DELAYED GERMINATION IN WHEAT

BY

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CONTENTS

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INTRODUCTION

The subject of germination is one that has received a great deal of attention of late and is one of vital importance. Poor germination often means a poor crop and a poor crop has caused the hardship of nations. The study of the germination of seeds is still in its infancy and has been of a practical nature concerning economic seeds rather than one of a theoretical study.

Before the establishment of seed laboratories, little or no consideration was given to seeds. A farmer reaped what he sowed and often his harvest was a disappointment for the low purity and poor germination of his seed gave opportunity for the growth of weeds.

Since the development of seed laboratories special attention has been given to the purity and the per cent of germination of seed. It has been found that seeds differ greatly in their manner of germination, some germinate better when placed in one temperature, others in another. Some germinate more quickly than others and consequently the time required for a test is shorter.

The nature of research in seed germination in the seed laboratory has been to find the optimum conditions for the germination of each kind of seed in order that the highest germination possible may be obtained.

The Official Seed Analysts Association of North

America has agreed that the optimum germination conditions for wheat are: (1) seed to be placed in germinator at 20 degrees centigrade between moist blotters, and (2) that there shall be a preliminary count in three days except Durum wheat (99), and a final count in six days.

A great deal of trouble has been experienced in seed laboratories with newly harvested cereals and grasses. When such wheat is placed in a germinator at 20 degrees centigrade a very low per cent germination is obtained in the three day counts. If the seed is held and germinated after *September 15, a normal germination is obtained. This delay has been termed the after-ripening period.

A special condition has been observed in the Colorado Seed Laboratory namely that wheat sent to the laboratory from certain parts of the state, fail to germinate normally, this condition continuing after the after-ripening period is passed.

This study was undertaken to find out if possible the cause of the after-ripening period in wheat and the

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*It has been found in the compiling of germination tests in the Colorado Seed Laboratory, that very little delay in germinations due to after-ripening occurs after September 15.

distribution, causes, and duration of the delay that occurs after the usual after-ripening period has passed.

HISTORY

Choate (19) states, "The subject of germination has received much attention of late and the literature is extensive. In general, however, investigation has been towards two phases of the subject: (1) the external factors necessary for and affecting germination, and (2) the chemical changes occurring within the various parts of the seed during the process."

Rose (75) found that delayed germination and poor germination are due to one or more of the following causes: hard-coatedness, a need of after-ripening, exclusions of oxygen by the seed coat, the effect of frost on seeds, fungi on or in seeds ,and dead seeds.

Harrington seeking the causes of delayed germination in various seed, found (45) that coatless viviparous seeds, like animal embryos, generally can undergo no cessation of activity at all comparable with the seed-rest of our ordinary plants without injury or death. He states, "So far as enforcing a condition of dormancy is concerned the coats may wholly or partially exclude water or oxygen; preventing the outward diffusion of internal metabolic inhibitors such as CO_2 or aldehyde; or oppose to the expanding embryo a mechanical force greater than the inhibitional or growth force of the embryo." In determining the resistance of seed to dessication, he found (44) that Silver maple (Acer saccharinum), wild rice (Zizania palustris) and various

species of willows (Salix) were unable to withstand even ordinary air-drying and if once dried their viability is lost and they will not germinate. But that the percentage of germination was not materially changed when seeds of wheat, barley, Sudan grass, Kentucky blue grass and Johnson grass were dried to less than one per cent. In regard to germination of Johnson grass (45) he says, "Removing the hulls hastens germination and increases the germinating capacity whatever temperature is employed and whether the seeds are fully after-ripened or not." In (46) he has determined that it is impossible to distinguish between impermeable and permeable seeds except by taking their ability to absorb water at a temperature favourable for germination.

Pfeffer (70) states, "Certain seeds are capable of immediate germination, whereas others must first rest for a few weeks, months, or even years, even when they are not dry, but kept under conditions favourable for germination." He gives as an example the seeds of Water Caltrop (Trapa natans) and says, "The seeds of Trapa natans and probably of most aquatic plants, which sink to the bottom when ripe, germinate next spring."

Howard (58) noted rest periods in seeds used in experiments carried on at the Missouri Experiment Station during 1907-8. In all ninety-three species of annuals, biennials, and woody and herbaceous perennials were under

test. Of the ninety-three,species, forty per cent showed a definite rest period. The rest period (33, 59) in seeds is due to a physiological condition and that exposure of seeds to the action of the weather tends to increase the percentage of germination and also to shorten the dormancy period.

Crocker (22), in determining the role of the seed coat in delayed germination states that delayed germination generally lies in the seed coat rather than the embryo. The delay in Iris seeds are due to the endosperm and cap stopping water absorption before the quantity necessary for germination is obtained by the embryo, and in nature the growth of the delayed seed comes through the disintegration of the seed coat structure. That in the hawthorn where the delay is secured by embryo characters the germination finally comes about in the course of long exposure to germination conditions and not in dry storage.

Davis and Rose (27), working with the hawthorn (Crataegus mollis) determined that the after-ripening and germination in the hawthorn is a continuous process, that is, we cannot tell where one leaves off and the other begins. Seeds with carpels intact require one or more years to germinate, seeds with carpels removed but testas intact, placed in the cold for ninety to ninety-six days at 50°-60° C., and then removed to the warm greenhouse, germinated seventy-four per cent. With both carpels and testas removed,

after twenty-eight days at 60° C., germinated 78 per cent in five days in the greenhouse.

Erickson (31), in a chemical study of the after-ripening of Crataegus, says, "Near the end of the period of after-ripening, there is a sudden increase in the acidity. Correlated with this is a sudden increase in water-holding power and an increase in the activity of catalase and peroxidase."

In working on the paired seeds of the cocklebur (Xanthium sp.) McHargue (68) says, "When well developed paired seeds are removed from the burs and subjected to condition suitable for germination, they will germinate at approximately the same time. The mechanical conditions within the bur are the cause of the delayed germination in the cocklebur seeds. The chemical composition and the cell structure of the two seeds are similar." Arthur (5, 6) found in the cocklebur, the cause of the difference of the two seeds appears to be constitutional; a hereditary character residing in the protoplasm of the embryo. The purpose of this seemingly unique character is to distribute the two seed of the bur in time; the customary distribution in space being impossible owing to the indehiscent structure. Shull (81) found that the oxygen pressure for the seeds of Xanthium necessary for germination is low and differs with the two seeds. Later shull(83) came to the conclusion that the seeds of Xanthium have a high oxygen requirement

and the requirement is not the same for both seeds.

Appleman (2, 4) in his work with the tubers of Solanum tuberosum found, that the rest period in potatoes is not firmly fixed and hereditary, nor due to metabolic changes, but is governed by maintaining a proper adjustment between the bud tissue and the external agents, chiefly oxygen, By removing the skin, permitting oxygen to enter the bud tissue, the bud can be forced to grow at any time.

Brown and Morris (15) working on barley for malting purposes found that germinating barley harvested at different stages of ripeness, showed a delay in germination which correlated with the ripeness of the grain. Those grains harvested in the milk stage showed a delay in germination, while those harvested fully ripe germinated with little or no delay.

Acton (1) in his research on the reserve material of wheat on keeping in which he uses wheat that has been stacked for thirty years and also some of the previous year's harvest from the same field ,finds ,that on germinating these two lots of grain, the one stack for thirty years had no apparent germination, when placed under the best possible conditions for germination, while that of the previous years crop germinated ninety per cent.

Crocker and Davis (24) state, "Dormancy in the akenes

of Alisma plantago (Water plantain) is due to the mechanical restraint of the seed coat. This restraint enables the seed to be in water for years without germinating.

Burgess (16) in determining the relation of heat to the viability of seeds found that, "wheat was seriously affected by high temperatures. The viability in this test was reduced to sixty per cent by temperature of 230 degrees C., lasting one hour and to fifty-five per cent by a temperature of 248 degrees C., lasting one hour. The check showed a viability of ninety-two per cent.

Stone (91) in working with delayed germination in newly harvested grains, germinated ten samples of winter wheat and found the averages as follows: five days after harvesting the average germination was forty-five per cent, while twenty days after harvesting an average germination of ninety-two per cent was obtained.

White (95) in working with the ferments and latent life of resting seeds found no increase in the germination of seeds soaked in enzyme solution, but rather a decrease due to the increased fungal action. He also found the life of Triticum to be seventeen years, with no loss of enzyme activity.

Duvel (30) working on the vitality and germination of seeds, finds, that seeds loose their viability through

respiration, implying that through respiration the food materials are exhausted, and the seed in time loses its viability.

Brown (13) gives evidence through research that the seeds of wheat are enclosed in a semi-permeable membrane, which has a selective power against imbibing substances.

Dahlberg (26) in germinating the seeds of Quack grass (Agropyron repens) at different stages of maturity shows that germination depends to a large extent upon the ripeness of the seed at the time of harvest.

Goss (35) found, that the hulling of Timothy seed greatly increased the per cent of germination. Using unhulled Timothy he obtained a germination of twelve per cent while with the hulled sample he obtained a germination of fifty-five per cent.

Kondo (65) working with the after-ripening of rice, determined that the time of harvest was a factor causing delayed germination. His results correlate very closely with the data on delayed germination in wheat.

Rose (74) found that after-ripening is normal to species of Tilia, Sambucus, and Rubus. In Rubus he says, "The dormancy is probably due to the high breaking strength of the endocarp."

Atwood (7) in working with wild oats (Avena fatua) states, "The germination of Avena fatua has been found less delayed with the shell coat removed from the seed.

(Shell coat constitutes the palea and lemma). However, with the shell coat removed there exists after harvest a germination delay which disappears with subsequent weeks. Hence the after-ripening occurs independent of the shell coat."

Kiesselbach and Ratcliff (64) carried on extensive experiments with corn, in determining the loss of viability due to the action of frost upon corn containing varying degrees of moisture. They state that, "The underlying causes of such injury are : (1) late maturity, (2) abnormally early freezing weather. The vitality of corn containing from fifteen to twenty per cent of moisture will not be injured by ordinary autumn freezing; and corn with ten to fourteen per cent of moisture will stand the most severe winter temperature without injury to its germinative power."

MATERIAL

Varieties of wheat for this study were secured from experiment stations, seed laboratories, county agents and farmers. The varieties used were: Kubanka, Preston, Marquis, Red Fife, Red Russian, Defiance, Baart, Bunyip, Club, Hard Federation, Propo, Sonora, White Australian, White Federation, Acme, Arnautka, Black Don, Bluestem, Turkey Red, Currell #3806, Alabama Bluestem, Fulcaster, Dietz Medeterranean, Leaps #12, Stoner, Fultz (Arkansas Selection #3), Prolific, Red May, Kanred, Marvelous, Cornell Selection #3030, Black Hull, Kharkov, Beloglina, Dawson's Golden Chaff #9-235, Turkey Hybrid #514, Turkey Red #10-110, Wisconsin #18, American Banner, Crimean #845, Minhardi #1505, Minturhi #1507, Burbank Super, Montana, #36, Forty Fold, Rooli, White Winter, Forward, Honor, Hybrid #86, Hybrid #1027 al 8-6-12, Junior #6, Selection Dietz 105-5, Gleason, Purple Straw, Stoner's Miracle, Valley, Trumbull, Portage, Gladden, Fultzo Medeterranean, Red Huston, Harvest King, Pennsylvania #44, Wash. Hybrid #126, Tennessee #1981, Tennessee #2008, Illinois Chief, Poole, Tennessee #180, Wood #1421, Reliable, Pedigree #2, Prelude, Ducklow, Norka and Ruby.

All of these varieties entered into the determination of the geographical distribution of delayed germination throughout the United States, while twenty-one varieties

were used:

(1) In determining the cause of delayed germination as it already existed in wheat.

(2) Producing in normal grains a condition of delayed germination and determining these causes.

SUBJECT.

Crocker (21) "In securing delayed germination of seeds, plants are not limited to the dead monotony of one method. As one studies the problem more fully he wonders whether there is any conceivable method of securing delayed germination not made use of in one plant or another. I believe that failure to grasp the variety of methods and the similar attempts to explain all delays by one or at most two methods, is the main source of the controversy, error and confusion that has prevailed in this field."

Crocker (21) determined the cause of delayed germination under ordinary germinative conditions to be: (1) "Rudimentary embryos that must mature before germination can begin; (2) complete inhibition of water absorption; (3) mechanical resistance to the expansion of the embryo and seed content by inclosing structures; (4) encasing structures interfering with the oxygen absorption by the embryo and perhaps carbondioxide elimination from it, resulting in the elimination of the process depending upon these; (5) a state of dormancy in the embryo itself or some organ of it in consequence of which it is unable to grow when naked and supplied with all ordinary germinative conditions; (6) combination of two or more of these; (7) assumption of second dormancy."

One may observe from the experimental work of Crocker and others, that the field of delayed germination and

and dormancy in seeds is a large one and that dormancy in all seeds is not the result of the same cause.

Many seeds of economic importance which have a delayed germination or dormancy have been worked on by a great number of investigators in order to seek the cause of this delay or dormancy.

The cause or causes of the delay in: Crataegus mollis (hawthorn) has been sought by Crocker (22,23), Davis and Rose (27), Eckerson (32) and Sherman (79); Xanthium sp. (cocklebur) by Arthur (5, 6), Crocker (22), McHargue (68), and Shull (81, 83); Alisma Plantago (water plantain) by Crocker (24); Iris by Crocker (22); Avena fatua (wild oats) by Atwood (7); Agropyron repens (quack grass) by Dahlberg (26); Johnson grass by Crocker (25), and Harrington (43); Timothy by Goss (39) and Stone (91); Rubus (brambles) Tilia (basswood) and Sambucus by Rose (74); Linden, Maple and Peach by Crocker (23); Potato by Appleman (3, 4); and the cereals by Acton (1), Bailey (8), Brown (13), Choate (19), Crocker (25), Fawcett, (33), Howard (58), Kiesselback and Ratcliff (64), Konds (65), Stone (90), and White (95).

In many cases like that of Xanthium sp., in which a great deal of work has been done in seeking the cause of the delay, each person finds a new cause for its delay and so no real definite conclusions have been reached. So it is with a great many seeds, the delay is there but we do not know its cause.

As far as data can be found it appears that the delay

in germination in wheat has never been worked upon, except in the after-ripening stages. The after-ripening period has only been studied to a slight extent, by seed analysts due to the low germination obtained with freshly harvested grain.

In the study of the delay in germination or dormancy in wheat, we find that it divides itself into two definite groups:

(1) After-ripening in wheat due to a normal physiological condition within the seeds.

(2) Delayed germination due either to a physiological condition in the seed normal to that seed or caused by a condition existing in the seed due to external factors.

AFTER-RIPENING IN WHEAT.

In his study of seeds Guppy (41) states, "It is thus evident that the rest-period must be often a transient feature with the seeds of many plants. Not only is this the case, but there are many plants where the seeds experience after-ripening, the immature embryo of the resting seed continuing to grow up to the time of germination." Harrington (45) "Seeds characterized by a dormancy under certain conditions and with the lapse of a longer or shorter period of time lose this characteristic and become capable of germination. The little understood complex of changes by which this comes about is known as after-ripening, because the changes occur after the seed has come to apparent maturity." Crocker (22), "There are some freshly harvested seeds in which the embryo will not grow at all or only abnormally when they are naked and given all ordinary germination conditions. Some embryos must go through certain fundamental physiological changes in the germinator before they germinate normally. Such seeds are spoken of as having dormant embryos and the changes that occur and lead up to their normal germination are known as the after-ripening of the embryos. Stone (91) states, "One of the serious problems of a practical nature facing the seed analyst in the grain producing states and in the "timothy belt" is that of shortening the period required to obtain satisfactory germination tests on newly harvested

rye, winter wheat and timothy seed."

In Table 1, confirming the work of Crocker (32) and Stone (91) for the seed sent into the Colorado

Table 1
GERMINATION TEST OF WHEAT SAMPLES SENT TO THE COLORADO SEED LABORATORY BETWEEN JULY 1 AND SEPTEMBER 1, 1921

Counties	No. of Samples	Average Germination	
		3 days	6 days
Boulder	1	3	83
Delta	1	65	92
Denver	8	54.7	95.7
Larimer	4	55.6	88.8
Morgan	3	65	91.6
Pueblo	1	18	60
San Miguel	1	48	96
Sedgwick	3	82.3	92.3
Weld	2	18	91.5
	Average	45.51	87.89

Seed Laboratory in 1921, between July 1 and September 15, for test, had an average germination in the three day test of 45.51 per cent and in the six day test of 87.89 per cent.

The study of the delay in germination in wheat due to a period of after-ripening was undertaken to see if the cause could be determined, and if this cause was a normal physiological condition existing in all wheats or occurring only in wheats from certain localities, and to determine if possible the duration of the delay due to after-ripening.

All seeds were germinated in a Minnesota germinator at 20° centigrade. The drying oven used is a Freas Electric oven at 30° centigrade. The refrigerator used is a Leonard cleanable, one piece porcelain type, the chamber in which the seeds were kept varied in temperature between 9.1° and 13.4° centigrade.

A Brown-Duvel moisture tester was used to determine the amount of moisture in seeds at different periods.

In this study seeds which show less than 80 per cent germination in three days are considered as having a delayed germination. All seeds showing a minimum of 80 per cent germination are considered normal.

A seed to be counted as germinated must show the plumule and three primary or seminal roots projecting through the outer coat.

The wheat in this test was subjected to five different conditions:

1. Seeds placed between moist blotters in a germinator at 20° centigrade.
2. Seeds placed in a Freas drying oven at 30° centigrade then between moist blotters, in a germinator at 20° C.
3. Seeds placed between moist blotters in a refrigerator for three days, then in a germinator at 20° centigrade.
4. Seeds placed in a dry condition in a refrigerator for three days, then in a germinator at 20° centigrade.
5. Seeds covered with water and placed in a refrigerator for three days and then between moist blotters in a germinator at 20° centigrade.

The first test shown in table 2, was with the Defiance

where is Table 2?
B45

wariety, grown on the College Farm, in 1921. Germination tests were made of this wheat before the crop was harvested. The first germination tests were made July 22 and the crop harvested July 28. The tests on this variety ran for a period of 120 days.

With seed placed directly in the germinator we find in the three day tests that seed taken from the field (July 22) before harvesting (July 28) gave a zero germination, while 120 days later (November 17) gave a germination test in three days of 95 per cent reaching a normal germination September 16, fifty days after the crop was harvested.

In the six day test a normal germination was reached (August 15) twenty-two days after harvested. At the time the crop was harvested the seed contained 11.6 per cent moisture while 120 days later (November 17) the grain contained only 8.4 per cent moisture or a loss of 3.2 per cent of moisture. At the time a normal germination was reached (September 16), the grain contained 11.2 per cent moisture.

We observe from this test with an increase in the percentage of germination as a normal germination is reached there is a decrease in the percentage of moisture held in seed.

The seed placed in the drying oven did not show a normal germination in a three day test but a normal germi-

nation was reached in the six day test. September 15, fifty days after the crop was harvested.

In the per cent loss in grams per 100 grains after three days in the oven we find an average loss for the first ten days after harvesting to be 5.99 per cent while the average for the last ten days was 2.03 per cent or a difference of 3.96 per cent.

The per cent of moisture in the grain after three days in the oven at the time of harvest was 9.3 per cent and at the end of the test (120 days), 6.6 per cent or a difference of 2.7 per cent of moisture.

From this test we see as the seed reaches normal germination, there is less moisture loss in the oven showing that there is less moisture held by the grain.

The seed placed between moist blotters in a refrigerator did not show a normal germination in a three day test but in the six and twelve day tests a normal germination was reached in the first test (July 22) or six days before the crop was harvested (July 28).

We see in this test that grain between moist blotters after three days in the refrigerator and three days in the germinator produced a normal germination in immature grain, harvested July 22.

Seed placed under dry conditions in a refrigerator did not show a normal germination in the three day test but in the six day test the grain reached a normal germination, September 15, forty-eight days after the crop was harvested.

In the average per cent gain per 100 grains, after three days in the refrigerator for the first ten days after harvesting was 2.27 per cent, while the average for the last ten days of the test was 2.90 per cent or a gain of .63 per cent.

The per cent of moisture in the grain after three days in the refrigerator at the time of harvest was 17.4 per cent moisture and at the end of the test (November 17), was 10.7 per cent or a loss of 6.7 per cent moisture. At the time (September 16) a normal germination was reached in the six day test the grain contained 12.4 per cent moisture after three days in the refrigerator.

While the test shows a slight gain (0.63 per cent) when the grain was placed in the refrigerator under dry conditions, there was a loss (6.7 per cent) in moisture due to the drying out through the duration of the test plus the amount taken up in the refrigerator.

This shows that grain placed in the germinator under dry conditions gained slightly in weight, but did not come to a normal germination until September 16 or fifty-six days after the test in which moisture was supplied to the grain in the germinator.

Seed Placed under water in a refrigerator did not show a normal germination in the three day test. In the six and twelve day tests a normal germination was reached in the first test (July 30)

In the per cent gain in grams per 100 ~~grains~~ after three days under water in the refrigerator, taking the average for the first ten days after harvesting was 40.8 per cent while the average for the last ten days of the test was 59.3 per cent or a difference of 18.5 per cent.

In the per cent of moisture in the grain after three days, in the refrigerator under water, at the beginning of the test (July 30), was 40.2 per cent which at the end of the test (November 17) was 42.4 per cent or a gain of 1.8 per cent.

We have similar results shown here as in the test in which the seeds were placed in the refrigerator between moist blotters. That it requires both moisture and refrigerator conditions to produce a normal germination in immature seed or seed at harvest time (dead ripe stage).

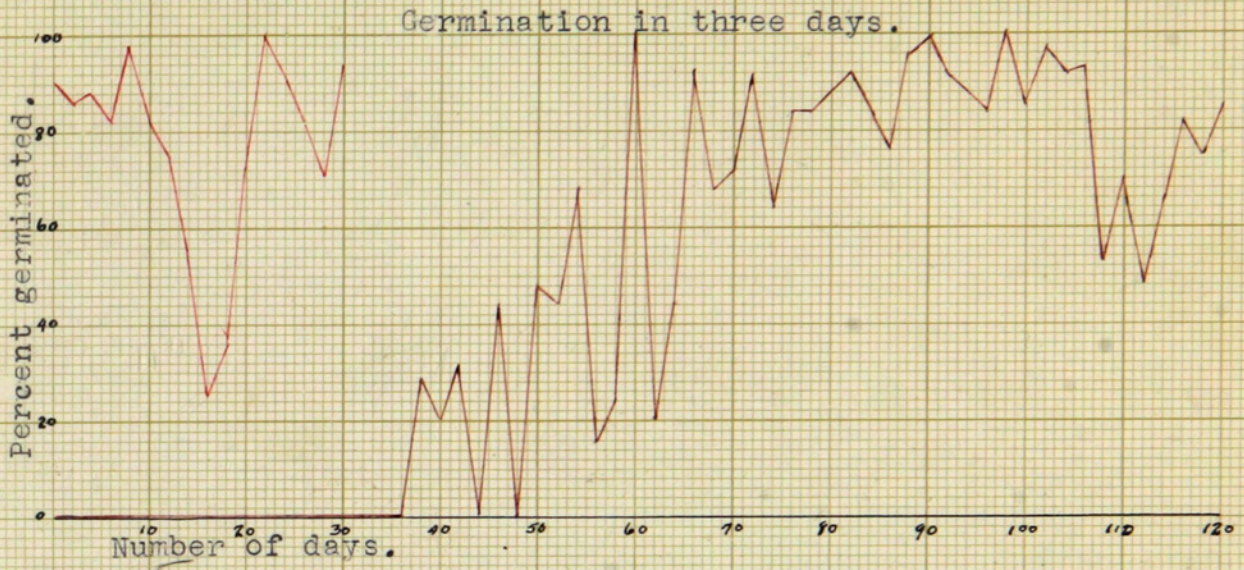
In Graph 1 and 2 the seed was planted April 9, 1921, harvesting began July 7, ten days after heads appeared (the grains were still in the milk stage). The seed was so immature when harvesting began that great care had to be taken in order not to crush the kernel when separating from the lemma and palea.

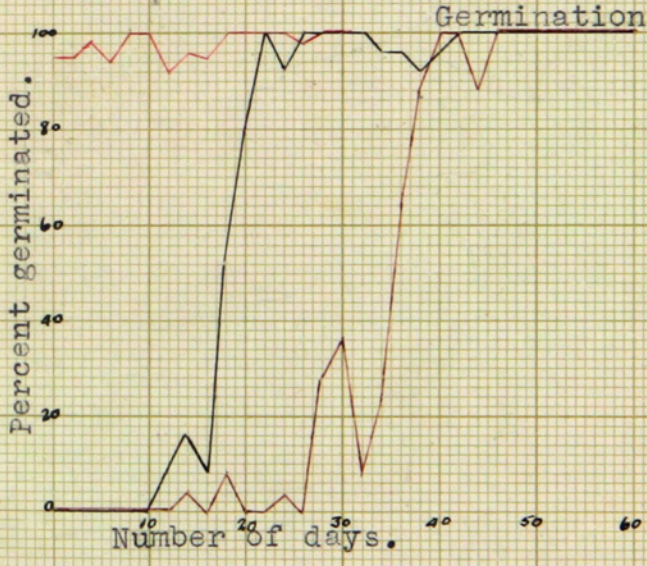
In Graphs 1 and 2 it is easy to trace the path of the after-ripening in Marquis and Defiance to a normal germination in the three day test.

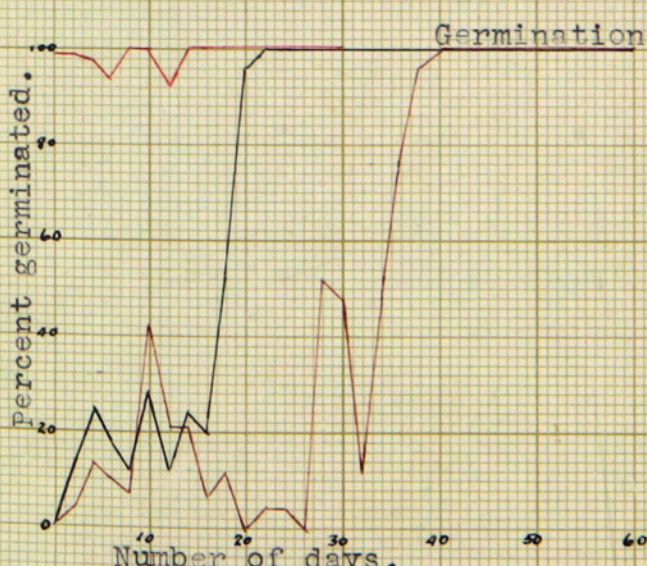
In these graphs we see the results of the after-ripening when subjected to three conditions: (1) where the seed was placed in the germinator (brown lines) as soon as harvested; (2) the seed was placed in a refrigerator (black

GRAPH No.1

Marquis wheat grown at the Experiment Station, Fort Collins, Colorado, in 1920, was planted at the Experiment Station, Fort Collins, Colorado, April 9, 1921. Harvests were made every other day beginning July 7, 1921.







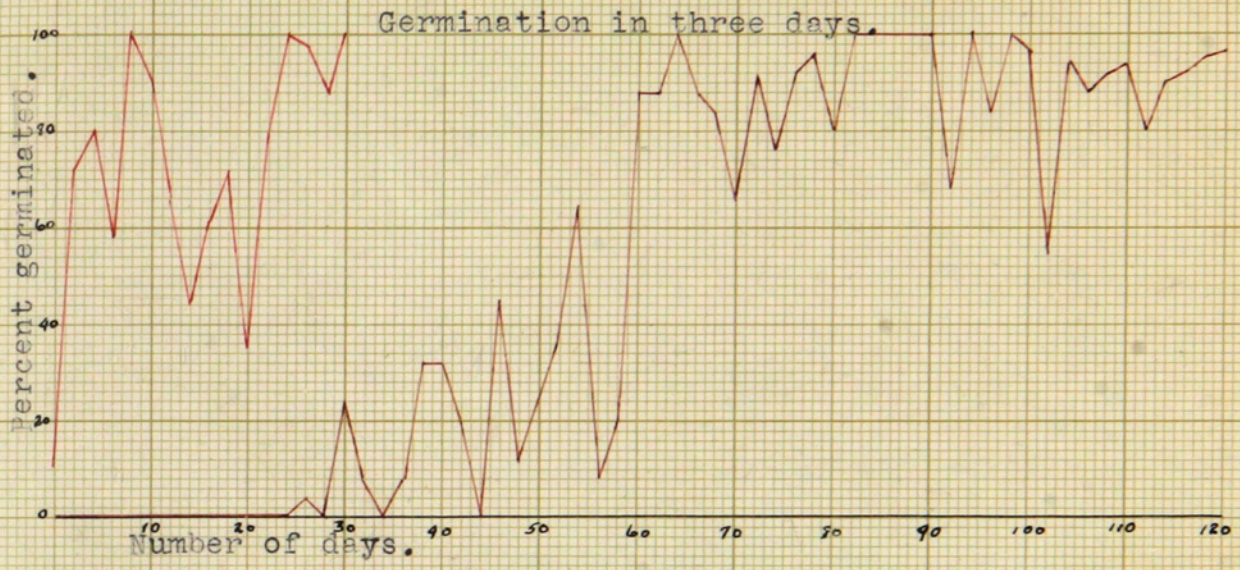
Red lines indicate that the wheat was not germinated until ninety days after harvesting.

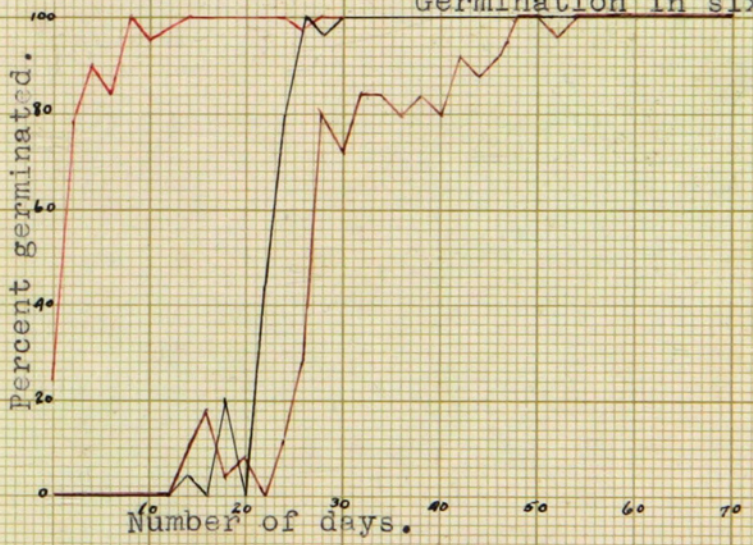
Brown lines indicate that the wheat was germinated as soon as harvested.

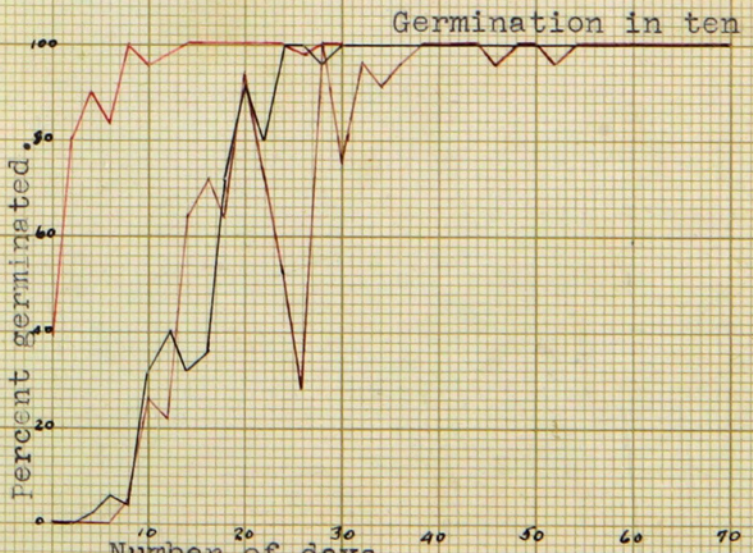
Black lines indicate that the wheat, as soon as harvested was placed in a refrigerator for three days between moist blotters, before being placed in the germinator.

GRAPH No.2

Defiance wheat grown at the Experiment Station, Fort Collins, Colorado, in 1920, and showing normal germination, was planted at the Experiment Station, Fort Collins, Colorado, April 8, 1921. Harvests were made every other day beginning July 7, 1921.







Red lines indicate that the wheat was not germinated until ninety days after harvesting.

Brown lines indicate that the wheat was germinated as soon as harvested.

Black lines indicate that the wheat, as soon as harvested was placed in a refrigerator for three days between moist blotters, before being placed in the germinator.

lines) for three days before being placed in a germinator; and (5) the seed was held for ninety days from the date of harvesting before being placed in a germinator.

The Marquis variety in the three day test (Graph 1), we see that the seed placed in the germinator as soon as harvested did not reach normal germination until the harvest seventy-six days after harvesting began. The seed placed in the refrigerator between moist blotters failed to reach a normal germination in a three day test and the seed held for ninety days before germinating reached a normal germination in the first harvest (July 7).

In the six day test, the seed which was placed in the germinator came to normal germination in the harvest thirty-eight days after harvesting began. That placed in the refrigerator for three days and did not germinate in three days, in the six day test, came to normal germination in the harvest twenty days after harvesting began.

We see that seed placed under refrigerator conditions for three days and then placed in the germinator for three days came to a normal germination twenty days before that placed directly in the germinator, which shows that the cold condition of the refrigerator caused a change within the grain which increased the rate of germin tion and shortened the after-ripening period.

We still have shorter periods of after-ripening in the ten day tests in which the seed placed in the refrigerator for three days came to normal germination twelve days before that placed directly in the germinator.

The Defiance variety (Graph 2) in the three day test, the seed did not reach normal germination until the harvest sixty days after harvesting began. The seed placed in the refrigerator between moist blotters for three days failed to germinate at all, and the seed held ninety days after harvesting a normal germination was reached in the harvest six days after harvesting began. That placed in the refrigerator for three days and then in the germinator for three days, came to a normal germination in the harvest twenty-two days after harvesting began and that held for ninety days before germinating came to normal germination in the harvest two days after harvesting began. In the ten day test we find that the seed placed in the refrigerator for three days and then in the germinator for seven days came to a normal germination eight days before that placed in the germinator for ten days.

In summarizing graphs 1 and 2 we find that after-ripening occurs in both Marquis and Defiance and the duration of the after-ripening depends upon the variety.

In the three day test in which the seed was placed in the germinator as soon as harvested, Marquis came to a normal germination in the harvest seventy-six days after

harvesting began. In the six day test, the seed placed in the refrigerator for three days and then in the germinator for three days, came to a normal germination in Marquis eighteen days and in Defiance eight days before that placed in the germinator direct. In the ten day tests the seed came to a normal germination earlier than in the six day test.

We have seen by previous results that the grain held ninety days before germinating produced a normal germination on or soon after the first harvest depending upon the variety. In the germinating of this seed, harvested every other day beginning July 6 and after ninety days, offers some very interesting results. In table 3 is a summary of the germination tests.

Table 3.
GERMINATION TEST 90 DAYS AFTER HARVEST.

	Date Harvested	Date of Test	Germination Test 3 days	6 days	8 days	10 days	Total
April 9	July 6	Oct. 6	0	0	0	0	0
"	July 8	Oct. 8	41.2	17.6	0	0	59.8
"	July 10	Oct. 10	100	0	0	0	100
"	July 12	Oct. 12	100	0	0	0	100
"	July 14	Oct. 14	83.7	16.3	0	0	100
"	July 16	Oct. 16	95.8	4.2	0	0	100
"	July 18	Oct. 18	96.6	3.4	0	0	100
"	July 20	Oct. 20	100	0	0	0	100
"	July 22	Oct. 22	100	0	0	0	100
"	July 24	Oct. 24	100	0	0	0	100
"	July 26	Oct. 26	95.1	4.9	0	0	100
"	July 28	Oct. 28	88.2	11.8	0	0	100
"	July 30	Oct. 30	92	4	0	0	100
"	Aug. 1	Nov. 1	84.2	15.8	0	0	100

Plates 1 to13 show grains and seedlings from above mentioned tests.

The grains and developing seedlings in these plates are approximately one and one half times normal size.

Plate 1, pp. 192 harvested July 6, ten days after heads appeared (grain was in the milk stage) and germinated October 6, shows a kernel of little development and with a zero germination in the three and six day tests.

Plate 2 pps. 193 and 194, harvested July 8 and germinated October 8, shows a poor developed grain yet far advanced over that in plate 1. In the three day test a germination per cent of 41.2 was secured. There was a long but weak development of the plumules (71) and a very weak development of the seminal roots (70). Only one, and in some cases, two, or three weak seminal roots were produced. In the six day test a germination of 59.8 per cent was secured. The plumule being long and weak with very poorly developed seminal roots.

Plate 3 pps. 195 and 196, harvested July 10 and germinated October 10. The caryopses are nearly normal size, yet poorly filled and shrunken. In the three day test a germinating per cent of 100 was secured with a little stronger development of the plumules and stronger development of the seminal roots than in plate 2. In the six day test a much longer and thicker root development of the plumules and a more longer seminal root development than in the preceding plates, indicating more vitality.

Plate 4, pps.197 and 198, harvested July 12 and germinated October 12. A 100 per cent germination was secured in the three day test, with a thickening up of the plumules and a stronger development of seminal roots. In the six day test we see a much greater development of seminal roots than in the preceding plates.

Plate 5, pps.199 and 200, harvested July 14 and germinated October 14. Here we have grains of normal size but with deep sutures and shrunken kernels showing that they were not completely developed at harvest time. In the three day test an 83.7 per cent germination was secured. The plumules are becoming shorter and thicker and the seminal roots stronger. In the six day test we see plumules much shorter yet thicker and seminal roots a great deal longer than in any preceding plates.

Plate 6, pps. 201 and 202, harvested July 16 and germinated October 16. The caryopses in this plate are of normal size, but are shrunken to a slight extent showing that filling was not complete. A 95.8 per cent germination was secured in the three day test. Here it can be noticed we have a short thick development of the plumule with well developed long seminal roots, showing greater vitality than in preceding plates. In the six day test a short thick development of the plumules are shown and a long strong development of four seminal roots, showing greater vitality.

Plate 7, pps. 203, and 204, harvested July 18, and germination October 18. A germination test of 96.6

per cent was secured in the three day test. In these plates we have seeds that lack very little of being fully developed. In the development of the young plant in three days we have plumules as thick and longer than in plates 5 , and 6 . In the development in the six day test shows a shorter but thick development of the plumules and a long strong development of the seminal roots.

Plate 8, pps. 205 and 206 , harvested July 20, and germinated October 20. Here we have seeds lacking very little of being fully developed, yet a slight shrinkage in the kernel can be seen. A 100 per cent germination was secured in the three day test. In the development of the young plant in the three day test we have a thicker development of plumules than in the preceding plates and a stronger development of seminal roots.

In the six day test we have a thicker plumule and a good development of four seminal roots.

Plate 9, pps. 207 , and 208 , harvested July 22 and germinated October 22. The grain has reached a normal size and to the eye appears fully developed. In this harvest a 100 per cent germination was secured in the three day test. A shortening of the plumules and a stronger development of roots is seen. In the six day test we have thick curling plumules which indicate vitality. Here we see for the first time five seminal roots.

Plate 10, pps. 209 , and 210, harvested July 24 and germinated October 24. In this harvest we have grains that appe r to the eye to be fully matured. In the three

day test a 100 per cent germination was secured. The plumules are thicker and shorter than in any preceding plates, and a very strong development of seminal roots is shown. In the six day test we have the strong, thick, curled plumules and a stronger development of the five seminal roots than in plate 9.

Plate 11, pps. 211 , and 212, harvested July 26 and germinated October 26. The grains in this test appear to be fully ripened. In the three day test a 95.1 per cent germination was secured. Both plumules and roots show a strong development. In the six day test the plumules are long and thick and a strong development of the fine seminal roots is shown.

Plate 12, pps. 213, and 214 , harvested July 28 and germinated October 28. The grains here are fully developed. We see an extra strong development of plumules and seminal roots with a germination of 88.2 per cent in the three day test. In the six day test, thick strong plumules are seed and for the first time we have the appearance of six seminal roots.

Plate 13, pps. 215 , and 216 , harvested July 30 and germinated October 30. The grains were fully developed and a 96 per cent germination was secured in the three day test. This plate shows a very thick development of the plumules with a very thick but shorter development of the seminal roots. In the six day test there is a shortening of the plumules,but with a strong d evelopment of seminal roots.

Plate 14, pps. 317 and 318, harvested August 1 and germinated November 1. The grains here are fully developed. In the three day test, 84.2 per cent of the seed germinated. The plumules are short but very thick and the seminal roots show a strong development. In the six day test we see a shorter but very thick, curled plumule with a strong development of seminal roots, which divide at the tip indicating a strong vitality and growth.

In a comparison of the plates, the seed first harvested (July 6) no germination took place. In the second harvest (July 8) the grains were very poorly developed, a germination of only 41.2 per cent was secured in the three day test. The plumules were very long and slender and from one to three very short weak and seminal roots were produced. As the seed advanced from the milk to the dead ripe stage we see a shortening and thickening up of the plumules and an increase in number and a lengthening of stronger seminal roots. In the changing from the long, slender plumules to short, thick and strong plumules and from a few (1-3) poorly developed seminal roots to numerous (5-6) long strongly developed seminal roots, there is a lowering in the per cent of germination while this change is taking place.

As the harvests advance (between July 26 and August 1) the seed has advanced toward complete development. There is a shorter, but thicker development of both the plumules and seminal roots.

When the tests were allowed to run for eight days, the harvests up to July 26 showed very little development after the six day tests, but the harvests from July 26 to August 1 showed a large increase in size of both plumule and seminal roots showing that in matured grain, the germination is slower but the vitality is greater than in immature grains.

In the preceding tests we see that an after-ripening period occurs in wheat and the duration of the delay is in the neighborhood of fifty days from the time of harvest (dead ripe stage).

When immature seed or seed at harvest is placed in the germinator between moist blotters it nearly always fails to germinate and if the seed germinates, the germination is poor and the time required to germinate the seed is prolonged. If some of the same seed is placed in the refrigerator under dry conditions for three days and then placed in a germinator, the seed fails to germinate or germinates very slowly, requiring a longer time than does wheat that has reached a normal germination. If some of the same wheat be placed in a refrigerator between moist blotters or under water for three days and then placed in a germinator, a normal germination is secured in the germinator in three days, showing that a change has taken place within the seed under moist refrigerator conditions which cause a normal germination immediately .

Crocker and Harrington (25) "Seeds that after-ripen in a germinator at low temperature (commercial layering)

and in which the dormancy of the emoryo is self-imposed and the embryo experiences fundamental time-ripening, changes for after-ripening, show a great increase in catalase activity with after-ripening (hawthorn, basswood, peach). The catalase activity in dry peach seeds is very slow, but rises as the seeds lie in the germinator imbibed. The rise continues for weeks and is much more rapid at seven degrees centigrade than at twenty or twenty-five degrees centigrade. The optimum temperature for after-ripening seems to be optimum for catalase increase. In other seeds having dormant emoryos, so far as studied by other investigators, the same relation holds."

Crocker (21) "Low temperature, but not freezing or freezing and thawing, hastens the after-ripening in the embryo of Crataegus. Evidence indicates, however, that the benificial effects of freezing are often through coat changes."

Walster, H. L. (Bot. Gaz., 69, 97-126, 1912), translation of Gassner and Gumme (36), "That seedlings germinated at the lower temperatures had a higher sugar content than seedlings germinated at a higher temperature.

Brown and Morris (15) "When barley in different stages of development is taken fresh out of the field, we find on testing in the usual way, that the epithelium of the excised and immature embryos is incapable of secreting any enzyme which will act upon the starch granules. It is this

inability to liquify starch-paste which differentiates the enzyme of the resting seed from that of germinated grains, the latter having extremely active liquifing and saccharifying powers.

Crocker (31) and Harrington and Crocker (35) say that seed germinated under low temperature have a shorter after-ripening period and germinate more readily than seed germinated at a higher temperature.

Sherman (79) and Crocker and Harrington (35) state that seeds germinated under low temperature have an increase in catalase activity and Crocker and Harrington (35) "The optimum temperature for after-ripening seems to be optimum for catalase increase." Gassner and Gumme (36) seedlings germinated at low temperature show a higher sugar content than seedlings germinated at a higher temperature.

We see that seed germinated at low temperature have an increased catalase activity and a greater accumulation of sugar content. Brown and Morris (15) working with barley state, "That immature seeds are incapable of secreting any enzyme which will act upon starch granules. It is this inability to liquify starch paste which differentiates the enzyme of the resting seed from that of the germinated grain." This inability of enzymes to liquify starch paste is possibly what causes immature seed not to germinate when placed directly in the germinator. When the immature seed is placed under

moist conditions for three days and then placed in a germinator, it germinates at once, that is, if the grain is not too immature. The change taken place in the refrigerator must be a change in which there is an increase in an active enzyme (diastase) content and this an increase in the rate of germination.

Coate (19) in a microchemical study on the germination in wheat found the following changes:"No change is apparent in the contents of the grain (aside from the swelling due to absorption of water and softening of the tissues) until ten to twelve hours after the material has been put into germinating dishes. At this time dextrin appears in the scutellum and coleorhiza, and starch in the root cap. At about the same time dextrin appears in the coleoptile and shortly afterward in the plumule. After twelve hours reducing sugar is found in the coleorhiza and appears also in the root, endosperm, coleoptile, plumule and scutellum by the end of twenty-four, thirty-six, forty-eight and ninety-six hours respectively. At no time was oxidase found in any part of the germinating seedling, but peroxidase and catalase were present in all parts. After the appearance of the sugar in the coleorhiza and coleoptile, the amount of dextrin present decreases and the amount of sugar increases. In the root the amount of sugar increases up to the fourth day, after which the sugar content does not increase proportionately with the increase in the root tissue. At all times it is found most abundantly in the zone

of the root hairs. In the endosperm reducing sugar is first found near the basal end of the embryo, but eventually is found throughout the whole tissue. All tests indicate that this reducing sugar is glucose. At the end of seven days starch is still present in the greatly disorganized endosperm, although practically all the grains still remaining show marked corrosion."

We observe from the work of others that the principle enzymes in dormant and germinating seed of wheat are peroxidase, catalase and diastase. Peroxidase and catalase are confined to the splitting of hydrogen peroxide into water and oxygen. The principal enzyme in wheat germination is diastase, which according to Green (100) "The two vegetable diastases may be compared ; (1) translocation diastase. This dissolves starch grains without corrosion, has a very slow action on starch-paste though it readily converts soluble starch into sugar; works best at a temperature of forty-five to fifty degrees centigrade; is much more active at a low temperature than secretive diastase; and (2) diastase of secretion. This corrodes starch grains and disintegrates them before solution; rapidly liquifies starch-paste; works most advantageously at a temperature of fifty to fifty-five degrees centigrade. It will stand heating to seventy degrees centigrade without destruction."

Diastase of translocation functions in starch translocation; the movement of starch from one part of the plant to another, and lays down starch in the endosperm of

seeds. Diastase of translocation is found in wheat soon after fertilization or as soon as starch begins to be laid down around the embryo. Diastase of translocation is found through the tissues of the endosperm.

Diastase of secretion according to Brown and Morris (15) is found in seed at the time of germination and is secreted from the epithelial cells of the scutellum, converting the starch granules of the endosperm into sugar (glucose) which is transferred to the growing part of the young plant.

Summarizing the work of Brown and Morris (15) and Green (100) it appears that the reason why immature seeds do not germinate when placed in a germinator is because the diastase of translocation, the only active enzyme, has little or no action on starch-paste in the seed. Newly harvested seeds do not germinate in the three day test and only slightly in the six day test because the diastase of secretion is not active and the diastase of translocation is slow in acting.

If these immature seeds and seed at harvest time are placed in a refrigerator for three days under low temperature (9.1° - 13.4° C.) and then in a germinator, germination takes place at once and according to Green (100) diastase of translocation is more active under cold condition than diastase of secretion; it would be reasonable to conclude that the diastase of translocation becomes active in converting starch into sugar (glucose) in immature seed and seed

at harvest time when placed in a refri erator, causing germination to take place readily when placed in a germinator.

When the seed is held ninety days after harvesting before germinating, it germinates readily in the germinator under normal germinative conditions. Brown and Morris (15) state that germination in mature seed is due to the secretion of the "diastase of secretion" from the epithelial cells of the scutellum, converting starch granules into sugar (glucose).

At the time of harvest the seed contains no quick acting enzymes, when placed in the germinator under normal germinative conditions, but when placed under the cold condition of a refrigerator the diastase of translocation becomes active. At the time of normal germination the diastase of secretion becomes active.

This shows that with the gradual loss of moisture and a gradual increase toward a normal germination, there is a gradual increase in the power of the diastase of secretion. when a normal germination is reached the diastase of secretion becomes fully active. The conclusion would appear to be that the after-ripening is due to the absences of active enzymes and a normal germination is reached due to the active power of the "diastase of secretion."

Table 2

DEFIANCE WHEAT SHOWING NORMAL GERMINATION

Date Test Began			
Average Weight per 100 grains.			
Placed in a germinator between moist blotters at 20 degrees C.	Germination	3 days	0
		6 days	0
		12 days	0
	Per cent moisture in normal grain		
Placed in a Freas drying oven at 30 degrees C., and then between moist blotters in a germinator at 20 degrees C.	Germination	3 days	
		6 days	
		12 days	
	Per cent loss in grams per 100 grains after 3 days in oven.		
	Per cent moisture after 3 days in oven.		
Placed in a refrigerator between moist blotters for 3 days and then in a germinator at 20 degrees C.	Germination	3 days	0
		6 days	92
		12 days	94
Placed in a refrigerator under dry conditions for 3 days and then between moist blotters in a germinator at 20 degrees C.	Germination	3 days	
		6 days	
		12 days	
	Per cent gain in grams per 100 grams in 3 days in refrigerator.		
	Per cent moisture after 3 days in refrigerator.		
Placed in a refrigerator under water for 3 days and then between moist blotters in a germinator at 20 degrees C.	Germination	3 days	
		6 days	
		12 days	
	Per cent gain in grams per 100 grains in 3 days in refrigerator under water.		
	Per cent moisture after 3 days in refrigerator under water.		

The Defiance wheat used in these tests was secured from the College Farm, Fort Collins, Colorado, and was grown on this farm in 1921.

Germination tests were made of this wheat before it was harvested in the field. The first germination tests were made July 22, 1921, and the wheat harvested July 28, 1921.

Germination tests were made every other day.

As soon as the wheat was cut, some of the bundles were stored in a shed; this stored wheat was used for the germination tests, until the wheat in the field was threshed August 31, 1921, and then the threshed bulk was used for the germination tests.

7/24	7/26	7/28	7/30	8/1	8/3	8/5	8/7	8/9	8/11
			2.839	2.918	3.240	2.903	2.837	2.878	2.710
0	0	0	0	0	0	0	0	0	0
0	0	0	1	1	5	3	6	20	35
16	2	0	10	14	26	11	31	44	51
			11.6	13.6	19.8	12.0	10.4	10.0	11.7
			0	0	0	0	0	0	0
			0	0	0	0	0	0	0
			22	12	50	23	51	70	79
			2.30	6.94	12.90	5.20	1.61	4.36	1.20
			9.3	8.9	9.1	7.2	8.6	8.2	9.6
0	0	0	0	0	0	0	0	0	0
98	36	98	94	96	98	100	96	96	100
100	62	98	95	99	99	100	98	99	100
			0	0	0	0	0	0	0
			0	0	0	0	0	0	0
			11	13	19	10	30	36	46
				0.60		2.81	3.40	5.12	3.86
			17.4	17.4	16.4	13.4	12.2	11.6	13.1
			0	0	0	0	0	0	0
			96	94	93	89	98	95	79
			99	98	95	94	99	99	92
			56.4	41.0	34.9	37.3	37.4	40.5	59.1
				40.2	39.2	35.7	39.8	41.5	39.9

8/13	8/15	8/17	8/19	8/21	8/23	8/25	8/27	8/29	8/31
2.879	2.861	2.757	2.735	2.962	2.875	2.951	2.905	2.819	2.872
7	0	0	1	13	0	8	8	55	14
68	60	84	76	86	97	93	100	98	98
84	76	89	92	98	100	98	100	98	98
12.3	13.4	11.2	10.2	11.6	11.1	11.9	11.7	11.9	11.4
0	0	0	0	0	0	0	0	0	0
0	17	0	0	18	23	72	18	14	10
98	87	86	93	97	93	97	100	98	99
3.43	5.93	4.49	1.60	3.56	1.39	3.66	2.13	4.07	2.65
7.4	9.2	7.6	9.4	8.4	10.2	9.0	8.6	8.4	9.1
0	0	0	0	0	0	0	0	0	0
99	100	99	99	99	99	100	97	98	100
99	100	100	99	99	100	100	98	99	100
0	0	0	0	0	0	0	0	0	0
0	6	0	0	24	24	61	35	19	6
86	74	69	69	94	98	87	96	100	97
3.70	0.78	5.90	3.81	3.62	3.69	2.46	1.72	1.73	2.84
13.2	14.2	12.6	12.8	14.0	13.4	12.8	13.4	12.4	12.8
0	0	0	0	0	0	0	0	0	0
98	95	100	100	99	97	97	97	95	98
98	96	100	100	99	97	99	99	97	98
48.3	42.0	36.8	49.0	53.1	50.8	44.4	57.0	50.3	50.5
39.8	39.7	39.4	40.6	41.0	41.8	41.8	41.0	41.2	41.1

The wheat was threshed from the field August 31,1921.

9/2	9/4	9/6	9/8	9/10	9/12	9/14	9/16	9/18	9/20
2.890	2.907	2.833	2.950	2.903	2.876	2.905	2.850	2.892	2.787
47	51	70	53	52	87	71	82	71	93
96	98	97	98	99	98	98	98	97	99
96	99	98	98	99	100	98	98	98	99
11.2	11.0	10.7	11.4	10.8	9.6	10.8	11.2	11.2	10.6
0	0	0	0	0	0	0	0	0	0
311	80	14	63	42	82	53	94	87	96
99	100	100	99	100	99	96	99	98	100
4.66	3.26	4.40	3.61	4.56	2.88	4.75	3.62	5.88	3.28
7.0	8.0	7.0	7.9	6.8	9.1	7.1	8.1	6.9	8.2
0	0	0	0	0	0	0	0	0	0
99	99	97	95	97	98	98	97	99	100
99	100	98	97	98	98	99	99	100	100
0	0	0	0	0	0	0	0	0	0
51	82	39	47	35	77	71	98	90	96
100	99	100	98	99	99	96	100	96	99
1.96	3.09	2.54	3.56	2.35	1.84	2.06	2.20	2.08	1.81
13.4	12.5	12.2	12.6	12.6	11.7	13.0	13.4	13.2	13.1
0	0	0	0	0	0	0	0	0	0
98	93	98	96	95	98	97	96	99	96
99	99	100	97	98	100	99	97	99	97
49.5	52.5	55.4	55.2	55.8	55.8	50.4	54.2	54.0	51.7
41.2	42.4	41.9	43.3	41.6	42.4	40.9	42.4	41.6	42.7

9/22	9/24	9/26	9/28	9/30	10/2	10/4	10/6	10/8	10/10
2.825	2.841	2.854	2.798	2.749	2/843	2.817	2/766	2.877	2.866
94	82	84	94	89	96	96	96	95	95
97	99	100	100	100	97	99	97	98	100
97	99	100	100	100	97	99	97	98	100
11.0	9.9	9.8	9.8	9.0	9.4	9.2	8.8	9.6	9.1
0	0	0	0	0	0	0	0	0	0
88	87	79	97	96	82	94	90	64	93
100	99	97	99	99	96	98	99	97	99
4.17	2.65	4.52	1.73	2.43	1.95	2.99	2.04	3.68	3.34
7.0	7.9	6.5	7.4	6.6	7.2	6.5	7.6	6.8	7.6
0	0	0	0	0	0	0	0	0	0
97	100	99	95	100	100	99	98	99	99
97	100	100	97	100	100	99	98	100	99
0	0	0	0	0	0	0	0	0	0
94	92	91	94	98	92	97	87	84	89
97.	100	99	98	99	99	98	99	96	99
1.77	3.40	2.64	3.45	2.68	3.62	3.68	3.32	2.50	3.39
12.0	12.4	11.4	11.3	11.4	11.3	11.4	10.0	11.4	10.4
0	0	0	0	0	0	0	0	0	0
98	100	97	94	97	98	99	100	98	99
100	100	98	96	98	98	99	100	98	99
57.7	61.7	53.6	58.6	52.6	58.0	57.0	63.3	53.5	54.1
41.8	42.2	41.7	42.0	41.9	42.1	42.0	42.3	42.6	42.4

10/12	10/14	10/16	10/18	10/20	10/22	10/24	10/26	10/28	10/30
3.900	2.759	2.812	2.854	2.879	2/847	2,835	2.910	2.815	2.381
93	92	92	95	90	94	88	85	83	81
98	98	98	98	99	99	99	99	95	96
98	98	98	98	99	99	99	99	97	96
9.4	9.7	9.6	9.2	9.3	9.0	9.0	8.9	9.2	9.2
0	0	0	0	0	0	0	0	0	0
88	89	91	91	84	81	69	73	55	70
99	97	99	98	100	97	97	98	97	100
3.21	2.45	3.42	2.22	3.41	2.24	3.42	2.54	3.47	2.23
6.8	7.8	6.0	7.8	6.5	7.4	7.7	7.0	6.2	7.2
0	0	0	0	0	0	0	0	0	0
99	98	97	88	96	99	97	96	97	97
99	99	100	93	97	100	98	99	97	97
0	0	0	0	0	0	0	0	0	0
89	93	91	90	81	91	82	85	83	86
98	99	95	98	96	99	96	98	97	98
3.52	2.88	2.73	3.55	2.95	3.88	3.09	4.07	3.31	3.80
11.3	10.3	10.7	10.3	10.9	10.4	10.8	10.9	11.0	11.1
0	0	0	0	0	0	0	0	0	0
91	95	96	99	98	95	98	95	97	98
94	97	97	99	98	97	99	98	99	98
57.8	59.9	54.8	68.0	59.7	53.2	56.6	58.0	58.7	67.1
42.6	42.0	43.6	42.1	42.2	43.3	42.1	42.4	42.2	42.4

11/1	11/3	11/5	11/7	11/9	11/11	11/13	11/15	11/17
2.807	2.810	2.835	2.843	2. 827	2.872	2.826	2.823	2.833
91	94	97	95	91	96	91	93	95
99	99	97	99	97	99	98	99	99
99	99	97	99	97	99	98	99	99
9.0	8.8	8.7	8.4	8.3	8.7	8.2	8.8	8.4
0	0	0	0	0	0	0	0	0
70	88	82	78	72	63	67	79	89
96	98	97	98	96	95	97	96	97
3.87	2.03	3.38	1.86	1.67	2.18	1.97	2.50	1.82
6.2	7.0	6.4	73.	7.5	6.9	7.3	7.4	6.6
0	0	0	0	0	0	0	0	0
94	96	95	97	95	98	99	100	96
97	96	97	97	100	98	99	100	99
0	0	0	0	0	0	0	0	0
81	92	89	77	83	72	76	82	88
98	99	96	97	97	98	98	97	96
3.18	4.72	5.61	3.71	2.27	3.07	3.62	2.98	2.56
10.3	11.2	12.0	10.7	10.4	10.8	10.3	10.6	10.7
0	0	0	0	0	0	0	0	0
99	96	94	98	97	98	99	98	95
100	98	96	98	99	99	99	98	99
58.3	59.9	63.4	58.1	59.9	62.0	58.4	57.1	59.0
42.6	42.6	42.5	42.3	42.5	42.6	42.6	42.3	42.4

GEOGRAPHICAL DISTRIBUTION OF DELAYED GERMINATION.

In the study of delayed germination in wheat it was our purpose to seek out the distribution of delayed germination to see if it was localized in certain sections, and to see if the causes of the delay in one section were the same as the causes of the delay in other sections of the country.

Letters were written to experiment stations, seed laboratories, county agents and farmers in different sections throughout the United States in request for varieties best adapted to their regions. The request was exceedingly well granted for wheat was received from all the grain growing regions represented in the United States. Table 4 shows the varieties received from the different states and their germination tests.

Table 4

State	Varieties	Germination Tests 3 days	6 days	8 days	10 days	Total
ALABAMA						
	Currell #2806	80	8	0	0	88
	Alabama Bluestem	87.5	5.5	0	0	93
	Fulcaster	91	5	0	0	96
	Dietz Mediterranean	80.5	8.5	0	0	89
	Leap's #12	80.5	8.5	0	0	89
	Stoner	84	11.5	0	0	95.5
	Average	83.92	7.83	0	0	91.75
ARKANSAS						
	Fultz (Ark. Selection #3)	89.5	2.5	0.5	9	92.5
	Leap's Prolific	82.5	6.5	0	0	89
	Fulcaster	89	3.5	0	0	92.5
	Red May	87	6.5	0	0	93.5

State	Varieties	Germination Tests. 3 days	6 days	8 days	10 days	Total
ARKANSAS (continued)	Alabama Bluestem	96.5	1	0	0	97.5
	Kanred	90	5.5	0	0	95.5
	Marvelous	87.5	7.5	0.5	0	95.5
	Average	88.86	4.7	0.14	0	93.71
CALIFORNIA	Baart #3039	94.5	1.5	1	0	97
	Bunyip #3023	95.5	2	0	0	97.5
	Club #114	99	0.5	0	0	99.5
	Defiance #955	84.5	14.5	0	0	99
	Hard Federation #3083	91.5	7	0	0	98.5
	Propo #115	95	3	0	0	98
	Sonora #98	87.5	3.5	2	0	93
	White Australian #791	92.5	6	0	0	98.5
	White Federation #3213	95.5	3.5	0	0	99
	Average	93.82	4.61	.33	0	97.77
CONNECTICUT	Cornell Selection #3030	94.5	3	0	0	97.5
	Marquis	90.5	6.5	0	0	97
	Average	92.50	4.75	0	0	97.25
KANSAS	Black Hull #1	89	8	0	0	97
	Black Hull #2	90	4.5	0.5	0	95
	Kanred #1	88.5	7.5	0	0	96
	Kanred #2	86	9.5	0	0	95.5
	Kharkov	80	15	0	0	95
	Turkey Red #1	87	6.5	1	0	94.5
	Turkey Red #2	89.5	75.	0	0	97.0
	Average	87.14	8.36	.21	0	95.71
ILLINOIS	Beloglina	86.5	15	1	0	89
	Dawson Golden Chaff #9-226	90.5	1	0.5	0	92
	Kanred	78.5	6	0.5	0	85
	Malakoff #5-460	94.5	3.5	1	0	99
	Mediterranean	89	1	0.5	0	90.5
	Red Rock	88.5	15.	0	0	90
	Turkey Hybrid #509	93	1.5	0	0	94.5

State	Varieties	Germination Tests. 3 days	6 days	8 days	10 days	Total
ILLINOIS (continued)	Turkey Hybrid #514	86.5	1.5	0	0	88
	Turkey Red #10-110	91.5	5	0.5	0	97.0
	Wisconsin #18	90	1	0	0	91
	Average	88.85	2.35	0.40	0	91.60
MAINE	Preston	82.5	8	0	0	90.5
	Red Fife	90.5	2.5	0	0	93
	Average	86.50	5.25	0	0	91.75
MICHIGAN	American Banner	80.5	16.5	0	0	97
	Red Rock	80.5	7.5	1	0	89
	Average	80.5	12.0	0.5	0	93
MINNESOTA	Crimean #845	95.5	2	0	0	97.5
	Minnardi #1505	89	3	0	0	92
	Minturhi #1507	87	2.5	0	0	89.5
	Average	90.50	2.50	0	0	93.00
MONTANA	Burbank Super	82	11	0	0	93
	Kanred	78.5	15	0.5	0	94.5
	Kharkov	60.5	33	1	0	89.5
	Montana #36	66.5	22	1	0	89.5
	Turkey Red	77.5	15	0.5	0	93
	Average	73.6	19.2	0.6	0	92.4
NEVADA	Turkey Red #1	82	12.5	0	0	94.5
	Turkey Red #2	69	18.5	0.5	0	88
	Average	75.50	15.5	0.25	0	91.25
NEW MEXICO	Defiance	77	16.5	0.5	0	94
	Early Baart	88	5.5	2	0	95.5
	Forty Fold	93.5	3.5	0.5	0	97.5
	Kubanka	46.5	42	2.5	0	91
	Marquis	88	7.5	0	0	95.5
	Rooli	93	4	0	0	97
	Sonora	89	3.5	2	0	94.5
	Turkey Red	90	2	0	0	92
	White Winter	71.5	18.0	0	0	90.0
	Average	81.84	11.44	0.83	0	94.11

State	Varieties	Germination Tests. 3 days	6 days	8 days	10 days	Total
NEW YORK						
	Forward	88.5	11.5	0	0	100
	Honor	88.5	10	0.5	0	99.
	Hybrid #86	69	29.5	0	0	98.5
	Hybrid 1027A 1-8-6-12	72	25.5	0.5	0	98
	Junior #6	69	29	0	0	98
	Selection Dietz 105-5	78.5	16	0	0	94.5
	Average	77.50	20.36	0.17	0	98.00
N. CAROLINA						
	Gleason	83.5	14.5	0	0	98
	Alabama Bluestem	91	7.5	0	0	98.5
	Leap's Prolific	95	3.5	0	0	98.5
	Dietz Medeterranean	84.5	11	0	0	95.5
	Purple Straw	71.5	24.5	0	0	96
	Fulcaster	87.5	9.5	0	0	97
	Stoner's Miracle	87.5	6.5	0	0	94
	Average	85.71	11.00	0	0	96.71
OHIO						
	Valley	96	3	0.5	0	99.5
	Trumbull	70	26	0.5	0	96.5
	Dawson's Golden Chaff	84	14.5	0	0	98.5
	Portage	93.5	3.5	0	0	97
	Gladden	98	1	0	0	99
	Fultzo Mediterranean	93	7	0	0	100
	Average	89.08	9.19	0.17	0	98.42
OREGON						
	Red Huston	86.5	12.5	0	0	99.00
	Average	86.5	12.5	0	0	99.00
PENNSYLVANIA						
	Harvest King	91	3.5	0	0	94.5
	Leap's Prolific	89	3	0.5	0	92.5
	Pennsylvania #44	80	15	0.5	0	95.5
	Average	86.67	7.17	0.33	0	94.17

State	Varieties	Germination Tests 3 days	6 days	8 days	10 days	Total
S. CAROLINA						
	Leap's #12	91	7.5	0	0	98.5
	Fulcaster	95	3	0	0	98
	Currell	93.5	2	0	0	95.5
	Dietz Mediterranean	96.5	2.5	0	0	99
	Alabama Bluestem	91.5	3.5	0	0	95
	Stoner	92	7.5	0	0	99.5
	Average	93.25	4.33	0	0	97.58
S. DAKOTA						
	Acme	73.5	10	0	0	83.5
	Kanred	91	2.5	0.5	0	94
	Kubanka	74.5	8	0	0	82.5
	Marquis	94	2.5	0	0	96.5
	Turkey Red	92	1.5	0	0	93.5
	Average	85.00	4.90	0.10	0	90.00
TENNESSEE						
	#1981	85.5	9	0	0	94.5
	#2008	89.5	1.5	0	0	91
	Bluestem	97	1.5	0	0	98.5
	Fulcaster	88.5	3	0.5	0	92
	Illini Chief	92.5	5	0	0	97.5
	Kanred	94.5	3.5	0.5	0	98.5
	Leap's Prolific	95	2	0.5	0	97.5
	Pennsylvania #44	86	10.5	0	0	96.5
	Poole	96	0.5	0	0	96.5
	Tennessee #180	88.5	8.5	0	0	97
	Wood #1421	88	7	0	0	95
	Average	91.00	4.73	0.14	0	95.97
VIRGINIA						
	Blue Ridge	84.5	8	0.5	0	93
	Dietz Amber	82.5	13	0	0	95.5
	Fulcaster	89	6.5	0.5	0	97
	Leap's Prolific	88	2.5	0	0	90.5
	Stoner	88.5	11.5	0	0	100
	V Pl 112 (Selection from Poole)	87	7.5	0	0	94.5
	V Pl 131 (Selection from Fulcaster)	82.5	7.5	0	0	90.00
	Average	86.00	8.33	0.14	0	94.36

State	Varieties	Germination Tests. 3 days	6 days	8 days	10 days	Total
WASHINGTON						
	Bluestem Wash. #365	83	4.5	0	0	87.5
	Early Baart Wash. #818	87	3.5	0.5	0	91
	Forty Fold Wash. #315	73	16.5	0	0	89.5
	Hybrid 128 Wash. #592	90	4	0	0	94
	Marquis Wash. #576	87.5	6.5	0.5	0	94.5
	Turkey Red Wash. #326	86.5	12	0	0	98.5
	Average	84.5	7.80	0.2	0	92.50
WEST VIRGINIA						
	Ashland	89	5.5	0	0	94.5
	Fulcaster	91.5	3.5	0	0	95.0
	Gladden	95	1	0	0	96
	Reliable #80	88.5	3.5	0	0	92.0
	Average	91.00	3.38	0	0	94.38
WISCONSIN						
	Marquis	83	13	0.5	0	96.5
	Pedigree #2	75.5	12	0.5	0	88
	Prelude	83	1.5	0	0	84.5
	Average	80.50	8.83	0.33	0	89.66
WYOMING						
	Baart	70	14.5	0	0	84.5
	Bluestem	87.5	6.5	0	0	94
	Dicklow	90.5	0	0	0	90.5
	Kubanka	61	22	0.5	0	83.5
	Marquis	81.5	13	0	0	94.5
	Norka	89	3	0	0	92
	Red Fife	85	3	0	0	88
	Ruby	94	1	0	0	95
	Average	82.31	7.88	0.06	0	90.25

A study of the varieties showing a delay in germination are shown in table 5.

Table 5.
VARIETIES SHOWING DELAYED GERMINATION

Varieties	State	Germination Tests 3 days	6 days	8 days	10 days	Total
Kanred	Montana	78.5	15	0	0	94
Kharkov	"	60.5	33	1	0	94.5
Montana #36	"	66.5	22	1	0	89.5
Turkey Red	"	77.5	15	0.5	0	93
Turkey Red	Nevada	69	18.5	0.5	0	88
Defiance	N. Mexico	77	16.5	0.5	0	94
Kubanka	"	46.5	42	2.5	0	91
Hybrid #86	New York	69	29.5	0	0	98.5
" #1027 A (A 1-8-6-12)	"	72	25.5	0.5	0	98
Junior #6	"	69	29	0	0	98
Trumbull	Ohio	70	26	0.5	0	96.5
Acme	S. Dakota	73.5	10	0	0	83.5
Kubanka	"	74.5	8	0	0	82.5

The only varieties appearing more than once are Turkey Red, appearing twice with an average germination of 73.25 per cent and Kubanka appearing three times with an average germination of 60.67 per cent in a three day test.

The average germination test of Turkey Red in a three day test in all the tests made for the distribution of delayed germination was 84.0 per cent so the average of 73.25 per cent shown by the two samples in a three day test, shows that delay in germination does not normally occur in Turkey Red wheat. In Kubanka, the average for all the tests was 60.67 per cent, in a three day test, indicating that a normal delay occurs in Kubanka. Acme, a variety of the same subspecies as Kubanka, shows a germination of only 73.5 per cent in a three day test. The delay shown in Kubanka and Acme indicates that there is a delay in germination normal to that subspecies (Durum wheat).

The only state given any consideration as to location in which a delay in germination might exist was Colorado. Tables 6 and 7 show the number of samples

Table 6

GERMINATION TEST OF SAMPLES OF WHEAT SENT INTO THE COLORADO SEED LABORATORY BETWEEN JAN. 1 AND JULY 1 AND SEPT. 15 AND DEC. 31, 1921

Counties	No. of Samples	Average Germination	
		3 days	6 days
Adams	5	85.3	92.5
Arapahoe	1	86.5	94.5
Bent	1	94.5	97.5
Boulder	3	93.5	96.6
Cheyenne	1	99	99
Delta	4	91.7	98.4
Denver	25	87.4	95.3
Elbert	1	71	91
El Paso	3	86.1	93.1
Huerfano	2	82	89
La Plata	4	77	92.2
Larimer	18	88.1	95.5
Las Animas	1	74	94
Montrose	7	86.8	95.3
Morgan	6	90.2	95.5
Prowers	1	90	94
Pueblo	2	94	96.5
Routt	2	87.8	92.7
Weld	8	87.3	93.9
Average		87.39	94.55

Table 7.
GERMINATION TEST OF WHEAT SAMPLES SENT INTO THE COLORADO SEED LABORATORY FROM THE SAN LUIS VALLEY BETWEEN JAN. 1 AND JULY 1 AND SEPT. 15 AND DEC. 31, 1921.

Counties	No. of Samples	Average Germination		
		3 days	6 days	10 days
Costilla	12	37.5	81.6	92.1
Rio Grande	11	67.1	86.7	
Saguache	2	36.3	92.7	
Average		46.97	87.0	

sent into the Colorado Seed Laboratory by counties between January 1 and July 1 and September 15 and December 31, 1921 and their average germination tests. We see in table 7 that the three counties, Cositlla, Rio Grande and Saguache, situated in the San Luis Valley, had a germination on only 46.97 per cent in the three day test while the average for the rest of the counties, where seed was received, was 87.39 per cent in the three day test.

The counties outside of the San Luis Valley that show a delay in germination are Elbert, Huerfano, La Plata and Las Animas. The samples sent in by Elbert and Las Animas counties were both samples of durum type while one of the samples sent in by La Plata county was of the Durum type. Huerfano county was the only county outside of the San Luis Valley which show a delay similar to that existing in the San Luis Valley. It seems, therefore that the delay existing in varieties in tables 4, 5 and 6, not normal to the variety

is caused by conditions similar to thos existing in the San Luis Valley.

In combining tables 5, 6,7, 11 and 12, it is evident that in the geographical distribution of delayed germination two distinct types of delayed germination occur:

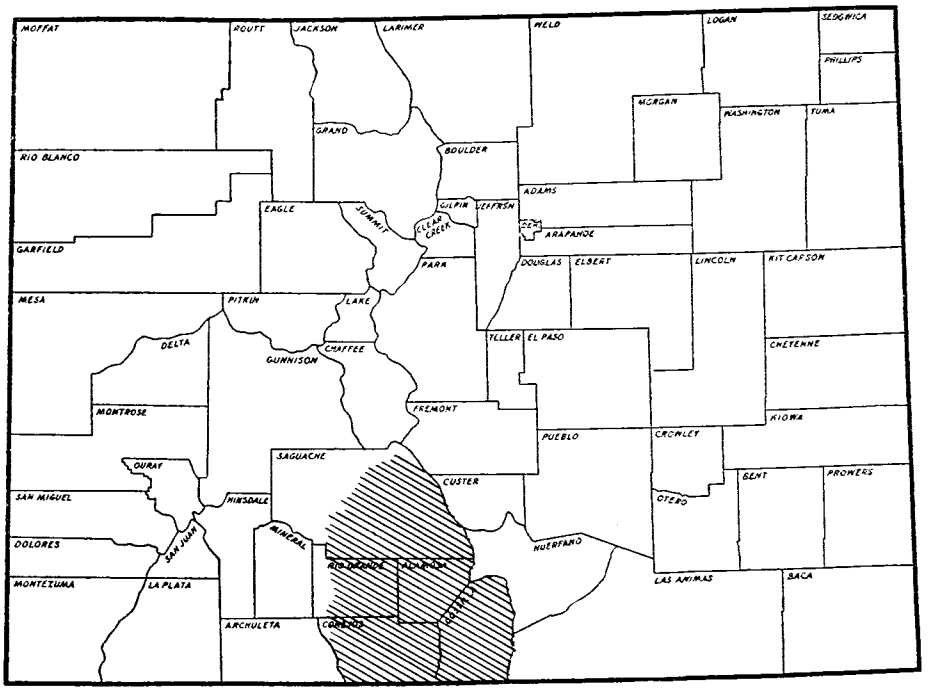
(1) In varieties grown under conditions similar to those existing in the San Luis Valley.

(2) In varieties represented by the subspecies Durum and which is a physiological condition normally existing in this type.

DELAYED GERMINATION CAUSED BY CONDITIONS EXISTING IN THE SAN LUIS VALLEY.

In the geographical distribution of the delay in germination in wheat, we find that there exists in the San Luis Valley, (Map No. 1) conditions which cause

Map No. 1



a marked delay in the germination after the after-ripening period is passed, but comes to normal germination after a period of time; the period of time required for this delayed wheat to reach a normal germination depends upon the variety. In this study of the delay in germination caused by conditions in the San Luis Valley, the subject divides itself under three heads: (1) conditions of after-ripening in seed showing delayed germination; (2) causes

of the delay in germination; and (3) the duration of the delay or the period of time required for the seed to reach a normal germination.

CONDITIONS OF AFTER-RIPENING IN SEED SHOWING DELAYED GERMINATION.

A study of germination tests of wheat grown in the San Luis Valley was undertaken in order to determine, if possible, whether the period of dormancy due to after-ripening and the consequent delayed germination is a continuous one or if the delay in germination is a secondary dormancy with a normal germination between.

The Defiance wheat used for these tests was secured from I. F. Rockey, Saguache, Colorado. It had been grown on his farm for the preceding five years. All seeds were germinated in a Minnesota germinator at 20° centigrade. The drying oven used is a Freas Electric oven. The refrigerator used is the Leonard cleanable, one piece porcelain type, the chamber in which seeds were kept varied in temperature from 9.1° to 13.4° centigrade.

The approved method of making germination tests of wheat is as follows: Place wheat between folds of moist blotting paper in a chamber at 20° centigrade. Make a preliminary count of all germinated seeds the third day, a final count the fifth day. A germination of 90 per cent or more the third day is to be expected from good seed that shows no delay.

Five sets of conditions were devised in order to ascertain whether the wheat used was of low vitality or merely required longer time for germination test, and also to study the effects of various conditions of moisture and

temperature during the germinating process.

Germination tests were made as follows:

1. Seeds placed between moist blotters in a germinator at 20° centigrade.

2. Seeds placed in a Freas drying oven at 30° centigrade for three days, then between moist blotters in a germinator at 20° centigrade.

3. Seeds placed between moist blotters in a refrigerator at 20° centigrade.

4. Seeds placed in dry condition in refrigerator for three days, then between moist blotters in germinator at 20° centigrade.

5. Seeds covered with water placed in refrigerator three days, and then between moist blotters in a germinator at 20° centigrade.

Tests under each of these five sets of conditions were started at two day intervals from September 18 to December 9, 1921. Germination counts in each case were made on the third, sixth and twelfth days. The results of these tests, table 8, show that throughout the entire period there is a delay when the usual laboratory germinating conditions are employed, that dry heat appears to retard germination, that dry refrigerator conditions retard germination, that seeds placed under water in a refrigerator are hastened to practically the same degree as those placed between moist blotters in a refrigerator.

A study of the entire series of tests shows that the change from delayed germination to normal germination is a

gradual one, and that once having reached normal, the germination continues normal. The behavior of the after-ripening in seeds having a delayed germination is similar to the after-ripening in normal seed.

Table 8

DEFIANCE WHEAT SHOWING DELAYED GERMINATION

Date Test Began		
Average Weight per 100 Seeds		
Placed in a germinator between moist blotters at 20 degrees centigrade	Germination	3 days
		6 days
		12 days
Placed in a Freas drying oven for 3 days at 30 degrees C., and then between moist blotters in a germinator at 20 degrees C.	Germination	3 days
		6 days
		12 days
	Per cent loss in grams per 100 grains after 3 days in oven	
Placed in a refrigerator between moist blotters for 3 days and then in a germinator at 20 degrees C.	Germination	3 days
		6 days
		12 days
Placed in a refrigerator under dry conditions for 3 days and then between blotters in a germinator at 20 degrees C.	Germination	3 days
		6 days
		12 days
	Per cent gained in grams per 100 grains in 3 days in refrigerator.	
Placed in a refrigerator under water for 3 days and then between moist blotters in a germinator at 20 degrees C.	Germination	3 days
		6 days
		12 days
	Per cent gained in grams per 100 grains in 3 days in refrigerator under water.	

9/18	9/20	9/22	9/24	9/26	9/28	9/30	10/2	10/4	10/6
	3.688	3.409	3.461	3.520	3.495	3.608	3.444	3.299	3.455
3	7	7	0	4	18	7	34	9	34
75	76	79	81	89	90	97	98	82	89
98	98	98	99	100	98	99	100	100	97
	0	0	0	0	0	0	0	0	0
	11	12	0	16	30	60	8	8	13
	99	96	100	100	86	99	95	97	98
	2.78	3.01	2.19	3.10	2.27	2.57	2.02	2.80	1.61
0	0	0	0	0	0	0	0	0	0
98	98	97	97	97	97	99	100	96	94
99	100	100	99	99	99	100	100	98	98
	0	0	0	0	0	0	0	0	0
	2	12	0	6	19	73	7	17	7
	92	96	87	96	92	97	98	96	97
	1.75	2.90	3.83	3.13	3.78	3.89	4.06	3.07	3.05
	0	0	0	0	0	0	0	0	0
	95	91	96	84	100	96	96	79	92
	98	97	99	95	100	99	98	85	98
	51.5	53.8	58.3	50.9	54.4	56.1	56.7	55.8	55.8

10/8	10/10	10/12	10/14	10/16	10/18	10/20	10/22	10/24	10/26
3.451	3.405	3.552	3.344	3.324	3.309	3.530	3.810	3.638	3.701
44	27	52	47	67	42	16	57	31	20
97	87	93	97	97	96	90	96	91	96
99	98	99	100	100	100	98	99	96	99
0	0	0	0	0	0	0	0	0	0
30	24	65	49	27	33	14	20	17	38
97	99	97	97	92	96	100	100	98	96
2.94	1.80	2.70	1.23	2.88	2.16	3.07	3.23	3.87	3.43
0	0	0	0	0	0	0	0	0	0
96	98	99	97	100	100	100	99	100	94
100	99	99	97	100	100	100	100	100	100
0	0	0	0	0	0	0	0	0	0
14	52	53	69	41	45	50	32	20	38
94	99	97	94	99	97	99	98	98	97
2.97	3.33	4.46	4.32	3.08	3.98	2.48	2.20	2.03	2.83
0	0	0	0	0	0	0	0	0	0
95	94	95	97	95	97	99	97	95	97
98	98	98	100	98	99	100	99	99	98
52.7	51.3	55.3	55.3	55.3	56.8	55.7	48.8	52.6	55.1

The spikes were threshed and the grain cleaned October 20,1921.

10/28	10/30	11/1	11/3	11/5	11/7	11/9	11/11	11/13	11/15
3.706	3.645	3.651	3.640	3.614	3.604	3.483	3.572	3.601	3.601
28	30	51	41	62	37	73	64	58	64
95	96	97	96	98	93	99	100	97	97
99	100	99	100	100	99	100	100	99	98
0	0	0	0	0	0	0	0	0	0
9	15	6	37	60	22	5	5	27	40
95	93	100	100	99	94	91	98	99	98
3.07	3.35	3.65	2.47	2.92	2.18	3.24	2.20	2.97	3.04
0	0	0	0	0	0	0	0	0	0
95	99	100	100	100	97	100	93	100	99
100	100	100	100	100	100	100	100	100	99
0	0	0	0	0	0	0	0	0	0
26	26	13	40	64	29	19	3	4	52
99	99	100	98	95	100	98	98	99	99
2.48	3.59	2.71	3.18	3.16	3.86	3.08	2.84	3.04	2.75
0	0	0	0	0	0	0	0	0	0
95	96	100	98	98	97	98	97	99	98
96	99	100	99	99	100	98	100	99	100
54.5	51.9	56.5	56.1	56.0	57.1	54.5	58.5	57.2	55.9

11/17	11/19	11/21	11/23	11/25	11/27	11/29	12/1	12/3	12/5
3.623	3.641	3.580	3.666	3.637	3.705	3.652	3.634	3.672	3.609
50	39	24	60	45	81	51	41	31	50
98	100	96	97	99	100	99	98	99	99
99	100	99	98	99	100	99	99	99	99
0	0	0	0	0	0	0	0	0	0
70	64	44	46	61	37	53	76	53	37
96	100	100	100	100	100	99	100	99	99
2.03	2.96	2.62	3.79	2.27	2.97	2.32	2.26	2.75	2.30
00	0	0	0	0	0	0	0	0	0
93	89	98	100	99	100	99	95	98	99
95	100	100	100	99	100	100	100	100	100
0	0	0	0	0	0	0	0	0	0
44	77	43	64	37	46	63	81	55	48
99	100	97	100	100	99	100	100	100	98
2.47	3.03	2.01	2.21	2.55	2.11	2.41	1.37	2.76	2.61
0	0	0	0	0	0	0	0	0	0
97	97	95	100	100	99	100	99	99	98
99	99	100	100	100	100	100	100	100	98
56.3	57.7	53.2	57.1	57.4	58.8	59.1	59.3	65.2	58.1

12/ .7	12/ .9	1/8	1/10	1/12	1/14	1/18	1/22	1/26	1/30
3.635	3.700								
50	54	57	56	63	72	59	66	64	68
98	99	96	100	100	100	99	97	100	100
100	100	97	100	100	100	100	100	100	100
0	0								
46	69								
100	99								
2.60	2.24								
0	0								
97	100								
100	100								
0	0								
56	81								
99	99								
3.43	2.15								
0	0								
98	99								
100	100								
51.7	61.1								

CAUSES OF DELAYED GERMINATION.

In order to determine the causes of delay in germination in wheat in the San Luis Valley, condition existing in this region must be studied. Lapman (66) says, "The San Luis Valley lies principally in the south-center part of Colorado. An extension of the valley extends in a north and south direction into New Mexico. The Valley extends in a north and south direction for about 80 miles and has a maximum width of 45 miles. The Valley is a basin-like depression, treeless and topographically featureless. It is a desert-like plain of gentle uniform slopes and except near the inclosing ranges apparently flat and broken only by miles of undeviating irrigation ditches. In the vicinity of the valley trough the slope becomes insufficient to afford free drainage and a more or less permanently wet condition extends over a large area which is traversed by no permanent streams and is in places characterized by shallow basins without drainage and occupied by alkali lakes."

Cone and Kezer (20), "In appearance the San Luis Valley is a vast plain. To the eye it appears to be level and devoid of hills and irregular slopes. Actually, it is the basin-shaped bottom on an ancient lake, which at present appears as a treeless plain surrounded by high and rugged mountains. The elevation of the Valley is high, its lowest point being over 7,500 feet above sea level.

Practically all of the farming land is at an elevation between 7,500 and 8,500 feet. The surface slopes are unusually uniform and gradual. Close to the eastern edge, which is the low portion of the Valley, or Valley trough, the slope is so slight that drainage is very poor, causing considerable areas of seeped land, some swampy portion and shallow basins filled with alkali lakes."

Combining the topographical and climatic conditions of the Valley, there are a great many factors that might enter into the causes of delayed germination. In order to determine if one or more of these factors causes the delay in germination, the experimental study was divided as follows:

1. Alkali as a factor causing delayed germination.
2. Altitude as a factor causing delayed germination.
3. Frost as a factor causing delayed germination.
4. Height of water table as a factor causing delayed germination.
5. Time of planting and time of harvesting as a factor causing delayed germination.

ALKALI AS A FACTOR CAUSING DELAYED GERMINATION.

In order to determine whether alkalies in the San Luis Valley play any part in the cause of delayed germination in wheat, the action of alkali salts was studied. Cone and Kezer (20), "In the vicinity of the alkali lakes in the eastern part of the Valley, there is an occurrence of some black alkali or sodium carbonate as well as some sodium bicarbonate. Outside of this small area the alkalies of the Valley are mostly the so-called white alkalies itself and are occasionally in sufficient qunatities to be injurious to vegetation." Lapman (66), "The soils generally support a heavy growth of the usual desert shrubs, but barren areas sometimes showing the surface incrustation of alkali salts occurs in the Valley. The soil is of great depth and exceptionally fertile. In some districts the per centage of alkali is of great depth and exceptionally fertile. In some districts the percentage of alkali is so high as to interfere with successful crop raising."

In experimenting with the action of alkalies, the test was divided into three parts:

(1) Wheat grown on normal soils containing little or no alkali for several years was taken into the San Luis Valley and planted.

(2) Defiance wheat that had been grown at Saguache, Colorado for five years was secured and planted at the Experiment Station Farm, Ft. Collins, Colorado, under normal soil conditions.

(3) Wheat was planted in pots (pot cultures) containing varying per cents of alkali salts.

WHEAT GROWN ON NORMAL SOIL CONTAINING LITTLE OR NO ALKALI FOR SEVERAL YEARS WAS TAKEN INTO THE SAN LUIS VALLEY AND PLANTED.

In the spring of 1921, the following varieties were secured from the Experiment Station Farm, Ft. Collins, Colorado: Kubanka, Preston, Red Fife, Red Russian, Marquis and Defiance; from the University Farm, Davis, California: Baart, Bunyip, Club, Defiance, Hard Federation, Marquis, Sonora, White Australian and White Federation; and from I. F. Rockey, Saguache, Colorado the variety Defiance showing a bad yellow-berry condition, and which through the tests where it is used, will be called "Delayed Defiance."

These varieties were taken into the San Luis Valley and planted at three places: Saguache, Saguache County; Del Norte, Rio Grande County and Hooper, Alamosa County; also a planting was made at the Experiment Station Farm, Ft. Collins, Larimer County, Colorado. In the fall of 1921, the varieties were harvested and taken into the seed laboratory and stored under the best possible conditions.

The seed from wheat grown in the San Luis Valley shows two distinct characteristics: (1) the seed does not succumb to a yellow-berry condition but retains its clear, horny transparent endosperm, and shows no condition of softness; (2) the seed becomes more or less yellow-berry, producing an endosperm of a soft, mealy texture.

Seed grown in the San Luis Valley showing a clear, hard endosperm.

Of the type that retains its original characteristics

Headden (54) states, "If the potash be in excess, then we have a yellow-berry . By this we mean that some grains of wheat will be yellow, while some may be wholly flinty and hard." We can see that among wheats growing side by side in the San Luis Valley, some will succumb to yellow-berry and others will retain their clear, hard transparent texture.

In this test, the hard, flinty kernels were separated from the soft, opaque, yellow-berry kernels, and both germinated. The results of these separations may be seen in table 9, and 10.

Table 9.
Tests of Defiance wheat grown at Saguache, Colorado, (San Luis Valley) for five years. The flinty kernels appearing in the sample were separated out, also those showing complete yellow-berry condition, and germinated.

Date Tested		Germination		
		3 days	6 days	10 days
2/20/22	Clear, flinty transparent grains	80	98	98
2/20/22	Soft, opaque yellow-berry grains	70	100	100
3/6/22	Clear, flinty transparent grains	82	99	99
3/6/22	Soft, opaque yellow-berry grains	67	99	99

Table 10.
Test of Defiance wheat sent in by Graden Mercantile Firm, Durango, Colorado. Separation being made and separates germinated.

Variety	Condition	Germination				
		3 days	6 days	8 days	10 days	Total
Defiance	No. yellow-berry	90	0	0	0	99
	Yellow-berry	48	48	1	0	97

Table 9 shows in both tests that Defiance wheat grown at Saguache having clear transparent grains producing a higher germination per cent than that showing yellow-berry.

Table 10 shows a large difference in the per cent germination in the two separates. The kernels showing no yellow-berry germinated 90 per cent, while the yellow-berry kernels germinated only 48 per cent in the three day test.

Table 9 shows the clear flinty transparent grains grown at Saguache, germinated only 80 and 82 per cent, while Defiance in table 11, pp. 85 , grown at Ft. Collins germinated 96 per cent. It shows that there is a slight delay in the clear, flinty, transparent grains which is not due to the conditions existing in yellow-berry grains. The summation of data shows that two different types are produced in the same variety (1) kernels showing soft opaque endosperms; and (2) kernels showing hard, transparent endosperms. Both types show a condition of delayed germination, but the soft opaque endosperms (yellow-berry) show the greatest delay in germination.

"Yellow-berry" in wheat grown in the San Luis Valley.

Wheat from different regions show a marked difference in appearance; those from the San Luis Valley are a great deal heavier than those grown in other regions. Headden (52) Wheats from La Jara and Del Norte were large, plump, mealy kernels, weighing 4.907 grams per 100 grains, while those from Ft. Collins were shrunken, flinty kernels, weighing 3.084 grams per 100 grains. The largeness and plumpness varies directly with the increase in weight per kernel and whenever there is a marked increase in weight there is a marked increase in the per cent of yellow-berry in the kernels.

Yellow-berry, according to Roberts and Freeman (73), is a distinct physiological growth product causing an imperfect product in which the spaces in the cells which are normally filled with proteids (gluten) contain merely water, which drying out with the ripening of the kernel, leaves air spaces which are responsible for the opaque appearance of the kernel.

Lyon and Kezer (30) determined yellow-berry to be a condition caused at harvesting time and they say the amount of yellow-berry can be controlled to a large extent by early cutting and stacking. Roberts and Freeman (73) say that the bleached opaque grains, due to weathering at harvesting time, are not "yellow-berries." The weathered kernels of grain have an opaque and rather dirty greyish yellow aspect.

Freeman (34) "There are two types of soft grain among wheat: (1) wheats of true softness (Pacific coast and southern wheats) in which the air spaces in the endosperm are diffuse and finally scattered, "b" and "c" in plate 29. This type of softness is only slightly affected by environmental conditions; and (2) a type commonly called "yellow-berry" in which the air spaces within the endosperm occur in flake-like groups with quite definite margins, "b", "c", and "d", plate 28 and "a" plate 29. The opaqueness thus arising may be confined to a small spot only, "b" and "c", plate 28, or may include the entire endosperm "d", plate 28. This type is very sensitive to environmental conditions. Headden (49, 50, 52 and 54), "The term "Yellow-berry" is used to designate a condition of the wheat kernel which gives it a mottled appearance, due to internal white spots. In bad cases, the whole berry may be affected, then the color will vary from white to a light yellow according to the color of the outer layers or covering of the kernel. Such kernels are more or less opaque when viewed in transmitted light, plates 28 and 29 . Normal grains are uniform when viewed by transmitted light." "a" plate 28 and "a" plate 29.

Lyon and Kezer (67) determined "yellow-berry" to be the results of condition at harvest time. Roberts and Freeman (73) say that this weathering condition at harvest time does not cause "yellow-berry" but that yellow-berry

in wheat is a physiological condition, but they give no cause for the existance of yellow-berry in the kernels. Headden (49, 50, 52 and 54) states that yellow-berry is caused by the relation of potash to soluble nitrogen, that is a condition in which there is an excess of potash over soluble nitrogen in the soil.

Lapman (66) in his analysis of the soil of the San Luis Valley gives the occurrence of the following alkalies: sodium sulphate, sodium chloric, sodium bicarbonates, potassium chloride and potassium sulphate. He states, "these salts are derived by decomposition of the minerals forming the soil. The salts are nearly all soluble and are carried from place to place in the drainage water."

The salts of potassium occur in excess in the San Luis Valley, which, according to Headden, is the cause of the yellow-berry kernels. This condition of yellow-berry in wheat is the cause not only of the mealy opaque endosperm, but is the cause of the abnormal increase in weight per kernal.

Table 11, shows the average of the varieties grown in the San Luis Valley in 1921 and that grown at Ft. Collins in 1920 and 1921. The average weight per 100 grains for the six varieties grown at Ft. Collins in 1920 is 2.842 grams; that grown at Ft. Collins in 1921, 2.930 grams; that grown at Del Norte in 1921, 3.539 grams; that at Saguache in 1921, 3.657 grams; and that at Hooper in 1921, 3.921 grams. The average weight for all these wheats grown in the San Luis Valley per 100 grains is 3.699 grams.

Table 11.

GERMINATION TEST OF COLORADO WHEATS GROWN IN DIFFERENT REGIONS.

Wheats grown in the San Luis Valley were harvested Sept. 2,1921. Germinated December 5,1921.

Variety	Year Harvested	Where Grown	Weight in grams per 100 grains	Germination				
				3days	6days	8days	10days	Total
Defiance	1920	Ft. Collins	2.391	84	13	0	0	97
	1921	" "	2.045	96	3	0	0	99
	1921	Del Norte	2.861	21.5	75	2	0.5	99
	1921	Saguache	3.648	57.5	42	0	0	99.5
Defiance showing delayed germination	1921	Ft. Collins	2.048	94.5	4	0.5	0	99
	1921	Del Norte	3.902	65.5	33.5	0	1	100
	1920	Saguache	3.820	93.5	6	0	0	99.5
	1921	"	4.388	71.5	28	0	0	99.5
Kubanka	1920	Ft. Collins	3.692	51	40	0.5	0	91.5
	1921	" "	3.524	23	74.5	1	0	98.5
	1921	Hooper	3.921	7	83	4	0	94
	1921	Del Norte	3.718	11.5	84	3.5	0	99
	1921	Saguache	3.415	13	85.5	1	0	99.5
Marquis	1920	Ft. Collins	2.891	89	7	0.5	0	96.5
	1921	" "	3.187	73.5	26.5	0	0	100
	1921	Del Norte	3.575	58	42	0	0	100
	1921	Saguache	3.740	66	34	0	0	100
Preston	1920	Ft. Collins	2.986	94.5	0.5	0	0	95
	1921	" "	2.770	94.5	5	0	0	99.5
	1921	Del Norte	3.639	72.5	27	0	0	99.5
	1921	Saguache	3.255	86	13.5	0	0	99.5
Red Fife	1920	Ft. Collins	2.735	91	3.5	0.5	0	95
	1921	" "	2.699	90	95	0	0	99.5
	1921	Saguache	3.332	81	18	0	0	99
Red Russian	1920	Ft. Collins	3.155	95.5	2	0	0	97.5
	1921	" "	3.357	82	18	0	0	100
	1921	Del Norte	3.539	34	63.5	2.5	0	100
	1921	Saguache	3.660	49.5	50	0.5	0	100
Average	1920	Ft. Collins	2.842	85.64	10.0	.29	0	95.93
	1921	" "	2.930	76.50	22.75	.17	0	99.42
	1921	Del Norte	3.539	43.83	54.17	1.33	.25	99.58
	1921	Saguache	3.637	60.64	38.72	.21	0	99.57
	1921	Hooper	3.921	7	83	4	0	94
Average	1920	Ft. Collins	2.842	85.64	10.0	.29	0	95.93
Average	1921	" "	2.930	76.50	22.75	.17	0	99.42
Average	1921	San Luis Valley	3.699	37.16	58.63	1.85	08	97.72

In combining the results of table 11, pp. 85 , and plate 15, pp. 219 , that A, a Defiance wheat harvested at Ft. Collins, Colorado, weighed 2.391 grams per 100 grains; B, harvested at Ft. Collins in 1921, 2.045 grams; C, harvested at Del Norte in 1921, 2.861 grams; and that harvested at Saguache in 1921, 3.648 grams.

Also in table 11, and plate 16, pp. 220, A, a Preston wheat harvested at Ft. Collins in 1920 weighed 2.986 grams per 100 grams; B, harvested at Ft. Collins in 1921, 2.770 grams; C, harvested at Del Norte in 1921, 3.639 grams; and D, harvested at Saguache, 3.255 grams.

Table 12, pp. 87 , shows the results obtained by sending varieties secured from Davis, California from the 1920 crop into the San Luis Valley and planting them at Del Norte and Hooper. A planting of these California varieties was also made at Ft. Collins in 1921.

The average weight in grams per 100 grains of the California varieties grown at Davis, California in 1920 was 3.179 grams; that grown at Davis, California in 1921, 3.493 grams; that at Ft. Collins in 1921, 2.035 grams; that at Del Norte, 3.954 grams; and that grown at Hooper, 3.983 grams. The averages of the weights per 100 grains divide themselves into three groups: (1) those grown at Davis, California; (2) those grown at Ft. Collins, Colorado; and (3) those grown at Del Norte and Hooper, Colorado (San Luis Valley.).

Using the weight of the California wheats grown at Davis,

Table 12.

GERMINATION TEST OF CALIFORNIA WHEATS GROWN IN DIFFERENT REGIONS

Variety	California No.	Year Harvested	Where Grown	Weight in Grams per 100 Grains	Date Planted	Date Harvested	Date of Germination Test	Germination 3 days	6 days	8 days	10 days	Total
	113	1920	Davis	3.750			11/24/21	87.5	4	0.5	0	92
	3029	1921	Davis	4.530			1/9/22	94.5	1.5	1	0	97
Baart	113	1921	Ft. Collins	2.590	5/6/21	8/25/21	11/24/21	91.7	8.3	0	0	100
	113	1921	Del Norte	4.826	4/29/21	9/12/21	11/24/21	16	79	4.5	0	99.5
	113	1921	Hooper	4.714	4/29/21	9/10/21	11/24/21	26.5	72.5	0.5	0	99.5
	3023	1920	Davis	4.049			11/24/21	99	0.5	0	0	99.5
	3023	1921	Davis	4.139			1/9/22	95.5	2	0	0	97.5
Bunyip	3023	1921	Ft. Collins	2.031			11/24/21	100	0	0	0	100
	3023	1921	Del Norte	4.692	4/29/21	9/12/21	11/24/21	8.5	80	9	2	99.5
	114	1920	Davis	2.789			11/24/21	93.5	2	0	0	95.5
	114	1921	Davis	2.678			1/9/22	99	0.5	0	0	99.5
Club	114	1921	Ft. Collins	1.139			11/24/21	95	3.5	0	0	98.5
	114	1921	Del Norte	3.375	4/29/21	9/12/21	11/24/21	31	64	2.5	0	97.5
	955	1920	Davis	2.955			11/24/21	93	2	0	0	95
	955	1921	Davis	3.390			1/9/22	84.5	14.5	0	0	99
Defiance	955	1921	Ft. Collins	1.367	5/6/21	8/25/21	11/24/21	73	27	0	0	100
	955	1921	Del Norte	3.714	4/29/21	9/12/21	11/24/21	37.5	53.5	8	0	99
	3063	1920	Davis	3.338			11/24/21	92	2.5	0	0	94.5
Hard	3063	1921	Davis	4.122			1/9/22	91.5	7	0	0	98.5
Federa-	3063	1921	Ft. Collins	3.432	5/6/21	7/25/21	11/24/21	70	25.5	0	0	95.5
tion	3063	1921	Del Norte	3.886	4/29/21	9/12/21	11/24/21	10.5	82.5	4	1	98.5
	1151	1920	Davis	2.455			11/24/21	90	4	0	0	94
Marquis	1151	1921	Ft. Collins	2.528			11/24/21	83	16.5	0	0	99.5
	1151	1921	Del Norte	4.050	4/29/21	9/12/21	11/24/21	52	46	1.5	0.5	100
	115	1920	Davis	2.339			11/24/21	88	4.5	0	0	92.5
Propo	115	1921	Davis	2.470			1/9/22	95	3	0	0	98
	115	1921	Ft. Collins	1.585	5/6/21	8/26/21	11/24/21	95	5	0	0	100
	115	1921	Del Norte	3.649	4/29/21	9/12/21	11/24/21	50.5	45	1.5	0	97
	98	1920	Davis	2.915			11/24/21	91	2.5	0	0	93.5
	98	1921	Davis	2.448			1/9/22	87.5	3.5	2	0	93
Sonora	98	1921	Ft. Collins	1.947			11/24/21	90.5	7.5	0	0	98
	98	1921	Del Norte	3.627	4/29/21	9/12/21	11/24/21	3.5	74.5	12.5	4.5	95
	98	1921	Hooper	3.519	4/29/21	9/10/21	11/24/21	42.5	57	0.5	0	100
	791	1920	Davis	3.419			11/24/21	85	3.5	0	0	88.5
White	791	1921	Davis	3.552			1/9/22	92.5	6	0	0	98.5
Austra-	791	1921	Ft. Collins	1.432			11/24/21	97	2.5	0	0	99.5
lian	791	1921	Hooper	3.715	4/29/21	9/10/21	11/24/21	64	36	0	0	100
	3213	1920	Davis	3.785			11/24/21	91.5	4	0	0	95.5
White	3213	1921	Davis	4.107			1/9/22	95.5	3.5	0	0	99
Federa-	3213	1921	Ft. Collins	2.307			11/24/21	93.5	4	0	0	97.5
tion	3213	1921	Del Norte	3.767	4/29/21	9/13/21	11/24/21	32	65.5	2	0	99.5
Average		1920	Davis	3.179			11/24/21	91.05	2.95	0.05	0	94.05
Average		1921	Davis	3.493			1/9/22	92.83	4.61	0.33	0	97.77
Average		1921	Ft. Collins	2.035			11/24/21	88.87	9.98	0	0	98.85
Average		1921	Del Norte	3.954			11/24/21	26.83	65.56	5.05	0.89	98.33
Average		1921	Hooper	3.983			11/24/21	44.33	55.17	0.33	0	99.83

Davis, California
Ft. Collins, Larimer County, Colorado.
Del Norte, Rio Grande County, Colorado.
Hooper, Alamosa County, Colorado.

California as a standard we see that the same wheat grown at Ft. Collins fell below the standard and that of the San Luis Valley above the standard.

The light weight per 100 grains of that grown in Ft. Collins is due to two factors: (1) soil condition, and (2) climatic condition. The seed was planted on soil containing little or no alkali and this produced a kernel high in nitrogen. The climatic conditions were unfavorable for the California varieties for, on account of the shorter season and little or no rain during the latter part of the season, the kernels did not fill to a plump condition.

The heavy weight of the kernels from the San Luis Valley is due to the large plump grains of mealy texture known as "yellow-berry."

In combining the results of table 12, and plate 15, pp. 219 , A, Baart, harvested at Davis in 1920 weighed 3.750 grams, per 100 grains; B, harvested at Davis in 1921, 4.530 grams; C, harvested at Del Norte in 1921, 4.826 grams and D, harvested at Hooper in 1921, 4.714 grams.

In combining the results of table 12 and plate 18, pp. 222 ; A, Bunyip harvested at Davis in 1920 weighed 4.049 grams per 100 grains; B, harvested at Ft. Collins in 1921, 4.139 grams; C, harvested at Ft. Collins in 1921, 2.031 grams; and D, harvested at Del Norte in 1921, 4.692 grams.

Also in combining the results in table 12 and plate 17, pp. 221 ; A, Sonora harvested at Davis in 1920 weighed

2.915 grams per 100 grains; B, harvested at Davis in 1921 2.448 grams; C, harvested at Del Norte in 1920, 3.627 grams; and E, harvested at Hooper in 1921, 3.519 grams.

Results from tables 11 and 12, show that the largest gain in weight was in the Defiance, which is a weak wheat and responds very easily to conditions under which it is grown. The varieties that gained the least in weight were three California varieties; White Australian, Hard Federation and White Federation.

It is shown by the following data that yellow-berry occurs in wheats grown in the San Luis Valley and that the percent of "yellow-berry" is proportional to the increase in weight or vice versa, from the standard of that variety. (The standard is based on the weight of 100 grains of wheat from the region from which the wheat was first secured.)

We have observed that the percent of "yellow-berry" in the kernels is proportional to the increase in weight.

The average germination of the wheat grown at Ft. Collins in 1920 was 85.64 per cent in the three day test; that grown at Ft. Collins in 1921, 76.50 per cent; and that grown in the San Luis Valley in 1921, 37.16 per cent.

The low averages of those grown at Ft. Collins and San Luis Valley in 1920 and 1921 are due in part to including in the average the Kubanka variety which normally has a delay (99) in the three day test.

The average germination for the wheats grown in the San Luis Valley in 1921 was 39.34 per cent lower than that grown at Ft. Collins in 1921 showing that a considerable delay occurs in the San Luis Valley grown seed.

The average germination of the California varieties harvested in 1920 was 91.05 per cent in the three day test; that harvested at Davis in 1921, 92.83 per cent; that harvested at Ft. Collins in 1921, 88.87 per cent; that harvested at Del Norte in 1921, 26.83 per cent; and at Hooper, 44.33 per cent. The average germination of the wheat harvested in the San Luis Valley (Del Norte and Hooper) is 35.58 per cent or 57.25 per cent lower than that harvested at Davis in 1921, and 53.27 per cent lower than that harvested at Ft. Collins in 1921.

In combining the results of table 12 and plate 18, A, Bunyip harvested at Davis in 1920 germinated 99 per cent in three days; B, harvested at Davis in 1921, 95.5 per cent; C, harvested at Ft. Collins in 1921, 100 per cent; and at Hooper, in 1921, 8.5 per cent.

In combining results of table 12 and plate 17, A, Sonora harvested at Davis in 1920 germinated 91 per cent; B, harvested at Davis in 1921, 87.5 per cent; C, harvested at Ft. Collins in 1921, 90.5 per cent; harvested at Del Norte in 1921, 3.5 per cent; and at Hooper in 1921, 42.5 per cent.

It has been shown that wheat grown in the San Luis Valley exhibits a marked delay in germination.

In a summation of results we find that a positive

correlation exists between the weight per 100 grains and a condition of delayed germination. Data also shows that a positive correlation exists between the weight and the per cent of "yellow-berry" in the kernels.

If these two conditions are true as have been shown by data collected, there must be a positive correlation between the amount of "yellow-berry" and a delay in germination.

"Yellow-berry" according to Headden (49, 50, 52 and 54) caused by certain potassium salts existing in the soil, it appears these alkali salts must be a factor entering into the cause of delayed germination of wheat from the San Luis Valley.

WHEAT FROM THE SAN LUIS VALLEY SHOWING DELAYED GERMINATION WAS PLANTED AT FORT COLLINS, COLORADO, UNDER SOIL CONDITIONS CONTAINING LITTLE OR NO ALKALI.

In this part of the test the variety Defiance was secured from I. F. Rockey, Saguache, Colorado. In order to distinguish this seed from the San Luis Valley, from the Defiance seed from other sections this seed will be called "Delayed Defiance."

This "Delayed Defiance" seed has been grown by I. F. Rockey for the last five years, on his farm eight miles northeast of Saguache, Colorado. This seed has succumbed to a complete yellow-berry condition, and the kernels were plump, round and did not show the deep suture which is characteristic of the Defiance variety.

In weight per kernel this seed far outweighs that of the normal Defiance seed. In table 11, in the weight in grams per 100 grains, that harvested at Saguache in 1920 weighed 3.820 grams; that harvested at Saguache in 1921 weighed 4.338 grams; at Del Norte in 1921 3.902 grams and thatharvested at Ft. Collins in 1921 3.048 grams. All the "Delayed Defiance" seed harvested in 1921 was grown from the seed harvested in 1920 by I. F. Rockey. The seed secured from the San Luis Valley was planted at the Experiment Station Farm in soil that does not contain an excess of alkalies.

In order to determine if the heavy yellow-berry kernels when grown under normal soil conditions would produce the characteristics normal to Defiance type and also

produce grains that would have a normal germination, a plot was planted on the Experiment Station Farm April 9, 1921. This plot was allowed to come to the dead ripe stage and then harvested, August 7, 1921. A comparison was made as shown in plate 11, pp. 85 , between the seed grown at Saguache, in 1920 which furnished the seed for the other three plantings, and the seed grown at Saguache in 1921; at Del Norte in 1921; and Ft. Collins in 1921. A, B, and C, plate 19, pp. 223 , which were grown in the San Luis Valley produced a kernel that is large, plump and completely yellow-berry, while D, plate 19, pp. 223 , grown at Ft. Collins under normal soil conditions produced a type normal to Defiance, a kernel that is medium long, medium hard with a deep wide suture. Plate 15, pp. 219 , shows a revision of plate 19, pp. 223 . A and B plate 15, pp. 219 , were Defiance wheats grown at Ft. Collins in 1920 and 1921. The kernels show the slightly shriveled, medium hard texture with the deep, wide suture, while in C and D plate 15, pp. 219 , grown at Del Norte and Saguache in the San Luis Valley represent the "Delayed Defiance" type; large, plump kernels with a shallow nearly closed suture.

It shows that this large, plump condition known as yellow-berry, is not of an hereditary character, but is one that can be changed by soil conditions.

In order to secure a more accurate result and to eliminate any condition that might be due to an abnormal condition in the growing season, plantings were made using both "Delayed Defiance" seed and normal Defiance seed, at different periods during the summer, and harvested at different period of ripeness.

Table 13, shows a compiled abstraction from tables 19, 20, 21, 22, 23, 24, 25, 26.

This table contrasts the behavior and rate of maturity of Defiance and "Delayed Defiance."

Table 13.

Table Number	Date Planted	Variety	Date Harvesting commenced	Date Normal Germination was secured
	April 9	Defiance	July 6	July 10
		Delayed Defiance	July 6	July 6
	April 23	Defiance	July 8	July 16
		Delayed Defiance	July 8	July 12
	May 7	Defiance	July 20	July 24
		Delayed Defiance	July 18	July 20
	May 21	Defiance	July 28	August 7
		Delayed Defiance	July 28	August 3
	June 4	Defiance	Aug. 19	August 27
		Delayed Defiance	Aug. 19	August 25
	June 18	Defiance	Sept. 28	Failed to produce normal germination
		Delayed Defiance	Failed to mature seed	
	July 2	Defiance	Sept. 22	Failed to produce normal germination
		Delayed Defiance	Sept. 30	Failed to produce normal germination
	July 16	Defiance	Oct. 24	Failed to produce normal germination
		Delayed Defiance	Oct. 22	Failed to produce normal germination

* Delayed Defiance used in this table is the progeny of the seed known as "Delayed Defiance" from the San Luis Valley in 1920.

The first planting (table 13) was made April 9, 1921, and harvesting began July 7, ten days after heads appeared. The seed was held ninety days before germinating. The table shows that "Delayed Defiance" came to normal germination July 6, while that of Defiance, July 10, or four days later than that of "Delayed Defiance".

This shows that there exists in the"Delayed Defiance" some character for early maturity. This character for the early maturity of "Delayed Defiance" over Defiance may be due to the adaptibility of this wheat to the short frostless season in the San Luis Valley from which it came.

In the second planting (April 23), harvesting began in both Defiance and "Delayed Defiance" July 20,"Delayed Defiance" came to normal germination (July 12), four days before Defiance (July 16). In the third planting (May 7), harvesting began in the "Delayed Defiance" (July 18) two days before that of Defiance (July 20). "Delayed Defiance" came to normal germination (July 20) four days before Defiance (July 24). In the fourth planting (May 21), harvesting began in both Defiance and "Delayed Defiance" July 28. "Delayed Defiance" came to normal germination (August 3), four days before Defiance (August 7). In the fifth planting (June 4) harvesting began in both Defiance and "Delayed Defiance" August 19. "Delayed Defiance" came to normal germination (August 25) two days before Defiance (August 27). The sixth planting (June 18) "Delayed Defiance" failed to mature seed, while harvesting began in Defiance September 28, and failed to reach a normal germination

during the test. In the seventh planting (July 2) harvesting began in Defiance (September 22), eight days before "Delayed Defiance" (September30). In this planting both Defiance and "Delayed Defiance" failed to reach a normal germination test. In the eighth planting (July 16) harvesting began in"Delayed Defiance" (October 22), two days before that of Defiance (October 24). In this planting as in the seventh planting (July 2) both Defiance and "Delayed Defiance" failed to reach a normal germination.

The table shows the lagging of Defiance behind the "Delayed Defiance" in the time of harvest and the time required to come to a normal germination test.

The failure of the sixth (June 18) , seventh (July 2) and eighth (July 18) plantings to come to normal germinations, is due to the varietal weakness of the variety to produce normal kernels under abnormal conditions.

In graph No. 3 we see the results of"Delayed Defiance" when subjected to three different conditions: (1) where the seed was placed in the germinator (brown lines) as soon as harvested; (2) the seed was placed in a refrigerator (black lines) for three days before being placed in the germinator; (3) the seed was held (red lines) for 90 days from the date of harvesting before being placed in the germinator. The seed that was placed in the germinator as soon as harvested did not reach a normal germination until the harvest 38 days after harvesting began. That placed in the refrigerator did not germinate at all, because

at the end of three days it was taken from the refrigerator and placed in the germinator, but at the end of six days produced a higher germination than the seed harvested on the same day. That held for ninety days, produced a normal germination at the first harvest.

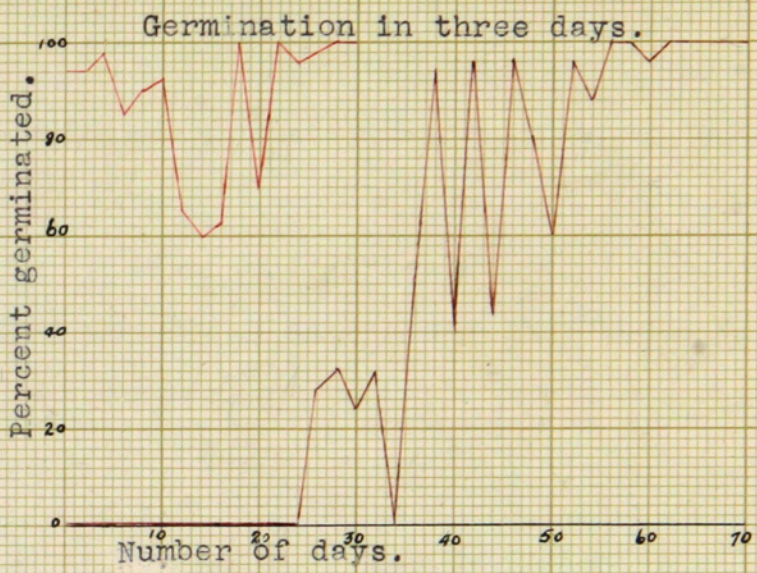
In contrasting graph No. 2, pp. 32 , with graph No.3 pp. 98 , we observe a marked difference in the "Delayed Defiance" and Defiance. "Delayed Defiance" when placed in the germinator as soon as harvested came to normal germination in the three day test in thirty-eight days while that of Defiance required sixty days. In the three day test where the seeds of both Defiance and "Delayed Defiance" were placed in the refrigerator no germination occurred. When the seeds were held ninety days before germinating, "Delayed Defiance" came to normal germination with the first harvest (July 6) while that of Defiance was four days later (July 10).

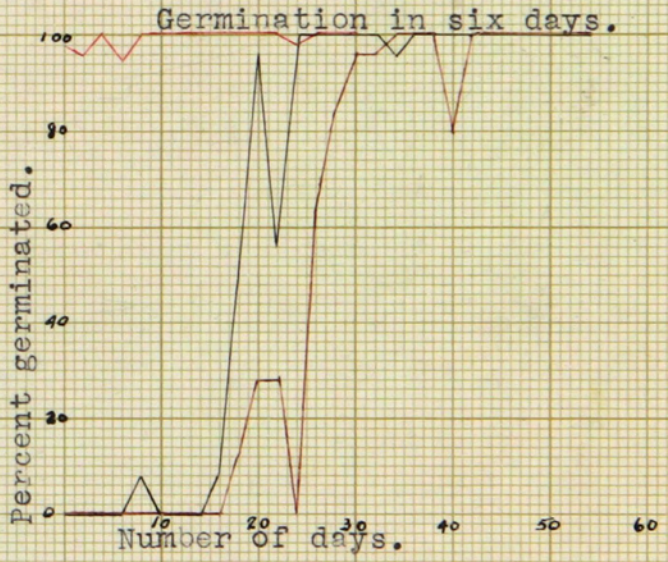
In the six and nine day tests when "Delayed Defiance " and Defiance were subjected to the three different conditions in each case, the "Delayed Defiance" came to normal germination first and also showed a higher germination at an earlier date than Defiance.

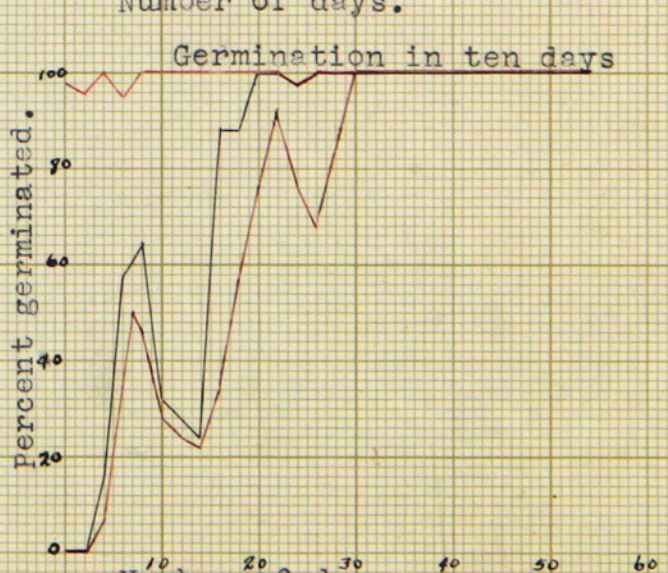
In plate 19, pp. 223, D, showing the three day test of the "Delayed Defiance" grown at Ft. Collins, 1921, A, B, and C, the three day germination test of "Delayed Defiance" grown in the San Luis Valley in 1920 and 1921 which had reached a stage of normal germination. That

GRAPH NO. 3

Defiance wheat secured from Saguache Colorado, and showing delayed germination was planted at the Experiment Station at Fort Collins, Colorado, April 9, 1921. Harvests were made every other day beginning July 7, 1921.







Red lines indicate that the wheat was not germinated until ninety days after harvesting.

Brown lines indicate that the wheat was germinated as soon as harvested.

Black lines indicate that the wheat as soon as harvested was placed in a refrigerator for three days between moist blotters, before being placed in the germinator.

grown at Ft. Collins having the characteristics normal to the Defiance variety produced in the germinating grains seminal roots equal to those in A, B and C, and produced a plumule over twice as long as that produced in A, B, and C.

In a summation, data shows that wheat in a complete yellow-berry condition such as that grown in the San Luis Valley and showing delayed germination, when grown under normal soil conditions produces a type of kernel with the characteristics of that of normal Defiance and one that does not show a delayed germination.

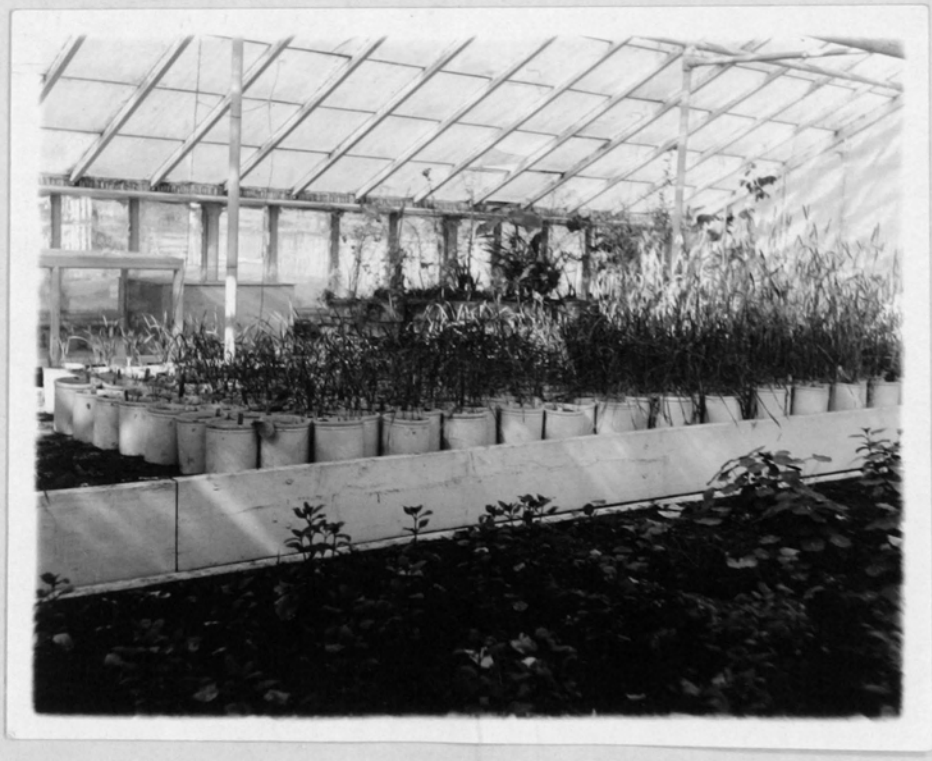
Also that when the "Delayed Defiance" seed was planted under normal soil conditions beside normal Defiance, the "Delayed Defiance" produced a grain of a more shriveled character and seed that produced a normal germination from two to four days before that of normal Defiance.

POT CULTURES.

In this division the test on alkalies, pots holding two kilograms of soil were used. These pots were glazed, water tight pots. The salts were used in the proportion of salts to water free soil based on parts per million and pounds per acre, on the grain weight ratio. The salts were mixed thoroughly with the soil and then placed in the pots.

Defiance wheat was used because being a weak wheat it responded to conditions under which it was grown easier than any other wheat used in these experiments.

The wheats in the pots were grown out of doors during the warm weather, but when danger of frost threatened the pots were brought into the greenhouse.



As the grain in the pots ripened, they were harvested and brought into the laboratory and stored.

No consideration was given to this seed until February 20, when it was threshed and germinated. The results of the germination tests may be seen in the following tables:

Table 14

Na cl

Parts per million	Pounds per acre	Germination		
		3 days	6 days	10 days
250	875	69	100	100
300	1050	88	100	100
350	1225	90	96	96
400	1400	68	100	100
450	1575	64	100	100
500	1750	42	93	100

Table 15

Kcl

Parts per million	Pounds per acre	Germination		
		3 days	6 days	10 days
250	875			
300	1050			
350	1225			
400	1400	100	100	100
450	1575	55	80	85
500	1750	83	100	100

Table 16

Na_2SO_4

Parts per million	Pounds per acre	Germination		
		3 days	6 days	10 days
250	875	29	100	100
300	1050	68	100	100
350	1225	70	98	98
400	1400	55	100	100
450	1575	84	100	100
500	1750	73	100	100

Table 17.

$K_2 SO_4$

Parts per million	Pounds per acre	Germination 3 days	6 days	10 days
250	875	100	100	100
300	1050	94	98	98
350	1225	56	100	100
400	1400	90	100	100
450	1575	63	100	100
500	1750	80	99	99

Table 18

Na_2CO_3

250	875	50	100	100
300	1050			
350	1225	75	100	100
400	1400	78	100	100
450	1575	85	100	100
500	1750	70	100	100

In the comparison of Na cl and Kcl in tables 14 and 15 we see that Na cl has a greater action on the wheat causing a delay than has Kcl when 500 parts per million were used, with Na cl only 42 per cent germination in three days, while with Kcl 83 per cent germination or a normal germination in three days, while with 450 parts per million only a 55 per cent germination was secured.

In tables 16 and 17 where the salts Na_2SO_4 and K_2SO_4 were used, the sodium salt in this case produced a greater delay in three days than the potassium salts as was the case where Nacl and Kcl were used.

In table 18 where Na_2SO_3 (black alkali) was used a delay occurred in all parts used except 450 parts per acre which germinated 80 per cent.

In the preceding tests for alkalies we have shown that a delay in germination results from wheat in a complete "yellow-berry" condition. This condition according to

Headden is caused by excessive potassium salts in the soil.

Osterhout (69) "The accepted idea that sodium and potassium have entirely different effects upon plants is not valid in the field of toxic and protective action. Their behavior shows the close similarity which their near chemical relationship would lead us to expect."

If we assume Osterhout's statement that sodium is similar to potassium in its action toward plants, and also the data taken in plates 14, 15, 16, 17 and 18, it would appear that sodium is a factor entering into the cause of delayed germination as well as potassium.

In the summation of results in this test we see that Defiance wheat grown under soil condition having an excess of alkali (Na cl, KCl, Na_2SO_4 and Na_2SO_3) produced a condition of delayed germination. So if the Defiance variety has succumbed to a condition of delayed germination, caused by excessive alkalies, it is assumed that other wheats, would be affected by the same condition and the extent to which they would pass under this condition depends upon the varietal strength to resist these alkalies.

In summing up the three divisions of the test for alkalies, we find: (1) wheat showing a normal germination (Colorado and California varieties) planted in the San Luis Valley under excess alkali conditions produced a condition of delayed germination; (2) wheat from the San Luis Valley showing a marked delay in germination was planted at Ft.

Collins, Colorado, under normal soil conditions. The seed produced showed no delay in germination, but a great vitality and came to a normal germination before the normal wheat of the same variety; and (3) Defiance wheat grown in pots containing varying per cents of sodium and potassium salts, produced seed showing delayed germination.

We find in these tests that there is a marked delay in germination in wheat grown on soils containing an excess of alkalies, so we conclude from these tests that alkali is a factor entering into the cause of delayed germination in wheat.

ALTITUDE AS A FACTOR CAUSING DELAYED GERMINATION.

Cone and Kezer (30), "The elevation of the Valley (San Luis) is high, its lowest point being over 7,500 feet above sea level. Practically all of the farming land is at an elevation between 7,500 and 8,500 feet." Lapman (66) is speaking of the San Luis Valley says, "It reaches an elevation of slightly more than 7,500 feet above sea level and is one of the most extensively cultivated irrigated districts of this altitude in the United States." Trimble (94) describes the San Luis Valley as a remarkably flat, immense basin, which was evidently a lake or sea bed with an elevation from 7,000 to 10,000 feet.

Cary (18) Although a large part of the San Luis Valley is included in the Upper Sonoran (elevation to 7,800 feet), on the zone map, this region is very nearly on the border between the Upper Sonoran and Transitional zone (elevation below 9,000 feet).

It can be seen that the elevation of the San Luis Valley might be a factor entering into or causing the delay in germination of wheat obtained from this Valley.

In order to determine the effect of altitude upon the germination in wheat, tests were made with uniform soil at different altitudes.

Ten boxes, twelve inches square and eighteen inches deep were used in this test. All cracks were sealed over

so that the boxes were water tight. The boxes were filled with a well mixed silt-loam soil which was taken from a field on the College Farm.

All boxes when planted were at Fort Collins at an elevation of 4,981 feet, this being the lowest elevation used in the experiment and therefore being the earliest possible planting for frost occurs late at high altitudes. Two varieties of wheat were planted, Marquis and Defiance. Five of the boxes were planted to Marquis and five to Defiance. As soon as the possibilities of frost were past, the boxes were moved to their permanent stations. The wheat in the boxes being about four inches high. Two boxes were placed at each station, one sown to Marquis and the other to Defiance.

Station #1. Located at Fort Collins, Colorado at an elevation of 4,981 feet.

Station #2. Located at the Mouth of the Big Thompson Canyon, near Loveland, Colorado, elevation between 5,000 and 5,550 feet.

Station #3. Located at the Forks Hotel in the Big Thompson Canyon at an elevation between 7,200 and 7,500 feet.

Station #4. Located at Estes Park, Colorado at an elevation of 7,547 feet.

Station #5. Located at the Lewiston Challets, near Estes Park, Colorado at an elevation of about 7,850 feet.

The wheat was harvested from all stations September

3, 1921, except the Defiance at Station #4 which had been eaten off by some animal. The wheat at Station #1 was in the dead ripe stage and the straw was completely turned and dry while at Station #5, the straw was still partly green but the grain well filled.

The germination tests were made January 4, 1922, the results are given in table 19.

Table 19.

Station	Variety	Germination Tests 3 days	6 days	8 days	Total
Ft. Collins, Colorado 4,981 ft.	Defiance	95	5	0	100
	Marquis	92	6	0	98
Mouth of Big Thompson Canyon 5,000-5,500 ft.	Defiance	96	4	0	100
	Marquis	84	14	0	98
Forks Hotel, Big Thompson Canyon, 7,200-7300 ft.	Defiance	85	15	0	100
	Marquis	100	0	0	100
Estes Park, Colorado, 7,547 feet	Marquis	80	18	2	100
Lewiston Challets, Estes Park, Colorado 7,850 ft.	Defiance	78	20	0	100
	Marquis	84	12	0	96

The germination tests of the Marquis variety, from Station 1, 2 and 3 were good, while those from stations 4 and 5 were lower, showing that a delay had occurred. The germination tests of the Defiance variety from stations 1, 2 and 3 were good, equaling that of the Marquis for these stations (1,2 and 3), while the Defiance variety from station #5, showed a marked delay as compared with stations 1, 2 and 3.

The summation of the results indicate that the wheat grown at stations (4 and 5), which were over 7,547 feet in elevation, showed a delay in germination in contrast with the wheat grown at stations (1, 2 and 3) below 7,547 feet. The data secured from these plantings appears to indicate that altitude is a factor entering into the cause of delayed germination in wheat.

FROST AS A FACTOR CAUSING DELAYED GERMINATION.

Hopkins (72) mapped out the average length of frostless season for the San Luis Valley as between seventy-five to one hundred and twenty-five days, while nearly all of the western half falls within the seventy-five to one hundred day limit.

Cone and Kezer (20) in their study of the Valley state, "Frosts are liable to occur any month of the year."

In considering the normal growing season for wheat which falls between ninety to one hundred and twenty days, wheat grown in the San Luis Valley is subjected to the action of frost.

In the use of the sand bed in stratification of seeds (peach, plum, pear, apple, beech and oak) for germination Brown (14) states, "The seeds remain in these beds during the winter season where they absorb water and swell sufficiently to crack the shell. When warm weather comes in the spring, sprouts appear."

Karns (62) "Whether freezing is necessary to cold climate seed germination is not decided. It does not, however, injure the seed germ, but often helps in removing natural obstructions such as hard shells."

Kiesselback and Ratcliff (64) in a table compiled by them upon the freezing injury of seed corn have found that the loss of viability by freezing is directly proportional to the per cent of moisture in the kernels.

Here we have represented two different classes of seeds; those in which moisture and freezing is necessary in order that seeds may germinate, and the other class in which moisture combined with freezing is very detrimental to the viability of the seed.

In wheat we have conditions similar to those in corn described by Kiesselback and Ratcliff, for if wheat grains are placed in a moist condition unfavorable for germination the embryo is soon destroyed, either by rotting or eruption of the embryotic cells by freezing.

In this test the action of frost and freezing conditions were carried out in the field. The action of these abnormal conditions for growth may be seen in Tables 25, 26, 27 and 28.

The first killing frost occurred September 21, and after this date frosts and freezing occurred frequently. The kernels at first were normal in size with good color, but those harvested toward the last (November 21), were shriveled and of poor color.

Table 27, pp. 137, shows the action of abnormal growing condition in the different varieties. All varieties came to normal germination before the last harvest, except Defiance and Delayed Defiance, which shows the weakness of the variety to withstand abnormal conditions.

Table 28, pp. 140, the spikes did not appear until September 28, while the frost occurred September 22.

All varieties, except Marquis, show a more or less delayed germination and near the end of the test failed to germinate at all. A heavy snow fell November 21 and the remainder of the plot was harvested November 21, and this harvest used for the final test for the freezing action on the viability in wheat.

The Kubanka variety plate 21, pp.225 , threshed a rather large shrunken kernel which germinated poorly, germinating only five per cent in the three day test.

Preston, plate 22, pp. 226 , Defiance, plate 26, pp.230 , and Delayed Defiance, plate 27, pp. 231, failed to produce grains of any size after fertilization was complete. This is caused by the inability of the plant to assimilate plant food, due to the varietal weakness under abnormal conditions.

Red Fife, plate 23, pp. 227 , and Red Russian, plate 25, pp. 229, produced kernels of good size, but badly shrunken and these kernels failed to germinate.

Marquis, plate 24, pp. 228 , is the only variety of the eight that produced a normal grain and one that germinated a high per cent (ninety-four) in the three day test. It shows that the ability to withstand abnormal growing conditions is a varietal characteristic.

In the summation, the action of frost and freezing conditions on wheat is clearly shown, in that, the first harvest after September 21, frost and abnormal conditions had no effect upon the viability. As

conditions became more severe, a delayed germination appears and in the last germination, except Marquis, a very low or no germination occurred.

Under field culture nearly all grains reach a full development long before frosting time and if frost does occur before the spikes appear, the grain may show a delay in germination or no germination at all. Grain having a normal appearance at frost time, its viability is unaffected by frost and slight freezing.

HEIGHT OF WATER TABLE AS A FACTOR CAUSING DELAYED GERMINATION.

In the San Luis Valley where delayed germination in wheat occurs, Cone and Kezer (20) found, that there are approximately three-fourths of a million acres needing more or less artificial drainage. Lapman (66) states, in speaking of the San Luis Valley, "In the vicinity of the valley through, the slope becomes insufficient to afford free drainage and more or less permanently wet condition extends over a large area." Cone and Kezer (20) also state, "Probably more drainage is done by seepage in many of the wet alkali sections than by the white alkali itself."

In determining if the height of the water table has any effect upon the germination in wheat, the following experiments were undertaken in 1921.

Galvanized iron cans were used in these tests, each can measuring fourteen inches in diameter and eighteen inches deep. Each can was made with a side-arm, so that the height of the water level could be measured at all times with little difficulty.

The soil used was that of a silt-loam type, and was well mixed to assure uniformity in the entire lot.

All water added was applied to the surface of the soil, and all readings, as to the height of the water level, were taken in the side-arm.

Both Marquis and Defiance, were planted in each can

May 9, 1921, that similar conditions might effect both varieties, and the results are shown in table 20.

Table 20
GERMINATION OF WHEAT GROWN UNDER DIFFERENT HEIGHTS OF WATER TABLE.

Condition	Variety	Date Planted	Date Harvested	Date of Germination test.	Germination 3 days	6 days	8 days	10 days
Water Level Below 18"	Defiance	May 9	Aug. 21	Aug. 24	0	9	28	11
				Dec. 12	100	0	0	0
	Marquis	May 9	Aug. 9	Aug. 24	23	64	10	3
				Dec. 12	99	1	0	0
Water Level 10" from Surface	Defiance	May 9	Aug. 21	Aug. 24	0	6	32	7
				Dec. 12	100	0	0	0
	Marquis	May 9	Aug. 21	Aug. 24	0	6	17	7
				Dec. 12	75	25	0	0
Water Level 6" from Surface	Defiance	May 9	Aug. 21	Aug. 24	0	4	22	5
				Dec. 12	100	0	0	0
	Marquis	May 9	Aug. 21	Aug. 24	0	12	23	7
				Dec. 12	75	25	0	0

CAN NO. 1.
(Water level below eighteen inches.)

In this test the can was filled completely with soil, and the soil kept in a good moist condition, but at no time was water allowed to accumulate in the bottom of the can.

The Marquis variety, ripened earlier than the Defiance and so was harvested August 9, while the Defiance was not harvested until August 21. The first germination tests were made August 24. The Marquis germinating twenty-three per cent in three days and the Defiance zero per cent in three days.

The low germination obtained just after harvesting is due to the after-ripening in wheat.

In the final tests, December 12, Marquis germinated ninety-nine per cent in three days and Defiance one hundred per cent in three days, showing that after the after-ripening period is passed, that no delay in germination occurs.

CAN NO. 2.
(Water level ten inches from the surface)

In this division of the test the can was filled to within ten inches of the top with fine gravel and then ten inches of soil packed on top of the gravel. In this way a very good water table can be maintained between the side-arm and the can.

Both varieties, Marquis and Defiance, were harvested August 21, and germinated August 24. In three days both varieties germinated zero per cent. In the final tests, December 12, Defiance germinated one hundred per cent and Marquis seventy-five per cent in three days, showing that no delay in germination occurred.

CAN NO. 3.
(Water level six inches from the surface.)

In this test the can was packed to within six inches of the top with fine gravel, and the remaining six inches packed with soil.

Both varieties, Marquis and Defiance, were harvested August 12, and all germination tests were identically the same as those for CAN NO. 2.

In these tests for determining the effect of the water level on the viability of seed, shows that as soon as the after-ripening period is passed, both Marquis and Defiance came to normal germination and do not show any signs of delayed germination.

The tests shows that the water level acting independently does not cause a continued delayed germination in wheat.

TIME OF PLANTING AND THE TIME OF HARVEST AS A FACTOR CAUSING DELAYED GERMINATION

In testing for the time of planting and time of harvest as a factor in delayed germination, the entire growing season must be considered in order that all conditions throughout the growing season may be considered in relation to the delayed germination.

Seven varieties were chosed for this test; six varieties, Kubanka, Preston, Red Fife, Marquis, Red Russian and Defiance. The seed of these varieties were secured from the Colorado Experiment Station Farm, from the 1930 crop. These six varieties represent the types of wheat best adapted to northern Colorado for in this way the factors that enter into the adaptibility are limited and a more accurate test for delayed germination may be secured.

The seventh variety was a variety of Defiance that had been grown in 1930 by I. F. Rockey, Saguache, Colorado. This wheat has been grown by him for five years, and showed a marked delay in germination.

All varieties were planted at the Colorado Experiment Station Farm in 1931. Table 21 was planted April 9; Table 22 April 23; Table 23 May 7; Table 24 May 21; Table 25 June 4; Table 26 June 18; Table 27 July 2; and Table 28 July 18. Two weeks intervened between each planting.

The plots were watched closely and when over half of a plot was headed the date was noted and harvesting started

ten days from this date. Harvests were made very other day and continued until the plot was ripe and harvested.

All harvests were held ninety days before being germinated, for in this way the delayed germination due to after-ripening has been accounted for.

Plot No. 1 Table No. 21, pp. 125.

Planted April 9. Spikes appearing in Kubanka, Preston, Marquis, Red Russian and Delayed Defiance (June 27) seventy-nine days after planting. In Red Fife and Defiance (June 28) eighty-one days after planting. Harvesting began July 7, and was continued every other day until the plot was ripe (August 7) and harvested. All varieties, except Kubanka, showed normal germination as soon as harvested, and an increase in the percentage of germination in three days as ripeness increased. Kubanka showed a delay in the three day germinations, also showing a lower germinating per cent as the dead ripe stage approached.

The duration from planting until harvest was 119 days.

Plot No. 2. Table No. 22, pp. 127.

Planted April 23. Spikes appeared in Kubanka, Preston, and Red Russian (June 28) sixty-six days after planting. In Preston and Delayed Defiance (June 29) sixty-seven days after planting and Red Fife and Defiance (July 1) sixty-nine days after

planting. Harvesting began July 8 and continued every other day until plot was ripe (August 13) and harvested. Marquis came to normal germination first July 8; Preston July 10; Red Russian and Delayed Defiance July 12; Red Fife July 14; and Defiance July 16. All varieties reached normal germination, except Kubanka, and it shows its usual delay in the three day test, but germinating a high per cent in six and ten days.

The duration from planting to harvest was 112 days.

Plot No. 3, Table 23, pp. 129.

Planted May 7. Spikes appeared in Kubanka and Marquis (July 2) forty-six days after planting; Preston and Red Russian (June 3) forty-seven days after planting; Red Fife (July 7) fifty-one days after planting; Delayed Defiance (July 9) fifty-three days after planting; and Defiance (July 11) fifty-five days after planting. Harvesting began July 12 and continued every other day until plot was ripe. (August 19) and harvested. Preston and Marquis coming to normal germination July 14; Red Russian July 16; Red Fife July 18; Delayed Defiance July 20; and Defiance July 24. All varieties came to normal germination, except Kubanka, and it showed its usual delay in germination.

Duration from planting to harvest was 104 days.

Plot No. 4, Table 24, pp. 131.

Planted May 21. Spikes appeared in Preston, Marquis, and Red Russian (July 18) sixty-one days after planting, Kubanka (July 20) sixty-three days after planting and Red Fife, Defiance and Delayed Defaince (July 23) sixty-six days after planting. Harvesting began July 28 and continued every other day until the plot was ripe (August 27) and harvested. Marquis and Red Russian coming to normal germination June 28; Preston and Red Fife August 1; Defiance and Delayed Defiance August 7. All varieties came to normal germination except Kubanka which showed its usual normal delay in the three day test.

Duration from planting until harvest, 101 days. Plot No. 5, Table 25, pp. 133.

Planted June 4. Spikes appeared in Kubanka, Preston, Red Fife, Marquis and Red Russian (August 5) sixty-two days after planting. Defiance and Delayed Defiance (August 8) sixty-five days after planting. Harvesting began August 15 and continued every other day until plot was ripe (September 4) and harvested. Preston and Marquis coming to normal germination August 15; Red Fife August 17; Red Russian and Delayed Defiance August 25; and Defiance August 27. Red Russian, Defiance and Delayed Defiance showed a slight delay caused by the unripe and shriveled condition of the grain. Kubanka showed its usual

delay in germination.

Duration of time from planting until harvest was ninety-two days.

Plot No. 6, Table No. 26, pp.135.

Planted June 18. Spikes appeared in Marquis and Red Russian (September 2) seventy-six days after planting; Defiance (September 18) ninety-two days after planting. Of the entire plot only the varieties, Marquis, Red Russian and Defaince produced spikes and only Marquis (September 22) and Red Russian (September 20) came to normal germination. A slight delay occurred at first in these two varieties caused by the unripe and shriveled condition of the grain. Plot was frosted September 21.

Duration of time from planting until harvest was 118 days.

Plot No. 7, Table No. 27 pp.137.

Planted July 2. Spikes appeared in Kubanka, Preston, Marquis, Red Russian and Defiance (September 12) seventy-nine days after planting; Red Fife and Delayed Defiance (September 18) seventy-eight days after planting. Harvesting began September 22, and was continued every other day until the plot was ripe (November 7) and harvested. Preston and Marquis coming to normal germination September 22; Red Russian September 24; Red Fife

September 30; Defiance and Delayed Defiance did not come to normal germination during the entire test. Kubanka showed its usual delay in germination and in many cases as the dead ripe stage approached, failed to germinate at all. This entire plot was harvested after the normal growing period, for frost appeared September 21.. In this test a great deal of abnormal germination appears, but it does not appear in the form of a delayed germination, but in grains that fail to germinate at all.

Toward the last of the test (October 28 to November 7), a large per cent of low germination appears. Marquis and Red Russian are the only two that show a high per cent of germination.

Duration of time from planting until harvest, 128 days.

Plot No. 8, Table No.28, pp. 140.

Planted July 16. Spikes appeared in Marquis and Red Russian (September 28) seventy-four days after planting; Kubanka and Preston (October 6) eighty-two days after planting; Red Fife and Delayed Defiance (October 13) eighty-eight days after planting; and Defiance (October 14) ninety days after planting. Harvesting began October 8 and continued every other day until the plot was ripe (November 21) and harvested. Marquis

came to normal germination October 8; Preston October 24; and Red Russian November 5. Kubanka showed its usual delay, but toward ripening a high per cent of poor germination was secured. Preston reached the height of its germination November 24 and then gradually dropped until no germination was obtained November 21. Red Fife, Defiance and Delayed Defaince did not reach normal germination. Red Russian came to normal germination late (November 5) and dropped off to zero per cent germination on November 21. Marquis is the only variety that germinated a high per cent throughout the test, germinating ninety-four per cent, November 21. The poor germinations are not caused by delayed germination, except Kubanka, but are due to the grains failing to germinate at all.

Duration of time from planting until harvest, 128 days.

In combining the results of tables 21, 22, 23, 24, 25, 26, 27 and 28, we find that during the normal growing season ended September 21 by frost, that the varieties came to normal germination, except Kubanka, soon after harvesting started and continued to increase in germinating per cent until the plot was completely harvested. The poor germination obtained after September 21 is due to abnormal growing conditions.

It is found that Marquis wheat had the greatest viability of all the varieties, in that in the average of all plots it comes to normal germination first, also produces the highest germination under abnormal conditions, in the latter part of the season. Red Russian is next to Marquis in its viability. Red Fife and Red Russian come to normal germination early, but have a great variation in germination in all the tests at the end of three days. In the average test of all the plots, considering all varieties, Preston has the highest average in the three day germination tests. Defiance and Delayed Defiance in the early part of the season show a good viability, but in the later plots shows the weakness of the variety, beginning to show its weakness in the plot Planted May 7, and failing to come to normal germination in the harvest after September 4.

Kubanka, due to its hardness, fails to reach a normal germination in three days throughout the entire test.

In a summation of the entire data it is found that the time of planting and the time of harvest, in the normal growing season, except the first harvest of each plot which is due to the shriveled unfilled grains, is not a factor entering into the cause of delayed germination.

Table 21.

PLANTED APRIL 9,1921. HARVESTING BEGAN(JULY 7,1921),TEN DAYS AFTER HEADS APPEARED,AND WAS CONTINUED EVERY OTHER DAY UNTIL THE GRAIN WAS RIPE AND HARVESTED.

Date Test Began		7/6	7/8	7/10	7/12	7/14	7/16	7/18	7/20
Kubanka	3 days	69	64	92	68	72	45	40	35
	6 days	95	90	98	100	100	91	100	98
	10 days	97	94	98	100	100	91	100	100
Preston	3 days	98	97	98	93	95	99	96	100
	6 days	99	100	100	100	100	99	100	100
	10 days	100	100	100	100	100	99	100	100
Red Fife	3 days	76	80	98	88	96	74	42	10
	6 days	93	86	100	100	98	97	100	97
	10 days	94	86	100	100	98	97	100	97
Marquis	3 days	91	86	88	82	98	82	75	55
	6 days	95	95	98	94	100	100	92	97
	10 days	99	99	98	94	100	100	92	100
Red Russian	3 days	58	87	78	42	90	67	0	18
	6 days	98	97	96	97	100	97	100	100
	10 days	98	97	96	97	100	97	100	100
Defiance	3 days	12	72	80	58	100	90	67	44
	6 days	24	78	90	84	100	96	98	100
	10 days	29	80	90	84	100	96	98	100
Delayed Defiance	3 days	94	94	98	85	90	92	65	60
	6 days	97	96	100	95	100	100	100	100
	10 days	97	96	100	95	100	100	100	100

7/22	7/24	7/26	7/28	7/30	8/1	8/3	8/5	8/7
34	17	23	18	50	29	18	60	12
94	78	100	100	100	100	100	100	100
100	100	100	100	100	100	100	100	100
97	95	95	95	97	100	100	98	100
100	100	98	100	100	100	100	100	100
100	100	98	100	100	100	100	100	100
64	45	84	78	85	83	64	94	71
100	98	98	100	100	98	100	100	100
100	98	98	100	100	97	100	100	100
25	36	72	100	91		71	92	
95	100	100	100	100		100	100	
100	100	100	100	100		100	100	
30	40	24	87	91	97	60	90	96
100	100	100	93	100	100	100	100	100
100	100	100	97	100	100	100	100	100
61	76	33	80	100	98	89	100	
100	100	100	100	100	98	100	100	
100	100	100	100	100	98	100	100	
82	100	70	100	96	98	100	100	
100	100	100	100	98	100	100	100	
100	100	100	100	98	100	100	100	

Table 22.

PLANTED APRIL 23,1921. HARVESTING BEGAN(JULY 8,1921)TEN DAYS AFTER HEADS APPEARED,AND WAS CONTINUED EVERY OTHER DAY UNTIL THE GRAIN WAS RIPE AND HARVESTED.

Date Test Began		7/8	7/10	7/12	7/14	7/16	7/18	7/20	7/22
Kubanka	3 days	0	0	35	0	82	80	0	3
	6 days	0	20	80	7	96	100	88	100
	10 days	1	20	80	15	96	100	98	100
Preston	3 days	35	100	92	96	94	95	66	95
	6 days	74	100	92	100	98	97	100	100
	10 days	74	100	92	100	98	97	100	100
Red Fife	3 days	33	40	66	72	98	86	85	32
	6 days	44	40	72	94	100	93	100	100
	10 days	44	40	75	94	100	95	100	100
Marquis	3 days	84	92	98	100	93	92	60	75
	6 days	92	96	98	100	100	97	100	100
	10 days	92	96	98	100	100	97	100	100
Red Russian	3 days	56	60	94	88	94	93	58	80
	6 days	85	60	100	98	97	98	100	100
	10 days	85	60	100	98	97	98	100	100
Defiance	3 days	0	0	44	0	96	87	88	77
	6 days	0	0	64	0	100	96	97	100
	10 days	0	0	64	0	100	96	97	100
Delayed Defiance	3 days	7	15	100	76	100	98	89	80
	6 days	17	17	100	78	100	100	97	100
	10 days	19	17	100	78	100	100	97	100

7/24	7/26	7/28	7/30	8/1	8/3	8/5	8/7	8/9	8/11	8/13
40	2	23	44	21	34	17	54	48	47	21
100	92	97	100	98	100	100	100	100	88	100
100	100	97	100	98	100	100	100	100	92	100
100	100	97	100	98	100	100	100	100	95	100
100	100	100	100	98	100	100	100	100	100	100
100	100	100	100	98	100	100	100	100	100	100
92	61	83	97	97	87	79	94	97	100	76
100	100	98	100	100	100	100	100	100	100	100
100	100	98	100	100	100	100	100	100	100	100
54	60	71	64	94	82	73	90	77	83	85
97	100	99	100	100	100	100	98	97	100	100
100	100	99	100	100	100	100	100	97	100	100
52	40	45	42	40	62	81	92	97	96	80
100	100	100	100	100	100	100	100	100	100	100
100	100	100	100	100	100	100	100	100	100	100
84	82	78	79	88	98	74	91	87	96	89
100	100	100	97	100	100	100	100	100	100	100
100	100	100	97	100	100	100	100	100	100	100
100	92	77	80	86	86	100	98	100	100	91
100	98	100	100	100	100	100	100	100	100	100
100	98	100	100	100	100	100	100	100	100	100

Table 23.

PLANTED MAY 7,1921. HARVESTING BEGAN(JULY 12,1921)TEN DAYS AFTER HEADS APPEARED;AND WAS CONTINUED EVERY OTHER DAY UNTIL THE GRAIN WAS RIPE AND HARVESTED.

Date Test Began		7/12	7/14	7/16	7/18	7/20	7/22	7/24	7/26
Kubanka	3 days	0	42	50	43	25	51	48	52
	6 days	0	66	75	75	70	100	100	100
	10 days	0	66	75	75	70	100	100	100
Preston	3 days	60	100	94	80	97	86	95	94
	6 days	75	100	97	82	97	94	100	100
	10 days	75	100	97	82	97	96	100	100
Red Fife	3 days			56	80	95	97	74	91
	6 days			65	94	95	100	96	100
	10 days			65	94	95	100	96	100
Marquis	3 days	37	88	92	85	97	100	91	51
	6 days	45	94	92	98	97	100	98	100
	10 days	45	94	92	98	97	100	98	100
Red Russian	3 days	0	36	94	81	89	88	87	97
	6 days	0	47	100	85	100	100	87	100
	10 days	0	47	100	85	100	100	87	100
Defiance	3 days					8	61	91	99
	6 days					12	70	98	99
	10 days					12	70	98	99
Delayed Defiance	3 days				73	88	98	97	74
	6 days				84	92	98	100	100
	10 days				84	92	98	100	100

7/28	7/30	8/1	8/3	8/5	8/7	8/9	8/11	8/13	8/15	8/17	8/19
34	64	55	8	9	48	37	18	4	0	0	20
98	100	95	100	100	100	100	100	100	100	100	100
98	100	95	100	100	100	100	100	100	100	100	100
84	98	100	100	92	90	100	89	95	90	94	95
100	98	100	100	100	96	100	95	100	100	100	100
100	98	100	100	100	96	100	95	100	100	100	100
79	93	100	93	90	95	80	90	97	89	88	89
100	100	100	99	100	100	97	100	100	100	98	100
100	100	100	99	100	100	99	100	100	100	98	100
57	64	76	95	72	96	86	89	73	96	82	90
100	98	98	100	97	100	100	100	100	100	100	97
100	98	98	100	97	100	100	100	100	100	100	97
63	79	52	40	65	84	68	92	54	67	86	84
100	100	100	100	100	100	99	100	100	100	100	100
100	100	100	100	100	100	99	100	100	100	100	100
95	98	90	89	82	76	92	96	58	72	41	93
100	100	100	100	100	98	100	96	100	94	100	100
100	100	100	100	100	98	100	96	100	94	100	100
78	88	100	98	78	100	86	99	94	91	87	97
95	100	100	100	100	100	98	99	100	97	100	97
95	100	100	100	100	100	98	99	100	97	100	97

Table 24.

PLANTED MAY 21,1921. HARVESTING BEGAN(JULY 28,1921)TEN DAYS AFTER HEADS APPEARED,AND WAS CONTINUED EVERY OTHER DAY UNTIL THE GRAIN WAS RIPE AND HARVESTED.

Date Test Began		7/28	7/30	8/1	8/3	8/5	8/7	8/9	8/11
Kubanka	3 days	0	44	53	43	77	44	3	59
	6 days	0	85	100	100	83	98	36	100
	10 days	0	88	100	100	83	100	57	100
Preston	3 days	60	73	100	100	97	97	100	97
	6 days	64	88	100	100	100	100	100	100
	10 days	64	84	100	100	100	100	100	100
Red Fife	3 days	0	0	84	93	100	91	97	83
	6 days	0	0	97	100	100	97	97	100
	10 days	0	0	97	100	100	97	97	100
Marquis	3 days	82	97	90	95	100	94	100	84
	6 days	100	97	90	95	100	100	100	100
	10 days	100	97	90	95	100	100	100	100
Red Russian	3 days	100	86	90	75	100	92	95	15
	6 days	100	86	100	75	100	100	100	100
	10 days	100	86	100	75	100	100	100	100
Defiance	3 days	0	0	0	42	70	82	100	34
	6 days	0	0	0	79	90	100	100	100
	10 days	0	0	0	83	90	100	100	100
Delayed Defiance	3 days	0	0	0	30	0	91	100	69
	6 days	0	0	0	35	0	100	100	100
	10 days	0	0	0	40	0	100	100	100

8/13	8/15	8/17	8/19	8/21	8/23	8/25	8/27
79	29	10	70	18	69	30	60
100	68	100	95	97	100	95	100
100	68	100	95	97	100	95	100
95	90	100	100	100	100	100	97
97	100	100	100	100	100	100	97
97	100	100	100	100	100	100	97
	91	91	100	100	95	100	91
	100	100	100	100	95	100	100
	100	100	100	100	95	100	100
80	96	97	97	98	94	100	98
100	100	100	100	100	100	100	100
100	100	100	100	100	100	100	100
78	89	89	89	95	93	100	95
98	100	100	100	95	96	100	95
98	100	100	100	95	96	100	95
84	87	81	84	80	71	92	98
97	100	94	100	96	71	100	100
97	100	94	100	96	71	100	100
100	60	100	96	100		95	
100	100	100	100	100		95	
100	100	100	100	100		95	

Table 25.

PLANTED JUNE 4,1921. HARVESTING BEGAN(AUGUST 15,1921) TEN DAYS AFTER HEADS APPEARED,AND WAS CONTINUED EVERY OHTER DAY UNTIL THE GRAIN WAS RIPE AND HARVESTED.

Date Test Began		8/15	8/17	8/19	8/21	8/23	8/25	8/27	8/29
Kubanka	3 days	67	68	68		13	86	50	75
	6 days	92	100	95		96	95	100	100
	10 days	100	100	95		96	95	100	100
Preston	3 days	80	100		97	100	97	100	96
	6 days	100	100		100	100	100	100	100
	10 days	100	100		100	100	100	100	100
Red Fife	3 days	50	87	82	100	95	100	96	95
	6 days	68	96	100	100	95	100	100	100
	10 days	74	96	100	100	95	100	100	100
Marquis	3 days	78	93	100	79	100	89	98	97
	6 days	100	93	100	98	100	100	100	100
	10 days	100	93	100	98	100	100	100	100
Red Russian	3 days	44	64	58	84	15	93	100	
	6 days	100	100	100	100	100	100	100	
	10 days	100	100	100	100	100	100	100	
Defiance	3 days			91	64	45		89	100
	6 days			100	100	68		96	100
	10 days			100	100	68		96	100
Delayed Defiance	3 days			11	33	44	100	84	
	6 days			74	97	80	100	100	
	10 days			81	97	84	100	100	

8/31	9/2	9/4
37	41	82
100	100	82
100	100	97
100	97	98
100	100	100
100	100	100
100	88	90
100	96	95
100	96	95
96	97	97
96	100	97
96	100	97
100	100	100
100	100	100
100	100	100
90	78	100
100	96	100
100	96	100
91	96	
100	100	
100	100	

Table 26.

PLANTED JUNE 18,1921. HARVESTING BEGAN(SEPTEMBER 12,1921) TEN DAYS AFTER HEADS APPEARED,AND WAS CONTINUED EVERY OTHER DAY UNTIL THE GRAIN WAS RIPE AND HARVESTED.

Date Test Began		9/12	9/14	9/16	9/18	9/20	9/22	9/24	9/26
Kubanka	3 days								
	6 days								
	10 days								
Preston	3 days								
	6 days								
	10 days								
Red Fife	3 days								
	6 days								
	10 days								
Marquis	3 days	76	38	77	75	73	100	87	85
	6 days	82	61	86	75	83	100	92	85
	10 days	82	61	86	75	83	100	92	85
Red Russian	3 days	86	66	54	40	85	100	77	83
	6 days	100	95	93	96	97	100	100	98
	10 days	100	95	93	96	97	100	100	98
Defiance	3 days								
	6 days								
	10 days								
Delayed Defiance	3 days								
	6 days								
	10 days								

9/28	9/30	10/2	10/4	10/6	10/8	10/12	10/14
75	80	100	92	100	83	90	100
92	80	100	98	100	83	96	100
92	80	100	98	100	83	96	100
85	100	82	87	100	84	96	
93	100	86	100	100	97	96	
93	100	86	100	100	97	96	
46		33					
92		41					
92		41					

Table 27.

PLANTED JULY 2,1921. HARVESTING BEGAN(SEPTEMBER 22,1921) TEN DAYS AFTER HEADS APPEARED,AND WAS CONTINUED EVERY OTHER DAY UNTIL THE GRAIN WAS RIPE AND HARVESTED.

Date test Began		9/22	9/24	9/26	9/28	9/30	10/2	10/4	10/6
Kubanka	3 days	8	72	43	71	60	0	93	0
	6 days	84	96	97	100	94	5	97	0
	10 days	84	96	97	100	94	5	97	0
Preston	3 days	100	100	0	100	85	90	58	89
	6 days	100	100	0	100	100	90	68	100
	10 days	100	100	0	100	100	90	68	100
Red Fife	3 days				82	75	36	100	
	6 days				82	92	54	100	
	10 days				82	92	54	100	
Marquis	3 days	92	95	100	100	100	100	100	100
	6 days	96	100	100	100	100	100	100	100
	10 days	96	100	100	100	1 00	100	100	100
Red Russian	3 days	51	85	56	68	57	92		100
	6 days	100	100	100	97	100	100		100
	10 days	100	100	100	97	100	100		100
Defiance	3 days	0			0	63			0
	6 days	14			0	84			0
	10 days	14			0	84			0
Delayed Defiance	3 days					0		0	23
	9 6 days					0		0	28
	10 days					0		0	28

10/8	10/10	10/12	10/14	10/16	10/18	10/20	10/22	10/24	10/26	10/28	10/30
17	17	44	78	28	0	0	32	0	0	77	
35	55	66	93	100	0	0	100	0	0	100	
35	55	66	93	100	0	0	100	0	0	100	
100	92	86	0	100	80	100	90		80	100	75
100	100	98	0	100	90	100	90		80	100	100
100	100	98	0	100	90	100	90		80	100	100
0	100		100	100	100	97	40	53	100	87	100
0	100		100	100	100	99	60	70	100	89	100
0	100		100	100	100	99	60	70	100	89	100
100	95	100	100	100	100	100	100	80	96	93	40
100	100	100	100	100	100	100	100	80	100	96	50
100	100	100	100	100	100	100	100	80	100	96	50
83	100		92	74	84		68	100	100	84	100
100	100		100	100	100		90	100	100	100	100
100	100		100	100	100		90	100	100	100	100
0											
0											
0											
			0		33		0	0		0	
			0		58		0	0		34	
			0		58		0	0		45	

11/1	11/3	11/5	11/7
81	30	0	0
100	100	0	18
100	100	0	18
72	92	72	0
72	100	87	0
72	100	87	0
88	86		0
100	100		0
100	100		0
100		93	100
100		93	100
100		93	100
80	84	100	100
100	100	100	100
100	100	100	100

Table.28.

PLANTED JULY 16,1921. HARVESTING BEGAN(OCTOBER 8,1921) TEN DAYS AFTER HEADS APPEARED,AND WAS CONTINUED EVERY OTHER DAYS UNTIL THE GRAIN WAS RIPE AND HARVESTED.

Date Test Began		10/8	10/10	10/12	10/14	10/16	10/18	10/20	10/22
Kubanka	3 days					0	0	0	0
	6 days					0	25	0	0
	10 days					0	25	0	0
Preston	3 days					23	87	92	40
	6 days					93	87	92	87
	10 days					93	87	92	87
Red Fife	3 days								0
	6 days								0
	10 days								0
Marquis	3 days	100	100	100	16	100	100	96	96
	6 days	100	100	100	16	100	100	100	100
	10 days	100	100	100	16	100	100	100	100
Red Russian	3 days	35	35	53	30	64	54	0	72
	6 days	45	84	91	79	100	100	0	96
	10 days	45	84	91	79	100	100	0	100
Defiance	3 days								
	6 days								
	10 days								
Delayed Defiance	3 days								0
	6 days								0
	10 days								0

10/24	10/26	10/28	10/30	11/1	11/3	11/5	11/7	11/9	11/11	11/13	11/15	11/21
0	35	0	17	0	55	0	0	26	0	0		5
0	85	0	92	0	100	0	0	91	0	0		20
0	85	0	92	0	100	0	0	91	0	0		20
100	95	90	0	70		51	42	92	44	50		0
100	100	100	0	80		51	83	100	87	82	70	0
100	100	100	0	80		51	83	100	87	82	80	0
	0	75	0	0	0	0	11	0				0
	0	83	0	0	0	0	11	0				0
	0	91	0	0	0	0	11	0				0
90	91	95	90		89	81	90	74	0	0	0	94
100	100	100	100		100	100	100	100	0	4	0	96
100	100	100	100		100	100	100	100	0	12	0	96
50	0	45	74	18	74	80	82	78	84	0	0	0
100	0	95	100	36	87	100	100	93	84	42	0	0
100	0	98	100	36	87	100	100	100	84	88	31	0
0		0										0
0		0										0
0		0										0
0	0	20		0		0	0					0
0	0	40		0		0	0					0
0	0	40		0		0	0					0

DURATION OF THE DELAY IN WHEAT SHOWING DELAYED GERMINATION

In determining the duration of time necessary for wheat from the San Luis Valley showing a marked delay in germination, to come to a normal germination, tests were made extending over a period of one year.

The germination records on seed wheat from the San Luis Valley which came into the Colorado Seed Laboratory during the fall and winter of 1920 were inspected and all records of wheat grown in 1920 and showing a delay in germination were saved and a test made one year from the date of the first test.

Table 29.

Colo. Seed Laboratory Number	Variety	Date	Germination tests 3 days	6 days	10 days
9393	Bluestem	Dec. 11, 1920	29.5	98	98
9877	Defiance	Jan. 3, 1921	35.5	85.5	95
10258	Turkey Red	Jan. 24, 1921	77.5	97.5	97.5
10446	Defiance	Feb. 9, 1921	24.5	77.5	91
10464	Defiance	Feb. 13, 1921	14	55	79.5
10905	Defiance	March 7, 1921	80	97	97
10916	Defiance	March 4, 1921	24	80.5	91.5
10918	Defiance	March 9, 1921	12.5	82	89

Table 30

Colo. Seed Laboratory Number	Variety	Date	Germination Tests 3 days	6 days	10 days
9393	Bluestem	Dec. 11, 1921	94.5	98	98
9877	Defiance	Jan. 3, 1922	95.5	96.5	96.5
10258	Turkey Red	Jan. 24, 1922	90	95	97
10446	Defiance	Feb. 9, 1922	95	96	96
10464	Defiance	Feb. 13, 1922	90	95	95
10905	Defiance	Mar. 8, 1922	91	96	96
10916	Defiance	Mar. 8, 1922	92	95	95
10918	Defiance	Mar. 8, 1922	97	98	98

Table 29 shows the germination of various varieties at the first test and table 30 shows the same varieties germinated about one year later.

In Bluestem #9393 germinated December 11, 1920 germinated 39.5 per cent in the three day test while a year later (December 11, 1921) germinated 94.5 per cent . Defiance #9877 germinated 35.5 per cent on January 3, 1921 and 95.5 per cent on January 3, 1922 in a three day test. Turkey Red #10258 germinated 77.5 per cent on January 24, 1921, and 90 per cent on January 24, 1922. Defiance #10446 germinated 24.5 per cent on February 9, 1921 and 95 per cent on February 9, 1922. Defiance #10464 germinated 14 per cent on February 12, 1921 and 90 per cent on February 12, 1922. Defiance #10195 germinated 80 per cent on March 7 and 91 per cent on March 8, 1922. Defiance #10198 germinated 24 per cent on March 4, 1921 and 92 per cent on March 8, 1922. Defiance #10918,germinated March 9, 1921 ,12.5 per cent and on March 8, 1922, 97 per cent.

We see in each case when the seed was germinated a year after the first test that a normal and high germination was secured.

Table 31

DELAYED DEFIANCE - HARVESTED SEPTEMBER 5, 1921

Where Grown	Germination Test Dec. 5, 1921			Germination Test Feb. 15, 1922	
	3 days	6 days	10 days	3 days	6 days
Saguache 1920	93.5	99.5	99.5	88	96
Saguache 1921	71.5	99.5	99.5	93	100
Del Norte 1921	65.5	98.5	99	89	100
Ft. Collins 1921	94.5	98.5	99	89	98

Also in combining the germination test of table 11, pp. 85 , and table 47 , pp. 171 , into table 31, similar results have been shown as in tables 29 and 30. In correlation with table 31, is plate 19, pp. 223, showing the delayed Defiance wheat after it had reached a normal germination. A, B and C show the Delayed Defiance harvested in the San Luis Valley in 1920 and 1921 and after reaching a normal germination, while C shows the Delayed Defiance harvested at Ft. Collins 1921, which did not show a delay in germination at all.

From the data shown in these tables (29, 30 and 31) we see that the delay in germination caused by conditions (alkalies and altitude) existing in the San Luis Valley has a duration of less than one year. As spring wheat are the principal wheats grown in the San Luis Valley, a normal germination is reached before planting time.

SUMMARY OF THE DELAY PRODUCED UNDER SAN LUIS VALLEY CONDITIONS.

In the geographical distribution a delay in germination occurs in wheat grown in the San Luis Valley due to conditions existing in the Valley. The average germination of wheat sent into the Colorado Seed Laboratory from the San Luis Valley during 1921 was 48.97 per cent in a three day test and 87.00 per cent in a six day test.

In the study of the after-ripening of seed harvested in the San Luis Valley, it was found to be similar to the after-ripening in normal seed, except the after-ripening and delayed germination are continuous and it can not be determined where one leaves off and the other begins.

The seed grown in the Valley behaves as normal seed except when placed in a three day test. When subjected to dry conditions in an oven or dry conditions in a refrigerator, a normal germination is not secured in a three day test, but when placed in a refrigerator between moist blotters or under water for three days and then in a germinator, a normal germination is secured in three days. This shows that the delay in germination is similar to the after-ripening for both can be brought to a normal germination at any time by submitting the seed (both after-ripening and delayed) to the low temperature of a refrigerator under moist conditions.

Considering the geographical and climatic conditions of the San Luis Valley, tests were made to determine if alkali, altitude, frost, height of water table, and the time of planting and time of harvesting were factors causing delayed germination.

Frost, height of water table, and time of planting and time of harvesting were not factors causing a delayed germination for wheat grown to maturity under these conditions behaved as normal wheat.

Two types of wheat are produced on the heavy alkali soil of the Valley; one type which retains its clear transparent endosperm showing only a slight delay and the other type which produces large, opaque kernels known as "yellow-berry." In this type the biggest delay in germination occurs. Delayed seed from the Valley was planted under normal conditions or soil containing a little or no alkali, the "yellow-berry" condition is grown out and normal seed is produced which has a greater vitality than seed of the same variety grown under normal conditions. When Defiance wheat was grown in pots containing varying percents of sodium, and potassium salts, a delayed germination was produced.

In the altitude tests wheat was grown from an elevation of 4,981 feet to 7,850 feet. As the elevation increases the seed harvested from the plantings at different elevations shows a greater delay as higher elevations are reached.

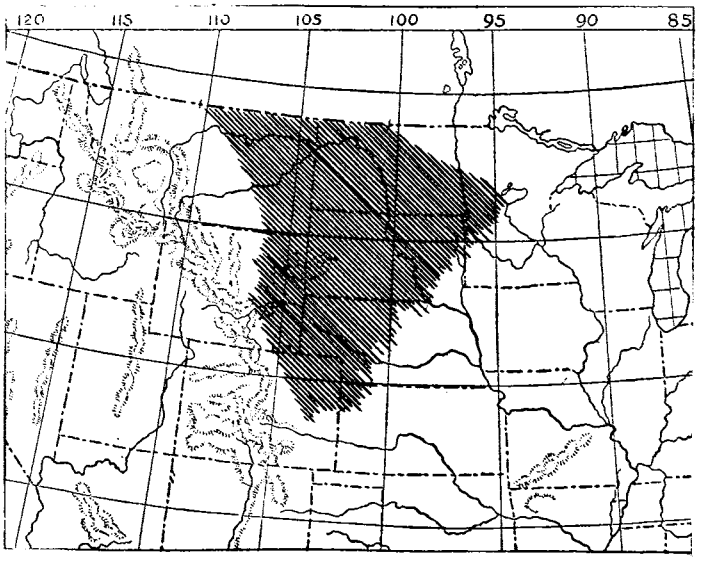
The duration of the delay was found to vary with the variety, and the condition of storage but in all cases a normal germination was reached within a year after the first test was made.

DELAYED GERMINATION IN DURUM WHEAT.

The third cause of delayed germination in wheat is a physiological condition and one normal to those subspecies producing varieties with exceedingly hard kernels. To this class belong the durum wheats (Triticum durum Desf.). Carleton (17) in his book on Small Grains, states: "The varieties of this subspecies (Triticum durum Desf.) are most widely known as durum wheats. In Europe they are called simply hard wheats and correctly so, as they are the hardest kerneled wheats that are known. The principal variety of North American durum is Kubanka."

The geographical distribution of durum wheat in United States is very localized and is within the limits set forth (97) in the durum wheat district and may be seen in map #2.

Map #2



In determining the cause of this delay in durum wheats the following varieties were used: Acme, Black Don, Arnautka and Kubanka.

The results of the germination tests of these four varieties may be seen in table 32.

Table 32
GERMINATION TEST ON DURUM WHEATS.

Variety	Germination 3 days	6 days	8 days	10 days	Total
Acme	72.5	12.5	0	0	85
Black Don	75.5	13.5	0.5	0	89.5
Arnautka	70.5	28.5	0	0	99
Kubanka	64	27	0	0	91

Black Don produced the highest germination test (75%) in three days, while Acme 72.5 per cent and Arnautka 70.5 per cent in the three day tests. Kubanka produced the lowest test, only 64 per cent in the three day test.

Table 33 shows the germination tests of samples of durum wheat sent to the Colorado Seed Laboratory during 1921. The after-ripening period was disregarded so the low test of some of the samples may be due to this condition.

Table 33
GERMINATION TEST ON DURUM WHEAT SENT TO THE COLORADO SEED LABORATORY DURING 1921

Counties	No. of Samples	Average Germination 3 days	6 days
Elberta	1	71	91
La Plata	1	55	90
Larimer	1	18	96.5
Mesa	1	7.5	87.5
Montrose	1	5	95.3

Morgan	1	65	90
Routt	1	58	90.5
Weld	1	67.5	94.5
	Average	43.37	91.91

The average of the germination (table 33) in the three day test is 43.37 per cent. Correlating the results in tables 32 and 33, with Carleton's (17) statement that Kubanka is the hardest wheat, and also with the rules for seed testing (99) which states, "Preliminary date for making germination report - 4 days; final report six days . The reason for this change as easily can be seen is due to the extreme hardness of the durum wheats. The experiences of the western analysts shows that it requires a day longer to obtain a satisfactory germination test on durum than other wheats." We find a delay occurring in the three day tests.

The rules adopted by the seed analysts,(99) shows that the durum wheats due to their extreme hardness, produces a poor germination test in three days, so they have ruled that four days elapse before the first or preliminary count is made. The poor germination secured in the three day tests are shown in plate 20, in which the four varieties A - Acme, B - Black Don, C - Arnautka and D - Kubanka are shown before being placed in the germinator and also after three days in the germinator.

The growth of the primary or seminal root are very poor as compared with those of the variety Preston shows

in plate 16, pp. 220 . But the main delay in germination is shown in the plumule, for the development of the plumule was very slow, especially in Kubanka as compared with that of the Preston variety.

Kubanka grown in the San Luis Valley probably shows the most characteristic delay in germination of any other variety tested. This type with an extremely hard texture is subjected to a combination of two separate causes, which cause a delayed germination in wheat: (1) that due to the extreme hard texture of the endosperm and (2) that due to climatic and soil conditions which exist in the San Luis Valley. The low germination for Kubanka wheat harvested at Ft. Collins in 1920 is due to hard, flinty texture of the endosperm while that of 1921 is due to a condition of after-ripening which is slow in coming to a normal germination (table 11, pp 85). In "a" plate 28, pp. 232 , and "a" plate 29, pp. 233 , shows the hard flinty endosperm of the durum type. The Kubanka grown at Hooper, Del Norte and Saguache represent the combination of the two causes for delayed germination. They have both the hard texture and characteristics caused by the condition in the San Luis Valley. The seed grown at Hooper in 1921 germinated 7 per cent; that at Del Norte in 1921, 11.5 per cent and that at Saguache in 1921, 13 per cent.

Plate 28, pp. 232 shows the durum wheat in a complete yellow-berry condition, "b" and "c" in a medium condition of yellow-berry and "a" normal durum wheat with hard flinty endosperm.

The reason for the delay in germination in the three day test, which is shown in table 11, pp. 85 plate 20, pp. 224 , and the results of the western analysts (99) is due to the hardness of the kernel.

The hardness of the kernel as is shown in table 34, prevents the rapid intake of water. In the tables to , on the percentage grains in weight due to water absorbed in the first forty-eight hours shows the six varieties of wheat grown at Ft. Collins, Colorado in 1921:

Table 34
Per cent water absorbed.

Varieties	12 hours	24 hours	36 hours	48 hours.
Kubanka	26.53	37.56	46.29	50.96
Preston	27.48	39.56	49.46	58.40
Red Fife	26.99	42.06	53.14	61.94
Marquis	24.64	38.14	48.38	55.28
Red Russian	28.06	39.87	53.28	64.24
Defiance	33.64	45.51	60.11	74.22

In the twelve hour test, Marquis fell below Kubanka while the rest had a higher per cent of water absorbed. In the twenty-four, thirty-six and forty-eight hour test Kubanka fell below the others in the per cent of water absorbed, and shows that the intake of water is slower in Kubanka and likewise the durum wheats, than in the other subspecies.

Table 35

Colo. Seed Laboratory Number	Variety	Date	Germination Test 3 days	6days	10days
10544	Kubanka	Feb. 18, 1920	71	91	91
10806	Kubanka	Mar. 4, 1920	65	90	90

Table 36

Colo. Seed Laboratory Number	Variety	Date	Germination Test 3 days	6days	10 days
10544	Kubanka	Feb. 18, 1921	70	92	92
10806	Kubanka	Mar. 4, 1921	72	92	92

Tables 35 amd 36 show that Kubanka wheat #10544, harvested in the fall of 1920 and germinated February 18, 1920, germinated 71 per cent in three days. When germinated about a year later, February 12, 1921, germinated 70 per cent. Kubanka wheat #10806 show the similar results, when germinated March 4, 1920, germinated 65 per cent and when germinated March 8, 1921, germinated 72 per cent.

Table 11, pp. 85 , show that Kubanka wheat harvested in 1920 and when germinated over a year later, only germinated 51 per cent in a three day test. In table 50 , pp. 175 , Kubanka show the similar results, averaging 48.5 per cent in a three day test.

In the summation of results we observe that the hardness of the kernels of durum wheats prevent a rapid water intake and also prevent a rapid development (germination) of the plumule and seminal roots as compared with other wheats. This abnormal rate of development due to the hardness of the endosperm and conditions existing in the San Luis Valley

causes a delayed germination in the three day tests, and this delayed seed does not come to a normal germination at any time but is a constant physiological condition. As durum wheat seed ages, it loses its viability, as does the normal varieties.

WATER ABSORPTION IN WHEAT.

In the spring of 1921 the following varieties were sent into the San Luis Valley and grown during the season of 1921; Colorado varieties were Kubanka, Preston, Red Fife, Marquis, Red Russian, and Defiance; California varieties were, Baart, Bunyip, Club, Defiance, Hard Federation, Marquis, Propo, Sonora, White Australian, and White Federation, and the variety "Delayed Defiance" received from the San Luis Valley from the crop of 1920.

Plantings were made at three places in the Valley, Saguache, Del Norte and Hooper. A planting was also made at the Experiment Station Farm, Ft. Collins, Colorado.

The seed as harvested was brought into the seed laboratory and stored. Seed from the California varieties was secured from Davis, California, from the 1921 crop.

All seed was stored under laboratory conditions until tests were made.

This study was undertaken to see if the delay in germination was correlated in any way with per cent or rate of intake of water by the seed.

The seed grown at Ft. Collins, Colorado, will be called throughout this test, "Colorado grown seed;" that grown at Davis, California, "California grown seed" and that grown at Del Norte, Hooper and Saguache, "San Luis Valley grown seed."

Two trials were made for each variety and their averages calculated. In each test 100 seeds were used. The seeds were weighed and placed in a germinator at 20 degrees centigrade, between double moist blotters. Each test was weighed every twelve hours up to ninety-six hours and then every twenty-four hours up to one hundred and forty-four hours. A constant supply of moisture was given the seed by soaking the outer blotter in water every twenty-four hours throughout the test. The seeds were counted at three and six days. The per cent gain in weight was based on the original weight before the seed was placed in the germinator.

Table 37, is a combined summary of tables 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 51, 52, 53, 54, 55, 56,

Table 38, is a condensed summary of table 37.

As stated by Choate (19), "No change is apparent in the content of the grain (aside from swelling due to absorption of water and softening of the tissue) 10-12 hours after the material has been put into the germinating dishes." The real test of the ability of a lot to absorb water lies in the first twelve hours after being placed in a germinator. After twelve hours in the germinator, sugar appears and germination begins. Some of the seeds have no viability and so fail to germinate, lowering the per cent of germination for the lot. Those that do germinate, give an average that represents the amount of water absorbed

by the type of seed.

Table 38, shows the average of the two types of the same varieties of seed. The first type grown in the San Luis Valley during the seasons of 1920 and 1921, and the second type that grown in California and Colorado in 1920 and 1921. In the weight per 100 grains, that grown in the San Luis Valley weighed 3.771 grams, while that grown in Colorado and California 2.882 or an increase in the seed grown in the San Luis Valley of .889 grams per 100 grains.

In the average per cent in weight due to water absorbed, after twelve hours in the germinator for the seed grown in the San Luis Valley, was 25.89 per cent and that grown in Colorado and California, 30.88 per cent or a gain of 4.99 per cent for the Colorado and California grown seed.

The average increase in the per cent of water absorbed throughout the test was greater in the Colorado and California grown seed than in San Luis Valley grown seed.

As stated by Stevens (87), "The rate of absorption is very rapid the first few hours, then slower until sprouts appear, when it increases rapidly."

The per cent of the rapidity of the increase depends upon the viability of the seed and the vitality of the young sprout. In the seventy-two hour or three day test, the seed grown in the San Luis Valley germinated 80.08 per cent with a water absorption of 83.94 per cent, while

the seed grown in Colorado and California germinated 95.5 per cent with a water absorption of 103.91 per cent, an increase in germination of 13.44 per cent and an increase in water absorption of 20.97 per cent for the Colorado and California grown seed. In the 144 hour or six day test, the seed grown in the San Luis Valley germinated 98.75 per cent while that grown in Colorado and California, 97.30 per cent. The water absorption in the seed grown in the San Luis Valley was 215.22 per cent, while the seed grown in Colorado and California was 241.42 per cent. The seed grown in the San Luis Valley had a 1.45 per cent higher germination than that grown in Colorado and California, while that grown in Colorado and California had a 36.20 per cent greater water absorption than the San Luis Valley grown seed. The San Luis Valley grown seed is slower than the Colorado and California grown seed until after the third day, and then is rapid, producing a higher germination in the six day test. Although the germination is greater in the six day test with the San Luis Valley grown seed, the rate of germination was slow until after three days and the rate of water absorption up until three days paralleled the germination. The viability of the Colorado and California grown seed being greater than the seed grown in the San Luis Valley produced longer sprouts, due to the greater rate of absorption.

The rate of absorption being so slow in the San Luis Valley test that shorter sprouts were produced and so a greater gain in weight due to water absorption in the Colorado and California grown seeds is shown throughout the test.

This low percentage of intake of water in the San Luis Valley grown seed as compared with the normal seed grown in Colorado and California, shows that there is some inhibitor that prevents the rapid intake in the seed grown in the San Luis Valley. The inhibitor of the water absorption lies as is the belief of the writer, in two possible places; semi-permeable membrane; and the seed coat. Brown (13) in his work on the seeds of Gramineae states,"the grasses are inclosed in a semi-permeable or selective covering which permits the passage of iodine and water to the interior of the grain, but prevents the passing of sulphuric and hydrochloric and all salts of metals at present examined, when they are in an aqueous solution. The semi-permeable membrane is located in the spermoderm or the grain. The spermoderm lies next under the paracarp. Probably this layer of the spermoderm is derived from the epidermis of the nucleus, but its identity has not been satisfactorily determined at present."

The seed coat of wheat, according to Choate (19) "as the coat of the grain is easy permeable and in no way delayed germination, no particular study was made of it."

The work of Choate (19) and Brown (13) must have been with normal grain only, for the intake of water was very rapid and in no way delayed germination.

In the San Luis Valley grown seed, the intake of water is 4,99 per cent lower than that of the normal seed of the same varieties in twelve hours and the germination of the San Luis Valley grown seed in the three day test was 13.44 per cent lower than that of the normal seed of the same varieties, showing that an inhibition occurs in the San Luis Valley grown seed which causes a slow intake of water and a lower per cent germination and thus enters into the cause of delayed germination.

We have seen that the rate of germination in the three day test is correlated with the rate of absorption of water when the seed is under the period of delayed germination, but as soon as the seeds reach a normal germination, the rate of absorption does not cause a low germination in the three day test, for the seed seems to obtain enough moisture, even though the inhibitor causes a slower rate of absorption, to produce a normal germination.

The varieties which did not reach a normal germination when the tests were made were : Defiance, (table 48) grown at Del Norte in 1921 showing a 5.88 per cent lower water absorption in twelve hours than that grown at Ft. Collins in 1921 and a 15.5 per cent lower germination than that grown at Ft. Collins in 1921 in a three day test; Defiance, California #955 (table 53) grown at Del Norte in 1921, showing a .23 per cent lower water absorption in twelve hours below

that of the same variety grown at Davis, California in 1921. The germination of that grown at Del Norte was 40.5 per cent lower than that grown at Davis California in 1921; Propo, California No. 115, (table 42) grown at Del Norte in 1921, show a 7.56 per cent lower water absorption in twelve hours than that grown at Davis, California in 1921. Also show a 33 per cent lower germination in the three day test than that grown at Davis in 1921; Bunyip California #15023, (table 43) grown at Del Norte in 1921, shows a 3.19 per cent lower water absorption in twelve hours than that grown at Davis in 1921 and a 15.12 per cent lower germination, than that grown at Ft. Collins in 1921. The germination of that grown at Del Norte in 1921 was 24 per cent lower than that grown at Davis in 1921 and 30 per cent lower than that grown at Ft.Collins in 1921; Baart California #113, (table 40) grown at Hooper and Del Norte in 1921. That grown at Hooper shows a 20.3 per cent lower water absorption in twelve hours and a 49.5 per cent lower germination in a three day test than that grown at Davis in 1921. That grown at Del Norte show a .56 per cent lower water absorption in twelve hours and a .43 per cent lower germination in three day test than that grown at Davis in 1921; and White Australian California #791 (table 41) grown at Hooper show a 2.94 per cent lower water absorption in twelve days and a 75.5 lower germination in a three day test than that grown at Davis in 1921, also shows a 24.56 per cent lower water absorption in twelve

hours and a 76 per cent lower germination in a three day test than that grown at Ft. Collins in 1921.

The varieties which reached a normal germination before the tests were made were, Preston (table 51) grown at Del Norte in 1921 show a 1.50 per cent lower water absorption in twelve hours and a .5 per cent lower germination in a three day test than that grown at Ft. Collins in 1921. That grown at Saguache in 1921 show a 1.40 per cent higher water absorption in twelve hours and a 3 per cent higher germination in a three day test than that grown at Ft. Collins in 1921; Marquis (table 44), grown at Del Norte in 1921 show a 2.01 per cent higher water absorption in twelve hours than that grown at Ft. Collins and the same germination (87 per cent) in the three day test. That grown at Saguache in 1921 show a 2.88 per cent higher water absorption in twelve hours and a 5.5 per cent higher germination than that grown at Ft. Collins in 1921; Red Russian (table 45), grown at Del Norte in 1921 show a 1.17 per cent lower water absorption in twelve hours and a 1.5 per cent higher germination than that grown at Ft. Collins in 1921. That grown at Saguache in 1921 had a .53 per cent lower water absorption in twelve hours and a .5 per cent higher germination than that grown at Ft. Collins in 1921; Red Fife (table 46), seed harvested at Saguache in 1921 snow a 4.67 per cent lower water absorption in twelve hours and a .5 per cent higher germination in the three day test than that grown at

Ft. Collins in 1921; White Federation California #3213 (table 54), grown at Del Norte had a 4.34 per cent lower water absorption in twelve hours and a 7.6 per cent lower germination in the three day test than that grown at Davis in 1921, also show a 21.47 per cent lower water absorption in twelve hours and a 8.5 per cent lower germination in the three day test than that grown at Ft. Collins in 1921; Hard Federation California #3063 (table 55), grown at Del Norte in 1921 show a 1.79 per cent lower water absorption in twelve hours and a 2.5 per cent lower germination in the three day test than that grown at Davis in 1921; also a .88 per cent lower water absorption in twelve hours and a 4 per cent lower germination than that grown at Ft. Collins in 1921. Sonora California #98 (table 56), grown at Del Norte in 1921 show a 7.06 per cent lower water absorption in twelve hours and a 3 per cent higher germination than that grown at Davis in 1921, also a 10.02 per cent lower water absorption and a 1.5 per cent lower germination than that grown at Ft. Collins in 1921. That grown at Hooper in 1921 had a 6.08 per cent lower water absorption in twelve hours and a 5 per cent lower germination than that grown at Davis in 1921, also a 9.04 per cent lower water absorption in twelve hours and a 10.5 per cent lower germination than that grown at Ft. Collins in 1921; and Delayed Defiance (table 53) which before coming to a normal germination showed a very marked delay in germination. That grown at Saguache in 1921, showed a 13.56

per cent lower water absorption in twelve hours and a 4 per cent higher germination in the three day test than that grown at Ft. Collins in 1921. That grown at Del Norte in 1921 show a 12.75 per cent lower water absorption in twelve hours and a 4.5 per cent lower germination in the three day test than that grown at Ft. Collins in 1921.

In the water absorption tests with the seventeen varieties, only two varieties (Marquis and Preston) show a greater water absorption in twelve hours in the seed grown in the San Luis Valley than the same varieties grown in California and Northern Colorado. Both varieties (Marquis and Preston) were of the Colorado varieties and are varieties which showed up in their ability to withstand abnormal conditions under which they are grown.

The tests show that the rate of intake of water (absorption) has a marked effect upon the per cent and rapidity of germination in seed during the period of delayed germination and a slight effect upon seed after reaching a normal germination, indicating that the lower rate of absorption occurring in seed grown in the San Luis Valley, which shows a delay in germination is a factor entering into the cause of the delay in germination. If the intake of water is slower when placed under moist conditions, then the evaporation or drying out of the seed is slow for the inhibitor that tends to keep the water out

of the seed will have a likewise effect in keeping the water in the seed and as diastase increases as the per cent of water decreases, and the decrease of moisture being slower due to the inhibitor, the action of the diastase of secretion is delayed from acting and thus prevents the seed from germinating readily causing a delay in germination.

In the very hard (Kubanka) wheat of the subspecies "Durum" show some very interesting and characteristic data as to water absorption.

In table 39, which represents the condensed summary of table 50, of the Kubanka grown in 1921. Kubanka grown at Ft. Collins in 1921 weighed.053 gram per 100 grains below that raised in the San Luis Valley. It has been shown in a previous test on the germination of the Durum types that the delay in germination in this type of wheat grown in the San Luis Valley is due to two causes: (1) flinty endosperm which does not allow a ready intake of water due to its hardness, and (2) a physiological condition within the seed caused by conditions existing in the San Luis Valley.

In the twelve hour test the seed grown in the San Luis Valley had a .70 per cent higher water absorption than the seed grown at Ft. Collins and the cause of this is produced by the condition of "yellow-berry" which tends to soften the endosperm allowing a more rapid intake of water. After the twelfth hour test the intake of water

was more rapid in Kubanka grown at Ft. Collins.

In the three day germination test the seed grown at Ft. Collins in 1921 germinated 62.5 per cent, while that grown in the San Luis Valley 48.16 per cent or an increase of 14.34 per cent for Ft. Collins grown Kubanka.

In the six day test the seed grown at Ft. Collins in 1921 had a water absorption of 199.68 per cent and a germination of 100 per cent while that grown in the San Luis Valley a water absorption of 180.60 per cent and a germination of 93 per cent.

The Kubanka not only shows the delay caused by the hard endosperm which causes a slow water absorption but also shows a delay in germination caused by the conditions (alkali and altitude) existing in the Valley which causes a delay in germination.

Table 37

Where Grown	Varieties	Number of Varieties Tested	Weight in grams per 100 grains	Percentage gain in weight due to water absorbed.								Germination	
				12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs,	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	3 days	6 days
Ft. Collins 1920	Colorado	5	2.779	30.49	42.06	55.74	65.77	86.21	101.58	118.74	139.84	194.22	244.21	90.50	96.30
Ft. Collins 1921	Colorado	6	2.626	29.82	37.72	54.71	64.65	85.36	108.98	128.90	156.41	233.58	291.17	98.75	99.17
Del Norte 1921	Colorado	5	3.550	26.53	39.92	49.61	55.72	69.79	86.40	104.85	125.39	186.16	240.24	88.70	99.60
Saguache 1920	Delayed Defiance	1	3.826	36.89	38.76	48.70	53.72	68.78	85.89	93.83	106.17	166.21	200.99	88.00	96.00
Saguache 1921	Colorado	6	3.620	25.97	38.46	47.08	53.63	66.88	84.44	99.91	136.91	197.48	230.54	95.00	99.83
Davis, Calif. 1920	California	10	3.221	31.48	45.59	58.07	69.44	85.93	93.48	124.20	149.19	188.46	232.65	91.05	93.90
Davis, Calif. 1921	California	9	3.403	28.01	41.81	51.73	62.95	80.14	86.15	116.59	141.06	173.31	225.96	95.00	98.00
Ft. Collins 1921	California	6	2.366	34.62	51.03	64.45	79.09	104.64	130.36	157.88	189.99	259.86	313.10	98.33	99.13
Del Norte 1921	California	9	3.946	24.55	39.49	48.88	56.84	70.93	86.18	101.21	125.03	160.56	212.62	77.39	98.72
Hooper 1921	California	3	3.915	25.55	38.20	46.39	53.14	59.02	71.78	86.31	107.53	145.09	191.71	51.33	99.50

Table 38

Where Grown	Weight in grams per 100 grains	Percentage gain in weight due to water absorbed.									Germination	
		12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	3 days	6 days
San Luis Valley 1920-1921	3.771	25.89	38.37	48.13	54.61	67.08	82.94	97.22	120.21	171.10	215.22	80.08	98.73
Colorado and California 1920-1921	2.882	30.88	43.64	56.94	68.38	88.45	103.91	129.26	155.29	209.88	241.42	93.52	97.30

Table 39

Where Grown	Weight in grams per 100 grains	Percentage gain in weight due to water absorbed									Germination	
		12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	3 days	6 days
Ft. Collins T 1921	3.639	26.53	37.56	46.29	50.96	59.43	70.20	88.68	103.60	144.47	194.68	62.50	100
San Luis Valley 1921	3.692	27.23	37.40	45.86	49.34	56.12	63.21	77.80	90.14	126.33	180.60	48.16	93.00

Table 40

Baart California #113 (Test began 1/26/22)

Where Grown	Trials	Weight per 100 Grams	Percentage gain in weight due to water absorbed. 12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	Germination 3 days	6 days
California 1920	First	3.537	31.21	43.92	53.09	60.23	72.66	90.26	110.48	127.04	156.43	205.48	91	94
	Second	3.594	30.88	42.51	52.47	59.47	70.67	87.32	107.99	123.92	150.07	199.13	89	92
	Average	3.566	31.05	43.22	52.78	59.85	71.67	88.79	109.24	125.48	153.25	202.32	90	93
California 1921	First	4.304	26.90	40.21	47.09	56.17	61.71	73.98	89.80	110.90	133.62	174.99	93	95
	Second	4.348	24.65	38.38	45.00	53.74	59.12	71.06	91.23	109.12	132.06	172.18	87	98
	Average	4.326	25.78	39.30	46.05	54.96	60.42	72.52	90.52	110.01	132.84	173.59	90	96.5
Hooper 1921	First	4.613	24.19	34.64	42.95	48.65	54.88	68.29	80.92	103.04	118.57	152.03	41	100
	Second	4.751	23.30	33.27	40.01	47.52	53.69	66.30	76.84	102.09	119.98	157.93	40	99
	Average	4.682	23.75	33.96	41.48	48.09	54.29	67.30	78.88	102.07	119.28	154.98	40.5	99.5
Del Norte 1921	First	4.640	24.97	36.04	44.95	50.01	56.69	65.47	77.95	107.43	123.42	162.59	42	100
	Second	4.416	25.26	37.22	46.07	51.05	57.98	67.92	80.87	109.21	135.87	169.76	52	100
	Average	4.528	25.12	36.63	45.51	50.58	57.34	66.70	79.41	108.32	124.65	166.18	47	100

Table 41

White Australian, California #791 (Test began 1/26/22)

Where Grown	Trials	Weight per 100 Grams	Percentage gain in weight due to water absorbed. 12 hr	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	Germination 3 days	6 days
California 1920	First	3.528	28.34	38.80	47.57	53.79	64.91	78.79	99.29	115.13	152.22	196.49	87	92
	Second	3.299	30.25	40.89	49.04	56.44	67.95	79.69	103.55	117.39	154.93	207.73	81	86
	Average	3.414	29.30	39.90	48.31	55.12	66.43	79.24	101.42	116.26	153.58	202.11	84	89
California 1921	First	3.512	27.90	38.66	46.89	52.79	62.55	73.61	98.92	114.27	160.39	217.99	95	99
	Second	3.497	27.89	38.23	46.23	51.58	59.51	69.00	91.65	105.52	151.07	207.00	93	99
	Average	3.505	27.90	38.45	46.56	52.19	61.03	71.31	95.79	110.00	155.73	213.50	94	99
Ft. Collins 1921	First	1.324	51.28	60.65	75.03	88.28	120.39	145.09	198.03	229.23	297.55	387.51	96	98
	Second	1.382	47.75	58.47	72.64	83.72	107.09	128.52	180.79	210.19	285.39	378.68	97	99
	Average	1.353	49.52	59.56	73.89	86.00	113.74	136.81	189.41	219.71	291.52	383.10	96.5	98.5
Hooper 1921	First	3.631	24.54	34.39	43.13	49.32	55.22	61.63	80.50	93.88	144.34	203.03	18	99
	Second	3.563	25.37	35.61	43.69	49.67	56.10	62.28	79.45	94.68	147.47	201.77	23	100
	Average	3.597	24.96	35.00	43.41	49.50	55.66	61.96	79.98	94.28	145.91	202.40	20.5	99.5

Table 42

Propo California #115 (Test began 1/26/22)

Where Grown	Trials	Weight per 100 Grams	Percentage gain in weight due to water absorbed. 12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	Germination 3 days	6 days
California 1920	First	3.525	33.73	47.93	53.82	63.09	75.72	102.30	120.11	153.07	183.36	259.97	91	94
	Second	2.448	34.75	46.44	56.12	66.35	82.88	106.91	124.92	168.25	191.25	268.22	83	92
	Average	2.487	34.24	47.19	54.47	64.72	79.30	104.61	122.52	160.66	187.31	264.60	87	93
California 1921	First	2.495	33.62	45.44	54.47	65.41	78.59	105.89	126.85	170.19	195.71	270.37	95	99
	Second	2.393	34.31	44.78	56.03	67.98	80.12	108.13	130.04	174.86	200.46	273.41	97	99
	Average	2.444	33.94	45.11	55.25	66.70	79.36	107.01	128.45	172.53	198.09	271.89	96	99
Del Norte 1921	First	4.450	27.79	35.06	42.55	48.13	55.03	68.94	86.32	120.65	147.42	200.04	67	96
	Second	4.422	24.97	34.92	43.61	48.63	56.92	69.32	86.77	121.39	148.36	201.84	59	99
	Average	4.436	26.38	34.99	43.08	48.38	55.98	69.13	86.55	121.02	147.89	200.94	63	97.5

Table 43

Bunyip California #13023 (Test began 1/26/22)

Where Grown	Trials	Weight per 100 Grams	Percentage gain in weight due to water absorbed. 12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	Germination 3 days	6 days
California 1920	First	3.805	26.75	44.01	57.26	72.86	85.65	100.43	118.34	155.06	192.78	220.13	97	97
	Second	4.138	25.94	42.51	55.84	69.94	82.65	96.07	113.96	150.05	182.65	208.70	89	94
	Average	3.972	26.35	43.26	56.55	71.40	84.15	98.25	116.15	152.56	187.72	214.42	93	95.5
California 1921	First	4.247	23.60	39.02	46.91	56.54	73.20	88.02	102.02	118.76	154.88	179.06	91	97
	Second	4.291	23.82	39.26	47.49	57.00	74.55	89.25	102.12	120.34	156.25	180.37	95	98
	Average	4.269	23.71	39.14	47.25	56.77	73.88	88.63	102.07	119.55	155.57	179.72	93	97.5
Ft. Collins 1921	First	2.003	35.74	52.87	72.09	88.56	120.66	147.12	175.44	213.33	288.41	326.26	100	100
	Second	2.108	35.53	52.60	71.84	88.00	119.30	145.60	174.02	211.19	286.03	325.41	98	98
	Average	2.056	35.64	52.73	71.94	88.28	119.98	146.36	174.73	212.26	287.22	325.84	99	99
Del Norte 1921	First	4.440	21.03	39.05	50.00	56.84	71.69	82.65	99.32	117.28	159.52	192.53	73	100
	Second	4.556	20.01	38.00	48.67	54.60	69.20	80.07	98.16	116.83	158.65	190.70	65	100
	Average	4.498	20.52	38.53	49.34	55.72	70.45	81.36	98.74	117.06	159.09	191.62	69	100

Table 44

Marquis (Test began 2/15/22.)

Where Grown	Trial	Weight per 100 Grains	Percentage gain in weight due to water absorbed.									Germination	
			12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	3 days	6 days
Ft. Collins 1920	First	2.713	28.78	41.43	53.04	61.74	73.32	95.57	107.19	130.51	180.42	234.61	90	99
	Second	2.839	27.86	40.60	53.98	62.30	80.60	94.17	106.03	125.16	173.00	220.40	89	96
	Average	2.776	28.32	41.02	53.51	62.02	79.96	94.87	106.61	127.84	176.71	227.51	89.5	97.5
Ft. Collins 1921	First	3.255	24.15	37.88	47.24	54.48	67.43	88.63	105.16	128.05	184.26	225.21	87	99
	Second	3.187	25.13	38.40	49.51	56.07	70.21	91.40	108.63	133.50	191.26	237.50	87	100
	Average	3.221	24.64	38.14	48.38	55.28	68.82	90.02	106.90	130.78	187.76	231.36	87	99.5
Del Norte 1921	First	3.627	25.85	39.26	48.46	55.08	65.84	78.72	99.30	118.36	157.29	202.68	88	99
	Second	3.525	27.45	41.50	53.63	59.20	69.90	85.60	106.30	126.50	170.91	227.40	86	99
	Average	3.576	26.65	40.38	51.05	57.14	67.87	82.16	103.80	122.43	164.10	215.04	87	99
Saguache 1921	First	3.932	27.39	38.43	47.61	53.41	63.83	79.17	90.36	110.20	151.96	203.79	93	100
	Second	3.724	27.64	38.63	47.90	54.60	62.15	75.19	84.63	104.20	143.60	193.54	94	100
	Average	3.828	27.52	38.53	47.76	54.01	62.99	77.18	87.50	107.20	147.78	198.67	93.5	100

Table 45

Red Russian (Test began 2/15/22.)

Where Grown		Weight per 100 Grains	Percentage gain in weight due to water absorbed.									Germination	
			12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	144	144 hrs.	3 days	6 days
Ft. Collins 1920	First	3.105	31.65	43.51	57.32	68.76	84.99	107.08	133.19	154.75	211.48	265.20	94	95
	Second	3.208	32.07	44.06	57.34	68.21	85.06	107.20	134.82	155.60	213.03	270.40	95	95
	Average	3.152	31.86	43.79	57.33	68.49	84.98	107.14	134.01	155.18	212.26	269.30	94.5	95
Ft. Collins 1921	First	3.255	28.17	40.09	53.48	64.18	83.31	110.20	136.20	159.85	225.07	289.00	97	99
	Second	3.215	27.94	39.65	53.07	64.29	84.07	112.20	137.14	161.09	227.63	290.40	99	100
	Average	3.235	28.06	39.87	53.28	64.24	83.69	111.20	136.67	160.47	226.35	289.70	98	99.5
Del Norte 1921	First	3.651	27.03	40.31	50.84	58.45	72.23	97.81	120.65	142.45	197.67	225.23	100	100
	Second	3.545	26.74	39.60	50.05	57.20	70.96	96.80	118.20	141.20	195.20	255.06	99	100
	Average	3.598	26.89	39.96	50.45	57.83	71.60	97.32	119.43	141.83	196.44	255.15	99.5	100
Saguache 1921	First	3.588	27.40	40.49	50.75	59.33	74.94	98.29	120.07	145.27	215.08	273.61	98	99
	Second	3.703	27.65	41.07	51.13	60.90	75.95	99.60	122.40	147.60	219.40	276.60	99	100
	Average	3.646	27.53	40.78	50.99	60.12	75.45	98.95	121.23	146.44	217.24	275.11	98.5	99.5

Table 46

Red Fife (Test began 2/15/22)

Where Grown	Trials	Weight per 100 Grams	Percentage gain in weight due to water absorbed									Germination	
			12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	3 days	6 days
Ft. Collins 1920	First	2.705	29.65	39.00	55.93	64.28	78.07	95.27	110.61	129.83	166.54	210.83	87	95
	Second	3.757	29.70	39.05	55.60	64.00	76.93	94.07	107.26	129.34	166.80	213.43	89	96
	Average	2.731	29.68	39.03	55.77	64.14	77.50	94.67	108.94	129.57	166.67	212.13	88	95.5
Ft. Collins 1921	First	2.651	27.53	42.14	53.11	61.59	81.70	101.48	116.30	146.02	207.43	262.88	92	99
	Second	2.590	26.45	41.98	53.17	62.29	83.90	104.52	120.07	150.80	212.60	269.90	98	100
	Average	2.621	26.99	42.06	53.14	61.94	82.80	103.00	118.19	148.41	210.02	266.39	95	99.5
Saguache 1921	First	3.144	21.98	36.26	45.73	52.45	65.23	83.04	99.06	123.66	177.92	229.29	97	100
	Second	3.223	22.65	38.40	46.72	52.90	64.70	81.91	97.43	124.60	179.07	231.07	95	100
	Average	3.184	22.32	37.33	46.23	52.68	64.97	82.47	98.24	124.13	178.50	230.18	96	100

Table 47

Delayed Defiance (2/15/22)

Where Grown	Trials	Weight per 100 Grams	Percentage gain in weight due to water absorbed									Germination	
			12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	3 days	6 days
Saguache 1920	First	3.740	27.37	39.38	49.14	54.54	70.25	82.17	96.33	110.13	171.49	208.96	91.	96
	Second	3.912	26.41	38.13	48.26	52.90	67.30	89.60	91.33	102.20	160.92	193.02	85	96
	Average	3.826	26.89	38.76	48.70	53.72	68.78	85.89	93.83	106.17	166.21	200.99	88	96
Saguache 1921	First	4.345	24.64	35.90	43.13	48.05	58.64	70.05	83.17	94.36	149.43	183.22	92	100
	Second	4.356	24.58	34.11	41.57	46.42	58.83	69.55	81.49	92.63	147.13	183.93	94	100
	Average	4.351	24.61	35.01	42.35	47.24	58.79	69.80	82.33	93.50	148.28	183.58	93	100
Del Norte 1921	First	3.987	25.33	37.87	46.52	51.52	64.83	75.19	90.12	106.17	181.54	241.06	85	100
	Second	3.945	25.45	38.40	47.47	52.32	66.46	76.48	90.44	106.64	175.41	225.86	85	100
	Average	3.966	25.39	38.14	47.00	51.86	65.65	75.84	90.28	106.41	178.48	233.46	84.5	100
Ft. Collins 1921	First	1.990	38.24	50.90	62.21	72.06	93.36	113.82	141.05	160.80	260.30	310.65	89	98
	Second	1.987	38.09	51.43	65.57	75.54	103.02	104.96	150.12	169.54	270.61	327.93	89	98
	Average	1.989	38.17	51.17	63.89	73.80	98.19	119.39	145.59	165.17	265.46	319.29	89	98

Taole 48

Defiance (Test began 3/15/22)

Where Grown	Trials	Weight per 100 Grains	Percentage gain in weight due to water absorbed										Germination	
			12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	3 days	6 days
Ft. Collins 1920	First	2.314	33.06	44.72	59.97	74.06	93.72	116.91	136.04	165.60	221.04	298.30	92	95
	Second	2.304	32.48	43.48	58.85	71.93	88.23	111.09	128.30	151.85	206.38	253.13	84	94
	Average	2.309	32.77	44.10	59.41	73.00	90.98	114.00	131.17	156.63	214.17	270.22	88	94.5
Ft. Collins 1921	First	1.987	34.32	46.30	61.19	75.84	99.28	133.01	146.21	191.99	275.69	349.52	93	100
	Second	1.934	32.96	44.71	59.02	72.30	95.33	125.20	137.13	183.62	261.18	321.82	92	98
	Average	1.961	33.64	45.51	60.11	74.22	97.31	129.11	141.67	187.81	268.44	335.67	92.5	99
Del Norte 1921	First	3.004	27.69	40.04	49.87	56.45	69.60	84.88	102.60	134.30	173.40	224.13	80	98
	Second	2.818	27.82	40.23	50.07	55.96	69.13	85.96	104.60	130.17	181.19	235.87	74	100
	Average	2.911	27.76	40.14	49.97	56.21	69.37	85.42	103.60	127.24	177.30	229.70	77	99
Saguache 1921	First	3.415	25.18	37.42	48.53	52.85	64.65	83.35	95.43	113.03	172.41	227.20	92	100
	Second	3.642	24.74	36.21	44.97	50.85	63.18	78.19	90.32	107.63	162.42	211.30	89	100
	Average	3.529	24.96	38.82	45.75	51.75	63.92	80.74	92.88	110.33	167.42	219.25	90.5	100

Table 49

Marquis Calif. #115 (Test began 3/15/22)

Where Grown	Trials	Weight per 100 Grains	Percentage gain in weight to water absorbed.										Germination	
			12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	3 days	6 days
California 1920	First	2.516	30.44	52.70	68.68	77.06	94.12	107.19	134.92	150.08	314.11	242.41	82	89
	Second	2.553	30.47	53.07	70.43	83.96	97.54	111.20	130.19	161.53	227.15	260.51	88	91
	Average	2.534	30.46	52.89	69.56	80.51	95.83	109.20	132.56	155.81	230.63	251.46	85	90
Ft. Collins 1921	First	2.343	33.89	45.88	58.98	70.85	96.03	116.89	142.08	171.38	248.82	305.35	100	100
	Second	2.330	26.82	45.20	59.06	71.30	96.17	118.30	145.16	178.26	256.80	311.24	99	100
	Average	2.337	27.86	45.54	59.02	71.08	96.10	117.60	143.62	174.81	252.71	308.30	99.5	100
Del Norte 1921	First	4.009	24.74	41.55	52.33	59.41	75.97	92.44	108.60	130.85	181.96	211.95	87	98
	Second	3.843	25.32	41.63	53.60	60.32	77.07	95.30	113.40	135.36	187.30	219.60	84	97
	Average	3.926	25.03	41.59	52.97	59.87	76.52	93.87	110.30	133.61	184.58	215.78	85.5	97.5

Table 50

Kubanka (Test began 2/25/22)

Where Grown	Trials	Weight per 100 Grains	Percentage gain in weight due to water absorbed.									Germination	
			12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	3 days	6 days
Del Norte	First	3.856	27.59	38.72	48.13	49.97	59.54	66.70	81.58	93.93	126.78	180.05	50	100
	Second	3.847	27.68	38.55	47.49	51.10	57.99	65.71	80.76	92.91	129.45	183.00	47	99
	Average	3.852	27.64	38.64	47.81	50.54	58.77	66.21	81.17	93.42	128.12	181.53	48.5	99.5
Hooper	First	3.758	24.55	34.57	43.58	47.47	53.35	59.63	72.43	83.24	118.52	169.02	34	99
	Second	4.005	24.34	34.68	43.47	47.29	53.31	59.72	70.21	83.29	118.67	173.64	33	100
	Average	3.882	24.45	34.63	43.53	47.38	53.33	59.68	71.32	83.27	117.60	171.33	33.5	99.5
Saguache	First	3.341	29.90	39.17	46.39	50.28	56.42	64.11	80.18	93.41	133.00	186.32	60	100
	Second	3.344	29.31	38.69	46.08	49.96	56.07	63.33	81.66	94.25	133.52	191.56	65	100
	Average	3.343	29.61	38.93	46.24	50.12	56.25	63.72	80.92	93.83	133.26	188.94	62.5	100
Ft. Collins 1920	First	3.947	26.95	37.82	47.75	51.33	60.45	70.35	84.11	93.66	127.06	168.10	76	90
	Second	3.375	27.34	38.42	46.04	50.99	60.34	67.20	85.51	96.80	129.48	171.28	67	88
	Average	3.661	27.15	38.02	46.90	51.11	60.40	68.68	84.81	95.23	128.27	169.60	71.5	89
Ft. Collins 1921	First	3.588	26.87	37.62	46.59	51.17	60.09	71.01	89.96	104.72	146.01	204.40	60	100
	Second	3.689	26.18	37.49	46.08	50.74	58.76	69.39	87.39	102.47	142.93	194.95	65	100
	Average	3.639	26.53	37.56	46.29	50.96	59.43	70.20	88.68	103.60	144.47	199.68	63.5	100

Table 51

Preston (Test began 2/25/22)

Where Grown	Trials	Weight per 100 Grains	Percentage gain in weight due to water absorbed									Germination	
			12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	3 days	6 days
Ft. Collins 1920	First	2.976	29.30	42.31	53.15	62.40	81.72	100.33	114.65	132.73	205.88	244.32	90	98
	Second	2.884	30.47	42.40	52.18	60.02	77.53	94.14	111.26	127.25	197.71	239.45	95	100
	Average	2.930	29.84	42.36	52.67	61.21	79.63	97.24	112.96	129.99	201.30	241.89	92.5	99
Ft. Collins 1921	First	2.751	27.44	39.80	49.62	58.26	80.62	101.26	125.18	145.48	245.52	302.94	96	99
	Second	2.708	27.47	39.32	49.29	58.53	82.05	101.03	123.59	146.12	241.39	286.25	94	100
	Average	2.730	27.46	39.56	49.46	58.40	81.34	101.15	124.39	145.80	243.46	294.60	95	99.5
Del Norte 1921	First	3.678	25.88	39.91	49.62	55.17	73.19	90.35	106.17	128.44	215.79	267.24	94	100
	Second	3.720	26.03	40.00	49.54	55.91	75.72	92.17	110.18	129.67	213.23	268.46	97	100
	Average	3.699	25.96	39.96	49.58	55.54	74.46	91.26	108.18	129.05	214.51	267.85	95.5	100
Saguache 1921	First	3.214	28.86	40.20	49.37	55.55	74.67	97.19	115.46	136.34	218.69	268.87	99	99
	Second	3.153	28.86	40.43	49.44	56.45	75.70	97.84	119.06	143.32	232.63	284.07	98	100
	Average	3.184	28.86	40.32	49.41	56.00	75.19	97.52	117.26	139.83	225.66	276.47	98.5	99.5

Table 52

Club California #114 (Test began 3/25/22)

Where Grown	Trials	Weight per 100 Grains	Percentage gain in weight due to water absorbed.									Germination	
			12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	3 days	6 days
Davis California 1920	First	2.794	30.38	52.07	68.86	80.48	106.73	119.30	148.67	174.53	229.31	286.07	89	95
	Second	2.834	30.62	51.94	68.83	80.81	103.20	114.61	140.07	161.20	201.16	247.65	87	88
	Average	2.764	30.50	52.01	68.85	80.65	104.97	116.96	144.37	167.87	215.24	266.86	88	91.5
Davis California 1921	First	2.700	27.26	46.40	55.19	68.96	97.20	122.40	141.16	173.18	209.19	266.73	96	98
	Second	2.732	28.56	47.13	56.07	68.85	97.13	123.16	141.54	170.17	204.00	260.69	98	99
	Average	2.716	27.91	46.77	55.63	68.91	97.17	122.78	141.35	171.68	206.60	263.71	97	98.5
Del Norte 1921	First	3.492	24.60	38.19	50.96	68.90	87.13	93.33	115.16	150.70	183.31	217.96	97	100
	Second	3.409	26.08	40.21	52.01	64.64	78.44	89.63	114.60	151.71	191.57	226.49	89	100
	Average	3.451	25.34	39.20	51.49	66.77	82.79	91.18	114.88	151.21	187.44	222.23	93	100

Table 53

Defiance California #955 (Test began 3/6/22)

Where Grown	Trials	Weight per 100 Grains	Percentage gain in weight due to water absorbed									Germination	
			12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	3 days	6 days
Davis California 1920	First	3.007	30.52	44.39	56.16	70.33	88.67	114.83	140.20	164.61	203.88	251.68	93	93
	Second	2.938	32.06	46.66	59.18	73.34	92.07	119.00	147.77	172.90	232.90	273.76	93	94
	Average	2.973	31.29	45.53	57.67	71.84	90.37	116.92	143.99	168.76	218.14	262.72	93	93.5
Davis California 1921	First	3.473	27.01	41.11	48.81	59.14	83.60	103.24	119.99	147.71	177.60	241.96	99	99
	Second	3.454	27.66	41.87	48.23	58.70	81.16	100.03	117.20	145.92	173.20	233.55	98	99
	Average	3.464	27.34	41.49	48.52	58.92	82.38	101.64	118.60	146.82	175.40	237.76	98.5	99
Del Norte 1921	First	3.582	27.24	41.26	46.30	55.54	78.16	97.97	110.20	130.16	150.20	187.01	49	99
	Second	3.574	26.97	40.97	45.63	54.18	80.30	100.65	115.40	142.71	187.20	212.92	87	100
	Average	3.578	27.11	41.12	45.97	54.86	79.23	99.31	112.80	136.44	158.70	199.97	58	99.5

Table 54

White Federation Calif. #3213 (Test began 3/8/22)

Where Grown	Trials	Weight per 100 Grains	Percentage gain in weight due to water absorbed									Germination	
			12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	3 days	6 days
Davis California 1920	First	3.800	28.88	43.55	54.30	63.05	82.41	108.31	128.31	151.97	187.44	228.34	98	99
	Second	3.712	29.31	43.97	55.61	65.21	84.59	109.20	128.16	153.21	190.59	230.53	98	99
	Average	3.756	29.10	43.76	54.96	67.13	83.50	107.21	127.28	152.59	189.02	224.44	98	99
Davis California 1921	First	4.277	27.35	41.57	52.16	62.12	77.49	95.20	111.27	125.32	157.19	198.53	97	99
	Second	4.108	27.65	41.91	53.13	62.49	78.15	96.91	112.65	127.55	1 2.18	207.08	98	100
	Average	4.196	27.50	41.74	52.15	62.31	77.82	96.06	111.96	126.44	159.69	202.81	97.5	99.5
Ft. Collins 1921	First	3.428	35.50	52.05	73.19	86.57	113.19	151.31	181.39	215.19	291.30	374.33	100	100
	Second	2.405	35.76	53.19	75.29	85.13	112.36	149.17	177.15	210.63	271.19	332.17	98	99
	Average	2.417	35.63	52.62	74.24	85.85	112.78	150.24	179.22	213.91	281.25	353.40	99	99.5
Del Norte 1921	First	3.473	23.07	37.57	45.29	52.55	67.93	80.48	97.54	116.87	151.60	200.65	91	100
	Second	3.727	23.24	37.94	45.67	53.09	67.04	78.23	95.61	113.91	157.13	189.55	90	99
	Average	3.600	23.16	37.76	45.48	52.82	67.49	79.36	96.58	114.89	154.37	195.10	90.5	99.5

Table 55

Hard Federation Calif. #3063 (Test began 3/8/22)

Where Grown	Trials	Weight per 100 Grains	Percentage gain in weight due to water absorbed									Germination	
			12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	3 days	6 days
Davis California 1920	First	3.154	30.37	47.14	59.32	73.22	91.18	110.75	127.19	150.41	185.16	223.30	96	98
	Second	3.284	30.09	46.93	58.76	71.15	88.07	108.51	125.63	146.21	178.99	215.17	95	95
	Average	3.219	30.23	47.04	59.04	71.69	91.68	109.63	126.41	148.31	183.08	219.24	95.5	96.5
Davis California 1921	First	3.163	25.26	43.13	56.18	71.67	96.34	117.65	131.98	157.84	185.40	249.09	99	99
	Second	3.134	25.54	43.65	56.27	70.91	95.99	116.63	131.04	156.63	185.19	247.87	96	96
	Average	3.144	25.40	43.39	56.23	71.29	96.17	117.14	131.51	157.24	185.80	248.48	97.5	97.5
Ft. Collins 1921	First	4.188	23.40	43.46	54.16	66.37	87.91	106.75	128.70	138.08	178.63	304.08	100	100
	Second	4.080	23.82	43.83	54.54	66.91	88.37	107.16	123.34	140.16	182.01	310.58	98	100
	Average	4.134	23.61	43.65	54.35	66.64	88.14	106.96	123.02	139.12	180.32	307.34	99	100
Del Norte 1921	First	4.061	22.80	42.52	55.33	64.19	85.35	100.26	115.31	129.94	175.30	209.16	92	100
	Second	3.977	22.65	42.16	55.03	63.81	85.00	98.91	112.31	134.16	166.81	194.68	88	98
	Average	4.019	22.73	42.34	55.18	64.00	85.68	99.59	113.71	127.05	171.06	201.42	95	99

Table 56

Sonora Calif. #98 (Test began 3/8/22)

Where Grown	Trials	Weight per 100 Grains	Percentage gain in weight due to water absorbed										Germination	
			12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	84 hrs.	96 hrs.	120 hrs.	144 hrs.	3 days	6 days
Davis California 1920	First	3.856	33.48	41.06	57.20	71.83	91.56	110.82	123.33	144.64	178.60	220.85	98	98
	Second	3.827	32.22	40.86	56.83	71.30	91.27	110.70	122.89	142.70	175.83	215.97	98	98
	Average	3.842	32.34	40.96	57.02	71.57	91.42	110.76	123.11	143.67	177.72	218.41	97	98
Davis California 1921	First	3.545	33.71	41.56	58.63	74.73	93.20	115.93	129.33	155.48	190.27	243.67	93	96
	Second	2.575	31.63	40.20	57.30	74.29	92.90	115.53	128.86	155.03	189.90	242.73	90	95
	Average	2.560	32.67	40.88	57.97	74.51	93.05	115.78	129.10	155.36	190.09	243.20	91.5	95.5
Ft. Collins 1921	First	1.941	35.38	53.04	53.13	76.71	97.16	125.28	137.96	173.21	208.29	305.73	97	98
	Second	1.861	35.87	53.18	53.37	76.73	97.02	123.16	136.61	173.09	205.97	305.53	97	98
	Average	1.901	35.63	53.11	53.27	76.72	97.09	124.22	137.29	173.15	207.13	305.63	97	98
Del Norte 1921	First	3.402	25.36	43.03	50.53	58.73	82.91	84.58	97.30	114.64	156.20	188.35	95	100
	Second	3.491	25.95	42.21	49.07	58.32	82.87	85.70	98.21	116.63	158.30	192.88	96	99
	Average	3.447	25.61	42.62	49.88	58.53	82.89	85.14	97.76	115.64	157.25	190.62	95.5	95.5
Hooper 1921	First	3.483	26.44	42.83	49.93	59.65	83.03	85.81	98.41	118.35	162.31	200.90	80	98
	Second	3.446	26.73	43.13	50.61	60.07	85.13	87.59	100.71	121.63	167.15	213.13	93	100
	Average	3.465	26.59	42.98	50.27	59.36	84.08	86.70	99.56	119.99	164.73	207.54	86.5	99

SUMMARY

In the study of wheat in the after-ripening condition, we find that after-ripening is a normal physiological condition existing in all wheats and the length of the delay due to after-ripening is a varietal characteristic. The average length of the after-ripening period in wheat is about fifty days after the seed has been harvested.

If the seed as soon as harvested is stored in a warm dry storage (laboratory conditions) causing a more rapid loss of moisture from the seed, the period of after-ripening is shorter than if stored under average conditions.

The delay due to after-ripening appears to be a period of inactive enzyme secretion. The only active enzyme during the period of filling and after-ripening of the seed is diastase of translocation, which is only slightly active on starch paste under normal germinative conditions, but which becomes very active under cool moist conditions. A normal germination is reached in after-ripening wheat under favorable germinating conditions, only when the diastase of secretion, secreted from the epithelial cells of the scutellum, become active.

A normal germination may be secured in after-ripening wheat at any time by placing the seed in a refrigerator under cool (9.1 to 13.4 degrees C.) moist conditions for three days and then in a germinator at 20 degrees C. for three days.

The after-ripening in delayed germinating seed behaves in a similar manner to the after-ripening in normal seed when subjected to the same conditions.

The period of after-ripening and delayed germination is a continuous one and it is impossible to tell where one leaves off and the other begins.

In the geographical distribution of delayed germination in the United States, data shows that two distinct types of delayed germination occur: (1) in varieties grown under conditions similar to those existing in the San Luis Valley; (2) in varieties represented by the subspecies Durum and which is a physiological condition normally existing in this type.

The delayed germination existing in wheat grown in the San Luis Valley is due to conditions existing in the Valley, for a condition of delayed germination can be produced by planting normal seed in the Valley. Normal germinating seed can be produced from the delayed germinating seed of the San Luis Valley, by planting the seed at Ft. Collins, under different climatic conditions.

Combining the topographical and climatic conditions of the Valley, there are a great many factors that might enter into the causes of delayed germination. The factors considered under this study were alkali, altitude, frost, height of water table, and the time of planting and the time of harvest.

Frost, height of water table, and the time of planting and time of harvesting were not factors causing a delayed germination, for wheat grown to maturity under these conditions behaved as normal wheat.

The only two conditions existing in the San Luis Valley, as far as the experimental study was undertaken, which enter into the cause of delayed germination were alkali and altitude.

Two types of seed are produced on the alkali soils in the San Luis Valley; one type retaining its clear, transparent endosperm showing only a slight delay in germination, and the other type producing large, opaque kernels known as "yellow-berry." In the "yellow-berry" type the biggest delay in germination occurs.

When the delayed seed from the San Luis Valley was planted at Ft. Collins under soil conditions containing little or no alkali, the "yellow-berry" condition was grown out and a normal seed produced which has a greater vitality than seed of the same variety grown at Ft. Collins for several years.

When Defiance wheat was grown in pots containing varying per cents of sodium and potassium salts, a delayed germination was produced.

In the altitude tests, Marquis and Defiance varieties were grown between the altitudes of 4,891 feet and 7,850 feet and data secured from these tests indicate that a gradual increase in delay in germination was secured as the altitude increased. The Defiance variety grown at 4,891 feet germinated 95 per cent in three days, while that grown at 7,850 feet germinated only 74 per cent. Marquis variety grown at 4,891 feet germinated 92 per cent in three days, while that grown

at 7,850 feet germinate only 84 per cent and so indicating that altitude enters into the cause of delayed germination.

The duration of the delay in after-ripening was found to be about fifty days after harvesting. The duration of delayed germination depends as with after-ripening, upon the varietal characteristics and upon storage conditions.

In all cases the duration of the delay in germination was less than one year after the first test was made.

When delayed germinating seed was placed under the same conditions as were used in bringing after-ripened seed to a normal germination, the delayed germinating seed behaved similar to the after-ripened seed, for a normal germination may be secured either in after-ripening or delayed germinating seed at any time, by placing the seed under cool, moist conditions in a refrigerator for three days and then in a germinator at 20 degrees C. for three days.

The similar behavior of after-ripening and delayed germinating seed under the same germinating conditions would indicate that the delayed germination in wheat is but a prolonged after-ripening period.

The second type of delayed germination under the geographical distribution is one of a normal physiological condition and one normal in the subspecies (durum) producing exceedingly hard grains. From data secured the delayed

germination in durum wheat appears to be due to the extreme hardness of the endosperm, preventing a rapid intake of water and also preventing a rapid development of the plumule and seminal roots. Durum wheat does not reach a normal germination in three days and as the wheat of this type ages it loses its viability as does normal germinating varieties.

The Kubanka (durum) grown in the San Luis Valley shows a greater delay than either the delayed germinating seed from the San Luis Valley or the delay in germination normal to the durum type, for Kubanka grown in the Valley has a combination of both types.

Water absorbed by the seeds from different regions also represents two distinct types, seed grown in the San Luis Valley and seed grown in California and Colorado.

The seed grown in the San Luis Valley weighed .889 grams per 100 grains more than the seed grown at California and Colorado, but the seed grown at California and Colorado had a 4.99 per cent greater water absorption in twelve hours after the seed was placed in the germinator than the seed grown in the San Luis Valley.

In the seventy-two hour or three day test, the seed grown in the San Luis Valley had a 13.44 per cent lower germination and a 20.97 per cent lower water absorption than that grown at California and Colorado.

The rate of intake of water indicates that conditions in the San Luis Valley produce an inhibitor which causes a slow intake of water, and likewise would prevent a rapid drying out of the seed, and thus delay the activity of the

diastase of secretion and produces a delay in germination.

RESULTS

Three types of delay in germination in wheat were found to exist in this study:

(1) Delay in germination due to after-ripening, which is a normal physiolcgical condition existing in all wheats. The duration of this delay is about fifty days. The cause of this delay due to after-ripening as far as available data shows is due to a period of inactive enzymes, and a normal germination is reached only when the "diastase of secretion" becomes active.

(2) Delay in germination (delayed germination) existing in wheat after the period of after-ripening is passed. This type of delay is limited to conditions similar to those existing in the San Luis Valley. As far as experimental study was undertaken, the two conditions in the Valley entering into the cause of delayed germination were alkali and altitude. The conditions existing in the Valley also produce in the seed an inhibitor which prevents a rapid intake of water and likewise prevents a rapid drying out of the seed.

Seed with this type of delay when placed under the same conditions as seed in an after-ripening condition, behaves in the same manner, and a normal germination can be produced in both types at any time by placing the delayed seed in a refrigerator under cool moist conditions for three days and then in a germinator for three days at 20 degrees centigrade.

The similar behavior of the two types of delayed seed indicate that the delay is the same and that the delay in germination after the normal after-ripening period is passed is but a prolonged period of after-ripening produced by conditions similar to those existing in the San Luis Valley.

The duration of this delay in germination caused by conditions similar to those existing in the San Luis Valley was found to be less than one year after the first germination test was made, and a normal germination is reached under normal germinating conditions only when the "diastase of secretion" becomes active.

(3) Delay in germination due to a normal physiological condition existing in the subspecies (Triticum durum Desf.) due to the hard endosperm preventing a rapid intake of water and a rapid development of the plumule and seminal roots. This type of delay does not come to a normal germination in the three day tests, and as the seed ages it loses its viability as does normal germinating seed.

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PLATE 1.

PLANTED APRIL 9. HARVESTED JULY 6.
GERMINATED OCTOBER 6.

Defiance wheat before being placed in the germinator.

Defiance wheat after three days in the germinator.

Total germination in 3 days	0

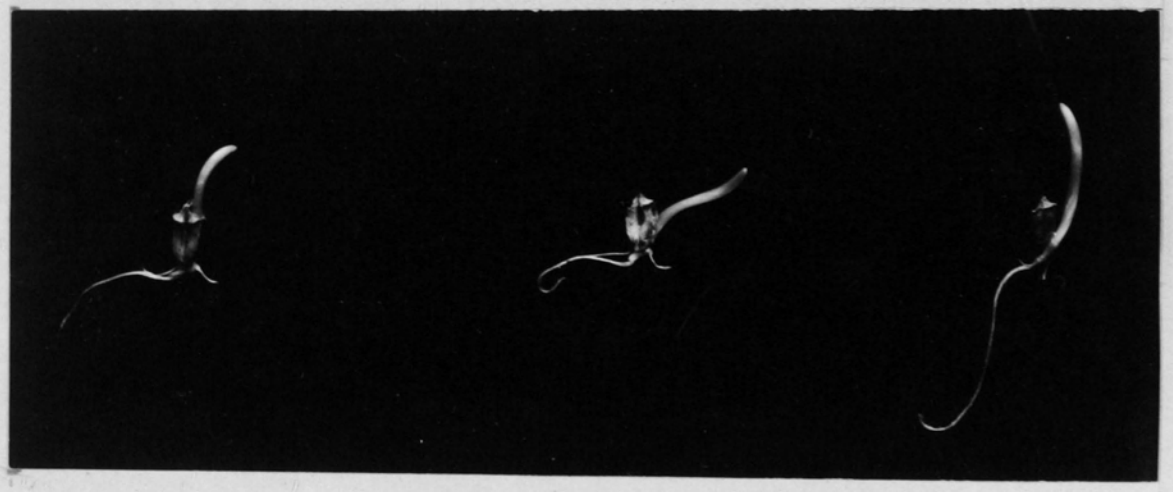
Total germination in 6 days	0

PLATE 2.

PLANTED APRIL 9. HARVESTED JULY 8.
GERMINATED OCTOBER 8.

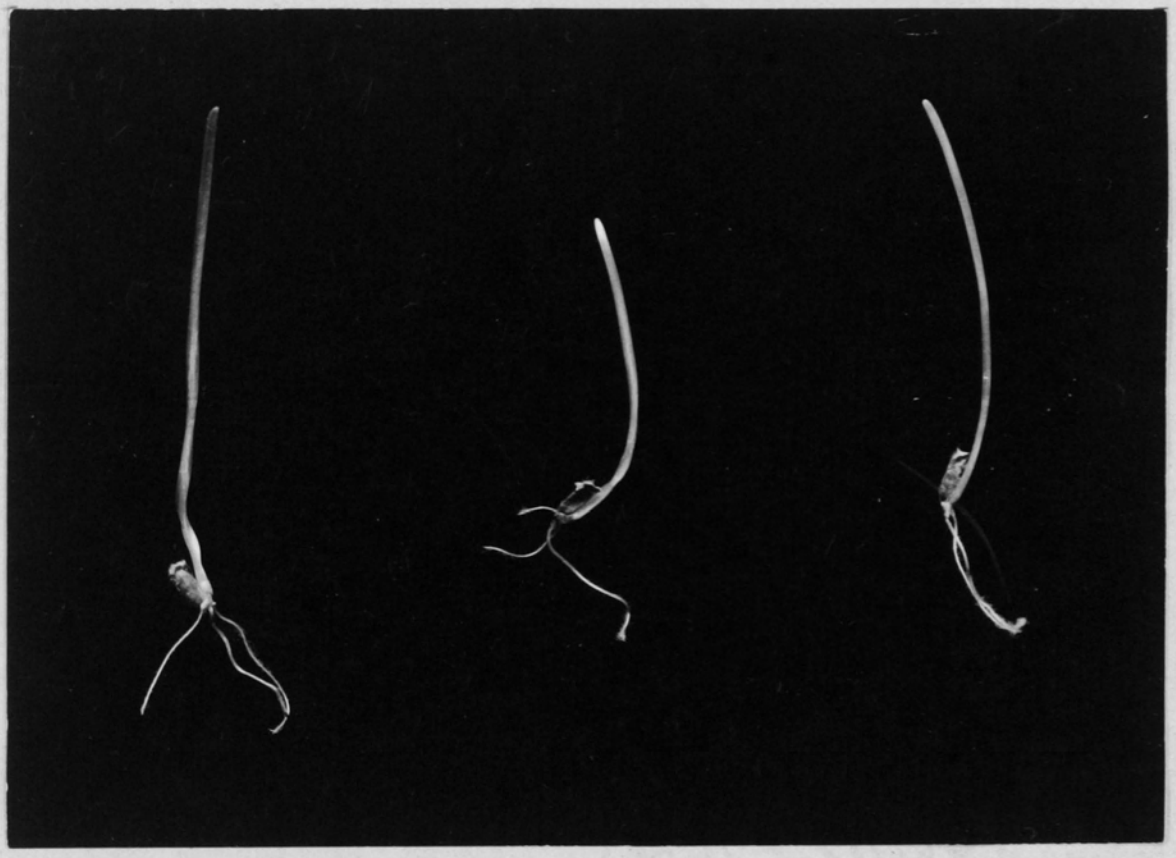
Defiance wheat before being placed in the germinator.

Defiance wheat after three days in the germinator.



Total germination in 3 days	41.2

Defiance wheat after six days in the germinator.



Total germination in 6 days	59.8

PLATE 3.

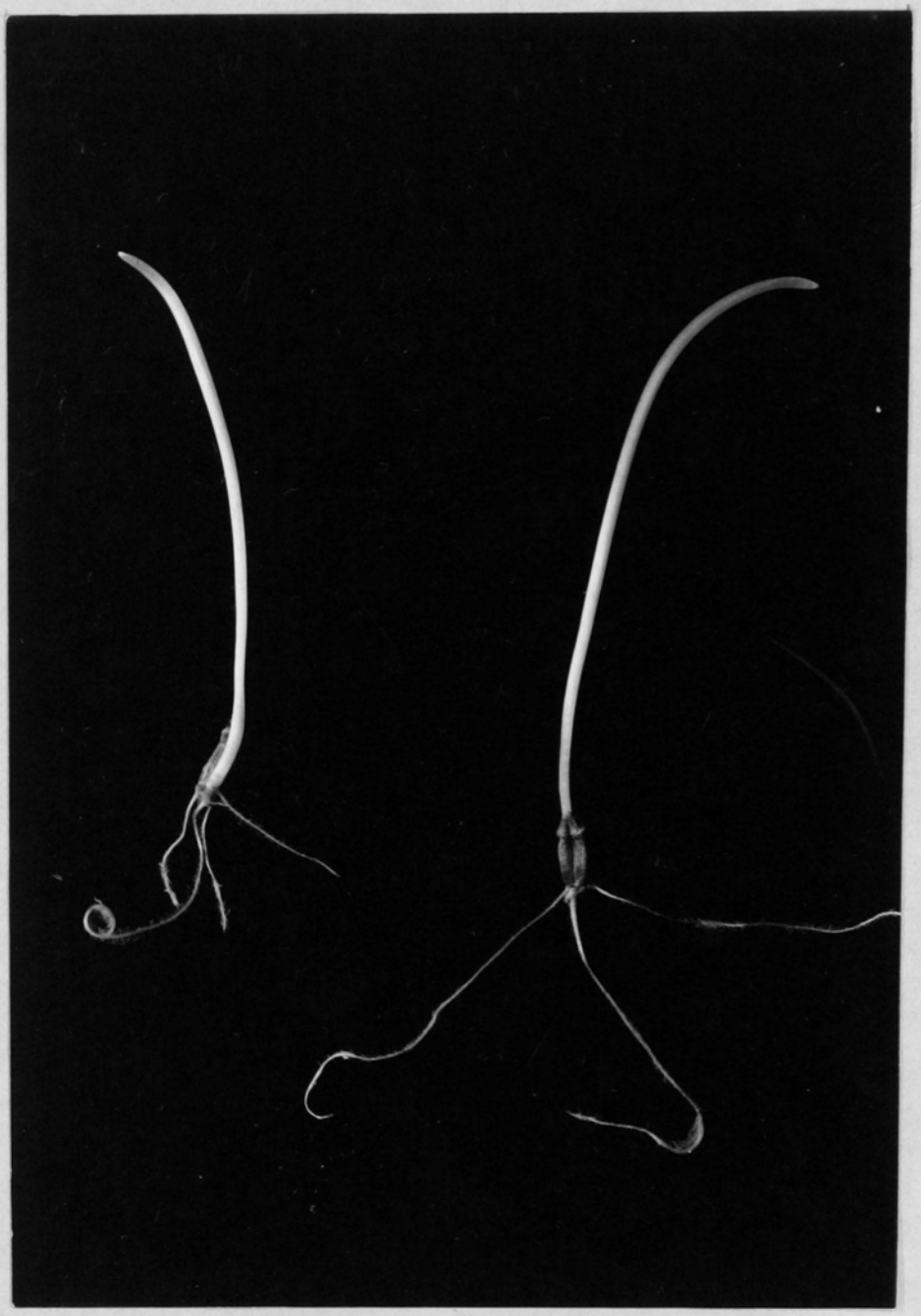
PLANTED APRIL 9. HARVESTED JULY 10.
GERMINATED OCTOBER 10.

Defiance wheat before being placed in the germinator.

Defiance wheat after three days in the germinator.

Total germination in 3 days	100

Defiance wheat after six days in the germinator.



Total germination in 6 days	100

PLATE 4.

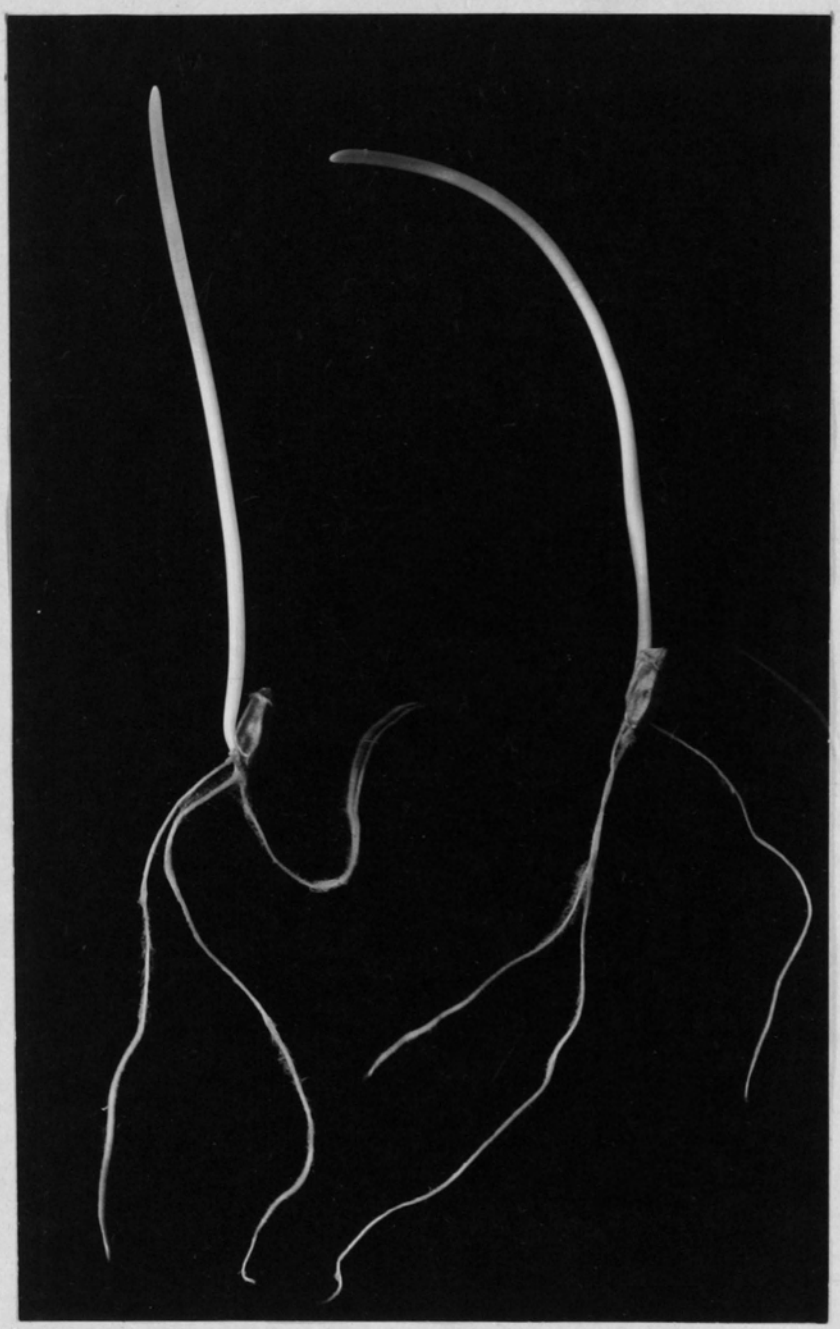
PLANTED APRIL 9. HARVESTED JULY 12.
GERMINATED OCTOBER 12.

Defiance wheat before being placed in the germinator.

Defiance wheat after three days in the germinator.

Total germination in 3 days	100

Defiance wheat after six days in the germinator.



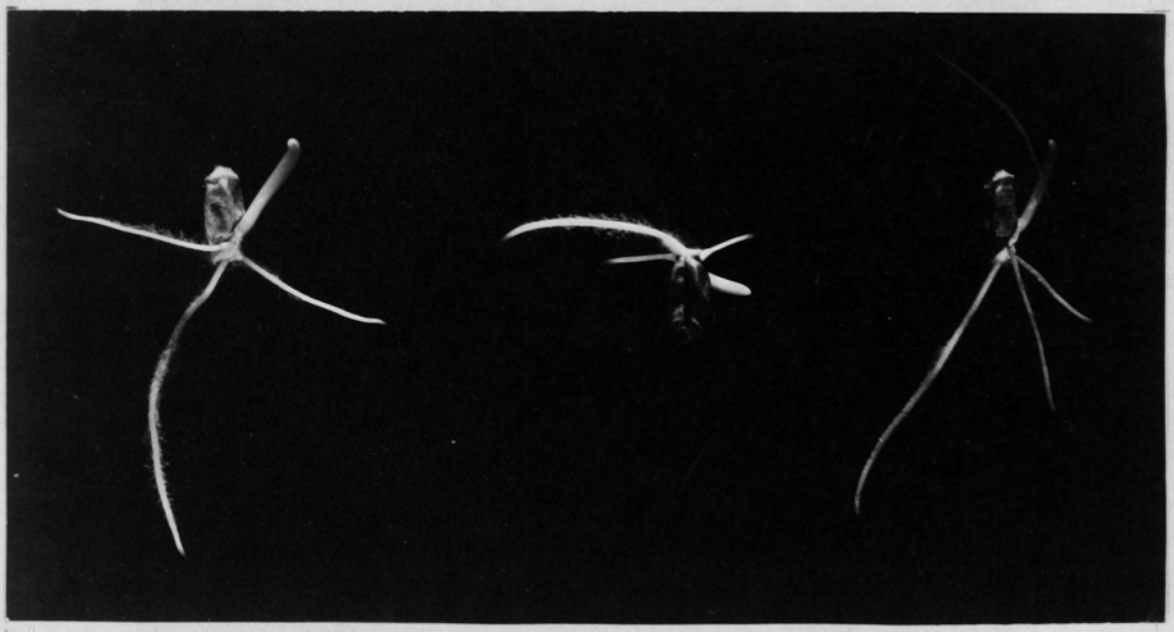
Total germination in 6 days	100

PLATE 5.

PLANTED APRIL 9. HARVESTED JULY 14.
GERMINATED OCTOBER 14.

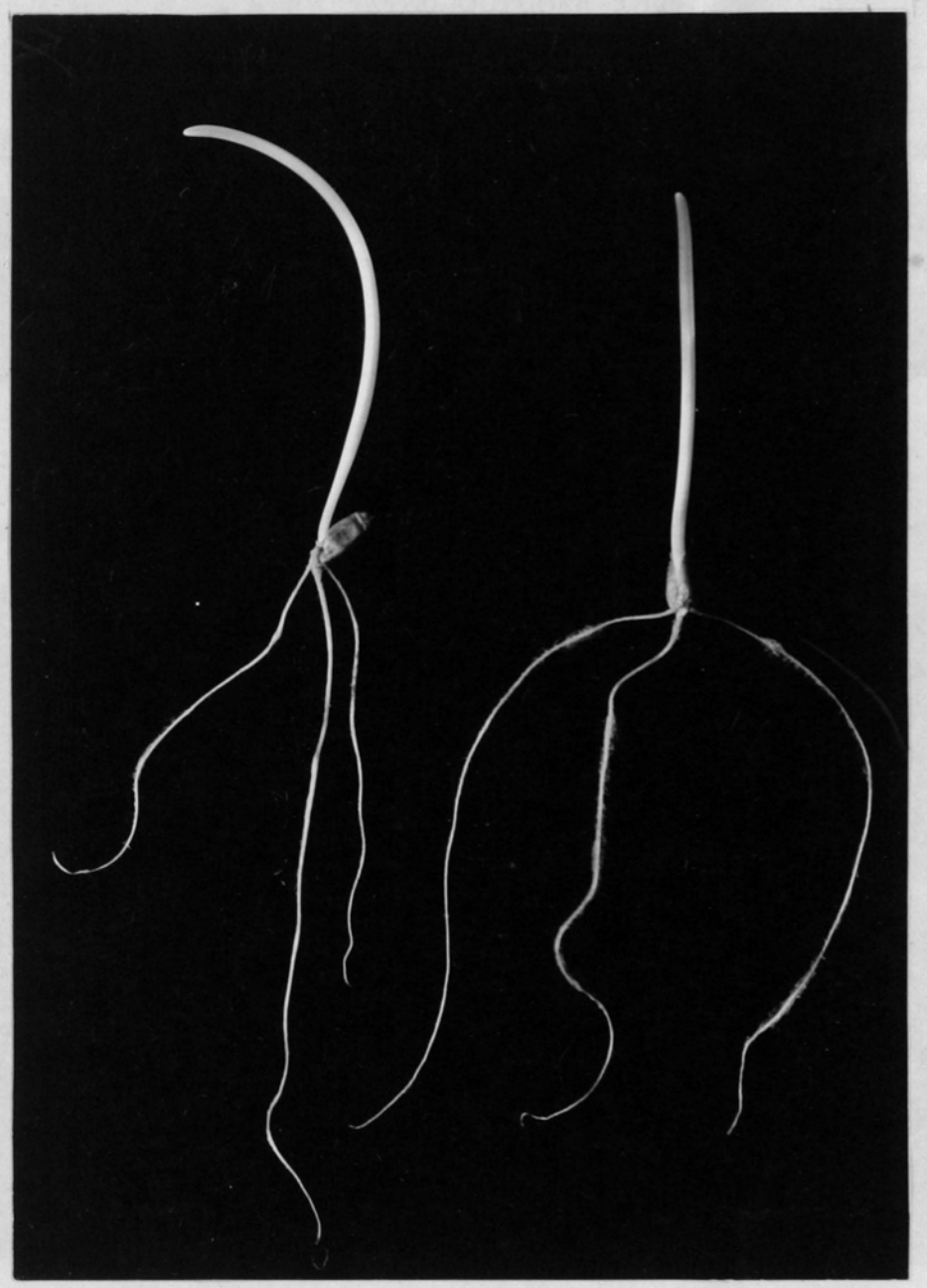
Defiance wheat before being placed in the germinator.

Defiance wheat after three days in the germinator.



Total germination in 3 days 83.7

Defiance wheat after six days in the germinator.



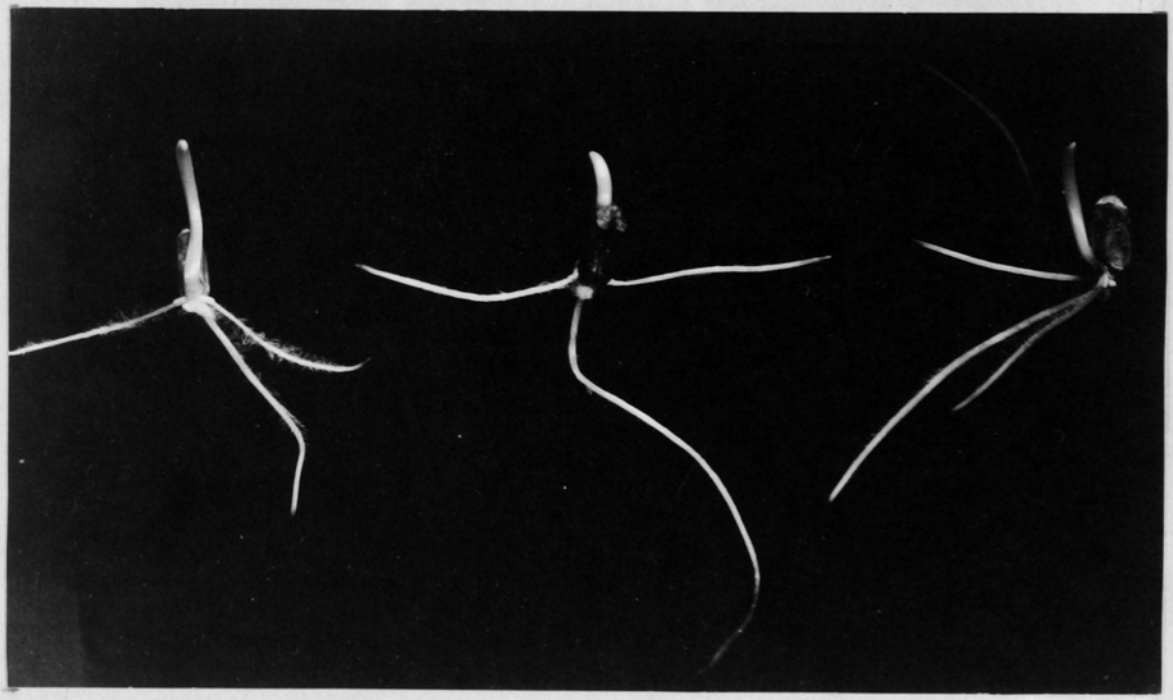
Total germination in 6 days	100

PLATE 6.

PLANTED APRIL 9. HARVESTED JULY 16.
GERMINATED OCTOBER 16.

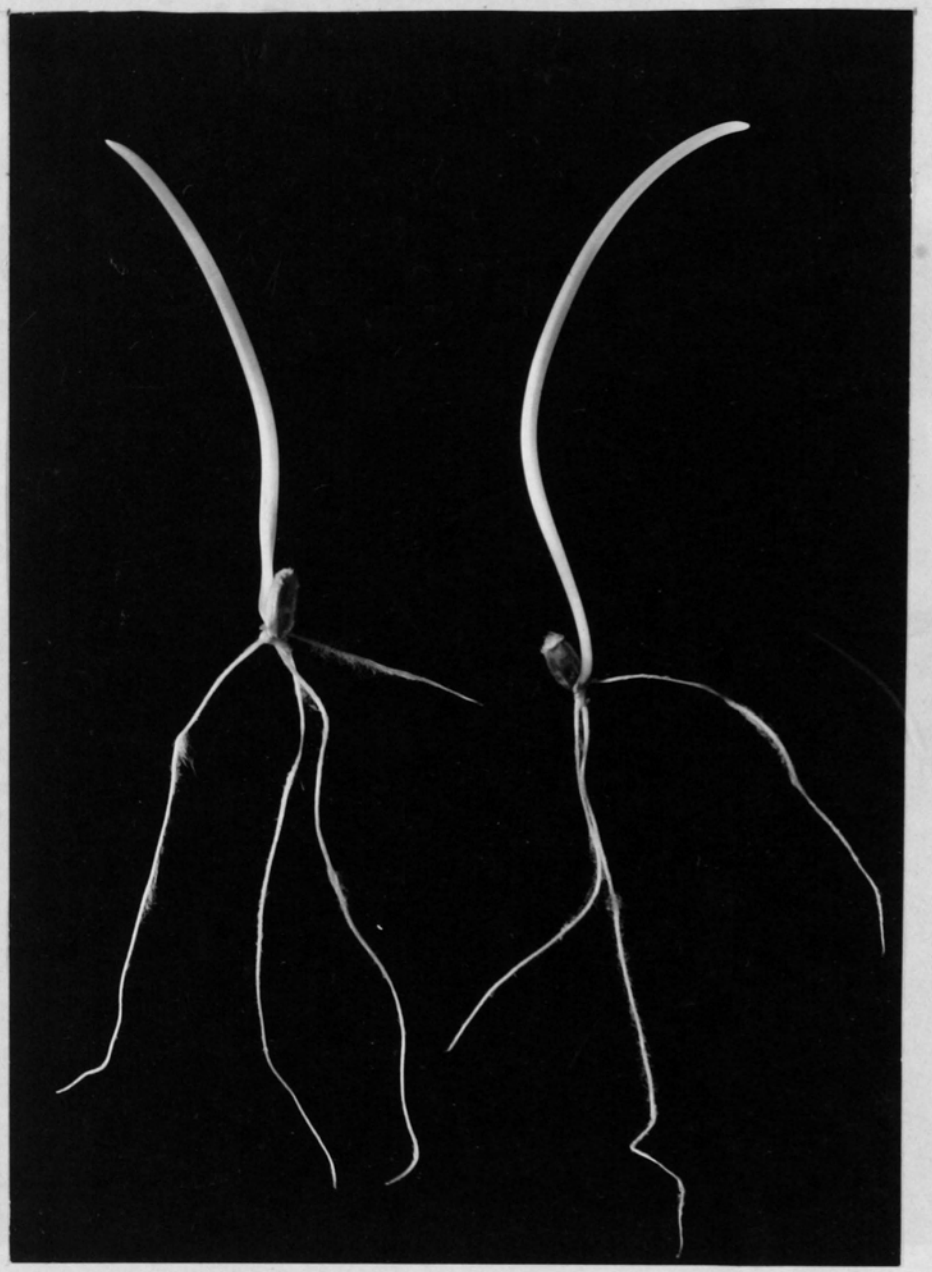
Defiance wheat before being placed in the germinator.

Defiance wheat after three days in the germinator.



Total germination in 3 days 95.8

Defiance wheat after six days in the germinator.



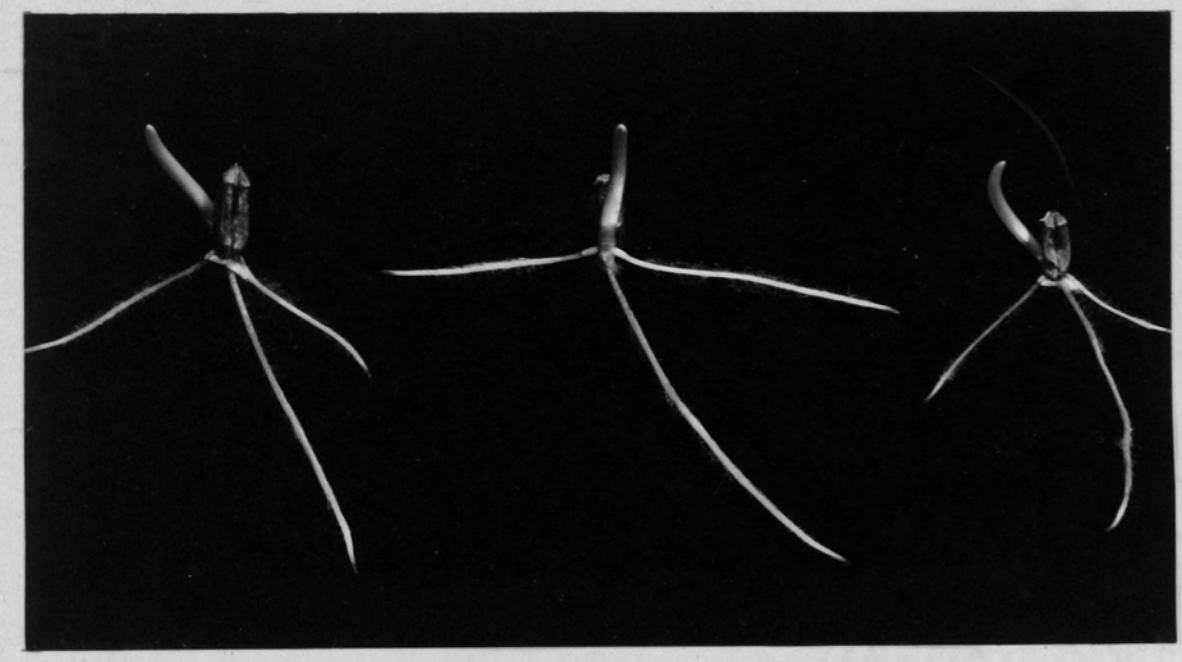
Total germination in 6 days	100

PLATE 7.

PLANTED APRIL 9. HARVESTED JULY 18.
GERMINATED OCTOBER 18.

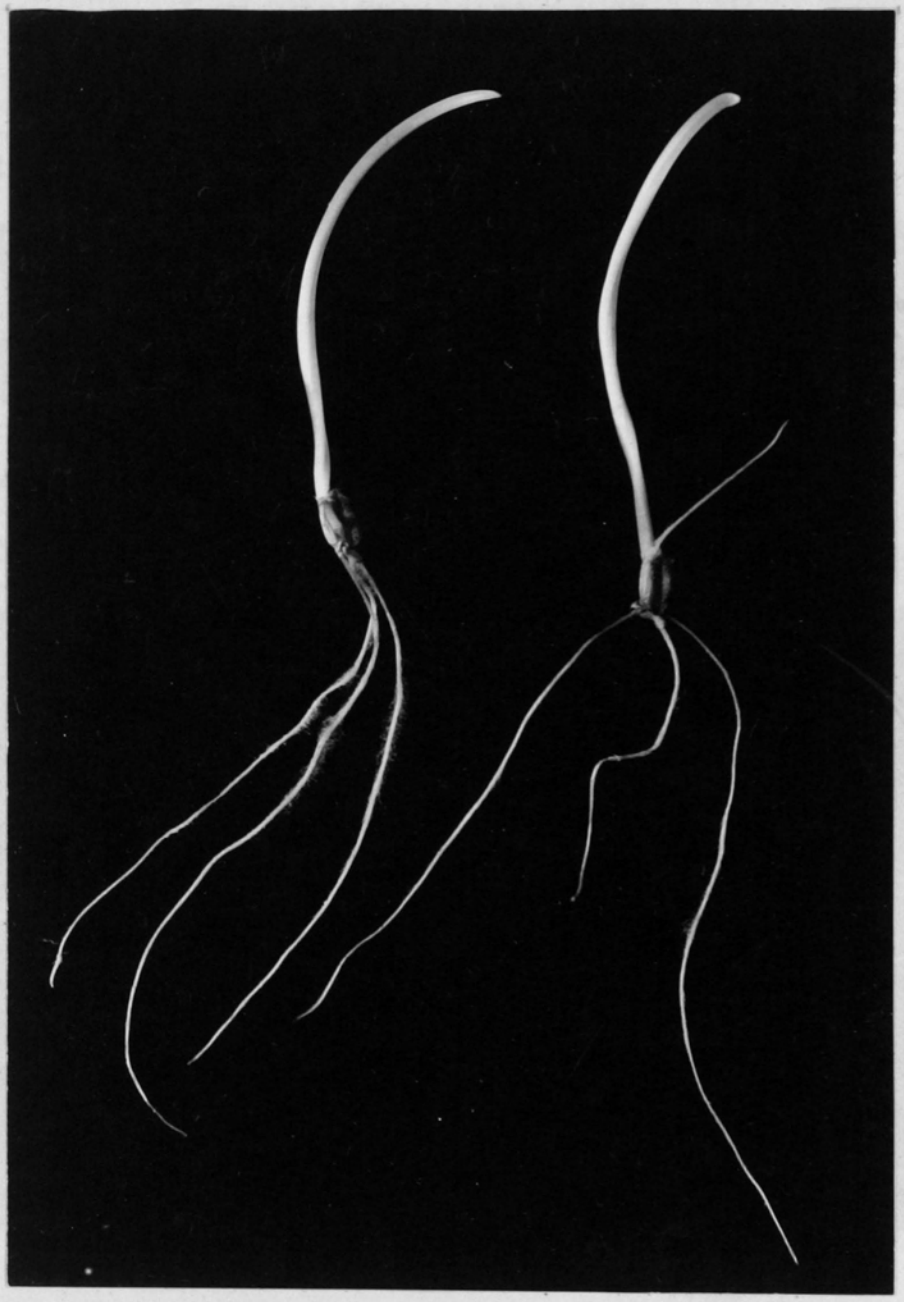
Defiance wheat before being placed in the germinator.

Defiance wheat after three days in the germinator.



Total germination in 3 days 96.6

Defiance wheat after six days in the germinator.



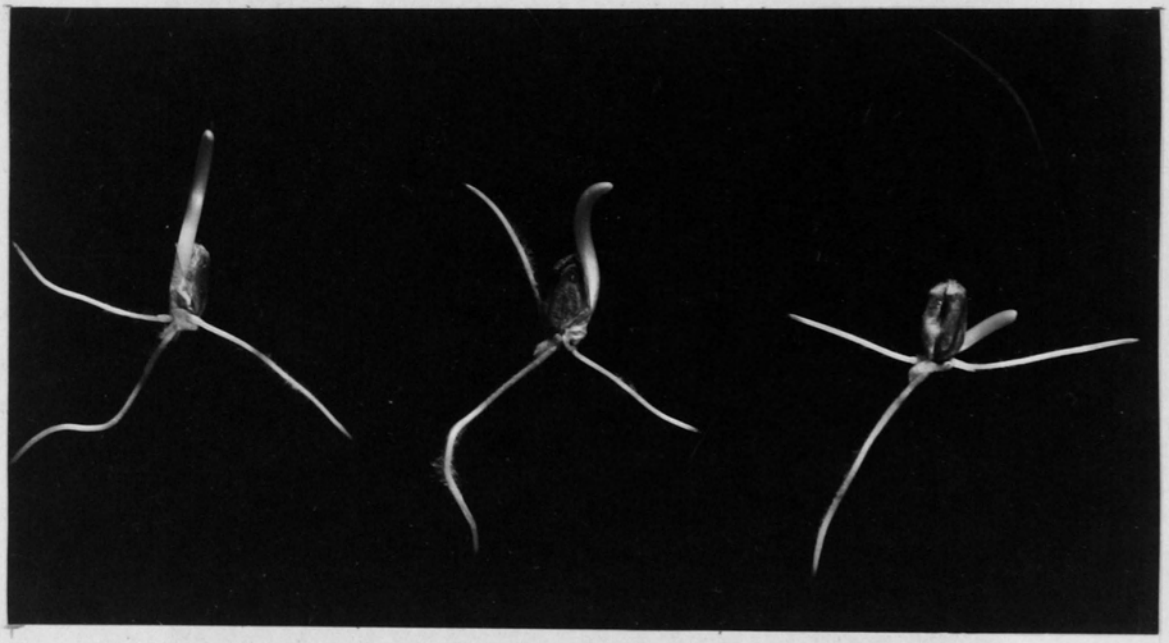
Total germination in 6 days 100

PLATE 8.

PLANTED APRIL 9. HARVESTED JULY 20.
GERMINATION OCTOBER 20.

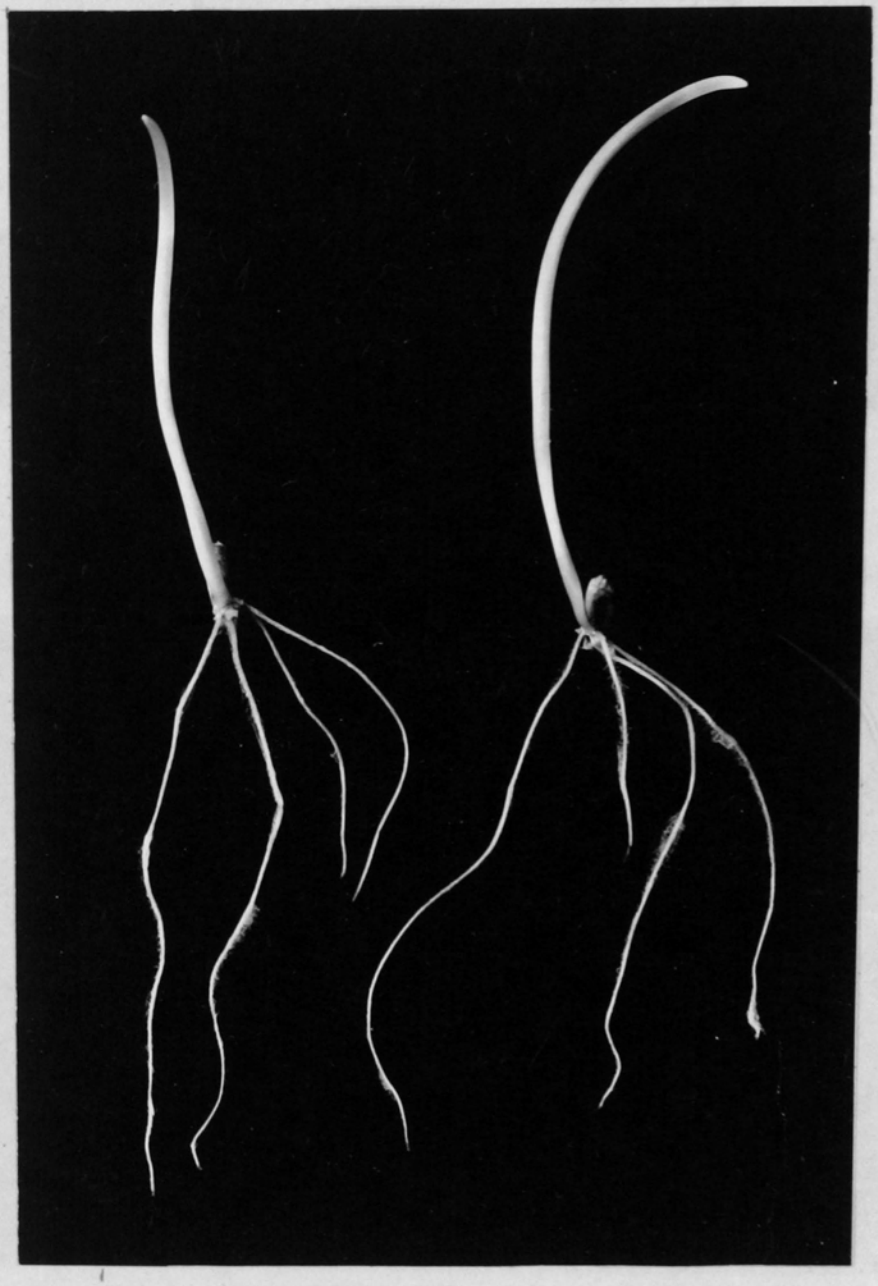
Defiance wheat before being placed in the germinator.

Defiance wheat after three days in the germinator.



Total germination in 3 days	100

Defiance wheat after six days in the germinator.



Total germination in 6 days	100

PLATE 9.

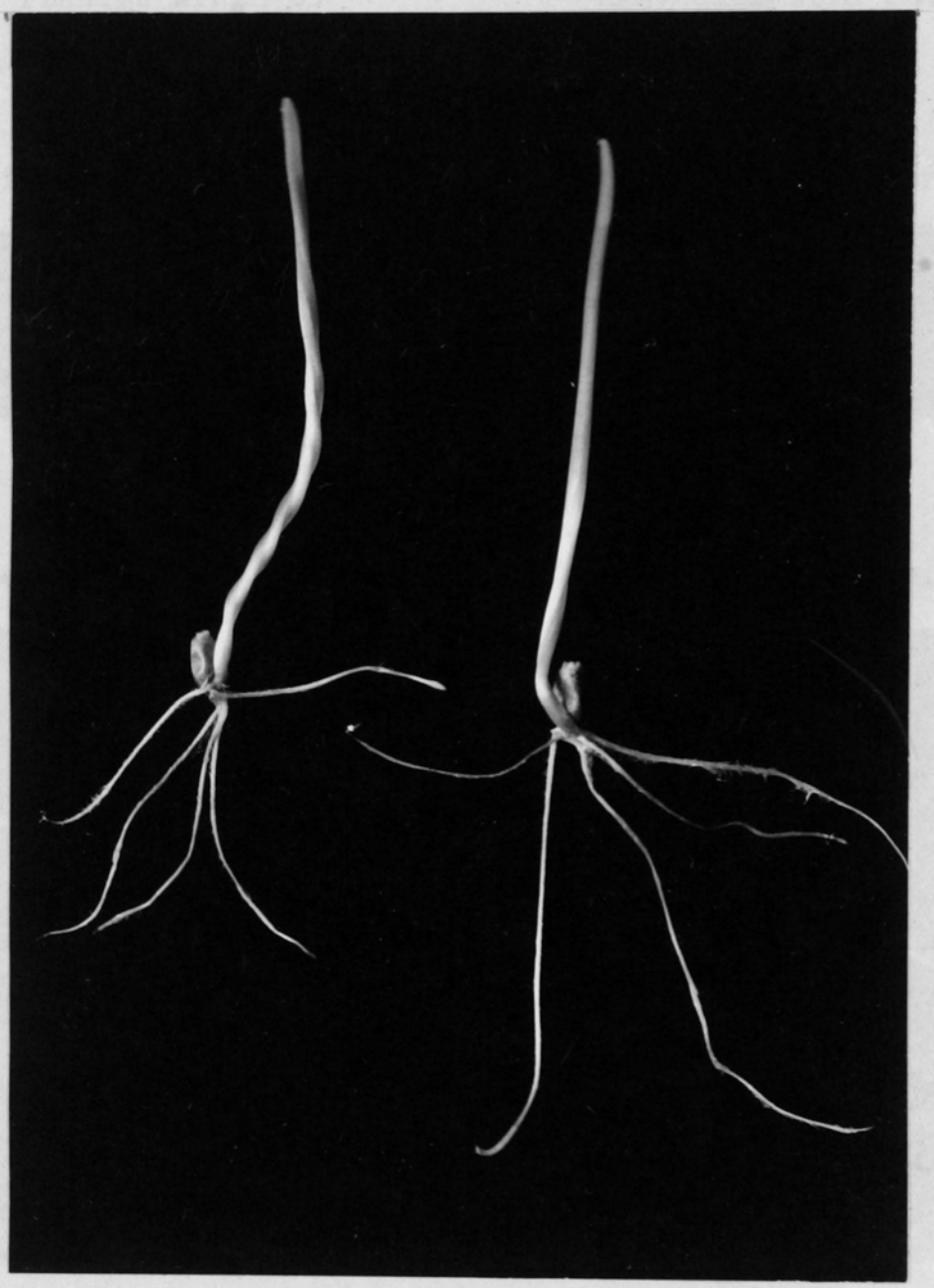
PLANTED APRIL 9. HARVESTED JULY 22.
GERMINATED OCTOBER 22.

Defiance wheat before being placed in the germinator.

Defiance wheat after three days in the germinator.

Total germination in 3 days	100

Defiance wheat after six days in the germinator.



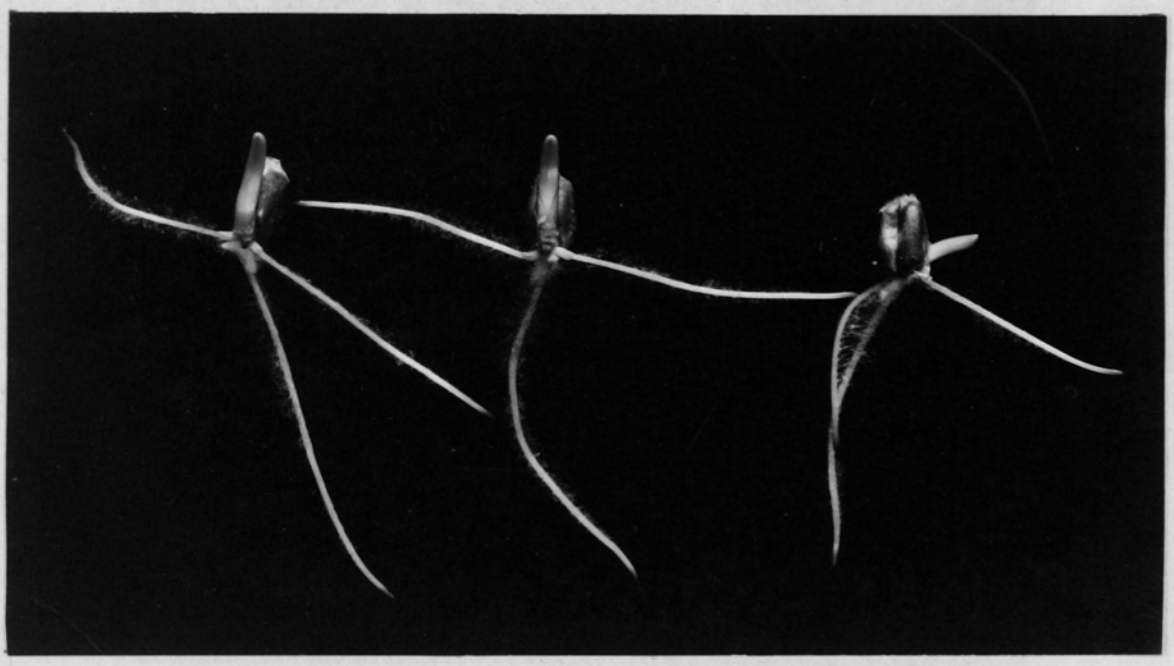
Total germination in 6 days	100

PLATE 10.

PLANTED APRIL 9. HARVESTED JULY 24.
GERMINATED OCTOBER 24.

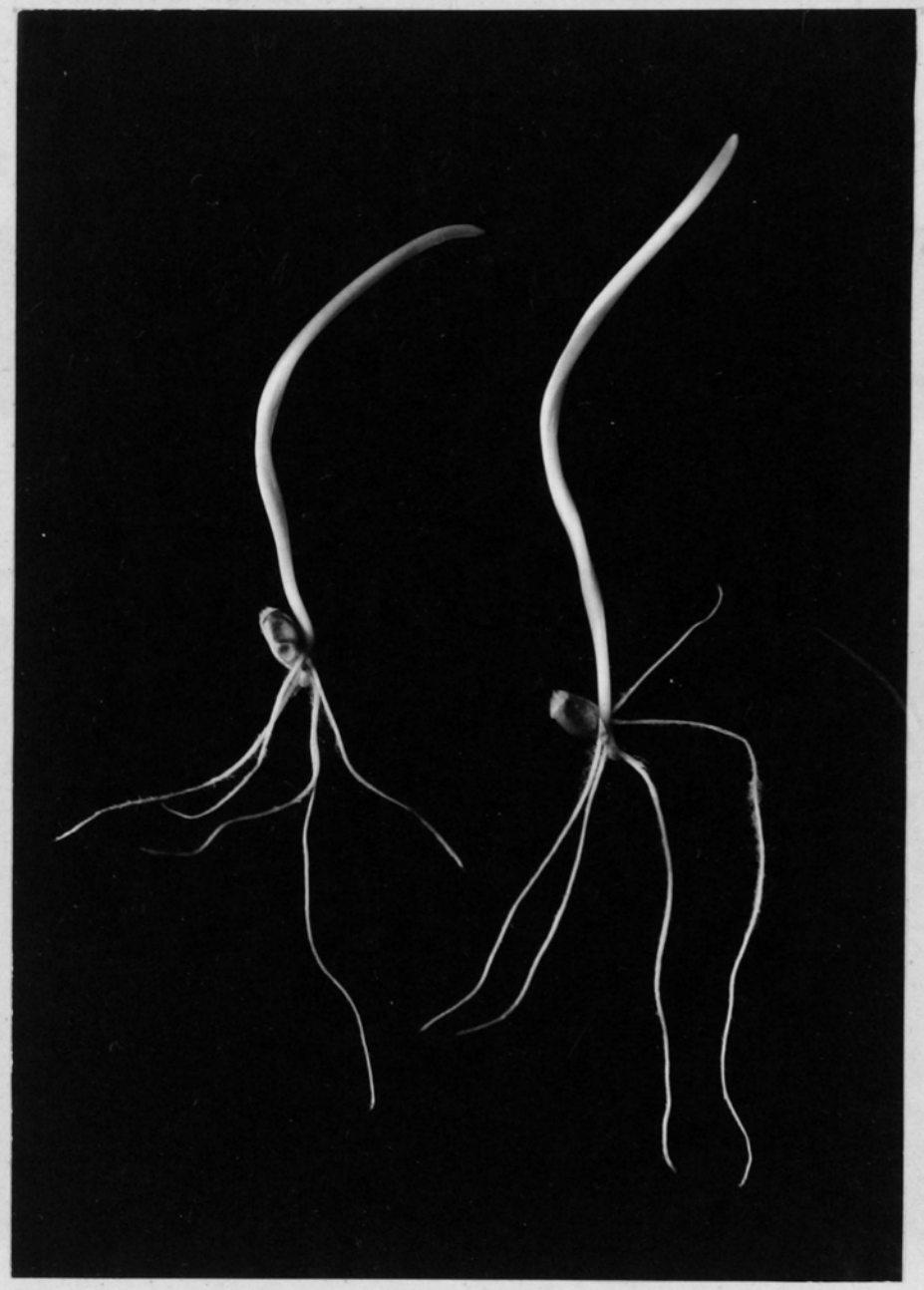
Defiance wheat before being placed in the germinator.

Defiance wheat after three days in the germinator.



Total germination in 3 days	100

Defiance wheat after six days in the germinator.



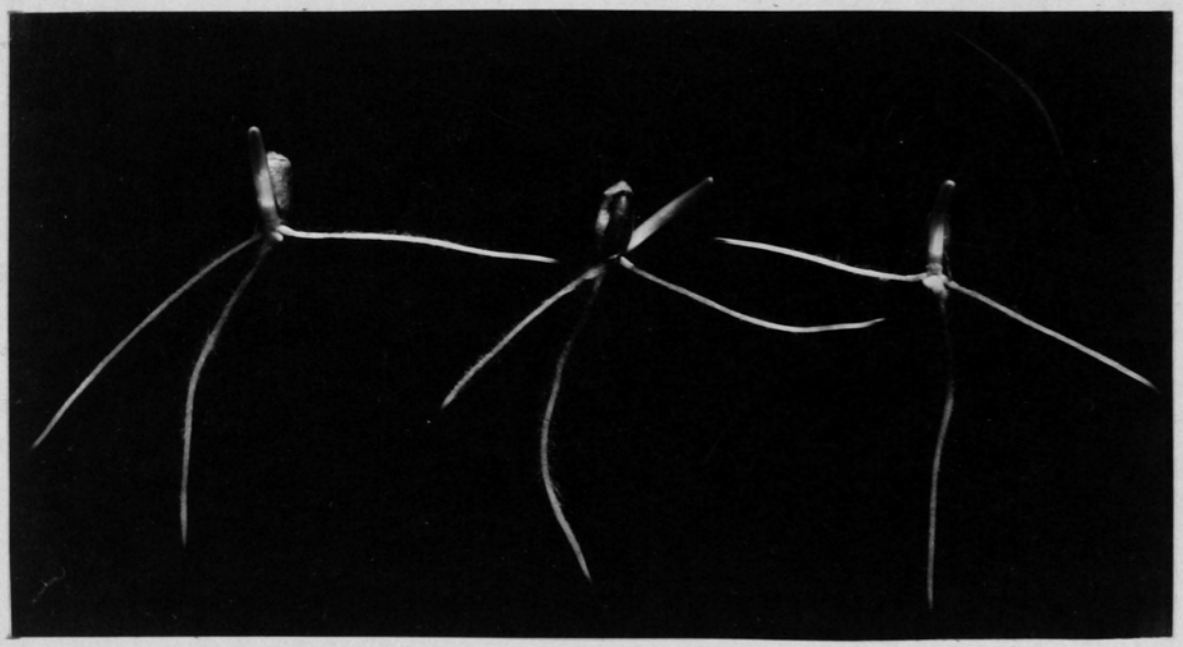
Total germination in 6 days	100

PLATE 11.

PLANTED APRIL 9. HARVESTED JULY 26.
GERMINATED OCTOBER 26.

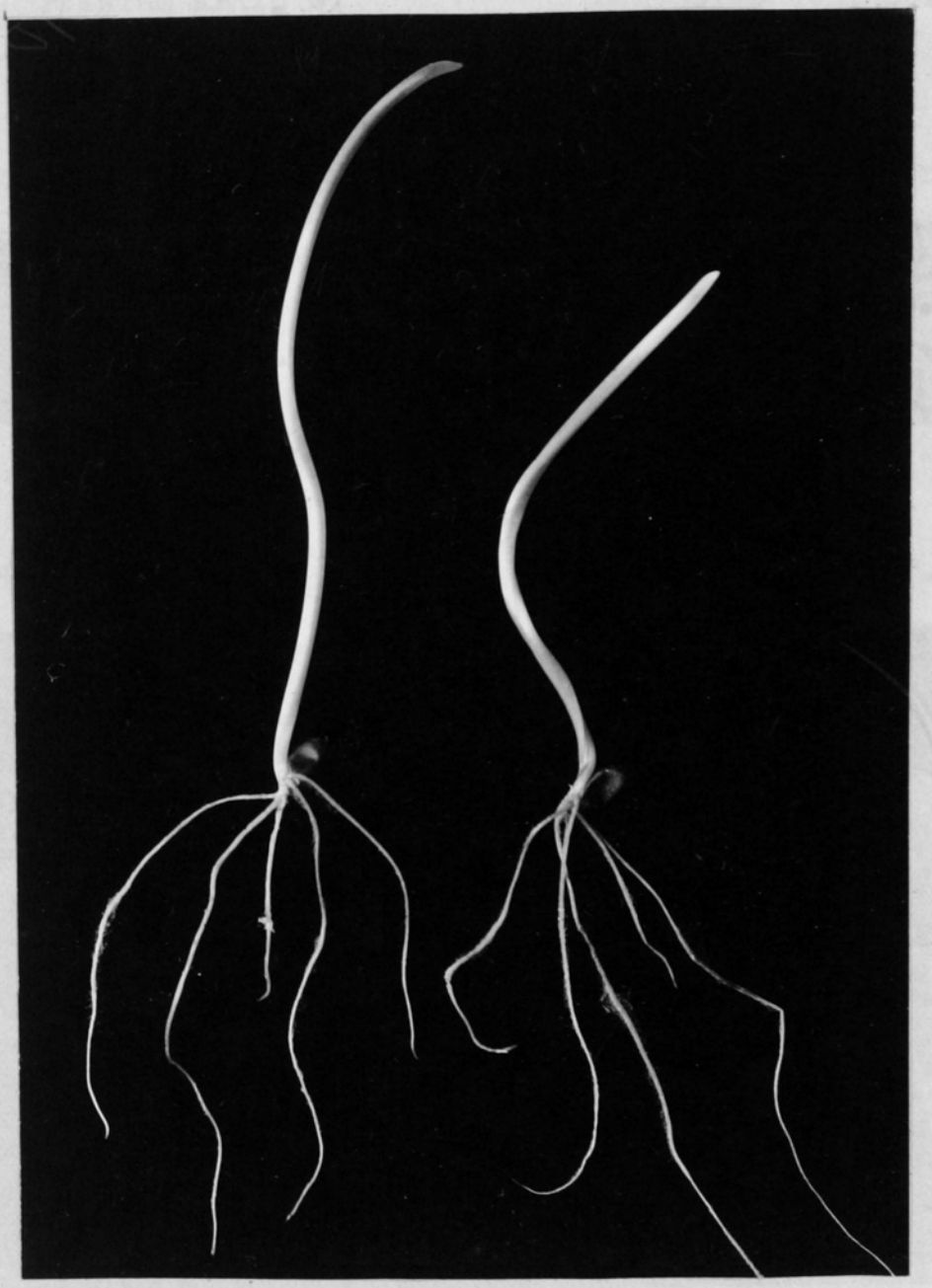
Defiance wheat before being placed in the germinator.

Defiance wheat after three days in the germinator.



Total germination in 3 days	95.1

Defiance wheat after six days in the germinator.



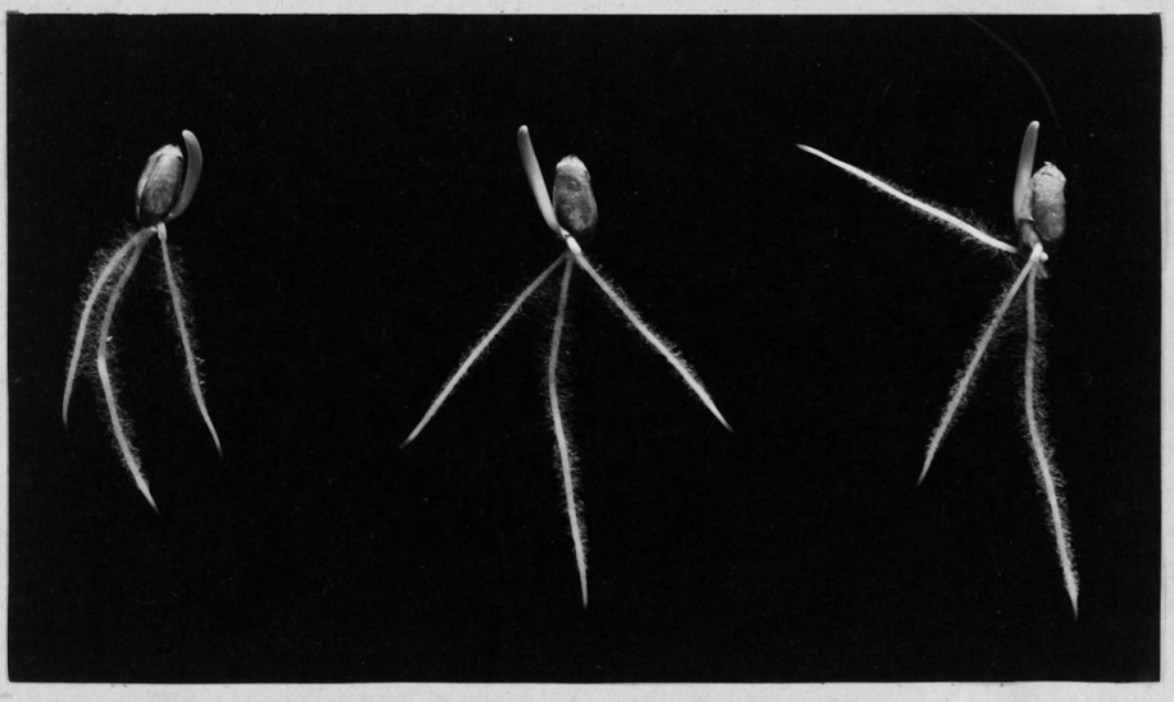
Total germination in 6 days	100

PLATE 12.

PLANTED APRIL 9. HARVESTED JULY 28.
GERMINATED OCTOBER 28.

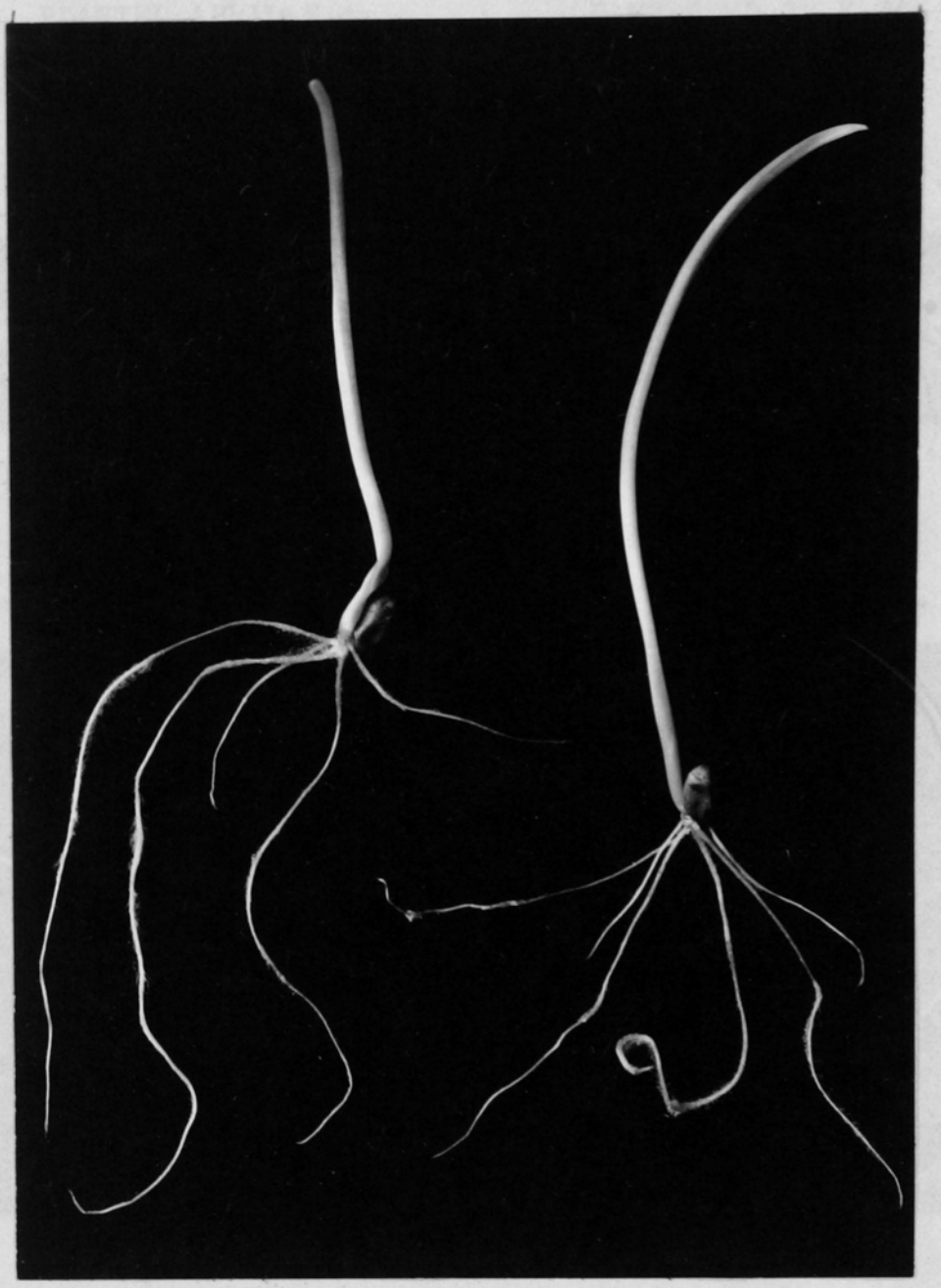
Defiance wheat before being placed in the germinator.

Defiance wheat after three days in the germinator.



Total germination in 3 days 88.2

Defiance wheat after six days in the germinator.



Total germination in 6 days	100

PLATE 13.

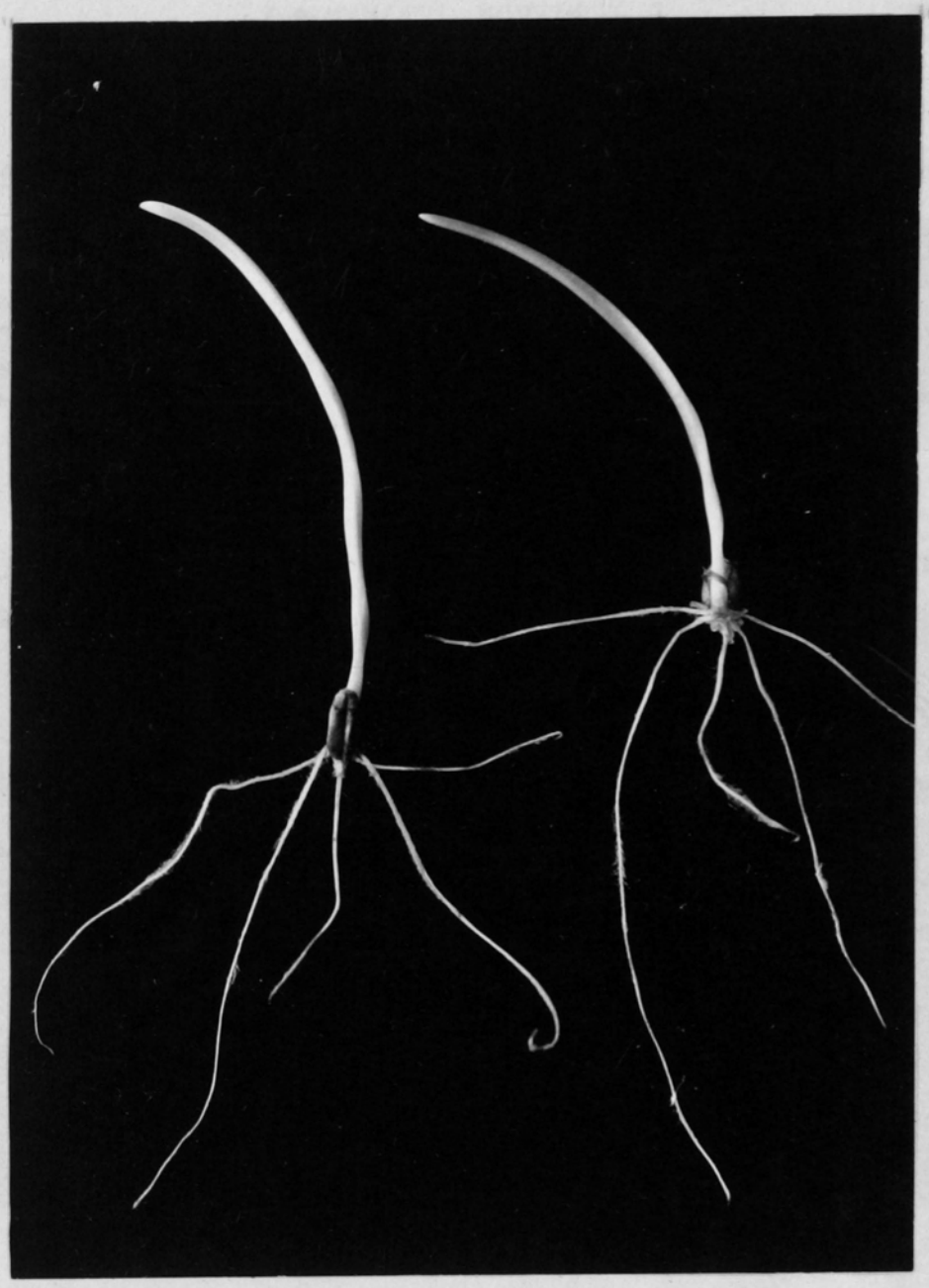
PLANTED APRIL 9. HARVESTED JULY 30.
GERMINATED OCTOBER 30.

Defiance wheat before being placed in the germinator.

Defiance wheat after three days in the germinator.

Total germination in 3 days	96

Defiance wheat after six days in the germinator.



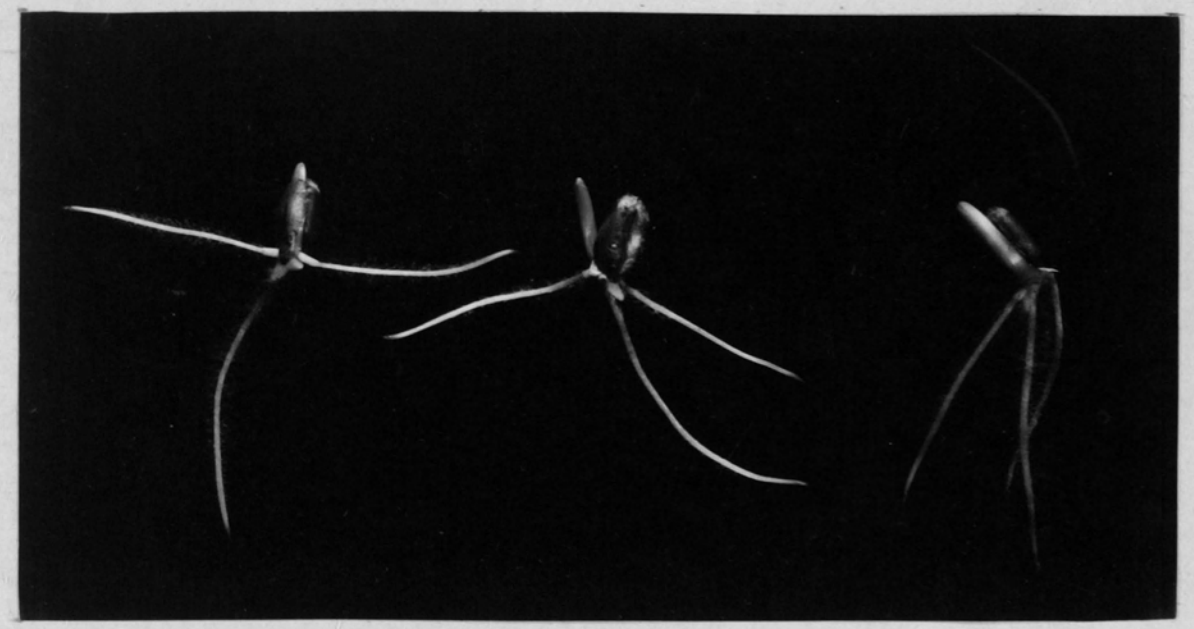
Total germination in 6 days	100

PLATE 14.

PLANTED APRIL 9. HARVESTED AUGUST 1.
GERMINATED NOVEMBER 1.

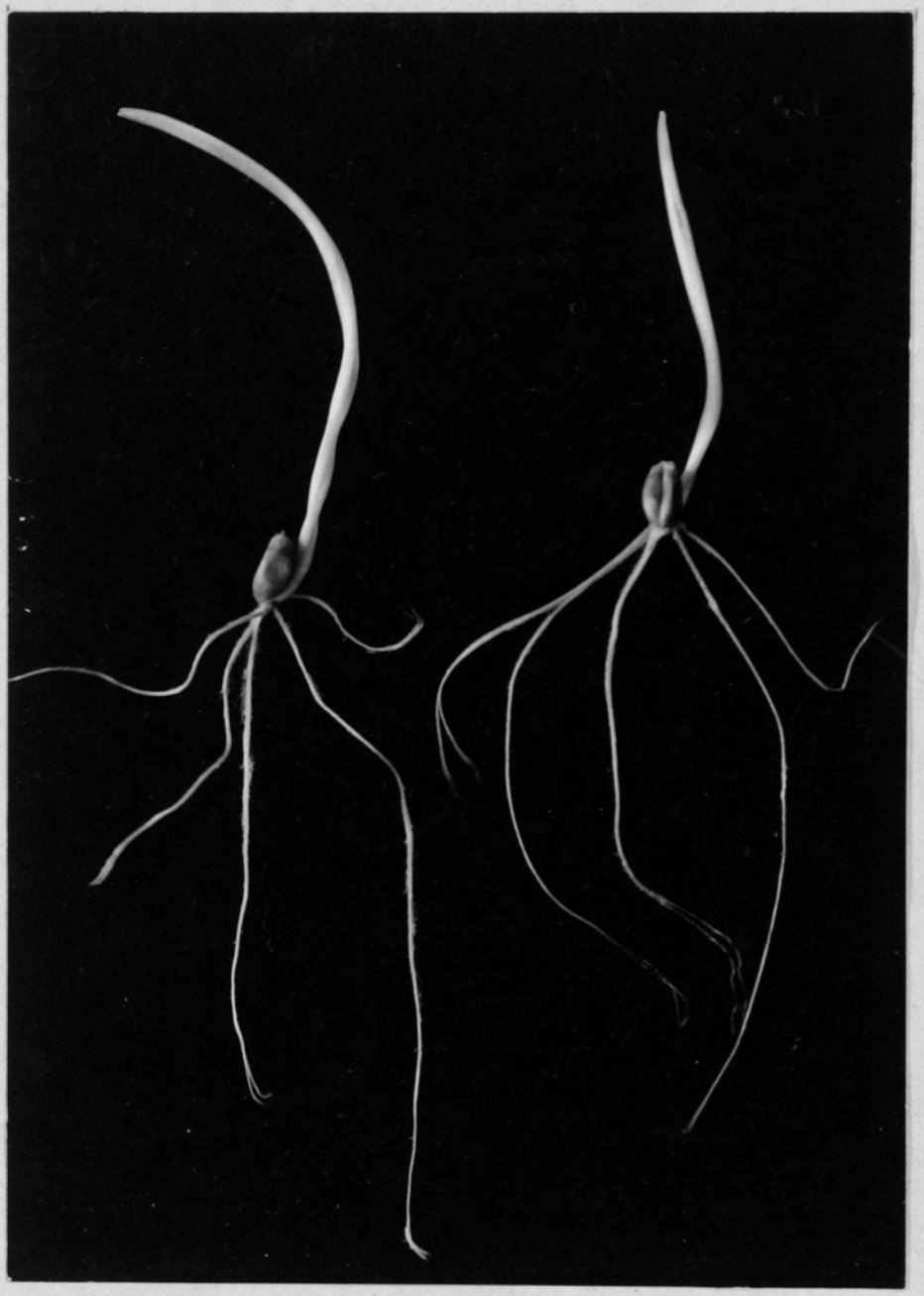
Defiance wheat before being placed in the germinator.

Defiance wheat after three days in the germinator.



Total germination in 3 days	84.2

Defiance wheat after six days in the germinator.

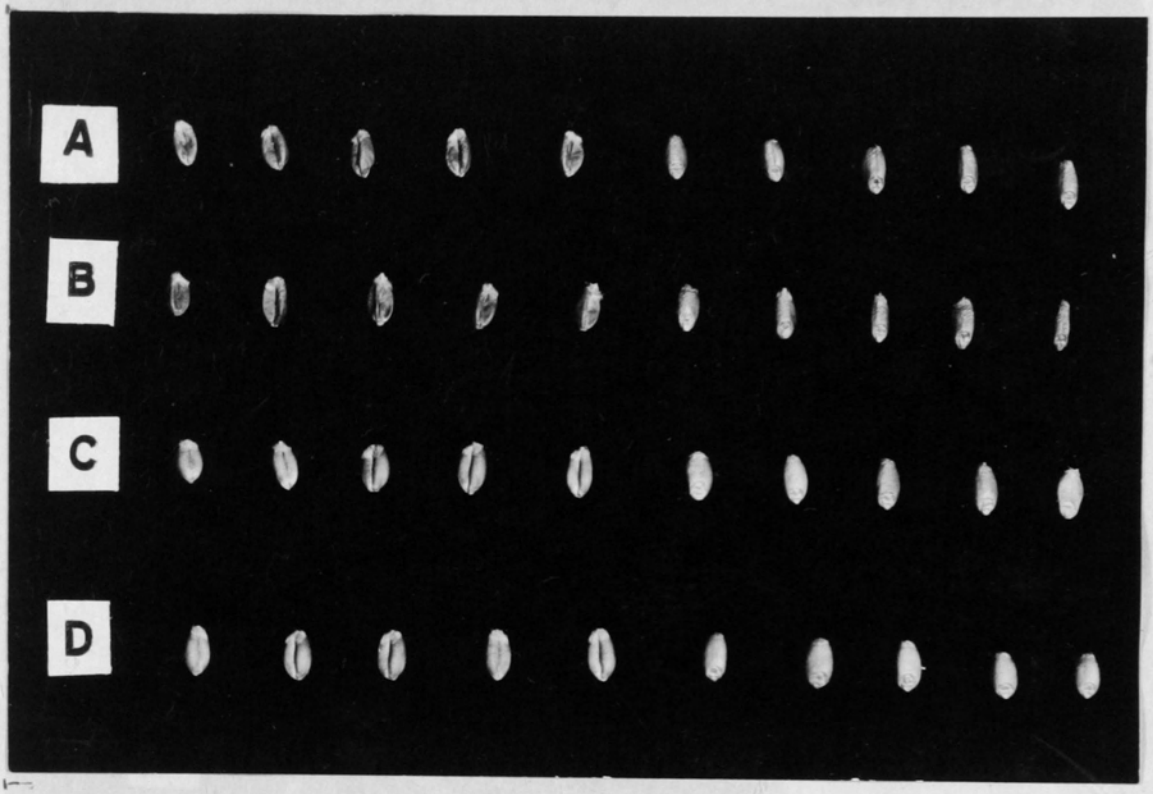


Total germination in 6 days	100

PLATE 15.

DEFIANCE.

A--Grown at Ft.Collins, Colo.in 1920.
B--Grown at Ft.Collins, Colo.in 1921.
C--Grown at Del Norte, Colo.in 1921.
D--Grown at Saguache, Colo.in 1921.



BAART.

A--Grown at Davis, Calif.in 1920.
B--Grown at Davis, Calif.in 1921.
C--Grown at Del Norte, Colo. in 1921.
D--Grown at Hooper, Colo.in 1921.

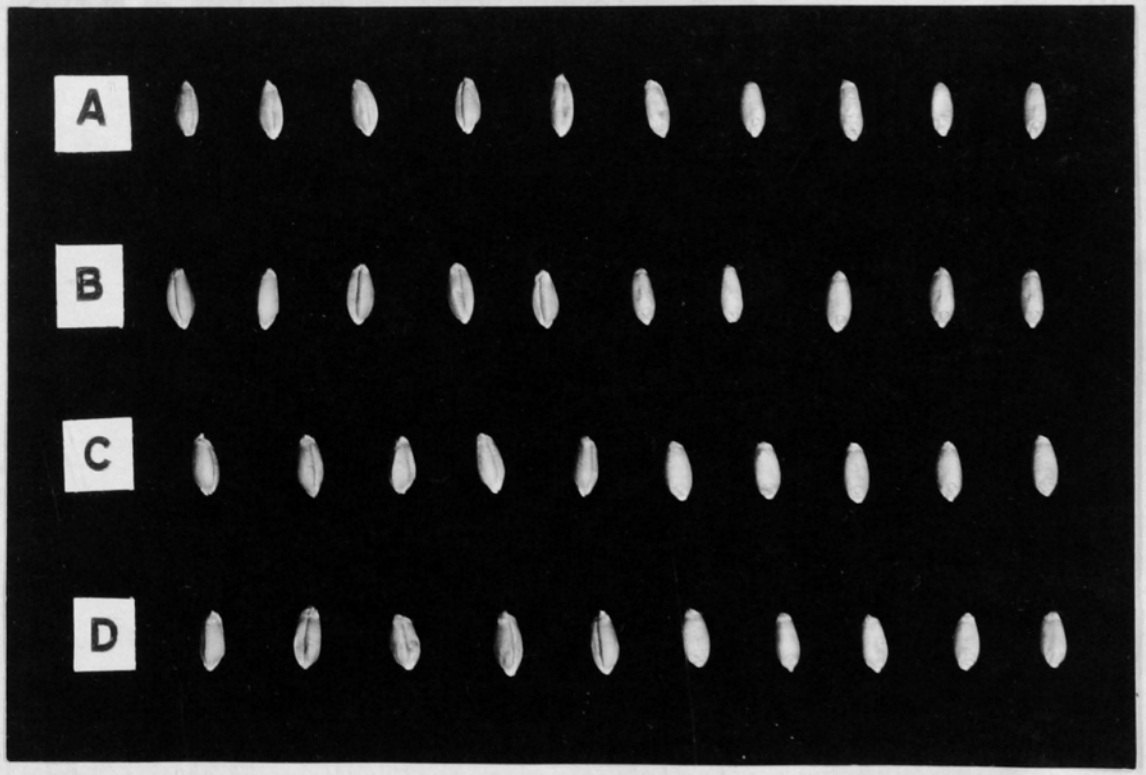
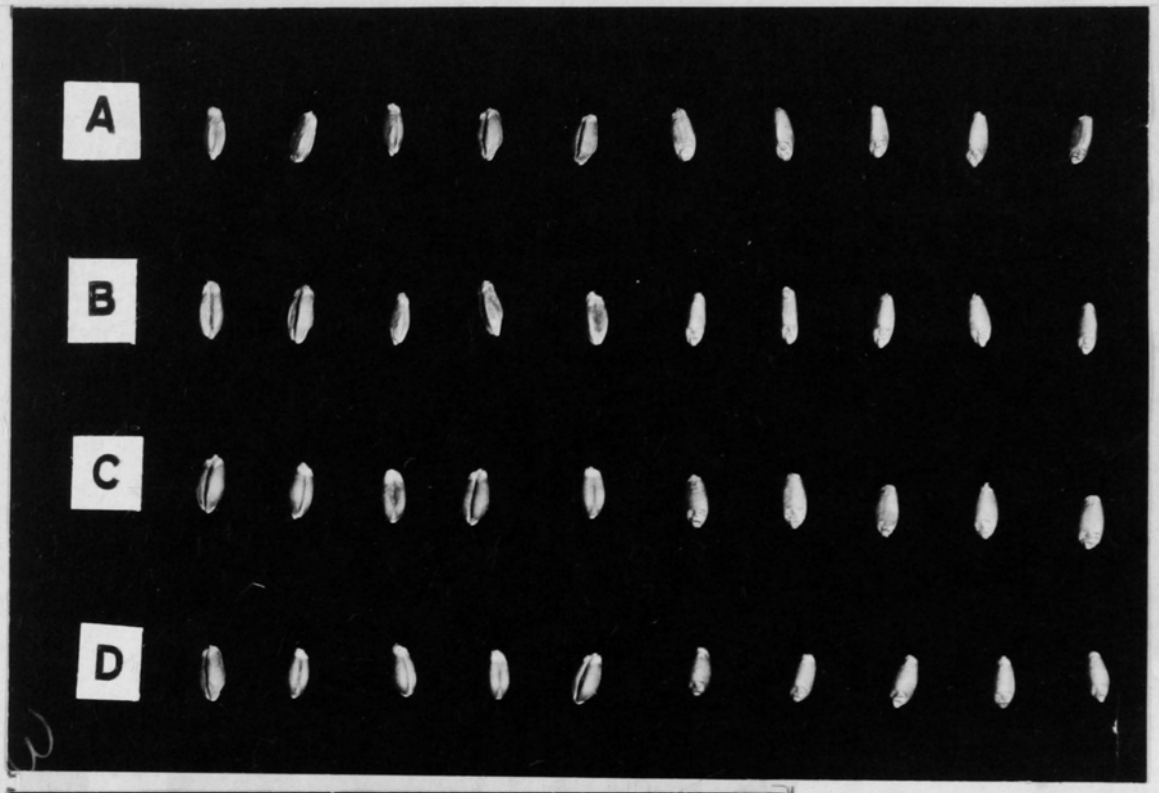
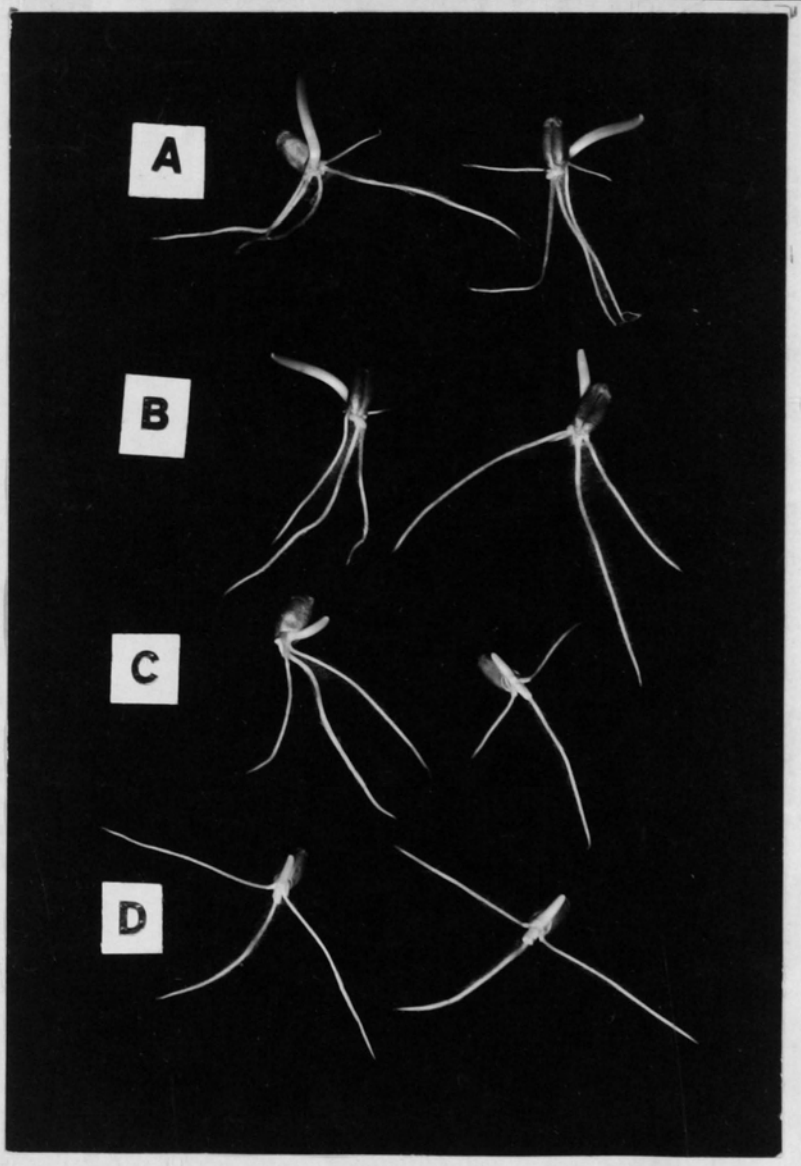


PLATE 16.





PRESTON.

A--Grown at Ft.Collins, Colo.in 1920.

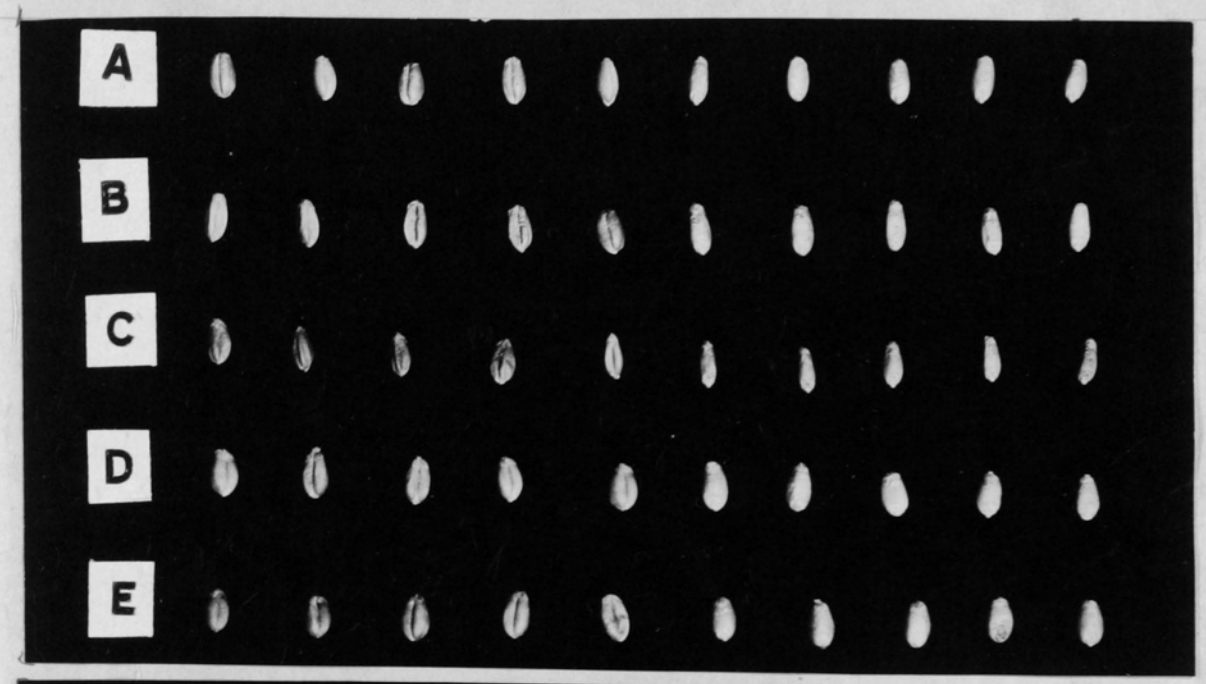
B--Grown at Ft.Collins, Colo.in 1921.

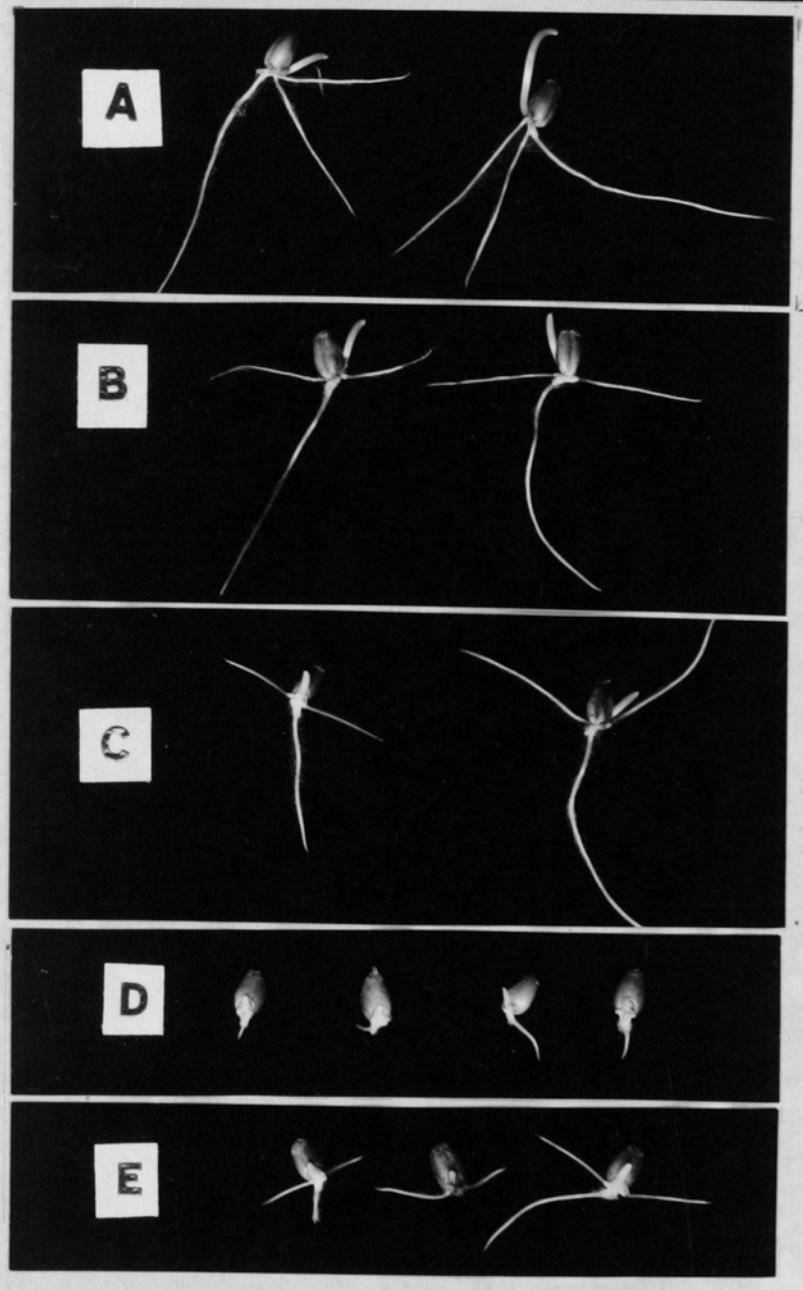
C--Grown at Del Norte, Colo.in 1921.

D--Grown at Saguache, Colo.in 1921.

The germinating grains were photographed after being in the germinator for three days.

PLATE 17.





SONORA.

A--Grown at Davis, Calif.in 1920.

B--Grown at Davis, Calif.in 1921.

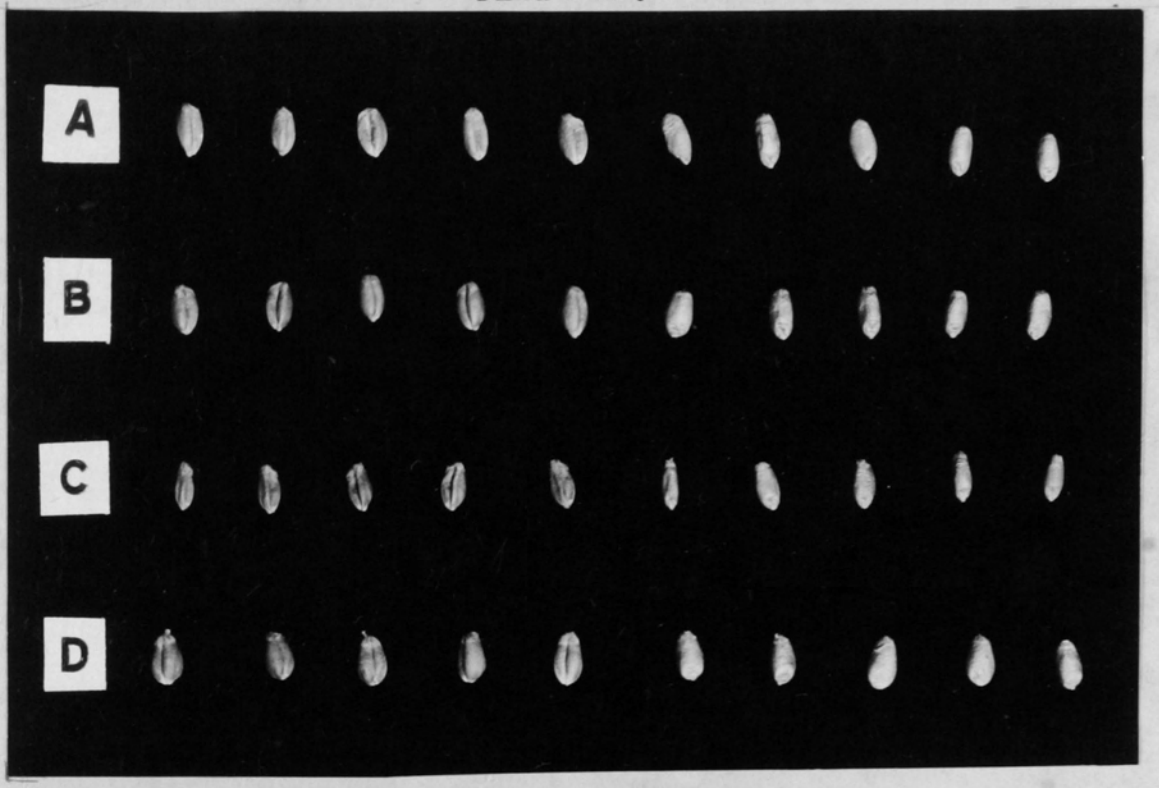
C--Grown at Ft.Collins, Colo.in 1921.

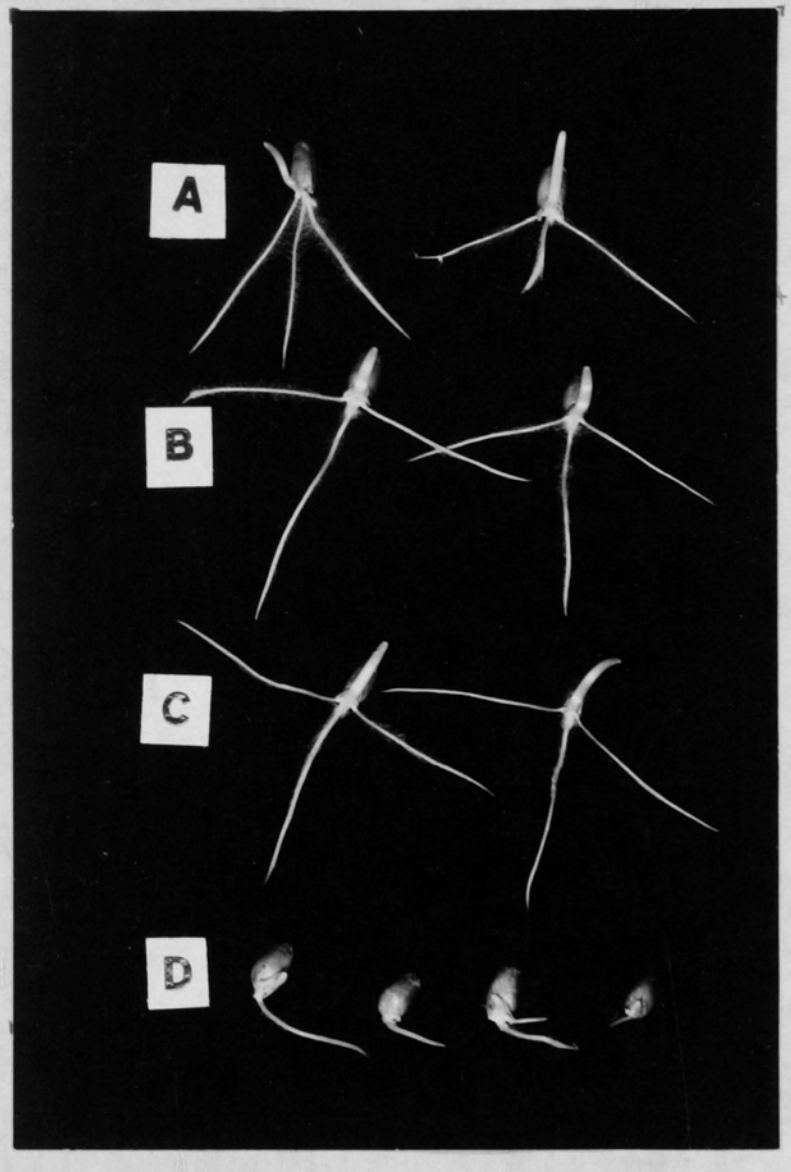
D--Grown at Del Norte, Colo.in 1921.

E--Grown at Hooper, Colo.in 1921.

The germinating grains were photographed after being in the germinator for three days.

PLATE 18.





BUNYIP.

A--Grown at Davis, Calif.in 1920.

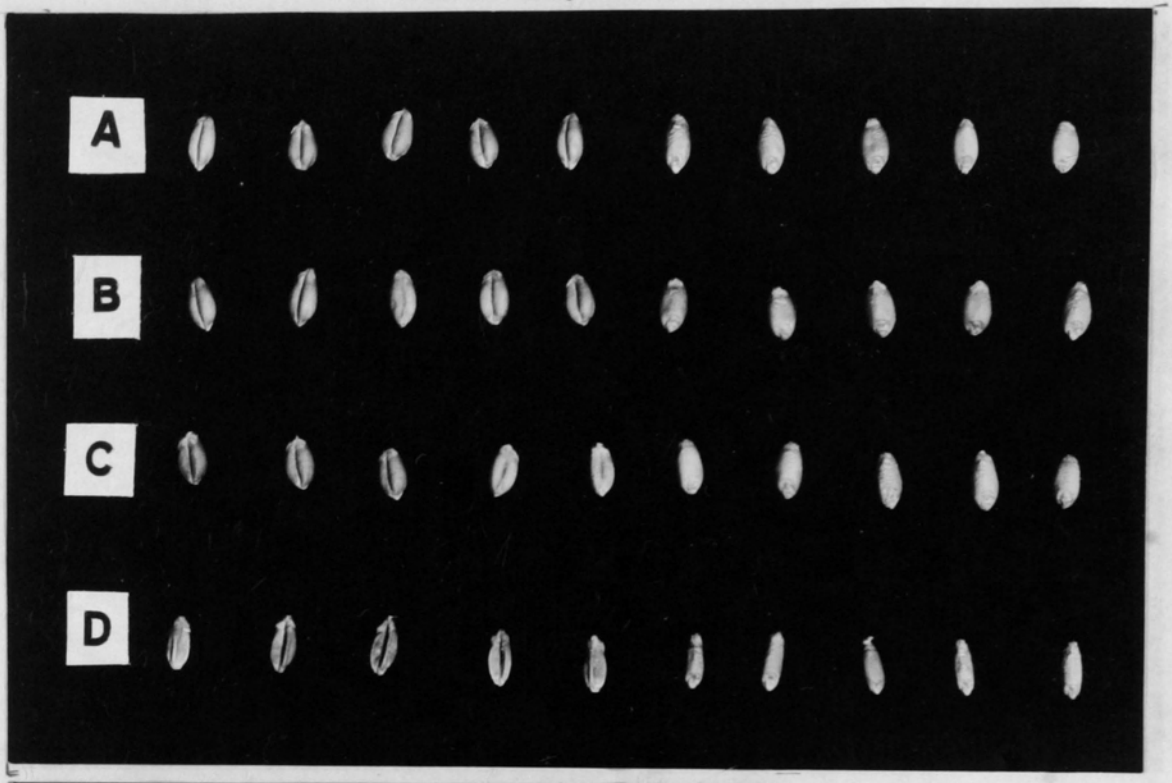
B--Grown at Davis, Calif.in 1921.

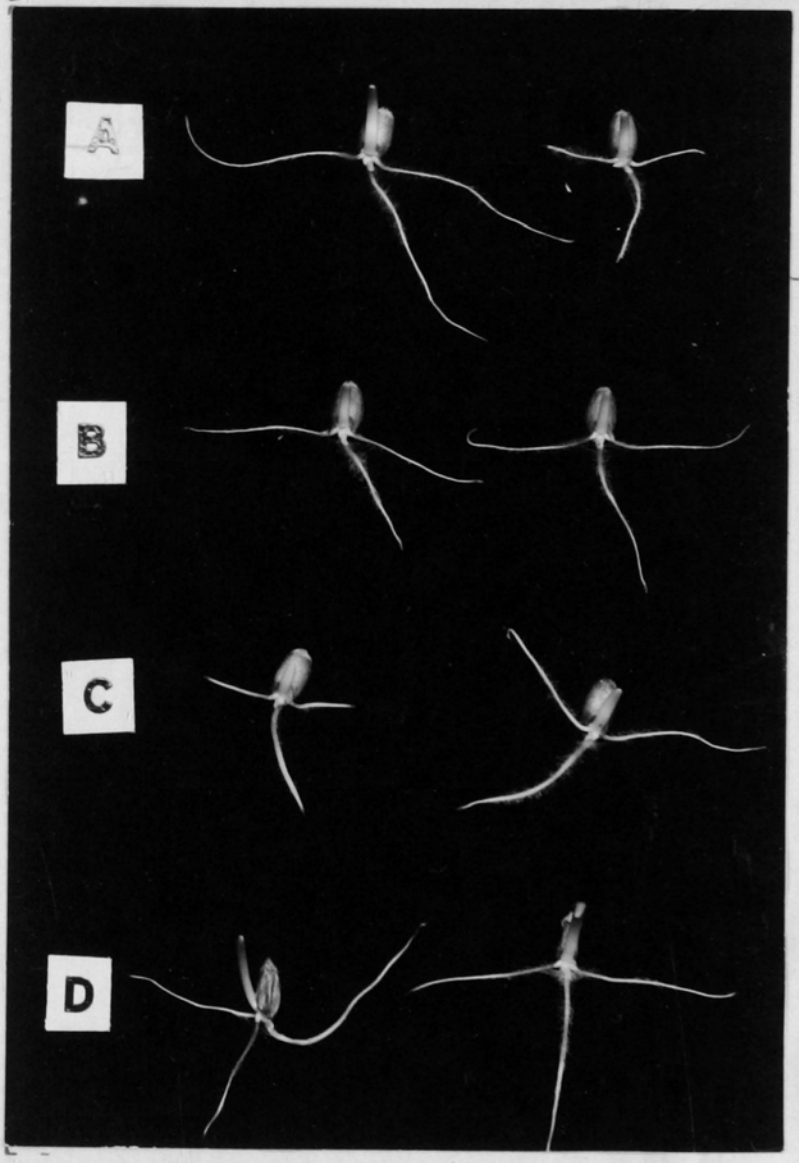
C--Grown at Ft.Collins, Colo.in 1921.

D--Grown at Del Norte, Colo,in 1921.

The germinating grains were photographed after being in the germinator for three days.

PLATE 19.





DELAYED DEFIANCE.

A--Grown at Saguache, Colo.in 1920.

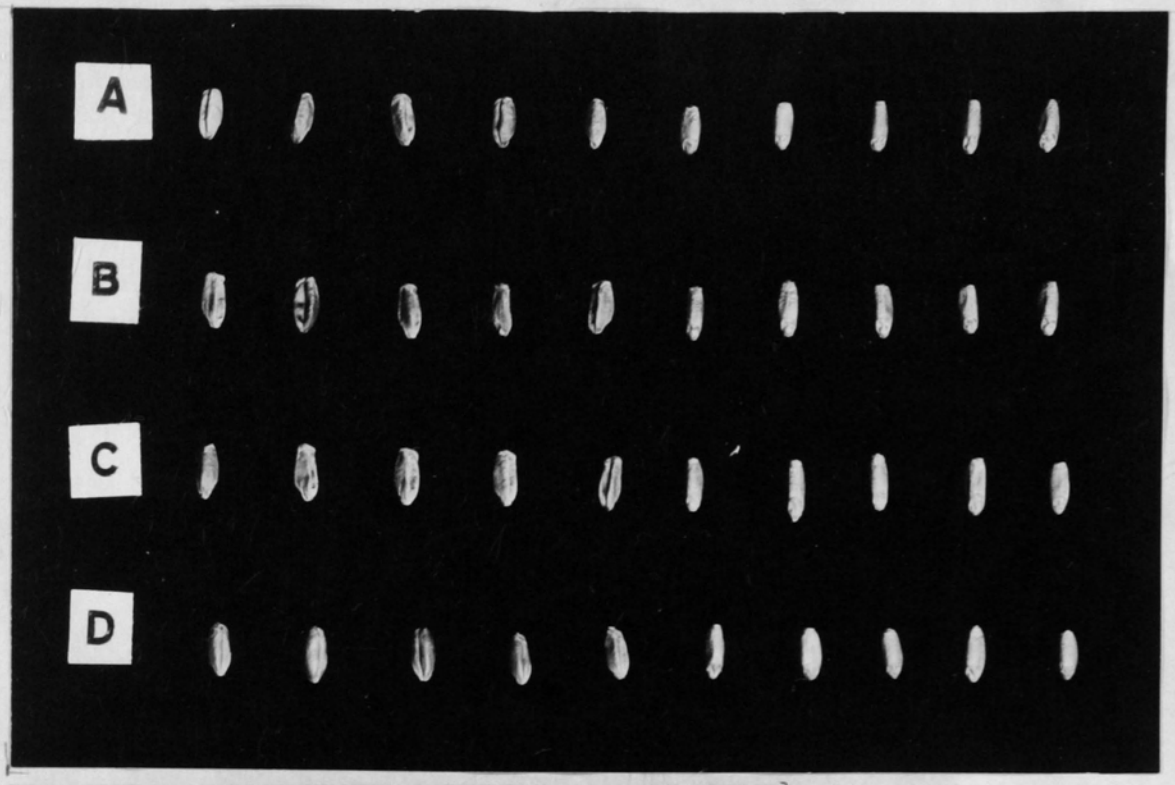
B--Grown at Saguache, Colo.in 1921.

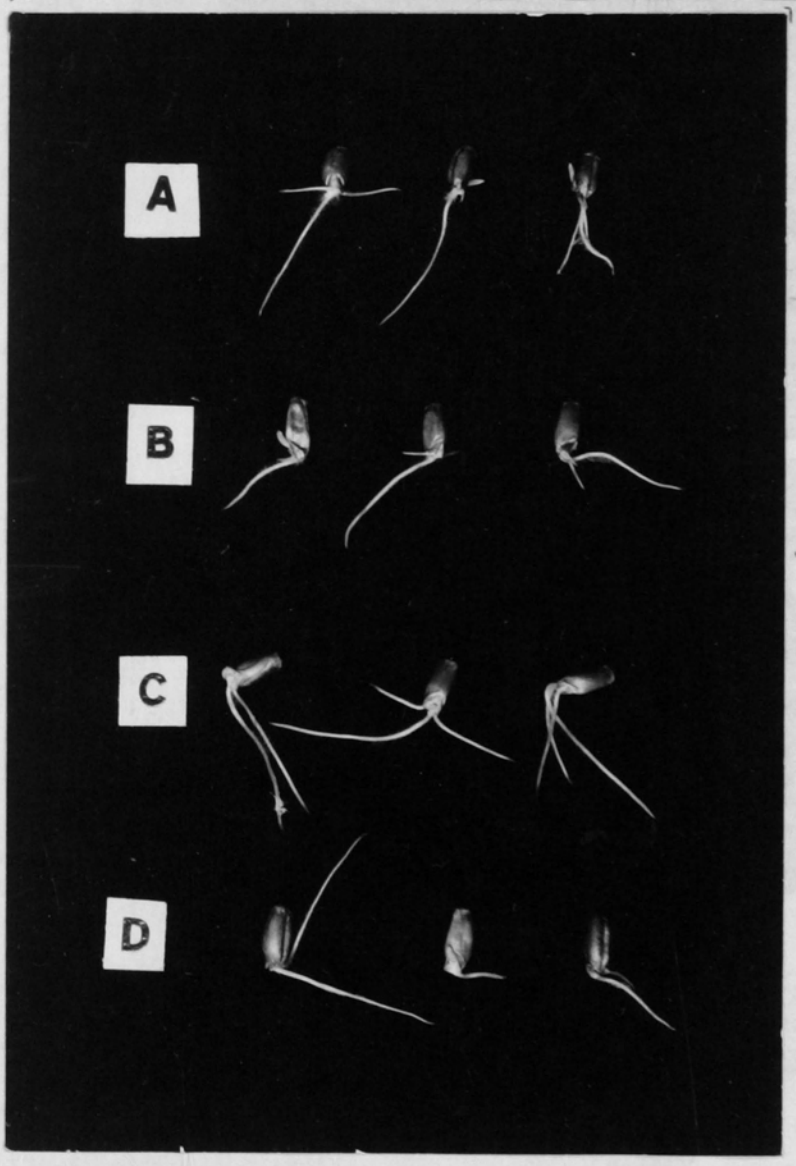
C--Grown at Del Norte, Colo.in 1921.

D--Grown at Ft.Collins, Colo.in 1921.

The germinating grains were photographed after being in the germinator for three days.

PLATE 20.





DURUM WHEATS.

A--Acme, S.D.#5284. Grown at Brooking, S.D. in 1921.

B--Black Don, Grown at Brooking, S.D. in 1921.

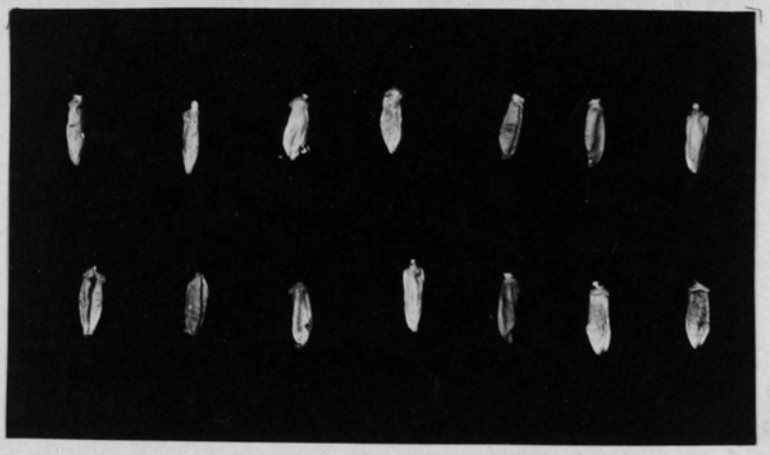
C--Arnautka, S.D.#1001. Grown at Brooking, S.D. in 1921.

D--Kubanka, S.D.#75. Grown at Brooking, S.D. in 1921.

The germinating grains were photographed after being in the germinator for three days.

PLATE 21.

KUBANKA WHEAT.
PLANTED JULY 23. HARVESTED NOVEMBER 21.
GERMINATED FEBRUARY 21.



Total germination in 3 days	5
Total germination in 6 days	20
Total germination in 10 days	20

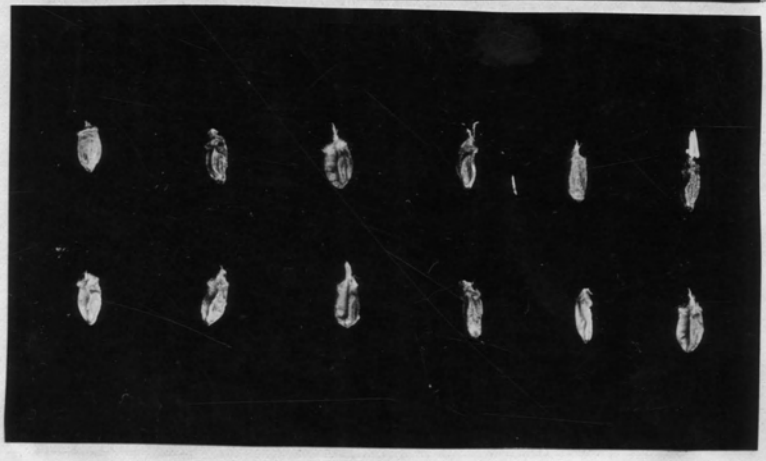
PLATE 22.

PRESTON WHEAT.
PLANTED JULY 23. HARVESTED NOVEMBER 21.
GERMINATED FEBRUARY 21.

Total germination in 3 days	0
Total germination in 6 days	0
Total germination in 10 days	0

PLATE 23.

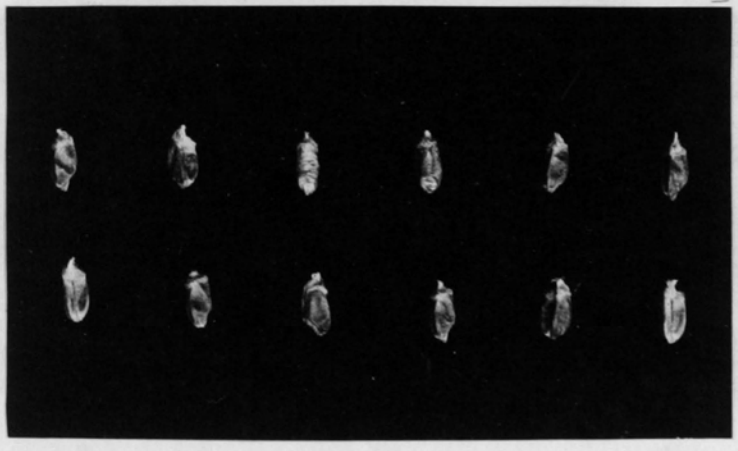
RED FIFE WHEAT.
PLANTED JULY 23. HARVESTED NOVEMBER 21.
GERMINATED FEBRUARY 21.



Total germination in 3 days	0
Total germination in 6 days	0
Total germination in 10 days	0

PLATE 24.

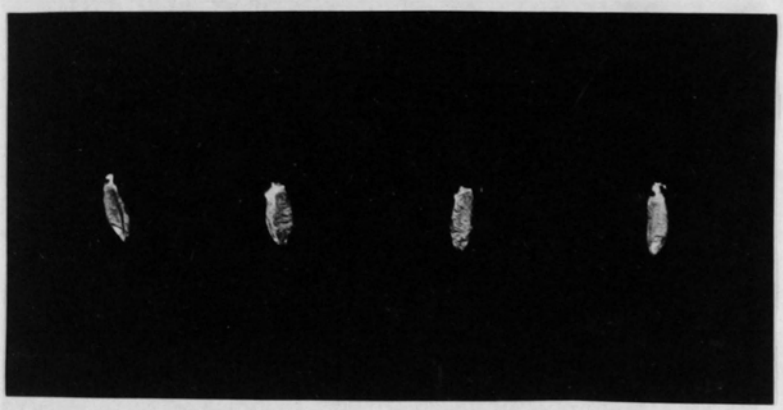
MARQUIS WHEAT.
PLANTED JULY 23. HARVESTED NOVEMBER 21.
GERMINATED FEBRUARY 21.



Total germination in 3 days	94
Total germination in 6 days	96
Total germination in 10 days	96

PLATE 25.

RED RUSSIAN WHEAT.
PLANTED JULY 23. HARVESTED NOVEMBER 21.
GERMINATED FEBRUARY 21.



Total germination in 3 days	0
Total germination in 6 days	0
Total germination in 10 days	0

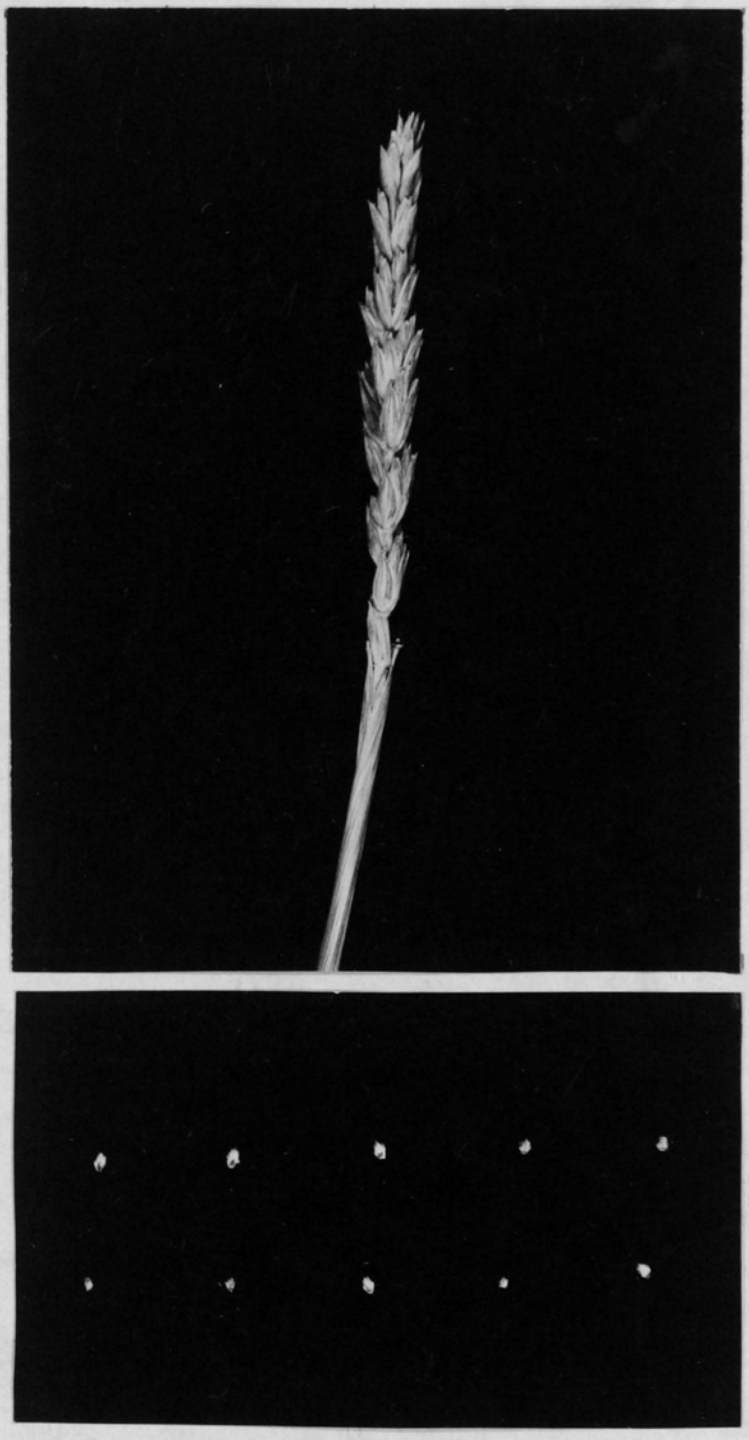
PLATE 26.

DEFIANCE WHEAT.
PLANTED JULY 23. HARVESTED NOVEMBER 21.
GERMINATED FEBRUARY 21.

Total germination in 3 days	0
Total germination in 6 days	0
Total germination in 10 days	0

PLATE 27.

DELAYED DEFIANCE WHEAT.
PLANTED JULY 23. HARVESTED NOVEMBER 21.
GERMINATED FEBRUARY 21.

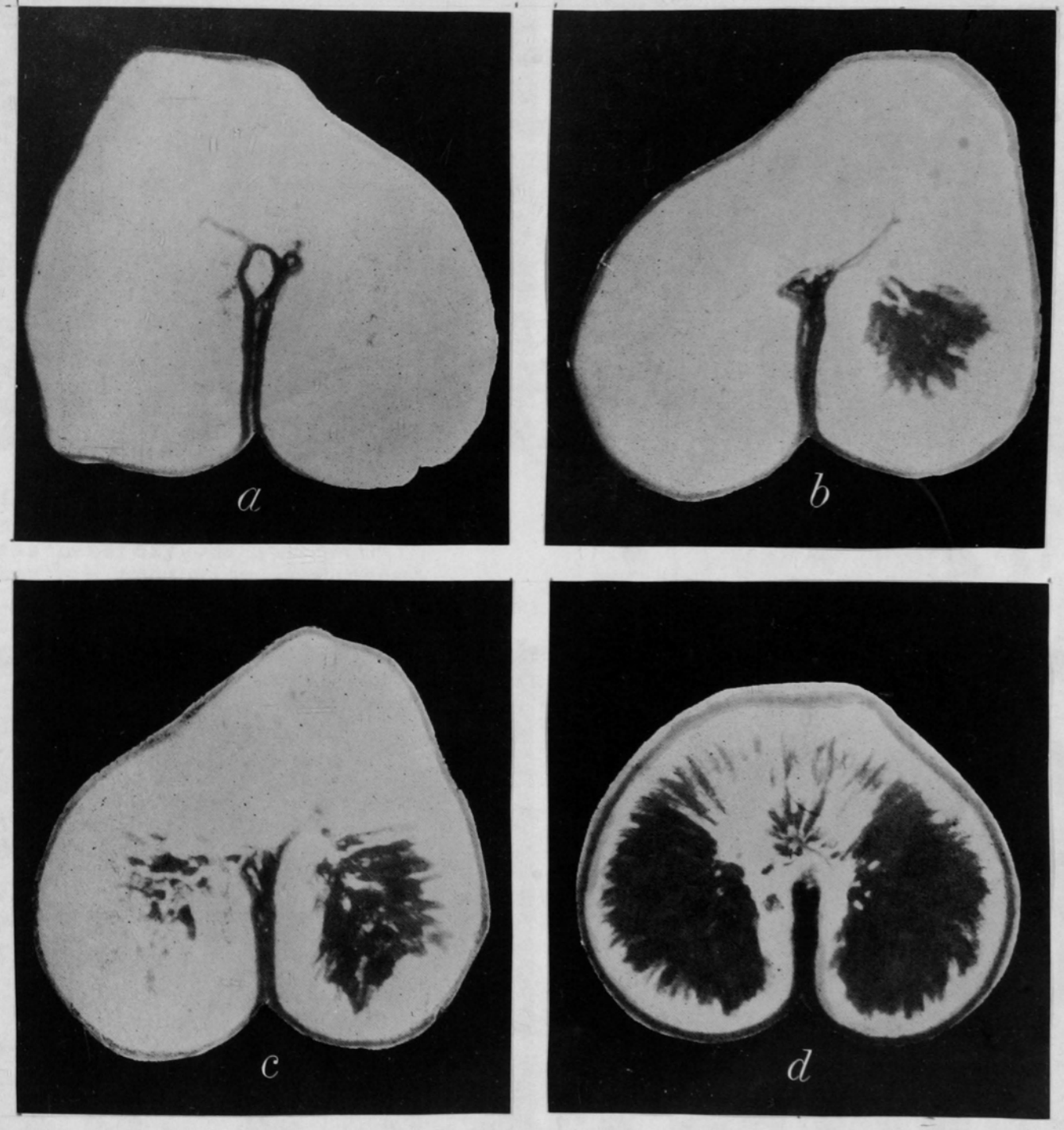


Total germination in 3 days	0
Total germination in 6 days	0
Total germination in 10 days	0

PLATE 28.

MACARONI WHEAT KERNEL CROSS SECTION SHOWING YELLOW-BERRY SPOTS.

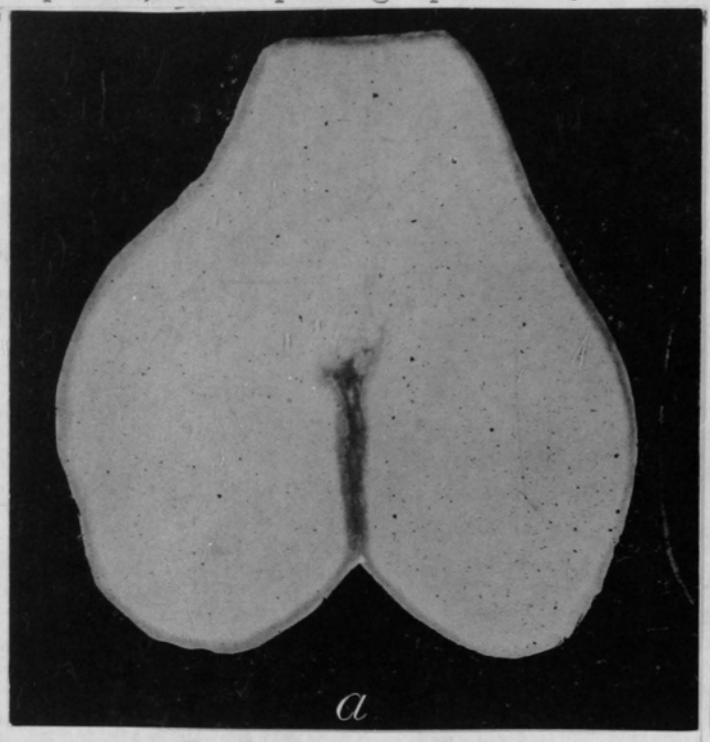
Cross sections of the seed of pure macaroni wheat plant, showing clear hard grains (a), and varying sizes of yellow-berry spots (b,c,d). The air spaces causing these opaque spots, lie in the plates with quite definite margins.

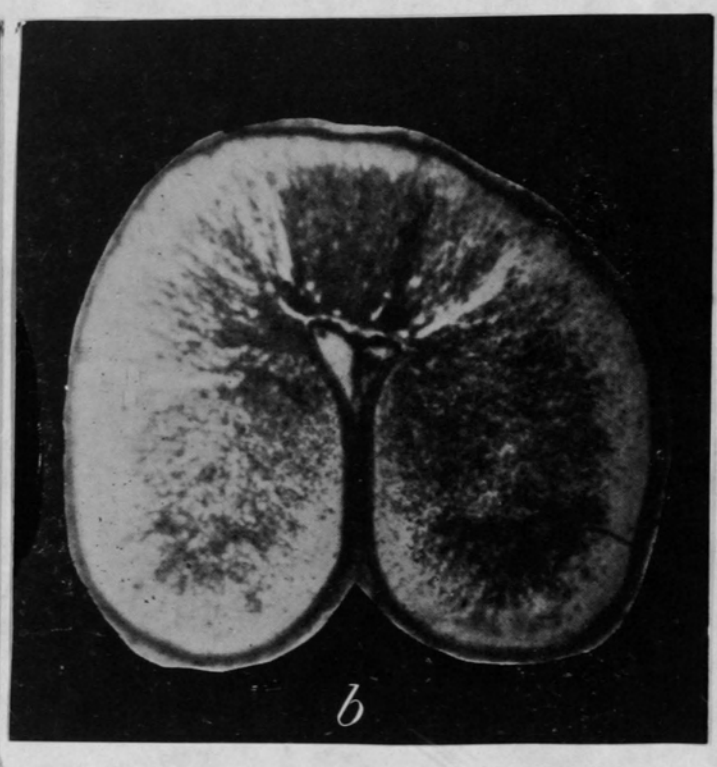


Plates taken from, Jour. of Heredity, Vol. 9:219.

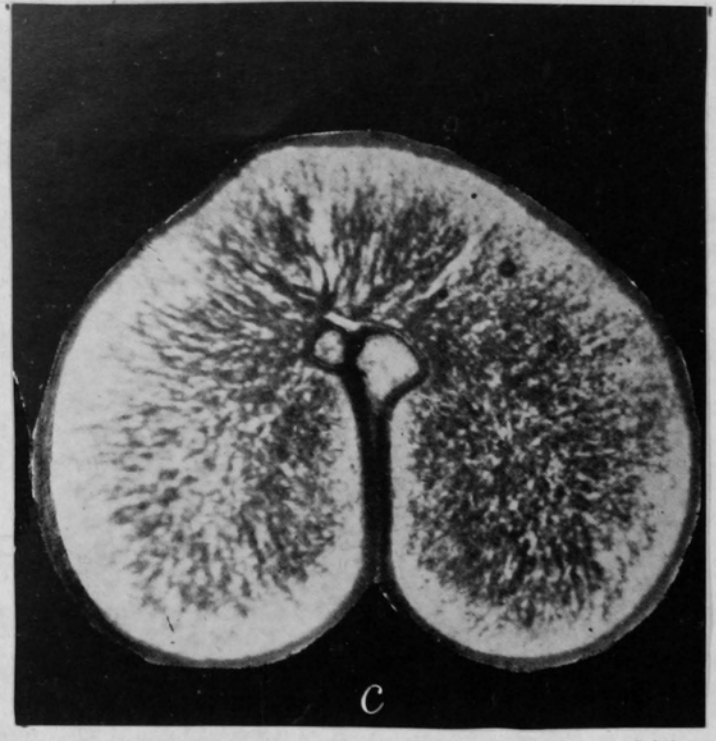
PLATE 29.

Cross sections of wheat grains photographed by transmitted light.(a) Pure macaroni.Endosperm texture flinty and translucent, consequently photographing white.(b) Pure Sonora.Endosperm texture soft,rendered nearly opaque by many small diffusely scattered air spaces,which photograph dark.

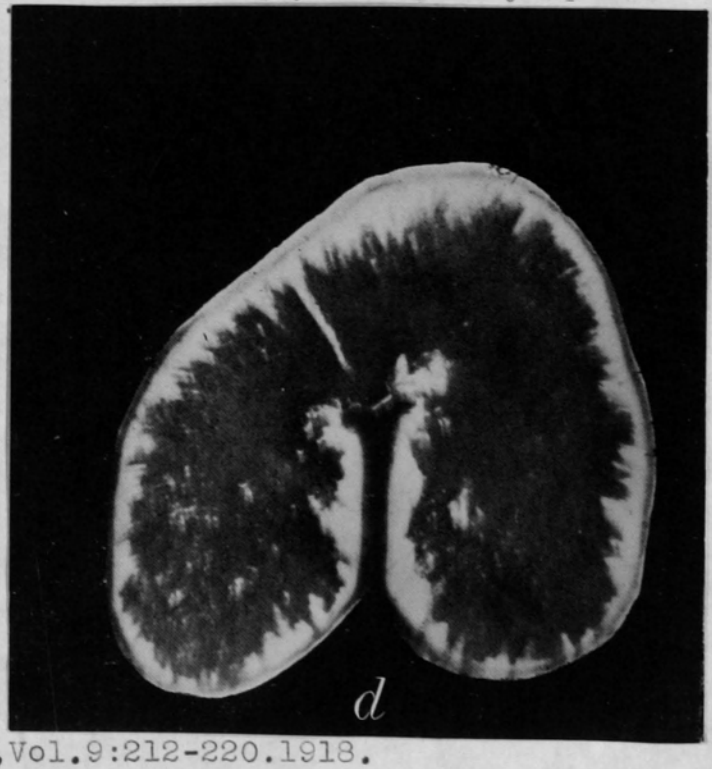




(c)Seed from F_2 plant of a macaroni-Sonora cross,which was heterozygous for grain texture,producing seed predominantly soft. (Not yellow-berry)



(d)Seed from F_2 plant of a macaroni-Sonora cross,which was homozygous for hard grain, but showing yellow-berry spots.



Plates taken from,Jour.of Heredity,Vol.9:212-220.1918.