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Solar energy components in cotton and safflower crops

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सार — कपास (गौसिपियम हिर्सुटम) और कुसुंभ (कार्थेन्स टिक्टोरियस) फसलों की विभिन्न परिअवस्थाओं में सौर ऊर्जा घटकों का मूल्यांकन किया गया। विभिन्न घटकों के प्रतिशत का परिकलन किया गया। कपास में पुष्पन की अवस्था के दौरान तथा कुसुंभ में बीज स्थापन अवस्था के दौरान सौर ऊर्जा उपयोग घटक अधिकतम पाया गया। कपास की फसल में एल्बिडो पुष्पन की अवस्था तक स्थिर रहता है किन्तु धीरे-धीरे बढ़ता हुआ बाल विकास की अवस्था पर अधिकतम हो जाता है और बाद में धीरे-धीरे कम हो जाता है। कुसुंभ के मामले में, एल्बिडो बीज स्थापन की अवस्था तक धीरे-धीरे बढ़ता है और फिर कम हो जाता है । दोनों फसलों में पारेषित घटक पहले कम होता है और बाद में बढ़ जाता है।

ABSTRACT. Solar energy components at different phenophases of cotton (*Gossypium hirsutum*) and safflower (*Carthanus tinctorius*) crops were measured. The percentage of different components are calculated. Solar energy utilisation component is found maximum during flowering stage in cotton and during seed setting stage in safflower. The albedo is constant till the flowering stage and gradually increases reaching a maximum at the boll development stage and later decreases gradually in the cotton crop. In the case of safflower, the albedo gradually increases till the seed setting stage is attained and decreases. The transmitted component first decreases and then increases in both the crops.

Key words—Vegetative phase, chlorophyll efficiency, phenophase and seed setting.

1. Introduction

Solar energy is a major factor controlling the agricultural productivity. It is the source of energy for growth, evaporation and environmental heating. The absorption or utilisation of the incident solar energy is mainly depending on chlorophyll efficiency and density of stomata on the leaf of the crop and the leaf area index of the crop. The interaction of solar energy and its components over different field crops has been studied by several scientists like Monteith and Szeicz (1961), Stanhill *et al.* (1966), Fritschem (1967), Campbell *et al.* (1981), Andre and Viswanathan (1983) and Rajegowda and Ratnam (1987). Only Fritschen has studied net and solar radiation over cotton and other irrigated crops. Here we have attempted to study the distribution of different components of solar energy during different phenophases of cotton and safflower crops.

2. Material and methods

The radiation observations were made using a pyranometer (National instruments, Calcutta, India) in the experimental field of College of Agriculture, Dharwad, India. Cotton variety, Laxmi (*Gossypium hirsutum*) was sown on 20 August 1984 in plots of size 4.8 m×2.7 m with a spacing of 60 cm × 30 cm. The safflower (*Carthanus tinctorius*) of variety A-300, was sown on 5 November 1984 in a plot size 2.5 m× 2.5 m with a spacing of 60 cm×30 cm. All normal cultivation practices were followed with required irrigations, recommended dose of fertilizers like 2000-2500 kg compost and 15 kg N, 10-20 kg P_2O_5 and 10 kg K_2O per acre were applied, 15-20 days before sowing. Plant protection chemicals were also sprayed in equal three instalments and fields were kept free from weeds. The observations were made at fortnightly intervals starting from 52nd day and 61st day after sowing for cotton and safflower respectively. Measurements could not be made before as there was no sufficient vegetative growth of the crops.

The incoming and the reflected solar radiations were measured at an height of one metre above the canopy at all stages of the crops. The transmitted component below the canopy was measured keeping the pyranometer on the ground at the centre of the plot. By deducting the reflected and transmitted components from the incident solar energy, the solar energy utilised by the crop for its growth in different stages is computed. These measurements were made between 0800 IST and 1700 IST. The percentage of different radiation components were also computed.

3. Results and discussion

3.1. *Cotton*

As the leaf area increases slowly the observations were started from the vegetative phase. During the vegetative phase four observations were recorded on 52nd, 67th, 81st and 96th day after sowing. In the flowering stage two observations were recorded on

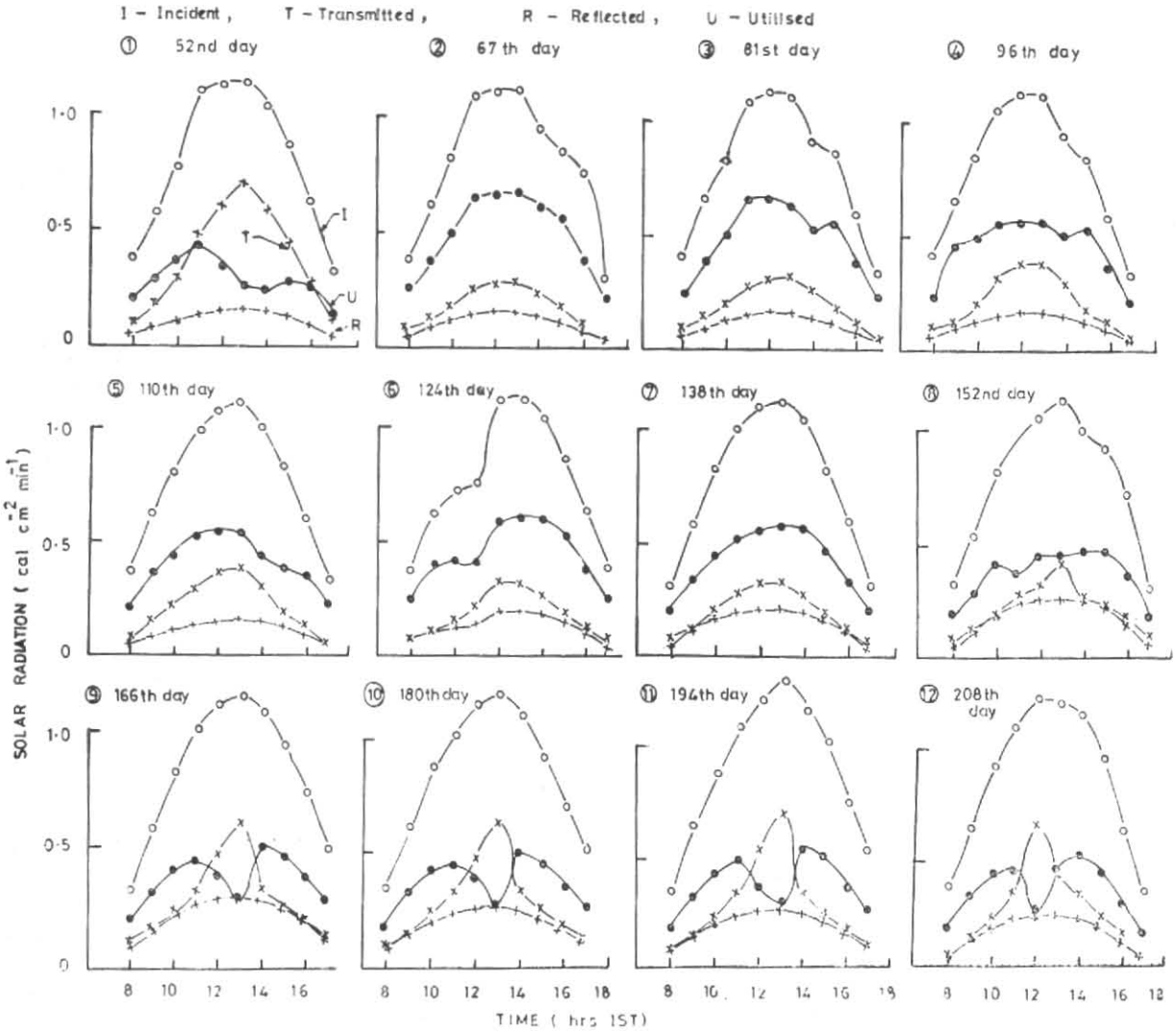

Fig. 1. Diurnal solar radiation components in cotton

110th day and 124th day. During the boll development stage three observations were recorded on 138th, 152nd and 166th day. In the boll bursting and harvesting stage the readings were taken on 180th, 194th and 208th day from the day of sowing. Table 1 gives the day of observation from the sowing date, average height of the crop on the day of observation and different components of total solar energies in cal/cm² between 0800 IST and 1700 IST.

In Fig. 1, we have plotted the diurnal variation of different components of solar energy in different stages. The incident radiation was maximum during 1300 IST on almost all the days. The incident radiation increased from 0.4 cal/cm²/min reaches a maximum of 1.3 cal/cm²/min around 1300 IST and decreases gradually which shows bell shaped curves. The reflected solar energy curves are almost same on all the days. The transmitted and utilised components are varied with different phenophases. The transmitted component is found to be gradually increased and decreased in vegetative, flowering and beginning of the boll development stages, and in the boll bursting and harvesting stage it increases steeply till the noon and decreases suddenly. The utilised solar energy increases till noon and then gradually decreases in all stages except at the later stages. In the latter stages this component shows two peaks one in the morning and the other one in the evening.

In Table 1, we have given the different components of total energy on the day of observation. The percentage of solar energy components are plotted against the day of observation after the sowing as shown in Fig. 2.

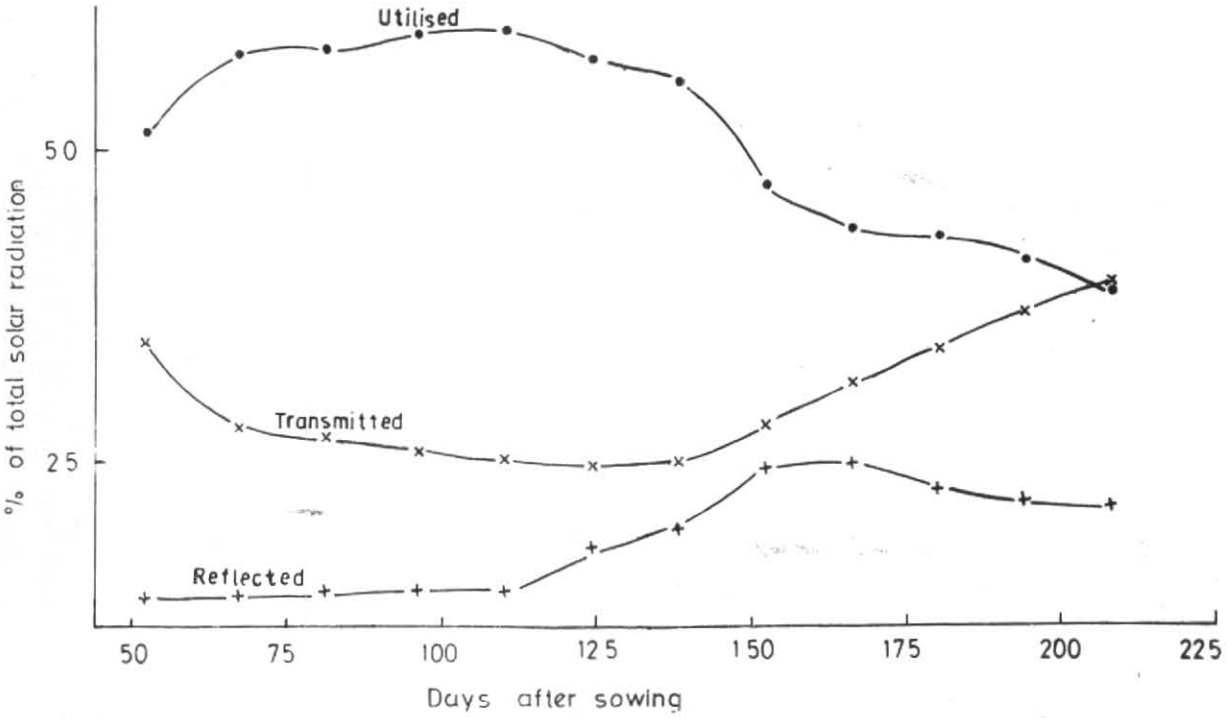

Fig. 2. Percentage of total solar radiation components in different stages in cotton

TABLE 1

Days after sowing, height of the crop, stages of the crop and total solar energy components between 0800 IST and 1700 IST on the day of observations at different stages of the cotton crop and safflower

No. of observations	The day of observations after sowing	Average height of the crop (cm)	Stages of the crop	Total solar energy (cal/cm²)			
				Incident	Transmitted	Reflected	Utilized
			Cotton				
1	52	70	Vegetative	461.76	159.12	64.56	238.08
2	67	80	Vegetative	465.60	129.60	66.24	269.76
3	81	95	Vegetative	451.44	122.40	66.72	262.32
4	96	100	Vegetative	457.44	118.08	68.16	*271.20*
5	110	107	Flowering	448.32	115.20	66.24	266.88
6	124	108	Flowering	440.64	109.20	79.68	251.76
7	138	102	Boll development	456.48	114.24	90.00	252.24
8	152	101.4	Boll development	456.00	128.16	113.04	214.80
9	166	100.4	Boll development	480.73	151.41	*119.52*	210.00
10	180	98.6	Boll bursting and harvesting	486.24	164.16	111.60	210.48
11	194	96.2	Boll bursting and harvesting	516.24	191.40	113.04	212.16
12	208	93.0	Boll bursting and harvesting	500.86	*198.00*	108.46	194.40
			Safflower				
1	61	64	Flowering	456.48	*230.88*	60.72	164.88
2	75	67	Flowering	456.00	195.12	72.48	188.40
3	89	69	Seed setting and maturity	480.72	150.48	114.00	216.24
4	103	69	Seed setting and maturity	510.24	97.68	*120.96*	*291.60*
5	117	69	Seed setting and maturity	516.24	129.12	118.32	268.80
6	131	69	Harvesting	486.24	167.52	105.12	213.60

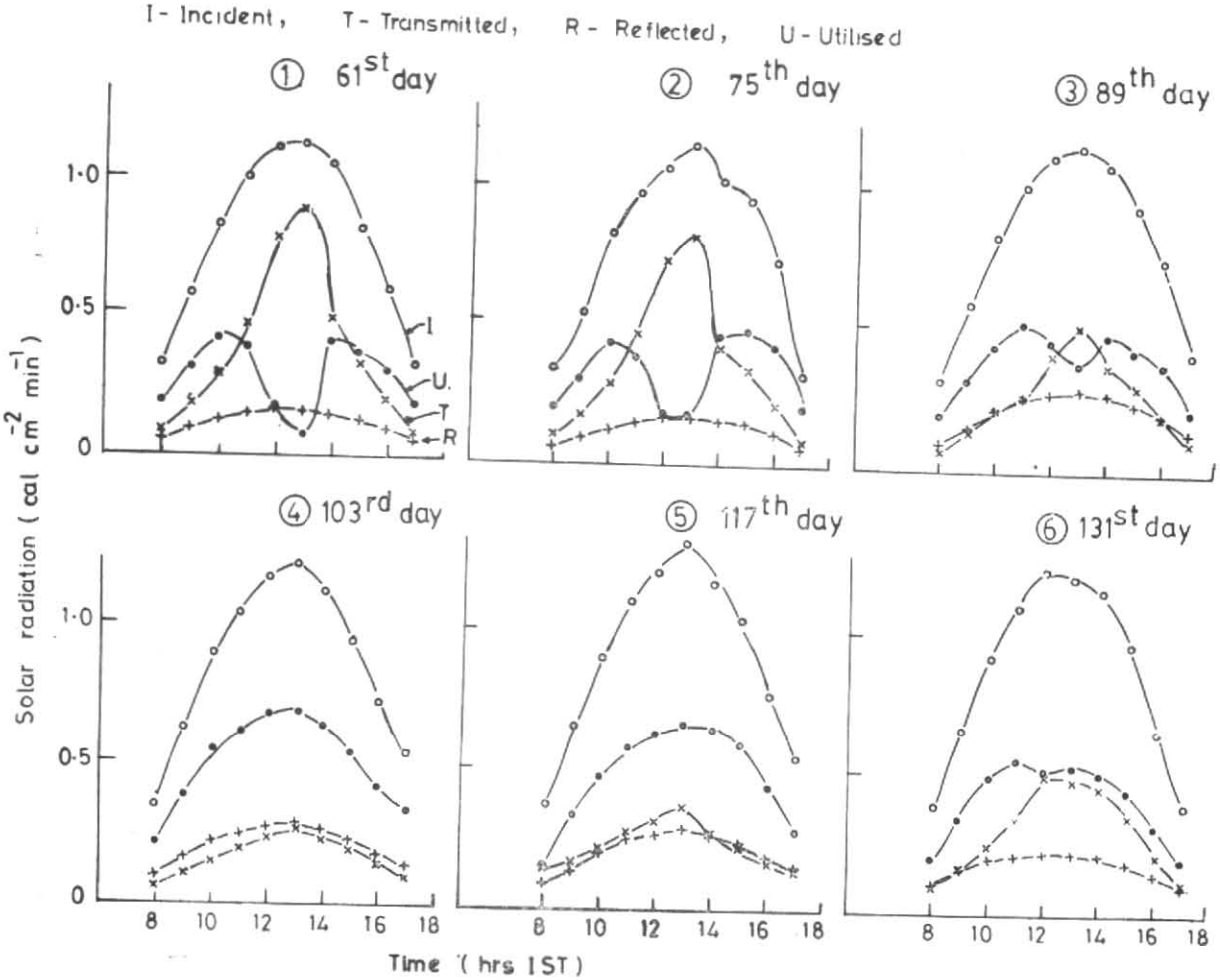

Fig. 3. Diurnal solar radiation components in safflower

The utilised solar energy is found to be very high compared to the other two components and it is maximum during flowering and minimum during harvesting stage. As the leaf area and density is maximum during the flowering stage maximum percentage has been absorbed in this stage. The transmitted component decreases as the leaf density increases up to flowering stage and it started increasing from boll development stage reaching maximum during harvesting stage. This increase in transmitted energy was observed due to the old and withered leaves. The reflected component is constant up to the end of flowering stage and gradually increased in the boll development stage and decreases in the boll bursting and harvesting stages.

3.2. *Safflower*

In the case of safflower the observations were made on 61st and 75th day in the flowering stage, 89th day, 103rd day and 117th day in seed setting and maturity stage and 131st day in harvesting stage after sowing.

Fig. 3, shows diurnal variation of different solar energy components. Here also the incident radiation is found to be maximum at 1300 IST and have bell shaped curves. The reflected component is found to be follows the similar trend at all stages of the crop, that is a gradual increase till noon and decreases. The transmitted component follows a bell shaped curve

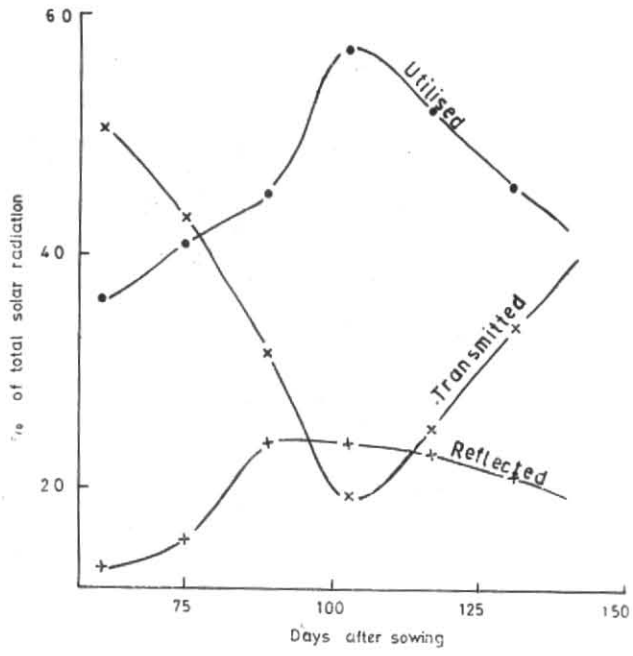

Fig. 4. Percentage of total solar radiation components in different stages in safflower

in the flowering and comparatively low raise in the peak during seed setting and maturity and harvesting stages. This is again because of low density of leaves and old and withered leaves. The diurnal variation of utilised component in the crop is different in different stages. In the flowering stage it increases till 1000 IST and then decreases to minimum at 1300 IST and again it increases till 1500 IST and decreases. In the seed setting and maturity stage this utilised component follows bell shaped curves.

Different components of energy at different stages are given in Table 1. In Fig. 4, we have plotted the percentage of total solar energy components on the day of observations. The percentage of reflected radiation increase till the seed setting stage is reached and afterwards gradually decreases. Transmitted energy decreases very sharply till the end of maturity stage and then again increases. But the utilised energy gradually increases right from the beginning and reaches a maximum during the middle of the seed setting and maturity stage and then sharply decreases. It is obvious from this figure, that the utilised component is higher than the other two components in the entire life cycle of the crop.

4. Conclusions

Percentage of total solar energy utilised between 0800 IST and 1700 IST is maximum (59.5%) during flowering stage in the cotton and it is maximum (57.1%) during seed setting and maturity stage in the case of saflower. Transmitted components are very low during above stages in both the crops. Transmitted energy component is very high (39.5%) during harvesting stage in the cotton crop and it is maximum (50.6%) during flowering stage in the safflower. The albedo follows the same trend in both the crops, it increases to maximum (24.8%) during boll development stage in the cotton and (23.7%) during seed setting and maturity in the case of safflower. Fristschen obtained the albedo values between 0.19 & 0.22. As there is not enough work has been done in the field of solar energy over cotton and safflower, it is further required to study in detail about the spectral nature over these crops in different phenophases.

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