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GROWTH IN THE FIELD AND CO_2 EXCHANGE CHARACTERISTICS IN RELATION TO TEMPERATURE OF YOUNG ASPARAGUS

(*Asparagus Officinalis* L.)

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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 UC157 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^{0}C) on the ontogenetic changes of photosynthesis, the second the effects of temperatures (20/20, 25/25, 30/20, 35/15 and 40/20^{0}C) on plant respiration and AC_i curve. The final experiment examined the effects of high temperatures (20/20, 25/25, 30/20, 35/15 and 40/20^{0}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. UC157 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^{0}C. Brocks had a lower photosynthesis at 20/20^{0}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^{0}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^{0}C, while at 35/15^{0}C the photorespiration rate of Brocks was lower compared to the other cultivars.

The CO_2 compensation point (Γ) increased as the temperature increased. The increase was mainly due to photorespiration but at 40^0C 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 $35/15^0C$, 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 (α) 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 α 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.

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GLOSSARY OF ABBREVIATIONS

Γ	CO_2 compensation point
ABA	abscisic acid
AC_i	photosynthetic response to internal CO_2
ATP	adenosine triphosphate
CE	carboxylation efficiency
CER	CO_2 exchange rate
C_i	internal CO_2
cv	cultivar
g_i	mesophyl conductance
HU	heat unit
IRGA	Infra Red Gas Analizer
IRGA	Infra Red Gas Analizes
K_m	Michael Menten kinetic
LCP	light compensation point
lg	stomatal limitation
NADPH	nicotinamide adenine dinucleotide phosphate
NAR	net assimilation rate
PAR	photosynthetic active radiation
PCR	photosynthetic carbon reduction
Pg	gross photosynthesis
PGA	phosphoglyceric acid
Pi	inorganic phosphate
PIB	post illumination CO_2 burst
Pmax	maximum photosynthesis at light saturation
Pn	net photosynthesis
Pn700	ratio of photosynthesis at standard light level to maximum photosynthesis
PPFD	photosynthetic photon flux density

Rd	dark respiration
rg	gas phase resistance
RGR	relative growth rate
Rl	photorespiration
rm	mesophyl resistance (1/CE)
RPGR	relative total plant growth rate
Rubisco	Ribulose-1,5 biphosphate carboxylase -oxygenase
RuBP	Ribulose-1,5 biphosphate
Tb	base temperature
TCA	tricarboxylic acid
T_{max}	maximum temperature
T_{mean}	mean temperature
T_{min}	minimum temperature
TPU	triose phosphate utilisation
V_c	rate of carboxylation reaction
V_o	rate of oxygenation reaction
α	quantum yield
Φ	ratio of oxygenase to carboxylase