terms is usually very smaller than the experimental error in measurement of the major components these have been ignored, so that the following equation adequately describes the energy budget:

$$R_n = G + A + LE$$

$$LE = \frac{R_n - G}{1 + \beta}$$  \hspace{1cm} (2)

Bowen’s ratio ($\beta$) = 0.66, $\triangle t / \triangle e$

where,

- $\triangle t$ — Temperature gradient between two heights,
- $\triangle e$ — Vapour pressure gradient between two heights.

The photosynthetically active radiation was measured with the help of quantum sensor during noon hours at top of crop canopy and on the ground in the crop stand. For the measurement of reflectivity the sensor was inverted at the top of canopy.

3. Results and discussion

3.1. Various components of solar radiation — The values of different components of solar radiation are plotted against the time (Fig. 1) at various phenophases. As it was summer, large quantity of radiation was incident at the top of crop canopy. The maximum incoming solar radiation was around 100 mw/cm² at 1500 IST.
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The net energy available at the top of the crop canopy increased up to 1300 IST and decreased afterwards. The general trend of curve with respect to latent heat flux (LE), sensible heat flux (A) and soil heat flux (G) components of net radiation (Rn) was at peak during the noon hours and the curve showed increasing trend in the morning and decreasing trend in the evening hours. The values of sensible heat flux (A) and soil heat flux (G) were smaller than that of latent heat flux (LE) throughout the day at all the phenological stages of crop.

The per cent net energy utilized into various components (G, A and LE) differed at various phenophases (Table 1). The per cent net energy utilized towards LE was maximum (76.3%) during vegetative stage whereas leaf area index (LAI) was maximum and this energy was minimum (65.3%) at maturity stage (Table 1). The energy utilized towards A and G components increased with the advancement of the crop. This increase may be ascribed to decrease LAI due to old and withered leaves.

<table>
<thead>
<tr>
<th>Phenophases</th>
<th>Rn</th>
<th>LE</th>
<th>A</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetative</td>
<td>396.1</td>
<td>301.1</td>
<td>78.4</td>
<td>16.6</td>
</tr>
<tr>
<td></td>
<td>(19.8)</td>
<td>(19.8)</td>
<td>(4.2)</td>
<td></td>
</tr>
<tr>
<td>Flowering</td>
<td>451.3</td>
<td>334.8</td>
<td>96.6</td>
<td>19.9</td>
</tr>
<tr>
<td></td>
<td>(21.4)</td>
<td>(21.4)</td>
<td>(4.4)</td>
<td></td>
</tr>
<tr>
<td>Pod formation</td>
<td>459.6</td>
<td>335.5</td>
<td>109.2</td>
<td>23.9</td>
</tr>
<tr>
<td></td>
<td>(21.8)</td>
<td>(21.8)</td>
<td>(5.2)</td>
<td></td>
</tr>
<tr>
<td>Maturity</td>
<td>405.0</td>
<td>264.5</td>
<td>106.5</td>
<td>34.0</td>
</tr>
<tr>
<td></td>
<td>(26.3)</td>
<td>(26.3)</td>
<td>(6.4)</td>
<td></td>
</tr>
</tbody>
</table>

*Per cent values of LE, A and G with respect to Rn are given in parenthesis.

### TABLE 2

Optical characteristics over summer moong at various phenophases (per cent)

<table>
<thead>
<tr>
<th>Phenophases</th>
<th>Transmitted (PAR)</th>
<th>Reflected (PAR)</th>
<th>Absorbed (PAR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetative</td>
<td>4.2</td>
<td>24.8</td>
<td>71.0</td>
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<tr>
<td>Flowering</td>
<td>5.1</td>
<td>24.3</td>
<td>70.6</td>
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<tr>
<td>Pod formation</td>
<td>6.4</td>
<td>23.7</td>
<td>69.9</td>
</tr>
<tr>
<td>Maturity</td>
<td>8.4</td>
<td>22.8</td>
<td>68.8</td>
</tr>
</tbody>
</table>

3.2. Photosynthetically active radiation (PAR) interception – The values presented in Table 2 indicate that optical characteristics of moong crop varied with the occurrence of phenophases. The optical characteristics are the amount of PAR received at the top of canopy, reflected by the canopy, absorbed by the canopy and transmitted to the ground in crop field. The transmitted values of PAR increased with the crop growth stage and reached maximum (8.4%) at maturity of the crop. The range of reflected PAR was 22.8 to 24.8 per cent and the trend was reverse to that of transmitted PAR. The PAR absorbed by crop canopy was maximum during vegetative and flowering stages and decreased thereafter. The PAR absorption was higher during vegetative and flowering stages due to thick leaves and more LAI. With the advancement of the crop age the amount of absorbed and reflected PAR decreased whereas transmitted PAR increased due to reduction in LAI, as PAR interception by crop plants mainly depends upon foliage characteristics, the colour, internal water content of leaf, crop geometry and leaf angle.
Among the various phenophases, the albedo was lowest at maturity stage due to old and withered leaves (Fig. 2). The diurnal range of albedo was 7 to 17 per cent at maturity stage and for vegetative stage, the range was 18 to 30 per cent. Kumar (1985) reported the albedo values of 16 and 19 per cent at the initial and middle stages of season for a fingermillet crop. Similar pattern of diurnal variation of albedo (20 to 45%) in jowar was reported by Murthy and Rao (1982). Rajegowda and Ratnam (1987) reported the diurnal variation of albedo in cowpea from 15 to 25 per cent. The average value of albedo was higher in these crops as compared to moong because of more height and leaf area.

4. Conclusion — The amount of energy utilized for the process of LE was maximum at vegetative phase and minimum at maturity phase. However, the values of A and G increased with the advancement of the crop. The absorbed PAR was maximum at vegetative stage and decreased thereafter with the advancement of crop age. The albedo variations were lowest at maturity stage.

References


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SOME HYDROMETEOROLOGICAL FEATURES OF TORSA RIVER

1. General features of river Torsa and its catchment — The river Torsa originates from Chumbai valley in the south Tibet at an altitude of about 7000 metres. After flowing through Tibet and Bhutan, it enters Jalpaiguri district of West Bengal. It flows a distance of about 99 km in West Bengal before entering Bangladesh where it joins Brahmaputra near Nagaswari.

The slope of the river Torsa is about 95 m/km near its origin and of the order of 77 m/km in the downstream stretch up to Bhutan. Below Indo-Bhutan border and up to crossing of M.G. Railway line at Hasimara, the slope is about 4.5 m/km which subsequently falls to 0.38 m/km below NH-31 wooden bridge (district Jalpaiguri).

River Torsa on entering the State of West Bengal, flows through deep forest for a length of about 40 km before reaching the alluvial region of the plains. The M.G. Railway line crosses the river at Hasimara Railway bridge. The river bifurcates into two channels from about 1600 m below the bridge point. The western channel is named as Chur Torsa and the eastern one as Sil Torsa which takes comparatively greater quantum of discharge. The two channels re-unite 40 km downstream near Patlakhowa forest in Cooch Behar district. This combined flow continues for about 13 km up to Hanskhowa where it bifurcates into two channels. The eastern channel carries the bulk discharge and river Kaljani joins it. The western one, also known as Dharala merges with Jalduhaka but is almost dead now. Another small river named Gadadhar, originating in the forest of Indo-Bhutan border and joins the combined flow of Torsa-Kaljani rivers in Bangladesh to join finally Brahmaputra river.

The river of Kaljani and Gadadhar are tributaries of the river Torsa. The rivers of Joyanti and Jaugti are tributaries of the river Gadadhar. The Torsa catchment area including its tributaries is about 7459 sq km as per records of North Bengal Flood Control Commission and Central Water Commission, Jalpaiguri. Out of this, about 2305 sq km is in Bhutan and 3419 sq km is in India. The rest catchment area is in Tibet. On the other hand, about 3419 sq km of the catchment lies in plains and rest of about 4040 sq km is in hilly area. In this study, the total catchment area in Bhutan and India only has been used. The river catchment is bounded by 26° 15’ N and 28° 0’ N latitudes and 89° 15’E and 89° 40’E longitudes.

2. Rainfall features — The study is based on 10-12 years (1974-85) rainfall data of 18 ordinary raingages and 4 self recording raingages in and around the basin, using isohyetal technique for analysis of data. Chief features of rainfall are as under:

(i) The average rainfall over the Torsa basin for the monsoon season (Jun-Sep) is about 303 cm, the monthly break up being June 79 cm, July 96 cm, August 75 cm and September 53 cm.