UNIVERSITY OF MINNESOTA.

EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE,

ST. ANTHONY PARK, RAMSEY CO., MINN.

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BULLETIN No. 6.

EXPERIMENTS, WITH FROSTED, RUSTED, AND STACK-BURNED WHEAT.

AGRICULTURAL

EXPERIMENT STATION

OF THE

UNIVERSITY OF MINNESOTA.

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INTRODUCTORY.

In carrying out the objects of the organization of an "Agricultural Experiment Station," we cordially invite the co-operation of all persons interested in its success. Suggestions as to lines of experimental work, problems to be solved, inquiries relating to agriculture, horticulture, stock, and the dairy will be cheerfully received, and answered as far as possible, but no work will be untertaken unless of public value, and the results of which we are at liberty to use for the public good.

Specimens of grains and grasses; seeds of fruit and forest trees; vegetables, plants, and flowers, that are true to name; varieties of beneficial and injurious insects; samples of mineral waters and ores, and whatever may illustrate any department of agriculture will be gladly received, and due acknowledgments made in annual reports. Directions for collecting, packing and shipping such specimens will be furnished on application, and all expenses paid.

Bulletins will be issued at least quarterly, giving the results of experimental work as fast as completed, together with such suggestions and information as may be thought valuable to the farmers of Minnesota.

The bulletins and reports of this Station are sent free to every citizen of Minnesota who applies for them. Copies are sent as soon as issued to every newspaper in the State, to every Grange, Farmers' Alliance, or other Agricultural Organization, whose addresses can be obtained. Bulletins and reports are also sent to the leading Agricultural papers of the country, and will be sent to *any* paper that may desire to exchange.

Letters relating to any special line of work should be directed to the officer in charge of that division, but all general correspondence relating to the work of the Station should be addressed to

EDWARD D. PORTER,
Director of Experiment Station,
St. Anthony Park, Ramsey County, Minnesota.

NOTES ON THE EFFECTS OF FROST AND RUST ON THE GERMINATION OF WHEAT.

EDWARD D. PORTER, DIRECTOR.

In September last, I received the following communication from S. M. Owen, Editor of "*Farm, Stock and Home.*"

MINNEAPOLIS, MINN., Sept. 18th, 1888.

Prof. E. D. Porter, State Experiment Station :

DEAR SIR: Have you any knowledge, experimentally or otherwise, as to the effect of "frosting" on the germinating power of wheat? To what extent, if any, can immature wheat be frosted, and yet reproduce itself?

Again, can you, or any of your staff, tell us, without a chemical analysis, what effect "frosting" has on the flour-producing qualities of the kernel, and what effect on the gluten it contains; that is, how near will a pound of frosted wheat come to making as much flour as a pound of sound, the bulk, of course being greatest in the former?

Our Northern readers are much disturbed in these directions, and any light you can give them will be thankfully received.

Yours respectfully, S. M. OWEN, Editor.

In preparing to make a reply to the above, I was surprised to find so little information of a reliable character bearing upon this subject. In order to obtain some facts relating to the second inquiry, the milling value of frosted wheat, I enclosed the letter to Hon. J. S. Pillsbury, of the C. A. Pillsbury Co., the well known flour manufacturers of Minneapolis, and received the following reply:

OFFICE OF C. A. PILLSBURY & CO.,
MINNEAPOLIS, MINN., Oct. 18th, 1888.

Prof. E. D. Porter, Director Agricultural Experiment Station:

DEAR SIR: In reply to your inquiries concerning the value of frosted wheat for making flour, I will state that from our experience we find that the flour produced is of a very low grade; it is "clammy," and of very little strength, in fact the berry is softened and the flour-producing quality nearly destroyed,—the gluten being softened, loses its strength.

One pound of sound wheat will probably make four times the quantity of flour that a pound of frosted wheat will, and as to *quality*, there is no com-

parison, Sound wheat makes good strong flour, with a good yield, while frosted wheat will make a small quantity of weak, clammy, poor flour.

There is great danger that frosted wheat will be mixed with sound wheat, and in that case the whole mixture will be reduced to the grade of frosted wheat. Farmers should be very careful to sell their frosted wheat by itself, in order to receive the best returns from an unfortunate crop. We have never had a chemical analysis made of frosted wheat.

Yours respectfully, J. S. PILLSBURY.

In consideration of the large interests involved in the production and manufacture of spring wheat in this state, and throughout the great wheat belt of the Northwest, and the liability of a recurrence of the early and disastrous frosts of August last, we determined to undertake an investigation of the subject of frosted wheat at this station, and as a preliminary to this work the following notice was published in "*Farm, Stock and Home*," of Feb. Oct. 15th, 1888:

A CALL FOR SAMPLES.

Since the untimely frosts in the great wheat belt of the Northwest it has been discovered that agricultural literature contains no reports or data of any kind regarding the effect produced on immature wheat by frosting. At this juncture it would be both valuable and interesting to know positively what effect freezing has on the germinating power of the grain; at what stage of development the germ succumbs or can withstand the freezing, and also reliable data concerning the relative quality and quantity of flour, wheat so injured will yield; but no such information is at hand, save the claimed experience of millers regarding the flour producing part of the problem.

The Minnesota State Experiment Station, has decided to investigate this matter, by chemical analysis, artificial propagation this winter and natural propagation next season. To this end the Station requests that farmers in the frosted districts will send half-pound to pound samples of injured wheat and accompany them with information concerning the following points: date of frost; condition of berry when frozen, whether in the water, milk or dough stage; general appearance of straw and head before frosting. It is expected that wheat was in different stages of development when frozen, and to make the contemplated experiments valuable, as correct information as possible must be given on this point. The packets may be sent by express at the Station's expense, or if sent by mail, the postage will be refunded by the Station. Address Prof. E. D. Porter, St. Anthony Park, Minn.

I regret to say that the response to the above call was neither as prompt or as extended as I had reason to expect from the many letters I had received making inquiries upon this subject, and the attention which had been directed to it by the press of

the country,—*six samples* having been received up to dec. 20th, 1888, *four* from R. A. Whitney, Esq., Whitney Farm, Stephen, Minn., *one* from James Rowe, Esq., Felton, Minn., and *one* from Hon. George R. Roberts, Stephen, Minn.

Fearing to delay longer for assistance from the farmers of the state, Dr. Lugger, the botanist of the station, kindly undertook the task of making a personal inspection of that portion of the state most severely affected by the August frosts. His familiarity with that portion of the country, and his presence there during the growing season, in connection with the ravages of the "Rocky Mountain locusts," enabled him to make careful comparisons between the "frosted" and "rusted" wheat fields. He secured samples of both of these varities, as well as some known as "stack-burned," of previous years, which we needed for our investigation. I also procured from the "Northern Elevator Co.," of Minneapolis, twelve samples of all the different grades of wheat, inspected and certified by the state grain inspectors to be used as a basis for comparison; also samples of wheat known as "Saskatchawan Fife," and "Wellman Fife," were secured of the crop of 1887, which received the "First Premium" of the State Agricultural Society's Fair of that year.

These samples were divided into *four* parcels; the *first* was placed in the hands of Prof. Samuel B. Green, horticulturist, for tests for germination; the *second* were placed in the laboratory, with Dr. Harper for chemical analysis; the *third* reserved for field test in the ensuing spring, and the *fourth* placed in the museum for future reference.

The microscopic and botanic investigation of "frosted" and "rusted" wheat has been ably discussed by Dr. Lugger, as reported in Bulletin No. 5 of this station. The chemical analyses of these wheats are now being made by Dr. Harper, and the field experiments will be completed by the Division of agriculture as soon as the season opens, and the results of both the above, given in a future bulletin.

The comparative tests, for germination and growth of these different samples are most lucidly set forth by Prof. Green in the following article:

The plates accompanying this number I had made from photographs of growing specimens of wheat plants.

PLTAE NO 1.

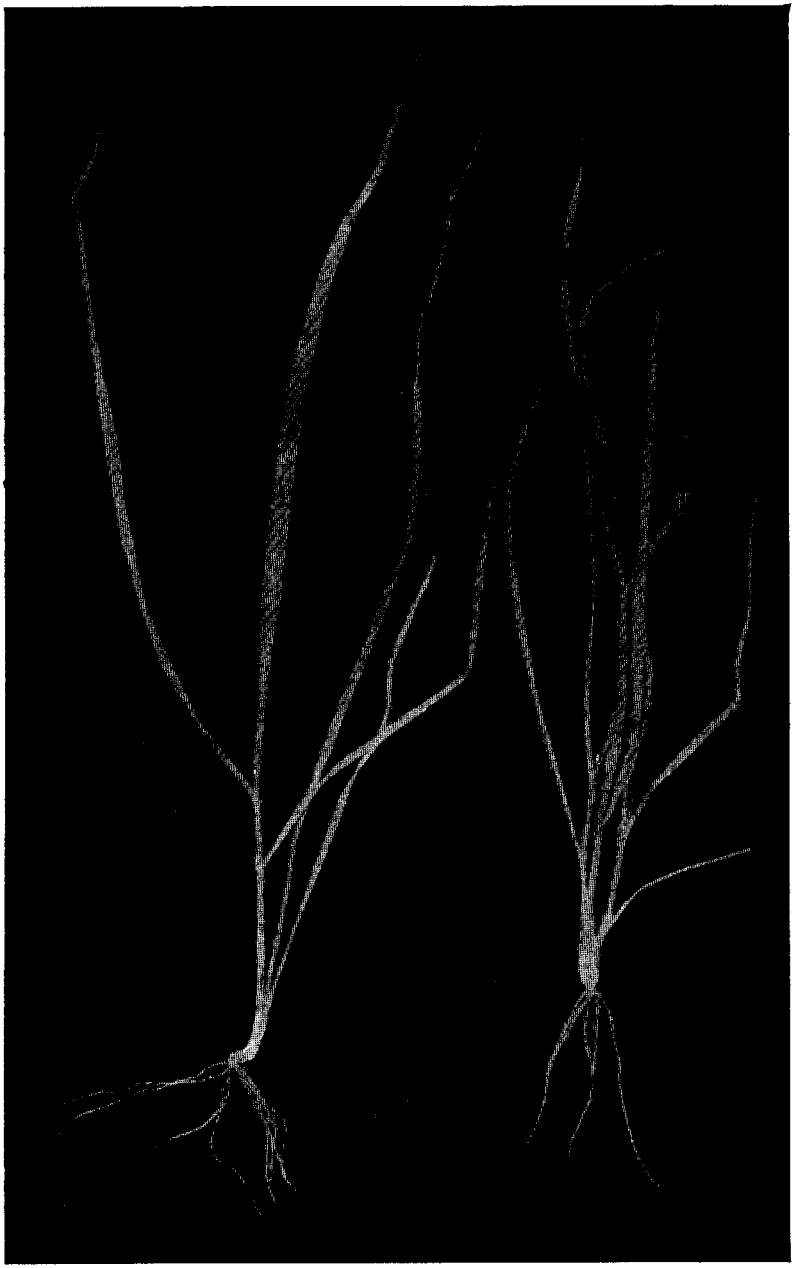
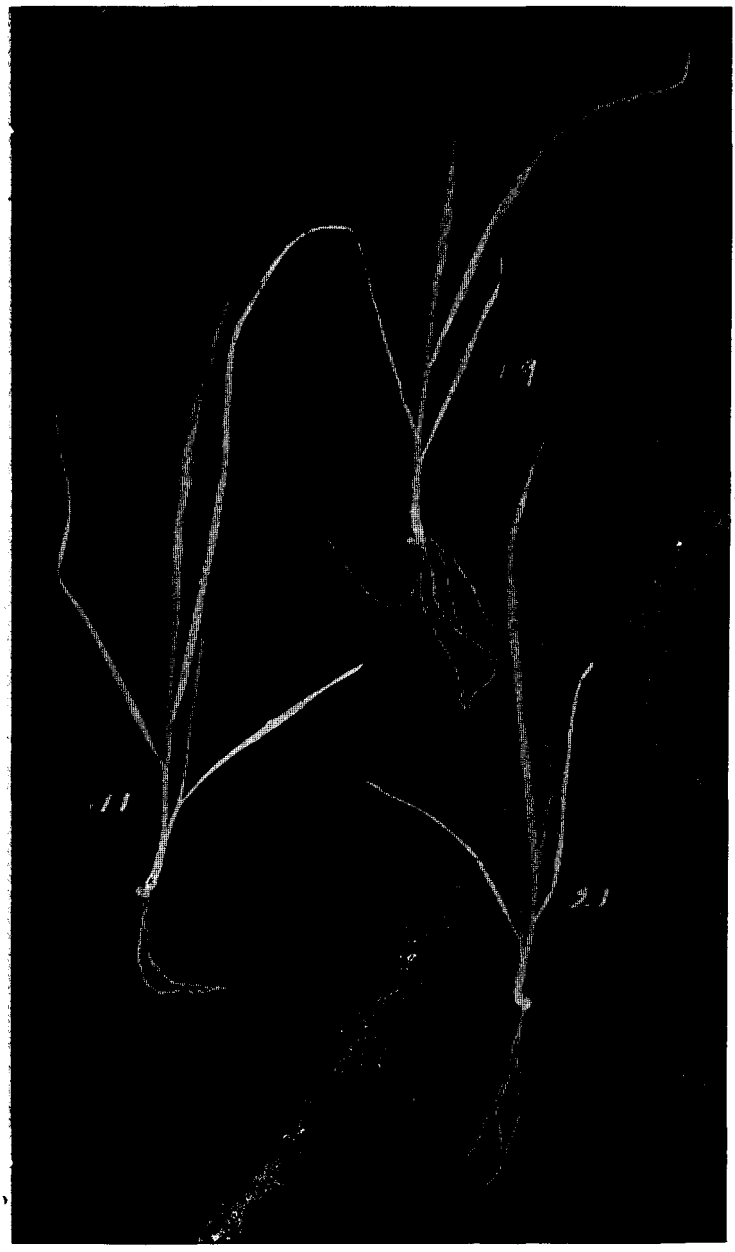


Plate No. 1 exhibits on the left hand one of the most vigorous plants of the best quality of No. 1 hard wheat, and on the right a fair average sample of frosted and blistered wheat, both sown the same day.

PLATE NO. 2



On Plate No. 2 is shown samples of No. 1 hard (the one marked (11) of No. 1 Northern, marked (19), and the one marked (21) the poorest quality of frosted wheat.

DIVISION OF HORTICULTURE.

SAMUEL B. GREEN.

EXPERIMENTS IN GERMINATION AND GROWTH OF DAMAGED WHEAT AND BARLEY.

In the description of these samples I have given all the information concerning them, that was obtained from the parties from whom they came. There is a very general feeling that rust in many sections of this State caused more real damage to the wheat crop the past season than frost, and that its effect cannot readily be distinguished in the grains from the effect of frost. That the difference between rusted and frosted wheat is not clear even to those who are the best judges of wheat, I am confident, from the fact that wheat from sections where rust prevailed, but no frost, the past summer, is very generally pronounced frosted wheat, and also from the fact that last year's wheat has been judged as frosted. The peculiarly blistered appearance of the kernels, which is said to be characteristic of frosted wheat, is found in wheat of the crop of 1887, as well as in that of 1888, and is not reliable as a test for frosted wheat. All the samples of wheat in this test were inspected by State officials from the grain inspection department. The green house in which these tests were made is a house running north and south with an A shaped roof. The wheat was sown in the centre bench, in rows running east and west. This house is light and receives the full effect of the sun. The seed was sown one-half inch deep in good prairie soil, and fifty kernels of a variety were sown in each row 30 inches long, thus making a distance of about one-half inch between the kernels. The house was maintained at a temperature varying from forty degrees at night to sixty-five degrees in the day, throughout the experiment. When the plants which are considered in table I were seven inches high, and those

considered in table II were six inches high, the leaves of all the plants were burned by tobacco smoke, while fumigating to kill insects on other plants in the same house; about three inches of the leaves were killed and turned white, which retarded them for a few days, but they recovered, and outgrew this damage.

In each case the first leaf appeared above the soil in about three days after planting. As a rule all the plants that appeared above the soil were strong enough to continue growing, but in a few cases they were too weak to grow, and in making up the percentage of growth, these weak plants have been considered as if they had not started into growth.

SECTION NO. I.

This section consists of tests of five different lots of wheat, said to be frosted, and one sample of damaged barley. They were received at various times in December and were sown in the green house, December 28th, in the following manner: Three hundred kernels from each sample were counted without any selection of grains. From the number thus counted, the one hundred best were picked out, to serve as the best. One hundred more kernels of the best remaining were then selected from the two hundred in the same lot, and were called the medium quality. The remaining one hundred were then marked the poorest. These three sets or grades of each sample were then sown separately in the green house, under as nearly the same conditions as practicable. In each case the grade of sample termed "best" gave a much higher percentage of germination, and a little better growth than that termed poorest.

The samples of wheat referred to above were of much better quality than samples twenty-one, twenty-two and twenty-three, considered in Section II. Where the per cent. of germination is given in descriptions of all these samples, it is the average per cent. of germination and growth of the three grades of each sample. In table No. 1, will be found the germination of the best, medium, and poorest grade of each sample discussed in this section. The height and stooling qualities were taken February 4th.

Sample No. 1.—From R. A. Whitney, Stephen, Minn. No grade.—More than half the grains fairly well filled out, but blistered; the balance much shrunken. Marked "frosted, Aug. 30th, in dough stage; straw green. Would like to know if it will do for seed."

The growth consists of vigorous and healthy plants of a rich green color, eleven inches high. The plants have stooled finely, most have three and many five strong shoots, and 85 per cent. of the seeds formed good plants.

There were three samples selected from this lot and they have all grown well, but the poorest quality has not tillered so much as the best.

Sample No. 2.—From R. A. Whitney, Stephen, Minn. No grade.—About one-fourth of the kernels were fairly well filled out, but blistered, the balance much shrunken, and some apparently stack-burnt. Marked: "Frosted August 17th and 30th, soft dough stage; straw green."

The growth consists of vigorous healthy plants, of good color, and twelve inches high. Most of the plants have stooled and have three vigorous shoots of the height given above, while some plants have five shoots, and 67 per cent. of the seed formed good plants. The best quality selected gave the strongest growth.

Sample No. 3.—From R. A. Whitney, Stephen, Minn. No grade.—About one-half of the kernels were fairly well filled out, but blistered, the balance badly shrunken. Marked "Frosted Aug. 30. Different stages of development; some in dough, straw green." The growth consists of vigorous, healthy plants of good color, eleven inches high, stooling well. Most of the plants have three shoots of the height given above. The best selected sample in this lot gave the strongest plants and 74 per cent. of the seed made good plants.

Sample No. 4.—From R. A. Whitney, Stephen, Minn. Grade No. 5; barley; was harvested before our first frost, Aug. 17th, but seems to be damaged. There is in this case no apparent difference in the growth from the best selected, and poorest seed from the same sample. It all germinated and 100 per cent. of the seeds sown formed fine, vigorous, healthy plants, fourteen inches high.

Sample No. 5.—No grade. This sample would probably weigh about fifty pounds per bushel, it is much shrunken and contains some very dark grains but it is mostly quite hard; the growth is healthy and vigorous, about eleven inches high, and is developing rapidly. This sample did not stool quite as well as No. 6, and 72 per cent. of the seed formed good plants.

Sample No. 6.—From George R. Roberts, Stephen, Minn

TABLE NO. I.—FROSTED WHEAT AND DAMAGED BARLEY.

No. of sample.	No. of grade.*	Who from.	Kind of grain.	Grade given by inspector.	When sown.	When up.	Per cent. of growth in each lot.	Height of plants taken Feb. 4.	Condition of growth.	Total per cent. of growing seed in whole sample.
1	1′	R. A. Whitney, Stephen, Minn.	Frosted wheat ...	No grade..	Dec. 28.	Jan. 3	96	11 inches.	Growth healthy and vigorous	85
	1′′		" "	" "	"	"	90	11 "	" " "	
	1′′′		" "	" "	"	"	70	11 "	" " "	
2	2′	R. A. Whitnay, Stephen, Minn.	" "	" "	"	Jan. 4	88	12 "	" " "	67
	2′′		" "	" "	"	"	60	12 "	" " "	
	2′′′		" "	" "	"	"	54	12 "	" " "	
3	3′	R. A. Whitney, Stephen, Minn.	" "	" "	"	"	80	11 "	" " "	74
	3′′		" "	" "	"	"	72	11 "	" " "	
	3′′′		" "	" "	"	"	70	11 "	" " "	
4	4′	R. A. Whitney, Stephen, Minn.	Damaged barley...	No. 5.....	"	Jan. 2	100	14 "	" " "	100
	4′′		" "	"	"	"	100	14 "	" " "	
	4′′′		" "	"	"	"	100	14 "	" " "	
5	5′	James Rowe, Fulton Clay Co.	Frosted wheat.....	No grade..	"	Jan. 4	80	11 "	" " "	72
	5′′		" "	" "	"	"	68	11 "	" " "	
	5′′′		" "	" "	"	"	68	11 "	" " "	
6	6′	Geo. R. Roberts, Stephen, Minn.	" "	" "	"	Jan. 3	62	11 "	" " "	52
	6′′		" "	" "	"	"	55	11 "	" " "	
	6′′′		" "	" "	"	"	44	11 "	" " "	
		D. L. Wellman, Frazee City, Minn.	Saskatchewan fife†	No. 1 h...	"	Jan. 4	81	15 "	" " "	81

*One prime (′) refers to the best quality. Two prime (′′) refers to the second best quality. Three prime (′′′) refers to the p orest quality.

†This sample was from crop of 1887, and was sowed to serve as a basis of comparison. The kernels were large and plump but a very little bleached and blistered. It took the prize at the state fair in 1887.

No grade.—About one-half of the kernels were fairly well filled out, but badly blistered, the remainder were badly shrunken. Marked "A large number of farmers in this vicinity are depending upon wheat of this kind for seed next season." The growth is healthy, vigorous and about eleven inches high. The stooling consists of two and three shoots well developed, and 52 per cent. of the seed sown made good plants. This kind of seed should be more carefully cleaned before being used for seed and, all the light kernels should be blown out.

Saskatchawan Fife.—From D. L. Wellman, of Frazee City; crop of 1887.—This sample was planted as a basis for the comparison of the growth of different samples. The height of plants is fifteen (15) inches and most of them formed two or three strong shoots. Eighty-one (81) per cent. of the seed sown formed strong plants. This was a picked sample and was made up of very large grains, and in table No. 2, where it was sown on same day as No. 1 hard, it made a greater growth than No. 1 hard.

SECTION II.

In this section is considered a lot of samples of widely varying qualities. The samples were received during December and January, and were sown January 5th. In order to clean the seed, and also to grade it by weight a certain amount of each sample was thrown into water, and was carefully shaken to expel any air which might adhere among the hairs on the kernels aiding them to float. The sinking and floating portions were carefully dried to ordinary dryness and each portion weighed separately. Thus was obtained what will be found referred to in the table and descriptions as "sunk" seed, and this is similar to seed wheat as ordinarily or well cleaned, and the light seeds taken out. The proper understanding of this matter of sunk seeds is necessary to get a full idea of the extreme poorness of some of the samples received. In the descriptions herewith and in table No. II, only the sunk seeds will be found referred to, but with the percentage of growth of these seeds will also be found a statement of the percentage of growth of the whole sample.

In table No. II, will be found the full data in connection with No. 1 hard and other grades of merchantable wheat, which have been taken in the same manner as the poorest grades in order to

serve as a basis of comparison. Also a sample of Saskatchawan fife, from D. L. Wellman's crop of 1887, has been similarly treated, and the data concerning it will be found in the same table.

In table No. III, will be found a consideration of the germination and growth of the floating seeds in those samples where they formed a large proportion of the whole.

The heights and stooling of each sample were recorded February 4th.

Sample No. 7.—Grade No. 2 Northern.—Car 10896, M. & M. R. R., December 22nd, 1888; from Hereford, received from M. & N., Elevator Company, weight per bushel 54 lbs. The growth is healthy and some of the plants are commencing to stool. The height of plants is ten inches; and ninety-six per cent. of the seed sown produced healthy plants.

Sample No. 8.—Grade No. 1 Northern, car 4582, M. & M., December 22nd, 1888, from Alexandria, Minnesota: Weight per bushel 57 pounds. The growth is healthy, and the plants are commencing to stool. The height of the plants is ten inches. Eighty-four per cent. of the seed sown produced good plants.

Sample No. 9.—No grade.—About one-fourth of the kernels plump but blistered, and the balance shrunken.—Car 2548, M & M. R. R.; M. & N. Elevator Company, December 20th, 1888, from Argyle, Minnesota; weight per bushel 51 pounds. The growth is healthy; some of the plants are commencing to stool. The height of the plants is ten inches. Eighty-six per cent. of the seed produced good plants.

Sample No. 10.—Grade No. 3; car 2532, M. & M. R. R., M. & N. Elevator Company, from Neche; weight per bushel 58 pounds. The growth is healthy, vigorous and stocky. The plants are stooling well, and are ten inches high. Ninety-two per cent. of the seed sown produced healthy plants.

Sample No. 11.—Grade No. 1 hard, car 5848, M. & M. R. R.; M. & N. Elevator Co., from Cleremont, Dec. 22d, 1888; weight per bushel, 58 pounds. The growth is healthy, vigorous and stocky. The plants have commenced to stool and are ten inches high. Ninety-two per cent. of seed sown produced healthy plants.

Sample No. 12.—Grade rejected, by cleaning would be No. 3.—Car 6080, M. & M. R. R.; M. & N. Elevator Co., Dec. 27, 1888, from St. Thomas; weight per bushel, 55 pounds. The growth is healthy and vigorous, the plants are starting well and are ten

inches high. Ninety-two per cent of the seed produced good plants.

Sample No. 13.—Grade No. 3, 2 pounds off.—Car No. 6648, M. & M. R. R. Co.; M. & N Elevator Co., from Arguiville; weight per bu. 55 pounds. The growth is healthy, vigorous and stocky. The plants have commenced to stool and are ten inches high. Seventy-eight per cent. of the seed sown produced good healthy plants.

Sample No 14.—Grade No. 1, 2 pounds off; car 10224, M. & M. R. R.; M. & N. Elevator Co., December 22d, 1888, from Brandon; weight per bushel, 57 pounds. The growth is healthy and vigorous. The plants have commenced to stool and are ten inches high. Ninety-six per cent. of the seed sown produced good plants

Sample No. 15. No grade; about one-sixth fairly well filled, but badly blistered, the balance much shrunken, and light. Car 2582, M. & M. R. R., M. & N. Elevator Co., December 28th, 1888, from Crary. Weight per bushel 44 lbs. The growth is healthy and vigorous; the plants are stooling well, and are eleven inches high. Seventy-two per cent. of the seeds sown formed good plants.

Sample No. 16.—Grade No. 1, 1½ lbs. off.—Car 11554 M. & M. R. R., M. & N. Elevator Co., December 28, 1888, from Nelson. Weight per bushel 57 lbs. The growth is healthy and vigorous; the plants are stooling well, and are eleven inches high. Ninety per cent. of the seed sown produced good plants.

Sample No. 17.—Grade No. 1, 2 lbs off.—Car 2662, M. & M. R. R., M. & N. Elevator Co., December 26, 1888, from Edinburgh, Dakota. Weight per bushel 57 lbs. The growth is healthy and vigorous, the plants are stooling well, and are eleven inches high. Ninety-two per cent. of seed sown produced good plants.

Sample No. 18.—Grade No. 3, 1½ lbs. off.—Car 2768, M. & M. R. R., M. & N. Elevator Co., December 28, 1888, from Emerado. Weight per bushel 56 lbs. The plants are healthy and vigorous. They are ten inches high and commencing to stool. Eighty per cent. of seed sown produced good plants.

Sample No. 19.—Grade No. 3; Scotch fife from Fergus Falls; marked: "Shrunken from rust and heat;" raised by William Benzman; received December 31, 1888; weight per bushel, 54 pounds. The plants are healthy and vigorous. They are com-

mencing to stool and are nine inches high. Eighty-four per cent. of the seed sown produced good plants.

Sample No. 20.—Grade rejected.—Blue stem wheat; supposed to be frosted; from E. A. Miller, 6 miles from Pelican Rapids; weight per bushel, 54 pounds. The plants are healthy and vigorous and stooling well, with a heighth of ten inches. Eighty-six per cent. of the seed sown produced good plants.

Sample No. 21.—No grade.—Shrunken, blistered, light and exceedingly poor; marked: "Poor wheat, but an average sample of Saskatchawan fife wheat, from Kimmelbach, near Crookston, rusted and frosted;" weight per bushel, 39 pounds. The plants are healthy and rather vigorous. They are commencing to stool and are nine inches high. Forty-eight per cent. of seed sown, or only thirty-four per cent. of the whole sample, produced good plants. Only thirty-nine per cent. of this sample sank in water.

Sample No. 22.—No grade.—Soft, shrunken, light, blistered and exceedingly poor. Rusted and frosted, Saskatchawan Fife from Kimmelbach, Crookston, Minn. Grown on light soil; weight per bushel 40 pounds. The plants are healthy and rather vigorous. They are commencing to stool and are nine inches high. Fifty per cent. of seed sown produced good plants, or forty-eight per cent. of the whole sample. Of this sample only thirty-nine per cent. was heavy enough to sink in water.

Sample No. 23.—No grade.—Soft shrunken, blistered and light, though a little better than No. 22. "Rusted and Frosted Saskatchawan fife. Best quality raised by Kimmelbach, Crookston, Minn;" weight per bushel 43 pounds. The plants are healthy and vigorous, and are now, February 4th, commencing to stool. They are nine inches high, and sixty per cent. of seed sown produced good plants, or forty-two per cent. of the whole sample. Sixty-two and a half per cent. of the whole sample was sunk seed.

Sample No. 24.—No grade.—Soft, shrunken, light and blistered, with an occasional well filled grain. It was said to be rusted and frosted Scotch Fife wheat, best quality grown by Kimmelbach near Crookston, Minn; weight per bu. 41 pounds. The plants are healthy and fairly vigorous, and stooling well. They are nine inches high, and 60 per cent of the seed sown produced good plants, that is forty-six per cent. of the whole sample. Fifty-five per cent. of whole sample was heavy enough to sink in water.

Sample No. 25.—No grade.—Soft, shrunken, light, badly blistered, and with no heavy grains. Marked: "Rusted and frosted Scotch Fife wheat." It was said to be an average sample of wheat from the region southwest of Crookston, Minn., and was collected by Samuel Merriam; weight per bushel 39 pounds. The plants are healthy, rather vigorous and are commencing to stool. They are nine inches high, and sixty-eight per cent. of seed sown, or forty-two per cent. of the whole sample prodcued good plants. Sixty-eight per cent. of the whole sample was heavy enough to sink in water.

Sample No. 26.—No grade.—All the seed was much shrunken and badly blistered, but harder than No. 23. Marked: "Rusted and frosted Scotch Fife." Best sample from region southwest of Crookston, Minn., collected by Samuel Merriam; weight per bu. 40 pounds. The plants are healthy and vigorous, and stooling well. They are ten inches high, and sixty per cent. of seed sown produced good plants. or fifty-six per cent. of the whole sample. Sixty-seven per cent. of the whole sample sank in water.

Sample No. 27.—No grade.—Shrunken, blistered and apparently somewhat stack burnt, about one-half of the kernels quite hard; the balance very soft. Marked: "Rusted and Frosted" Mammoth spring wheat, grown by Samuel Merriam, southwest of Crookston; weight per bushel 46 pounds. The plants are healthy and vigorous, and stooling well. They are eleven inches high and sixty-six per cent. of seed sown produced good plants, or sixty per cent. of the whole sample. Seventy-two per cent. of the whole sample sank in water.

Sample No. 28.—No grade.—About one-sixth of the kernels fairly well filled out, but blistered, the remainder shrunken, soft and much blistered. Marked, "Rusted and frosted. Blue Stem wheat," from S. S. Collins, Crookston. Weight per bushel 47 pounds.

The plants are healthy and vigorous, and stooling well. They are eleven inches high and seventy-eight of the sunk seed, or sixty-three per cent. of the whole sample produced good plants. Sixty-seven per cent. of the seeds were heavy enough to sink.

Sample No. 29.—No grade.—About one fourth of the kernels were well filled, but blistered; the remainder shrunken, but very much better than No. 22, being harder and not so much bleached. Marked, "Rusted and frosted, blue stem wheat." Bought by the M. & N. Elevator Co. from S. L. Collins farm Crookston. Weight per bushel 51 pounds. The plants are

healthy and vigorous, and stooling well. They are eleven inches high and eighty-six per cent. of the sunk seed or fifty-seven per cent. of the whole sample produced good plants; ninety-one per cent. of the seeds were heavier than water.

Sample No. 30.—No grade.—About one-sixth of the kernels were fairly well filled out, but badly blistered. The remainder much shrunken, but quite hard. Marked, "Rusted and frosted. Saskacthawan Fife wheat, from Kelso farm, near Hallock, Minn. Weight per bushel 43 lbs." The plants are healthy and vigorous and are stooling well. They are ten inches high, and seventy-four per cent. of the sunk seed, or sixty-nine per cent. of the whole sample produced good plants. Eighty-three per cent. of the whole sample was heavy enough to sink.

Sample No. 31.—No grade.—About one-third fairly well filled out, but somewhat shrunken and blistered; the remainder badly shrunken and blistered. Marked: "Rusted and frosted. Saskatchawan Fife. Best sample from Kelso farm near Hallock, Minn. Crop of 1888." Weight per bushel 45 lbs. The plants are healthy and vigorous, and stooling well. They are ten inches high, and seventy-six per cent. of the sunk seed or fifty per cent. of the whole sample produced good plants. Sixty per cent. of the whole sample sunk in water.

Sample No. 32.—Graded rejected.—This appears to be a little stack-burned. One-third of the kernels are well filled out, but blistered and bleached. The remainder are shrunken, but pretty hard. Marked: "Stack burned wheat, crop of 1887, slightly frosted. Will it germinate?" Weight per bushel 53 lbs. The plants are vigorous and healthy and stooling well. They are ten inches high, and sixty-six per cent. of the sunk seed produced good plants.

Sample No. 33.—Damaged barley, grade No. 5. Marked: "Frosted barley, from Kelso farm, near Hallock, Minn.;" weight per bushel, 34 pounds. The plants are very vigorous and healthy. They are eleven inches high and eighty-four per cent. of the sunk seed produced good plants.

Sample No. 34.—Shrunken, bleached, blistered and soft, with an occasional fairly well developed kernel. Marked: "Frosted wheat," from W. J. Anderson, Grand Forks, Dak.; weight per bushel, 40 pounds (this sample was sown Jan. 8). Eighty-six per cent. of the sunk seed, or about 67 per cent. of the whole sample, produced good plants.

Sample No. 35.—No grade.—Nearly two-thirds of the kernels

TABLE NO. II.—PERCENTAGE OF GERMINATION IN CLEANED OR SUNK SEED ALSO IN ENTIRE SAMPLE.

No. of Sample.	Where from.	Grade of sample as determined by state inspectors.	Weight per bushel.	Per cent. of sunk seeds in sample.	When Sown.	When up.	Per cent. of healthy growing plants from sunk or cleaned seed.	Height of plants Feb. 4.	Per cent. of seed from whole sample forming healthy plants.	Condition of plants.
7	Hereford	No. 2 Northern, 2 lbs. off	55	96	Jan. 5.	Jan. 8.	96 pr. ct.	10 inches.	92 prct	Healthy
8	Alexandria	No. 1 Northern, 2½ lbs off	57	96	" "	" "	84 " "	10 "	84 "	"
9	Argyle	No. 3 Northern, 1 lb off	52	78	" "	" "	86 " "	10 "	6.86 "	"
10	Neche	No. 3 Northern, 1 lb off	58	96	" "	" "	92 " "	10 "	92 "	"
11	Cleremont	No. 1 hard, 2 lbs off	59	98	" "	" "	92 " "	10 "	92 "	"
12	St. Thomas	Rejected	56	96½	" "	" "	92 " "	10 "	92 "	"
13	Argueville	No. 3 Northern, 2 lbs off	56	97½	" "	" "	78 " "	10 "	78 "	"
14	Mandon	No. 3 Northern, 2 lbs off	57	97	" "	" "	92 " "	10 "	92 "	"
15	Crary	No Grade	44	72½	" "	" "	68 " "	11 "	68 "	"
16	Nelson	No. 1 Northern, 1½ lbs off	57	97½	" "	" "	88 " "	10 "	88 "	"
17	Edinburgh, Dak	No. 1 Northern, 2 lbs off	57	96½	" "	" "	90 " "	11 "	90 "	"
18	Emerado	No. 3 Northern, 1½ lbs off	56	96½	" "	" "	88 " "	10 "	88 "	"
19	Fergus Falls	No. 3 Northern	54	94½	" "	" "	82 " "	9 "	82	"
20	Pelican Rapids	Rejected	54	93	" "	" "	86 " "	10 "	86 "	"
21	Crookston	Chicken Feed	39	35	" "	" "	48 " "	9 "	43 "	"
22	Crookston	" "	40	39	" "	" "	48 " "	9 "	48 "	"
23	Crookston	" "	43	62½	" "	" "	60 " "	9 "	42 "	"
24	Crookston	" "	41	55	" "	" "	60 " "	9 "	46 "	"
25	Crookston	" "	39	68½	" "	" "	67 " "	9 "	42 "	"
26	Crookston	" "	40	67½	" "	" "	64 " "	10 "	56 "	"
27	Crookston	" "	46	72½	" "	" "	66 " "	11 "	60 "	"
28	Crookston	No. grade	47	67½	" "	" "	76 " "	11 "	63 "	"
29	Hallock	" "	51	91	" "	" "	86 " "	11 "	79 "	"
30	Hallock	" "	43	83½	" "	" "	74 " "	10 "	69 "	"
31	Hallock	Chicken Feed	45	66	" "	" "	76 " "	10 "	50 "	"
32	Hallock	Rejected	53	66	" "	" "	66 " "	10 "	66 "	"
33	Hallock	No. 5 barley	34	93	" "	" "	80 " "	11 "	80 "	"
	Frazee City, 1887	Prize wheat	59	100	" "	9.	78 " "	12 "	78 "	"

are fairly well filled out, but blistered and a little shrunken, although quite hard; the remainder badly shrunken. It is a much better sample than most damaged wheat this year. It was marked: "Promising in June, but rusted in damp days following; yielded five bushels per acre." Raised in Otter Tail county by Ames, French & Co., 1888. Weight per bushel, 50 pounds. This sample was sown Jan. 16. It is now, February 4, nine inches high and healthy. Eighty-nine per cent. of the sunk seed or about eighty-two per cent. of the whole sample, produced good plants.

Sample No. 36—No grade.—About one third of the kernels were fairly well filled out, but blistered, the remainder shrunken with some stack-burned grains. Most of the kernels are quite hard, Better than most damaged wheat this year. Raised by Peter Cornelius, Crookston, Minn. Weight per bushel 51 pounds. This sample was sown January 26th, and now, February 4th, it is five inches high and vigorous. About ninety per cent. of the whole sample has produced good plants.

Sample No. 37.—No grade.—About one-tenth of the kernels were well filled out, but blistered; the remainder is much shrunken though quite hard. Better than average samples of damaged wheat this year. Reported as, "Rusted, from A. H. Halloway, Sabin, Clay county, Minn." Weight per bushels 51 pounds. About eighty per cent. of the whole sample produced good plants

TABLE NO. III.

THIS TABLES SHOWS THE PER CENT. OF GROWTH IN THE SEEDS WHICH WERE SO LIGHT THAT THEY FLOATED ON THE SURFACE OF WATER.

No. of Sample.	Where From.	Per cent. of Light Wheat.	Per cent. of Light Wheat Forming Good Plants.	Per c't. of Heavy Wheat Forming Good Plants.	Total per cent. of Good Plts from Whole Sample.
21	Crookston.....	65	12	48	34
22	"	61	18	48	48
23	"	37¾	18	60	42
24	"	45	30	60	46
25	"	31½	16	67	42
26	"	32½	50	64	56
27	"	27½	23	66	60
28	"	32½	18	76	63
31	Hallock.....	34	16	76	50

Light wheat means wheat too light to sink in water. Heavy wheat means wheat that will sink in water.

TABLE IV.—THE SAMPLES CONSIDERED UNDER THIS HEAD WERE RECEIVED AFTER JANUARY 5.

No. of Sample.	Where From.	Condition of Sample.	Weight per bu. in pounds.	Per Ct. of Sunk Seeds in Sample	When Sown.	When Up.	Per centage of Healthy Growing Plants from Seed Sown.	Height of Plants Feb. 5.
34	Grand Forks, Dak	No Grade	40	67½	Jan. 8	Jan. 11	86	8 inches.
—	Frazee City, 1887	*Prize Wheat	59	100	Jan. 8	Jan. 12	76	10 "
35	French, Otter Tail County	No Grade	50	92	Jan. 16	Jan. 19	89	9 "
—	Frazee City, 1887	Prize Wheat	59	100	Jan. 16	Jan. 20	76	8 "
36	Crookston	No Grade	51	95	Jan. 26	Jan. 29	90	5 "
—	Frazee City, 1887	Prize Wheat	59	100	Jan. 26	Jan. 30	76	5 "
37	Sabin, Clay County	No Grade	51	95	Jan. 28	Feb. 1	80	3 "
—	Frazee City, 1887	Prize Wheat	59	100	Jan. 28	Feb. 2	76	2½ "

*Prize wheat refers to wheat from D. L. Wellman which took the first premium at the State Fair in 1887.

THE DIFFERENCE BETWEEN GROWING PLANTS IN A GREENHOUSE AND IN THE OPEN GROUND.

It has been found in practice, that many seeds which have but a weak vitality will frequently germinate in the greenhouse, while in the open ground they will not start if the soil or season is very unfavorable. Some of our most reliable seedsmen have found that a simple germination of seeds in moist air, or on cloth or paper, is not sufficient, but that the plants should grow for some time in soil, in order to test their real strength, and that they should be grown by the side of seeds known to be of good quality, so that the test of vitality may be a relative one.

In considering this greenhouse test of seed wheat, and deducing conclusions for guidance in field planting, there are a few important points to be considered.

1st. This wheat was germinated at a temperature ranging from forty degrees at night to sixty-five degrees in the day; which is a higher and more favorable temperature than wheat ordinarily has in the open ground.

2d. This wheat was planted one-half inch deep, and had perfect drainage and the proper amount of moisture; while in the open ground the conditions would not, probably, be so favorable.

3d. The season at which these experiments were commenced was very unfavorable for plant growth. The days in January are very short, and plants get comparatively little effect from the very oblique rays of the sun.

4th. Although as high as fifty per cent. of some of the wheat which was soft as well as shrunken has germinated, yet its apparent vitality is not so great as that of wheat which is shrunken but hard. In every test made with wheat that was hard, although it might be shrunken, by rust or other cause, and be graded only as chicken feed, there was a good per cent. of germination and a strong growth. Wheat which does not weigh over forty pounds to the bushel, such as is considered under numbers 21 to 25, inclusive, uniformly gave a low per cent. of germination, and a little inferior growth, as compared with others of greater weight per bushel.

CONCLUSIONS.

The work of testing this wheat did not devolve upon me, because of my knowledge of raising wheat as a business, but on account of my possessing facilities for growing plants in the

winter. Since undertaking these tests, I have become much interested in them, and have endeavored by drawing out the opinions of practical men, to obtain an idea of their practical significance. Submitted herewith will be found the opinions of several experienced wheat men, who are much interested in the subject, and who have kindly allowed me the use of their letters for publication. The general feeling, as expressed by those who have examined these tests, is that the conditions under which the samples are growing are exceedingly favorable for growth. One and all express surprise at the high precentage of germination, and the amount of vigor exhibited by these plants, and think that, should we have a favorable season, much of the poor wheat would grow and develop good plants and good crops. I am disposed to be very careful about recommending the planting of poor seed, for I am aware of the millions of dollars that are at stake, and would much prefer to urge extra care in the selection of seed wheat, than to suggest the lowering of the standard even for a single year. For this reason, I have given full data in connection with each sample received, and will allow those more particularly interested to draw their own conclusion.

At my request for criticisms of these experiments, the following letters have been received at the station:

Director State Experiment Station, Sir:—

I have had the privilege of examining the experiments made by Prof. S. B. Green of the Horticultural department, for the purpose of testing the rusted and frozen wheat that is so plenty in many sections through the Northwest, from this last season's crop, to ascertain its value for seed, so that the farmers may have some data to govern them in their seeding operations next spring.

Prof. Green in his experiment seems to have covered about all the combinations possible to be made, with some thirty samples collected by Prof. Lugger, and others, from different parts of the state, which includes all the grades, from gilt edge No.1 hard, down through all the list of merchantable, rejected, no grade, and the poor rotton stuff "not fit to feed to the hogs," as reported to the governor by Prof. Lugger, also extra nice seed from the 1887 crop.

One of the "combinations" was to sow the wheat at different times—one week apart—Dec. 28th and Jan. 5th, and the plats show no difference in per cent. of growth except the usual difference in size—eight and five inches.

I have now seen the wheat three times since Jan. 12th, and every time that I examine it I am the more instructed and surprised at its remarkable growth, for by counting the standing plants, it shows that the poor and inferior grades of unmerchantable wheat give nearly as large a per cent. of germination as the high grades. The best "high grade" plants have the ad

vantage of only one or two inches in height. Many of the plants of nearly all the grades already have two, three and four stools.

"The "poor rotten stuff" shows 50 per cent. of growth of good plants. Chicken feed, or rusted, shows a very large per cent. of good healthy plants. All of these 30 rows of plants have a small bottle standing at the end of each that contains some of the seed they were grown from, for examination, so that a person can see and know, to a dead certainty, the results, as shown at the present time; and if it is possible for Prof. Green to describe the many grades in the bottles, when he makes his report for distribution, then the farmers and interested parties can judge for themselves whether they are safe in sowing such seed as they have on hand, in preference to going into debt for more costly seed.

Judging from what is shown in the experiments, I have no hesitation in saying that the farmers need not be afraid to sow such seed as they have at hand, if they will and can prepare their soil next spring so that the conditions in favor of germination and growth may be as near as possible to those n green-house culture.To do that, I would suggest and recommend that the fields should be thoroughly harrowed, at least three times over, before the seed is put on the field, and then, if hoe seeders are used, the hoes should be let well back, so as not to shovel up the soil and cover the seed deep, and then one more harrowing would complete a good job.

This three times harrowing before the seeder will work the soil down solid and compact, and give a fine tilth, and warm it up, so that the conditions are similar to green-house culture, and the shallow work of the seeder hoes will not get any of the seed over an inch deep. One-half inch is the depth of the experimental planting, and field culture should average the same, and then the sun of early spring days can warm the soil and wheat to that depth, which it could not if sowed from one to three inches deep, as is usually done if sowed on the rough ground of fall plowing. It seems plain to me that poor seed would not do well if planted deep and carelessly. It is feeble and needs nursing and care.

Many persons suggest the inquiry: "Even though this poor seed does start a good-looking and vigorous plant, is it sure to go on to maturity of stalk and head the same as good seed would?" I cannot see that it makes any difference what the seed was after the plant has started with good root and top and takes its nourishment all from the soil and the air.

Yours, etc., D. L. WELLMAN.

PROF. SAMUEL B. GREEN,

STATE EXPERIMENTAL STATION, ST. ANTHONY PARK, MINN.

Dear Sir.—In response to your request that we should express an opinion as to the advisability of using frosted wheat for seed, and give you our deductions drawn from the recent inspections at the State Experiment Station, of the plants growing from such frosted seeds. We are pleased to state that our visit was one of great pleasure, and instruction as well. It would be a misnomer to say that the sight of several hundred wheat plants, apparently vigorous and healthy, that had sprung from grains of wheat evidently *ruined*, by frost, for any practical purpose whatever, *was a surprise*, for it was in fact, an astonishing revelation.

The first question that arises in our minds, is, whether these plants will mature, notwithstanding their present healthy condition; or in other words whether these frosted and blighted grains contain sufficient vitality to produce plants and carry them to a point where they will be able to take care of themselves; Prof. Otto Lugger, whom we all regard as high authority expresses some apprehension on this subject, in his report to Governor McGill, under date of Jan. 2d, 1889.

Another point to be seriously considered, is the exceptionally favorable conditions under which the experiments are being conducted, as against the actual conditions under which wheat is sown, and under which it labors, in the preliminary stages of its growth. In your experiments, the seeds are sown at the uniform depth of one-half inch; in actual seeding, much deeper. The amount of vitality required in seed to push its way to light and air would, in the latter case, be correspondingly greater. Again; the conditions of heat and moisture under which these plants are being nursed, are almost perfect, while the conditions under which wheat in the Northwest is grown, are rugged in comparison. From these facts and observations we conclude that reasonably well filled grains of frosted wheat can be used for seed with comparative safety, while the use of the inferior class of frosted wheat would be attended with considerable risk.

The importance of determining just what class of frosted grain can be safely sown, cannot, in our opinion, be overestimated; and the earnest efforts of your colleagues and yourself will be watched with great interest. We believe you will be able to fully determine the question by natural propagation the coming season. We think you will concur with us in the opinion that the results and information obtained from the present experiments by artificial propagation, would hardly warrant the recommendation to sow any but the better qualities of frosted wheat.

Thanking you for courtesies extended in our recent visit, we remain,

Very truly, Yours, J. A. JAMES,
A. C. CLAUSEN.

ADDITIONAL EXPERIMENTS.

Since the foregoing experiments were completed, the following additional tests have been made:

Test No. 1.—Feb. 4th, thirteen samples of very much damagep wheat, of the grades so abundant this year, and considered in the foregoing report under numbers 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, together with a sample of No. 1 hard to save as a basis of comparison, were sown in a box in the greenhouse, in good prairie soil, without manure, one inch deep and kept moderately moist Feb. 8th. Just as the young blades showed about one-half inch above ground it was subjected to a temperature of twenty-two (22°F) degrees in the open air for three hours. This caused the young spouts to look very watery but did not seem to injure them, The following day, Feb. 9th, the plants were again placed in the open air for three hours,

where the thermometer recorded ten degrees (10°F). This time the young leaves were frozen so severely that about three-quarters of an inch of the ends was killed. The plants were now allowed to grow in the greenhouse until the morning of February 11th, by which time they had commenced to grow again and were two inches high. They were then, for the third time, placed in the open air, where the recorded temperature was four degrees above zero (4°F) with the result that about two inches of the tops, were so completely frozen as to be killed outright. I feared they would not recover, but by the morning of the fourteenth they were again two inches high, and fast outgrowing the damage. Only a very little difference could be seen between the growth and power of recovery of the plants from No. 1 hard wheat and those from very much damaged wheat.

Test No. 2.—This was carried on the same as test number one, only the soil was kept in a muddy condition. The result in this case was that the seed required a little longer time to germinate, but the plants recovered from the freezing they were subjected to, apparently in the same degree as the same samples in test number one.

Test No. 3.—This consisted in sowing the seed at the uniform depth of two inches and firmly packing the soil over it. The result in this case, so far as per cent. of germination went, was practically the same as in the foregoing report, where the seed was sown at a depth of only one-half inch.

REMARKS.

If this wheat had been grown at a lower temperature, than was the greenhouse, it would have been hardier and have resisted the freezing much better.

These tests are valuable in that they help to show the vitality of the seed and the power to resist unfavorable influences at the most critical period of its growth.

This poor wheat, some of which is frosted only, and some both frosted and rusted, and some only rusted, has given a high per cent. of germination, and shown an amount of vigor which has surprised me.

The wheat considered in the body of this report is, at this date, February 14th, in about the same relative condition as therein reported; and plants from the lightest frosted wheat do not show quite so much vigor as plants from the best grades.