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Methods of Breaking Seed Dormancy in Oats

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燕麥의 休眠打破法에 關한 硏究

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ABSTRACT

Dormancy breaking methods were studied on *Avena sterilis* seeds. The treatments were: application of alcohol, hot water, low temperature, pure oxygen, thiourea and gibberellic acid. Thiourea treatment with 3 different concentrations (0.25×10^{-2}M, 0.625×10^{-2}M, 1.25×10^{-2}M) had little effect in breaking dormancy. Gibberellic acid treatment applied at 5ppm, 50ppm, 500ppm were effective and maximum germination was obtained with 500ppm. Low temperature treatment at 3°C for a week in a refrigerator was also very effective in breaking dormancy. Other treatments were not effective. In all cases, primary seeds germinated significantly better than secondary seeds. Different *A. sterilis* strains varied significantly in their response to gibberellic acid treatment. Different concentrations of gibberellic acid also gave significantly different responses in breaking dormancy.

1. INTRODUCTION

Dormancy is found in many of cultivated oats as well as in wild species. Dormant seed will not germinate uniformly after planting, resulting in poor stands and reduced yields. The dormancy of *A. sterilis* delays breeding work with this species because the seed may not germinate for several months after ripening. An effective method of breaking dormancy would permit more rapid incorporation of the *A. sterilis* resistance into adapted types. Although some dormancy breaking methods have been successful with *A. sterilis* under certain conditions, better techniques are needed.

Many workers have attempted to break dormancy by means of either physical or chemical treatments. Naylor and Simpson(4) studied dormany in seed of *A. fatua* using seeds stored for 1 and 24 months. In seed stored 1 month the rate of germination was increased with increased concentration of gibberellic acid over the range(0.02-50)ppm, while in seed stored for 24 months, germination occured much more promptly and in response to a lower range of concentration (0.001-0.1)ppm. Smith and Murphy(6) used a number of physical and chemical treatments for breaking dormancy and found that gibberellin was effective at 100 ppm when seeds were treated for 3 minutes. Corns(2) applied gibberellin to seeds of 19 species of weeds, including wild oats. Gibberellin had a significant effect in overcoming dormancy of wild oats, wild mustard and stinkweed. The best germination of wild oats was obtained by soaking the seeds in 1000ppm solution for 24 hours.

Thompson and Kosar(7) obtained stimulatory effects with sulphur compounds. A 0.5% thiourea solulted in some stimulation of germination in all lots of dormant seed. In some cases, nearly 100% germination was obtained with seed that remained completely dormant

when water alone was applied. Other investigators attempted to break dormancy by oxygen treatment. In a strain of wild oat seed which was very dormant, Black(1) found that germination could be obtained by cutting the seed coat and placing the caryopsis in an atmosphere of 100% oxygen.. Prechilling has been reported by several workers as being effective in overcoming the dormancy of sorghum. Robins et al(5) reported that prechilling at 5°C for 6 days was effective in breaking the dormancy of sorghum seeds. Frey, Ruan and Wiggans(3) found that a pregermination chilling treatment of oat seeds at 4°C for 10 days considerably increased the germination percentage.

The present study was designed to find effective methods of breaking seed dormancy of *A. sterilis*.

2. MATERIALS AND METHODS

Several strains of *A. sterilis* were used in the dormancy study. Immediately after harvest, the secondary seed of a spikelet was seperated from primary seed and all seeds were dehulled. The groats were treated with Arasan to prevent disease infection during germination. Treated seeds were planted in 9cm petri dishes. The treatments used were application of alcohol, hot water, low temperature, pure oxygen, thiourea and gibberellic acid. Two methods (gibberellic acid application and low temperature application) were tested with 3 treatments in 3 replications on the primary and secondary seeds. Each petri dish was considered as a replication and contained 10 seeds of a strain with 1 level of a treatment. Thiourea treatments were 0.25×10^{-2}M, 0.625×10^{-2}M and 1.25×10^{-2}M. This method was tested without replication.

Dehulled and Arasan treated groats were soaked in the different concentrations of gibberellic acid for 16 hours. The seeds were washed with sterilized distilled water before transplanting to petri dishes. Planted petri dishes were placed in a room where the room temperature ranged from 22.2~24.4°C during germination. Germination was recorded at the end of 1 week.

Three ml of the thiourea solutions were applied to the petri dishes in which seeds were planted. The seeds remained in the solutions permanently. Germination was read 12 days after planting.

In the low temperature treatment, petri dishes in which the seeds were planted in sterilized distilled water were placed in a refrigerator for a week with a temperature of 3°C. Since the interior of the refrigerator was dark, 1 series of checks for the low temperature treatment was covered with aluminum foil to exclude light and placed in a room which had temperatures of 22.2~24.4°C. In another series of checks, light was not excluded. Germination was recorded 10 days after planting.

For the hot water treatment, water was heated in a beaker to 54°C. Seeds were placed in a cheesecloth bag and immersed in the hot water for 3-and 6-minute periods. The bags then were cooled in running water and the seeds were planted in petri dishes. Seeds planted on moistened filter paper in petri dishes were placed in a pure oxygen atmosphere in a closed pressure chamber with 5 pounds per square inch pressure for 2, 4, 6, 8, and 10 days. Dry seeds were kept in 25 pounds pressure for 2 weeks and then were planted on moistened filter paper in petri dishes. Groats were pricked in the germ area and immersed in 95% alcohol for 1, 3 and 5 minutes. Seeds were planted on moistened filter paper in petri dishes immediately following treatment. Hot water, oxygen and alcohol treatments were tested without replication.

To determine the significance of difference among strains and among treatments, an analysis of varience of the results of the dormancy studies was performed.

This study was made at Texas A & M University, College Station, Texas in the United States during 1967-1968.

3. RESULTS AND DISCUSSION

Since the kernels of *A. sterilis* do not germinate for several months after harvesting, an effective method of breaking dormancy would be helpful to enable more rapid incorporation of crownrust resistance from *A. sterilis* into adapted cultivated types. Alcohol, oxygen and hot water treatments were not effective in breaking dormancy of *A. sterilis* seeds. Thiourea had some effect while gibberellic acid and low temperature had significant effects on breaking dormancy. Data will be presented only for the effective treatments.

Table 1. Number and percentage of primary and secondary seeds of 5 strains of *A. sterilis* germinating after treatment with different concentrations of gibberellic acid.

Strain	Number and percentage of seeds germinating							
	Check		5ppm		50ppm		500ppm	
	No.	%	No.	%	No.	%	No.	%
			Primary seed					
P.I. 287211	0	0	9	30	23	76	30	100
C.I. 8295	0	0	9	30	26	86	30	100
P.I. 295919	0	0	7	23	23	76	30	100
P.I. 296244	0	0	13	43	28	93	30	100
P.I. 296265	0	0	4	13	21	70	29	96
			Secondary seed					
P.I. 287211	0	0	2	6	6	20	28	93
C.I. 8295	0	0	6	20	8	26	22	73
P.I. 295919	0	0	2	6	13	43	29	96
P.I. 296244	0	0	2	6	14	46	28	93
P.I. 296265	0	0	2	6	10	33	20	66

Table 2. Factorial analysis of varience of primary and secondary seeds of 5 strains of *A. sterilis* after treatment with different concentrations of gibberellic acid.

Source	D.F.	Sum of squares	Mean squares	F
Mean	1	2822.40		
Treatments				
Seed class(A)	1	160.00	160.00	164.94**
GA concentrations(B)	2	807.47	403.73	416.21**
Strains(C)	4	24.38	6.09	6.27**
(A)×(B)	2	45.60	22.80	23.50**
(A)×(C)	4	5.89	1.47	1.51
(B)×(C)	8	15.75	1.97	2.03
(A)×(B)×(C)	8	19.98	2.49	2.56
Error	50	58.00	0.97	
Total	90	3959.47		

** Significant at 0.01 level.

The number and percentages of germination of primary and secondary seeds from 5 strains of *A. sterilis* treated with different concentrations of gibberellic acid are given in Table 1. A factorial analysis of varience was performed to determine the significance of differences between the germination of primary and secondary seeds, germination among strains and among different concentrations of gibberellic acid and the interactions of these factors(Table 2).

At 5ppm of gibberellic acid, the percent germination ranged from 13 to 43% in primary seeds of 5 strains, but it was only 6 to 20% in secondary seeds. At 50 ppm 70 to 93% of the primary seeds germinated while only 26 to 46% of the secondary seeds germinated.

At 500ppm, germination was essentially 100% for the primary seeds, while the secondary seeds germinated 66 to 96%. Smith and Murphy(6) found that germination increased when seeds of *A. sterilis* were

Table 3. Number of primary and secondary seeds of 10 strains of *A. sterilis* greminating after treatment by different concentrations of thiourea.

Strain	Treatments			
	Checks	0.25×10^{-2}M	0.625×10^{-2}M	1.25×10^{-2}M
	Primary seeds			
C.I. 8298	0*	0	2	2
6-112-1-22	0	2	2	6
P.I. 296272	0	0	1	2
P.I. 318391	0	0	1	4
P.I. 318001	0	2	3	9
P.I. 317988	0	1	4	5
P.I. 317733	2	6	8	10
P.I. 318056	1	2	6	4
P.I. 318344	0	2	0	3
C.W. (C.5) 491-4	3	2	6	5
	Secondary seeds			
C.I. 8298	0	0	0	0
6-112-1-22	0	0	1	1
P.I. 296272	0	1	1	0
P.I. 318391	0	0	0	1
P.I. 318001	0	0	0	2
P.I. 317988	1	1	4	2
P.I. 317733	1	2	0	2
P.I. 318056	4	6	1	0
P.I. 318344	0	0	0	0
C.W.(C.5) 491-4	2	2	2	2

* Number of seeds germinating out of 10 tested.

treated with 100ppm of gibberellin for 3 minutes. In the present study, seeds were treated for 16 hours. Possibly the time of treatment is as important as concentration of solution.

Analysis of varience showed a highly significant difference between germination of primary and secondary seeds. Primary seeds showed more response to gibberellic acid than secondary seeds, especially at lower concentrations. Highly significant differences in germination due to concentration of gibberellic acid also were observed. Germination of both primary and secondary seeds was best at 500ppm of gibberellic acid. The variation of germination among strains also was significant. P.I. 296265 gave the lowest germination, indicating a higher degree of seed dormancy.

The germination of seed when treated with different concentrations of thiourea are shown in Table3. The responses to treatments of this chemical were poor. Concentrations of 0.25×10^{-2}M and of 0.625×10^{-2}M gave only slight increases over the check. The highest concentration, 1.25×10^{-2}M gave the best germination. There were small differences in response among strains, with P.I. 317733 giving the best response. Untreated seeds of 3 strains germinated from 1 to 3 seeds. Few secondary seeds germinated after thiourea treatment, even at the highest concentration. No previous work was reported on the effect of thiourea in breaking dormancy of *A. sterilis* seed but it was effective in breaking dormancy of letuce seeds.

Low temperature during germination was found to be highly effective in breaking dormancy of *A. sterilis* as shown by the data presented in Table 4. One

Table 4. Germination of primary and secondary seeds of 5 strains of *A. sterilis* under various conditions of light and temperature.

Strain	Treatment					
	Room temperature				Low temperature**	
	Light not excluded		Light excluded			
	No.*	%	No.	%	No.	%
			Primary seed			
P.I. 296244	5	16	2	6	28	93
P.I. 295919	1	3	0	0	29	96
P.I. 296265	0	0	2	6	30	100
C.I. 8295	0	0	0	0	30	100
P.I. 287211	2	6	0	0	29	96
			Secondary seed			
P.I. 296244	0	0	1	3	3	10
P.I. 295919	0	0	0	0	14	46
P.I. 296265	1	3	0	0	16	53
C.I. 8295	0	0	0	0	5	16
P.I. 287211	0	0	0	0	20	66

* Number of seed. ** 3°C for 1 week.

Table 5. Factorial analysis of variance of germination of primary and secondary seeds of 5 strains of *A. sterilis* stimulated by low temperature.

Source	D.F.	Sum of square	Mean square	F
Mean	1	1394.00		
Treatments				
Seed class (A)	1	251.33	251.33	204.33**
Strains (B)	4	31.33	7.83	6.36**
(A)×(B)	4	40.67	10.16	8.26**
Error	20	24.67	1.23	
Total	30	1742.00		

** Significant at 0.01 level.

series of seeds was germinated in the dark in a refrigerator. Another series of seeds was germinated at room temperature in the dark by wrapping the petri dishes in aluminum foil. Another series was germinated at room temperature in normal light.

Light exclusion did not affect germination appreciably. Cold treatment of 3°C for 1 week after planting resulted in germination of more than 90% of the primary seed of each of the *A. sterilis* strains. Germination of secondary seed also was greatly enhanced by this treatment, although the germination percentages were much lower(10 to 66%). Germination at room temperature ranged from 0 to 16% for primary seeds and 0 to 3% for secondary seeds.

The analysis of varience of these data(Table 5) shows that there were significant differences among strains, among treatments, between seed classes, and in the strain x seed class interactions.

4. 摘 要

野生귀리 *Avena sterilis*의 種子休眠을 타파하기 爲하여 알콜, 酸素, 溫水, 低溫, thiourea, 지베레린 等을 處理하여 그것들의 效果에 對해서 硏究하였다. Thiourea는 약간의 效果만을 보였고 지베레린과 低溫處理는 큰 效果를 보였다. 다른 처리들은 아무 效果도

없었다.

1. 지베레린處理 5ppm, 50ppm, 500ppm 中 500ppm은 가장 效果가 컸으며 第一小穗에 對해서는 거의 100% 第二小穗에 對해서는 66~96%의 效果를 보였다. 지베레린의 效果는 處理濃度에 따라 그리고 *Avena sterilis* 系統間에 差異가 컸으며 그 差異는 統計分析에서도 有意性이 있었다.
2. Thiourea의 處理는 이 實驗에서 第一高濃度이었던 0.625×10^{-2}M에서 가장 效果的이었으나 全體的으로 볼 때 thiourea의 效果는 저조하였다.
3. 섭씨 3도를 유지한 냉장고내에서 一週日間 저온 처리한 第一小穗種子들은 90% 第二小穗種子들은 10~66%의 發芽率을 보이었다. 저온처리에 依한 發芽率의 差異는 系統間에도 현저하였다.

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