OKLAHOMA
AGRICULTURAL AND MECHANICAL COLLEGE
AGRICULTURAL EXPERIMENT STATION
STATE OF OKLAHOMA
STILLWATER, OKLAHOMA

MOISTURE IN COMBINED WHEAT

By
A. DAANE
Head of Field Crops and Soils Department

September, 1928. Bulletin No. 183.

MOISTURE IN COMBINED WHEAT

By
A. DAANE

In combining wheat it is well to remember that high moisture content of wheat is due to:

1. Immaturity of crop.
2. Low places in the field.
3. Thick stands.
4. Lodged grain.
5. Rain.
6. Dew.
7. High humidity of the atmosphere.
8. Weeds.

The standing grain will not dry rapidly unless there is a:

1. Relatively high temperature.
2. Low humidity.
3. Breeze or wind.

Operating the combine should not begin:

1. Until the crop is well matured.
2. Until the dampness of night is gone.
3. Until the dew has thoroughly dried off.
4. Until the effects of a rain or wet spell have disappeared.

That moisture is a very important factor in the grade and condition of wheat.

Before the combine harvester and thresher came to be so common on Oklahoma farms, the wheat crop was cut with a binder or header, shocked or stacked for a few weeks and then threshed. By so doing, the grain had time to thoroughly dry and cure before it was threshed. The moisture content was not high even though the crop might have been cut a little on the green side. There was little cause then for complaint regarding the moisture content of the crop when brought to market. But conditions have changed, and the combined harvester and thresher which the farmer is using to reduce the cost of producing the wheat crop is now a rather common machine in Oklahoma.

Since the advent of the combine, there has been much said about the moisture content of the wheat so harvested. A large per cent of the wheat farmers have no facilities for storing the grain on the farm, consequently, much of the crop is forthwith hauled to the elevators direct from the combine. This new wheat if confined to a bin or car for a few days often starts heating and if left for many hours longer the grain is bound to spoil even if it contains but a small excess of moisture. Many of the farmers who store the combined wheat on the farm or with the elevator man who buys or handles the wheat direct from the machine, have found that infrequently they are running a risk of grain spoiling due to excess moisture unless proper precautions have been taken in harvesting the crop. It is admitted that if proper care is exercised by the farmer, less trouble will be experienced in handling the wheat through the regular market channels. It is also known that to market wheat with a higher per cent of moisture, if it can be marketed at all, the farmer must accept a greatly reduced price for his product. It is possible, however, that a better product with better prices may be realized by the farmer if more information can be had of the moisture in the grain in the field at the time of harvest.

As moisture is such an important factor in combined wheat, the amount governing each grade according to the Official Grain Standards of the U. S. D. A. is here given.

Grade No. 1, 13.5% or less
Grade No. 2, 14.0% or less but more than 13.5%
Grade No. 3, 14.5% or less but more than 14.0%
Grade No. 4, 15.5% or less but more than 14.5
Grade No. 5, 15.5 or less but more than 14.5%
Sample Grade, over 15.5%

"The wheat in grades Nos. 1 to 4, inculsive, shall be cool and sweet. The wheat in grade No. 5 shall be cool, but may be musty or slightly sour."

For the purpose of securing information in a systematic way, L. H. Brannon, a graduate of this Institution, was sent to the southwestern part of the state to secure samples of wheat direct from the combines operating in the fields. His first samples were taken on June 12, which is fully two weeks later than the season usually begins. The field selected was one of one hundred and ten acres near Frederick, Oklahoma. After the field was opened, samples were taken from the combine as it made the rounds of this field. These samples came from hills, hollows, thick stands, thin stands and lodged places. Rounds were made with the machine and samples taken every two hours of the day. Notes were also taken on climatic conditions as follows: number of hours since the last rain, presence or absence of dew in the morning, temperature, humidity, wind and sky conditions—whether cloudy or not.

Sample Number

GENERAL INFORMATION

Name .....

Address ..... R. .....

Distance and Direction from P. O. .....

Variety of Grain .....

Size of Field, Acres .....

Storage Facilities .....

CONDITION OF FIELD WHERE SAMPLE WAS TAKEN

Immature ..... Ripe ..... Dead Ripe .....

Lodged ..... Weedy ..... Unevenly Ripened .....

Hill ..... Hollow ..... Stand: Thick .....

Medium ..... Thin .....

TYPE OF SOIL

Sandy Loam ..... Clay Loam .....

Upland ..... River Bottom .....

WEATHER

Sun Shining ..... Partly Cloudy ..... Cloudy .....

Calm ..... Slight Breeze ..... Windy .....

Number of Hrs. after Rain ..... Dew .....

Temperature

Dry Bulb .....

Wet Bulb .....

TIME ..... A. M. ..... P. M. Date .....

ADDITIONAL DATA

FIGURE 1.—The above represents a page on which was indicated the conditions under which a sample was taken. Each sample when placed in a container was accompanied by this information.

The combine was started June 12, 2:00 p. m., on the farm of W. P. McIntire, Frederick, Oklahoma. There was no dew that morning. Twelve samples were taken before work stopped at 7:00 p. m. The average moisture content of these samples was 13.3%. The last sample taken had 12.6% moisture. However, there was dew the next morning. The combine was started at 8:45 a. m., continuing all day until 7:00 p. m. The following table shows the moisture in the samples taken at the various hours indicated.

Table 1.—Moisture per cent in wheat as shown in samples taken at various hours during the same day.

Time of Day	Temperature	Relative Humidity	Moisture
8:45 A. M.	72	55	14.1
8:50 A. M.	72		13.9
8:55 A. M.	72		14.3
9:00 A. M.	72		13.3
9:45 A. M.	73	54	13.8
9:50 A. M.	73		13.6
9:50 A. M.	73		14.2
10:00 A. M.	73		14.1
11:30 A. M.	74	51	14.7
11:32 A. M.	74		13.2
11:35 A. M.	74		13.9
11:40 A. M.	74		12.7
		Average:	13.8
2:45 P. M.	85	41	12.4
2:50 P. M.	85		13.1
2:55 P. M.	85		13.3
3:00 P. M.	85		14.3
4:40 P. M.	84	47	11.3
4:45 P. M.	84		12.7
4:50 P. M.	84		12.9
5:00 P. M.	84		12.8
6:45 P. M.	86	47	11.9
6:50 P. M.	86		11.9
6:55 P. M.	86		12.6
7:00 P. M.	86		13.3
		Average:	12.7

Date—6—12—28, Frederick, medium upland, rolling, slight breeze, sun shining, medium stand, 30 hours after rain, dew.

Other factors being equal, only three samples graded No. 1. Four samples graded No. 2, four graded No. 3, and one graded No. 4. The average of the wheat cut in the morning was No. 2. In the afternoon twelve samples were taken and of this number eleven graded No. 1 and only one graded No. 3. The morning's harvest yielded a wheat which graded No. 2. The afternoon's harvest gave a No. 1 wheat. If all of this wheat were put in the same bin and mixed, the moisture content would probably be high enough to cause it to grade a No. 2. No. 1 wheat permits no more than 13.5% of moisture.

The second full day of samples was taken June 18 on the W. G. Drennan farm. Work started at ten o'clock a. m., with no dew. The table follows:

Table 2.—Moisture per cent in wheat as shown in samples taken at various hours during the same day.

Time of Day	Temperature	Relative Humidity	Moisture
10:00 A. M.	90	47	14.0
10:00 A. M.	90	47	12.5
10:00 A. M.	90	47	13.1
11:45 A. M.	94	44	13.6
11:50 A. M.	94	44	13.5
11:55 A. M.	94	44	13.3
		Average:	13.3
1:55 P. M.	99	39	12.7
2:00 P. M.	99	39	12.4
2:04 P. M.	99	39	11.9
3:50 P. M.	100	35	12.6
3:55 P. M.	100	35	12.2
6:25 P. M.	94	42	12.0
6:30 P. M.	94	42	11.7
6:35 P. M.	94	42	12.2
		Average:	12.2

Date—6—18—28, Frederick, rolling upland, windy, sun shining, medium to thin stand, 72 hours after rain, no dew.

Here it will be noted that the average of the samples taken in the forenoon was 13.3% moisture—low enough to grade No. 1. There were only two samples grading as low as No. 2. In the afternoon the grain was drier. All samples being safely under the No. 1 grade, the average was but 12.2%.

Such grain will give no trouble in storage. However, if perchance there was lodged grain in a hollow of a field, the moisture of this wheat most likely would be over 14.5% in which case a few bushels of this kind could spoil much of the drier by heating.

The third full day of samples were taken June 23 on the Roy Marriot farm at Greenfield, west central Oklahoma. Work started at 10:00 a. m., with a dew in the morning. The following table shows the results:

Table 3.—Moisture per cent in wheat as shown in samples taken at various hours during the same day

Time of Day	Temperature	Relative Humidity	Moisture
10:00 A. M.	75	58	17.5
10:05 A. M.	75	58	16.9
11:55 A. M.	85	44	16.0
11:58 A. M.	85	44	15.3
12:00 A. M.	85	44	15.1
12:03 A. M.	85	44	16.0
		Average:	16.1
2:01 P. M.	87	38	15.2
2:04 P. M.	87	38	14.3
2:07 P. M.	87	38	14.7
2:10 P. M.	87	38	14.5
4:00 P. M.	93	30	15.1
4:03 P. M.	93	30	13.9
4:05 P. M.	93	30	14.1
4:08 P. M.	93	30	15.2
6:30 P. M.	85	41	14.3
6:35 P. M.	85	41	13.5
6:40 P. M.	85	41	13.4
6:40 P. M.	85	41	13.4
		Average:	14.3

Date—6—23—28, Grandfield, rolling land, slight breeze, sun shining, medium to thick stand, 72 hours after rain, dew.

With the exception of two samples in the morning which graded No. 4 all the samples were sample grade due to excessive moisture. Undoubtedly this wheat will give trouble in storage. In the afternoon two samples graded No. 1 but the average of all the samples then taken is No. 3. It will be be seen that the per cent of moisture gradually decreased from sample grade rating in the morning to No. 1 grade late in the afternoon. The next morning, even though the combine was not started until 11:30 A. M., the grain

cut before noon averaged 16.9 per cent moisture. The last two samples taken between 6:30 P. M. and 7:00 P. M. had a moisture content of only 13.2 per cent. It was a windy day with a temperature of 79 degrees. Here is a very striking example of a change in moisture content of wheat harvested the same day in the same field.

The following is a table showing results of moisture tests in samples of wheat taken at various hours during the day on the farm of Walter Jesse at Supply in northwestern Oklahoma.

Table 4.—Moisture per cent in wheat as shown in samples taken at various hours during the same day.

Time of Day	Temperature	Relative Humidity	Moisture
9:05 A. M.	90	44	11.9
9:10 A. M.	90	44	11.5
9:13 A. M.	90	44	11.4
9:15 A. M.	90	44	12.1
11:00 A. M.	97	32	11.3
11:05 A. M.	97	32	11.5
11:08 A. M.	97	32	11.5
11:10 A. M.	97	32	11.5
		Average:	11.6
1:10 P. M.	100	26	10.9
1:10 P. M.	100	26	10.6
1:10 P. M.	100	26	10.6
1:10 P. M.	100	26	10.9
3:05 P. M.	102	26	10.9
3:08 P. M.	102	26	10.2
3:12 P. M.	102	26	10.9
3:15 P. M.	102	26	10.7
		Average:	10.7

Date—7—2—28, Supply, upland, stand medium to thick, sun shining, windy, 72 hours after rain, no dew.

While conditions in northwestern Oklahoma were ideal for combine harvesting, the above table shows that wheat was much drier in the afternoon than in the forenoon. None of this wheat should give any trouble in storage or shipment.

The following table shows the per cent of moisture in wheat as affected by the stand:

Table 5.—Average per cent of moisture in wheat as affected by the stand of grain.

PLACE	THIN	THICK	MEDIUM	LODGED
Northwest Okla.	9.95	10.30	9.81	10.17
West Central Okla.	15.03	15.16	15.13	14.97
Southwest Okla.	13.70	16.35	13.39	14.50

The figures in above table are averages of all determinations made. In west central Oklahoma all wheat was rather high in moisture as the weather was rainy much of the time. This explains why there was not a greater difference in the percentages of moisture found in thin, thick and medium stands and lodged grain. In southwestern Oklahoma, thin to medium stands showed decidedly less moisture than thick stands or those in hollows. On the farm of Williis Laney, a place in the field with a thick stand had a moisture content in the wheat of 20.5 per cent, while a sample taken immediately after from a thin stand had only 13.3 per cent moisture. These two samples would have graded sample grade No. 1 respectively. Again, three samples taken in succession from a thick stand in the same field showed 17.9 per cent, 21.5 per cent and 16.4 per cent moisture. A fourth sample taken five minutes later from a thin stand showed only 12.9 per cent moisture.

In northwestern Oklahoma where the wheat was thoroughly ripe and dry conditions prevailed, a sample taken from a thick stand contained 13.9 per cent moisture while the moisture in a sample from a thin stand nearby was only 11.8 per cent. However, the former sample was the only one of all the samples taken in this part of the state which contained more than 12.8 per cent moisture. There were only five samples from this section of the state that contained 12.0 per cent or more of moisture.

It might also be stated that in some instances, thin stands showed a slightly higher percentage of moisture than thick stands in the same field. This fact emphasizes the necessity of considering the maturity of the grain before starting the combine.

Table 6.—Average per cent of moisture in wheat as shown in samples taken at various hours for the harvest season.

PLACE	Up to 10 A. M.	10 A. M.-12 A. M.	1 P. M.-3 P. M.	3 P. M.-5 P. M.	5 P. M.
Northwest Okla.	10.46	10.23	9.85	9.82	9.49
West Central Okla.	19.00	16.45	15.24	14.81	13.90
Southwest Okla.*	14.06	13.57	14.10	13.58	13.83

*Slightly immature.

This table shows the average per cent of all samples taken at the various hours of harvest during the day. It is plainly seen that the moisture decreases as the day passes. However,in southwestern Oklahoma this is hardly true but the reason is that it was the beginning of the season and the grain could hardly be called ripe enough. Consequently, the samples in the afternoon contained about as much moisture as those taken in the forenoon.

Samples of wheat were also taken from hills, hollows and on level places in the field. This was done to determine whether any great variation existed in the moisture content of the wheat harvested in these places. Table 7 gives averages as follows:

Table 7.—Average per cent of moisture in wheat as affected by the topography of field.

PLACE	HILL	HOLLOW	LEVEL
Northwest Okla.	10.23	10.42	9.76
West Central Okla.	14.58	15.76	14.60
Southwest Okla.	12.72	14.31	14.23

Hills and hollows would naturally vary in the stage of ripeness at the beginning of the season and also in the thickness of the stand. The hills usually ripen first while the hollows are slower in maturing. From the table above, the variation in favor of the hills over the hollows ranges from a small fraction of one per cent in northwestern Oklahoma to about 1½ per cent in the west central part and over 1½ per cent in the southwestern part of the state.

While this table shows distinct differences in the moisture content of the wheat, much more striking results can be given in individual cases. The wheat on a hill in the field of F. C. Wynn had a moisture content of but 12.5% while in an adjoining hollow the wheat had a moisture content of 14.6%. This is a sufficient difference to lower the grade of wheat from a No. 1 to a No. 4.

In the field of Roy Marriott, west central Oklahoma, the wheat on a hill had a moisture content of 13.1% but in the hollow the moisture content of the wheat was 18.6%. This would make the wheat from the hill grade a No. 1 and that from the hollow a sample grade.

Likewise in northwestern Oklahoma in the field of R. L. Vaughan, the moisture per cent for the wheat in a hollow was 13.9 and on a hill 11.1.

Rate of Drying After Rain

A rain of 1½ inches fell on June 15. The next morning at 10:00, sixteen hours after the rain, a sample of wheat was threshed by hand. It contained 21.4% moisture. Another sample was threshed by hand three hours later. Its moisture content was 18.1%. At 4:00 that afternoon another sample was threshed which contained 15.6%. The weather was good, the sun was shining and there was sufficient wind to dry the grain rapidly. These conditions obtained for the first two samples after which it became cloudy and after the third sample was taken, rain interrupted. The above rate of drying was about one per cent per hour. This of course was under rather ideal conditions.

In west central Oklahoma rain fell more or less intermittently June 25, 26 and 27. Here a sample contained 22.0% moisture two hours after a rain. Two hours later it tested 21.2% moisture. Even twenty-four hours after rain on June 28 it contained 15.6% moisture. Thirty-one hours after the rain the moisture content was down to 13.7%. By the morning of June 19 after a heavy dew, the moisture was up to 19.4%. This was forty-eight hours after the rain. The moisture was still up to 18.3% at two o'clock in the afternoon when the combine had finished the field. The humidity of the air was high—around 70%, a slight breeze was blowing and the sky was cloudy.

The rate of drying of wheat or the amount of moisture in the grain varies with the condition of the air and the stage of maturity of the grain. As the humidity changes the moisture content of the grain in the field changes. This is shown in Table 8 where the humidity of the atmosphere is compared with the moisture in the grain.

Table 8.—Humidity of air compared with moisture content of wheat.

Date	Hours After Rain	Average Temperature	Average Humidity	Average % of Moisture
July 1	48	98	30	11.7
July 2	72	97	31	11.0
July 3	96	99	27	9.5
July 5	144	97	23	8.6
July 6	168	92	35	9.7

In Tables 1 to 4, inclusive, it is also shown in each case that the moisture content of the grain varies directly with the humidity except that late in the afternoons the humidity begins to increase but it does not show immediately in the per cent of moisture in the wheat.

Effect of Moisture on the Weight per Bushel

Tests of weight per bushel were made on many of the samples of wheat sent in to the laboratory. The better wheats showed a higher test weight per bushel than the poorer wheats with the same moisture content. The relationship of moisture content to test weight per bushel in shown in the following table.

Table 9.—Showing the relation of moisture content to test weight per bushel in wheat.

Per Cent of Moisture	Test Weight per Bushel
20.1	52.3
18.8	53.0
17.9	54.3
17.2	55.0
16.9	56.5
16.1	57.6
15.0	58.2
14.2	59.0
13.8	60.0
13.3	61.0
12.2	61.5

This data shows that as the moisture content of the grain decreases, the weight per bushel increases. It also shows that moisture in wheat controls the grade more so than does the weight per bushel. In other words, moisture will affect the grade more than will the test weight per bushel. With this grain taken from the same field, there were more and lower grades due to moisture than to test weight per bushel. In the above test, if the moisture content of the grain is brought down to where it will give little trouble in storing the grain, the test weight per bushel will be practically as high as the quality of the kernel will permit.

Of all the samples taken in southwestern Oklahoma:

49% were classed as No. 1 grade according to moisture content
15% were classed as No. 2 grade according to moisture content
15% were classed as No. 3 grade according to moisture content
10% were classed as No. 4 grade according to moisture content
11% were classed as Sample grade according to moisture content

In west central Oklahoma the samples secured were classified as follows:

15% were classed as No. 1 grade according to moisture content
14% were classed as No. 2 grade according to moisture content
13% were classed as No. 3 grade according to moisture content
24% were classed as No. 4 grade according to moisture content
34% were classed as Sample grade according to moisture content

In northwestern Oklahoma all samples graded No. 1 except one sample which had a moisture content of 13.9% which would cause it to grade a No. 2.

Since it has been found that wheat is likely to give trouble in storage if it contains more than 14 to 14½ per cent moisture, the farmer should allow his wheat to mature or ripen as much as possible before the harvest is begun. Especially is this true in fields that have an uneven stand, where high and low places appear or where the grain is lodged. In such cases, uneven ripening of the grain is bound to occur. Unless such fields are permitted to mature well, the less matured spots will cause heating of the grain in storage. It is not only the grain which contains the high percentage of moisture that will spoil, but much of the drier grain that is mixed with it.

In inspecting wheat for seed for the season of 1928, it was quite noticeable that in fields that were turning ripe, there were a great many heads on short straws that were much later in maturing than the heads on the straw of normal length. There may be more of these one season than another but at any rate they were quite numerous this year. No data were taken on this point though it might be a factor yet to consider. Fields of wheat are often considered ripe but after getting into them with a combine it is found to be too immature.

The grain that is harvested early in the morning after a dew or that which is combined too soon after a rain, likewise contains too high a percentage of moisture and causes damage through heating in storage not only to itself but also to the other grain mixed with it.

Green weeds in wheat are another source of trouble in some parts of Oklahoma, especially in the north central section. Green leaves, stems and seeds that get in with the grain from a combine even if the grain is dry increase the moisture content of the wheat so that heating in storage often results. However, weeds in wheat are not as common here as in some other sections of the wheat belt of the United States. In the parts of the state from which samples were secured this year, practically no weeds were encountered. They were not sufficiently prevalent to be a factor in the moisture problem of newly combined wheat. Last year the U. S. D. A. secured some very interesting results in a study made in Montana. There, weeds are common in wheat and are a serious menace to the safety of the grain when put in storage. It was found that Russian thistle tips containing 71.6%

moisture increased the moisture content of wheat with which they were mixed from 10.0% to 14.2% in eighteen hours. In another lot, the increase was from 13% to 17% in eighteen hours.

The results of this study are published in technical bulletin No. 70 entitled "The Combined Harvester-Thresher in the Great Plains." This shows the necessity of even greater care in combining wheat where weeds are common. It emphasizes the importance of clean cultural practices in growing the crop.

The length of time that a farmer should wait in the morning or after a rain before the combine is started depends largely on the drying conditions. If ideal drying conditions exist by having a good wind, high temperature and low humidity drying will take place at the rate of about one per cent moisture per hour. If the moisture in the wheat has not increased to a great extent it might be that the combine could be started in a few hours. However, if the moisture in the wheat is high and unfavorable drying conditions prevail, days may be required instead of hours before the moisture content of the wheat is low enough to store it with safety.

Good storage facilities for wheat on the farm will help much to minimize the trouble with the high moisture content of wheat which is now too commonly experienced when the crop is put on the market.