Effect of desiccation temperature on viability of immature dandelion (*Taraxacum* agg.) seeds dried in mowed inflorescences

Z. Martínková[1], A. Honěk[2]

[1]*Crop Research Institute, Prague, Czech Republic*
[2]*Faculty of Environmental Sciences, Czech University of Life Sciences, Prague, Czech Republic*

ABSTRACT

After flowering has ceased, dandelion (*Taraxacum* agg.) capitula close to enable maturation of seeds. In late summer the period of seed maturation lasts for 9 days. The capitula mowed later than 4 days after the start of this period and desiccated at 25°C produce viable seeds. If cut and prostrated on insolated ground inflorescences can experience temperatures exceeding 50°C which may impair seed viability. We determined the effect of desiccation temperature (5, 15, 25, 35, 45 or 55°C) on viability of ripening seeds using inflorescences harvested on September 5, 2008 at Prague-Ruzyne (50°05'N, 14°18'09 E), five days after flowering ceased (about 4 days before seed dispersal). As control, ripe seeds were collected at dispersal on the same day and desiccated at identical temperatures. Desiccated seeds were germinated at constant 17°C. Ripening seeds of maturing capitula only remained germinable if desiccation temperatures were ≤ 35°C (optimum 25°C) and were killed at 45 and 55°C. The viability of ripe seed was not affected by any of the desiccation temperatures. Time of germination of 50% seeds that germinated was significantly shorter in ripe than ripening seeds. Exposure of mowed dandelion inflorescences on insolated ground (solarization) may thus decrease production of viable seeds because of high temperatures experienced during desiccation.

Keywords: dandelion; *Taraxacum* agg.; seed; maturation; viability; cutting; temperature; desiccation; solarization

Dandelion (*Taraxacum* agg., section Ruderalia) is an annual herbaceous plant native in central Europe, abundant at disturbed sites, pastures, sparse stands of permanent crops, orchards and urban habitats (Grime et al. 2007) and aggressively colonizing agriculture grasslands (Pavlu et al. 2007). The plant may grow from parts of tap roots (Naylor 1941, Khan 1973, Mann and Cavers 1979) but the main mode of reproduction is windborne seed (Solbrig and Simpson 1974). Flowering continues for 2–3 days followed by 8–13 days of seed ripening when bracts of inflorescences remain closed (Gray et al. 1973, Martinkova and Honek 2008). The bracts then open enabling dispersal of seeds drifted away by wind. The seed can germinate immediately after dispersal (Mezynski and Cole 1974, Collins 2000) but is viable already before. Capitula cut when 'the dandelions were in full bloom' and then dried in full sunshine provided seeds of which 13% germinated. Inflorescences cut at about mid of the period of seed ripening and dried at room conditions (25°C and 40% relative humidity) produce a certain proportion of viable seeds (Roberts 1936). As the proportion of viable seeds in maturing capitula increases gradually, repeated cutting can limit reproduction by seed (Pavlu et al. 2008b). However, little is known about the effect of temperature during desiccation of mowed capitula on viability of maturing seeds. This information is essential because inflorescences cut and spread on insolated ground may experience temperatures far exceeding 50°C (Bonan 2002) and the high desiccation temperatures may become fatal for maturing seeds. The 'solarization' (Standifer et

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al. 1984) of mowed capitula can extend the period when seed is not viable.

In this study we compared the effect of desiccation temperature on viability of ripening seeds of closed capitula harvested at the time when it is just about to be viable and ripe seeds harvested at dispersal. We tested the hypotheses that (i) ripe and ripening seeds will respond differently to desiccation temperature and (ii) ripening seeds are killed at high temperatures.

MATERIAL AND METHODS

The experiment was made during late summer peak of dandelion flowering when the course of seed ripening is similar to that in the main flowering period in the spring (von Hofsten 1954). Dandelion capitula and seeds were collected at a 200 m^2 grassland situated at the ground of the Crop Research Institute at Prague-Ruzyne (50°05'11.2''N, 14°18'09.3''E, altitude 320 m a.s.l.). Ripening seeds originated from 48 flowers labelled on August 31, 2008 when the flowering had just ceased and harvested on September 5, on the day 5 after flowering ceased. This is a critical period after which unviable ripening seeds become viable (Roberts 1936). The six day study period was marked by warm an dry weather, mean air temperature 19.0 ± 1.7°C, daily minima 6.5–15.0°C, maxima 22.5–28.7°C and total precipitations 6.2 mm (using data from the local meteorological station of Crop Research Institute, Prague).

Eight of the labelled inflorescences were eaten by slugs or decayed before harvest. The inflorescences were cut complete with their peduncles. Immediately after cutting they were put each into large (11 × 30 cm) open paper bag and desiccated at following temperatures and periods: 5°C (for a total of 17 days), 15°C (17 days), 25°C (17 days), 35°C (5 days), 45°C (1 day) or 55°C (0.25 day); these periods allowed desiccation at particular temperatures. After desiccation the seeds from each inflorescence were removed and stored at –20°C until required for germination. Ripe seeds of 40 capitula spreading seeds for dispersal were collected at the same site on September 5. These seeds were mixed and divided into six samples each of which was kept at different temperature, the same and for the same periods as the ripening inflorescences, and were then stored at –20°C until required for germination.

For the germination tests, a sample of 50 seeds was taken from each of the inflorescences, and was weighed to an accuracy of 0.01 mg. Each sample was put in a 9-cm-diameter Petri dish lined with filter paper moistened with 2.5 ml tap water. The dishes were then kept at 15°C in a 18 h light: 6 h dark photoperiod. Germinating seeds were counted daily until no germination occurred for 3 days. Percentage of germination, time of germination of 50% of the seeds that germinated (T_{50}) and mass of 1 seed were determined for each 50 seeds. The differences were tested using a one-way ANOVA, with percentage germination, time T_{50} or 1 seed mass as response variables, and kind of the seed (ripening vs. ripe) or desiccation temperature as a factor. Linear regression ($y = a_0 + a_1x$) of average values of percentage germination and T_{50} on temperature was calculated and is reported when significant. Means ± S.E. are cited throughout the paper. The calculations were made using the Statistica 5.5 for Windows (www.statsoft.com).

RESULTS

As expected, seed mass of ripe seeds (0.42 ± 0.016 mg) was significantly higher ($F_{1.68}$ = 534.2, P < 0.001) than the mass of ripening seeds (0.26 ± 0.006 mg). Desiccation temperature did not significantly affect the mass of ripe seeds ($F_{5.24}$ = 0.159, ns) or ripening seeds ($F_{5.34}$ = 1.348, ns). Percentage of germination of ripe seeds (94.4 ± 0.58%) was significantly higher ($F_{1.68}$ = 286.7, P < 0.001) than the average percentage of germination of ripening seeds (16.0 ± 3.98%). The temperature at which the seeds were desiccated affected the percentage of germination of ripe seeds ($F_{5.24}$ = 4.395, P < 0.01) as well as ripening seeds ($F_{5.34}$ = 8.493, P < 0.001). While the variation in percentage of germination of the ripe seeds between desiccation temperatures was small (Figure 1a), in ripening seeds only those produced by capitula desiccated at ≤ 35°C germinated. Percentage germination was the greatest at desiccation temperature 25°C (54.0 ± 8.84%) and lower at 5, 15 and 35°C (Figure 1a). The time of germination T_{50} in ripe seeds (4.3 ± 0.08 day) was significantly shorter ($F_{1.46}$ = 138.3, P < 0.001) than T_{50} for ripening seeds (8.3 ± 0.42 day). In ripe seeds the differences in T_{50} between desiccation temperatures (Figure 1b) were small but significant ($F_{5.24}$ = 9.969, P < 0.01) and significantly increased with temperature (a_0 = 3.802, a_1 = 0.0171, P < 0.05). In ripening seeds, T_{50} for seeds desiccated at all the temperatures between 5 and 35°C did not differ significantly ($F_{3.14}$ = 0.937, ns) and was minimum (7.3 ± 0.70 day) in seeds desiccated at 25°C (Figure 1b).

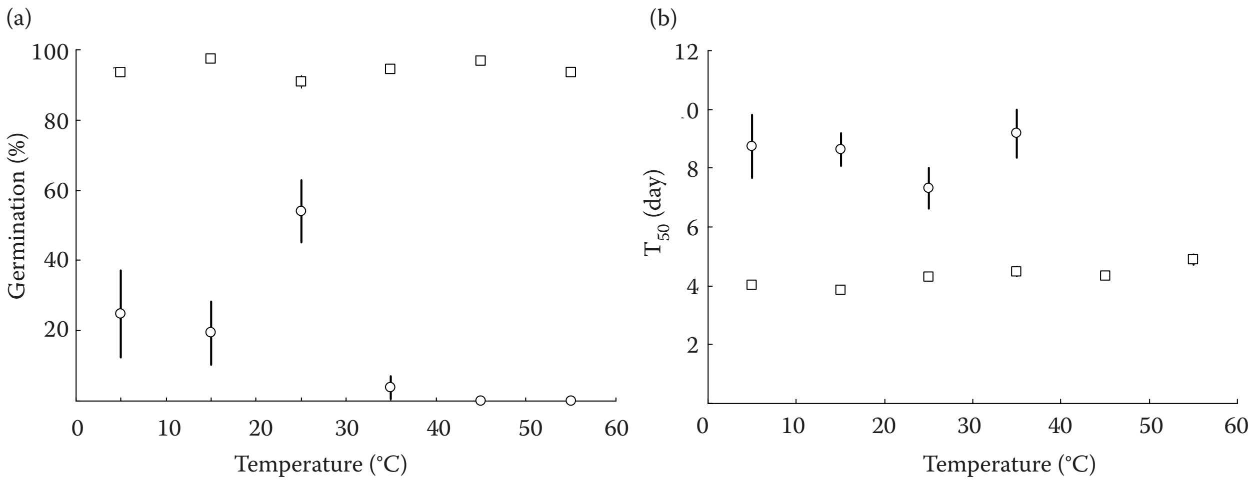

Figure 1. (a) Average percentage of germination (± SE) and (b) average time to germination of 50% of the seeds that germinated T_{50} (± SE) of (○) ripening seeds from inflorescences harvested on day 5 of seed maturation and desiccated at one of six temperatures ranging from 5 to 55°C and of (□) ripe seeds collected at dispersal and desiccated at the same temperatures (SE of ripe seeds was smaller than the size of the symbols)

DISCUSSION

The period of seed maturation within closed capitula can be divided into a 3–5 day long initial period when seed is unviable, a median period lasting 2–3 days during which seed becomes viable and a final period when seed is fully viable (Z. Martínková, A. Honěk, J. Lukáš unpubl.). The temperature of desiccation is important at the critical period of the transition to produce ripe seeds. In this period seeds became viable only at desiccation temperatures of ≤ 35°C with most germinating at 25°C, while temperatures of 45–55°C prevented seed germination. Water content of seeds decreases with maturation (Bewley and Black 1983) and ripening dandelion seed is presumably sensitive to high temperatures because its water content is higher than in ripe seed. This would be consistent with the studies of imbibed seeds (Egley 1990, Dahlquist et al. 2007) which showed that temperatures above 50°C are fatal for seeds of twelve weed species, some of which (*Echinochloa crus-galli* L. Beauv., *Sisymbrium irio* L., *Sonchus oleraceus* L.) are killed within few hours even at temperatures between 40–50°C. Slow desiccation of mowed inflorescences at low temperatures may also contribute to seed viability. At low temperatures the seeds may continue to mature whereas at high temperatures the rapid desiccation terminated all biological activity.

Cutting in 6-day intervals beginning after flower appearance in summer or 9-day intervals in the spring and autumn (Z. Martínková, A. Honěk, J. Lukáš unpubl.) could prevent reproduction by seed because during this period seed is unviable. If the period of cutting is longer, seed viability is affected by desiccation. In late spring and summer, ground surfaces exposed to sunshine reach temperatures above 50°C. Desiccation while on the ground will then decrease the viability of dandelion seed. This benefit of 'solarization', an established method of non-chemical control of weeds (Stapleton et al. 2002), increases an effect of grassland cutting on preventing dandelion dispersal and reproduction by seed (Pavlu et al. 2008b). However, benefits and cost of frequent cutting should be weighed because mowing also favours the survival and growth of already established dandelion plants (Gaisler et al. 2006, 2008) while abandoning defoliation practices reduces abundance of dandelion due to competition with grasses (Pavlu et al. 2008a).

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Corresponding author:

RNDr. Alois Honěk, CSc., Výzkumný ústav rostlinné výroby, Drnovská 507, 16106 Prague 6-Ruzyně, Česká republika
e-mail: honek@vurv.cz