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The Effect of Soil Moisture Content on Certain Factors in Wheat Production

BY

F. S. HARRIS and HOWARD J. MAUGHAN

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DEPARTMENT OF AGRICULTURE.

L. M. WINSOR, B. S. Irrigation Engineer
J. W. JONES, B. S. Assistant Agronomist
THE EFFECT OF SOIL MOISTURE CONTENT ON CERTAIN FACTORS IN WHEAT PRODUCTION

BY F. S. HARRIS and HOWARD J. MAUGHAN.

INTRODUCTORY

A knowledge of the intimate relations between the crop and the moisture of the soil is important to every farmer, and particularly to those in the arid parts of the world. While wheat is not an intensive crop and probably will not give as great returns to the acre for extra care as some other crops, it is well worth while to know how this crop responds to various treatments. The effect of high and low soil moisture during various stages in the growth of the crop is of particular interest. The work of other experimenters on this subject has been reviewed in earlier publications* and will consequently not be discussed in this bulletin, which is the report of experiments on the water requirements of wheat conducted during three years in large tanks.

In these experiments an attempt was made to control more nearly than is possible under field conditions, the moisture of the soil during various stages in the growth of the crop. Records were also kept of the quantity of water used in order to study some of the factors involved in water economy.

DESCRIPTION OF THE EXPERIMENT

The experiment was carried on at Logan, Utah, during the years 1913, 1914, and 1915 in 36 galvanized iron tanks, each of which contained an equivalent of 476 pounds of water-free soil. The tanks were 2 feet in diameter and 2½ feet deep. They were kept on cars and wheeled under a steelyard for weighing. A more complete description of this apparatus is found in Utah Station Bulletin No. 105.

The soil is known locally as College loam and was taken from the fields east of the building on the Agricultural College campus.

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Harris, F. S. The Irrigation of Wheat. Utah Station Bulletin No. 146 (1916).
It was the surface foot of a fertile loam high in lime. The soil after being placed in the tanks on June 4, 1913, was not removed during the three years of the experiment.

Sufficient New Zealand spring wheat was planted in three rows on each tank to give a good stand. After the seeds were planted the soil was covered with a half-inch sand mulch to reduce evaporation. When the plants were 2 or 3 inches high they were thinned to 30 plants in each tank and the tank sealed with paraffined paper to reduce evaporation from the soil to a minimum. This did not entirely prevent evaporation because of the difficulty of getting the paper to fit well around the plants. There were 2 tanks for each test, which made 18 separate moisture treatments in the 36 tanks.

The life of the wheat plant was divided into 3 periods as follows: 1st period, from planting until there were 5 leaves; 2nd period, from the 5-leaf stage until the plants were in full boot; 3rd period, from full boot to maturity. These periods were used in connection with the moisture treatments.

The tanks were weighed weekly while the plants were young and semi-weekly later, the loss being made up with very pure tap water at each weighing.

Explanation of Figures

The results of the experiments are presented in 15 figures arranged in a uniform manner. The lower part of these figures in each case gives the average moisture content of the soil during each of the three periods in the growth of the crop. In some cases it was uniformly high; in others it was uniformly low; while in still others it changed during the different periods.

In reading from left to right it will be noted that in the first ten treatments the moisture was approximately the same during all the periods; and varied from 7½ to 35 per cent of the soil. The high winter precipitation, however, caused most of the tanks to be a little higher in moisture during the early part of the season than they were maintained later. In the others there were various combinations of low and high moisture, the low usually being 12½ per cent and the high 25 per cent. In some cases, however, these percentages were slightly upset by precipitation.

Yield of Grain and Straw

The yield of grain produced with the different treatments is
given in Figure 1, which shows the largest yield where the soil was kept moderately moist, the yield on the very wet and the very dry soil being decidedly less. The tank having 35 per cent of moisture had free water above the surface; hence no crop was produced. The tanks with 30 per cent moisture had free water nearly at the surface in 1913 and a little above the surface in 1915 when the soil had become thoroughly settled; this is, therefore, practically the point of saturation for this soil.

The least grain was produced by the soil which was originally made up to 25 per cent moisture and no more added. This treatment is shown at the extreme right of the figures. With this condition there was a rank growth at first, but as the soil became dried, the plants withered. The volume of soil was too small to carry sufficient moisture to mature the crop.

It is evident that the period prior to the boot stage of the grain is very critical, and if the plant is injured by drought during this period it does not recover even if given plenty of water later. Similar results obtained under field conditions have already been reported in Utah Station Bulletin No. 146.
Fig. 2.—Effect of soil moisture during different periods on the weight of straw.

Fig. 3.—Effect of soil moisture during different periods on the yield of dry matter.
SOIL MOISTURE IN WHEAT PRODUCTION

A comparison of Figures 1 and 2 shows that the yield of straw and that of grain are not affected exactly alike by the moisture, although the two are in general very similar. Low moisture during the critical period mentioned above does not affect the yield of straw so much as it does that of grain.

Figure 3 gives the total production of dry matter included in both grain and straw. It combines the results shown in Figures 1 and 2.

Character of the Grain

The number of kernels produced in each tank as shown in Figure 4 varies in a manner very similar to the total weight of grain. Indeed the yield of grain is dependent largely on the number of kernels matured. Soil with very low and very high moisture content, as well as those in which only the original soil moisture was given, all produced very few kernels of grain. In the most favorable tanks nearly 2400 kernels of wheat were produced while there were less than 100 in the least favorable.

The treatment affected the weight of 100 kernels very much
less than it did the number of kernels produced. In general, the conditions favoring a high yield of grain also favored heavy

Fig. 5.—Effect of soil moisture during different periods on the weight of 100 kernels.

Fig. 6.—Effect of soil moisture during different periods on the number of heads produced.
kernels, although Figure 5 shows there were a number of exceptions to this.

Nature of Heads

That the number of heads produced bears a much closer relationship to the weight of straw than to the weight of grain appears from Figure 6. This indicates that where the moisture conditions are unfavorable, there is a tendency for heads to form even when they do not fill with grain.

The length of head is shown in Figure 7 to be less affected by the treatment than any of the measurements examined thus far. While the effect of the treatment can readily be seen, there is a tendency for the heads to be of uniform length if produced at all.

Figure 8 shows the average number of kernels and Figure 9 the average weight of grain in each head. The results are much the same as for the yield of grain. These are, in reality, two of the important factors which determine yields.

Tillering.

The amount of tillering, or stooling, is indicated in Figure 10,
Fig. 8.—Effect of soil moisture during different periods on the number of kernels per head.

Fig. 9.—Effect of soil moisture during different periods on the weight of grain per head.
Fig. 10.—Effect of soil moisture during different periods on tillering.

Fig. 11.—Effect of soil moisture during different periods on the height of the plants.
which gives the number of culms growing from each plant. In
general, the tillering increases with an increase in moisture until
the very high saturations are reached. When the effect of water
during various stages is studied, it is found that the moisture dur­ing
the early stages in the growth of the plant determines large­
ly the number of culms sent up by each plant.

Height of Plants

Figure 11 shows that the height of plants was determined
much more by the moisture during the second than by that during
the first or third periods; the first had a greater effect than the
third. Conditions favoring high yields also produced the high­
est plants.

Date of Maturity

Figures 12, 13, and 14 give the effect of soil moisture on the
length of the stages in the life of wheat plants. A difference of
about three weeks is seen in the date of maturity between the
plants on a dry and on a wet soil. This leaves out the tanks to

Fig. 12.—Effect of soil moisture during different periods on the time for
the heads to come out of boot.
Fig. 13.—Effect of soil moisture during different periods on the time for the heads to become half ripe. Results from 1914 and 1915.

Fig. 14.—Effect of soil moisture during different periods on the time for the heads to mature. Results from 1915.
which water was added at first, but none added later. Plants on these did not really ripen, but were withered to a sort of maturity by extreme drought. Each figure shows some interesting relations regarding the development of the plants under various conditions, but the three figures are not directly comparable because Figures 12, 13 and 14 show 3, 2 and 1 years results respectively.

**Loss of Moisture**

The total loss of moisture from the tanks including evaporation and transpiration is shown in Figure 15. The tanks producing the largest crops lost the most water, but the loss from the very wet soils was high even though the plant growth was small. In the tanks with free water, although no crops were produced, the loss was greater than from the drier soil on which a fair crop was growing. It will be remembered that the soil surfaces were covered with paraffined paper; this did very little good on the tanks where free water was an inch or two above the surface.
SUMMARY

1. This bulletin gives the results of three years' experiments on the water relations of wheat.

2. The experiments were conducted in large tanks where the moisture could be kept under control much better than in the field.

3. The highest yield of grain was obtained when the soil contained about 20 per cent moisture throughout the season. This was about two-thirds of the moisture required to completely saturate the soil.

4. The wheat plant seems particularly sensitive to soil moisture conditions during the period immediately preceding the boot stage.

5. Results are given for the effect of the moisture treatments on the number of kernels produced, the weight of 100 kernels, the number of heads produced, the length of heads, the average number of kernels in each head, the weight of grain produced by each head, the amount of tillering, the height of plants, and the date of maturity.

6. There was a greater loss of moisture by evaporation and transpiration from soil producing a large crop than from a free water surface, but the loss was greater from the water surface than from a soil producing only a small crop.

7. The importance of a favorable soil moisture condition to a good yield of wheat is made clear. The yield was more than 20 times as great with proper moisture conditions as with unfavorable ones.

8. It is just as bad to have the soil too wet as too dry.

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