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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 Szeicz 1961, Fritschen 1967, Pereira *et al.* 1982 and Andre and Viswanathan 1983). In India Subrahmanyam 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 × 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 :

$$R_n = G + A + LE + P + M \qquad (1)$$

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 :

$$R_n = G + A + LE$$

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

Bowen's ratio (β) = $0.66.\ \triangle t / \triangle e$

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 1300 IST.

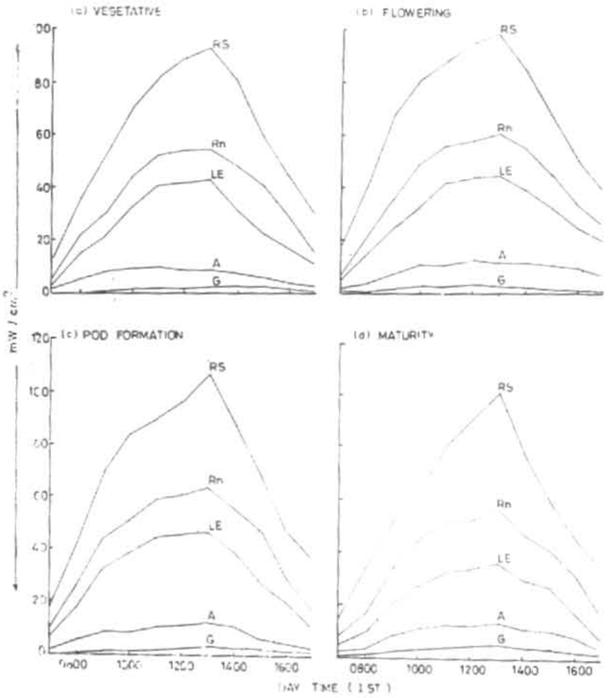

Fig. 1. Radiation balance at various phenophases

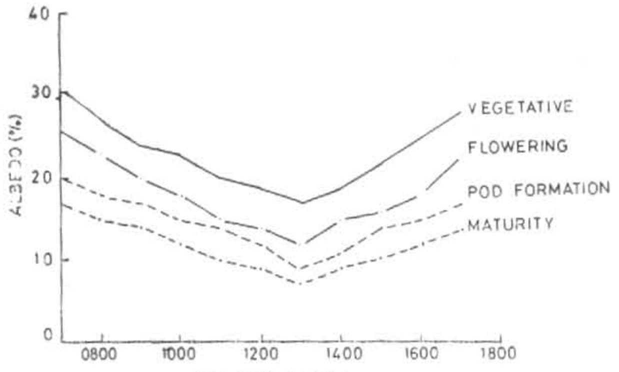

Fig. 2. Albedo variations at various phenophases

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 (R_n) 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%) during vegetative stage when 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 1

Radiation balance (mw/cm²) components at different phenophases at Hisar

Phenophases	R_s	R_n	*LE*	*A*	*G*
Vegetative	650.9	396.1	301.1	78.4	16.6
			(76.0)*	(19.8)	(4.2)
Flowering	734.2	451.3	334.8	96.6	19.9
			(74.2)	(21.4)	(4.4)
Pod formation	749.8	459.6	335.5	100.2	23.9
			(73.0)	(21.8)	(5.2)
Maturity	660.7	405.0	264.5	106.5	34.0
			(65.3)	(26.3)	(6.4)

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

TABLE 2

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

Phenophases	Transmitted (PAR)	Reflected (PAR)	Absorbed (PAR)
Vegetative	4.2	24.8	71.0
Flowering	5.1	24.3	70.6
Pod formation	6.4	23.7	69.9
Maturity	8.4	22.8	68.8

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.

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