Photosynthesis- CO_2 Concentration Response of Korean Native Phytoremediation Plant, *Iris ensata*

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Introduction

Iris ensata is a Korean native plant and perennial iris that grows fast and survives in different kinds of soil conditions (Nam 2009). It is recognized as a phytoremediation plant that remediates soil in an environmentally friendly way due to its high tolerence to flooding and heavy metal removal capacity, including cadmium. Physiological and ecological research on useful resources plants, which are needed due to increasing CO_2 concentration and temperature by climate change, still falls short. In this regard, this study was carried out to gain basic materials about physiological characteristics for improving use and productivity of useful resources plants.

Methods and materials

On March 30, 2006, *Iris ensata* was divided from the genetic field of Gyeongsangbuk-do Agricultural Research and Extension Services, then transplanted at a spacing of 30 cm x 30 cm. In March 2007, it was applied with $5ton \cdot 10a^{-1}$ decomposed manure. Tab. 1 and Fig. 1 show physico-chemical properties of experimental soil and meteorological conditions of the field. In March, May, July, and September, photosynthetic rate and stomatal conductance were measured using a portable photosynthesis measurement system equipped with CO_2 cartridge and light source. CO_2 was 25, 50, 100, 200, 400, 600, 800, 1,000 and 1,500 $\mu mol \cdot mol^{-1}$, light intensity was 800 $\mu mol \cdot m^{-2} \cdot s^{-1}$, leaf temperature was 25℃. C.E. (carboxylation efficiency), Vcmax (maximum rate of RuBP carboxylation), Jmax (maximum rate of electron transport) were calculated based on the correlation between intercellular CO_2 and photosynthetic rate.

Tab. 1: Physico-chemical properties of experimental soil.

pH (1:5)	EC ($ds \cdot m^{-1}$)	O.M. ($g \cdot kg^{-1}$)	Av. P_2O_5 ($mg \cdot kg^{-1}$)	Ex. cation ($cmol^+ \cdot kg^{-1}$)			Soil texture (%)		
				K	Ca	Mg	Clay	Silt	Sand
6.4	0.54	37.8	744	0.56	8.58	2.66	10	21	69

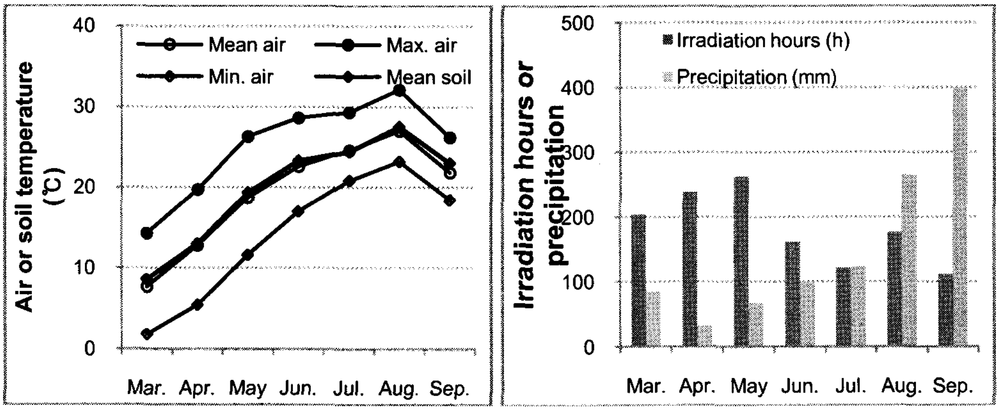

Figure 1: Meterological conditons during experimental period.

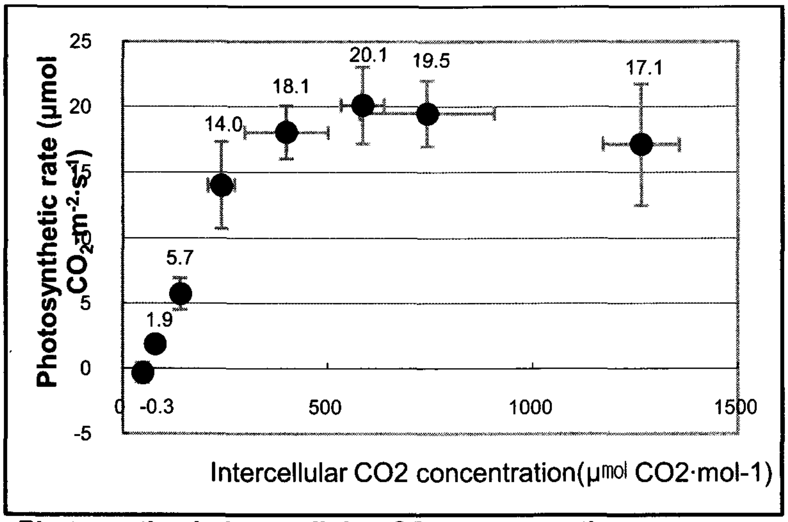

Figure 2: Photosynthesis-intercellular CO_2 concentration response of Korean native phytoremediation plant, *Iris ensata*.

Tab. 2: Photosynthetic characteristics as affected by intercellular CO_2 concentrations and growth periods in Korean native phytoremediation plant, *Iris ensata*.

Growing season	CO_{2comp}^{z}	C.E.^{y}	Vc_{max}^{x}	J_{max}^{w}	TPU^{v}	Leaf temp. (℃)
March	28.8	88.1	31.8	33.3	2.2	26.2
May	73.0	83.1	65.5	70.3	4.9	26.9
July	85.5	59.7	43.3	43.4	5.8	30.4
September	48.3	59.5	40.2	34.9	6.0	28.0
	*	*	**	**	*	-

$^{z}CO_2$ compensation point ($\mu mol \cdot mol^{-1}$), ^{y}Carboxylation efficiency ($mmol \cdot mol^{-1}$), ^{x}Maximum rate of RuBP carboxylation ($\mu mol \cdot m^{-2} \cdot s^{-1}$), ^{w}Maximum rate of electron transport ($\mu mol \cdot m^{-2} \cdot s^{-1}$), ^{v}Triose-phosphate utilization, *Significant for P<0.005, **Significant for P<0.001.

Results and conclusions

Fig. 2 indicates that the photosyntehtic rate increased as intercelluar CO_2 concentration rose, however, the rate was stagnant or declined at a certain level of concentration ($A = -1.51 + 0.06Ci - 3.46Ci^2$, $R^2=0.94$). For example, expected maximum rate of photosythesis was 22.7 $\mu mol \cdot m^{-2} \cdot s^{-1}$ when maximum rate of photosynthesis at Ci was 836 $\mu mol \cdot mol^{-1}$. Photosynthetic rate of most plants rises as CO_2 concentration increases, even though the rise is different according to plant and photosynthetic rate climbs up at a high light intensity as the CO_2 concentration goes up (Makino & Mae 1999). The pace of photosynthesis is determined by the pace of re-phosphorylate of CO_2 fixation system at an area where CO_2 concentration is high. Photosynthesis of plants exposed to high CO_2 concentration for a long time is inhibited by accumulated starch-grain, which hinders spread of CO_2 in a chloroplast (Ro *et al.* 2001).

It was confirmed that assimilation capacity of *Iris ensata* improves with the increase of CO_2 concentration, however, further review is needed for longterm change. C.E. showed high value during early or mid growing season, Vc_{max}, J_{max} also showed high value in May and carbon use efficiency in March and May was relatively high.

On the other hand, the efficiency was on the decline as the growing season matures (Tab. 2). Carbon fixation capacity changed according to growth period and this is attributable to envrionmental factors such as temeprature, light, soil moisture, etc (Cannel & Thornley 1998). C.E., TPU had negative correlation with leaf temperature and this means long-term temeperature increase will affect carbon fixation capacity of *Iris ensata* negatively.

In conclusion, *Iris ensata*, a Korean native phytoremediation plant, showed high carbon fixation capacity when it is exposed to high CO_2 concentration for a short period of time. Its limiting concentration was 836 $\mu mol \cdot mol^{-1}$ and carbon use efficiency reduced according to leaf temperature increase. It is expected that CO_2 concentration in the atmosphere will rise by 600-1000 ppm (Cox et al. 2000). In this regard, *Iris ensata* will maintain its carbon fixation capacity and remain physiologically active against long-term climate change and will be useful as a remediation plant.

References

Borjigidai A., Hikosaka K., Hirose T., Hasegawa T., Okada M., & Kobayashi K. (2006): Seasonal changes in temperature dependence of photosynthetic rate in rice under a free-air CO_2 enrichment. Annals of Botany 97:549-557.

Cannel M.G.R. & Thornley J.H.M. (1998): Temperature and CO_2 responses of leaf and canopy photosynthesis: a clarification using the non-rectangular hyperbola model of photosynthesis. Annals of Botany 82:883-892.

Cox P.M., Bets R.A. Jones C.D., Spall S.A. & Totterdell I.J. (2000): Acceleration of global warming due to carbon-cycle feedbacks in a coupled climatic model. Nature 408:184-187.

Farquhar G., von Caemmerer S., Berry J.A. (1980): A biochemical model of photosynthetic CO_2 assimilation in leaves of C_3 species. Planta, 149:78–90.

Lee S.H. (2010): Cadmium removal ability of *Iris pseidacorus* and *Acorus calamus* for phytoremediation. Ph. D. Thesis, University of Seoul. Korea.

Makino, A. & Mae, M. (1999) Photosynthesis and plant growth at elevated levels of

CO_2. Plant Cell Physiol. 40:999-1006.
Nam H.H., Lee H.S. & Woo J.H. (2009): Seasonal changes of dry matter productivity of Korean native plants, *Aster koraiensis*, *Iris ensata*, and *Hemerocallis fulva*. Kor. J. Hort. Sci. Technol. 27:371-379.
Ro H.M, Kim P.G., Lee I.B., Yiem M.S., & Woo S.Y. (2001) Photosynthetic characteristics and growth responses of dwarf apple (*Malus domestica* Borkh. cv. Fuji) saplings after 3 years of exposure to elevated atmospheric carbon dioxide concentration and temperature. Trees 15:195-203.