Germination of *Ligustrum lucidum* W.T.Ait. and *L. sinense* Lour. at different temperatures

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Summary

The time-course of germination of *Ligustrum lucidum* and *L. sinense* was followed at 5°, 10°, 15°, 20°, 25° and 30°C. Optimum temperatures for germination were 15°C in *L. lucidum* and 20° to 25°C in *L. sinense*. Ungerminated seeds from temperatures above and below the optima showed accelerated germination when transferred to the optimum temperatures. The exceptions were those seeds held at 30°C. In *L. lucidum* germination of such seeds at the optimum was slow and delayed; in *L. sinense* there was little further germination.

Introduction

The two privet species *Ligustrum lucidum* W.T.Ait. (large-leaved privet or Chinese white wax tree) and *L. sinense* Lour. (small-leaved or Chinese privet) are recognized as important naturalized weeds of urban bushland along the central coast of New South Wales. In suitable habitats, such as moist fertile valleys, they are becoming dominant (Adamson and Buchanan, 1974) by replacing native species such as *Pittosporum undulatum* Vent. and even *Eucalyptus* spp. (Adamson and Fox, 1981). As well as showing this aggressiveness, pollen from both species is believed to cause asthma (Anon., 1979a). Despite these reasons for interest, however, little is known of the biology of the two species. In this paper we report the germination response of the two species under different temperature regimes as an initial contribution towards filling this gap.

Materials and methods

Fresh fruit of *L. lucidum* and *L. sinense* was collected during August 1980. Seed was removed from the fruit by hand, sterilized in dilute sodium hypochlorite and rinsed thoroughly with distilled water. Two hundred seeds of each species in four replicates of 50 seeds were tested for germination at each of six temperatures. The seeds, on wetted filter paper in petri dishes, were placed in dark constant temperature rooms at 5°, 10°, 15°, 20°, 25° and 30°C. Germination (defined as the first appearance of root tip from the seed) was recorded daily under low light intensity (<2 W m^{-2} or about 0.5% daylight).

After 33 days any seeds which had not germinated were tested for germinability by transferring them from the test to the optimum temperature determined during the course of observations. Germination under these temperatures was followed for a further 14 days.

Results

The time-course of germination of both species at each temperature (Figures 1 and 2) was described using the Gompertz relationship, $p = a \exp(-be^{-ct})$ where p is the cumulative percent germination and a is the maximum germination percentage; b and c are constants and t the time. This convenient relationship fitted the data better than the more widely used monomolecular equation (Bould and Abrol, 1981) which poorly describes the early time-course of germination. Both relationships are forms of the complex Richards' functions (Causton and Venus, 1981) which are difficult to use because of an additional parameter in the equation describing their form. A fully satisfactory solution to the problem of fitting these functions to germination is not yet available.

The form used for fitting the Gom-

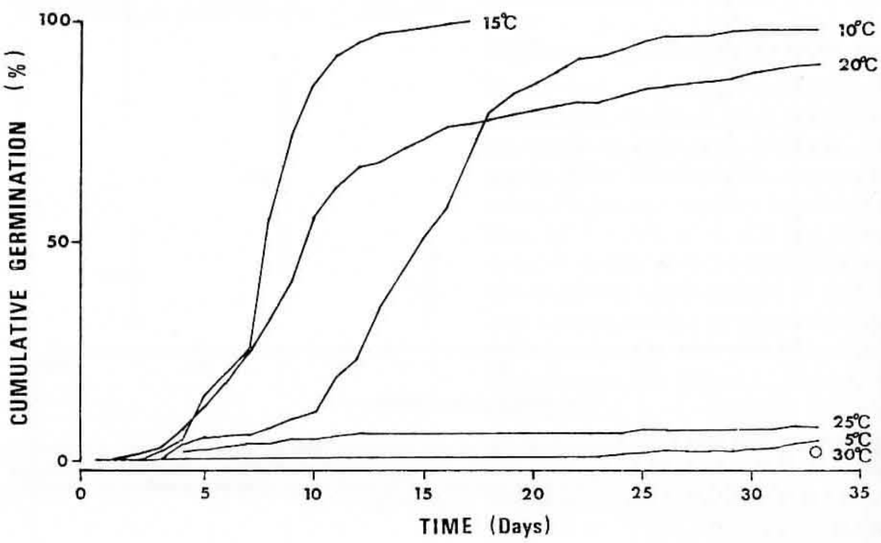

Figure 1 Time-course of germination of *Ligustrum lucidum* at different temperatures.

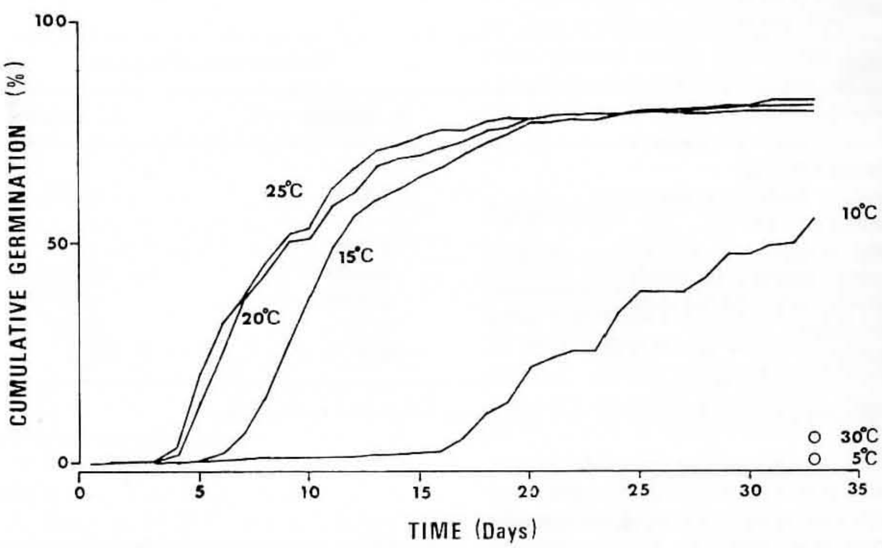

Figure 2 Time-course of germination of *Ligustrum sinense* at different temperatures.

pertz relationship was $ln\ (ln\ a/p) = b - ct$ (Milthorpe and Moorby, 1979). The relationships and their correlation coefficients are given in Table 1. No relationship was determined for treatments with low germinations (5°, 25° and 30°C for *L. lucidum* and 5° and 30°C for *L. sinense*).

Gompertz relationships fitted to each replicate were used to calculate three important germination characteristics: the time for the first seed to germinate (t_1), the time to germination of half the germinable seeds ($t_{a/2}$) and the slope of the curve at this time (dp/dt) a measure of the spread of germination. Mean values of these characteristics and of a for both species at each temperature (Table 2) were used to determine the optimum germination temperatures.

In *L. lucidum* the optimum temperature was taken to be 15°C for the following reasons. Maximum germination (99%) occurred at 10° and 15°C. t_1 declined with increasing temperature to a minimum at 20°C. At this temperature however both a and dp/dt were significantly reduced below the values at 15°C. At 15°C dp/dt was at a maximum. In *L. sinense* maximum germination (which was 20% less than in *L. lucidum*) occurred over a rather broad range of temperatures (15°C to 25°C). t_1 and $t_{a/2}$ were minimal at 20° and 25°C, but there was no significant difference in the spread of germination between 15°C and 25°C. There was however a marked delay in the initiation of germination at 15°C which was reflected in the higher $t_{a/2}$. The optimum temperature in this species was taken to be 20°C since this represented the midpoint of a range of temperatures over which a and dp/dt were highest. Transferring ungerminated seeds to the optimum temperatures caused an immediate and rapid response with the sole exception of seeds of *L. sinense* previously held at 30°C. In *L. lucidum* values were obtained for a of 95.0%, 98.5%, 97.0% and 82.0% for seeds brought from 5°, 20°, 25° and 30°C, respectively. In *L. sinense* seeds transferred to 20°C from 5°, 10° and 30°C gave values of 73%, 88.5% and 8.5%, respectively. These improvements were accompanied by a reduction in t_1 (*L. lucidum*, 5° to 15°C) or an increase in dp/dt (*L. lucidum*, 25° to 15°C; *L. sinense*, 5° to 20°C) relative to the values for seeds held continuously at the optimum temperatures. The effects were less marked in seeds of *L. lucidum* and did not occur in seeds of *L. sinense* transferred from 30°C. The failure of seeds of *L. sinense* to respond to the change in temperature regimes may have been the result of severe fungal infection to which seeds of that species seemed particularly susceptible. However the few additional seeds which germinated did so despite infection. *L. lucidum* was not seriously infected.

Table 1 Gompertz equations fitted to the time-courses of germination at different temperatures for two privet species (a/p in %; t in days)

Temperature °C	*L. lucidum* Relationship	R^2	*L. sinense* Relationship	R^2
10	$ln\ ln\ (a/p) = 2.93 - 0.252\ t$	.963	$ln\ ln\ (a/p) = 4.07 - 0.198\ t$	.986
15	$ln\ ln\ (a/p) = 3.32 - 0.540\ t$	.986	$ln\ ln\ (a/p) = 2.47 - 0.260\ t$	.985
20	$ln\ ln\ (a/p) = 1.52 - 0.186\ t$	.961	$ln\ ln\ (a/p) = 1.15 - 0.188\ t$	.965
25			$ln\ ln\ (a/p) = 1.88 - 0.283\ t$	.980

Table 2 Variation of the germination characteristics of *Ligustrum lucidum* and *L. sinense* with temperature

Temperature °C	a	t_1	$t_{a/2}$	dp/dt
L. lucidum				
5	5 ± 3.8 c	>33	-	-
10	98 ± 2.8 a	6.4 ± 3.1 a	13.8 ± 1.5 a	8.5 ± 2.2 a
15	100 ± 0.0 a	3.8 ± 0.6 a	7.2 ± 0.5 b	18.2 ± 3.5 b
20	90 ± 7.5 b	0.0 ± 1.4 b	9.9 ± 1.1 c	5.8 ± 1.2 a
25	7.5 ± 5.3 c	>33	-	-
30	3.0 ± 1.9 c	>33	-	-
L. sinense				
5	1 ± 1.2 c	>33	-	-
10	55 ± 5.3 b	13.3 ± 2.3 a	22.3 ± 1.4 a	3.9 ± 1.2 a
15	81 ± 4.4 a	4.5 ± 1.5 b	10.8 ± 1.0 b	7.8 ± 1.1 b
20	82 ± 3.0 a	0.3 ± 3.1 c	8.6 ± 1.2 c	6.3 ± 1.8 b
25	79 ± 8.4 a	1.2 ± 2.0 bc	7.4 ± 0.6 c	8.0 ± 2.5 b
30	6.5 ± 5.5 c	-	-	-

Maximum germination (a in %); time in days for the first seed (t_1) and the median seed to germinate ($t_{a/2}$); and rate of germination at $t_{a/2}$ (dp/dt, d^{-1}).

The same letter attached to values for particular characteristics indicates these values are not significantly different from each other at 5% level.

Table 3 Average maximum and minimum air temperatures, minimum surface temperatures and soil temperature at 25 mm depth. Sydney Observatory (Anon., 1979b)

Position	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Year
screen max	25.7	25.4	24.5	22.1	19.0	16.6	15.8	17.4	19.7	21.9	23.5	24.9	21.4
screen min	18.3	18.4	17.3	14.5	11.2	9.1	7.8	8.7	10.8	13.3	15.3	17.2	13.5
surface min	15.6	15.8	14.6	11.5	8.1	5.9	4.4	5.1	7.2	9.9	12.4	14.5	10.4
soil at 25 mm depth	21.2	21.4	20.6	18.4	15.1	12.7	11.3	12.3	14.3	16.6	18.5	20.1	16.9

Discussion

In the central coast region of New South Wales privet fruit mature and ripen during June and fall from the bushes, or are removed by birds, during July and August. There may be slight seasonal and regional variations in these times. During these two months temperatures are at a minimum (Table 3) but are unlikely to inhibit germination significantly. Perhaps the best available indication of seed bed temperatures are those in the soil at 25 mm depth. In July and August average soil temperatures are 11.3° and 12.3°C respectively. Both *L. lucidum* and *L. sinense* germinate slowly at these temperatures (Table 2). Seeds may also experience significantly lower temperatures; average minimum surface temperatures (Table 3) are a guide. The lowest minimum surface temperatures (−4.4° and −3.3°C) are recorded in July and August. These lower temperatures may initially depress germination (Table 2), but subsequently promote it. Similar effects have been observed in other privets. For example, prompt germination of *L. vulgare* was obtained after low (0° to 2°C) temperature stratification (Rudolf, 1974). Such responses may reflect characteristics of the species which have evolved under the environmental conditions of their centres of origin, which for *L. lucidum* and *L. sinense* appears to be north-eastern Asia (Rehder, 1958). They also suggest that privet seeds may exhibit dormancy (Khan, 1977). However, the rapid germination of both species at higher temperatures would tend to repudiate this. As seed bed temperatures increase towards the optimum, germination is likely also to increase. Consequently temperatures in the Sydney region should be favourable throughout the year.

There is no quantitative evidence that the species show different habitat preferences related to the differences in their germination response to temperature; in suitable habitats both species almost invariably occur together. There are, however, small local differences. *L. lucidum* appears to be more abundant in cooler shady sites and *L. sinense* in warmer exposed sites (D. Adamson, personal communication). Seed bed temperatures may contribute towards this pattern but other factors during ontogeny will be important.

Privet seeds are long lived; they germinate well up to two years after collection – at least when stored under ambient temperatures in the laboratory. Both species are prolific fruiters and estimates of the seed burden range from 10^5 to 10^7 on a single bush (D. Adamson, personal communication). It must therefore be considered surprising that the species, although regarded as aggressive to competitors, are not even more successful and widely spread than the present restricted distribution. There are two possible germination-related reasons for this. Firstly, irregular rainfall and high evaporation rates maintain relatively dry seed beds for the bulk of the year except in favourable habitats; this effectively inhibits germination in otherwise suitable conditions. Secondly, seed bed temperatures in exposed habitats may rise to levels which cause seed death.

Even if germination is successful, drought-induced seedling mortality is likely to be high. Nevertheless, small privet seedlings are often found on ridge tops and slopes. They appear neither to replace native species nor to grow to significant sizes. The reduction in vigour may be the result of the species response to the harsher environment – water stress may be particularly important. It could also reflect a degree of susceptibility to fire; fire frequency is much lower in the moist gullies where the species is most successful. Both hypotheses warrant further investigation.

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