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Original scientific paper

EFFECTS OF HABITAT, LIGHT AND TEMPERATURE ON GERMINATION OF COMMON CHICKWEED (*STELLARIA MEDIA* (L.) VILL.) SEEDS

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Effects of habitat, temperature and light on the germination of seeds of the widespread weed species common chickweed (*Stellaria media* (L.) Vill.) were investigated. All seeds were collected from the same site in Belgrade and examined in the laboratory.

Common chickweed seeds were kept in a polythermostat at 10 different temperatures ranging from 2.4±1°C to 29.5±1°C. The seeds germinated in the dark within a temperature range of 2.4±1°C to 26.3±1°C. Maximum germination was reached within a narrow temperature range of 15-18°C, and it sharply decreased at higher and lower temperatures. Germination was mere 0.5% at the maximum and minimum temperature margins.

All seeds originated from the same population but their germinability differed depending on conditions in which they had previously matured, i.e. in which the mother plants had grown. The seeds

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collected from plants growing under deep shade germinated at 24.5±1°C twice as much as those collected from plants growing under slight shade nearby. Differences in germination were insignificant at the optimal temperature of 15.6±1°C.

Germinability of various seed sizes was also tested. Seeds were divided into six groups based on their absolute weight (0.14 g to 0.48 g). The percentage of germination of the largest seeds at 24.5±1°C was four times lower than that of the smallest seeds. Germination gradually increased from the largest towards smallest seeds.

After imbibition at different temperatures, the seeds were exposed to red light for 6 hours and continued to develop under the same temperatures. Exposure to red light expanded the temperature range of maximal germination towards the lower temperatures. When the same temperatures were used to germinate seeds that were previously imbibed at 25°C, the stimulating effect of red light decreased, especially at lower temperatures.

Key words: Stellaria media, L. Vill, seed

INTRODUCTION

Studies of weed reproduction, seed germination and seed banks in soil (KOVAČEVIĆ and MOMIROVIĆ, 2000) are currently attracting a growing attention in modern agricultural research, especially after the expansion of organic and sustainable agriculture. Knowing the time and pattern of germination, and the emergence of different weed speices could be crucial for developing weed control strategies (OGG and DAWSON, 1984). The use of knowledge of the seed bank dynamic and forcasts of weed emergence in bioeconomic models for weed control have created a possiblity to reduce the use of herbicides without affecting crop yield or the overall level of weed control, achieving rather the same or even better results (LYBECKER *et al.*, 1991; FORCELLA *et al.*, 1996; BUHLER *et al.*, 1996). Hitherto models, however, have mostly been based on the effects of two factors, namely temperature and moisture. Investigation of more factors, primarily light and nitrogen compounds, is an inevitable path to pursue in future research, and each step along that path has appropriate significance.

Common chickweed (*Stellaria media* (L.) Vill., fam. Caryophyllaceae) is a widespread cosmopolitan species and a frequent weed species. It grows in moist, fertile, humus-rich and well aerated soils and in habitats situated at altitudes from sea level to the alpine. It is an annual species, frequently overwintering, and growing 10-40 cm in height. It flowers nearly all year round. The flowers are tiny, white and star-shaped. The fruit, which is a pod, has an egg-like elongated shape and is longer than the calyx and opens into six segments from the central point. A single plant produces between 15,000 and 25,000 seeds annually, and they retain germinability up to 23 years. Seeds may germinate at temperatures as low as 2°C and germination continues almost all year round in the top soil (up to 3 cm depth).

The seed has a round or kidney-like shape, dark brown colour, small dimensions (0.8 x 1.3 mm) and round or conical protuberances. Plants are able to produce two generations annually.

Common chickweed seeds have very fine mechanisms of perception of conditions existing in the environment, and their germination in sufficiently moist media is a result of the activities of several factors. A better insight into their interactions could lead to better understanding of the behaviour of weed seeds in agroecosystems, the dynamic of seed banks in soil, time of germination and emergence of seedlings.

This experiment aimed to investigate the effects of several factors, both morphological (seed size) and ecological (habitat, temperature and light), on seed germination of common chickweed (*Stellaria media* (L.) Vill.) collected from a site in Belgrade.

MATERIALS AND METHODS

Seeds of common chickweed (*Stellaria media* (L.) Vill.) were collected in Belgrade in April 2000 and 2002. Before use, they were kept at room temperature in the dark.

One hundred seeds were counted and placed into each Petri dish 6 cm in diameter, and 2 ml destilled water was measured out into each dish. Temperature-dependent germination was determined using a 10-chamber polythermostat with a temperature range from 2.4±1°C to 29.5±1°C. The seeds were kept in the polythermostat for periods of between four and over 20 days due to the different dynamic of germination at different temperatures.

All seeds originated from plants of the same population but, in order to test the effect of seed maturation conditions on germinability, the seeds originating from plants growing under deep shade and slight shade germinated separately. The seeds germinated at 24.5±1°C and 15.6±1°C.

To test a correlation of germination and seed size, seeds were graded into six groups according to their apsolute weight (i.e. weight per 1000 seeds in grams). In the experiments testing the effect of red light on seed germination, lights of different duration but equal intensity were used. Exposure to red light lasted 6 hours.

Flurescent tubes Philips TL 20/15 (Philips, Hamburg, Germany) were used as red light sources, equipped with accessory 3-mm-thick plastic filter Rohm and Haas (Dermstadt, Germany) No. 501. The photone flux density of the red light sources was 3.035 mmol m^{-2} s^{-1}.

RESULTS AND DISCUSSION

The temperature range within which seeds of a species are able to germinate differs from one population to another. We investigated the germination of common chickweed (*Stellaria media* (L.) Vill.) collected at a Belgrade site at 10 different temperatures ranging from 2.4±1°C to 29.5±1°C. The seeds kept in the dark germinated at temperatures ranging between 2.4±1°C and 26.3±1°C (Fig. 1). Germination reached a maximum of nearly 100% within a narrow range of 15-18°C, dropping sharply at higher and lower temperatures. A bare 0.5% seeds germinated at the maximum and minimum temperature margins.

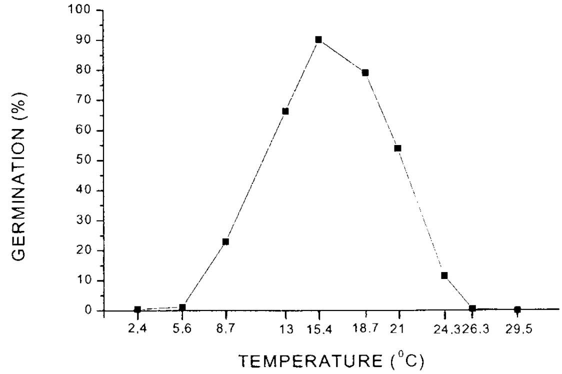

Fig. 1. - Germination of common chickweed seeds at different temperatures in the dark

The seeds showed different levels of germinability depending on conditions existing at the time of their maturing, i.e. conditions under which the mother plants producing the seeds were growing. Those collected from plants growing under deep shade germinated at 24.5±1°C twice as much as the seeds collected from plants growing under slight shade in close proximity. Under the optimal temperature of 15.6±1°C, differences in germination had no statistical significance (Fig. 2).

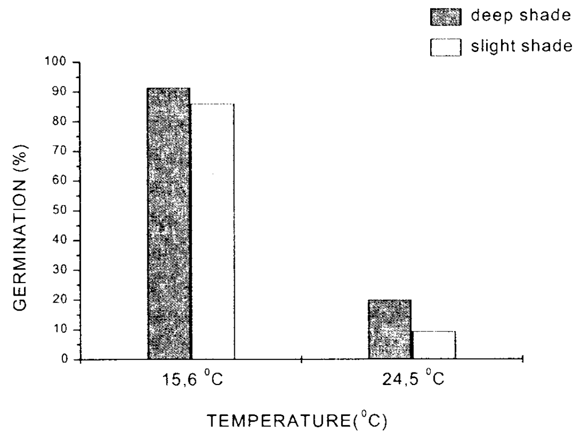

Fig. 2. - Germination of common chickweed seeds after maturation under conditions of deep shade and slight shade

All seeds were collected from plants of a single population, which suggests that the difference existing in their germinability most likely resulted from the conditions existing during their maturation. The quality of light received by the seeds during maturation may crucially influence their germinability (SHROPSHIRE, 1973; CRESSWELL and GRIME, 1981). An active form of phytochrome B accumulates in seeds under their exposure to red light during maturation, which makes possible seed germination in complete dark (Hayes and Klein, 1974; SHINOMURA *et al.*, 1994; CASAL *et al*, 1997). Plants growing in a shade receive light characterised by a lower ratio of red (R) and far-red (FR) light. The seeds of plants growing in shade consequently have lower accumulation of the active phytochrome and a lower percentage of them germinate in the dark (MCCULLOUGH and SHROPSHIRE, 1970; HAYES and KLEIN, 1974; GUTTERMAN and PORATH, 1975; OROZCO-SEGOVIA *et al*, 1993). In this experiment, however, common chickweed seeds kept at a temperature close to maximum in the dark had a higher percentage of germination if they matured under deep shade.

Concentration of the active form of phytochrome does not depend on light wavelength (SMITH and FORK, 1992) alone. High-intensity sunlight is known to reduce germination in several plant species (SHROPSHIRE, 1973, BARTLEY and FRANKLAND, 1982; CASAL and SMITH, 1989; SMITH and WHITELAM, 1990; OROZCO-SEGOVIA *et al.*, 1993) as intermediary, non-active forms of phytochrome, rather than its active form, accumulate under such conditions (BROCKMANN *et al.*, 1987; SMITH and FORK, 1992).

Common chickweed seeds used in this experiment were harvested all at the same time. Plants growing under deep shade normally flower with a delay, so that the physiological age of the seed-producing plants could have affected germination. Seeds of the species *Amaranthus retroflexus* were found to have a significantly lower percentage of germination when plant age in a short-day treatment aiming to induce flowering was increased from 6 to 15 days (KIGEL *et àl*, 1979). However, the dependency of germination on the age of the plants on which seeds have matured is hardly the same in all species. Some plant species were found to have a higher percentage of germinating seeds from younger plants (GOO, 1948; KIGEL *et al.*, 1979), while some other species had a higher percentage of germination from seeds originating from older plants (OLSON, 1932; Thompson, 1937; OKUSANYA and UNGAR, 1983).

The properties of light under which seeds mature on a plant may affect the properties of the seeds. OROZCO-SEGOVIA *et al.* (2000) exposed *Sicyos deppei* plants undergoing seed maturation to full sunlight and far-red light. The seeds exposed to far-red light during maturation had a lighter colour and significantly lower weight, size and water content than those exposed fully to sunlight during development. Seed size and colour may also vary within a population of a species. These two seed properties also have different effects on germination. Some species have been found to produce a higher percentage of large germinating seeds (MUNNS, 1921; RADFORD, 1977; TRIPATHI and KHAN, 1990; PRINZIE and CHMIELEWSKI, 1994), while small seeds of some other species germinater better (MAUN and CAVERS, 1971; AKPAN and BEAN, 1977; STAMP, 1990), and the size bore no relevance on germination in a third group of species (BEVERIDGE and WILSIE, 1959; CIDECIYAN and MALLOCH, 1982; BRETAGNOLLE *et al.*, 1995). Reports have also been made of light-coloured seeds of some species germinating better than dark-coloured ones (BEADLE, 1952; UNGAR, 1971; NOBS and HAGAR, 1974), but contrary reports exist of dark-coloured seeds (MAURYA and Ambasht, 1973).

Common chickweed seeds were sieved and graded to form 6 groups. To ensure accuracy, the groups were defined according to seed weight, i.e. weight per 1000 seeds (Table 1). Germination depended on seed size (Fig. 3). The largest seeds germinated at 24.5±1°C in the dark at a nearly four times lower rate than the smallest. Germination was found to gradually grow from the largest to the smallest seeds.

Table 1. - Weight per 1000 seeds according to groups

Group	Weight (g)
group 1	0,484
group 2	0,313
group 3	0,224
group 4	0,192
group 5	0,169
group 6	0,144

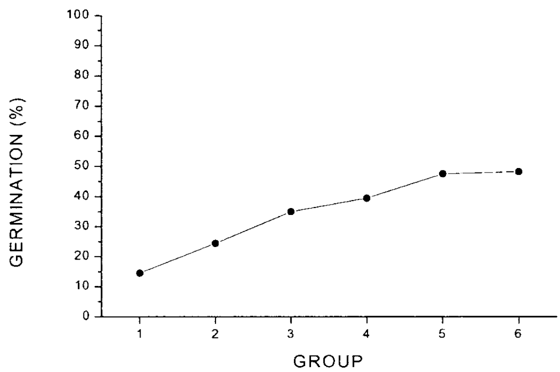

Fig. 3. - Common chickweed germination depending on seed size (group marks as in Table 1)

Apart from temperature alone, an interaction of temperature and light also has a great influence on seed germination in natural habitats. Such interaction has been reported for many species. In *Amaranthus retroflexus* L., germination was stimulated by light at temperatures exceeding 20°C, but at 20°C light and darkness produced the same germination, and temperatures below 20°C were found to produce more germinating seeds in the dark (JANJIĆ and KOJIĆ, 2000). Light was found to induce germination in *Amaranthus* plants even when seeds merely imbibed at higher temperatures (CHADOEUF-HANNEL and TAYLORSON, 1985).

An interaction of light and temperature treatments was investigated in this experiment. A red light treatment expanded the temperature range under which germination became maximal towards lower temperatures (Fig. 4). Seed exposure to stimulating red light may safely be assumed to lead to a partial discontinuation of dormancy at lower temperatures.

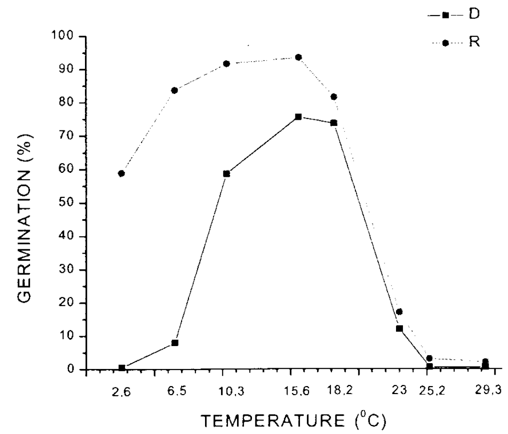

Fig. 4. Germination of common chickweed seeds at different temperatures in the dark (D) and under red light (R)

In order to check the role of temperature treatment prior to exposure to light, we investigated the germination of common chickweed exposed to red light depending on imbibition temperature (Fig. 5). The seeds that imbibed in the dark under constant temperature (25°C) before being exposed to red light for 6 hours and were returned to darkness under 10 different temperature regimes germinated at a lower percentage than those that imbibed in the dark under the same temperature regimes as those to which they were returned after exposure to light. In both cases, the optimal temperature range was 6.5-18°C, while maximum germination was achieved at 15.6°C (Fig. 5). Under temperatures exceeding 23°C, the percentage of germinating seeds was very low, so that chickweed seeds showed a pronounced dormancy at higher temperatures.

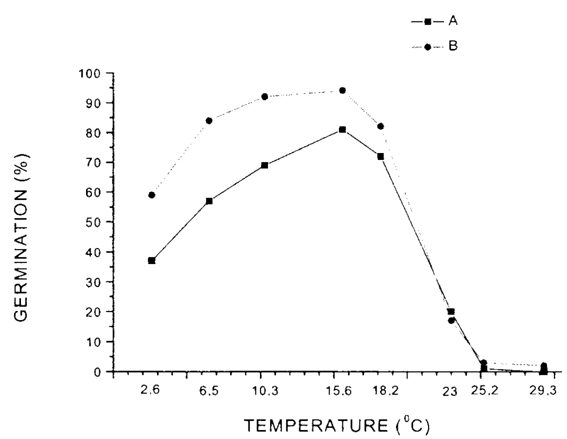

Fig. 5. Germination of common chickweed seeds exposed to red light depending on temperature of imbibition (A-seeds imbibing at 25°C; B - seeds imbibing at a temperature to which they returned after light treatment)

CONCLUSION

Common chickweed (*Stellaria media* (L.) Vill.) seeds collected at a Belgrade site germinated in the dark within a temperature range of 2.4-26.3±1°C. Germination reached a maximum of nearly 100% within a narrow temperature range of 15-18°C.

Germinability was found to differ depending on the conditions of maturation, i.e. conditions under which the seed-producing mother plants were growing. The seeds collected from plants growing under deep shade germinated at 24.5±1°C twice as much as those collected from plants growing under slight shade nearby. The possible cause of such difference is either that light had a significantly higher intensity under slight shade during maturation, or that the seed-producing plants growing under deep shade were physiologically younger than those under slight shade.

The common chickweed seeds investigated in this experiment differed in germination depending on size. At 24.5±1°C in the dark, the largest seeds germinated at a percentage that was four times lower than those smallest in size. Germination gradually increased from the largest to smallest seeds.

Exposure to red light expanded the temperature range under which maximal germination occurs towards lower temperatures. Seed imbibition at 25°C before exposure to red light treatment reduced the stimulating effect of red light, especially under lower temperatures.

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UTICAJ STANIŠTA, SVETLOSTI I TEMPERATURE NA KLIJANJE SEMENA MIŠJAKINJE (*STELLARIA MEDIA* (L.) VILL.)

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Izvod

Ispitivan je uticaj staništa, temperature i svetlosti na klijanje semena mišjakinje (*Stellaria media* (L.) Vill.), široko rasprostranjene korovske biljke. Sva semena su ubrana sa jednog lokaliteta u Beogradu i ispitivana u laboratorijskim uslovima. U politermostatu sa 10 različitih temperatura, od 2,4±1 °C do 29,5±1 °C, seme mišjakinje je, bez prisustva svetlosti, klijalo u rasponu od 2,4±1 °C do 26,3±1 °C. Klijavost je dostizala maksimum od skoro 100 % u uskom opsegu, između 15 °C i 18 °C, a pri višim i nižim temperaturama je naglo opadala. U graničnim tačkama, na maksimalnoj i minimalnoj temperaturi, klijavost je bila samo 0,5 %.

Sva semena su pripadala istoj populaciji, ali su imala različitu klijavost zavisno od uslova u kojima su sazrevala, odnosno od uslova u kojima su rasle biljke sa kojih su ubrana. Semena ubrana sa biljaka koje su rasle u uslovima jake senke su na 24,5 ± 1 °C klijala u dva puta većem procentu od semena ubranih sa biljaka koje su rasle u neposrednoj blizini, ali u uslovima slabe senke. Na optimalnoj temperaturi od 15,6±1 °C su razlike u klijavosti bile neznatne. Ispitivana je klijavost semena različite veličine. Semena su podeljena u šest grupa, zavisno od njihove veličine, odnosno apsolutne težine (od 0,14 g do 0,48 g). Najkrupnija semena su na 24,5 ± 1 °C klijala u gotovo četiri puta manjem procentu od najsitnijih. Klijavost je postupno rasla od najkrupnijih ka najsitnijim semenima.

Semena su, nakon imbibovanja na različitim temperaturama, osvetljavana crvenom svetlošću u trajanju od 6 sati i dalje gajena na istim temperaturama. Osvetljavanje crvenom svetlošću je temperaturni opseg pri kome dolazi do maksimalnog klijanja proširilo ka nižim temperaturama. Kada su na istim temperaturama isklijavana semena koja su imbibovala na 25 °C pre osvetljavanja, stimulativni efekat crvene svetlosti je bio manji, naročito na nižim temperaturama.

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