BRIEF COMMUNICATION

Effect of temperature on photosynthesis of *Miscanthus* clones collected from different elevations

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Abstract

Six to twenty-eight months after transplanting, the net photosynthetic rate (P_N) of *Miscanthus* leaves was measured at leaf temperatures between 18 to 37 °C. P_N of clones from high mountain areas was more adaptable to low temperature, while that of clones from low mountain areas was more adaptable to high temperature. The clones from the lowlands were best adapted to both high and low temperatures. These characteristics lasted at least 28 months after transplanting. Thus *Miscanthus* had differentiated into different ecotypes to adapt to the thermal environments of different elevations. Comparison of the P_N values measured in different seasons and durations after transplanting indicated that P_N in *Miscanthus* could acclimate to environments with various temperature ranges resulting from elevation and seasonal changes.

Additional key words: highland; lowland; net photosynthetic rate.

Miscanthus spp. is a perennial pasture C_4 grass that can be interbred with sugarcane to obtain new sugarcane cultivars (Chen *et al.* 1993). Recently, it has also been grown as a new biomass or fiber crop in northwestern Europe (van der Werf 1993). C_4 plants are rare in cooler climates (Teeri and Stowe 1976), and the number of C_4 species decreases with increase in latitude and elevation (Takeda and Hakoyama 1985, Mateu-Andrés 1993). *Miscanthus* is distributed in the Pacific islands, Philippines, China and Japan (up to 45°N), and is an important native grass in Taiwan (21°55'N-25°18'N). It grows vigorously from the coastline up to 3000 m above sea level. *Miscanthus* can adapt and grow well under various temperatures and

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altitudes. In order to elucidate the adaptive mechanisms of *Miscanthus* grown at various elevation in Taiwan, its photosynthetic traits under different temperatures were determined.

Eleven clones of *Miscanthus* collected from the lowlands of northern and southern Taiwan, and ten clones collected from mountain areas between 1000 and 2550 m above sea level in central Taiwan were used in the experiment. Plants were collected and planted in pots (38 cm in diameter) filled with soil between March and April 1986. The plants were grown outdoors on the campus of the National Chung-Hsing University at Taichung (24°10'N, 78 m). P_N of fully expanded youngest leaves attached to plants were determined in an open gas system, by measuring differential CO_2 concentration with an infrared analyzer (*AR-600, Anarad,* U.S.A.) under 18-37 °C (leaf temperature), 80 % relative air humidity, 1500 μmol m^{-2} s^{-1} photon flux density (PAR), and 1.5 m s^{-1} wind speed. The chamber was irradiated with a *YOKO* lamp (*D400, Toshiba,* Japan), and PAR was controlled by cheese-cloth screens and measured with a quantum sensor (*LI-185A, LI-COR,* U.S.A.). The temperature in the chamber was controlled by water circulating through a radiator inside the chamber. The leaf temperature was measured with copper-constantan thermoelements connected to the abaxial surface of the leaves. The humidity of air entering the chamber was controlled by passing the air flow through temperature-controlled water, and was monitored with a flow-through hygrometer (*1100AP, General Eastern,* U.S.A.). The air in the chamber was stirred with a variable speed fan. The P_N was determined from September to October 1986, February to March of 1987 and 1988, and August 1988, respectively.

The P_N of all the tested *Miscanthus* clones showed a quadratic relationship with leaf temperature ($p<0.01$), and varied remarkably among clones. The P_N of three clones measured in September-October 1986 was selected as example (Fig. 1). The P_N of the clone collected from the high mountain area (2550 m) showed the maximum below 30 °C. However, the P_N's of the clones from low mountain area and lowland did not reach a maximum until 37 °C. As the temperature increased, the increase of P_N was more obvious in clones from the lowlands and low mountain areas than those from high mountain areas.

The % rates of P_N at 35 and 30 °C (P35/30) were 110-120 % for lowland clones and 85-125 % for mountain clones, respectively. These values declined with the increase in elevation, according to the values measured from September to October 1986. The % rates of P_N at 20 and 30 °C (P20/30) were 50 65 % for lowland clones and 40-65 % for mountain clones, and increased with increase in elevation (Fig. 2). Both the P20/30 and P35/30 of clones were closely related with their original habitats when measured in August 1988. However, when compared with the values measured from September to October 1986, the P20/30 values for all the tested mountain clones became lower, and those of P35/30 of high mountain clones became higher (Fig. 2). The values of P20/30 for all the tested clones were 40-70 % of those determined in February to March, 1987 and 1988. These values were near to those obtained in September to October 1986, but did not show a significant relationship with their original habitat elevation (Fig. 2). The values of P35/30 from lowland

clones were near to those determined in September to October 1986. The P_N of the mountain clones was still significantly related to their original elevation habitats in 1987. However, the values of P35/30 became lower for low mountain clones and higher for high mountain clones compared with those determined in September to October 1986.

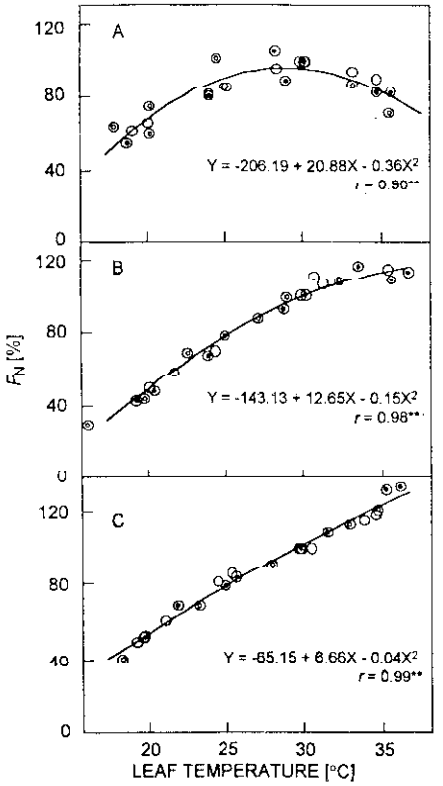

Fig. 1. Examples of leaf net photosynthetic rates (P_N) of *Miscanthus* related to leaf temperatures. *A*: plants collected from 2550 m above sea level; *B* and *C*: plants collected from lowlands (similar patterns were observed in clones collected from low mountain areas). Measurements were taken from September to October 1986, the relative % photosynthetic rates at 30 °C were 100 %. Different symbols show replications. ** $p<0.01$.

In the present study, the response of P_N of *Miscanthus* to temperature varied widely among clones. As concerns photosynthesis, the clones collected from high mountain areas were more adaptable to low temperature, while those from lowland and low mountain areas were more adaptable to high temperature. These results are similar to those on the effects of temperature and to the comparison of northern and southern C_4 populations (Berry and Björkman 1980, Potvin 1986, Schwarz and Redmann 1989, Earnshaw *et al.* 1990).

The seasonal variance in habitat temperature is important for photosynthetic processes (Nilsen and Karpa 1994). In the lowlands of Taiwan, the average temperatures are 15-20 °C (north-south) in January, and about 28 °C in July. At Mountain Alisan (21°13'N, 2400 m), the average temperatures were 6 and 13 °C in January and July, respectively. *Miscanthus* plants in Taiwan grow throughout the year in the lowlands and become dormant in mountain areas during the winter season. Both the average temperatures of lowlands in winter and those of high

mountain area in summer were near or lower than 15 °C. *Miscanthus* is certainly differentiated into ecotypes that adapt to different elevations or different water status (Weng 1993). Our results indicate that photosynthesis of *Miscanthus* may acclimate to temperature environments in different locations and seasons.

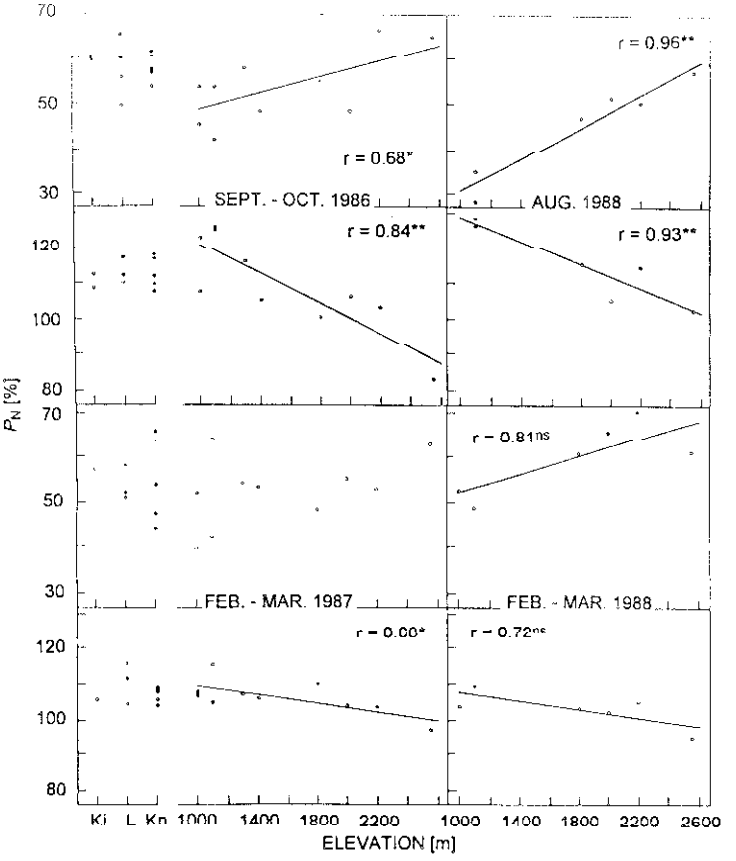

Fig. 2. Relative photosynthetic rates at 20 and 35 °C (30 °C is taken as 100 %) of *Miscanthus* clones collected from lowland and mountain areas. Measurements were taken from September to October 1986, in August 1988, and from February to March 1987 and 1988. Ki, L and Kn: plants collected from 25°08'N, 24°53'N and 21°58'N, respectively. * $p<0.05$, ** $p<0.01$.

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