IMPACT OF LIGHT ON THE RICE PLANT*

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A biologist faces a wide field when he attempts to deal with the influence of light on the living matter. The definition of living matter itself is rather vague, whether it is a mass of protein responsible for exhibiting responses—self-maintaining, self-regulating and self-perpetuating which are known as manifestation of life. Then again the philosophy of J. C. Bose (1902) is non-existence of barrier between living and non-living and the response of living matter foreshadowed in the non-living. The science of living matter can be traced back to the influence of light on the origin of life by chemical evolution after the amino-acids and proteins from which living matter came were synthesized from the atmospheric gas with the help of light energy. This would mean that life originated from non-life through the impact of light which also provides the materials for life and allows to maintain it. In this transformation we have to assume that input of energy from light was subject to such variations as were determined by conditions existence on the earth surface. Since the availability of light on our planet is related to the characteristic feature of the solar system, particularly to spin of the earth, the problem of light energy supply is subject to external influences resulting diurnal and seasonal variations. Thus the basic consideration lies in the origin of life by light and its maintenance in the earth through the diurnal and seasonal variations in its energy input.

Sunlight as it reaches on the surface of the earth it produces a set of reactions in a plant which depending on the condition are evaluated in terms of low and high energy reactions. The high energy reaction is largely manifested in the storage of solar energy in photosynthesis, through the primacy of chlorophyll and the synthetic processes associated with its formation. The low energy reaction is exhibited by photomorphogenesis which implies the effects of visible light over growth, development and differentiation of a plant independent of photosynthesis. The responses to low energy reactions are seed germination, cell elongation, tillering, leaf enlargement, anthocyanin formation, plumular hook unfolding, epinasty, formation of protochlorophyll, pigment formation in the cuticle, IAA oxidase activity, and endogenous diurnal rhythm. All these phenomena involving photochemical reactions independent of photosynthesis are mediated through phytochrome

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pigment system. The problems that the author and his associates have been interested are on two aspects—one dealing with low energy exhibited in the photoperiodic control of flowering and seed germination and the other involving high energy reactions in photosynthetic efficiency of the rice plant under a set of environmental conditions prevailing in the Eastern part of India. Todays talk will present an outline of the more important facts that have emerged from these studies.

PHOTOMORPHOGENESIS

Photoperiodic behaviour of a large number of rice varieties has been reported and short-day response to vegetative growth and acceleration of flowering has been established (Sircar, 1939, 1942, 1948, 1963). In these studies 16 hours dark period has been found optimum for dark reactions for flower initiation (Sircar, 1942, 1948). The remarkable effect of 16 hours dark period was acceleration of flowering by more than 90 days in a winter cultivar *Rupsail* after an exposure of 4 weeks short photoperiod (Sircar and Parija, 1949). During this period the initiation of flower primordia takes place after the growing apex elongates rapidly. Along the edges of the apex several groups of cells protrude which develop into branch rachides forming more than one spikelet. Change from the vegetative apex to the initiation of flower primordia in the main shoot takes place in the third week. Once the primordium is formed it contnues to grow and is not altered by non-inductive condition (Sircar and Sen, 1950, 1953). In the photoperiodic reaction temperature effect in the flower initiation and grain formation was evident. Difference of 4° C modified the effects; 16° C to 20° C produced empty spikes but at 20° to 32° C normal grain formation was noticed. The critical temperature of maturity was 32° C after anthesis (Sircar and Sen, 1951). The formative effects of photoperiods and temperature dependence of several other varieties of rice have been confirmed by other workers in India (Misra, 1955 *a*, *b*, *c*, *d*; Ghosh and Shastri, 1954; Ganguly, 1954, 1955).

The significance of dark period in photoperiodic behaviour of plants has been established and the set of reactions initiated in the dark period is nullified by a flash of light in the middle of dark period. The effects thus produced are found to vary with spectral composition of light particularly the red and far-red rays on flower initiation. The relation of red and far red rays is reversibly mediated by phytochrome which has paved the way in understanding the relation of low energy that is involved in the transition of vegetative apex to flowering shoot or control of seed germination and similar such photomorphogenetic effects. In the background of the information of low energy reactions the influence of dark period, incandescent white light, and wavelength variations on 3 phases namely (i) germination, (ii) vegetative growth indicated by height and tillering and (iii) flowering of the rice plant have been studied by the author and his associates (Sircar and Biswas, 1960; Sarkar, 1967; Sarkar and Sircar, 1971). The varietal differences in these characteristics have been brought out.

Rice seeds are sensitive to light as percentage of germination is stimulated in darkness after an exposure of 8 hours natural day length. The interaction of wavelength and dark period on germination indicates blue light increases the percentage but green light inhibits the process. Red and far-red treatments are photoreversible. In the cultivar *Dudkalmi*, red light acts as stimulant and far-red following it inhibits the process. The reverse picture is noticed with wild rice *Fatua* and *Latifolia* (Sarkar, 1967). The mechanism involved is presumably similar to the photoreceptive system in which reversible red and far-red pigment phytochrome operates. The phytochrome control of rice seed germination has further been demonstrated from the effects of red and far-red light on seeds losing viability with age. In fresh seeds white and red light has more or less the same effect on germination, far-red reduces the percentage to a small extent. As the seeds age in storage there is a gradual fall in the percentage of germination but when they are treated with red there is marked promotion. It is interesting to note that the seeds lost viability in course of storage for one year but treatment with red induced the germinating capacity of these seeds up to 20 per cent.

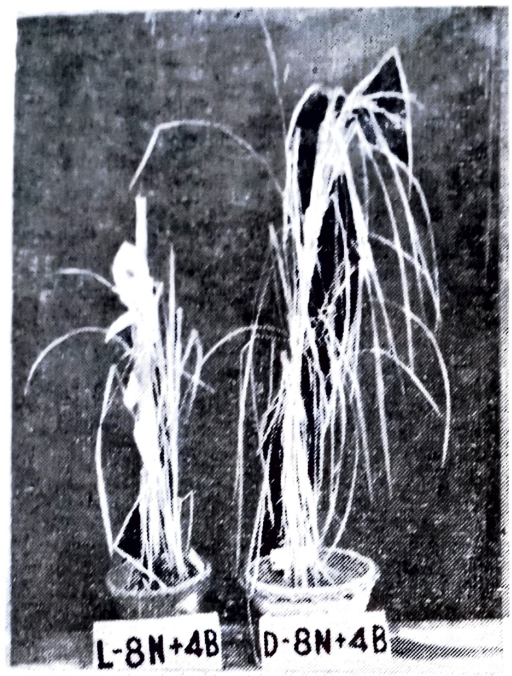
Phytochrome acts in seed germination by controlling the synthesis of enzymes or by the mediating action of growth substances. In view of this the effects of red, far red, blue and white light on inhibitor formation and enzyme synthesis are now being studied. The preliminary results (Biswas and Sircar, 1969) indicate that the α-amylase activity in the embryo and endosperm increases both with age and after exposure to far-red. IAA oxidase activity in the embryo is absent in dark and in far-red and red light-treated seedlings the activity is less than in white light. The reduction of IAA oxidase in red and far-red is suggestive of the presence of the oxidase inhibitor which presumably promotes growth rate by inhibiting IAA breakdown. In addition both red and far-red treatment indicated the presence of root and shoot growth inhibition in different elutes of the chromatogram. Further work on the nature of the inhibitors and the synthesis of the enzyme system in different wavelengths and possibility of their phytochrome control is now in progress.

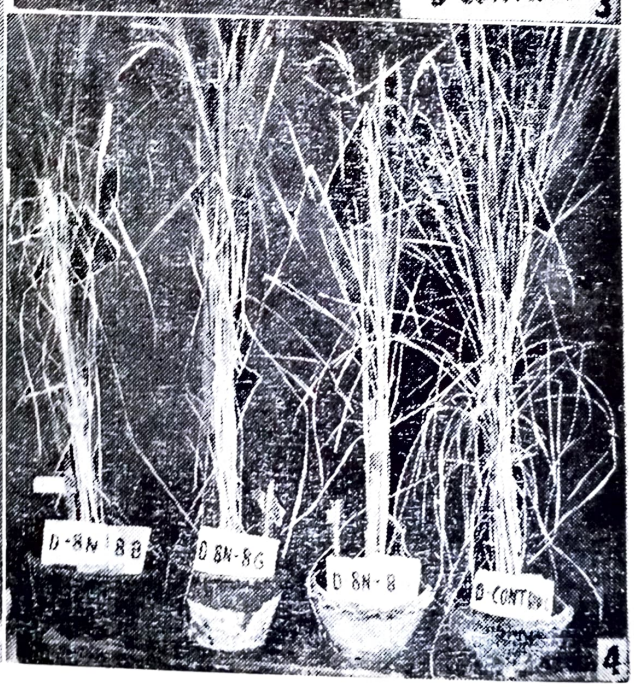
The effects of dark period and wavelength variations on vegetative growth show varietal response. Height in *Dudkalmi* and *Latifolia* is greater in white light than in other wavelengths with the same duration of dark period. The behaviour of *Fatua* is different which exhibits reduction in white light but increases after 2 hours far-red illumination (Sarkar, 1967). This evidently suggests that the formation of R-phytochrome by far-red is linked with the elongation of the rice stem. Blue, red and far-red induced marked variations in stem elongation of the plant. According to Down *et al.* (1957), variation of elongation in light and darkness is photocontrolled through phytochrome. Far-red tends to increase height and red decreases it; the ratio of the two forms will determine the final length of the plant. At the close of the photoperiod, the pigment is in the far-red saturated condition due to larger source of far-red in the sunlight. Then in darkness almost

all the pigment is in red absorbing form after 3 hours (Hendricks, 1956, 1960). Thus elongation results when the far-red form is transferred into red-absorbing form. In the present experiment incandescent light is used which is richer in far-red resulting greater conversion of far-red to red form of the pigment. The question arises how R-phytochrome helps in elongation. One suggestion is that R-phytochrome might lead to the production of stem elongation factor, gibberellin. The pertinent enquiry would be whether any of the wavelengths affect gibberellin (GA) level. The other consideration of stem elongation in relation to photoperiod and wavelength variations is the internal IAA level. The relation of IAA level to various aspects of growth and reproduction of the rice plant show that the internal IAA level regulates stem elongation and tillering behaviour (Sircar, 1958; Sircar and Chakravarty, 1957; Sircar and Kundu, 1960).

Synthesis of auxin at the nodal meristem controlling the elongation of internodal cells of the plant has been suggested by Sircar (1958). Reports have been published showing photo-oxidation of IAA by blue light in presence of riboflavin (Galston and Baker, 1949). The inhibiting effect of blue light on stem elongation may thus be caused by IAA inactivation. There is also a suggestion that antagonism exists between blue, red and far-red light in stem elongation. Reversible nature of red and far-red light in the activity of indole acid oxidase has been reported by Hillman (1957). Red light decreases the IAA oxidase activity resulting in higher IAA level. This is reversed by far-red exposure. Since the auxin level is greatly influenced by light quality, the conclusion would be the effects of different wavelengths on the auxin level modifying the growth of the rice plant. The auxin content of the plant in light treatments has not yet been estimated hence the explanation is tentative. The difference in response to blue, red and far-red light in different species or varieties has been brought out by Vince and Stoughton (1957) and Meijer (1957) in their experiments on the effect of light qualities on elongation.

Red and far-red radiations controlling the process of flowering through the mediation of the reversible pigment phytochrome is now a well-established fact (Borthwick, 1959, 1964). The phytochrome control of flowering in rice plants has been studied by Sarkar (1967), Sarkar and Sircar (1971). The experimental approach has been made by the use of supplementary light of different wavelengths interposed before the beginning, at the middle or after the end of the dark period. The critical dark period for the initiation of flowering of wild and cultivated winter varieties of rice lies between 11 and 13 hours. The cultivated variety *Dudkalmi* flowers in nature when dark period is approximately 13 hours. In wild variety *Latifolia* the critical dark period is 12 hours as flowering takes place when dark period more than 12 hours is available under natural condition. It is interesting to note that flowering could be induced in *Dudkalmi* and *Latifolia* with fixed dark period for 12 hours when the natural light of 8 hours is supplemented with 4 hours incandescent white or coloured light (Table I, Fig. 1)





FIGS. 1–4. Fig. 1. Flower induction in *Latifolia* (L) and *Dudkalmi* (D) after 8 hours natural day length + 4 hours blue light (200 Watt) followed by 12 hours darkness (after Sarkar, 1967). Fig. 2. Absence of flowering in *Latifolia* (L) and *Dudkalmi* (D) after 8 hours natural day length + 8 hours supplementary blue light followed by 8 hours darkness (after Sarkar, 1967). Fig. 3. Effect of half-an-hour blue light interposition after 4 hours dark period on flowering duration (after Sarkar, 1967). Fig. 4. Phytochrome-controlled flower induction by one hour red followed by one hour far red after 8 hours natural day length in *Dudkalmi* (D) which remained vegetative after 8 hours natural light + 8 hours blue (B) green (G) and white incandescent (W) light (200 Watt) (after Sarkar, 1967).

TABLE I

Flowering duration of rice cv. Dudkalmi *under different light treatments. Duration of treatment at 4 leaf stage after 4 weeks from sowing to the date of ear emergence* (after Sarkar, 1967)

Abbreviations: 8N– 8 hours natural day length 0·5, 2, 4, 8 and 12 hours while incandescent (W), blue (B), red (R), green (G) far-red (FR) and darkness (D).

Treatments	Flowering duration from sowing to ear emergence	Treatments	Flowering duration from sowing to ear emergence
Control natural day length above 13 hours	227	8N+4D+0·5B+11·5D ..	80
8N+16D ..	84	8N+4D+1B+11D ..	99
8N+2W+14D ..	130	8N+4D+1·5B+10·5D ..	140
8N+2B+14D ..	97	8N+4D+2B+10D ..	164
8N+2R+14D ..	113	8N+4D+0·5R+1 ·5D ..	100
8N+4W+12D ..	95	8N+4D+1R+11D ..	135
8N+4B+12D ..	125	8N+4D+1·5R+10·5D ..	Expired
8N+4R+12B ..	137	8N+4D+2R+10D ..	,,
8N+1R+1FR+14D .	89	8N+4D+0·5FR+11·5D ..	96
*8N+8W+8D ..	..	8N+4D+1FR+11D ..	119
*8N+8B+8D ..	..	8N+4D+1·5FR+10·5D ..	Expired
*8N+8R+8D ..	..	8N+4D+2FR+10D ..	,,

* Treatment continued after control plants flowered there was no flowering but subsequent treatment with 1 hour red followed by 1 hour far-red induced flowering within 2-7 days.

while flowering is not noticed in these two varieties at 12 hours natural dark period. This would obviously suggest that monochromatic light immediately before the beginning of the dark period has some significance in setting up the photochemical reactions leading to flowering which is thus accelerated by low energy and not dependent on the high energy reactions from the sunlight. Sarkar (1967) further reported changes in the flowering duration according to the nature of the wavelengths applied before the beginning of the dark period. Two to four hours white incandescent, blue, red and far-red show varying degree of acceleration but with 8 hours illumination with these wavelengths flowering either fails or is delayed beyond the control (Table I, Fig. 2). The important function of dark period in flower initiation

is the conversion of F-phytochrome to R-phytochrome with the concomitant release of timing reaction to initiate the synthesis of flowering stimulus (Salisbury and Bonner, 1956). This conversion time according to them is during the first 4 hours of the dark period. Taking this fact into consideration, it may be argued that illumination with supplementary light of different spectral composition after natural day length and before the beginning of dark period results different rates of conversion of F-phytochrome to R-phytochrome. With incandescent light the far-red proportion is greater than red and this would result conversion of more of the far-red to the red-absorbing form which will accelerate the timing reaction for flowering. The nature of flowering response varies with the time of application of supplementary light of different spectral composition. There is reduction in flowering duration when blue, red or far-red is applied before the beginning or after the end of the dark period. It is of interest to note that blue light has also shown marked effect on the vegetative growth and flowering duration (Table II). But interposition after 4 hours

TABLE II

Flowering duration of wild rice Latifolia *under treatments with light and darkness. Duration of treatment at* 4 *leaf stage after* 4 *weeks from sowing to the date of ear emergence* (after Sarkar and Si car, 1971)

Treatments	Flowering duration from sowing to ear emergence
Control—natural day length above 13 hours	166
8 N + 16 D	83
8 N + 0·5 B + 15·5 D	117
8 N + 4 D + 0·5 B + 11·5 D	149
8 N + 8 D + 0·5 B + 7·5 D	167
8 N + 12 D + 0·5 B + 3·5 D	92
8 N + 0·5 R + 15·5 D	110
8 N + 4 D + 0·5 R + 11·5 D	141
8 N + 8 D + 0·5 R + 7·5 D	171
8 N + 12 D + 0·5 R + 3·5 D	99
8 N + 0·5 FR + 15·5 D	110
8 N + 4 D + 0·5 FR + 11·5 D	141
8 N + 8 D + 0·5 FR + 7·5 D	201
8 N + 12 D + 0·5 FR + 3·5 D	105

Abbreviations as in Table I.

in the dark period the acceleration of flowering is reduced (Fig. 3) and in the middle of 16 hours dark period the reaction leading to flowering stimulus is neutralised and flowering takes place along with the control or is delayed (Table II). The situation is not clear whether blue light for short durations induces such a pronounced effect either by the mediation of a separate photo-reactive system or by the synergistic effect of blue light on the phytochrome system.

Photoreversible phytochrome reaction in the flowering behaviour in the rice plant is visualised from the effect of incandescent white, red and far-red light for different durations. Flowering in *Latifolia* and *Dudkalmi* is qualitatively accelerated when red is followed by far red rather than red follows white light before the beginning of the dark period. The phytochrome conversion in flowering is evident from the fact that these plants remain in the vegetative condition much longer than the control under treatment with 8 hours natural and 8 hours supplementary light of different wavelengths but flowers after 2 to 7 days when red is followed by far red (Fig. 4, Table I).

The facts discussed here impress upon the significance of photobiology of the rice plant. They emphasize the need for more information on the diverse manifestations in the life-cycle of the plant that are controlled by light intensity. We are still in the dark to clarify the precise cause-and-effect relationship in the low intensity blue, red and far-red light reactions as envisaged in the variety of responses from seed germination to flowering. The important task in this field would be to link the characteristic response to biochemical and biophysical changes in the living matter impinged by the light energy.

Photosynthetic Efficiency

The influence of sunlight is largely felt on the photosynthetic productivity of different varieties of rice. Accordingly, basic knowledge on the interaction between solar energy, photosynthesis, respiration and dry matter production in the plant is essential. The fai ure of high doses of nitrogen fertilizers to increase rice production in In dia is due to varietal differences for unavailability of sufficient photoslynthetic carbohydrates for assimilation of nitrogen. A comparative study of the effect of the climatic influence on the Indian varieties of rice has shown that monsoon season due to absence of bright sunlight imposes limitation on the photosynthetic efficiency of the leaves which leads to reduced nitrogen assimilation and protein synthesis while respiratory loss during the season is large because of higher day and night temperatures and large leaf mass. These adverse effects are not seen in winter with bright sunlight and lower temperature range (Sircar, 1966; Roy, 1968).

For productivity of grains the period after flowering is important. Greater the dry matter production after flowering higher the grain

yield. In order to increase dry matter production it is necessary to enlarge the availability of solar radiation and to make more efficient use of light energy after flowering. The former can be achieved by adjusting the flowering time so that ripening occurs within the period of maximum solar radiation. Sircar (1966 *a*, 1966 *b*) and Roy (1968) reported that by altering the practice of cultivation from monsoon to winter season having natural lower temperature and sunny days, the photosynthetic efficiency, net assimilation product and grain yield

TABLE III

The amount of solar energy incident on the surface of different leaves of different stages of growth

(*Expressed in calories/m²/hour*) *Position of leaves counted from top.*
Variety: IR-8 (Dry Season)

Stage	1st leaf	2nd leaf	3rd leaf	4th leaf
I	336·15	332·00	315·40	307·10
II	348·60	336·15	307·10	253·15
III	332·00	302·95	257·30	178·45
IV	344·45	294·65	240·70	161·85
V	377·65	311·25	253·15	174·30

TABLE IV

The amount of solar energy incident on the surface of different leaves of different stages of growth

(*Expressed in calories/m²/hour*). *Position of leaves counted from the top.*
Variety: IR-8 (Wet Season)

Stage	1st leaf	2nd leaf	3rd leaf	4th leaf
I	311·25	311·25	294·65	286·35
II	294·65	278·05	211·65	132·80
III	323·70	261·45	219·95	112·05
IV	298·80	265·60	186·75	87·15
V	294·65	273·90	178·45	85·00

Stage I. 10 days after transplantation. Stage II. 20 days after transplantation. Stage III. Tillering stage. Stage IV. Pre-flowering stage. Stage V. Post-flowering stage.

increased. The second possibility concerns the breeding of varieties with the necessary traits for photosynthetic efficiency. The aim of the breeders should be optimum leaf area index (LAI) composed of well-arranged active leaves at flowering without mutual shading, maintenance of these characters for longer period and short culm. In view of these considerations the important problems for increased productivity of rice need investigations are (1) effect of nitrogen supply on the photosynthetic accumulation of dry matter before and after flowering;

TABLE V

The amount of solar energy incident on the surface of different leaves of different stages of growth

(*Expressed in calories/m²/hour*) *Position of leaves counted from top.*
Variety : LATISAIL (Dry Season)

Stage	1st leaf	2nd leaf	3rd leaf	4th leaf
I	336·15	327·85	307·10	298·80
II	348·60	323·70	261·45	174·30
III	340·00	294·65	211·65	161·85
IV	354·45	282·20	182·60	116·20
V	382·65	302·95	190·90	—

TABLE VI

The amount of solar energy incident on the surface of different leaves of different stages of growth

(*Expressed in calories/m²/hour*) *Position of leaves counted from Top.*
Variety : LATISAIL (Wet Season)

Stage	1st leaf	2nd leaf	3rd leaf	4th leaf
I	311·25	307·10	294·65	278·80
II	294·65	253·15	174·30	120·35
III	323·70	244·85	145·25	87·15
IV	298·80	215·80	99·60	66·40
V	294·65	219·95	5·45	..

Stage I—10 days after transplantation. Stage II—20 days after transplantation. Stage III—Tillering stage. Stage IV—Pre-flowering stage. Stage V—Post-flowering stage.

(2) influence of nitrogen on photosynthetic and respiratory activities in ripening grains. The large differences in yield potentials have been noticed between Japonica and Indica varieties. This consideration has led us to examine more critically the photosynthetic efficiency of the varieties grown in India and to assess the comparative performances of the local varieties with the introduced ones. The objective is to find out the physiological basis and morphological characters contributing towards grain yield. The experiments with IR 8 and local winter cultivars *Latisail* and *Patnai* were carried out by the author and his associates at the experimental stations at Chinsurah and Shyamnagar. The photosynthetic efficiency and carbohydrate metabolism were measured from net assimilation rate of leaves (NAR), leaf area index (LAI), chlorophyll content, light transmission ratio (LTR) plant height, tiller and spikelet numbers, grain yield and respiration rate of the leaves. These measurements were taken at different stages in the life-cycle of the plant grown with varying levels of nitrogen, potash and phosphate (Das and Sircar, 1970). The results show that the light energy incident on the surface of the topmost leaf is at a higher level and diminishes gradually in the lower leaves due to shading (Tables III to VII). With the advancement of growth the decline in

TABLE VII

Light Transmission Ratio (LTR) percentage from ground level to the top of the plant

Stages	Variety		
	Latisail	IR 8	Patnai
Tillering	11·9	20·7	7·4
Pre-flowering	10·0	16·9	4·3
Post-flowering	32·4	43·8	32·8

the amount of energy on the surface of lower leaves is well marked because of mutual shading by the upper leaves. Between the two varieties it is apparent that in the lower leaves of *Latisail* there has been larger reduction in light energy because of the spreading leaves of the variety, while IR 8 maintains higher energy level on lower leaf surface for its erect leaf with less shading. The availability of light energy on the leaf surfaces of both the varieties is further reduced in the wet season due to cloudy weather in comparison to dry season with bright sun-light. This is related to lower assimilation rate and reduced grain yield of the varieties in the monsoon season (Sircar, 1966). In accordance with the incidence of solar energy on the leaf surfaces the NAR is higher in IR 8 than in *Latisail* (Tables VIII to XI). IR 8

TABLE VIII

Net assimilation rates of different leaves

(Expressed in gm/100 cm² leaf area/day) Position of leaves counted from top. Variety : IR 8 (Wet Season)

Stage	1st leaf	2nd leaf	3rd leaf	4th leaf
I	0·029	0·034	0·022	0·021
II	0·043	0·045	0·038	0·034
III	0·112	0·119	0·103	0·097
IV	0·126	0·121	0·117	0·105
V	0·084	0·071	0·055	0·051

TABLE IX

Net assimilation rates of different leaves

(Expressed in gm/100 cm² leaf area/day) Position of leaves counted from top. Variety : IR 8 (Dry Season)

Stage	1st leaf	2nd leaf	3rd leaf	4th leaf
I	0·038	0·039	0·028	0·024
II	0·049	0·052	0·048	0·040
III	0·182	0·194	0·173	0·124
IV	0·221	0·217	0·205	0·145
V	0·114	0·103	0·087	0·075

Stage I—10 days after transplantation. Stage II—20 days after transplantation Stage III—Tillering stage. Stage IV—Preflowering stage. Stage V—Post-flowerin stage.

TABLE X

Net assimilation rates of different leaves

(Expressed in gm/100 cm² leaf area/day) Position of leaves counted from top. Variety : LATISAIL (Wet Season)

Stage	1st leaf	2nd leaf	3rd leaf	4th leaf
I	0·022	0·030	0·021	0·019
II	0·038	0·041	0·032	0·029
III	0·082	0·091	0·073	0·051
IV	0·109	0·101	0·077	0·050
V	0·064	0·051	0·041	—

TABLE XI

Net assimilation rates of different leaves

(Expressed in gm/100 cm² leaf area day). Position of leaves counted from top. Variety : LATISAIL (Dry Season)

Stage	1st leaf	2nd leaf	3rd leaf	4th leaf
I	0·028	0·032	0·024	0·020
II	0·045	0·048	0·037	0·032
III	0·110	0·113	0·107	0·098
IV	0·128	0·120	0·115	0·103
V	0·073	0·067	0·052	..

Stage I—10 days after transplantation. Stage II—20 days after transplantation. Stage III—Tillering stage. Stage IV—Pre-flowering stage. Stage V—Post-flowering stage.

further maintains higher photosynthetic rates in pre-flowering and post-flowering stages which are mainly responsible for larger grain filling and yield. The superiority of IR 8 in photosynthetic efficiency is also seen in the wet season where the NAR in all the leaves is larger than the local variety *Latisail*. On the other hand LAI (Table XII)

TABLE XII

Leaf Area Index (LAI) *of rice leaves*

Stages	Variety		
	Latisail	IR 8	*Patnai*
Tillering	3·49	2·95	3·53
Pre-flowering	4·00	3·54	5·32
Post-flowering	2·27	2·08	2·06

and height are larger in the local varieties but because of shading effect higher LAI does not contribute more to the photosynthetic production, on the contrary the larger leaf mass tends to reduce carbohydrates by respiration. The presence of higher chlorophyll content for longer duration in IR 8 (Table XIII) is also contributory to higher photo-synthetic production. Similarly, the respiratory loss of carbohydrates

TABLE XIII

Chlorophyll contents of rice leaves expressed as absorbancy at 665 mμ per gm fresh weight per 100 ml. 80% ethanol

Stages	Variety	
	Latisail	IR 8
Tillering	0·797	0·867
Pre-flowering	1·215	1·097
Post-flowering	0·585	0·785

at the tillering and pre-flowering stages is higher in IR 8 but the loss at post-flowering is lower than *Patnai* which would mean more carbohydrates available for grain filling (Table XIV). It is thus evident that the higher yield potentials of IR 8 are attributed to greater photosynthetic efficiency of the leaf presumably due to its characteristic shape. Application of different fertilizer levels indicate that the photosynthetic efficiency of a leaf could be increased by increasing the supply of N, P and K, the increase being 20 tc 30 per cent at 60 lb. of N, P and K per acre. The yield difference between *Latisail* and IR 8 is 47 per cent (Table XV).

TABLE XIV

Respiration rates of rice leaves O_2 uptake in μl/100 mg fresh weight/hour

Stages	Variety		
	Latisail	IR 8	*Patnai*
Tillering	104·5	117·5	107·6
Pre-flowering	95·9	99·2	88·3
Post-flowering	55·3	60·0	71·6

Two aspects of photosynthetic efficiency are thus reported on the rice plant. One deals with seasonal and diurnal variations of light intensity showing considerable differences in yield potentials of the same variety in wet and dry seasons. The other aspect is the varietal characters in the maximum utilization of sunlight for photosynthetic production. The leaf characters, age, chlorophyll content and senescence are mainly contributing towards greater carbohydrate production

TABEL XV

Grain Yield in lbs per Acre (1967–68)

(Computed from the yield of unit area 5 sq. meter)

N level K×P levels	Var : *Latisail*		Var : *IR 8*		Var : *Patnai*	
	N_{30}	N_{60}	N_{30}	N_{60}	N_{30}	N_{60}
K_0P_0 ..	1679·14	2199·40	3008·1	4432·5	2452·0	3921·9
K_0P_{60} ..	1794·68	2411·04	3342·1	4839·6	3179·1	4266·9
$K_{60}P_0$ ..	1168·48	2610·18	3898·6	5105·1	3240·7	4419·6
$K_{60}P_{60}$ ..	1933·20	3052·88	4062·5	5535·0	3878·2	4667·4

and translocation for grain filling. This would imply that with the same light energy falling on the leaf surfaces it is the plant type that determines the optimum utilization of sunlight. In this talk I have presented the potent effects light has on the physiological make of the rice plant in the processes that are concerned in the growth characters and productivity of the plant.

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