DRY MATTER PARTITIONING IN *Zantedeschia* K. Spreng, AS INFLUENCED BY TEMPERATURE AND PHOTOSYNTHETIC PHOTON FLUX

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1993

A thesis presented in partial
fulfilment of the requirements
for the degree
of Doctorate of Philosophy in
Horticultural Science at
Massey University

ABSTRACT

The in vivo and in vitro dry matter accumulation and partitioning in plants of the *Zantedeschia pentlandii*-like (Watson) Wittm. selection 'Best Gold' were described under a range of either temperature and photosynthetic photon flux (PPF) regimes, or sucrose concentrations, using plant growth analysis.

The initiation of tuber growth, as denoted by increases in both structural and starch dry weights, did not require an obligative environmental trigger.

Relative rates of dry matter accumulation (RGR_W) increased linearly with increasing temperature up to a maximum of 28 C, with maximum final total and tuber dry weight occurring between 21 and 26 C both in vivo and in vitro. The linear relationship between the relative rate of dry matter accumulation of the tuber (RGR_T) and temperature, indicated a PPF dependent base temperature for tuber growth between 4.8 and 6.1 C.

By principally altering dry matter partitioning, total dry matter accumulation was highly adaptive to PPF regime. The ability to alter the photosynthetic rate and the partitioning of the daily increment of dry matter into leaf area (LWP), resulted in greater values of the estimated final total plant dry matter under the low PPF regime (348 $\mu mol \cdot m^{-2} \cdot s^{-1}$), at temperatures less than 22 C. At temperatures greater than 19 C the estimated maximum total plant dry weight was either not influenced by PPF or was slightly greater under the high PPF regime (694 $\mu mol \cdot m^{-2} \cdot s^{-1}$). This ability to effectively utilize a low PPF regime indicates that this selection is shade tolerant. The optimum PPF for growth was found to be temperature dependent: estimated maximum total plant dry weight occurred under high PPF at 25 C, whereas the estimated maximum tuber dry weight occurred at 24.5 C under low PPF.

RGR_W was highly correlated with LWP. In contrast, only a poor correlation was determined between RGR_W, and either the efficiency of these leaves to produce additional dry matter, i.e., net assimilation rate (NAR), or starch concentration or soluble carbohydrate concentration. Photosynthetic rate was correlated with RGR_W, but not with RGR_T. While the photosynthetic process must be involved in contributing photoassimilates for tuber growth, it was suggested that the plant's response to dry matter partitioning into the leaf, i.e., LWP, and the tuber, i.e., TWP, had a greater influence in determining tuber growth than could be accounted for by the photosynthetic rate.

Mechanisms of acclimation under both PPF regime suggested that tuber growth was principally source limited. Source limitation was expressed either in terms of:

1) enhanced intersink competition for assimilates, as occurred under the low PPF regime, where enhanced leaf area development (LWP) was in direct competition with enhanced tuber growth (RGR_T). This was also confirmed in vitro where dry matter partitioning to the tuber was reduced under limited source strength.

2) efficiency of dry matter accumulation of leaf area present, as occurred under the high PPF regime, where large increases in RGR_T were correlated with increased NAR. This was also confirmed in vitro where increased source strength increased tuber dry weight.

However, in vitro experiments where source strength was controlled, illustrated that tuber growth was also potentially sink limited at temperatures both lower and higher than the optimum. At 31 C the sink limitation of tuber growth arose from more than the temperature-induced limitation on growth and respiration found at other sink limiting temperatures. At this temperature an additional form of sink limitation was evident where partitioning of dry matter towards the tuber was also restricted. It was suggested that this additional form of sink limitation may have arisen from high temperature inactivation of starch metabolising or sucrose unloading enzymes.

Application of the dry matter partitioning term TWP, provided a more sensitive measure of short term changes in partitioning than the conventionally used term, harvest index.

The optimum temperature range for growth was close to the average daily air temperature during the season for the sites of natural habitat of the suggested parent specie, *Zantedeschia pentlandii*. Similarly the shade tolerance status of this selection was paralleled by the diversity of PPF habitats it naturally occupies, as created by open grassland and forest margins. It was therefore suggested that *Zantedeschia* 'Best Gold' is well adapted to optimise growth under the temperature and PPF regimes of its natural habitat.

This study suggests that improvements in commercial yield of *Zantedeschia* tubers can be achieved in all regions of New Zealand through the use of protected cultivation with supplemental heating. However, unless using protected cultivation, the potential improvements in commercial tuber yields, through the application of shading, are only likely to be evident in warmer regions of New Zealand where growers utilize extended periods of cultivation and optimise leaf area duration.

ACKNOWLEDGEMENTS

The completion of this thesis is a piece of independent research, but so many individuals have contributed either directly or indirectly. In particular, I would like to the thank the following:

my supervisors Dr I.J. Warrington, Dr J.A. Plummer and Dr E.W. Hewett for their challenges, guidance and constructive criticism;

Dr D.J. Chalmers for his leadership and foresight as Head of Department of the then Department of Horticultural Science, to initiate the unique opportunity for me to study towards my PhD;

the management and staff of HortResearch (formally DSIR Plant Physiology Division, and DSIR Fruit and Trees) especially Dr D. Cohen, and the Department of Plant Science (formally the Department of Horticultural Science) for the provision of facilities and technical advice;

Massey University Research Fund (MURF), Massey University Agricultural Research Fund (MUARF), and The C. Alma Baker Trust who all provided various forms of financial contribution;

Dr J.M. Wilson for an endless supply of tubers and seed, as well as thought provoking discussion;

my family and friends who either provided moral support or without knowing it, suitable distractions that created some semblance of normality during a demanding few years of my life.

Parts of Sections 1, 3, 4 and 5 of this thesis have been published in the following;

Funnell, K.A. 1993. Zantedeschia, p. 683-739. In: A. De Hertogh and M. Le Nard (eds.). The physiology of flower bulbs. A comprehensive treatise on the physiology and utilization of ornamental flowering bulbous and tuberous plants. Elsevier Science Publishers, Amsterdam.

Funnell, K.A., J.A. Plummer and I.J. Warrington. 1990. Temperature and light effects on tuber growth in calla lilies. Abstracts XXIII Intl. Hort. Congr., Firenze, Italy, 1990, no. 3261.

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LIST OF ABBREVIATIONS

α . . . . . apparent photosynthetic quantum yield
$\alpha_{W,A,L,Ls,T \text{ or } Ts}$ . . . . . upper asymptote of factor under investigation
A . . . . . leaf area
$\beta_{W,A,L,Ls,T \text{ or } Ts}$ . . . . . a measure of the starting size of the factor under investigation
BA . . . . . benzyl (1*H*-purin-6-yl) amine
C . . . . . Celsius
cm . . . . . centimetre
cm^2 . . . . . square centimetre
CE . . . . . controlled environment
CO_2 . . . . . carbon dioxide
DTEMP . . . . . day temperature
g . . . . . gram
GA_3 . . . . . gibberellic acid
GA_{4+7} . . . . . gibberellin 4 and 7
h . . . . . hour
ha . . . . . hectare
HPLC . . . . . high performance liquid chromatograph
i.e. . . . . *(id est)* that is
$\kappa_{W,A,L,Ls,T \text{ or } Ts}$ . . . . . rate constant of factor under investigation as a function of size
kg . . . . . kilogram
L . . . . . leaf weight
LAP . . . . . leaf area partitioning
LAR . . . . . leaf area ratio
LWP . . . . . leaf weight partitioning
LWR . . . . . leaf weight ratio
$\log_e$ . . . . . natural logarithm
Ls . . . . . leaf starch dry weight
LS . . . . . Linsmaier and Skoog organic additives
m . . . . . metre
m^2 . . . . . square metre
m^3 . . . . . cubic metre
mg . . . . . milligram
min . . . . . minute
ml . . . . . millilitre
M . . . . . molar
mm . . . . . millimetre
MS . . . . . Murashige and Skoog medium

n . . . . . number of observations in a sample
ng . . . . . nanogram
nm . . . . . nanometre
NAR . . . . . net assimilation rate
N.B. . . . . (*nota bene*) note well
NTEMP . . . . . night temperature
P . . . . . probability
Pa . . . . . Pascal
pH . . . . . measure of acidity or alkalinity
Pmax . . . . . maximum photosynthetic rate at saturating PPF
Pn . . . . . net photosynthetic rate
PPF . . . . . photosynthetic photon flux
ppm . . . . . parts per million
r . . . . . partial correlation
R . . . . . respiration rate
r^2 . . . . . coefficient of determination
RGR . . . . . relative growth rate
RLAER . . . . . relative leaf area expansion rate
RLSWR . . . . . relative leaf starch weight rate
RLWR . . . . . relative leaf weight rate
RWP . . . . . root weight partitioning
s . . . . . second
SAS . . . . . Statistical Analysis System (statistical software)
s.e. . . . . standard error of the mean
SLA . . . . . specific leaf area
str . . . . . dry weight of structural material (i.e., minus soluble sugars and starch)
t . . . . . time
t_c . . . . . time to commencement of tuber growth
T . . . . . tuber dry weight
$T_{\%}$ . . . . . percentage tuber weight loss at the commencement of tuber growth
tanh . . . . . hyperbolic tangent
Ts . . . . . tuber starch dry weight
Tstr . . . . dry weight of tuber structural material (i.e., minus soluble sugars and starch)
TWP . . . . . tuber weight partitioning
µl . . . . . microlitre
µm . . . . . micrometre
µmol . . . . . micromole
viz. . . . . . *(videlicet)* namely
v/v . . . . . volume (mix ratio)

W . . . . . total plant dry weight
%LA . . . . . .percentage maximum leaf area
_°_'S . . . . angular distance on its meridian South of equator in degrees and minutes
δ . . . . . .mathematical notation for an interval
ΔP . . . . . difference between photosynthetic rate under saturating PPF and photosynthetic rate under the growth PPF
ns,*,**,*** . . . . . unless otherwise stated, probability of a significant F value; nonsignificant or significant at P = 0.10, 0.05, or 0.01, respectively

NOTES ON CITATION FORMAT

With a view to publishing this thesis as a series of scientific papers in journals such as those produced by the American Society for Horticultural Science (ASHS), the style of literature citation follows that recommended by ASHS. The citation system used therefore follows the Harvard system, and abbreviations for periodical titles are as suggested by ASHS.

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