INHIBITION OF STOMATAL OPENING BY DL-GLYCERALDEHYDE, AN INHIBITOR OF CALVIN CYCLE

R. MANNAR MANNAN and SALIL BOSE
School of Biological Sciences, Madurai Kamaraj University, Madurai 625 021, India.

ABSTRACT

DL-glyceraldehyde, an inhibitor of Calvin cycle was fed to the leaves of *Commelina bengalensis* L. This treatment inhibited light-dependent oxygen evolution and stomatal opening. However, it did not cause stomatal closure in isolated epidermal strips. By contrast, application of 3-(3,4-dichlorophenyl)-1,1-dimethyl urea caused stomatal closure to both the leaves and the isolated epidermal strips. Taken together, these observations suggest that (a) the mechanism controlling the stomatal closure in intact leaves is different from that in isolated epidermal strips and (b) DL-glyceraldehyde can be used as a tool to study the stomatal function.

INTRODUCTION

DL-GLYCERALDEHYDE is an inhibitor of Calvin cycle and it does not affect the photochemical events in photosynthesis[1]. This inhibitor, when fed to the leaves through transpiration stream, can bring about total inhibition of carbon assimilation as revealed by changes in the slow secondary fluorescence kinetics of intact leaves[2]. In this paper we describe the effect of this Calvin cycle inhibitor on stomatal opening both in intact leaves and in isolated epidermal strips.

EXPERIMENTAL

Leaves of *Commelina bengalensis* L were collected fresh from the field grown plants. The leaves were floated on distilled water under a bank of fluorescent lamps (10,000 lux) for 2 hr. After this pre-illumination, leaves were kept in various experimental solutions with their petioles dipped. Pure distilled water served as the control and DL-glyceraldehyde (Sigma, USA) and DCMU (Dupont, USA) were used at the concentration of 20 mM and 50μM respectively. At different times the epidermis was removed and the pore width of the stomata was measured using a light microscope fitted with a precalibrated oculo-meter.

Photosynthesis was measured as the light-dependent rate of oxygen evolution from the leaf bits (1 mm^2) using a Clark type oxygen electrode (Yellow Spring Instruments, USA) connected to a locally made amplifier and a strip-chart recorder (Toshniwal Bros, India). During the measurement of oxygen exchange, the leaf bits were kept stirred in the respective experimental solution.

RESULTS AND DISCUSSION

When the cut ends of the leaves were kept dipped in 20 mM solution of DL-glyceraldehyde, complete stomatal closure occurred in about 90 min (figure 1). After this period, the photosynthetic capacity of the leaves was also found completely inhibited (table 1). However, DL-glyceraldehyde could not cause stomatal closure in isolated epidermal strips (figure 2).

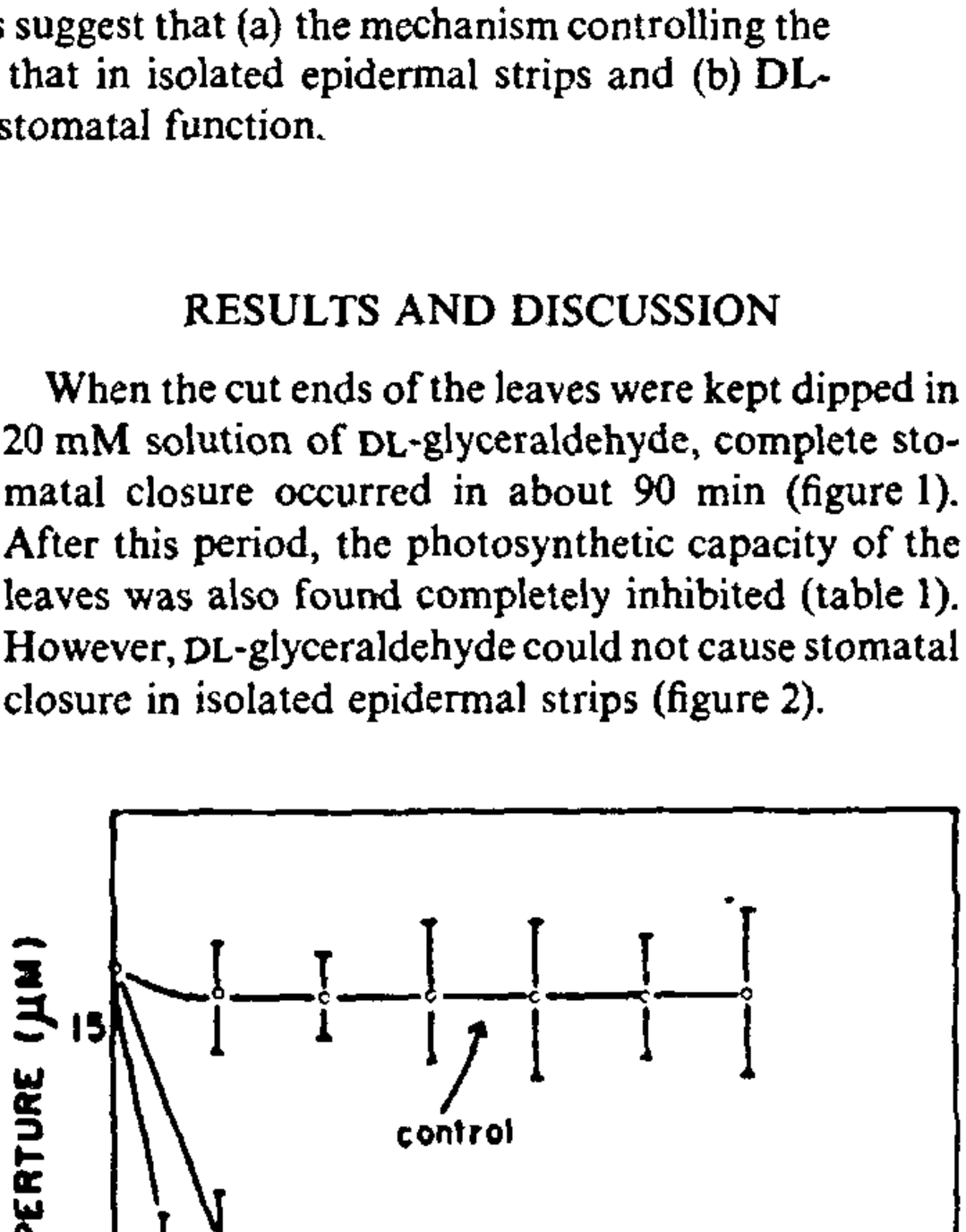

Figure 1. Effect of DCMU and DL-glyceraldehyde on stomatal opening in intact leaves.

Table 1 *Effect of* DL-*glyceraldehyde and* DCMU *on photosynthesis and respiration*

	Respiration μmol O_2 consumed mg Chl hr	Photosynthesis μmol O_2 evolved/mg Chl, hr
Control	23.3	21.3
DL-glyceraldehyde	22.9	Not detectable
DCMU	23.2	Not detectable

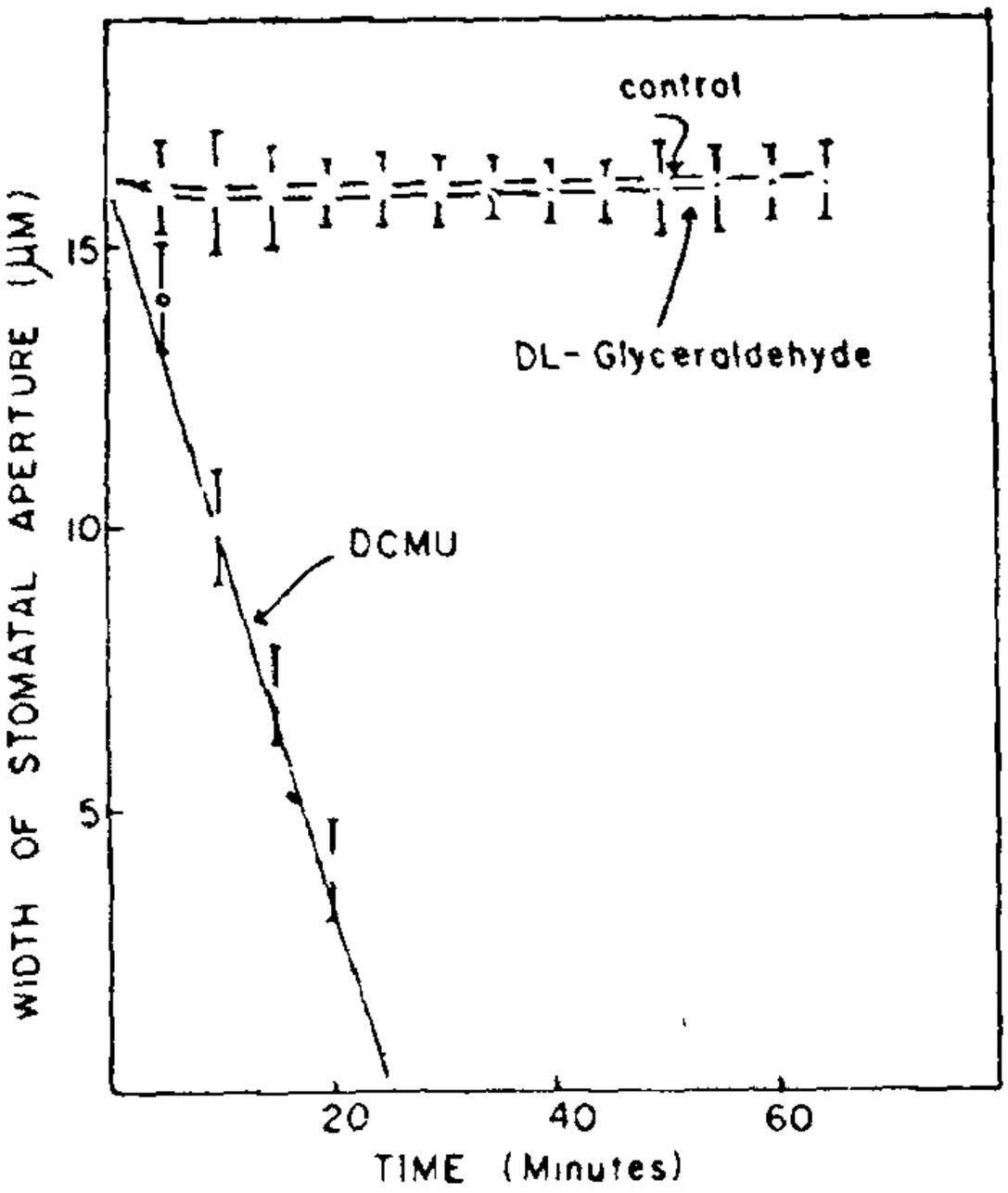

Figure 2. Effect of DCMU and DL-glyceraldehyde on stomatal opening in isolated epidermal strips.

For comparison, the effect of DCMU, a specific inhibitor of non-cyclic photosynthetic electron transport, on stomatal opening and photosynthesis was followed. DCMU was found to be more potent than DL-glyceraldehyde in inducing the stomatal closure. DCMU could bring about stomatal closure in intact leaves within 30 min while it took about 90 min for DL-glyceraldehyde (figure 1). Further, DCMU could bring about stomatal closure even in the isolated epidermal strips (figure 2).

Earlier experiments have shown that stomatal opening in isolated epidermal strips is driven by a common pool of ATP contributed from oxidative and photophosphorylation[3]. Recent observations have indicated that the guard cell chloroplasts contain a functional photosystem II and operate a DCMU sensitive electron transport[4–8]. In the light of these information, our observation on the effect of DCMU in the isolated epidermal strips indicates the significance of non-cyclic photosynthetic electron transport in maintaining the stomatal opening.

The inability of DL-glyceraldehyde in inducing the stomatal closure in isolated epidermal strips could be attributed to the fact that the Calvin cycle is not operative in the guard cell chloroplasts[4]. Both micro-histochemical[9] and immunological[10] approaches have shown that the guard cell chloroplasts lack the key enzymes of Calvin cycle.

One could explain the stomatal closure induced by DL-glyceraldehyde in intact leaves in terms of a possible correlation existing between mesophyll photosynthesis and stomatal conductance. Wong *et al*[11] suggested that stomata respond to a metabolite of photosynthesis in the leaf mesophyll tissue. They have shown that when the capacity of the leaves to fix CO_2 is altered by various means, the diffusive conductance of the epidermis is also changed in nearly the same proportion as the rate of CO_2 assimilation. However it should be pointed out that the approaches of Wong *et al*[11] to modulate the CO_2 fixation capacity of the mesophyll were not specific to mesophyll. All their three methods to modulate CO_2 fixation in mesophyll namely, DCMU treatment, different levels of irradiance and difference in water potential and nutrient status are known to bring about stomatal closure even in isolated epidermal strips[12,13]. In contrast, in our experiments, the application of DL-glyceraldehyde specifically inhibited the mesophyll photosynthesis without having any effect on the chloroplasts of guard cells. Thus our observation lends support to the suggestions of Wong *et al*[11] more than their own experimental observation and also stands as a new method to specifically manipulate the CO_2 fixation capacity of the mesophyll cells in the study of stomatal function.

29 May 1984

1. Stocks, D. M. and Walker, D. A., *Biochem. J.*, 1972, **128,** 1147.
2. Walker, D. A., *Planta*, 1981, **153,** 273.
3. Raghavendra, A. S., *Plant Physiol.*, 1981, **67,** 385.
4. Zeiger, E., *Annu. Rev. Plant Physiol.*, 1983, **34,** 441.

5. Melis, A. and Zeiger, E., *Plant Physiol.*, 1982, **69,** 642.
6. Zeiger, E., Armond, P. and Melis, A., *Plant Physiol.*, 1981, **67,** 17.
7. Ogawa, T., Grantz, D., Boyer, J. and Govindjee, *Plant Physiol.*, 1982, **69,** 1140.
8. Shimazaki, K., Gotow, K. and Kondo, N., *Plant Cell Physiol.*, 1982, **23,** 871.
9. Outlaw, W. H. Jr., Manchester, J., Dicamelli, C. A., Randall, D. D. Rapp, B. and Veith, G. M., *Proc. Natl. Acad. Sci. USA*, 1979, **76,** 6371.
10. Schnabl, H., *Planta*, 1981, **152,** 307.
11. Wong, S. C., Cowan, I. R. and Farquhar, G. D., *Nature* (*London*), 1979, **282,** 424.
12. Raschke, K., *Annu. Rev. Plant Physiol.*, 1975, **26,** 309.
13. Lurie, S., *Planta*, 1978, **140,** 245.

ANNOUNCEMENTS

COMPUTER WITH ARTIFICIAL INTELLIGENCE TO SUPPORT POWER PLANTS

Seven large turbine-generators at three major power plant sites in Texas will be the first in the world to be connected to a remote, central computer programmed with artificial intelligence. The system will enhance the operating performance of the plants by giving early warning of potential trouble.

The project marks the first application of artificial intelligence to power plant operations. It is also the first time that turbine-generators will be equipped with a diagnostic system which provides around-the-clock support. The system also provides maintenance planning assistance.

For details contact: Susan L. Howell, Westing House Electric Corpn. Pittsburgh, Pensylvania 152 22, USA.

INDIAN NATIONAL SEMICONDUCTOR SOCIETY

During the general body of the Third National Conference on the Physics of Semiconductors at the Indian Institute of Science, Bangalore, it was decided to form 'Indian National Semiconductor Society' and elected the following office bearers: Chairman: Prof. S. C. Jain, Director, Solid State Physics Laboratory, Delhi; Vice Chairman (i) Prof G. Suryan, Department of Physics, Indian Institute of Science, Bangalore; (ii) Dr A. Bhaskara Rao, Siltronics (India) Ltd., Hosur; Secretary: Prof P. C. Mathur, Department of Physics & Astrophysics, Univeristy of Delhi, Delhi; Treasurer: Prof K. L. Bhatia, M. D. University, Rohtak.

The Society will play a leading role in shaping the development of the entire area of Semiconductor Technology in the Country and will also safeguard the professional interest of the workers in this field, besides planning and conducting the technical activities like lectures, workshops and seminars.

The Life-membership fee of the Society is Rs. 260/- (250 plus 10 as admission fee). The annual membership is Rs. 35/- including Rs. 10/- as admission fee.

Further particulars may be had from Prof P. C. Mathur, Secretary, Indian National Semiconductor Society, Department of Physics & Astrophysics, University of Delhi, Delhi 110007.