Medium- and Long-Term Storage for Spice Seeds – Part II

M. Kretschmer
Research Station, POB 1154,
D65358 Geisenheim, Germany

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Abstract

The tested spice seeds of three origins (I, II, III) were stored for 6 years (*Anthriscus cerefolium* III) and 20 years (*Rumex acetosa* I, II, III, *Sanquisorba minor* I, II) respectively, at +10/30, +5 and –20 °C air-tight in 2 x 100 µ PE bags. The seed moisture content of all seeds ranged from 7,4 to 9,9 %. Germination was tested at temperatures from 10 to 30°C (steps of 5°C). High germination results were found for *A. cerefolium* (III) seeds after 6 years in all storage variants. Seeds of *R. acetosa* (II, III) germinated in variant –20 after 20 years to a high percentage at 10 to 25°C. After seven years the germination of seeds of all origins decreased in variant –20 at temperatures 10 and 15°C but later tests revealed an increase. Therefore this pattern indicates a temporary dormancy. For *S. minor* seeds I and II, high germination results were found in variant +5 after 18 and 20 years at germination temperatures from 15 to 25 °C.

INTRODUCTION

In all civilisations spices were and are still used as completion and enrichment of human food to enhance its digestibility. The production of spices took place in Babylon and Assyria for instance in special laid out gardens and later during the Middle Ages in monasteries (Gööck, 1977). Consequently spices were coming along horticultural plants not least because of their small productions areas. Due to the industrialization and the increase of population in Europe and Northern America, the production moved partly to larger agricultural areas in order to supply also the food industry. By cultivating spices of more different species the farmers are also able to enlarge the range of agricultural production. With the increasing commercial production of spices taking place, particularly for the fresh market from the 70s onwards, farmers as well as the official advisory services in Germany have requested data about the seed storage of spices. This requests promoted the first experiments in Geisenheim using seeds of *Anthriscus cerefolium* (chervil), *Rumex acetosa* (sorrell) and *Sanquisorba minor* (burnet). The storage time was calculated for medium-term (5 to 10 years) and for long-term storage conditions (10 to 20 years and more) so as to supply data on the safe conservation of the genetic diversity of these resources.

MATERIAL AND METHODS

Seeds of *A. cerefolium* were stored for 6 years and seeds of *R. acetosa* and of *S. minor* for 20 years in air-tight welded PE-bags at +10/30°C (room, variant +10/30), + 5°C (fridge, variant +5) and –20°C (freezer, variant –20). The seeds used in the experiment were from different origins. As packing, 100 µ PE-bags were chosen and some seed portions were packed with the same material. Between the PE-films, silica gel was added for humidity control. The experiments started in the beginning of 1978 using seeds harvested in 1977. Seed moisture content (smc) was determined following the ISTA's rules with three replicates. Germination tests were carried out in 1978, from 1980 to 1985, and in 1994, 1996 and in 1998 at different germination temperatures ranging from 10 to 30°C (steps of 5°C) always according to ISTA. The average of the first germination results of all temperatures are indicated as basic germination. A germination limit for the storage time was fixed depending on first germination results at different temperatures. All data were subjected to analysis of variance – ANOVA – (P = 5%).

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RESULTS

The smc of *A. cerefolium* seeds was 9,66 and the basic germination 95 % (Table 1). The seeds germinated at temperature from 10 to 25°C between 96 and 98 % and at 30°C to 85 %. The ANOVA revealed in variant +10/30 a result of 83, in variant +5 of 82 and in variant –20 of 87 %. Therefore the germination was preserved very well in variant –20. The decrease in germination in all three variants was only caused by the temperature 30°C. This reduced germination is reflected by the results of storage time (Table 2). High germination was found at 10 to 25°C for 6 years in all variants.

The smc of *R. acetosa* seeds of three origins was extended from 9,86 to 9,89 % and the basic germination for seeds I was 78, for seeds II and III 97 respectively 93 % (Table 3). Seeds I germinate at 10 to 25°C between 79 and 82 %, at 30°C to 66 %, whereas seeds II and III showed at all temperatures a germination of more than 90 %. Consequently the optimal germination temperature range for seeds II and III was more extensive than for seeds I. The ANOVA results ranged from 32 to 44 in variant +10/30, from 54 to 73 in variant +5 and from 65 to 82 % in variant –20. In spite of the high basic germination of seeds II and III seeds II germinated in variant +10/30 and +5 to a higher percentage.

After 7 years, the germination of seeds of all origins was decreasing at 10 and 15°C in variant –20. They germinated only to an average of 27 % whereas after six years it was 81 % (Table 4). Germination tests after 16 years revealed an average of 87 %. This pattern indicates a temporary dormancy only appearing at temperatures 10 and 15°C in variant –20. There were no effects of origin. As table 5 shows the germination limit of 75 % was preserved for seeds I at germination temperatures from 10 to 25°C in all variants between 2 and 3 years. Seeds II and III indicated a high germination mostly at temperatures from 10 to 30°C in variant +10/30 and +5 for 2 to 7 years. In variant –20 the germination of seeds II and III at 10 to 25°C remained unchanged for 20 years. These results indicate the reduction of the optimal germination range to temperatures of 10 to 25°C. In table 5 the temporary dormancy was not considered because of its limited appearance only in variant –20 at 10 and 15°C.

The smc of *S. minor* seeds of two origins was 7,75 and 7,42 % and the basic germination was 77 and 85 % (Table 6). Seeds I germinated at 10 to 25°C between 78 and 82 % and seeds II between 83 and 91 %. 30°C reduced the germination of seeds I and II to 67 % respectively to 75 %. The results of the ANOVA were in +10/30 variant 47 and 57 %, in +5 variant 68 and 78 % and in –20 variant 58 and 63 %. Therefore the highest results for both origins were found in +5 variant. Basic germination as well as germination in every variant was higher for seeds II than for seed I. The higher germination results in variant +5 correspond to the numbers of years in which the germination was also high. Seeds of both origins germinated in variant +10/30 between 2 and 4 years and in variant –20 between 4 and 5 years (Table 7). 30°C reduced germination in all variants considerably. In variant +5 seeds I and II germinated at 10°C during 5 and 6 years of storage to a high percentage. At 15 to 25°C the high germination went on for 18 years or remained after 20 years without any decrease.

In table 1, 3 and 6 the results of the estimation are also being provided. The main factor influencing the storage results of *A. cerefolium* seeds was the germination temperature (B) with 59 % (Table 1). The interaction germination temperature x storage time (BxC) showed an influence of 24 %. For seeds of *R. acetosa* the ANOVA marked out an influence of the factor storage time (C) from 33 to 40 % (Table 3). The influence of the factor storage temperature (A) ranged from 20 to 23 % and the germination temperature (B) from 6 to 20 %. The interaction storage temperature x storage time (AxC) revealed an influence of 17 to 21 %. Similar to the results of *R. acetosa* were those of *S. minor* (Table 6). The ANOVA indicated a high influence of the factor storage time (C) with 46 % for seeds I respectively 53 % for seeds II. The value of the factor storage temperature (A) ranged from 13 to 16 %. The influence of the interaction storage temperature x storage time (AxC) was about 23 %. Altogether the ANOVA revealed high significant differences for the single factors as well as for the interactions.

DISCUSSION

The smc of these more-fat accumulating seeds was between 7,42 and 9,89 % consequently above 5 %. During storage, this content remained unchanged by the PE bags as former results proved (Kretschmer, 2001). Furthermore still high germination was found for *S .minor* in variant +5 and for *R. acetosa* in variant –20 after 18 and 20 years. Seeds of *A. cerefolium* stored for only 6 years showed in all three storage variants high germination results, too. Therefore the high germination results confirm a sufficient smc adjusted by the seed companies (I, II, III). Former results of 6 year storage experiment with different other spice seeds showing a smc between 5,55 and 9,82 % demonstrated also high germination in some storage variants (Kretschmer, 1989). New results of long-term storage at –20°C with more fatty vegetable seeds demonstrated also that an adjustment range of smc can be fixed between 5 to 10 % (Kretschmer, 2001). On the other side Roberts and Ellis (1977) and also Roos (1986) recommend a smc of 5 % for seed storage at –18 or –20°C.

The results of temporary dormancy of *R. acetosa* seeds in variant –20 at the germination temperatures 10 and 15°C were surprising. In contrast to the results of *Solanum melongena* as reported in part I in this Acta Horticulturae there were no origin effects for *R. acetosa* seeds. Because the experiments were continued in the 16th year it is not possible to determine the moment of break down of dormancy for both species.

Another point worth mentioning is that seeds II and III of *R. acetosa* showed a high basic germination with more than 90 % and an almost identical smc of 9,86 (II) respectively 9,89 % (III). Nevertheless during the long-term storage of 20 years differences appeared in variant +10/30 and +5. Similar differing results in the germination pattern were found for *Brassica pekinensis* seeds of three origins also published in part I of this Acta. The developed seed viability equation by Ellis and Roberts (1981) neither include the mentioned differences nor the recognizability of temporary dormancy. The authors wrote: “This new equation may be applied to predict the viability of seed lots to cultivars of species after any period under a very wide range of storage environment”.

The main results of these mostly long-term storage experiments in part I and II were the different changes in germination and also the temporary dormancy for two species. These results could be found because of the use of seeds of three origins for most of the species, the storage of three different temperature conditions and the germination tests of temperatures ranging from 10 to 30°C.

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Tables

Table 1. Influence of storage temperature on germination of *Anthriscus cerefolium* seeds.

origin	smc (%) 1978	basic germ. (%) 1978	storage temperature (°C) +10/30	+5	–20
			germination (%)		
III	9,66	95	83b	82b	87a

Estimation of components of variance	Factor	Astor. temp.	Bgerm. temp.	Cstor. time	AxB	AxC	BxC	AxBxC	Error
	III	1	59	10	1	0	24	1	4

ANOVA

Table 2. Influence of storage temperature and germination temperature on the storage time of *Anthriscus cerefolium* seeds III*.

storage temperature (°C)	+10/30	+5	–20
germ. temp. (°C)		storage time (year)	
10	6	6	6
15	6	6	6
20	6	6	6
25	6	6	6
30	0	0	0

germination limit: 80%; *duration of experiments: 6 years

Table 3. Influence of storage temperature and origin on germination of *Rumex acetosa* seeds.

origin	smc (%) 1978	basic germ. (%) 1978	storage temperature (°C) +10/30	+ 5	–20
			germination (%)		
I	9,86	78	32c	54b	65a
II	9,86	97	44c	73b	82a
III	9,89	93	37c	54b	81a

Estimation of components of variance	Factor	Astor. temp.	Bgerm. temp.	Cstor. time	AxB	AxC	BxC	AxBxC	Error
	I	23	20	37	2	17	5	4	2
	II	22	18	33	3	18	5	5	1
	III	20	6	40	2	21	5	5	1

ANOVA

Table 4. Influence of storage time on average germination at 10 and 15 °C in variant –20 of *Rumex acetosa* seeds of three origins.

storage time (year)	6	7	16
germination (%)	81a	27b	87c

ANOVA

Table 5. Influence of storage temperature, germination temperature and origin on the storage time of *Rumex acetosa* seeds.

storage temperature (°C)	+10/30			+5			–20		
origin	I	II	III	I	II	III	I	II	III
germin. temp.° C				storage time (year)					
10	2	3	3	3	6	6	3	20	20
15	3	3	3	2	6	6	3	20	20
20	3	3	3	3	7	6	2	20	20
25	2	3	3	2	7	5	3	20	20
30	0	3	3	0	2	0	0	2	2

germination limit: seeds I = 75 %, seeds II and III = 80 %

Table 6. Influence of storage temperature and origin on germination of *Sanquisorba minor* seeds.

origin	smc (%) 1978	basic germ. (%) 1978	storage temperature (°C) +10/30	+5	–20
			germination (%)		
I	7,75	77	47c	68a	58b
II	7,42	85	57c	78a	63b

Estimation of components of variance	Factor	Astor. temp.	Bgerm. temp.	Cstor. time	AxB	AxC	BxC	AxBxC	Error
	I	16	7	46	0	24	2	2	3
	II	13	6	53	0	22	1	2	3

ANOVA

Table 7. Influence of storage temperature and germination temperature on the storage time of *Sanquisorba minor* seeds.

storage temperature (°C)	+10/30		+5		–20	
origin	I	II	I	II	I	II
germin. temp. °C)			storage time (year)			
10	4	3	5	6	5	5
15	3	3	20	20	5	5
20	3	3	18	20	5	4
25	2	2	18	18	5	4
30	0	0	0	0	0	0

germination limit: seeds I = 70 %; seeds II = 80 %