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VIABILITY OF NATIVE FORB SEED STORED UNDER 2 DIFFERENT ENVIRONMENTS

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Abstract: The ability to maintain viability in seeds of native forbs for long periods of time is important to the seed industry and prairie restoration efforts. Seeds stored in eastern Kansas in an uncontrolled environment, subjected to wide fluctuations in ambient temperature and humidity, are known to experience reduced longevity. We examined seeds of 7 prairie forbs native to the Central Great Plains that were stored under two different storage environments in Manhattan, Kansas, to determine what effect the two storage conditions had on the longevity of seed viability. Three of the species stored in a controlled environment (low temperature, relative humidity, rodent and insect free) remained viable after 26 yr of storage. The longevity of seeds stored in an uncontrolled environment varied from 2 to 10 yr. Of all the species tested, seeds of native legumes maintained the greatest level of viability under both storage conditions.


Key words: Asteraceae, Fabaceae, Lamiaceae, native forbs, seed storage, seed viability.

Long-term storage facilities can provide a source of valuable seed stocks without maintaining large numbers of plants for seed production (Fig. 1). Bass (1980) emphasized the importance of maintaining small samples of many kinds of seeds, indefinitely, for breeding purposes. Seeds stored in environmentally uncontrolled warehouses are, however, subject to wide fluctuations in temperature and humidity in eastern Kansas, where the average annual humidity ranges from 51 to 81% and average annual temperatures range from -8.6 to 33.2° C (16.5 to 91.8° F). Such conditions are detrimental to the longevity of grass seeds in storage (Priestly et al. 1985).

In 1973, the USDA-Soil Conservation Service built a long-term environmentally controlled seed storage facility to preserve valuable seed stocks at the Plant Materials Center, Manhattan, Kansas. The rodent-proof facility is temperature and humidity controlled. Although the storage requirements for many plant species are known, little information is available documenting the benefits of a controlled versus an uncontrolled environment for storing seeds of native forbs. Harrington's (1960) rule of thumb is that the percent relative humidity (RH) + temperature in degrees Fahrenheit (F) should not exceed 100 for safe seed storage. Rincker and Maguire (1979) and Rincker (1981) found that even after 14 yr germination was greater than 80% for several grasses stored at -15° C (5° F) and 60% RH (Ackigoz and Knowles 1983). Attention has focused primarily on range and forage grasses, forage legumes, vegetable crops, and common weeds such as curly dock (Rumex crispus L.) and red root pigweed (Amaranthus retroflexus L.). Information on long-term storage of native forbs is lacking. Our objective was to evaluate how different storage conditions (an uncontrolled
storage environment vs. a controlled storage environment) affects the germination rates of stored native forb seed over time.

MATERIALS AND METHODS

Seeds were harvested in 1979 and processed the winter of 1980, except for round-head lespedeza which was harvested in 1985 and processed in 1986. Seed storage facilities consisted of a seed storage building with a controlled environment and an uninsulated warehouse without a controlled environment. The seed storage building was all metal construction and insulated throughout. The storage room itself was sealed to exclude outside air and humidity.

We controlled temperature and humidity in the seed storage building using a UNA-DYN, model A30T, (Universal Dynamics, Inc.) two tower, desiccant bed dehumidifier and a standard air conditioning unit. We set temperature controls to maintain 18° C (64.4° F) summer, 13° C (55.4° F) fall-spring, and -1 to 7° C (30.2 to 44.6° F) in the winter. Relative humidity was maintained between 10 and 20%. We used a hygro-thermograph, model 613A, (Henry J. Green Instruments, Inc.) to monitor temperature and humidity. The warehouse was wood frame construction on a concrete slab with clapboard siding, and was subject to wide fluctuations in temperature and humidity. The environment in the warehouse was not monitored.

We divided each seed lot into two equal 2.27 kg portions after each lot was processed and placed them in burlap and/or cotton duck bags for storage. We placed a portion of each lot in the warehouse in a steel drum to prevent rodent damage. We placed pest strips containing 2-2 dichlorovynyl dimethyl phosphate (Vapona) (20% active ingredient) in each barrel for insect control. We placed the second portion of each seed lot on shelves inside the seed storage building without rodent or insect control.
The initial purity and germination test and subsequent germination tests were conducted in accordance with the Association of Official Seed Analysts (AOSA) Rules for Seed Testing (AOSA 1978). The initial germination test results would serve as a baseline for comparing subsequent tests results, Table 1. We drew samples (50 g) of all seed lots on an annual basis (except 1990 and 1992) and sent them on an annual basis to the Kansas State Board of Agriculture Seed Laboratory for standard germination tests through 1993, and to the Kansas Crop Improvement Association thereafter. Subsequent germination test results were compared to the initial germination test. We removed seed lots from the study when germination test results for that lot dropped below 10% of the original test.

RESULTS

We plotted germination curves for each species in the study. We grouped the various species according to plant family to compare similarities and dissimilarities in their germination curves over time. Maximilian sunflower seeds stored under controlled environmental conditions (CEC) remained viable and germinated up to 25% after 26 yr of storage. The viability of Maximilian sunflower seeds stored under uncontrolled environmental conditions (UEC) (ambient temperature and humidity) was reduced to 1% after 5 yr of storage (Fig. 2). The initial germination test results for false sunflower was 78%. The germination steadily dropped off over the years that followed. The slope of the curve was greater for the UEC than for the CEC. By year 6 of the study most of the viability has been lost in the UEC while the CEC maintained 69% viability. After 25 yr 6% of the seed remained viable (Fig. 3). The initial germination for grayhead prairie coneflower was 82%, which increased to 89% after one year in storage before declining rapidly over the next 2 yr in the UEC while seeds in the CEC declined slowly over time to 39% viability (Fig. 4) after 10 yr in a CEC. Some seed was still viable through year 17 of the study. Initially the viability of seeds of prairie blazing star was 56% but declined rapidly in the first 2 yr of the study. The seeds in the UEC lost most of their viability by the second year, while seeds in the CEC were 17% viable. Some viability existed up to 16 yr in the CEC (Fig. 5). Purple prairie clover started out with a germination of 81% and remained around the 80% level for the first 4 yr in the UEC began to decline at year 5 and testing was terminated after 9 yr of storage when the germination dropped to 18%. In the CEC viability was maintained at or above the 80% level for 14 yr before fluctuating. After 25 yr germination was at 68%, Fig. 6. The initial germination of round-head lespedeza was 83%, it increased in subsequent years and maintained viability at or above the 80% level (often in the 90’s) for the first 12 yr before declining and leveling out at about 70% for 3 yr, dropping to 43% at year 16 and then improving to 80% plus in year 17 and back to 70% by year 20 in the CEC. In the UEC germination dropped off after 1 year before leveling off for the next 2 yr before declining. It was dropped from the study with 18% viability remaining, Fig. 7. The initial germination of pitcher sage was 30%. In the UEC the germination was reduced by one-half at the end of year 3 and dropped to 5% by year 5 (withdrawn from the study at that point). In the CEC, viability

Table 1. Plant families and genera represented in the seed storage study, Manhattan, Kansas.

<table>
<thead>
<tr>
<th>Family</th>
<th>Scientific name</th>
<th>Common name</th>
<th>Harvest date</th>
<th>Processed date</th>
<th>Purity (%)</th>
<th>Initial germination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asteraceae</td>
<td>Helianthus maximiliani</td>
<td>Maximilian sunflower</td>
<td>11/1979</td>
<td>02/1979</td>
<td>99.66</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>Helianthus helianthoides var. scraba</td>
<td>false sunflower</td>
<td>08/1979</td>
<td>01/1979</td>
<td>98.72</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>Liatris pycnostachya</td>
<td>prairie blazing star</td>
<td>10/1979</td>
<td>02/1979</td>
<td>96.80</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>Ratibida pinnata</td>
<td>grayhead prairie coneflower</td>
<td>09/1979</td>
<td>02/1979</td>
<td>82.02</td>
<td>82</td>
</tr>
<tr>
<td>Fabaceae</td>
<td>Dalea purpurea</td>
<td>purple prairie clover</td>
<td>07/1979</td>
<td>01/1979</td>
<td>98.61</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>Lespedeza capitata</td>
<td>round-head lespedeza</td>
<td>10/1985</td>
<td>02/1986</td>
<td>99.77</td>
<td>83</td>
</tr>
<tr>
<td>Lamiaceae</td>
<td>Salvia azurea var. grandiflora</td>
<td>pitcher sage</td>
<td>10/1979</td>
<td>02/1979</td>
<td>98.57</td>
<td>30</td>
</tr>
</tbody>
</table>
Fig. 2. Annual seed test results for Maximilian sunflower at Manhattan, Kansas, following 26 yr under 2 different environments.

Fig. 3. Annual seed test results for false sunflower at Manhattan, Kansas, following 26 yr under 2 different environments.
Fig. 4. Annual seed test results for grayhead prairie coneflower at Manhattan, Kansas, following 17 yr under 2 different environments.

Fig. 5. Annual seed test results for prairie blazing star at Manhattan, Kansas, following 17 yr under 2 different environments.
Fig. 6. Annual seed test results for purple prairie clover at Manhattan, Kansas, following 26 yr under 2 different environments.

Fig. 7. Annual seed test results for round-head lespedeza at Manhattan, Kansas, following 20 yr under 2 different environments.
DISCUSSION

Seed germination, when displayed over time for a species indicated a trend in viability for the seed stock. For example, we noted similar patterns under controlled storage conditions for 3 Asteraceae family members, Maximilian sunflower, false sunflower and grayhead prairie coneflower (Fig. 2-Fig. 4) though the germination rate was not the same at any given point. The percent germination for Maximilian sunflower, false sunflower and grayhead prairie coneflower at 1 year was 70%, 74%, and 89%, respectively. After 5 yr, it was 72%, 61%, and 70% and after 10 yr of storage, the germination rate was 61%, 54%, and 39%. After year 15, the germination rate stood at 45%, 36%, and 11%, and after 20 yr it was 17%, 11%, and 0%. Yet the slope of the linear regression was the same for the 3 species under the CEC. Therefore fitting a pattern, this suggests a trend in viability for the Asteraceae family members in a CEC. The same could not be said for seeds in the UEC but the decline in germination rate was rapid for all 3 species. While prairie blazing star deviated from this pattern initially, the germination rate dropped rapidly the first 2 yr. Similarities appear by the fifth year of storage when the germination rate rebounded to 24% from a low of 13% in year 3. By year 10 the germination rate was 10% and by year 15 it had dropped to just 3% and no viable seed remained by year 17. The slope of the linear regression was not the same; however, the steady decline in viability over time was similar to the other Asteraceae family members. The slope of the linear regression for both species in the Fabaceae family showed similar trends that suggest a pattern where one could predict a survival curve for the 2 native legumes as illustrated in Fig. 6 and Fig. 7. Seeds stored in the UEC declined rapidly for all species in the study except for purple prairie clover.

Although the rate of decline for Fabaceae family members was not the same, the patterns were similar under the CEC. Given a high germination rate initially, it appears from these results that one can expect a high level of viability.
for many years in the future under CEC. In the case of purple prairie clover, it is safe to store seed in the UEC for 5 yr. However, this was not the case for round-head lespedeza. Storing seeds of the Fabaceae family members was more successful due to the hard seed that is prevalent in native legume species. The breakdown of the germination test results in the purple prairie clover in the CEC and UEC, Fig. 9 and Fig. 10, respectively, reveals the amount of viability coming from the standard germination and from hard seed. Seeds in the UEC dwindled to just 1% standard germination by year 8 with hard seed making up the remainder of viable seed. In stark contrast, seeds in CEC maintained viability in both standard germination and hard seed for 26 yr. The benefits of storing seeds in a controlled environment are apparent and the importance of such a facility is invaluable to plant research and plant preservation efforts.

Though the slopes of the linear regression did not fit a pattern in the UEC, a rapid decline in viability was observed for all species. This fact is important to seedsman who are unable to control storage environment or do not have facilities to do so. Native forb seeds need to be utilized rather quickly to avoid loss in viability and subsequently failure to obtain a stand of plants.

Our initial germination test results (time zero), Table 1, were slightly lower than subsequent tests for all species in the CEC except prairie blazing star and false sunflower. This was also observed in grayhead prairie coneflower and purple prairie clover in the UEC. A low germination rate was expected for pitcher sage (Fig. 8), as this is typical for the species (KCIA, 1976). The negatively sigmoid curves of seeds in UEC showed a rapid deceleration indicative of seeds deteriorating during storage (Roberts 1972). Species stored in the UEC experienced a rapid decline in viability and were dropped between 2 and 10 yr into the study. In contrast, the viability of seeds stored in the CEC declined gradually. Hard seed helped the legumes maintain high germination rate levels in the CEC as illustrated in Fig. 9. This was also true for purple prairie clover the first 4 yr in the UEC (Fig. 10). Maximilian sunflower was the most successful non-legume with a germination rate of 40% after 23 yr in the CEC. The implications are
that one can use these trends to predict the shelf life for a given species under certain storage conditions.

We identified variables that could affect the test results. Fluctuations in year-to-year germination test results may be due to the set of storage conditions: temperature, humidity, and moisture content of the seed, at the time of the test. Predation from rodents and insects could also be a factor if adequate protective measures are not in place. A lack of uniformity in the seed lot is especially a problem in non-flowable seed stocks and inconsistency in sampling procedures. Variation in germinator environment and inconsistency in handling the seed sample and reading the test create opportunities for variation in the laboratory.

CONCLUSIONS

All seed lots stored under CEC were viable for at least 17 yr. Three of the seed lots remained viable after 25 yr of storage. All seed lots stored under UEC lost their viability with the last seed lots being dropped from the study after 10 yr of storage. The legumes stayed viable longer and had higher germination rates than the other forbs. Seeds of Maximilian sunflower had the best viability of the non-legumes 15 yr into the study, followed by false sunflower. Seeds of prairie blazing star had the shortest shelf life of all species in the study under UEC. It is possible to extend the storage life of seeds of all the forb species we studied under controlled environmental conditions for many years. Seed stored in uncontrolled environments should not be held more than 1 to 4 yr because of their rapid decline in viability.

LITERATURE CITED


