ประสิทธิภาพของ PS II ในไลเคน *Parmotrema tinctorum* หลังย้ายปลูกไปยังบริเวณที่มีมลพิษทางอากาศ

EFFICIENCY OF PS II IN EPIPHYTIC LICHEN *Parmotrema tinctorum* AFTER TRANSPLANTATION TO AIR POLLUTED AREA

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บทคัดย่อ: Photosystem II (PS II) เป็นศูนย์กลางในการรับพลังงานแสง และแปลงพลังงานแสงเป็นสารประกอบอินทรีย์ กิจกรรมบางอย่างที่มีความสำคัญกับการสังเคราะห์ด้วยแสงเริ่มขึ้นที่ PS II เช่น การแตกตัวของน้ำเพื่อให้อิเล็กตรอนทดแทน และการปล่อยแสงฟรูออเรสเซนต์ เป็นต้น สภาพแวดล้อมที่มี ความเครียดย่อมมีผลกระทบต่อ PS II และส่งผลต่อไปยังระบบอื่น ๆ ทำให้ประสิทธิภาพการสังเคราะห์ด้วยแสงลดลง การศึกษาในครั้งนี้มีวัตถุประสงค์เพื่อ ตรวจวัดประสิทธิภาพของ PS II ในไลเคนเมื่อได้รับความเครียดจากสิ่งแวดล้อม เพื่อใช้ในการบ่งบอกคุณภาพอากาศ โดยการย้ายปลู กตัวอย่างไลเคน *Parmotrema tinctorum* จากอุทยานแห่งชาติเขาใหญ่ มายังกรุงเทพ ฯ จากนั้นทุก 60 วัน เก็บตัวอย่างมาวัดค่าคลอโรฟิลล์ฟรูออเรสเซ็นต์ซึ่งทำในห้องปฏิบัติการ โดยให้แสง 500 µmol $m^{-2}s^{-1}$ อุณหภูมิ 25 ± 2 °C ความชื้นอิ่มตัว รวมทั้งหมด 4 ครั้ง 240 วัน พบว่า เมื่อระยะเวลาในการย้ายปลูกเพิ่มขึ้น ประสิทธิภาพของ PS II ในไลเคนที่บริเวณกรุงเทพ ฯ มีค่าลดลงอย่างมีนัยยะสำคัญทางสถิติ ซึ่งประเมินจากค่า Fv/Fm, ΦPSII, ETR และ (Fm-Ft)/Ft บ่งบอกว่าไลเคนในกรุงเทพ ฯ ได้รับความเครียดจากสิ่งแวดล้อมสูงกว่า ซึ่งความเครียดดังกล่าวน่าจะเกิดจาก สภาพภูมิอากาศเฉพาะแห่ง (microclimate) และมลพิษทางอากาศ

Abstract: Photosystem II (PS II) is the reaction center for taking light energy and converted to organic compounds. Activities that relate to photosynthesis start at the PS II, such as breakdown of water to provide electron, dissipated of chlorophyll fluorescence. Environmental stress affects PS II and electron transport, which consequently decrease efficiency of photosynthesis. The objective of this study is to evaluated of efficiency of PS II in epiphytic lichen under different environmental stress. Thalli of the lichen *Parmotrema tinctorum* were collected from KYNP and transplanted to Ladkrabang, Rama 9, and Ramkhamhaeng University in Bangkok. Every 60 days the transplanted thalli were collected for measuring chlorophyll fluorescence at the laboratory of RU. The conditions during the measurements were set at 500 µmol $m^{-2}s^{-1}$ light intensity, temperature 25±2 °C and saturate humidity. Four measurements were performed during 240 day of transplantation. The result showed that longer exposure time in the city resulted in decreasing efficiency of PS II of the transplanted lichens as indicated by values of Fv/Fm, ΦPSII, ETR and (Fm-Ft)/Ft. It implied that lichens in Bangkok were exposed to environmental stress more than those from KYNP. The detrimental factors could be microclimate or air pollution.

Introduction: Lichens receive sources of nutrients from the atmospheric. In addition, they are absent of cuticle layer, which protected them from pollutants. Many lichens disappear from the cities. Therefore, they are sensitive to atmospheric impurity, and are widely used for bioindicator of air quality in Europe and America. Pollutants that enter the thallus cause damage to photosynthetic system, and consequences decline in photosynthesis, retard growth and finally death of lichens. Photosystem II (PS II) is the reaction center for light energy, by which conversion to organic compounds occur. PSII can be affected by pollutants causing decline in biosynthesis of higher plants and epiphytic lichens [3,5]. Chlorophyll fluorescence measurement in widely used to assess stress of PS II from environmental [2,6]. Bangkok has high density of population and high numbers of traffic vehicles, which are the main sources of pollution in the atmosphere. These pollutants include i.e. nitrogen oxide (NO_x), small particle (PM_{10}). Few lichens are able to grow in polluted areas. These tolerance species are, for example *Pyxine cocoes*, *Dirinaria applanata*. They are regarded as nitrophilic lichens [1,2]. The objective of this study was to use chlorophyll fluorescence parameters of PSII as indicator of pollutant stress to lichen. Our hypothesis, is that the efficiency of PS II in lichen decline after transplanted from Khao Yai National Park to Bangkok area, because different of microhabitats and pollutant levels.

Methodology: The lichen *Parmotrema tinctorum* (Delise *ex* Nyl.) Hale from the controlled site (unpolluted) at Khao Yai National Park (KYNP) was collected and transplanted to polluted sites in Bangkok. The polluted sites consisted of Ladkrabang (LKB), Rama 9 (R.9), and Ramkhamhaeng University (RU). Lichen thalli were fixed on plastic nets, size 30 x 20 cm. Five thalli of lichen were attached to one piece of plastic net making up a total of 25 plastic nets. Every 60 days samples were collected and brought to laboratory at RU. for chlorophyll fluorescence measurements. The collections and measurements were performed for 4 times during 11 November 2008 to 11 July 2009). The condition during the measurement were kept constant at light intensity 500 µmol $m^{-2}s^{-1}$, temperature 25±2 ^{o}C and saturate humidity. The measurements were repeated three times at different locations on each thallus, making up fifteen measurements from each location in both dark adapted and light adapted environment. Photosynthesis Yield Analyzer MINIPAM was used for the measurements. The parameter for assessing the efficiency of PS II included Fv/Fm, ΦPSII, ETR and (Fm-Ft)/Ft [2]. Data were transferred to Excel program and statistical analysis was then performed by the one-way analysis of variance (ANOVA) and Turkey's pairwise comparisons at the significance level $P < 0.05$.

Results, Discussion and Conclusion: Chlorophyll fluorescence parameter included Fv/Fm, ΦPSII, ETR and (Fm-Ft)/Ft, from KYNP and Bangkok areas were showed in Table 1, and Figure 1. Samples in Bangkok areas had significantly lower PSII efficiency than those from the control as indicated by chlorophyll fluorescence parameter. This parameter suggested the following order of PSII efficiency: KYNP > LKB > R.9 > RU.

Table 1. Chlorophyll fluorescence parameter, Fv/Fm, ΦPSII, ETR and (Fm-Ft)/Ft) from the lichen *P. tinctorum* after transplanted from KYNP to Bangkok areas.

Means ± SD		Days of Measurements				
Parameter	Sampling sites	0	60	120	180	240
Fv/Fm	KYNP	0.66±0.02a	0.69±0.02a	0.67±0.03a	0.69±0.03a	0.69±0.03a
	LKB	0.66±0.02a	0.59±0.11a	0.58±0.09b	0.66±0.02b	0.66±0.03b
	R.9	0.66±0.02a	0.64±0.04a	0.58±0.07b	0.67±0.02b	0.63±0.03c
	RU	0.66±0.02a	0.43±0.19b	0.02±0.05c	0.00±0.00c	0.00±0.00d
	ANOVA	*F* = 0.00	*F* = 13.90	*F* = 22.23	*F* = 15.98	*F* = 30.25
		P = 1.00	*P* = 0.01	*P* = 0.01	*P* = 0.01	*P* = 0.01
ΦPS II	KYNP	0.33±0.06a	0.29±0.03a	0.33±0.07a	0.33±0.06a	0.26±0.04a
	LKB	0.33±0.06a	0.25±0.05ab	0.25±0.09b	0.26±0.07b	0.26±0.08a
	R.9	0.33±0.06a	0.21±0.05b	0.22±0.05b	0.27±0.06b	0.25±0.06a
	RU	0.33±0.06a	0.15±0.06c	0.01±0.01c	0.00±0.00c	0.00±0.00b
	ANOVA	*F* = 0.00	*F* = 19.84	*F* = 26.31	*F* = 23.50	*F* = 20.25
		P = 1.00	*P* = 0.01	*P* = 0.01	*P* = 0.01	*P* = 0.01
(Fm-Ft)/Ft	KYNP	1.08±0.44a	0.55±0.34a	0.87±0.52a	0.99±060a	0.91±0.49a
	LKB	1.08±0.44a	0.42±0.51a	0.46±0.27ab	0.44±0.35b	0.43±0.19b
	R.9	1.08±0.44a	0.38±0.56a	0.34±0.49b	0.30±0.54b	0.35±0.40b
	RU	1.08±0.44a	0.19±0.40a	0.06±0.45c	0.00±0.00c	0.00±0.00c
	ANOVA	*F* = 0.00	*F* = 1.15	*F* = 7.28	*F* = 14.57	*F* = 19.18
		P = 1.00	*P* = 334	*P* = 0.01	*P* = 0.01	*P* = 0.01
ETR	KYNP	67.0±12.2a	61.7±6.3a	67.6±15.1a	68.0±14.2a	53.2±7.8a
	LKB	67.0±12.2a	49.4±11.8ab	49.6±16.0b	53.5±11.1b	51.8±15.2a
	R.9	67.0±12.2a	42.5±11.1bc	42.3±13.8b	57.5±13.6ab	50.7±12.7a
	RU	67.0±12.2a	32.7±13.2c	1.4±3.2c	0.0±0.0c	0.0±0.0b
	ANOVA	*F* = 0.00	*F* = 13.77	*F* = 24.31	*F* = 24.23	*F* = 21.29
		P = 1.00	*P* = 0.01	*P* = 0.01	*P* = 0.01	*P* = 0.01

* Values in each vertical column followed by the same letter do not differ significantly at $P < 0.05$ by Turkey's pairwise comparisons, n = 15 for each station.

KYNP

Results from the control site at KYNP showed that the values of ΦPSII, ETR and (Fm-Ft)/Ft decreased in the day 60 of the observation, increased in days 120 and 180. This was probably due to the effect of transplantation, and recovery after period of adaptation. The declining of these values in days 240 may be explained by acclimation of lichen to low light intensity during the rainy season, approximately 300 µmol $m^{-2}s^{-1}$. Under high light intensity during the measurement in the laboratory, 500 µmol $m^{-2}s^{-1}$, PSII may undergo photoinhibition. Nevertheless, Fv/Fm values were relatively stable between 0.66 and 0.69, which had no significant different. It indicated that the component of PS II remained high vitality, ready for activity when environment was appropriated.

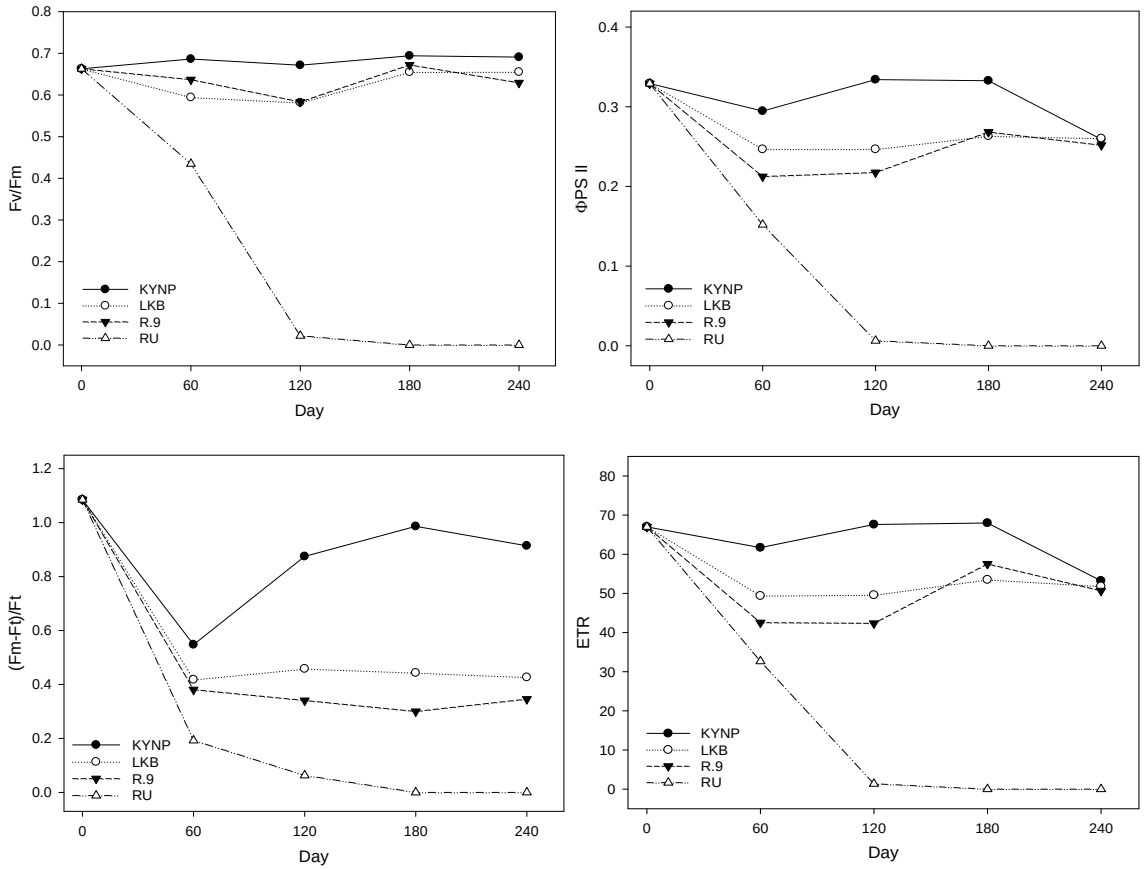

Figure 1. Chlorophyll fluorescence parameter: Fv/Fm, ΦPSII, ETR and (Fm-Ft)/Ft) from lichen samples after transplanted from KYNP to Bangkok areas. Lichens in the Bangkok areas, especially RU samples, had lower PSII efficiency comparing with those from KYNP.

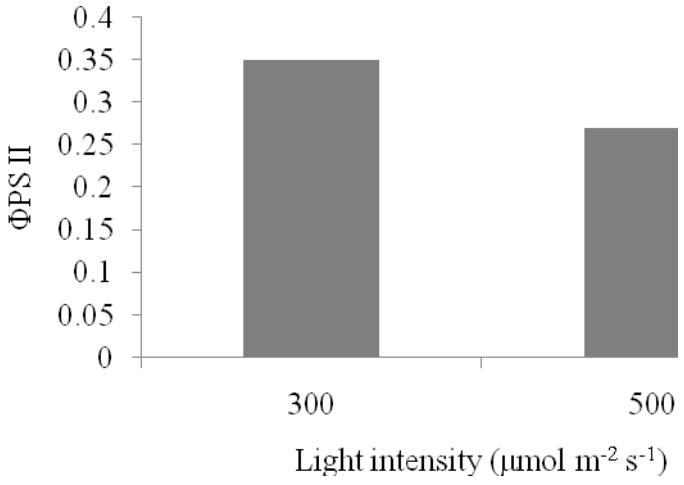

Figure 2. Values of ΦPSII from lichen after 240 days of transplantation at KYNP under light intensity 300 µmol $m^{-2}s^{-1}$ and 500 µmol $m^{-2}s^{-1}$. Value of ΦPSII under lower light intensity of 300 µmol $m^{-2}s^{-1}$ was higher than that measured under 500 µmol $m^{-2}s^{-1}$.

Ladkrabang and Rama 9
The transplanted lichens at Ladkrabang and Rama 9 showed no significant differences of Fv/Fm, ΦPSII, ETR and (Fm-Ft)/Ft from KYNP, although the values were smaller. These result indicated that lichens at these two locations were less affected from air pollution. This was probably due to distances that are relatively far from the central of the city.

Ramkhamhaeng University
Ramkhamhaeng University area had the lowest values of Fv/Fm, ΦPSII, ETR and (Fm-Ft)/Ft and declined significantly with time after transplantation. It appeared that these values approached zero and the lichens were finally died. Air pollution and microclimate were possibly the main cause of lichen death. RU campus is in the heavy traffic area with air pollution problem.

This study indicated that the efficiency of PS II in transplanted lichen can be used to monitor air quality. LKB and R.9 had better air quality than RU campus because the formers are far from the inner city and had less traffic.

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