GERMINATION AND SEEDBED ECOLOGY OF *CENTAUREA MACULOSA* SEEDS

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INTRODUCTION

SPOTTED KNAPWEED (CENTAUREA MACULOSA) IS ONE OF THE SEVERAL SPECIES OF THE GENUS WITH VARIABLE LIFE FORMS. IT CAN BE AN ANNUAL, BIENNIAL, OR SHORT LIVED PERENNIAL. IT IS A TAP ROOTED SPECIES WITH REPRODUCTION ONLY BY SEEDS. DURING THE LAST DECADES OF THE 20TH CENTURY THIS EXOTIC INVASIVE SPECIES HAD A SPECTACULAR RATE OF SPREAD IN THE PACIFIC NORTHWEST AND NORTHERN ROCKIES. IT COMPETES WITH DESIRABLE FORAGE SPECIES ON RANGE AND WOODLANDS.

SPOTTED KNAPWEED IS ONE OF THE SPECIES OF CENTAUREA THAT DISPERSES ITS SEEDS (ACHENES) VERY RAPIDLY AFTER MATURITY. THE SUBTENDING BRACTS SURROUNDING THE SEEDHEAD REFLEX AT MATURITY AND THE ACHENES RAPIDLY ARE DISPERSED AS THE STIFF FLOWER STALKS MOVE WITH WIND. THE SEEDS HAVE A PERSISTENT SHORT PAPPUS. THE SEEDS ARE SMALL, ONLY ABOUT 3 MM LONG.

BECAUSE PROPAGATION OF THIS SPECIES IS ONLY ACCOMPLISHED BY SEED MATURATION, DISPERSAL, AND SEEDLING ESTABLISHMENT, THE SEED AND SEEDBED ECOLOGY OF THE SPECIES IS VERY IMPORTANT IN THE DEVELOPMENT OF SUPPRESSION STRATEGICS.

PURPOSE

OUR PURPOSE WAS TO INVESTIGATE THE GERMINATION OF SPOTTED KNAPWEED SEEDS AT A WIDE RANGE OF CONSTANT OR ALTERNATING INCUBATION TEMPERATURES AS A FIRST STEP IN UNDERSTANDING THE SEED AND SEEDBED ECOLOGY OF THE SPECIES.

METHODS

Seeds of spotted knapweed were collected from stands located in California, Montana, and Idaho in 2002 and 2003. Seeds were collected from numerous plants at each collection site and composited together. After threshing, the seeds were cleaned and stored in paper bags in the laboratory until germination test were conducted. Germination test were conducted on freshly harvested (1 month after harvest) seeds and from the same lot after 6 months post maturity to check for afterripening requirements.

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 spotted knapweed 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.
d. Fluctuating: 5/35 through 5/40 C, 10/35, 10/40, an 15/40 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 1. Quadric response surface with calculated percentage germination and confidence interval ($P \leq 0.01$) for seeds of spotted knapweed incubated at 55 constant or alternating temperatures. Seeds collected at National Sheep Research Station, Idaho, in 2002 test conducted December 2002.[1]

Percentage germination: Cold period temperature C \ Warm period temperature C	0	2	5	10	15	20	25	30	35	40
	%									
0	0+14	3±12	5±12	10±11	66±8	83±6	62±8	40±9	40±9	1±14
2	0+14	0+14	16±11	67±8	96±5*	66±8	49±8	45±8	2±14	
5	2±14	43±9	70±7	82±6	92±5*	95±5*	49±7	2±14		
10	46±8	74±7	88±6	84±6	82±6	62±8	7±12			
15	84±6	[100±8*]	95±5*	92±6*	92±6*	68±9				
20	91±6	92±6*	90±6	75±7	56±9					
25	51±8	70±7	56±9	12±11						
30	21±11	41±9	2±14							
35	0+14	1±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. Summary of germination profiles for spotted knapweed germination-temperature profiles for 2002.

Parameter	Sheep Station Idaho	Susanville, CA landfill	Susanville, CA mill site
	%		
Profile characteristics			
Mean	38	53	55
Regimes with some germination	90	96	96
Mean of optima	94	98	95
Regimes with optima	16	24	18
Maximum germination	100	100	98
	15/20 C	multiple	5/20 C
Seedbed temperature categories			
Very cold	2	11	15
Cold	39	69	71
Cold fluctuating	48	63	64
Fluctuating	38	58	53
Warmer	21	30	38
Moderate	79	86	86

Table 3. Summary of germination temperature profiles for seeds of spotted knapweed from two sites in California in for 2002 and 2003. For seeds produced in 2002 the data is presented for freshly harvested and 6 months afterripening. For 2003 data is presented for freshly harvested seed only.

Parameter	Susanville, CA mill site			Susanville, CA landfill		
	1 month		6 months	1 month		6 months
	2002	2003		2002	2003	
	%					
Profile characteristics						
Mean	18	15	53	46	49	51
Regimes with some germination	84	85	96	94	89	96
Mean of optima	32	38	98	90	93	96
Regimes with optima	10	9	24	18	13	18
Maximum germination	100	98	98	94	94	98
Seedbed temperature categories						
Very cold	0	0	11	10	9	11
Cold	12	4	69	60	64	61
Cold fluctuating	13	13	63	62	68	63
Fluctuating	34	38	58	50	53	58
Warmer	8	9	38	30	32	38
Moderate	38	45	86	66	69	86

RESULTS

A GERMINATION TEMPERATURE PROFILE FOR SEEDS COLLECTED AT THE NATIONAL SHEEP EXPERIMENT STATION IN IDAHO PROVIDES AN EXAMPLE OF THE BASIC DATA SET (TABLE 1)
THE MEAN GERMINATION FOR THE SPOTTED KNAPWEED ACCESSION OBTAINED FROM IDAHO IN 2002 WAS LOWER THAN FOR SEEDS OF ACCESSION OBTAINED FROM NORTHEASTERN CALIFORNIA (TABLE 2). THE MAXIMUM GERMINATION OBSERVED FOR SEEDS FROM THE IDAHO SEED LOT WAS 100%, WHILE THE CALIFORNIA ACCESSION HAD 98 AND 100% MAXIMUMS. THE DIFFERENCES IN THE PROFILES THAT RESULTED IN THE LOWER MEAN GERMINATION OCCURRED AT WHAT WE CLASSIFY AS VERY COLD AND COLD SEEDBED TEMPERATURES. THE COLLECTION SITES FOR THE CALIFORNIA SEEDS WERE IN THE GREAT BASIN AT RELATIVE HIGH ELEVATIONS, BUT NORTHEASTERN IDAHO IS A MUCH COLDER ENVIRONMENT THAN NORTHEASTERN CALIFORNIA. FOR THE NORTHEASTERN CALIFORNIA COLLECTIONS SITES WE HAVE DATA FOR TWO CONSECUTIVE YEARS FROM THE SAME SPOTTED KNAPWEED COMMUNITIES (Table 3). THE SITES ARE LOCATED WITHIN 5 KM OF EACH OTHER AND AT SLIGHTLY DIFFERENT LOCATIONS, BUT SEEDS FOR THE TWO SITES HAVE DIFFERENT RESPONSES TO AFTERRIPENING. THE LANDFILL SITE HAS NO APPARENT AFTERRIPENING REQUIREMENTS WHILE THE LOWER ELEVATION MILL SITE DOES.

WE WILL PROBABLY FIND ADDITIONAL VARIABILITY AMONG AND WITHIN ACCESSIONS AS THE STUDY CONTINUES.

CONCLUSION

SEEDS OF SPOTTED KNAPWEED CAN GERMINATE AT A WIDE RANGE OF CONSTANT AND ALTERNATING TEMPERATURES, INCLUDING VERY COLD SEEDBED TEMPERATURES. AT OPTIMUM TEMPERATURES FOR GERMINATION, THE PERCENTAGE GERMINATION MAY APPROACH OR EQUAL 100%.

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