Original Research Article

Seedling Emergence and Seed Germination of Shepherd's needle *(Scandix pecten-veneris)* as Affected by Seed Weight and Burial Depth.

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ABSTRACT

Shepherd's needle (*Scandix pecten-veneris* L.) is a very common broadleaf weed in winter cereals in Greece. Knowing the behavior of the weed seeds in the soil may help in designing its management strategy. Field and laboratory experiments were conducted to evaluate the effect of seed weight and burial depth on seedling emergence and seed germination. For seed weight effect on germination and seedling emergence light and heavy seeds were tested by Petri dish assay and in the field (sowing depth 4cm). For burial depth study six depths- 2.5, 5, 7.5, 10, 12.5 and 15cm - were examined in field trials made in two periods of time: 25 November and 15 March for two years. Percentage of seed germination, seedling emergence and mean emergence time were measured. Results showed that light seeds germinated better (74-95%) and earlier (20.5-31.0 days) than heavy seeds (34-58% and 25.4-33.8 days respectively). The burial depth influenced seedling emergence and mean emergence time (MET) in most cases. Low emergence percentage (1.7-33.8%) was found at the depth of 15cm and high at depth of 2.5, 5, 7.5cm. Seeds sowed 15cm deep had higher MET (27.0-55.1 days) than those sowed at 2.5cm (20.9-41.6 days).

Keywords: burial depth; germination; Scandix pecten-veneris; seed weight; seedling emergence.

1. INTRODUCTION

Nowadays, the increasing concerns for environmental protection and the demand for less use of chemicals in agriculture have made important the need of efficient, sustainable and economical alternative methods in weed control such as integrated weed management systems. However, the development of effective integrated weed management systems depends on a thorough understanding of weed seed biology [1]. Seed germination and seedling emergence are key events in determining the success of a weed in an agroecosystem [2]

Shepherd's needle (*Scandix pecten-veneris)* is a very common annual broadleaf weed of Apiaceae family in winter cereals in Greece [3] and is controlled mainly by chemical methods. To improve its control where this weed is a problem, it is important and useful to know its germination behavior. However, studies on factors affecting seed germination and emergence of this weed, such as seed weight and burial depth, are scarce. The weight of seed is known to play a major role in plant population dynamics and community structure [4]. Heavy seeds are considered to have better adaptation in competitive conditions [5] while lighter seeds show often high dispersal and much persistence in the seed bank [6]. Another factor that alters the weed seed emergence is burial depth and species-specific emergence responses to this have already been well-documented [7]. Generally, with increasing burial depth plant seed emergence decreases. Carefully chosen cultivations, tailored to the weed species composition in the reservoir of seeds in the soil, can be used either to encourage emergence and hence the premature depletion of this seed bank, or to bury them to depths from which they cannot germinate and successfully emerge [8].

The objective of this research was to reveal the influence that seed weight and burial depth have on germination, seedling emergence, and mean emergence time of *Scandix pecten-veneris* thus, expanding our knowledge into managing the population of this weed species.

2. MATERIAL AND METHODS

2.1 Plant material

All needed weed fruits were harvested, in a totally random way, from the natural population that exists at the research farm Velestino, University of Thessaly, in the middle of July in 2007 and 2009 (Shepherd's needle plants maturity occurs in central Greece at the end of spring-May). Each flower produces a fruit (mericarp) consisting of two seeds which remain joined until they ripe. Each seed has a long scabrid needle-like appendage up to 6cm in length, which acts as a spring dispersal mechanism as the seed ripens. Only fruits with both well developed seeds were selected and stored in paper bags in laboratory temperature. The field experiments were carried out in a field where *Scandix pecten-veneris* had never been seen emerged before. The soil texture (depth 0-30 cm) was S 47%, Si 30%, C 23% (Loam). Irrigation was applied after sowing and during the tests at any time it was necessary. For the laboratory tests, the amount of soil used was collected from the above field.

2.2 Mean emergence time and seed weight trial

Selected fruits were divided into two classes, small-light and big-heavy, based on the size of the fruit and seeds derived from them had mean weight 8 or 15mg, made up the small-light class, and 35 or 53mg made up the big-heavy class in 2008 or 2010 trials respectively. Forty seeds of each class were sowed in the field at a depth of 4cm in a randomized complete block design (RCB) with four replications per treatment (weight class) on 24 March 2008 and 12 February 2010. The number of emerged seedlings (cotyledons completely unfolded) was recorded daily until no more seedlings were observed. Mean emergence time (MET) was calculated according to the equation of Ellis & Roberts [9] as follow:

$$MET = \sum Dn / \sum n$$

where n is the number of seeds, which were emerged on day D, and D is the number of days counted from the beginning of the test.

2.3 Seed germination and seed weight trial

The effect of seed weight on seed germination was evaluated in laboratory tests carried out in June 2008 and 2010. Twenty seeds of each heavy and light class (described above) were placed in a plastic Petri dish (5 dishes-replications per treatment-class, in completely randomized experiment design). Then, dishes were filled with 50 mL of dry sieved soil (2mm size sieve) and irrigated with 20 mL distilled water. The applied temperature (temperature selection was based on previous experimental data of the authors [10]) and photoperiod inside the incubator was 15°C/ dark 24 h. Petri dishes were left at these conditions for 35 days, then the germinated seeds were carefully removed, counted and the final germination percentage was calculated. Germination was recorded only once (end of experiment) and not daily to avoid the risk of breaking the radicles by digging into soil to check germinated seeds.

2.4 Seedling emergence and seed burial depth trial

For these tests, all the selected fruits were of medium size-weight (to avoid possible interactions between light or heavy seed weight and burial depth) and derived seeds had mean weight 25mg. Six burial depths were examined: 2.5, 5, 7.5, 10, 12.5 and 15cm in field trials carried out during two different periods of time - 25 November and 15 March for two years 2008-09 and 2010-11. Forty seeds were planted at each depth in a RCB design with 4 replications per treatment-depth, and emergence of seedlings was recorded every day until no more seedlings were observed. Mean emergence time (MET) was also calculated as mentioned before. Soil temperature at a depth of 5cm was recorded (1 record/30 min) by a data logger (type i-button Dallas Semiconductor) placed near the plots.

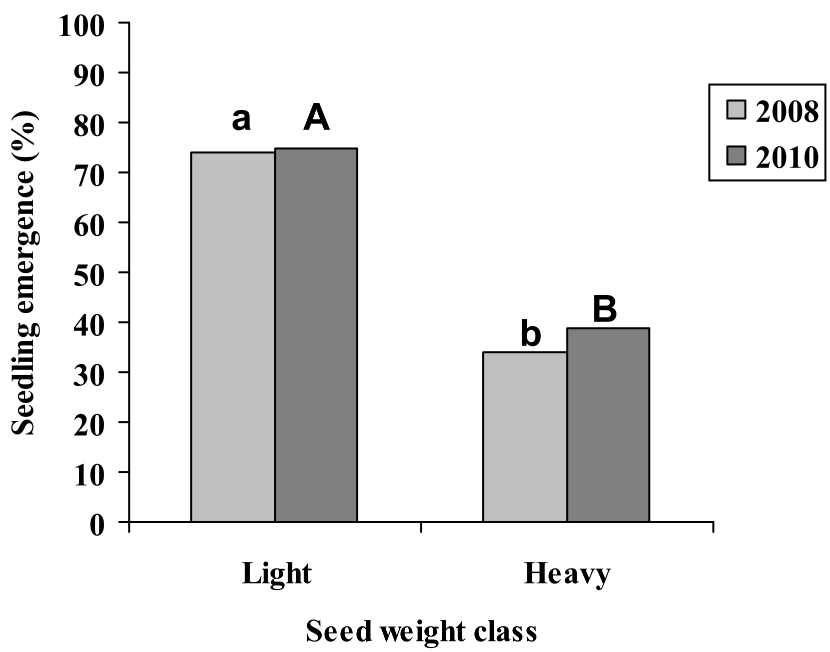
2.5 Statistical analysis

Shepherd's needle final emergence-germination percentage and mean emergence time data were analyzed by an ANOVA with the use of SPSS software (v13.0 for Windows). Where ANOVA indicated significant differences among the treatments (at $P<.05$), Tukey's Honestly Significant Difference test was performed to identify the homogeneous groups.

3. RESULTS

3.1 Seed weight effect on seedling emergence – seed germination

Emergence of seedlings was found to be affected by seed weight significantly in both field experiments, in 2008 and in 2010 (Fig. 1). The final percentage of light seeds emerged (74-75%) was almost double of that of heavy seeds (34-39%). Mean emergence time of light seeds was lower (20.5 and 31.0 days) compared to that of heavy seeds (25.4 and 33.8 days) in 2009 and 2011 trials, respectively (Fig. 1).



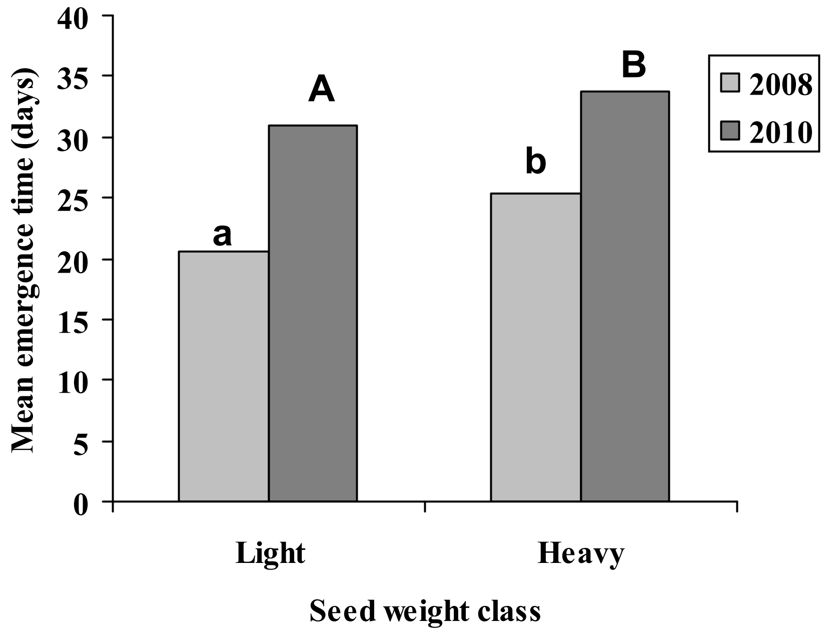


Fig. 1. Seedling emergence as % (above) and mean emergence time in days (below) of Shepherd's needle as affected by seed weight.

For each year, different letters above bars indicate significant difference at P =.05

Results derived from laboratory tests were similar to those of field experiments. Light seeds had a statistically significant higher level of germination percentage, 78-95%, than heavy seeds, 35-58% in both years 2008 and 2010 (Fig. 2).

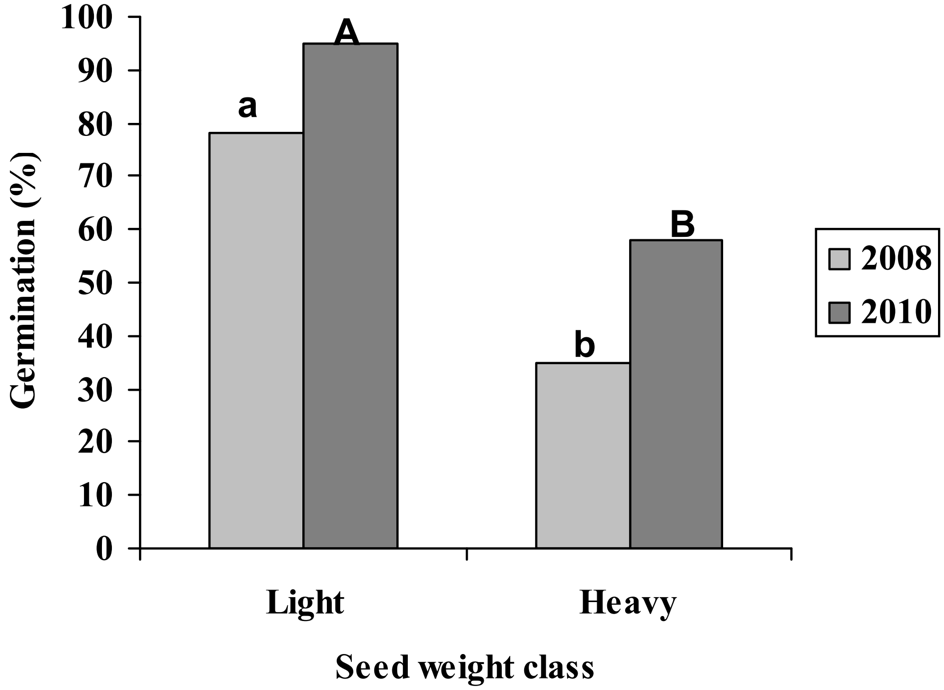


Fig. 2. Seed germination (%) of Shepherd's needle as affected by seed weight.
For each year, different letters above bars indicate significant difference at P =.05

3.2 Seed burial depth effect on seedling emergence

The mean soil temperature in these field trials is shown in Fig. 3. Significant influence of burial depth on Shepherd's needle emergence was measured in 2008-09 and 2010-11 trials in both periods of time 25 November and 15 March (except Nov. 2010) as shown in Table 1. Emergence percentage generally decreased as burial depth increased. The lowest percentages 1.7 to 33.8% was found at the depth of 15cm. Emergence above 70% was measured in all trials where seeds sowed 2.5 to 10cm deep in soil except March 2011 test where the highest percentage (51,7%) observed only in 2.5cm depth.

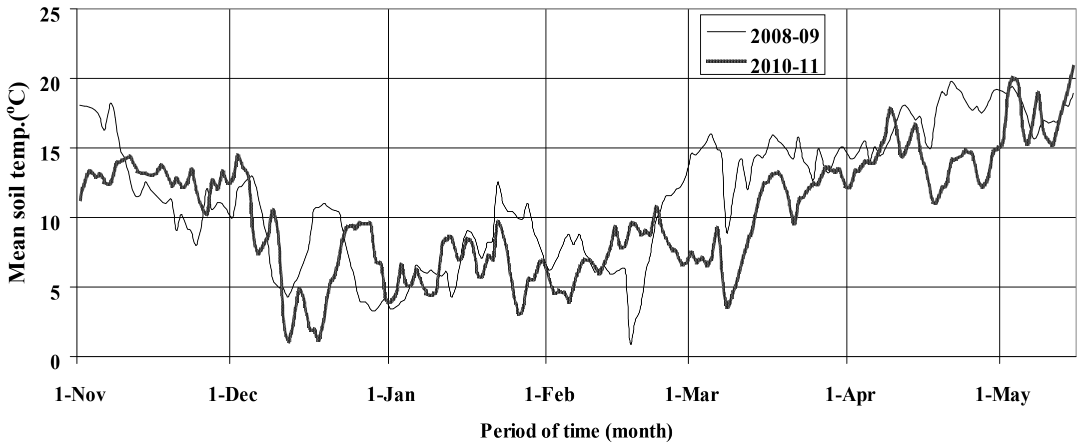


Fig. 3. Mean soil temperature at 5cm depth in fields trials 2008-09 and 2010-11

Table 1. Seedling emergence (%) of Shepherd's needle as affected by burial depth in two periods of time in 2008-09 and 2010-11 trials

	2008-09		2010-11	
Depth (cm)	**25 Nov.**	**15 Mar.**	**25 Nov.**	**15 Mar.**
2.5	86.3^{ab}	75.0^{ab}	68.3	51.7^{a}
5	90.0^{a}	81.3^{ab}	65.0	41.7^{ab}
7.5	85.0^{ab}	87.5^{a}	80.0	45.0^{ab}
10	72.5^{ab}	78.8^{ab}	70.0	26.7^{ab}
12.5	51.3^{bc}	61.3^{b}	66.7	10.0^{b}
15	26.3^{c}	33.8^{c}	66.7	1.7^{c}
			NS	

Means in each column followed by same letter do not differ significantly according to Tukey's HSD at P =.05, NS: Non significant

Mean emergence time (MET) of Shepherd's needle was also affected by burial depth in all trials in both years. When seeds were sowed deeper in the soil emergence was delayed. MET in 15cm treatments (Nov: 54.1, Mar: 27.0 days) in 2008-09 was higher than that in 2.5cm (31.8, 20.9 days, respectively) as shown in Table 2. Similar results were taken in 2010-11 study.

Table 2. Mean emergence time (days) of Shepherd's needle as affected by burial depth in two periods of time in 2008-09 and 2010-11 trials

	2008-09		2010-11	
Depth (cm)	**25 Nov.**	**15 Mar.**	**25 Nov.**	**15 Mar.**
2.5	31.8[a]	20.9[ab]	41.6[a]	25.4[a]
5	29.0[a]	20.1[a]	47.8[ab]	30.7[a]
7.5	35.6[ab]	21.7[ab]	48.1[ab]	35.6[ab]
10	39.5[ab]	24.7[cd]	48.5[ab]	35.4[ab]
12.5	45.0[b]	23.7[bc]	50.5[ab]	32.3[a]
15	54.1[c]	27.0[d]	55.1[b]	47.0[b]

Means in each column followed by same letter do not differ significantly according to Tukey's HSD at P=.05

4. DISCUSSION

Seed weight had a strong influence on Shepherd's needle seed germination and seedling emergence as derived from the experimental results (Fig. 1, 2). Larger-heavier seeds had significantly lower percentage of germination-emergence as compared to small-lighter seeds. Similar results to these findings have been observed for *Erodium brachycarpum* [11]. Contrary to this, it has been reported that heavier seeds of *Abutilon theophrasti* [12], *Lithospermum arvense* [13] and *Panicum racemosum* [14] had greater germination. However, for other species like *Ambrosia artemisiifolia* [15], *Dactylis glomerata* [16], *Andropogon tectorum* [17], *Rumex obtusifolius* [18] weight of seed had no any effect on their germination. Baskin and Baskin [19] suggested that this effect is species dependant and different seed sizes may have low, high or same germination percentage. Shepherd's needle light seeds had lower mean emergence time than heavy seeds and that means earlier germination in soil. Earlier germination of light seeds had also been found in *Pastinaca sativa* [20], *Cakile edentula* [21], *Erodium brachycarpum* [11], *Alliaria petiolata* [22] and *Senna obtusifolia* [23]. However, Stanton [24] found that seed size of *Raphanus raphanistrum* had no effect on emergence time. Stamp [11] attributed the earlier germination of small seeds to their greater access to water as a result of their higher surface to volume ratios. Hence, small seeds imbibed water faster and broke dormancy sooner. Susko and Lovett-Doust [22] stated that more rapid uptake of water, as well as thinner seed coats, may be responsible for the earlier loss of dormancy in small seeds of *Alliaria petiolata.* In a previous germination study of Shepherd's needle seeds carried out by the authors of this article (unpublished data) it was found that seeds of same size treated with a 98% sulphuric acid solution had higher germination percentage than seeds treated with distilled water. This means that sulphuric acid made the seed coats become thinner, therefore quicker water uptake was easier. So, thinner seed coat of light seeds may be one reason for their earlier germination compared to heavy seeds.

Many studies have reported the negative effect of increasing burial depth on emergence of several weeds species such as *Amaranthus spinosus and A. viridis* [1], *Phalaris paradoxa* [25], *Xanthium strumarium, Abutilon theophrasti, Pharbitis purpurea* [26], *Plantago lanceolata, Digitaria sanguinalis, Portulaca oleracea, Stellaria media* [27], *Ambrosia artemisiifolia* [15]. Burial depth also influenced Shepherd's needle emergence percentage and MET in our study. In most cases, as seeds were sowed deeper in soil the total emergence percentage decreased and MET increased. It seemed that the 12.5cm was the critical depth (for the given soil type) for emergence of this weed, below which the seeds poorly could give seedlings and if so emergence was too delayed. In the burial tests carried out during March, mean emergence time generally was smaller than that of November trials (independently of burial depth). Differences in mean soil temperature at this period of time could explain this (Fig. 3).

Benvenuti and Macchia [28] suggest that affections of burial depth on weed seed germination could be attributed to variation of different soil's layer characteristics, water holding-capacity and gas environment conditions. Suicide seed germination could be also another reason for low emergence at deep sowing depths but it is only a hypothesis since no retrieval of buried seeds was made in this study to check germination afterwards. In November 2010 trial, statistically significant difference in total emergence percentage between treatments was not observed (although there was for MET measurements). During field experiment installation soil moisture was very close to saturation due to extended rainfall and the soil used to cover the buried seeds was not compressed properly as in the other trials in order to avoid excessive soil compaction. This may have altered soil's layer characteristics and, perhaps, the results that were observed.

To summarize, seed weight of Shepherd's needle influenced its germination and emergence characteristics, light seeds germinated-emerged quicker and in higher percentage than heavy seeds. It seems that the variable seed size is a biological trait that could allow this weed like other weed species to cope with the variable soil environment conditions found in different fields. Also, the fact that seedling emergence is limited and delayed considerably where seeds sit 12.5cm or deeper below soil surface could make soil tillage at a depth of 15cm or more with moldboard plough a useful tool in controlling this weed where it is a problem.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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