FACTORS INFLUENCING THE GERMINATION OF ERODIUM CICUTARIUM.

Agronomy, 199.

January - May - 1926.

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April 27, 1926.

The sources of information, while complete in their subjects, were very inadequate for the needs of this problem. Information was obtained from papers written by former graduate and undergraduate students, bulletins from experiment stations, articles in newspapers and magazines and letters on the subject in the files of the Agronomy Division. Any information appearing to be of value in this experiment was noted and so far as possible tried.

Thus far, some twenty of the suggested methods, were tried and many are yet to be investigated, such as the proper stage of maturity for gathering the seed and methods of storage to insure the greatest viability and germination.

The results of all experiments have been noted whether positive or negative, and while good results have been obtained from simple methods, only continued investigation will disprove or prove their worth.

It was decided that the seed used should be the same as is available to the general public, in order to be in keeping with the purposes of the investigation, so the firms of C.C. Morse and Company of San Francisco and Aggeler and Musser Company of Los Angeles were requested to send seed to be used in these experiments. In response, these firms sent the writer one quarter pound each, or volumetrically, about one quart of seed.

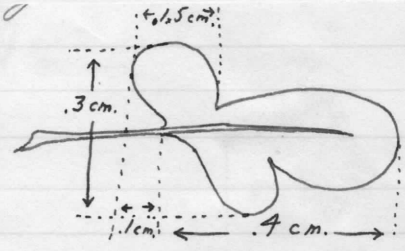
The seed of Erodium is very light and bulky and conse-

quently a small weight of seed will cover a large area when sown.

This seed is familiar to many children as "clocks" because of the style attached at one end which winds and unwinds, depending on whether the seed is dry or moist. It is also pubescent, which, with the spiral motion imparted to it by the style, helps to hold and bury it in the soil. This motion was clearly evident in the greenhouse, while carrying on the work of the problem.

The seed used was called "Small Seeded Filaree" by both firms supplying it and was later identified as Erodium cicutarium. The source of the seed was not disclosed by either of the firms further than that it was bought of a commercial collector established in Los Angeles. For this reason, seed must be collected locally and more investigations made to determine the influence of the various factors on seed grown in this climate.

The plant is dicotyledonous, sending up upon germination, two notched cotyledons about .4 cm long x .3 cm. wide. They are tri-lobed and are illustrated below. By the time the first true leaves appear, the cotyledons have attained the general dimensions of .8 cm. x .4 cm. As the true leaves develop, the plant assumes the form of a rosette, two leaves appearing simultaneously, with the seed stalks arising from regions near the center of the rosette. Each seed stalk bears many flowers on separate ramifications of the seed stalk.



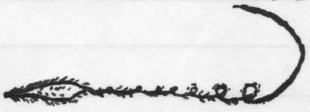
Cotyledon of Erodium cicutarium.

The flowers are purplish blue at the margins of the petals, shading to a light blue at the centers.

When fertilized, they develop into a "bundle" of seeds, varying in number from three to six, each with a long style attached. The styles are adherent one to the other, which has caused them to be called "Stork bills" and "Scissors" by children. To the stockman and ranger, it is best known as "Filaree."

2X.

Seed Stalk of Erodium cicutarium.



X 4.

Seed of Erodium cicutarium, Showing Curled Style and Hairs Pointing Away From Point of Seed.

The seed of this plant is not grown commercially and must be gathered in places where a good stand is grown as range feed. It is scraped from ruts where it lodges and other depressions in which it may catch. For this reason the seed sold on the markets is often contaminated with weed seeds and seeds of other species of Erodium. The weed seeds are the greatest detriment, but the other species of seeds are of no advantage to the stockman, as the stock prefer E. cicutarium to all other species and eat the others only when the area is cleared of Erodium cicutarium.

Pure seed can be obtained only by careful growing and harvesting, which is made more difficult by the fact that the

seed doesn't all ripen at the same time.

This plant is adapted to arid regions and has developed an extensive root system, some plants used in this system having branching roots 2 to 3 feet long.

In order that a check and comparison could be made under similar conditions, a control was planted each time treated seed was planted. The seed was planted in "flats" 10" x 20", 100 of each allotment to a flat in rows, 1" apart and 1" between plants in a soil containing one part of sand to four parts of fine screened loam.

All flats received the same amount of water, so far as it was possible to regulate the amounts and all were watered at the same time, with intervals averaging two days between watering. One check was grown outside the greenhouse, but as no others were planted outside, it is of little value.

As has been noted, this problem started after the regular or normal season for germination of Erodium, which seemed to inhibit rather than advance the rate and percentage of germination.

The first operation in carrying out the actual experimental work of this problem consisted of counting out seed, 100 being placed in a packet, and ten packets of each allotment being counted. More were placed in packets as the need for them arose.

In order to simplify tabulation and avoid confusion, the seed from C.C. Morse and Co., was assigned No. K. 1015 and that from Aggeler and Musser Co., No. K. 1031. Both of these numbers are entered in the Miscellaneous Seed Accession Register of

Dr. P.B. Kennedy at 118 Hilgard Hall, University of California in Berkeley, California.

Observations were made every two days and any changes were noted such as, appearance of new plants, increase or decrease of vigor and condition of the soil.

The experiments tried dealt with, used chemical, thermal and mechanical methods of altering the seed coat and valve in an effort to increase and hasten germination.

Chemical Treatment.

H_2SO_4 - Soaking hard seeds in sulphuric acid, 25-28°C. at 1.84 specific gravity for one hour was held by F. Todars, (in Staz. Sper. Agr. Ital. #34, (1901) No. 7, pp. 613-689) to make them germinate promptly and to secure more rapid and uniform sprouting.

100 seeds each of K1015 and K1031 were placed in test tubes and Spec. Gr. 1.84 sulphuric acid was poured over them.

After soaking 45-60 minutes, they were washed and planted immediately.

Results -	Control	K1015	K1031
6 days	2%	53%	60%
8 "	2%	61%	67%
14 "	3%	66%	67%

The treated seed germinated more readily, but after the 14th day, the control plants seemed to have greater vigor than those treated with sulphuric acid. The plants from the treated seed were then thinned out, one half of all the plants being removed, which caused the plants to regain vigor to a slight degree. These

plants, however, were smaller thruout their life than were those of the control flat.

Lime - It is claimed by Von Brekmer (Gartenwelt, 11 (1907) No. 14, pp. 163-164) that with seeds of varieties of flowers, a large percentage of germination was secured in every case where there was an abundance of lime present.

A seed bed was prepared in a flat and before planting 100 grams of air slaked lime was spread evenly over the surface. One hundred seeds each of K 1015 and K 1031 were then planted in the lime and covered with finely sifted soil.

Results.	Control.	K 1015	K 1031
6 days	2%	2%	0%
14 "	2%	2%	2%
20 "	3%	4%	2%

On the 14th day, it was discovered that the lime had formed a hard impervious layer above the seed which had the texture of plaster. When this was broken up and water applied a slight increase in germination was obtained. Those plants that succeeded in piercing the hard strata of lime were the most hardy of all grown, having deep green leaves and covering an area 1/2 to three times as great as the other plants. These plants also were the first to produce seed.

Conclusion - it is of no avail to use lime in this manner as it runs together and inhibits germination. The method suggested is that the lime be mixed thruout the soil and not in a layer just below the surface.

$CuSO_4$ - In the New York State Bulletin, #41 (1892) pp. 35-43), Copper sulphate, 5% by weight, was found to increase germination of certain seeds from 12% to 22%, but also to kill some seeds.

Accordingly, a planting was made and watered with 5% $CuSO_4$ solution.

Results.	Control.	K 1015	K 1931
6 days	0%	1%	0%
12 "	3%	2%	2%
16 "	3%	2%	3%
20 "	3%	2%	3%

The absence of weeds was noted in this experiment, however, they seemed to be killed in the seedling stage rather than having the germ killed in the seeds.

These plants appeared to be sickly, the leaves being pale green, and upon being placed in the sun wilted and died in a few days.

Conclusion - Cu SO_4 applied in this manner appears to have a detrimental effect upon Erodium cicutarium plants and seeds.

Cu SO_4 - As the preceding experiment was not forthcoming with beneficial results, the writer decided to try germinating Erodium seed in the laboratory germinator.

The seeds were placed upon blotters and covered with a paper towel and moistened with 5% $CuSO_4$ solution.

Results	Control.	K 1015	K 1931
10 days	0%	0%	0%
20 "	1%	0%	0%
30 "	3%	0%	0%

Conclusion - Comparing this experiment with that preceding the soil must have some beneficial effect in retarding the action of $CuSO_4$. However, the control seed also was delayed in germination and the percentage was decreased.

$FeSO_4$ - Ferrous sulphate increased the germination of grain seeds, Voelcker, G. (Journal of the Royal Agricultural Society of England 66(1905) pp. 205-211).

2% solutions of Fe SO_4 were used, watering one plot and keeping the other moist in the germinator as in the two preceding experiments. The same control was used in these two experiments as was used in the two preceding.

Results - Flat in Greenhouse -

	Control	K 1015	K 1931
6 days	0%	0%	1%
12 "	3	1	2
16 "	3	3	3
20 "	3	3	5

The only apparent difference between the control and the plants under observation was the color of the leaves. The treated plants had a deeper green color, but their size was not increased to any noticeable extent.

Conclusions - Treating seed in this manner does not give results that warrant the expense and time necessary to carry out the treatment.

Fe SO_4 - Seeds in germinator.

As the above experiment failed to give the desired results,

the writer tried the same solution on seeds in the laboratory germinator.

Results	Control	K 1015	K 1031
10 days	0%	0%	0%
20 "	1	0	0
30 "	3	0	0

Conclusion - This method is impractical and doesn't warrant the expense necessary to carry out the process.

Thermal Treatment.

Freezing - Dry.

It was suggested to the writer that possibly freezing and thawing would aid in germination, so an attempt was made to simulate natural conditions in areas where the ground froze up in winter.

The seeds were put in covered tin dishes dry and placed in the refrigerator at 40°F. for 20 hours and then brought out into the sun for 4 hours. They were then placed in a temperature of 32°F. 20 hours and placed in the sun for four hours. After this they were placed in 26°F. for 20 hours and thawed out in the sun four hours and 25 seeds were planted of each. The remainder were put back in 26°F. for 20 hours of freezing and 4 hours of thawing and a second planting was made. Two more plantings were similarly made.

RESULTS -

		1st Planting		2nd Planting		3rd Planting		4th Planting.	
	Con-trol	K 1015	K 1931	K 1015	K 1031	K 1015	K 1031	K 1015	K 1031
6 days	2%	0%	1%	0%	1%	1%	0%	0%	0%
10 "	2	0	1	1	1	1	0	0	1
16 "	3	1	1	1	1	1	0	0	2
20 "	4	2	3	1	2	1	0	0	2

Conclusions - In this experiment the advantages of this treatment failed to make themselves shown, but in no case was the germination as great as in the control.

Freezing - Wet.

The procedure followed in this experiment was the same as followed in "Freezing - Dry" except that the pans each had a small amount of water in them in which the seed was placed. The same control was used for both of these experiments.

RESULTS

		1st Planting		2nd Planting		3rd Planting		4th Planting	
	Control	K 1015	K 1031	K 1015	K 1031	K 1015	K 1031	K 1015	K 1031
6 days	2%	0%	1%	1%	0%	0%	1%	0%	0%
10"	2	0	1	1	0	0	1	1	0
16"	3	0	1	1	1	1	1	1	1
20"	4	0	1	1	1	1	2	1	1

Conclusion - The treated seed failed to respond as fast as the untreated seed and in no case did they equal the germination rate of the control seed. At the end of 60 days, the results were no different from those of 20 days.

All the plants matured equally well and made about the same growth.

HEAT Treatment -

The oven in the laboratory was regulated to 112°-115°F. and seeds were baked for various lengths of time. The first planting was made after 96 hours of continuous heating, the second after 192 hours and the third after 288 hours of continuous heating.

RESULTS -

	Control	1st Heating (96 Hours)		2nd Heating (192 Hours)		3rd Heating (288 Hours)	
		K 1015	K 1031	K 1915	K 1031	K 1015	K 1031
3 days	0%	4%	0%	4%	4%	4%	4%
4 "	0	4	0	12	8	4	4
5 "	1	8	0	24	8	12	8
10 "	2	12	0	24	12	24	16
20 "	3	12	0	24	12	28	24

Conclusion's - Steady heat treatment appears to be of benefit to Erodium seeds and increases with the length of time the seed is treated. Just how long this effect would be obtained is not known as yet because further heating on this seed was prevented by having the power cut off in the building for about 16 hours. In this time the oven had become cold and the continued heating process was brought to a close.

Effect on Depth of Planting.

"Most seeds when planted one inch deep give best results." Letter on file in office.

To try out this statement seeds were planted one fourth, one half, three fourths and one inch deep. These figures indicate the number of plants living at the end of the given number of days. Death in most cases resulted from exposure of the radicle to the sunlight and the plants growing out of the ground.

RESULTS

Days from Planting	1/4" deep		1/2" deep		3/4" deep		1" deep	
	K 1015	K 1031	K 1013	K 1031	K 1015	K 1031	K 1015	K 1031
7	2	3	0	0	0	0	0	0
13	4	6	3	2	1	3	0	1
17	3	6	5	7	4	5	6	2
22	1	3	4	7	5	6	9	7
30	0	2	4	7	7	6	10	11
34	0	1	3	6	8	8	10	11
40	0	0	3	6	8	8	10	11
47	0	0	3	6	8	8	10	11
51	0	0	3	6	8	8	10	11

Conclusion - Greater germination and longer lived plants seem to be obtained from seed planted one inch deep, and plants that weathered 34 days lived until the end of the test. The rate of germination was slightly higher in the deeper planted seeds, but they took longer to appear on the surface.

After the first plants appeared, these seeds were not watered. About the twentieth day, we had some very hot weather and this also may partly account for the death of many of the young plants.

Water Treatment -

Seeds soaked in running water for 24 hours were claimed to germinate faster and increase in rate of germination. Three lots of seeds were used, one untreated, one soaked in running water and the third soaked in still water.

RESULTS

Days from planting	Control	Still water		Running water	
		K 1015	K 1031	K 1015	K 1031
5	1%	0%	1%	2%	2%
12	1%	2%	2%	3%	2%
18	1%	3%	2%	3%	3%
22	2%	3%	3%	4%	3%
24	2%	Broke up surface soil because of caking			
30	4%	4%	5%	5%	4%

Conclusions - This experiment showed but slight advantage in favor of slaking for twenty four hours over planting untreated seed and the final result showed no advantage in running water over still water.

Mechanical Alteration of Seeds.

Removing Style as an aid to Germination.

The styles of one hundred of each sample of seed were removed and planted and observations made to determine advantage over untreated seed.

RESULTS.

Days	Control.	Seed with Styles removed. K 1015	K 1031
7	1%	1%	4%
9	1	1	4
13	2	1	5
20	3	2	6

Conclusion - With sample K 1015 the rate of germination was less than that of the control, but with sample K 1031, a 50% increase was obtained in 20 days.

Removing valve and style by scarification.

In this experiment, the valve and style were removed and the seed coat scarified between two blocks of fine sand-paper. The control used was the same as that in the preceding experiment.

RESULTS.

Days	Control	Scarified Seed.	
		K 1015	K 1031
7	1%	10	7
9	1	17	11
13	2	19	12
20	3	20	15
22	3	21	15

Conclusion - Mechanical scarification is of benefit to the seeds of Erodium cicutarium and greatly increases the rate of germination.

Conclusions -

The methods of increasing the rate of germination most are, in order of benefit derived from the treatment,

1. Treating with H_2SO_4
2. Baking at 112°F. for 192 hours or more.
3. Scarification, and
4. Deep planting.

In each of these experiments, the advantage was gained thru altering the condition or texture of the seed coat. The H_2SO_4 treatment and the scarification treatment each removed the valve and style and altered the seed coat, while heating and deep planting

enabled water to penetrate more readily.

Of these methods, deep planting is the least expensive and easiest to perform, with scarification coming second for the same reasons.

Treating with H_2SO_4 however is the best method investigated and for the average farmer would be cheaper than baking as few of them have ovens in which the heat can be controlled.

The striking thing about these four best methods used is that as the cost of treatment decreases, the rate of germination decreases also, excepting the matter of the cost of buying and running a controlled oven.

On the other end of the scale, the four most ineffective means were:

1. Freezing and thawing, Wet.
2. Freezing and Thawing - Dry.
3. Cu SO_4 - Watering with, and
4. Fe SO_4 - Watering with.

The lime treatment is disregarded because of the layer of lime becoming impervious upon being watered and the fact that those plants that germinated did so well.

These results are not claimed by the writer to be conclusive, because it is only by repeated plantings that absolute results may be obtained, however, with the seed used and the methods here stated, the results have been collected and are here presented.

ACKNOWLEDGMENTS

1. To the firms of C.C. Morse & Company of San Francisco and Aggeler and Musser Co. for seed used in this problem.

2. To Lawrence M. Mah for help obtained from his paper "Germination of Seed."

3. To A.L. Babcock for ideas received from his paper "Some Factors Influencing the Germination of Seeds."

4. And to the Staff of the Agronomy Division for their kindly interest in this project.