GERMINATION ECOLOGY OF SEEDS OF *CENTAUREA SULPHUREA*

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INTRODUCTION

SICILIAN STARTHISTLE (*CENTAUREA SULPHUREA*) IS AN EXOTIC SPECIES THAT HAS BEEN ACCIDENTALLY INTRODUCED TO CALIFORNIA FROM SOUTHWESTERN EUROPE. THE *CENTAUREA* SPECIES THAT HAVE BEEN INTRODUCED TO NORTH AMERICA RANGE FROM ANNUALS TO LONG LIVED PERENNIALS WITH BIENNIAL AND SHORT LIVED PERENNIAL SPECIES INCLUDED. SICILIAN STAR THISTLE IS AN ANNUAL WITH PROPAGATION ONLY BY SEEDS. MANY OF THE SPECIES OF *CENTAUREA* HAVE SPINES ESPECIALLY ON THE BRACTS THAT SUBTEND THE SEEDHEAD. SICILIAN STARTHISTLE EXPRESSES THIS CHARACTERISTIC TO AN EXTREME WITH THE SEEDHEADS ARMED WITH VICIOUS SPINES. FROM A SEEDBED ECOLOGY STAND POINT, SICILIAN STARTHISTLE IS INTERESTING BECAUSE THE ACHENES ARE VERY LARGE COMPARED TO OTHER SPECIES IN THE GENUS AND THE ABUNDANT PAPPUS IS VERY PERSISTENT (Figure 1).

PURPOSE

AS A FIRST STEP TOWARD UNDERSTANDING THE SEED AND SEEDBED ECOLOGY OF SICILIAN STARTHISTLE, WE INVESTIGATED THE GERMINATION OF SEEDS (ACHENES) OF THIS SPECIES AT A WIDE RANGE OF CONSTANT AND ALTERNATING TEMPERATURES.

METHODS

Seeds of Sicilian starthistle were furnished by the biological weed control scientist of the California Department of Food and Agriculture. They were collected from stands growing near Sacramento, California. Collections from multiple plants at each collection site were composited for testing.

In all experiments 4 replications of 25 seeds each were used in a randomized block design. Seeds were placed on top of non-toxic commercial germination paper in closed Petri dishes and kept wet with tap water. Germination trials were conducted in the dark. Incidental light was received during initial wetting and germination counts. Seeds were considered germinated when the radical emerged 1 mm. Germination counts were made after 1, 2, and 4 weeks. Constant incubation temperatures were 0, 2, and 5 C and at 5 degree increments through 40 C. Alternating regimes included 16 hours at each constant temperature, plus 8 hours at each possible higher temperature per 24 hours. For example, 35 C alternated with 40 C only, while 0 C alternated with 2, 5, 10, 15, 20, 25, 30, 35, and 40 C. This made a total of 55 constant and alternating temperature regimes (Young et al. 1991).

The germination responses of the accessions of Sicilian starthistle were compared using the following seedbed temperature regime definitions (Young and Evans 1982):

a. Very cold: 0/0 (constant 0 C), 0/2 (0 C for 16 hours and 2 C for 8 hours in each 24 hour), 0/5 and 2/2 C.
b. Cold: 0/10, 0/15, 2/5, 2/10, 2/15, 5/5, and 5/10 C.
c. Cold fluctuating: 0/20 through 0/40 C and 2/20 through 2/40 C.
e. Moderate: 5/20 through 5/30, 10/10 through 10/30 C, 15/15 through 15/35 C, 20/20 through 30/35 C, and 25/25 through 25/30 C.
f. Warm: 20/40, 25/35, and 25/40 C, 30/30 through 30/40 C, 35/35, 35/40, and 40/40 C.

The temperature categories reflect germination environments of field seedbeds based on several years of monitoring in the Great Basin (Evans et al. 1970, Evans and Young 1970, 1972).

Data from each base temperature and its alternating temperature regimes were used to generate a quadratic response surface with estimated means and confidence intervals at the 1% level of probability (Young et al. 1980, Evans et al. 1982, Palmquist et al. 1987). A number of germination parameters were calculated from the quadratic response surfaces (Table 1) (Young and Evans 1982). These germination parameters were individually subjected to analysis of variance and the means separated by Duncan's Multiple Range Test.

Table 3. Quadric response surface with calculated percentage germination and confidence interval (P≤0.01) for seeds of Sicilian starthistle incubated at 55 constant or alternating temperatures. Seeds collected in July 2003, and test conducted in September 2003. Seeds collected from same stand as seeds for Tables 1 and 2.[1]

Cold period temperature C \ Warm period temperature C	0	2	5	10	15	20	25	30	35	40
	Percentage germination									
	%									
0	22±10	[38±9*]	34±9*	24±10	26±10	17±10	13±12	5±12	4±12	1±14
2		15±11	32±10*	25±11	15±12	10±10	10±10	8±12	8±12	12±12
5			22±10	25±11	23±10	15±12	15±12	9±12	8±12	12±12
10				18±10	18±10	20±10	29±10*	20±10	24±10	22±10
15					11±12	12±12	19±10	18±10	17±10	20±10
20						17±12	14±12	12±12	12±12	16±12
25							3±10	4±10	10±10	12±12
30								4±10	11±12	14±12
35									4±12	4±12
40										0±14

[1]Number following the mean is one half of the confidence interval as determined from regression equations used to develop the response surface (Palmquist et al. 1987). The maximum calculated germination is enclosed by brackets [ ]. * indicates means not lower than the maximum germination minus one half of its confidence interval, our definition of optimum germination.

Table 1. Quadric response surface with calculated percentage germination and confidence interval (P≤0.01) for seeds of Sicilian starthistle incubated at 55 constant or alternating temperatures. Seeds from an archival source that was several years old when tested.[1]

Cold period temperature C \ Warm period temperature C	0	2	5	10	15	20	25	30	35	40
	Percentage germination									
	%									
0	60±9	[100±7*]	98±6*	98±6*	98±6*	[100±6*]	95±6*	88±6	38±11	0+14
2		90±6	90±6	98±6*	98±6*	98±6*	95±6*	68±8	40±11	0+14
5			80±7	98±6*	83±7	83±7	80±7	95±7*	38±11	0±14
10				78±7	88±6	90±6	95±6	[100±7*]	80±8	5±12
15					80±7	90±6	90±6	[100±7*]	98±7*	65±9
20						83±7	95±7*	95±7*	90±6	65±8
25							98±7*	[100±6*]	93±7	35±10
30								46±10	48±10	30±10
35									0+14	0±14
40										0+14

[1]Number following the mean is one half of the confidence interval as determined from regression equations used to develop the response surface (Palmquist et al. 1987). The maximum calculated germination is enclosed by brackets [ ]. * indicates means not lower than the maximum germination minus one half of its confidence interval, our definition of optimum germination.

Table 2. Quadric response surface with calculated percentage germination and confidence interval (P≤0.01) for seeds of Sicilian starthistle incubated at 55 constant or alternating temperatures. Seeds collected in 2002 and tested in January 2003.[1] Collected from same stand as Table 1, but seed harvested at known date.

Cold period temperature C \ Warm period temperature C	0	2	5	10	15	20	25	30	35	40
	Percentage germination									
	%									
0	51±9	94±7*	98±6*	96±6*	[100±6*	100±6*]	94±6*	78±6	30±11	0+12
2		85±7	86±6	94±6*	98±6*	96±6*	94±6*	60±8	44±11	0+12
5		80±7		96±6*	80±7	83±7	80±7	96±7*	29±11	0+12
10				78±7	88±6	90±6	[100±6*	100±7*]	78±8	0+12
15					80±7	90±6	96±6*	[100±7*]	98±7*	65±9
20						83±7	95±7*	95±7*	90±6	65±8
25							98±7*	96±6*	93±7	35±10
30								40±10	42±10	23±10
35									0+14	0+14
40										0±14

[1]Number following the mean is one half of the confidence interval as determined from regression equations used to develop the response surface (Palmquist et al. 1987). The maximum calculated germination is enclosed by brackets [ ]. * indicates means not lower than the maximum germination minus one half of its confidence interval, our definition of optimum germination.

Table 4. Comparison of germination-temperature profile parameters for three different post harvest age accessions of Sicilian starthistle seeds collected form the same stand in different years.

Parameter	Accessions: Archival seed > 1 year old (Table 1)	6 months old 2002 (Table 2)	1 month old 2003 (Table 3)
	%		
Profile characteristics			
Mean	68	66	17
Regimes with some germination	89	87	98
Mean of optima	98	97	33
Regimes with optima	31	38	7
Maximum germination	100	100	29
Seedbed temperature categories			
Very cold	87	82	27
Cold	95	93	24
Cold fluctuating	62	60	9
Fluctuating	38	34	17
Warmer	35	33	8
Moderate	90	91	15

RESULTS

FOR BOTH THE ARCHIVAL SEED THAT WAS AT LEAST 1 YEAR POST HARVEST WHEN TESTED (TABLE 1) AND THE SEED COLLECTED IN 2002 AND TESTED 6 MONTHS LATER (TABLE 2) THE GERMINATION TEMPERATURE PROFILES INDICATE VERY GOOD GERMINATION FOR THE SICILIAN STARTHISTLE ACCESSIONS. CONDUCTING THE GERMINATION-TEMPERATURE PROFILES 1 MONTH AFTER HARVEST INDICATED AN AFTERRIPENING DORMANCY, WHICH PROBABLY WILL DISAPPEAR WITH PASSAGE OF TIME AFTER HARVEST (TABLE 3). IT IS REMARKABLE THAT SEEDS OF SICILIAN STARTHISTLE, A SPECIES FROM SOUTHWESTERN MEDITERRANEAN EUROPE AND ADAPTED TO SIMILAR CLIMATE OF THE CENTRAL VALLEYS OF CALIFORNIA WOULD HAVE ABOVE 80% GERMINATION AT VERY COLD AND COLD CATEGORIES OF SEEDBED TEMPERATURES (TABLE 4). GERMINATION OPTIMA ACTUALLY OCCURRED AT THESE TEMPERATURES WHICH IS HIGHLY UNUSUAL FOR MORE THAN 1,000 SPECIES WE HAVE TESTED AND CERTAINLY IS NOT COMMON FOR OTHER SPECIES OF *CENTAUREA*. REMEMBER THAT IM TRUE MEDITERRANEAN CLIMATES THE RAINFALL OCCURS DURING THE COOLER WINTER MONTHS.

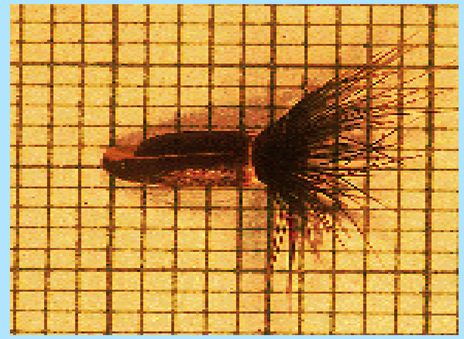

FIGURE 1. SICILIAN STARTHISTLE SEED ON 1 MM GRID. THIS IS ONE OF THE LARGER SEEDED SPECIES OF *CENTAUREA*.

CONCLUSION

SEEDS OF SICILIAN STARTHISTLE, OTHER THAN FRESHLY HARVESTED SEEDS, HAVE RELATIVELY HIGH GERMINATION AT A WIDE RANGE OF CONSTANT AND ALTERNATING TEMPERATURES. FURTHER TESTING IS NECESSARY TO ASSESS THE NATURE AND DURATION OF POTENTIAL AFTERRIPENING RELATED DORMANCY.

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