GROWTH AND YIELD IN WINTER WHEAT

by

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INTRODUCTION

Seed production represents the ultimate in the life of the wheat plant. Any factor that acts unfavorably upon the wheat plant during any stage of its life history may be reflected in the amount or quality of the seed, or grain, that is produced.

The amount of seed produced by a given area of wheat is spoken of as "yield" and is expressed in bushels per acre. Yield is the result of the number of kernels produced and the size of each kernel. In general, the size of kernel will be most influenced by conditions which occur between fertilization and maturity, while the number of kernels will be influenced prior to and during fertilization. This is a generalization that may not always hold true.

It is generally assumed that a plant does the best it can under the environmental conditions in which it finds itself. In the suboptimal conditions under which most of the world's wheat is grown, the plant seldom has the opportunity to develop to its fullest extent, or in other words, it is limited in its production of grain by the various environmental factors.

There are a great many factors which can limit the growth and yield of a plant or group of plants. Temperature, soil moisture, rainfall, sunlight, hail, leaf rust, stem rust, bunt, and Hessian fly injury are only a few of them. The same limiting factor occurring at different stages of the plant may influence yield in different ways. Thus, an early attack of leaf rust will influence the number of kernels formed, while a late attack occurring after fertilization can affect only the size of each kernel.

An unfavorable environment at an early stage may be partially overcome by more favorable conditions at a later stage. An example of this would be a situation in which low soil moisture limited the number of tillers and heads formed, while later abundant moisture resulted in more and perhaps larger kernels per head being formed than if the normal number of heads had been present. A masking effect, as in the case of bunt, also must not be overlooked.

Since any ecological factor in a suboptimal environment will eventually express itself in terms of yield, it seems logical to assume that the ecological factor may be measured and its effect upon yield calculated. If it were known just how much a leaf rust infection of 50 percent on May 1 would decrease the eventual yield of a field or group of fields, the farmer, warehouseman, merchant, jobber, broker, and the public in general would benefit.

Aside from the practical aspect, it would be of scientific interest to know why the same variety planted and cared for in the same way on the same or similar fields will vary so greatly from year to year. A study of several years' yield, weather, and disease data would probably explain a great deal.

Since growth conditions vary greatly throughout a year or even between adjacent weeks or days, it follows that several years' results may be simulated by exposing plants in varying stages of development to the same condition. For instance, a light frost may completely kill the pollen of a blooming plant and prevent seed formation, while a plant which bloomed a few days earlier may have only the tips of its leaves injured.

A series of wheat plots has been seeded at intervals in the fall at the Agronomy Farm at Manhattan for several years to determine the optimum date of seeding. It would appear, from a purely abstract point of view, that the earlier a plant was started, the longer the period it would have to grow before harvest, and the higher it would yield. Actually, that is not the case for plots seeded as early as September 15 have rather consistently been outyielded by plots seeded from September 28 to October 6 during the period 1932 to 1939, inclusive.

Perhaps the reasons for this phenomenon are the same as in the case of varieties yielding differently in apparently similar years. The use of this approach may greatly reduce the time required to get significant results from the crop-weather project which has been started at Manhattan with the Kansas Agricultural Experiment Station and the United States Department of Agriculture cooperating.

This thesis problem was planned with the purpose of studying the influence of given ecological conditions upon comparable plants in different stages of development. The general lag in the physiologic stages of growth that had been observed in the date of seeding plots at Manhattan was considered sufficient to allow some of the plots to escape a given condition which acted upon other plots at some definite stage of development, as at heading. It will be shown that this lag actually occurred and that the plants reacted differently to environmental conditions.

This experiment included plans for a careful study of kernels per head and size of kernel, but because of the violent hailstorm of June 7, 1939, those phases were largely abandoned. The data presented are those which could be salvaged from the original plan. The complete experiment is being repeated and the data will probably be made available in some publication.

REVIEW OF LITERATURE

Literature directly applicable to this problem is rather scanty, so more or less related material has been studied. This will be reviewed under several headings, namely:

Plant characters determining yield
Number of plants per area
Tillering and head formation
Negative factors
Growth of winter wheat
Influence of variation in seeding date

Plant Characters Determining Yield

Yield of wheat is measured in bushels per acre and is the result of kernels per acre and the weight (or size) of each kernel. The number of kernels will vary with the heads per acre and the kernels per head. The former is the function of the number of plants and the rate of tillering, while the latter is determined by the number of fertile spikelets and the kernels per spikelet. This can be shown in outline as follows:

```
          (Kernel size          (Fertile spikelets
          (                     (per head
          (                     (
Bushels   (          (Kernels   (Kernels per
per acre  (          (per head  (spikelet
          (Number of(
          (kernels   (                    (Rate of seeding
                     (Number of(Number of(
                     (heads     (plants   (Percent survival
                                (
                                (Heads per(Rate of tillering
                                (plant    (
                                          (Percent of tillers
                                          (forming heads
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Kernel size, kernels per head and number of heads are the most easily determined values and include the more important subdivisions. Quisenberry (1928) found the number of heads per sample most closely correlated with yield in 1926. Grantham (1917) thought that the size of the kernel was most important, while Laude (1938) showed that the relative importance of the three may vary with the season.

Bridgeford and Hayes (1931) correlated yield positively with plumpness, 1000 kernel weight, date of heading, and height, and negatively with leaf rust. Dunham (1938) found an association of yield with weight of straw and with 1000 kernel weight in spring wheat. Goulden and Elders (1925) gave correlation values between yield, stem rust index, leaf rust, earliness, and strength of straw. Hayes, Aamodt, and Stevenson (1927) obtained a multiple correlation of .6592 between yield and leaf rust, stem rust, date of heading, height of plant, and percent plumpness of the grain in spring wheat. The same factors and winter injury gave a correlation of .8961 for winter wheat. Sprague (1929) found a high correlation of grain yield per acre with number of spikes per area, and with the straw yield per area. Woodworth (1931) considered seed yield in wheat to be the function of the number of plants per unit area, number of heads per plant, yield per head, and weight of kernel.

Number of Plants Per Area

The number of plants per area is determined by the rate of seeding, percent germination, and seedling survival. Percival (1921) computed the number of kernels that would be spread over an acre at different rates of seeding. He stated that 90-95 percent of the kernels would germinate and 15-30 percent of the seedlings would die.

Size of seed will influence the number of kernels sown for a given rate of seeding. Brown (1936) stated that larger seeded varieties should be sown at a higher rate of seeding than small seeded varieties. Laude (1939), Kiesselbach (1925) and Percival (1921) showed that high test weight seed produced a higher yield than comparable low test weight seed, largely because of the additional heads per acre.

Tillering and Head Formation

The process of tiller formation has been reviewed by Hayward (1938), Percival (1921), and Weaver (1926). Germination of the seed produces an elongating plumule and from three to eight primary roots. The plumule elongates until light perception allows the cotyledon to grow through its tip.

Percival stated that the subcrown internode is formed by elongation of the second internode of the embryo. The first, or lower, internode remains very short. If the growth of the second internode does not reach the surface soil, the third and fourth internodes may elongate until the upper inch of soil is reached. This occurs frequently when the seed is placed four inches or more deep. With favorable later conditions tillers may form at these nodes, or even at the lowest node. (Percival, 1921, and Webb and Stephens, 1936). The depth at which the crown is formed varies with the variety and external factors, such as depth of seeding and environment, especially temperature (Webb and Stephens, 1936). Soon after the cotyledon emerges two foliage leaves develop. Buds are observable in the axils of these leaves as early as in the embryo of the ungerminated seed.

These buds develop rapidly, the plant then showing three shoots above the ground, one on each side of the main stem, arranged in alternate order. Two more shoots soon spring from the primary stem above the first pair and about the same time each of the first two shoots produce two shoots. This makes a total of nine tillers. Additional ones can be formed from any existing tiller. The symmetrical pattern is soon lost, because of crowding, latent buds, and dying of weak tillers (Percival, 1921).

The roots develop about the same time. The primary root system, consisting of from three to seven seminal roots, arises from the embryo of the seed. These roots have been observed, under abnormal conditions, to carry a plant to maturity. (Locke and Clark, 1924). Hayward (1938) stated that in such cases the plant does not tiller to any extent and only the main culm develops, which, though reduced in size, is normal but tends to lodge, because of the absence of the support usually afforded by the crown roots.

The secondary or permanent root system consists of whorls of adventitious roots which arise from the lower nodal regions of the main stem, and its branches near the soil level. The first adventitious roots appear at the tillering node about an inch below the soil level, often not until sometime after leaves from the second and third nodes have appeared. These first roots consist of a pair of roots arising at right angles to the stem and parallel to the seminal roots. These are the permanent roots of the main tiller. Each secondary tiller produces its own adventitious system in a manner similar to that of the main culm, except that a single root instead of a pair is usually produced at the base of each secondary or succeeding lateral axis (Hayward, 1938, and Percival, 1921). Janssen (1929) believed that secondary roots produced in the fall did not resume growth in the spring but were replaced by new secondary roots.

When elongation begins in the spring, each tiller probably draws only on its own secondary roots, rather than on the plant roots as a whole. An experiment was described by Percival (1921) in which a wheat plant was divided into its tillers and replanted three times to secure 500 plants, which produced 21,109 heads and 47 pounds, 7 ounces of grain. Weaver (1926) found the number of secondary roots produced and the number of tillers present closely associated. His data seemed to show that conditions favorable to tiller formation in November and December might not be favorable to secondary root formation, with the result that the number of tillers exceeded the number of secondary roots during that period. During the earlier growth, however, one tiller and one root appeared about every fourth or fifth day.

Percival (1921) stated that many of the tillers would be weak, slender, and develop small heads. Many would die, even after they have reached a height of three to six inches. This was most frequently observed in dry seasons when the adventitious root system associated with each shoot and essential to its nutrition had developed too late, or had dried up before obtaining an adequate hold on the soil.

The time of the cessation of tillering and the elongation of the growing point are varietal characteristics influenced by length of day and temperature. McKinney and Sando (1935) concluded that a critical photoperiod or critical temperature was not involved, for heading occurred over a wide range of these conditions. Wanser (1922) indicated that two different photoperiods may be concerned.

Adams (1924) advanced the theory that a winter wheat plant requires "L" amount of light and "H" heat units before heading can occur. He believed that a plant would head with less "H" and more "L" than the optimum, and vice versa, as long as the maximums and minimums of each were not exceeded.

Bonnett (1936) studied the development of the wheat spike. He stated that the reproductive stage begins when the smooth growing point of the tiller, at that time very near the plant crown, starts forming double ridges upon its surface. The number of spikelets present on the mature spike is determined in this early stage, but adjustment to growth conditions may be made by varying the number of fertile flowers per spikelet. Kiesselbach and Sprague (1926) stated that growing point differentiation takes place about April 1 and that the number of spikelets in the mature spike is determined by May 1 at Lincoln, Nebraska.

Florell and Faulkner (1934) recorded the rate of growth of the wheat culm between stooling and ripening. Under irrigated conditions in Idaho the growth of the stem between first heading and full heading was much more rapid than observed elsewhere. They record a maximum daily height increase of 19.5 cm. for spring sown Baart wheat in 1931. The daily maximum growth for all varieties was 6.0 cm. in 1931, 7.0 cm. in 1932, and 5.5 cm. in 1933.

Thatcher (1915) determined the dry weight per kernel for two varieties of wheat by sampling twice weekly. He could not correlate gains in dry weight with any meteorological measurement available.

Negative Factors

Johnston (1931), Johnston and Miller (1934) and many other workers have shown the effect of diseases upon the yield of wheat. Laude (1938) summarized the negative factors such as diseases as follows:

1. Drought early in the spring may reduce tillering and heads per area, while drought shortly before harvest will affect only the kernel size.

2. Bunt and similar diseases in general will act to reduce the number of heads.

3. Stem rust will affect the size of kernel in most cases.

Thus, the time of infection may determine which yield factor will be acted upon and the degree of infection may express the relative extent to which that factor will be influenced.

The Growth of Winter Wheat

The growth curve of wheat is the symmetrical sigmoid curve typical of many plant species and of the grains and grasses in particular. Bartel and Martin (1938), Pope (1932), Robertson (1923), and Ebiko (1938) gave examples.

Hanna (1925) believed that the manner of measurement was of great importance. He stated that plant height was only an approximate measure of growth while dry weight measured actual growth. Plants were observed to increase in height in the dark, probably because of translocation and assimilation of food materials already stored in the plant.

The rate of growth may be shown by any one of several formulas. Briggs, Kidd, and West (1921) used the formula $R = \frac{W_2 - W_1}{W_1} \times 100$ where W_1 is the measurement taken at the beginning of a period, and W_2 is the measurement taken at the end of the period. This expresses the increase as a percent of the first measurement. Fischer's formula $R = \frac{W_2 - W_1}{\frac{1}{2}(W_1 + W_2)} \times 100$ is considered to be the best by Van De Sande and Alsberg (1927). This expresses the increase as a percent of the average of the two measurements.

Robertson (1923) believed growth in plants to be an autocatalyzed reaction. He used the formula $\log \frac{X}{A - X} = K(T - T_1)$ where X = weight attained in time (T), T = time, T_1 = the time at which growth is one-half completed, or where $X = \frac{1}{2}A$, A = total growth during the cycle, and K = a constant, the magnitude of which determines the slope of the curve. This was calculated from the observed values of X, then substituted into the formula and theoretical values of X calculated. Marked correlation between observed and calculated values was obtained. Van De Sande and Alsberg (1927) suggest that this formula may be in error in assuming a single factorial basis of growth. Ebiko (1938) found complete dominance of K value in an early x late spring wheat cross.

The growth of wheat as related to the environmental factors has been studied largely for lethal effects and for influence on yield. Salmon (1927) associated the northern limit of winter wheat production with the 10° F. January minimum isotherm. Suneson and Peltier (1934a, 1934b), Peltier and Kiesselbach (1934), Worzella (1935), Laude (1937), Suneson (1930), and other workers have studied the low lethal temperatures of wheat at various stages of development.

Hurd-Karrer (1933) stated that some growth takes place as low as 8 to 10° C. Lundegardh (1931) reported that temperatures above 30° C. decreased carbon dioxide assimilation in a sun plant during the day, while temperatures of 15 to 30° C. increased carbon dioxide assimilation. Huntington and others (1923) used a macro-climatic method of determining the optimum environment for wheat. McKinney and Sando (1935) stated that barley has a lower optimum temperature for tillering than for stem elongation.

Call and Hallsted (1915), Cole (1938), Matthews (1923), Hallsted and Coles (1930), Chilcott (1927), and others have studied rainfall and soil moisture in relation to yield of wheat.

Influence of Variation in Seeding Date

The influence of the date of seeding on growth and yield of wheat has been recognized for many years. There are few experiment stations which have not determined the optimum date of seeding for a period of years. Practically all of these experiments have been concerned with determining the optimum date of seeding for maximum yield. Jardine (1916) summarized the early rate and date of seeding experiments at Manhattan, Kansas.

Bayles and Martin (1931) planted wheat over an eight month period. They found that in plots planted later than a certain date, depending upon the season, yielded considerably less grain than earlier plots, while very late spring planted plots did not even form heads. Percival (1921) reported similar results. These very late seeded plants will form heads at the normal time the next year unless they are severely injured by drought or winterkilling.

Martin (1926) stated that the optimum date of seeding for winter wheat was independent of soil type, annual precipitation, variety, or rate of seeding, but related somewhat to temperature. He reported that Swanson (unpublished) found a correlation of yield and mean temperature at date of seeding, with the highest yield at 65° F.

Janssen (1929) found that excessive fall growth associated with early planting resulted in greater winter injury and later resumption of growth in the spring while late plantings were fragile and very susceptible to heaving. Harrington and Horner (1935) attempted to find varietal differences in optimum date of seeding for spring wheat. Suneson and Kiesselbach (1934) found increased winterhardiness and Hessian fly infestation in early dates of seeding.

MATERIALS AND METHODS

In this study samples from measured areas in 14 plots of winter wheat, representing two varieties seeded at weekly intervals from September 15 to October 29, inclusive, were obtained previous to and during the spring growing season. The number of plants, tillers on each plant, and the oven dry weight of each sample were recorded. In later samples, the number of heads and total dry weight of heads were taken and where possible the head samples were threshed.

The plots were located on slightly rolling Nuckolls silt loam in the southeast corner of Field A at the Agronomy Farm of Kansas State College. The seed used was grown in the wheat variety test at Manhattan in 1938. Kanred, a widely grown mid-season hard red winter wheat, and Early

Blackhull, an early maturing hard red winter wheat, were the two varieties used. The Kanred seed had a test weight of 50 pounds per bushel, while the Early Blackhull weighed 55 pounds per bushel from plots that yielded 17 and 12 bushels per acre, respectively. The low yields and test weights were due to early and severe attacks of leaf and stem rust.

The samples were dried in a 28 cubic foot electric oven. Thermostatic control at 95° C. was used for all samples. The oven is illustrated in Fig. 1.

A Class A weather station, shown in Fig. 2, was located about 200 yards north of the plots. Readings taken at the station were available for micro-climatic studies. Periodic observations were taken with the following equipment:

1. Minimum and maximum thermometers
2. Sling psychrometer
3. Weather vane
4. Three cup anemometer
5. Large open-pan evaporimeter
6. Standard rain gauge
7. Weighing and recording rain gauge
8. Weekly recording hygrothermograph
9. Weekly recording thermograph
10. Three point soil thermograph with points set one-half, three, and six inches deep under bare soil
11. Black and white spherical atmometers

All equipment was maintained at the station, shown in Fig. 2. On May 1 the thermograph was moved from the station to a guard plot near the center of the plots and set up on the ground in such a way as to be protected from the

EXPLANATION OF PLATE I

Fig. 1. Twenty-eight cubic foot oven used in dry weight observations.

PLATE I

Fig. 1

EXPLANATION OF PLATE II

Fig. 2. Class A weather station located at the Agronomy Farm, Manhattan, Kansas.

PLATE II

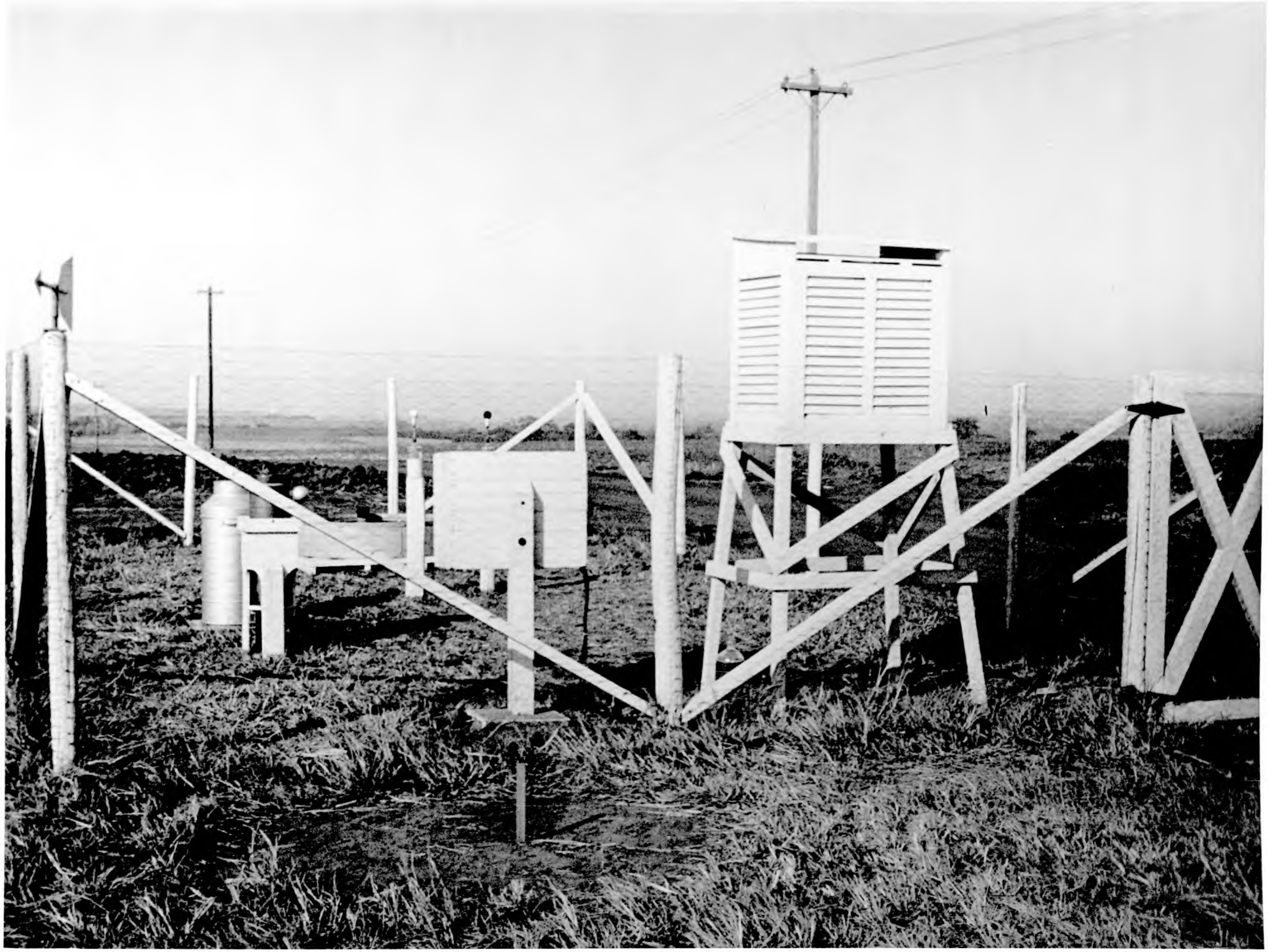

Fig. 2

weather and allow free circulation of air. Atmometers were set up nearby with bulbs three, eighteen, and thirty-six inches above the ground.

Recommended practices were followed to prepare the land for winter wheat. The plots were laid out systematically with the blocks of Early Blackhull, Quivira, Kanred, and Oro in succession from south to north. Each block consisted of eight plots; a guard, planted September 15, and seven plots seeded in order from south to north on September 15, September 22, September 29, October 6, October 13, October 20, and October 27. They were 1/40 acre plots, 8 feet wide and 136 feet, 3 inches long. Guards and alleys separated the four blocks from the rest of the field. Because of the labor involved only the Early Blackhull and Kanred plots were sampled for this study.

A common type, seven foot drill with twelve spouts seven inches apart was used. All plots were seeded at the rate of 5.5 pecks per acre. The two earliest plots were seeded four inches deep because of dry soil, while the other plots were planted three inches deep.

It was assumed that 100 plants would give a representative sample of each plot. From the field counts made in determining the number of plants per acre, it was estimated that 9 feet of drill row would probably contain about 100 plants in a majority of the samples. This size of sample actually gave an average of 89.46 plants for 280 samples taken at 10 stages of plant development.

Hudson (1939) stated that the optimum sample size and shape in wheat is six feet of drill row taken as three feet of two adjacent drill rows, but that little accuracy was lost in using one and one-half feet of drill row of five adjacent rows. The sample used follows his results in that it consisted of 27 inches of drill row of 4 adjacent rows, or an area 27 by 28 inches.

Since it was necessary to conserve plots space and desirable to secure duplicate samples, the samples within the plots were located as follows: The 12 drill rows of each plot were numbered 1 to 12 from the south side of the plot. The "west" sample consisted of an area including parts of the second, third, fourth, and fifth rows, while the "east" sample consisted of an area including parts of the eighth, ninth, tenth, and eleventh rows. On the next sampling date the "east" and "west" samples were reversed. That is, the "west" sample would contain parts of the eighth, ninth, tenth, and eleventh rows and the "east" sample would be taken from the second, third, fourth, and fifth drill rows. This left the two outer and two inner drill rows, or the first, sixth, seventh, and twelfth rows as guards between samples. A strip was also left between adjacent samples of the same drill rows. Samples were secured by digging out the plant or by cutting off the roots just under the crown with a sharp hoe. The plants were secured undamaged in a great majority of the cases, only an occasional plant being injured when the ground was dry and hard. Each sample was placed in a labeled paper bag and the top folded in. When the plants approached maturity the roots and crowns were placed in the paper bag and the tops of the sample tied together with a string. The string was also labeled so that any sample could be positively identified. Height notes were taken by measuring to the tip of the tallest leaf or culm at each end of each drill row sampled. This gave eight values for each sample, or sixteen for each plot.

The groups of samples were carried into the laboratory where they were analyzed as soon as possible. When it was necessary to hold them overnight or longer, they were hung in a cool place outside.

As each sample was removed from its paper bag, a cardboard tag with a sample number identical with the label on the bag was placed with it. This tag remained with the sample and served as identification until the sample was discarded after dry weight determination.

The crowns and roots of each plant and the leaves and stems, when necessary, were carefully washed in tap water to remove all the soil present in the sample. Running water was used and a quarter-inch mesh screen served to catch leaves or young plants which might have been broken off or lost.

After washing, the number of tillers on each plant was determined and recorded. Every leaf roll that had developed chlorophyll was included in the total. For each plant with a given number of tillers, one mark was made in the appropriate column and row on the frequency sheet. Thus, if sample K3E contained one plant with three tillers, one mark would be put in the "3 tillers per plant" row of the "K3E" sample. If this same sample contained two plants with three tillers each, two marks would be put in the same place. Plants with 20 tillers or less were recorded in this way, while plants with more than 20 tillers were recorded by number.

The prominent subcrown internode allowed each plant to be separated from adjacent plants. This was of greatest value where two or more plants had intergrown. Free tillers from plants which had been broken up in digging were sorted out and were assumed to be the products of one or more plants, depending upon the number of tillers and the apparent average tillers per plant.

The heads were clipped from the culms on which the base of the head was visible above the collar of the upper leaf sheath. Not more than one-fourth inch of straw was left attached to each head. After counting, the heads were placed in a labeled paper bag and dry weight obtained.

The roots were trimmed as closely as possible to the crown with a pair of scissors. Then each sample was put into a clean paper bag and dried for 48 hours at 95° C. in the oven already described.

The samples were removed from the oven six or seven at a time and allowed to cool for a few minutes before weighing. Small samples were weighed on a torsion balance with a sensitivity of 0.01 gram, while larger samples were weighed on a balance accurate to one-tenth of a gram.

The dry head samples were stored for several months, then threshed on a small head thresher. The weight of grain and the average weight of three 500 kernel samples were taken. From these values the number of kernels per sample and kernels per head were calculated. Samples damaged in storage were discarded.

The following values were obtained for each sample:

1. Total dry weight. This was obtained as a direct measurement, or by adding the dry weight of the heads to

the dry weight of the straw in later samples.

2. Total number of plants. Totaling the number of entries in the frequency table gave this value.

3. Total number of tillers. An example must be used to explain this. In a sample of ten plants, two plants may have one tiller, two may have two tillers, and six may have three tillers. In such a case there are two tillers in the one tiller group, four in the two tiller group, and eighteen in the three tiller group, or a total of 24 tillers for the ten plants.

4. Average number of tillers per plant. This was obtained by dividing the total tillers by the total plants in each sample.

5. Average dry weight per plant. The total dry weight divided by the number of plants gave this value.

6. Average dry weight per tiller. Dividing total dry weight by total number of tillers gave this index of tiller size.

7. Average height of sample. The height of the eight plants left exposed at the end of the drill rows by the removal of the sample was recorded in centimeters. Height was taken as the distance from the ground to the tip of the upper leaf, or to the tip of the head excluding awns, after the latter value became greater.

8. Total number of heads per sample. The heads were counted as they were clipped from the sample.

9. Total weight of heads. This was measured directly.

10. Average dry weight per head. The total dry weight was divided by the total number of heads.

The plot values were determined by averaging the "east" and "west" samples. Samples were taken on December 22, March 20, April 4, April 20, April 27, May 4, May 11, May 18, May 26, June 1, June 9, and June 15. Only one sample from each plot could be secured on May 18 because of inclement weather. A hailstorm on June 7 resulted in such severe damage that dry weight and threshed grain observations for June 9 and June 15 were of little value. An estimate of the damage was made and is included in the field notes.

The following field notes were taken for each plot:

1. Date of emergence. This was taken as the day on which a full stand was first observed and after which there was no marked increase in plant density.

2. Date of first heading. The day on which the first heads were pushed completely above the boot.

3. Date of full heading. The first day on which all heads were completely free of their boots.

4. Date first ripe. Day on which the earliest heads reached the "binder" stage of ripeness.

5. Date full ripe. Day on which all heads had reached the "binder" stage, and the plot was ready for cutting.

6. Date harvested. The time of binding.

7. Disease readings were made by qualified persons at opportune times.

8. Number of plants per acre. This was determined by averaging the number of plants in five, five-foot drill row sections selected at random and transposing this figure into an acre value. The counts were made after full emergence and before tillering.

9. Number of heads per acre. After the plots were bound, the number of culms in twelve five-foot drill row sections was determined by means of a stubble count. These counts were averaged and an acre equivalent calculated.

10. Height. This was the average of ten measurements taken at random throughout the plot just prior to binding. The height in inches to the tip of the head, excluding beards, was used.

11. Weight of 100 ten centimeter sections of straw. Samples were taken at random in the plot to obtain at least 100 culms. These were stored, and later ten centimeter sections were cut from the center of each of the 100 culms and the group weighed.

12. Yield. Plots were threshed on an eighteen inch threshing machine which was cleaned between plots. The yield per acre was calculated from the weight of grain obtained.

13. Bushel weight. The standard dockage kicker and Boerner test weight apparatus were used.

14. 1000 kernel weight. This is an average obtained from the weight of three samples of 500 kernels each.

15. Hail damage. This was estimated as the percent of the total culms which were broken over and the percent of the total grain shattered.

These notes are recorded in Table 3.

EXPERIMENTAL DATA

All of the experimental data collected are presented in Tables 1 to 5, inclusive. Table 1 gives the observed and calculated values per sample and per plot upon which the analysis of the experiment was made. In subjecting the bulk of the data to analysis of variance, the samples taken on May 18 and June 15 were omitted, the May 18 values because only one sample per plot could be taken, and the June 15 samples because the earliest plots had been harvested. This left 280 observations upon which to base conclusions.

Table 2 presents the plot values obtained by recording the number of tillers on each plant. These data are presented graphically on Plates III and IV. In these plates the date of planting is shown on the left and the date of sampling is shown above. Each group of bars designates the averages of a plot and the height of each bar shows the percent of the total plants. Thus, for Early Blackhull wheat seeded October 20 and sampled May 18, 37 percent of the plants had one tiller, 21 percent had two tillers, 21 percent had three tillers, 9 percent had four tillers, 4 percent had five tillers, and 8 percent had six tillers.

The field notes taken on each plot are presented in Table 3. Yields of the plots were in about the same order as the long-time averages for similar dates of seeding, but the hail injury tended to bring the plot yields closer together than has usually been the case. This was especially true for the first four dates of seeding. An estimate of hail injury is given in the table.

The temperature records for the sampling periods of March, April, and May are given in Table 4. The minimum and maximum readings were taken from equipment at the weather station, while the hourly readings were secured from the thermograph located at the station until May 1, and in the wheat plots thereafter.

After the head samples were dried and weighed, they were stored and later were threshed on a small head thresher.

Table 1. Observed and calculated values obtained from twelve periodic samples of two varieties of winter wheat seeded at weekly intervals, Manhattan, Kansas, 1938-1939.

Sampled	Date seeded	No. of plants			No. of tillers			Total dry wt. in grams			Ave. tillers per plant			Ave. dry wt. per plant			Ave. dry wt. per tiller			Height in centimeters		
		E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.
Early Blackhull																						
Dec. 22 1938	Sept. 15	112	49	80.5	662	272	467.0	64.81	25.00	44.911	5.970	5.550	5.760	.5786	.5102	.544	.098	.092	.0944			
	Sept. 22	97	47	72.0	583	205	394.0	45.68	12.66	29.17	6.010	4.360	5.185	.4709	.2694	.370	.078	.062	.0701			
	Sept. 29	138	93	115.5	627	318	472.5	29.34	14.82	22.03	4.540	3.420	3.980	.2126	.1594	.186	.047	.047	.0467			
	Oct. 6	59	174	116.5	163	339	251.0	5.36	7.84	6.60	2.760	1.950	2.350	.0908	.0451	.068	.033	.023	.0280			
	Oct. 13	86	72	79.0	112	94	103.0	1.96	1.83	1.90	1.300	1.310	1.305	.0228	.0254	.024	.018	.020	.0185			
	Oct. 20	79	101	90.0	80	101	90.5	.87	1.85	1.36	1.010	1.000	1.005	.011	.0183	.015	.011	.018	.0146			
	Oct. 27	81	90	85.5	81	90	85.5	.81	.20	.81	1.000	1.000	1.000	.0099	.0091	.010	.010	.009	.0095			
Mar. 20 1939	Sept. 15	112	152	132.0	814	618	716.0	56.8	42.6	49.70	7.270	4.070	5.670	.507	.280	.394	.070	.069	.0695			
	Sept. 22	77	73	75.0	724	503	613.5	37.9	27.3	32.60	9.400	6.890	8.145	.492	..374	.433	.052	.054	.0533			
	Sept. 29	125	96	110.5	909	461	685.0	38.1	19.4	28.75	7.270	4.800	6.035	.305	.202	.254	.042	.042	.0420			
	Oct. 6	84	141	112.5	441	469	455.0	12.25	11.5	11.88	5.250	2.330	4.290	.146	.082	.114	.028	.025	.0261			
	Oct. 13	66	72	69.0	178	143	160.5	2.44	2.63	2.54	2.700	1.990	2.345	.037	.037	.037	.014	.018	.0161			
	Oct. 20	85	103	94.0	134	161	147.5	1.94	2.74	2.34	1.580	1.560	1.570	.023	.027	.025	.015	.017	.0158			
	Oct. 27	100	73	86.5	114	75	94.5	1.51	1.30	1.41	1.140	1.030	1.085	.015	.018	.017	.013	.017	.0153			
Apr. 4 1939	Sept. 15	107	125	116.0	984	893	938.5	131.2	84	107.60	9.200	7.140	8.170	1.230	.670	.950	.133	.094	.1137			
	Sept. 22	80	67	73.5	927	466	696.5	85.2	45	65.10	11.560	6.960	9.275	1.060	.670	.865	.092	.097	.0918			
	Sept. 29	135	84	109.5	1020	577	798.5	89.9	40.7	65.3	7.560	6.870	7.215	.670	.480	.575	.088	.071	.0793			
	Oct. 6	66	93	79.5	475	453	464.0	28.6	19.6	29.10	7.200	4.87	6.035	.430	.210	.320	.060	.043	.0518			
	Oct. 13	96	98	97.0	483	433	458	14	11.5	12.75	5.030	4.42	4.725	.160	.120	.140	.029	.027	.0278			
	Oct. 20	73	106	89.5	160	288	224	4.7	9.7	7.20	2.190	2.72	2.455	.060	.090	.075	.029	.034	.0316			
	Oct. 27	66	74	70.0	152	172	161.0	4.5	3.4	3.95	2.300	2.32	2.310	.070	.050	.060	.030	.020	.0247			
Apr. 20 1939	Sept. 15	106	115	110.5	813	687	750	189.3	104.	146.65	7.670	5.970	6.820	1.790	.900	1.345	.233	.151	.1921			
	Sept. 22	47	61	54.0	570	474	522.0	106.1	62.5	84.30	12.130	7.770	9.950	2.260	1 .020	1.640	.186	.132	.1590			
	Sept. 29	130	146	138.0	1008	721	864.5	151.7	98.7	125.20	7.750	4.940	6.345	1.170	.680	.925	.151	.137	.1437			
	Oct. 6	99	72	85.5	657	419	538.0	69.1	39.3	54.20	6.640	5.820	6.230	.700	.550	.625	.015	.094	.0995			
	Oct. 13	77	99	88.0	436	423	429.5	26.5	30.2	28.35	5.660	4.270	4.965	.340	.310	.325	.061	.071	.0661			
	Oct. 20	86	84	85.0	248	343	395.5	14.8	23.2	19.00	2.884	4.083	3.484	.172	.276	.224	.060	.069	.0637			
	Oct. 27	53	91	72.0	192	223	207.5	9	10.6	9.80	3.625	2.451	3.038	.170	.116	.143	.047	.049	.0472			

Table 1 continued.

Sampled	Date seeded	No. of plants			No. of tillers			Total dry wt. in grams			Ave. tillers per plant			Ave. dry wt. per plant			Ave. dry wt. per tiller			Height in centimeters			No. of heads			Total dry wt. of heads in grams			Ave. dry wt. per head		
		E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.
Early Blackhull																																		
Apr. 27 1939	Sept. 15	105	143	124.0	727	566	646.5	246.4	154.7	200.55	6.920	3.960	5.440	2.347	1.082	1.7155	.3397	.273	.3061	58.2	45.6	51.9									
	Sept. 22	90	84	87.0	619	392	505.5	209.2	106.9	154.05	6.878	4.670	5.774	2.324	1.273	1.799	.338	.273	.3054	58.5	43.6	51.6									
	Sept. 29	104	92	98.0	693	428	560.5	184.4	121.2	152.80	6.660	4.650	5.655	1.773	1.317	1.545	.266	.283	.2747	54.5	39.1	46.8									
	Oct. 6	83	118	100.5	612	491	551.5	151.3	101.2	126.25	7.370	4.160	5.765	1.823	.858	1.341	.247	.206	.2267	45.8	40.2	43.0									
	Oct. 13	129	78	103.5	537	303	420.0	111.4	50.4	80.9	4.160	3.880	4.020	.864	.646	.755	.207	.166	.1869	40.8	33.9	37.4									
	Oct. 20	102	129	115.5	447	396	421.5	57.8	64.4	61.10	4.382	3.070	3.776	.567	.499	.533	.129	.163	.1460	31.4	29.8	30.6									
	Oct. 27	74	57	65.5	269	195	232.0	19.1	16.7	17.90	3.635	3.421	3.520	.258	.293	.276	.071	.086	.0783	28.9	25.8	27.4									
May 4 1939	Sept. 15	117	110	113.5	500	510	505.0	320.2	230.3	275.25	4.274	4.636	4.455	2.737	2.094	2.416	.640	.452	.5460	83	70.2	76.6									
	Sept. 22	68	86	77.0	458	494	476.0	273.3	212.1	242.70	6.735	5.844	6.290	4.019	2.466	3.243	.597	.429	.5131	83	70.8	76.9									
	Sept. 29	121	108	114.5	539	549	544.0	254	251.7	255.35	4.455	5.083	4.769	2.140	2.331	2.236	.481	.459	.4695	73.4	70.0	71.7									
	Oct. 6	102	115	108.5	459	384	421.5	177.6	160.3	168.95	4.500	3.339	3.920	1.741	1.394	1.568	.387	.417	.4022	63.9	61.9	62.9									
	Oct. 13	68	85	76.5	367	383	375.0	104.9	114.7	109.80	5.397	4.506	4.952	1.543	1.349	1.446	.286	.300	.2927	48.4	51.5	50.0									
	Oct. 20	95	99	97.0	362	338	350.0	97.6	97.	97.30	3.811	3.414	3.613	1.027	.980	1.004	.270	.287	.2783	49.9	48.5	49.2									
	Oct. 27	61	71	66.0	270	256	263.0	55	36.9	45.95	4.426	3.606	4.016	.902	.520	.711	.204	.144	.1739	41.1	30.9	36.0									
May 11 1939	Sept. 15	131	129	130.0	411	469	440.0	407.3	391.5	399.4	3.137	3.636	3.387	3.109	3.035	3.072	.991	.835	.9129	93.5	86.6	90.1									
	Sept. 22	92	67	79.5	417	300	358.5	397	242.2	319.6	4.533	4.478	4.506	4.315	3.615	3.965	.952	.807	.8791	88.5	82.1	85.3									
	Sept. 29	74	62	68.0	386	203	294.5	267.2	169.3	218.25	5.216	3.274	4.245	3.611	2.731	3.171	.692	.834	.7631	81.6	72.2	76.9									
	Oct. 6	110	101	105.5	528	385	456.5	356.1	271.8	313.95	4.800	3.812	4.306	3.237	2.691	2.964	.674	.706	.6902	79.4	72.0	75.7									
	Oct. 13	94	75	84.5	383	280	331.5	203.4	147.6	175.50	4.074	3.733	3.804	2.164	1.968	2.066	.531	.527	.5291	69.5	67.9	68.7									
	Oct. 20	67	107	87.0	209	263	236.0	94.9	131.0	112.95	3.119	2.458	2.789	1.416	1.224	1.320	.454	.498	.4761	57.2	52.0	54.6									
	Oct. 27	61	76	68.5	232	259	245.5	87.3	83.2	85.25	3.803	3.408	3.606	1.431	1.095	1.220	.376	.321	.3488	54.8	45.5	50.2									
May 18 1939	Sept. 15	83			345			406.8			4.157			4.901			1.179			110.0			246			61.8			.251		
	Sept. 22	88			316			428.4			3.591			4.868			1.356			104.9			262			67.0			.256		
	Sept. 29	81			223			256.3			2.753			2.164			1.149			88.0			163			44.5			.273		
	Oct. 6	122			383			301.0			3.139			2.467			.786			100.2			206			47.8			.232		
	Oct. 13	80			302			224.2			3.775			2.802			.742			87.0			147			34.9			.237		
	Oct. 20	67			164			136.8			2.448			2.042			.834			71.9			20			4.6			.230		
	Oct. 27	45			192			104.8			4.267			2.329			.546			67.5			—			—			—		

Table 1 continued.

Sampled	Date seeded	No. of plants			No. of tillers			Total dry wt. in grams			Ave. tillers per plant			Ave. dry wt. per plant			Ave. dry wt. per tiller			Height in centimeters			No. of heads			Total dry wt. of heads in grams			Ave. dry wt. per head		
		E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.
Early Blackhull																															
May 26 1939	Sept. 15	122	106	114.0	360	349	354.5	410.3	494.9	452.6	2.951	3.292	3.122	3.363	4.669	4.016	1.140	1.418	1.279	105.3	114.8	110.1	256	301	278.5	106.3	114.9	110.6	.415	.382	.399
	Sept. 22	58	79	68.5	303	283	293.0	410.6	455.6	433.1	5.224	3.582	4.403	7.079	5.767	6.423	1.355	1.610	1.483	110.8	107.0	108.9	252	235	243.5	109.2	106.1	107.7	.433	.451	.442
	Sept. 29	89	104	96.5	272	317	294.5	297.4	440.4	368.9	3.056	3.048	3.052	3.342	4.235	3.789	1.093	1.389	1.241	93.1	96.5	94.8	198	266	232.0	88.3	128.2	108.3	.446	.482	.464
	Oct. 6	102	77	89.5	275	287	281.0	301.8	412.2	357.0	2.696	3.727	3.212	2.959	5.353	4.106	1.097	1.436	1.267	105.1	99.8	102.5	197	228	212.5	70.6	111.7	91.2	.358	.490	.424
	Oct. 13	72	64	68.0	215	227	221.0	222.5	269.7	246.1	2.986	3.547	3.267	3.090	4.214	3.652	1.035	1.188	1.112	99.5	97.8	98.7	174	172	173.0	51.7	70.7	61.2	.297	.411	.354
	Oct. 20	81	79	80.0	263	219	241.0	195.5	262.9	229.2	3.247	2.772	3.010	2.414	3.328	2.872	.743	1.200	.972	92.2	94.5	93.4	155	176	165.5	41	57.3	49.2	.265	.326	.296
	Oct. 27	81	55	68.0	242	163	202.5	229.4	147	188.2	2.988	2.964	2.876	2.832	2.673	2.753	.948	.903	.925	89.4	73.5	82.0	167	86	126.5	40	25.4	32.7	.240	.295	.268
June 1 1939	Sept. 15	120	84	102.0	360	322	341.0	542.1	492.3	517.15	3.	3.833	3.417	4.517	5.860	5.189	1.506	1.529	1.518	109.2	108.6	108.9	288	262	275.0	183.5	170	176.9	.637	.649	.643
	Sept. 22	103	95	99.0	298	240	269.0	432.4	375.7	404.05	2.893	2.526	2.710	4.198	3.955	4.077	1.451	1.565	1.508	102.9	111.5	107.2	260	215	237.5	163.4	131	147.2	.628	.609	.618
	Sept. 29	93	101	97.0	288	285	286.5	358.1	406.9	382.50	3.097	2.822	2.960	3.805	4.029	3.917	1.243	1.428	1.336	95.0	101.5	98.3	208	239	223.5	132	149.9	141.0	.635	.627	.631
	Oct. 6	100	103	101.5	301	270	285.5	432.5	395.4	413.95	3.010	2.621	2.816	4.325	3.839	4.082	1.437	1.464	1.451	106.2	101.4	103.8	240	233	236.5	146.1	144.5	145.3	.613	.620	.617
	Oct. 13	110	72	91.0	268	193	231.5	309.5	255.1	282.30	2.436	2.681	2.559	2.814	3.543	3.178	1.155	1.322	1.239	92.2	101.2	96.7	210	155	182.5	110.3	84.1	97.2	.525	.543	.534
	Oct. 20	71	81	76.0	192	190	191.0	223.1	252.6	237.85	2.704	2.346	2.525	3.142	3.119	3.131	1.162	1.329	1.246	96.2	93.1	94.7	150	165	157.5	65.1	82.6	73.9	.434	.501	.468
	Oct. 27	54	63	58.5	152	164	158.0	157.6	174.6	166.10	2.815	2.603	2.709	2.919	2.771	2.845	1.037	1.065	1.051	86.5	82.2	84.4	135	145	140.0	39.1	47.9	43.5	.290	.330	.310
June 9 1939	Sept. 15	79	88	83.5	231	258	244.5	284.6	380.6	332.6	2.924	2.932	2.928	3.603	4.325	3.964	1.232	1.475	1.354				194	235	214.5	109.5	145.4	127.5	.564	.619	.597
	Sept. 22	96	74	85.0	284	228	256.0	396.3	317	356.65	2.958	3.081	3.020	4.128	4.284	4.206	1.395	1.390	1.393				258	192	225.0	152.8	127.3	140.1	.592	.663	.628
	Sept. 29	92	97	94.5	239	221	230.0	276.7	268.4	272.55	2.598	2.278	2.430	3.008	2.767	2.888	1.158	1.214	1.186				193	192	192.5	104.1	98.4	101.3	.539	.512	.526
	Oct. 6	82	88	85.0	207	235	221.0	258.9	330.2	294.55	2.524	2.670	2.597	3.157	3.752	3.455	1.251	1.405	1.328				175	201	188.0	99.5	129.6	114.6	.569	.645	.607
	Oct. 13	82	72	77.0	177	208	192.5	215.3	269.7	242.5	2.159	2.889	2.524	2.626	3.746	3.186	1.216	1.297	1.257				149	185	167.0	81.5	113.6	97.6	.546	.614	.581
	Oct. 20	75	57	66.0	145	156	150.5	170.4	221.9	196.15	1.933	2.737	2.335	2.272	3.893	3.083	1.175	1.422	1.298				124	136	130.0	60.6	84.2	72.4	.489	.619	.554
	Oct. 27	91	50	70.5	204	123	163.5	256.	124.2	190.1	2.242	2.460	2.351	2.813	2.484	2.649	1.255	1.010	1.133				191	101	146.0	95.6	44.2	69.9	.500	.438	.469
June 15 1939	Sept. 15							Plots harvested																							
	Sept. 22							"	"																						
	Sept. 29							"	"																						
	Oct. 6							"	"																						
	Oct. 13		66			176			219.5			2.667			3.326			1.247						138			84.1			.609	
	Oct. 20	97	77	87.0	249	169	209.0	294.3	181.5	237.9	2.567	2.195	2.381	3.034	2.357	2.696	1.182	1.074	1.128				210	111	156.0	111.3	60.2	85.8	.554	.542	.548
	Oct. 27	37	48	42.5	100	111	105.5	110.7	132.1	121.4	2.703	2.312	2.508	2.992	2.752	2.872	1.107	1.193	1.150				84	117	100.5	41.5	54.8	48.2	.494	.468	.484

Table 1 continued.

Sampled	Date seeded	No. of plants E	No. of plants W	No. of plants Ave.	No. of tillers E	No. of tillers W	No. of tillers Ave.	Total dry wt. in grams E	Total dry wt. in grams W	Total dry wt. in grams Ave.	Ave. tillers per plant E	Ave. tillers per plant W	Ave. tillers per plant Ave.	Ave. dry wt. per plant E	Ave. dry wt. per plant W	Ave. dry wt. per plant Ave.	Ave. dry wt. per tiller E	Ave. dry wt. per tiller W	Ave. dry wt. per tiller Ave.
Kanred																			
Dec. 22 1938	Sept. 15	104	118	111.0	563	618	590.5	40.23	50.45	45.34	5.410	5.240	5.325	.387	.428	.407	.0714	.0816	.0765
	Sept. 22	84	77	80.5	547	370	458.5	35.26	21.25	28.26	6.510	4.810	5.660	.420	.276	.348	.0645	.0574	.0610
	Sept. 29	51	108	79.5	191	453	322.0	7.33	19.81	13.57	3.750	4.190	3.970	.144	.183	.164	.0384	.0437	.0411
	Oct. 6	58	52	55.0	73	136	104.5	1.35	4.59	2.97	1.260	2.620	1.940	.023	.088	.056	.0184	.0338	.0261
	Oct. 13	98	70	84.0	103	82	92.5	1.65	1.00	1.33	1.050	1.170	1.110	.016	.014	.015	.0160	.0121	.0141
	Oct. 20	141	64	102.5	141	64	102.5	2.46	.75	1.61	1.000	1.000	1.000	.018	.012	.014	.0176	.0117	.0147
	Oct. 27	88	79	83.5	88	79	83.5	.82	.89	.86	1.000	1.000	1.000	.009	.011	.010	.0093	.0113	.0103
Mar. 20 1939	Sept. 15	106	118	112.0	1115	857	986.0	69.6	49.7	59.65	10.52	7.260	8.890	.657	.421	.539	.0624	.0580	.0602
	Sept. 22	89	61	75.0	709	642	675.5	30.4	28.3	29.35	7.97	10.52	9.245	.342	.464	.403	.0429	.0441	.0435
	Sept. 29	86	100	93.0	801	792	796.5	22.5	22.9	22.7	9.31	7.92	8.615	.262	.229	.246	.0281	.0289	.0285
	Oct. 6	86	59	72.5	465	431	498.0	12.31	10.11	11.21	6.57	7.31	6.940	.143	.171	.157	.0218	.0236	.0227
	Oct. 13	113	58	85.5	367	171	269.0	6.08	2.89	4.49	3.25	2.95	3.100	.054	.050	.052	.0166	.0169	.0168
	Oct. 20	107	65	86.0	150	75	112.5	2.78	1.61	2.20	1.40	1.150	1.275	.026	.025	.026	.0185	.0215	.0200
	Oct. 27	86	110	98.0	92	112	102.0	1.67	2.22	1.95	1.07	1.020	1.045	.019	.020	.020	.0182	.0198	.0190
Apr. 4 1939	Sept. 15	131	82	106.5	1346	822	1084.0	133.	68.7	100.85	10.27	10.02	10.14	1.020	.840	.930	.0988	.0836	.0912
	Sept. 22	90	120	105.0	990	864	927.0	84.0	62.4	72.20	11.00	7.20	9.10	.930	.520	.725	.0848	.0722	.0785
	Sept. 29	77	83	80.0	842	544	693.0	62.0	21.9	41.95	10.94	6.55	8.75	.810	.260	.535	.0736	.0403	.0570
	Oct. 6	55	71	63.0	374	549	461.5	18.1	21.2	19.65	6.80	7.73	7.27	.330	.300	.315	.0484	.0386	.0435
	Oct. 13	95	96	95.5	524	380	452.0	17.1	10.0	13.55	5.52	3.96	4.74	.180	.100	.140	.0326	.0263	.0295
	Oct. 20	77	79	78.0	211	144	177.5	6.6	3.7	5.15	2.74	1.82	2.28	.090	.050	.070	.0313	.0257	.0285
	Oct. 27	82	110	96.0	136	146	141.0	5.0	4.5	4.75	1.66	1.33	1.50	.060	.040	.050	.0368	.0308	.0338
Apr. 20 1939	Sept. 15	150	127	138.5	1221	1022	1121.5	212.5	139.6	176.15	8.14	8.05	8.10	1.420	1.100	1.260	.1740	.1366	.1553
	Sept. 22	[illegible]	83	98.5	1162	694	928.0	173.0	74.8	123.90	10.19	8.36	9.28	1.520	.900	1.210	.1489	.1078	.1284
	Sept. 29	86	81	83.5	763	654	708.5	77.4	62.3	69.85	8.87	8.07	8.47	.900	.770	.835	.1014	.0953	.0984
	Oct. 6	81	77	79.0	726	663	694.5	72.4	60.1	66.25	8.96	8.61	8.79	.890	.780	.835	.0997	.0906	.0952
	Oct. 13	101	80	90.5	514	574	544.0	31.0	36.2	33.60	5.09	7.17	6.13	.310	.450	.380	.0603	.0631	.0617
	Oct. 20	86	67	76.5	345	253	299.0	19.2	14.2	17.7	4.01	3.78	3.90	.220	.210	.215	.0557	.0561	.0559
	Oct. 27	88	81	84.5	231	223	227.0	13.4	10.3	11.85	2.62	2.75	2.69	.150	.130	.140	.0580	.0462	.0521

Table 1 continued.

Sampled	Date seeded	No. of plants			No. of tillers			Total dry wt. in grams			Ave. tillers per plant			Ave. dry wt. per plant			Ave. dry wt. per tiller			Height in centimeters		
		E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.
Kanred																						
Apr. 27 1939	Sept. 15	100	118	109.0	676	807	741.5	195.3	206.7	201.10	6.760	6.839	6.800	1.955	1.752	1.854	.2892	.2561	.2727	52.9	36.0	44.45
	Sept. 22	99	86	92.5	756	595	675.5	187.6	136.3	151.95	7.636	6.919	7.278	1.895	1.585	1.740	.2481	.2291	.2386	51.8	30.5	41.15
	Sept. 29	98	95	96.5	642	645	643.5	152.1	145.5	148.80	6.550	6.789	6.670	1.552	1.532	1.542	.2369	.2256	.2313	47.5	27.1	37.30
	Oct. 6	45	75	60.0	318	505	441.5	66.6	89.0	77.8	8.400	6.733	7.567	1.480	1.187	1.334	.2094	.1762	.1928	38.2	30.5	34.35
	Oct. 13	86	100	93.0	511	623	567.0	53.9	64.7	54.3	5.942	6.230	6.086	.627	.647	.637	.1055	.1039	.1047	29.2	22.8	26.00
	Oct. 20	82	94	88.0	320	385	352.5	35.0	32.5	33.75	3.902	4.096	3.999	.427	.346	.387	.1094	.0844	.0969	23.4	18.5	20.95
	Oct. 27	72	88	80.0	264	250	257.0	24.8	21.5	23.65	3.667	2.841	3.254	.344	.244	.294	.0939	.0860	.0900	18.1	14.0	16.05
May 4 1939	Sept. 15	117	115	116.0	767	564	665.5	343.8	278.6	311.20	6.556	4.904	5.730	2.938	2.423	2.681	.4482	.4940	.4710	73.6	64.5	69.05
	Sept. 22	109	70	89.5	780	562	671.0	309.3	187.0	298.50	7.156	8.029	7.593	2.838	2.681	2.760	.3965	.3340	.3653	64.1	50.6	57.35
	Sept. 29	90	113	101.5	700	720	710.0	233.5	245.8	239.65	7.778	6.372	7.075	2.594	2.175	2.390	.3336	.3414	.3375	61.0	63.1	62.05
	Oct. 6	74	99	86.5	527	533	530.0	157.0	167.5	162.25	7.122	5.384	6.253	2.122	1.692	1.907	.2979	.3143	.3061	54.2	53.5	53.85
	Oct. 13	93	89	91.0	488	602	545.0	98.3	112.6	105.45	5.247	6.764	6.006	1.057	1.265	1.161	.2014	.1870	.1942	39.9	39.2	39.55
	Oct. 20	96	86	91.0	337	308	327.5	67.0	48.8	52.90	3.510	3.581	3.546	.698	.567	.633	.1988	.1584	.1786	36.2	33.4	34.80
	Oct. 27	95	88	91.5	315	322	318.5	53.5	51.6	52.55	3.316	3.659	3.488	.563	.586	.575	.1698	.1602	.1650	33.8	35.2	34.50
May 11 1939	Sept. 15	125	118	121.5	635	528	581.5	413.8	392.1	402.98	5.080	4.475	4.778	3.310	3.323	3.317	.6517	.7426	.6972	88.4	76.6	82.50
	Sept. 22	119	71	95.0	712	284	498.0	445.3	204.2	324.75	5.983	4.000	4.992	3.742	3.876	3.808	.6254	.7190	.6722	79.6	72.1	75.85
	Sept. 29	75	77	76.0	468	309	388.5	302.5	142.5	222.50	6.240	4.010	5.127	4.033	1.850	2.942	.6464	.4612	.5530	75.0	58.6	66.65
	Oct. 6	48	84	66.0	290	356	323.0	151.3	216.9	184.10	6.042	4.238	5.140	3.152	2.582	2.867	.5217	.6093	.5655	60.0	60.9	60.45
	Oct. 13	108	78	93.0	395	330	362.5	130.0	110.2	120.10	3.657	4.231	3.944	1.204	1.413	1.309	.3291	.3339	.3315	54.0	44.9	49.45
	Oct. 20	96	67	81.5	332	270	301.0	119.6	73.3	96.45	3.458	4.030	3.744	1.246	1.094	1.170	.3602	.2715	.3159	46.2	38.4	42.30
	Oct. 27	91	94	92.5	278	278	278.0	91.2	85.5	88.35	3.055	2.957	3.006	1.002	.910	.056	.3281	.3076	.3179	42.9	39.0	40.95
May 18 1939	Sept. 15	105			505			440.3			4.810			4.193			.8719			91.6		
	Sept. 22	91			489			442.3			5.374			4.860			.9045			91.5		
	Sept. 29	77			409			346.9			5.312			4.505			.8482			81.0		
	Oct. 6	70			331			253.8			4.729			3.626			.7668			72.6		
	Oct. 13	87			287			129.0			3.299			1.183			.4495			61.6		
	Oct. 20	92			347			190.6			3.772			2.072			.5493			55.4		
	Oct. 27	94			287			137.5			3.053			1.463			.4791			52.8		

Table 1 continued.

Sampled	Date seeded	No. of plants			No. of tillers			Total dry wt. in gms.			Ave. tillers per plant			Ave. dry wt. per plant			Ave. dry wt. per tiller			Height in centimeters			No. of heads			Total dry wt. of heads in gms.			Ave. wt. per head		
		E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W	Ave.	E	W.	Ave.
Kanred																															
May 26 1939	Sept. 15	115	99	107.0	489	380	434.5	484.9	442.1	463.50	4.252	3.838	4.045	4.217	4.466	4.342	.9916	1.1630	1.0773	111.4	111.4	111.4	329	340	334.5	67.9	69.1	68.5	.206	.203	.205
	Sept. 22	81	60	70.5	436	279	357.5	388.0	322.7	355.35	5.383	4.650	5.017	4.790	5.378	5.084	.8899	1.1570	1.0235	109.8	102.5	104.2	273	222	247.5	57.8	52.7	55.3	.212	.237	.225
	Sept. 29	81	95	88.0	383	380	381.5	350.8	361.3	356.05	5.728	4.000	4.864	4.331	3.803	4.067	.9159	.950	.9334	101.9	96.1	99.0	256	281	268.5	54	58.4	56.2	.211	.208	.210
	Oct. 6	67	90	78.5	343	350	351.5	336.4	374.1	355.25	5.119	3.978	4.549	5.020	4.157	4.589	.9808	1.0450	1.0129	102.8	104.1	103.5	235	270	252.5	49.4	63.7	56.6	.210	.236	.223
	Oct. 13	78	72	75.0	254	255	254.5	220.6	221.1	220.85	3.256	3.542	3.399	2.828	3.071	2.950	.8685	.8671	.8678	85.9	83.9	84.9	52	84	78.0	14.3	22.5	18.4	.275	.259	.267
	Oct. 20	57	79	68.0	216	230	223.0	172.6	188.5	180.55	3.789	3.911	3.851	3.028	2.386	2.657	.7991	.8196	.8097	78.2	73.5	75.9	--	--	--	--	--	--	--	--	--
	Oct. 27	99	92	95.5	274	254	264.0	186.6	187.4	187.00	2.768	2.761	2.765	1.885	2.037	1.962	.6810	.7378	.7094	69.4	73.0	71.2	--	--	--	--	--	--	--	--	--
June 1 1939	Sept. 15	100	98	99.0	452	422	437.0	519.7	470.7	499.70	4.520	4.306	4.413	5.197	4.803	5.000	1.1500	1.1150	1.1325	114.9	107.8	111.4	355	314	334.5	114.	111.2	112.6	.321	.354	.338
	Sept. 22	113	101	107.0	465	404	434.5	541.0	482.3	511.65	4.115	4.000	4.058	4.788	4.775	4.782	1.1630	1.1940	1.1785	104.9	104.5	104.7	330	330	330.0	117.	119.2	118.1	.355	.361	.358
	Sept. 29	56	88	72.0	294	344	319.0	421.0	353.4	387.20	5.250	3.990	4.580	7.500	4.016	5.760	1.4320	1.0270	1.2295	105.6	95.9	100.8	290	250	270.0	94.2	86.6	90.4	.325	.346	.336
	Oct. 6	61	85	73.0	244	269	256.5	307.1	301.5	304.34	4.000	3.165	3.583	5.034	3.547	4.241	1.2590	1.1210	1.1900	104.8	98.8	101.8	199	233	216.0	64	71.7	67.9	.322	.309	.316
	Oct. 13	108	106	107.0	319	298	308.5	326.7	303.8	315.25	2.954	2.811	2.883	3.025	3.866	3.446	1.024	1.0190	1.0215	89.2	96.6	92.9	265	249	257.0	65.5	67.8	66.7	.247	.272	.260
	Oct. 20	66	83	74.5	235	246	240.5	249.9	272.5	261.20	3.561	2.964	3.263	3.786	3.282	3.535	1.0630	1.1080	1.0855	88.9	87.2	88.1	200	206	203.0	46.	49.8	47.9	.230	.242	.236
	Oct. 27	66	90	78.0	192	221	206.5	193.8	207.8	200.80	2.909	2.456	2.683	2.936	2.309	2.623	1.0090	.9403	.9747	90.4	91.8	91.1	113	170	141.5	24.2	37.8	31.	.214	.222	.218
June 9 1939	Sept. 15	103	87	95.0	393	408	400.5	421.8	368.4	395.10	3.816	4.690	4.253	4.095	4.234	4.165	1.073	.9029	.9830				312	345	328.5	130.2	139.0	134.6	.417	.403	.410
	Sept. 22	86	112	99.0	362	464	413.0	389.2	506.2	447.70	4.209	4.143	4.176	4.526	4.520	4.523	1.0750	1.0910	1.0830				287	392	339.5	125.8	173.4	149.6	.438	.442	.440
	Sept. 29	97	83	90.0	418	347	382.5	456.8	397.3	427.05	4.309	4.181	4.245	4.709	4.787	4.748	1.0930	1.1450	1.1190				316	285	300.5	151.7	126.2	139.0	.480	.443	.462
	Oct. 6	82	84	83.0	300	311	305.5	385.1	376.6	380.85	3.658	3.703	3.675	4.696	4.483	4.590	1.2840	1.2110	1.2475				282	274	278.0	126.7	130.4	128.6	.449	.476	.463
	Oct. 13	83	70	76.5	259	242	250.5	295.9	282.6	289.25	3.120	3.457	3.289	3.565	4.037	3.801	1.1420	1.1680	1.1550				239	224	231.5	94.4	94.1	94.3	.395	.420	.408
	Oct. 20	88	74	81.0	266	211	238.5	297.0	241.9	269.45	3.023	2.851	2.937	3.375	3.269	3.322	1.1170	1.1460	1.1315				243	199	221.0	85.1	73.3	79.2	.350	.368	.359
	Oct. 27	71	79	75.0	166	207	186.5	175.0	241.1	208.05	2.338	2.620	2.479	2.465	3.053	2.759	1.0540	1.1650	1.1095				144	197	170.5	46.1	66.9	56.5	.320	.340	.330
June 15 1939	Sept. 15	101	88	94.5	442	333	387.5	444.3	350.7	397.50	4.376	3.784	4.080	4.399	3.985	4.192	1.0050	1.0530	1.0290				315	262	288.5	130.8	113.0	121.9	.438	.431	.435
	Sept. 22	77	92	84.5	393	344	363.5	380.7	335.6	358.15	4.974	3.739	4.357	4.944	3.648	4.296	.9940	.9756	.9048				266	236	251.0	120.7	102.2	111.5	.454	.433	.444
	Sept. 29	80	67	73.5	371	220	295.5	451.9	253.6	352.75	4.637	3.284	3.961	5.649	3.785	4.717	1.2180	1.1530	1.1855				315	180	247.5	158.3	88.6	123.5	.503	.492	.498
	Oct. 6	69	80	74.5	243	279	261.0	315.0	282.9	298.95	3.522	3.487	3.505	4.565	3.536	4.050	1.2960	1.0140	1.1550				194	238	216.0	102.0	116.9	109.5	.526	.491	.509
	Oct. 13	70	81	75.5	222	212	217.0	255.9	218.3	237.10	3.170	2.617	2.894	3.656	2.695	3.176	1.1530	1.0300	1.0915				204	177	190.5	91.8	75.6	83.7	.450	.427	.439
	Oct. 20	86	70	78.0	209	195	202.0	232.7	269.1	250.90	2.430	2.786	2.608	2.675	3.844	3.260	1.1130	1.3800	1.2465				185	193	189.0	84.3	97.5	90.9	.456	.505	.481
	Oct. 27	59	83	71.0	190	214	202.0	196.6	232.8	216.20	3.220	2.579	2.899	4.383	2.805	3.594	1.0350	1.0880	1.0615				158	188	173	64.1	81.0	72.6	.406	.431	.429

Table 2. Numerical frequency distribution of tillers per plants in periodic samples of two varieties of winter wheat seeded at weekly intervals from September 15 to October 27, Manhattan, Kansas, 1938-1939.

	Average			Percentage of plants having a given number of tillers from 1 to more than 20																				
	Dry wt. per plant	Tillers per plant	Dry wt. per tiller	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	More than 20
Early Blackhull seeded Sept. 15																								
Dec. 22	.544	5.760	.0944	8.07	5.59	9.35	16.15	9.94	14.26	8.70	7.45	6.21	6.21	3.11	4.35	6.21								
Mar. 20	.394	5.670	.0693	9.47	8.71	18.56	15.15	10.23	8.31	4.92	6.06	3.41	4.17	1.89	3.79	2.27	.76	.38	.38		.38	.38		.38
Apr. 4	.950	8.170	.1137	5.17	3.88	11.21	10.34	6.47	4.31	8.62	9.05	7.33	6.90	4.31	4.74	3.88	4.31	3.02	1.29		1.29	.86		3.05
Apr. 20	1.345	6.820	.1921	4.52	1.81	7.69	14.03	13.57	11.76	7.69	8.14	8.60	9.05	4.52	3.17	1.81	1.81	.45	.90		.45			
Apr. 27	1.715	5.440	.3061	15.32	7.66	19.35	13.31	9.68	8.06	4.03	2.42	5.65	4.44	3.63	1.21	1.21	1.21	.40	.81	.81				.81
May 4	2.416	4.455	.5460	18.06	8.81	14.10	15.98	10.13	11.89	8.37	5.73	2.64	3.08	.88	.88	.44								
May 11	3.072	3.387	.9129	21.15	14.62	23.08	17.31	10.77	5.77	5.00	.77	1.15	.77			.38								
May 18	4.901	4.157	1.1790	8.43	8.43	24.10	19.28	18.07	8.43	7.23	4.82	1.20												
May 26	4.016	3.122	1.2790	16.23	20.61	28.95	16.67	10.09	4.82	.88	1.32	.44												
June 1	5.189	3.417	1.5175	14.71	20.59	26.47	19.12	6.86	5.39	2.45	1.47	2.45	1.47											
June 9	3.964	2.928	1.3535	17.96	23.95	33.53	12.57	3.59	2.40	1.80	.60													
Kanred seeded Sept. 15																								
Dec. 22	.407	5.325	.0765	16.22	9.46	13.96	8.56	9.46	9.91	5.86	9.46	5.86	2.25	1.80	3.15	1.35	.45		.90	.45		.45		.45
Mar. 20	.539	8.890	.0602	13.84	1.79	9.82	4.46	5.80	7.14	4.91	6.70	8.04	4.02	4.91	2.23	5.36	3.57	1.79	1.34	4.02		2.68	1.34	6.25
Apr. 4	.930	10.14	.0912	7.51	.94	7.04	7.51	3.29	2.82	2.82	5.63	7.98	8.45	8.92	7.98	3.76	5.16	5.16	1.41	3.76	3.29	1.41	1.88	3.29
Apr. 20	1.26	8.095	.1553	7.58	4.33	9.39	6.14	5.42	7.58	9.03	7.22	5.42	6.14	9.39	7.947	.72	2.17	2.89	1.81	3.97	1.08	.72		1.08
Apr. 27	1.854	6.800	.2727	10.09	4.59	7.80	10.55	7.80	11.01	10.55	6.88	6.42	4.13	5.50	3.21	5.05	2.29	1.83	1.38	.46	.46			
May 4	2.681	5.730	.4711	12.50	9.05	11.21	12.93	9.91	4.74	7.76	6.03	9.48	3.88	5.60	3.88		1.29	1.29		.43				
May 11	3.317	4.778	.6972	11.15	13.58	15.23	14.81	14.52	8.23	7.00	5.35	6.58	1.65	1.23	1.65	1.23	.82							
May 18	4.193	4.810	.8719	8.57	9.52	16.19	16.19	16.19	11.43	4.76	5.71	6.67	1.90	1.90		.95								
May 26	4.342	4.045	1.0773	17.76	14.95	16.82	15.42	9.81	5.61	7.01	7.48	.93	1.40	1.87	.47	.47								
June 1	5.000	4.413	1.1325	16.67	9.60	19.19	15.66	9.09	5.05	8.08	8.59	4.04	.51	1.52	.51	1.01	.51							
June 9	4.165	4.253	.9880	15.26	13.68	12.63	16.32	16.32	9.47	4.21	5.26	3.16	3.16	.53										
June 15	4.192	4.080	1.029	15.87	12.17	20.11	15.87	12.17	5.82	6.88	4.76	3.17	5.29	1.59	1.06									

Table 2 continued.

	Average			Percentage of plants having a given number of tillers from 1 to more than 20																				
	Dry wt. per plant	Tillers per plant	Dry wt. per tiller	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	More than 20
Early Blackhull seeded Sept. 22																								
Dec. 22	.370	5.185	.0701	13.85	7.94	18.75	10.45	8.33	4.17	6.94	6.25	9.03	4.86	3.47	3.47	2.08	1.39							
Mar. 20	.433	8.145	.0533	14.00	4.00	8.00	10.00	3.33	4.00	6.00	4.67	7.33	7.33	8.00	6.00	2.00	4.00	2.00	2.00	.67	.67	1.33	.67	4.00
Apr. 4	.865	9.275	.0918	8.84	4.08	8.16	6.12	2.72	4.76	10.88	6.12	5.44	8.84	4.08	3.40	3.40	3.40	2.04	4.08	1.36	2.04	2.04	.68	7.48
Apr. 20	1.640	9.950	.1590	18.52	4.63	8.33	2.78	3.70	3.70	2.78	4.63	3.70	5.56	3.70	4.63	3.70	3.70	5.56	4.63		1.85	1.85	1.85	10.19
Apr. 27	1.799	5.774	.3054	16.66	4.60	16.09	9.20	8.62	6.90	5.75	6.32	8.05	3.45	4.02	3.45	2.30	2.30	.58		1.15				.58
May 4	3.243	6.290	.5131	14.29	7.14	15.58	6.49	7.14	4.55	7.79	9.74	7.79	2.60	3.90	4.55	3.25	1.95	.65			.65	1.95		
May 11	3.965	4.506	.8797	21.38	11.32	16.98	10.06	8.81	7.55	6.29	6.29	3.77	1.26	1.26	.63	2.52		.63		.63	.63			
May 18	4.868	3.591	1.3560	34.09	12.50	12.50	7.95	9.09	9.09	6.82	2.27	2.27	1.14				1.14	1.14						
May 26	6.423	4.403	1.4825	18.98	16.06	17.52	9.49	8.76	7.30	5.11	3.65	5.84	3.65	1.46	1.46			.73						
June 1	4.077	2.710	1.5080	26.26	19.19	29.80	14.65	5.56	2.02	2.02			.51											
June 9	4.206	3.0195	1.3925	29.41	20.00	16.47	17.65	3.53	8.24	2.94	1.18	.59												
Kanred seeded Sept. 22																								
Dec. 22	.348	5.660	.0610	28.57	3.11	11.80	4.35	5.59	4.97	9.94	6.83	5.59	3.11	3.11	4.97	2.48	.62	1.24	1.86	.62	.62			.62
Mar. 20	.403	9.245	.0435	20.00		9.33	4.67	6.00	3.33	4.67	4.00	8.00	5.33	6.00	4.00	.67	3.33	2.67	2.67	2.00	2.00	1.33		8.67
Apr. 4	.725	9.100	.0785	15.71	3.81	8.10	5.71	5.71	5.24	4.76	4.29	5.71	6.19	4.76	3.81	4.76	3.33	2.38	3.33	1.90	1.43	1.90	1.90	5.71
Apr. 20	1.210	9.275	.1284	9.14	1.52	11.68	7.11	2.54	7.61	4.57	6.09	5.08	5.58	4.57	6.60	5.08	4.06	3.05	2.54	2.54	1.52	1.52	.51	7.11
Apr. 27	1.740	7.278	.2386	20.54	4.32	7.03	3.78	5.95	4.32	6.49	8.11	8.65	5.41	4.32	4.86	2.70	2.16	2.70	2.70	2.16	.54	1.08	1.62	.54
May 4	2.760	7.593	.3653	12.29	4.47	8.38	6.15	6.70	10.06	5.03	6.15	11.73	2.79	7.82	3.91	2.79	3.91	1.12		3.35	1.12	.56	1.12	.56
May 11	3.808	4.992	.6722	27.37	6.32	8.42	7.89	5.26	6.84	6.84	7.37	8.95	4.74	4.21	2.63	1.05	.53	.53		.53	.53			1.05
May 18	4.860	5.374	.9045	13.19	9.89	10.99	9.89	10.99	13.19	4.40	7.69	9.89	3.30	2.20	2.20	1.10				1.10				
May 26	5.084	5.017	1.0235	26.95	7.80	16.31	9.22	6.38	2.13	5.67	5.67	3.55	3.55	2.13	3.55	.71	2.13	.71	.71		.71	1.42		.71
June 1	4.782	4.058	1.1785	14.02	14.49	21.50	11.68	10.28	11.21	7.94	5.14	1.87	1.40		.47									
June 9	4.523	4.176	1.0830	13.13	15.66	17.17	17.17	11.62	5.05	8.59	5.56	3.03	1.52	1.01	.51									
June 15	4.296	4.357	.9848	14.20	11.83	21.89	15.38	8.88	6.51	7.10	7.10	2.37	1.18	2.37		.59	.59							

Table 2 continued.

	Average			Percentage of plants having a given number of tillers from 1 to more than 20																				
	Dry wt. per plant	Tillers per plant	Dry wt. per tiller	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	More than 20
Early Blackhull seeded Sept. 29																								
Dec. 22	.186	3.980	.0467	16.88	9.09	25.11	13.42	10.39	7.79	6.49	3.46	4.76	.87	.43		1.30								
Mar. 20	.254	6.035	.0420	13.57	4.07	15.32	11.76	4.52	9.92	6.79	10.86	5.88	4.98	1.81	.90	1.81	1.81	1.36	.90	.90		.45	.45	1.81
Apr. 4	.575	7.215	.0793	7.31	5.02	12.33	6.39	8.22	7.31	5.97	10.50	7.76	6.39	6.85	3.20	3.65	2.74	3.20		1.37	.46	.46	.91	
Apr. 20	.925	6.345	.1437	9.78	6.52	17.39	13.04	7.25	6.52	5.43	8.70	5.07	3.26	3.26	5.07	2.17	2.17	1.45	.36			.73	.73	1.09
Apr. 27	1.545	5.655	.2747	18.88	5.61	14.29	8.72	7.14	5.61	8.16	5.61	6.12	5.10	4.08	4.59	2.55	1.02	1.53	1.02					
May 4	2.236	4.769	.4695	17.47	13.54	15.28	10.92	9.65	7.86	5.68	2.62	6.55	4.37	2.62	1.75	1.31					.87			
May 11	3.171	4.245	.7631	20.59	8.82	18.38	11.03	12.50	8.09	6.62	1.47	5.15	2.21	3.68	1.47									
May 18	3.164	2.753	1.1490	45.68	9.88	11.11	12.35	7.41	7.41	3.70	2.47													
May 26	3.789	3.052	1.2410	25.99	17.62	23.32	13.99	8.81	4.15	2.07	3.11	.52	.52											
June 1	3.917	2.960	1.3355	24.74	19.07	20.10	19.07	8.25	7.22	1.03	.52													
June 9	2.888	2.438	1.1860	35.98	22.22	23.28	8.47	5.82	1.59	1.06	1.06	.53												
Kanred seeded Sept. 29																								
Dec. 22	.1637	3.970	.0405	29.56	9.43	15.10	5.66	12.58	5.66	6.29	5.03	3.77	3.77	1.89	1.26									
Mar. 20	.246	8.615	.0285	14.52	3.23	8.60	8.60	2.69	7.53	6.99	4.30	4.30	4.30	3.76	4.84	5.91	4.84	1.08	2.69	1.63	1.08	2.69	1.63	4.84
Apr. 4	.535	8.745	.0570	18.75	7.50	11.25	5.63	4.38	2.50	7.50	4.38	4.38	1.88	3.13	4.38	2.50	1.25	1.25	1.25	2.50	.63	1.25	1.88	11.88
Apr. 20	.835	8.470	.0984	14.37	3.59	7.19	7.78	5.39	5.39	5.99	3.59	4.79	6.59	5.39	4.19	5.99	1.80	3.59	2.99	5.39	1.20	1.20	.60	2.99
Apr. 27	1.542	6.670	.2313	8.29	4.66	12.95	12.95	9.33	6.74	6.22	8.29	8.29	6.74	3.63	2.59	6.11	2.59	.52			.52		1.04	1.55
May 4	2.390	7.075	.3375	11.82	2.46	10.34	12.32	2.96	7.88	11.33	8.37	7.39	5.91	4.43	3.44	2.46	1.97	1.97	.49	.99	.49	1.97		.49
May 11	2.942	5.127	.5538	21.71	11.18	13.16	9.21	7.89	3.95	5.92	3.95	7.24	5.26	2.63	3.29	1.97	.66		.66	.66	.66			
May 18	4.505	5.313	.8482	22.08	9.09	6.49	7.79	7.79	6.49	11.69	9.09	6.49	6.49		3.90		1.30	1.30						
May 26	4.067	4.864	.9334	25.00	11.36	8.52	14.77	10.23	7.95	7.39	2.27	4.55	4.55	1.14		.57	.57	.57	.57					
June 1	5.767	4.580	1.2295	21.53	13.19	12.50	13.89	6.25	4.86	8.33	5.56	6.94	3.47	2.08	.69			.69						
June 9	4.748	4.245	1.1190	15.00	13.89	18.33	15.00	13.33	5.56	3.33	5.56	5.00	1.67	2.78		.56								
June 15	4.717	3.961	1.1855	17.69	12.24	21.09	16.33	8.84	6.12	7.48	2.72	4.08	2.04			.68		.68						

Table 2 continued.

	Average			Percentage of plants having a given number of tillers from 1 to more than 20																				
	Dry wt. per plant	Tillers per plant	Dry wt. per tiller	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	More than 20
Early Blackhull seeded Oct. 6																								
Dec. 22	.068	2.355	.0280	44.64	13.73	30.90	5.58	3.43	.86	.86														
Mar. 20	.114	4.290	.0262	20.89	13.78	15.11	14.22	8.00	7.56	6.22	7.11	4.00	2.22	.89										
Apr. 4	.320	6.035	.0518	10.06	5.03	15.09	18.87	13.84	3.14	5.66	8.18	6.92	3.14	1.26	1.26	1.89	1.26		1.26	.63	.63			1.89
Apr. 20	.625	6.230	.0995	11.11	7.60	13.45	7.02	8.19	6.43	7.02	9.94	11.70	4.09	2.92	2.92	2.92	1.75	.59	1.17	.59				.59
Apr. 27	1.341	5.765	.2267	8.46	9.45	15.92	16.42	7.98	8.46	9.45	5.47	6.97	3.98	.99	.99	.99	1.49	1.49	.50	.50		.50		
May 4	1.568	3.920	.4022	26.73	9.68	14.75	17.05	6.91	6.91	4.61	5.99	3.69	1.85	.92		.92							.46	
May 11	2.964	4.306	.6902	10.90	12.32	18.48	17.06	12.32	8.53	8.53	7.11	2.84	.95			.47			.47					
May 18	2.467	3.139	.7859	22.13	13.93	25.41	18.03	12.30	4.92	2.46		.82												
May 26	4.106	3.212	1.2665	16.76	22.90	25.14	18.99	9.50	1.68	2.23	.56	.56	1.12	.56										
June 1	4.082	2.816	1.4505	28.57	21.67	22.67	9.85	9.85	2.96	1.48	2.46		.49											
June 9	3.455	2.597	1.3280	23.53	28.82	28.82	7.65	7.06	7.06			.60												
Kanred seeded Oct. 6																								
Dec. 22	.056	1.94	.0261	57.27	8.18	24.55	7.27	2.73																
Mar. 20	.157	6.940	.0227	11.72	2.76	9.66	11.03	8.97	5.52	7.59	6.21	8.97	7.59	8.28	4.14	2.07	.69	.69	1.38		2.76			
Apr. 4	.315	7.265	.0435	11.40	9.52	7.14	10.32	4.76	7.94	4.76	4.76	7.94	3.97	3.97	5.56	3.97	3.17	2.38	1.59	1.59	.79	3.17	.79	
Apr. 20	.835	8.785	.0952	4.43	5.06	7.59	5.70	5.06	8.23	7.59	11.39	6.96	4.43	6.33	6.33	3.80	3.80	1.90	1.27	1.40	2.53	2.53	1.27	1.90
Apr. 27	1.334	7.567	.1928	7.50	4.17	8.33	10.00	10.00	8.33	5.00	7.50	6.67	9.17	6.67	7.50	2.50	2.50	.83	.83	.83	.83			.83
May 4	1.907	6.253	.3061	14.45	5.20	15.03	10.98	6.94	6.94	8.09	5.78	6.36	2.89	4.63	4.62	2.31	1.73	1.16		.58	1.16			1.16
May 11	2.867	5.140	.5655	18.18	10.61	15.15	10.61	9.09	6.82	6.82	6.06	8.33	3.03	7.76	1.52		.76	.76	.76		.76			
May 18	3.626	4.729	.7668	18.57	11.43	17.14	12.86	1.43	8.57	5.71	7.14	7.14	2.86	5.71	1.43									
May 26	4.589	4.549	1.0129	21.66	10.83	9.55	15.92	11.46	7.64	4.46	6.37	4.46	2.55	2.55	1.27	1.27								
June 1	4.240	3.583	1.1900	28.77	14.38	13.01	16.44	7.53	7.53	2.74	4.11	1.37	3.42	.68										
June 9	4.590	3.330	1.2475	19.28	16.87	15.06	16.87	12.05	8.43	5.42	1.81	3.01	1.20											
June 15	4.051	3.505	1.1550	21.48	17.44	22.15	12.08	9.40	5.37	3.36	4.70	2.01	1.34	.67										

Table 2 continued.

	Average: Dry wt. per plant	Average: Tillers per plant	Average: Dry wt. per tiller	Percentage of plants having a given number of tillers from 1 to more than 20: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	More than 20
Early Blackhull seeded Oct. 13																								
Dec. 22	.024	1.305	.0185	73.42	22.78	3.80																		
Mar. 20	.037	2.345	.0161	45.65	14.49	17.39	10.14	10.14	1.45		.73													
Apr. 4	.140	4.725	.0278	15.46	6.19	15.46	19.07	10.30	8.25	6.19	8.25	4.12	3.61	1.03	1.03	.52		.52						
Apr. 20	.325	4.965	.0661	12.50	7.39	14.77	18.18	13.67	5.68	6.82	7.39	5.11	5.68	2.27	.57									
Apr. 27	.755	4.020	.1869	16.43	14.01	16.43	17.39	14.96	7.25	.97	3.86	2.90	4.35	.97		.48								
May 4	1.446	4.952	.2927	14.38	7.19	15.69	15.69	11.76	5.88	3.27	9.80	11.11	2.61	1.96		.65								
May 11	2.066	3.904	.5291	18.34	13.61	16.57	17.75	13.02	7.10	2.37	4.14	3.55	2.37	1.18										
May 18	2.802	3.775	.7424	17.50	16.25	20.00	18.75	8.75	3.75	6.25	2.50	3.75		1.25	1.25									
May 26	3.652	3.267	1.1115	18.38	18.38	25.74	18.38	7.35	4.41	5.15	.74	.74		.74										
June 1	3.179	2.559	1.2385	28.57	25.27	26.37	10.91	4.85	2.75	2.20														
June 9	3.186	2.524	1.2565	33.77	18.83	24.68	14.29	4.55	2.60	1.30														
June 15	3.326	2.667	1.2470	19.70	28.79	25.76	18.18	6.06	1.52															
Kanred seeded Oct. 13																								
Dec. 22	.015	1.110	.0141	92.26	5.36	2.38																		
Mar. 20	.052	3.100	.0168	36.26	7.02	16.37	21.05	5.85	3.51	5.26		2.92	1.75											
Apr. 4	.140	4.740	.0295	18.88	8.38	14.14	12.57	9.95	8.90	8.38	6.81	3.66	2.09	2.09	3.14	.52	.52							
Apr. 20	.380	6.130	.0617	6.08	5.52	19.34	13.81	11.05	9.94	5.52	3.87	5.52	7.18	2.76	1.68	3.31		1.10	.55			.55		.55
Apr. 27	.637	6.086	.1047	6.45	6.45	13.44	9.14	15.59	11.83	11.29	5.38	3.23	4.30	3.76	3.23	2.15	1.08		.54	1.08		1.08		
May 4	1.161	6.006	.1942	13.19	8.79	9.89	19.23	8.24	4.95	6.04	4.95	3.85	3.85	3.85	3.85	2.75	1.10	1.65	.55	1.65	.55	.55		.55
May 11	1.309	3.944	.3315	25.81	11.29	16.16	12.90	10.75	6.99	4.84	2.15	3.23	3.15	1.08	.54	.54		.54			.54			
May 18	1.483	3.299	.4495	24.14	18.39	14.94	18.39	12.64	4.60	3.45				1.15	1.15									
May 26	2.950	3.399	.8678	18.67	18.00	26.00	15.33	7.33	4.00	5.33	2.67	2.00			.67									
June 1	3.446	2.883	1.0215	30.37	19.63	19.63	12.15	9.35	3.27	3.27		1.40	.93											
June 9	3.801	3.289	1.155	23.53	15.03	20.92	16.99	9.85	7.84	1.96	1.96	1.96												
June 15	3.176	2.894	1.0915	17.88	29.80	23.84	15.89	9.27	2.65	.66	1.32													

Table 2 continued.

	Average			Percentage of plants having a given number of tillers from 1 to more than 20																				
	Dry wt. per plant	Tillers per plant	Dry wt. per tiller	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	More than 20
Early Blackhull seeded Oct. 20																								
Dec. 22	.015	1.005	.0146	99.44	.66																			
Mar. 20	.025	1.570	.0158	71.81	7.45	15.43	2.66	2.66																
Apr. 4	.075	2.455	.0316	35.20	16.76	24.58	15.64	5.03	1.68			1.12												
Apr. 20	.224	3.484	.0637	24.12	9.41	29.41	31.53	7.65	5.88	2.35	1.76	3.53		1.76	.59									
Apr. 27	.533	3.776	.1452	19.05	12.12	23.81	18.18	12.12	4.33	2.60	3.03	1.73	1.30	.61	.61									
May 4	1.004	3.613	.2783	24.23	15.98	16.49	14.43	6.70	8.25	4.12	6.19	1.55	.52	1.55										
May 11	1.320	2.789	.4761	32.18	17.82	24.71	10.92	6.90	3.45	2.87	.58		.58											
May 18	2.042	2.448	.8341	37.31	20.90	20.90	8.96	4.40	7.46															
May 26	2.872	3.009	.9717	22.50	17.50	26.25	14.38	11.88	5.00	1.88		.63												
June 1	3.131	2.525	1.2455	33.55	22.37	21.71	11.84	6.76	2.63			1.32												
June 9	3.083	2.335	1.2985	45.45	18.94	30.30	11.36	3.79	3.79	.76		.76												
June 15	2.696	2.381	1.1280	33.91	22.41	22.99	13.79	4.60	1.72	.57														
Kanred seeded Oct. 20																								
Dec. 22	.0147	1.000	.0147	100.00																				
Mar. 20	.026	1.275	.0200	80.33	9.88	8.72	1.16																	
Apr. 4	.070	2.280	.0285	45.51	15.38	21.79	8.33	5.13	1.92	.64	.64	.64												
Apr. 20	.215	3.895	.0559	10.46	9.80	25.49	19.61	17.65	8.53	4.58	1.96	6.54	1.31											
Apr. 27	.387	3.999	.0969	13.64	14.77	20.45	20.45	7.95	7.95	5.68	2.84	1.14	2.84	1.70	.57									
May 4	.633	3.546	.1786	15.93	18.68	21.43	19.78	10.99	6.04	.55	2.75	1.10	1.10	.55	.55	.55								
May 11	1.170	3.744	.3159	14.72	14.72	27.61	17.18	11.04	3.68	4.29	3.68	3.07	.61	.61										
May 18	2.072	3.772	.5493	19.57	10.87	25.00	11.96	13.04	7.61	5.43	1.09	3.26	1.09				1.09							
May 26	2.657	3.850	.8034	19.12	19.12	24.26	13.24	11.03	6.09	2.21	1.47	.74	.74											
June 1	3.535	3.263	1.0855	21.48	16.19	22.82	21.84	8.05	3.36	3.36	2.01	.67				.67								
June 9	3.322	2.937	1.1315	20.37	27.16	19.14	18.52	9.88	4.32	1.23		.62												
June 15	3.260	2.608	1.2465	23.08	27.56	27.56	12.18	8.33	1.28															

Table 2 continued.

	Average			Percentage of plants having a given number of tillers from 1 to more than 20																				
	Dry wt. per plant	Tillers per plant	Dry wt. per tiller	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	More than 20
Early Blackhull seeded Oct. 27																								
Dec. 22	.010	1.000	.0095	100.																				
Mar. 20	.017	1.085	.0153	93.06	4.62	2.31																		
Apr. 4	.060	2.310	.0247	37.86	20.71	23.51	12.86	2.86	.71		1.43													
Apr. 20	.143	3.038	.0472	25.69	15.28	30.56	16.67	6.25	2.78	.69	1.39			.69										
Apr. 27	.276	3.528	.0783	19.85	24.43	14.50	16.03	6.87	6.11	3.05	2.29	4.58		1.53	.76									
May 4	.711	4.016	.1739	17.42	9.85	25.76	12.88	14.34	3.79	3.79	3.79	4.55	3.03			.76								
May 11	1.220	3.606	.3488	20.44	11.68	20.44	17.52	13.87	5.11	6.57	2.92	.73	.73											
May 18	2.329	4.267	.5258	22.22	6.67	11.11	20.00	8.89	13.33	4.44	4.44	6.67			2.22									
May 26	2.753	2.976	.9249	24.26	20.59	24.26	18.38	6.62	3.68	2.94	2.21		.74											
June 1	2.845	2.709	1.0510	35.90	19.66	16.24	15.38	4.27	1.71	4.27	.85	.85	.85											
June 9	2.649	2.351	1.1325	26.24	21.28	15.60	17.02	2.84	2.13				.71											
June 15	2.872	2.508	1.1500	29.41	24.71	23.53	12.94	9.41																
Kanred seeded Oct. 27																								
Dec. 22	.010	1.000	.0103	100.00																				
Mar. 20	.020	1.045	.0190	97.45	1.02	1.53																		
Apr. 4	.050	1.495	.0338	67.19	19.27	13.02	.52																	
Apr. 20	.140	2.685	.0521	23.08	23.08	31.36	15.38	2.96	2.37	.59	.59		.59											
Apr. 27	.294	3.254	.0900	15.00	16.25	27.50	28.75	7.50	1.25	1.88		1.25		.63										
May 4	.575	3.488	.1650	22.95	13.66	20.77	17.49	8.74	7.10	3.28	1.64	1.64	1.64	1.10										
May 11	.956	3.006	.3179	16.76	23.16	32.43	16.22	5.41	2.70	2.16	1.08	.54	.54											
May 18	1.463	3.053	.4791	19.15	22.34	30.85	11.70	4.26	6.38	3.19		1.06	1.06											
May 26	1.962	2.765	.7094	23.04	23.04	25.13	17.28	8.38	1.57	1.05	.52													
June 1	2.623	2.683	.9747	23.08	26.28	24.36	17.31	7.69	.64	.64														
June 9	2.759	2.479	1.1095	30.67	24.00	21.33	16.67	4.67	2.67															
June 15	3.594	2.899	1.0615	16.20	26.06	14.79	17.61	8.45	2.82															

EXPLANATION OF PLATE III

The frequency distribution of tillers per plant for seven plots of Early Blackhull seeded at weekly intervals from September 15 to October 27 and sampled periodically during the growing season.

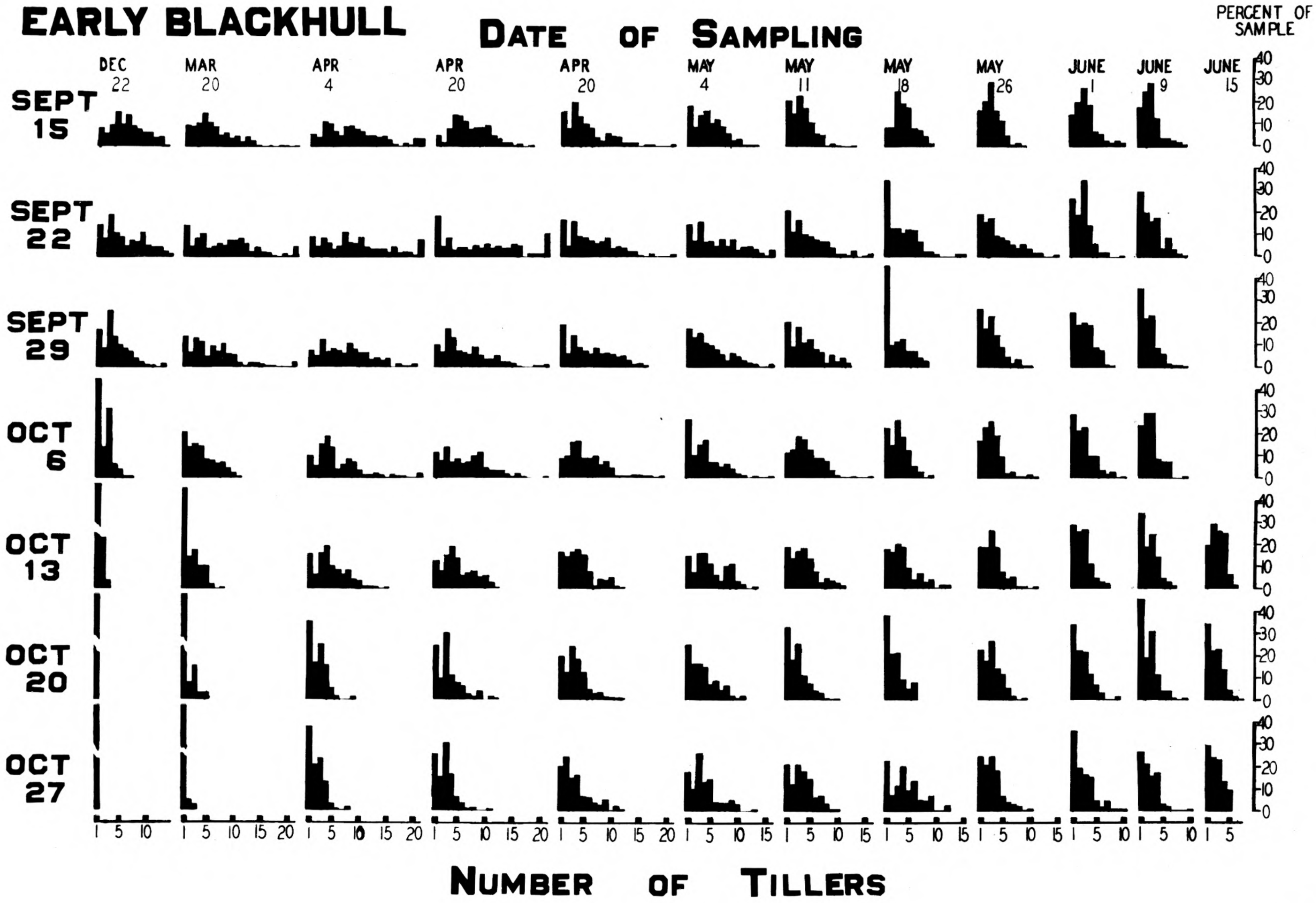
EARLY BLACKHULL
DATE OF SAMPLING
PERCENT OF SAMPLE
DEC 22
MAR 20
APR 4
APR 20
APR 20
MAY 4
MAY 11
MAY 18
MAY 26
JUNE 1
JUNE 9
JUNE 15
SEPT 15
SEPT 22
SEPT 29
OCT 6
OCT 13
OCT 20
OCT 27
NUMBER OF TILLERS

PLATE III

EXPLANATION OF PLATE IV

The frequency distribution of tillers per plant for seven plots of Kanred seeded at weekly intervals from September 15 to October 27 and sampled periodically during the growing season.

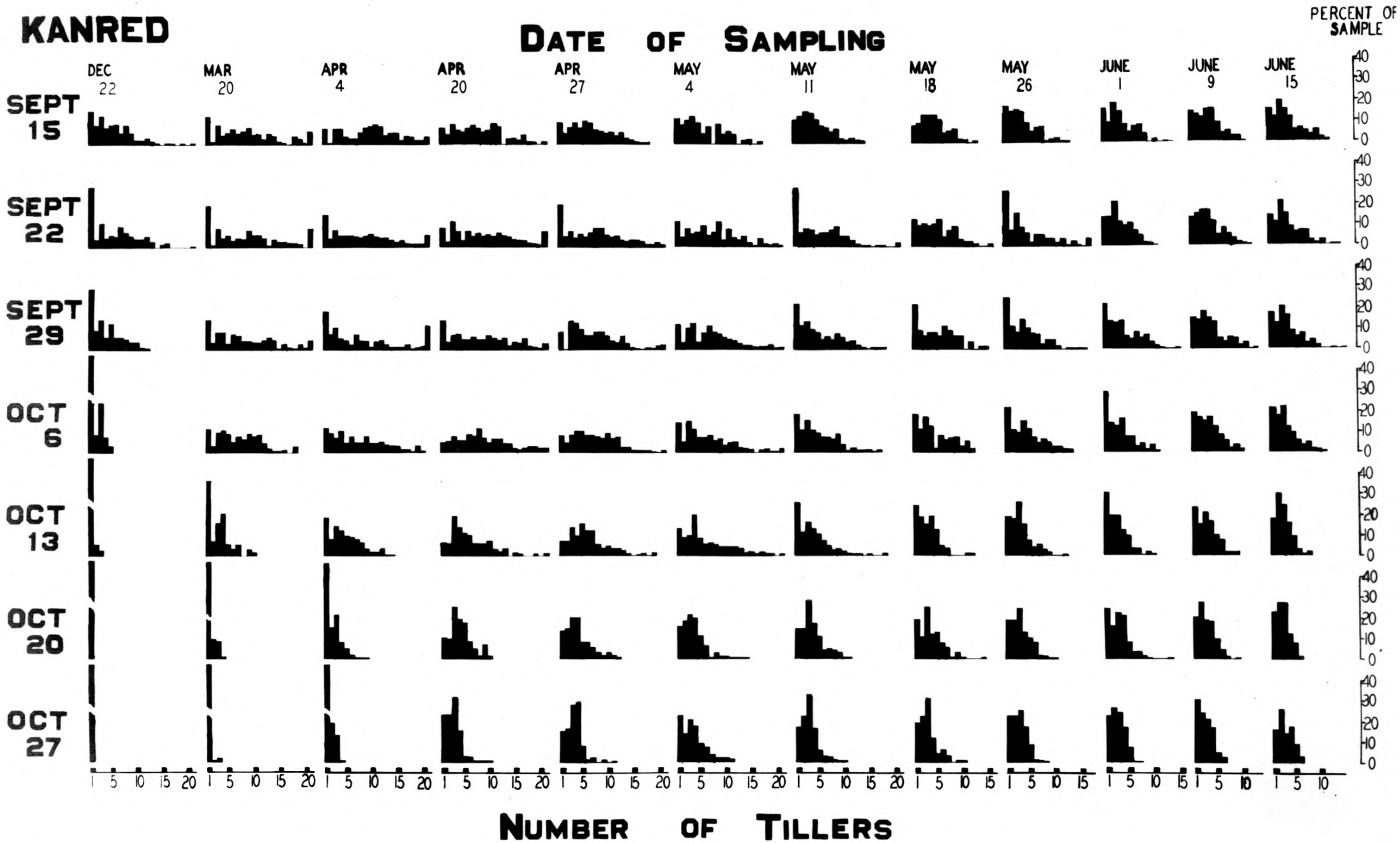
KANRED
DATE OF SAMPLING
PERCENT OF SAMPLE
DEC 22
MAR 20
APR 4
APR 20
APR 27
MAY 4
MAY 11
MAY 18
MAY 26
JUNE 1
JUNE 9
JUNE 15
SEPT 15
SEPT 22
SEPT 29
OCT 6
OCT 13
OCT 20
OCT 27
0 10 20 30 40
1 5 10 15 20
NUMBER OF TILLERS

PLATE IV

Table 3. Agronomic data for Early Blackhull and Kanred winter wheat grown in field plots, Manhattan, Kansas, 1938-1939.

	Date of seeding	Date of first heading	Date of full heading	Date ripe	Length fruiting period	Rust infection: % stem rust	Rust infection: % leaf rust	Stand 1/1000 Acre: Plants in fall	Stand 1/1000 Acre: Culms at harvest	Height in inches	Hail damage: % grain shattered	Hail damage: % of culms broken	Wt. of 100 10-cm. straw sections, gms.	Test wt.	Yield bus. per acre	Wt. per 1000 kernels gms.	Kernels per head	Gms. of grain per head
Early Blackhull	9/15	5/9	5/12	6/7	29	5	45	781	1922	40.2	10	65	9.05	58.3	17.6	27.14	9.18	.249
	9/22	5/9	5/13	6/8	30	5	45	831	1666	37.0	10	70	8.35	58.5	14.2	27.60	8.41	.232
	9/29	5/10	5/15	6/9	30	5	50	644	1872	37.4	10	60	9.18	58.6	15.8	28.06	8.20	.230
	10/6	5/11	5/15	6/10	30	10	50	573	1637	38.2	10	60	8.81	58.4	13.6	28.40	7.96	.226
	10/13	5/15	5/24	6/15	31	25	50	644	1453	36.4	10	75	7.75	57.6	7.2	27.94	4.82	.135
	10/20	5/18	5/26	6/18	31	25	70	660	1392	36.6	10	80	8.40	56.7	6.1	25.54	4.68	.119
	10/27	5/19	5/27	6/21	33	40	70	558	1357	33.2	10	85	10.55	55.3	5.7	23.26	4.94	.115
Kanred	9/15	5/17	5/22	6/17	31	10	65	615	2602	39.8	10	65	8.88	55.7	16.0	25.00	6.71	.168
	9/22	5/18	5/23	6/18	31	10	55	715	2484	39.8	10	75	7.45	55.7	17.4	23.80	8.01	.191
	9/29	5/20	5/24	6/21	32	10	55	534	2214	38.2	10	75	6.87	55.2	16.4	24.34	8.28	.202
	10/6	5/21	5/24	6/22	32	15	55	547	2064	37.8	10	75	8.92	54.4	18.5	24.26	10.05	.244
	10/13	5/23	5/29	6/23	31	15	70	623	1648	34.4	5	75	9.17	53.5	10.9	23.20	7.75	.180
	10/20	5/24	5/31	6/24	31	20	70	537	1661	33.2	5	70	8.60	52.7	8.5	22.94	6.06	.139
	10/27	5/28	6/7	6/26	29	20	75	555	1526	32.0	5	60	7.73	51.8	7.4	23.14	5.73	.133

Table 4. Air temperature during the spring growing period of 1939.

Date	March				April				May			
	Max.	Min.	Total hours between 50° and 86° F.	Hours between 46° and 86° F. 8 A.M.-5 P.M.	Max.	Min.	Total hours between 50° and 86° F.	Hours between 46° and 86° F. 8 A.M.-5 P.M.	Max.	Min.	Total hours between 50° and 86° F.	Hours between 46° and 86° F. 8 A.M.-5 P.M.
1					62	41	14	9	83	50	24	9
2					67	39	16	9	81	52	24	9
3					52	39	4	8	81	48	22	9
4					58	45	14	9	81	57	24	9
5					51	35	5	4	81	58	24	9
6					49	28	--	-	83	63	22	7
7					60	26	8	9	74	56	24	9
8					66	31	12	9	71	51	24	9
9					78	43	19	9	81	40	17	9
10					57	43	10	0	74	52	24	9
11					42	25	--	-	68	48	23	9
12					43	20	--	-	63	45	22	9
13					69	31	13	9	74	33	15	9
14					77	42	24	9	83	44	20	8
15					70	52	24	9	79	50	24	7
16					55	42	12	9	90	45	12	3
17					43	35	--	-	85	57	24	7
18					44	39	00	-	77	58	24	9
19					62	30	12	9	83	55	24	9
20	65	35	11	9	57	45	13	9	80	59	24	9
21	78	38	15	9	62	36	11	9	86	61	24	3
22	80	40	19	9	79	42	17	9	82	61	24	9
23	81	46	20	9	86	58	24	9	94	63	16	3
24	72	49	23	9	84	62	24	9	94	68	15	1
25	62	48	23	9	84	59	24	9	85	66	24	9
26	68	46	17	9	79	53	24	9	81	61	24	9
27	53	37	5	7	78	41	17	9	76	57	24	9
28	37	31	--	0	72	42	19	9	80	56	24	9
29	40	30	--	0	72	44	19	9	90	54	17	3
30	58	28	9	8	77	44	20	9	94	64	16	2
31	66	38	12	9					90	61	17	3

The observed and calculated values are recorded in Table 5. The June 1 observations for Kanred are probably inaccurate in respect to the grain and kernel measurements because the small immature seeds were easily broken in threshing, blown away in cleaning, and improperly sampled in determining 1000 kernel weights.

The fall condition of the plots is shown in Plate V. Early development of the plants was hindered and the stand visibly affected by the dry surface soil during October. Plate VI shows the condition of the Kanred plots in January. Figure 37 graphically presents the dry weight per plant, tillers per plant, and dry weight per tiller for samples taken two weeks earlier.

A comparison of the plots on March 23 is given on Plate VII. The plots had just resumed growth. Plate VIII compares the growth of one Kanred plot and the seven Early Blackhull plots just after the full heading stage. Pronounced differences in height, maturity, and tillering can be observed. The extent of the hail damage occurring on June 7 is indicated by Fig. 24.

Table 5. Data regarding heads and grain of samples taken June 1 and June 9.

Plot and sample	June 1: No. of heads	Wt. of heads	Wt. of grain	1000 kernel wt.	No. of kernels	Kernels per head	June 9: No. of heads	Wt. of heads	Wt. of grain	1000 kernel wt.	No. of kernels	Kernels per head
Early Blackhull												
1E	288	183.5					194	109.5	74.7	26.8	2789	14.4
1W	262	170.0	93.53	20.87	4481	17.1	235	145.4	91.9	27.2	3385	14.4
2E	260	163.4	98.00	22.66	4325	16.6	258	152.8	99.4	27.2	3656	14.2
2W	215	131.0	76.92	20.95	3672	17.1	192	127.3	83.9	27.4	3057	15.9
3E	208	132.0					193	104.1	68.9	26.7	2585	13.4
3W	239	149.9	92.27	20.14	4581	19.2	192	98.4	62.4	27.2	2290	11.9
4E	240	146.1	84.04	20.25	4150	17.3	175	99.5	66.9	25.6	2613	14.9
4W	233	144.5	83.47	31.24	3929	16.9	201	129.6	82.2	27.1	3033	15.1
5E	210	110.3	61.67	16.61	3713	17.7	149	81.5	50.2	24.2	2074	13.9
5W	155	84.1	43.76	17.40	2515	22.7	185	113.6	73.7	26.3	2803	15.2
6E	150	65.1	32.00	13.10	2443	16.3	124	60.6	38.4	23.6	1700	13.7
6W	165	82.6					136	84.2	53.9	26.1	2065	15.2
7E	135	39.1					191	95.6	56.7	21.4	2653	13.9
7W	145	47.9	19.30	10.23	1886	13.0	101	44.2	22.5	19.5	1155	11.4
Kanred												
1E	355	114.0	58.40	14.61	3996	11.3	312	130.2	90.2	23.2	3894	12.5
1W	314	111.2	56.70	15.33	3698	11.8	345	139.0	92.7	22.0	4205	12.2
2E	330	117.0	61.80	13.04	4739	14.4	287	125.8	71.9	21.9	3279	11.4
2W	330	119.2	43.50	13.15	3309	10.0	392	173.4	105.9	21.3	4974	12.7
3E	290	94.2	37.00	9.13	4054	14.0	316	151.7	93.5	21.4	4377	13.9
3W	250	86.6	41.30	13.34	3347	13.4	285	126.2	78.9	20.0	3954	18.9
4E	199	64.0	22.70	7.94	2859	14.4	282	126.7	66.5	16.6	3999	14.2
4W	233	71.7	23.70	8.59	2758	11.8	274	130.4	72.4	19.1	3799	13.9
5E	265	65.5	18.50	5.74	3223	12.2	239	94.4	54.9	19.3	2849	11.9
5W	249	67.8	22.20	6.20	3581	14.4	224	94.1	55.9	18.8	2970	13.3
6E	200	46.0	8.80	5.84	1507	7.5	243	85.1	45.7	17.1	2677	11.0
6W	206	49.8	12.10	5.22	2318	11.3	199	73.3	39.0	16.8	2321	11.7
7E	113	24.2	4.13	2.85	1149	12.8	144	46.1	19.2	11.5	1668	11.6
7W	170	37.8	7.70	4.49	1716	10.1	197	66.9	24.5	10.8	2259	11.5

EXPLANATION OF PLATE V

Fig. 3. Varietal plots of wheat on October 15. Dry surface soil had hindered growth and prevented secondary root formation.

Fig. 4. Varietal plots on November 10. A two inch rain on November 2 had resulted in rapid tiller and root development.

PLATE V

Fig. 3

Fig. 4

EXPLANATION OF PLATE VI

Fall growth of Kanred wheat seeded at weekly intervals. Drill row photographed January 14.

Fig. 5. Seeded September 15.

Fig. 6. Seeded September 22.

Fig. 7. Seeded September 29.

Fig. 8. Seeded October 6.

Fig. 9. Seeded October 13.

Fig. 10. Seeded October 20.

Fig. 11. Seeded October 27.

PLATE VI

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9

Fig. 10

Fig. 11

EXPLANATION OF PLATE VII

Kanred plots photographed March 23.

Fig. 12. Seeded September 15 (left) and September 22 (right).

Fig. 13. Seeded September 29 (center) and October 6 (right).

Fig. 14. Seeded October 13 (center) and October 20 (right).

Fig. 15. Seeded October 20 (center) and October 27 (right).

PLATE VII

Fig. 12

Fig. 13

Fig. 14

Fig. 15

EXPLANATION OF PLATE VIII

Plot photographs taken at the full heading stage on May 21.

Fig. 16. Kanred seeded September 15.

Fig. 17. Early Blackhull seeded September 15.

Fig. 18. Early Blackhull seeded September 22.

Fig. 19. Early Blackhull seeded September 29.

Fig. 20. Early Blackhull seeded October 6.

Fig. 21. Early Blackhull seeded October 13.

Fig. 22. Early Blackhull seeded October 26.

Fig. 23. Early Blackhull seeded October 27.

PLATE VIII

Fig. 16

Fig. 17

Fig. 18

Fig. 19

Fig. 20

Fig. 21

Fig. 22

Fig. 23

EXPLANATION OF PLATE IX

Fig. 24. Damage to the field plots resulting from the hailstorm of June 7. This plot of Kanred was planted September 29 and photographed June 18.

PLATE IX

Fig. 24

Analysis of Data

Because of the complexity of the problem, the discussion of results will be presented under several subheadings.

Number of plants per sample. The number of plants per sample was determined by counting the number of entries in the frequency table of tillers per plant. An analysis of variance was made of the samples which were complete and comparable. This involved a total of 280 readings from ten dates of sampling, two varieties, seven dates of seeding, and duplicate samples. Table 6 shows the results obtained.

Table 6. Analysis of variance of number of plants per sample, date of seeding plots at Manhattan, Kansas, 1938-39.

Source of variance	df	Sum of squares	Variance	F	5%	1%
Varieties	1	243.289	243.289	.76	3.89	6.76
Date of seeding	6	27110.143	4518.357	14.09	2.14	2.90
Date of sampling	9	3992.246	443.583	1.38	1.92	2.50
Variety x date of sampling	9	1626.104	180.678	.56	1.92	2.50
Variety x date of seeding	6	15561.686	2595.614	8.09	2.14	2.90
Date of seeding x date of sampling	54	20016.929	370.684	1.16	1.42	1.62
Error	194	62212.071	320.681			
Total	279	130762.568				

The only significant F values obtained are between dates of seeding and date of seeding x variety interaction. The latter is probably due to the influence of the date of seeding variation. The highly significant values obtained between dates of seeding indicates that different conditions resulting in different germination percentages and vigor of seedlings existed at the time of planting the several plots and that this difference affected the number of plants per sample regardless of time of sampling, variety, or sampling error from duplication of samples. The average numbers of plants and standard deviations for the varieties and dates of seeding are given in Table 7. The grand mean of all samples was 89.46 ± 21.64.

Table 7. Average number and standard deviation of plants in dry weight samples from date of seeding plots, Manhattan, Kansas, 1938-39. Average of 20 samples.

Seeded	Early Blackhull	Kanred
Sept. 15	110.60 ± 23.37	111.55 ± 15.79
Sept. 22	77.05 ± 16.20	91.25 ± 18.82
Sept. 29	104.20 ± 22.05	86.00 ± 15.09
Oct. 6	98.45 ± 26.22	71.65 ± 15.27
Oct. 13	83.35 ± 16.59	89.10 ± 15.17
Oct. 20	88.00 ± 17.01	82.70 ± 18.85
Oct. 27	71.10 ± 14.59	87.45 ± 11.41
Ave.	90.393	88.529

Since these plants were taken from a known area, an estimate of the number of plants per acre is possible. The estimated value thus obtained is comparable in Table 8 to the estimate from five five-foot counts taken immediately after emergence.

Table 8. Plants per 1/1000 acre in the date of seeding plots as determined by two different methods.

Date of seeding	Early Blackhull		Kanred	
	1/8309 acre dug sample	5 5-foot drill row counts	1/8309 acre dug sample	5 5-foot drill row counts
Sept. 15	919	781	927	615
Sept. 22	640	831	758	715
Sept. 29	866	644	715	534
Oct. 6	818	573	595	547
Oct. 13	693	644	740	623
Oct. 20	731	660	687	537
Oct. 27	591	558	727	555

The results from the ten 1/8309 acre samples are probably most reliable. They represent a total of 90 feet of drill row, compared to 25 feet for the row counts. Other reasons for differences are that seed may have established plants after the 25 foot counts were made, some of the weaker plants may have died, and an occasional tillered plant may have been counted as more than one plant. A bias may exist in that the 20 dug samples each had 160 drill ends, while the 5 5-foot counts had only 10 end points.

Rate of tillering. The number of tillers per plant was determined by dividing the number of tillers by the number of plants for each sample. The plot values were secured by averaging the two samples. An analysis of variance was run on 280 samples. The summary is given in Table 9.

Table 9. Analysis of variance of tillers per plant.

Source of variance	df	Sum of squares	Variance	F	5%	1%
Varieties	1	46.455	46.455	57.288	3.89	6.76
Dates of seeding	6	506.056	84.343	104.011	2.14	2.90
Dates of sampling	9	386.069	42.897	52.900	1.92	2.50
Seeding x sampling	54	291.237	5.393	6.651	1.42	1.62
Error	209	169.470	.811			
Total	279	1399.287				

The highly significant values obtained may be explained by the tendencies of Kanred to tiller more than Early Blackhull and for early seeded plots to tiller markedly more than later seeded ones, although a larger proportion of the tillers formed may die. These tendencies are illustrated in Fig. 27 and Fig. 28. That the number of tillers per plant varied with the density of stand is shown in Fig. 25. Each line on the figure indicates a plot, and the date of seeding is shown by the number adjacent to it. The September 15 planting is indicated by 1, the September 22 by 2, and so on. Duplicate samples for each plot were connected by straight lines, black for Early Blackhull and red for Kanred. This same procedure is followed in Fig. 26 and Fig. 31.

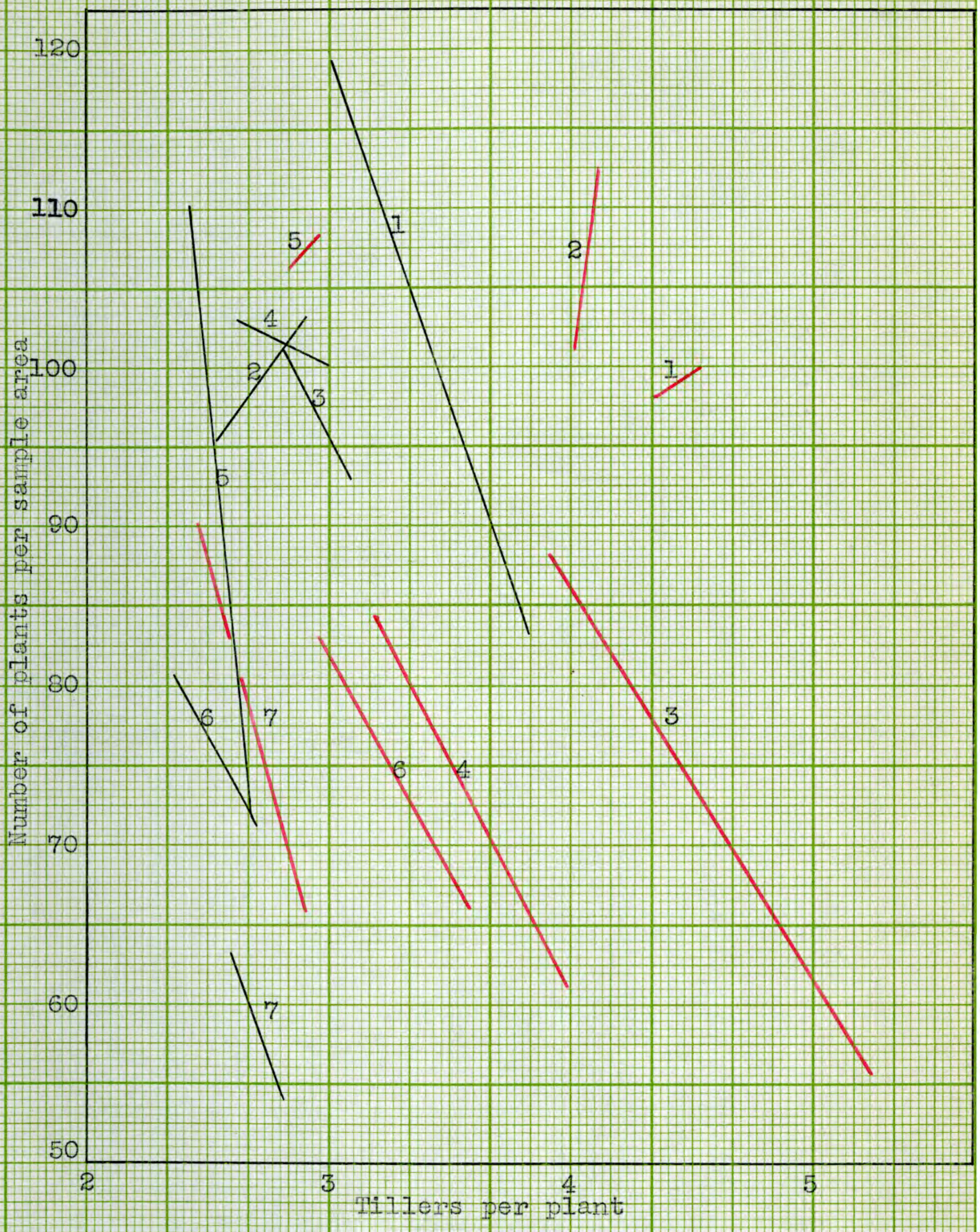

Fig. 25. Relationships of plants per sample area and tillers per plant for two varieties of winter wheat.

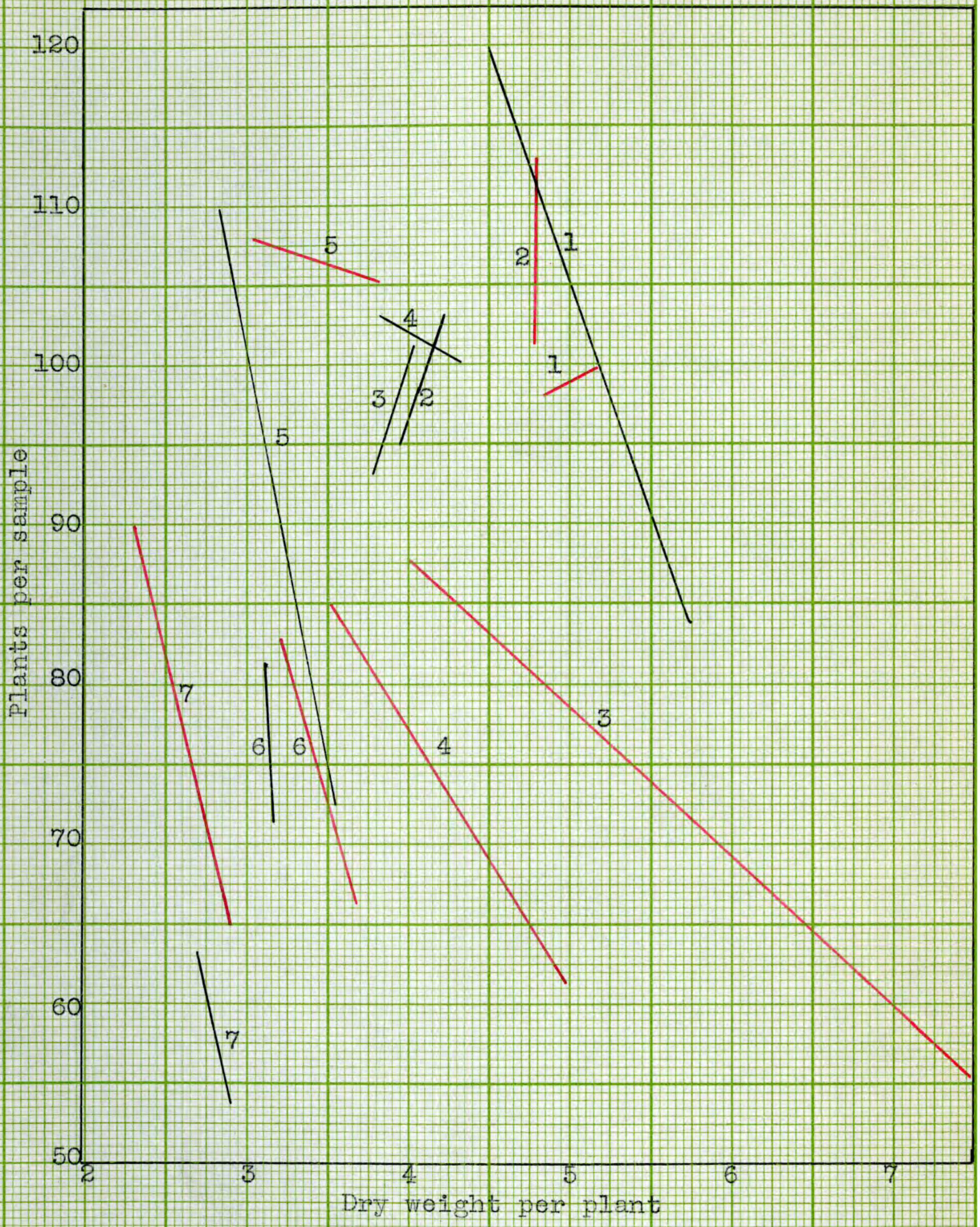

Fig. 26. Relationship between dry weight per plant and plants per sample.

Figure 25 illustrates that for the two varieties on June 1, the number of tillers per plant varied inversely with the plants per sample area within a plot. A slight difference in plants per area did not influence the rate of tillering, but in general the greater the difference in plants per area, the greater the difference in tillers per plant. An examination of Table 1 shows this is true also for samples taken June 9 and June 15.

An examination of Plates III and IV showed that as the average number of tillers per plant increased, the size of the largest plants increased proportionally. It was only in the later samples, where competition had limited the number of tillers that the measurements of the plants approached a normal distribution (Snedecor, 1938, p. 47). Figures 27 and 28 give the average numbers of tillers per plant for Early Blackhull and Kanred.

Unit of growth measurement. Hanna (1925) in comparing increase in height with increase in dry weight in wheat, found that the greatest increase in height took place in the darkness and considered this as evidence that height is only a relative measure of growth in that it measures utilization of food materials after they are formed, while dry weight is a positive measure of growth.

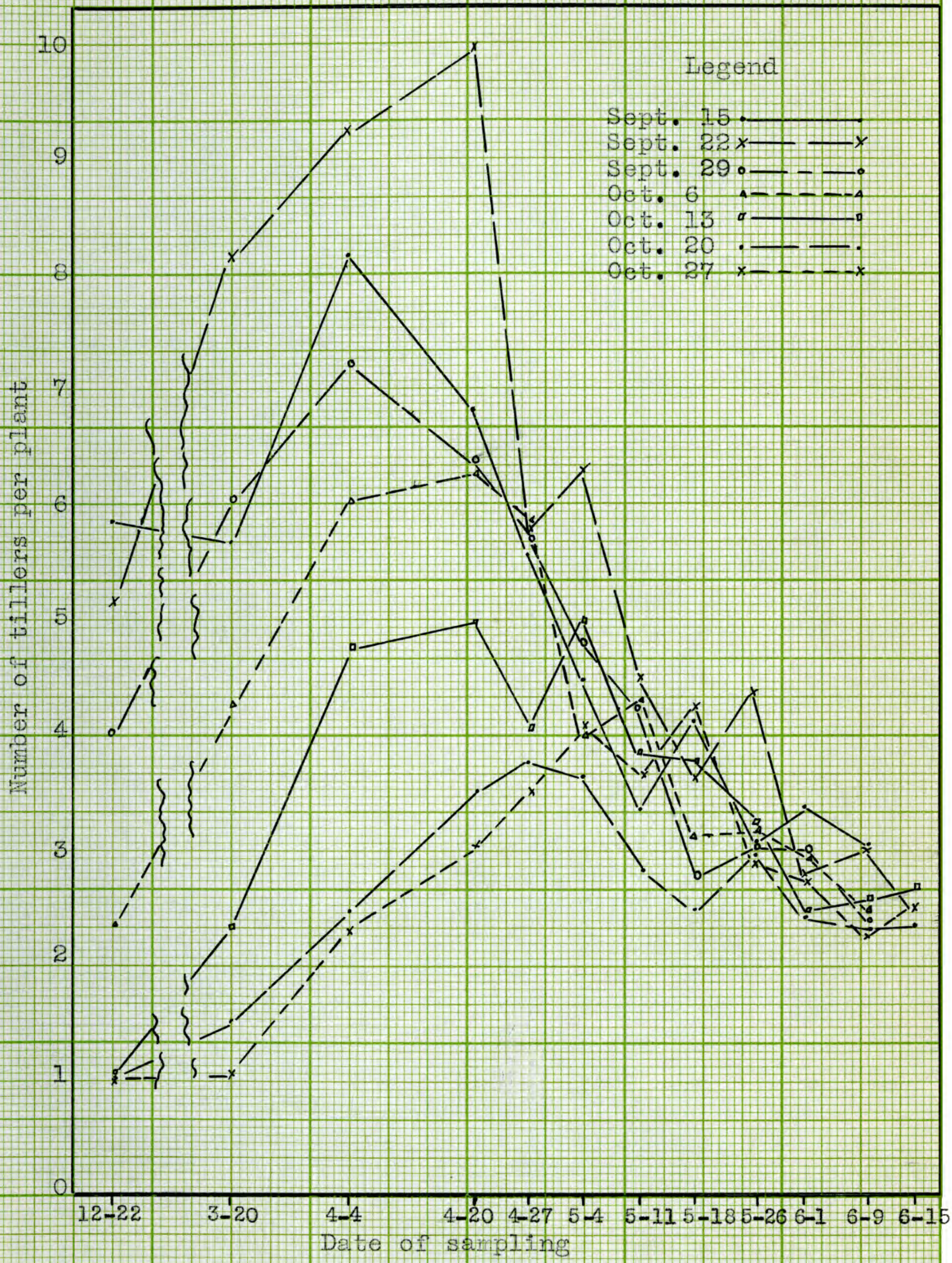

Fig. 27. Tillers per plant for Early Blackhull wheat seeded at weekly intervals.

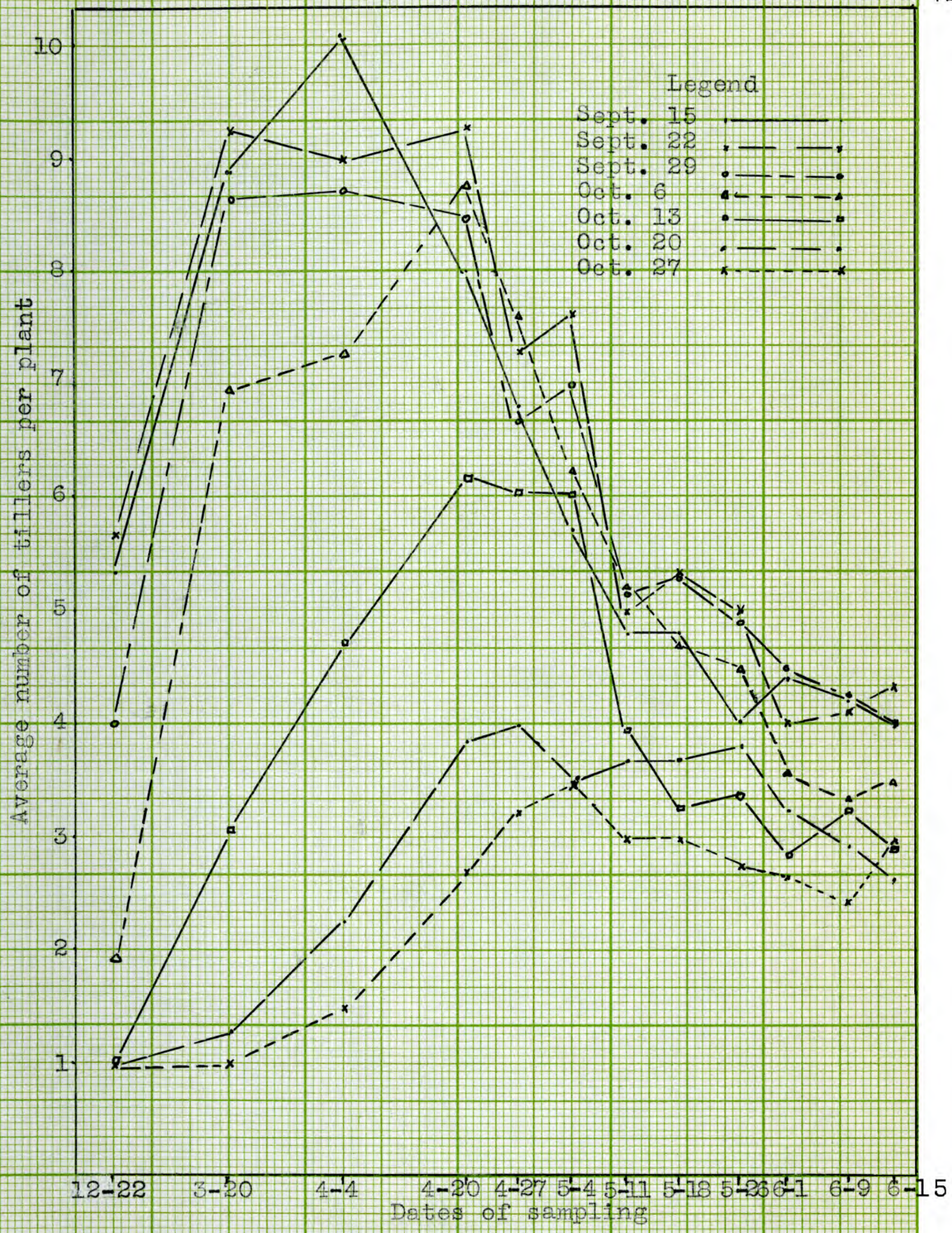

Fig. 28 . Tillers per plant for Kanred wheat seeded at weekly intervals.

Height is easily measured and allows the same individuals to be measured several times. The plant reaches its greatest height some time before photosynthesis and translocation have stopped. Dry weight measurements, on the other hand, are a positive measure of growth, but involve total destruction of the individual and introduce sampling variation.

Dry weight measurements may be expressed in several ways. Some of these are:

1. Dry weight per sample. The variation in number of plants per sample results in fluctuations due to sampling.

2. Dry weight per plant. The variation in plant size due to thickness of stand, and the fact that the plants do not follow a normal distribution with respect to tillers per plant make this calculation vary greatly between samples.

3. Dry weight per tiller. This measures the activity of the various growing points within a sample.

4. The theoretical dry weight per tiller could be obtained by dividing the observed dry weight per plant by the average number of tillers per plant for the preceding sample. This would correct the dry weight per tiller in such a way that new tillers formed are assumed to be part of the tillers which formed them. A decrease in the number of tillers per plant, as in the later stages of growth, would upset

this hypothesis, and also, more nearly representative samples would be assumed than may be true.

A positive measure of the sample under consideration would be more desirable than a theoretical one. The dry weight per sample varies so much, especially when uneven stands are sampled, that this value is unsuited to growth rate studies. A choice may be made between dry weight per plant and dry weight per tiller.

In the review of literature and experimental data the following points tend to support the use of the dry weight per tiller measurement:

1. Formation of its own root system by each tiller.

2. Association of secondary roots and tillers in the young plants.

3. General stunting or lack of tillers when secondary roots do not develop.

4. Dying of tillers which fail to establish sufficient root systems.

5. Ability of tiller to grow and reproduce when separated from the parent plant.

6. Location of the growing point within the tiller during the period of greatest growth.

7. Smoother growth curves from dry weight per tiller than from dry weight per plant as shown in Figs. 29, 30, 32, and 33.

Fig. 29. Dry weight per plant for seven plots of Early Blackhull wheat seeded at weekly intervals.

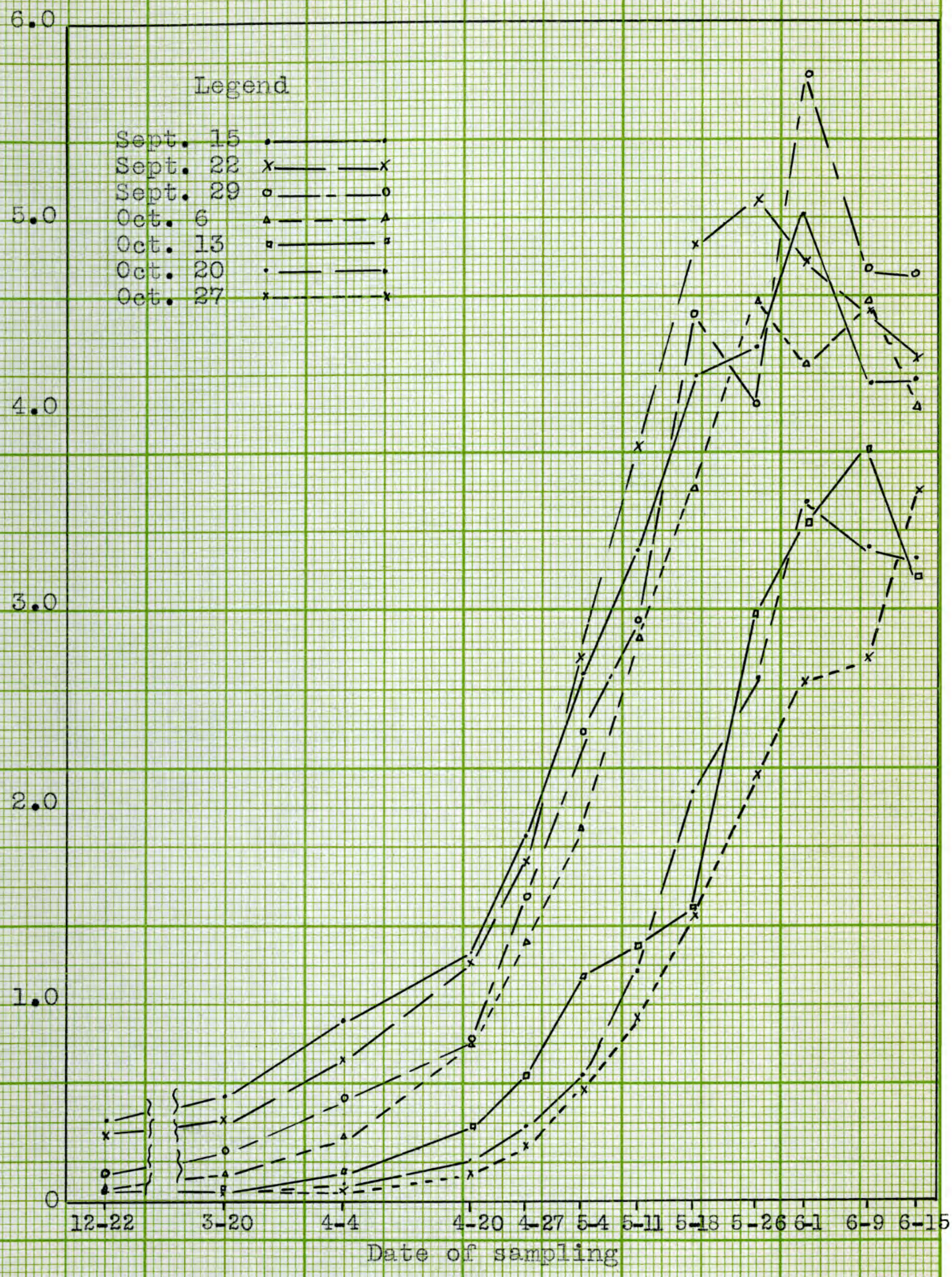

Fig. 30. Dry weight per plant for seven plots of Kanred wheat seeded at weekly intervals.

8. Greater variation in size of plant with variations in stand than in size of tillers as shown in Figs. 26 and 31.

It is believed that a measurement which takes into consideration the number of growing points in a sample is of more value than one which uses a group of growing points, the number in the group varying between samples.

<u>Size of tiller</u>. Dry weight per tiller was determined by dividing the total dry weight per sample by the number of tillers per sample. The weight was calculated to 1/10,000 of a gram. An analysis of variance was made on 280 samples and the summary given in Table 10 shows highly significant differences between varieties, dates of seeding, and dates of sampling.

Table 10. Analysis of variance of dry weight per tiller.

Source of variance	df	Sum of squares	Variance	F	5%	1%
Varieties	1	.6692	.6692	85.703	3.89	6.78
Dates of seeding	6	1.5298	.2550	32.655	2.14	2.90
Dates of sampling	9	62.2869	6.9319	887.782	1.92	2.50
Seeding x sampling	54	1.0099	.0187	2.395	1.42	1.62
Error	209	1.6319				
Total	279	67.2277				

The size of the tillers may be influenced inversely by the thickness of stand, as indicated in Fig. 31. These are

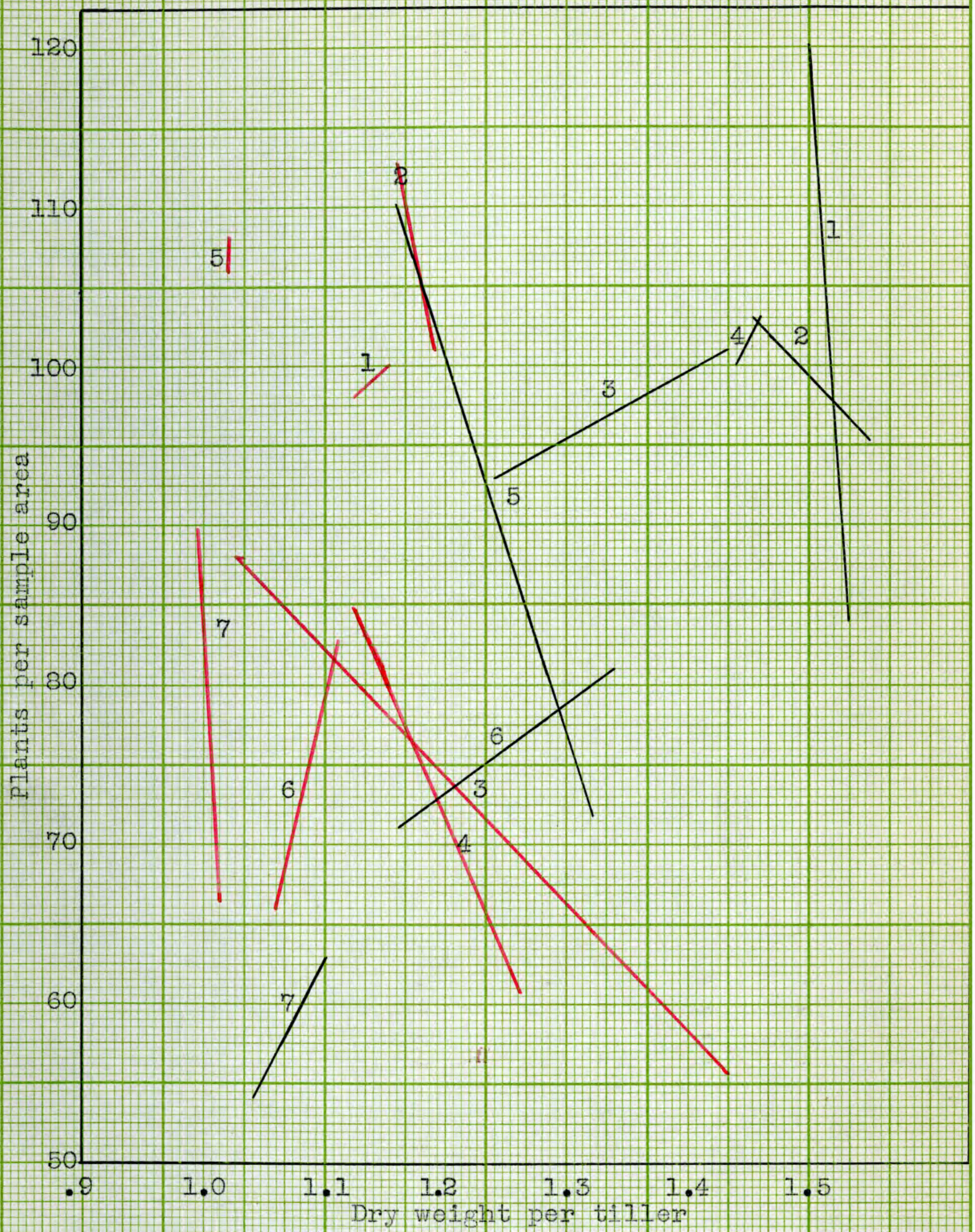

Fig. 31. Relationships of plants per sample area and dry weight per tiller for two varieties of winter wheat, Manhattan, June 1, 1939.

the same June 1 samples as are shown in Fig. 26, and the trend toward larger tillers is much less pronounced than the trend toward more tillers per plant in thinner stands.

The dry weight per tiller is shown in Fig. 32 for Early Blackhull and in Fig. 33 for Kanred. The June 9 and June 15 values were plotted but these were not reliable because of hail damage. With three exceptions the plots which showed the highest dry weight per tiller in Fig. 32 and Fig. 33 showed the highest yield per acre in Table 3. This may be associated with the size of head in a continuation of this problem in other years.

Relative growth rate. The dry weight per tiller was used as a basis for computing the relative growth rate, using Fischer's formula of $R = \frac{W_2 - W_1}{\frac{1}{2}(W_1 + W_2)} \times 100$ where R = the relative growth rate, W_1 = the dry weight at the beginning of the period and W_2 = the dry weight at the end of the period. This expresses the increase in weight as a percent of the average weight during the period.

The calculated relative growth rates are given in Table 11. The two varieties were averaged and the results presented graphically in Fig. 34.

An analysis of variance was made of the 112 values calculated. The results are given in Table 12.

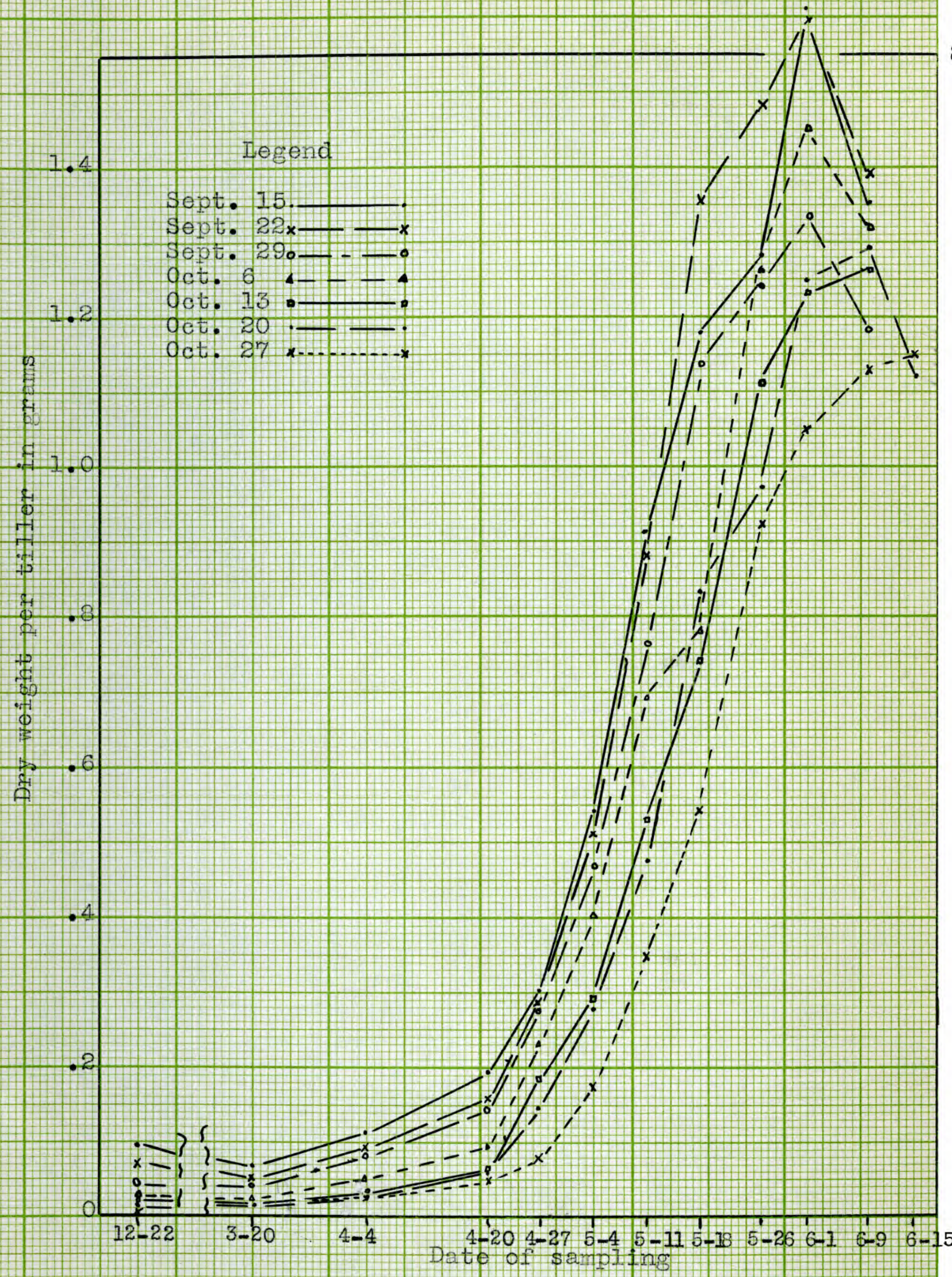

Fig. 32 . Dry weight per tiller for seven plots of Early Blackhull wheat seeded at weekly intervals.

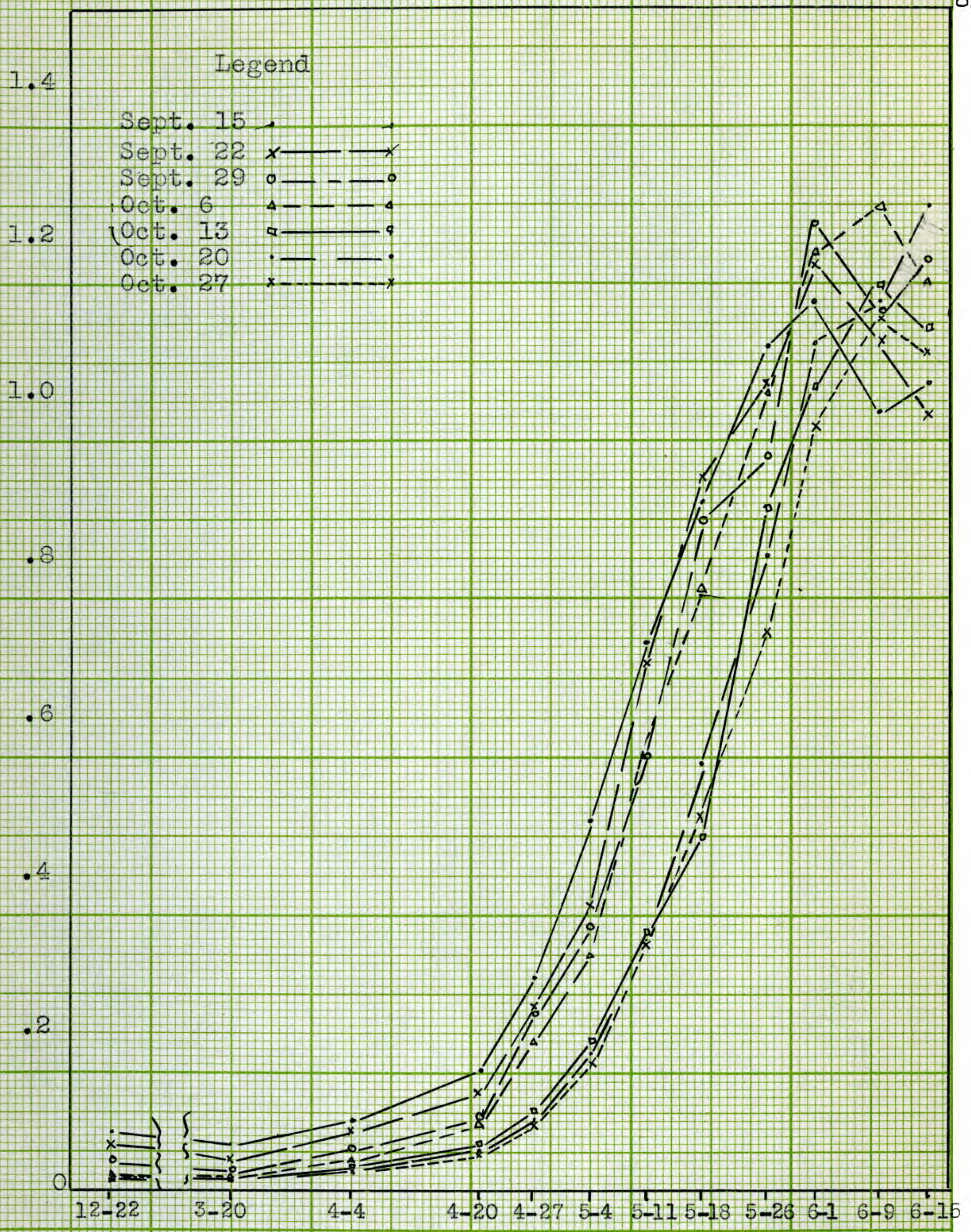

Fig. 33. Dry weight per tiller for seven plots of Kanred wheat seeded at weekly intervals.

Table 11. Relative growth rates of two varieties of winter wheat for eight sampling periods.

Date seeded	Mar. 20 to Apr. 4	Apr. 4 to Apr. 20	Apr. 20 to Apr. 27	Apr. 27 to May 4	May 4 to May 11	May 11 to May 18	May 18 to May 26	May 26 to June 1	Variety averages	Date of seeding average
					Early Blackhull					
Sept. 15	48.19	51.26	45.76	56.31	50.30	25.44	8.14	17.06	37.81	
Sept. 22	53.02	53.64	63.03	50.76	52.65	42.61	8.91	1.71	40.79	
Sept. 29	61.50	57.76	62.60	52.37	47.64	40.36	7.70	7.34	42.16	
Oct. 6	65.73	63.14	77.97	55.82	52.74	12.97	46.83	13.54	48.57	
Oct. 13	53.59	81.58	95.47	44.13	57.55	33.55	39.82	11.81	52.19	
Oct. 20	66.81	67.44	78.53	62.39	52.44	54.66	15.23	24.70	52.77	
Oct. 27	47.31	62.59	49.56	75.81	66.91	44.06	51.55	12.77	51.33	
					Kanred					
Sept. 15	40.95	23.34	81.12	53.36	38.70	22.27	21.08	5.00	35.73	36.77
Sept. 22	57.38	48.20	60.09	41.95	59.17	29.47	12.34	14.08	40.33	40.56
Sept. 29	66.59	53.32	80.64	37.36	48.54	42.00	9.56	27.39	45.68	43.92
Oct. 6	62.84	74.50	67.82	45.42	59.52	30.22	27.66	16.08	48.01	48.30
Oct. 13	54.98	70.76	51.68	59.89	52.24	30.22	63.51	16.27	49.94	51.07
Oct. 20	35.05	64.93	53.66	59.31	55.52	53.97	38.28	29.15	48.73	50.75
Oct. 27	56.06	42.61	53.29	58.87	63.31	40.47	38.75	31.50	48.11	49.71
Period Average	55.00	58.22	65.80	53.84	54.08	35.88	27.81	16.31		45.87

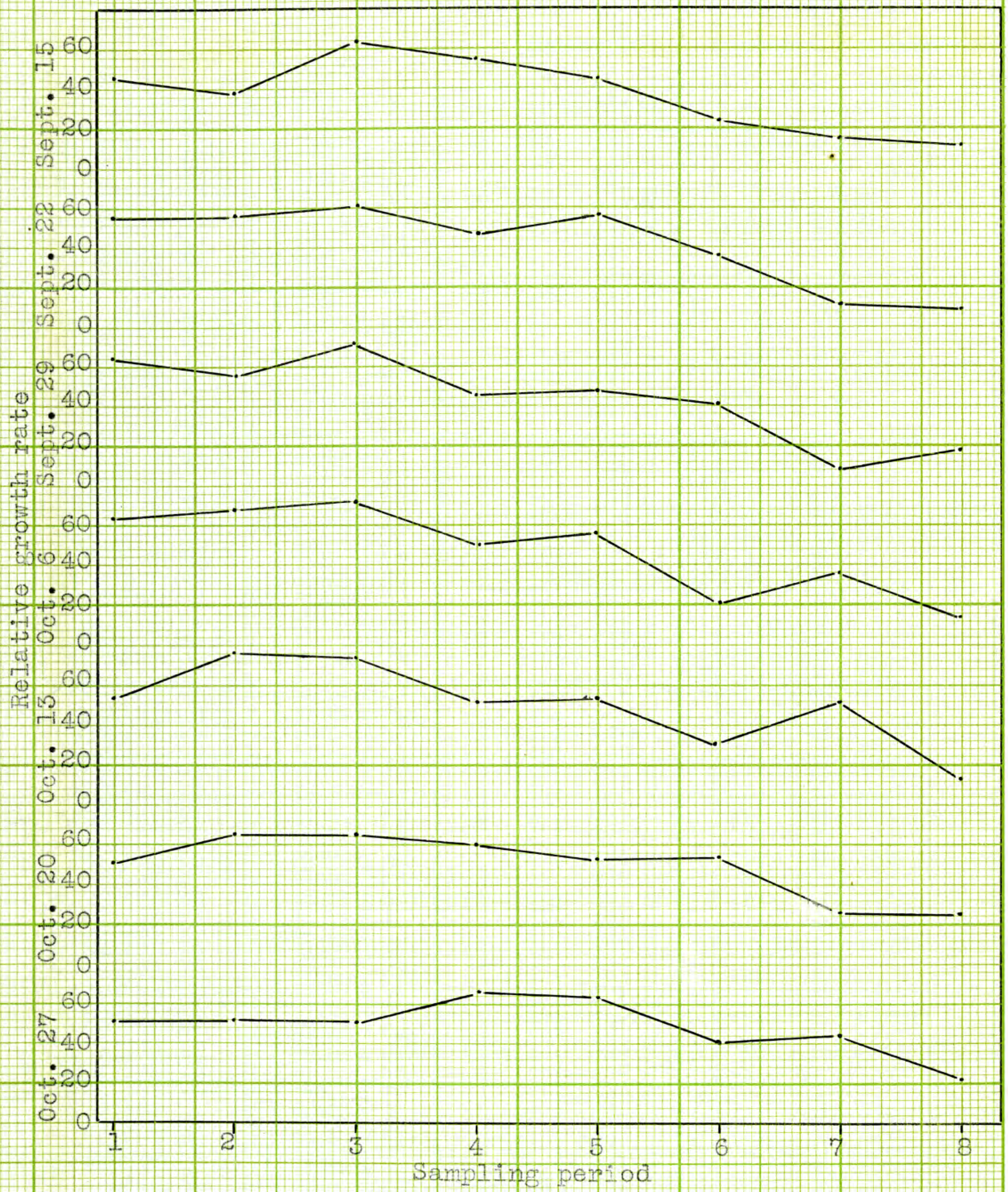

Fig. 34. Relative growth rates of winter wheat for seven dates of seeding and eight sampling periods.

Table 12. Analysis of variance of relative growth rates.

Source of variance	df	Sum of squares	Variance	F	5%	1%
Varieties	1	47.333	47.333	.454	3.94	6.90
Dates of seeding	6	2981.727	496.955	4.771	2.19	2.99
Dates of sampling	7	28891.860	4127.409	39.624	2.10	2.82
Error	97	10104.043	104.165			
Total	111	42042.960				

The non-significant value obtained between varieties was unexpected, in view of the highly significant differences in dry weight per tiller obtained in Table 10. This shows that in spite of the great differences in size of tiller the two varieties were reacting in the same way to whatever environmental changes were taking place.

The highly significant F value between dates of seeding show the lag that is illustrated in Fig. 32 and accentuates the fact that plants (or tillers) at different stages of development will react differently to a given weather condition. The highly significant F values between dates of sampling were expected, in view of the sigmoid growth curves of the small grains.

It seemed logical to assume that the relative growth rate for the various sampling periods could be related to the weather during those periods, particularly since the two varieties acted alike. Moisture, or rainfall, was not a limiting factor during the year, so some relationship between relative growth rate and temperature was to be expected.

Lundegardh (1931) has given the maximum temperature for growth of Triticum vulgare as 30° C., while Hurd-Karrer (1933) stated that the minimum temperature for growth of wheat is probably 8 to 10° C. These temperatures are equal to 86° F. and 46 to 50° F.

The number of hours daily that fell between the extremes of 86° and 50° was obtained from the recording thermograph for the sampling periods. The instrument was maintained in the instrument shelter until May 1, and then was transferred to the wheat plots.

Since the plant can manufacture materials for growth only in the presence of sunlight, some interaction of light and temperature was possible. The number of hours of growing temperatures between 8:00 A.M. and 5:00 P.M. was secured for each day and averaged for the period. Table 13 shows the calculations made. When these values were plotted against the relative growth rates, a striking correlation was found for all except the first two sampling periods.

The length of the daily growing period was limited by the low temperature limit in the earlier sampling periods and by the maximum temperature in the later periods.

Table 13. Average number of growing hours available during eight sampling periods.

	No. of days	Total hours	Hours between 8 A.M. & 5 P.M.	Hours 46-86° 8 A.M. to 5 P.M.	Average daily
March 20 to April 3, inc.	15	360	135	114	7.60
April 4 to April 19, inc.	16	384	144	94	5.875
April 20 to April 26, inc.	7	168	63	63	9.001
April 27 to May 3, inc.	7	168	63	63	9.001
May 4 to May 10, inc.	7	168	63	61	8.71
May 11 to May 17, inc.	7	168	63	52	7.43
May 18 to May 25, inc.	8	192	72	52	6.50
May 26 to May 31, inc.	6	144	54	35	5.83

Lowering the minimum temperature from 50 to 46° increased the daily growing periods of the first two samples, but did not effect the others. The association noted between the relative growth rate and the average daily growing period is shown in Fig. 35.

The period from 8:00 to 5:00 was chosen because this represents the period of the day in which photosynthetic activity is most intense. Cloudiness would be a negligible factor, while if the 12 to 14 hour day was used, cloudiness and light intensity would perhaps need to be included.

The association noted between the daily growing period and the relative growth rate may be entirely coincidental, as the growth rate of the plant gradually decreases as maturity is reached, until an actual loss of dry matter occurs

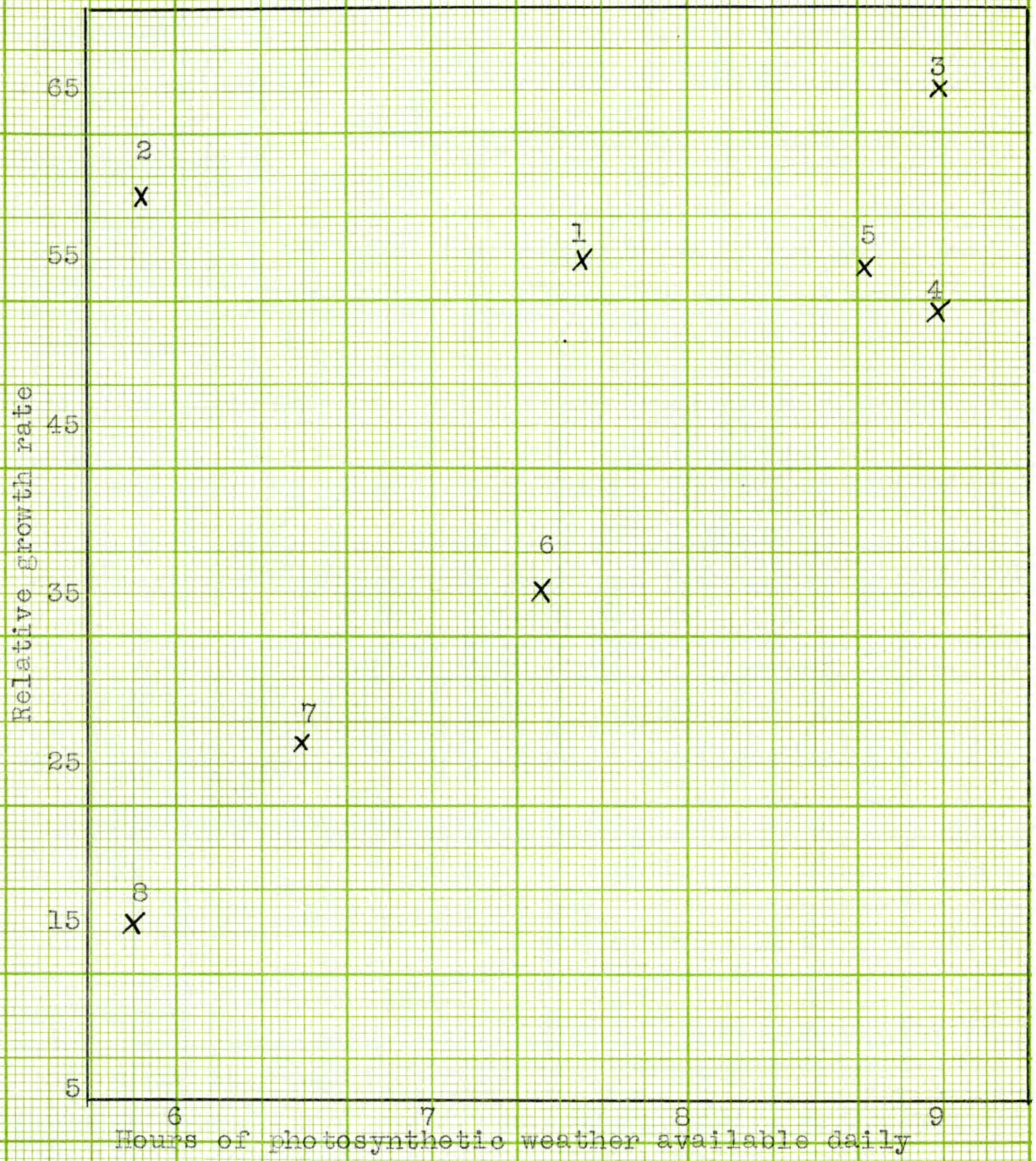

Fig. 35. Relationship between relative growth rate and the average number of hours in which the air temperature remained within the limits of 46° and 86° F. between 8:00 A.M. and 5:00 P.M.

just prior to ripening. As the daily mean temperatures increase the temperatures tend to rise above 86° earlier in the day and return below that point later in the day, gradually shortening the number of hours of sunlight with a temperature between 46° and 86°.

Changing the minimum temperature of growth to 46° from 50° did not bring the two exceptions entirely into line. This may indicate that the tiller has a lower minimum temperature for growth in a younger stage just as it has a lower lethal minimum. The two exceptions may also be the only true associations, the other six measurements coincidentally associating themselves with temperature changes. A repetition of this experiment is being made to discover whether the same relationships will hold in another year.

Number of heads per sample. A correlation between the length of the fall growing season and the heads per sample in June is shown in Fig. 36. Figure 37 shows that the length of the fall growing season is associated with the dry weight per tiller, tillers per plant, and dry weight per plant in December (Plate VI). It is not immediately clear which of these four values are most closely associated with the heads per acre in June.

A review of the literature indicates that root development at the beginning of the stage of elongation may

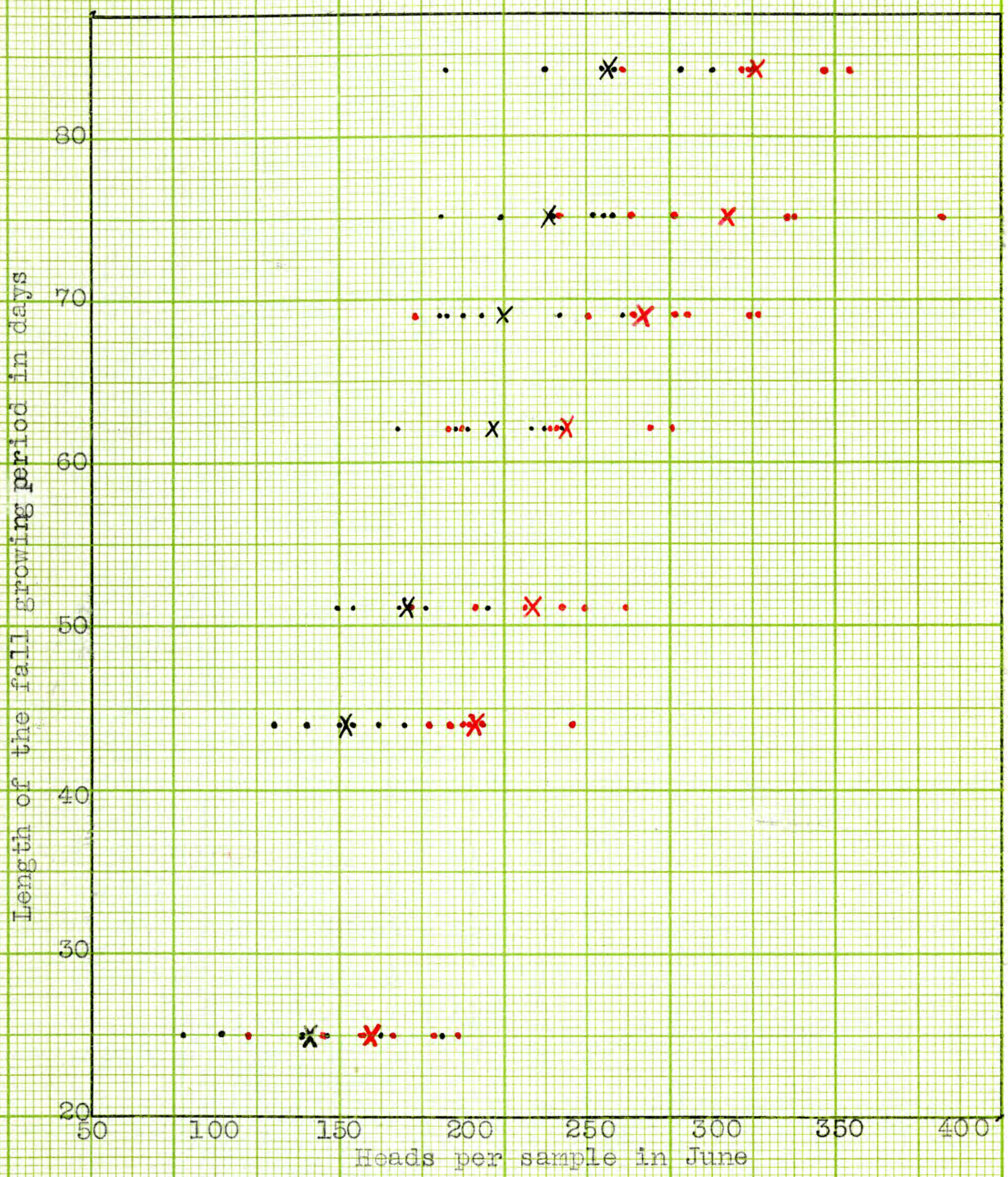

Fig. 36. Relationship of the length of the fall growing period and heads per sampling area in June. The means are indicated by crosses.

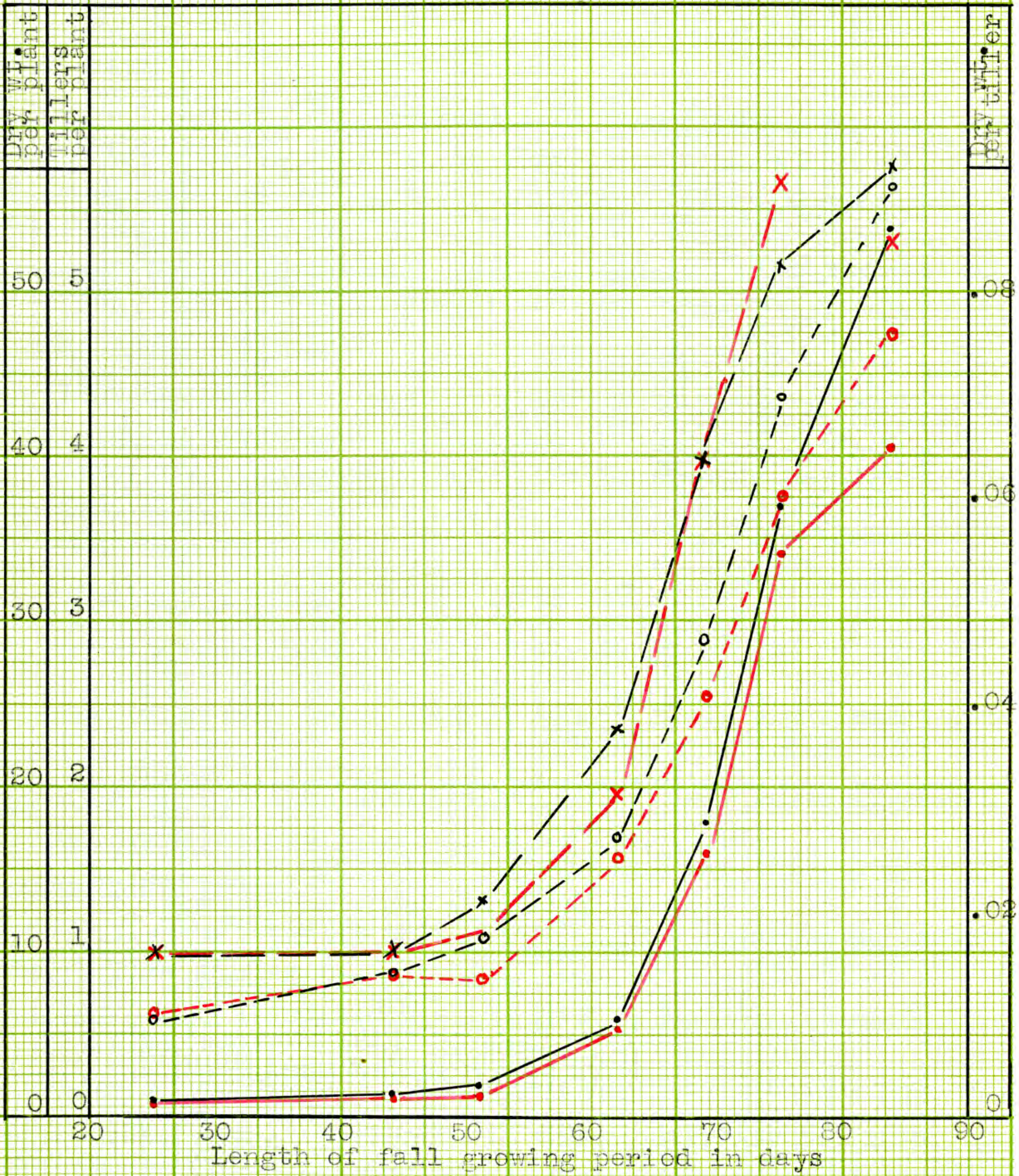

Fig. 37. Relationships between length of fall growing period and dry weight per plant (•——), tillers per plant (×——), and dry weight per tiller (o-----) for Kanred (red) and Early Blackhull (black) wheat.

determine the number of tillers on each plant which will develop heads. This is being considered in a repetition of the experiment.

The relationship between the number of tillers and the number of heads present in each sample is shown in Fig. 38 for Early Blackhull and Fig. 39 for Kanred. As shown in Fig. 27 and 28 the number of tillers per plant decreased rapidly after stem elongation began, and yet all of the tillers which were capable of maintaining themselves did not produce heads. The one-to-one line, on which the readings would fall, if every tiller formed a head, has been placed on Figs. 38 and 39.

Negative factors. A review of leaf and stem rust data from the triplicated wheat variety plots grown on the Agronomy Farm in 1937 and 1938 showed that the yield varied inversely with the degree of leaf and stem rust infection. The data are summarized in Table 14.

Table 14. Effect of leaf and stem rust on yield and test weight of winter wheat.

Disease	Year	Influence on	Regression equation	Correlation coefficient
Leaf rust	1937	Bushels per acre	47.4-.079X	-.61
Leaf rust	1938	" " "	27.3-.162X	-.92
Stem rust	1937	Test weight	67.0-.0542X	-.73
Stem rust	1938	" "	54.4-.0568X	-.44

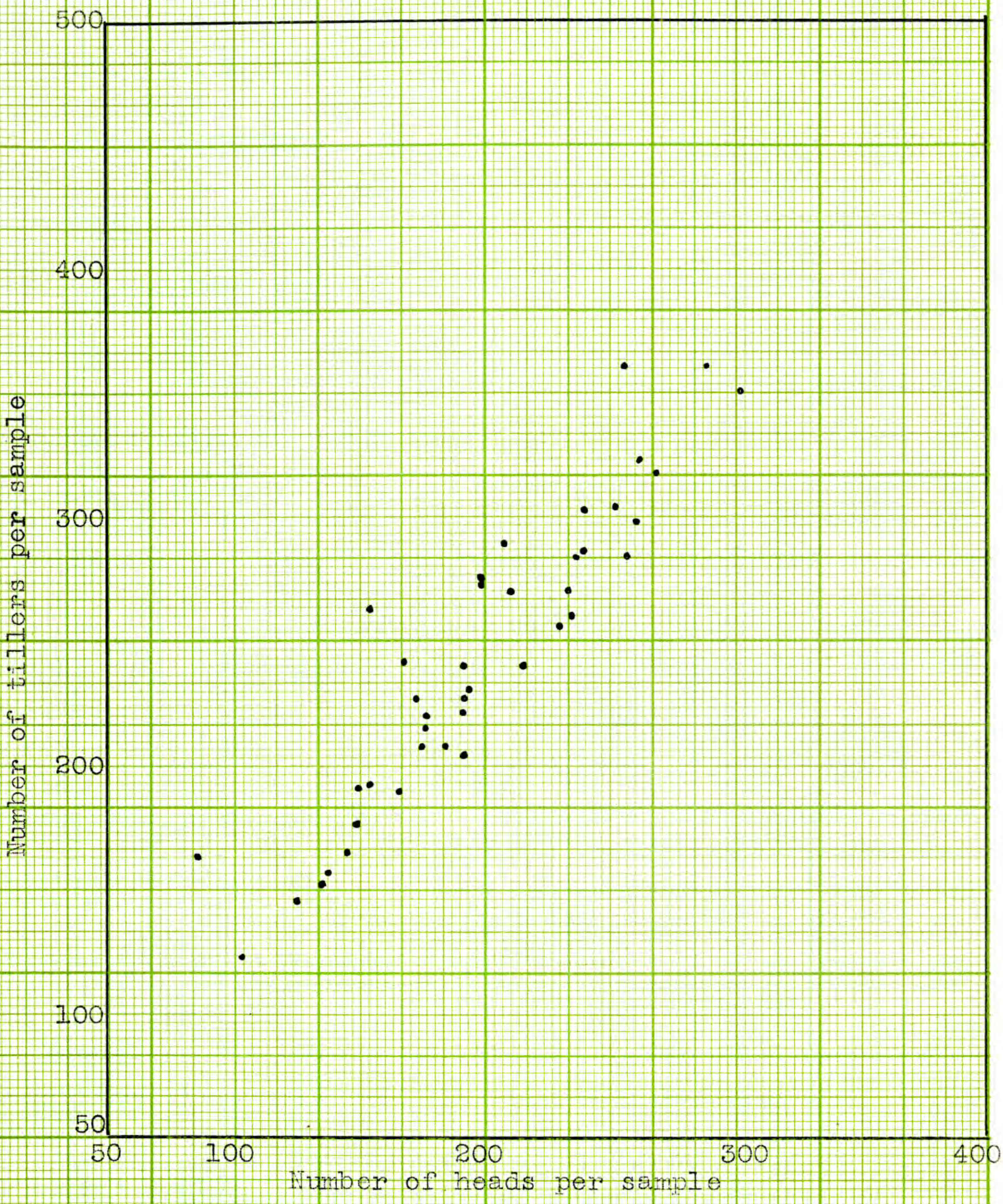

Fig. 38. Relationship between tillers per sample and heads per sample in 42 Early Blackhull samples.

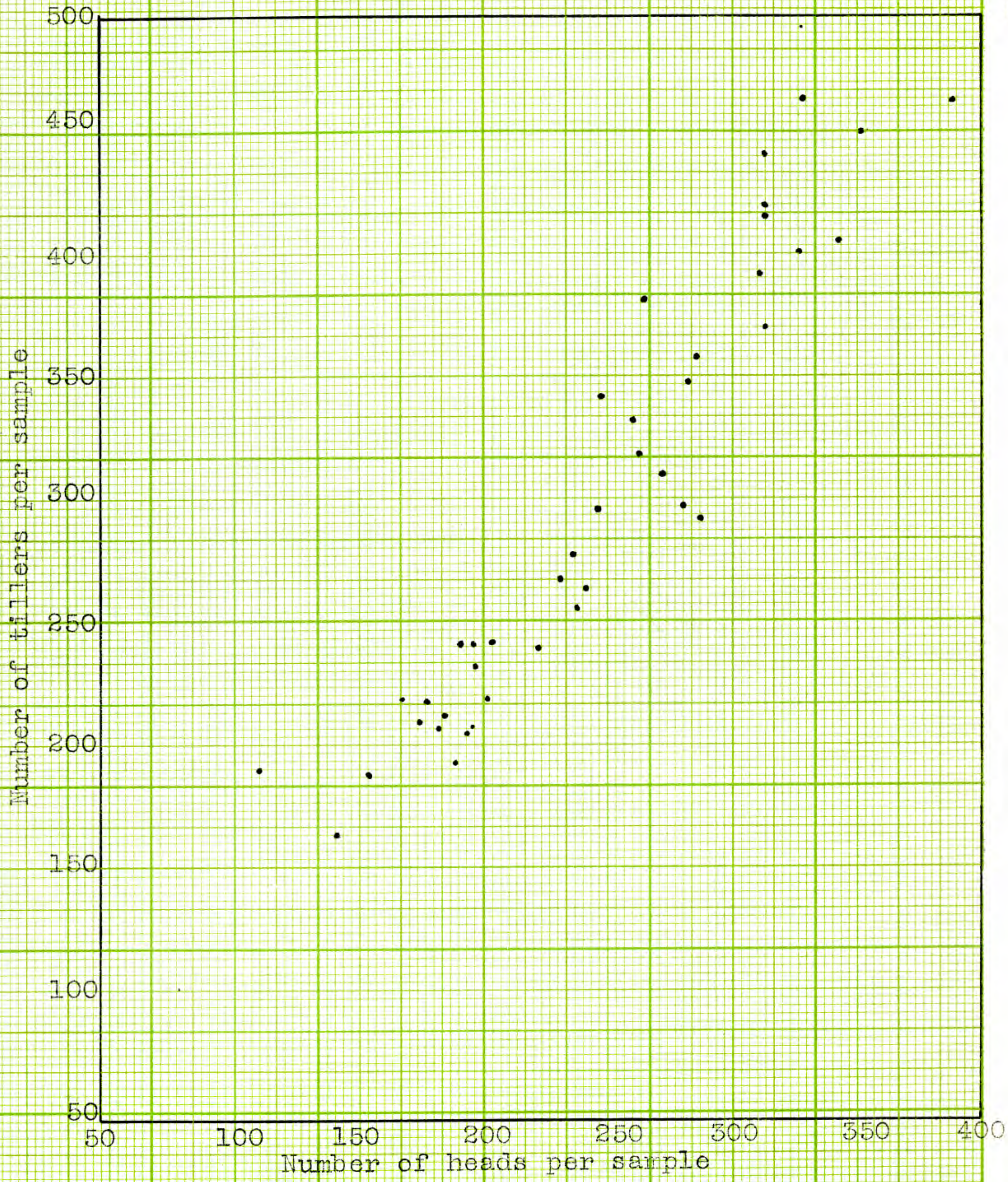

Fig. 39. Relationship between heads per sample and tillers per sample in 42 Kanred samples.

The varietal means of the triplicated series were used in computation. Table 14 shows that varieties very susceptible to leaf rust tended to yield less than more resistant varieties, while susceptibility to stem rust was associated with lower test weight. In the regression equation, X is any percent of rust infection.

Calculations involving yield could not be made in 1939 because of the hail damage. The damage, estimated as percent of broken straw and percent of grain shattered, is given in Table 3.

The heads from a few dry weight samples were available for threshing. When the threshed grain was calculated as grains per head, a comparison of the number of grains per head before and after the storm of June 7 was possible.

Table 15. Kernels per head in dry weight samples.

	Date taken	Kernels per head	Date taken	Kernels per head	Percent shattering: Measured	Percent shattering: Estimated
Blackhull	6/5	14.29	6/14	12.11	18.0	10
Tenmarq	6/5	16.27	6/14	13.07	24.5	8
Kanred	6/5	13.44	6/14	12.70	5.8	10

The small immature seeds of the date of seeding plots resulted in loss of seeds or introduced errors in counting to such an extent that the samples were not comparable.

SUMMARY

1. Periodic dry weight measurements were taken in duplicate from 14 plots of winter wheat, representing 2 varieties seeded at weekly intervals from September 15 to October 27, during the winter and the spring growing period of 1938-1939.

2. Because of extreme hail damage, no association of vegetative growth and yields could be established.

3. It was found that the number of plants per sample varied with the seeding conditions.

4. The size of plant, as measured by the number of tillers per plant, did not follow the normal distribution curve in early stages but tended toward it near maturity. Thinner stands resulted in more tillers per plant rather than in larger tillers. Only pronounced differences in stand showed any effect.

5. The study indicated that the calculation of the relative growth rates should be based on the dry weight of the tiller rather than that of the sample or the plant, particularly in the later stages of growth.

6. An association was found between the relative growth rate and the number of hours with temperatures of 46 to 86° F. occurring between 8:00 A.M. and 5:00 P.M.

7. Positive correlations of the length of the fall growing period, dry weight per tiller, and tillers per plant with the number of heads formed in June were shown to exist.

8. The negative influence of leaf rust on yield and stem rust on test weight is shown by an analysis of previous years' data.

ACKNOWLEDGMENT

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