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BRIEF COMMUNICATION

Influence of low irradiance on chloroplast proteins and photosystem activities in rice cultivars

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Abstract

In six rice cultivars the relative amounts of 55, 26-28 and 15 kDa polypeptides were mostly lower in plants grown for 15 d under low irradiance than in plants grown under saturating irradiance. This decline in the polypeptides, especially in those related to light-harvesting chlorophyll proteins, was accompanied with a decrease in the whole chain electron transport and the photosystem 2 activity.

Key words: acclimation , electron transport, *Oryza*, polypeptides

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Tall rice cultivars are generally superior to semi-dwarf types in photosynthetic efficiency, especially under low irradiance (Vinayarai and Murty 1977, Janardhan and Murty 1980). The high yielding shade adapted cultivars Vijaya, CO43 and Ponni are able to photosynthesize under low irradiance at a greater rate than the shade susceptible cultivars like IR20 (Mohandass 1989, Chowdhury *et al.* 1994). These may improve the rice productivity in wet seasons. Knowledge of the primary structure and photochemical functions of chloroplasts and their variation due to low irradiance is a important part in manipulation of photosynthetic activity for technological advancement.

Four early cultivars, including two promising hybrids (ADT37, IR50, TNRH1 and TNRH2) and two medium duration cultivars (CO43 and IR20) of rice (*Oryza sativa* L.) were grown in mud pots under normal irradiance, agronomic and plant protection practices till panicle initiation stage. As this stage, potted plants were transferred for 15 d to the growth chamber (model *E 15*, *Conviron Products Co.*, Manitoba, Canada) providing either saturating (800 μmol(PAR) m^{-2} s^{-1}) or low (400 μmol m^{-2} s^{-1}) irradiance (N and L plants, respectively). The air temperature and relative humidity were computer fixed at 25 °C and 80 %, respectively. At the end of the treatment the leaves were collected and used for isolation of intact and broken (type II)

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chloroplasts following Foyer and Furbank (1992). Analysis of chloroplast proteins was carried out by 12 % *SDS-PAGE* along with *Sigma* grade markers according to Laemmli (1970). The destained protein gel of *SDS-PAGE* was scanned at 660 nm with the help of *Beckman DU-640* UV spectrophotometer for quantification of bands of chloroplast proteins. The comparison with scanned individual Coomassie Blue stained lane indicated the presence of about 24 poly-peptides separated in the lanes for different cultivars. The intact chloroplasts obtained from the contrasting cultivars CO43 and IR20 were utilised for measuring the whole chain, photosystem (PS)1 and PS2 activities with the *Hansatech* O_2 electrode available at Madurai Kamarajar University, Madurai.

The computed areas of polypeptides (Table 1) showed differences in concentrations of those of molecular mass 55 kDa [large subunit (LSU) of ribulose-

Table 1. Chloroplast protein polypeptides (relative areas) in plants grown for 15 d under low irradiance (L - 400 μmol m^{-2} s^{-1}) or saturated irradiance (N - 800 μmol m^{-2} s^{-1}) at constant temperature (25 °C) and relative humidity (80 %). Early duration tolerant (ADT37, TNRH2) and susceptible (IR5O, TNRH1) rice cultivars and medium duration tolerant (CO43) and susceptible (IR20) cultivars were compared.

Polypeptides	Irradiance	ADT37	TNRH2	IR50	TNRH1	CO43	IR20	CD at 5 % irrad.	cv.
55 kDa	N	17.0	17.4	18.2	18.6	17.5	17.2	1.20**	1.25**
(LSU)	L	15.4	16.0	14.0	16.0	18.0	12.4		
26 kDa	N	6.8	6.8	7.5	7.6	6.6	6.8	NS	0.50**
(LHCP)	L	7.1	6.8	7.0	7.4	8.2	5.0		
28 kDa	N	5.4	6.0	6.2	6.2	5.4	5.2	NS	0.49**
(LHCP)	L	5.7	6.3	5.8	6.0	6.8	4.8		
15 kDa	N	4.6	4.8	5.2	5.5	4.2	4.5	0.11**	0.67**
(SSU)	L	4.5	4.7	3.8	5.0	4.4	3.4		

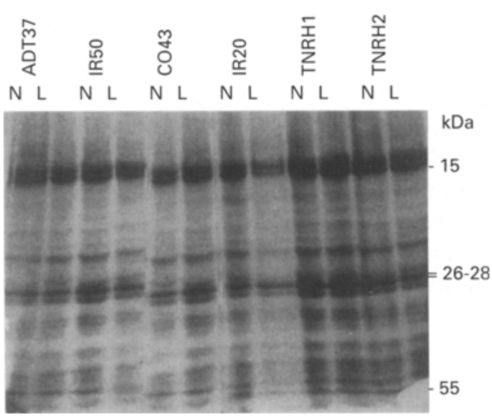

Fig. 1. Chloroplast protein profile of rice cultivars under saturated (N) and low (L) irradiance.

1,5-bisphosphate carboxylase/oxygenase (RuBPC/O)], 28 and 26 kDa [light-harvesting chlorophyll protein (LHCP)] and 15 kDa [small subunit (SSU) of RuBPC/O] in chloroplasts of plants grown under different irradiance (Fig. 1).

The highest relative amount of LSU was found in N plants of cv. TNRH1 while the least one was recorded in L plants of cv. IR20. Except cv. CO43, all cultivars showed a reduction between 8.0 (cv. TNRH2) and 27.9 % (cv. IR20) in N *vs.* L plants. The L plants generally had relatively low expression of the 15 kDa (SSU) polypeptide in comparison with the N plants. The reduction in the content of SSU was high in cv. IR 50 (26.9 %) and cv. IR20 (24.4 %). The 26 kDa polypeptide of LHCP was detected in higher concentration in L plants of tolerant types, while it was affected in susceptible types. In tolerant cv. CO43 its concentration was 24.2 % higher in L plants than in the N plants, while the largest decline in L plants was observed in cv. IR20 (26.5 %). Except for a marginal increase (5.0 %) in cv. TNRH2 a similar trend for the 28 kDa polypeptide was observed in all the cultivars.

The whole chain electron transport ($H_2O \rightarrow MV$) and PS 2 ($H_20 \rightarrow DCPIP$) activities were higher in chloroplast from N than L plants of the both cultivars (more in cv. IR20 than in cv. CO43). The PS1 activity ($DCPIPH_2 \rightarrow MV$) was a little higher in plants grown under low irradiance, but these differences were not significant (Table 2).

Table 2. Whole chain ($H_2O \rightarrow MV$), PS1 ($DCPIPH_2 \rightarrow MV$) and PS2 ($H_2O \rightarrow DCPIP$) electron transport activities [mmol(O_2 or DCPIP) kg^{-1}(chl) s^{-1}] in chloroplasts of rice cultivers grown under saturating (N) and low (L) irradiance.

Irradiance	Whole chain IR2O	CO43	PS 1 IR20	CO43	PS 2 IR20	CO43
N	34.7	32.3	96.7	91.9	52.2	51.1
L	28.7	30.8	98.3	92.4	39.6	48.9

The reduced expression of LSU of RuBPC/O under LI in sensitive rice cultivars was in agreement with the results of Hidema *et al.* (1992). The expression of SSU was not so much affected under LI as LSU, but it may be suppressed under stress *e.g.* cold (Hahn and Walbott 1989). The higher expression of LHCP under LI was in agreement with the results of Dela Torre and Burkey (1990) for barley, Leong and Anderson (1984a) and Chow and Anderson (1987) for pea, Wild *et al.* (1986) for mustard, Davies *et al.* (1986) for tomato and Terashima and Evans (1988) for spinach.

The activity of the whole chain and PS 2 electron transport was reduced under L in both cultivars. Chowdhury et al. (1994) has also reported decreased Hill activity, a indicator of PS2 acticity, in these cultivars when irradiance was reduced to about 50 % of sunlight from panicle initiantion to harvest. Similar trend in reduction of the whole chain and PS2 electron transport was apparent in experiments with several plant species (Boardman 1977), including pea (Leong and Anderson 1984b, Evans 1987), tomato (Davies *et al.* 1986) and barley (Dela Torre and Burkey 1990).

However, the magnitude of reduction under LI was cultivar specific. The PS1 electron transport was not affected similarly as in the experiments of Björkman *et al.* (1972) and Chow and Anderson (1987). The acclimation ability of cv. CO43 was superior by having relatively stable rate of both PS 2 and whole chain activities which decide the photosynthetic efficiency under LI.

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