RESPONSE OF VEGETATIVE GROWTH TO LIGHT AND TEMPERATURE IN *ANIGOZANTHOS*

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The aim of this experiment was to study the response of the vegetative growth of two commercially important *Anigozanthos* species (Kangaroo paws) to varying temperature and light conditions under short-day glasshouse conditions.

MATERIALS AND METHODS

A glasshouse trial using *A. flavidus* and *A. manglesii* was conducted at the University of Sydney's Darlington glasshouse complex between July and September, 1981.

Seed of *A. manglesii* was pretreated by soaking in hot water (60°C) for 2 hours before sowing. Seed was sown in a mix of 1 part perlite: 1 part sand on 18 April, 1981 and germination was complete by 18 May 1981. Seedlings were pricked out into a sand/peat growing medium and grown on in a propagation glasshouse for 3 weeks. On 7 June, 1981, 240 plants of each species were selected for uniformity and transferred to the temperature controlled glasshouses. Water was applied by hand when required and humidity varied with temperature and frequency of watering.

Six day/night temperature ranges were employed, namely: 15°/10°C; 18°/13°C; 21°/16°C; 24°/19°C; 27°/22°C; and 30°/25°C. The two light levels were: full sun and 50% shade, using cloth suspended 60 cm above the plants.

The treatment design within each temperature was a split plot in time with the two species and two light levels as the main plots and four harvest times as the subplots. The experimental design was an incomplete block design (4) with whole plots arranged completely at random. Twenty plants were allocated to each whole plot using random number tables. Plants were subsequently re-randomised every 3 weeks. Temperature treatments were not replicated due to the unavailability of replicated environment rooms. Hence differences between temperatures cannot be tested statistically and a graphical presentation is used.

Assessment involved the random selection of 3 plants from each main plot every 7 days between 18 August, 1981 and 7 September, 1981, totalling 12 plants per treatment. Parameters measured were leaf area using a Paton Electronic Planimeter (CSIRO) with an accuracy of 0.5mm^2, oven-dry top weight, oven-dry root weight, (plants had not developed rhizomes) and total plant height measured from the soil surface to the tip of the longest leaf. Qualitative data on morphological differences were also recorded.

RESULTS AND DISCUSSION

Previous researchers (2,5) have suggested that the most favourable temperature range for the vegetative growth of kangaroo paws is between 15°C and 20°C.. These findings have not been substantiated by the results obtained in this experiment. These results indicate that both species will respond with increased vegetative growth to temperatures higher than previously recommended.

Plant Height, Leaf Area, Shoot Weight and Root Weight. At 3 months the effect of temperature on growth in plant height was clear, height increasing with temperature up to 27°/22°C (Figure 1). Significant height differences between species were only apparent at temperatures above 21°/16°C, (Table 1)

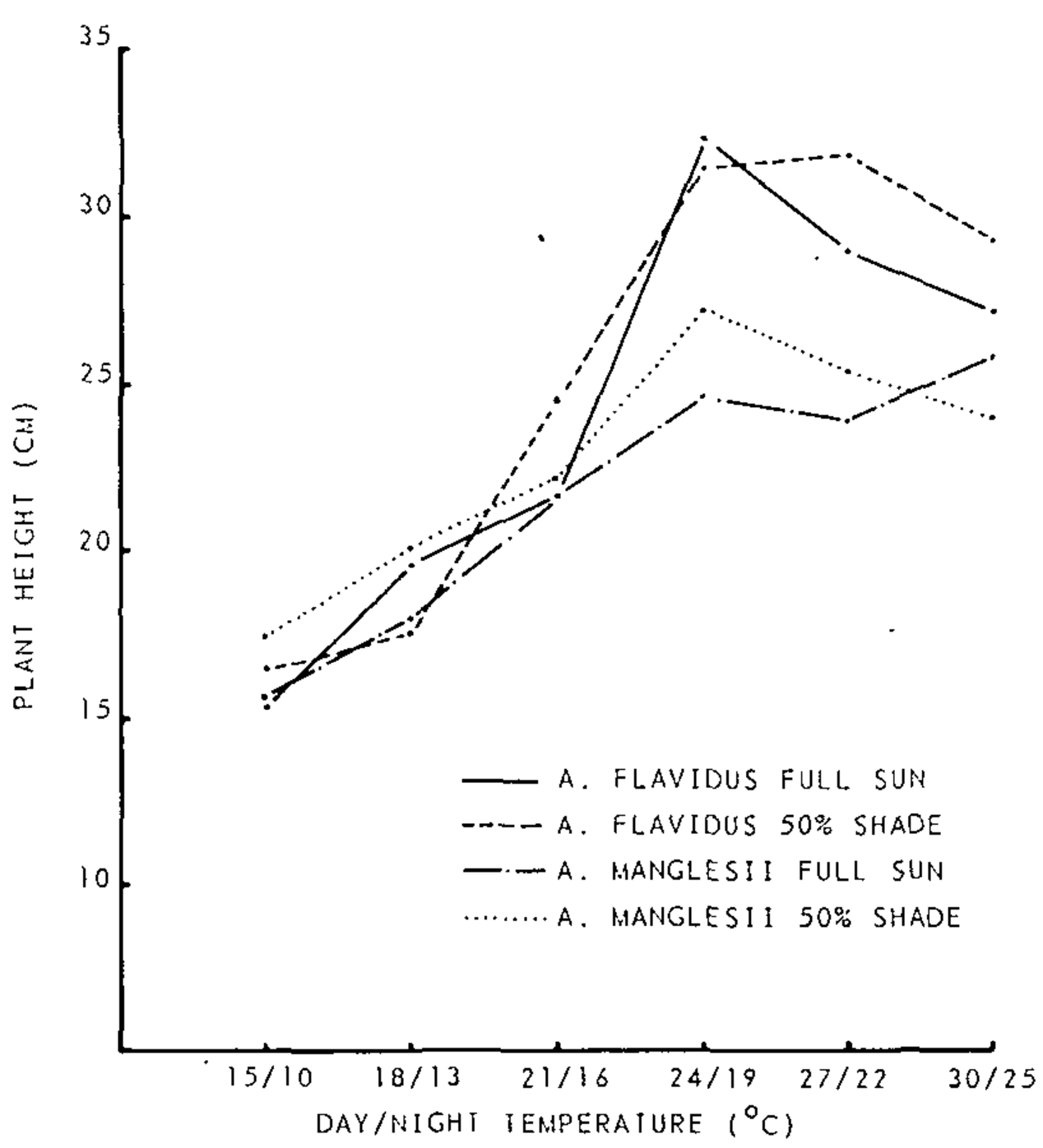

Figure 1. Plant height response of *A. flavidus* and *A. manglesii* to temperature and light after 12 weeks growth.

In most cases, plants subjected to 50% shade reached their maximum height at a higher temperature than those exposed to direct sun. The light level had no significant effect on the height of either species within any of the 6 temperature ranges (Table 1).

The response of leaf area to increasing temperature was, as might be expected, similar to the pattern for height growth (Figure 2). Both species attained maximum leaf areas at 24°/19°C, (full sun) and at 27°/22°C (shaded).

Leaf area decreased markedly in all cases above 27°/22°C and only at temperatures above 21°/16°C did the leaf area of *A. flavidus* significantly exceed that of *A. manglesii*. Light level had no significant effect on the leaf area of either species within the temperatures tested, (Table 1).

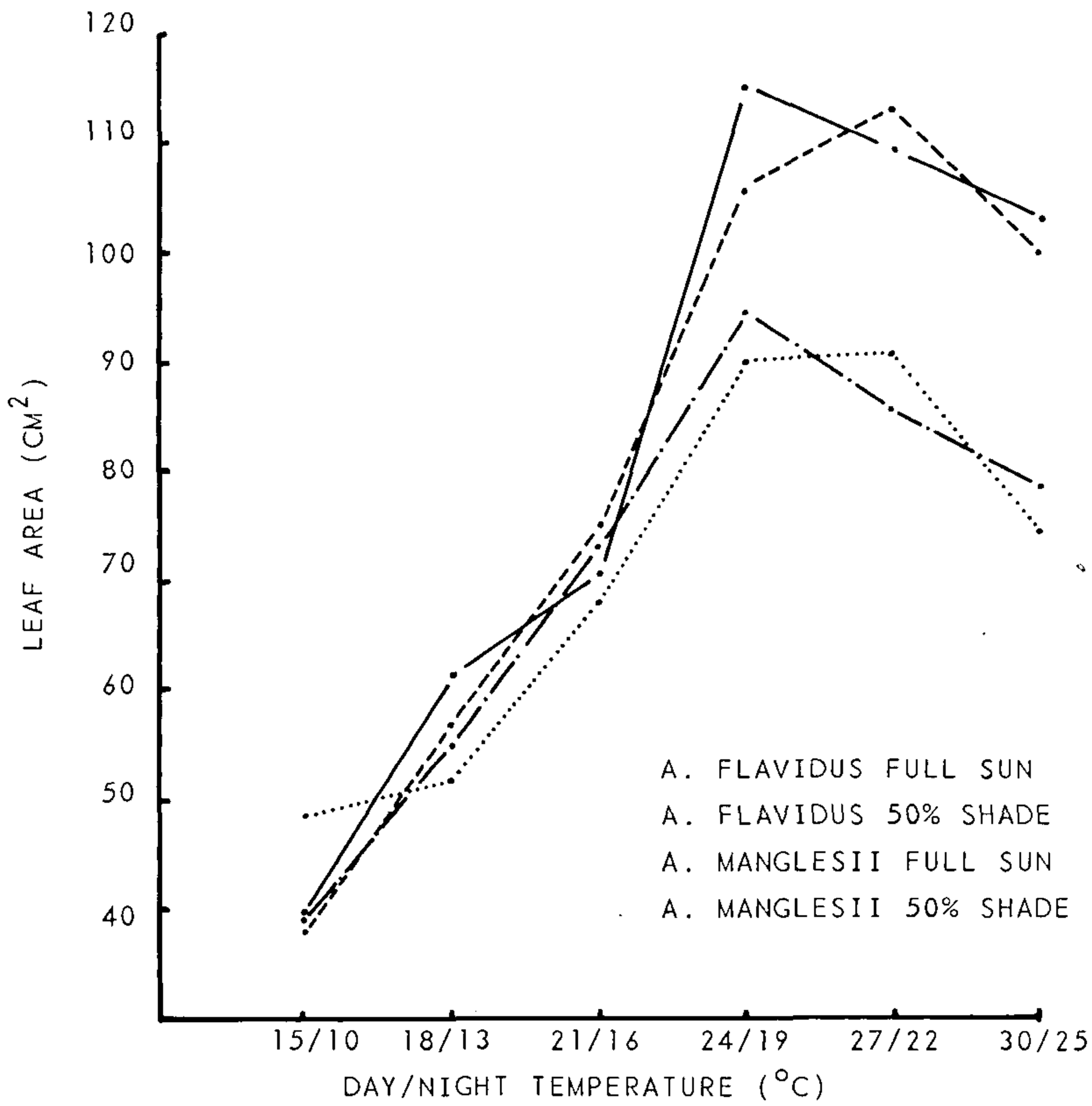

Figure 2. Effect of temperature and light on the leaf area of *A. flavidus* and *A. manglesii*.

Table 1. Variance ratios (F) and significance levels[1] (P) for the influence of light intensity and species type on leaf area, shoot dry weight, root dry weight and plant height at different day/night temperatures.

Comparison	15/10°C		18/13°C		21/16°C		24/19°C		27/22°C		30/25°C	
	F	P	F	P	F	P	F	P	F	P	F	P
Leaf Area												
Between species	<1	N.S.	<1	N.S.	0.57	N.S.	7.11	*	10.36	*	13.13	**
Light level within A.f.$_{(2)}$	<1	N.S.	<1	N.S.	0.12	N.S.	1.46	N.S.	<1	N.S.	<1	N.S.
Light level within A.m.$_{(3)}$	<1	N.S.	<1	N.S.	<1.25	N.S.	<1	N.S.	<1	N.S.	<1	N.S.
Shoot Weight												
Between species	<1	N.S.	3.81	N.S.	7.23	*	3.56	N.S.	8.78	*	41.8	***
Light level within A.f.	2.99	N.S.	3.14	N.S.	2.99	N.S.	2.74	N.S.	1.57	N.S.	4.22	N.S.
Light level within A.m.	3.36	N.S.	7.49	*	1.92	N.S.	6.00	*	1.62	N.S.	49.86	***
Root Weight												
Between species	3.86	N.S.	11.58	**	22.46	***	11.26	**	6.02	*	51.73	***
Light level within A.f.	7.20	*	3.83	N.S.	14.41	**	5.42	*	6.90	*	3.57	N.S.
Light level within A.m.	6.17	*	12.15	**	11.87	**	1.21	N.S.	10.85	*	35.45	***
Plant Height												
Between species	<1	N.S.	<1	N.S.	1.17	N.S.	36.69	***	23.23	***	9.57	*
Light level within A.f.	<1	N.S.	<1	N.S.	1.96	N.S.	<1	N.S.	5.25	N.S.	<1	N.S.
Light level within A.m.	2.18	N.S.	1.21	N.S.	<1	N.S.	3.17	N.S.	1.31	N.S.	1.61	N.S.

(1) : * = $P < 0.05$
: ** = $P < 0.01$
: *** = $P < 0.005$
: at ⅛ degrees of freedom
(2) *A. flavidus*
(3) *A. manglesii*

Mean values for shoot and root dry weight are shown in Figures 3 and 4. Both species showed maximum shoot weight at 27°/22°C, dropping sharply at 30°/25°C particularly in *A. manglesii* under 50% shade.

Shoot weight of *A. flavidus* was significantly higher than that of *A. manglesii* at these two temperatures. Shading had no significant effect on the shoot weight of *A. flavidus* and little effect on *A. manglesii* except at 30°/25°C where the suppression of shoot weight was highly significant.

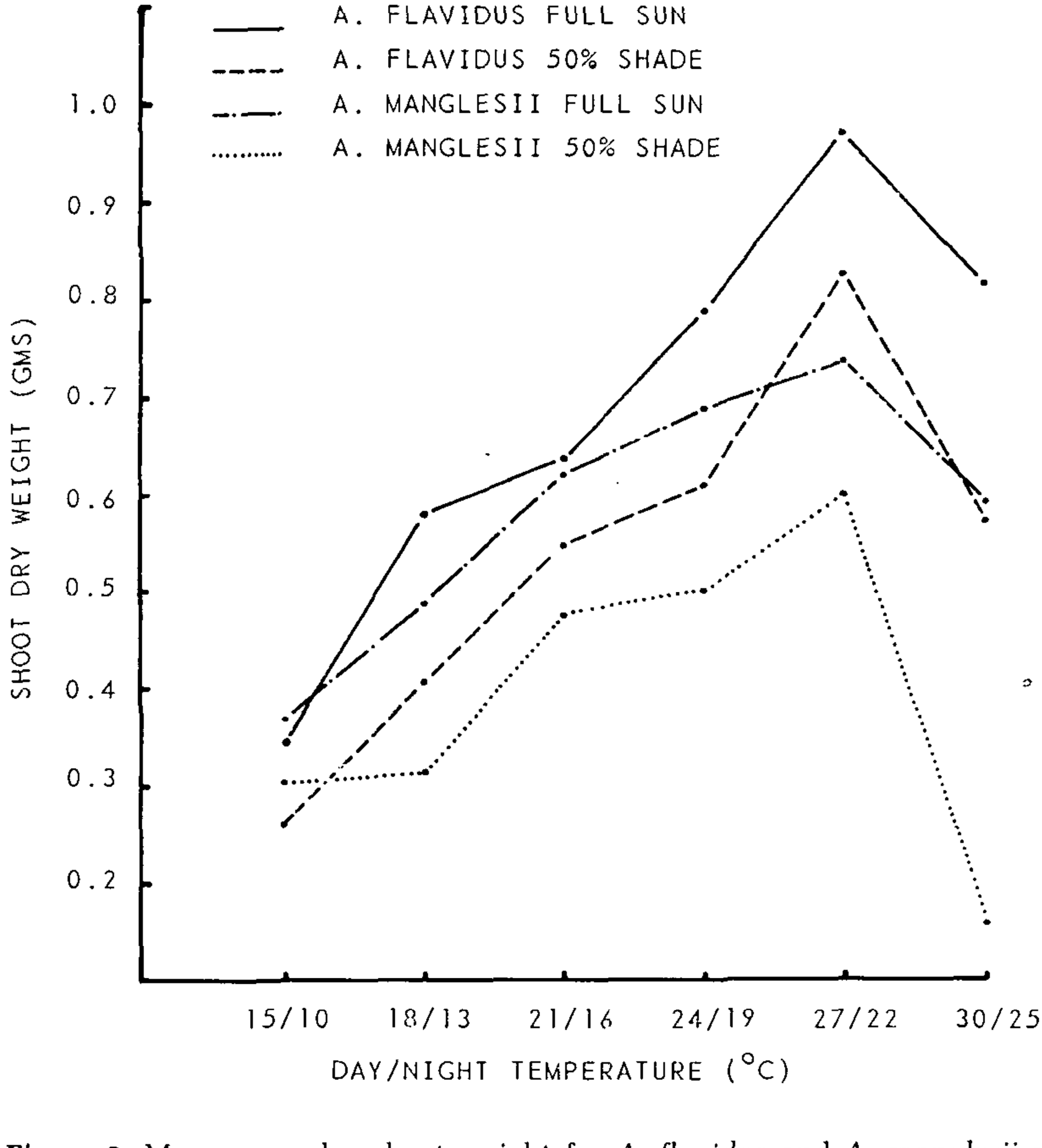

Figure 3. Mean oven dry shoot weight for *A. flavidus* and *A. manglesii* vs temperature at two light levels.

Results obtained for plant height, leaf area, and shoot weight indicate that the critical day/night temperature range for both species lies somewhere between 24°/19°C and 27°/22°C beyond which plants are increasingly stressed. The de-

crease in growth above these temperatures and the morphological aberrations observed, namely twisted, drooping leaves and dead root tips, may be due to metabolic disturbances associated with high respiration rates and a decline in net photosynthesis resulting in the loss of carbohydrates which otherwise would be available for growth. Water stress may also have affected growth. High temperatures associated with low relative humidity could have led to rapid depletion of the available water, followed by stomatal closure and decreased photosynthesis. The blue spotting on the leaves and blue staining of the roots of *A. manglesii* suggests that this species was particularly stressed at 30°/25°C. The production of blue phenolic substances is a well known response of plants in this genus to physiological stress.

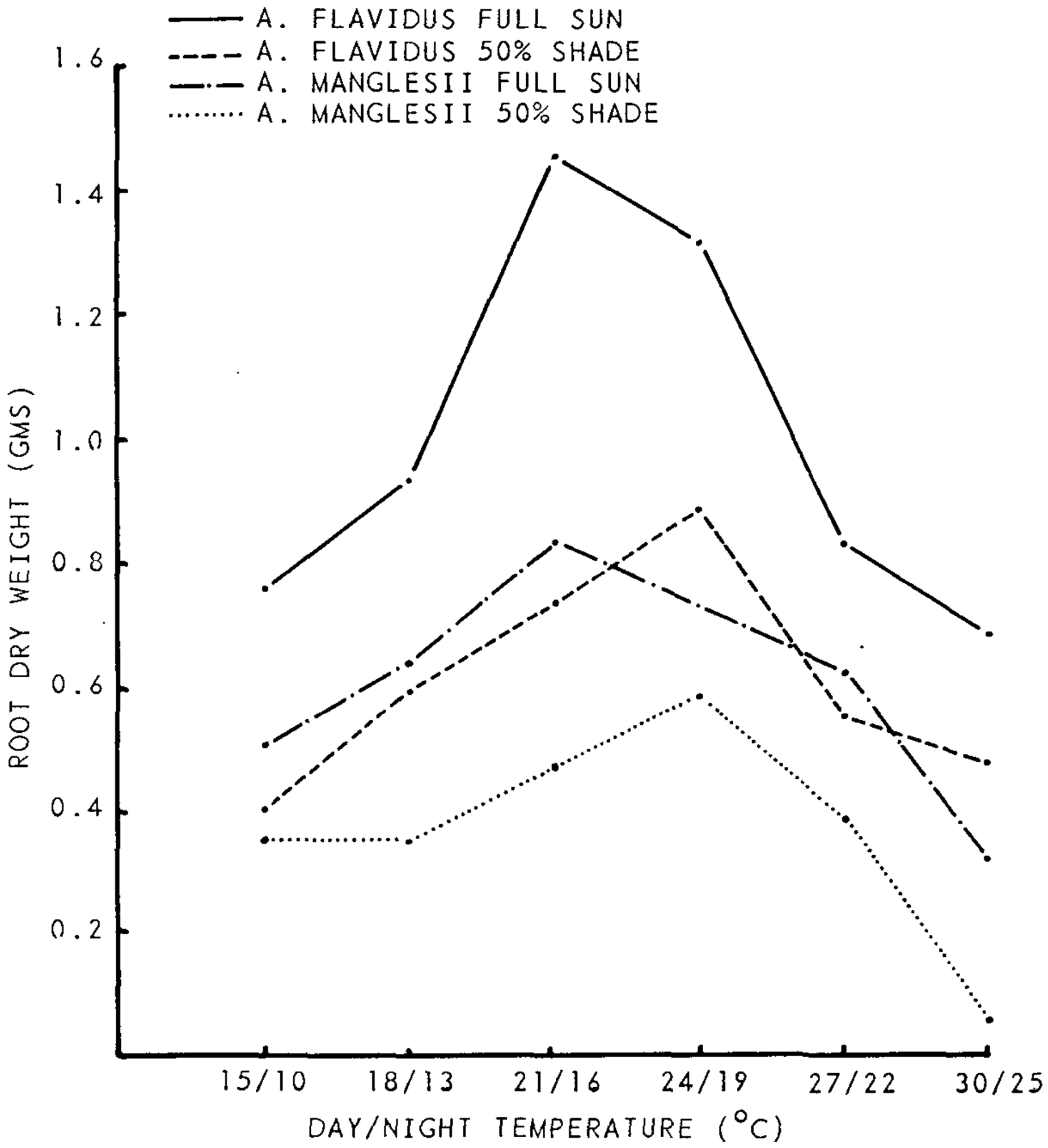

Figure 4. Mean oven dry root weight for *A. flavidus* and *A. manglesii* vs temperature at two light levels.

Root weight differed from shoot weight in its response to temperature, showing maximum development at 21°/19°C in full sun and 24°/19°C in 50% shade. This may be an adaptation to the natural environment in which plants of this genus grow where deep sandy soils provided a cool run for the plants. The fact that the maximum root weights for shaded plants occurred at a higher temperature than for plants in full sun is probably due to the lower pot temperatures experienced by the roots under shade as a result of more moist soil conditions.

Root and shoot weight was found to be significantly reduced by shading at higher temperatures. It is well documented (6) that an increase in temperature beyond a certain minimum will not produce a corresponding increase in photosynthesis even though respiration continues to rise, and that the effect of high temperatures on photosynthesis is more marked under low light conditions.

Root/Shoot Ratio. The root/shoot ratios of both species decreased with temperature above 24°/19°C (Fig 5). Characteristic root/shoot ratios for kangaroo paws grown in the field have not yet been established and are not available for comparison with these results. At most temperatures shading also reduced the root/shoot ratio. In a discussion on this subject Kramer and Kozlowski (3) suggested that shading decreased root growth as a result of a reduction in photosynthesis and a diversion of carbohydrates to leaf production. As pointed out

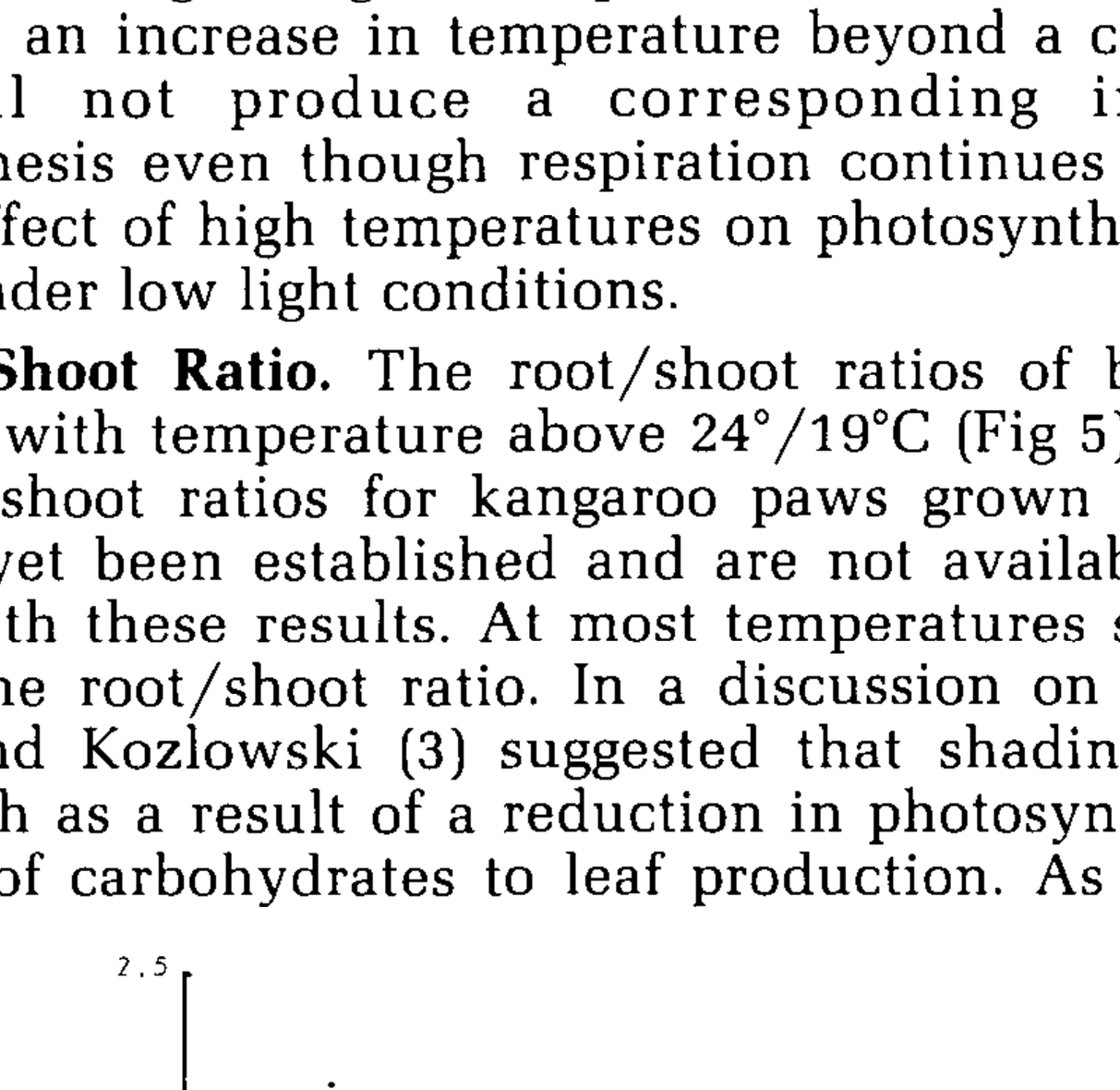

Figure 5. Mean root/shoot ratios for *A. flavidus* and *A. manglesii* vs temperature at two light levels.

by Brouwer (1) this reduction in the root/shoot ratio has adaptive value. A decrease in the ratio at low light intensities guarantees favourable light interception.

CONCLUSIONS

In view of the results obtained, the optimum conditions for vegetative growth of *A. flavidus* and *A. manglesii* under glasshouse conditions would appear to be a 24°/19°C day/night temperature range.

The high root/shoot ratio obtained at this temperature gave these plants superior adaption to transplanting into the field, compared to plants grown at higher temperatures. Shading was found to have no beneficial effect on growth.

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