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GROWTH IN THE FIELD AND CO₂ EXCHANGE CHARACTERISTICS IN RELATION TO TEMPERATURE OF YOUNG ASPARAGUS

(Asparagus Officinalis L.)

A thesis presented in partial fulfilment of the requirements for the degree of
DOCTOR OF PHILOSOPHY in
Horticultural Science
at Massey University
New Zealand

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September 1993
ABSTRACT

Studies on asparagus plants were conducted in the field and in growth rooms during 1990 to 1992. The field experiment was carried out to study the growth and development of young asparagus using successional plantings, from September to March, with two commonly grown cultivars, namely VC157 and Jersey Giant. The growth room study was divided into three separate experiments with the following four cultivars: UC157, Brocks, Tainan 1 and Larac. The first experiment studied the effects of high temperatures (30/20, 35/25 and 40/30°C) on the ontogenetic changes of photosynthesis, the second the effects of temperatures (20/20, 25/25, 30/20, 35/15 and 40/20°C) on plant respiration and ACj curve. The final experiment examined the effects of high temperatures (20/20, 25/25, 30/20, 35/15 and 40/20°C) on the light response curve.

In the field experiment, a logistic model based on a heat unit time scale was used to describe changes in total, crown and shoot dry weight. The curves showed that the earlier plantings resulted in larger plants at the end of the season. VC157 performed best from the September planting, while Jersey Giant suffered from low temperatures resulting in the differences between the September and October plantings being marginal. In addition, plant dry weight at the final harvest (autumn) decreased as the planting date was delayed. Planting later than October resulted in inferior plant quality based on carbohydrate storage and shoot, bud and root numbers criteria. In general the effect of treatment was carried over into the spring. A sharp decrease in total plant RGR late in the season was due, in particular, to the fall in shoot RGR. The fall in the shoot RGR was greater than the fall in crown RGR.

The shoot to root dry weight ratio in the first season increased up until February and then decreased regardless of planting date and cultivar. The allometric relationship between shoot and crown dry weight showed a similar trend. It was suggested that the change in the ratio and in the allometric relationship was due to a seasonal factor, probably temperature. In early spring of the second season the ratio increased for a short period of time and then decreased or stabilised.
Shoot, bud and root production increased exponentially for earlier plantings, particularly for UC157. UC157 had a higher number of these three plant parts than Jersey Giant. However, Jersey Giant had larger shoots, buds and roots as the total dry weights of these organs were not different to UC157.

The bud to shoot number ratio increased as the season progressed suggesting that shoot growth predominated over bud production during early growth. Meanwhile the cumulative shoot plus bud to root number ratio was high and similar for all plantings during early growth suggesting that young plants gave priority to shoot and bud development. The ratio then decreased sharply before stabilising late in the season. At the final harvest the cumulative shoot plus bud was supported by about two roots for the early plantings.

The CO$_2$ exchange studies of asparagus seedlings found that maximum photosynthesis was achieved on fern of an intermediate age regardless of cultivars. Photosynthesis of young and mature ferns was similar. Photosynthesis decreased as temperature increased from 20 to 40°C. Brocks had a lower photosynthesis at 20/20°C compared to Tainan 1 and Larac, while at high temperatures both Brocks and UC157 had a higher photosynthetic rate than Tainan 1 and Larac.

Shoot and crown dark respiration all increased with temperature but the $Q_{10}$ was low. The low $Q_{10}$ of crown respiration was possibly due to low oxygen availability and the capacity of storage roots to conserve storage carbohydrate.

The fern photorespiration and dark respiration also increased with temperature, but at 40/20°C the photorespiration rate decreased. The decrease suggests that photorespiratory enzymes are labile to temperature compared to dark respiratory enzymes. There was a trend for Brocks to have a higher photorespiration rate compared to Tainan 1 and Larac at 20/20°C, while at 35/15°C the photorespiration rate of Brocks was lower compared to the other cultivars.
The CO$_2$ compensation point ($\Gamma$) increased as the temperature increased. The increase was mainly due to photorespiration but at $40^\circ$C dark respiration made a more significant contribution.

The carboxylation efficiency (CE) was the major limitation at low temperature but as temperature increased stomatal limitation (lg) became an important factor. The increase in lg was possibly due to the effect of a high VPD.

Mature fern photosynthesis responded biphasically to increasing light intensities. The only difference in the light response curve between cultivars was at 35/15$^\circ$C, where Brocks had a higher rate of photosynthesis than other cultivars at light intensities ranging from 300 to 750 $\mu$mol m$^{-2}$ s$^{-1}$. Furthermore, the quantum yield ($\alpha$) and maximum photosynthesis at light saturation (Pmax) decreased and the light compensation point (LCP) increased as the temperature was raised. Tainan 1 had a higher LCP and lower $\alpha$ than other cultivars, while UC157 had a higher Pmax.

Thus overall decrease in carbon accumulation with temperature was mainly due to an increase in stomatal limitation, a decrease in quantum yield, an increase in photorespiration (low carboxylation efficiency), and an increase in dark respiration.
ACKNOWLEDGEMENTS

In the name of Allah the most gracious and most merciful. This study will not have been possible without the help of Allah s.w.t.

I am also genuinely indebted to these following people who have helped with various aspects of this thesis work:

My supervisors Dr. K. J. Fisher, Dr. M. A. Nichols and Dr. D. J. Woolley for their guidance, encouragement and criticism;

The management and staff of Crown Research Institute (CRI) Palmerston North and the Plant Science Department of Massey University for the provision of facilities and technical advice;

The staff of Plant Growth Unit especially Mr. C. Forbes who built an excellent closed system design for CO₂ exchange measurement; Mr. B. R. McKay who helped the statistical analysis, and also Mrs. Nikki Wanoa who helped planting the seedling transplants and kept the weeds out of the experimental area;

The Chairman of The Doctoral Research Committee, Professor K. S. Milne, all Indonesian and Iranian and others students for their help and great moral support;

My parents and family for their encouragement and moral support;

My sincere thank to Indonesian and New Zealand governments for the financial assistance that made this study possible;

And last, but not least, my wife Rosita Arniati and my young wonderful sons Abdul Rahman Halim and Muhammad Husni for their patient, persistent encouragement and give me a meaningful life.
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<tr>
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<tr>
<td>Γ</td>
<td>CO₂ compensation point</td>
</tr>
<tr>
<td>ABA</td>
<td>abscisic acid</td>
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<td>ACₗ</td>
<td>photosynthetic response to internal CO₂</td>
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<td>adenosine triphosphate</td>
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<td>Rd</td>
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