

Treatment and Germination of Florida Native Wildflower Seeds
for Commercial Production and Natural Landscaping

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OBJECTIVES

The fundamental aim of this project was to establish ecophysiology of seed germination and assessment of seed viability of the Florida native wildflower species, including *Ipomopsis rubra* (L.) Wherry (Standing Cypress, Spanish Larkspur), *Rudbeckia mollis* Elliot (Softhair Coneflower), and *Gaillardia pulchella* Foug. (Firewheel). Determination of presence or absence of dormancy under room temperature, cold storage (refrigeration), and stratified (buried) conditions have been the objectives of this project

METHODS AND MATERIALS

Seeds of *I. rubra* and *R. mollis* were purchased from Seedsower Farm (3650 SW CR 242, Lake City, FL 32024). These were divided into three lots each, where one lot was divided and placed in 12 perforated plastic pollination bags and buried (stratified based on Baskin and Baskin's (2001) recommendations) in a depth of 7 cm in sand and placed in a 30% shadehouse so as to maintain exposure to natural conditions. These were irrigated to field capacity by application of 450cc of distilled water once weekly. The containers were sheltered from rain with plastic. Another seed batch was divided into a total of 64 lots of 50 seeds (to include four replications per treatment) and placed in Petri dishes on moist sand and located in germination incubators of various temperatures and exposed to light or dark. One-half of the Petri dishes were covered with aluminum foil so as to simulate complete darkness and the other half were exposed to 12/12hr light/dark cycle. Incubator temperatures included eight regimes: 5/20 °C, 10/20°C, 10/25°C, 15/25°C, 15/30°C, 20/25 °C, 20/30°C and 23/33°C. Germination percentages were determined in 7, 14, and 21 day cycles (*cf.* Baskin and Baskin, 2001).

Seeds were divided into three equal batches intended for buried, refrigerated, and room temperature, and subsequently 12 bags of about 400 seeds each were buried in sand. Other two seed batches were placed in a refrigerator (~4° C = 40° F) and in the laboratory (room temperature: 21 to 23° C = 68 to 72° F). Simultaneously four groups of 50 seeds each were examined for viability (pre-germination TZ test) and a total of 64 lots or 50 seeds each were placed in incubators under various temperature and light/dark regimes to determine initial germination percentages.

On subsequent monthly bases a bag of the buried seed was removed and divided into 64 lots of 50 seeds each (four replications per treatment) and placed in germination incubators under various temperature and light/dark regimes. An additional four replications of 50 seeds each were used for pre-germination viability test. Germination percentage was determined on 7, 14, and 21 days (shown as average 30 day intervals in tables). And after 21 days ungerminated seeds were tested again with TZ for potential existence of viability in each of the four replications of the 16 (light/dark) treatments.

On monthly bases, refrigerated (4°C) and room temperature-stored ($\pm 22^\circ\text{C}$) seeds were also divided into groups of 64 lots of 50 seeds each in Petri dishes and placed in germination incubators. Initial TZ test was performed on four lots of 50 seeds each. Also, four replications of fifty seeds each was placed in Petri dishes and treated as described above, in light and dark and varying temperature regimes, and used for the final viability (TZ) test. Germination percentage was determined on 7, 14, and 21 days. The intent was to contrast germination tests with the TZ tests to correlate viability retention with percent germination.

Viability tests were performed by placing seeds in 1% Tetrazolium (2, 3, 5 Triphenyl-2H-Tetrazolium Chloride) (TTC) solution and kept at 30°C for 48 hours and under continuous light. Only seeds with turgid visibly plump and red embryo were considered viable.

RESULTS:

***Ipomopsis rubra*, First Trials**

First trial was initiated in July 2004 and terminated November of the same year. Seeds had a high initial viability percentage (95%) when tested with TZ and remained high for the next two monthly (60 days) germination trials with seeds stored at room temperature (Tables 1A and 1B). However, on the third monthly trial (October) both TZ results and germination percentage were drastically reduced, indicating a temporary reduction in seed viability. We cannot offer a logical explanation for this occurrence. This was evident for the most part in all treatments. Hypothetically, since these seeds were collected in the previous year (2003) time or genetically induced dormancy at the outset of cooler weather is a plausible explanation. Although to a lesser degree, there is a correspondence with data for refrigerated seeds (Table 2A and 2B). There was a drastic drop in percent germination under the highest temperature (23/33°C) regime. There was also lower germination percentage in all cases when differential in day/night temperature was 15°C /30°C. While there was noteworthy difference in TZ tests (Table 1B), with but a few notable exceptions there was no difference in percent germination between light and dark exposure (Table 1A). By contrast, germination in stratified (buried) seeds was nil to none in the three month period (Table 3A), although in the TZ test some viability was indicated for the first month since stratification began (Table 3B). The practical implication of these findings is that neither refrigeration nor stratification is necessary for seed germination or short-term viability in this species although there may be a critical planting time and planting depth involved. Planting is perhaps best accomplished in late winter and/or early spring. However, long term refrigeration may be useful in extending viability period. Long-term trial over several years is necessary to make definitive determination. Although these are preliminary data and statistical analysis is yet to be performed there does not appear to be a significant difference in either germination

percentage or seed viability as a result of continuous dark exposure. Practical implication of this is that seeds may be buried for long periods of time but will germinate when environmental conditions are suitable for germination.

TABLE 1A. Effects of light and dark regimes and varying temperatures on percent* germination of *Ipomopsis rubra* seed stored at room temperature.

Temperature	Light				Dark			
	Day 30	Day 60	Day 90	Day 120	Day 30	Day 60	Day 90	Day 120
5°C-20°C	44	57	7	35	46	40	3	28
10°C-20°C	49	48	13	39	56	43	15	36
10°C-25°C	44	39	7	22	54	52	15	34
15°C-25°C	55	42	13	28	54	44	5	30
15°C-30°C	33	36	5	26	20	23	5	20
20°C-25°C	50	49	16	23	45	40	9	24
20°C-30°C	44	41	7	17	43	43	2	16
23°C-33°C	15	38	3	26	7	21	2	13

*Average of four replications each at 7, 14, and 21 days.

TABLE 1B. Effects of light and dark regimes and varying temperatures on percent* viability (TZ) of *Ipomopsis rubra* seed stored at room temperature.

Temperature	Light				Dark			
	Day 30	Day 60	Day 90	Day 120	Day 30	Day 60	Day 90	Day 120
5°C-20°C	75	70	12	57	86	42	4	57
10°C-20°C	82	72	15	55	81	45	18	49
10°C-25°C	80	68	10	44	84	54	16	55
15°C-25°C	86	64	20	51	82	46	7	54
15°C-30°C	82	63	9	40	74	23	11	42
20°C-25°C	73	74	22	43	67	41	10	54
20°C-30°C	77	70	8	26	76	43	4	39
23°C-33°C	74	61	8	45	64	22	5	32
Pre-germ TZ	95	92	92	88				

*Average of four replications.

TABLE2A. Effects of light and dark regimes and varying temperatures on percentage germination* of *Ipomopsis rubra* seed stored in refrigerator.

Temperature	Light				Dark			
	Day 30	Day 60	Day 90	Day 120	Day 30	Day 60	Day 90	Day '120
5°C-20°C	51	50	19	45	56	24	15	49
10°C-20°C	57	54	45	48	58	42	6	43
10°C-25°C	55	52	29	45	52	43	11	43
15°C-25°C	56	53	33	54	45	54	6	48
15°C-30°C	41	54	0	33	11	42	0	27
20°C-25°C	55	48	9	44	50	45	0	39
20°C-30°C	47	51	8	35	38	44	1	21
23°C-33°C	14	52	2	39	8	41	0	14

* Average of four replications each at 7, 14, and 21 days.

TABLE 2B. Effects of light and dark regimes and varying temperatures on percent* viability (TZ) of *Ipomopsis rubra* seed stored in refrigerator.

Temperature	Light				Dark			
	Day 30	Day 60	Day 90	Day 120	Day 30	Day 60	Day 90	Day 120
5°C-20°C	71	67	25	69	73	50	17	74
10°C-20°C	78	66	48	61	78	64	8	58
10°C-25°C	68	79	33	67	72	68	16	62
15°C-25°C	74	72	35	71	66	73	9	69
15°C-30°C	61	72	1	54	38	65	2	42
20°C-25°C	73	67	11	66	72	66	4	54
20°C-30°C	67	73	14	52	65	60	2	38
23°C-33°C	75	70	11	58	72	63	2	33
Pre-germ TZ	92	90	90	86				

*Average of four replications.

TABLE 3A. Effects of light and dark regimes and varying temperatures on percentage germination of *Ipomopsis rubra* seed buried in sand.

Temperature	Light				Dark			
	Day 30**	Day 60	Day 90	Day 120	Day 30**	Day 60	Day 90	Day 120
5°C-20°C	41	0	0	0	53	1	0	0
10°C-20°C	59	0	0	0	54	0	0	0
10°C-25°C	49	0	0	0	50	0	0	0
15°C-25°C	49	0	0	0	58	0	0	0
15°C-30°C	34	1	0	0	6	0	0	0
20°C-25°C	54	0	0	0	45	1	0	0
20°C-30°C	7	0	0	0	8	0	0	0
23°C-33°C	42	1	0	0	32	0	0	0

*Average of four replications each at 7, 14, and 21 days.

**Control, initial reading prior to burial.

TABLE 3B. Effects of light and dark regimes and varying temperatures on percent* viability (TZ) of *Ipomopsis rubra* seed buried in sand.

Temperature	Light				Dark			
	Day 30**	Day 60	Day 90	Day 120	Day 30**	Day 60	Day 90	Day 120
5°C-20°C	78	37	0	0	82	30	0	0
10°C-20°C	81	23	0	0	77	21	0	0
10°C-25°C	78	29	0	0	81	32	0	0
15°C-25°C	76	28	0	0	81	23	0	0
15°C-30°C	71	38	0	0	74	68	0	0
20°C-25°C	74	21	1	0	73	29	0	0
20°C-30°C	72	65	0	0	78	70	0	0
23°C-33°C	65	23	0	0	75	43	0	0
Pre-germ TZ	89	1	0	0				

*Average of four replications.

**Control, initial reading prior to burial.

***Ipomopsis rubra*, second Trials**

The second trials was initiated in May 2005 and terminated in October of the same year. The experiment was repeated because there was no germination of the buried seed in the first trial. Germination of refrigerated seed appeared to be significantly greater than either buried or room-stored seed. There was little difference in germination of buried and room-stored seed. Seed viability of buried seed when examined with TZ appeared to be significantly higher at the outset but in time viability was reduced, hence there was no germination after the first month of trials (Tables 4A and 4B), thereby confirming the results of the first trial.

By contrast, seeds stored in room temperature maintained high viability during the experimental period but had approximately the same germination rate as that of the control unburied seed (*cf.* Table 4A and 4A and 5B). Refrigerated seed had the same viability as both buried and room temperature stored seed but the highest germination percentage of all treatments (Tables 6A and 6B).

Although there does not appear to be a stratification requiring specific dormancy in seeds of *Ipomopsis rubra*, to extend longevity of the seeds, refrigerated storage is advisable. There is, however, a preferred seeding time in early spring to allow germination and seedling growth prior to flowering in mid to late summer. Field observations support this recommendation. Although seeds germinate under controlled light and temperature experimental conditions it does not necessarily follow that seedling would survive either dry or cold periods.

TABLE 4A. Effects of various temperatures and light and dark regimes on percent * germination of buried *Ipomopsis rubra* seeds.

Temperature	Light				Dark			
	Day 30	Day 60	Day 90	Day 120	Day 30	Day 60	Day 90	Day 120
5°C-20°C	18	0	0	0	16	2	0	0
10°C-20°C	26	0	0	0	19	2	0	0
10°C-25°C	25	0	0	0	21	4	0	0
15°C-25°C	23	0	0	0	18	3	0	0
15°C-30°C	19	0	0	0	19	3	0	0
20°C-25°C	22	0	0	0	24	2	0	0
20°C-30°C	19	0	0	0	17	3	0	0
23°C-33°C	16	0	0	0	16	1	0	0

* Average of four replications each at 7, 14, and 21 days.

**Control, initial reading prior to burial.

TABLE 4B. Effects of light and dark regimes and varying temperatures on percent * viability of buried *Ipomopsis rubra* seeds.

Temperature	Light				Dark			
	Day 30	Day 60	Day 90	Day 120	Day 30	Day 60	Day 90	Day 120
5°C-20°C	76	0	0	0	75	0	0	0
10°C-20°C	76	0	0	0	67	1	0	0
10°C-25°C	68	0	0	0	68	0	0	0
15°C-25°C	68	0	0	0	62	0	0	0
15°C-30°C	50	2	0	0	59	1	0	0
20°C-25°C	62	0	0	0	65	0	0	0
20°C-30°C	68	0	0	0	57	0	0	0
23°C-33°C	48	0	0	0	53	0	0	0
Pre-germ TZ	89	1	0	0				

*Average of four replications.

**Control, initial reading prior to burial.

TABLE 5A. Effects of various temperatures and light and dark regimes on percent * germination of *Ipomopsis rubra* stored at room temperature.

Temperature	Light				Dark			
	Day 30	Day 60	Day 90	Day 120	Day 30	Day 60	Day 90	Day 120
5°C-20°C	25	21	24	22	26	23	20	17
10°C-20°C	22	18	22	17	1	25	28	12
10°C-25°C	25	27	21	15	23	28	19	21
15°C-25°C	18	25	26	22	22	30	19	18
15°C-30°C	18	20	21	23	21	21	16	32
20°C-25°C	24	26	26	18	24	18	19	13
20°C-30°C	28	25	21	16	20	29	18	15
23°C-33°C	23	16	20	0	19	14	17	13

* Average of four replications each at 7, 14, and 21 days.

TABLE 5B. Effects of various temperatures and light and dark regimes on percent * viability of *Ipomopsis rubra* stored at room temperature.

Temperature	Light				Dark			
	Day 30	Day 60	Day 90	Day 120	Day 30	Day 60	Day 90	Day 120
5°C-20°C	68	60	73	84	65	69	69	82
10°C-20°C	74	67	74	74	65	59	71	81
10°C-25°C	72	69	72	85	61	63	76	89
15°C-25°C	75	63	80	81	69	61	66	86
15°C-30°C	72	46	58	64	63	32	39	51
20°C-25°C	76	68	71	81	49	40	54	66
20°C-30°C	79	70	68	68	48	53	50	66
23°C-33°C	77	55	67	72	56	31	55	65
Pre-germ TZ	87	84	85	97				

*Average of four replications.

TABLE 6A. Effects of various temperatures and light and dark regimes on percent * germination of refrigerated *Ipomopsis rubra* seeds.

Temperature	Light				Dark			
	Day 30	Day 60	Day 90	Day 120	Day 30	Day 60	Day 90	Day 120
5°C-20°C	47	50	55	50	48	50	52	47
10°C-20°C	54	55	59	51	46	52	50	54
10°C-25°C	53	52	56	52	46	51	49	51
15°C-25°C	50	51	57	51	47	48	56	45
15°C-30°C	43	45	46	40	38	43	51	23
20°C-25°C	49	48	55	47	44	48	47	54
20°C-30°C	42	49	54	46	42	40	48	47
23°C-33°C	54	36	39	41	40	36	48	35

* Average of four replications each at 7, 14, and 21 days.

TABLE 6B. Effects of light and dark regimes and varying temperatures on percent * viability of refrigerated *Ipomopsis rubra* seeds.

Temperature	Light				Dark			
	Day 30	Day 60	Day 90	Day 120	Day 30	Day 60	Day 90	Day 120
5°C-20°C	64	78	70	76	64	82	70	76
10°C-20°C	67	78	78	74	66	78	67	79
10°C-25°C	73	79	66	74	62	80	65	78
15°C-25°C	66	78	73	75	64	75	71	73
15°C-30°C	59	66	56	80	57	69	61	67
20°C-25°C	73	71	75	73	68	74	73	74
20°C-30°C	61	68	77	69	65	70	68	74
23°C-33°C	71	62	65	69	60	56	71	66
Pre-germ TZ	91	88	91	93				

*Average of four replications.

Rudbeckia mollis

Trials were initiated on 10/05/04 and terminated on 9/10/05. Seeds were treated the same as *I. rubra* and germination and corresponding results are presented in tables 7A to 9B. Although in both room temperature- and refrigerated-stored seeds there were an initial significant difference in germination and viability in light versus dark in the first 30 days (= 7, 14, and 21 days), there was no major difference in the following periods (Table 8A and 8B; 9A and 9B). However, in the stratified (buried) seeds there was as a drastic drop in the 60 day trials in both light and dark. The apparent partial dormancy, however, was overcome in the following periods. Except for the 90 day trials there was a significant drop in germination when the temperature difference was 10 or 15°C (15/25 °C and 15°C /30°C) and also in (23/33°C) regime (Table 7A). Similar to *I. rubra*, there does not appear to be any major difference in germination or viability between room temperature- and refrigerated-stored seeds (Tables 8A to 9B), but stratification appears to have a negative long-term effect (Table 7A and 7B).

As a practical matter, based on data presented, seed of *R. mollis* may be sown on any time of year. Drought and excessive heat may be the limiting factors in rapid uniform germination. Although seeds remained viable during the experimental period additional research is necessary to determine their long-term longevity in room temperature and under refrigeration.

TABLE 8A. Effects of various temperatures and light and dark regimes on percent* germination of *Rudbeckia mollis* stored at room temperature.

Temperature	Light												Dark																	
	Day			Day			Day			Day			Day			Day			Day			Day								
	30	60	90	120	150	180	210	240	270	300	30	60	90	120	150	180	210	240	270	300	30	60	90	120	150	180	210	240	270	300
5°C-20°C	30	38	40	33	39	39	36	45	56	50	6	32	43	45	32	51	39	35	55	45	7	52	49	43	49	50	57	35	57	52
10°C-20°C	42	65	59	50	52	58	49	49	56	57	15	43	55	47	52	53	50	44	55	47	2	46	51	48	51	66	48	56	59	52
10°C-25°C	45	54	57	50	50	53	57	54	49	51	1	24	38	45	42	52	38	43	49	36	3	53	51	44	47	55	41	50	53	50
15°C-25°C	40	53	51	56	50	55	51	51	58	59	8	21	51	28	44	57	50	50	52	48	7	18	34	26	26	30	35	21	48	24
15°C-30°C	25	29	43	36	40	56	53	47	53	45																				
20°C-25°C	27	58	52	55	55	60	56	58	59	50																				
20°C-30°C	35	37	58	32	58	59	55	59	54	58																				
23°C-33°C	13	37	52	43	45	48	52	47	53	47																				

* Average of four replications each at 7, 14, and 21 days.

TABLE 8B. Effects of various temperatures and light and dark regimes on percent* viability of *Rudbeckia mollis* stored at room temperature.

Temperature	Light												Dark																	
	Day			Day			Day			Day			Day			Day			Day			Day								
	30	60	90	120	150	180	210	240	270	300	30	60	90	120	150	180	210	240	270	300	30	60	90	120	150	180	210	240	270	300
5°C-20°C	30	41	43	42	44	46	54	56	58	56	6	37	48	52	37	61	56	43	62	55	11	59	53	50	58	54	62	50	60	59
10°C-20°C	47	71	64	52	58	65	62	57	59	65	22	46	59	51	57	59	59	56	58	57	5	48	53	51	56	72	55	63	64	60
10°C-25°C	53	59	62	55	52	61	68	62	57	59	5	30	45	52	49	58	46	51	53	41	5	57	54	48	55	61	50	57	56	50
15°C-25°C	52	57	55	57	55	61	60	54	64	64	8	27	56	36	49	61	54	57	54	53	9	35	39	28	31	38	42	25	53	33
15°C-30°C	25	37	48	40	46	62	62	54	58	55																				
20°C-25°C	30	63	55	59	63	65	61	63	62	51																				
20°C-30°C	41	44	63	47	64	62	62	61	56	60																				
23°C-33°C	17	45	53	46	48	51	55	49	53	52																				
Pre-germ TZ	81	82	77	80	72	76	72	76	79	82																				

*Average of four replications.

TABLE 9A. Effects of light and dark regimes and varying temperatures on percent* germination of *Rudbeckia mollis* stored in refrigerator.

Temperature	Light												Dark											
	Day			Day			Day			Day			Day			Day			Day			Day		
	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	
	30	60	90	120	150	180	210	240	270	300														
5°C-20°C	14	60	56	56	57	60	69	65	64	53														
10°C-20°C	26	68	60	56	66	59	68	61	58	54														
10°C-25°C	41	65	57	56	67	54	62	68	64	66														
15°C-25°C	36	61	63	69	73	53	67	66	60	67														
15°C-30°C	12	50	50	53	55	54	52	45	56	55														
20°C-25°C	45	52	59	61	64	69	61	61	64	65														
20°C-30°C	29	60	58	57	61	63	58	63	62	70														
23°C-33°C	13	41	50	54	57	51	58	52	57	63														

* Average of four replications each at 7, 14, and 21 days.

TABLE 9B. Effects of light and dark regimes and varying temperatures on percent* viability of *Rudbeckia mollis* stored in refrigerator.

Temperature	Light												Dark											
	Day			Day			Day			Day			Day			Day			Day			Day		
	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	
	30	60	90	120	150	180	210	240	270	300														
5°C-20°C	28	75	56	64	69	75	75	68	69	64														
10°C-20°C	36	71	64	62	72	64	70	65	65	58														
10°C-25°C	50	72	58	64	73	66	67	71	67	70														
15°C-25°C	42	67	65	74	77	58	73	68	65	71														
15°C-30°C	20	71	54	62	61	61	58	50	63	70														
20°C-25°C	50	56	62	68	69	70	62	64	66	68														
20°C-30°C	34	64	58	59	65	66	62	63	65	73														
23°C-33°C	29	45	51	57	68	56	60	52	61	67														
Pre-germ TZ	83	66	83	69	82	77	77	78	73	71														

*Average of four replications.

Gaillardia pulchella

Trials initiated on April 28, 2005 and terminated on September 8, 2005. Light or dark do not appear to significantly influence germination percentage irrespective of temperature exposure. The highest germination rate, however, occurred at 20 C to 30 C which corresponds to early spring germination in Florida. There is a striking correspondence between number of buried germinated seeds (Table 10A) and viable seeds examined with TZ (Table 10B). This indicates that viable Gaillardia seed germinate readily within a short time period after planting.

By contrast, both refrigerated seeds and those stored in room temperature had a profound and seemingly significant effect on both germination (Tables 11A and 12A) and viability (Tables 11B and 12B) maintenance with time. Temperature variation in incubators had little effect on germination. We regret that there was insufficient time for determination of the viability for longer periods when seeds are kept under refrigeration.

TABLE 10A. Effects of various temperatures and light and dark regimes on percent * germination of burried *Gaillardia pulchella* seeds.

Temperature	Light				Dark			
	Month 0**	Month 1	Month 2	Month 3	Month 0	Month 1	Month 2	Month 3
5°C-20°C	11	4	0	0	13	2	0	0
10°C-20°C	14	3	0	0	15	2	0	0
10°C-25°C	13	1	0	0	13	4	0	0
15°C-25°C	9	2	0	0	11	3	0	0
15°C-30°C	8	1	0	0	9	3	0	0
20°C-25°C	21	3	0	0	11	2	0	0
20°C-30°C	11	2	0	0	15	3	0	0
23°C-33°C	12	2	0	0	13	1	0	0

* Average of four replications each at 7, 14, and 21 days.

**Control, unburied seed exposed to various temperatures and light/dark cycle.

TABLE 10B. Effects of various temperatures and light and dark regimes on percent * viability of burried *Gaillardia pulchella* seeds.

Temperature	Light				Dark			
	Month 0**	Month 1	Month 2	Month 3	Month 0	Month 1	Month 2	Month 3
5°C-20°C	11	6	0	0	14	2	0	0
10°C-20°C	14	3	0	0	15	2	0	0
10°C-25°C	14	1	0	0	14	4	0	0
15°C-25°C	9	2	0	0	11	3	0	0
15°C-30°C	9	1	0	0	10	3	0	0
20°C-25°C	21	4	0	0	12	3	0	0
20°C-30°C	12	2	0	0	15	4	0	0
23°C-33°C	12	2	0	0	13	1	0	0
Pre-germ TZ**	21	4	0	0				

*Average of four replications.

**Control, unburied seed exposed to various temperatures and light/dark cycle.

TABLE 11A. Effects of various temperatures and light and dark regimes on percent * germination of *Gaillardia pulchella* seeds stored at room temperature.

Temperature	Light				Dark			
	Month 1	Month 2	Month 3	Month 4	Month 1	Month 2	Month 3	Month 4
5°C-20°C	24	24	17	23	16	23	19	18
10°C-20°C	24	21	26	22	20	22	22	30
10°C-25°C	21	19	21	18	24	25	22	22
15°C-25°C	38	19	18	23	40	17	25	20
15°C-30°C	35	22	22	24	43	20	19	1
20°C-25°C	29	28	19	18	24	14	20	20
20°C-30°C	23	15	19	28	12	24	22	19
23°C-33°C	20	23	19	14	14	19	21	11

* Average of four replications each at 7, 14, and 21 days.

TABLE 11B. Effects of various temperatures and light and dark regimes on percent * viability of *Gaillardia pulchella* seeds stored at room temperature.

Temperature	Light				Dark			
	Month 1	Month 2	Month 3	Month 4	Month 1	Month 2	Month 3	Month 4
5°C-20°C	26	24	17	23	16	23	19	18
10°C-20°C	24	21	26	22	20	22	22	30
10°C-25°C	22	19	21	18	24	25	22	22
15°C-25°C	39	19	18	23	40	17	25	20
15°C-30°C	35	22	23	24	43	21	19	17
20°C-25°C	29	28	19	18	24	14	20	20
20°C-30°C	23	15	19	28	12	24	22	19
23°C-33°C	20	23	19	14	14	19	21	11
Pre-germ TZ**	26	18	24	18				

*Average of four replications.

TABLE 12A. Effects of various temperatures and light and dark regimes on percent * germination of *Gaillardia pulchella* stored in refrigerator (40°F).

Temperature	Light				Dark			
	Month 0**	Month 1	Month 2	Month 3	Month 0	Month 1	Month 2	Month 3
5°C-20°C	27	25	30	33	25	30	34	34
10°C-20°C	29	30	29	26	34	26	29	30
10°C-25°C	34	25	24	25	21	30	29	28
15°C-25°C	28	29	24	25	31	31	26	23
15°C-30°C	31	26	29	34	27	36	21	32
20°C-25°C	25	22	34	41	29	27	30	27
20°C-30°C	26	30	25	25	26	30	21	22
23°C-33°C	27	22	26	21	23	26	23	20

* Average of four replications each at 7, 14, and 21 days.

**Seeds not refrigerated prior to exposure to various temperatures and light/dark cycle.

TABLE 12B. Effects of light and dark regimes and varying temperatures on percent * viability of *Gaillardia pulchella* stored in refrigerator (40°F).

Temperature	Light				Dark			
	Month 0**	Month 1	Month 2	Month 3	Month 0	Month 1	Month 2	Month 3
5°C-20°C	27	25	30	33	26	30	34	34
10°C-20°C	29	30	29	26	34	26	29	30
10°C-25°C	35	25	24	25	21	30	29	28
15°C-25°C	28	29	25	25	31	31	26	23
15°C-30°C	31	26	29	34	27	36	21	32
20°C-25°C	25	22	34	41	30	27	30	27
20°C-30°C	27	30	25	25	27	30	21	22
23°C-33°C	28	24	26	21	23	26	23	20
Pre-germ TZ**	29	29	31	25				

*Average of four replications.

**Seeds not refrigerated prior to exposure to various temperatures and light/dark cycle.

General Comments

Examination of germination and viability data for all wildflower seeds examined thus far in our studies indicate that, with all due respect to Baskin and Baskin (2001), burying seeds in sand, placing them outdoors, and irrigating them weekly does not necessarily emulate effect of natural environmental factors on germination, at least not for all plants. Variable environmental factors (temperature, rainfall, etc.) have profound effects on seed viability and germination and strict regulated experimental procedures do not agree with natural changes. Seeds may germinate and die or go through secondary dormancy and perhaps never germinate (BD's opinion). On several occasions we observed seeds germinate while still buried under sand. All required environmental factors including temperature, light (presence or absence), and oxygen are met by using germination incubators. Many seeds germinate when buried but are destroyed making it difficult to determine actual viability over time.

***Ipomopsis rubra* and *Rudbeckia mollis* Seed Production Plots – Weed Management**

Methods

Weed management regimes were evaluated for *Ipomopsis rubra* (Standing Cypress) and *Rudbeckia mollis* (Softhair Coneflower) in a landscape fabric seed production system. On April 5, 2005, transplants of both species were planted in 10-ft x 2-inch weed free plots. The narrow plots were created by a 2-inch gap between adjacent strips of landscape fabric. The experiment was a randomized complete block within a species, with one species per row. Nine plants were spaced 1 ft on-center within a replication (10-ft plot), with four replications per weed management regime. Three weed management regimes evaluated were: 1 – Snapshot TG (isoxaben + trifluralin; 200 lb product per acre) applied preemergent + Vantage (sethoxydim; 60 oz product per acre) as needed for postemergent grass control; 2 – Snapshot TG (isoxaben + trifluralin; 200 lb product per acre) applied preemergent + Vantage (sethoxydim; 60 oz product per acre) as needed for postemergent grass control + Raptor (imazamox; 6 oz product per acre) for nutsedge control; 3 – hand weeded control (once per month). Snapshot was applied to weed free plots on April 21 and June 3. Raptor was applied on May 5, and Vantage was applied on May 20. Weed control and phytotoxicity were evaluated periodically until when evaluations had to be discontinued due to the high level of disease incidence (see below).

Time required for hand weeding the narrow 10-ft long plots was also recorded to gain some insight into the amount of labor required for weeding. Weeds are a significant pest, especially during establishment of new production plots.

Results

Despite the use of fungicides to minimize disease in these species, disease incidence in July became high enough in July such that the experiments with both species had to be terminated. Both species are native to sandhills habitats and our production plots were in an Orangeburg loamy fine sand, which is a "heavier" soil than would be found in sandhills. We had thought that the use of fungicides would have prevented or substantially limited diseases but the very wet spring may have facilitated disease incidence. Hence, we recommend that these species only be grown in production plots with deep sandy soils.

Weed control in Regime 1 (Snapshot + Vantage), as of May 4, was rated as good to excellent in production plots of both species. For *Ipomopsis*, weed control was only fair from May 19 through July 1; weed control was poor by July 27. In *Rudbeckia*, weed control was fair on May 19; no further weed control ratings were performed due to disease. Snapshot provided control of carpetweed (*Mollugo* sp.) and spurge (*Chamaesyce* sp.), and seemed to reduce the size of nutsedge (*Cyperus* sp.). The addition of Raptor (Regime 2) resulted in good to excellent control in production plots of both species on May 19 (2 weeks after application of Raptor) and fair to good weed control in *Ipomopsis* plots on July 1; by July 27 weed control was poor in *Ipomopsis* plots. Raptor helped to suppress growth of new nutsedges but did not seem very effective on nutsedges that existed when Raptor was applied. Crabgrass (*Digitaria* sp.) and goosegrass (*Eleusine indica*) that occurred in Regime 1 and 2 plots were controlled by the postemergence application of Vantage.

Through July 27, Snapshot caused only minimal injury to both species (plants were slightly smaller than normal) but injury was deemed acceptable. In contrast, Raptor caused moderate to

severe injury (stunting and necrosis) to both species. Vantage did not cause any injury. It should also be noted that the fungicides (Heritage, Medallion, Cleary's 3336) used to control disease(s) might have reduced plant height of *Ipomopsis*. Plants seemed smaller than anticipated due to branching (plants normally have only one main shoot unless the apical bud dies or is removed) and/or stunting.

The amount of time required for hand weeding of nonherbicide 10-ft plots on May 19 (about 6 weeks after transplanting) was ~24 min in *Ipomopsis* plots and about 19 min in *Rudbeckia* plots. The difference in time required for weeding probably was because *Rudbeckia* were larger than *Ipomopsis* and hence were competitive with weeds. On July 1, about 7 min was required to hand weed *Ipomopsis* plots; *Rudbeckia* was not hand weeded on July 1 because too many plants had died. The time required for hand weeding clearly shows the need for an effective herbicide regime during establishment. Once plants are established and much larger, they are better able to compete with weeds.

In conclusion, Snapshot can be used during establishment of *Ipomopsis* and *Rudbeckia* production plots (via transplants) to provide some weed control. However, some hand weeding will be necessary, especially to control nutsedges. Vantage can be used to control grass weeds that emerge. Raptor, which was evaluated since it is labeled for nutsedge control, is not an acceptable option for use in *Ipomopsis* and *Rudbeckia* production plots because it is too phytotoxic.

Evaluating Seed Viability of *Coreopsis floridana*

The main goal of this study was to determine whether normal, white, turgid embryos of *Coreopsis floridana* (Florida Tickseed) are viable as is currently thought.

Methods

Seed of *Coreopsis floridana* were harvested from containerized plants in early November 2004. Two weeks later seed were subjected to pregermination tetrazolium (TZ) testing (1% TZ at 90F for 24 hr in dark) and germination testing. There were four 50-seed replications for the pregermination TZ and germination tests. Nongerminated seed were subjected to TZ testing as described above. Embryos extracted from seed that had been subjected to TZ testing were classified as turgid and either white, partially stained pink or red, fully stained pink, or fully stained red; empty achenes and mushy seed were classified as nonviable.

Results

The germination test correlated well with the results of pregermination TZ test (Figure 1). The total number of the seed that were normal and turgid, regardless of staining, nearly equaled the total germinated seed (42.5 vs. 43.5). None of the nongerminated seed were viable. Similar results with other *Coreopsis* species leads us to conclude that if a *Coreopsis* embryo is white, turgid, and otherwise appears normal, it is viable.

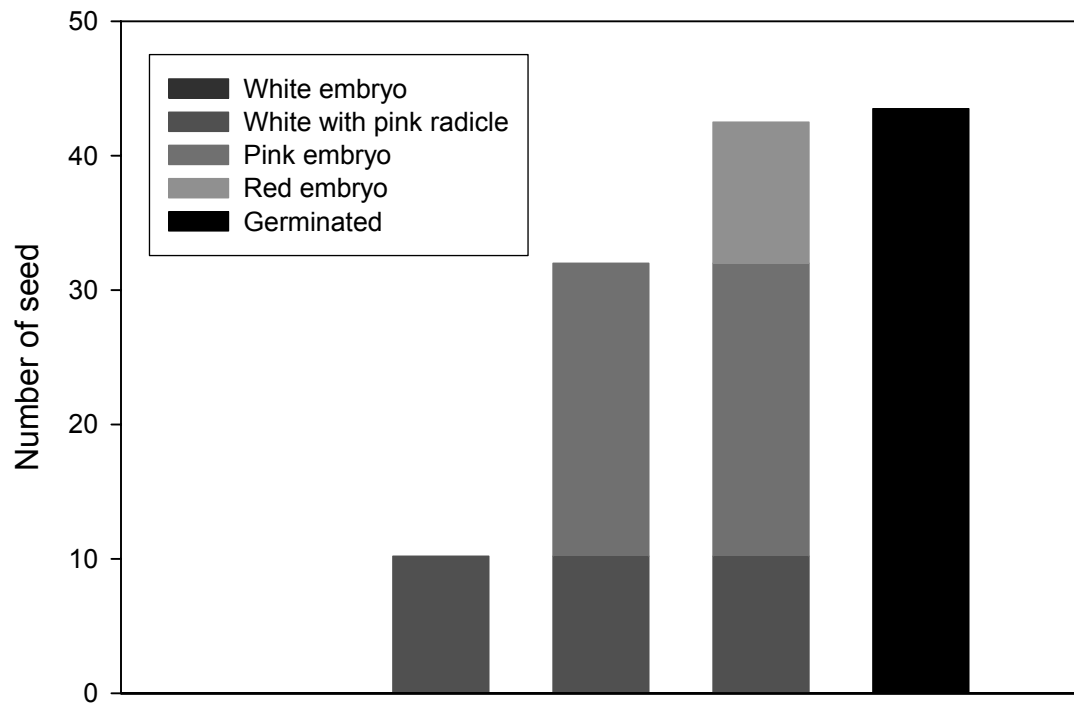


Figure 1. Germination and viability (tetrazolium test) of intact *Coreopsis floridana* seed.