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Pruning the Roots of Corn: Deep vs. Shallow Cultivation—Improving Corn: Cross Fertilization and Selection—Peas, Beans, Flax, and other Crops—Results of Seeding Rusted, Frosted and Frozen Wheat of 1888. Further Observations.

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PRUNING THE ROOTS OF CORN—DEEP VS. SHALLOW CULTIVATION.

WILLET M. HAYS.

In 1889 a trial was made to see what effect pruning the roots of corn would have on the crop of grain and fodder. In a field thirty-two rods long and eleven rods wide Rose Dent corn was planted in hills, with a check-row planter, and was cultivated with a shallow cultivator (Towers'). Twenty rows, running lengthwise near one side of the field, were chosen for the experiment. The roots of every alternate row were pruned as described below, while the even numbered rows alternating with them were untouched. The twenty rows were divided in the middle, thus giving two halves of twenty rows each. Eight one-tenth acre plots were then made, in the following manner: The first five odd numbered rows (pruned) at the south end, beginning at the west side, are called plot 1, and the first five even numbered rows alternating with them, constituted plot 2. So plot 3 was the five pruned rows in the southeast corner, and plot 4 the five rows alternating with them, and not root-pruned. Likewise, plot 5 was the five root-pruned rows in the north end, at the west side, while plot 6 was the rows alternating with them, and plots 7 and 8 were the five root-pruned and the five rows not pruned, in the north end, at the east side.

For pruning the roots, a strong butcher's knife was set into a piece of two by six scantling, fashioned into a runner, to slide on the ground. In front was a tongue, by which a man could pull the device, and behind, cultivator handles were placed, enabling another man to guide it. The knife blade was set in the runner so as to extend six inches into the ground, when the runner was on the surface of the soil. This implement was run along either side of the rows, six inches from the hills. Plots 1, 3, 5 and 7, were thus root-pruned, by going the long way of the rows, when the corn was seven inches high. On the same day the roots on plots 1 and 3 were more completely cut off by going across the field, skipping every other hill, so as not to disturb the even numbered rows on plots 2 and 4. This, of course, cut all the roots on plots 1 and 3 at a distance of six inches from the hills, on four sides, since all the main roots while the corn is at this age run n a nearly horizontal direction, unless the land is very dry.

When the corn was fifteen inches high, plots 1, 3 and 5 were again root-pruned the long way of the rows, and plot 1 was also root-pruned cross-wise. Passing on both sides of the hill being counted as one pruning, plot 1 was pruned four times, plot 3 three times, plot 5 twice, and plot 7 only

once. The effect upon the growth of the corn was very marked. The difference in the size of the plants in the alternate rows at the south end of the field was so great that many persons whose attention was directed to the field, without knowing of the experiment, noticed that the even numbered rows were decidedly larger than those which had their roots cut off.

The table given below emphasizes the fact, now generally accepted, that deep, close plowing of corn, is a source of great injury to the crop, which can be avoided by medium or shallow cultivation, cutting but few roots. The corn was not completely dry when husked, but the weights compare correctly, since the shocks were uniform in size, and therefore equally well dried. The planting and cultivating was uniform over the entire field. Since the plots root-pruned and those not pruned were made up of alternating rows, planted with a check-rower, no differences of soil or planting existed, and the difference in yield can be attributed to the root pruning alone.

PLOT.	GRAIN.		FODDER.	
	Pounds.	Bu. per a.	Pounds.	Tons per a.
1. Pruned 4 times	284	34	255	1 1-6
2. Not root-pruned	401	48	375	1 4-6
3. Pruned 3 times	253	30 1-4	300	1 2-6
4. Not root-pruned	417	50	305	1 2-6
5. Pruned 2 times	326	39	300	1 2-6
6. Not root-pruned	402	48 1-4	400	1 5-6
7. Pruned 1 time	308	37	340	1 3-6
8. Not root-pruned	399	48	350	1 3-6
Average of root-pruned Plots	293	35	299	1 1-3
Average of those not root-pruned	405	48 1-2	357	1 3-5

It will be observed that the difference in yield is more marked in those plots where the most root-pruning was done. An average difference per acre of thirteen and one-half bushels of corn, and of one-fourth ton of fodder, against root-pruning, was astonishing, though a very careful study of the habits of corn roots during several years past had shown me that great injury is done them by deep, close culture with the ordinary four shoveled, two horse corn cultivator, or with the "double-shovel" plow. Plowing deep and close to the hills is harmful at any time, but is especially so late in the season, as the larger roots developed late, as well as those which originated on the stalk earlier in its development, are severed.

In field L, which had also been cultivated on the shallow plan, two rows, seventy-five rods long, were root-pruned, with the same instrument as above mentioned, five inches deep and eight inches from the hill. This was done just as the corn was "laid by," the knife being run on two sides of each hill. Two other rows by the side of these were hilled up with a hoe to the height of four inches; and still two other rows, separating the two pairs of rows above mentioned, were left untouched. The season immediately following was quite dry, though the corn grew rapidly. The table below shows neither good nor harm arising from hilling done at this time, when compared with the two rows not treated. The two rows root-pruned, however, show an injury amounting to nearly three bushels of corn

per acre, from this apparently slight pruning of the roots, after cultivation had ceased.

ROW.	BU. PER ACRE.
1. Root-pruned	58
2. Hilled	60
3 and 4. Not touched	60 1-2
5. Root pruned	57
6. Hilled	61
Average of root-pruned	57 3-4
Average of others	60 1-2

As no detailed report of corn cultivator trials will be made before a year hence, it seems wise to here make a few statements regarding the best kind of implements for cultivating corn.

Some of the shallow cultivators used at this Station the past season, are more satisfactory than the common four shoveled, two horse corn cultivator. Of these, Towers' Cultivator gave rather the best satisfaction. But this, like many of the shallow cultivators, has the two handles and the beams bearing the blades held rigidly together, and can not, therefore, be "handled" to so good advantage by the plowman as if the beams could be worked independently of each other. Director R. P. Speer, of the Iowa Experiment Station, tried this, and a number of other cultivators, the past season. He reports, in substance, that the spring tooth cultivator, and others with the beams working separately, as in the common two horse walking cultivator, but having three or four, instead of only two shovels or teeth, on either beam, gave best satisfaction. I look on this class of cultivators as very promising. They can be run shallow and yet do good work, making a uniformly good "dust blanket," that will last throughout the season; and with them, the rows, as well as the spaces between the rows, can be kept clean. It is a great advantage to have the beams swing independently, especially when "cross-plowing" corn not dropped perfectly straight. The very best corn cultivator is the smoothing harrow. It should be diligently used until the the corn is four or five inches high.

IMPROVING CORN—CROSS FERTILIZATION AND SELECLION.

WILLET M. HAYS.

During the past two seasons the writer has studied and performed experiments, with a view to finding the best methods of growing, cross-fertilizing, and selecting corn, looking to the development of definite good varieties for each locality, and each particular use, as grain, fodder, etc. Progress in this kind of work is necessarily slow. Some interesting notes have been made upon crosses produced, some of which, together with a few facts suggested, and also hints regarding methods of raising corn for seed, are here given. I cannot refrain from repeating that along the northern edge of the corn belt no such clearly defined varieties are found as farmers have developed in sections farther south, where corn is King. Here the small patches grown are often of several varieties planted together, where they naturally mix, and the seed is selected without regard to any definite

type. Where corn receives more attention many farmers have learned, from long experience, that care in selecting and preserving seed is of great importance. Here there is even more need of thorough work in developing varieties, since we have so little seed which will really ripen, and is adapted to producing the best crop of ears and fodder.

In 1888, ears of numerous varieties were fertilized with pollen from other varieties, bags being placed over the ears to prevent the introduction of other pollen. As an example, pollen from a plant of an eight rowed white or yellowish Flint variety (No. 22, Squaw Corn) was placed on the silks of an ear of twelve rowed white Sweet corn (No. 35, Crosby's Early). The resulting ear had, of course, the general form of the Sweet variety, since the pollen from another plant affects only the grains the first season, the cob being merely a receptacle for the kernels. The grains, however, on this ear, are three-fourths like the male parent, resembling Flint grains, while the remaining one-fourth look like Sweet grains. There is no distinct gradation between the two kinds of grains, each one being in appearance either like Sweet corn or like kernels of Flint; Some of the latter showing only a slight tendency to wrinkle on the top.

A dozen or more of each of the two kinds of grains from this ear were planted the past season in separate, isolated places. The sweet kernels produced ears in form and size closely resembling Crosby's Early; a few showing no Flint grains; while most of them had a few, or several grains, in appearance like Flint corn. Most of them had twelve rows, like the female parent, while a few had eight, like the Flint, and one stood between the two in this respect, having ten rows of grains on the cob. The Flint like kernels produced ears much more slender, and longer, resembling the Flint parent. A few, however, were in form nearly like the Sweet corn, and with ten rows; or, with the two added rows reaching only part way from the butt. While the Sweet grains produced ears nearly all Sweet, the kernels of Flint produced ears with about the same proportion of the two kinds as were on the parent ear produced by the cross, viz.: one-fourth Sweet and three-fourths Flint.

Another example is had in an ear of a small yellow Dent variety (No. 13 Pride of the North), fertilized in '88 with pollen from a single plant of medium sized white Dent (No. 5, Rustler). The resulting ear had yellow and white grains in the proportion of one of yellow to two of white; though, in this case, the colors seemed to be more or less mixed in the same kernel. A dozen of the yellow kernels planted in an isolated place, produced ears resembling Pride of the North, excepting one ear, which closely resembled the white parent, both in form and in color. Several of the lighter colored grains were also planted in an isolated place. Most of the dozen resulting ears were nearly white, one nearly all yellow, while the light colored ears had several, or even a few dozen, yellowish grains. Both in form of ear and grain, the characteristics of the white parent predominated.

These results most clearly show how easily variations in corn can be made and "fixed." Radical results like these, in influencing the form of ear, kind of grain, etc., from the first season, illustrates that only a few years of careful selection are necessary to develop and fix a type of corn.

AN INTERESTING CASE OF CROSS-FERTILIZING CORN.

The engraving of corn herewith, represents a very interesting case of reversion to previous more or less remote ancestors. In a field in the northeast part of the Station Farm, was planted in 1888, Mercer Yellow Flint corn (Fig. 1). Thirty rods south, across a field planted to small grains and root crops, were planted a few rows of Black Mexican Sweet corn (Fig. 2). When husking the field of Flint corn, the laborers were told to save any ears having black grains, as it was thought some of the pollen from the Black Mexican would be carried across the field, and cross-fertilize grains of the Flint. Several ears of Mercer Flint were found, each with one or a few black grains. In no case had the Sweet variety given these grains the rough form of Sweet corn, but merely the color, while in form and hardness they resembled the Flint grains. A dozen of these dark colored grains were planted in the vineyard in 1889, far enough away from other growing corn so that no foreign pollen reached the plants. Three or four dozen ears were produced, every one of which was a proof that the pollen from the Black Mexican corn was the male parent which had fertilized the dark colored grains on the ears of Flint the previous year. Every ear had a few or many grains exactly similar in appearance to grains of Black Mexican Sweet. These grains are shown in Fig. 3, a few of which are marked B. S. The yellow Flint corn impressed its characteristics of form and color on some grains, a few of which are marked Y. F. The smooth yellow grains all have the appearance of Yellow Flint corn, and the form of the ear and cob also seemed to resemble this parent, though a few had twelve rows of grains. The Flint parent had eight rows, while the Sweet parent had, as a rule, twelve rows. Besides the Yellow Flint grains and the Black Sweet grains, above mentioned, there are Yellow Sweet, Y. S., grains, and Black Flint, B. F., grains. Even more surprising is it to find a few white Sweet grains, W. S., and a few white Flint grains, W. F., on nearly every ear. The color of the black Flint grains can be explained by assuming that the Flint parents form was predominant, while the color of the Sweet prevailed. And in case of the yellow Sweet grains we can assume that the form of the Sweet grains and the color of the Flint predominated. But in the case of the white Sweet grains, no such assumptions can be made, and no better presumption appears than that the black Sweet corn had, in no distant generation, been mixed with a very light colored variety of Sweet corn; and, in case of the white Flint grains, the form is after the form of the yellow Flint parental stock. and the color may have come from a previous ancestor of white Flint, or even of white Sweet. A still further, and even stronger proof of this "breeding back," or taking the qualities of ancestors more or less remote, is the fact that on several of the ears were grains of Sweet corn showing a reddish, or flesh colored tinge. This reddish color is peculiar to a class of Sweet corn called Early Narragansett, and the color here may be from some reversion to previous ancestors of this kind of corn, with which the Black Mexican grand-parent may have been mixed.

The practical lesson taught by the example of an ear with six or seven kinds of corn shown, is that we must "breed" our corn for a number of years pure, and carefully select the seed, according to some type, if we

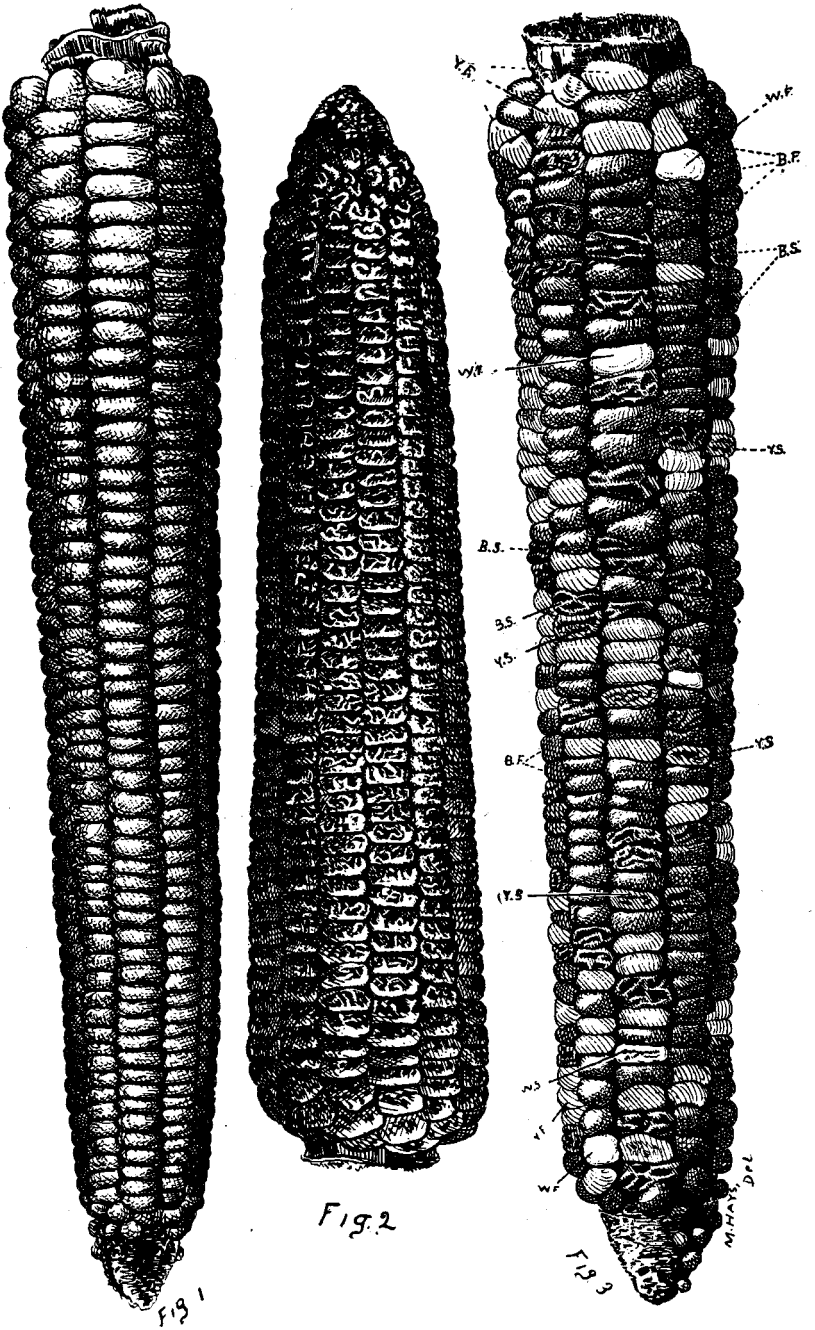

Plate showing two parent ears. Fig. 1, Yellow Flint; Fig. 2, Black Sweet; and the result of the cross, Fig. 3.

would have distinct varieties. The principles of heredity may find as practical application in breeding corn as in breeding cattle. This is a good illustration of the value of pedigrees, and also plainly and forcibly illustrates the value of thoroughbred ancestry in raising animals. Here both parents probably had recently been crossed with different varieties, and the different ancestral characteristics reappeared, and determined the form or color, or both, of some of these kernels. Further, we have illustrated here the effect of making radical crosses. Some of the young grains resemble one parent, and some the other, while yet others resemble parents more remote. The same thing occurs here as when Jerseys and Short Horns of other especially beefy type are bred together. In that case, some veritable Jerseys for performance at the pail, are produced, and others, like the Short Horns, are adapted for beef. Others revert to remote ancestors, or in some way manifest a combination of the inherited qualities of their ancestors, and are in appearance quite unlike either parent.

So, in corn growing, it pays to keep seed pure. Retain one intelligently selected type, and by cultivation and selection, and even by cross-fertilization, improve and "fix" the desired type.

A PLAIN WAY OF IMPROVING CORN.

Farmers in every corn growing locality should develop varieties of corn suited to the existing conditions, and raise seed for sale. And other farmers should encourage such work, by paying well for well preserved seed of varieties especially and successfully "bred" for their needs. At one dollar per bushel for the selected one-third of the crop, money can be made at raising seed corn. I have been repeatedly asked two and one-half dollars per bushel for inferior seed, in the neighborhood of the Station, and the price of seed corn in our seed stores is often unwarrantably high, considering the quality. Carefully saved seed, kept pure, and selected to one type adapted to this immediate locality, would soon get a reputation, and could be sold at a good price. The kind of corn most desired here is a Dent variety, which will yield large crops of good grain. The fodder comes along with the crop of grain so cheaply that we hardly need pay attention to developing stalks of a certain type. We should select large, early maturing, well formed, solid ears, with deep grains; and, if a Dent variety, a cob large enough to carry a goodly number of rows.

A small part of the farm could profitably be set apart for growing seed corn. This should be rich land, which is neither subject to being too wet, nor drouthy. A deep, open clay, or loamy sub-soil, is best. A three years' rotation could be carried out, with a small grain crop and clover, or the last named crop sowed with the corn and turned under green for the corn crop. The land should be thoroughly prepared, for corn. It may be manured, with well rotted barnyard manure, and should be plowed in the fall previous, six or seven inches deep, or deeper in moister climates and on stiffer soils. In the spring the soil should be thoroughly pulverized, to the depth of two to four inches, and the seeds planted in hills. Two, or at most, three stalks in each hill are sufficient; and if the trait of stooling, or tillering, is entirely absent from the variety chosen, only one or two stalks may

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be better, as the proportion of good seed ears would thus be increased, though less bushels of corn would be produced than if raising the crop merely for grain. The land should be harrowed with a smoothing harrow, several times before the corn is five inches high. Then the rows should be cultivated rather shallow, about once a week, until the corn is nearly ready to tassel. No weeds should be allowed to grow, and the hoe should be used both before and after ceasing to cultivate with the plow. Corn growing so thinly upon the ground will not produce enough shade to prevent the growth of weeds, even after it has reached the full size, and these will use the moisture and plant food in the soil which should be conserved for the corn.

For foundation stock, the best corn that can be had in the vicinity should be secured. A trial of several promising kinds may be made in small plots the first year, while getting the land ready, and the best of these can be chosen. Enough seed of each variety planted should be secured, so that some of the original found best can be saved to plant the next year, as that raised in the small plot tests will have become mixed with the other varieties. When the corn is beginning to show its tassels, the field should be passed over every two or three days and the tassels destroyed on all except the stalks which show the best promise of good ears. This insures that only pollen from stalks bearing ears fertilize the corn. Then when the selection of ears having good size and form is made in the fall, the chances are that the male parent as well as the female parent of each kernel was a plant bearing a good ear. With many varieties it is rather difficult to determine whether a stalk will bear a good ear before the tassel is out, and some good ears will be developed on stalks from which the tassels were cut.

The seed should be "picked" from the field while the stalks are yet standing. If it is desired to produce an early ripening variety, those ears maturing earliest should be chosen (a rather sandy, warm, "early" soil might also help in securing early development). While selecting the seed, the choicest ears, those most nearly approaching the desired type, should be placed alone, to be used for seed in this "seed corn patch." The remaining good ears can be used for field planting, or sold at a good profit. Doubtless the best method for drying seed corn is by artificial heat. The corn should be hung up by the husks, or loosely laid on shelves, not piled up, in a room where moderate heat may be kept up very cheaply for a few weeks, by means of a stove. This corn can then be laid in a dry, cool place, for the winter, but should never be hung over bins of grain, nor where the vapors from animals will reach them. Corn thus thoroughly dried seems to better withstand cold, damp soils, if planted early in spring. It is wise to keep enough of this selected seed with which to re-plant, or to plant the succeeding season, should accident befall the "seed patch" crop. By this method of improvement, the farmer could continually improve the quality of his corn, and its adaptability to his locality. Those who purchase this seed would not be successful competitors in raising his kind of seed corn unless they used similarly good methods, and had as good or better soil; and his business would, with a little judicious advertising, increase from year to year. As a rule, only one or two varieties should be grown for this pur-

pose on the same farm, and these "seed corn fields" should be thirty or more rods from any other corn. This is one of the small diversities in farming which would well repay the careful farmer who has suitable land, and it would be of great benefit to his neighbors.

A year ago I asked farmers to send half a dozen ears of any promising kind of corn of distinct type, now successfully grown in the State, to the Station, where we would pay the express. Only three samples came. I repeat the request, and would be pleased to correspond with farmers regarding their varieties of corn. Fifteen bushels per acre could be added to Minnesota's corn crop, by continuous and intelligent selection, by skillful practice in the production, and proper care of the seed.

PEAS, BEANS, FLAX, AND OTHER CROPS.

WILLET M. HAYS.

Small plots, on a rather rich soil, were planted in the spring of 1889, to the following named fodder and grain crops, as a beginning in studying the value of peas, beans, etc., for feeding to stock; also to make comparative tests of the varieties of all these crops.

HORSE BEANS, from Thorburn, planted May 28, in rows two and one-half feet apart, also broadcast, did fairly well, growing to the height of 26 inches, until the flowers and pods began to form, when the hot sun, dry atmosphere, or other unfavorable condition, prevented the formation of only a small crop of seeds.

Lupin's, Yellow, Thorburn, planted May 28, in rows and also broadcast. Grew to a height of only 10 inches. Not worthy of cultivation.

Lupin's, Blue, Thorburn, grew two feet high, and produced the 24th of July, 10½ tons of green fodder per acre. This is the best of the Lupins, as shown by a test here during two seasons. It might pay some farmers to grow this variety, especially those who keep sheep.

Lupin's, White, Thorburn, grew 20 inches high, and yielded 7½ tons of green fodder per acre.

COW PEAS.—Several varieties of cow peas were drilled in rows two and one-half feet apart. They produced from 10¾ tons to 18¾ tons of green fodder per acre, thus furnishing large crops of rough feed, rather rich in albuminoid compounds. None of these plants ripen here, and but few varieties succeed in even forming pods.

Seeds from Henderson were planted May 6th. Frosts killed the plants, and it was necessary to replant in the latter part of May. Only a fair stand was produced. When cut, Sept. 6, a few pods were showing, and a yield of 11 tons of green fodder was harvested.

The following named varieties of cow peas were received from Mr. J. H. Alexander, Augusta, Ga., and were planted May 25th, or nearly as early as was safe, on account of late frosts.

Unknown Pea.—Quite inclined to falling down. When cut, Sept. 6th, many pods were showing, and a yield of 16 tons per acre, of green material, was harvested.

White Table, or Mush Pea.—Stood rather erect. Sept. 6th, was not yet in blossom, but yielded 12¾ tons of green fodder per acre.

Black Pea.—Stood up well. Sept. 6th, was not yet blossoming, and yielded 13¾ tons of green material per acre.

Yellow Crowders.—Stood up well. Sept. 6th, was not yet blossoming, but yielded 10¾ tons of green fodder per acre.

Speckled, or Java Pea.—Sept. 6th, not yet in flower, but yielded 10 tons of green material per acre.

Red Rippers' Pea.—Sept. 6th, was mown, yielding 11¾ tons of green fodder per acre. An upright grower. No flowers.

Miller Pea.—Sept. 6th, yielded 18¾ tons green fodder per acre.

FIELD PEAS.—A number of varieties of field peas were planted, part of most plots in drills and part broadcast. The figures below, giving yield of green fodder per acre, all refer to the broadcast seeding.

Blue Canada Field Peas.—Henderson. Planted April 26th. Rather erect, standing 40 inches high. Cut July 22d, two days past the "green pea" stage, when they yielded 11 tons of green fodder per acre.

White Canada Field Peas.—Henderson. Planted April 26th. Two weeks earlier, but did not yield so large a crop as the one named above. This is not like other white Canada field peas mentioned below.

Blue Canada Field Peas.—Henderson. Planted May 6th. Peas large enough for cooking July 22d, when those sown broadcast yielded 9½ tons of green fodder per acre. Another plot of the same, harvested Aug. 23d, yielded 28 bushels per acre of ripe peas.

No. 1, White Field Peas.—Ferry. Planted and harvested same time as last. Yielded 12 tons of green fodder and 18½ bushels of ripe peas per acre.

Common White Field Peas.—Gregory. Sowed broadcast May 12th. Yield of ripe peas 40 bushels per acre.

Blue Prussian Field Peas.—Gregory. Planted May 12th, harvested Aug. 23d, yielding 32 bushels of ripe peas per acre.

In these field peas we certainly have a most promising crop for producing muscle forming foods or grains, to go with our great quantities of very cheap rough fodders, as hay, straw, corn fodder, etc., and to balance them up so as to furnish animals more nearly standard rations. Whether we can afford to grow them on our cheap lands, with high priced labor, better than to purchase bran, shorts, or even oil cake, is not certain.

Our machine inventors should originate machinery for harvesting and threshing large crops of these. If we had pea machinery as well perfected as machinery for wheat, crops of peas would pay well. They are excellent in rotation with wheat, as they, like clover, put the land in good condition for that cereal.

GARDEN PEAS.—Several varieties of common garden peas were also planted, but these did not produce so much feed per acre as the Canada field peas.

New White Prince Albert, for example, was one of the best, and produced only 6½ tons of green fodder per acre, when in the green pea stage, on July 22d; while

White Marrowfat, planted April 26th, yielded on July 24th, when a little past the green pea stage, 8½ tons per acre of green fodder.

Numerous other varieties were grown, but as they made comparatively small yields, no note is made of them. Doubtless none of these kinds will compare favorably with Canada field peas for producing ripe peas, green fodder, or for sowing with oats.

OATS AND PEAS SOWED TOGETHER.

Three plots were sown to white Canada Field Peas and Probster Oats, in various proportions, to get at the proper amounts of each to sow in this kind of a mixture, grown for fodder or for hay.

Sowing seventy pounds of peas with sixty pounds of oats per acre, resulted in the oats smothering the peas, on this rich land.

One hundred and five pounds of peas with forty-five pounds of oats likewise proved to be too small a proportion of peas.

Even in the third plot, on which one hundred and forty pounds of these white field peas were sown with only a bushel of oats, there were too many oats. The conditions were favorable to the stooling of oats, and they smothered many of the plants of peas.

Similar plots, in which Blue Canada Field Peas were mixed with Probster Oats in the same proportions as the three before named plots, did nearly the same, in that the oats crowded the peas too much, even in the plot on which two and one-third bushels of peas per acre were sown with one bushel of oats.

Though further experiments are necessary, I think that either the Blue or White Canada field peas are the best sorts to sow with oats. I would advise sowing in the proportion of three bushels of peas with a bushel of oats, or, where the oats will stool a great deal, two-thirds of a bushel of oats. Theodore Louis, of Wisconsin, on his manured land sows only one-half bushel of oats and two bushels of peas per acre, but on drouthy and poor land, in a former trial, I did not find two bushels of peas enough. How this crop will compare with peas alone, as a fodder and hay crop, our experiments do not as yet indicate. The thinly seeded oats are in many cases useful in preventing the peas lying very flat. Certainly this annual crop would leave the land in our wheat growing sections in nice shape for that cereal the next year. So much seed per acre would seem rather expensive, since peas usually sell for rather more per bushel than does wheat.

BUCKWHEAT.—Several plots were sown to Buckwheat in the last of April, but frosts shortly after the middle of May cut them down. A few were re-sown May 25th, and made good crops. Silver Hull—from Northrop, Braslin, Goodwin & Co., of Minneapolis, stood three feet high, and was harvested Sept. 6th, yielding 20 bushels of seed per acre. Quality good.

Japanese Buckwheat.—N., B., G. & Co. Stood 30 inches high and yielded 20 bushels per acre.

Common Buckwheat.—Hend. 20 bushels per acre.

Japanese Buckwheat.—Thorb. 33 bushels per acre.

Common Buckwheat.—Thorb. 26 bushels per acre.

MILLET.—Several kinds of Millet were sown May 25th, on a rather rich soil.

Common Millet.—N., B., G. & Co. In flower July 23d, and yielded 9¾ tons per acre of green fodder. Another plot of the same yielded 10½ tons per acre.

Hungarian Millet.—Hend. Was cut Aug. 14th, yielding 10½ tons of green material per acre.

Golden Wonder Millet.—N., B., G. & Co. On Aug. 14th yielded 12½ tons of green forage per acre.

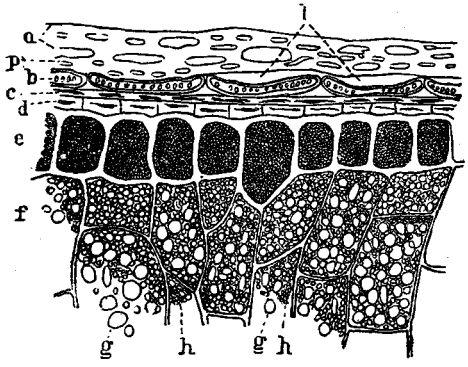
In purchasing Millet seed, care should always be taken to get only the best seeds, of the largest kinds, German or Golden Millet, as these are best. If seedsmen send you "pidgeon grass" or "fox tail" seed, or other small kinds of the millet family, let it be known. Our attention has been called to some such cases already. For hay, millet should always be cut before all the heads are in blossom, as the quality is much better than when the seeds have formed, and this crop is rather hard on the land if allowed to form or ripen its seeds.

Millet, instead of so much summer fallow, pays in many of our wheat raising districts, as wheat seems to do as well after millet as on summer fallow, and this crop is very effective in killing weeds. In extreme northern counties of the Red River Valley, some farmers prefer the medium sized or common millet, as they can harvest it earlier, giving a chance to "fall plow the land" earlier than the German or golden millet, which matures later, when its large stalks cure slowly.

RESULTS OF SEEDING RUSTED, FROSTED AND FROZEN WHEAT OF 1888. FURTHER OBSERVATIONS.

D. N. HARPER.

The wheat grain although apparently so simple is yet a very complex body. Of the numerous varieties of wheat, all, if uninjured, have essentially the same structure and contain the same chemical compounds but in different proportions. At one end of the grain there is a depression where the *germ* is enclosed—a minature plant folded up—and at the other end is a multitude of verv fine hairs called the *beard*. The interior of the grain, the *eudosperm*, comprising about 85 (⅞) per cent. of its weight, is almost exclusively starch and gluten. Oblong grains of starch are surrounded by numerous smaller grains of gluten, and, according to Mege Mouries, the proportion of gluten increases from the center of this interior part outwards to its limits. Surrounding this interior part is a thick, tough, tight-fitting



a, the epicarp; b, the endocarp; c, the testa; d, the tegmen; e, the perisperm; f, the endosperm; g, starch granules; h, aleurone grains—gluten.

covering, the *perisperm*, which ends at the top and bottom of the germ, and comprises about one-tenth of the total weight of the grain. Contrary to the general opinion it contains *no gluten* but the albumen of the grain, oil, mineral salts (phosphates etc.) and cerealine, which, according to Mege Mouries, is a ferment the same as in yeast. This layer acts as a sort of digestive apparatus for the wheat germ. It takes up the moisture from the soil, converts the albumen, starch, gluten, etc., into soluble forms, and carries these to the germ as food. Outside this covering and surrounding the entire grain are two very thin layers making about 2 per cent. (1-50) of its weight. The inner one, the *tegmen*, is transparent and the outer one,

the *testa*, is colored. The color of the wheat, yellow, red, etc., is derived from this layer. Surrounding these and not adhering very closely are three layers, the *endocarp*, the *epicarp*, the *epidermis* or *cuticle*, of the same chemical composition as the straw. All are transparent and elastic and comprise about 3 per cent. (1-33) of the weight of the grain. In milling, these outer layers are first separated and then by the Hungarian system (the roller process) the other layers are separated down to the interior of gluten and starch. The old process of milling does not remove the three layers immediately surrounding the gluten and starch, or does so only imperfectly, and this makes the distinction between such flour and "patent" flour. If any of the perisperm is ground up and left in the flour it causes this to be more or less discolored when moistened. Wheat can be milled the more easily and economically the smoother the hull is, and if for any reason this has been badly injured the value of the wheat for making patent flour is hereby decreased. The hull of wheat may be badly injured without affecting the germ or the interior; so that although for milling it is poor and consequently grades low, it may be of good quality for seed inasmuch as the power to grow and reproduce does not depend upon the smoothness of the hull but upon the vitality of the germ and the amount of readily derived food. In 1888 unfavorable conditions affected the wheat so that it failed to grade well according to our empirical standards; for commercial purposes it was therefore generally known as "poor" wheat without further distinctions being made. But the causes producing this "poor" wheat were different and they effected different results so that there were really several kinds of "poor" wheat. These differ in appearance as well as in the nature and proportion of the chemical constituents. As indicating the cause of injury I have classified them as bleached, rusted, blistered, and frozen.

BLEACHED WHEAT.

This is caused by the wheat grains being subjected after harvest to a succession of rains and hot suns whereby the outer envelopes, instead of being transparent and elastic, are rendered opaque and brittle. This is a purely physical injury and it does not affect the wheat for seed unless this succession of drenching rains and hot suns has continued for a considerable time. Then indeed the injury may be more than superficial. No wheat in 1888 was rendered poor for seed by reason of its being bleached but there is doubtless some of the last crop thus injured.

RUSTED WHEAT.

The greater part of the Red River Valley in Minnesota was affected more or less by rust.* The eastern border of the Valley where the soil is light and sandy and therefore drained well was least affected or not at all. Some places in the interior of the Valley and many others on the lands nearest the river also escaped or were but slightly affected on account of favorable local conditions. Rust was prevalent in Dakota, too, but I have not observed its limitation as closely as in Minnesota. Where the parasitic rust had longest to operate while the wheat was yet far from mature we find the

*See Bulletin No. 5, pp. 46, et seq.

worst diseased or rusted wheat. Between these extremes of only slightly rusted and badly rusted wheats are many grades of "poor" rusted wheat.

Rusted (blighted) wheat is more or less shrunken in appearance, usually of deeper amber color than normally and has had the relations of its chemical constituents somewhat altered without there being any chemical change in these. Rusted wheat of 1888 contains more gluten and protein and less starch than where normal so that it appears likely that the rust has lived upon the saccharine and starchy juices of the plant, thus diminishing the amount of starch. It is a poor wheat for milling because of the bad condition of the hull. If not too much injured the results of this year show it may be made good for seed, as detailed further on.

BLISTERED (FROSTED) AND FROZEN WHEATS.

In Polk, Marshall and Kittson counties as well as in isolated localities farther south,—Rolette, Pelican Rapids, etc.—the frosts of August 9th–17th, 1888, caused other results. Wheat that had not been attacked by the rust was for the most part too far advanced to be injured by frost, if indeed not already harvested; or the conditions which had prevented rust operating also prevented frost. The effects of low temperature on the wheat grain vary greatly according to the stage of growth and the severity of the low temperature. Before maturity water is present holding substances in solution. As the grain ripens these are deposited, and when mature the amount of water present is directly dependent upon the amount in the atmosphere, and its condition is similar—being excess moisture. Our cured wheat is not affected by our lowest temperature, but a few degrees below freezing has its effects on immature and uncured wheat.* In the early stage of the grain water is the chief constituent, but this becomes less and less as the grain approaches maturity when there is the least. "In the milk" the grain consists of about 75 per cent. (¾) water while when mature this is only about 10 per cent. of its weight. By sweating, still more water is taken out. Wheat well into "the dough" stage if subjected to a temperature below freezing may be *blistered* (frosted) but when "in the milk" the same temperature produces *frozen* wheat. As blisters may be caused by other means than frost and even after the wheat is cut, it is not correct to call all such wheat *frosted.*

BLISTERED WHEAT.

Blisters are an unnatural condition of the hull which instead of being tough and elastic is brittle; but no change in the chemical constituents of the grain is apparent.

In *blistered* wheat, where the cause was frost, the life of the plant may have been cut short by a few days or more and the small amount of food (it may be exclusively starch) which would then have been laid up is lost but that already stored up has not been affected.

Blistered (frosted) wheat retains the normal amber color but has in many cases more gluten and protein and less starch than sound wheat, and is injured for milling on account of the bad condition of the hull. Only in

*See Bulletin No. 5.

extreme cases has there been any injury to the germ and its surrounding food, so that it is all right for seed, if well cleaned, except in some cases where frost has caused the injury, because of the tardiness of the wheat to mature. Killing frosts may be expected in the most northern counties by the middle of August, and it requires at least eighty-five to ninety days from the time the seed is sown and sprouted for a crop to mature. If under favorable conditions the wheat has required much more than that time it shows a tendency to become later ripening and although the grain in itself may not be injured this fact renders it unfit for seed.

FROZEN WHEAT.

Frozen wheat is badly shrunken, has lost the normal trauslucent amber color, is of an opaque bronzed appearance and has had the composition of its chemical constituents changed as well as the internal structure of its cells destroyed. It is unfit for milling because no midlings can be separated and there is left no gluten or only slight quantities very badly injured. The best samples of frozen wheat may be no worse for seed than the poorest grades of blistered wheat—both are bad.

These various kinds of poor wheat were used for seed in the spring of 1889 and since the beginning of June I have made a number of trips through the portions of the state affected, studying the results. Many samples of the seed and its crop have been collected and analyzed and from these analyses, the reports of farmers raising the grain and my own observations it is shown (1) that seed of the different kinds of poor wheat of 1888, directly affected the crop, producing differences in its quality and quantity. (2) Frozen wheat has not yielded a good crop either in quantity or quality; (3) rusted and frosted wheats have exceeded all expectations and where well cleaned have yielded a good crop so that (4) the inspection grade of wheat, which is based upon the commercial value for milling purposes, does not, invariably, determine the value of wheat for seed; (6) the better the seed as determined by its density, the greater its vitality and the better the crop in every way.

FROZEN SEED AND ITS CROPS.*

In *frozen wheat* besides the life of the plant having been cut short there has also been a change in the chemical constituents and a further mechanical change of the interior whereby the former cell structure has been destroyed. This destruction of the cell structure and sudden change in the chemical constituents did not cease with the cause that produced them. Fermentation set in and the chemical constituents were further changed into acetic acid, etc., so that stacks of such wheat are spoken of as "vinegar factories." This wheat when planted in the spring was much worse than when harvested and threshed. But in the majority of the grains the germ was not killed so that the wheat therefore grew and produced—the same kind of wheat.

Where this frozen seed was sown on land on which such wheat was raised in 1888 the greatest number of similar grains are to be found in the crop. Even where the seed was good if the previous crop on the land was badly frozen there are such grains in this last crop, and this is to be ex-

pected. Every year there is more or less volunteer wheat; next spring there will be less than for many years because the conditions of temperature and moisture last fall were most favorable for germination of the wheat which shelled in harvesting, and of course the subsequent cold weather has destroyed these plants. But the fall of 1888 was very dry, the wheat shelled badly in harvesting and the dry fall forced most of these grains to wait over until spring for germination.

The results of this year seem to show that here we have an example of the transmission to the offspring of a characteristic developed in the parent by accidental outside influences I have not attempted to establish this by the product from individual frozen grains but wherever 1888 wheat containing frozen grains has been used for seed, there are so many grains in the crop similar in appearance and properties to these frozen grains, and without a repetition of the conditions which originally produced them, that it can be explained only in this way.

321. Scotch fyfe of crop of 1888, from W. H. ——, S. E. of Crookston. The measured bushel contains 1,231,500 grains of which 61.5 per cent. (3-5) are frozen and immature grains devoid of gluten, 35 per cent. (over ⅓) are blistered and shrunken but contain gluten and 2.5 per cent. are sound, uninjured grains. This was the best wheat harvested on this farm in 1888. Before seeding in the spring of 1889 two-thirds were cleaned out and the crop is from the remaining third.

598. Best of the crop from 321. 52 per cent. of the grains are similar to the frozen grains of the seed and appear to be devoid of gluten. The remainder are uninjured.

597. From the same farm but the crop from 1 Hard wheat, brought from the western river border N. W. of Crookston. Excellent wheat except for a few grains similar to the frozen grains of the 1888 crop on this same land. Samples 597 and 598 were raised under the same conditions of cultivation, etc. 598 is from three years old land and 597 from land on which this is the 5th to 8th consecutive wheat crop.

Fifteen per cent. of 321 is too light to sink in water. The analysis is of the part which sunk.

	321	598	597
100 grains weigh (grams)	1.410	2.270	2.734
Water, per cent	9.92	8.66	8.51
Protein, "	16.56	14.71	12.08
Starch, etc."	73.52	76.63	79.41
	100.00	100.00	100.00
Gluten, fiesh, per cent	18.95	26.65	28.7
Gluten, dry, "	7.06	10.66	11.48
Gluten, quality	very poor	very poor	excellent.

Samples 597 and 598 were taken before the heavy rains and scorching suns during harvest had their full effect. Samples of the same after the wheat was for several more weeks thus exposed, are very much worse in appearance, being badly bleached, but the difference due to the seed is apparent, however. Sample 598 is very poor wheat because of the many grains

similar to frozen wheat, which are undoubtedly direct descendents of those frozen grains. That there are some of the same in 597 is not at all surprising. The fall of 1888 was very dry and but little of the wheat which shelled during harvest sprouted then. The Spring of 1889 was dry and this "volunteer" wheat grew up along with the good seed. The wheat most damaged shelled the most in 1888. The natural order was here reversed. Grains at the end of a head of wheat mature earliest and shell out but here an exceptional cause produced exceptional results, so that the seed for the "volunteer" crop of 1889 was doubtless very much poorer than sample 321 where only 2.5 per cent. of the seed was sound and even the remaining grains, which contained gluten, were of much reduced vitality. The seed actually planted was much better than 321, but when the contest came between an army of plants from badly frozen grains, either intentionally or accidentally seeded, and fewer plants from better grains, many plants from the badly frozen grains must have continued to grow, particularly when a vast maiority of even the best grains were of much reduced vitality. In 597, however, the seed was sound so that when a conflict came between these plants from this good seed and the "volunteer" plants from frozen seed the latter must for the most part have been overcome so that fewer plants from frozen seed could continue to grow and produce a crop. Wherever wheat has been sown on ground where there was frozen wheat in 1888 some grains have appeared similar to those frozen grains. Where the seed was of great vitality there have been the fewest of these grains, but where the same seed that was raised in 1888 off this land was again planted in 1889, there has been the greatest number of these bad grains. The better the wheat was cleaned for seed the better the chances for a good crop. During the growing season and until after the wheat was harvested the difference between 597 and 598 was not very marked. On examining the field from which 598 was taken on September 10th, 1889, Mr. H. remarked "Well, that wheat has changed terribly since it was cut! It was then nice and plump." But 597 seemed better then than ever, probably by the contrast. Now I have observed this to be a characteristic of the crop from frozen seed—without any external cause it has fallen away "terribly" after being harvested.

590. Scotch fyfe from M. C. W——, Stephen, Minn., raised in 1889 from good No. 1 Hard seed brought from the sandy lands about fifteen or twenty miles to the east. Fine light amber colored grains plump and sound with an occasional grain like the 1888 frozen grains; the sixth crop raised on this particular field. The measured bushel contains 916,176 grains.

591. Another crop from the same seed, and on an adjoining field on which this is the second crop. The grains are larger than those of 590, the measured bushel containing 820,300 grains; otherwise like 590.

592. Crop from the farm adjoining to the east, and raised on new land from the best of wheat of the previous year's crop. I could obtain no sample of the seed as it had all been used. The screenings cleaned out were badly frozen and shrunken grains. Some of the grains of 592 are perfect but most of them are shrunken somewhat and many are similar in appearance to the badly frozen grains of the previous crop.

593. From summer fallowed land on the same farm. The measured bushel contains 913,400 grains of which one-third (33.3 per cent.) are similar to the frozen grains of the previous crop; 58 per cent. are of good amber color but shrunken and 8 per cent. are perfect.

594, 595. Samples from old land—three to six years—from same seed as 593 and 592 on same farm. The measured bushel contains 1,167,000 and 1,001,000 grains respectively. 592-595 are of about the same appearance, —the wheat from the older lands being poorer than from new and summer fallowed ones.

	590	591	592	593	594	595
100 grains weigh	2.623	3.06	2.325	2.348	1.856	2.400
Water	9.00	8.89	9.99	9.35	6.88	8.58
Protein	15.79	14.57	14.95	16.81	15.34	15.28
Starch, etc	75.21	76.54	75.06	73.84	77.78	76.14
	100.00	100.00	100.00	100.00	100.00	100.00
Gluten, fresh	36.50	35.64	31.06	31.17	32.26	29.63
Gluten, dry	14.60	14.26	12.42	12.46	12.90	11.85
Gluten, quality	excel.	excel.	poor	poor	poor	poor

The seed from which 592-595 was raised is from the original seed used on the farm. It has therefore spent seven or eight generations there. It is likely that notwithstanding considerable care the vitality has been impaired by its long residence on one farm. On the large farms in the Red River Valley it is almost impossible to prevent deterioration of the seed unless it be changed frequently. There are many causes for this which will suggest themselves immediately to those familiar with the conditions.

Here again as everywhere that frozen wheat was planted, the difference between the crop from sound seed and the crop from frozen was not marked until after the wheat had been harvested.

322. Scotch fyfe of 1888 from S. M. ——, S. E. of Crookston. The measured bushel contains 1,392,600 grains of which 4.5 per cent. are sound, 25.5 per cent. are shrunken and 70 per cent. are frozen. I do not know how well this was cleaned before seeding and have not yet gotten a sample of the crop. An examination of this on the farm before threshing showed it to be similar to the crop from 321.

	322
100 grains weigh, grams	1.488
Water, per cent	8.91
Protein "	17.38
Starch, etc."	73.71
	100.00
Gluten, fresh, per cent	16.50
Gluten, dry, "	5.85
Gluten, quality	very poor.

325. Blue stem wheat from S. C. ——, Crookston. The measured bushel contains 2,006,400 grains of which 12 per cent. are sound, 30 per cent.

are shrunken and 58 per cent. are frozen. It was cleaned before seeding but I do not know how much. I have not been able to get a sample of this crop.

	325
100 grains weigh (grams)	1.825
Water, per cent	8.79
Protein, "	14.75
Starch, etc."	76.46
	100.00
Gluten, fresh, per cent	21.3
Gluten. dry, "	8.5
Gluten, quality	poor.

The farmer said to me in explanation, "When I saw the wheat after it had been threshed I was so mad I didn't want to have anything more to do with it. Before that I was sure that I should show you that I could raise a good crop from such poor seed. Then you would have had a sample." This may explain why it has been almost impossible to get samples from such seed unless I have been on the ground myself.

464. Blue stem wheat from W. C——, Stephen. The measured bushel contains 1,101,200 grains of which 18 per cent. are uninjured, 54 per cent. are shrunken and 28 per cent. are frozen and immature. The crop contains very many grains similar to the frozen ones in the seed.

	464
100 grains weigh (grams)	1.975
Water, per cent	12.97
Protein, "	13.04
Starch, etc."	73.99
	100.00
Gluten, fresh	12.08
Gluten, dry	4.83
Gluten, quality	very poor.

468. Blue stem from E. M—, Devils Lake, N. Dak. The measured bushel contains 1,381,000 grains of which 2 per cent. are sound, 11 per cent. are shrunken, and 87 per cent. are frozen and immature. Mr. M. writes that the crop is a failure and he can send no samples. Sample 467 of Defiance seed on the same farm has yielded sound wheat although the great drought made the yield very light.

	468
100 grains weigh (grams)	1.290
Water, per cent	8.64
Protein, "	13.71
Starch, etc."	77.65
	100.00
Gluten	none.

475. Blue stem wheat from G. H. W—., Grand Forks, N. Dak. The measured bushel contains 1,234,700 grains of which 2 per cent. are sound, 40 per cent. are shrunken, 58 per cent. are frozen and immature. The

crop from this seed was, in the first part of August, one of the finest stands in the valley. I have not yet received a sample of the crop but know it to have been of very poor quality. In this locality the conditions throughout the season were most favorable and if such seed did not produce good wheat it is certain to fail anywhere.

	475
100 grains weigh (grams)	1.394
Water, per cent	12.03
Protein, "	11.25
Starch, etc."	76.72
	100.00
Gluten	none.

476. Scotch fyfe from L. S., Larimore, N. Dak. The measured bushel contains 1,316,500 grains of which 27 per cent. are badly frozen and contain no gluten, 65 per cent. are more or less shrunken and 7.5 per cent. are sound and plump. Over one-half was cleaned out and the balance seeded. Only a small strip on the edge of the field near the buildings was seeded, where the snow had been banked up in the winter previous. The crop from this was poorer by far than the rest where good seed was sown. This is the nearest approach to a good crop from such seed, but as cleaned, very few, if any, frozen grains could have been seeded.

	476
100 grains weigh	1.554
Water, per cent	11.06
Protein, "	13.61
Starch, etc."	75.33
	100.00

BLISTERED AND RUSTED WHEATS AND THEIR CROPS.

317. Scotch fyfe wheat from E. A. M., Pelican Rapids, Minn., crop of 1888. The measured bushel contains 1,121,900 grains of which 50 per cent. are sound, 43 per cent. more or less shrunken and 7 per cent. are immature grains with an occasional frozen one. I am not informed how well this was cleaned before seeding.

891. The crop from 317 from land on which this is the fourth to seventh successive wheat crop. The yield was 22 bushels per acre, machine measure, but from 2½ acres which the preceding year grew potatoes there were 42 bushels per acre reported. This farm was originally cleared from timber of ash and poplar, and for the last crop was fall plowed and seeded by Van Brunt broad-cast seeder, one bushel per acre by measure.

	317	891
100 grains weigh (grams)	1.747	
Water, per cent	6.40	7.92
Protein, "		9.33
Starch, etc."		82.75
		100.00

Gluten, fresh, per cent	21.30	23.35
Gluten, dry "	8.69	9.34
Gluten, quality	fair.	good.

Sample 317 is next to the poorest sample of 1888 wheat that I have observed anywhere in this locality. On account of the shrunken condition of many of the heavy grains it is not of great value for making patent flour, but Mr. M. informs me he had some milled for home use and got thirty pounds of flour to the bushel.

663. Scotch fyfe wheat from J. C. M., Pelican Rapids, crop of 1888. The measured bushel contains 1,573,000 grains of which 34.5 per cent. are sound, 45.5 per cent. are more or less shrunken and 20 per cent. are immature grains with an occasional frozen one, but more than in 317. This is the poorest sample of rusted wheat which I have seen anywhere in Ottertail county. I have not yet received any samples from the crop, but an examination of it on Tuesday, Sept. 17th, while in the stack showed it to be of good quality. There was a noticeable difference at that time between this and Mr. E. A. M.'s just mentioned, particularly as regards yield.

	663
100 grains weigh (grams)	1.386
Water, per cent	6.32
Protein, "	13.49
Starch, etc."	80.19
	100.00
Gluten, fresh, per cent	23.96
Gluten, dry, "	9.58
Gluten, quality	fair.

In these two cases we have a excellent illustration of the possibilities of obtaining a crop from "rejected" and "no grade" rusted wheat when well cleaned. In place of there being any strong conflict between the plants from frozen grains and others of much reduced vitality this is between the plants from small grains of great vitality and others of less vitality and the struggle ends in the best wheat producing a good crop. This same result is well shown in all cases I have examined and is largely influeneed by the extent to which the seed was cleaned. One mile south of Pelican Rapids, another striking case of the favorable results from cleaning wheat is given. The farmer cleaned No. 2 wheat so that only about 20 or 25 per cent. remained for seed. The result was a large yield—35 to 40 bushels—of No. 1 Hard wheat. Now this matter of getting the densest wheat is everywhere shown to be of great influence on the crop. The wheat germ has vastly more food stored up than is absolutely necessary to insure its growth but it is a widely established fact that the differences in the vitality of plants of the same species and their capabilities of reproduction are largely dependent upon the start given during the first few weeks of growth. If we can eliminate the weakest plants before seeding, the struggle that takes place after germination will be between only the strongest plants and the general result must be a vast improvement, if outside conditions have not been too unfavorable.

331. Scotch fyfe wheat from C. J. W., Fergus Falls. The measured bushel contains 1,460,200 grains of which 25 per cent. are sound, 63 per cent. are more or less shrunken and 12 per cent. are immature—but no frozen grains. Before seeding two-thirds of the grains were cast out and only the remaining third—the densest grains—were seeded. That graded 1 N. and 2 N.

896. Crop from 331. This is a sample of most excellent milling wheat but like most of this season's wheat in this locality it contains many starchy grains.

	331	896
100 grains weigh (grams)	1.428	
Water, per cent	9.46	9.04
Protein, "	15.41	12.08
Starch, etc,"	75.03	78.88
	100.00	100.00
Gluten, fresh, per cent	31.43	27.55
Gluten, dry "	12.57	10.00
Gluten, quality	good.	excell.

The seed from which 331 was produced came from the northwestern part of Minnesota where in 1887 a most excellent crop was harvested. The crop of 1888 was fine until the damp, muggy weather during July which favored the propagation of rust; and this injured the crop. But the germ was not injured and as the analysis shows the wheat contained a large amount of gluten. Sample 896 was raised on land on which corn grew in 1888. It was seeded by dragging the wheat in on the stubble and yielded 40 bushels per acre. The rest of the farm, which was old land, yielded 20 bushels per acre. Although the crop is much superior for milling to the wheat from which it grew it is not so good for seed. If well cleaned by removing those grains which are in themselves the lightest—of the least density—896 can be greatly improved for seed. If seeded as it is the improvement noticeable this year will probably not be maintained. During the past season it has been abundantly proven everywhere that cleaning the wheat well has improved the crop. Indeed in many cases seed cleaned from very poor wheat has yielded better than wheat originally good but uncleaned. The density of wheat must largely determine its value for seed. Another very important point is illustrated by 331 and its crop, namely; the change of seed. In many cases it cannot be clearly shown why a change of seed produces better results but it seems to be advisable to make this change every three or four years, or oftener.

434. Well cleaned 2 N. Scotch fyfe wheat of crop of 1888, seeded by W. B. D., Mapleton, N. Dak. This wheat is not the product of this farm for 1888. The measured bushel contains 1,186,800 grains of which 70 per cent. are uninjured and the balance slightly shrunken and some blistered. The crop from this on new land and summer fallowed was very heavy. On the slough bottoms I measured some heads as long as seven inches. On old land the wheat was of good quality but very short so that some on the oldest lands could not be caught by the binder. This was the case to a

greater or less extent on some spots of the oldest land in the neighborhood of Fargo, where the drought was most severe. On land which had not been cropped for many years in succession—over two or three years—the crop was the best. This is also another instance of the beneficial effects of a change of seed, but I can not speak more in detail as I have not yet analyzed the crop.

	434
100 grains weigh (grams)	2.180
Water, per cent	12.04
Protein, "	13.49
Starch, etc."	74.47
	100.00
Gluten, fresh, per cent	27.66
Gluten, dry, "	11.06
Gluten, quality	good.

453. Lost Nation wheat of 1888 from C. L. ——, Larimore, N. Dak. The measured bushel contains 1,065,600 grains of which 84 per cent. are sound, the balance are shrunken somewhat and blistered, with an occasional frozen grain.

800. Crop from same, from summer fallowed land, seeded with a press drill—1½ bushels per acre. Yield was 33 bushels per acre. 54 per cent. are perfectly sound, the balance are more or less bleached.

	453	800
100 grains weigh (grams)	2.260	2.865
Water, per cent	10.89	8.01
Protein, "	12.62	12.62
Starch, etc."	76.49	79.37
	100.00	100.00
Gluten, fresh, per cent	26.16	30.30
Gluten, dry, "	10.46	12.12
Gluten, quality	fair.	good.

460. Scotch fyfe from H. F. A—, Larimore, N. D. The measured bushel contains 1,285,500 grains all of which except for an occasional frozen grain are of a very deep amber color. Many of the grains are sound and but 30 per cent. are noticeably shrunken. This wheat was raised on the east side of the farm and sowed with the Havana Press drill on heavier land on the west side—one bushel per acre.

892. Crop from 460, from land which had borne five crops but was summer fallowed previous to this crop. 75 acres yielded 32 bushels per acre. All grains are of excellent quality excepting a few which are bleached. 893 is another sample grown on 60 acres of new-breaking and yielded 25 bushels per acre. 894 is another sample from land on which this is the fifth successive wheat crop. 60 acres yielded 12 bushels per acre. The last named samples contain more bleached grains but are otherwise good. 894 is quite dirty from weed seeds.

	Seed, 460.	Crop, 892.
100 grains weigh (grams)	1.818	
Water, per cent	11.70	8.00
Protein, "	11.51	
Starch, etc."	76.79	
	100.00	
Gluten, fresh, per cent		29.8
Gluten, dry, "		11.92
Gluten, quality		excellent.

461. Saskatchewan fyfe of 1888 from R. A. W., Stephen, Minn. The measured bushel contains 1,119,000 grains of which 27 per cent. are sound, 65 per cent. are blistered and shrunken and 8 per cent. immature—none frozen. About 25 per cent. of the wheat was cleaned out and the remainder seeded—1¾ bushels per acre—with a Buckeye hoe seeder on land that in 1888 yielded barley. This is the ninth crop and yielded 18 bushels per acre.

817. The crop. 74 per cent. are sound, 20 per cent. are somewhat shrunken and 6 per cent. are immature—no grains similar to 1888 frozen ones. The grains are large but nearly all are more or less bleached. That this wheat, Saskatchewan fyfe, is less capable of making a plump berry under conditions not altogether favorable, I am not fully prepared to say, although many cases seem to indicate this. In all cases in 1888 where Scotch fyfe and Saskatchewan fyfe were seeded near by, the latter was injured the most.

	461	817
100 grains weigh (grams)	2.102	2.847
Water, per cent	12.71	
Protein, "	10.93	
Starch, etc."	76.36	
	100.00	
Gluten, fresh, per cent		
Gluten, dry, "		
Gluten, quality		

462. Scotch fyfe of 1888 from I. P. C——, Fargo, N. Dak. The measured bushel contains 1,251,636 grains of which 60 per cent. are sound the balance being blistered with a few shrunken, immature grains—no frozen ones.

867. Crop from 462. A few grains are slightly shrunken and blistered. The remainder are sound and plump.

	462	867
100 grains weigh (grams)	2.115	2.802
Water, per cent	11.28	9.74
Protein, "	12.79	12.59
Starch, etc."	75.93	77.57
	100.00	100.00
Gluten, fresh, per cent	20.53	31.00
Gluten, dry, "	8.21	12.4
Gluten, quality	fair.	excel.

465. Wellman's fyfe from W. S. C——, Stephen, Minn. The measured bushel contains 924,600 grains of which 16 per cent. are uninjured in any way, while of the remaining 84 per cent a few are immature and the rest blistered more or less. There are no frozen grains. This wheat is said to have completely escaped the rust in 1888. The crop is reported to be the best in this neighborhood.

	465
100 grains weigh (grams)	2.467
Water, per cent	12.42
Protein, "	11.51
Starch, etc."	76.07
	100.00
Gluten, fresh, per cent	17.67
Gluten, dry "	7.07

It was impossible to mechanically separate all the gluten.

467. Defiance wheat from E. M——, Devils Lake, N. Dak. The measured bushel contains 1,017,700 grains of which 75 per cent. are sound, 10 per cent. are shrunken, 10 per cent. are frozen and 5 per cent. are immature. Well cleaned for seed. 160 acres of new land which had been backset the fall of 1888 was seeded April 19, 1889, with a Dowagiac shoe drill—one bushel per acre. "The wheat sprouted unevenly and ripened the same way; from August 1st, on." Therefore only harvested in spots.

801. Crop from same. 75 per cent. are perfectly sound, the balance immature and sightly shrunken, with an occasional frozen grain resembling the frozen grains of the seed.

	467	801
100 grains weigh (grams)	2.407	2.813
Water, per cent	8.64	
Protein, "	13.71	
Starch, etc."	77.65	
	100.00	
Gluten, fresh, per cent	32.28	
Gluten, dry, "	12.95	
Gluten, quality	excel.	

On this same farm was seeded 468—*frozen* blue stem wheat. No sample of its crop was sent me and I made a request to get it particularly. Mr. M—— replies that wherever it was seeded it was a failure and he could not collect any.

866. Scotch fyfe of 1888 from H. P——, Pelican Rapids, Minn. The grains are small but 57 per cent. sound, 30 per cent. are shrunken somewhat, 10 per cent. are immature and 3 per cent. are frozen. Well cleaned and seeded.

863. Crop of 866 from fifty acres of mixed land—yield was 12 bushels per acre. Part of the land is new, part has raised seven consecutive wheat crops and part was in corn and timothy the year previous. It was seeded March 25th with a broad-cast seeder—1½ bushels per acre; harvested July 30th. A sample of fine wheat. All grains are sound.

864. Another sample from thirty acres of prairie land which has borne eight successive crops—two of wheat and the rest timothy; yield was 10 bushels per acre. Seeded March 22nd with a Hoosier broad-cast seeder. The winds and drought necessitated re-seeding May 12th; harvested July 30th. Not so fine a sample as 863; contains some shrunken grains.

	Seed, 866.	Crop, 863.	Crop, 864.
100 grains weigh (grams)	1.754	2.651	2.423
Water, per cent		8.23	
Protein, "		15.08	13.49
Starch, etc."		76.69	
		100.00	
Gluten, fresh, per cent	25.30	40.30	31.87
Gluten, dry, "	10.01	16.00	12.75
Gluten, quality	good.	excel.	excel.

435. Scotch fyfe of 1888 from M. Van K——, Grand Forks, N. Dak. The measured bushel contains 1,243,200 grains of which a few are slightly blistered or shrunken and an occasional one is immature. The remainder are sound—no frozen grains. I am not informed how well cleaned before seeding which was done with a shoe drill between April 13th and May 2nd —one bushel per acre. Fifteen acres were new land, twenty acres summer fallowed and the balance was the second and third crop after summer fallowing.

838. The crop which was harvested between August 8th and 22nd, and stacked. Yield was 24 bushels per acre. Some grains are slightly shrunken or blistered while the rest are sound. Only an occasional bleached grain.

	435	838
100 grains weigh (grams)		2.893
Water, per cent	10.85	8.58
Protein, "	13.87	12.37
Starch, etc."	75.28	79.05
	10.000	10.000
Gluten, fresh, per cent	27.55	29.50
Gluten, dry, "	11.01	11.8
Gluten, quality	very good.	excel.

Sample 435 is an extremely good, rusted wheat while 663 is a very poor one. Between these two extremes are many grades of wheat all of which have yielded wheat containing gluten, depending in amount upon the quality of the seed and local conditions, which have also greatly influenced the yield. Many farmers have otherwise explained the result but these conflicting views are due to failure in distinguishing the different kinds of "poor" wheat used for seed. Without careful examination these differences are not noticed and when no sample of the seed sowed has been saved it has not been possible to make note of them later. Therefore when the crop from one kind of "poor" wheat turned out to be good, and from another kind bad it was supposed to be explained by saying, "it just happened so." Others who appreciated the differences in the seed have explained the results in two

ways; (1) that the grains lacked vitality—were simply weak. Therefore, those grains that were strong took food from the soil at the expense of the weaker grains. This is a rational explanation for some grains being perfect and others shrunken where all were fully matured. But it does not explain why some grains are devoid of gluten. (2) Another explanation is that the product of "frozen" grains mature much slower than that from sound grains and that the crop from the former was caught again by the frost this past year. We might accept this as an explanation if all wheat of 1889 containing grains similar to the frozen ones of 1888 had been subjected to frosts the past year. But with the possible exception of one case all that I have here reported were not at all affected by frost. The most rational explanation is that we have here in the case of a vegetable something similar to the contraction of consumption in animals. Without further experience it cannot be told whether the injury which frozen wheat has sustained is such that it can never again become good wheat, but I have reports of several well authenticated cases where since 1885 similar results to these here cited have been observed. At that time the distinctive characteristics of frozen wheat were not known.

OTHER CAUSES FOR POOR WHEAT IN 1889.

All the poor wheat of 1889 is not to be attributed to the seed sown. In some localities, as around Hallock, I am informed that some of the wheat which was planted early in April did not sprout until after the rains, the latter part of June and beginning of July. This caused the wheat to ripen unevenly and of course there are in all such cases immature grains. As illustrative of a number of such cases that I have observed I give the following one:

677. Crop from seed which graded 1 Hard to No. 3 from W. F. K——, Hallock, Minn. This seed was gotten from the unaffected sandy lands to the east, but as all was sown I could obtain no sample. Much of it did not germinate until about July 4th and the crop was harvested early in August. As a result there are nearly 20 per cent. of immature grains in the sample I got Sept. 8th. The rest are sound except for a very few grains slightly blistered. The measured bushel contains 952,822 grains.

100 grains weigh (grams)	2.409
Protein, per cent	15.19
Gluten, fresh,"	34.03
Gluten, dry, "	13.6
Gluten, quality	excellent.

This was the first threshed and only a small part of the crop. After this rains set in and continued for several weeks. The result was that the wheat was very badly bleached so that the grade was reduced.

It was thought in this case that the light frost of August 4th had also done some damage and it may have, but a personal inspection of several places in this section at the time of the frost failed to show any damage

done. I have since received some samples from this section which show unmistakably the effects of local frosts.*

The unusual rains and succeeding hot suns during August and September prevented the threshing of wheat and caused it to be bleached. Thus good wheat was made to grade low while bad wheat was made worse. A superficial examination of such wheat might not show the great difference caused by the difference in the seed. But any one who will more carefully examine cannot fail to see this. Here lies the danger which threatens farmers this spring. To determine the value for seed an altogether different basis must be had than the rules for its State Inspection. These do not anticipate this matter but the farmer can readily make himself the most competent judge by understanding the distinction between a good "grade" of wheat for milling and the same for seed.

To most successfully carry on the mechanical operations of milling it is first necessary to have plump wheat in which the hull has not been injured. Then the best flour, after the hull is gotten rid of, is made of that wheat which contains the most gluten and the least water. Other conditions of the wheat also enter as a factor.

To grow the best crops the first necessity is to have the germ of the wheat sound and then to have compactly stored up, plenty of the proper kind of food—gluten, etc. Outside influences may cause the hull to be uneven or brittle without injuriously affecting the germ and its food. And this wrinkling of the hull may not be a property which will be transmitted by the seed to the crop, although in some cases it doubtless is. But certain changes in the character of the germ and its food are unmistakably transmitted. In blistered, rusted and bleached wheats the superficial characteristics of the wheat are changed while in frozen wheat changes seem to have been made in the reproductive faculties.

In any lot of wheat, even of the highest grade, some grains are vastly better than others for seed, and it is a simple matter to determine which they are and how to secure them. If it had not been clearly proven before, the last wheat crop has conclusively shown that the denser any grain of wheat the better it is for seed. These are the grains which are the heaviest for their size. If wheat is well cleaned by a blast of wind the lightest grains are cast out and the heaviest remain. In these the germ is best developed and protected and has most readily available the greatest amount of necessary food. Of this gluten is of chief importance and its quantity and quality can be easily determined. For this I have given a method in Bulletin No. 7.

*I have examined hundreds of samples from farms between Glyndon and St. Vincent. These with the reports of the farmers show the effects of frost have been quite limited. Results similar in all cases to those here stated were observed. At Warren one farmer told me he had sold all his wheat of 1888 for 1 Hard. He bought frozen seed and sowed it on speculation. The crop in 1889 was about as good as the seed he sowed and his losses last year exceeded his profits of the year before.

CONCLUSIONS.

From the cases above cited and many others I draw the following general conlusions:

1. A vast difference as to their seed value, exists between the various kinds of "poor" wheat.

2. Rusted wheat and blistered (frosted) if well cleaned are safe to use for seed.

3. Frozen wheat which is utterly worthless for milling is likewise of no value for seed. It cannot produce a good crop.

4. The more thoroughly wheat is cleaned the better the seed resulting and the better the crop—particularly in yield. And by cleaning I mean besides separating the dirt, also casting out the weaker grains of wheat. Thus poor milling wheat may be made vastly better for seed than wheat of high milling value if the latter is uncleaned.

5. Wheat should invariably be tested as regards its gluten and per centage of germination before being seeded. It seems absolutely necessary that the seed shall cantain good gluten if it is to be in the crop.

OBSERVATIONS FOR THIS YEAR.

While the results of last season seem very conclusive, it is desirable that our investigations shall be continued. Any one can casily and without appreciable expense make observations of great value. I should suggest that every farmer keep in a stoppered bottle six ounces or more of the seed just as he planted it, and make a memorandum of the kind of soil, its condition, etc., when seeded, and the number of times thus successively cropped. When the wheat is about mature select representative heads from different parts of the farm. After the wheat is harvested and cured shell out from the shocks sufficient to make a fair sample of the crop and preserve this in another bottle. Compare these samples with the wheat after it has been threshed. In this way a fair judgment can be made of the results due to the seed, and, if rains etc. have occurred between harvest and threshing, their effects are seen. Such samples exhibited at the State and county fairs must result in great good. I desire to have such samples sent me by mail at any time, and if an analysis can give more light I shall be glad to make the same. One cannot remember sufficiently clearly the quality of any seed sown if no sample has been preserved. With this, however, our judgment need not err.