An Analysis of Growth in C3 and C4 Plant Populations Using Newly Built Temperature Gradient Chamber and CO_2-Temperature Gradient Chamber

Jae-Seok LEE

A dissertation submitted to the Doctoral Program in Biological Sciences,
the University of Tsukuba in partial fulfillment of the requirements
for the degree of Doctor of Philosophy (Science)

January, 2001

TABLE OF CONTENTS

ABSTACT 1

GENERAL INTRODUCTION 7

II. EXPERIMENTAL FACILITIES

High performance of Temperature Gradient Chamber and CO_2-Temperature Gradient Chamber newly built for studying global warming effect on a plant and plant population 19

II-1. MATERIALS AND METHODS ---------- 20

II-1-1. Chamber design ---------- 20

II-1-2. Creation of a temperature gradient ---------- 23

II-1-2-1. During the daytime with high solar radiation ---------- 23

II-1-2-2. During the nighttime with low or no incident solar radiation ----- 29

II-1-3. Creation of a CO_2 concentration gradient in the CTGC ---------- 30

II-1-4. Monitoring of environmental conditions ---------- 32

II-2. RESULTS ---------- 32

II-2-1. Temperature gradient in both chambers ---------- 36

II-2-2. CO_2 concentration gradient in the TGC and the CTGC ---------- 36

II-2-3. Moisture condition ---------- 37

II-2-4. The relationship between incident solar radiation, ventilation rates and wind speed in both chambers ---------- 41

II-2-5. Construction and operation costs ---------- 45

III. PLANT GROWTH EXPERIMENT

Effects of elevated temperature and CO_2 on the growth of C3 plant and C4 plant populations ---------- 46

III-1. MATERIALS AND METHODS ---------- 47

III-1-1. Plant growth conditions; temperature and CO_2 condition in both chambers and integrated solar radiation ---------- 47

III-1-2. Experimental species and culture ---------- 49

III-1-3. Plant development and seed collecting ---------- 51

III-1-4. Plant growth and biomass allocation ---------- 52

III-1-5. Data analysis ---------- 53

III-2. RESULTS ---------- 53

III-2-1. Phenological response to elevated temperature and CO_2 conditions ---------- 53

III-2-2 Dry-matter accumulation of the C3 and C4 plant populations to elevated temperature and CO_2 ---------- 56

III-2-3. Growth analysis ---------- 61

III-2-4. Reproductive output in population level ---------- 68

III-2-5. Temperature and light conditions during vegetative and reproductive stages ---------- 71

III-2-6. Effects of elevated temperature and CO_2 on size hierarchies -------- 76

IV. GENERAL DISCUSSION 77

IV-1. Facilities for studying effects of the global warming on plant growth ---------- 78

IV-2. Effects of the global warming on thermal condition and plant phenology ---------- 81

IV-3. Interactions between elevated temperature and CO_2 on plant growth ---------- 83

IV-4. Effects of elevated temperature and CO_2 on size hierarchies ---------- 90

IV-5. Reproductive output under elevated temperature and CO_2 ---------- 92

IV-6. Responses at the levels of the individual and population of C3 plant to elevated CO_2 ---------- 94

V. CONCLUSIONS 98

VI. ACKNOWLEDGEMENTS 102

VII. REFERENCES 105