COMPARATIVE BIOLOGY OF CRUCIFEROUS WEEDS: A PRELIMINARY STUDY

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Summary. Temperature and light responses of a number of crucifers were screened in the laboratory. Their developmental rates were also compared in a pot experiment. *Hirschfeldia incana* and *Sisymbrium officinale* showed a preference for light at almost all temperatures. However, several other species germinated best in the dark at lower temperatures and in the light at higher temperatures. *Hirschfeldia incana* took by far the longest to flower.

INTRODUCTION

Sixty nine species of Brassicaceae have become established in Australia, mostly from Europe. Thirty seven of these are considered as weeds by Auld and Medd (2). Despite their importance in agriculture and their significance in the naturalised flora, little is known of their biology and ecology. There are some exceptions to this statement. *Raphanus raphanistrum* and *Sinapis arvensis* have been studied widely overseas. As a major weed of the Australian wheat belt *R. raphanistrum* has received attention in respect of its control, seed bank dynamics, phenology and seed biology (3,4). *Sinapis arvensis* has similarly been studied in the northern hemisphere. There have been some studies of germination, competition with crops and herbicidal control of *Brassica tournefortii* (5). Even species causing major (but local) problems in cropping in Australia, such as *Rapistrum rugosum* and *Sisymbrium orientale*, or widespread weeds of pasture and roadsides, such as *Hirschfeldia incana*, remain virtually unstudied.

One of the most notable features of the introduced crucifers is the patchiness of their distributions (as can be seen from the maps in Flora of Australia, Volume 8). Even though some of the species have been introduced for over 150 years, it is likely that few have reached equilibrium in their distributions. Even the most abundant and widespread in cropping, *R. raphanistrum*, is believed to be still spreading. Within the climatically suitable regions, it is likely that abundance is affected by land-use and edaphic factors. For example, *S. arvensis* is most abundant in the northern hemisphere on heavy soils, neutral to alkaline, but it can occur on more acidic soils. Within Australia, *Rapistrum rugosum* in crops tends to occur on heavy, alkaline soils; its dominance as a weed in northern NSW and Southern Queensland may indicate a preference for higher temperatures and summer rainfall (though it also occurs as a weed in parts of South Australia). *Hirschfeldia incana* is one of the most common Brassicaceae on the southern tablelands of NSW, perhaps indicating a preference for cooler temperatures, higher rainfall and a dislike of cropping.

From published distribution maps, the current ranges of many weedy Brassicaceae appear to overlap little within New South Wales and within Australia as a whole. Indeed, it is seldom that more than one cruciferous weed is found in any crop. To what extent do their distributions reflect accidents of history, climatic adaptations or edaphic preferences? If we want to understand comparative distributions of species, we require comparative biological and ecological data. The experiments described here are part of a project to determine the extent to which soil pH and temperature responses are likely to affect crucifer distributions in Australia.

METHODS

Seeds of a range of species were collected throughout New South Wales in November 1990. They were stored in sealed containers in the laboratory. Due to limitations of space, only one source of seeds for most species was included in the study. In the pot experiment, two sources of *Brassica fruticulosa* and *Raphanus raphanistrum* were included. The study was of the nature of a preliminary screen; the data were not amenable to parametric statistical analysis.

Temperature and light response. Seeds were germinated in petri dishes at a range of temperatures, from 5°C to 35°C. There were three replicates of each species, both in the dark and in the light (12 hour photoperiod). Thirty seeds were placed in each petri dish, on top of two Whatman No.1. filter papers. Sufficient distilled water was added to fully moisten the papers. Periodically, further water was added as papers began to dry out. The species and their origins were as follows: *Brassica fruticulosa* (Port Botany); *B. tournefortii* (Hillston); *Sinapis arvensis* (Walgett); *Sisymbrium orientale* (unknown); *S. irio* (Quirindi); *S. officinale* (Denman); *S. erysimoides* (Hillston); *Hirschfeldia incana* (Gunning). Seeds of *Raphanus raphanistrum* remain in pod segments; in petri dishes they did not germinate and rotted. *B. tournefortii* did not germinate in water; seeds were pre-rinsed for ten minutes in 1% sodium hypochlorite to break dormancy. For the same reason *S. arvensis* were imbibed in 5ppm GA_3. Germination was recorded daily at high temperatures, less often at lower temperatures; seeds with at least their radicle or cotyledons visible were counted and removed.

Time to flowering. Seeds were sown on each of 5 dates: 16 April, 15 May, 4 July, 26 August, 30 September 1992. Seeds were planted in 15 cm pots at a depth of 0.5 cm (except for *S. orientale*, which were spread on the soil surface). There were 50 seeds in each pot. Following poor germination in April, seeds of *R. raphanistrum*, *B. fruticulosa* (Valley Heights only), *S. arvensis and B. tournefortii* were imbibed in 2ppm GA_3 overnight before later sowings. After emergence, seedlings were thinned to three per pot. For each sowing there were three replicates in a randomised complete block design. The same seed sources were used as before, with the addition of *B. fruticulosa* (Valley Heights), *R. raphanistrum* (Cobbitty and Rutherglen) and *Rapistrum rugosum* (Gunnedah). Every week the number of plants which had started to bolt and those which had begun to flower were counted.

RESULTS

Temperature and light response. Germination at optimal temperatures was good, with the exception of *S. irio* and *S. orientale* (Fig. 1). *H. incana* and *S. officinale* showed preferences for light throughout most of the temperature range. Most other species appeared to prefer light at the higher temperatures (*S. orientale*, *S. irio*, *S. erysimoides*, *S. arvensis*, *B. fruticulosa*); some species showed a distinct preference for darkness at lower temperatures (*B. tournefortii*, *S. erysimoides*, and possibly *S. orientale* and *S. irio*). Most species showed at least some germination at 5°C (the only exception was *S. officinale*). It was not possible from the daily counts to determine base temperatures (T_b) from the rates of germination. From Figure 1 it would appear that *S. officinale* may have a T_b of near 10°C, and *B. fruticulosa* may have the lowest T_b (based on the highest % germination at 5°C). In the light, several species appear to have base temperatures above 5°C (*S. arvensis*, *B. tournefortii*, *S. orientale*). *S. erysimoides* appears to have a T_b in the light over 10°C, but of below 5°C in the dark.

Time to flowering. For all sowing dates *H. incana* was the slowest to flower. The most rapid to flower for most sowing dates was *S. erysimoides*. *B. fruticulosa* and *R. raphanistrum* were also quick to flower from winter sowings. As would be expected, all species flowered quicker from spring sowings than from winter sowings. There was considerable mortality in the September sowing, following a period of high temperatures, hence data are not available for some species. Some species did not germinate well in the April sowing (see Methods); this was mostly due to dormancy, since emergence after imbibition in GA_3 was much better

Table 1. Time in days from 50% emergence to first flower on 50% of plants. Emergence was recorded to the nearest day, flowering to the nearest week.

Species	Sowing dates				
	16.4.92	15.5.92	4.7.92	26.8.92	30.9.92
B. fruticulosa (Valley Heights)	64	77	69	56	41
B. fruticulosa (Port Botany)	-	76	62	48	41
R. raphanistrum (Cobbitty)	(71)[a]	73	62	40	33
R. raphanistrum (Rutherglen)	-	73	69	48	41
Rapistrum rugosum (Gunnedah)	122	103	76	60	-
Sinapis arvensis (Walgett)	(95)	91	76	48	41
Sisymbrium officinale (Denman)	-	111	76	60	-
S. orientale (unknown)	(57)	99	75	54	47
S. irio (Quirindi)	-	90	55	60	-
S. erysimoides (Hillston)	-	70	48	34	49
Brassica tournefortii (Hillston)	(84)	85	69	68	-
Hirschfeldia incana (Gunning)	(190)	142	116	83	76

[a] Parentheses indicate small sample size.

Most species bolted some time before flowering began; however, *S. erysimoides* began to flower as it started to bolt. For most species bolting was fairly synchronous, whereas for *H. incana* there were sometimes differences of several weeks between individuals.

DISCUSSION

Greater germination of crucifers in the light than in the dark has been recorded for various species (eg 1). However, within a species the response to light can be variable, depending on the age of the seed and the duration of burial (e.g. *S. arvensis*). The two species most consistently showing a light preference across all temperatures, *H. incana* and *S. officinale*, often occur in pastures and not in tilled systems. Cheam (*pers. comm.*) found that *B. tournefortii* germinated best in the dark; Cousens *et al.* (unpublished) reported slightly higher germination in the dark for *R. rugosum*, but this became reduced with duration of storage. The response to light by the *B. tournefortii* in this study had clearly changed during seed storage. Up to

September 1991 there was virtually no germination in the light after bleach pre-treatment, and good germination in the dark (unpublished). Imbibition of *B. tournefortii* seeds with GA_3 in February 1991 resulted in good germination in both light and dark.

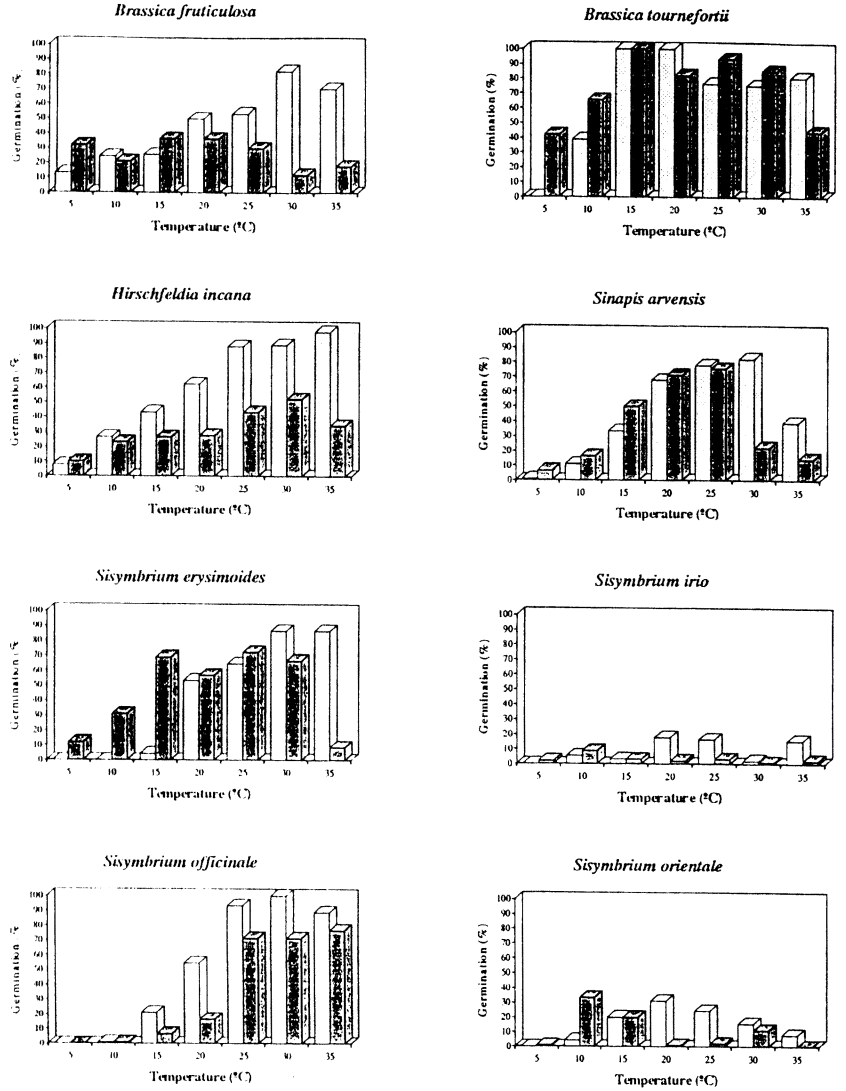

Figure 1. Germination in light/dark (stippled) and dark (shaded).

The length of time taken to flower has seldom been studied in crucifers. The most rapid development of 33 days for *R. raphanistrum* is somewhat less than the 49 days recorded by Cheam (3). However , soil temperatures in the pots are likely to have been higher than in the ground, perhaps leading to more rapid development. Because soil temperatures were not recorded, no attempt was made to compute any day degree requirements of the species (4). Time to flowering was notably longer for *H. incana* than for other species; for most sowing dates it took about twice as long as *R. raphanistrum* to flower. A species with a long developmental period is unlikely to succeed in an annual cropping system. By remaining as a rosette, it will suffer from competition with the crop for light. It may also be unable to reach maturity before the crop is harvested. This slow development may explain the predominance of this species in non-cropping areas.

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