Germination ecology of wild living walls for sustainable vertical garden in urban environment

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Abstract

Germination characteristics of 10 xerophytic species, widespread in the Mediterranean were studied. A variety of seed treatments were explored to overcome the seed dormancy, including scarification and stratification. Only in *Convolvulus cantabrica* dormancy was shown to be physical, since it could be removed by seed coat scarification. Several species showed light-dependent germination, possibly related to the fact that in their micro-environment of incubation they are exposed to minimum seed burial. Emergence tests in peat-perlite substrate were carried out in order to verify the optimal burial conditions for seed propagation. This inhibition was found to be inversely related to the low unit weight of seed. Species with minute seeds, such as *Erigeron karviskianus* and *Phagnalon rupestris*, had the best performance of germination without burial, while the larger ones such as *C. cantabrica* and *Centranthus ruber*, had the best performance at 6 and 4 mm of sowing, respectively.

1. Introduction

Green spaces in landscape can enhance urban living and offer benefits such as psychological recreation and environmental improvement (Ulrich, 1979) especially in terms of noise reduction (Smardon, 1988). Urban vegetation is essential for creating wildlife habitat, which is linked to biodiversity in man-made ecosystems (Burgess et al., 1988). Although in cities space is limited at ground level, vertically it is not, hence there exists a possibility of green urban walls. This vertical vegetation, which has been referred as "vertical gardens" (Solecki and Welch, 1995), "living walls" (Dunnett and Kingsbury, 2004) or "green walls" (Viles and Wood, 2007), has high aesthetic impact and value (Gobster, 1998). Such micro-ecosystem (Perini et al., 2013) has shown reduction of "heat island effect" (Gill et al., 2007), linked to its evaporative cooling (Davis and Hirmer, 2015). One of the benefits of living walls has been their capacity to provide clean air into the building on which they are growing (Bolund and Hunhammar, 1999). However, due to the live nature of the walls, some economic and ecological questions arise, as plants need water to survive and grow. The use of any cultivated plant in an urban environment necessitates sustained input of water and hence questions their ecological sustainability (Brandes, 1995). In contrast, wild xerophytic vegetation (native and/or naturalized) is able to grow without irrigation (Benvenuti and Bacci, 2010) and this reduced water requirements is important in view of future climatic scenarios (Le Hoùerou, 1996).

In contrast, old buildings are often colonized by a certain type of vegetation which is able to survive and grow in such disturbed ecological niche without human intervention (Hruskaˇ , 1987; Caneva et al., 1992; Lisci and Pacini, 1993; Lisci 1997) not only in Mediterranean environment but even in other climatic conditions (Rishbeth, 1948; Reis et al., 2006). An example of this 'neglected' biodiversity has been found in the Colosseum in Rome where more than 680 species have been recorded (Caneva et al., 2003). A survey of flora growing on ancient Byzantine walls in Thessaloniki (Greece) showed the presence of 420 different taxa (Krigas et al., 1999). Such rich biodiversity has been attributed to their ability to survive in stressful ecological conditions and to their dispersal strategies (Benvenuti, 2004). The ecological stress is not only due to scarcity of nutrients, but also to overall erratic water availability that typically distinguishes walls of urban ecosystems.

Even if this naturalized flora did not evolve in the urban ecosystem, it was able to spread due to its remarkable ability to colonize new areas, both in terms of survival and seeds dispersal (Benvenuti, 2004). Its origin can be traced to rocky outcrops in neighbouring ecosystems and in urban areas similar to their endemic sites (Láníková and Lososová, 2009; Ceschin et al., 2014). Ironically, due to the loss of natural habitats such man-made environments have become important for biodiversity protection (Francis, 2010).

Additional benefit of wall flora is their ability to adapt to pollutants which are typically present on walls (due to urban atmospheric pollution) of historic buildings (Saiz-Jimenez, 1993), thereby implying species higher chance of survival in the urban environment. In addition, due to their endemic origin, Mediterranean species (native and/or naturalized) represent the most suitable vegetation to tolerate stresses of urban environment; it is worth noting that even from a point of view of landscape ecology native, or naturalized, flora (i.e. *Erigeron karviskianus* D.C., Depth Weber, 1997), represents the best floristic expression of Mediterranean environment compared to exotic species such as Carpobrotus edulis (L.) N.E.Br. and other ornamental species (Simberloff, 2003). Cultivation of wild Mediterranean flora has been recently successfully tested for dry (no supplemental water beyond establishment) green roofs (Benvenuti and Bacci, 2010). The germination ecology of these species has not been studied extensively; such information would be of essential for the practical realisation of living walls without input of irrigation, or dry living walls.

Many plant species have dormant seeds, since this feature represents an important survival strategy in environment typified by ecological disturbances (Hilhorst, 1996). Seed dormancy allows successful ecosystem colonization and temporal synchronization of germination (Koornneef et al., 2002). Although such biological adaptation is beneficial for species survival in its natural habitat, it does present an obstacle to cultivation. Therefore, the aim of this work was to study germination of selected species with potential for naturalized green walls and to determine effective means of overcoming seed dormancy.

2. Materials and methods

Seeds of ten species (Table 1; Fig. 1) were collected in 2007 and 2008 (during August and September) from natural "living walls" of different localities of Tuscany (central Italy) with the exception of *Campanula versicolor* Andrews, which has been collected from the walls of old buildings in Matera city (Basilicata region, South Italy, 40° 65'N, 16° 60' E). Seeds were collected from senescent plants (5–10 for each of the 3–4 localities), pooled and carefully cleaned from fruit and related tissues. Botanical, biological, chorological and ecological information are provided in Table 1. Species were chosen for their aesthetic characteristics and perennial life cycle (with the exception of *Tuberaria guttata* (L.) Fourr.). The last feature is desirable in order to avoid annual re-planting. Phenological dynamics of selected species are summarized in Fig. 2.

Seeds (or fruits, as in the cases of Asteraceae) were extracted from 20 to 30 senescent plants, air-dried, cleaned and stored in glass jars under standard conditions (20 ◦C and 12% relative humidity).

Seeds were imbibed on a single sheet of filter paper moistened with distilled water and placed in 12 cm Petri dishes. Seeds were incubated in climate-controlled chambers (20 ◦C under either white light (50 mol m^{-2} s^{-1} provided by neon fluorescent lamps PHILIPS THL 20W/33 or darkness). After this preliminary germination

test, four different seed treatments were carried out: cold stratification (chilling), scarification, gibberellic acid (GA_3, Sigma–Aldrich, Saint Louis Missouri, USA) or sodium hypochlorite. For the chilling treatment, seeds were placed in Petri dishes (described previously) lined with moistened filter paper, and maintained at low temperatures (4 ◦C) in darkness for one month in a climate-controlled chamber. Scarification was performed by rubbing seeds mechanically with sand paper for approximately 1–2 min. For the gibberellic acid treatment, seeds were soaked in a solution of 200 ppm of gibberellic acid for 30 min. Similar soaking procedure lasting 10 min was performed using 20% sodium hypochlorite. At the end of this treatment seeds were rinsed and seed weight was determined by weighing 1000 seeds chosen randomly, according to ISTA rules for seed testing (ISTA, 1999). Germination tests were carried out in plastic pots (12 × 12 × 10 cm) filled with a peat-perlite (2:l v/v) medium (Hawita, Germany). Pots were incubated in the above cited chambers, under identical conditions of light and temperature. Fifty seeds of each species were sown in each pot at a depth of 0, 1, 2, 4, 6 and 10 mm (only one depth for each pot, in total 18 pots for each species).

Inhibition data of each species (0% of germination = 100% inhibition and vice versa) were fitted by polynomial regression to assess seed germination performances as a function of increasing depth. These equations have provided the soil depth at which emergence rate reached 50%, by using a modified "X intercept" method (Benvenuti et al., 2001). The intercept between the polynomial regression and the translated X axis on the selected Y for 50% depth inhibition (D50%) corresponds to the relative soil depth inhibition. This method allowed identification of the sowing depth able to halve the germination, and to use this parameter (i.e. depth inhibition) as comparative indicator between species.

Viability test was performed in the case of apparent deep dormant seed. A modified system for small-size seed was adopted (López-Granados and García-Torres, 1999). Depth values (of 50% inhibition as a function of the unburied germination) were plotted with the corresponding 1000-seed weight and fitted with linear regression.

All germination and emergence tests were replicated three times and each experiment was repeated twice. A completely randomized design was used. After test of variance for homogeneity, arc sin transformation of emergence percentages was applied. Angular values were subjected to ANOVA using the Student-Newman-Keuls test ($p < 0.05$ and/or $p < 0.01$) for means separations. Commercial software was used (CoHort software, Minneapolis, MN USA).

3. Results and discussion

Table 2 shows germination performances of various species before any seed treatment. Only *Phagnalon rupestre* (L.) DC. and *T. guttata* exhibited germination rate above 50% (74 and 57% respectively), indicating general seed dormancy in the remainder species. Deep dormancy (poor germination despite optimal ecological

conditions) was found in *E. karviskianus* and *Convolvulus cantabrica* L., since germination was below 20% (11 and 14%, respectively).

Dormancy was reduced by various seed treatments (discussion follows), among which the most effective in removing seed dormancy was stratification at 4 ◦C, achieving a significant germination increase in 5 of the 10 tested species. Cold stratification has been found effective in breaking dormancy in several species (Bewley, 1997), often from arid environments (Nadjafi et al., 2006), as a consequence of the degradation of seed inhibitors during cold-wet storage.

P. rupestre and *T. guttata* did not show any significant difference, both before or after seed treatment (Table 2), since the germination rate was high even without any seed treatment. Germination of *Centranthus ruber* (L.) DC., *Cymbalaria muralis* Gaertn., Mey. & Scherb. and *C. versicolor* Andrews was improved by 30-day cold stratification treatment. A different response was observed in *Lobularia maritima* (L.) Desv. and *Antirrhinum latifolium* Mill., which showed greatest germination increase after treatment with gibberellic acid (GA_3).

It seems opportune to underline that the species that increased their germination by the use of GA_3, showed positive effects even with chilling (data not shown), suggesting that both treatments may have similar action mechanisms. Increase in germination using both gibberellins and cold stratification, has been previously reported (Fang et al., 2006). It has been hypothesized that gibberellic acid and chilling may be involved in the release of dormancy through their promotion activity of hydrolytic and proteolytic enzymes, which mobilise food reserves in cotyledons or in endosperm (Adkins et al., 2002).

C. cantabrica responded well to scarification with germination of approximately 90%. Primary physical dormancy due to impermeable testa is a common feature of members of Convolvulaceae family (Baskin et al., 2000). Only *Erysimum cheiri* (L.) Crantz and *E. karviskianus* exhibited a loss of primary dormancy by the use of sodium hypochlorite. The efficacy of this seed treatment was already evidenced in other species, and has been attributed both to oxidative phenomena (Pradhan and Badola, 2010) and to modification of the testa, and may be related to increased oxygen supply to the embryo (Hsiao and Quick, 1984).

The fact that each species required different treatments to overcome seed dormancy, highlights the various strategies implemented by different species and is rooted in the environmental conditions of their endemic habitat (Baskin and Baskin, 2004).

Diversified seed germination in temporal sense, is a survival strategy even more important for walls' flora, since survival in extremely erratic environments (i.e. environment fluctuations such as drought and temperature extremes, leading to a preponderance of abiotic stresses) depends on the plant's capacity to colonize habitats. While the agricultural seedbank desynchronizes germination overall as a consequence of

environmental, deep-mediated dormancy (Benvenuti et al., 2001), wall flora needs endogenous dormancy due to the light burial of their seeds associated with the lack of soil. This dormancy could play an ecological role, enabling seeds to synchronize germination with most favourable environment. In other words this appears be a survival strategy able to maintain viable seeds in erratic environments (De Freitas et al., 1996). Our argument confirms older finding that seeds of the typical flora living on historic buildings were found to be characterized by high dormancy and longevity (Spira and Wagner, 1983).

The germination dynamics are also conditioned by the presence or absence of light, since many species, are characterized by photosensitive seeds (Kendrick, 1985). The approximate burial occurring in recent or ancient walls does not appear to deter light penetration, as it happens in the soil (Benvenuti, 1995).

Table 3 shows germination of the 10 species in dark or light conditions after seed treatment. In 8 species (*A. latifolium, C. versicolor, C. muralis, E. karviskianus, E. cheiri, T. guttata, L. maritima* and *P. rupestre*) light exerted a positive effect in germination, possibly increasing germination via phytochrome activation. Such photosensitivity was significant ($p > 0.05$) in *A. latifolium, C. versicolor, E.karviskianus* and *L. maritima* and even highly significant ($p > 0.01$) in *C. muralis, E. cheiri, P. rupestre* and *T. guttata*. In contrast, *C. ruber* and *C. cantabrica* exhibited a germination unaffected by light conditions. This insensitivity to light was positively correlated with seed size and is in agreement with the hypothesis that light dependence is inversely related to seeds' size (Milberg et al., 2000).

With the exception of the light-independent germination of *C. cantabrica* (approximately 90%), light optimized germination even in E. cheiri (96%). Enhanced germination rates were also reached by *P. rupestre, A. latifolium, L. maritima* and *T. guttata* (78, 72, 67, and 63%, respectively). A lower germination rate was observed in C. muralis and C. versicolor (53 and 41% respectively), while very low was the germination performance of *E. karviskianus* (only 23%), despite seed treatment and light availability.

From an ecological point of view, the light-dependence of germination could be linked to the particular habitat found on building walls. This adaptation process could have evolved in a rocky environment with no obstacles hindering the perception of light by seeds, condition that strongly differs from shade environments such as soil burial (Benvenuti, 2007) or leaf canopies (Schmitt and Wulff, 1993).

In addition, seeds' movement and burial into the walls cracks are virtually impossible since they are normally mediated by gravity forces (Benvenuti, 2007), that on a vertical wall are almost ineffective.

From an ecological point of view, a crucial condition which makes possible wall colonization by flora, is the characteristics of small seeds, which facilitate their penetration in the micro-cracks and also anemochory (wind-assisted seed dispersal). Consequently, photodormancy requirement for germination of the most tested

species in this study is in agreement with literature linking seed size and light sensitivity (Milberg et al., 2000).

The exception to this rule is represented by *Capparis spinosa* L. (species not studied in the present work), which is characterized by large seeds in spite of its broad diffusion on ancient walls (Hruskà, 1987). However, in this case the dispersal strategy is due to myrmecochory: ants move seeds and their collocation in the wall cracks, a phenomenon virtually impossible without this biotic vector of dispersal (Benvenuti, 2004).

Table 4 shows the weight of 1000 seeds of the various plant species tested. Most of the seeds were very small (200–300 m). In eight species, the weight of 1000 seeds was less than 1 g, with some cases of extremely lightweight seeds, for example *P. rupestre* (0.011 g), *E. karviskianus* (0.074 g), *C. muralis* (0.087 g) and *L. maritima* (0.091 g). Still under 1 g were found C. versicolor (0.102 g), *E. cheiri* (0.31 g) and *A. latifolium* (0.797). The largest seed size among the examined species was found in *C. cantabrica* (2.989 g) and *C. ruber* (1.254 g). Table 4 shows also the soil burial depth at which germination was halved, compared to absence of burial (seeds placed on soil surface).

The two species characterized by smaller seeds (*P. rupestre* and *E. Karviskianus*) showed the best germination performance if placed on the substrate surface. A very light burial (1 mm) was optimal for *C. versicolor*, *C. muralis* and *L. maritima*, while a slightly deeper burial (2 mm) was found to be optimal for *A. latifolium*, *T. guttata* and *E. cheiri*. In contrast, larger seeds exhibited best emergence with deeper burial, as shown by *C. ruber* and *C. cantabrica* (4 and 6 mm respectively). Such relationship between seed size and emergence was also evidenced by calculating the depth at which germination is halved; this confirms the previously observed phenomenon that burial inhibition is inversely related to seed's weight (Benvenuti et al., 2001).

Table 4 shows also the percentage of emergence of different species, placed at their optimal burial levels. As expected, these tests (in pots in substrate) are similar to the "in vitro" tests (in optimal condition in Petri dishes), evidencing that at this shallow burial depth, seeds do not undergo soil-mediated inhibition.

This has been linked to reduction of light penetration (Tester and Morris, 1987) and even to limitations in terms of gas diffusion in the micro-environment surrounding the seeds (Benvenuti, 2003). However, in spite of the slight differences between "in vivo" and "in vitro" germination performances, E. cheiri and C. cantabrica showed the highest emergence percentages (87 and 85% respectively). Good emergence rates were achieved also by *P. rupestre* (75%), *A. latifolium* (65%), *T. guttata* (57%) and *L. maritima* (52%). Acceptable emergence rates (although below 50%) were observed in the seedlings of *C. ruber*, *C. muralis* and *C. versicolor* (47, 45 and 38% respectively). Low seedling emergence of *E. karviskianus* (15%) warrant further investigation. It is important to note that ungerminated seeds are dormant, no dead, since the seed crush test

method (Sawma and Mohler, 2002) showed their viability of 95%. Deep dormancy is frequent in other wild species that are widespread in similar arid environments, such as desert plants (Gutterman, 1994).

Finally, a significant ($p < 0.05$) linear regression between 1000 seed weight and depth-mediated inhibition was found (Fig. 3). This implies an advantage, from an ecological point of view, an advantage for small seeds in terms of greater capacity of seed dispersal (via anemochory) however, it also hinders their capacity to germinate from deeper burial. On the other hand, wall flora (and other species endemic to rocky outcrops) has probably evolved towards production of large number of small seeds, in order to increase colonization of micro-cracks (Benvenuti, 2004).

4. Conclusions

Thorough investigation of any impediments to rapid and uniform germination is critical to plant propagation and subsequent cultivation. Species which colonize building walls are frequently characterized by small seeds, and those are often dormant. We confirmed an inverse relationship between seed weight and seed dormancy was found (Rees, 1996). Small seed size may play an ecological role in increasing their dispersal in the surrounding environment (Westoby et al., 1996), and even in allowing their burial in walls' craks (Benvenuti, 2004). This generalized dormancy could be overcome by appropriate seed treatments (mechanical means, chemicals, and/or temperature, aimed at overcoming various seed dormancies). However, these seeds must be buried superficially, a few millimetres at most, since their germination is strongly inhibited by burial.

In spite of the ecotype-dependent variability of germination ecology even within the same species, (Foley and Fennimore, 1998), these results could provide useful information for propagation of wild species, potentially utilizable for vertical urban greening. The small seed size of species successful in colonizing walls could be a potential obstacle to commercial cultivation. However, it could be overcome by seed coating, and/or mixing with sand and/or vermiculite prior to planting (Kaufman, 1991). A standard protocol designed to scale-up production of wall flora species would also incorporate species-specific recommendations of overcoming seed dormancy and seeding depth guidelines for optimal germination. Our research demonstrated that seed propagation of wild flora naturalized on building walls could be achieved with standard treatments to overcome seed dormancy.

Finally vertical design with "synurbic" species (Francis and Chadwick, 2012) could be a strategy for conservation and implementation of urban biodiversity and could become a new frontier for ecological engineering (Francis, 2010).

Future research is needed to verify the ecological success of these xerophyte walls' species in terms of growth and survival in the urban environment.

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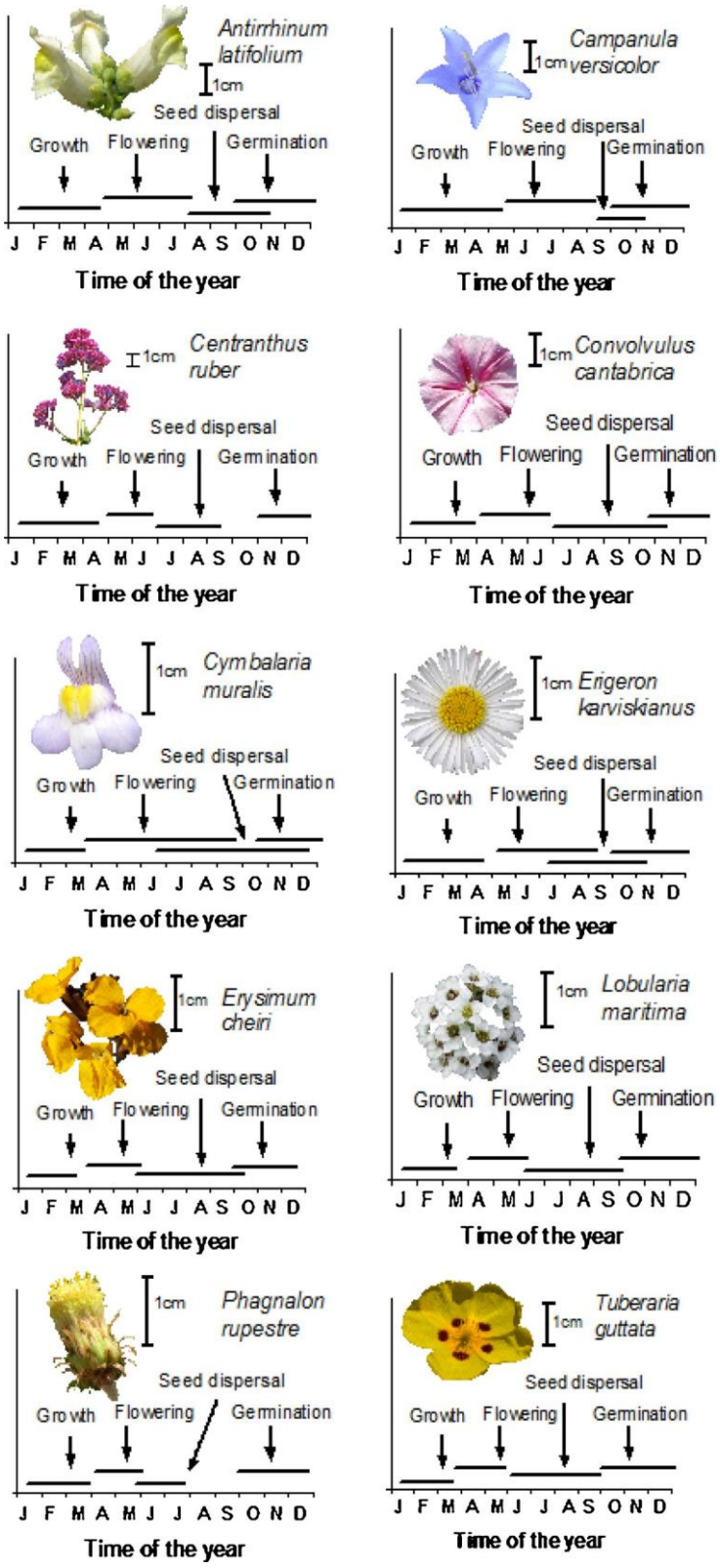

Fig. 1. Schematic representations of phenological stages of ten wall flora species. Information on phenology was obtained through visual observations carried out in Tuscany (Italy) environment. X-axis equals one year with months shown as abbreviated letters. The respective flower morphologies are shown with 1 cm scale for reference.

Fig. 2. *Erysimum cheiri* (L.) Crantz during anthesis in their natural colonization of ancient walls in an urban environment of Pisa.

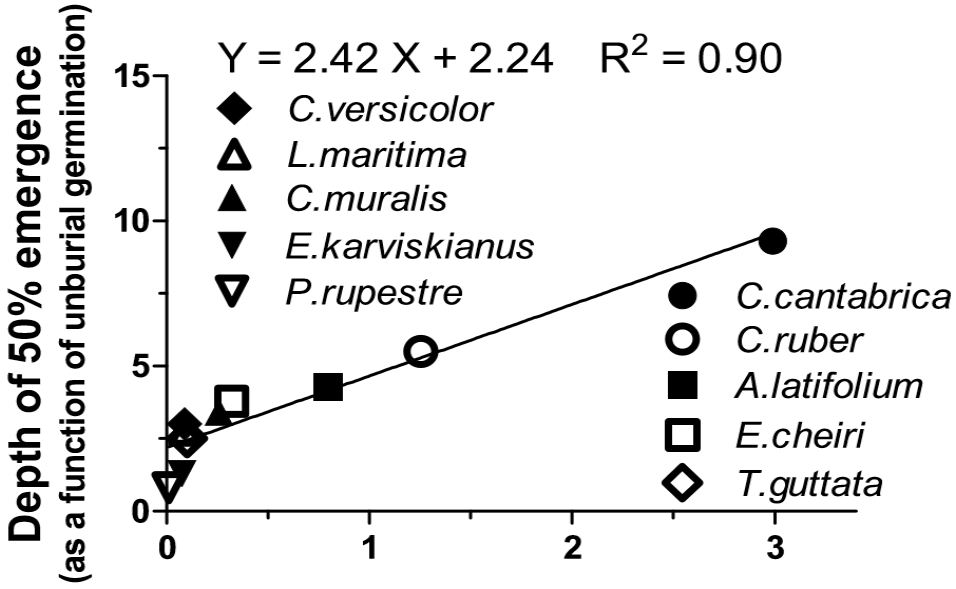

Fig. 3. Linear regression between burial depth necessary to reduce emergence ofthe 10 tested plant species to 50% (as a function of the unburied germination) andthe corresponding 1000 seed weight.

Table 1. Botanical, biological (Life form[1]: Ch = chamephyte, H = emicryptophyte, T = terophyte, Pignatti et al., 2005), chorological (Chorotype[2] = Pattern of geographical distribution: Stenomediterranean = spread along the Mediterranean coasts; Eurimediterranean = spread along South Europe; Subcosmopolites = spread almost all over the world; Subtropical = spread in subtropical environments) and ecological information (Ellenberg indicator[3]: classification of plants according to the position of their realized ecological niche along an environmental gradient, of the studied species (Schaffers and Sykora, 2000).

Plant species	Family	Life form (1)	Choroptype (2)	Ellenberg indicator (3)				
				L	T	U	N	S
Antirrhinum latifolium Mill.	Scrophulariaceae	Ch	W-Stenomedit.	11	8	2	1	0
Campanula versicolor Andrews	Campanulaceae	H	NE-Stenomedit.	11	8	4	2	0
Centranthus ruber (L.) DC.	Valerianaceae	Ch	Stenomedit.	6	8	2	1	0
Convolvulus cantabrica L.	Convolvulaceae	H	Eurimedit.	8	9	3	2	0
Cymbalaria muralis Gaertn., Mey. & Scherb.	Scrofulariaceae	Ch	Subcosmop.	7	7	5	6	0
Erigeron karviskianus DC.	Asteraceae	H	Subtrop.	8	10	3	2	0
Erysimum cheiri (L.) Crantz	Brassicaceae	Ch	Eurimedit.	8	7	3	3	0
Lobularia maritima (L.) Desv.	Brassicaceae	H	Stenomedit.	8	9	2	1	0
Phagnalon rupestre (L.) DC.	Asteraceae	Ch	Stenomedit.	7	9	2	1	0
Tuberaria guttata (L.) Fourr.	Cistaceae	T	Eurimedit.	11	10	2	1	0

Table 2. Seed treatments for overcoming seed dormancy and previous germination performances

under light conditions (temperature of 20 ◦C). Means followed by one or two asterisks differ significantly at the $p < 0.05$ and $p < 0.01$ respectively.

Plant species	Germination under light at 20°C (%)	Most effective seed treatment	Significance level
Antirrhinum latifolium Mill.	38	GA_3	**
Campanula versicolor Andrews	27	Cold stratification 4 ◦C	*
Centranthus ruber (L.) DC.	37	Cold stratification 4 ◦C	*
Convolvulus cantabrica L.	14	Scarification	**
Cymbalaria muralis Gaertn., Mey. & Scherb.	32	Cold stratification 4 ◦C	*
Erigeron karviskianus DC.	11	Sodium hypochlorite	*
Erysimum cheiri (L.) Crantz	43	Sodium hypochlorite	*
Lobularia maritima (L.) Desv.	46	GA_3	**
Phagnalon rupestre (L.) DC.	74	Cold stratification 4 ◦C	n.s.
Tuberaria guttata (L.) Fourr.	57	Cold stratification 4 ◦C	n.s.

Table 3. Germination rates of different species incubated in light or dark conditions (temperature of 20 ◦C) after the seed treatment. Means of seeds' weight are followed by relative ± standard errors. Means followed by one or two asterisks differ significantly for $p < 0.05$ and $p < 0.01$ respectively.

Plant species	Germination (%)		Significance
	Light	dark	
Antirrhinum latifolium Mill.	72 ± 3.8	57 ± 3.0	*
Campanula versicolor Andrews	41 ± 2.7	32 ± 2.6	*
Centranthus ruber (L.) DC	52 ± 3.1	42 ± 2.91	ns
Convolvulus cantabrica L.	88 ± 4.0	87 ± 3.1	ns
Cymbalaria muralis Gaertn., Mey. & Scherb	55 ± 3.2	37 ± 2.4	**
Erigeron karviskianus DC.	23 ± 1.8	12 ± 0.3	*
Erysimum cheiri (L.) Crantz	96 ± 3.3	32 ± 2.2	**
Lobularia maritima (L.) Desv	67 ± 3.2	52 ± 2.8	*
Phagnalon rupestre (L.) DC	78 ± 3.6	46 ± 2.0	**
Tuberaria guttata (L.) Fourr	63 ± 3.4	32 ± 2.4	**

Table 4. Seed weight, optimal seeding depth and emergence% of the different ten plant species. Means of seeds' weight are followed by the relative ± standard errors.

Plant species	Weight (g) 1000 seed	Optimal seeding depth (mm)	Depth of 50% emergence (mm)	Emergence % at optimal depth
Antirrhinum latifolium Mill.	0.797 ± 0.02	2	4.1 ± 0.2	65 ± 3.3
Campanula versicolor Andrews	0.102 ± 0.04	1	2.7 ± 0.2	38 ± 2.8
Centranthus ruber (L.) DC.	1.254 ± 6.08	4	5.5 ± 0.2	47 ± 3.0
Convolvulus cantabrica L.	2.989 ± 3.48	6	9.3 ± 0.2	85 ± 4.7
Cymbalaria muralis Gaertn., Mey. & Scherb.	0.087 ± 0.01	1	3.0 ± 0.2	45 ± 2.8
Erigeron karviskianus DC.	0.074 ± 0.02	0	1.2 ± 0.2	15 ± 2.1
Erysimum cheiri (L.) Crantz	0.321 ± 0.07	2	3.8 ± 0.2	87 ± 4.9
Lobularia maritima (L.) Desv.	0.091 ± 0.07	1	2.8 ± 0.2	52 ± 3.7
Phagnalon rupestre (L.) DC.	0.011 ± 0.01	0	1.1 ± 0.2	85 ± 4.4
Tuberaria guttata (L.) Fourr.	0.257 ± 0.40	2	4.6 ± 0.2	57 ± 3.3