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Albedo, net and solar radiations over rice, wheat and Bermuda grass

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ABSTRACT

Measurements of solar radiation, net radiation and albedo were made over wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.) and Bermuda grass (*Cynadon dactylon* L.) at Pantnagar. Solar radiation on clear days ranged from 11.1 to 26.8 $MJm^{-2}day^{-1}$ during the year. At solar noon, the solar radiaion over Bermuda grass and wheat was between 2.9 and 3.8 $MJm^{-2}h^{-1}$ but the net radiation ranged from 1.8 to 2.3 $MJm^{-2}h^{-1}$ over Bermuda grass and 1.7 to 2.1 $MJm^{-2}h^{-1}$ over wheat. Proportion of solar radiation absorbed by the wheat crop was greatest during the milking stage (March 3rd week). Daily average albedos of Bermuda grass, rice and wheat ranged from 0.20 to 0.26, 0.19 to 0.25, and 0.18 to 0.24, respectively. The standard deviation from the regression was between 0.12 and 0.17 MJm^{-2} for the hourly data and 0.70 and 0.72 MJm^{-2} for the daily data.

Key Words : Albedo, Solar radiation, Rice, Wheat, Bermuda grass.

Net radiation is the principal climatic factor controlling evapotranspiration rates (Tanner, 1963; Jensen, 1973). The estimates of net radiation from solar radiation, sunshine hour and albedo are satisfactory for computing evapotranspiration required for scheduling of irrigation (Jensen, 1973; Tripathi, 1992). High albedo is associated with low absoption of solar energy for evaporation and vice versa (Kalma and Badham, 1972). This paper presents solar radiation, net radiation and albedo over wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.), and Bermuda grass (*Cynadon dactylon* L.) together with empirical relationships for solar and net radiations.

MATERIALS AND METHODS

Measurements of net radiation, solar radiation, and albedo were made over rice, wheat and Bermuda grass at Pantnagar (29°N, 79° 30' E, elevation 243.8 m). The crops were grown in Patherchatta sandy loam associated with water table fluctuating between 2.5m and 3.8m depths. Twenty six day old seedlings of rice were transplanted in the first week of July 1982, under puddled condition in rows, 0.2 m apart, at a plant to plant spacing of 0.1m. The crop was harvested in the second week of October. Well-watered condition of rice was maintained by irrigating 75 mm 2 days after disappearance of ponded water. The crop was fertilized with 120 kg N, 60 kg P_2O_5 and

Table 1 : Radiation receipt on certain days and time of the year during the crop season.

Crop	Growth stage	Radiation at solar noon ($MJ\ m^{-2}$)		Albedo (%)	Date of observation
		Solar	Net		
Rice	Panicle initiation	4.16	2.52	0.19	18-8-1982
	Flowering	3.91	2.61	0.23	03-9-1982
	Hard dough	3.65	2.48	0.25	30-9-1982
Wheat	Late jointing	3.01	1.68	0.18	01-2-1983
	Flowering	3.14	1.76	0.24	21-2-1983
	Milk/soft dough	3.35	2.14	0.22	21-3-1983
	Hard dough	3.77	2.14	0.21	05-4-1983
Bermuda grass	Average height maintained =0.1 m	3.36	2.18	0.20	20-12-1982
		2.93	1.85	0.21	22-1-1983
		3.71	2.31	0.25	05-5-1983
		3.82	2.14	0.26	13-6-1983

40 kg K_2O per hectare. Wheat was planted on December 2, 1982 in rows 0.22 m apart, at a seed rate of 100 kg ha^{-1} and harvested in the second week of April 1983. Each irrigation was 60 mm given at crown-root initiation, late tillering, late jointing, flowering and milk stages. The crop was fertilized with 120 kg N, 60 kg P_2O_5, and 40 kg K_2O per hectare. The Bermuda grass was planted in October 1981, in a mini-observatory of 30 m x 23 m size adjacent to the cropped field and maintained to an average height of 0.1 m. Net radiometer (Medos Co., Australia) and albedometer (Kipp and Zonen, Holland) were mounted 0.6 m above the canopies of Bermuda grass, and rice and wheat crops over the rows. The solarimeter (Kipp and Zonen, Holland) was placed at a height of 1.5 m from the grass level in the observatory. Hourly measurements of radiation receipts over wheat and rice crops, and Bermuda grass were made from 20 days after sowing to a week before maturity on rainless days and 4 days after irrigations. Surface characteristics of Bermuda grass were maintained alike during the measument periods. Daily average albedos were also calculated from daily totals of radiations. Linear regression analysis was done of net radiation (Rn) on solar radiation (Rs), and Rs, Rn and ratio of Rs to solar radiation receipts at the earth's surface (Rso) on ratio of actual to possible sunshine hour (n) to possible sunshine hour (N).

RESULTS AND DISCUSSION

Variation of solar radiation and net radiations

There was a general increase in solar and net radiation receipts from sunrise to solar noon followed by a decline (Fig 1). However, the rate of increase in net radiation was lower than in solar radiation. Net radiation ranged from 1.84 to 2.3 $MJm^{-2}h^{-1}$ and the solar radiation from 2.93 to 3.82 $MJm^{-2}h^{-1}$ during December to June. A comparison of solar radiation receipts on September 13,1982 and May 5, 1983 (Fig. 1) showed that despite high solar radiation in September the air tempeartures were highest in May. These differences might be due to atmospheric turbidity and dry soil conditions in May, and relatively clear atmosphere after rainfall and moist soil conditions in September.

Albedo

Albedo (σ) was highest at dawn and dusk and lowest during the solar noon, exhibiting a parabolic course (Fig. 1). The daily average albedo of grass surface was 0.20, 0.21, 0.25 and 0.26 on December 20, 1982, January 22, and May 5 and June 13, 1983, respectively. Lower albedo in December and January might be due to greater soil wetness, high average humidity (74%), and cooler conditions (average temperature 13.2°C) than in May and June (humidity 47-54% and average temperature 26.5-28.6°C).

Albedo of rice crop was 0.19, 0.23 and 0.25 during panicle intiation (August 18), flowering (September 3) and hard dough (September 30), respectively (Table 1). The increase in albedo was associated with increasing crop cover. Lowest albedo in August may be due to relatively greater consumption of incoming solar radiation by exposed soil water surface. After full growth, the albedo of rice was similar to the grass.

Albedo of wheat crop was 0.18, 0.24, 0.22 and 0.21 during late jointing (February 1), flowering (February 21), milking (March 21) and hard dough (April 5) respectively. A rapid increse in albedo from 0.18 to 0.24 in February may be attributed to increased crop cover and dry matter production (Kalma and Badham, 1972). A decrease of albedo in April was associated with yellowing and reduced effective crop cover due to gradual senescence and maturing of inflorescence. Greater albedo of Bermuda grass than wheat may be associated with denser stand and leaves oriented at all angles as against thinner wheat stands and more errect leaves.

Net radiation, solar radiation and sunshine hours relationship

Regression of daily and hourly net radiation on solar radiation over wheat, rice and Bermuda grass individually and all pooled gave linear relationship (Fig. 2). The correlation coefficients were more than 0.98 for the hourly data and between 0.92 and 0.97 for the daily data (Fig. 3). The standard deviation from regression was 0.14, 0.17 and 0.12 MJm^{-2} for the hourly data over wheat, rice and grass respectively, and 0.72 MJm^{-2} over wheat and 0.70 MJm^{-2} over the grass for the daily data (Fig. 3).

Thus, the standard error in estimating net radiation from solar radiation for any of the crops using either

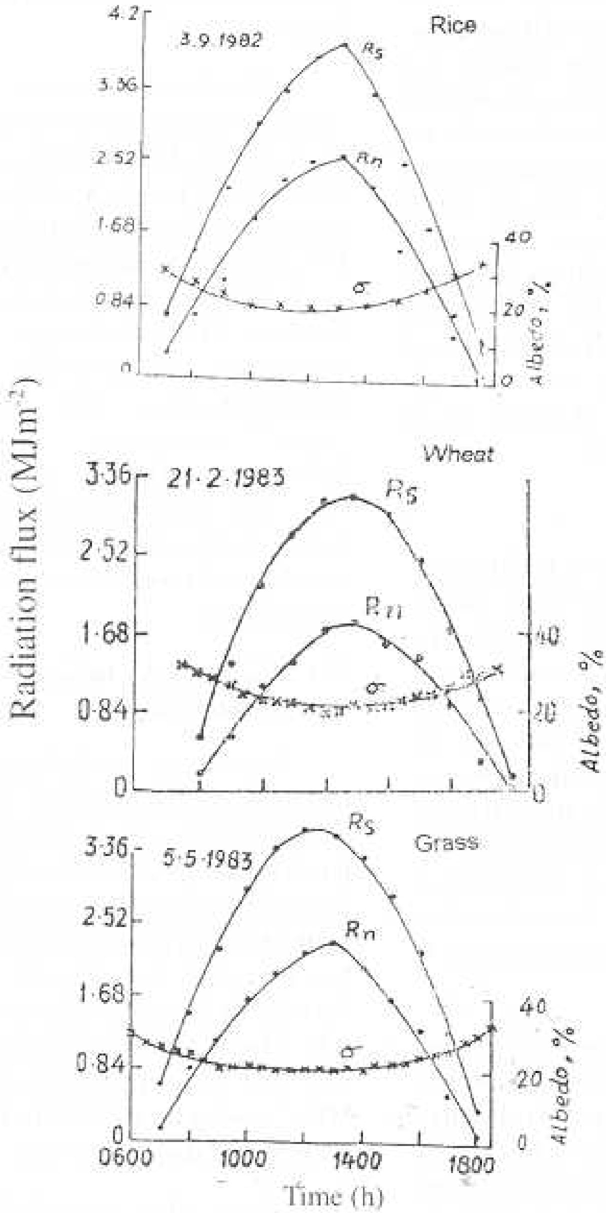

Fig. 1 : Day time variations of solar radiation (Rs), net radiation (Rn) and albedo (σ) on selected clear days over rice, wheat and Bermuda grass.

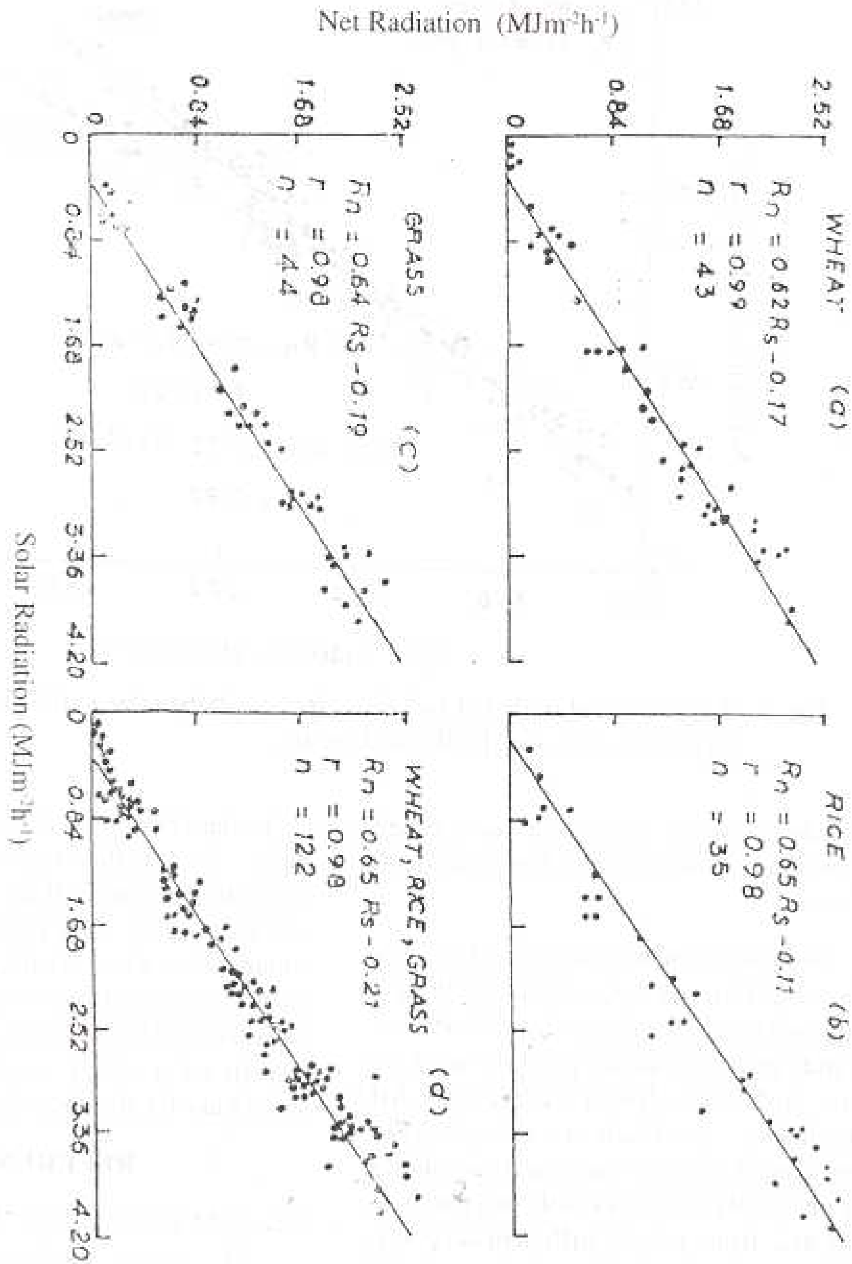

Fig. 2 : Regression of hourly net radiation (Rn) on hourly solar radiation (Rs) over: (A) Wheat, (B) Rice, (C) Grass and (D) Wheat, Rice and Bermuda grass.

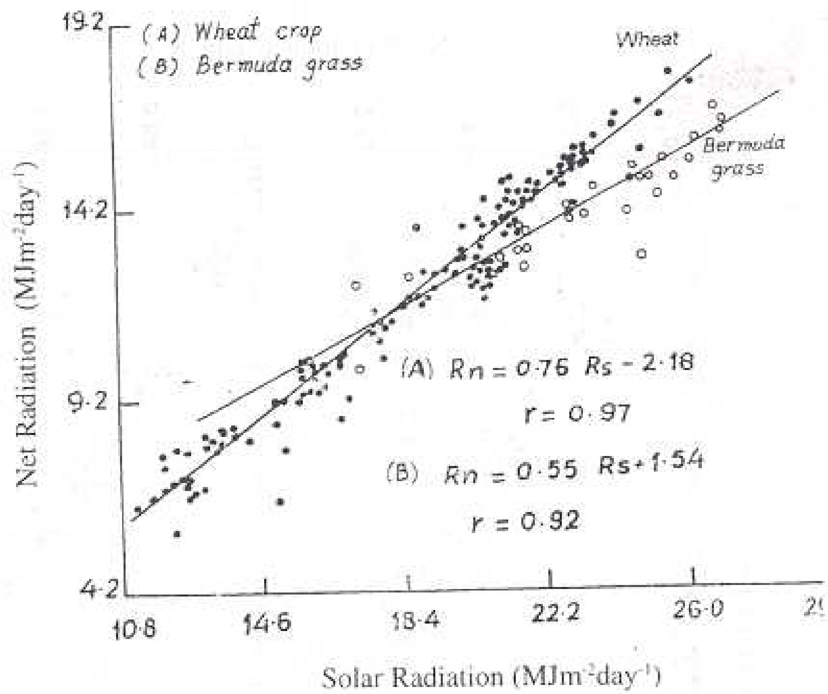

Fig. 3 : Regression of daily net radiation (Rn) on daily solar radiation (Rs) over (A) wheat crop and (B) Bermuda grass.

individual crop's regression or pooled regression would be within less than 5-10 per cent.

Regression of net radiation (Rn) over wheat and Bermuda grass individually and combined together on actual sunshine hour (n) and ratio of actual to possible sunshine hour (n/N) was linear (Table 2). All correlation coefficients were highly significant. The regression analysis shows that in case Rs is not available, Rn could be estimated from n with sufficient accuracy. The regression of daily Rs on both n and n/N was highly significant (Table 2) but the value of standard error from regression showed that daily Rs in this region can be better estimated from n than from n/N. The standard error was minimum with the summer data when weather variations were least compared to the other seasons. The regression of Rs/Rs on n or n/N was highly significant with the summer data but not significant for the data of other seasons.

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Table 2 : Regression of daily Rn, Rs and on actual sunshine hour (n) and ratio of actual to possible sunshine hour (n/N).

Crops	Regression equation	σ,x	r
Wheat	Rn = 24.92 n + 3.05	2.24	0.66
	Rn = 201.05 n/N + 5.78	2.68	0.44
Grass	Rn = 16.33 n + 7.16	1.00	0.82
	Rn = 216.56 n/N + 7.30	1.05	0.80
Wheat and Grass	Rn = 24.03 n + 3.49	2.10	0.69
	Rn = 207.95 n/N + 5.95	2.79	0.47
Wheat	Rs = 32.88 n + 6.88	2.79	0.68
	Rs = 268.32 n/N + 10.30	3.39	0.46
Summer	Rs = 28.97 n + 10.64	1.46	0.87
	Rs = 378.57 n/N + 11.05	1.62	0.83
Entire data	Rs = 34.98 n + 6.53	2.72	0.73
	Rs = 295.94 n/N + 10.30	3.51	0.48
Wheat	Rs/Rso = 0.06 n + 0.012	0.03	0.17
	Rs/Rso = 0.58 n/N + 0.016	0.03	0.13
Summer	Rs/Rso = 0.04n + 0.014	0.002	0.89
	Rs/Rso = 0.53 n/N + 0.014	0.002	0.84
Entire data	Rs/Rso = 0.43 n + 0.017	0.028	0.13
	Rs/Rso = 0.49 n/N + 0.019	0.028	0.11

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