Dormancy and germination studies of the wild oat (Avena fatua)
by David H Leighty

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Agronomy
Montana State University


Abstract:
Seed of the wild oat, Avena fatua, which had been collected from Northwestern states and Canada and then grown at Bozeman, Montana were used in all tests. Twelve strains of wild oats stored in a normal heated room germinated 28 percent more than the same strains stored without heat. Seed which wintered in the soil germinated 25 percent more than seed which wintered on the soil surface. Percent of seed recovered after being buried under sod for one, two, and three years was 59, 34, and 15 percent respectively. In soil under bare ground the comparable figures are 44, 11, and 3 percent. In 1956 and 1957 approximately 100 percent of recovered seed germinated. Seed under continuous light germinated 8 percent more than seed in the dark. Oxygen concentrations of 40, 50, 60, 70, 80, and 90 percent, increased the average germination by 9, 25, 18, 21, 24, and 12 percent respectively. Paper chromatography revealed that non-dormant embryos contain material from various sections of the chromatogram, which inhabits and stimulates Triticum vulgare Coleoptile elongation in about equal proportions. Dormant embryos contain a preponderance of inhibiting material.

# DORMANCY AND GERMINATION STUDIES OF THE WILD OAT (AVENA FATUA)

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Master of Science in Agronomy

at

Montana State College

Approved:

A. V. Post
Head, Major Department

Laurence O. Baker
Chairman, Examining Committee

Leon D. Johnson
Dean, Graduate Division

Bozeman, Montana
June, 1958

ACKNOWLEDGMENT

I would like to express my appreciation to L. O. Baker for his advice and assistance in this study, also to Dr. J. E. Gander for his assistance and time in the chromatography phase of my work. To Dr. A. H. Post, Dr. E. R. Hehn, Dr. I. K. Mills, and Mr. Robert F. Eslick my thanks for the editing of this material.

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## ABSTRACT

Seed of the wild oat, Avena fatua, which had been collected from Northwestern states and Canada and then grown at Bozeman, Montana were used in all tests. Twelve strains of wild oats stored in a normal heated room germinated 28 percent more than the same strains stored without heat. Seed which wintered in the soil germinated 25 percent more than seed which wintered on the soil surface. Percent of seed recovered after being buried under sod for one, two, and three years was 59, 34, and 15 percent respectively. In soil under bare ground the comparable figures are 44, 11, and 3 percent. In 1956 and 1957 approximately 100 percent of recovered seed germinated. Seed under continuous light germinated 8 percent more than seed in the dark. Oxygen concentrations of 40, 50, 60, 70, 80, and 90 percent, increased the average germination by 9, 25, 18, 21, 24, and 12 percent respectively. Paper chromatography revealed that non-dormant embryos contain material from various sections of the chromatogram, which inhibits and stimulates Triticum vulgare coleoptile elongation in about equal proportions. Dormant embryos contain a preponderance of inhibiting material.

# INTRODUCTION

Seed of wild oats, Avena fatua, has the ability to remain viable in the soil and not germinate. Wild oats also mature early in comparison to many of the crops with which it grows. These two characteristics make eradication extremely difficult.

Delayed germination or dormancy, could be the result of many factors. Impermeability of seed coat to oxygen or water, inhibiting substances in hull, endosperm, or embryo could be some of the factors involved.

Haun (8) found highly significant increases in germination of dormant seed associated with hulling. He also found that the caryopsis of both dormant and non-dormant seed absorbed more water in the absence of hulls.

The effect of various concentrations of oxygen, storage conditions, and light on germination of wild oat seed is reported herein. The possibility of the presence of germination inhibitors was considered and some preliminary work was done using paper chromatography.

The wide variability of results reported by different investigators could have been caused by using different strains[1] of wild oats. The strains used in these experiments were collected from the Northwestern states and Canada. Many of these strains appeared to breed true, but no attend was made to correlate dormancy with seed phenotypes.

This is a continuation of the work initiated by Haun (8) at Montana State College during the years of 1954 to 1956.

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[1] Wild oat seed collected from each location is considered as a strain.

## REVIEW OF LITERATURE

The common wild oat is a noxious weed in many parts of the North American continent, being particularly troublesome in the hard red spring wheat region of Minnesota, the Dakotas, Montana, and Canadian Provinces. The wild oat (22) differs from the cultivated oat in producing taller, more vigorous plants and strongly twisted geniculate awns. The grain has a pronounced sucker mouth at the base, and sometimes a hairy lemma. The mature lemmas may be hairy or non-hairy and yellowish-white, gray, greyish-red, or brownish-black in color.

Wood (23) states that wild oats are inclined to be choosey as to environment. Their preference seems to be for cool, moist soil conditions. This may be observed in at least two ways. First, seldom are wild oats a serious problem in the more arid and hot sections of the northern plains, except where moisture becomes available through irrigation. Second, wild oats are usually more abundant on the lower, damper parts of the field, especially in water runs, than they are on the knolls or southern exposures.

It is known that after fertilization of the oat flower, modifications take place in the tissues enveloping the embryo. Robbins (14) states that before fertilization, the enveloping tissues of the oat seed consist of the following, named successively from the outer to the inner; outer epidermis parenchyma layer, chlorophyll layer, inner epidermis, outer integument, inner integument, and the nucellus. After fertilization, all of these tissues are more or less completely absorbed, with the exception of the outer epidermis and the inner integument. In the mature seed the outer epidermis with remnants of the parenchymatous layer forms the pericarp,

while the inner integument becomes the testa. The pericarp and the testa are fused to form the seed coat.

Robbins (14) concluded, on the basis of his results that delayed germination of the wild oat is due to agencies operating after, and influenced by fertilization. These affect the development or absorption of tissues enveloping the embryo in such a manner as to prevent germination of the seed until after a certain period of after-ripening has elapsed.

The ability of wild oat seed to lie dormant in the soil for a period of years before germinating is the cause of the extreme difficulty experienced in eradication of this weed. Bibbey (3) defined dormancy as "A viable seed not in active growth." One main type of dormancy is primary dormancy. This is caused by some inherent or physiological condition or factor of the seed. It could be physical structure of seed or some material in the seed which prevents germination. Secondary dormancy is the result of unfavorable germination conditions which put seeds into a dormancy, so they will not germinate when shifted to a favorable condition.

Primary dormancy is often overcome with time. A delayed ripening period is present in many varieties of plants. Lutes (13) results suggested that immature seeds of wild oats are more dormant and slower to after-ripen than mature seeds. Johnson (11) found that seed germinability increases progressively from the lower to upper whorls in the panicle. Secondary seeds require a much longer period of after-ripening before germinating. Atwood (2) stated that there is an increase of acidity in the embryo with after-ripening. After-ripening occurs along with drying of the seed, but is independent of the water content, as air dry seed soon

after harvest had lower germination than similar seed the following spring.

Stoa (15) found that machine harvested and threshed wild oats germinated more readily than hand harvested, possibly due to seed coat injury.

In experiments with reduced oxygen concentrations using seared (seed touched with hot object) and unbroken seed, Atwood (2) found that the seed coat, by excluding oxygen, delays germination. Harrington (9) found oxygen relations important in the germination of not after-ripened cereals. He reported that the beneficial effects of mechanical treatments on the seed coats are probably related to an increased oxygen supply to the embryo. He further found 36 percent oxygen had the maximum effect on germination. With higher partial pressures of oxygen, the percentage of germination was about the same, but rate of growth was less. Thornton (16) found that germination of the intact imbibed upper seed of the cocklebur takes place in 20 percent oxygen at a temperature of 30 degrees centigrade or higher. Germination of these seeds at 25 degrees centigrade can be forced by the use of 80 to 100 percent oxygen. Bibbey (3) obtained good germination of wild oat seed under low oxygen and high carbon-dioxide pressure, but germination percenages were higher up to a point with more oxygen.

Johnson (11) in a study of delayed germination of offspring of A. fatua crossedwith A. sativa theorized that germinability is dominant over dormancy, consequently the non-dormant segregates in a hybrid population are first to germinate after maturity. These probably would be killed by any cultural operation or climatic factors unfavorable to the plants. Bibbey (3) states that wild oat seed does not require light for optimum germination. In all of Black and Naylor's (4) experiments with wild oats to date, both

tungsten-filament light and "daylight" fluorescent light have been found to inhibit germination. This would appear to be a true light effect and not one dependent upon increased temperatures, since the heating effect of fluorescent lighting is small. Furthermore, experiments have shown that high temperature does not prevent germination in darkness. Cumming's (5) studies with wild oats obtained from localities in Eastern and Western Canada, and from plants grown under temperature and humidity controlled greenhouse conditions, indicate that light, compared to darkness, decreases the amount of germination in partially dormant seed, but does not decrease the germination of non-dormant seed. Evidence therefore indicates an interaction between levels of dormancy and presence or absence of light. This suggests that under conditions of sufficient moisture, fall cultivation which will bury partially dormant seed may encourage germination, and therefore help to eliminate wild oat infestations. In direct contradiction to Johnson's (11) and Cumming's (5) work, Bibbey (3) and Stoa (15) in separate publications agreed that to shorten dormancy it is best to have the dormant seed on the surface of the soil and not to cultivate until spring.

Toole (19) states that wild oat seed collected from different sections in the Western states showed no significant correlation of sections with germinability. Marked differences in seed characters were found, such as seed size, color, pubescence, etc., but no correlation between seed characters and germinability or dormancy were evident. Lute's (13) results showed that different collections of wild oats may differ in dormancy even after having been grown and harvested under uniform conditions. Her results were supported by Haun (8) who reported large differences in dormancy between

sources. The progeny reacted in the same way.

Housley and Bentley (10) report that it is frequently asserted that 3-Indoleacetic acid (IAA) is either the dominant hormone or the only naturally occurring growth promoter in plants. The only growth promoter other than IAA, isolated from vegetative tissues of higher plants is 3-Indolylaceton itrile (IAN). Alexandra Polyakoff-Mayber et.al. (1), working with lettuce seed, said that natural IAA is not present in dry seeds. It is possible that growth inhibitors present in the dry seeds may be precusors of IAA. Two acidic growth inhibiting substances were the only growth active substances present in dry seeds. These substances apparently disappear when germination proceeds. A variety of other unidentifiable active substances appear during germination.

Stoa (15) found short periods of high temperature comparable to burning stubble tending to break or shorten dormancy. He also found that chilling dry and soaked seeds increased germination slightly. Alternate wetting and drying also increased germination slightly. Johnson (11) found that soaking the seeds in 2 percent $KNO_3$ for 24 hours produced 64 to 68 percent germination. In water, germination was only 4 percent. Na CNS showed some promise in stimulating germination at concentrations below 1 percent.

Evanari (7), in his work on germination inhibitors, has identified a number of compounds produced by plants which inhibit the germination of their own, or other, plant seeds. These include unsaturated lactones, akaloids, essential oils, and others. The presence of these compounds has been found to be responsible for the dormancy of seeds of many plants. Some of Black and Naylor's (4) preliminary experiments have shown that an

aqueous extract of wild oat hulls has marked inhibitory properties when tested on lettuce seed. This extract has been chromatographed and it would appear that two inhibitory substances are present, running at different Rf. values. Elliott and Leopold (6), in their investigation of the seed of A. sativa, variety Victory, have demonstrated a water soluble inhibitor in the hulls, which appears to be a high molecular weight protein. This substance could be washed out of the hulls with water. Haun (8) attempted the same experiment with wild oats, but in all his tests in which he washed the seeds he obtained a sharp reduction in germination. This could possibly be the result of secondary dormancy due to unfavorable conditions for germination.

Toole (20), reporting the final results of the Duvel buried seed experiment, stated that wild oat seed buried in 1902 at 22 inches germinated 8 percent and at 42 inches 18 percent in 1903. None germinated after 1903. Waldron (21) found that in black alluvial loam soil, wild oats came up through five inches of soil. Seeds buried 7 to 10 inches deep for 20 months were practically dead, and buried 56 months all were dead. Thurston (18) found there was no evidence of induced dormancy in seeds buried at depths down to 20 inches. Plants from seed buried 6 inches deep came up yellow, but recovered and grew into healthy plants. All seeds which had not germinated within 4 years died. No seedlings appeared after 21 months from seeds buried 12 to 20 inches deep. Evidence indicated loss of vitality of the seed with prolonged burying in the soil. Haun (8) found that about 50 percent of the seed of a dormant sample of wild oats germinated or decomposed while buried at four depths in a silt loam soil for one year. Twenty percent of the recovered seeds germinated initially in the laboratory.

## MATERIAL AND METHODS

Wild oat seeds were obtained from North Dakota, Idaho, Utah, Colorado, Oregon, Washington, Alberta, and Saskatchewan, Canada. Location and cropping history are reported by Haun (8).

They were grown under irrigation at Bozeman. The progeny from the 1955 crop were planted in 1956, and the progeny from the 1956 crop were planted in 1957. Seed harvested in 1956 and 1957 was used in this study.

Monthly germinations were conducted on damp blotter paper in plastic boxes with lids. A germination cabinet was used with the temperature at approximately twenty degrees centigrade. Germination counts were made after 10 days.

One experiment was designed to study the effect of storage conditions on primary dormancy. Samples of each strain of wild oats were stored in an unheated building and at normal room temperature. Germination tests were conducted on the seed under each method of storing.

Germination of seed which wintered in the soil compared to seed wintering on the surface of the soil was studied. In September of 1956 seed of seven strains were placed in separate flats of soil in the field. In half of the flat seed was mixed with the soil, and in the other half it was left on the soil surface. The flats were covered with wire screen. The seed was recovered in June of 1957.

Haun (8) in 1955 initiated an experiment to determine the length of time wild oat seed will remain viable while buried at different depths in soil, in the field. Material and methods for this experiment are found in his thesis.

Twelve strains were used to test the effect on germination of continuous light as compared to continuous dark.

Germination was carried out in the usual manner except that fluorescent light was provided in one section of the germinating cabinet and all light was excluded from the other section.

The effect of various concentrations of oxygen on germination was determined by placing seed in a bell jar. The seeds were enclosed in blotter paper envelopes arranged so that the envelopes were not touching each other. A measured quantity of water was then placed in the jar and was replaced by oxygen. Knowing the quantity of water present, the concentration of the oxygen could be calculated. Duplicate samples were germinated at normal oxygen concentration adjacent to the bell jar. The size of the bell jar prevented it from being used in the germinator, therefore germination occurred at room temperature.

Paper chromatography was used to isolate substances from wild oat seed embryos. Two strains of wild oats were used. One strain exhibited extreme dormancy while the other germinated readily. An alcoholic extract of each strain was made using 100 embryos. The extract was filtered, dried, and then chromatographed using Whatman Number One filter paper. A solvent composed of butanol, saturated with ammonia and water was allowed to ascend fifteen centimeters past the spot of extract and then air dried. The filter paper was cut into five three-centimeter sections. These were irrigated with twenty milliliters of distilled water into separate Petri dishes. Ten ten-millimeter sections of etiolated Triticum vulgare coleoptiles were added to each dish. They were incubated in darkness for 18

hours after which each coleoptile was measured for elongation. Each analysis was accompanied by two checks; one of distilled water and the other of a dilute concentration of 2,4-D* (.01 normal solution). Results are based on average elongation of the 10 coleoptiles. The first extract was made from air dry embryos. Later, extracts were made of embryos which had imbibed water for 4, 8, 12, 16, 20, and 30 hours. After 30 hours the non-dormant strain was showing signs of germinating. Each separate analysis was repeated 4 times.

Three replicates of one-hundred embryos each, of dormant and non-dormant strains were used to study the affect on germination of various concentrations of IAA**. Fifty milliliters of solution were used and this was areated constantly with compressed air.

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* 2-4-Dichlorophenoxyacetic acid
** Indoleacetic acid

# RESULTS

## EFFECT OF STORAGE CONDITIONS ON GERMINATION OF WILD OAT SEED

Wild oat seed requires an after ripening period, following harvest, before the seed will germinate. Length of period is determined by inheritance, but may be affected by environmental conditions. To study the effect of storage as related to the length of after-ripening period, 23 strains of wild oat seed were stored under two conditions - an unheated building, and a normal heated room. Germination tests were started in February of 1957 and conducted for the succeeding three months.

The average germination for strains for 4 dates germinated varied from .5 percent to 41 percent after storage, in the unheated condition, with the average for the condition being 25 percent. The average germination after storage at room temperature varied from 3 to 75 percent and averaged 53 percent germination, Table I.

An analysis of variance reveals that storage treatments, dates germinated, and strains were significantly different at the one percent level, Table II. There was a significantly greater number of seeds which germinated after storage under the heated room condition, as compared to the unheated building. The strains also varied significantly in germination. This was expected as germination varied from zero in some strains to 93 percent in others.

The average germination under heated storage was never equal to or less than germination of seed under unheated conditions. Figure 1 shows graphically the average monthly germination under the two storage conditions. There is a distinct difference between the two conditions and

germination was increasing each month.

Table I. Average germination of 23 strains of wild oats stored under two conditions.

| Strain No. | Storage | | Strain No. | Storage | |
|---|---|---|---|---|---|
| | Unheated | Heated | | Unheated | Heated |
| 1 | 28.5 | 60 | 15 | 39 | 75 |
| 2 | 15 | 60 | 16 | 39 | 68.5 |
| 4 | 41 | 70.5 | 17 | 36 | 50.5 |
| 5 | 26 | 62 | 18 | 28.5 | 55 |
| 6 | 36 | 61 | 19 | 20 | 59 |
| 8 | 23 | 58 | 20 | 25 | 59 |
| 9 | .5 | 3 | 21 | 39 | 63 |
| 10 | 16.5 | 35 | 22A | 36.5 | 70 |
| 11 | 16 | 31 | 23 | 1 | 15 |
| 12 | 12 | 31 | 24 | 14.5 | 52 |
| 14 | 35 | 61 | 25 | 18 | 15 |
| 14A | 22.5 | 67 | Average | 25 | 53 |

Table II. Analysis of variance of germination of 23 strains of wild oat seed stored under two conditions and germinated at 4 dates.

| Source of variation | DF | MS |
|---|---|---|
| Dates germinated | 3 | 6,348 ** |
| Storage treatments | 1 | 37,136 ** |
| Strains | 22 | 1,608 ** |
| Treatment x Strains | 22 | 220 |
| Error* | 135 | 141 |
| Total | 183 | |

* Date germinated x storage treatments plus date germinated x strains plus date germinated x storage treatments x strains.
** Significant at 1 percent level.

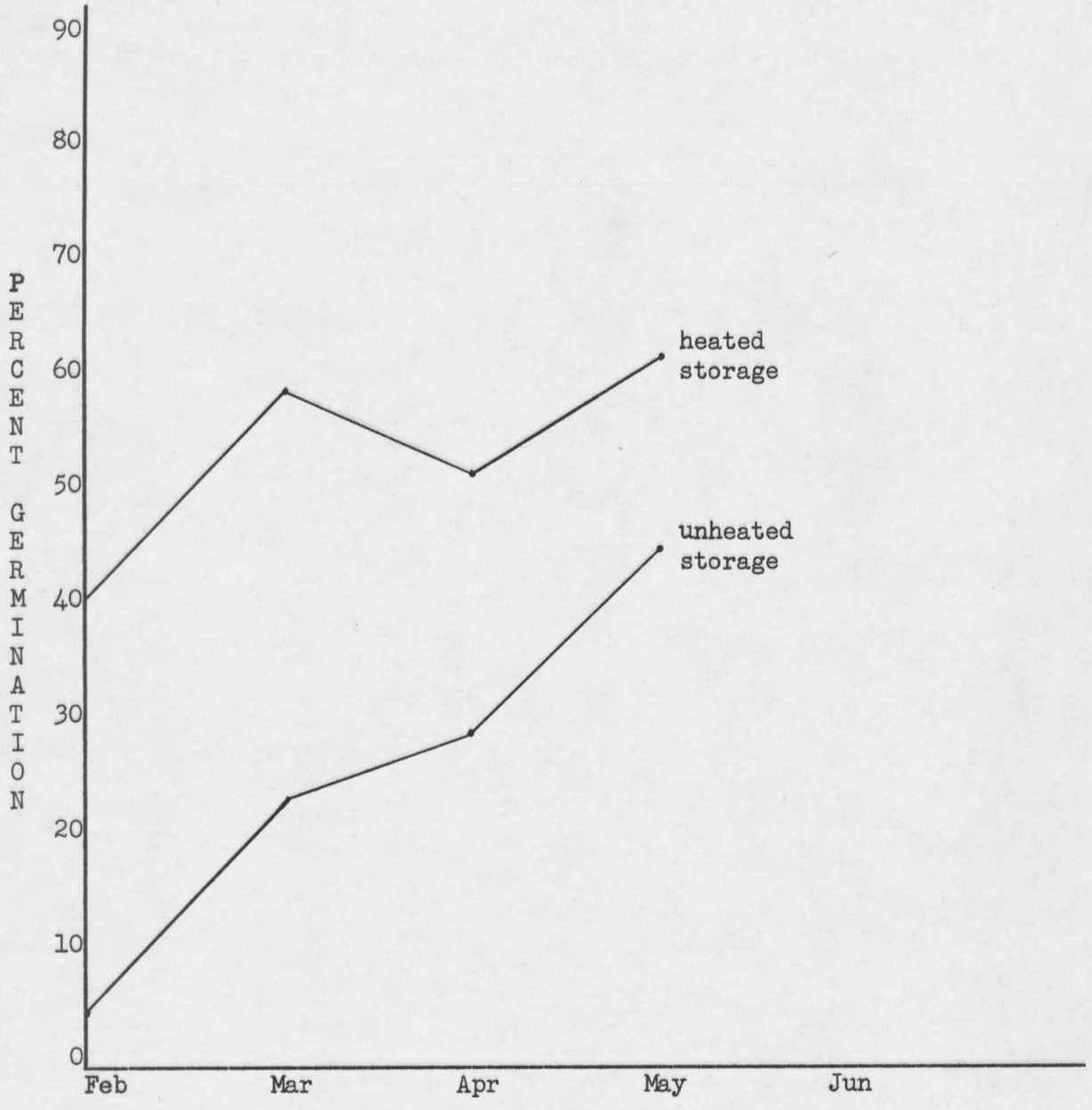


Figure 1. Graphic presentation of average germination of 23 strains of wild oats under two storage conditions.

## WINTER SURVIVAL OF WILD OAT SEED

Exposure to winter temperatures, snow, alternate freezing and thawing could be expected to have an effect on seed. Seed on the soil surface is in direct contact with the above conditions, while seed in the soil would have some protection.

Seven strains of wild oats were used to determine this effect. Half a greenhouse flat of soil had seed on the surface, while the other half of the flat had seed mixed with the soil. One strain was used in each flat.

No fall germination occurred from the seeds which were on the surface of the soil. Approximately 12 percent of the seeds germinated which were in the soil, these were removed.

In the spring the number of seeds which had germinated in the soil were estimated and the seeds on the surface of the soil were collected and placed in the germinator. Inital germination of the surface collected seeds was considered to be those which would have germinated after spring cultivation, Table III. Various treatments were used on the seeds which failed to germinate initially in an attempt to stimulate germination. Some of the seeds recovered from the surface of the soil failed to germinate under the various treatments, after four months of testing in the germinator. The average germination of the seeds which spent the winter in the soil was 62 percent, as compared to 37 percent of the seeds which spent the winter on the surface of the soil.

From this data it would seem you could expect a higher germination percentage from the seeds which spent the winter in the soil. This being true you would get a larger percentage of the seed germinated by fall cultivation.

This is comparable to the results of Cumming (5).

Table III. Percentage of wild oat seed capable of germinating after one winter in the field when mixed with the soil and on the soil surface.

| | Seed in soil | | | Seeds on surface of soil | |
|---|---|---|---|---|---|
| Strain | Fall Germination | Spring Germination | Final Germination | Initial Germination | Final Germination |
| 2 | 12* | 35 | 47 | 46 | 76 |
| 8 | 13 | 80 | 93 | 10 | 35 |
| 9A | 0 | 85 | 85 | 4 | 23 |
| 12A | 12 | 50 | 62 | 5 | 12 |
| 15 | 10 | 40 | 50 | 0 | 25 |
| 22 | 11 | 55 | 66 | 35 | 57 |
| 24 | 8 | 85 | 93 | 15 | 33 |
| Average | | | 62 | | 37 |

* Percent germination

## LONGEVITY OF BURIED WILD OAT SEED

The length of time wild oat seed will remain viable in the soil is subject to considerable controversy. Variable results as reported by Toole and Brown (20), Waldron (22), and Thurston (18), might be explained by wild oat strains having different degrees of dormancy, tests conducted in different soil types or under different conditions.

An experiment was established in November, 1954 in which seed of one of the most dormant strains (No. 9) was buried at 2, 4, 12, and 18 inch depths under bluegrass sod and under an area that was cultivated. In order to recover the seeds they were enclosed in plastic screen bags. Three, one-hundred seed samples were used for each treatment, and enough samples were buried so that annual tests could be made for five years.

The results after one year were presented by Haun (8). He recovered an average of 59 seeds from all burial depths under sod and 44 seeds. under bare ground. There was very little difference between the number of seeds recovered at different depths. Under sod the range was from 57 to 61, while under cultivation the seeds recovered varied from 40 to 46. The balance of the seeds had either germinated or decomposed, Table IV.

After two years in the soil an average of 34 seeds was recovered at all depths under sod and under the cultivated area the comparable average was 11 seeds. Seed recovered under sod ranged from 29 to 39 depending on burial depth and under the cultivated area the range was from 6 to 15 seeds, Table IV. In 1957 seed recovered under sod averaged 15 with a range from 13 to 19 at the various depths. An average of 3 seeds was recovered under

bare ground with a range of one to five.

In a three year period, the percent of seed recovered from under sod dropped from 100 to 15. A sharp drop was also evident under bare ground as recovered seed went from 100 to 3 percent. The percent of seeds recovered at each depth under each treatment is presented in Table IV. During each of the three years more seeds were recovered under sod than under bare ground. An analysis of variance of the results, which is presented in Table V showed cropping condition to be significantly different at the one percent level. Differences between depths of burial were significant only in 1956. The number of seeds recovered from each sample buried is presented in Appendix Table II.

To test the viability of recovered seeds, they were placed in the germinator after separating them from the soil. The seed recovered in 1955 from under sod germinated 41 percent after 7 days. Those from under bare ground germinated 60 percent. Results from each of the three years are given in Table V. Initial germination might also partially explain why more seeds are recovered under sod. Nineteen percent more seeds germinated when buried under bare ground than those under sod.

In 1956 and 1957 seeds were kept in the germinator 10 days. Initial germination results are presented in Table V. The number of seeds recovered and those which germinated are given in Figure 2, for each of the three years.

Seeds which failed to germinate initially in 1956 and 1957 were subjected to hulling, pricking the endosperm with a needle, and additional time in the germinator. These treatments resulted in complete germination

of seeds recovered under bare ground, and almost complete germination of those seeds from under sod in 1956. In 1957 using the same treatments, slightly less than one-hundred percent germination resulted under both burial conditions.

Table IV. Percent of wild oat seeds recovered after being buried one, two, and three years in the soil at four depths, under grass sod and cultivated soil.

| Buried Depth | Under grass sod | | | | Under cultivated soil | | | |
|---|---|---|---|---|---|---|---|---|
| | 1955 | 1956 | 1957 | Average | 1955 | 1956 | 1957 | Average |
| 2 | 57 | 29 | 13 | 33 | 46 | 6 | 1 | 21 |
| 6 | 61 | 39 | 14 | 38 | 50 | 9 | 5 | 21 |
| 12 | 61 | 37 | 19 | 39 | 42 | 15 | 5 | 21 |
| 18 | 57 | 30 | 13 | 33 | 40 | 13 | 3 | 18 |
| Average | 59 | 34 | 15 | | 44 | 11 | 3 | 19 |

Table V. Analysis of variance of percent of undecomposed wild oat seeds recovered in 3 successive years.

| Source of variation | DF | MS | | |
|---|---|---|---|---|
| | | 1955 | 1956 | 1957 |
| Replication | 2 | 14 | 1 | 161** |
| Depth buried | 3 | 47 | 77** | 26 |
| Cropping condition | 1 | 1276** | 3173** | 817** |
| Depth x cropping | 3 | 25 | 28** | 6 |
| Error | 14 | 128 | 2 | 27 |
| Total | 23 | | | |

** Significant at 1 percent level.

Table VI. Initial germination percentage of recovered wild oat seeds (7 days in germinator 1955, 10 days in 1956 and 1957)

| Buried Depth | Under grass sod | | | | Under cultivated soil | | | |
|---|---|---|---|---|---|---|---|---|
| | 1955 | 1956 | 1957 | Average | 1955 | 1956 | 1957 | Average |
| 2 | 10 | 36 | 57 | 34 | 47 | 42 | 100 | 63 |
| 6 | 50 | 36 | 43 | 43 | 37 | 64 | 64 | 55 |
| 12 | 37 | 28 | 69 | 45 | 60 | 58 | 43 | 54 |
| 18 | 42 | 49 | 38 | 43 | 77 | 79 | 50 | 68 |
| Average | 35 | 37 | 52 | | 55 | 61 | 64 | |

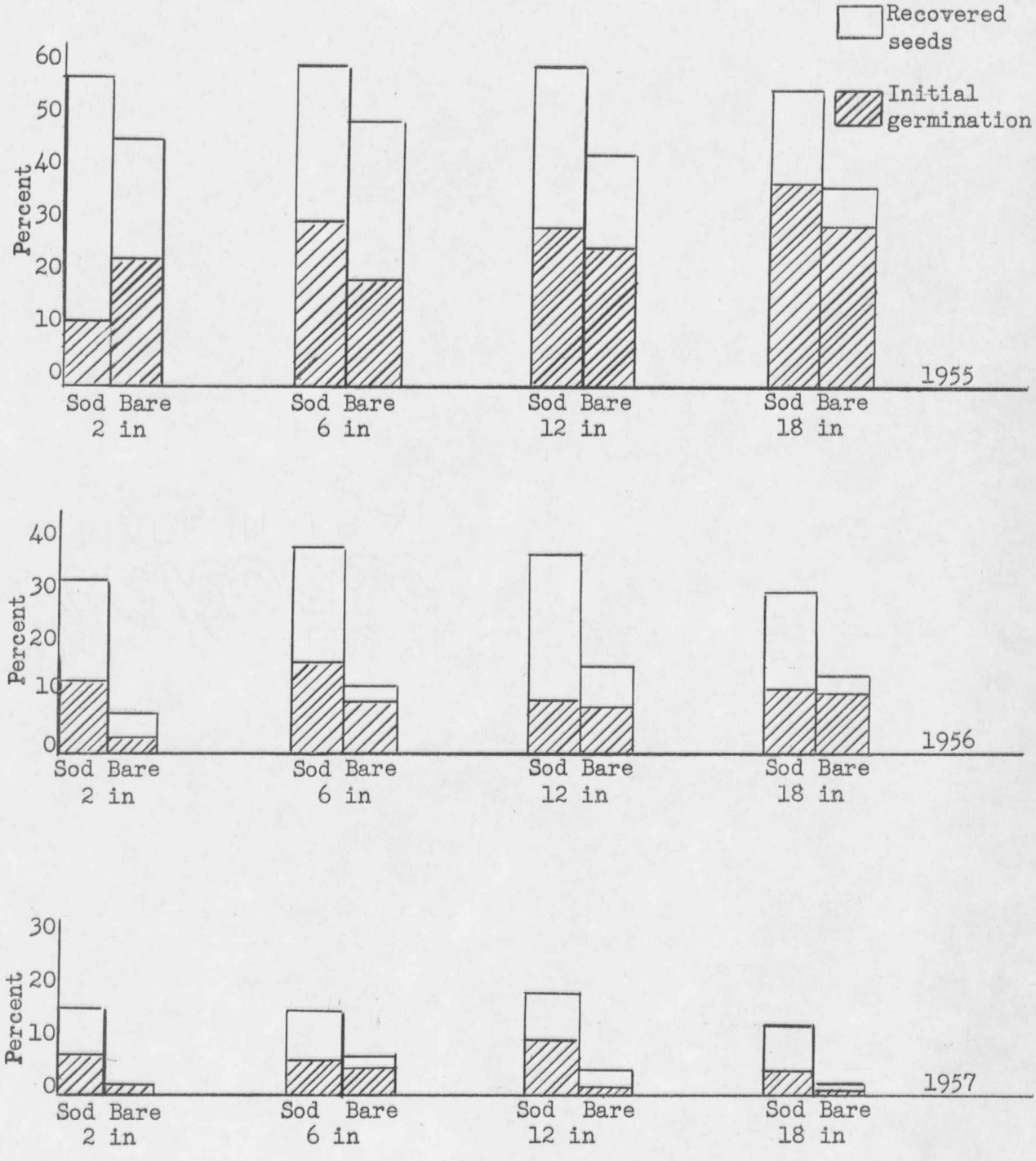


Figure 2. Recovered seed percentage and initial germination percentage of wild oat seed after being buried in the soil one, two, and three years, at 4 depths under grass sod and bare soil.

## EFFECT OF LIGHT ON GERMINATION

Light has been shown to effect the germination of wild oat seed. Cumming (5), and Black and Naylor (4) demonstrated that light as compared to darkness decreases the amount of germination in partially dormant seed, but does not decrease the germination of non-dormant seed.

In order to see if all wild oat strains reacted the same as the ones used by Cumming, 12 strains were tested for germination in continuous light and complete darkness. The experiment was carried out in a germinator cabinet where temperature was controlled automatically. There was no increase in temperature due to the use of lights. Three 100 seed samples of each strain were used for each treatment.

The average results for this test are presented in Table VII. A statistical analysis was made and results are given in Table VIII. Individual sample results are given in Appendix table III. Figure 3 is a graphic presentation of each strain's average germination under the two treatments.

The average germination for all strains under continuous light was 51 percent while the comparable average for seed germination in darkness was 43 percent. While the average difference of 8 percent is not large it is consistent with all strains except one. This strain (No. 4) showed a decrease of germination due to light; however, it amounted to only one percent. A statistical analysis indicates that the difference between the two treatments is significantly different at the one percent level, Table VIII.

The lack of agreement between Cumming's (5) and Black and Naylor's (4) work with these results is acknowledged. They found that light decreased germination, yet the single decrease obtained from light was in strain

(No. 4) and that was only one percent. It should be remembered that only fluorescent light, with a wave length ranging from 4,000 to 7,000 angstroms, was used.

Table VII. Average germination of wild oat seed of 12 strains under continuous light compared to complete darkness.

| | Strains number | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 5 | 8 | 9 | 10 | 12A | 14A | 17 | 23 | 24 | 25 | Ave. |
| Light | 56* | 62 | 53 | 54 | 8 | 62 | 34 | 56 | 61 | 26 | 73 | 69 | 51 |
| Darkness | 54 | 63 | 45 | 48 | 6 | 52 | 27 | 54 | 34 | 23 | 62 | 52 | 43 |
| Difference | 2 | -1 | 8 | 6 | 2 | 10 | 7 | 2 | 27 | 3 | 11 | 17 | 8 |

* Percent germination

Table VIII. Analysis of variance for the effect of continuous light as compared to darkness on germination of various strains of wild oats.

| Source of variation | DF | MS |
|---|---|---|
| Replication | 2 | 529 ** |
| Treatment | 1 | 1120 ** |
| Strain | 11 | 1861 ** |
| Treatment x strains | 11 | 85 |
| Error | 46 | 62 |
| Total | 71 | |

** Significant at 1 percent level

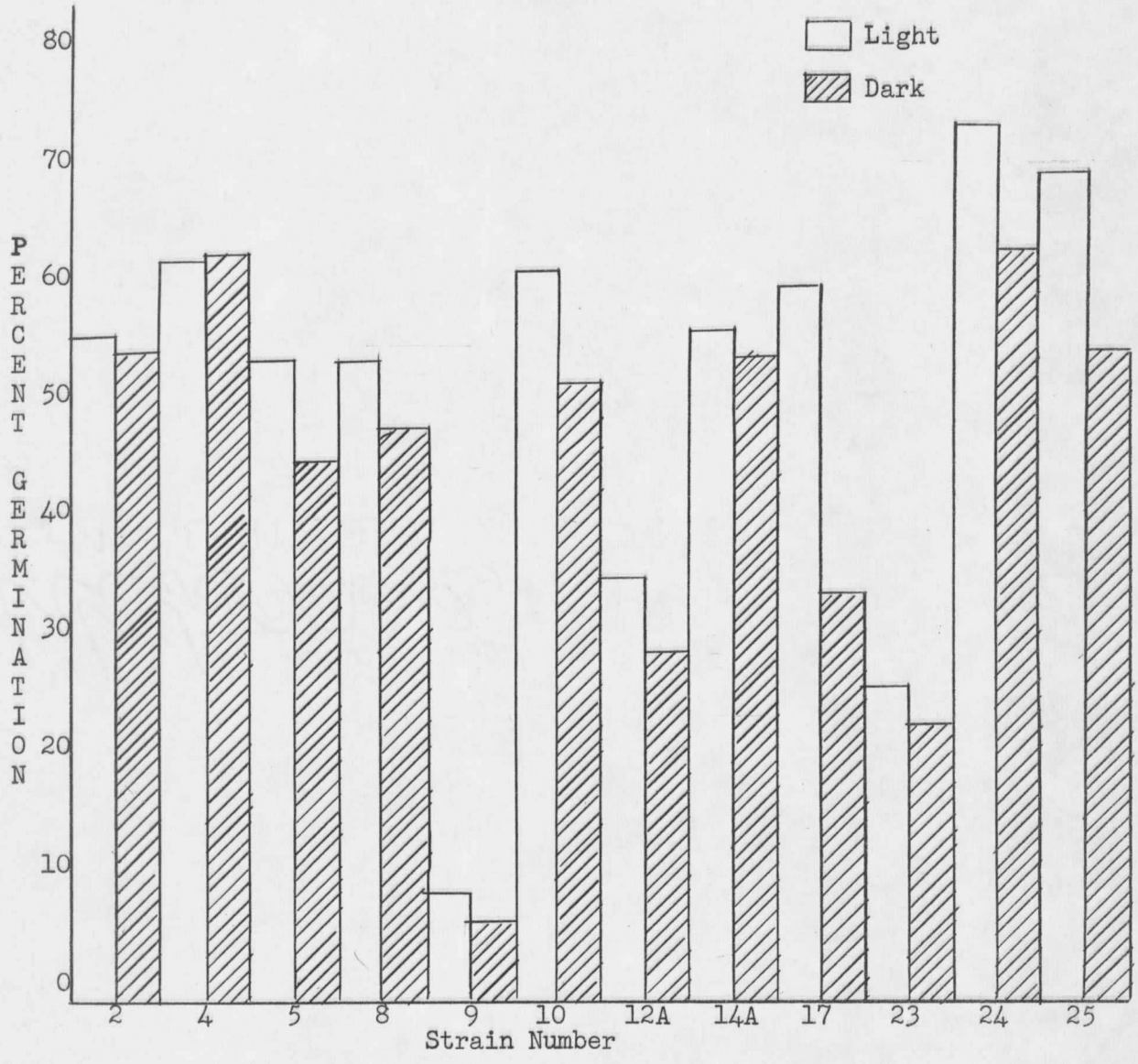


Figure 3. Average germination of wild oat seed of 12 strains under continuous light as compared to continuous darkness.

## EFFECT OF VARIOUS CONCENTRATIONS OF OXYGEN ON GERMINATION OF WILD OAT SEED

Seeds of many common weeds may lie buried in the soil without germinating. When the soil is plowed or otherwise disturbed so that these seeds are brought to or near the surface, germination usually occurs. The cause for this delay in germination might be low oxygen content, high carbon dioxide content, or both. Plowing may increase the oxygen supply in the environment of the seeds, and with other conditions not limiting, germination occurs.

This experiment was designed to show the effect of various concentrations of oxygen on germination of wild oat seed. Concentrations of oxygen used included 40, 50, 60, 70, 80, and 90 percent. One hundred percent oxygen was used in 1956 which resulted in complete destruction of all seeds without germination. To provide a check, each strain was germinated at the normal oxygen concentration each time a higher concentration was used.

A high correlation between germination of seeds at normal oxygen concentration and at the various higher concentrations was obtained except at 90 percent oxygen, Figure 4. At 90 percent concentration, germination of some strains (2, 9, and 17) was below that of the check. Other strains germinated, only slightly more than the check. It appears that at 90 percent concentration, oxygen becomes toxic to the seeds. Average germination of the strains without additional oxygen and those with additional oxygen are illustrated graphically in Figure 5.

Average increases due to the various concentrations of oxygen ranged from 9 at 40 percent oxygen to a maximum of 25 at 50 percent oxygen. Concentrations of 50, 60, 70, and 80 percent oxygen increased the germination

by an average of 22 percent. Increases were low at 40 and 90 percent oxygen levels. At the 40 percent level it would seem there was still a lack of oxygen, but at the 90 percent level oxygen was reaching toxic proportions. This is not in complete agreement with Harrington (9) as he found that 36 percent oxygen had maximum effect on germination, however, he was using freshly harvested wheat and other cereals.

A deficiency of oxygen seems to be one of the major factors in wild oat seed dormancy. One hundred percent germination was not obtained at any concentration. This indicates there are factors other than oxygen which are causing part of the dormancy of the wild oat seed.

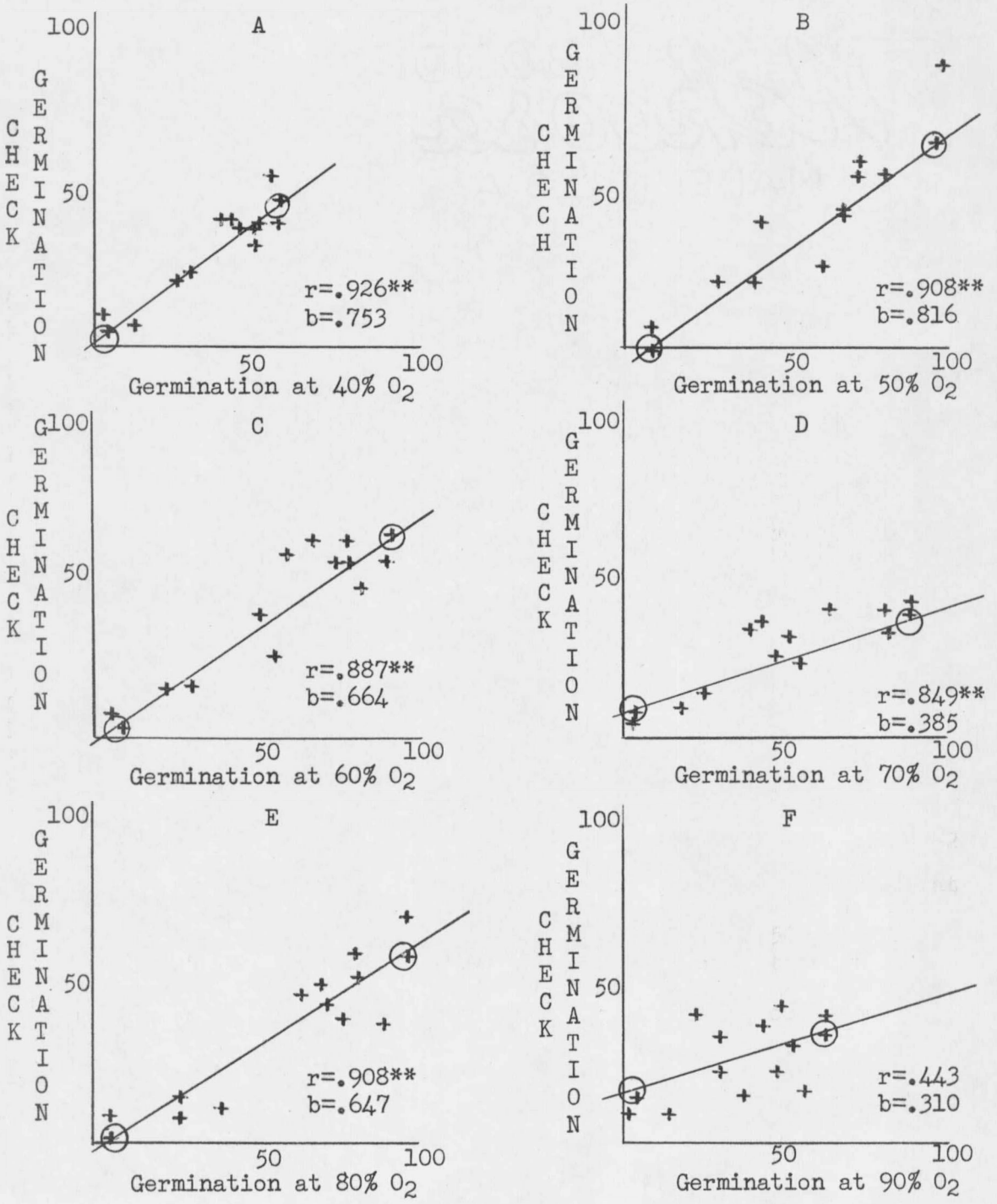


Figure 4. Correlation of germination in air and in various concentrations of oxygen.

** Significant at 1 percent level

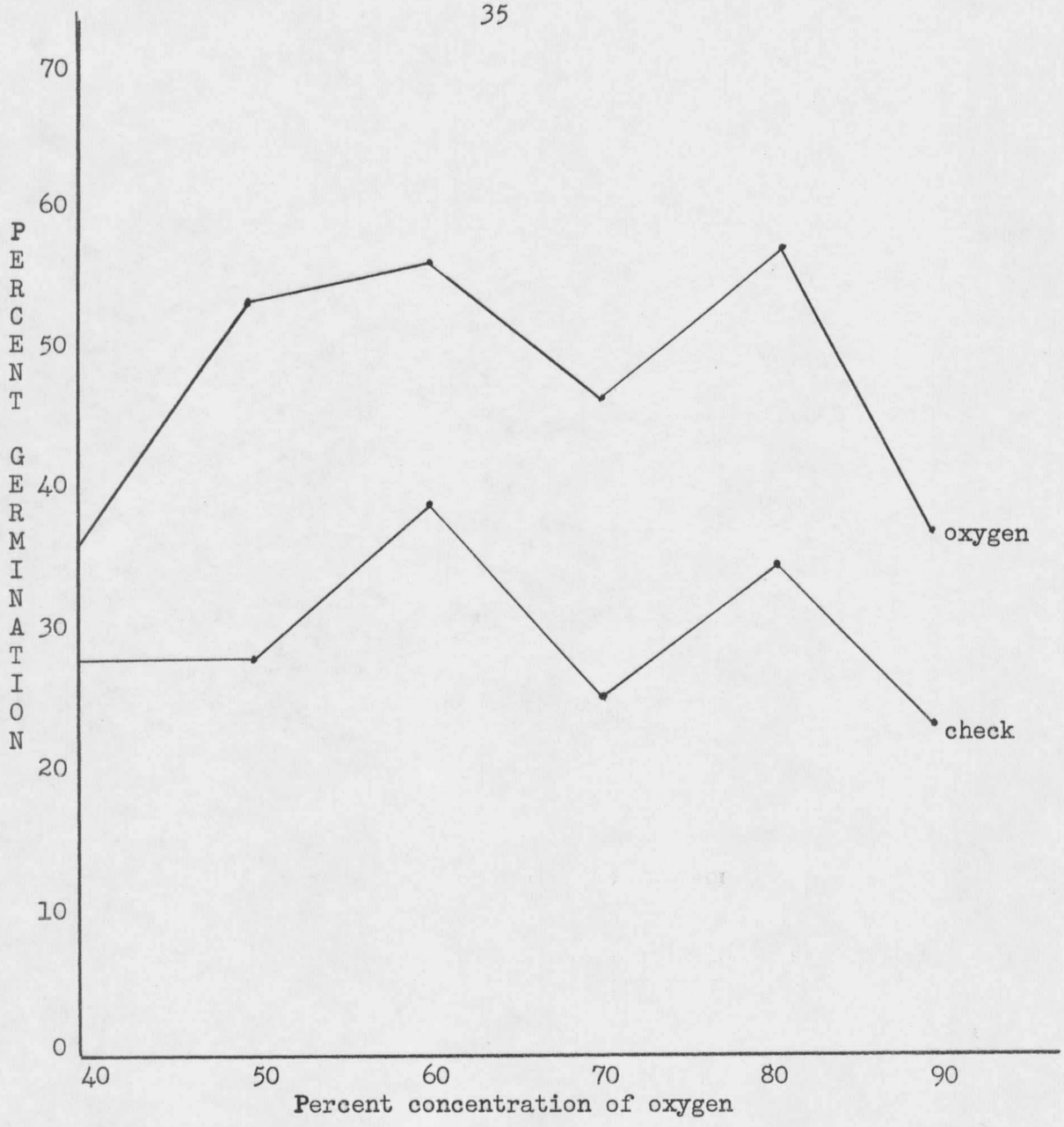


Figure 5. Average germination of 12 strains of wild oats under normal oxygen and various higher oxygen concentrations.

## PAPER CHROMATOGRAPHY OF WILD OAT EMBRYOS

Paper chromatography was used to investigate differences in concentrations and kinds of growth regulators in 95 percent Ethanol extracts of dormant and non-dormant strains of wild oats. Preliminary tests showed that germination of the dormant strain (No. 9) was very low with either whole seeds or embryos. Both embryos and whole seed of the non-dormant strain had high germination percentages, therefore only embryos were used in this test.

The embryos were germinated in the dark and chemical studies performed as indicated in the Material and Methods section.

Figure 6 A through E shows the average results of experiments in which extracts of non-dormant strains were chromatographed. The chromatogram was cut into five sections with Rf's[1] of 0 to .2, .2 to .4, .4 to .6, .6 to .8, and .8 to 1.0. Each section was irrigated with water and incubated with 10 millimeter sections of etiolated T. vulgare coleoptiles for 18 hours, followed by measuring the elongation of individual coleoptile. The results represent the average of 4 replicates for each time period indicated. Figure 7 F through J shows the results of similar studies on a dormant strain of wild oats.

These data represent only preliminary findings in that only one dilution of embryonic extract was used. A comparison of Figure 6 A through E with Figure 7 F through J, shows that the dormant strain (No. 9) contains material which inhibits the elongation of T. vulgare coleoptiles. The table below includes a summary of stimulating and inhibiting results obtained, expressed as mm/period.

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[1] Rf - measures the velocity of movement of the zone relative to that of the solvent front.

Table IX. Total stimulating and inhibiting effect on Triticum coleoptiles due to extracts from dormant and non-dormant strains of wild oat embryos.

| | Dormant Strain mm/period | Non-Dormant Strain mm/period |
|---|---|---|
| Stimulators | 1.6 | 5.3 |
| Inhibitors | 11.9 | 5.5 |

These results show that the non-dormant embryos contain both inhibiting and stimulating materials in about equal proportions. The dormant strain has a preponderance of material which inhibits the elongation of Triticum coleoptiles.

Figures D and I represent the sections of the chromatogram in which IAA would migrate for the non-dormant and dormant strains respectively. These figures show only the presence of inhibiting materials for extracts of the dormant strain (3.2 mm/period), while extracts from the non-dormant strain showed a marked increase in stimulating material between the 16th and 30th hour of germination period.

The identity of either the inhibiting or stimulating material is unknown; however, the nature of the method of extraction of the embryos would eliminate much of the high molecular weight proteins and the polysaccharides.

It should be kept in mind that there is no evidence for a correlation between chemical factors which stimulate elongation of etiolated coleoptiles and factors which stimulate germination. In view of this, it is interesting to note the marked inhibition of etiolated coleoptile growth by extracts of dormant strains of wild oats, and the apparent increase in concentration of

a material migrating like IAA in the non-dormant strain. Whether IAA is involved in the germination cannot be evaluated at present, however, IAA at concentrations between 1 p.p.m. to 1,000 p.p.m. did not stimulate germination of the dormant strain. IAA at the higher concentrations did not have any effect on the germination of the non-dormant strain, and these higher concentrations of IAA should have been toxic. It is unlikely that the IAA penetrated the surface of the embryo.

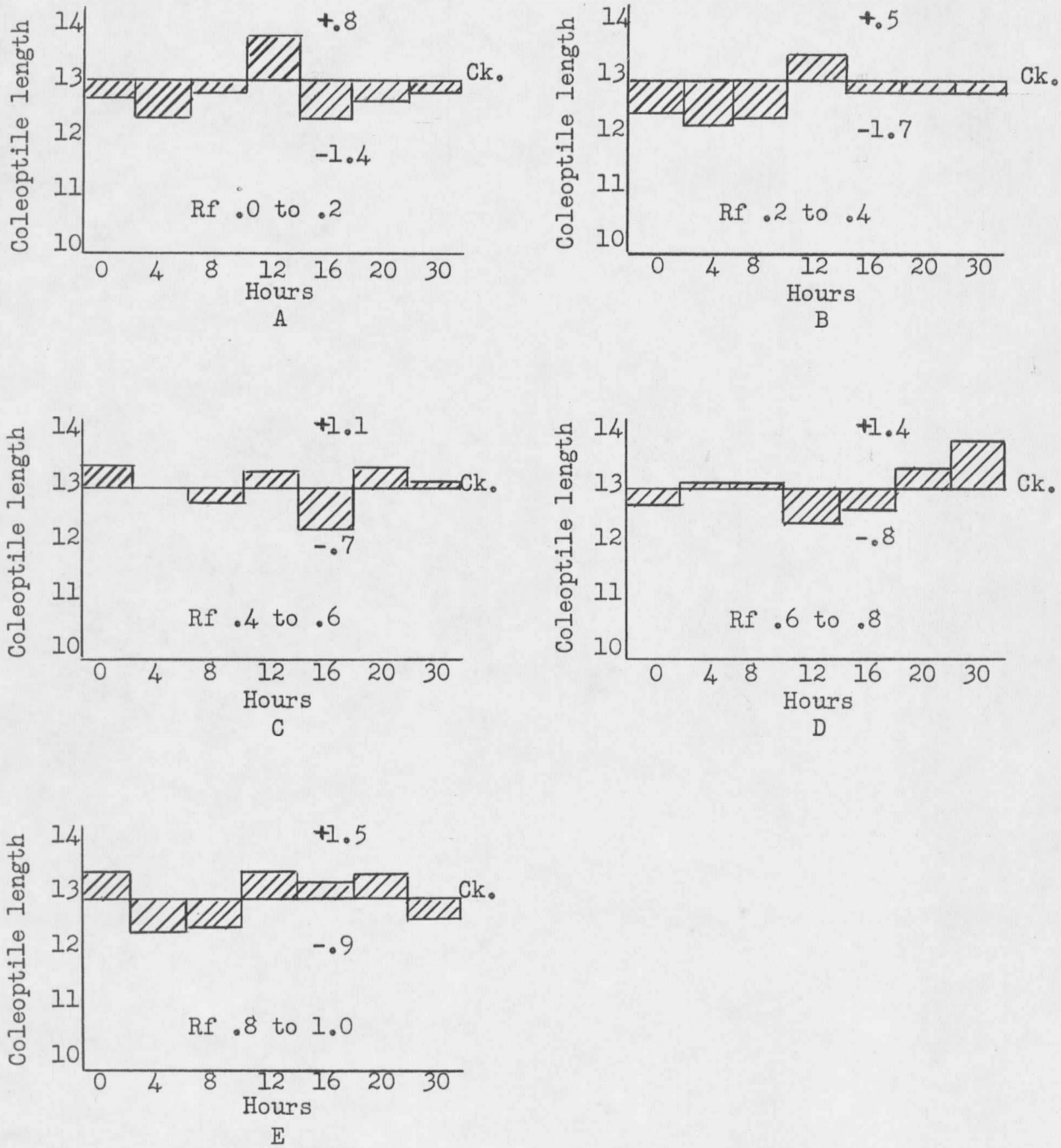


Figure 6. (A,B,C,D,E) Sections of a chromatogram of non-dormant strain at various time periods of imbibing water.

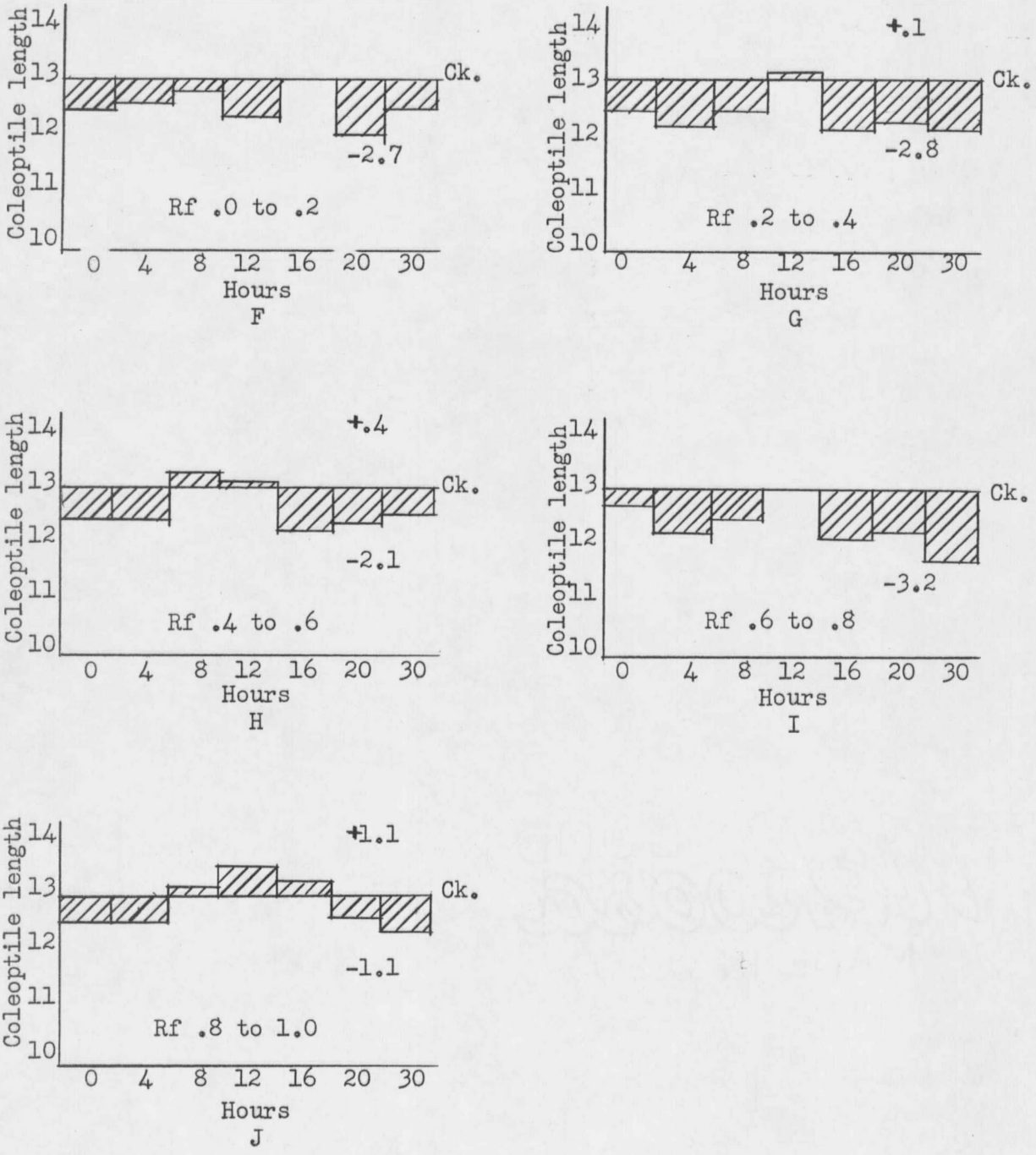


Figure 7. (F,G,H,I,J) Sections of a chromatogram of dormant strain at various time periods of imbibing water.

# DISCUSSION

Wide variation in dormancy, and the reactions of various strains to treatments, complicate any study of wild oats. A collection of wild oat seed from the Northwestern states and Canada, exhibited extreme variation after being grown at the same location for three successive years. Some strains are consistently low in germination while others are high. This seems to indicate that dormancy is inherited and some of the strains collected might actually be different varieties of A. fatua.

Delayed ripening, while beneficial in some crops, aggravates the wild oat problem. Storage conditions seem to have an effect on length of the after-ripening period. Seeds which were stored under heated conditions germinated 28 percent higher than those in unheated storage. The average germination of the seeds stored without heat in May was about the same as the average germination of those stored with heat three months earlier.

Bibbey (3) found that seeds on the surface of the soil, after-ripened much faster than those in the soil. Cumming (5), however, suggested that fall cultivation, which will bury partially dormant seed, may encourage germination. The results of this study showed that 25 percent more seeds germinated the following spring, when they spent the winter in the soil, than did seeds left on the soil surface.

Tests on seed taken from the soil surface were completed after four months. The seed which failed to germinate after this period may have been viable, but none of the treatments were able to break their dormancy.

Results obtained by various investigators on length of time wild oat seed will remain viable in the soil are extremely variable. Strain 9

(very dormant) was buried at four depths in the soil. The percent of recovered seed after one, two, and three years, was 53, 22, and 9. The type of ground cover also is a factor as the number of seeds recovered was consistently higher under sod, than under bare ground. More seeds were recovered from depths of 6 and 12 inches each year, but only in 1956 was depth significant. Strains, moisture, temperature, and ground cover appear to have an effect on the length of time wild oat seed will remain viable in the soil.

Seed germinated under one type of continuous light had an 8 percent average increase above the same strains germinated in the dark. In only one strain, did light decrease germination and this by only one percent. This is in opposition to the results of Black and Naylor (4) and Cumming (5) who found light decreased germination. Bibbey (3) also found that A. fatua did not require light for optimum germination.

Germination percentages of the strains tested varied in rate of response to various concentrations of oxygen. The range of response from 40 to 90 percent gave an average germination increase of 18 percent above the check. Fifty percent oxygen concentration gave the largest increase while 40 percent gave the least. Ninty percent seemed to be toxic to some strains but the average germination was still higher than the check. Harrington (9) and Thornton (17), while not using wild oats, also reported an increase of germination due to oxygen. Atwood (2) using reduced concentrations had similar results.

Paper chromatography and coleoptile elongation was used to study inhibiting action of embryo extracts from dormant seed. A correlation

between what will effect growth of coleoptile sections and germination of seeds was not proven. It was interesting to note, however, that embryo extracts of a non-dormant strain had inhibiting material in some sections of the chromatogram, and stimulating material in others in about equal proportions. Dormant embryos had a preponderance of inhibiting material. The non-dormant strain chromatogram at Rf value of .6 to .8 showed increased stimulation of coleoptile elongation as the length of time of imbibing water by embryos was increased. The dormant strain embryos at the same Rf value had only an inhibiting effect. It is to this Rf value that the IAA usually migrates. Black and Naylor (4) found an extract from hulls of wild oats which exhibited inhibiting properties when tested on lettuce seed.

## SUMMARY

Wild oat seed was collected from the Northwestern states and Canadian Provinces. Progeny have in most cases exhibited a similar degree of dormancy as the parent.

Wild oat seed stored in an unheated building germinated less than seed stored at normal room temperatures.

Wild oat seed mixed with the soil in the fall germinated to a higher degree in the spring than similar seed taken from the surface of the soil.

Fifteen percent of the wild oat seed buried under grass sod for three years was recovered. Only three percent was recovered after being buried under bare ground. Approximately 100 percent of the recovered seed germinated. Differences between depth of burial were significant only in 1956.

The germination of 11 strains of wild oat seed continuously exposed to fluorescent light was greater than similar seed germinated in complete darkness.

Germination of wild oat seed was increased by exposure to high concentrations of oxygen. Fifty percent oxygen gave the highest increase in germination. Lowest increases resulted from 40 and 90 percent.

It was found that embryos from a dormant strain contain a preponderance of materials which inhibited etiolated T. vulgare coleoptile elongation. Embryos from a non-dormant strain contained materials which inhibited and stimulated in about equal proportions.

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