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The Effects of Premature Harvesting on the Wheat Kernel

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(Read before The Western Canadian Society of Agrono my and published through the courtesy of that Society)

It has long been know that, under ordinary conditions, grain may be cut many days, perhaps even two weeks, before it is fully mature and may still give good and fairly plump kernels when allowed to ripen in the stook. A great deal, however, has yet to be learned about the effects of premature cutting, especially such cutting as deprives the grain altogether, or to a large extent, of any food supply from the leaves or straw. It should be noted that, when grain ripens in the stook, especially under fairly cool and not too dry conditions, there is a considerable opportunity for the food supply in the plant to be transferred to the kernels, much in the same way as would have occurred had the plants been left intact. We have here two distinct problems: first, a problem which is primarily practical, namely to decide how far in advance of ripeness grain may wisely be cut when there is believed to be danger of frost, high wind, or some other destructive agency, and, second, to study the physiological processes operating towards the end of the period of development of the grain. This second problem, which appears to be rather of a purely scientific than a practical character, becomes most practical in its nature when we have to consider the effects of a rust epidemic whereby the kernel is prematurely deprived of much of the material which would have gone towards building it up. In spite of all the work which has been done, we are today unable to confidently answer the question which farmers put to us when rust appears: "Is it wise to cut grain immediately when the leaves and stems are badly attacked?"

Investigations on the effect of premature cutting have been carried on in the experimental farm system for a few years past, and the writer presents in this paper the results of one series of observations. In the summer of 1917, Mr. G. G. Moe, (then the writer's chief assistant and now assistant professor of Agronomy at the University of British Columbia) gathered a number of heads of Marquis wheat at different dates. The following was the method used. In order to make sure that we were dealing with heads of uniform degree of maturity, about 1100 heads were marked on the same day, each head showing a few anthers, but only a few. Starting on July 21st, when the wheat was still perfectly green, 100 of these marked heads were gathered every second or third day until August 15th when the wheat was considered to be ready for ordinary harvesting. These heads were gathered in four groups according to the length of straw retained. All were taken indoors and hung up in a reversed position in a warm, well-ventilated loft. In the autumn all heads were very carefully threshed out by hand, every kernel being saved. When the heads were being harvested, notes were not always made on the appearance of the plants, but the following particulars will give some idea as to the character of the kernels from some of the lots gathered. The descriptions apply to the kernels when thoroughly dry.

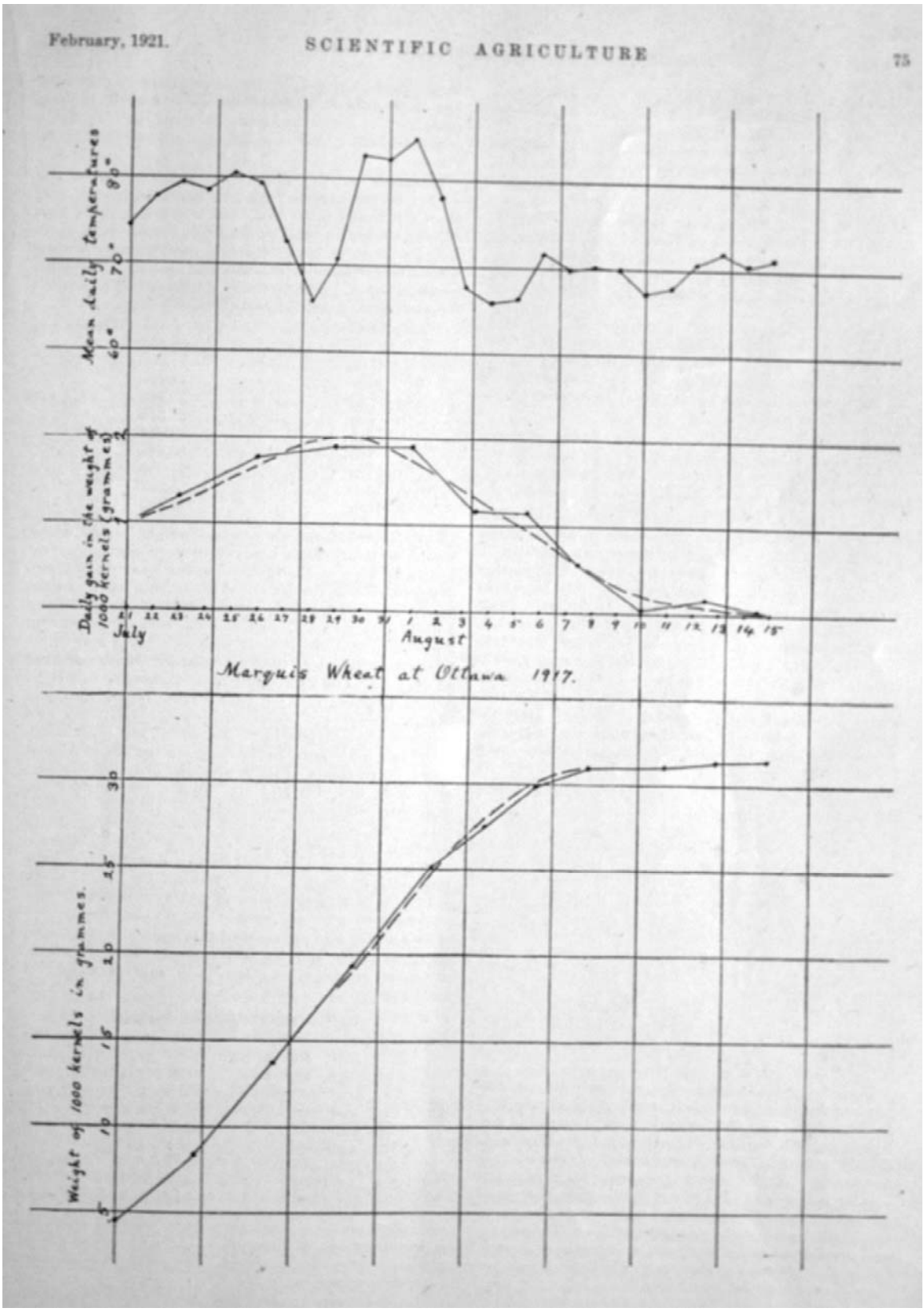
July 21st: all kernels very small and extremely shrivelled, very hard to remove from the heads;
July 24th: kernels much larger but still probably impossible to thresh with a machine;
July 27th: kernels very small but might perhaps have been threshed by a machine;
July 30th: kernels shrivelled but could be threshed out by a machine;
Aug. 4th: kernels not plump but might be accepted for milling purposes;
Aug. 8th: kernels fairly plump though not large; would be accepted for milling.

The kernels gathered on the other dates do not require special description. It should be noted, however, that the season was not favourable to the development of large kernels, so that even those harvested on the latest date (Aug. 15th) were rather small.

As a rule, the twenty-five heads in each group contained nearly 700 kernels, but the results have all been calculated on the basis of 1000 kernels. The following table gives the weight of a thousand kernels from each bunch of heads, on each date.

Marquis wheat harvested at different dates, and with different lengths of straw.

Date.	Amount of straw retained.	Weight in grammes of 1000 kernels.
July 21st	three inches	3.650
" "	half length	4.320
" "	full length	5.136
" "	fulll length with roots.	5.075
July 24th	three inches	8.176
" "	half length	8.391
" "	full length	8.114
" "	full length with roots.	9.127
July 27th	three inches	13.624
" "	half length	13.766
" "	full length	13.688
" "	full length with roots.	13.956
July 30th	three inches	19.122
" "	half length	19.595
" "	full length	18.940
" "	full length with roots.	20.053
Aug. 2nd	three inches	25.152
" "	half length	25.042
" "	full length	23.391
" "	full length with roots.	25.152
Aug. 4th	three inches	27.546
" "	half length	27.336
" "	full length	28.082
" "	full length with roots.	27.209
Aug. 6th	three inches	29.963
" "	half length	30.564
" "	full length	29.260
" "	full length with roots.	29.598
Aug. 8th	three inches	30.770
" "	half length	30.824
" "	full length	30.859
" "	full length with roots.	31.420


Mean daily temperatures
80°
70°
60°
Daily gain in the weight of 1000 kernels (grammes)
July
August
Marquis Wheat at Ottawa 1917.
Weight of 1000 kernels in grammes.
30
25
20
15
10
5

Aug. 11th	three inches	31.707
" "	half length	30,647
" "	full length	30.477
" "	full length with roots.	31.368
Aug. 13th	three inches	31.707
" "	half length	31,265
" "	full length	31.242
" "	full length with roots.	31.376
Aug. 15th	three inches	31.956
" "	half length	30.352
" "	full length	32.167
" "	full length with roots.	31.458

The above figures show a good deal of fluctuation which must be attributed to experimental error; yet, when the average results are taken, they are found to be fairly regular and satisfactory. The average weight of 1000 kernels for the whole period from each length of straw is as follows:

three inches	23.034	grammes
half length (about 20 inches)	22.918	"
full length	23.032	"
full length with roots	23.254	"

It is at first rather surprising to note that the heads which were gathered with only three inches of straw gave kernels fully as large as those with half length or full length of straw. They are, however, somewhat smaller than those obtained from the full length of straw with part of the roots attached. These facts can be easily explained. Under the conditions of the experiment, the drying of the straw would be very rapid and would allow scarcely any time for the transfer of material from the straw to the grain. With some of the roots attached, however, more moisture would be present and the period of activity after the harvesting would be longer. It is clear that when the drying process is very rapid, it is immaterial how much of the straw is retained.

An interesting observation on the ease with which the heads could be threshed was made during the study of this material. Quite often there was a noticeable difference in the ease of threshing between the heads with only three inches of straw and those having the full length of straw with the roots. In some cases the differences were more marked than in others. These facts can be explained in the same way as we explained the greater weight of kernel obtained from the heads with roots attached, namely, that the presence of the roots allowed a longer and therefore more thorough ripening to take place. As is well known, the riper the head, the easier it is to thresh. The heads which were gathered even as late as August 11th with only three inches of straw attached proved very hard to thresh.

In studying the irregularities of the results, one must not be too quick to suppose that they are always to be accounted for by experimental errors, because it must be remembered that the daily temperatures throughout this period fluctuated considerably. Obviously, the development of the kernel is more rapid at high temperatures, provided they be not fatally high, than under cooler conditions. During the progress of the experiment, the mean daily temperatures at Ottawa (the average between the maximum and minimum) varied from 65.9 degrees Fahrenheit on July 28th (and August 4th) to 84.8 degrees on August 1st.

The grain was cut finally on August 15th. It had then reached the proper degree of maturity for ordinary harvesting in eastern Canada, where it is often customary to allow the grain to stand in the field a good deal longer than is usually the case on the Central Plains.

Inasmuch as the differences noted between the weight of the kernels from the heads with only very short straw and those with long straw and roots were so very slight, we shall do better to consider the whole crop gathered on each date as a unit, thereby dealing with a larger number of seeds and reducing the experimental error. The average weight of 1000 kernels for each date of cutting is as follows:

July 21st	4.545	grammes
" 24th	8.452	"
" 27th	13.758	"
" 30th	19.427	"
Aug. 2nd	25.184	"
" 4th	27.543	"
" 6th	29.846	"
" 8th	30.968	"
" 11th	31.050	"
" 13th	31.398	"
" 15th	31.483	"

These figures form an almost perfect series which would certainly have been even more nearly perfect had there been no fluctuations in the mean daily temperatures. These results are very striking when plotted in the form of a rough curve. They show that from July 21st to about August 2nd the rate of increase in the weight of 1,000 kernels was very rapid and fairly constant, in spite of the cool weather which occurred on July 28th and 29th. The rate of increase in weight fell off after the very hot days August 1st and 2nd, and became slower and slower during the relatively cool weather which extended to the end of the experiment. There is a slight bend in the curve on the 4th of August which corresponds exactly with the low temperatures of August 3rd, 4th and 5th. When we consider the undoubted effect of temperature, we are quite justified in altering our curve slightly in accordance with the weather. Obviously a hot day will be one of abnormal activity and a cool day will show a slowing up of physiological processes. After making the slight alterations for abnormal weather the curve becomes extremely regular. (See the broken line on the chart.)

The writer also approached this matter from another point of view and has determined (as well as the available details allow) the daily gain in weight of 1000 kernels.

Gain in weight of 1000 kernels.

July 22nd, 23rd, and 24th	1.302	grammes	per	day
" 25th, 26th, and 27th	1.769	"	"	"
" 28th, 29th, and 30th	1.890	"	"	"
" 31st, Aug. 1st and 2nd	1.919	"	"	"
Aug. 3rd, and 4th	1.180	"	"	"
" 5th, and 6th	1.152	"	"	"
" 7th, and 8th	.561	"	"	"
" 9th, 10th and 11th	.027	"	"	"
" 12th and 13th	.174	"	"	"
" 14th and 15th	.043	"	"	"

In plotting the above figures each observed point has to represent two or three days. It is therefore placed in the middle of the period. The solid line connects these determinations.

The following are the mean daily temperatures ob-

served at Ottawa during the period of this experiment.

July	21st	74.4	degrees Fahrenheit
"	22nd	77.9	" "
"	23rd	79.2	" "
"	24th	78.4	" "
"	25th	80.3	" "
"	26th	79.2	" "
"	27th	72.5	" "
"	28th	65.9	" "
"	29th	70.7	" "
"	30th	82.8	" "
"	31st	82.2	" "
Aug.	1st	84.8	" "
"	2nd	78.0	" "
"	3rd	67.7	" "
"	4th	65.9	" "
"	5th	66.5	" "
"	6th	71.5	" "
"	7th	69.9	" "
"	8th	70.6	" "
"	9th	70.0	" "
"	10th	67.3	" "
"	11th	68.0	" "
"	12th	70.8	" "
"	13th	72.0	" "
"	14th	70.7	" "
"	15th	71.3	" "

Taking into consideration these temperatures we can construct a theoretical curve (the broken line) representing what probably would have been the normal course of the development of the wheat kernel under uniform conditions of temperature. This curve shows a rapid increase in the amount of material deposited daily from July 21st up to July 28th or 29th when, had the weather been normally warm, about 2 grammes per day of solid matter would have been added to each 1000 kernels. But the weather happened to be quite cool on the 28th and 29th, so that the amount deposited was certainly less than the normal for those days. Furthermore the excessive heat on August 1st caused more than the usual activity on that day. The period of very great daily gains extends from about July 25th to August 2nd. It seems fair to conclude that July 29th would have been the date of maximum activity, under conditions of even temperature—that is to say approximately seventeen days before the date of cutting.

A deposition in the wheat of two grammes per 1000 kernels would be equal to about 1/16 of the total crop, or about 120 pounds to the acre on a fairly good field. We must remember however that not all the heads would be in exactly the same stage of development at any one time. The amount of material added per day would therefore not be quite so great as appears from the figures given here. Nevertheless, I think it safe to say that in a good field, with favourable weather conditions occurring at the time of maximum physiological activity, about 100 pounds of material per acre would be transferred daily, for a few days, to the wheat kernels.

It is evident that during the early period of the development of the wheat kernel — 20 to 25 days before cutting in this case — the materials of which the grain is composed are deposited in it at a rapid rate. This rate increases in rapidity until about 17 days before harvest. It remains stationary for a short time and then decreases quite quickly, being reduced almost to nothing several days before the ordinary time of cutting in Ontario. It would appear, therefore, that, in an ordinary Ontario summer, there would be very little loss of crop in cutting wheat about a week before the ordinary date, and allowing it to finish the ripening process under the relatively favourable conditions which obtain in an ordinary stook. In those parts of Canada where the summer weather is cooler than at Ottawa the harvesting could probably be done without appreciable loss in yield at a relatively earlier period —perhaps two weeks before the grain would have been ripe. This indeed is a common practice in nearly all those districts, east or west, where the summer season is rather short.

Through the kindness of Dr. Frank T. Shutt, Dominion Chemist, the writer is able to give the results of protein determinations made in his laboratories with the samples of wheat which we are considering. The samples from the heads gathered with three inches of straw and those from the heads gathered with full length of straw were analyzed separately. The results of the two series are similar. The average results are given in the following table. The figures have been recalculated on the basis of wheat containing ten per cent. of moisture.

Analyses of Marquis Wheat.

			Grammes of protein in 1000 kernels.
July	21st	20.02	.884
"	24th	16.42	1.337
"	27th	14.09	1.925
"	30th	14.62	2.783
Aug.	2nd	15.09	3.814
"	4th	15.41	4.287
"	6th	15.57	4.610
"	8th	15.87	4.890
"	11th	15.89	4.940
"	13th	16.03	5.045
"	15th	15.92	5.104

It is noteworthy that the percentage of protein rapidly decreased from July 21st to July 27th, then slowly increased until August 13th. The actual amount of protein present, however, increased rapidly from July 21st to August 6th and then increased more slowly until the end of the test.

Evidently, therefore, in the earliest stages of the formation of the kernel, protein is added with much greater relative speed than later on. Between the 21st and 30th of July, although the amount of protein added was very great, the addition of other constituents (chiefly carbohydrates of course) was even more rapid.

The period during which carbohydrates were deposited most rapidly is also the period during which protein was deposited most rapidly. Towards the end, both processes became much slower but the deposition of both protein and carbohydrates did not cease in this case until after August 15th, by which time the grain was fit to cut and was well advanced towards ripeness.

The process of ripening has been described as merely a drying out of the kernel. This is evidently not the case if we use the word "ripening" in the sense it usually bears in Canada. Simple drying out may be the final stage, but up to a very late date protein and other materials are being deposited in the kernel. The amount of such deposition is, however, so small that farmers are fully justified in cutting their grain quite early whenever they have good reasons for doing so.

The study of this important problem of the effects of early cutting on wheat is being continued by the writer.