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A PHYSIOLOGICAL STUDY OF THE WINTER WHEAT PLANT AT DIFFERENT STAGES OF ITS DEVELOPMENT

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A PHYSIOLOGICAL STUDY OF THE WINTER WHEAT PLANT AT DIFFERENT STAGES OF ITS DEVELOPMENT[1]

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INTRODUCTION

Studies on the physiology of the winter wheat plant are in progress at the Kansas Agricultural Experiment Station, Manhattan, Kan. During the four years 1931 to 1935, certain phases of the metabolism of the nitrogen, phosphorus, potassium and carbohydrates of these plants were studied at intervals from the seedling stage to maturity.

Information of this nature is desirable because any knowledge concerning the physiology of a plant gives a better understanding of the factors pertaining to its more successful cultivation. These studies were made with plants of Kanred, a hard winter wheat, and with Harvest Queen, a soft winter wheat, typical of the various varieties grown in Kansas. In the experiments herein reported, the two varieties were always grown in alternate rows in the field so that they were developed under identical conditions of soil and climate.

EXPERIMENTAL METHODS

METHOD OF GROWING AND HARVESTING THE PLANTS

The plants used in these experiments were grown in the field during the growing seasons of 1931-'32 to 1934-'35, inclusive. During the first two years the plants were grown on a plot that had been continuously cropped to wheat for six years, while during the last two years they were grown on a plot a short distance from this one on which wheat or oats had been grown for several years. Immediately after harvest each year the soil was disked to keep down weeds, then plowed as soon as the moisture was sufficient, and worked until a suitable seedbed was obtained. The plot was cultivated at various times before seeding to keep the soil in good tilth and to prevent the growth of weeds.

The seed was sown each year sometime during the first five days in October as shown in the various tables[3] and was sown with a hand drill in rows one foot apart at the rate of 1.5 bushels per acre. During the season of 1931-'32 only Kanred wheat was used, but during the next three years both Kanred and Harvest Queen varieties were grown in alternate rows.

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1. Contribution No. 392 from the Department of Botany.

2. Acknowledgment is due Mr. Hugh G. Gauch for aid in the field and laboratory and for help in compiling the data.

3. All the tables are given in the appendix, page 84.

Beginning four weeks after seeding, samples of the plants were collected every two weeks if the weather permitted, until elongation started in the spring, when they were collected weekly until maturity. The aerial portion of the plant, including the crown, was taken. No attempt was made to collect the roots.[4] The heads were removed from the stalk, beginning at the time they had reached considerable size, but before they had yet emerged from the boot, and prepared separately for analysis. This procedure was continued each week until the grain had begun to form, when the heads, except during the first year, were further divided into the grain and the chaff so that these parts could be analyzed separately. Some of the general facts concerning the condition of the plants during May and June are given in Table I.

In these experiments the rate of growth during any period is expressed by the increase in the dry weight of 100 plants. The analyses of the various components are expressed on a percentage basis and on the amount present in 100 plants. This method of procedure necessitated the collection of a definite number of plants at each of the stages. The selection of a given number of plants in the field is a relatively simple matter until the tillers are fully formed, but after that it is impossible to distinguish the individual plants because the tillers of a given plant are separated so that the plant from which they originated cannot be distinguished.

The determination of a definite number of plants at the advanced stages of growth was made after the following manner: Immediately after tillering had been completed, the average number of culms per plant was determined from a relatively large number of observations. During the remainder of the season a certain number of culms was harvested at the desired time, their dry weight obtained and the total dry matter of 100 plants determined by calculation from the data thus obtained.

PREPARATION OF MATERIAL

In order to approach uniformity of the general conditions, especially in regard to the relation of light to the amount of carbohydrate in the plants, the samples were collected each time during the four years at about the same time of day. The hour of 1 p.m. was selected, simply because in the daily routine of affair it was the most convenient time. Immediately after collection the plants were brought into the laboratory and washed, care being taken in both the field and laboratory to prevent the loss of any plant parts. After washing, the plants were spread upon a large laboratory table and the heat from four radiant electric reflectors was focused upon

4. There is at present no accurate method for obtaining root samples of plants growing in the field. It is absolutely impossible to remove all the roots of a given plant from the soil. The larger roots can be fairly accurately obtained, but the fine ones can not be distinguished and separated from the myriads of particles of organic matter in the soil. The portions of the roots which are obtained must be washed so thoroughly to remove the adhering soil that a large amount of the soluble material in them must of necessity be leached and thus lost.

them. An electric fan at a remote part of the room kept the air moving slowly over the drying material. Although the temperature at the surface of the table did not exceed 70° C., the greater portion of the moisture of the plants was soon lost, and in 24 hours they were crisp and brittle. The material was then partially pulverized and transferred to a well-ventilated electric oven at 95° to 100° C., where it remained for 12 hours, after which its dry weight was determined. The material dried after this manner kept its greenish color and apparently retained all of its constituents in the form in which they were present at the time of its collection in the field. After the material was thus dried it was ground in a Wiley mill and in a mortar to the fineness of a 40-mesh sieve. It was then placed in jars and sealed until ready to be used, when it was again placed in an electric oven at 100° C., for 12 hours, after which it was transferred to a desiccator over calcium chloride until the desired portions were weighed for analyses.

DETERMINATIONS MADE

The weight of oven-dried material in 100 plants or in their plant parts was determined at all stages examined during the four years. The following components of this dried material were determined in percentage and in the number of grams per 100 plants or plant parts thereof:

1. Total nitrogen, protein nitrogen, protein-free nitrogen, and protein for all four years.
2. Total phosphorus, insoluble phosphorus and water soluble phosphorus for the first three years.
3. Total potassium for the first three years.
4. Total sugars, reducing sugars, nonreducing sugars, starches and hemicelluloses for all four years.

METHODS OF CHEMICAL ANALYSIS

NITROGEN DETERMINATIONS

Total Nitrogen.— The total nitrogen was determined after a modified Kjeldahl-Gunning-Arnold method as follows: One gram of the dried material was transferred to a Kjeldahl flask and 17.5 grams of a digestive mixture, consisting of the proportions of 80 grams of mercuric oxide, 16 grams of anhydrous copper sulphate, and 1904 grams of potassium sulphate, added. After the addition of 30 c.c. of concentrated sulphuric acid, the contents of the flask were digested in the usual manner. The flask was cooled after digestion, 250 c.c. of tap water, 50 c.c. of a solution of sodium thiosulphate (80 grams per liter) and a pinch of granulated zinc added and the contents made alkaline by the addition of a 50 percent solution of sodium hydroxide. The flask was then immediately placed upon the still and approximately 175 c.c. of distillate collected over N/5 sulphuric acid. The excess acid was neutralized by titration with N/10 sodium hydroxide, using methyl red as an indicator.

Protein Nitrogen. — One gram of the dry material was placed in a 400 c.c. beaker and extracted with 100 c.c. of water for 30 minutes with frequent stirring. The contents were then heated to boiling, 10 c.c. of a cupric hydroxide mixture [5] added and the contents of the beaker thoroughly stirred. After cooling, the contents of the beaker were filtered on filter paper and washed thoroughly with distilled water. The filter paper and the material collected upon it were then transferred to a Kjeldahl flask, and its nitrogen content determined after the same manner as the total nitrogen, except that twice the amount of the solution of sodium thiosulphate was used. The protein nitrogen was determined by subtracting from the nitrogen thus obtained the amount of nitrogen contained in the filter paper and in 10 c.c. of the cupric hydroxide mixture as previously determined. The protein-free nitrogen was obtained by subtracting the amount of protein nitrogen from the amount of total nitrogen.

CARBOHYDRATE DETERMINATIONS

The reducing sugars, total sugars, nonreducing sugars, starches and hemicelluloses were determined from the same sample as follows:

A charge of 3 grams of the dry material was placed in a 500 c.c. Erlenmeyer flask and after the addition of 200 c.c. of 50 percent alcohol, was heated on the water bath below boiling for two hours with frequent shaking and with a funnel in the neck of the flask. The contents of the flask were filtered while hot into a 400 c.c. beaker and the residue washed three times with hot 95-percent alcohol. The filtrate thus obtained was used for the sugar determinations and the residue on the filter for the determination of the starches and hemicelluloses.[6]

DETERMINATION OF SUGARS

Reducing Sugars. — The alcoholic filtrate obtained after the alcoholic extraction was placed on the water bath and evaporated to 100 c.c. to remove all the alcohol, after which 50 c.c. of distilled water was added. The proteins and tannins present in the solution were next precipitated by the addition of 10 c.c. of a saturated solution of neutral lead acetate. The contents of the beaker were then filtered and the filtrate collected in a 250 c.c. beaker. Dry sodium

5. This mixture was prepared by dissolving 100 grams of copper sulphate in five liters of water, adding 2.5 c.c. of glycerine and a solution of 10 percent sodium hydroxide until the liquid was slightly alkaline. This mixture was then filtered, the collected precipitate rubbed in a mortar with water containing 5 c.c. of glycerine per liter and washed by decantation until the washings were no longer alkaline. The precipitate was then rubbed in a mortar with 10 percent glycerine producing a gelatinous mixture that could be measured with a pipette.

6. All the carbohydrates were hydrolyzed to reducing sugars and determined as d-glucose in the following manner. An aliquot of the sugar solution was added to 50 c.c. of Fehling's solution prepared fresh for each determination by mixing 25 c.c. of the copper sulphate solution and 25 c.c. of the alkaline tartrate solution in a 400 c.c. beaker. This beaker covered with a watch glass was then placed on an electric heater which was so regulated that boiling began in four minutes, and boiled for two minutes. The contents of the beaker were next filtered while hot through an asbestos mat of a weighed Gooch porcelain crucible. The collected precipitate was washed thoroughly with hot water, next with 10 c.c. of 95 percent alcohol, and finally with 5 c.c. of ether. The crucible was then placed in an oven at 100° C. for 45 minutes, removed, cooled and placed in a desiccator until weighed. The equivalent in d-glucose of the cuprous oxide thus obtained was determined from Munson and Walker tables.

carbonate was then added to this filtrate to precipitate the excess lead, using a few drops of phenolphthalein as an indicator. The contents of this beaker were then filtered and the filtrate collected in a 250 c.c. volumetric flask. This filtrate was then neutralized with hydrochloric acid, made up to the mark and duplicate 50 c.c. portions taken for the determination of reducing sugars.

Total Sugars.—The remaining 150 c.c. of the filtrate in the flask were acidified with 2.5 percent hydrochloric acid and hydrolyzed on the water bath for 45 minutes. After cooling, the contents of the flask were neutralized with dry sodium carbonate, using phenolphthalein as an indicator and made to 250 c.c. Duplicate 50 c.c. portions were taken for the determination of the total sugars.

Nonreducing Sugars.—The amount of nonreducing sugars was obtained by computing the difference between the total sugars and the reducing sugars.

DETERMINATION OF STARCHES

The residue remaining on the filter after the sugar extraction was transferred by rinsing with hot water into a 250 c.c. beaker and made to approximately 100 c.c. The beaker was then heated and the contents allowed to boil for two minutes to gelatinize the starch. After cooling, 20 c.c. of fresh filtered saliva and 1 c.c. of toluene were added and the contents of the beaker stirred thoroughly. The beaker was then covered with a watch glass and placed in the oven at 37° to 40° C. to digest for 24 hours. After that time a drop of the contents of the beaker was placed on a slide, treated with iodine solution and examined under the microscope for starch. If starch were yet present the contents of the beaker were filtered, the filtrate retained, the residue washed into a beaker and treated after the same routine as before. This procedure was repeated until the material was free of starch. Usually all the starch was digested by one treatment, but in the grain with a high content of starch two treatments generally were necessary.

The filtrate thus obtained was hydrolyzed on the water bath for 45 minutes with 2.5 percent hydrochloric acid to digest the maltose formed and any dextrins that might yet be present. After cooling, the solution was transferred to a 250 c.c. volumetric flask, neutralized with dry sodium carbonate, and made to the mark. Duplicate 50 c.c. portions were taken for sugar determinations.

DETERMINATION OF HEMICELLULOSES

The residue remaining on the filter after the treatment for starch was washed into a 500 c.c. Erlenmeyer flask, made to 150 c.c. by the addition of water, and hydrolyzed on a steam bath with 2.5 percent hydrochloric acid for 2.75 hours with a reflux condenser. The mixture was then filtered into a 250 c.c. volumetric flask, cooled, neutralized with dry sodium carbonate, and made to the mark. Duplicate 25 c.c. portions were then taken for sugar determinations.

PHOSPHORUS DETERMINATIONS[7]

Total Phosphorus.—A 1-gram sample of the dry material was placed in a 250 c.c. Pyrex beaker, 10 c.c. of a magnesium nitrate solution (1,000 grams per liter) added, and the beaker heated on a hot plate until no further action took place. While hot, the beaker was transferred to a muffle and allowed to remain at low heat until the charge was thoroughly oxidized. It was then moistened with water, dissolved with 10 c.c. of 50 percent hydrochloric acid, evaporated to dryness, and dehydrated on a hot plate for several hours to render the silica insoluble. The residue was then moistened with 5 to 10 c.c. of 50 percent hydrochloric acid, 50 c.c. of water added, and the total heated for a few minutes and filtered immediately, the filter paper being thoroughly washed. The filtrate was then made slightly alkaline with 50 percent ammonium hydroxide and then barely acid with 50 percent nitric acid, using litmus paper as an indicator.

Ten c.c. of an ammonium nitrate solution of a concentration of 100 grams per 100 c.c. were next added to the filtrate which was further diluted to 125 c.c., and 25 to 30 c.c. of freshly filtered molybdate solution added. The beaker was then placed in a water bath at a temperature of 45° to 50° C. and allowed to remain for one-half hour, stirring frequently. The precipitate was washed three times through a filter by decantation with 25 to 30 c.c. of water free of carbon dioxide, after which the precipitate was transferred to the filter and thoroughly washed.

The precipitate and the filter paper were then transferred to the original beaker and dissolved in a small excess of standard alkali, which was then neutralized with standard acid, using phenolphthalein as an indicator. The phosphorus was calculated from the amount of standard alkali required to dissolve the precipitate.

Water-soluble Phosphorus.—A 2.5-gram sample of the dry material was placed upon a 12 cm. filter paper and washed into a 250 c.c. volumetric flask with successive small washings of boiling water until the filtrate amounted to approximately 200 c.c. This was then cooled, a small amount of formaldehyde added as a disinfectant and made to the mark. An aliquot of this solution, representing one gram of the sample, was placed in a beaker and after the addition of 15 c.c. of 50 percent nitric acid, evaporated on a hot plate until about 15 c.c. of liquid remained. Five c.c. of 50 percent hydrochloric acid were then added and evaporation continued to approximate dryness. After the oxidation of the organic matter, the beaker was removed from the hot plate, the contents diluted with water, made slightly alkaline with ammonia and then made barely acid with nitric acid. After the addition of 10 c.c. of the ammonium nitrate solution, further procedure was identical with that for the determination of total phosphorus.

7. The determinations of phosphorus and potassium were made by members of the Department of Chemistry, Kansas State College of Agriculture and Applied Science. The methods herein given were used by them in obtaining the amount of these two elements present in the dry material.

POTASSIUM DETERMINATION

A 2-gram sample was placed in a platinum dish, saturated with concentrated sulphuric acid and ignited in a muffle at a low red heat. After the addition of a small amount of 50 percent hydrochloric acid to the ashed sample, it was warmed slightly to loosen the mass from the dish and transferred to a 100 to 250 c.c. volumetric flask. To the hot solution was added a slight excess of ammonium hydroxide and sufficient saturated ammonium oxalate solution to precipitate the lime present. The solution was then cooled, diluted to volume, and filtered through a dry filter, An aliquot of this solution was then placed in a platinum dish, evaporated nearly to dryness, approximately 0.5 c.c. of 50 percent sulphuric acid added, then evaporated to dryness and ignited to whiteness. The residue was dissolved in hot water, filtered into, a small casserole, approximately 0.5 c.c. of 50 percent hydrochloric acid added and then an excess of chlorplatinic acid solution, 10 to 15 drops of this solution usually being sufficient. This mixture was then evaporated on a water bath to a thick paste, avoiding any exposure to ammonia. After determining that an excess of the chlorplatinic acid solution was present, the material was treated with 80 percent alcohol, using 10 c.c. portions, decanting through a Gooch crucible, repeating the process until the alcoholic filtrate was colorless. After washing five or six times with 10 c.c. portions of Lindo-Gladding ammonium chloride solution, the precipitate was again washed with 80 percent alcohol, dried for 30 minutes at 110° C., cooled, weighed and calculated as potassium.

METEOROLOGICAL DATA

A general summary of the weather during the winter wheat seasons (October 1 to July 1) for the four years concerned in this study is given in Table II. These data show a considerable variation for each year in the amount and distribution of the rainfall and in the duration of mild and extreme temperatures. Thus from October 1, 1931, to January 1, 1932, the rainfall amounted to 7.62 inches, while for the same period the following year the total was only 2.18 inches. The rainfall from April 1 to July 1, 1932, was only 5.12 inches, as compared to 14.93 inches during the same period in 1935. The total rainfall was 19.12 9.47, 10.37, and 21.09 inches, respectively, for each of the four seasons of the experiment.

The temperatures during autumn and winter were at times relatively low, but no prolonged periods of extreme temperatures occurred except during 1934-'35. During the season of 1931-'32, only twice was the soil frozen so solid that samples of plants could not be collected at biweekly intervals, and then in each case the time between collections was only three weeks. In 1933-'34 there was one period of five weeks and another of four weeks during which samples could not be taken because of low temperatures. The season of 1934-'35 had the longest continued low temperature periods of any of the seasons of the experiments. Due to frozen soil, four

weeks elapsed between sampling on November 23 and December 20, while from December 20, 1934, to March 14, 1935, four samples were taken at three-week intervals.

The mild temperatures during the autumn and winter are reflected in the increase in dry weight of the aerial parts of the plants during that time. During the first and second seasons no single period showed a loss in dry weight of the aerial parts, while in the third year there was only a slight loss in one variety at one period. During the relatively severe season of 1934-'35 both varieties of plants showed a loss of dry weights of their aerial parts at two periods of sampling.

During the month of June when the grain was maturing the temperatures were relatively mild for 1932 and 1935, the maximum temperatures during that month for the two seasons never reaching 100° F. During this same period, however, in 1933 and in 1934, the temperatures were relatively high, the average maximum temperatures for 5-day periods in several instances being well above 100° F.

SOIL DATA

The moisture content of the soil for each foot to the depth of four feet was determined at various times during each season. The data in this regard are tabulated in Table III. With the exception of 1935 the reserve moisture in the soil from spring until harvest was extremely low and for much of the time the maximum percentage was at or near the wilting coefficient. The moisture in the soil became so scanty in May and June of 1932 that, to save the crop, the plot, was irrigated at the three dates indicated in Table III. During all four years, however, there was a reserve supply of moisture in the soil sufficient for vigorous vegetative growth of the plants during the autumn and early spring.

DISCUSSION OF EXPERIMENTAL DATA

TOTAL DRY WEIGHT OF PLANTS

REVIEW OF LITERATURE

The studies relative to the dry weight of cereals have been made for the most part for two reasons: To determine the effects of the time of harvesting upon the weight and quality of the grain, and to determine what portion of the dry matter of the grain is furnished by the materials that have been manufactured in the stems and leaves previous to the formation of the head.

Betford *(9, 10)* noted that wheat cut at various times from the early milk stage to the ripe, yellow condition gave progressively increased yields, varying from 16 bushels at the first cutting to 29 bushels per acre at the last cutting. The dry weight per bushel increased from 45.5 lbs. at the milk stage to 60 lbs. at the fully matured stage. Crozier and Briggs *(22)* found that the grain of wheat derived additional weight from the straw after cutting, even when

the plant was fully ripe when harvested. McDowell *(59)* considered that the stiff dough stage was the best period for cutting wheat.

Brenchley *(16)* and Brenchley and Hall *(17)* noted that the lower portion of the wheat grain was first filled and that five weeks after pollination the infilling of the grain was completed. The dry weight of the plant increased until a week prior to harvest. It was evident, therefore, that the intake of solutes and the manufacture of organic compounds did not cease until the migration of materials into the head was nearly completed. The dry weight of the entire plant decreased during the last week before harvest. This loss in weight was attributed to respiration.

Shutt *(78, 79)* found that there was an appreciable increase in the weight of the grains of wheat after harvest if connections with the stem and leaves were left intact. He considered that this was indicative of the translocation of materials from the straw to the grain during the curing of the plants.

Guthrie and Norris *(30)* found that the wheat which was harvested in the dough stage frequently gave a heavier sample of grain than that which was harvested when it was dead ripe. The grain from the plants which were cut in the milk stage was always the lowest in weight of any of the samples in the experiments.

It was reported by Haigh *(31)* that the stalks of wheat contained their maximum amount of dry matter at the time of blooming. After that time some of the materials present in the stem migrated into the ripening heads. Keitt and Tarbox *(48)* found that the dry matter of the oat plant at maturity was distributed as follows: Grain 39.2, stem 28.8, leaves 28.0 and glumes 4.0 percent, respectively. Trowbridge, Haigh and Moulton *(87)* found indications that some of the dry matter from the stem, leaves and roots of wheat was transferred to the head as it ripened.

Harlan *(32),* Harlan and Anthony *(33, 34),* and Harlan and Pope *(35, 36, 37)* made extensive and detailed studies on the manner of growth and development of the barley kernel. At the fifth or sixth day after flowering, the growth in length of the kernel was checked, and the gain in dry matter began and continued until very near the point of absolute ripeness. Observed kernels of barley were able to abstract a limited amount, of food material from the culm even when they were dried at once after harvest in an arid atmosphere. These authors considered that the changes which occur in the grain in the shock, even when harvested at maturity, may be of importance. Saunders *(75)* found in Marquis wheat that the weight of 1,000 kernels increased in dry weight from 4.55 grams on July 21 to 31.48 grams on August 15 at harvest. The maximal increase in dry weight per day was approximately 2 grams per 1,000 kernels and the minimal gain only 0.027 grams. The increase in weight during the last 10 days before harvest was insignificant. Hibbard and Gershberg *(41)* studied the nutrition of Marquis wheat from the 5-week stage of growth to maturity. They found under greenhouse conditions that the plants produced greatest total dry weight in a

cultural solution high in magnesium sulfate and relatively low in both calcium nitrate and potassium phosphate.

Kiesselbach *(49)* found that the yield of wheat was greater when the plants were harvested at maturity than when harvested in either the early or the late dough stage.

It was observed by Arny and Sun *(4)* that the dry weight of the grains of wheat and oats increased until they were in the medium dough stage. If the plants were harvested previously to that time, there was a reduction in yield and a lower weight per bushel.

Wilson and Raleigh *(91)* harvested Marquis wheat and Victory oats at different stages of maturity. They found that the yield of grain increased from the milk stage to the mature stage. The quality of the grain as measured by increased weight per bushel was greater when the plants matured before harvest. There was no difference in the kernel weight of grains left attached to the full length of plants after harvest as contrasted with seeds from severed spikes. Apparently the transfer of materials from the plant to the seed after harvest was too small to appear in increased weight of the grain. McLean *(61)* noted that there was no significant reduction in the yield per acre or in the weight per kernel when the plants were harvested one week before maturity.

OBSERVED TOTAL DRY WEIGHT

In the experiments herein reported the total dry weight of the aerial parts of the plant for each period of sampling is tabulated in Table IV and illustrated by graphs in figure 1. From these sources it is noted that with the exception of some minor fluctuations during the winter months of three of the seasons, the total dry weight of the plants increased to the time of harvest. During the season of 1933-'34 there was a decrease in the total dry weight of the plants of Kanred during the two weeks preceding harvest and of the plants of Harvest Queen during the week before harvest. These decreases in dry weight, however, were relatively small. For Kanred this decrease amounted to 2.88 and 1.4 percent, respectively, on June 13 and 20, of the dry weight of the previous sample. For Harvest Queen this decrease on June 20 was 3.8 percent of the dry weight of the previous sample.

On January 11 and February 21, 1935, the dry weights of the plants of Kanred were 2.2 and 2.8 percent less, respectively, than the weights shown at their previous weighing. On March 21, 1934, and on February 1 and 21, 1935, the dry weights of the plants of Harvest Queen were 1.2, 2.9, and 1.7 percent less, respectively, than those of the previous samples. The plants that were collected on March 21, 1934, and February 1 and 21, 1935, had been injured by freezing so that portions of some of the leaves had been lost. This fact accounts for the decrease of the dry weight of the plants on these dates. The plants of Harvest Queen were always more severely injured by freezing than those of Kanred. The slight decrease in the dry weight of the plants of Kanred on January 11,

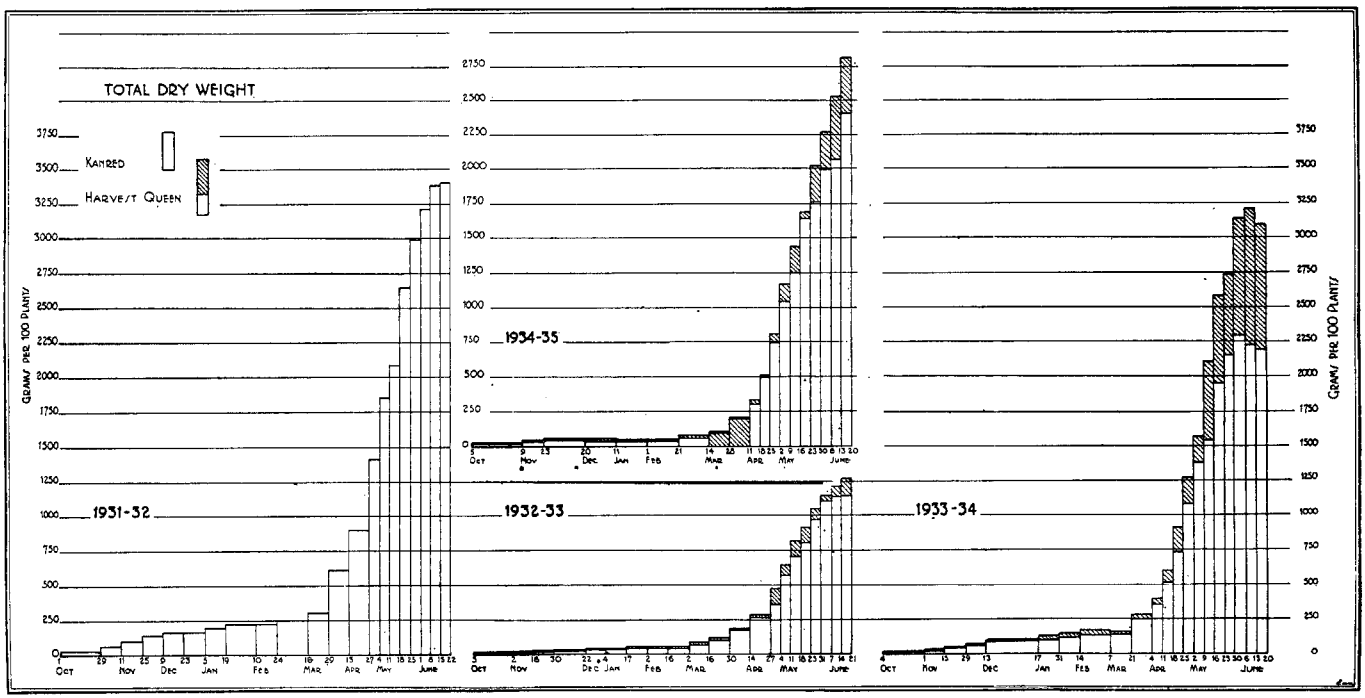

FIG. 1.—The total dry weight of 100 wheat plants at various stages of growth during the four years, 1931-'32 to 1934-'35, inclusive.

1935, might have been due to an error in sampling. This error could occur easily since the increase in dry weight during the winter periods was relatively low.

The actual increase or decrease in the dry weight of 100 plants at the various stages of growth for each year is shown graphically in figures 2 and 3. The data there shown were obtained from Table IV. These figures show that the increases in dry weight were relatively small for any period during the autumn and winter. The increments in dry weight, however, were very marked as soon as growth was stimulated by the warmer weather of spring. This marked increase generally occurred the latter half of March. The maximal weekly increase in dry weight usually occurred somewhere between the beginning of jointing in late April or early May and blooming, which generally occurred during the week beginning May 15. The weekly increments in dry weight were very irregular and the factors causing such marked variation could not be determined. Some of the more important variations in the dry weight may be observed in Table V.

It may be observed in Table V that in a single week from May 4 to 11, 1933, and from May 16 to 23, 1934, Kanred plants absorbed and manufactured approximately 18 percent of the total dry matter produced by them during the respective growing seasons. During the week of May 9 to 16, 1934, the plants of Harvest Queen produced approximately 17 percent of their total dry weight of the season. It is worthy of note that the next to the greatest weekly increase in dry matter of these plants did not precede or follow the week of maximal increase except for Harvest Queen in 1934. In this case the next to the greatest weekly increase followed directly the greatest weekly increase in dry matter. The amount of the increase in dry matter varied widely for the two varieties at the same dates. Thus in 1934, the maximal weekly increase for Harvest Queen occurred from May 9 to 16, while that of Kanred occurred from May 16 to 23. In 1935 the maximal weekly increase in dry weight of Harvest Queen occurred from May 2 to 9, while that of Kanred was from May 16 to 23.

The percentage of the maximal dry weight of the plant that was produced in any period and the percentage increase or decrease of the dry matter as compared to the previous period of sampling are shown in Table VI and pictured in figure 4. These data show that the wheat plants of the two varieties studied were, under the general conditions of the experiment, never in a dormant period but were capable always of growth whenever favorable conditions were presented.

The proportion of the maximal dry weight of the plants that was produced from October 1 to April 1, a period of 5 months, was relatively low. Thus in Kanred it amounted to 8.97, 8.77, 5.68, and 3.38 percent, respectively, for each of the years of investigation, For Harvest Queen it was 9.01, 4.81, and 3.56 percent, respectively,

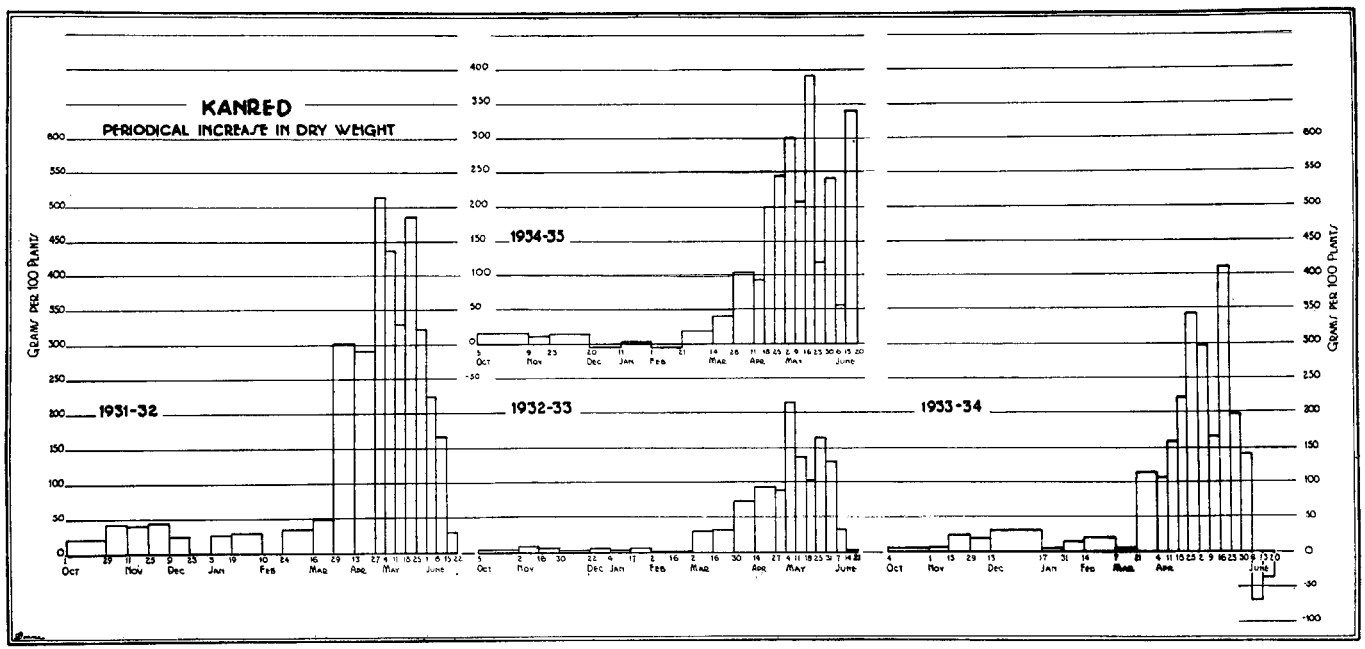

FIG. 2.—The increase or decrease in the dry weight of 100 Kanred wheat plants during each of the various stages of growth during the four years, 1931-'32 to 1934-'35, inclusive.

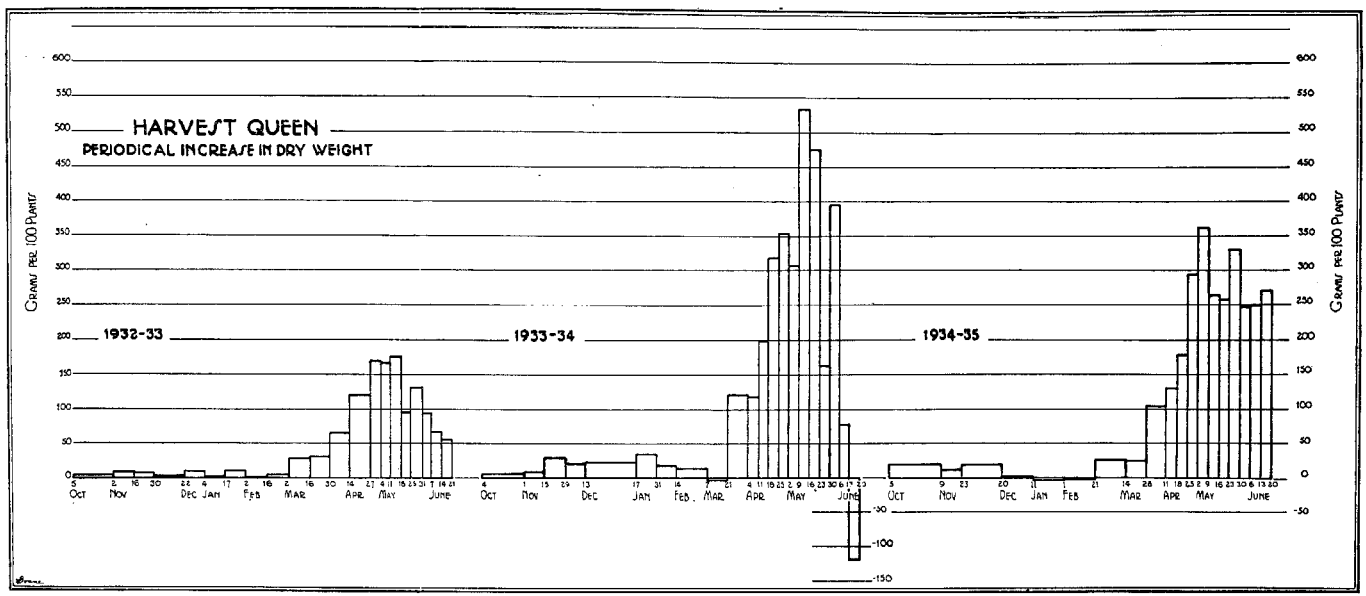

FIG. 3.—The increase or decrease in the dry weight of 100 Harvest Queen wheat plants during each of the various stages of growth during the three years 1932-'33 to 1934-'35, inclusive.

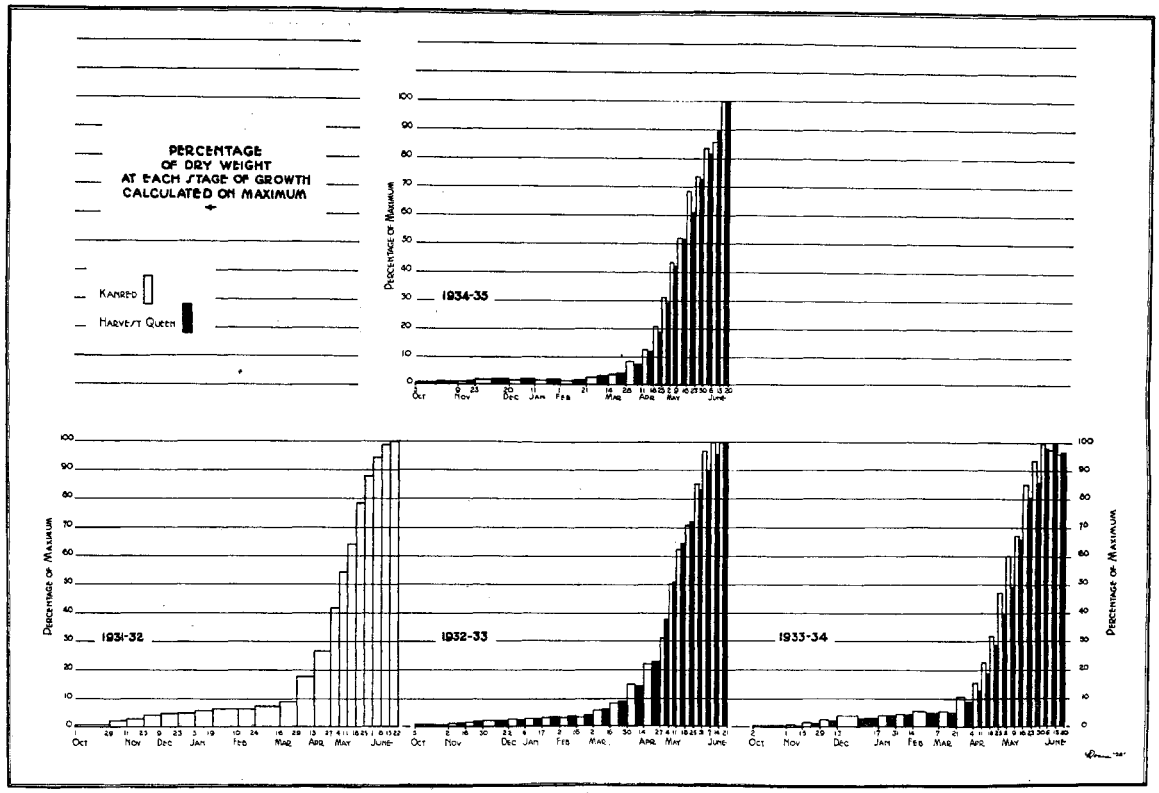

FIG. 4.—The percentage of dry matter at each stage of growth, calculated on the maximal dry weight, in Kanred and Harvest Queen wheat plants during the four years, 1931-'32 to 1934-'35, inclusive.

for each consecutive year. On or about June 1 of each of the four consecutive years 87.7, 85.5, 93.9 and 73.4 percent of the total dry matter had been absorbed or manufactured in Kanred, and 82.7, 85.3 and 72.4 percent of that of Harvest Queen for the three years that that variety was grown. Thus three weeks before harvest three-fourths to twenty-three twenty-fifths of the maximum total dry matter was present in the plants.

DRY WEIGHT OF DIFFERENT YEARS AND FOR DIFFERENT PLANTS

The data presented in Table IV and figure 1 show that plants growing in the same soil may vary markedly in their production of dry matter during different years. The following tabulation illustrates that point.

Year	Date harvested.	Dry weight of 100 plants at maturity.	
		Kanred.	Harvest Queen.
		Grams	Grams
1931-'32	June 22	3,408	.....
1932-'33	June 21	1,138	1,268
1933-'34	June 20	2,190	3,091
1934-'35	June 20	2,395	2,785

The greatest dry weight of the plants of Kanred occurred in 1932. This was 3, 1.55 and 1.42 times, respectively, the dry weight of the plants at the time of maturity in 1933, 1934 and 1935. The greatest dry weight of Harvest Queen plants was produced in 1934. This weight was 2.35 and 1.11 times, respectively, that of the plants at maturity in 1933 and 1935.

With three exceptions, the dry weight of the aerial portion of Harvest Queen was always greater than that of Kanred. In two of these exceptions the weights of the plants were equal and in the other the Kanred plants were only 0.6 percent heavier than an equal number of Harvest Queen plants. At the time of maturity the plants of Harvest Queen weighed 1.11, 1.41 and 1.16 times, respectively, more than the Kanred plants of 1933, 1934, and 1935. Apparently the plants of different varieties are affected differently by the same climatic environment. Thus for the years 1933, 1934, and 1935 the dry weight of the Kanred plants at maturity was the highest in 1935, while that of Harvest Queen was the highest in 1934.

DRY WEIGHT OF DIFFERENT AERIAL PARTS

The dry weight of the stems and leaves, chaff and grain of the plants at weekly intervals is shown in Table VII. From the data in this table, it is noted that the stems and leaves of Kanred plants constituted 59.47, 65.95, 62.62 and 64.92 percent, respectively, of their total dry matter at maturity in 1932, 1933, 1934 and 1935.

The stems and leaves of the Harvest Queen plants composed 72.20, 67.84 and 73.80 percent, respectively, for the three years that these plants were grown. The heads of the wheat plant at maturity thus composed from 25 to 40 percent of its total dry weight, depending upon the season and the variety. The relation of the dry weights of the stems and leaves, heads, grain and chaff and entire plant to the dry weight of the grain is shown in Table VIII.

It is seen in this table that the dry weight of the stems and leaves of Kanred is from 2.3 to 2.9 times the weight of the grain, while the total dry weight of the plant is from 3.7 to 4.5 times that of the grain. For Harvest Queen, the dry weight of the stems and leaves was from 2.8 to 4.2 times that of the grain, while the total dry weight, of the plant was from 4.1 to 5.8 times the dry weight of the grain. Thus in Harvest Queen the weight of the grain is less in proportion to the aerial parts than in the Kanred variety.

TRANSLOCATION TO HEADS

The leaves and stems increase in dry matter up to or after the blooming period. The materials that were absorbed or manufactured by the plant during that time were used mostly in vegetative growth, although some were apparently stored as a reserve. It was found in 16 of the 19 observations of the plants after blooming that the stems and leaves showed a decrease in dry matter. In 17 of these observations the heads showed an increase in dry matter. In all these cases the increase in the dry matter of the heads was much greater than the decrease in the weight of the stems and leaves, Thus apparently some of the materials were withdrawn from the stems and leaves and translocated to the heads. The greater portion of the increased dry matter in the heads, however, was absorbed and manufactured by the plant and then translocated to it. Apparently the wheat plant continued to function in absorption of inorganic materials and in the manufacture of organic matter until it matured. The data relative to the changes in the weight of the dry matter in the stems and leaves, and heads are tabulated in Table IX.

NITROGEN METABOLISM

REVIEW OF LITERATURE

The literature on the nitrogen metabolism of cereals may be summarized under the following general headings: (1) the total nitrogen in the plant, (2) the nitrogen in the grain, and (3) the translocation of nitrogen.

Total Nitrogen of the Plant.— Lawes and Gilbert *(63)* in England found that in the five weeks following June 21, there was little increase in the quantity of nitrogen in wheat plants, although more than one-half of the total carbon of the crop was accumulated during that time. Snyder *(80)* observed in Minnesota that wheat plants which headed in 65 days and reached the milk stage of grain formation in 81 days after planting, had taken from the soil in the first 50 days 86 percent of the nitrogen which they finally contained.

Henry *(40)* showed that the periods of the greatest absorption of nitrogen by wheat, barley and rye varied widely. The two periods of maximal absorption by wheat were early in May, at the time of grain formation. Schulze *(76)* found that rye at the close of winter had absorbed one-half of its nitrogen, while wheat absorbed the greater portion of its nitrogen between the last of April and the time that the kernels began to form. Wheat continued to absorb nitrogen until the plants were headed, while rye did not.

Shutt *(78, 79)* found that the actual amount of nitrogen in the straw of wheat did not change from the time of flowering to the time of ripeness. There was, however, a fall in the percentage amount due to an increase in nonnitrogen constituents. Haigh *(31)* stated that the plants of wheat and timothy absorbed nitrogen at the greatest rate during the younger stage and at a decreasing rate as growth proceeded.

Nitrogen of the Grain. — Lucanus *(56)* noted in the grain of rye that the weight of the nitrogenous and nonnitrogenous substances increased regularly from the green condition to ripeness, but that the percentage of these components did not change materially during the time from the milk stage to the ripened condition. Heinrich *(38, 39),* however, found that the percentage of proteins in the kernels regularly decreased until ripeness. Kedzie *(46, 47)* noted that the starch in the grain increased in greater proportion than the proteins, so although the latter were constantly increasing in amount, their percentage declined rapidly until the time of ripening. Failyer and Willard *(28)* observed that the percentages of total nitrogen, albuminoid nitrogen, and protein in the grain of corn decreased slightly from the milk stage to ripeness. Teller *(82, 83, 84)* found that the percentages of amides, fat, fiber, dextrins, pentosans and proteins decreased in the wheat grain from its formative stage until ripeness, while the percentage of starch rapidly increased. During the earlier period of grain formation, there was a continuous increase of gliadin and a corresponding but less marked decrease in the proportion of glutein. Andre *(2, 3)* found that the barley grain at maturity contained 16.4 percent less nitrogen than it did at its maximal content of this element.

Brenchley *(16)* and Brenchley and Hall *(17)* found in the formation of the wheat grain that the percentage of the nitrogen in the dry matter fell rapidly at first and then became practically constant. The actual amount of nitrogen per grain rose regularly until three days before harvest. The total nitrogen and the total ash in the whole plant continued to increase to within a few days of harvest. These figures did not include the roots, which cannot be removed from the soil without loss and without the introduction of extraneous matter. They considered that the question of the final cessation of nutrition and assimilation can be definitely determined only when the roots can be examined and that their evidence indicated there was no cessation of the absorption of nutrients or of

assimilation before the ripening of the wheat grain. They stated that this condition might hold only for the relatively humid climate of England, where the wheat plant retains some green active tissue until it is harvested.

Thatcher *(85, 86)* noted that the percentage of ash, ether extract, and crude fiber of the grain of wheat, progressively decreased as maturity was approached. The percentage of protein in the dry matter decreased slightly until the milk stage, when it began to increase. The percentage of sugar decreased very rapidly during the early stages of development, but after the milk stage it slightly decreased. The actual quantity of all these materials in the grain increased during each successive period of growth with the exception of the sugars, which decreased on account of their conversion into starch. He concluded that climate was the chief factor in determining the composition of the crop for any given season or locality.

It was noted by Rousseaux and Sirot *(74)* that the amount of nitrogen in the wheat grain reached its maximum before the plant became yellow. The percentage of soluble nitrogen steadily decreased during the development of the grain. Gordon *(29)* traced the development of the aleurone layer and starchy endosperm in some of the common cereals. The free nuclei of the embryo sac passed to its walls where, after being invested with individual cell walls, they formed a single layer of cells which assumed the nature of a cambium which produced new cells only on its inner surface. The cells thus formed enlarged, remained thin-walled, and became the starchy endosperm. After division had ceased in this row of cells they became filled with protein, thickened their walls and became the aleurone layer.

Jodidi and Markley *(44)* demonstrated that in the whole wheat grain 1.4 to 2.3 and 1.5 to 1.9 percent, respectively, of the total nitrogen were in the form of amino acids and amides. It was also established that in the grain 3.9 and 5.1 percent of the total nitrogen were in the polypeptide form. The seed was shown also to contain nucleic acid, phytosterol, lecithin and traces of arginine.

Woodman and Engledow *(92)* found that the percentage of the total nitrogen of the grain showed but little variation during the period of its development. The slight increase in the percentage of nitrogen during the last week of ripening was considered to be due to the loss of nonnitrogenous material in the grain by respiration rather than by the actual gain of nitrogenous material by transport. The amount of amino and amide nitrogen in the head represented approximately 16 percent of the total nitrogen. This percentage dropped gradually until at maturity it constituted only 0.75 percent of the total nitrogen of the grain. As the amino acids appeared in the developing grain, they were quickly transformed into the more complex forms of nitrogen. The amount of ash in the grain from 100 heads increased from 0.72 gram to 2.61 grams at 47 days and remained constant until maturity 18 days later. This indicated that

the transport of inorganic materials into the grain ceased at the beginning of desiccation.

Sharp *(77),* in a study of immature wheat kernels, concluded that desiccation was not necessary for the conversion of amino compounds into more complex ones. Freezing tended to cause an increase in the amount of amino acid in the developing grain in contrast to a decreasing amount under normal conditions. Newton and Brown *(68)* in studying cold resistance in winter wheat also noted that noncoaguable nitrogen increased as the season progressed.

Booth *(14)* found in the development of the oat kernel from the time of pollination to maturity that the amount of nitrogen increased rapidly during the first 10 days, after which there was considerable fluctuation in the amount of this element in the grain. Blanck, Giesecke and Heukeshoven *(12)* and Blanck and Giesecke *(13)* observed that the amount of nitrogen reached its maximum in the roots and tops at heading. The grain at maturity contained its maximal amount of this element. McCalla *(57)* fractioned the total nitrogen in the developing wheat grain into nonprotein nitrogen and three protein fractions. All fractions increased in amide and decreased in arginine nitrogen during kernel development.

Translocation of Nitrogen.— Deherain and Dupont *(24)* considered that in wheat the nitrogenous substances in the plant rise from the lower to the upper leaves and are translocated finally into the grain. Adorjan *(1)* noted that the intake of nitrogen into the wheat plant continued to within 5 days of harvest, at which time the nitrogen of the grain reached its maximum. The amount of nitrogen in the glumes, leaves and stems at the time of the maximum nitrogen content of the plant was 26, 45 and 40 percent, respectively, lower than at the time of their maximal amount of this element.

The grain drew from the stem, leaves and glumes during its formation 4.77 grams of the 7.00 grams of the nitrogen which was stored in it. Thus the amount of nitrogen absorbed by the roots during the formation of the grain was 2.23 grams. Of the total nitrogen in the grain at maturity, 68.1 percent was obtained from the stems, leaves and glumes and 31.9 was absorbed from the soil. The greater portion of the nitrogen of the wheat was thus obtained by the plant at a relatively early stage, stored in the various plant parts and later moved to the developing grain. LeClerc and Breazeale *(54)* found that four rains on ripe wheat plants removed 27 to 32 percent of their nitrogen.

Brenchley *(18)* found in barley that the nitrogen in the grain continued to increase after it had reached its maximal content in the plant as a whole. This indicated that nitrogen was being transferred from the stem to the grain during the ripening period. Olson *(70,71)* noted that nitrogen was moved from the vegetative parts of the wheat plant into the developing grain. The nitrogen in the chaff appeared to be first depleted, followed by that in the stem above the top node. Under favorable conditions for grain development, all the stored nitrogen in the different parts of the plant was transferred

into the kernel. Eckerson *(26)* found by microchemical means that the largest amount of potassium nitrate occurred in the roots and stems of wheat just prior to the formation of the spike, after which it decreased rapidly in these parts. Jones and Huston *(45)* observed that nitrogen in the grain of corn was increased at the expense of this constituent in the stem and leaves although the total amount in the whole plant was increasing.

Burd *(18)* found that the nitrogen in the barley plant increased during the first 8 or 9 weeks in conformity to the gain in total dry weight. For a short period following this stage, there were indications of a loss of nitrogen into the soil. After that time, the nitrogen content, however, again increased until approximately the fifteenth week, when it again decreased. Berry *(11)* found in oat plants that the absorption of nitrogen was completed at the beginning of kernel development. The nitrogen stored in the grain thus appeared to be derived entirely from that of the stem, leaves and glumes.

Bailey *(6)* summarized the work that had been done to that date concerning the intake and translocation of nutrients, and the formation and disposition of the organic materials of the wheat plant. Most of the literature to that date indicated that the bulk of the nitrogen entered the plant during the preflowering period. The data to that time also showed that if wheat plants were cut while still green, the translocation of materials from the straw might continue for a considerable period.

Knowles and Watkin *(50)* found that the amount of total nitrogen in the entire wheat plant increased until three weeks before harvest, while the elaboration of protein continued until a week later. In the straw there was a decrease in the amount of both protein and nonprotein nitrogen until maturity. In the heads, the amount of protein nitrogen increased rapidly until two weeks before harvest, while the amount of nonprotein nitrogen was constant. These facts indicated that the intake of nitrogen and its elaboration into protein proceeded at equal rates. It was noted by Fagan and Watkin *(27)* that the migration of nitrogen from the straw into the spikelet continued until the grain had matured. Wagner *(89)* also found with the oat plant that nitrogen was moved into the developing head from the leaves and stalks after it had reached a maximum in these parts. Doneen *(25)* in Washington found that the maximum dry weight occurred and the maximum quantity of nitrogen was absorbed by wheat at the blooming stage under conditions of inadequate soil moisture. A decrease in the dry weight and in the nitrogen in the aerial parts of the plant occurred between blooming and maturity. This decrease amounted to as much as 5 percent of the total at the stage of blooming. Doneen assumed that under these conditions some of the nitrogen and carbohydrates in the aerial parts were translocated to the roots. Bossie *(15)* found that the total nitrogen in the head of wheat reached its maximum at the time of maturity.

In the plant as a whole, however, the total nitrogen accumulated until the time of flowering, after which it remained constant. Ayres *(5)* observed in the sugar cane that the quantity of nitrogen absorbed during the first three months amounted to 25 percent of the total absorbed by the plant during the first year of its growth. Kobayashi *(52)* found that nitrogen was leached by rains from the older leaves and sheaths of the rice plant. The amount of leaching approximated 5.3 percent, based on the maximum amount that was absorbed. Maume and Dulac *(65)* found that the heads of wheat used more nitrogen than the stems.

EXPERIMENTAL WORK ON NITROGEN

Total Nitrogen

Percentage of total nitrogen.— The amount of total nitrogen in the plants at the different periods of growth, expressed in percentage of dry weight is shown in Tables X and XI and is expressed graphically in figures 5 and 6.

The total nitrogen in the seed which was sown varied from 2.25 to 3.24 percent during the various years of the experiment. The percentage of nitrogen in the aerial parts of both varieties of wheat was relatively high from the early part of October until the last of March or early April, when it began to decline. The minimum during this period was 3.4 percent and the maximum 5.6 percent. The average percentage of nitrogen in the stems and leaves of Kanred for this time was 4.33, 4.67, 4.54 and 4.12, respectively, for each of the four seasons and 4.60, 4.45 and 4.16 percent for Harvest Queen during the three seasons. From figures 5 and 6 it can be observed that the percentage of total nitrogen in the two varieties was practically identical at each period during the three years. The average percentage of nitrogen for both varieties from autumn until the forepart of April was 4.43 for 39 observations of Kanred and for 28 cases of Harvest Queen. The percentage of nitrogen in the stems and leaves of both varieties markedly increased at the first observation in late October over that of the seed from which the plants originated. There was then a gradual but evident fall in the percentage of this element until early December, after which it remained constant until the middle of February. After that time the percentage increased until vigorous growth began late in March. From that time there was a gradual decline until harvest, when the nitrogen in the stems and leaves barely exceeded one-half percent in the extreme sample. In 1932 there was an increase of 0.21 percent in the total nitrogen of Kanred during the week preceding harvest. In 1933 there was an increase of 0.7 percent and in 1934 an increase of 0.03 percent in the nitrogen content of the stems and leaves of Harvest Queen during the week before harvesting.

The percentage of nitrogen in the chaff of both varieties decreased from the beginning of grain formation to maturity. The percentage of nitrogen in the grain behaved similarly for the two

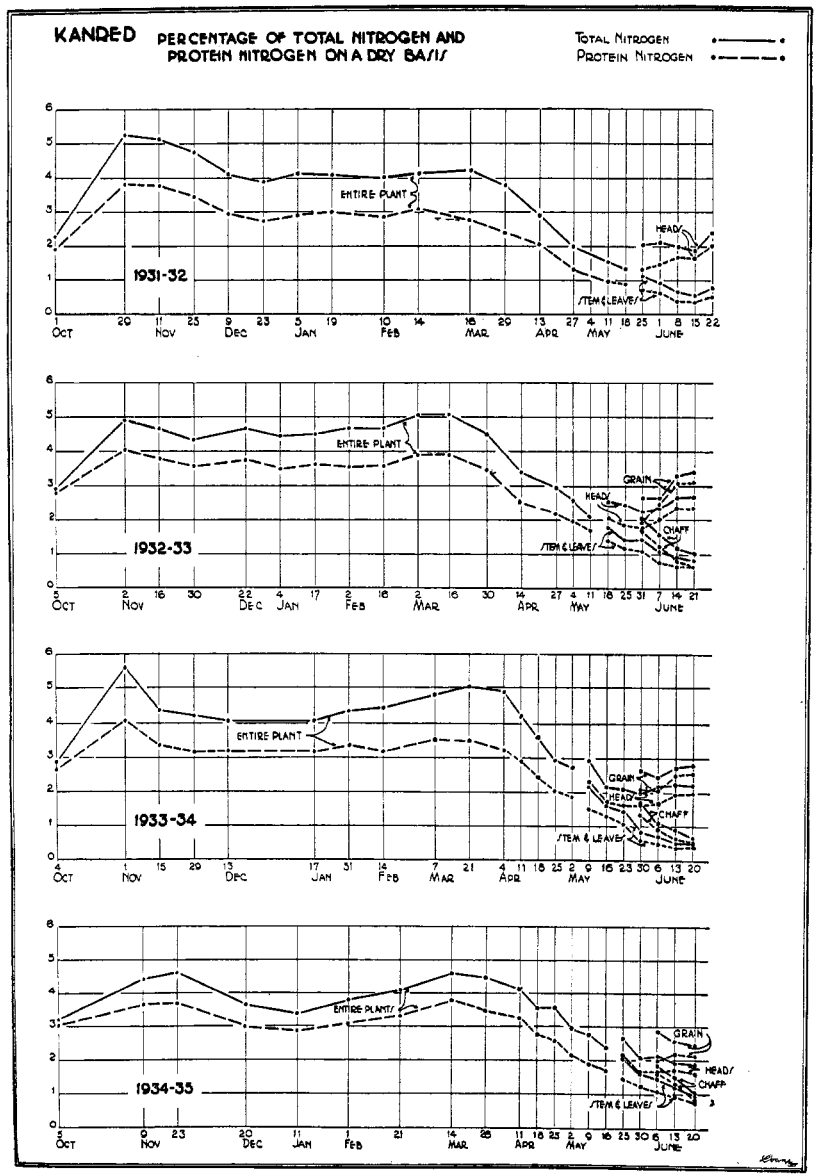

FIG. 5.—The percentage on a dry basis of total nitrogen and protein nitrogen in the stems and leaves, heads, chaff and grain of the plants of Kanred wheat at the various stages of growth during the four years, 1931-'32 to 1934-'35, inclusive.

varieties. Thus in 1933 the nitrogen in the grain of Kanred increased from 2.73 percent, on May 31 to 3.43 percent on June 21, while the percentage in Harvest Queen rose from 2.65 on May 31 to 3.71 on June 21. In 1934 the percentage of nitrogen in the grain of Kanred decreased from 2.67 on May 30 to 2.44 on June 6 and gradually rose to 2.8 at harvest on June 20. Harvest Queen decreased from a percentage of 2.63 on May 30 to 2.50 on June 6

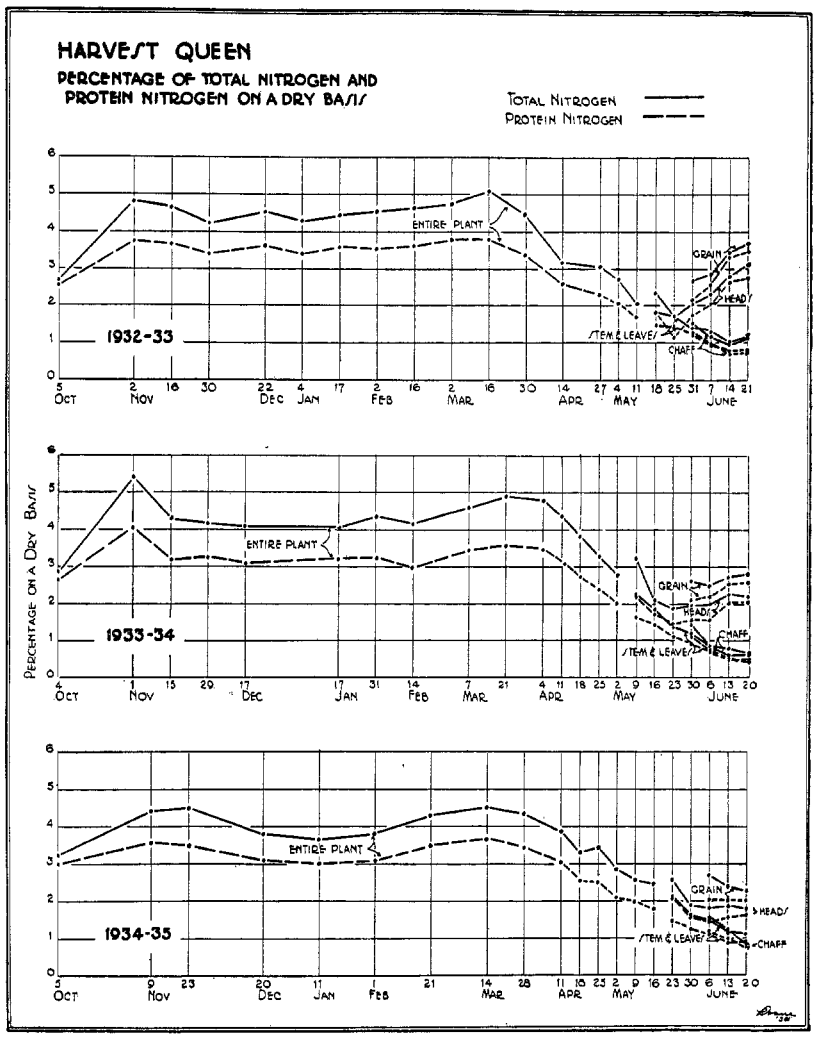

FIG. 6.—The percentage on a dry basis of the total nitrogen and protein nitrogen in the stems and leaves, heads, chaff and grain of the plants of Harvest Queen wheat at the various stages of growth during the three years, 1932-'33 to 1934-'35, inclusive.

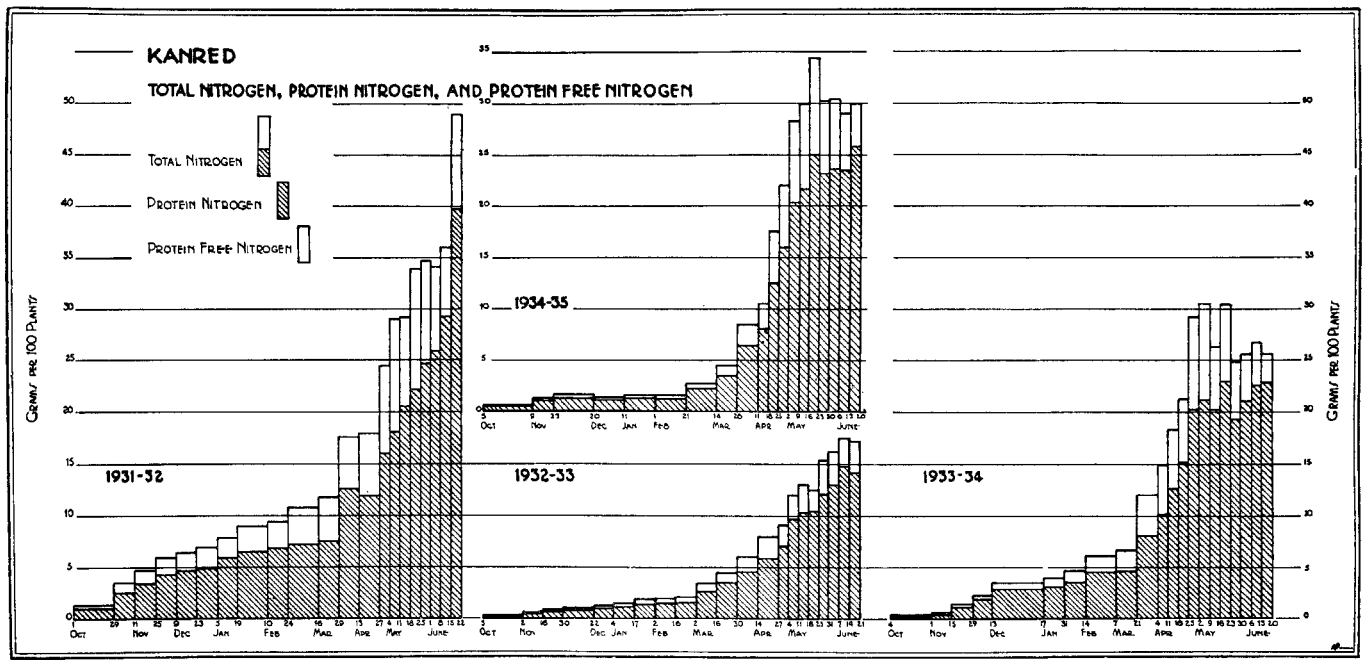

FIG. 7.—The amount of total nitrogen, protein nitrogen and protein-free nitrogen in 100 plants of Kanred wheat at the various stages of growth during the four years, 1931-'32 to 1934-'35, inclusive.

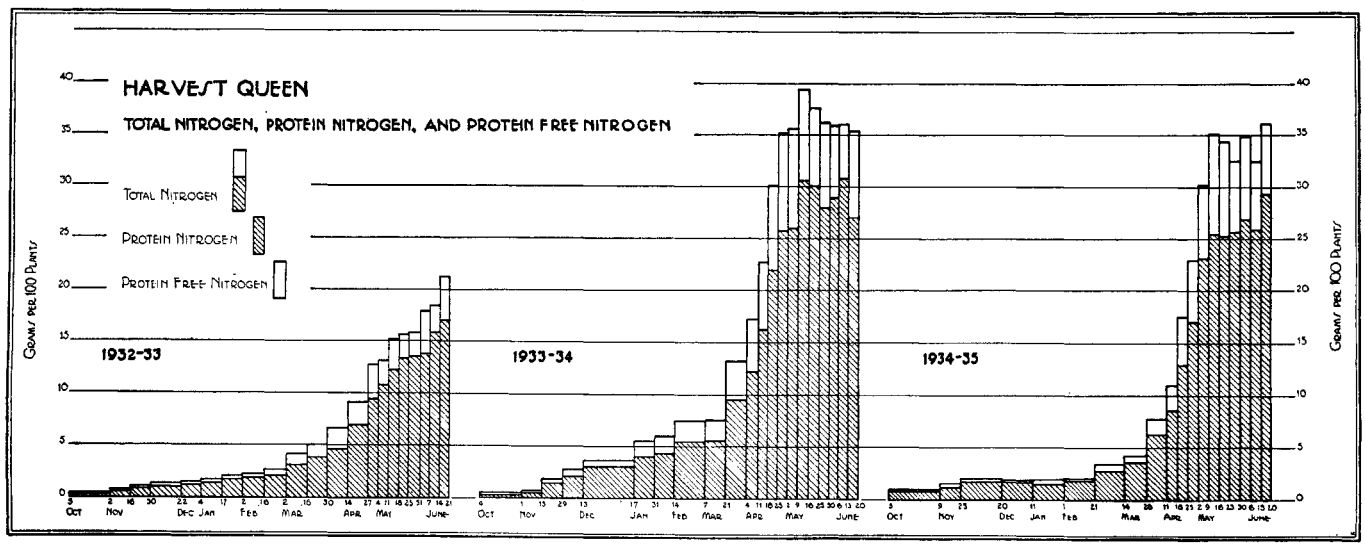

FIG. 8.—The amount of total nitrogen, protein nitrogen and protein-free nitrogen in 100 plants of Harvest Queen wheat at the various stages of growth during the three years, 1932-'33 to 1934-'35, inclusive.

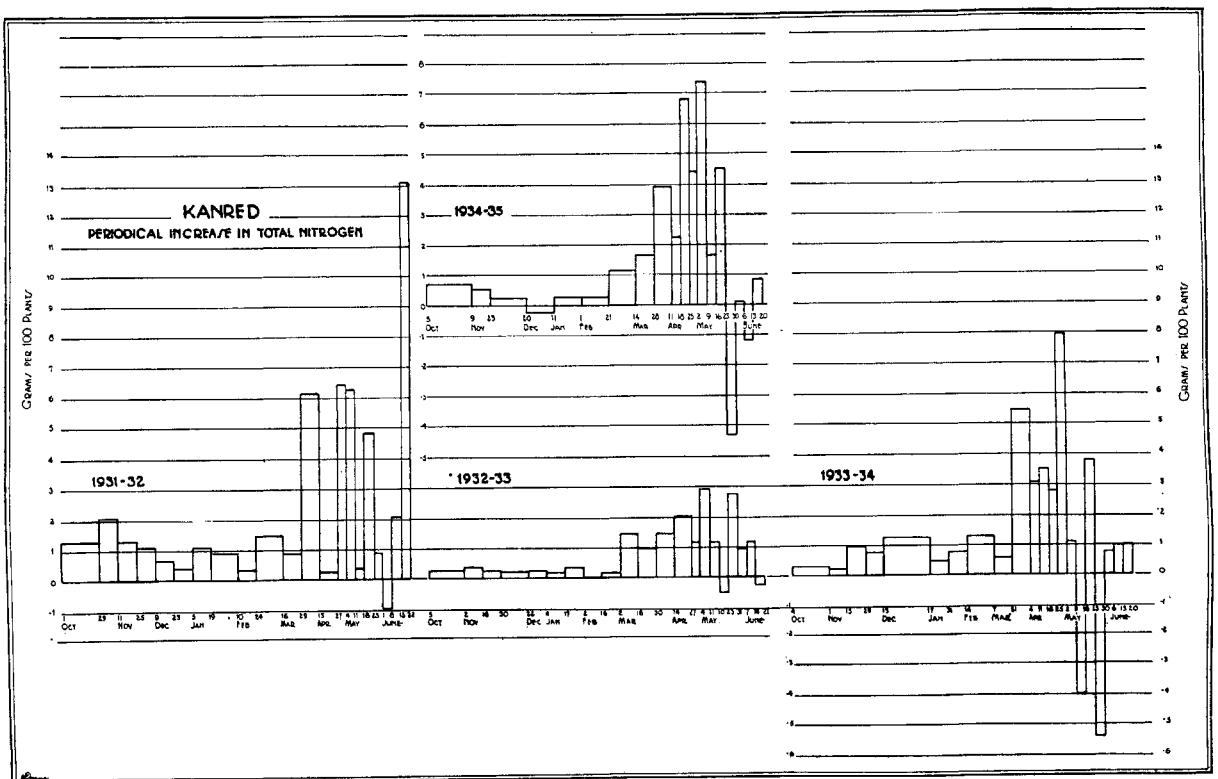

FIG. 9.—The increase or decrease in the amount of total nitrogen in 100 plants of Kanred wheat at the various stages of growth during the four years, 1931-'32 to 1934-'35, inclusive.

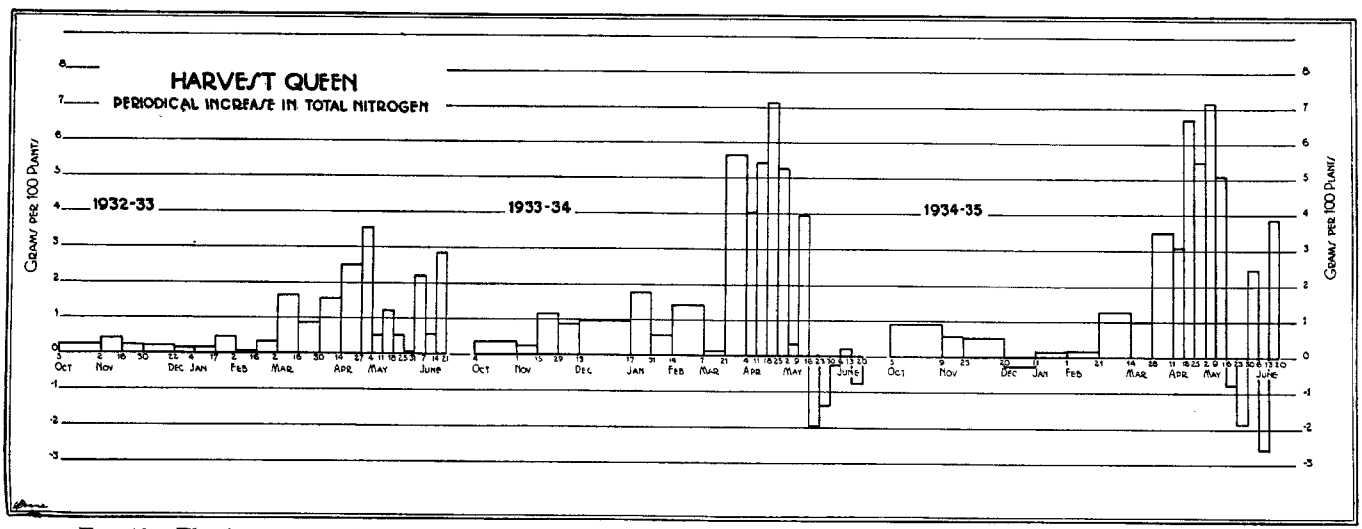

FIG. 10.—The increase or decrease in the amount of total nitrogen in 100 plants of Harvest Queen wheat at the various stages of growth during the three years, 1932-'33 to 1934-'35, inclusive.

and increased to 2.81 on June 20. In 1935 the percentage of nitrogen in the grain of Kanred fell from 2.88 on June 6 to 2.44 on June 20, while that of Harvest Queen fell from 2.72 on June 6 to 2.28 on June 20.

Amount of nitrogen in 100 plants.— The amount of nitrogen present at the various observed periods expressed in grams per 100 plants is shown in Tables X and XI and in figures 7 and 8. Except in 1931-'32 the actual amount of nitrogen in the plants of Kanred reached its peak before harvest. In 1932-'33 the highest amount was reached the week preceding harvest, while in 1933-'34 and 1934-'35 the maximum amount of nitrogen was attained the fifth week previous to harvest. The total nitrogen of Harvest Queen reached a maximum in 1932-'33 and 1934-'35 the week of harvest, but in 1933-'34 the peak was reached six weeks before that time.

The increase or decrease of total nitrogen during each period is pictured in figures 9 and 10. With one exception the total nitrogen in the plants of Kanred increased in amount during each period from the first seedling stage examined until approximately the middle of May. In 1931-'32 the actual amount of nitrogen in the plants dropped only once and that from June 1 to 8. During 1932-'33 there was a slight decrease in nitrogen during the weeks of May 18 to 25 and from June 14 to 21. In 1933-'34 there was a marked drop from May 9 to 16, which was almost regained the succeeding week, only to be followed by the greatest decrease noted during any period of the four years. Although there were substantial gains during the next three weeks, this relatively high decrease was not regained. During 1934-'35 there was a decrease in the nitrogen content of the plant during the period of December 20, 1934, to January 11, 1935. There was a marked decrease in the total nitrogen from May 23 to 30, and this loss was never fully regained during the subsequent life of the plant.

The plants of Harvest Queen showed no loss of nitrogen at any period during 1932-'33. During the following year there was a decrease from May 16 to 23 which was never fully regained. During 1934-'35 this variety also showed a decrease in nitrogen during the period of December 20, 1934, to January 11, 1935, which was comparable to that of Kanred. From May 16 to harvest, on June 20, the nitrogen content fluctuated greatly. Thus there was a slight decrease from May 16 to 23, followed by a large decrease during the succeeding week, then from May 30 to June 6 an increase greater than these losses, then a loss from June 6 to 13, followed by an increase greater than any of these losses. Although the changes in the amount of nitrogen varied widely, the greatest increases occurred between the beginning of rapid growth in the spring and the heading of the plants. The decreases for the most part occurred between heading and harvest.

The marked increase in the amount of nitrogen in the Kanred plants during the week preceding harvest in 1932 was very striking.

This increase amounted to 36.5 percent of the total nitrogen present the preceding week. This marked increase at such a late period in the life of the plant was apparently due to the abundance of moisture in the soil, since the total rainfall during that week was approximately 3.5 inches. Apparently, the roots were yet functioning and the conditions were favorable for absorption. This explanation is strengthened by the fact that the amount of phosphorus and potassium in the plant was likewise greatly increased over that of the preceding week.

The maximal weekly increase of nitrogen in the plants of Kanred during the other three seasons was 32.1, 37.3 and 29.5 percent, respectively, of the total nitrogen in the plants during the preceding period. The maximal increase in the plants of Harvest Queen during these same seasons was 38.4, 32.0 and 31.1 percent of the amount already present. During the season of 1934-'35 the date of the weekly maximal nitrogen increase was identical for both varieties. During the seasons of 1932-'33 and 1933-'34 there was only a week between the weekly maximal absorption dates of the two varieties, the maximal date for Harvest Queen always being the earlier.

There was only one weekly decrease in nitrogen in the Kanred plants during the season of 1931-'32. This occurred from June 1 to 8, three weeks before harvest and amounted to only 2.5 percent of the total nitrogen in the plants during the preceding week. The periods at which a loss of nitrogen occurred and the amount of loss for each of the two varieties during three seasons are shown by the following data:

Kanred.		Harvest Queen.	
DATE.	Percentage decrease based on amount present preceding week.	DATE.	Percentage decrease based on amount present preceding week.
1932-'33.		*1932-'33.*	No decrease at any weekly period.
May 18 to 23	3.8	*1933-'34*	
June 14 to 21	1.5	May 16 to 23	5.0
1933-'34.		May 23 to 30	3.6
May 9 to 16	12.9	June 13 to 20	2.0
May 23 to 30	17.5	*1934-'35.*	
1934-'35.		December 20 to January 11	13.8
December 20 to January 11	13.8	May 16 to 23	2.2
May 23 to 30	12.4	May 23 to 30	5.5
June 6 to 13	3.9	June 6 to 13	7.4

The intake of nitrogen by the wheat plant is apparently influenced by the environmental factors and by the stage or rate of growth. Since the roots can not be satisfactorily analyzed, it is impossible to know definitely whether the loss of nitrogen was due to loss of leaves or to the migration into the roots. There is apparently no relationship between the loss of nitrogen and possible leaching by rains. On only two dates for each variety was there any opportunity to attribute the loss of nitrogen to leaching from the leaves. Those dates were May 9 to 16, 1933-'34, and May 23 to 30, 1934-'35 for Kanred and May 16 to 23 and May 23 to 30, 1934-'35 for Harvest Queen. The losses of nitrogen at these dates, however, were not so great as they were at other periods when there were no possible chances for leaching. The losses of nitrogen by the two varieties occurred only twice at the same date. The greatest losses were shown by the plants of Kanred.

Amount of Nitrogen Absorbed at Each Stage.—The proportion of the nitrogen that was absorbed by the plants to a given date or during any given period may be observed in Table XII and figure 11. The plants of Kanred absorbed approximately 20 percent of their total nitrogen during the first three years from the time of seeding in early October until the middle of March, but only 8 percent during the same time in 1934-'35. During the same time the plants of Harvest Queen had absorbed 12, 19 and 9 percent, respectively, of their total nitrogen during each of the three years this variety was grown. Thus during the first two-thirds of the life of the plants not to exceed 22 percent and not less than 8 percent of the maximal amount of nitrogen in the plant had been absorbed by Kanred, while not to exceed 20 percent and as little as 9 percent had been absorbed by the Harvest Queen variety during that time.

From four-fifths to nine-tenths of the nitrogen in the wheat plants was absorbed during the seven to 12 weeks following the middle of March. This fact can be illustrated by a few examples. In Kanred in 1933 during the two weeks from April 14 to 27 approximately 12 percent of the nitrogen was absorbed, while during one week, from May 4 to 11, 17 percent of the maximal amount of this element entered the plant. In 1934 from March 21 to April 4, a period of two weeks, 17 percent of the total nitrogen was absorbed, and 26 percent was absorbed during the week of April 25 to May 2. Similar results were observed for Harvest Queen. In 1935 during the weeks of April 18 to 25 and May 2 to 9, the plants absorbed 19 and 20 percent, respectively, of the maximal amount of the nitrogen in them.

Nitrogen of the Stems and Leaves, Heads, Chaff and Grain.—The proportion of the total nitrogen in the stems, leaves and head parts at the various stages is shown in Table XIII and figures 12 and 13. The maximal amount of nitrogen in the stems and leaves occurred at or about the time of heading. From Table XIV it is observed that, as a general rule, from heading until maturity, the

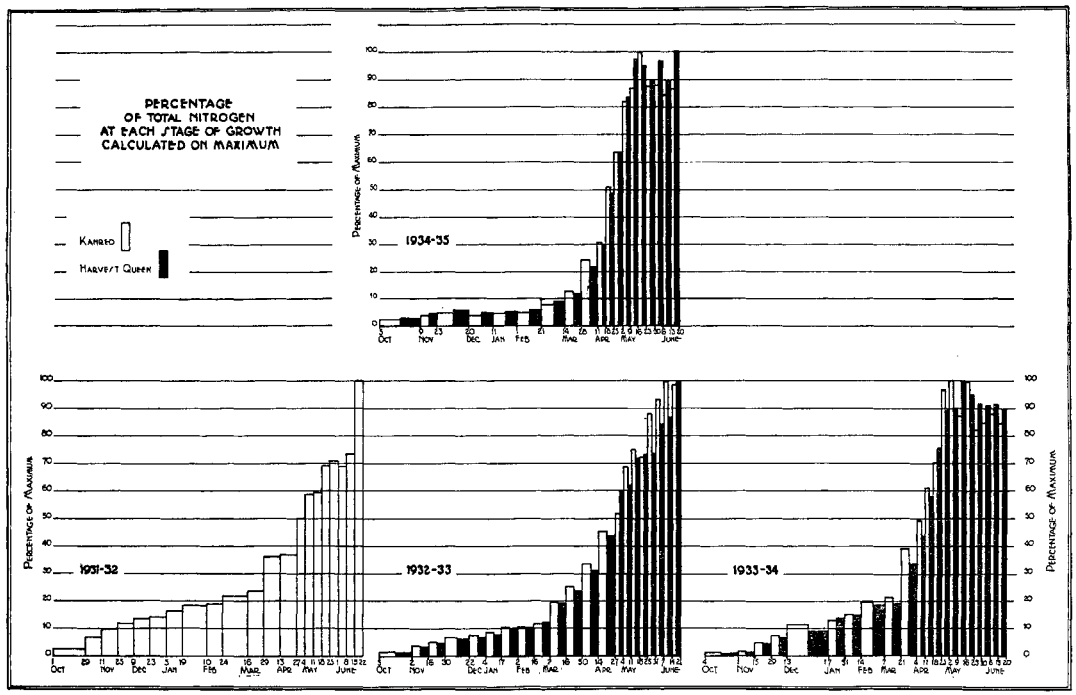

FIG. 11.—The percentage of total nitrogen at each stage of growth, calculated on the maximal amount, in the plants of Kanred and Harvest Queen wheat during the four years, 1931-'32 to 1934-'35, inclusive.

nitrogen content in these parts gradually decreased. The greatest decrease in nitrogen in the stems and leaves from heading until harvest was 74 percent in the Kanred in 1933-'34, and the smallest only 24 percent of the maximum amount present in Harvest Queen in 1932-'33. About the time the nitrogen began to decrease in the stems and leaves it began to increase in the heads. With the exception of Harvest Queen in one instance in 1934, the heads of both varieties showed a continuous increase in the amount of nitrogen from their emergence until harvest.

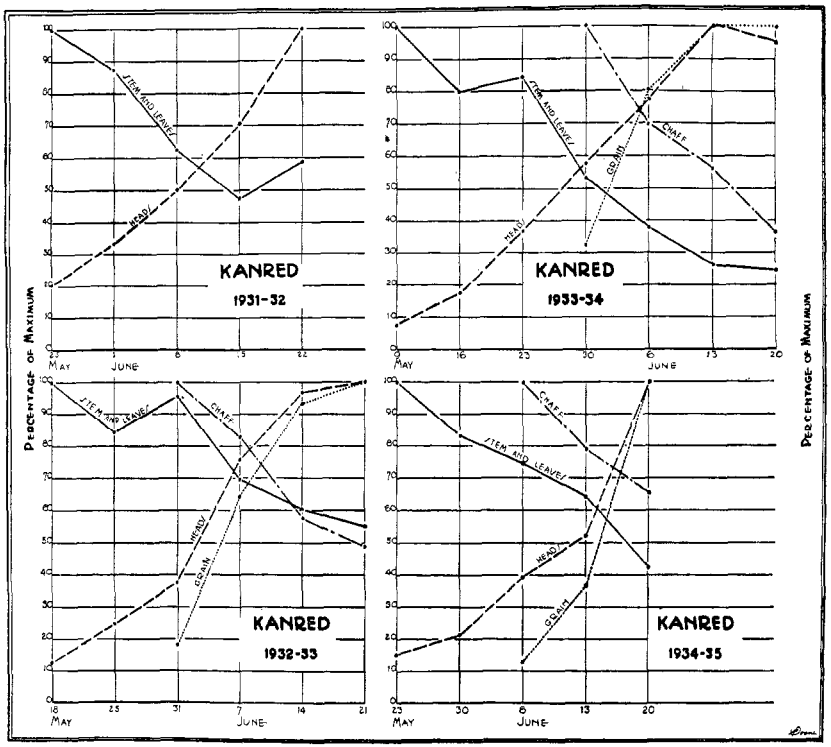

FIG. 12.—The percentage of the total nitrogen at the various stages of growth, calculated on the maximal amount, in the stems and leaves, heads grain and chaff of Kanred wheat during the four seasons, 1931-'32 to 1934-'35, inclusive.

The amount of total nitrogen in the chaff (glumes and rachises), with one exception, that of Harvest Queen on June 21, 1933, decreased in both varieties at every period from the first observation until maturity. At that period there was also a gain of nitrogen in the stems and leaves of this plant. The amount of nitrogen in the grain showed an increase at each period from the beginning of its formation until harvest. It can be observed from Table XIV that

in three cases each of Kanred and Harvest Queen, the stems and leaves showed a gain in the total nitrogen during some weekly period after the maximum amount of nitrogen in these parts had been attained. These gains were always less than the losses during the preceding period. In Kanred the gain of nitrogen in the stems and leaves was always less than the gain of that element in the heads during the same period. With Harvest Queen on one ob-

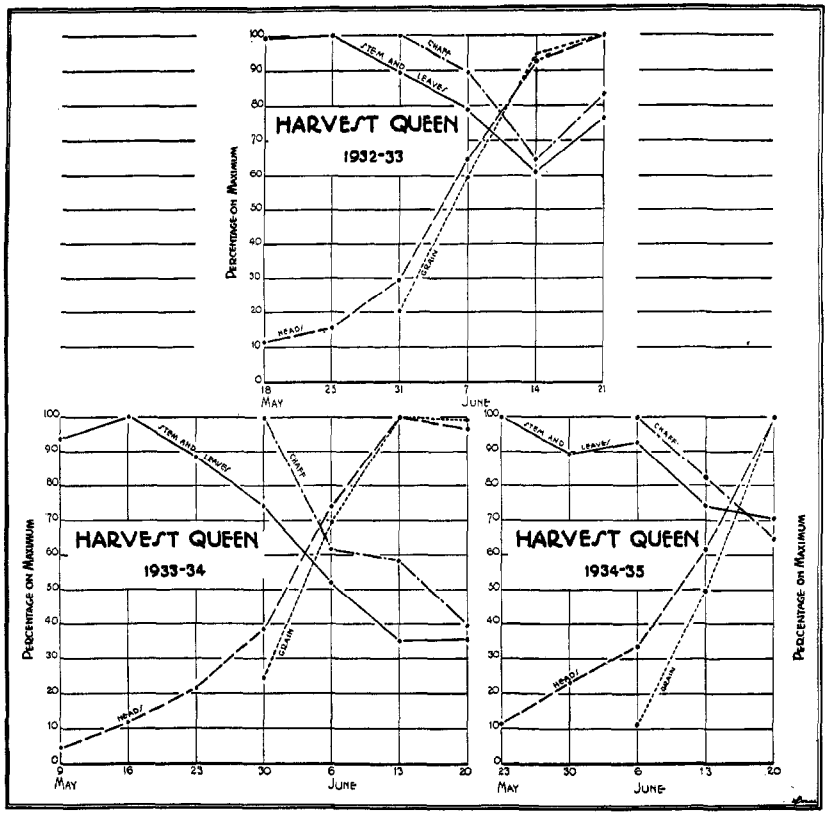

FIG. 13.—The percentage of the total nitrogen at the various stages of growth, calculated on the maximal amount, in the stems and leaves, heads, grain and chaff of Harvest Queen wheat during the three seasons, 1932-'33 to 1934-'35, inclusive.

servation date, the gain in the head was less that that in the stems and leaves, in another it was greater, while in a third, the heads showed a distinct loss.

In 15 observations the gain of nitrogen in the heads was greater than the loss from the stems and leaves. The plants thus must have absorbed this excess of nitrogen from the soil. In 12 observations

the gain of nitrogen in the heads was less than the loss in the stems and leaves. It is impossible to determine the fate of this nitrogen. It may have been lost from the plants by leaching, by translocation to the roots, or by a slight defoliation.

PROTEIN NITROGEN AND PROTEIN-FREE NITROGEN

The relationship of the total nitrogen, protein-free nitrogen, and protein nitrogen to one another may be observed in Tables X and XI and in figures 7 and 8.

The protein nitrogen of the planted seed in both varieties was higher than that found in the stems and leaves during their development. The protein nitrogen in the seed of Kanred was 85, 96, 92 and 93 percent, respectively, of the total nitrogen present during each of the successive years. The protein nitrogen of the seed of Harvest Queen amounted to 97, 92 and 93 percent of the total nitrogen during each of the years this variety was sown. The protein nitrogen in the stems and leaves of Kanred ranged from 62 to 84 percent and in Harvest Queen from 67 to 86 percent of the total nitrogen present. Roughly speaking the protein nitrogen approximated 75 percent of the total nitrogen present. The relative amounts of protein nitrogen and protein-free nitrogen remained strikingly in the same proportion in the stems and leaves during the entire life of the plants.

In 1932-'33 the protein-free nitrogen in the chaff of Kanred increased from 16.6 percent at the first observation to 35.5 percent of the total nitrogen at harvest. In 1933-'34 it increased from 19 percent to 25.7 percent at the close of the season. In 1934-'35 the percentage was irregular. It amounted to 13.4 percent of the total nitrogen at the first observation, 10.6 percent at the second, and 17.2 percent at the last observation. The protein-free nitrogen in the chaff of Harvest Queen in 1932-'33 increased from 15.4 at first observation to 36.1 percent at harvest. In 1933-'34 the percentage decreased from 20.4 at the first inspection to 40 percent two weeks later, after which it decreased to 21 percent of the total nitrogen. In 1934-'35 it decreased from 18.5 percent of the total nitrogen to 9.8 percent during a period of three weeks.

The protein-free nitrogen of the grain of Kanred decreased in amount from its beginning to maturity. Thus in 1932-'33 it decreased from 28.3 to 9.1 percent. In 1933-'34 from 22.5 to 7.9 percent and in 1934-'35 from 30.6 to 11.9 percent. In the grain of Harvest Queen in 1932-'33, the protein-free nitrogen decreased from 18.5 to 3.3 percent and then increased to 6.8 percent during the week preceding harvest. In 1933-'34 it decreased from 19.4 to 7.8 percent and in 1934-'35 from 25.0 to 10.0 percent of the total nitrogen present.

PHOSPHORUS AND POTASSIUM METABOLISM

REVIEW OF LITERATURE

Hornberger *(42)* noted that in maize there was a period of maximum absorption of many of the elements about the time of blooming, after which there was a decrease in the rate of intake. This period of decrease was followed by a period of rapid absorption, which was succeeded by the ripening period in which there were absolute losses of all the constituents except phosphorus.

Liebscher *(55)* stated that the amount of nutrients in the wheat plant reached its maximum after blooming. After this period only small amounts of some nutrients were absorbed, while those materials which had been stored temporarily in the stems and leaves were moved to the grain. At maturity the total amount of the various nutrients in the plant had declined slightly.

It was observed by Failyer and Willard *(28)* that the percentage of ash in the grain of corn decreased from the milk stage until ripeness.

Maxwell *(66)* believed that in light the seedlings of cotton, bean and corn can utilize the phosphorus in the seed for the formation of lecithin bodies. When the seedling becomes independent of the seed it decomposes and utilizes these bodies in its development.

It was observed by Snyder *(80)* in Minnesota, that wheat plants which headed in 65 days absorbed from the soil during the first 50 days, 75 percent of the potassium and 80 percent of the phosphorus they finally contained. At the age of 50 days, the plants were only 18 inches in height and contained less than one-half of the dry matter which they eventually produced, yet they contained at this time three-fourths of the total mineral matters that they absorbed from the soil. More potassium was found in the plants at the milk stage than at harvest time. He considered that some of the potassium that had been absorbed by the plant was later returned to the roots and then to the soil. On that account plants contain more potassium during the growing period than they do at maturity. Snyder stated that for optimum crop development, the soil must contain a larger working supply of potassium than is found in the plants at maturity. Adorján *(1)* found that wheat plants increased in the amount of ash until five days before harvest. The actual amount of phosphorus in the stems, leaves and glumes gradually decreased during the 25 days preceding harvest, while the grain gained steadily in that element. During that period, the grain produced on one square meter of soil gained 2.564 grams of phosphorus while the stems, leaves and glumes lost 1.494 grams of this element. Thus of the total phosphorus in the grain, 54.4 percent was drawn from the vegetative parts of the plant, while 45.6 percent was absorbed directly from the soil.

Schulze *(76)* noted that phosphorus was absorbed during the intensive growth in the spring and until heading by plants of wheat and rye in the field. Potassium was absorbed by both crops during

the winter but the largest quantities of this element were used from the beginning of growth in the spring until heading. Apparently the greatest need of potassium was simultaneous with the most active formation of carbohydrates and cellular tissue.

Wilfarth, Römer and Wimmer *(90)* conducted pot and field experiments with barley, spring wheat, peas, mustard and potatoes to determine the quantity of the different nutrients absorbed by different crops at various stages of growth. Barley and spring wheat, absorbed the maximum amount of nutrients from the beginning of blooming to the beginning of the formation of the grain. The amount of phosphorus in the plant did not decrease, but there was a striking loss of potassium and nitrogen from the plant during the interim between blooming and maturity. It was considered that these nutrients were returned to the soil by a downward movement of sap and that this movement seemed to be dependent upon the supply of available plant nutrients. Relatively larger amounts of potassium were returned to the soil when the supply of this element was inadequate than when it was sufficient.

LeClerc and Breazeale *(54)* found that four rainfalls removed from ripe wheat plants 20 to 22 percent of their phosphorus and 63 to 66 percent of their potassium.

It was noted by Brenchley *(16)* and Brenchley and Hall *(17)* that in the development of the grain of wheat, the ash constituents entered the grain in constant proportion to the nitrogen.

Brenchley *(18)* reported that the intake of ash into the entire plant of barley reached its maximum at the same time that the nitrogen content reached its highest, point. When the maximum was reached the amount of ash in the whole plant began to fall steadily, although the migration into the grain continued for some time longer. There were indications that phosphorus during the ripening period was transferred from the stem to the grain. Haigh *(31)* observed that the plants of wheat and barley absorbed the ash constituents at a decreasing rate as growth proceeded.

Jones and Huston *(45)* found in corn that there was a very rapid absorption of potassium at or about the time of tasseling and that there was a loss of this element at the approach of maturity. The potassium and phosphorus were increased in the grain at the expense of these constituents in the stems and leaves. The increase in the amount of these elements in the grain was greater than the amount lost by the stems and leaves. This shows that some absorption from the soil was occurring during this translocation into the grain.

Eckerson *(26)* noticed that the maximum amount of free phosphate was found in the stem and in all parts of the spike of wheat during the development of the sporogenous tissue.

It was reported by Rosseaux and Sirot *(74)* that in wheat the phosphorus tended to parallel the nitrogen content of the grain during its formation.

Burd *(19)* observed the amount of potassium, calcium, magnesium and phosphorus absorbed by barley plants at various stages of development. Eight to nine weeks after planting, the increase in the amount of these constituents conformed closely to the gain in the total dry weight of the plant. These elements then diminished in the plant for a period indicating a movement into the soil. This movement was especially marked for potassium. Later all these elements increased sharply until about the fifteenth week, when they again decreased.

Berry *(11)* observed that the amount of potassium absorbed by the oat plant during the last six weeks of growth, equaled that passing into the seed so that there was little or no exhaustion from the stems and leaves. The phosphorus continued to enter and increase in amounts in the plant until maturity. The amount absorbed was less than the amount moved into the seed. No loss of either potassium or phosphorus into the soil was observed.

Maschaupt *(63)* analyzed spring wheat at weekly intervals from May to August. The ash of the ripe wheat contained a smaller amount of potassium, calcium, chlorine, and sulphur than did that of the unripened plants.

Booth *(14)* observed in the daily growth of the kernel of the oat that the amount of ash increased rapidly during the first 10 days. It increased slightly during the ripening period, but it did not decrease with delayed harvesting.

Inosemtsev *(43)* reported that the greater part of the potassium of plants exists in a complex nondialyzable form. The small amount that is dialyzable is probably in the organic form.

Knowles and Watkin *(50)* in England examined samples of winter wheat taken at weekly and biweekly intervals during the seven weeks preceding harvest. The percentage of potassium and phosphorus in the entire plant decreased, while that of silicon increased as maturity was approached. Two weeks before harvest, the percentage of phosphorus was constant, while that of potassium and chlorine continued to decrease until maturity. All the various inorganic nutrients were being absorbed by the plant before the emergence of the head, but soon after this stage the intake of potassium, calcium, and chlorine ceased, while that of phosphorus followed two to three weeks later. Large losses of potassium, calcium and chlorine occurred during the period following their maximum in the plant. These authors did not believe that the loss of these constituents could be explained by mechanical losses of parts or by leaching from rain. A comparison of the chemical composition of the straw and stubble showed a higher content of potassium and chlorine in the latter than in the former. This suggests a downward movement of these elements. It is possible that other elements that are generally regarded as incidental and nonessential for growth may be present in the earlier life of the plant in considerable quantities, play a role in growth and development and then return to the roots and soil, leaving only a trace in the mature plant.

In 1932 Knowles and Watkin *(51)* studied the amount and distribution of some of the organic compounds of nitrogen and phosphorus in the wheat plant during the seven weeks preceding harvest. The amount of lipin phosphorus increased steadily until blooming. The amount remained constant until four weeks before harvest, when it decreased by approximately one-half and remained at that level until maturity.

The amount of phytin phosphorus in the entire plant increased until three weeks before harvest, after which it remained constant. The amount of this type of phosphorus in the stem and leaves decreased steadily from the emergence of the heads until harvest, while it increased in the heads.

The inorganic phosphorus in the whole plant steadily increased in amount until harvest. Its migration from the straw to the heads occurred rapidly in the month following their emergence and ceased about two weeks before harvest. The increase in the head was not so great as the decrease in the straw, since a portion of the inorganic phosphorus was being elaborated into phytin.

Fagan and Watkin *(27)* studied the oat plant from the time of the emergence of the panicle until ripeness and found that the migration of dry matter, ash, phosphorus, potassium and iron from the stems and leaves into the spikelet continued until maturity.

Wagner *(89)* found that after the absolute amount of phosphorus and potassium had reached a maximum in the leaves and stems of the oat plant, the phosphorus was translocated from these parts to the fruiting organs, while potassium was moved only from the leaves,

Norman *(69)* noted that the percentages of ash in spring barley increased slightly during the earlier stages and then steadily decreased as the plant developed and matured.

Tavcar *(81)* found that in Jugoslavia the poor-yielding varieties of wheat had more ash in the grain and straw than did the best-yielding varieties.

Blanck, Giesecke and Heukeshoven *(12)* and Blanck and Giesecke *(13)* found that the amount of potassium and phosphorus in the oat plant growing in sand cultures reached its maximum in the roots and tops at heading time. It then decreased and again rose to a maximum at full ripeness. The grain contained a maximum of each of these elements at maturity.

Maume and Dulac *(64)* noted that the percentage of potassium in wheat plants at any definite stage of growth and under the same environmental conditions varied with the variety. Petrie *(73)* found from the expressed sap of perennial rye grass *(Lolium perenne)* that the absolute amount of potassium rose to a maximum at maturity or during late senescence and then declined until the death of the plants.

Dadswell *(23)* reported that the wheats grown in Victoria and New South Wales, Australia, contained in general smaller amounts of calcium, potassium, phosphorus and magnesium than the wheats grown in other parts of the world. Copper, iron and manganese

were present in approximately the same proportions as the wheats grown elsewhere.

Morris and Sayre *(67)* stated that the potassium in corn tissue is all in solution in the cell sap and with the possible exception of the cob tissue there was no evidence of any insoluble or fixed forms of potassium in this plant.

Penston *(72)* reviewed the literature pertaining to the loss of certain elements from the plant into the soil at various stages of growth.

Bossie *(15)* reported that the total quantity of mineral salts reached a maximum in the stems and leaves of wheat at about two weeks before flowering, after which it diminished. In the head, however, the ash and its constituents attained their maximum at maturity. The calcium and potassium attained their maximal accumulation in the plant during the time of flowering, after which they decreased until maturity. The phosphorus, however, accumulated until the time of flowering, after which it remained constant in amount until maturity. Calcium, magnesium, phosphorus and potassium migrated to the head after its appearance. It was observed that potassium was the most mobile of any of the elements that were studied and that, beginning with the migration of this element into the head, a negative migration from the stem and leaves began to occur. Kobayashi *(52)* found that the salts of phosphorus and potassium were leached by rain from the older leaves and sheaths of the rice plant. This amount of leaching was 13.0 and 35.8 percent, respectively, for phosphorus and potassium based on the maximal amounts of these elements that had been absorbed.

Ayres *(5)* noted that in the sugar cane, the rate at which the mineral nutrients were absorbed, varied with the age of the plant. During the first three months approximately 10 percent of the uptake of potassium and phosphorus occurred. At the age of 10 months, the rates of absorption of calcium, magnesium and potassium diminished while the uptake of silicon and phosphorus continued at essentially constant rates for 14 months after which the experiment was discontinued. Maume and Dulac *(65)* found that in fertile soil the heads of wheat used more phosphorus but less potassium than the stems while on poorer soils the heads were richer in potassium.

PHOSPHORUS METABOLISM

Percentage of total phosphorus.— The percentage of total phosphorus in the stems and leaves, head, chaff and grain at the various stages is shown in Tables XV and XVI and in figure 14. It is seen from these sources that the maximal percentage of total phosphorus in the stems and leaves, based on dry matter, was always less than 1 percent. The maximal percentage in Kanred varied from 0.44 in 1933-'34 to 0.81 in 1931-'32. In Harvest Queen it varied from 0.47 in 1932-'33 to 0.52 in 1933-'34. The percentage of total phosphorus in the four-week seedlings was always much

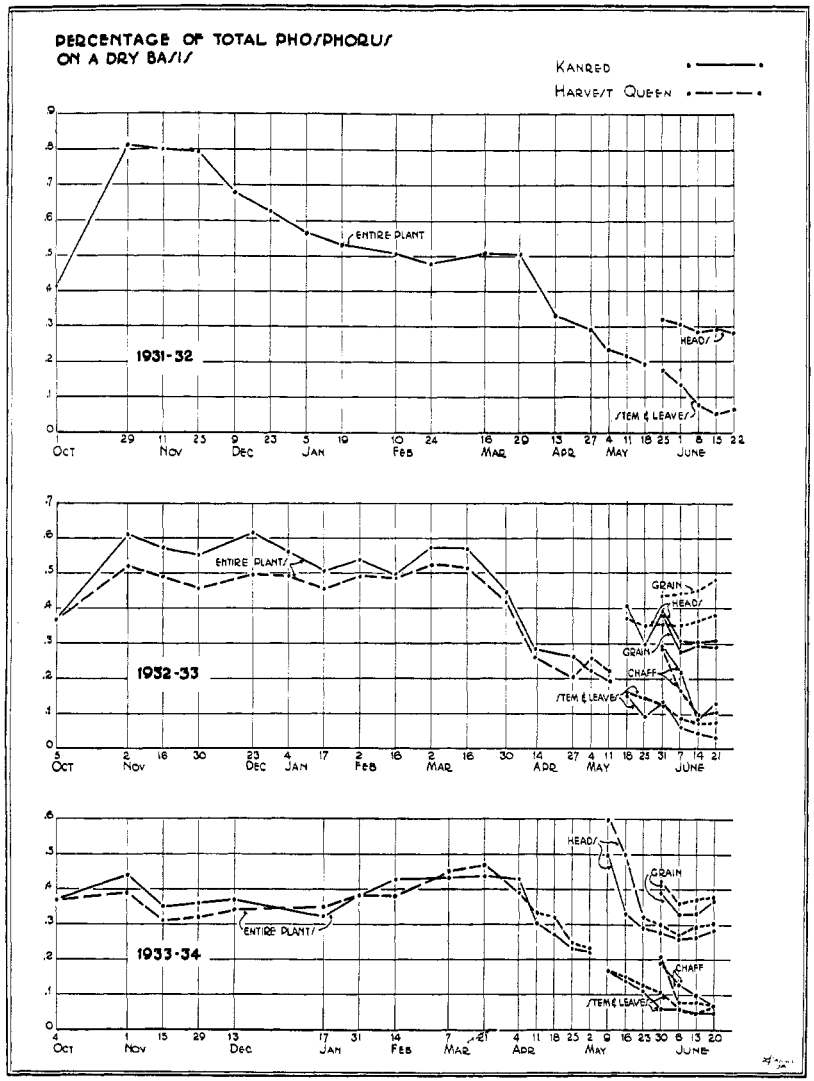

FIG. 14.—The percentage of total phosphorus on a dry basis in the stems and leaves, heads, chaff and grain of the plants of Kanred and Harvest Queen wheat at the various stages of growth during the three years, 1931-'32 to 1933-'34, inclusive.

higher than that of the seeds that were sown. The percentage of phosphorus in this age of seedlings was the maximal, or near to the maximal, in the stems and leaves during the year. The percentage of total phosphorus in the stems and leaves of the plants of Kanred during 1931-'32 decreased gradually, with but two exceptions, from the maximum of 0.81 in the month-old plants to a minimum of 0.053 percent a week before harvest. During the following week there was a slight increase in percentage to 0.068.

In 1932-'33 the percentage of total phosphorus in the stems and leaves of Harvest Queen was considerably lower than that of Kanred from November 2 to April 27. It then became slightly higher than the percentage in Kanred and so remained until harvest. The two curves indicating the percentages of phosphorus in the stems and leaves of these two plants parallel each other throughout the year. In 1933-'34 the percentage of phosphorus in the stems and leaves of the two varieties was practically the same. The percentage decreased, then remained constant for a period, then slightly increased and from March 21 it gradually decreased until harvest.

In 1931-'32 the percentage of total phosphorus in the heads of Kanred showed a slight decrease from the time of their formation to harvest. In 1932-'33 it showed one marked fluctuation, but in the main a decrease from formation to maturity. During the same year, the heads of Harvest Queen had a percentage of phosphorus higher than that of Kanred and varied only slightly in amounts during six weeks, showing a slight increase during the two weeks preceding harvest. In 1933-'34 the heads of both varieties had the highest percentage of phosphorus of any time during the three seasons, amounting to 0.5 for Kanred and 0.6 for Harvest Queen. The percentage of phosphorus showed a marked decrease in each variety for four weeks, after which for two weeks it slightly increased until harvest. The curves representing the changes in percentage of phosphorus almost parallel each other during the season. The percentage of total phosphorus in the chaff of the two varieties was approximately the same and showed a marked decrease from head formation to harvest.

The percentage of total phosphorus in the grain was always higher for Harvest Queen than for Kanred. In 1932-'33 it slightly increased in the latter from early formation to maturity, while that of Kanred decreased at first and then slightly increased until harvest. In 1933-'34 in both varieties the percentage decreased during the first week and then increased until harvest, the two curves paralleling each other.

Amount of Phosphorus in 100 plants.— The amount of total phosphorus in 100 plants at each of the various stages is shown in Tables XV and XVI and in figures 15 and 16. In both varieties, with one exception, the total amount of phosphorus in the plants reached its maximum at harvest. The one exception was Kanred, which, in 1932-'33, showed its maximal content of phosphorus during

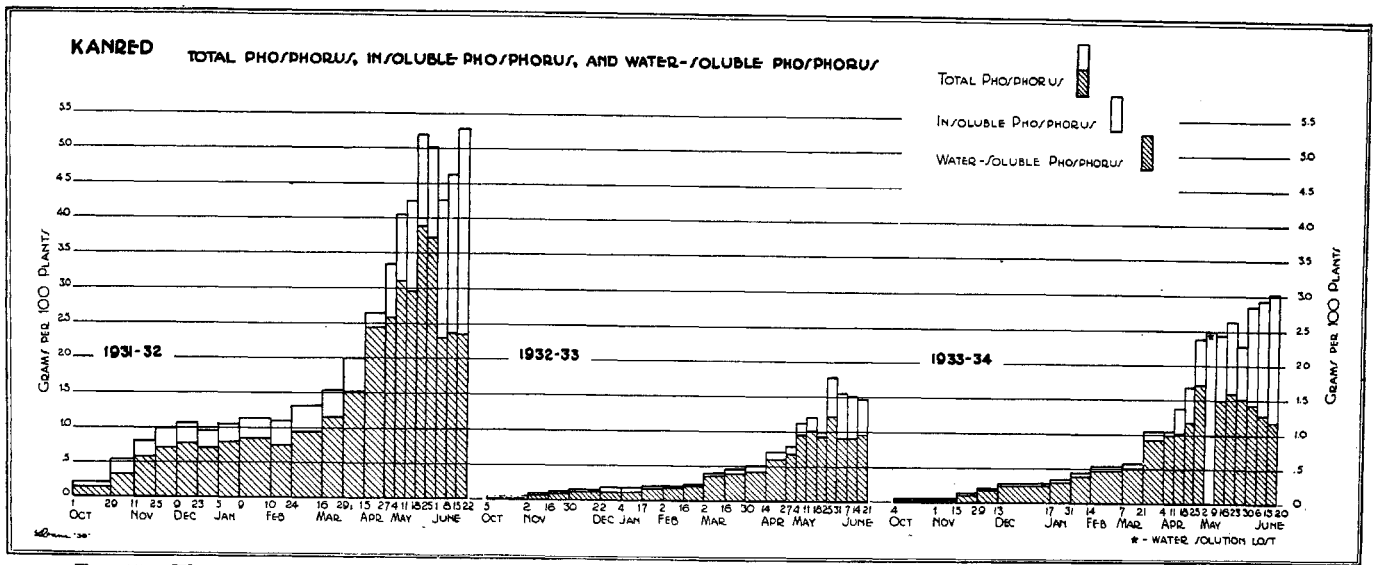

FIG. 15.—The amount of total phosphorus, insoluble phosphorus, and water-soluble phosphorus in 100 plants of Kanred wheat at various stages of growth during the three years, 1931-'32 to 1933-'34, inclusive.

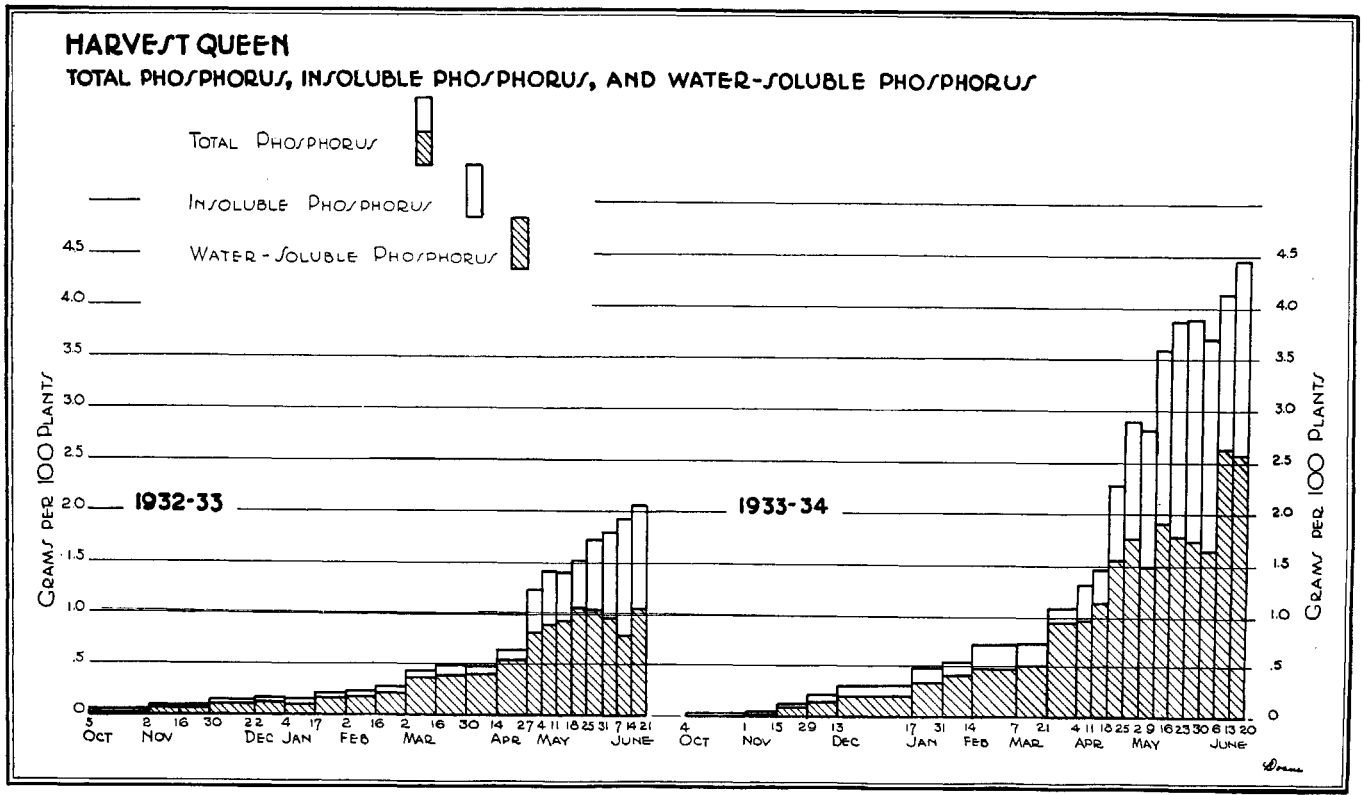

FIG. 16.—The amount of total phosphorus, insoluble phosphorus and water-soluble phosphorus in 100 plants of Harvest Queen wheat at various stages of growth during the two years, 1932-'33 and 1933-'34, inclusive.

the week of May 25 to 31, three weeks before harvest. It then gradually declined until that time. During the two years of comparison, the plants of Harvest Queen had a greater content of total phosphorus than did those of Kanred. This difference was due to the greater dry weight of the plants of the former variety, since the percentage of this element was approximately the same in the two varieties, or it was lower in Harvest Queen than in Kanred.

With some more or less isolated fluctuations the amount of total phosphorus increased in the plants from the seedling stage until the maximum was reached. The dates at which these decreases occurred and the percentage of decrease based on the amount present the preceding week are shown below.

Kanred.		Harvest Queen.	
DATE.	Percentage decrease based on the amount present the preceding week.	DATE.	Percentage decrease based on the amount present the preceding week.
1931-'32.		*1931-'32.*	
December 23 to January 5	9.8		
February 10 to 24	5.0		
May 25 to June 1	3.2		
June 1 to 8	14.8		
1932-'33.		*1932-'33.*	
May 18 to 25	20.4	May 11 to 18	13.2
May 31 to June 7	13.2		
June 7 to 14	3.1		
June 14 to 21	2.4		
1933-'34.		*1933-'34.*	
May 9 to 16	2.6	May 2 to 9	3.1
May 23 to 30	13.0	May 30 to June 6	4.8

The causes for these losses are not known. At none of the dates of loss was there sufficient rainfall to cause leaching except during one week, May 9 to 16, 1934, but the loss in total phosphorus during that time was next to the lowest observed. Evidently these decreases in phosphorus were not due to leaching from the stems and leaves.

The most marked increases in the amount of phosphorus were, like the increase in nitrogen, at the time when rapid growth started in the spring. In Kanred plants of 1931-'32, there was a marked increase in the total phosphorus during the week before harvest. The probable cause for this is discussed under the intake of nitrogen.

Amount of phosphorus absorbed at each stage.— The proportion of the phosphorus that was absorbed by the plants to a given date or during any given period may be observed in Table XVII and in figure 17.

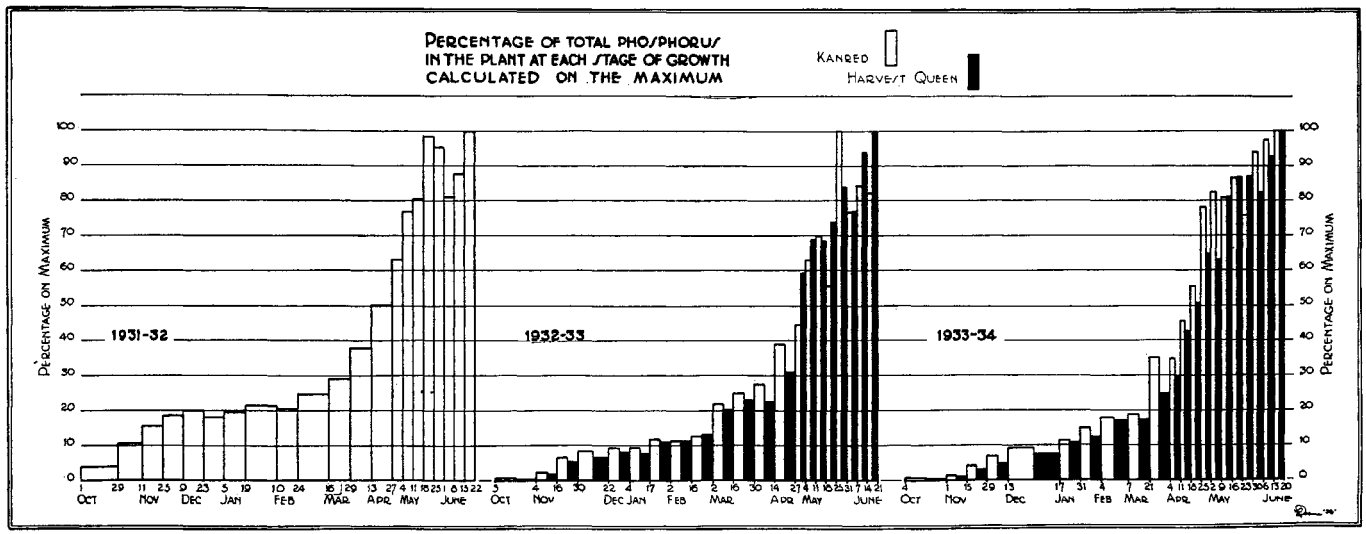

FIG. 17.—The percentage of total phosphorus, calculated on the maximal amount, in the plants of Kanred and Harvest Queen wheat at different stages of growth during the three years, 1931-'32 to 1933-'34, inclusive.

In 1931-'32 the plants of Kanred had absorbed approximately 20 percent of their phosphorus by February 24. By April 27 they had absorbed 50 percent of their maximum amount. During the following four weeks 98.5 percent of the maximum amount of phosphorus had been absorbed. Thus in four weeks the plants absorbed 48.5 percent of the total phosphorus that was absorbed by them from seeding until harvest.

In 1932-'33 the plants of both Kanred and Harvest Queen had absorbed 20 percent or more of their total phosphorus by March 16. By May 4 the plants of Kanred had absorbed 44.4 percent of their phosphorus, while Harvest Queen plants had absorbed 59.5 percent of their total amount of this element. At the end of the following four weeks, the plants of Kanred had absorbed their maximum amount of phosphorus. Thus these plants in a single month absorbed 55.6 percent of their maximal amount of phosphorus. At the close of this period the plants of Harvest Queen had absorbed only 85.6 percent of their total phosphorus and they continued to absorb phosphorus until harvest.

In 1933-'34 the plants of both varieties had not yet absorbed 20 percent of their phosphorus by March 21. With increased growth beginning at this time the absorption of phosphorus rapidly increased, so that by April 25, 55.4 percent of the phosphorus had been absorbed by Kanred and 50.9 percent by Harvest Queen. During the next seven weeks the remainder of the phosphorus was absorbed and the maximal amount was not attained in either variety until harvest. The data for the three years show that under the conditions of these experiments, the phosphorus is not absorbed at an early date in the life of the plant and stored to be used later. Apparently this element was absorbed by these wheat plants as it was needed in the metabolism of the plant.

Phosphorus of the stems and leaves, heads, chaff and grain. —The gain or loss of the phosphorus in the stems and leaves, heads and parts of the heads at the various stages of growth is shown in Table XVIII. In Table XIX and in figure 18 is shown the percentage of total phosphorus in these parts at each stage, calculated on the maximum amount in them. It is observed from these sources that in general the amount of phosphorus in the stems and leaves declined from a maximum at or about heading, to a minimum at harvest or the week preceding it. The amount of phosphorus in the heads with but one exception increased in amount from their appearance until maturity.

The stems and leaves of Kanred showed at three times a gain in total phosphorus over that which was present during the preceding week. In 1932 these parts showed a marked gain during the week preceding harvest. This was true also for nitrogen and potassium, and as mentioned under nitrogen, was apparently due to exceptionally favorable conditions for absorption during that time. There

was a gain in phosphorus by these parts during the week preceding harvest in 1934, but it was so slight as to fall within the limit of error of the experiment. There was a marked gain in phosphorus in the stems and leaves in 1933 during the second week following heading. The causes for such an abrupt increase are not known. With one exception, the amount of phosphorus of the chaff of both varieties decreased at each observation below that of the preceding period. During the week preceding harvest in 1933, the chaff of both varieties increased in this element. With only one exception,

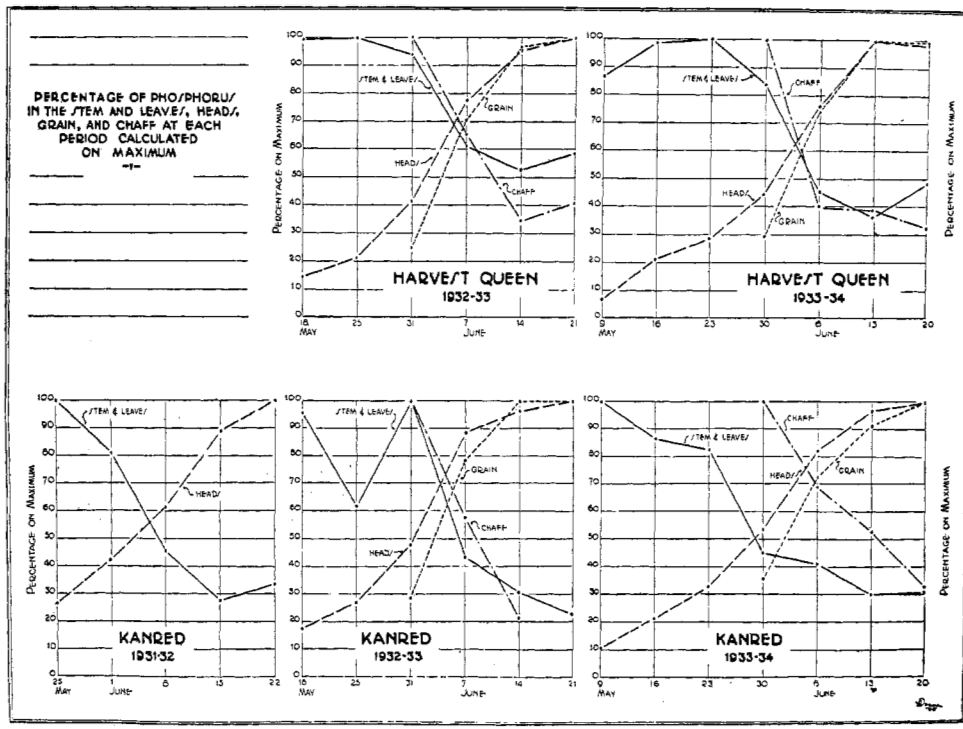

FIG. 18.—The percentage of the total phosphorus, calculated on the maximal amount, in the stems and leaves, heads, grain and chaff of Kanred and Harvest Queen wheat at the various stages of growth during the three seasons, 1931-'32 to 1933-'34, inclusive.

the phosphorous content of the grain of both varieties increased from the first observation until harvest. In eight of the eleven observations during two years, the stems and leaves showed a decrease in the amount of their phosphorus over the amount present in the preceding week. The gain during the first week was small and was probably within the limit of error of the experiment. The other two gains were significant and occurred in each case during the week preceding harvest.

In seven of the fifteen observations on Kanred and in eight of the amounts of the total, water soluble, and insoluble phosphorus in the head mas greater than the loss or gain of this element in the stems and leaves. This indicated that a part of the phosphorus that was migrating into the heads had come directly from the soil.

Insoluble and soluble phosphorus.—The percentages and amounts of the total, water soluble, and insoluble phosphorus in the different plant parts and at the various stages are shown in Tables XV and XVI. The amounts of each of these types per 100 plants at the various stages are shown in figures 15 and 16.

The amount of the total phosphorus in the soluble form in the seeds that were sown in the autumns of 1931, 1932 and 1933 was 54.7, 44.8 and 48.7 percent, respectively, for Kanred and 49.3 and 37.8 percent for Harvest Queen during the respective autumns of 1932 and 1933.

In the stems and leaves of the growing plants the amount of soluble phosphorus was at times double this amount. Thus, in the stems and leaves of Kanred plants in 1931-'32 from the month-old seedlings on October 29 to June 8 when the grain was being formed, the soluble phosphorus in the stems and leaves varied from 60 to 92 percent of the total phosphorus present. The average amount of soluble phosphorus for the 19 stages examined was 72.5 percent of the total phosphorus. During the season of 1932-'33 the amount of soluble phosphorus in the stems and leaves ranged from 77 to 96 percent of the total phosphorus and the average for the 20 stages that were examined from November 2 to June 7, inclusive, was 84.6 percent. During the season of 1933-'34, the water soluble phosphorus in the stems and leaves varied from 71 to 93 percent and averaged 83 percent of the total phosphorus during the 15 observations from November 1 to May 9, inclusive.

During 1932 in Kanred plants the amount of the phosphorus that was soluble decreased from 70.4 percent on June 8 to 54.7 percent on June 15, and then to 39.7 percent at harvest on June 22. In 1934 the amount of the phosphorus that was soluble was for each week from May 16 to June 20, respectively, 57.1, 54.5, 66.6, 50, 40, and 40 percent.

In Harvest Queen the amount of the total phosphorus in the soluble form in the stems and leaves for 1932-'33 from November 2 to May 25 varied from 60 to 88 percent, with an average of 77.7 percent for 18 observations. From November 2 to May 16 during 1933-'34, the percentage ranged from 50 to 87, averaging 70.1 for 16 observations. For each of the weekly periods following May 25, 1933, the amount of the total phosphorus that was in the soluble form in the stems and leaves was 55, 66, 49 and 71 percent, respectively. In 1934 for each weekly period following May 16, the amount of soluble phosphorus was, respectively, 39, 36, 50, 80 and 55 percent of the total phosphorus present. As a general rule, there was a marked decrease in the amount of soluble phosphorus in the stems and leaves of both varieties of plants following heading.

The amount of soluble phosphorus in the chaff approximated that present in the stems and leaves during the same period. Thus in 1933 in Harvest Queen, the amount of soluble phosphorus in the stems and leaves during each week following May 25 was respectively 55, 66, 49 and 71 percent of the total phosphorus present in them. The amount of soluble phosphorus in the chaff on the same dates and on the same basis was 53, 60, 54 and 60 percent, respectively.

The amount of phosphorus in the grain that was in the soluble form was relatively large during the first week of observation, but it fell markedly during the following week and remained practically constant for the remainder of the season. Thus on May 31, 1933, the amount of phosphorus in the soluble form in the grain of Kanred was 77.7 percent. The amount, however, fell so that on June 7, 14, and 21 it was 44, 43 and 43 percent, respectively. In the grain of Harvest Queen during the same season and on the same dates the amount of total phosphorus in the soluble form was respectively 85, 42, 35, and 38 percent.

POTASSIUM METABOLISM

Percentage of total potassium. — The percentage on a dry basis of the potassium in the stems and leaves and in the various plant parts at various stages is shown in Table XX and in figure 19. The percentage of potassium in the stems and leaves was practically identical for the two varieties. The maximal amount of this element in these parts was between 5 and 6 percent. There were two maximal and two minimal percentages of potassium in the stems and leaves each year. The first maximum occurred in each year when the plants were four weeks of age, on or about the first of November. The first minimum for Kanred during the season of 1931-'32 was reached on February 10, 1932. In 1932-'33 the first minimum was reached by the plants of both varieties on January 4, and in 1933-'34 on January 17. Either directly following these minima or a few weeks thereafter, the percentage increased and reached the second maximum for both varieties on practically the same dates during the three seasons. The value of these maxima was approximately the same as the first ones. In 1931-'32 the second maximum occurred on April 13 for Kanred, in 1932-'33 it occurred on April 14, and in 1933-'34 on April 11. After these dates the percentage of potassium declined until it reached a minimum at harvest or the week preceding that time.

In 1931-'32 the minimum percentage of potassium in the stems and leaves of Kanred occurred one week before harvest. At that time it amounted to 1.7 percent and at harvest one week later it was 1.9 percent. In 1932-'33 the percentage fluctuated to a small degree in both varieties during the three weeks preceding harvest. In 1933-'34 the percentage of potassium in the stems and leaves of both varieties decreased from the second maximum to harvest.

In 1931-'32 the maximal amount of potassium in the heads of Kanred was 0.85 percent at the first analysis, on May 25, and gradually decreased to 0.46 percent on June 22 when the crop was harvested. In 1932-'33 the percentage of potassium in the heads of Kanred decreased from the first observation on May 18 to June 7, then increased the following week after which it decreased until harvest. The percentage of this element in the heads of Harvest

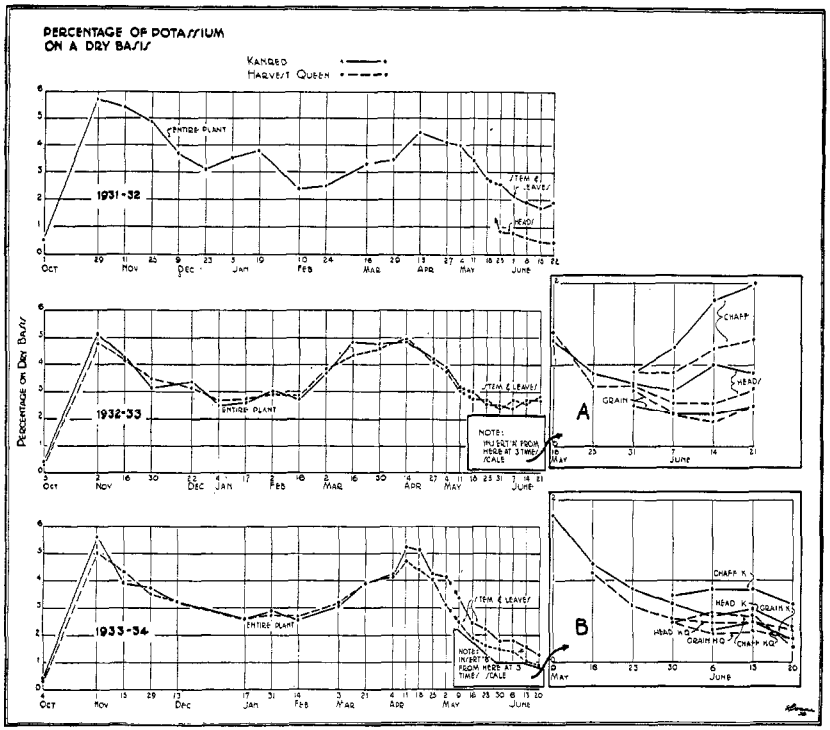

FIG. 19.—The percentage of total potassium on a dry basis in the stems and leaves, heads, chaff and grain of the plants of Kanred and Harvest Queen wheat at the various stages of growth during the three years, 1931-'32 to 1933-'34, inclusive.

Queen was slightly higher than that of Kanred on May 18, then fell below the percentage of the latter variety and remained so until the close of the season. The percentage fell to a minimum on June 7, remained constant until June 14, and then slightly increased until harvest on June 21.

The chaff of Kanred increased in the amount of potassium from slightly less than 1 percent on May 31 to approximately 2 percent at harvest. The chaff of Harvest Queen on the same date had the same percentage of potassium as Kanred, but its increase from that time until harvest amounted to only one-half that of Kanred. The

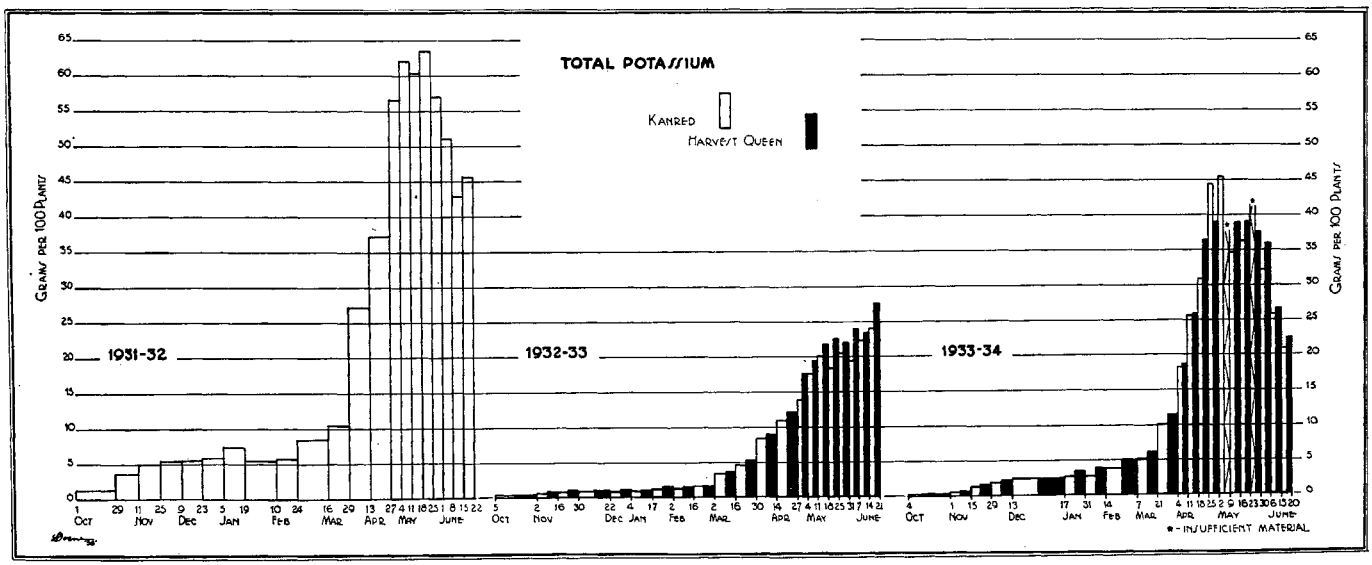

FIG. 20.—The total potassium in 100 plants of Kanred and Harvest Queen wheat at various periods of growth during the three years, 1931-'32 to 1933-'34, inclusive.

percentage of potassium in the forming grain of both varieties fell slightly the first week. In Kanred it increased slightly from that point until maturity, while in Harvest Queen it continued to fall for another week, after which it increased until the crop was harvested. In 1933-'34 the percentage of potassium in the heads of both varieties declined from its maximum at the first observation to a minimum at the time of harvest. The percentage of potassium in the chaff of Kanred was higher than that in Harvest Queen. In both plants the curve representing the percentage changes was dome shaped. The percentage of potassium in the grain of Harvest Queen decreased during the first week, remained constant the second, and then decreased during the last week. There were no data concerning potassium for the grain of Kanred the first week of grain formation, but the percentage increased during the second week and then decreased the following one.

Amount of potassium in 100 plants.— The amount of potassium expressed in grams per 100 plants at the various stages of development is shown in Table XX and in figure 20.

These sources show that in 1931-'32 the maximal content of potassium in Kanred plants was reached on May 25, four weeks before harvest. In 1932-'33 this maximum in both varieties did not occur until harvest. In 1933-'34 the maximal content of potassium in Kanred occurred on May 29, six weeks before harvest, while in Harvest Queen it occurred two weeks later on May 23, four weeks before harvest.

The results obtained for the years 1931-'32 and 1933-'34 are similar to those obtained by other investigators in that the maximal content of potassium was reached at a considerable time before harvest and then declined markedly until that time. The results for 1932-'33, however, showed that the date of the maximal content of potassium may depend upon the climatic conditions that prevail during the growing season, for during that year in both varieties it did not occur until the plants were fully matured.

Amount of potassium absorbed at each stage.— The percentage of the maximal amount of potassium that was present in the plants at the various stages of growth is shown in Table XXI and in figure 21.

From these sources it is seen that in 1931-'32 on March 29, only 16.5 percent, or approximately one-sixth of the maximal amount of potassium, had been absorbed by the plants during the 26 weeks following seeding. During the following two weeks, however, the percentage rose to 42.8, so that during that period 26.3 percent or more than one-fourth of this element was taken into the plant. During the period from April 13 to 27 approximately 16 percent of the potassium entered the plant. The maximal amount of potassium was absorbed during the week of April 27 to May 4 when 30.5 percent of this element entered the plant. Thus by May 4, approximately 90 percent of the potassium had beeen absorbed by the plant.

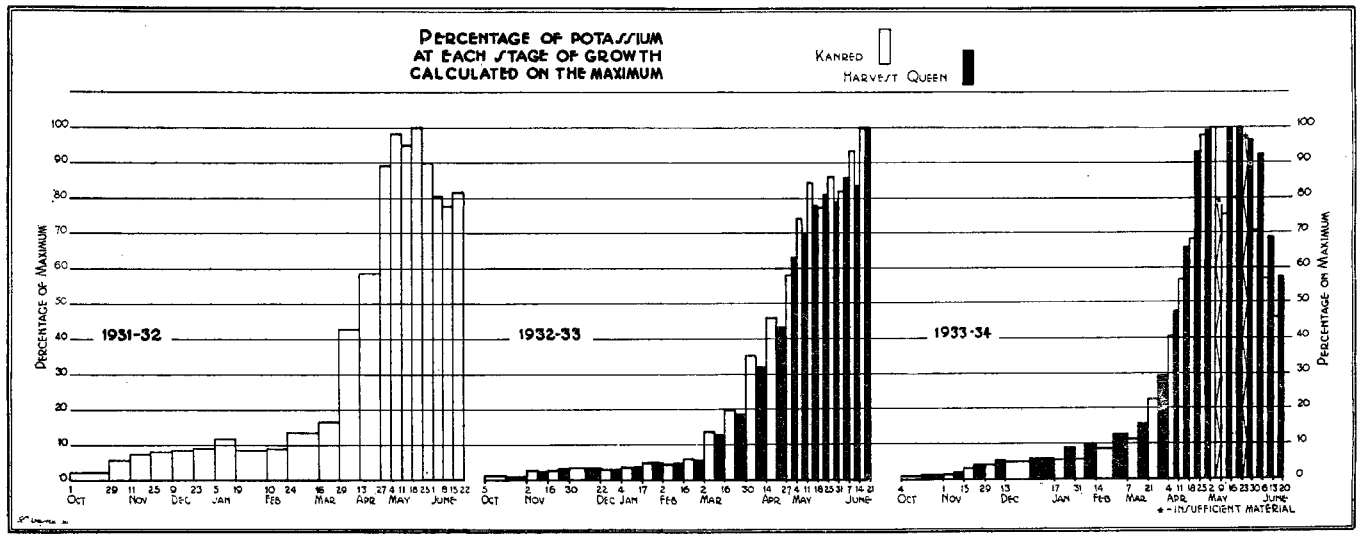

FIG. 21.—The percentage of potassium, calculated on the maximal amount, in the plants of Kanred and Harvest Queen wheat at each stage of growth during the three years, 1931-'32 to 1933-'34, inclusive.

During the following three weeks the absorption of potassium was relatively low, for during that time only 10 percent of this element was absorbed, the maximal content being attained on May 25, four weeks before harvest. The amount of potassium decreased during the following three weeks, so that by June 15 it amounted to only 67.5 percent of the maximal amount. In three weeks approximately one-third of the potassium had disappeared from the aerial parts of the plant. During the next week there was a slight increase in the absorption of potassium, as has previously been mentioned for nitrogen and phosphorus. Thus by the time of harvest on June 22 the plants contained only 71.7 percent of the maximal amount of potassium that they possessed on May 25.

In 1932-'33, on March 2, after the elapse of 21 weeks from seeding, the plants of Kanred and Harvest Queen had absorbed only 6.0 and 5.3 percent, respectively, of their total potassium. The absorption of potassium from this date until harvest was relatively uniform for each biweekly or weekly period. In Kanred the greatest amount of potassium in any biweekly period was 15.7 percent from March 30 to April 14. The greatest weekly absorption was 16.1 percent and occurred from May 4 to 11. The greatest absorption of this element during a biweekly period by Harvest Queen was 13.4 percent and occurred from March 30 to April 14, the same period during which Kanred absorbed its greatest biweekly amount. The maximal weekly absorption by Harvest Queen was 19.7 percent and occurred from April 27 to May 4. The maximal amount of potassium in both varieties was attained on June 21 at the time of harvest.

In 1933-'34 the plants of Kanred 22 weeks after seeding had absorbed only 8.6 percent of the maximal amount of their potassium. The greatest amount of absorption of this element during a biweekly period was 11.4 percent from March 21 to April 4. The increases were relatively high during each of the four weeks following April 4. They amounted to 17.6, 16.1, 11.6 and 29.7 percent, respectively, to May 2, when 97.6 percent of the maximal amount of potassium had been absorbed. The maximal amount of potassium in this variety was reached on May 9, six weeks before harvest. From that time it declined until the amount in the plants at harvest was only 45.9 percent of the maximal amount.

In 1933-'34 the absorption of potassium by Harvest Queen amounted to 9.9 percent of the total absorbed during the season. The greatest absorption for a biweekly interval was approximately 18 percent and occurred from March 21 to April 4. During the next three weeks the absorption was 18.1, 18.5 and 26.8 percent, respectively, so that on April 25 the potassium in these plants was 92.7 percent of the maximal amount. On May 2 the percentage of this element that had been absorbed reached 99.4 of the maximal which was attained three weeks later. Since the difference between the amount present in the plants at this period and three weeks later was within the limit of error of the determinations, it can be

considered that the maximal amount of potassium absorbed by these plants was reached on May 2, seven weeks preceding harvest. After May 23 the amount of potassium in the plants declined so that at harvest on June 20 it amounted to only 57.1 percent of the maximal amount.

The potassium that was lost from the aerial parts of the plant during 1931-'32 and 1933-'34 may have been removed by the defoliation of the older leaves, may have been leached from the plants by rains, or may have been translocated to the roots. The fact that the total dry matter of the aerial portions of the plants, with but one exception, continued to increase until harvest, would indicate that little or no potassium was lost from the plant by defoliation.

Since the potassium in plants is all in the soluble form, some or all of the loss may have been due to the leaching of the compounds of this element from the aerial parts. Thus on May 26 to 30, the rainfall was 1.38 inches and the loss of potassium from the stems and leaves of Kanred from May 25 to June 1 was 10 percent of that present during the preceding week. From June 1 to 8, the rainfall was 0.73 inch, while the loss of potassium was 10 percent of the amount present the preceding week. From June 8 to 15 the rainfall was 1.00 inch and the loss of potassium during that same week was 16 percent. However, from June 16 to 22, the rainfall totaled 2.38 inches but the amount of potassium in the plants was 6 percent higher than that of the previous week.

In 1933-'34 from May 6 to 15 the rainfall amounted to 3.26 inches and from May 9 to 16 the potassium of Kanred decreased 24 percent from that in the plants during the previous week. The rainfall from June 6 to 15 approximated 1.53 inches, while the loss of potassium from the plants from June 6 to 13 was 19.5 percent of the amount occurring in the plants during the previous week. From June 13 to 20 the plants lost 19.1 percent of the amount of potassium present during the previous week, while the rainfall from June 11 to 20 amounted to 1.14 inches. The weekly loss of potassium from Harvest Queen from May 23 to June *6* amounted approximately to 4.3 percent. During that period there was only a trace of rain. From June 6 to 15 there was a rainfall of 1.53 inches and a loss of potassium from June *6* to 13 of 25.3 percent of that present the preceding week. From June 13 to 20 the loss of potassium amounted to 16.5 percent and from June 11 to 20 there was a rainfall of 1.14 inches.

The losses of potassium for the most part occurred after the heading period and when there was considerable rainfall during the period under consideration. An examination of the data, however, shows that there was apparently no direct correlation between the amount of rainfall during a given period and the amount of potassium lost during that time. That the rainfall at the later stages of development may cause the loss of potassium by leaching is indicated by the fact that during 1932-'33 there was no rainfall of any consequence during May and June and that there was no loss

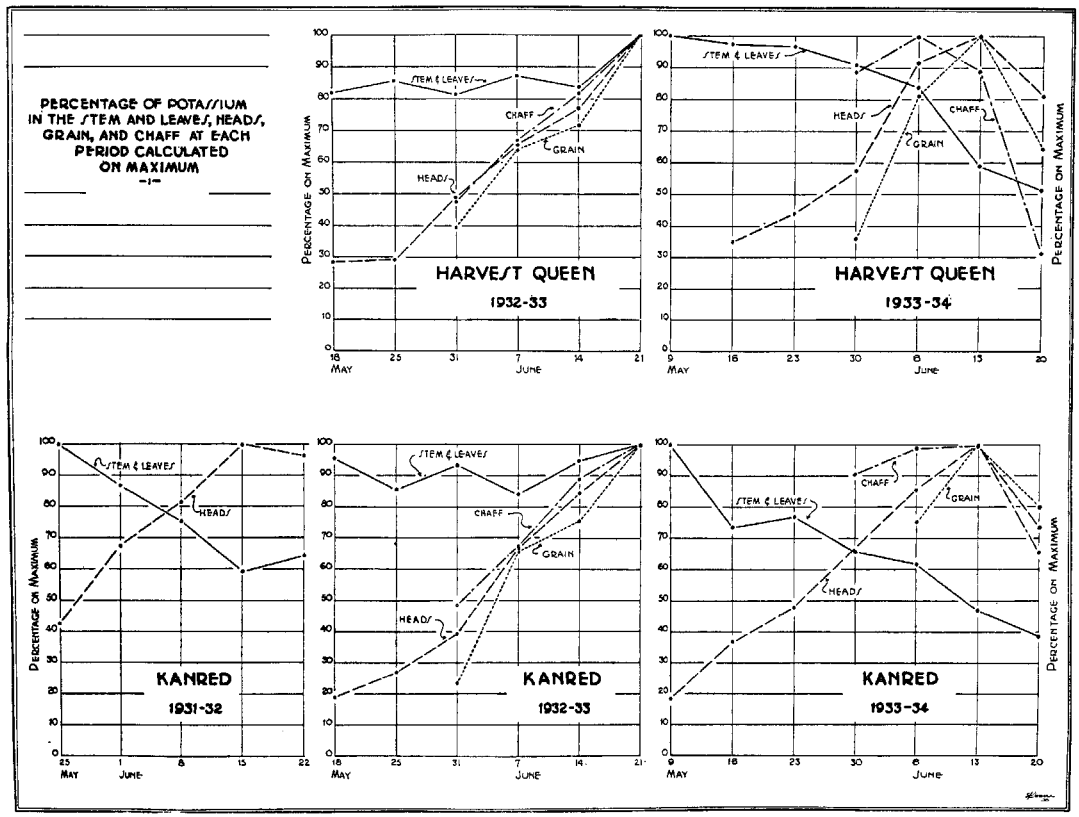

FIG. 22.—The percentage of potassium, calculated on the maximum, in the stems and leaves, heads, grain and chaff of Kanred and Harvest Queen wheat during the three seasons, 1931-'32 to 1933-'34, inclusive.

of potassium from the plant and this element continued to increase in amount until maturity. However, from June 16 to 22, 1932, there was a rainfall of 2.38 inches and the plants from June 15 to 22 made a 6 percent gain in potassium over that of the previous week.

If potassium is leached from the stems and leaves by rain during the later stages of development, it must be assumed that the permeability of the cells to the compounds of this element increases with age. Thus in 1931-'32 from April 16 to 20, there was a rainfall of 1.42 inches and during the same period in 1932-'33, a rainfall of 1.01 inches. During the same year from March 21 to 25 there was 1.08 inches of rainfall and from April 21 to 25 there was a rainfall of 1.77 inches. The plants on these dates were large, vigorously growing plants, yet at none of these stages did they show any signs of losing any potassium but all showed a marked increase in this element.

Since no satisfactory analysis of the roots can be made, it is impossible to state whether any of the potassium lost from the leaves was translocated to them as the season progressed.

The fate of the potassium in the wheat plant is an interesting problem and should be investigated under more nearly controlled conditions that are possible in ordinary experiments in the field.

Potassium in the stems and leaves, heads, chaff and grain.— The gain or loss of the potassium expressed as grams per 100 plants in the stems and leaves, heads, chaff and grain at the various stages of growth is shown in Table XXII. In Table XXIII and in figure 22 is shown the percentage of potassium in these parts at each stage, calculated on the maximal amount in them.

From these, sources it is seen that in 1931-'32 in Kanred, the potassium in the stems and leaves rapidly declined in amount from a maximum on May 25 until June 15, a week before harvest. During the week preceding harvest, this element increased in these parts to the extent that approximately one-third of the loss of the previous week was regained.

In 1932-'33 the amount, of potassium in the stems and leaves of both varieties fluctuated markedly. There were in each, three periods of gain and two periods of loss. In only one observation were these fluctuations coincident for the two varieties. That was from June 14 to 21, when both types showed an increase in potassium. In 1933-'34, with one exception, the potassium in the stems and leaves declined from a maximum on May 9 to a minimum on June 20, at the time of harvest.

The heads in both varieties showed a continual increase in the amount of potassium until harvest or until the week preceding harvest. In three cases a loss of this element occurred during the week before harvest. In 1932-'33 the chaff of Kanred and Harvest Queen showed a continual gain in potassium until harvest. In the cases examined in 1933-'34 there was an increase in this element in the chaff and then a decrease. In 1932-'33 the grain of both varieties continued to increase in potassium until it was harvested. During

the following season it showed an increase until the week preceding harvest, when it markedly decreased in both varieties.

The increase in the amount of potassium in the heads of the plants, with two exceptions, was markedly less than the loss of that element from the stems and leaves. In these two exceptions the gain of potassium in the heads approximately equaled the loss from the stems and leaves. The heads apparently received their potassium from the stems and leaves but this does not nearly account for all the loss of this element from these parts.

CARBOHYDRATE METABOLISM

REVIEW OF LITERATURE

Deherain and Dupont *(24)* found that during the entire vegetative period no starch accumulated in the leaves of wheat plants. The heads were removed from a number of plant's which were harvested the following day, together with an equal number of intact plants and the stems and leaves analyzed in each case. The quantity of carbohydrates elaborated in the stems and leaves without heads was 5.94 percent of the dry matter, while it was only 1.63 percent in these same parts on which the heads had remained. This indicated that the stems and leaves elaborated carbohydrates for the developing grain.

Brenchley *(16)* and Brenchley and Hall *(17)* observed that the sugar in the grain of wheat amounted at first to 15 percent of the dry matter, but that this fell to approximately 2 percent two weeks preceding harvest.

Colin and Belval *(20, 21)* stated that the only carbohydrates contained in the leaves of the green wheat plant were sucrose and its products of hydrolysis. Before heading the stems contained only those carbohydrates received from the leaves.

McGinnis and Taylor *(60)* found that the loss of carbohydrate material was considerable during the ripening of the grains of wheat, oats, and barley. The greater percentage of this loss occurred before desiccation began, when the grain contained about 40 percent of moisture.

Vassiljew *(88)* found that photosynthesis in the wheat plant ceased at wilting and that hydrolysis of the complex carbohydrates to simpler forms occurred. He also believed that the disappearance of all soluble carbohydrates is one of the main reasons for death of the wheat plant at permanent wilting.

Malhotra *(62)* reported the analysis of Kanred wheat for sugars, starches and hemicelluloses at various stages of growth.

McLean *(61)* found in wheat that the percentage of reducing sugar increased to a maximum in the leaves until the firm dough stage, and in the culms and heads until the milk stage, with a subsequent decline to maturity in all these parts. The maximum sucrose content of the culms and heads occurred when the kernels were in

the milk stage while in the leaves this sugar reached its maximum one week earlier.

The amount of lignin was irregular, varying from a minimum of 14.4 to a maximum of 19.7 percent. It appears from these observations that the role of lignin in producing mechanical strength may not be so important as has generally been supposed. The percentage of pentose groups of the hemicelluloses was irregular, but was lowest

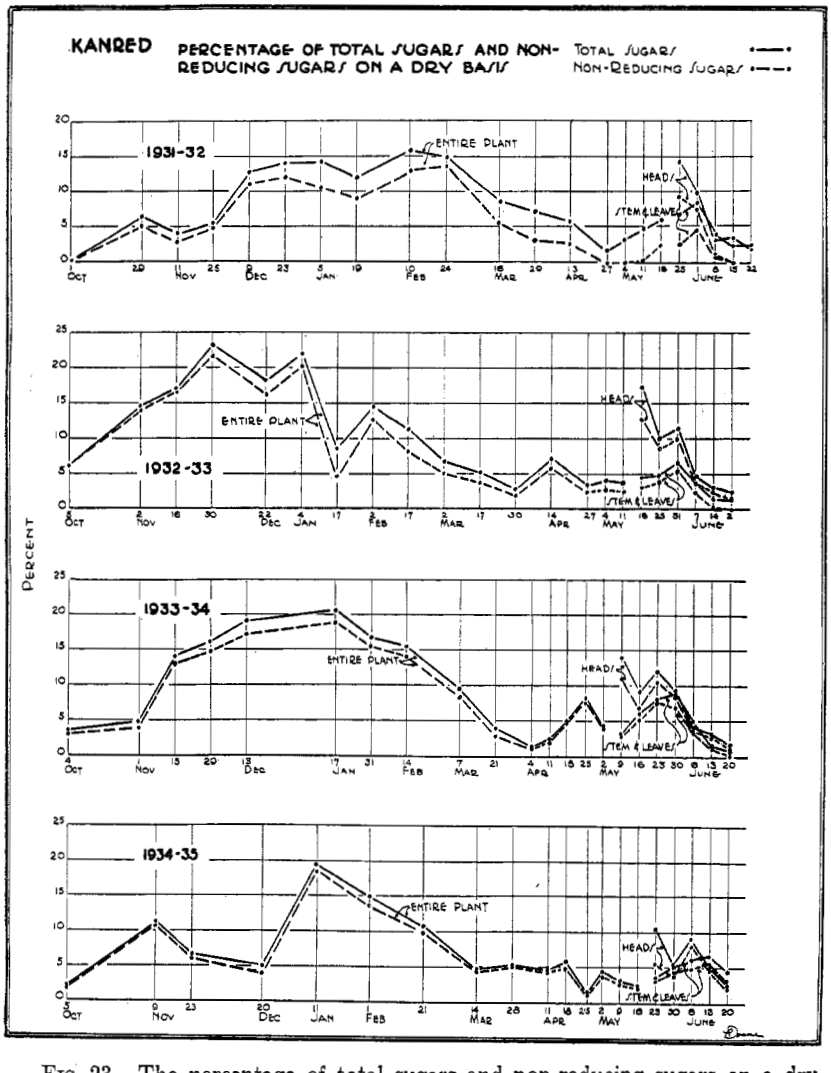

FIG. 23.—The percentage of total sugars and non-reducing sugars on a dry basis in the stems and leaves, and heads of Kanred wheat at various stages of growth during the four years, 1931-'32 to 1934-'35, inclusive.

in the mature plants, but the total amount in the plants increased with age. In the young plants the major portion of the pentose material was polyuronides, while in the mature plants it was the cellusans. The author considered it to be doubtful if either of these classes of hemicellulose could be regarded as reserves in the wheat or barley plant. He considered that although the polyuronides are

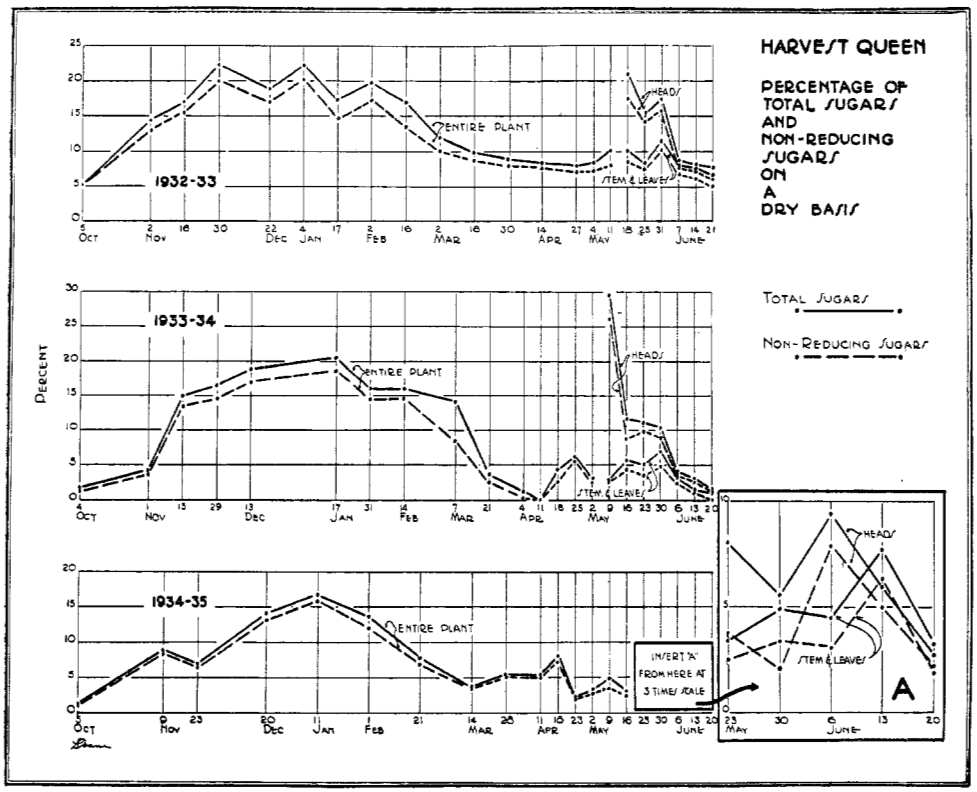

FIG. 24.—The percentage of total sugars and nonreducing sugars on a dry basis in the stems and leaves, and heads of Harvest Queen wheat at various stages of growth during the three years, 1932-'33 to 1934-'35, inclusive.

the least, stable of the structural polysaccharides, their role in cell metabolism is completely unknown at present.

McCarty *(58)* found that in the grasses *Elymus ambiguus* and *Muhlenbergia gracilis,* the seasonal march of the carbohydrates was in inverse ratio to the rate of growth of the plants.

Barnell *(7)* in England analyzed the Rivets and Wilhelmina varieties of wheat for sucrose, glucose and fructose at weekly and biweekly intervals. Sucrose always was present in the greatest amount, while glucose generally exceeded the quantity of fructose.

There was little change in the amounts of the sugars during the winter and early spring, but they began to increase towards the end of spring. They eventually rose to peak values which were attained at different times for each type of sugar, but in the same sequence each season. The glucose reached its highest value about the time of the emergence of the head, while sucrose, always the dominant sugar, rose to its maximum about two weeks later. The fructose reached its maximal value at the same time as did the sucrose and exceeded the amount of glucose until the time of harvest. Later *(8)* he studied the distribution of carbohydrates between component parts of the plant at monthly intervals from March 16 to July 24.

PERCENTAGE OF SUGARS

The percentages of the total, nonreducing and reducing sugars in the various organs of both varieties of plants at the different stages of growth are shown in Tables XXIV and XXV and in figures 23 and 24.

These sources show that the nonreducing sugars predominate in the seed and at practically all stages of development. The percentages of sugars in the seed and in the first seedlings examined four weeks after seeding are shown in the following data:

YEAR.	Kanred.		Harvest Queen.	
	Seed.	Seedlings four weeks after planting.	Seed.	Seedlings four weeks after planting.
1931-'32	0.00	6.40	0.00	0.00
1932-'33	5.97	14.77	5.25	14.55
1933-'34	3.44	4.75	1.72	4.35
1934-'35	1.55	11.36	1.36	9.08

With one exception the percentage of total sugars during the first month rapidly increased in the young plants over that of the seeds. An observation of figures 23 and 24 shows that the curves representing the changes in the percentages of sugars are different for different years but are remarkably similar for the two varieties during any one year. Thus, for example, the curves for 1933-'34 show that the percentage of sugars rose gradually until a maximum was attained by each variety on January 17. From this time the percentage declined and the minimum was reached by Kanred on April 4 and by Harvest Queen on April 11, a week later. The increases and decreases from these dates until harvest in point of time and amount were very similar.

The maximal percentages always occurred during the early stages of growth. The maximal percentage of sugars in the heads was at the first stage of formation. It then declined with some fluctuations until harvest.

AMOUNT OF SUGAR IN 100 PLANTS

The amount and kind of sugars in 100 plants are shown in Tables XXIV and XXV and in figures 25 and 26.

The amount of total sugars in the plants fluctuated more during the various stages of growth than any of the other components that were determined. There was a marked increase in sugars as vigorous growth commenced in the spring and this increase continued with slight interruptions until the maximum was reached. This maximum was striking in that with two exceptions it was exceedingly high as compared to the preceding or following week. In both varieties and for all four years the maximum amount of sugar occurred at approximately the time that the grain was in the early milk stage.

With the exception of 1931-'32, the nonreducing sugars predominated in amount until the week preceding harvest. In one case in Kanred and in two cases in Harvest Queen, the reducing sugars predominated during the week preceding harvest. The relatively large amounts of reducing sugars at various stages during 1931-'32 may be attributed to the very rapid growth of the plants as indicated in figure 1 by the large amount of dry matter produced during each stage.

SUGARS IN THE STEMS AND LEAVES, HEADS, CHAFF AND GRAIN

The percentages of total sugars and of nonreducing sugars in the grain and chaff is shown in Tables XXIV and XXV and in figures 27 and 28. From these sources it is seen that the percentage of total sugars in the grain was as high as 32.6 percent and as low as 11 percent at the first analysis. It declined rapidly at first and then more slowly until, at harvest, the amount approximated only 2 percent. The curves representing these changes differ during each year but are almost identical for the two varieties during any chosen year. The maximal percentage of sugar in the chaff ranged from 8 to 10 percent at the first analysis of these parts and then decreased as low as 0.6 percent at harvest.

The amount of total sugars in the heads of 100 plants is also shown in Tables XXIV and XXV and in figures 27 and 28. In general, the total sugars increased to a very prominent maximum and then slowly declined. The time of the maximal amount of sugar in the heads coincided exactly with that of the maximal quantity in the stems and leaves. With the exception of 1931-'32, the reducing sugars are relatively small in amount as compared to the nonreducing sugars. During that season, the reducing sugars were either equal to or composed the entire amount of the total sugars during the three weeks preceding harvest.

In general the amount of total sugars in the chaff was at a maximum at the first observation and declined to a minimum either at harvest or during the week preceding it. The total sugar in the

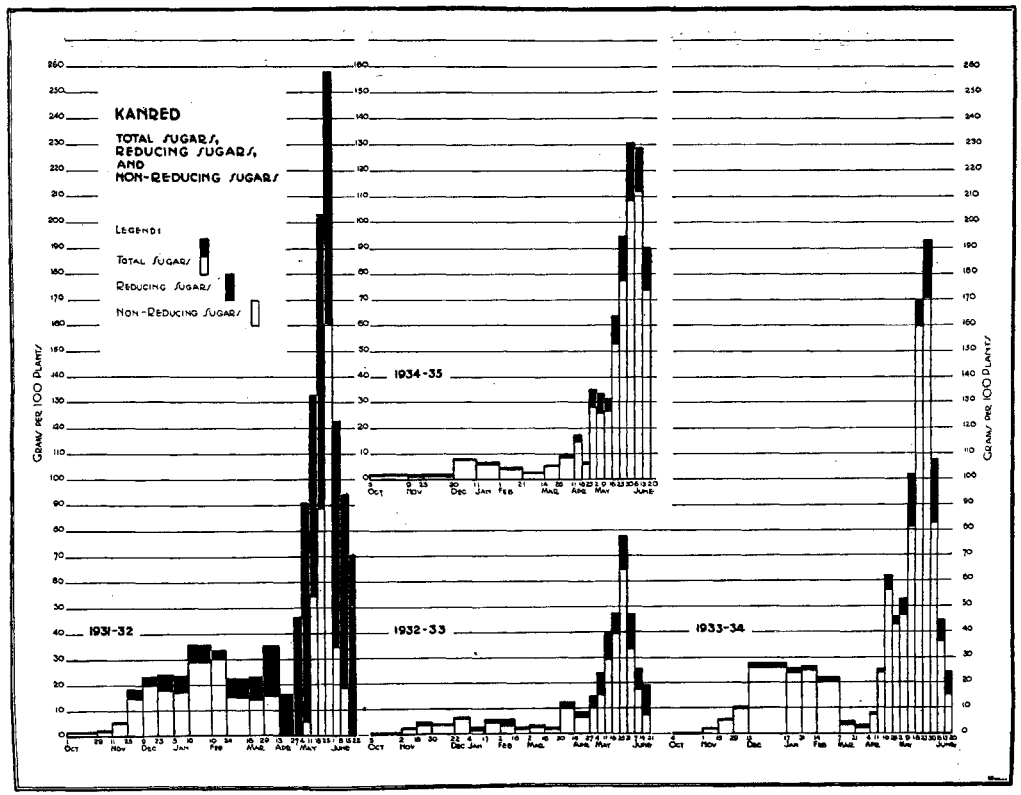

FIG. 25.—The amounts of total sugars, reducing and nonreducing sugars in 100 plants of Kanred wheat at various stages of growth during the four years, 1931-'32 to 1934-'35, inclusive.

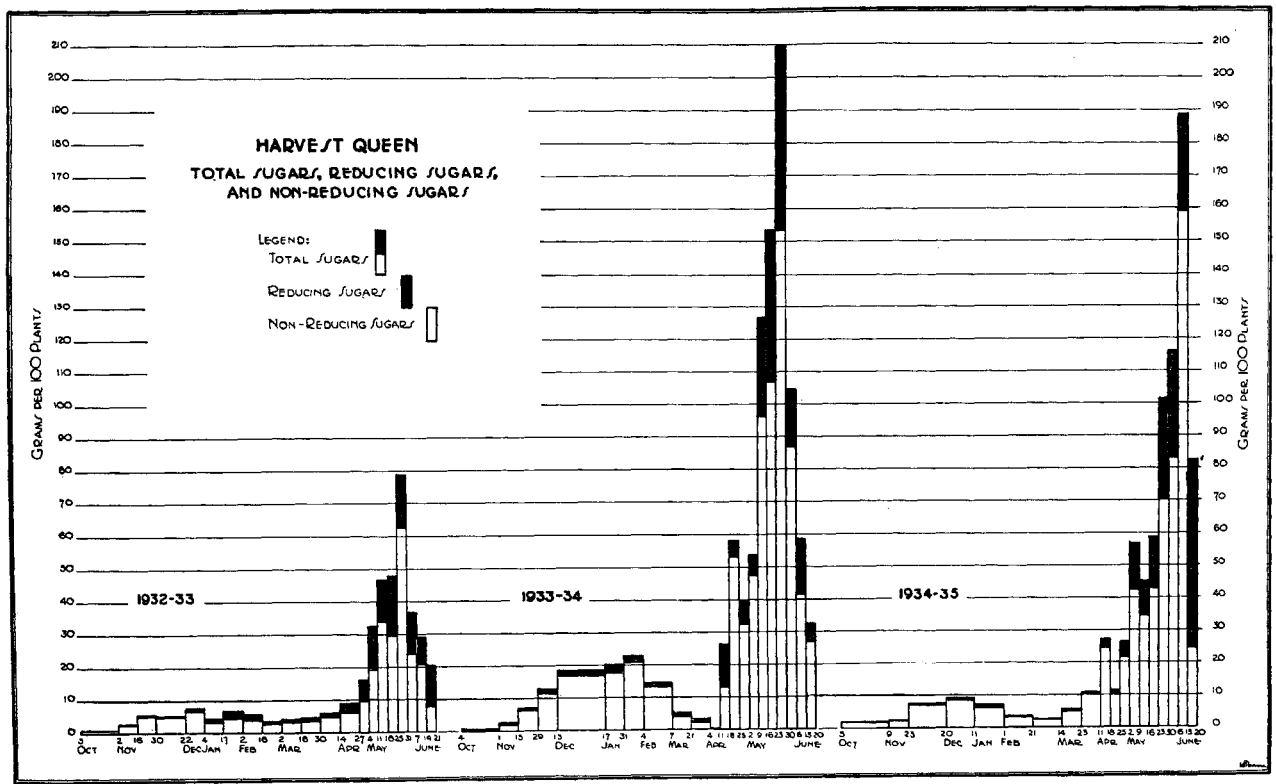

FIG. 26.—The amounts of total sugars, reducing sugars and nonreducing sugars in 100 plants of Harvest Queen wheat at the various stages of growth during the three years, 1932-'33 to 1934-'35, inclusive.

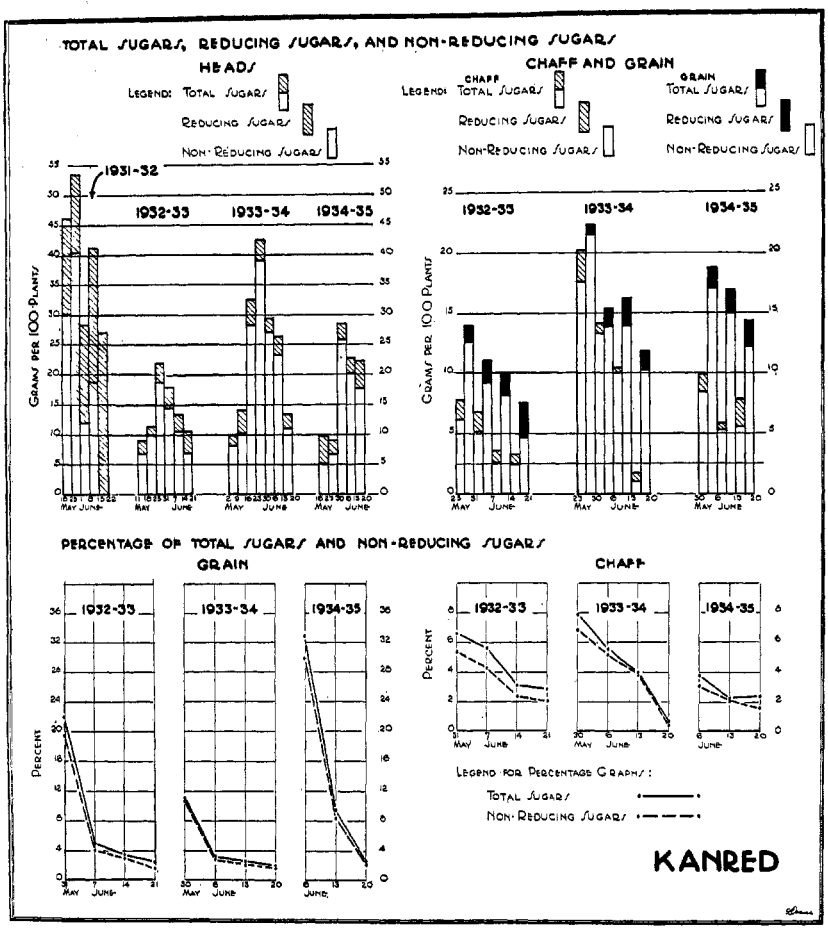

FIG. 27.—The amounts of total sugars, reducing sugars and nonreducing sugars in the heads, chaff and grain of 100 plants of Kanred wheat during the four seasons, 1931-'32 to 1934-'35, inclusive. The percentage of the total sugars and nonreducing sugars on a dry basis in the chaff, and grain of Kanred wheat during the three seasons, 1932-'33 to 1934-'35, inclusive.

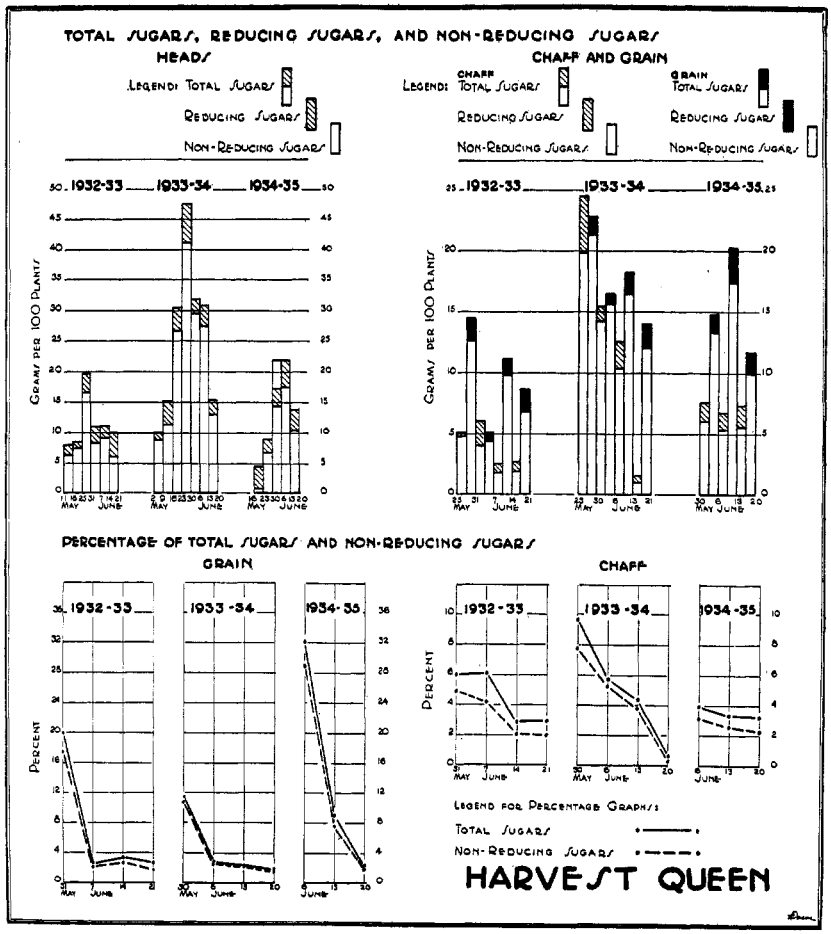

FIG. 28.—The amounts of total sugars, reducing sugars and nonreducing sugars in the heads, chaff and grain of 100 plants of Harvest Queen wheat during the three seasons, 1932-'33 to 1934-'35, inclusive. The percentage of total sugars and nonreducing sugars on a dry basis in the chaff and grain of Harvest Queen wheat during the three seasons, 1932-'33 to 1934-'35, inclusive.

grain was the highest at the first analysis of this part and generally declined to a minimum at harvest. In both the chaff and the grain the nonreducing sugars were always present in relatively large amounts as compared to the reducing sugars.

The weekly increase or decrease in grams per 100 plants of the carbohydrates included in the total sugars and starch in the stems and leaves and in the heads is given in Table XXVI.

In 19 weekly observations on Kanred the heads showed a gain in the amount of these two carbohydrates except in three cases. Two of the losses were relatively large and occurred during the week preceding harvest, while the third loss was small and occurred at the first analysis of the heads. In 15 weekly observations on Harvest Queen, the heads showed a gain in these carbohydrates except on two occasions, both of which were during the week preceding harvest. Once the losses in carbohydrates in the heads occurred at the same time for the two varieties. At present there seems to be no explanation for the marked loss in carbohydrates from the heads during the week preceding harvest.

The gains in carbohydrates by the stems and leaves occurred during the earlier stages of the formation of the head. With few exceptions the losses in the amount of these carbohydrates in the stems and leaves occurred during the three weeks preceding harvest. The greatest losses of carbohydrates from these parts were observed when the greatest increases in carbohydrates were occurring in the head. Apparently during the earlier stages of the formation of the heads, the manufacture of carbohydrates in the stems and leaves is in excess of the amount moved into the heads and as a result the stems and leaves show a gain in carbohydrates. The excess of the gain in carbohydrates in the heads over the amount lost from the stems and leaves was apparently caused by the removal of carbohydrates stored in these parts as well as that which was being manufactured by the stems and leaves. The excess of loss of carbohydrates from the stems and leaves over the gain in the heads can not be satisfactorily explained from the data at hand.

STARCHES AND HEMICELLULOSES

The amount of starch and hemicelluloses at each stage expressed as percentage on a dry basis and in the number of grams per 100 plants is shown in Tables XXVII and XXVIII.

The percentage of starch in the stems and leaves and chaff was variable, and with the exception of 1931-'32 was relatively low, rarely exceeding 2 percent and more frequently amounting to only a fraction of 1 percent. The amount of starch in the stems and leaves of Kanred during 1931-'32 varied from zero to over 9 percent. Due apparently to the unusual amount of vegetative growth of the plants during that year, the carbohydrate metabolism was different from that shown by the plants during each of the succeeding years.

The grain of Kanred that was sown contained 46.2, 35.1, 31.8 and 30.4 percent, respectively, of starch for each year. The grain of Harvest Queen that was sown contained 33.5, 33.1 and 26.6 percent of starch, respectively, for each of the three years. The maximal percentage of starch in the grain that was produced each year was 36.5, 33.6 and 28.9, respectively, for Kanred and in the same sequence 36.3, 32.6 and 29.9 for Harvest Queen.

The starch in the grain was deposited for the most part during the four weeks preceding harvest. The percentage of the starch in the grain at each date, calculated on the maximal amount present is shown by the following:

DATE.	Kanred.	Harvest Queen.
1932-'33.		
May 31	10.59	14.52
June 7	78.74	39.48
June 14	96.82	100.00
June 21	100.00	94.92
1933-'34.		
May 30	24.75	20.49
June 6	76.00	76.41
June 13	100.00	100.00
June 20	96.18	94.27
1934-'35.		
June 6	13.82	13.06
June 13	20.71	31.43
June 20	100.00	100.00

The amount of hemicelluloses in the grain that was sown ranged from 6 to 7 percent for Kanred and from 6 to 7.7 percent for Harvest Queen. In the grain of Kanred that was produced, the percentage of hemicelluloses was 6.7, 6.6, and 7.6, respectively; for the consecutive years and in the same sequence 7.5, 7.3 and 7.2 for Harvest Queen. The amount of hemicelluloses in the young plants was relatively low, varying from 1 to 5 percent. It gradually increased with considerable fluctuations to a maximum at or about blooming. From blooming until maturity the percentage of hemicelluloses in the stems and leaves fell somewhat below the maximum during the formation of the grain. The amount of hemicelluloses in the chaff was always from 7 to 9 percent greater than that of the stems and leaves. The amount of hemicellulose in the entire plant expressed in grams per 100 plants increased until harvest. It seems that none of this carbohydrate was utilized in any manner by the wheat plant.

SUMMARY

1. Kanred and Harvest Queen wheats were grown in alternate rows in the field during the three years, 1932-'33 to 1934-'35, inclusive, In 1931-'32 only Kanred wheat was grown.

2. Samples of these plants were collected for analysis each year, beginning four weeks after seeding and then at biweekly intervals, if the weather permitted, until elongation started in the spring, after which samples were collected weekly until maturity.

3. The aerial portions of the plant, including the crown, were taken, but no attempt was made to collect the roots. The heads were removed from the stalks, beginning at a period before they had emerged from the "boot." When the grain began to form the heads were further divided into chaff and grain.

4. The rate of growth during any of the periods was expressed by the increase in grams in the dry weight of 100 plants. The analyses of the various components were expressed on a percentage basis and on the amount present in grams in 100 plants.

5. The collected material was dried at a mild heat, ground in a Wiley mill and in a mortar to the fineness of a 40-mesh sieve. It was then heated 12 hours at 100° to 105° C. before samples were weighed for analysis.

6. The dried material was analyzed for total nitrogen, protein nitrogen and protein-free nitrogen for four years. For total phosphorus, insoluble phosphorus, water-soluble phosphorus and total potassium for the first three years. For total sugars, reducing sugars, nonreducing sugars, starches and hemicelluloses for all four years.

7. The maximal and minimal temperatures of each day were recorded during the four seasons, together with the rainfall. The percentage of water in the soil was also determined at various periods during the spring and summer.

8. With a few exceptions, the total dry weight of the plants increased to the time of harvest. In 1933-'34 both varieties showed a decrease in dry weight during the two weeks preceding harvest. These decreases did not exceed 3.8 percent of the weight of the previous weekly sample.

9. The biweekly or weekly increments in dry weight varied widely, but the factors causing such marked variations could not be determined definitely. The maximal weekly increases in dry weight occurred between the beginning of jointing in late April or early May and the beginning of blooming a few weeks later. For example, during the week from May 4 to 11, 1933, Kanred plants absorbed and manufactured 18 percent of the total dry matter produced by them during the year.

10. Wheat plants grown in the same soil varied markedly in their production of dry matter during different years. The greatest dry weight of the plants of Kanred occurred in 1932. This weight was 3.00, 1.55 and 1.42 times, respectively, the dry weight of the

plants in 1933, 1934, and 1935. The greatest dry weight of the plants of Harvest Queen was produced in 1934. This weight, was 2.35 and 1.11 times, respectively, that of the plants of this variety at maturity in 1933 and 1935.

11. The dry weight of the aerial portion of Harvest Queen, with three exceptions, was greater than that of Kanred at all stages. At the time of harvest in 1933, 1934 and 1935, the weight of the plants of Harvest Queen was respectively 1.11, 1.41 and 1.16 times that of the plants of Kanred.

12. The heads of wheat at maturity composed from 25 percent to 40 percent of the total dry weight of the plants. This relative proportion of dry matter depended upon the kind of season and the type of plant.

13. After blooming, with a few exceptions, the dry matter decreased in the stems and leaves and increased in the heads. The increase in the amount of dry matter in the heads, however, was greater than the decrease in the stems and leaves. Thus apparently some of the materials in the stems and leaves was withdrawn from them and moved to the heads. The greater portion of the increase in dry matter in the heads was, however, from materials that were translocated to them immediately after their absorption or manufacture by the stems and leaves.

14. The percentage of nitrogen in the two varieties was almost identical for each period. There were two slight but well defined maximal percentages of total nitrogen during each year. The first occurred in the four-week seedlings and the second near the middle of March. After March the percentage of nitrogen in the stems and leaves gradually declined until harvest. The amount of nitrogen in the stems and leaves ranged slightly over 5 percent to less than 1 percent at harvest.

15. The percentage of the total nitrogen in the chaff decreased in both varieties from the beginning of the formation of grain until maturity. The percentage of total nitrogen in the grain of the two varieties varied in a like manner during any one year. Thus during one year it decreased in both varieties from the beginning of grain formation until maturity, while during another year it decreased for a time and then increased.

16. The amount of nitrogen expressed in grams per 100 plants generally increased in amount from the seedling stage in early October until the middle of May. The decrease in nitrogen during each weekly period after that time varied from 1.5 percent to 17.5 percent of the total amount present during the preceding week. The causes for the decreases in the amounts of nitrogen in the plants during the four or five weeks preceding harvest could not be explained satisfactorily.

17. The amount of nitrogen absorbed by wheat plants from October until March was very small. During the first two-thirds of the life of the plants, not to exceed 22 percent and not less than 8 percent of the maximal amount of nitrogen in the plant had been

absorbed. From four-fifths to nine-tenths of the nitrogen in the plants were absorbed during the seven to twelve weeks following the middle of March.

18. The maximal amount of nitrogen in the stems and leaves occurred at or about the time of heading, and in general it decreased from that time until harvest. The minimal decrease in the amount of nitrogen in the stems and leaves from heading until maturity was 24 percent and the maximal decrease was 74 percent.

19. The amount of nitrogen began to increase in the heads at about the same time as it began to decrease in the stems and leaves. With one exception, the heads of both varieties showed a continuous increase in the amount of nitrogen from their emergence until harvest.

20. In 15 of the 27 observations, the gain of nitrogen in the heads was greater than the loss of this element from the stems and leaves. This excess nitrogen thus must have been absorbed from the soil and translocated to the heads. In 12 of the 27 observations, the gain in the amount of the nitrogen in the heads was less than the loss in the amount of this element in the stems and leaves. The nitrogen thus lost from the stems and leaves may have escaped by leaching, by translocation to the roots, by a slight defoliation, or perhaps by all three of these methods.

21. The amount of total nitrogen in the chaff, with one exception, decreased at every period. The amount of nitrogen in the grain showed an increase at each period from the beginning of its formation until maturity.

22. The protein-free nitrogen in the stems and leaves ranged from 14 percent to 38 percent of the total nitrogen. At most of the stages examined the protein-free nitrogen approximated 25 percent of the nitrogen present. The relative amounts of the protein-free nitrogen remained strikingly constant in the stems and leaves during the life of the plants. The protein-free nitrogen in the grain, with one exception, decreased in amount from the beginning of its formation until maturity.

23. The amount of total phosphorus in the stems and leaves and other aerial parts never reached one percent on a dry basis. The amount of total phosphorus in the stems and leaves varied from a maximal of slightly over 0.8 percent to a minimal amount of about 0.03 percent. The maximal percentage was reached in the first seedlings and the minimal percentage at or about harvest.

24. The percentage of the total phosphorus in the stems and leaves varied but little for the two varieties. The percentage of the total phosphorus in the chaff of the two varieties was approximately the same and showed a marked decrease from head formation until harvest. The percentage of total phosphorus in the grain of Harvest Queen was always higher than in the grain of Kanred.

25. With one exception, the amount of total phosphorus in 100 plants reached its maximum at harvest. There were, however, marked decreases in the amount of total phosphorus at numerous

times. The losses in phosphorus at these times were apparently not due t0 leaching, since the date of the losses does not correlate with the time of rainfall.

26. The plants absorbed from 12 to 25 percent of their total phosphorus by the first of March. Following this date the absorption of phosphorus was very rapid. Thus, in one case, 48.5 percent of the total phosphorus in the plant was absorbed during the four weeks following April 27. In another case, during the month following May 4, 55.6 percent of the total phosphorus entered the plant. Apparently this element is absorbed by the plant as it is needed.

27. In general, the amount, of phosphorus in the stems and leaves decreased from a maximum at or about, heading to a minimum at or about, harvest. With one exception, the amount of phosphorus in the heads increased in amount from their appearance until harvest. In the majority of observations the gain of total phosphorus in the head was greater than the loss or gain of this element in the stems and leaves. Thus, apparently a part of the phosphorus that was migrating into the heads came directly from the soil.

28. With a single exception, the amount of total phosphorus in the grain of both varieties increased from the beginning of its formation until harvest.

29. The water-soluble phosphorus for the most part was much greater than that in the insoluble form. The amount of soluble phosphorus frequently decreased in amount at or near harvest. The amount of soluble phosphorus varied from more than 96 percent to less than 40 percent of the total phosphorus. The amount of water-soluble phosphorus averaged or approximated about 75 percent of the total phosphorus.

30. The amount of soluble phosphorus in the grain of both varieties fell from a maximum of 80 percent of the total phosphorus present at the beginning of grain formation to a minimum of 38 percent at harvest.

31. The percentage of potassium in the stems and leaves was almost identical for the two varieties. The maximal amount was between 5 and 6 percent and the minimal amount about 1 percent. There were two marked maximal and minimal percentages of potassium in the stems and leaves during each season. The first maximum occurred when the plants were four weeks of age, and the second maximum during the first two weeks of April. The most marked minimum occurred at or near harvest.

32. In 1931-'32 the maximal amount of potassium in 100 Kanred plants occurred four weeks before harvest. In 1932-'33 the maximal amount of this element was not reached until harvest. In 1933-'34 the maximal amount of potassium was reached in Kanred six weeks preceding harvest and in Harvest Queen four weeks before harvest.

33. By the middle of March each year, or approximately 25 weeks after seeding, the amount of potassium that had been absorbed by the plants did not exceed 12 percent of the maximal amount. As soon as rapid growth began in the spring the absorption of po-

tassium markedly increased. Thus, during the two weeks following March 29, 1932, more than one-fourth of the maximal amount of potassium in the plant was absorbed. During the week following April 27, 1932, 30.5 percent of the maximal amount of this element entered the plant.

34. In 1931-'32 and 1933-'34 the amount of potassium in the stems and leaves rapidly declined from a maximum until harvest. At harvest on June 22, 1932, the aerial parts of the plants contained only 71.7 percent of the maximal amount of potassium that they possessed on May 25, four weeks before. When Harvest Queen plants were harvested on June 20, 1934, they contained only 57.1 percent of the maximal amount of potassium that they contained four weeks earlier. The plants of Kanred harvested at the same date contained only 45.9 percent of the amount of potassium that they showed on May 9, six weeks before.

35. There is some evidence that potassium might have been leached from the aerial parts by rain during the three to six weeks preceding harvest. In some cases the losses of potassium during that period were apparently correlated with the rainfall during the same time. In 1932-'33 there was no loss of potassium from the plants of either variety and it continued to increase in amount until harvest. There was no rainfall of any consequence for that year during the nine or ten weeks preceding the harvest.

36. If it is assumed that potassium is leached from the wheat plants by rain during their later stages of development, then it also must be assumed that the permeability of the protoplasmic membrane of the cells to the compounds of this element changes with age. When vigorous growth was occurring in the spring, there were marked gains in the amount of potassium in the plants although in many cases heavy rainfall was recorded.

37. The heads of both varieties of plants showed a continual increase in the amount of potassium until harvest or until the week preceding harvest. The increase in the amount of potassium in the heads, with two exceptions, was markedly less than the loss of that element from the stems and leaves.

38. The nonreducing sugars predominated in the seed and at practically all stages of the development of the wheat plants. The changes in the percentages of sugars were different for different years but were remarkably similar for the two varieties during any given year. The maximal percentage of sugars always occurred during the earlier stages of growth. In the heads, the maximal percentage of sugars was at the first stage of formation. It then declined with some fluctuations until harvest.

39. The amount of total sugars in the plants fluctuated more during the various stages of growth than any of the other components that were determined. There was a marked increase in the amount of sugars per 100 plants when vigorous growth commenced in the spring. This increase continued with slight interruptions until the maximum was reached.

40. In both varieties of plants and for all four years the maximal amount of sugar in 100 plants occurred approximately at the time that the grain was in the early milk stage. The maximal sugar content was striking in that with two exceptions, it was exceedingly high as compared to the preceding or the following week.

41. In the heads, the total sugars increased to a very prominent maximum and then slowly declined. The time of the maximal amount of sugar in the heads coincided exactly with that of the maximal quantity of sugar in the stems and leaves.

42. In 16 of the 19 weekly observations on Kanred, the heads showed a gain in the combined amount of sugars and starch and a loss in three instances. Two of the losses were relatively large and occurred during the week preceding harvest, while the third loss was small and occurred at the first analysis of the heads. In 15 weekly observations of Harvest Queen the heads showed a gain in the combined amount of starch and sugar in 13 cases and a decrease in two cases. Both of these losses were during the week preceding harvest.

43. The greatest gains in the amount of carbohydrates in the stems and leaves occurred during the earlier stages of the formation of the heads. With few exceptions, the losses in the amount of carbohydrates occurred during the three weeks preceding harvest. The greatest losses of carbohydrates from the stems and leaves were observed when the greatest increases in carbohydrates were occurring in the heads.

44. In four observations of Kanred and in three of Harvest Queen the combined gain of sugars and starches in the heads exceeded the loss of these components from the stems and leaves. In five analyses of Kanred and in three analyses of Harvest Queen the gains of these two carbohydrates in the heads were less than their loss from the stems and leaves. In seven observations each of Kanred and Harvest Queen, there was a gain in combined amount of total sugars and starch in both the stems and leaves and heads. In two observations of each variety there was a loss of these carbohydrates from both the stems and leaves and the heads. In Kanred in one instance there was a loss of these carbohydrates from the heads but a gain in the stems and leaves.

45. The percentage of starch in the stems and leaves and chaff was variable and with the exception of 1931-'32 was relatively low. The amount rarely exceeded 2 percent and more frequently it amounted to only a fraction of 1 percent. The percentage of starch in the grain varied from 27 percent to 37 percent and was deposited for the most part during the four weeks preceding harvest.

46. The hemicelluloses increased in amount in the plant from the seedling stage to maturity but apparently they were in no way utilized by the plants.

47. There were no striking differences in the amount or distribution of the various components determined, between Kanred, a typi-

cal hard winter wheat, and Harvest Queen, a typical soft winter wheat, when grown under the same conditions.

48. It should be emphasized that the data obtained is relevant only to the conditions under which the plants were grown. Under conditions that are different from those which prevailed in these experiments, different results might be observed.

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APPENDIX

TABLE I.—General facts concerning wheat plants for May and June during the four seasons, 1931-'32 to 1934-'35. Manhattan, Kan.

DATE.	Kanred.			Harvest Queen.	
	Height.		General.	Height.	
1931-'32.	*Ft.*	*In.*		*Ft.*	*In.*
May 11	3	2	Boot leaf fully opened but head scarcely noticeable in sheath		
May 18	3	9	One-half of heads out of sheath. Few heads in bloom		
May 25	4	4	Blooming finished		
June 1	4	4	Grain in early milk stage		
June 8	4	4	Grain in early dough stage		
June 15	4	4	Grain in late dough stage		
June 22	4	4	Grain fully ripe		
1932-'33.					
May 11	2	4		2	6
May 18	2	6	Between booting and heading	2	8
May 25	3	0	Blooming mostly finished	3	6
May 31	3	4	Grain in milk stage	3	10
June 7	3	4	Grain in early dough stage	3	10
June 14	3	4	Grain in late dough stage	3	10
June 21	3	4	Grain fully ripe	3	10
1933-'34.					
May 9	2	6	Only 5 percent of heads in the boot	3	0
May 16	2	9	Boot stage	3	4
May 23	3	8	Blooming finished	4	0
May 30	3	10	Grain in early milk stage	4	2
June 6	4	0	Grain in early dough stage	4	4
June 13	4	0	Grain in late dough stage	4	4
June 20	4	0	Grain fully ripe	4	4
1934-'35.					
May 9	2	8		2	10
May 16	3	3		3	5
May 23	3	7	Heads just emerging from boot	4	0
May 30	4	1	Blooming	4	7
June 6	4	1	Grain in early milk stage	4	7
June 13	4	1	Grain in early dough stage	4	7
June 20	4	1	Grain in late dough stage	4	7

TABLE II.—Summary of the climatic conditions at Manhattan, Kan., for the wheat seasons of 1931-'32, 1932-'33, 1933-'34, and 1934-'35

DATE.	Air temperature (degrees F.).					Precipitation.
	Maximum.	Minimum.	Average of—			
			Max.	Min.	Mean.	
1931-'32.						*In.*
Oct. 1- 5	90	52	84	60	72	.72
6-10	92	47	82	57	70	.....
11-15	82	42	70	49	60	1.11
16-20	32	33	74	44	59	.....
21-25	84	42	74	54	64	T
26-31	83	33	61	42	52	.21
Nov. 1- 5	74	22	67	31	49	.....
6-10	83	24	74	42	58	.10
11-15	73	35	66	45	56	2.25
16-20	70	32	61	43	52	.55
21-25	55	20	48	31	40	1.78
26-30	42	25	39	31	35	.44
Dec. 1- 5	51	21	43	24	34	T
6-10	54	21	49	30	40	.24
11-15	53	18	46	25	36	.11
16-20	64	21	56	29	43	.....
21-25	62	26	55	36	46	.....
26-31	62	26	56	35	46	.11
Jan. 1- 5	37	15	33	23	28	.59
6-10	39	1	34	11	23	T
11-15	55	10	38	21	30	T
16-20	60	22	47	29	38	.....
21-25	44	14	39	24	32	.....
26-31	47	1	32	13	23	.22
Feb. 1- 5	55	2	38	15	27	.01
6-10	69	22	57	31	44	.....
11-15	66	17	43	27	35	.17
16-20	59	18	44	24	34	.65
21-25	73	28	60	31	46	.....
26-29	81	33	74	39	57	.....
Mar. 1- 5	65	5	47	28	38	.31
6-10	22	—3	17	3	10	.04
11-15	65	7	40	14	27	.....
16-20	66	29	56	31	44	.01
21-25	73	23	57	29	43	.04
26-31	76	24	67	36	52	.....
Apr. 1- 5	86	33	82	46	64	.....
6-10	73	31	70	44	57	.01
11-15	82	29	73	35	54	.....
16-20	77	44	67	48	58	1.42
21-25	83	46	71	56	64	.46
26-30	70	32	61	42	52	.02
May 1- 5	85	38	79	55	67	.09
6-10	80	48	74	53	64	1.15
11-15	89	42	84	49	67	.....
16-20	86	38	75	46	61	.05
21-25	89	47	88	58	73	.....
26-31	85	42	74	54	62	1.38
June 1- 5	89	60	86	63	75	.73
6-10	93	57	87	62	75	.....
11-15	90	57	87	58	73	1.00
16-20	99	56	87	61	74	2.38
21-25	91	59	86	65	76	.....
26-30	97	57	87	63	75	.77

TABLE II.—*Continued*

DATE.	Air temperature (degrees F.).					Precipitation.
	Maximum.	Minimum.	Average of—			
			Max.	Min.	Mean.	
1932-'33.						*In.*
Oct. 1- 5	85	31	70	45	58	T
6-10	85	33	68	43	56	.22
11-15	88	30	81	44	63	.21
16-20	87	32	78	41	60	.....
21-25	77	33	64	44	54	.17
26-31	73	27	58	32	45	.....
Nov. 1- 5	72	21	65	31	48	T
6-10	66	26	50	34	42	.22
11-15	67	17	50	23	37	.02
16-20	62	5	45	19	32	.....
21-25	59	15	54	24	39	.....
26-30	73	14	59	22	41	.....
Dec. 1- 5	68	30	62	36	49	.....
6-10	54	5	24	10	17	.20
11-15	35	—11	22	1	12	.10
16-20	43	—14	32	4	18	.....
21-25	52	24	46	29	38	1.04
26-31	51	15	44	23	34	.....
Jan. 1- 5	58	19	53	25	39	.....
6-10	59	23	57	30	44	.....
11-15	61	15	51	21	36	.....
16-20	60	18	51	25	38	.12
21-25	68	20	60	29	45	.....
26-31	62	16	51	25	38	.....
Feb. 1- 5	48	4	44	11	28	T
6-10	50	—19	17	—6	6	.08
11-15	51	—5	40	10	25	.....
16-20	58	13	54	26	40	.....
21-25	73	24	66	33	50	.....
26-28	67	15	64	24	44	.....
Mar. 1- 5	66	22	56	32	44	.58
6-10	49	14	43	27	35	.06
11-15	79	19	66	35	51	.....
16-20	78	19	58	33	46	.10
21-25	56	15	48	27	38	1.08
26-31	77	32	71	42	57	.15
Apr. 1- 5	71	29	60	37	49	.02
6-10	83	25	69	43	56	.01
11-15	72	23	65	31	48	.04
16-20	82	27	74	44	59	1.01
21-25	72	40	66	46	56	1.77
26-30	83	37	75	49	57	.01
May 1- 5	66	44	60	46	53	.73
6-10	87	37	73	49	61	.....
11-15	81	40	74	47	61	.07
16-20	97	55	90	64	77	.03
21-25	86	50	83	61	72	.59
26-31	93	45	87	52	70	.15
June 1- 5	106	57	97	66	82	.....
6-10	109	66	103	73	88	.....
11-15	105	44	94	54	74	T
16-20	102	61	99	66	83	.....
21-25	107	67	105	72	89	.....
26-30	110	68	104	71	88	.69

TABLE II.—*Continued*

DATE.	Air temperature (degrees F.).					Precipitation.
	Maximum.	Minimum.	Average of—			
			Max.	Min.	Mean.	
1933-'34.						*In.*
Oct. 1–5	85	36	80	40	60	.....
6–10	80	30	71	37	54	.....
11–15	81	37	74	48	61	T
16–20	74	33	68	41	55	.99
21–25	70	30	64	37	51	.....
26–31	83	31	76	50	63	.04
Nov. 1– 5	83	24	59	38	49	.18
6–10	67	23	56	26	41	.....
11–15	71	23	62	34	48	.....
16–20	76	25	65	33	49	.....
21–25	69	27	59	36	48	.02
26–30	72	31	66	38	52	.....
Dec. 1– 5	64	34	57	40	49	.69
6–10	65	20	56	29	43	.....
11–15	66	16	47	23	35	.....
16–20	65	6	53	19	36	.....
21–25	72	15	56	24	40	T
26–31	54	6	40	19	30	.....
Jan. 1– 5	40	15	34	32	28	.55
6–10	46	17	35	22	29	T
11–15	58	24	48	28	38	.07
16–20	64	19	56	25	41	.....
21–25	68	14	56	31	44	T
26–31	69	3	49	17	33	T
Feb. 1– 5	71	19	60	26	43	.....
6–10	65	19	50	22	36	.....
11–15	76	25	62	31	47	.19
16–20	66	7	53	21	37	.25
21–25	39	7	29	14	22	.50
26–28	39	—16	26	—3	12	.....
Mar. 1– 5	62	31	57	35	46	.01
6–10	53	8	47	20	34	T
11–15	80	18	65	33	49	.....
16–20	86	10	72	25	49	.01
21–25	70	17	51	28	40	.01
26–31	76	13	60	31	46	.28
Apr. 1– 5	80	41	71	50	61	.39
6–10	90	37	78	45	62	T
11–15	79	30	69	40	55	.10
16–20	82	31	71	37	54	T
21–25	77	29	72	41	57	.....
26–30	86	39	78	48	63	.03
May 1– 5	84	52	77	57	67	.91
6–10	93	53	89	58	74	.71
11–15	87	45	79	51	65	2.55
16–20	90	47	86	58	72	.....
21–25	90	39	82	53	68	T
26–31	103	46	94	57	76	.....
June 1– 5	104	63	98	69	84	T
6–10	102	59	98	70	84	.53
11–15	97	54	93	63	78	1.00
16–20	104	56	93	65	79	.14
21–25	106	61	101	70	86	.22
26–30	109	75	105	77	91	.....

TABLE II.—*Concluded*

DATE.	Air temperature (degrees F.).					Precipitation.
	Maximum.	Minimum.	Average of—			
			Max.	Min.	Mean.	
1934-'35.						*In.*
Oct. 1- 5	85	48	81	53	67	.....
6-10	90	42	83	51	67	.....
11-15	87	48	84	52	68	.01
16-20	84	51	73	56	65	.62
21-25	84	40	80	45	63	.....
26-31	85	23	67	34	51	.....
Nov. 1- 5	67	19	61	34	48	.54
6-10	77	33	70	37	54	.....
11-15	74	23	64	30	47	.....
16-20	68	46	63	49	56	1.35
21-25	58	25	51	34	43	1.08
26-30	60	28	45	35	40	.82
Dec. 1- 5	49	20	45	25	35	.....
6-10	35	—2	30	15	23	.05
11-15	55	6	44	24	34	.....
16-20	52	23	46	27	37	.15
21-25	53	18	43	26	35	.....
26-31	52	5	36	21	29	T
Jan. 1- 5	56	11	51	23	37	.....
6-10	59	24	51	30	41	.16
11-15	54	20	45	28	37	.01
16-20	62	—2	44	19	32	.04
21-25	65	—7	37	6	22	.....
26-31	55	15	44	23	34	.....
Feb. 1- 5	72	18	56	26	41	.....
6-10	47	21	36	27	32	.33
11-15	56	27	49	34	42	.20
16-20	59	25	52	30	41	.04
21-25	73	12	56	28	42	.55
26-28	56	—1	42	13	28	.....
Mar. 1- 5	68	31	64	37	51	.12
6-10	52	9	47	28	38	.09
11-15	82	26	65	43	54	.....
16-20	73	17	65	37	51	T
21-25	84	47	78	53	66	.....
26-31	80	27	66	39	53	T
Apr. 1- 5	58	25	53	32	43	.....
6-10	62	27	53	37	45	.34
11-15	86	25	64	35	50	T
16-20	78	33	68	39	54	.04
21-25	81	41	79	57	68	.03
26-30	77	33	69	44	57	.64
May 1- 5	86	36	65	45	55	.11
6-10	77	41	75	46	61	.27
11-15	80	47	65	54	60	2.17
16-20	77	48	63	52	58	2.13
21-25	73	37	69	48	59	.07
26-31	80	57	77	60	69	2.34
June 1- 5	81	47	78	55	67	1.08
6-10	94	41	78	54	66	.15
11-15	89	59	85	65	75	.90
16-20	86	50	81	61	71	.40
21-25	94	48	85	59	72	.92
26-30	87	62	86	64	75	3.34

TABLE III.—The soil moisture content at various periods of the growing season expressed in percentage on a dry basis. Manhattan, Kan.

Growing season.	Depth in feet.				Growing season.	Depth in feet.			
	1	2	3	4		1	2	3	4
1931-'32.					*1933-'34.*				
May 17, 1932	10.9	12.2	13.2	13.5	Nov. 10, 1933	19.3	23.2	24.2	.....
May 24	8.9	11.5	11.8	12.7	Nov. 29	17.1	23.2	23.0	23.0
May 31	11.7	11.4	12.3	12.3	Dec. 13	18.4	22.5	22.7	.....
June 8	9.4	11.5	11.7	12.8	Mar. 7, 1934	21.9	22.3	23.9	23.7
June 15	13.9	11.4	12.5	12.9	Apr. 4*	18.2	21.2	23.1	23.2
					Apr. 11†	11.9	18.3	21.3	21.2
1932-'33.					Apr. 18	12.6	17.8	19.7	20.4
Oct. 22, 1932	19.6	19.8	13.2	14.2	Apr. 25	10.8	15.5	15.7	17.9
Nov. 30	16.2	17.1	12.4	12.6	May 2	10.2	11.4	12.7	14.9
Jan. 4, 1933	20.7	20.0	15.1	13.1	May 9	11.6	13.1	13.5	14.9
Mar. 2	15.0	18.1	14.8	16.2	May 16	24.7	14.6	14.2	14.0
Mar. 30	21.3	18.6	16.6	.....	May 23	13.0	12.7	13.4	14.8
Apr. 27	18.1	14.1	15.2	17.9	May 30	10.0	12.1	12.5	13.4
May 4	12.8	13.1	14.5	15.1	June 6	6.2	8.1	9.7	9.6
May 11‡	11.4	11.6	12.5	13.7	June 13	9.5	10.0	10.6	10.3
May 18¶	9.2	11.2	11.2	12.2					
May 20	18.8	12.2	13.6	13.4	*1934-'35.*				
May 25¶	13.6	11.4	12.4	13.6	Jan. 11, 1935	24.9	26.2	16.4	.....
May 31	19.3	12.9	12.0	13.8	Mar. 14	22.2	18.9	17.4	12.6
June 7¶	8.0	10.5	11.1	13.7	Mar. 28	14.5	19.5	16.0	12.8
June 14	16.8	11.1	10.8	12.8	Apr. 11	14.8	17.8	16.5	13.8
June 21	9.4	9.5	10.8	12.9	Apr. 18	11.5	13.3	15.2	13.8
					Apr. 25	11.2	15.5	19.6	20.3
					May 2	11.8	14.7	17.7	17.9
					May 9	14.9	16.7	17.8	19.0
					May 16	24.7	18.3	18.3	16.8
					May 23	27.6	27.8	17.8	17.0
					May 30	28.7	28.5	22.8	15.7
					June 6	24.8	25.9	15.5	13.3
					June 20	23.5	23.1	18.4	16.4
Wilting coefficient 1931-'32; 1932-'33	11.7	12.8	13.2	13.7	Wilting coefficient 1933-'34; 1934-'35	12.3	12.3	12.3	12.0

* Roots in 3d foot. † Roots in 4th foot. ‡ Roots in 3d and 4th foot. ¶ Irrigated on eves of these dates.

TABLE IV.—The total dry weight of 100 plants of Kanred and Harvest Queen wheats at various stages of growth. Manhattan, Kan.

DATE, 1931-'32.	Age of plants, weeks.	Dry weight of 100 plants.	DATE, 1932-'33.	Age of plants, weeks.	Dry weight of 100 plants.		DATE, 1933-'34.	Age of plants, weeks.	Dry weight of 100 plants.		DATE, 1934-'35.	Age of plants, weeks.	Dry weight of 100 plants.	
		Kanred.			Kanred.	Harvest Queen.			Kanred.	Harvest Queen.			Kanred.	Harvest Queen.
		Gms.			*Gms.*	*Gms.*			*Gms.*	*Gms.*			*Gms.*	*Gms.*
Oct. 1	Seed	3.0	Oct. 5	Seed	2.6	2.6	Oct. 4	Seed	2.2	2.7	Oct. 5	Seed	2.4	2.6
29	4	25.7	Nov. 2	4	6.8	7.6	Nov. 1	4	6.8	8.2	Nov. 9	5	17.9	22.6
Nov. 11	6	67.6	16	6	15.1	17.1	15	6	13.6	16.1	23	7	28.8	35.1
25	8	100.5	30	8	21.5	25.4	29	8	36.9	44.6	Dec. 20	11	43.5	54.4
Dec. 9	10	144.0	Dec. 22	11	23.9	28.6	Dec. 13	10	56.5	66.9	Jan. 11	14	40.6	55.6
23	12	168.0	Jan. 4	13	30.6	34.0	Jan. 17	15	87.0	90.4	Feb. 1	17	43.3	50.7
Jan. 5	14	169.0	17	15	33.6	36.8	31	17	91.3	125.3	21	20	39.6	48.1
19	16	195.0	Feb. 2	17	39.9	47.1	Feb. 14	19	105.5	143.7	Mar. 14	23	59.3	74.0
Feb. 10	19	223.0	16	19	40.3	48.2	Mar. 7	22	125.4	158.5	28	25	99.8	99.3
24	21	223.0	Mar. 2	21	40.5	53.1	21	24	130.0	154.6	Apr. 11	27	204.0	202.8
Mar. 16	24	257.0	16	23	69.6	83.0	Apr. 4	26	245.5	277.4	18	28	297.6	332.0
29	26	306.0	30	25	99.9	114.4	11	27	352.2	396.0	25	29	495.7	513.7
Apr. 13	28	608.0	Apr. 14	27	173.7	180.9	18	28	510.4	595.0	May 2	30	740.4	807.2
27	30	900.0	27	29	267.0	301.6	25	29	731.7	909.8	9	31	1,040.0	1,169.6
May 4	31	1,414.0	May 4	30	355.1	474.0	May 2	30	1,075.1	1,262.0	16	32	1,247.0	1,432.8
11	32	1,850.0	11	31	569.8	642.6	9	31	1,373.9	1,566.9	23	33	1,636.8	1,689.4
18	33	2,180.0	18	32	706.8	818.5	16	32	1,538.5	2,102.5	30	34	1,756.8	2,017.8
25	34	2,666.0	25	33	808.4	912.8	23	33	1,950.0	2,579.0	June 6	35	1,998.8	2,266.0
June 1	35	2,990.0	31	34	972.8	1,049.8	30	34	2,148.0	2,741.0	13	36	2,055.6	2,514.4
8	36	3,213.0	June 7	35	1,103.9	1,144.6	June 6	35	2,288.0	3,135.5	20	37	2,395.2	2,785.2
15	37	3,379.0	14	36	1,135.9	1,211.6	13	36	2,222.0	3,213.5	.....	.....	.....	.....
22	38	3,408.0	21	37	1,138.2	1,268.3	20	37	2,190.0	3,091.0	.....	.....	.....	.....

TABLE V.—A summary of the outstanding data relative to the changes in the weight of dry matter of Kanred and Harvest Queen wheat plants during the four growing seasons, 1931-'32 to 1934-'35. Manhattan, Kan.

	1931-'32.			1932-'33.			1933-'34.			1934-'35.		
	Period of increase.	Gain in weight.	Percent of maximum weight.	Period of increase.	Gain in weight.	Percent of maximum weight.	Period of increase.	Gain in weight.	Percent of maximum weight.	Period of increase.	Gain in weight.	Percent of maximum weight.
KANRED:		*Gms.*			*Gms.*			*Gms.*			*Gms.*	
Greatest gain	4-27—5-4	514.0	15.0	5- 4—5-11	214.7	18.8	5-16—5-23	411.5	17.9	5-16—5-23	389.8	16.2
Next greatest gain	5-18—5-25	486.0	14.2	5-25—5-31	164.2	14.4	4-25—5- 2	343.4	15.0	6-13—6-20	339.6	14.1
Last small gain before spring	3-16—3-29	49.0	1.4	2-16—3- 2	0.4	0.03	3- 7—3-21	4.6	0.2	2-21—3-14	19.7	0.8
First marked gain in spring	3-29—4-13	302.0	8.8	2- 2—2-16	29.1	2.5	3-21—4- 4	115.5	5.0	3-14—3-28	40.5	1.4
First week after maximum	5- 4—5-11	436.0	12.8	5-11—5-18	137.0	12.0	5-23—5-30	198.0	8.6	5-23—5-30	120.0	5.0
Second week after maximum	5-11—5-18	330.0	9.6	5-18—5-25	101.6	8.8	5-30—6- 6	140.0	6.1	5-30—6- 6	242.0	10.1
Gain or loss, week before harvest	6-15—6-22	29.0	0.8	6-14—6-21	6.9	0.6	6-13—6-20	—32.0	—1.4	6-13—6-20	339.6	14.1
HARVEST QUEEN:												
Greatest gain				5-11—5-18	175.9	13.8	5- 9—5-16	535.6	16.6	5- 2—5- 9	362.4	13.0
Next greatest gain				4-27—5- 4	172.4	13.6	5-16—5-23	476.5	14.8	5-23—5-30	328.4	11.7
Last small gain or lsos before spring,				2-16—3- 2	4.9	0.38	3- 7—3-21	—3.9	—0.12	3-14—3-28	25.3	0.8
First marked gain in spring				3- 2—3-16	29.9	2.3	3-21—4- 4	122.8	3.8	3-28—4-11	103.5	3.7
First week after maximum				5-18—5-25	94.3	7.4	5-16—5-23	476.5	14.8	5- 9—5-16	263.0	9.4
Second week after maximum				5-25—5-31	137.0	10.8	5-23—5-30	162.0	5.0	5-16—5-23	256.6	9.0
Gain or loss, week before harvest				6-14—6-21	56.7	4.4	6-13—6-20	—122.5	—3.8	6-13—6-20	270.8	9.7

TABLE VI.—Percentage of the total dry weight of the entire plant at each stage of growth calculated on its maximum dry weight, and the percentage increase or decrease of the total dry weight based on the previous sample. Manhattan, Kan.

DATE.	Age of plants, weeks.	Kanred.		Harvest Queen.	
		Percentage dry weight at various stages, based on maximum.	Weekly percentage increase or decrease of the total dry weight, based on the previous sample.	Percentage dry weight at various stages, based on maximum.	Weekly percentage increase or decrease of the total dry weight, based on the previous sample.
1931-'32.					
Oct. 1	Seed	0.09	.....	*.....	*.....
29	4	0.75	187.50	.....	.....
Nov. 11	6	1.98	81.51	.....	.....
25	8	2.94	24.33	.....	.....
Dec. 9	10	4.22	21.64	.....	.....
23	12	4.92	8.33	.....	.....
Jan. 5	14	4.95	0.29	.....	.....
19	16	5.72	7.69	.....	.....
Feb. 10	19	6.54	4.78	.....	.....
24	21	6.54	0.00	.....	.....
Mar. 16	24	7.54	5.08	.....	.....
29	26	8.97	9.53	.....	.....
Apr. 13	28	17.84	49.34	.....	.....
27	30	26.40	24.01	.....	.....
May 4	31	41.49	57.11	.....	.....
11	32	54.28	30.83	.....	.....
18	33	63.96	17.83	.....	.....
25	34	78.22	22.29	.....	.....
June 1	35	87.73	12.15	.....	.....
8	36	94.27	7.45	.....	.....
15	37	99.14	5.16	.....	.....
22	38	100.00	0.85	.....	.....
1932-'33.					
Oct. 5	Seed	0.22	.....	0.20	.....
Nov. 2	4	0.59	40.38	0.59	48.07
16	6	1.32	61.02	1.34	62.50
30	8	1.88	21.52	2.00	24.26
Dec. 22	11	2.09	3.72	2.25	4.17
Jan. 4	13	2.68	14.01	2.68	0.94
17	15	2.95	4.90	2.90	4.11
Feb. 2	17	3.50	9.37	3.71	13.99
16	19	3.54	0.50	3.80	1.16
Mar. 2	21	3.55	0.25	4.18	6.12
16	23	6.11	35.92	6.54	28.15
30	25	8.77	21.76	9.01	18.91
Apr. 14	27	15.26	36.93	14.26	29.06
27	29	23.46	26.85	23.77	33.36
May 4	30	31.19	32.99	37.37	57.16
11	31	50.06	60.46	50.66	35.56
18	32	62.09	24.04	64.53	25.81
25	33	71.02	14.37	71.97	11.52
31	34	85.46	20.33	82.77	13.91
June 7	35	96.98	13.47	90.24	9.03
14	36	99.79	2.89	95.52	5.85
21	37	100.00	0.20	100.00	4.67

TABLE VI.—*Concluded*

DATE.	Age of plants, weeks.	Kanred.		Harvest Queen.	
		Percentage dry weight at various stages, based on maximum.	Weekly percentage increase or decrease of the total dry weight, based on the previous sample.	Percentage dry weight at various stages, based on maximum.	Weekly percentage increase or decrease of the total dry weight, based on the previous sample.
1933-'34.					
Oct. 4	Seed	0.09	.....	0.08	.....
Nov. 1	4	0.29	52.27	0.25	50.92
15	6	0.59	50.00	0.50	42.07
29	8	1.61	85.66	1.38	88.50
Dec. 13	10	2.46	26.55	2.08	25.00
Jan. 17	15	3.80	10.79	2.81	7.02
31	17	3.99	2.47	3.89	19.30
Feb. 14	19	4.61	7.77	4.47	7.34
Mar. 7	22	5.48	62.84	4.92	3.43
21	24	5.68	1.83	4.81	—1.23(a)
Apr. 4	26	10.72	44.42	8.63	39.71
11	27	15.39	43.46	12.32	42.75
18	28	22.30	44.91	18.51	50.25
25	29	31.97	43.35	28.31	52.90
May 2	30	46.98	46.93	39.27	38.71
9	31	60.04	26.86	48.76	24.16
16	32	67.24	11.25	65.42	34.23
23	33	85.22	26.74	80.26	22.66
30	34	93.88	10.15	85.30	6.29
June 6	35	100.00	6.51	97.57	14.39
13	36	97.11	—2.88	100.00	2.42
20	37	95.71	—1.44	96.20	—3.81
1934-'35.					
Oct. 5	Seed	0.10	.....	0.09	.....
Nov. 9	5	0.74	129.16	0.81	153.84
23	7	1.20	30.44	1.26	27.65
Dec. 20	11	1.81	12.76	1.95	13.74
Jan. 11	14	1.69	—2.20(a)	1.99	0.73
Feb. 1	17	1.80	2.21	1.82	—2.93(a)
21	20	1.65	—2.84(a)	1.72	—1.70(a)
Mar. 14	23	2.47	16.58	2.65	17.94
28	25	3.38	34.14	3.56	17.09
Apr. 11	27	8.51	52.20	7.28	52.11
18	28	12.42	45.88	11.92	63.70
25	29	20.69	66.56	18.44	54.72
May 2	30	30.91	49.36	28.98	57.13
9	31	43.42	40.46	41.99	44.89
16	32	52.06	19.90	51.44	22.50
23	33	68.33	31.25	60.65	17.90
30	34	73.34	7.33	72.44	19.43
June 6	35	83.45	13.77	81.35	12.30
13	36	85.82	2.84	90.27	10.96
20	37	100.00	11.65	100.00	10.76

(a) Injured by freeze. Tips of leaves badly frozen causing the plots to have a blackened appearance.

* Harvest Queen not grown during 1931-'32 season.

TABLE VII.—The dry weight of the stems and leaves and chaff and grain of the wheat plants at weekly intervals. Manhattan, Kan.

DATE.	Age of plants, weeks.	Plant parts.	Dry weight, 100 plants.	
			Kanred.	Harvest Queen.
1931-'32.			*Gms.*	*Gms.*
May 25	34	Stems and leaves	2,340.0	
		Heads	326.0	
		Total	2,666.0	
June 1	35	Stems and leaves	2,460.0	
		Heads	530.0	
		Total	2,990.0	
June 8	36	Stems and leaves	2,368.0	
		Heads	845.0	
		Total	3,213.0	
June 15	37	Stems and leaves	2,161.0	
		Heads	1,218.0	
		Total	3,379.0	
June 22	38	Stems and leaves	2,027.0	
		Heads	1,381.0	
		Total	3,408.0	
1932-33.			*Gms.*	*Gms.*
May 18	32	Stems and leaves	654.5	767.4
		Heads	52.3	51.1
		Total	706.8	818.5
May 25	33	Stems and leaves	700.3	831.7
		Heads	108.1	81.1
		Total	808.4	912.8
May 31	34	Stems and leaves	792.7	893.2
		Chaff	115.8	84.1
		Grain	64.3	72.5
		Total	972.8	1,049.8
June 7	35	Stems and leaves	758.4	848.6
		Chaff	119.1	95.5
		Grain	226.3	200.5
		Total	1,103.8	1,144.6
June 14	36	Stems and leaves	753.3	859.8
		Chaff	110.8	86.5
		Grain	271.8	265.3
		Total	1,135.9	1,211.6
June 21	37	Stems and leaves	750.7	915.8
		Chaff	107.8	94.4
		Grain	279.7	258.1
		Total	1,138.2	1,268.3

TABLE VII.—*Concluded*

DATE.	Age of plants, weeks.	Plant parts.	Dry weight, 100 plants.	
			Kanred.	Harvest Queen.
1933-'34.			*Gms.*	*Gms.*
May 9	31	Stems and leaves	1,322.7	1,532.7
		Heads	51.2	34.2
		Total	1,373.9	1,566.9
May 16	32	Stems and leaves	1,388.5	1,971.5
		Heads	150.0	131.0
		Total	1,538.5	2,102.5
May 23	33	Stems and leaves	1,682.5	2,310.0
		Heads	267.5	269.0
		Total	1,950.0	2,579.0
May 30	34	Stems and leaves	1,692.5	2,287.0
		Chaff	253.5	255.5
		Grain	202.0	198.5
		Total	2,148.0	2,741.0
June 6	35	Stems and leaves	1,547.0	2,280.0
		Chaff	257.5	268.0
		Grain	483.5	587.5
		Total	2,288.0	3,135.5
June 13	36	Stems and leaves	1,356.0	2,182.0
		Chaff	255.0	266.0
		Grain	611.0	765.5
		Total	2,222.0	3,213.5
June 20	37	Stems and leaves	1,371.5	2,097.0
		Chaff	225.0	251.0
		Grain	593.5	743.0
		Total	2,190.0	3,091.0
1934-'35.				
May 23	33	Stems and leaves	1,546.8	1,632.4
		Heads	90.0	57.0
		Total	1,636.8	1,689.4
May 30	34	Stems and leaves	1,588.8	1,853.3
		Heads	168.0	164.5
		Total	1,756.8	2,017.8
June 6	35	Stems and leaves	1,689.2	2,027.5
		Chaff	252.0	192.7
		Grain	57.6	45.8
		Total	1,998.8	2,266.0
June 13	36	Stems and leaves	1,630.8	2,085.8
		Chaff	246.0	202.4
		Grain	178.8	226.2
		Total	2,055.6	2,514.4
June 20	37	Stems and leaves	1,556.4	2,055.7
		Chaff	310.8	245.5
		Grain	528.0	484.0
		Total	2,395.2	2,785.2

TABLE VIII.—The relation of the dry weight of stems and leaves, stems, leaves and chaff, and total plant to the dry weight of grain at maturity. Manhattan, Kan.

DATE.	Kanred.			Harvest Queen.		
	Stems and leaves to grain.	Stems, leaves and chaff to grain.	Total plant to grain.	Stems and leaves to grain.	Stems, leaves and chaff to grain.	Total plant to grain.
1932-'33	2.68	3.07	4.06	3.54	3.91	4.90
1933-'34	2.31	2.52	3.69	2.82	3.16	4.16
1934-'35	2.94	3.53	4.53	4.24	4.75	5.75

TABLE IX.—The gain or loss in weight of the heads of wheat as compared with the loss or gain in the stem and leaves. Manhattan, Kan.

DATE.	Gain or loss of dry matter in stems and leaves.	Gain or loss of dry matter in heads.	Dry matter absorbed by plant or manufactured by the stems and leaves.
KANRED.			
1931-'32.	*Gms.*	*Gms.*	*Gms.*
June 1—8	—92.0	+315.0	223.0
8—15	—207.0	+373.0	166.0
15—22	—134.0	+163.0	29.0
1932-'33.			
May 31—June 7	—34.3	+165.3	131.0
June 7—14	—5.1	+37.2	32.1
14—21	—2.6	+4.9	2.3
1933-'34.			
May 30—June 6	—14.5	+285.5	140.0
June 6—13	—191.0	+125.0	—66.0(a)
13—20	+15.0	—47.5	—32.5(b)
1934-'35.			
June 6—13	—58.4	+115.2	56.8
13—20	—74.4	+414.0	339.6
HARVEST QUEEN.			
1932-'33.			
May 31—June 7	—44.6	+139.4	94.8
June 7—14	+11.2	+55.8	67.0
14—21	+56.0	+0.7	56.7
1933-'34.			
May 23—30	—23.0	+185.0	162.0
May 30—June 6	—7.0	+401.5	394.5
June 6—13	—98.0	+176.0	78.0
13—20	—85.0	—37.5	—122.5(b)
1934-'35.			
June 13—20	—30.1	+300.9	270.9

(a) A greater loss in the stems and leaves than the gain in weight of the heads indicates that a portion of this decrease in weight may be due to the loss of leaves. The rainfall previous to this period was like similar periods in other years. Unless some unknown condition prevailed which would be conducive to leaching, this loss in weight could not be attributed to that factor.

(b) During this season there was an outbreak of army worms. These were controlled by poison bran mash. Although they caused no apparent damage, sufficient number of glumes, awns, spikelets, or portions of leaves may have been eaten or severed to cause the loss in weight that is noted herein.

TABLE X.—Percentage and actual amount in grams per 100 plants of the total nitrogen, protein nitrogen, protein-free nitrogen, and protein at various stages of growth of Kanred wheat during four seasons. Manhattan, Kan.

DATE.	Age of plants, weeks.	Plant parts.	Total N.		Protein N.			Protein N × 6.25.		Protein-free N.		
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Ratio protein N to total N.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage of total N.
				Gms.		*Gms.*			*Gms.*		*Gms.*	
1931-'32.												
Oct. 1	Seed	Seeds	2.25	0.06	1.91	0.056	0.849	11.94	0.349	0.34	0.010	15.1
29	4	Total	5.26	1.35	3.83	0.982	0.728	23.94	6.140	1.43	0.366	27.1
Nov. 11	6	Total	5.13	3.47	3.74	2.528	0.729	23.38	15.804	1.39	0.939	27.0
25	8	Total	4.74	4.78	3.41	3.427	0.719	21.31	21.416	1.33	1.336	28.0
Dec. 9	10	Total	4.10	5.90	2.98	4.291	0.727	18.63	26.827	1.12	1.610	27.3
23	12	Total	3.92	6.58	2.72	4.569	0.694	17.00	28.560	1.20	2.016	30.6
Jan. 5	14	Total	4.13	6.98	2.91	4.917	0.705	18.19	30.741	1.22	2.061	29.5
19	16	Total	4.13	8.06	3.01	5.869	0.729	18.81	36.679	1.12	2.184	27.1
Feb. 10	19	Total	4.03	8.98	2.90	6.467	0.720	18.13	40.429	1.13	2.519	28.0
24	21	Total	4.17	9.31	3.06	6.823	0.734	19.13	42.659	1.11	2.475	26.6
Mar. 16	24	Total	4.21	10.80	2.80	7.196	0.665	17.50	44.975	1.41	3.623	33.4
29	26	Total	3.81	11.65	2.45	7.497	0.643	15.31	46.848	1.36	4.161	35.6
Apr. 13	28	Total	2.93	17.81	2.05	12.464	0.700	12.81	77.884	0.88	5.350	30.0
27	30	Total	2.01	18.07	1.32	11.880	0.657	8.25	74.250	0.69	6.210	34.3
May 4	31	Total	1.73	24.49	1.13	15.978	0.653	7.06	99.828	0.60	8.484	34.6
11	32	Total	1.55	28.75	0.97	17.945	0.626	6.06	112.110	0.58	10.730	37.4
18	33	Total	1.33	29.11	0.94	20.492	0.707	5.88	128.184	0.39	8.50	29.3
25	34	Stems and leaves	1.16	27.21	0.75	17.550	0.647	4.69	109.746	0.41	9.59	35.3
		Heads	2.06	6.71	1.36	4.433	0.660	8.50	27.710	0.70	2.28	33.9
		Total		33.92		21.983			137.456		11.87	

TABLE X.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Total N.		Protein N.			Protein N × 6.25.		Protein-free N.		
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Ratio protein N to total N.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage of total N.
				Gms.		*Gms.*			*Gms.*		*Gms.*	
1931-'32.												
June 1....	35	Stems and leaves..	0.97	23.76	0.68	16.728	0.701	4.25	104.550	0.29	7.13	29.8
		Heads.....	2.08	11.02	1.50	7.950	0.721	9.38	49.714	0.58	3.07	27.8
		Total.....	.....	34.78	.....	24.678	.....	.....	154.264	.....	10.20	.....
8....	36	Stems and leaves..	0.72	17.00	0.49	11.603	0.681	3.06	72.460	0.23	5.45	31.9
		Heads.....	1.99	16.81	1.68	14.196	0.844	10.50	88.725	0.31	2.62	15.5
		Total.....	.....	33.81	.....	25.799	.....	.....	161.185	.....	8.07	.....
15....	37	Stems and leaves..	0.58	12.63	0.41	8.860	0.707	2.56	55.321	0.17	3.67	29.3
		Heads.....	1.91	23.25	1.67	20.340	0.874	10.44	127.159	0.24	2.92	12.0
		Total.....	.....	35.88	.....	29.200	.....	.....	182.480	.....	6.59	.....
22....	38	Stems and leaves..	0.79	15.98	0.56	11.351	0.709	3.50	70.945	0.23	4.66	29.1
		Heads.....	2.40	33.02	2.05	28.310	0.854	12.81	176.906	0.35	4.83	14.5
		Total.....	.....	49.00	.....	39.661	.....	.....	247.851	.....	9.49	.....

TABLE X.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Total N.		Protein N.			Protein N × 6.25.		Protein-free N.		
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Ratio protein N to total N.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage of total N.
				Gms.		*Gms.*			*Gms.*		*Gms.*	
1932-'33.												
Oct. 5....	Seed	Seeds.....	2.92	0.076	2.81	0.073	0.962	17.56	0.456	0.11	0.003	3.8
Nov. 2....	4	Total.....	4.93	0.335	4.03	0.274	0.817	25.19	1.712	0.90	0.061	18.3
16....	6	Total.....	4.69	0.708	3.79	0.572	0.808	23.69	3.575	0.90	0.136	19.2
30....	8	Total.....	4.35	0.935	3.56	0.765	0.818	22.25	4.781	0.79	0.170	18.2
Dec. 22....	11	Total.....	4.66	1.137	3.72	0.889	0.781	23.25	5.556	0.94	0.248	21.9
Jan. 4....	13	Total.....	4.43	1.355	3.47	1.061	0.783	21.69	6.331	0.96	0.294	21.7
17....	15	Total.....	4.52	1.518	3.60	1.210	0.796	22.50	7.562	0.92	0.308	20.4
Feb. 2....	17	Total.....	4.66	1.859	3.51	1.401	0.753	21.94	8.756	1.15	0.458	24.7
16....	19	Total.....	4.63	1.866	3.58	1.443	0.773	22.36	9.019	1.05	0.423	22.7
Mar. 2....	21	Total.....	5.07	2.053	3.86	1.563	0.761	24.13	9.769	1.21	0.490	23.9
16....	23	Total.....	5.01	3.487	3.84	2.673	0.766	24.00	16.706	1.17	0.814	23.4
30....	25	Total.....	4.48	4.475	3.46	3.456	0.772	21.62	21.600	1.02	1.019	22.8
Apr. 14....	27	Total.....	3.40	5.906	2.56	4.446	0.752	16.00	27.787	0.74	1.460	24.8
27....	29	Total.....	2.98	7.957	2.20	5.874	0.738	13.75	36.712	0.78	2.083	26.2
May 4....	30	Total.....	2.56	9.088	2.00	7.100	0.781	12.50	44.375	0.56	1.988	21.9
11....	31	Total.....	2.11	12.006	1.68	9.559	0.796	10.50	59.743	0.43	2.447	20.4
18....	32	Stems and leaves..	1.81	11.847	1.41	9.229	0.779	8.81	57.681	0.40	2.618	22.1
		Heads.....	2.56	1.338	2.07	1.082	0.808	12.94	6.762	0.49	0.256	19.2
		Total.....	.....	13.185	.....	10.311	.....	.....	64.443	.....	2.874	.....

TABLE X.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Total N.		Protein N.			Protein N × 6.25.		Protein-free N.		
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Ratio protein N to total N.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage of total N.
1932-'33.				*Gms.*		*Gms.*			*Gms.*		*Gms.*	
May 25....	33	Stems and leaves..	1.43	10.014	1.20	8.404	0.839	7.50	52.522	0.23	1.611	16.1
		Heads.....	2.45	2.648	1.82	1.967	0.742	11.37	12.296	0.63	0.681	25.8
		Total.....	.....	12.662	.....	10.371	.....	.....	64.818	.....	2.292	.....
31....	34	Stems and leaves..	1.43	11.336	1.13	8.957	0.790	7.06	55.981	0.30	2.379	21.0
		Chaff.....	2.00	2.316	1.67	1.933	0.834	10.43	12.081	0.33	0.383	16.6
		Grain.....	2.73	1.755	1.96	1.260	0.717	12.25	7.875	0.77	0.495	28.3
		Total.....	.....	15.407	.....	12.150	.....	.....	75.937	.....	3.257	.....
June 7....	35	Stems and leaves..	1.09	8.256	0.82	6.219	0.753	5.12	38.243	0.27	2.037	24.7
		Chaff.....	1.60	1.906	1.25	1.489	0.781	7.81	9.306	0.35	0.417	21.9
		Grain.....	2.73	6.179	2.42	5.477	0.886	15.12	34.231	0.31	0.702	11.4
		Total.....	.....	16.341	.....	13.185	.....	.....	81.780	.....	3.156	.....
14....	36	Stems and leaves..	0.95	7.156	0.71	5.348	0.745	4.44	33.425	0.24	1.808	25.5
		Chaff.....	1.20	1.329	0.88	0.975	0.733	5.50	6.093	0.32	0.354	26.7
		Grain.....	3.33	9.051	3.12	8.480	0.936	19.50	53.000	0.21	0.571	6.4
		Total.....	.....	17.536	.....	14.803	.....	.....	92.518	.....	2.733	.....
21....	37	Stems and leaves..	0.87	6.531	0.64	4.804	0.735	4.00	30.025	0.23	1.727	26.5
		Chaff.....	1.05	1.132	0.68	0.733	0.647	4.25	4.581	0.37	0.399	35.5
		Grain.....	3.43	9.594	3.12	8.727	0.909	19.50	54.544	0.31	0.867	9.1
		Total.....	.....	17.257	.....	14.264	.....	.....	89.150	.....	2.993	.....

TABLE X.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Total N.		Protein N.			Protein N × 6.25.		Protein-free N.		
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Ratio protein N to total N.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage of total N.
				Gms.		*Gms.*			*Gms.*		*Gms.*	
1933-'34.												
Oct. 4....	Seed	Seeds.....	2.87	0.063	2.64	0.058	0.920	16.50	0.365	0.23	0.005	8.0
Nov. 1....	4	Total.....	5.58	0.379	4.08	0.277	0.731	25.50	1.731	1.50	0.102	26.9
15....	6	Total.....	4.37	0.593	3.47	0.470	0.794	21.69	2.941	0.90	0.122	20.6
29....	8	Total.....	4.21	1.551	3.18	1.172	0.756	19.88	7.326	1.03	0.380	24.5
Dec. 13....	10	Total.....	4.03	2.278	3.18	1.798	0.789	19.88	11.238	0.85	0.481	21.1
Jan. 17....	15	Total.....	4.05	3.524	3.14	2.732	0.775	19.63	17.078	0.91	0.792	22.5
31....	17	Total.....	4.36	3.980	3.36	3.068	0.771	21.00	19.173	1.00	0.913	22.9
Feb. 14....	19	Total.....	4.46	4.705	3.23	3.408	0.724	18.75	19.781	1.23	1.298	27.6
Mar. 7....	22	Total.....	4.77	5.982	3.57	4.477	0.748	22.31	27.977	1.20	1.505	25.2
21....	24	Total.....	5.02	6.526	3.52	4.576	0.701	22.00	28.600	1.50	1.950	29.9
Apr. 4....	26	Total.....	4.87	11.956	3.26	8.003	0.669	20.38	50.033	1.61	3.953	33.1
11....	27	Total.....	4.27	15.039	2.89	10.179	0.677	18.06	63.607	1.38	4.860	32.3
18....	28	Total.....	3.64	18.579	2.49	12.709	0.684	15.56	79.418	1.15	5.870	31.6
25....	29	Total.....	2.92	21.366	2.07	15.146	0.709	12.94	94.682	0.85	6.219	29.1
May 2....	30	Total.....	2.73	29.350	1.90	20.427	0.696	11.88	127.722	0.83	8.923	30.4
9....	31	Stems and leaves..	2.19	28.967	1.52	20.105	0.694	9.50	125.657	0.67	8.862	30.6
		Heads.....	2.94	1.505	2.34	1.120	0.796	14.63	7.491	0.60	0.307	20.4
		Total.....	.....	30.472	.....	21.225	.....	.....	133.148	.....	9.169	.....

TABLE X.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Total N.		Protein N.			Protein N × 6.25.		Protein-free N.		
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Ratio protein N to total N.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage of total N.
				Gms.		*Gms.*			*Gms.*		*Gms.*	
1933-'34.												
May 16....	32	Stems and leaves..	1.67	23.188	1.28	17.773	0.766	8.00	111.080	0.39	5.415	23.4
		Heads.....	2.22	3.330	1.73	2.595	0.779	10.81	16.215	0.49	0.735	22.1
		Total.....	.....	26.518	.....	20.368	.....	.....	127.295	.....	6.150	.....
23....	33	Stems and leaves..	1.46	24.565	1.11	18.676	0.760	6.94	116.766	0.35	5.889	24.0
		Heads.....	2.18	5.832	1.66	4.441	0.761	10.38	27.767	0.52	1.391	23.9
		Total.....	.....	30.397	.....	23.117	.....	.....	144.533	.....	7.280	.....
30....	34	Stems and leaves..	0.91	15.402	0.70	11.848	0.769	4.38	74.132	0.21	3.554	23.1
		Chaff.....	1.68	4.259	1.36	3.448	0.810	8.50	21.548	0.32	0.811	19.0
		Grain.....	2.67	5.393	2.07	4.181	0.775	12.94	26.139	0.60	1.212	22.5
		Total.....	.....	25.054	.....	19.477	.....	.....	121.819	.....	5.577	.....
June 6....	35	Stems and leaves..	0.71	10.984	0.56	8.663	0.789	3.50	54.145	0.15	2.321	21.1
		Chaff.....	1.15	2.961	0.94	2.421	0.817	5.88	15.141	0.21	0.541	18.3
		Grain.....	2.44	11.797	2.08	10.057	0.852	13.00	62.855	0.36	1.741	14.8
		Total.....	.....	25.742	.....	21.141	.....	.....	132.141	.....	4.603	.....
13....	36	Stems and leaves..	0.57	7.729	0.43	5.831	0.754	2.69	36.476	0.14	1.898	24.6
		Chaff.....	0.94	2.397	0.67	1.709	0.713	4.19	10.685	0.27	0.689	28.7
		Grain.....	2.72	16.619	2.50	15.275	0.919	15.63	95.499	0.22	1.344	8.1
		Total.....	.....	26.745	.....	22.815	.....	.....	142.660	.....	3.931	.....
20....	37	Stems and leaves..	0.55	7.543	0.47	6.446	0.855	2.94	40.322	0.08	1.097	14.5
		Chaff.....	0.70	1.575	0.52	1.170	0.743	3.25	7.313	0.18	0.405	25.7
		Grain.....	2.80	16.618	2.58	15.312	0.921	16.13	95.732	0.22	1.306	7.9
		Total.....	.....	25.736	.....	22.928	.....	.....	143.367	.....	2.808	.....

TABLE X.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Total N.		Protein N.			Protein N × 6.25.		Protein-free N.		
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Ratio protein N to total N.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage of total N.
1934-'35.				*Gms.*		*Gms.*			*Gms.*		*Gms.*	
Oct. 5	Seed	Seeds	3.20	0.076	3.02	0.071	0.934	18.88	0.445	0.18	0.004	5.63
Nov. 9	5	Total	4.42	0.789	3.54	0.633	0.802	22.13	3.955	0.88	0.157	19.91
23	7	Total	4.60	1.324	3.65	1.051	0.794	22.81	6.569	0.95	0.274	20.65
Dec. 20	11	Total	3.64	1.583	2.99	1.301	0.822	18.69	8.130	0.65	0.283	17.86
Jan. 11	14	Total	3.36	1.363	2.83	1.148	0.842	17.69	7.179	0.53	0.215	15.77
Feb. 1	17	Total	3.76	1.629	3.06	1.326	0.814	19.13	8.289	0.70	0.303	18.62
21	20	Total	4.09	1.620	3.29	1.304	0.805	20.56	8.148	0.80	0.317	19.56
Mar. 14	23	Total	4.67	2.767	3.79	2.246	0.812	23.69	14.036	0.88	0.521	18.84
28	25	Total	4.45	4.441	3.43	3.423	0.771	21.44	21.397	1.02	1.018	22.92
Apr. 11	27	Total	4.11	8.384	3.23	6.589	0.786	20.19	41.188	0.88	1.795	21.41
18	28	Total	3.56	10.595	2.73	8.124	0.767	17.06	50.771	0.83	2.470	23.31
25	29	Total	3.53	17.498	2.52	12.492	0.714	15.75	78.073	1.01	5.007	28.61
May 2	30	Total	2.96	21.916	2.14	15.845	0.723	13.38	99.066	0.82	6.071	27.70
9	31	Total	2.73	28.392	1.95	20.280	0.714	12.19	126.776	0.78	8.112	28.57
16	32	Total	2.41	30.053	1.74	21.698	0.722	10.88	135.674	0.67	8.355	27.80
23	33	Stems and leaves	2.08	32.173	1.49	23.047	0.716	9.31	144.007	0.59	9.126	28.37
		Heads	2.66	2.394	2.17	1.953	0.816	13.56	12.204	0.49	0.441	18.42
		Total		34.567		25.000			156.211		9.567	

TABLE X.—*Concluded*

DATE.	Age of plants, weeks.	Plant parts.	Total N.		Protein N.			Protein N × 6.25.		Protein-free N.		
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Ratio protein N to total N.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage of total N.
				Gms.		*Gms.*			*Gms.*		*Gms.*	
1934-'35.												
May 30....	34	Stems and leaves..	1.69	26.851	1.28	20.337	0.757	8.00	127.104	0.41	6.514	24.26
		Heads.....	2.03	3.410	1.68	2.822	0.828	10.50	17.640	0.35	0.588	17.24
		Total.....	.....	30.261	.....	23.159	.....	.....	144.744	.....	7.102	.....
June 6....	35	Stems and leaves..	1.42	23.987	1.09	18.412	0.768	6.81	115.035	0.33	5.574	23.24
		Chaff.....	1.86	4.687	1.61	4.057	0.866	10.06	25.351	0.25	0.630	13.44
		Grain.....	2.88	1.659	2.00	1.152	0.694	12.50	7.200	0.88	0.507	30.56
		Total.....	.....	30.333	.....	23.621	.....	.....	147.586	.....	6.711	.....
13....	36	Stems and leaves..	1.27	20.711	0.99	16.145	0.780	6.19	100.947	0.28	4.566	22.05
		Chaff.....	1.51	2.715	1.35	3.321	0.894	8.44	20.762	0.16	0.394	10.60
		Grain.....	2.63	4.702	2.22	3.969	0.844	13.88	24.817	0.41	0.733	15.59
		Total.....	.....	29.128	.....	23.435	.....	.....	146.526	.....	5.693	.....
20....	37	Stems and leaves..	0.30	14.008	0.76	11.829	0.844	4.75	73.929	0.14	2.179	15.56
		Chaff.....	0.99	3.077	0.82	2.549	0.828	5.13	15.944	0.17	0.528	17.17
		Grain.....	2.44	12.883	2.15	11.352	0.881	13.44	70.963	0.29	1.531	11.89
		Total.....	.....	29.968	.....	25.730	.....	.....	160.836	.....	4.238	.....

TABLE XI.—Percentage and actual amount in grams per 100 plants of the total nitrogen, protein nitrogen, protein-free nitrogen, and protein at various stages of growth of Harvest Queen wheat during three seasons. Manhattan, Kan.

DATE.	Age of plants, weeks.	Plant parts.	Total N.		Protein N.			Protein N × 6.25.		Protein-free N.		
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Ratio protein N to total N.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage of total N.
1932-'33.				*Gms.*		*Gms.*			*Gms.*		*Gms.*	
Oct. 5....	Seed	Seeds.....	2.67	0.069	2.58	0.067	0.966	16.13	0.419	0.09	0.002	3.4
Nov. 2....	4	Total.....	4.82	0.366	3.79	0.288	0.786	23.69	1.800	1.03	0.078	21.4
16....	6	Total.....	4.66	0.797	3.70	0.633	0.794	23.13	3.956	0.96	0.164	20.6
30....	8	Total.....	4.21	1.069	3.42	0.868	0.812	21.37	5.425	0.79	0.201	18.8
Dec. 22....	11	Total.....	4.52	1.293	3.64	1.041	0.805	22.75	6.506	0.88	0.252	19.5
Jan. 4....	13	Total.....	4.31	1.465	3.42	1.163	0.793	21.38	7.268	0.89	0.303	20.7
17....	15	Total.....	4.48	1.649	3.64	1.340	0.812	22.75	8.375	0.84	0.309	18.8
Feb. 2....	17	Total.....	4.56	2.148	3.54	1.667	0.776	22.13	10.418	1.02	0.480	22.4
16....	19	Total.....	4.62	2.227	3.58	1.726	0.774	22.38	10.787	1.04	0.501	22.6
Mar. 2....	21	Total.....	4.87	2.586	3.78	2.007	0.776	23.62	12.543	1.09	0.579	22.4
16....	23	Total.....	5.08	4.216	3.79	3.146	0.746	23.69	19.662	1.29	1.071	25.4
30....	25	Total.....	4.47	5.114	3.35	3.832	0.749	20.94	23.950	1.12	1.281	25.1
Apr. 14....	27	Total.....	3.70	6.693	2.60	4.703	0.702	16.25	29.394	1.10	1.990	29.8
27....	29	Total.....	3.05	9.199	2.30	6.937	0.754	14.36	43.356	0.75	2.262	24.6
May 4....	30	Total.....	2.69	12.751	2.02	9.575	0.750	12.63	59.843	0.67	3.176	25.0
11....	31	Total.....	2.05	13.173	1.67	10.731	0.814	10.14	67.069	0.38	2.442	18.6
18....	32	Stems and leaves..	1.82	13.967	1.46	11.204	0.802	9.13	70.025	0.36	2.762	19.8
		Heads.....	2.36	1.206	1.83	0.935	0.775	11.44	5.844	0.53	0.271	22.5
		Totals.....	.....	15.173	.....	12.139	.....	.....	75.869	.....	3.033	.....

TABLE XI.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Total N.		Protein N.			Protein N × 6.25.		Protein-free N.		
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Ratio protein N to total N.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage of total N.
				Gms.		*Gms.*			*Gms.*		*Gms.*	
1932-'33.												
May 25....	33	Stems and leaves..	1.68	13.973	1.44	11.977	0.857	9.00	74.856	0.24	1.996	14.3
		Heads.....	2.02	1.638	1.60	1.298	0.792	10.00	8.113	0.42	0.340	20.8
		Total.....	.....	15.611	.....	13.275	.....	.....	82.969	.....	2.336	.....
31....	34	Stems and leaves..	1.40	12.505	1.20	10.718	0.857	7.50	66.987	0.20	1.787	14.3
		Chaff.....	1.50	1.261	1.27	1.068	0.846	7.94	6.675	0.23	0.193	15.4
		Grain.....	2.65	1.921	2.16	1.566	0.815	13.50	9.788	0.49	0.355	18.5
		Total.....	.....	15.687	.....	13.352	.....	.....	83.450	.....	2.335	.....
June 7....	35	Stems and leaves..	1.30	11.031	0.90	7.637	0.692	5.63	47.731	0.40	3.394	30.8
		Chaff.....	1.18	1.127	0.94	0.898	0.796	5.88	5.612	0.24	0.229	20.4
		Grain.....	2.86	5.734	2.56	5.132	0.895	16.00	32.075	0.30	0.601	10.5
		Total.....	.....	17.892	.....	13.667	.....	.....	85.418	.....	4.224	.....
14....	36	Stems and leaves..	0.99	8.512	0.74	6.363	0.747	4.63	39.768	0.25	2.150	25.3
		Chaff.....	0.94	0.813	0.69	0.597	0.733	4.31	3.731	0.25	0.216	26.7
		Grain.....	3.41	9.047	3.30	8.755	0.967	20.63	54.718	0.11	0.292	3.3
		Total.....	.....	18.372	.....	15.715	.....	.....	98.217	.....	2.658	.....
21....	37	Stems and leaves..	1.16	10.623	0.78	7.143	0.672	4.87	44.644	0.38	3.480	32.8
		Chaff.....	1.11	1.048	0.71	0.670	0.639	4.44	4.187	0.40	0.378	36.1
		Grain.....	3.71	9.575	3.46	8.930	0.932	21.62	55.812	0.25	0.645	6.8
		Total.....	.....	21.246	.....	16.743	.....	.....	104.643	.....	4.503	.....

TABLE XI.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Total N.		Protein N.			Protein N × 6.25.		Protein-free N.		
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Ratio protein N to total N.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage of total N.
				Gms.		*Gms.*			*Gms.*		*Gms.*	
1933-'34.												
Oct. 4....	Seed	Seeds.....	2.83	0.075	2.60	0.069	0.920	16.25	0.432	0.23	0.006	8.13
Nov. 1....	4	Total.....	5.42	0.443	4.03	0.330	0.745	25.19	2.061	1.39	0.114	25.65
15....	6	Total.....	4.28	0.690	3.21	0.517	0.749	20.06	3.232	1.07	0.172	25.00
29....	8	Total.....	4.16	1.856	3.27	1.459	0.786	20.44	9.120	0.89	0.397	21.39
Dec. 13....	10	Total.....	4.04	2.703	3.09	2.067	0.765	19.31	12.918	0.95	0.635	23.51
Jan. 17....	15	Total.....	4.05	3.661	3.24	2.929	0.800	20.25	18.306	0.81	0.732	20.00
31....	17	Total.....	4.34	5.438	3.23	4.047	0.744	20.19	25.298	1.11	1.391	25.58
Feb. 14....	19	Total.....	4.18	6.007	2.99	4.297	0.715	18.69	26.858	1.19	1.710	28.47
Mar. 7....	22	Total.....	4.69	7.434	3.43	5.437	0.731	21.44	33.982	1.26	1.997	26.87
21....	24	Total.....	4.88	7.544	3.54	5.473	0.725	22.13	34.213	1.34	2.072	27.46
Apr. 4....	26	Total.....	4.77	13.232	3.45	9.570	0.723	21.56	59.807	1.32	3.661	27.67
11....	27	Total.....	4.36	17.266	3.08	12.197	0.706	19.25	76.230	1.28	5.069	29.36
18....	28	Total.....	3.82	22.729	2.71	16.125	0.709	16.94	100.793	1.11	6.605	29.06
25....	29	Total.....	3.28	29.841	2.40	21.835	0.732	15.00	136.470	0.88	8.006	26.83
May 2....	30	Total.....	2.78	35.084	2.03	25.619	0.730	12.69	160.148	0.75	9.465	26.98
9....	31	Stems and leaves..	2.24	34.332	1.63	24.983	0.728	10.19	156.182	0.61	9.295	27.23
		Heads.....	3.26	1.115	2.34	0.800	0.717	14.63	5.003	0.92	0.315	28.22
		Total.....	.....	35.447	.....	25.783	.....	.....	161.185	.....	9.610	.....

TABLE XI.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Total N.		Protein N.			Protein N × 6.25.		Protein-free N.		
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Ratio protein N to total N.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage of total N.
				Gms.		*Gms.*			*Gms.*		*Gms.*	
1933-'34.												
May 16....	32	Stems and leaves..	1.86	36.670	1.43	28.192	0.769	8.94	176.252	0.43	8.477	23.12
		Heads.....	2.09	2.738	1.71	2.240	0.818	10.69	14.004	0.38	0.498	29.01
		Total.....	.....	39.408	.....	30.432	.....	.....	190.256	.....	8.975	.....
23....	33	Stems and leaves..	1.40	32.340	1.13	26.103	0.807	7.06	163.086	0.27	6.237	19.29
		Heads.....	1.89	5.084	1.42	3.820	0.751	8.88	23.887	0.47	1.264	24.87
		Total.....	.....	37.424	.....	29.923	.....	.....	186.973	.....	7.501	.....
30....	34	Stems and leaves..	1.19	27.215	0.91	20.812	0.765	5.69	130.130	0.28	6.404	23.53
		Chaff.....	1.42	3.628	1.13	2.887	0.796	7.06	18.038	0.29	0.741	20.42
		Grain.....	2.63	5.222	2.12	4.208	0.806	13.25	26.301	0.51	1.012	19.39
		Total.....	.....	36.065	.....	27.907	.....	.....	174.469	.....	8.157	.....
June 6....	35	Stems and leaves..	0.83	18.924	0.64	14.592	0.771	4.00	91.200	0.19	4.332	22.89
		Chaff.....	0.84	2.225	0.66	1.177	0.080	4.13	11.068	0.18	0.482	21.43
		Grain.....	2.50	14.688	2.22	13.043	0.888	13.88	81.545	0.28	1.645	11.20
		Total.....	.....	35.837	.....	28.812	.....	.....	183.813	.....	6.459	.....
13....	36	Stems and leaves..	0.59	12.874	0.45	9.819	0.763	2.81	61.314	0.14	3.055	23.73
		Chaff.....	0.80	2.128	0.48	1.277	0.600	3.00	7.980	0.32	0.851	40.00
		Grain.....	2.75	21.051	2.55	19.520	0.927	1.59	12.171	0.20	1.531	7.27
		Total.....	.....	36.053	.....	30.616	.....	.....	81.465	.....	5.437	.....
20....	37	Stems and leaves..	0.62	13.001	0.47	9.856	0.758	2.94	61.652	0.15	3.146	24.19
		Chaff.....	0.57	1.431	0.45	1.130	0.790	2.81	7.053	0.12	0.301	21.05
		Grain.....	2.81	20.878	2.59	19.244	0.922	16.19	120.292	0.22	1.635	7.83
		Total.....	.....	35.310	.....	30.230	.....	.....	188.997	.....	5.082	.....

TABLE XI.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Total N.		Protein N.			Protein N × 6.25.		Protein-free N.		
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Ratio protein N to total N.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage of total N.
				Gms.		*Gms.*			*Gms.*		*Gms.*	
1934-'35.												
Oct. 5....	Seed	Seeds.....	3.24	0.083	3.03	0.077	0.928	18.94	0.483	0.21	0.005	6.48
Nov. 9....	5	Total.....	4.42	0.999	3.57	0.807	0.808	22.31	5.042	0.85	0.192	19.23
23....	7	Total.....	4.48	1.570	3.50	1.227	0.782	21.88	7.669	0.98	0.343	21.88
Dec. 20....	11	Total.....	3.81	2.074	3.10	1.687	0.813	19.38	10.549	0.71	0.386	18.64
Jan. 11....	14	Total.....	3.65	1.785	3.01	1.674	0.938	18.81	10.460	0.64	0.111	17.53
Feb. 1....	17	Total.....	3.80	1.925	3.06	1.550	0.805	19.13	9.691	0.74	0.375	19.47
21....	20	Total.....	4.31	2.071	3.48	1.672	0.807	21.75	10.453	0.83	0.399	19.26
Mar. 14....	23	Total.....	4.54	3.357	3.67	2.713	0.808	22.94	16.964	0.87	0.643	19.16
28....	25	Total.....	4.36	4.329	3.45	3.426	0.791	21.56	21.409	0.91	0.904	20.87
Apr. 11....	27	Total.....	3.85	7.808	3.06	6.206	0.795	19.13	38.796	0.79	1.602	20.52
18....	28	Total.....	3.27	10.856	2.54	8.433	0.777	15.88	52.722	0.73	2.424	22.32
25....	29	Total.....	3.41	17.517	2.51	12.894	0.736	15.69	80.600	0.90	4.623	26.39
May 2....	30	Total.....	2.85	23.005	2.10	16.951	0.737	13.13	105.985	0.75	6.054	26.32
9....	31	Total.....	2.58	30.176	1.97	23.041	0.764	12.31	143.977	0.61	7.135	23.64
16....	32	Total.....	2.46	35.247	1.78	25.504	0.724	11.13	159.471	0.68	9.743	27.64
23....	33	Stems and leaves..	2.02	32.974	1.48	24.160	0.733	9.25	150.997	0.54	8.815	26.73
		Heads.....	2.57	1.465	2.04	1.163	0.794	12.75	7.268	0.53	0.302	20.62
		Total.....	.....	34.439	.....	25.323	.....	.....	158.265	.....	9.117	.....

TABLE XI.—*Concluded*

DATE.	Age of plants, weeks.	Plant parts.	Total N.		Protein N.			Protein N × 6.25.		Protein-free N.		
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Ratio protein N to total N.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage of total N.
				Gms.		*Gms.*			*Gms.*		*Gms.*	
1934-'35.												
May 30....	34	Stems and leaves..	1.59	29.467	1.24	22.981	0.780	7.75	143.623	0.35	6.487	22.01
		Heads.....	1.87	3.076	1.54	2.533	0.823	9.63	15.841	0.33	0.543	17.65
		Total.....	.....	32.543	.....	25.514	.....	.....	159.464	.....	7.030	.....
June 6....	35	Stems and leaves..	1.51	30.615	1.16	23.519	0.768	7.25	146.994	0.35	7.096	23.18
		Chaff.....	1.62	3.122	1.32	2.544	0.815	8.25	15.898	0.30	0.578	18.52
		Grain.....	2.72	1.246	2.04	0.934	0.750	12.75	5.840	0.68	0.311	25.00
		Total.....	.....	34.983	.....	26.997	.....	.....	168.732	.....	7.985	.....
13....	36	Stems and leaves..	1.17	24.404	0.92	19.189	0.786	5.75	119.934	0.25	5.215	21.37
		Chaff.....	1.27	2.570	1.08	2.186	0.851	6.75	13.662	0.19	0.385	14.96
		Grain.....	2.41	5.451	2.03	4.592	0.842	12.69	28.705	0.38	0.860	15.77
		Total.....	.....	32.425	.....	25.967	.....	.....	162.301	.....	6.460	.....
20....	37	Stems and leaves..	1.13	23.229	0.87	17.885	0.770	5.44	111.830	0.26	5.345	23.01
		Chaff.....	0.82	2.013	0.74	1.817	0.903	4.63	11.367	0.08	0.196	9.76
		Grain.....	2.28	11.035	2.05	9.922	0.899	12.81	62.000	0.23	1.113	10.09
		Total.....	.....	36.277	.....	29.624	.....	.....	185.197	.....	6.654	.....

TABLE XII.—Percentage of the total nitrogen in the entire plant at each stage of growth, calculated on the maximum nitrogen content, together with the weekly percentage increase or decrease of the total nitrogen, based on the previous sample. Manhattan, Kan.

DATE.	Age of plants, weeks.	Kanred.		Harvest Queen.	
		Percentage of total N at various stages, based on maximum.	Weekly percentage increase or decrease of total N, based on the previous sample.	Percentage of total N at various stages, based on maximum.	Weekly percentage increase or decrease of total N, based on the previous sample.
1931-'32.					
Oct. 1	Seed	0.12	.....	*	*
19	4	2.76	537.50	.....	.....
Nov. 11	6	7.08	78.52	.....	.....
25	8	9.76	18.88	.....	.....
Dec. 9	10	12.04	11.72	.....	.....
23	12	13.43	5.76	.....	.....
Jan. 5	14	14.24	3.04	.....	.....
19	16	16.45	7.74	.....	.....
Feb. 10	19	18.33	3.80	.....	.....
24	21	19.00	1.84	.....	.....
Mar. 16	24	22.04	5.33	.....	.....
29	26	23.78	3.94	.....	.....
Apr. 13	28	36.35	26.44	.....	.....
27	30	36.88	0.73	.....	.....
May 4	31	49.98	35.53	.....	.....
11	32	58.67	17.39	.....	.....
18	33	59.41	1.25	.....	.....
25	34	69.22	16.52	.....	.....
June 1	35	70.98	2.54	.....	.....
8	36	69.00	—2.79	.....	.....
15	37	73.22	6.12	.....	.....
22	38	100.00	36.57	.....	.....
1932-'33.					
Oct. 5	Seed	0.43	.....	0.32	.....
Nov. 2	4	1.91	85.20	1.72	107.61
16	6	4.04	55.67	3.75	58.88
30	8	5.33	16.03	5.03	17.06
Dec. 22	11	6.48	7.20	6.09	6.98
Jan. 4	13	7.73	9.59	6.90	6.65
17	15	8.66	6.01	7.76	6.28
Feb. 2	17	10.60	11.23	10.11	15.13
16	19	10.64	0.19	10.48	1.84
Mar. 2	21	11.71	5.01	12.17	8.06
16	23	19.88	34.92	19.84	31.52
30	25	25.52	14.17	24.07	10.65
Apr. 14	27	33.68	15.99	31.50	15.44
27	29	45.38	17.36	43.30	18.72
May 4	30	51.82	14.21	60.02	38.61
11	31	68.46	32.11	62.00	3.21
18	32	75.19	9.82	71.42	15.18
25	33	72.21	—3.97	73.48	2.89
31	34	87.86	21.68	73.84	0.49
June 7	35	93.19	6.06	84.21	14.06
14	36	100.00	7.31	86.47	2.68
21	37	98.41	—1.59	100.00	15.64

TABLE XII.—*Concluded*

DATE.	Age of plants, weeks.	Kanred.		Harvest Queen.	
		Percentage of total N at various stages, based on maximum.	Weekly percentage increase or decrease of total N, based on the previous sample.	Percentage of total N at various stages, based on maximum.	Weekly percentage increase or decrease of total N, based on the previous sample.
1933-'34.					
Oct. 4	Seed	0.21	.....	0.19	.....
Nov. 1	4	1.24	125.40	1.12	122.67
15	6	1.95	28.23	1.75	27.88
29	8	5.09	80.78	4.71	84.49
Dec. 13	10	7.48	23.44	6.86	22.82
Jan. 17	15	11.56	10.94	9.29	7.09
31	17	13.06	6.47	13.80	24.27
Feb. 14	19	15.44	9.11	15.24	5.23
Mar. 7	22	19.63	9.05	18.86	7.92
21	24	21.42	4.55	19.14	0.74
Apr. 4	26	39.24	41.60	33.58	37.70
11	27	49.35	25.79	43.81	30.49
18	28	60.97	23.54	57.68	31.64
25	29	70.12	15.00	75.72	31.29
May 2	30	96.32	37.37	89.03	17.57
9	31	100.00	3.82	89.95	1.03
16	32	87.02	—12.98	100.00	11.17
23	33	99.75	14.63	94.97	—5.03
30	34	82.22	—17.58	91.52	—3.63
June 6	35	84.48	2.75	90.94	—0.63
13	36	87.77	3.90	91.49	0.60
20	37	84.46	—3.77	89.60	—2.06
1934-'35.					
Oct. 5	Seed	0.22	.....	0.23	.....
Nov. 9	5	2.28	187.63	2.75	220.72
23	7	3.83	33.90	4.33	28.58
Dec. 20	11	4.58	4.89	5.72	8.03
Jan. 11	14	3.94	—4.63	4.92	—4.64
Feb. 1	17	4.71	6.51	5.31	2.61
21	20	4.69	—0.18	5.71	2.53
Mar. 14	23	8.00	23.60	9.25	20.70
28	25	12.85	30.25	11.93	14.48
Apr. 11	27	24.25	44.39	21.52	40.18
18	28	30.65	26.37	29.93	39.04
25	29	50.62	65.15	48.29	61.36
May 2	30	63.40	25.25	63.41	31.33
9	31	82.14	29.55	83.18	31.17
16	32	86.94	5.85	97.16	16.80
23	33	100.00	15.02	94.93	—2.29
30	34	87.54	—12.46	89.71	—5.51
June 6	35	87.75	0.24	96.43	7.50
13	36	84.27	—3.97	89.38	—7.31
20	37	86.70	2.88	100.00	11.88

* Harvest Queen not grown during 1931-'32 season.

TABLE XIII.—Percentage of the total nitrogen in the various plant parts at each stage of growth calculated on the maximum nitrogen content, together with the weekly percentage increase or decrease of the total nitrogen, based on the previous sample. Manhattan, Kan.

DATE.	Age of plants, weeks.	Plant parts.	Kanred.		Harvest Queen.	
			Percentage of total N at various stages, based on maximum.	Weekly percentage increase or decrease of total N, based on the previous sample.	Percentage of total N at various stages, based on maximum.	Weekly percentage increase or decrease of total N, based on the previous sample.
1931-'32.						
May 25	34	Stems and leaves..	100.00	.....	*.....	*.....
June 1	35	Stems and leaves..	87.32	—12.68	.....	.....
8	36	Stems and leaves..	62.48	—28.45	.....	.....
15	37	Stems and leaves..	46.42	—25.71	.....	.....
22	38	Stems and leaves..	58.73	26.52	.....	.....
May 25	34	Heads.....	20.32	.....	.....	.....
June 1	35	Heads.....	33.37	64.23	.....	.....
8	36	Heads.....	50.91	52.54	.....	.....
15	37	Heads.....	70.41	38.31	.....	.....
22	38	Heads.....	100.00	42.02	.....	.....
1932-'33.						
May 18	32	Stems and leaves..	100.00	.....	99.96	.....
25	33	Stems and leaves..	84.53	—15.47	100.00	0.04
31	34	Stems and leaves..	95.69	13.20	89.49	—10.51
June 7	35	Stems and leaves..	69.69	—27.17	78.95	—11.79
14	36	Stems and leaves..	60.40	—13.32	60.92	—22.84
21	37	Stems and leaves..	55.13	—8.73	76.03	24.80
May 18	32	Heads.....	12.47	.....	11.35	.....
25	33	Heads.....	24.69	97.91	15.42	35.82
31	34	Heads.....	37.95	53.74	29.95	94.26
June 7	35	Heads.....	75.38	98.60	64.59	115.62
14	36	Heads.....	96.77	28.39	92.82	43.71
21	37	Heads.....	100.00	3.33	100.00	7.74
May 31	34	Chaff.....	100.00	.....	100.00	.....
June 7	35	Chaff.....	82.30	—17.70	89.37	—10.63
14	36	Chaff.....	57.38	—30.27	64.47	—27.86
21	37	Chaff.....	48.88	—14.82	83.11	28.91
May 31	34	Grain.....	18.29	.....	20.06	.....
June 7	35	Grain.....	64.40	252.08	59.89	198.49
14	36	Grain.....	94.34	46.48	94.49	57.78
21	37	Grain.....	100.00	6.00	100.00	5.84

TABLE XIII.—*Concluded*

DATE.	Age of plants, weeks.	Plant parts.	Kanred.		Harvest Queen.	
			Percentage of total N at various stages, based on maximum.	Weekly percentage increase or decrease of total N, based on the previous sample.	Percentage of total N at various stages, based on maximum.	Weekly percentage increase or decrease of total N, based on the previous sample.
1933-'34.						
May 9	31	Stems and leaves..	100.00	.....	93.62	.....
16	32	Stems and leaves..	80.05	—19.95	100.00	6.81
23	33	Stems and leaves..	84.80	5.94	88.19	—11.81
30	34	Stems and leaves..	53.17	—37.30	74.22	—15.85
June 6	35	Stems and leaves..	37.92	—28.68	51.61	—30.46
13	36	Stems and leaves..	26.68	—29.63	35.11	—31.97
20	37	Stems and leaves..	26.04	—2.41	35.45	0.99
May 9	31	Heads.....	7.91	.....	4.81	.....
16	32	Heads.....	17.51	121.26	11.81	145.56
23	33	Heads.....	30.67	75.14	21.93	85.68
30	34	Heads.....	50.76	65.50	38.18	74.08
June 6	35	Heads.....	77.61	52.90	72.97	91.11
13	36	Heads.....	100.00	28.85	100.00	37.05
20	37	Heads.....	97.67	—4.33	96.25	—3.75
May 30	34	Chaff.....	100.00	.....	100.00	.....
June 6	35	Chaff.....	69.52	—30.48	61.33	—38.67
13	36	Chaff.....	56.28	—19.05	58.65	—4.36
20	37	Chaff.....	36.98	—34.29	39.44	—32.75
May 30	34	Grain.....	32.45	.....	24.81	.....
June 6	35	Grain.....	70.99	118.75	69.77	181.27
13	36	Grain.....	100.00	40.87	100.00	43.32
20	37	Grain.....	99.99	—0.01	99.18	—0.82
1934-'35.						
May 23	33	Stems and leaves..	100.00	.....	100.00	.....
30	34	Stems and leaves..	83.46	—16.54	89.36	—10.64
June 6	35	Stems and leaves..	74.56	—10.67	92.85	3.90
13	36	Stems and leaves..	64.37	—13.66	74.01	—20.29
20	37	Stems and leaves..	43.54	—32.36	70.45	—4.81
May 23	33	Heads.....	15.00	.....	11.23	.....
30	34	Heads.....	21.37	42.44	23.57	109.97
June 6	35	Heads.....	39.76	86.10	33.48	42.00
13	36	Heads.....	52.74	32.63	61.47	83.63
20	37	Heads.....	100.00	89.62	100.00	62.67
June 6	35	Chaff.....	100.00	.....	100.00	.....
13	36	Chaff.....	79.26	—20.74	82.32	—17.68
20	37	Chaff.....	65.65	—17.17	64.48	—21.67
June 6	35	Grain.....	12.88	.....	11.29	.....
13	36	Grain.....	36.50	183.42	49.40	337.48
20	37	Grain.....	100.00	173.99	100.00	102.44

* Harvest Queen not grown during 1931-'32 season.

TABLE XIV.—Gain or loss of total nitrogen in the stems and leaves, heads, chaff and grain of 100 plants. Manhattan, Kan.

DATE.	Kanred.		Harvest Queen.		Kanred.		Harvest Queen.	
	Stems and leaves.	Heads.	Stems and leaves.	Heads.	Chaff.	Grain.	Chaff.	Grain.
	Gms.	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*
1931-'32.								
May 25–June 1	—3.45	+4.31						
June 1–8	—6.76	+5.79						
June 8–15	—4.37	+6.44						
June 15–22	+3.35	+9.77						
1932-'33.								
May 18–25	—1.83	+1.31	+0.01	+0.432				
May 25–31	+1.32	+1.42	—1.47	+1.54				
May 31–June 7	—3.08	+4.01	—1.47	+3.68	—0.401	+4.424	—0.134	+3.813
June 7–14	—1.10	+2.30	—2.52	+3.00	—0.577	+2.872	—0.314	+3.133
June 14–21	—0.63	+0.35	+2.11	+0.76	—0.187	+0.543	+0.235	+0.528
1933-'34.								
May 9–16	—5.77	+1.83	×2.34	+1.62				
May 16–23	+1.38	+2.50	—4.33	+2.35				
May 23–30	—9.16	+3.82	—5.13	+3.77				
May 30–June 6	—4.42	+5.11	—8.29	+8.06	—1.298	+6.404	—1.403	+9.466
June 6–13	—3.26	+4.26	—6.05	+6.214	+0.564	+4.822	—0.097	+6.363
June 13–20	—0.19	—0.82	+0.12	—0.87	—0.822	—0.001	—0.697	+0.173
1934-'35.								
May 23–30	—5.32	+1.02	—3.51	+1.61				
May 30–June 6	—2.86	+2.94	+1.15	+1.29				
June 6–13	—3.28	+2.07	—6.21	+3.65	—0.972	+4.205	—0.552	+4.205
June 13–20	—6.70	+7.54	—1.18	+5.03	—0.638	+5.584	—0.557	+5.584

TABLE XV.—Percentage and actual amount in grams per 100 plants of the total phosphorus, water-soluble phosphorus, and insoluble phosphorus, at various stages of growth of Kanred wheat during three seasons. Manhattan, Kan.

DATE.	Age of plants, weeks.	Plant parts.	Total P.		Water-soluble P.		Percentage water-soluble of total P.	Insoluble P percentage dry basis.	Insoluble P amount per 100 plants.	Percentage insoluble P of total P.
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.				
				Gms.		*Gms.*			*Gms.*	
1931-'32.										
Oct. 1	Seed	Seeds	0.415	0.012	0.227	0.006	54.70	0.188	0.006	45.30
29	4	Total	0.808	0.207	0.498	0.127	61.63	0.310	0.080	38.37
Nov. 11	6	Total	0.802	0.542	0.480	0.324	59.85	0.322	0.218	40.15
25	8	Total	0.796	0.800	0.565	0.568	70.98	0.231	0.232	29.02
Dec. 9	10	Total	0.681	0.981	0.488	0.702	71.66	0.193	0.279	28.34
23	12	Total	0.630	1.058	0.451	0.758	71.59	0.179	0.300	28.41
Jan. 5	14	Total	0.565	0.954	0.417	0.705	73.81	0.148	0.249	26.19
19	16	Total	0.532	1.036	0.404	0.788	75.94	0.128	0.248	24.06
Feb. 10	19	Total	0.505	1.125	0.371	0.827	73.47	0.134	0.298	26.53
24	21	Total	0.479	1.068	0.332	0.740	69.31	0.147	0.328	30.69
Mar. 16	24	Total	0.508	1.306	0.364	0.935	71.65	0.144	0.371	28.35
29	26	Total	0.501	1.534	0.377	1.153	75.25	0.124	0.381	24.75
Apr. 13	28	Total	0.329	2.002	0.249	1.517	75.68	0.080	0.485	24.32
27	30	Total	0.294	2.642	0.271	2.442	92.18	0.023	0.200	7.82
May 4	31	Total	0.235	3.329	0.182	2.577	77.45	0.053	0.752	22.55
11	32	Total	0.219	4.051	0.165	3.062	75.34	0.054	0.989	24.66
18	33	Total	0.194	4.231	0.131	2.845	67.53	0.063	1.386	32.47
25	34	Stems and leaves	0.177	4.153	0.127	2.983	71.75	0.050	1.170	29.25
		Heads	0.316	1.031	0.271	0.882	85.76	0.045	0.149	14.24
		Total		5.184		3.865			1.319	

TABLE XV.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Total P.		Water-soluble P.		Percentage water-soluble of total P.	Insoluble P percentage dry basis.	Insoluble P amount per 100 plants.	Percentage insoluble P of total P.
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.				
				Gms.		*Gms.*			*Gms.*	
1931-'32.										
June 1.....	35	Stems and leaves....	0.136	3.360	0.098	2.401	72.06	0.038	0.959	27.94
		Heads.....	0.309	1.656	0.247	1.308	79.94	0.062	0.348	20.06
		Total.....	.....	5.016	.....	3.709	.....	.....	1.307	.....
8.....	36	Stems and leaves....	0.080	1.889	0.056	1.317	70.00	0.024	0.572	30.00
		Heads.....	0.281	2.373	0.114	0.960	40.57	0.167	1.413	59.43
		Total.....	.....	4.262	.....	2.277	.....	.....	1.985	.....
15.....	37	Stems and leaves....	0.053	1.153	0.029	0.633	54.72	0.024	0.520	45.28
		Heads.....	0.284	3.463	0.142	1.731	50.00	0.142	1.732	50.00
		Total.....	.....	4.616	.....	2.364	.....	.....	2.252	.....
22.....	38	Stems and leaves....	0.068	1.382	0.027	0.553	39.71	0.041	0.829	60.29
		Heads.....	0.281	3.882	0.130	1.795	46.26	0.151	2.087	53.74
		Total.....	.....	5.264	.....	2.348	.....	.....	2.916	.....

TABLE XV.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Total P.		Water-soluble P.		Percentage water-soluble of total P.	Insoluble P percentage dry basis.	Insoluble P amount per 100 plants.	Percentage insoluble P of total P.
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.				
				Gms.		*Gms.*			*Gms.*	
1932-'33.										
Oct. 5	Seed	Seeds	0.367	0.010	0.163	0.004	44.41	0.204	0.005	55.59
Nov. 2	4	Total	0.609	0.041	0.512	0.035	84.07	0.097	0.006	15.93
16	6	Total	0.571	0.086	0.472	0.071	82.66	0.099	0.015	17.34
30	8	Total	0.554	0.119	0.469	0.100	84.65	0.085	0.019	15.35
Dec. 22	11	Total	0.619	0.148	0.528	0.126	85.29	0.081	0.022	14.71
Jan. 4	13	Total	0.560	0.171	0.472	0.144	84.28	0.088	0.027	15.72
17	15	Total	0.503	0.169	0.433	0.145	86.08	0.070	0.024	13.92
Feb. 2	17	Total	0.538	0.214	0.433	0.173	80.48	0.105	0.041	19.52
16	19	Total	0.497	0.200	0.479	0.193	96.37	0.018	0.007	3.63
Mar. 2	21	Total	0.572	0.232	0.537	0.217	93.88	0.035	0.015	6.12
16	23	Total	0.568	0.395	0.508	0.354	89.43	0.060	0.041	10.57
30	25	Total	0.447	0.447	0.393	0.392	87.91	0.054	0.055	12.09
Apr. 14	27	Total	0.285	0.495	0.241	0.419	84.56	0.044	0.076	15.44
27	29	Total	0.262	0.699	0.222	0.593	84.74	0.040	0.106	15.26
May 4	30	Total	0.223	0.792	0.192	0.682	86.09	0.031	0.110	13.91
11	31	Total	0.197	1.122	0.165	0.940	83.75	0.032	0.182	16.25
18	32	Stems and leaves	0.158	1.034	0.127	0.831	80.37	0.031	0.203	19.63
		Heads	0.410	0.214	0.319	0.167	77.80	0.091	0.047	22.20
		Total		1.248		0.998			0.250	

TABLE XV.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Total P.		Water-soluble P.		Percentage water-soluble of total P.	Insoluble P percentage dry basis.	Insoluble P amount per 100 plants.	Percentage insoluble P of total P.
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.				
				Gms.		*Gms.*			*Gms.*	
1932-'33.										
May 25.....	33	Stems and leaves....	0.095	0.665	0.085	0.595	89.47	0.010	0.070	10.53
		Heads.....	0.303	0.328	0.291	0.315	96.03	0.012	0.013	3.97
		Total.....	.....	0.993	.....	0.910	.....	.....	0.083	.....
31.....	34	Stems and leaves....	0.136	1.078	0.093	0.737	68.38	0.043	0.341	31.62
		Chaff.....	0.343	0.397	0.204	0.236	59.47	0.139	0.161	40.53
		Grain.....	0.481	0.309	0.369	0.237	76.71	0.112	0.072	23.29
		Total.....	.....	1.784	.....	1.210	.....	.....	0.574	.....
June 7.....	35	Stems and leaves....	0.062	0.470	0.051	0.387	82.25	0.011	0.083	17.75
		Chaff.....	0.192	0.229	0.117	0.139	60.93	0.075	0.090	39.07
		Grain.....	0.375	0.849	0.166	0.376	44.26	0.209	0.473	55.74
		Total.....	.....	1.548	.....	0.902	.....	.....	0.646	.....
14.....	36	Stems and leaves....	0.044	0.332	0.048	(0.361)	(109.00)	.....	.....	.....
		Chaff.....	0.079	0.086	0.072	0.080	91.13	0.007	0.006	8.87
		Grain.....	0.398	1.082	0.169	0.459	42.46	0.229	0.623	57.54
		Total.....	.....	1.500	.....	0.900	.....	.....	.....	.....
21.....	37	Stems and leaves....	0.033	0.248	0.052	(0.390)	(157.00)	.....	.....	.....
		Chaff.....	0.126	0.136	0.054	0.058	42.85	0.072	0.078	57.15
		Grain.....	0.386	1.080	0.180	0.503	46.63	0.206	0.577	53.37
		Total.....	.....	1.464	.....	0.951	.....	.....	.....	.....

TABLE XV.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Total P.		Water-soluble P.		Percentage water-soluble of total P.	Insoluble P percentage dry basis.	Insoluble P amount per 100 plants.	Percentage insoluble P of total P.
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.				
				Gms.		*Gms.*			*Gms.*	
1933-'34.										
Oct. 4	Seed	Seeds	0.37	0.008	0.18	0.003	48.65	0.19	0.004	51.35
Nov. 1	4	Total	0.44	0.029	0.39	0.026	88.64	0.05	0.003	11.36
15	6	Total	0.35	0.047	0.30	0.040	85.71	0.05	0.006	14.29
29	8	Total	0.36	0.132	0.29	0.106	80.56	0.07	0.025	19.44
Dec. 13	10	Total	0.37	0.209	0.31	0.175	83.78	0.06	0.033	16.22
Jan. 17	15	Total	0.32	0.278	0.29	0.252	90.63	0.03	0.026	9.38
31	17	Total	0.38	0.346	0.33	0.301	86.84	0.05	0.045	13.16
Feb. 14	19	Total	0.43	0.453	0.37	0.390	86.05	0.06	0.063	13.95
Mar. 7	22	Total	0.43	0.539	0.38	0.476	88.37	0.05	0.062	11.63
21	24	Total	0.44	0.572	0.39	0.507	88.64	0.05	0.065	11.36
Apr. 4	26	Total	0.43	1.055	0.37	0.908	86.05	0.06	0.147	13.95
11	27	Total	0.30	1.056	0.28	0.986	93.33	0.02	0.070	6.67
18	28	Total	0.27	1.378	0.20	1.020	74.07	0.07	0.357	25.93
25	29	Total	0.23	1.682	0.16	1.170	69.57	0.07	0.512	30.43
May 2	30	Total	0.22	2.365	0.16	1.720	72.73	0.06	0.645	27.27
9	31	Stems and leaves	0.17	2.248	0.12	1.587	70.59	0.05	0.661	29.41
		Heads	0.50	0.256						
		Total		2.504						

TABLE XV.—*Concluded*

DATE.	Age of plants, weeks.	Plant parts.	Total P.		Water-soluble P.		Percentage water-soluble of total P.	Insoluble P percentage dry basis.	Insoluble P amount per 100 plants.	Percentage insoluble P of total P.
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.				
				Gms.		*Gms.*			*Gms.*	
1933-'34.										
May 16.....	32	Stems and leaves....	0.14	1.943	0.08	1.110	57.14	0.06	0.833	42.86
		Heads.....	0.33	0.495	0.26	0.390	78.79	0.07	0.105	21.21
		Total.....	.....	2.438	.....	1.500	.....	.....	0.938	.....
23.....	33	Stems and leaves....	0.11	1.850	0.06	1.009	54.55	0.05	0.841	45.45
		Heads.....	0.29	0.775	0.23	0.615	79.31	0.06	0.160	20.69
		Total.....	.....	2.625	.....	1.624	.....	.....	1.001	.....
30.....	34	Stems and leaves....	0.06	1.015	0.04	0.677	66.67	0.02	0.338	33.33
		Chaff.....	0.19	0.481	0.12	0.304	63.16	0.07	0.177	36.84
		Grain.....	0.39	0.787	0.27	0.545	69.23	0.12	0.242	30.77
		Total.....	.....	2.283	.....	1.526	.....	.....	0.757	.....
June 6.....	35	Stems and leaves....	0.06	0.928	0.03	0.464	50.00	0.03	0.464	50.00
		Chaff.....	0.13	0.334	0.06	0.154	46.15	0.07	0.180	53.85
		Grain.....	0.33	1.595	0.17	0.821	51.52	0.16	0.773	48.48
		Total.....	.....	2.857	.....	1.439	.....	.....	1.417	.....
13.....	36	Stems and leaves....	0.05	0.678	0.02	0.271	40.00	0.03	0.406	60.00
		Chaff.....	0.10	0.255	0.04	0.102	40.00	0.06	0.153	60.00
		Grain.....	0.33	2.016	0.15	0.916	45.45	0.18	1.099	54.55
		Total.....	.....	2.949	.....	1.289	.....	.....	1.658	.....
20.....	37	Stems and leaves....	0.05	0.685	0.02	0.274	40.00	0.03	0.411	60.00
		Chaff.....	0.07	0.157	0.03	0.067	42.86	0.04	0.090	57.14
		Grain.....	0.37	2.195	0.14	0.830	37.84	0.23	1.365	62.16
		Total.....	.....	3.037	.....	1.171	.....	.....	1.866	.....

TABLE XVI.—Percentage and actual amount in grams per 100 plants of the total phosphorus, water-soluble phosphorus and insoluble phosphorus at various stages of growth of Harvest Queen wheat during two seasons. Manhattan, Kan.

DATE.	Age of plants, weeks.	Plant parts.	Total P.		Water-soluble P.		Percentage water-soluble of total P.	Insoluble P percentage dry basis.	Insoluble P amount per 100 plants.	Percentage insoluble P of total P.
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.				
				Gms.		*Gms.*			*Gms.*	
1932-'33.										
Oct. 5	Seed	Seeds	0.369	0.010	0.182	0.005	49.32	0.187	0.005	50.68
Nov. 2	4	Total[1]	0.522	0.040	0.458	0.035	87.73	0.064	0.005	12.27
16	6	Total	0.488	0.083	0.416	0.071	85.24	0.072	0.012	14.76
30	8	Total	0.456	0.116	0.384	0.098	84.21	0.072	0.018	15.79
Dec. 22	11	Total	0.499	0.143	0.414	0.118	82.96	0.085	0.025	17.04
Jan. 4	13	Total	0.491	0.167	0.407	0.138	82.89	0.084	0.029	17.11
17	15	Total	0.451	0.166	0.359	0.132	79.60	0.092	0.034	20.40
Feb. 2	17	Total	0.491	0.231	0.385	0.181	78.41	0.106	0.050	21.59
16	19	Total	0.482	0.232	0.394	0.190	81.74	0.088	0.042	18.26
Mar. 2	21	Total	0.525	0.279	0.423	0.225	80.57	0.102	0.054	19.43
16	23	Total	0.516	0.428	0.423	0.351	81.97	0.093	0.077	18.03
30	25	Total	0.418	0.478	0.336	0.384	80.38	0.082	0.094	19.62
Apr. 14	27	Total	0.261	0.472	0.218	0.394	83.52	0.043	0.078	16.48
27	29	Total	0.214	0.645	0.179	0.540	83.64	0.035	0.105	16.36
May 4	30	Total	0.260	1.232	0.161	0.763	61.93	0.099	0.469	38.07
11	31	Total	0.222	1.427	0.139	0.893	60.36	0.083	0.534	39.64
18	32	Stems and leaves	0.160	1.228	0.102	0.783	63.76	0.058	0.445	36.24
		Heads	0.375	0.192	0.272	0.139	72.53	0.103	0.053	27.47
		Total		1.420		0.922			0.498	

TABLE XVI.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Total P.		Water-soluble P.		Percentage water-soluble of total P.	Insoluble P percentage dry basis.	Insoluble P amount per 100 plants.	Percentage insoluble P of total P.
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.				
				Gms.		*Gms.*			*Gms.*	
1932-'33.										
May 25	33	Stems and leaves	0.149	1.239	0.101	0.840	67.78	0.048	0.399	32.22
		Heads	0.351	0.285	0.271	0.220	77.20	0.080	0.065	22.80
		Total		1.524		1.060			0.464	
31	34	Stems and leaves	0.131	1.170	0.072	0.643	54.96	0.059	0.527	45.04
		Chaff	0.291	0.245	0.153	0.129	52.57	0.138	0.116	47.43
		Grain	0.434	0.315	0.369	0.267	85.02	0.065	0.048	14.98
		Total		1.730		1.039			0.691	
June 7	35	Stems and leaves	0.089	0.755	0.059	0.501	66.29	0.030	0.254	33.71
		Chaff	0.170	0.162	0.102	0.097	60.00	0.068	0.065	40.00
		Grain	0.441	0.884	0.185	0.371	41.95	0.256	0.513	58.05
		Total		1.801		0.969			0.832	
14	36	Stems and leaves	0.076	0.653	0.037	0.318	48.68	0.039	0.335	51.32
		Chaff	0.097	0.084	0.052	0.055	53.60	0.045	0.029	46.40
		Grain	0.452	1.200	0.159	0.422	35.17	0.293	0.778	64.83
		Total		1.937		0.795			1.142	
21	37	Stems and leaves	0.079	0.723	0.056	0.513	70.88	0.023	0.210	29.12
		Chaff	0.105	0.100	0.063	0.059	60.00	0.042	0.041	40.00
		Grain	0.483	1.247	0.184	0.475	38.09	0.299	0.772	61.91
		Total		2.070		1.047			1.023	

TABLE XVI.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Total P.		Water-soluble P.		Percentage water-soluble of total P.	Insoluble P percentage dry basis.	Insoluble P amount per 100 plants.	Percentage insoluble P of total P.
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.				
				Gms.		*Gms.*			*Gms.*	
1933-'34.										
Oct. 4.....	Seed	Seeds.....	0.37	0.009	0.14	0.003	37.84	0.23	0.006	62.16
Nov. 1.....	4	Total.....	0.38	0.031	0.31	0.025	81.58	0.07	0.005	18.42
15.....	6	Total.....	0.31	0.049	0.26	0.041	83.87	0.05	0.008	16.13
29.....	8	Total.....	0.32	0.142	0.27	0.120	84.38	0.05	0.022	15.63
Dec. 13.....	10	Total.....	0.34	0.227	0.23	0.153	67.65	0.11	0.073	32.35
Jan. 17.....	15	Total.....	0.35	0.316	0.24	0.216	68.57	0.11	0.099	31.43
31.....	17	Total.....	0.38	0.476	0.27	0.338	71.05	0.11	0.137	28.95
Feb. 14.....	19	Total.....	0.38	0.546	0.28	0.402	73.68	0.10	0.143	26.32
Mar. 7.....	22	Total.....	0.45	0.713	0.30	0.475	66.67	0.15	0.237	33.33
21.....	24	Total.....	0.47	0.726	0.33	0.510	70.21	0.14	0.216	29.79
Apr. 4.....	26	Total.....	0.39	1.081	0.34	0.943	87.18	0.05	0.138	12.82
11.....	27	Total.....	0.33	1.306	0.24	0.950	72.73	0.09	0.356	27.27
18.....	28	Total.....	0.32	1.904	0.19	1.130	59.38	0.13	0.773	40.63
25.....	29	Total.....	0.25	2.274	0.17	1.546	68.00	0.08	0.727	32.00
May 2.....	30	Total.....	0.23	2.902	0.14	1.766	60.87	0.09	1.135	39.13
9.....	31	Stems and leaves....	0.17	2.605	0.09	1.379	52.94	0.08	1.226	47.06
		Heads.....	0.60	0.205	0.30	0.102	50.00	0.30	0.102	50.00
		Total.....	.....	2.810	.....	1.481	.....	.....	1.328	.....

TABLE XVI.—*Concluded*

DATE.	Age of plants, weeks.	Plant parts.	Total P.		Water-soluble P.		Percentage water-soluble of total P.	Insoluble P percentage dry basis.	Insoluble P amount per 100 plants.	Percentage insoluble P of total P.
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.				
				Gms.		*Gms.*			*Gms.*	
1933-'34.										
May 16	32	Stems and leaves	0.15	2.957	0.08	1.577	53.33	0.07	1.380	46.67
		Heads	(0.50)	(0.635)	0.25	0.327	(51.49)	(0.25)	(0.317)	(48.51)
		Total		(3.592)		(1.904)			(1.697)	
23	33	Stems and leaves	0.13	3.003	0.05	1.155	38.46	0.08	1.848	61.54
		Heads	0.32	0.860	0.23	0.618	71.88	0.09	0.242	28.13
		Total		3.863		1.773			2.090	
30	34	Stems and leaves	0.11	2.515	0.04	0.914	36.36	0.07	1.600	63.64
		Chaff	0.21	0.536	0.13	0.332	61.90	0.08	0.204	38.10
		Grain	0.42	0.833	0.25	0.496	59.52	0.17	0.337	40.48
		Total		3.884		1.742			2.141	
June 6	35	Stems and leaves	0.06	1.368	0.03	0.684	50.00	0.03	0.684	50.00
		Chaff	0.08	0.214	0.05	0.134	62.50	0.03	0.080	37.50
		Grain	0.36	2.115	0.14	0.822	38.89	0.22	1.292	61.11
		Total		3.697		1.640			2.056	
13	36	Stems and leaves	0.05	1.091	0.04	0.872	80.00	0.01	0.218	20.00
		Chaff	0.08	0.212	0.04	0.106	50.00	0.04	0.106	50.00
		Grain	0.37	2.832	0.15	1.148	40.54	0.22	1.684	59.46
		Total		4.135		2.126			2.008	
20	37	Stems and leaves	0.07	1.467	(0.04)	(0.838)	(55.00)	(0.03)	(0.629)	(42.87)
		Chaff	0.07	0.175	0.05	0.125	71.43	0.02	0.050	28.57
		Grain	0.38	2.823	0.15	1.114	39.47	0.23	1.708	60.53
		Tota		4.465		(2.077)			(2.387)	

TABLE XVII.—The percentage of the total phosphorus in the entire plant at each stage of growth, calculated on the maximum phosphorus content, and the weekly percentage increase or decrease of the total phosphorus, based on the previous sample. Manhattan, Kan.

DATE.	Age of plants, weeks.	Kanred.		Harvest Queen.	
		Percentage of total phosphorus at various stages, based on maximum.	Weekly percentage increase or decrease of total phosphorus, based on the previous sample.	Percentage of total phosphorus at various stages, based on maximum.	Weekly percentage increase or decrease of total phosphorus, based on the previous sample.
1931-'32.					
Oct. 1	Seed	0.23	.....	*	*
29	4	3.93	406.25	.....	.....
Nov. 11	6	10.30	80.92	.....	.....
25	8	15.20	23.80	.....	.....
Dec. 9	10	18.64	11.31	.....	.....
23	12	20.10	3.92	.....	.....
Jan. 5	14	18.12	—4.91	.....	.....
19	16	19.68	4.30	.....	.....
Feb. 10	19	21.37	2.86	.....	.....
24	21	20.29	—2.53	.....	.....
Mar. 16	24	24.81	7.43	.....	.....
29	26	29.14	8.73	.....	.....
Apr. 13	28	38.03	15.25	.....	.....
27	30	50.19	15.98	.....	.....
May 4	31	63.24	26.00	.....	.....
11	32	76.96	21.69	.....	.....
18	33	80.38	4.44	.....	.....
25	34	98.48	22.52	.....	.....
June 1	35	95.29	—3.24	.....	.....
8	36	80.97	—15.03	.....	.....
15	37	87.69	8.31	.....	.....
22	38	100.00	14.04	.....	.....

TABLE XVII.—*Concluded*

DATE.	Age of plants, weeks.	Kanred.		Harvest Queen.	
		Percentage of total phosphorus at various stages, based on maximum.	Weekly percentage increase or decrease of total phosphorus, based on the previous sample.	Percentage of total phosphorus at various stages, based on maximum.	Weekly percentage increase or decrease of total phosphorus, based on the previous sample.
1932-'33.					
Oct. 5	Seed	0.56	.....	0.48	.....
Nov. 2	4	2.30	77.50	1.93	75.00
16	6	4.82	54.88	4.01	53.75
30	8	6.67	19.19	5.60	19.88
Dec. 22	11	8.30	8.12	6.91	7.76
Jan. 4	13	9.59	7.77	8.07	8.39
17	15	9.47	—0.58	8.02	—0.30
Feb. 2	17	12.00	13.31	11.16	19.58
16	19	11.21	—3.27	11.21	0.22
Mar. 2	21	13.00	8.00	13.48	10.13
16	23	22.14	35.13	20.68	26.70
30	25	25.06	6.58	23.09	5.84
Apr. 14	27	27.75	5.37	22.80	—0.63
27	29	39.18	20.61	31.16	18.33
May 4	30	44.39	13.30	59.52	91.01
11	31	62.89	41.67	68.94	15.83
18	32	69.96	11.23	68.60	—0.49
25	33	55.66	—20.43	73.62	7.32
31	34	100.00	79.66	83.57	13.52
June 7	35	86.77	—13.23	87.00	4.10
14	36	84.08	—3.10	93.57	7.55
21	37	82.06	—2.40	100.00	6.87
1933-'34.					
Oct. 4	Seed	0.26	.....	0.20	.....
Nov. 1	4	0.95	65.63	0.69	61.11
15	6	1.55	31.03	1.10	29.03
29	8	4.35	90.43	3.18	94.90
Dec. 13	10	6.88	29.17	5.08	29.93
Jan. 17	15	9.15	6.60	7.08	7.84
31	17	11.39	12.23	10.66	25.32
Feb. 14	19	14.92	15.46	12.23	7.35
Mar. 7	22	17.75	6.33	15.97	10.20
21	24	18.83	3.06	16.26	0.91
Apr. 4	26	34.74	42.22	24.21	24.45
11	27	34.77	0.09	29.25	20.81
18	28	45.37	30.49	42.64	45.79
25	29	55.38	22.06	50.93	19.43
May 2	30	77.87	40.61	64.99	27.62
9	31	82.45	5.88	62.93	—3.17
16	32	80.28	—2.64	80.45	27.83
23	33	86.43	7.67	86.52	7.54
30	34	75.17	—13.03	86.99	0.54
June 6	35	94.07	25.14	82.80	—4.81
13	36	97.10	3.22	92.61	11.85
20	37	100.00	2.98	100.00	7.98

* Harvest Queen not grown during 1931-'32 season.

TABLE XVIII.—Gain or loss of total phosphorus in the stems and leaves, heads, chaff and grain of 100 plants. Manhattan, Kan.

DATE.	Kanred.				Harvest Queen.			
	Stems and leaves.	Heads.	Chaff.	Grain.	Stems and leaves.	Heads.	Chaff.	Grain.
	Gms.	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*
1931-'32.								
May 25–June 1	—0.793	+0.625			*	*	*	*
June 1–8	—0.471	+0.717						
June 8–15	—0.726	+1.090						
June 15–22	+0.129	+0.419						
1932-'33.								
May 18–25	—0.369	+0.114			+0.011	+0.093		
May 25–31	+0.413	+0.378			—0.069	+0.275		
May 31–June 7	—0.608	+0.372	—0.168	+0.540	—0.415	+0.486	—0.083	+0.569
June 7–14	—0.138	+0.090	—0.143	+0.233	—0.102	+0.238	—0.078	+0.316
June 14–21	—0.084	+0.134	+0.050	+0.000	+0.070	+0.063	+0.016	+0.047
1933-'34.								
May 9–16	—0.305	+0.237			+0.352	+0.430		
May 16–23	—0.113	+0.280			+0.046	+0.225		
May 23–30	—0.835	+0.493			—0.488	+0.509		
May 30–June 6	—0.087	+0.661	—0.147	+0.808	—1.147	+0.960	—0.322	+1.282
June 6–13	—0.250	+0.342	—0.081	+0.421	—0.277	+0.715	—0.002	+0.717
June 13–20	+0.007	+0.081	—0.096	+0.179	+0.376	—0.046	—0.037	+0.009

* Harvest Queen not grown during 1931-'32 season.

TABLE XIX.—Percentage of the total phosphorus in the various plant parts at each stage of growth, calculated on the maximum phosphorus content, and the weekly percentage increase or decrease of the total phosphorus, based on the previous sample. Manhattan, Kan.

DATE.	Age of plants, weeks.	Plant parts.	Kanred.		Harvest Queen.	
			Percentage of total phosphorus at various stages, based on maximum.	Weekly percentage increase or decrease of total phosphorus, based on the previous sample.	Percentage of total phosphorus at various stages, based on maximum.	Weekly percentage increase or decrease of total phosphorus, based on the previous sample.
1931-'32.						
May 25	34	Stems and leaves	100.00	.....	*	*
June 1	35	Stems and leaves	80.91	—19.09	.....	.....
8	36	Stems and leaves	45.49	—43.78	.....	.....
15	37	Stems and leaves	27.76	—38.96	.....	.....
22	38	Stems and leaves	33.28	19.86	.....	.....
May 25	34	Heads	26.56	.....	.....	.....
June 1	35	Heads	42.66	60.62	.....	.....
8	36	Heads	61.13	43.30	.....	.....
15	37	Heads	89.21	45.93	.....	.....
22	38	Heads	100.00	12.10	.....	.....
1932-'33.						
May 18	32	Stems and leaves	95.92	.....	99.11	.....
25	33	Stems and leaves	61.69	—35.69	100.00	0.90
31	34	Stems and leaves	100.00	62.11	94.43	—5.57
June 7	35	Stems and leaves	43.60	—56.40	60.94	—35.47
14	36	Stems and leaves	30.80	—29.36	52.70	—13.51
21	37	Stems and leaves	23.01	—25.30	58.35	10.72
May 18	32	Heads	17.60	.....	14.25	.....
25	33	Heads	26.97	53.27	21.16	48.44
31	34	Heads	58.06	115.24	41.57	96.49
June 7	35	Heads	88.65	52.69	77.65	86.79
14	36	Heads	96.05	8.35	95.32	22.75
21	37	Heads	100.00	4.11	100.00	4.91
May 31	34	Chaff	100.00	.....	100.00	.....
June 7	35	Chaff	57.68	—42.32	66.12	—33.88
14	36	Chaff	21.66	—62.45	34.29	—48.15
21	37	Chaff	34.26	58.14	40.82	19.05
May 31	34	Grain	28.56	.....	25.26	.....
June 7	35	Grain	78.47	174.76	70.89	180.63
14	36	Grain	100.00	27.44	96.23	35.75
21	37	Grain	99.82	—0.18	100.00	3.92

TABLE XIX.—*Concluded*

DATE.	Age of plants, weeks.	Plant parts.	Kanred.		Harvest Queen.	
			Percentage of total phosphorus at various stages, based on maximum.	Weekly percentage increase or decrease of total phosphorus, based on the previous sample.	Percentage of total phosphorus at various stages, based on maximum.	Weekly percentage increase or decrease of total phosphorus, based on the previous sample.
1933-'34.						
May 9....	31	Stems and leaves..	100.00	.....	86.75	.....
16....	32	Stems and leaves..	86.43	—13.57	98.47	13.51
23....	33	Stems and leaves..	82.30	—4.79	100.00	1.56
30....	34	Stems and leaves..	45.15	—45.14	83.75	—16.25
June 6....	35	Stems and leaves..	41.28	—8.57	45.55	—45.61
13....	36	Stems and leaves..	30.16	—26.94	36.33	—20.25
20....	37	Stems and leaves..	30.47	1.03	48.85	34.46
May 9....	31	Heads.....	10.88	.....	6.73	.....
16....	32	Heads.....	21.05	93.36	20.86	209.76
23....	33	Heads.....	32.95	56.57	28.25	35.43
30....	34	Heads.....	53.91	63.61	44.97	59.19
June 6....	35	Heads.....	82.02	52.13	76.51	70.12
13....	36	Heads.....	96.56	17.73	100.00	30.70
20....	37	Heads.....	100.00	3.57	98.49	—1.51
May 30....	34	Chaff.....	100.00	.....	100.00	.....
June 6....	35	Chaff.....	69.44	—30.56	39.93	—60.07
13....	36	Chaff.....	53.01	—23.65	39.55	—0.93
20....	37	Chaff.....	32.64	—38.43	32.65	—17.45
May 30....	34	Grain.....	35.85	.....	29.41	.....
June 6....	35	Grain.....	72.67	102.67	74.68	153.90
13....	36	Grain.....	91.85	26.39	100.00	33.90
20....	37	Grain.....	100.00	8.88	99.68	—0.32

* Harvest Queen not grown during 1931-'32 season.

TABLE XX.—Percentage and actual amount in grams per 100 plants of the total potassium at various stages of growth of Kanred and Harvest Queen wheats. Manhattan, Kan.

DATE.	Age of plants, weeks.	Plant parts.	Kanred.		Harvest Queen.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*
1931-'32.						
Oct. 1	Seed	Seeds	0.483	0.014	*	*
29	4	Total	5.676	1.456		
Nov. 11	6	Total	5.409	3.656		
25	8	Total	4.874	4.898		
Dec. 9	10	Total	3.741	5.387		
23	12	Total	3.235	5.436		
Jan. 5	14	Total	3.475	5.864		
19	16	Total	3.799	7.409		
Feb. 10	19	Total	2.438	5.436		
24	21	Total	2.480	5.531		
Mar. 16	24	Total	3.305	8.494		
29	26	Total	3.424	10.476		
Apr. 13	28	Total	4.465	27.147		
27	30	Total	4.137	37.235		
May 4	31	Total	4.000	56.566		
11	32	Total	3.361	62.177		
18	33	Total	2.763	60.237		
25	34	Stems and leaves	2.591	60.624		
		Heads	0.850	2.771		
		Total		63.395		
June 1	35	Stems and leaves	2.137	52.573		
		Heads	0.834	4.420		
		Total		56.993		
8	36	Stems and leaves	1.932	45.740		
		Heads	0.637	5.381		
		Total		51.121		
15	37	Stems and leaves	1.675	36.208		
		Heads	0.542	6.595		
		Total		42.803		
22	38	Stems and leaves	1.930	39.115		
		Heads	0.460	6.357		
		Total		45.472		

TABLE XX.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Kanred.		Harvest Queen.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*
1932-'33.						
Oct. 5	Seed	Seeds	0.33	0.009	0.26	0.007
Nov. 2	4	Total	5.05	0.343	4.73	0.359
16	6	Total	4.24	0.640	4.28	0.732
30	8	Total	3.10	0.666	3.44	0.874
Dec. 22	11	Total	3.27	0.782	3.12	0.892
Jan. 4	13	Total	2.48	0.759	2.62	0.891
17	15	Total	2.55	0.857	2.73	1.005
Feb. 2	17	Total	3.01	1.201	2.97	1.399
16	19	Total	2.72	1.096	2.80	1.350
Mar. 2	21	Total	3.58	1.450	3.77	1.471
16	23	Total	4.76	3.313	4.29	3.561
30	25	Total	4.66	4.655	4.54	5.194
Apr. 14	27	Total	4.83	8.390	4.95	8.955
27	29	Total	4.10	10.947	4.02	12.124
May 4	30	Total	3.88	13.778	3.72	17.632
11	31	Total	3.09	17.607	3.02	19.407
18	32	Stems and leaves	2.96	19.374	2.74	21.027
		Heads	1.27	0.664	1.35	0.690
		Total		20.038		21.717
25	33	Stems and leaves	2.49	17.437	2.63	21.874
		Heads	0.87	0.940	0.87	0.706
		Total		18.377		22.580
31	34	Stems and leaves	2.41	19.104	2.33	20.812
		Chaff	0.92	1.065	0.85	0.715
		Grain	0.46	0.296	0.65	0.471
		Total		20.465		21.998
June 7	35	Stems and leaves	2.25	17.065	2.63	22.318
		Chaff	1.24	1.477	0.87	0.831
		Grain	0.37	0.837	0.38	0.762
		Total		19.379		23.911
14	36	Stems and leaves	2.56	19.284	2.49	21.409
		Chaff	1.77	1.961	1.18	1.021
		Grain	0.35	0.951	0.32	0.849
		Total		22.196		23.279
21	37	Stems and leaves	2.71	20.344	2.79	25.551
		Chaff	2.01	2.187	1.32	1.246
		Grain	0.45	1.259	0.46	1.187
		Total		23.790		27.984

TABLE XX.—*Concluded*

DATE.	Age of plants, weeks.	Plant parts.	Kanred.		Harvest Queen.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*
1933-'34.						
Oct. 4	Seed	Seeds	0.41	0.009	0.26	0.006
Nov. 1	4	Total	5.61	0.380	5.06	0.413
15	6	Total	3.92	0.531	3.91	0.629
29	8	Total	3.70	1.363	3.52	1.570
Dec. 13	10	Total	3.23	1.825	3.22	2.154
Jan. 17	15	Total	2.66	2.314	2.55	2.305
31	17	Total	2.84	2.592	2.78	3.483
Feb. 14	19	Total	2.52	2.658	2.71	3.894
Mar. 7	22	Total	3.10	3.887	3.16	5.008
21	24	Total	3.93	5.109	3.94	6.091
Apr. 4	26	Total	4.19	10.286	4.15	11.512
11	27	Total	5.20	18.314	4.70	18.612
18	28	Total	5.12	25.671	4.35	25.882
25	29	Total	4.23	30.950	4.00	36.392
May 2	30	Total	4.14	44.509	3.09	38.995
9	31	Stems and leaves	3.38	44.707	2.52	38.624
		Heads	1.77	0.906	.....	.....
		Total	.....	45.613	.....	.....
16	32	Stems and leaves	2.36	32.768	1.91	37.655
		Heads	1.22	1.830	1.12	1.467
		Total	.....	34.598	.....	39.122
23	33	Stems and leaves	2.02	33.986	1.62	37.422
		Heads	0.89	2.380	0.68	1.829
		Total	.....	36.366	.....	39.251
30	34	Stems and leaves	1.75	29.618	1.54	35.219
		Chaff	0.80	2.028	0.54	1.379
		Grain	.....	.....	0.50	0.992
		Total	.....	.....	.....	37.590
June 6	35	Stems and leaves	1.80	27.846	1.41	32.148
		Chaff	0.86	2.214	0.58	1.554
		Grain	0.43	2.079	0.38	2.232
		Total	.....	32.139	.....	35.934
13	36	Stems and leaves	1.54	20.882	1.04	22.692
		Chaff	0.88	2.244	0.52	1.383
		Grain	0.45	2.749	0.36	2.755
		Total	.....	25.875	.....	26.830
20	37	Stems and leaves	1.26	17.280	0.94	19.711
		Chaff	0.65	1.462	0.19	0.476
		Grain	0.37	2.195	0.30	2.229
		Total	.....	20.937	.....	22.416

* Harvest Queen not grown during 1931-'32 season.

TABLE XXI.—The percentage of the total potassium in the entire plant at each stage of growth calculated on the maximum potassium content, and the weekly percentage increase or decrease of the total potassium, based on the previous sample. Manhattan, Kan.

DATE.	Age of plants, weeks.	Kanred.		Harvest Queen.	
		Percentage of total potassium at various stages, based on maximum.	Weekly percentage increase or decrease of total potassium, based on the previous sample.	Percentage of total potassium at various stages, based on maximum.	Weekly percentage increase or decrease of total potassium, based on the previous sample.
1931-'32.					
Oct. 1	Seed	0.02	.....	*.....	*.....
29	4	2.30	2,575.00	.....	.....
Nov. 11	6	5.77	75.55	.....	.....
25	8	7.73	16.99	.....	.....
Dec. 9	10	8.50	4.99	.....	.....
23	12	8.57	0.45	.....	.....
Jan. 5	14	9.25	3.94	.....	.....
19	16	11.69	13.17	.....	.....
Feb. 10	19	8.57	—8.88	.....	.....
24	21	8.72	0.87	.....	.....
Mar. 16	24	13.40	17.86	.....	.....
29	26	16.52	11.67	.....	.....
Apr. 13	28	42.82	79.57	.....	.....
27	30	58.73	18.58	.....	.....
May 4	31	89.23	51.92	.....	.....
11	32	98.08	9.92	.....	.....
18	33	95.02	—3.12	.....	.....
25	34	100.00	5.24	.....	.....
June 1	35	89.90	—10.10	.....	.....
8	36	80.64	—10.30	.....	.....
15	37	67.52	—16.27	.....	.....
22	38	71.73	6.24	.....	.....
1932-'33.					
Oct. 5	Seed	0.04	.....	0.03	.....
Nov. 2	4	1.44	927.78	1.28	1,257.14
16	6	2.69	43.29	2.62	51.95
30	8	2.80	2.03	3.12	9.70
Dec. 22	11	3.29	5.81	3.19	0.69
Jan. 4	13	3.19	—1.47	3.18	—0.06
17	15	3.60	6.46	3.59	6.40
Feb. 2	17	5.05	20.07	5.00	19.60
16	19	4.61	—4.37	4.82	—1.75
Mar. 2	21	6.09	16.15	5.26	4.48
16	23	13.93	64.24	12.73	71.04
30	25	19.57	20.25	18.56	22.93
Apr. 14	27	35.27	40.12	32.00	36.21
27	29	46.02	15.24	43.32	17.69
May 4	30	57.92	25.86	63.01	45.43
11	31	74.01	27.79	69.35	10.07
18	32	84.23	13.81	77.61	11.90
25	33	77.25	—8.29	80.69	3.97
31	34	86.02	11.36	78.61	—2.58
June 7	35	81.46	—5.31	85.45	8.70
14	36	93.30	14.54	83.19	—2.64
21	37	100.00	7.18	100.00	20.21

TABLE XXI.—*Concluded*

DATE.	Age of plants, weeks.	Kanred.		Harvest Queen.	
		Percentage of total potassium at various stages, based on maximum.	Weekly percentage increase or decrease of total potassium, based on the previous sample.	Percentage of total potassium at various stages, based on maximum.	Weekly percentage increase or decrease of total potassium, based on the previous sample.
1933-'34.					
Oct. 4	Seed	0.02	.....	0.02	.....
Nov. 1	4	0.83	1,030.55	1.05	1,695.83
15	6	1.16	19.87	1.60	26.15
29	8	2.99	78.34	4.00	74.80
Dec. 13	10	4.00	16.95	5.49	18.60
Jan. 17	15	5.07	5.36	5.87	1.40
31	17	5.68	6.01	8.87	25.55
Feb. 14	19	5.83	1.27	9.92	5.90
Mar. 7	22	8.52	15.41	12.76	9.54
21	24	11.20	15.72	15.52	10.81
Apr. 4	26	22.55	50.67	29.33	44.50
11	27	40.15	78.05	47.42	61.67
18	28	56.28	40.17	65.94	39.06
25	29	67.85	20.56	92.72	40.61
May 2	30	97.58	43.81	99.35	7.15
9	31	100.00	2.48	.....	.....
16	32	75.85	24.15	99.67	.....
23	33	79.73	5.11	100.00	0.33
30	34	.....	.....	95.77	—4.23
June 6	35	70.46	.....	91.55	—4.41
13	36	56.73	—19.49	68.35	—25.34
20	37	45.90	—19.08	57.11	—16.45

* Harvest Queen not grown during 1931-'32 season.

TABLE XXII.—Gain or loss of potassium in the stems and leaves, heads, chaff and grain of 100 plants. Manhattan, Kan.

DATE.	Kanred.				Harvest Queen.			
	Stems and leaves.	Heads.	Chaff.	Grain.	Stems and leaves.	Heads.	Chaff.	Grain.
	Gms.	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*
1931-'32.								
May 25–June 1	—8.05	+1.65			*	*	*	*
June 1–8	—6.83	+0.96						
June 8–15	—9.53	+1.21						
June 15–22	+2.91	—0.24						
1932-'33.								
May 18–25	—1.94	+0.28			+0.847	+0.016		
May 25–31	+1.67	+0.42			—1.062	+0.048		
May 31–June 7	—2.04	+0.95	+0.412	+0.541	+1.506	+0.407	+0.116	+0.291
June 7–14	+2.22	+0.60	+0.484	+0.114	—0.907	+0.277	+0.190	+0.087
June 14–21	+1.06	+0.534	+0.226	+0.308	+4.142	+0.563	+0.225	+0.338
1933-'34.								
May 9–16	—11.94	+0.924			—0.969			
May 16–23	+1.22	+0.560			—0.233	+0.362		
May 23–30	—4.37				—2.203	+0.542		
May 30–June 6	—1.77	+0.186			—3.071	+1.415	+0.175	+1.240
June 6–13	—6.96	+0.700	+0.30	+0.670	—9.456	+0.352	—0.171	+0.523
June 13–20	—3.60	—1.336	—0.782	—0.554	—2.981	—1.433	—0.907	—0.526

* Harvest Queen not grown during 1931-'32 season.

TABLE XXIII.—The percentage of the total potassium in the various plant parts at each stage of growth, calculated on the maximum potassium content, and the weekly percentage increase or decrease of the total potassium, based on the previous sample. Manhattan, Kan.

DATE.	Age of plants, weeks.	Plant parts.	Kanred.		Harvest Queen.	
			Percentage of total potassium at various stages, based on maximum.	Weekly percentage increase or decrease of total potassium, based on the previous sample.	Percentage of total potassium at various stages, based on maximum.	Weekly percentage increase or decrease of total potassium, based on the previous sample.
1931-'32.						
May 25	34	Stems and leaves	100.00	.....	*	*
June 1	35	Stems and leaves	86.72	—13.28	.....	.....
8	36	Stems and leaves	75.45	—13.00	.....	.....
15	37	Stems and leaves	59.73	—20.84	.....	.....
22	38	Stems and leaves	64.52	8.03	.....	.....
May 25	34	Heads	42.02	.....	.....	.....
June 1	35	Heads	67.02	59.51	.....	.....
8	36	Heads	81.59	21.74	.....	.....
15	37	Heads	100.00	22.56	.....	.....
22	38	Heads	96.39	—3.61	.....	.....
1932-'33.						
May 18	32	Stems and leaves	95.23	.....	82.29	.....
25	33	Stems and leaves	85.71	—10.00	85.61	4.03
31	34	Stems and leaves	93.90	9.56	81.45	—4.86
June 7	35	Stems and leaves	83.88	—10.67	87.35	7.24
14	36	Stems and leaves	94.79	13.00	83.79	—4.07
21	37	Stems and leaves	100.00	5.50	100.00	19.35
May 18	32	Heads	19.27	.....	28.36	.....
25	33	Heads	27.28	41.57	29.02	2.32
31	34	Heads	39.50	44.79	48.75	67.99
June 7	35	Heads	67.15	70.02	65.47	34.32
14	36	Heads	84.50	25.84	76.86	17.39
21	37	Heads	100.00	18.34	100.00	30.11
May 31	34	Chaff	48.70	.....	57.38	.....
June 7	35	Chaff	67.54	38.69	66.69	16.22
14	36	Chaff	89.67	32.77	81.94	22.86
21	37	Chaff	100.00	11.52	100.00	22.04
May 31	34	Grain	23.51	.....	39.68	.....
June 7	35	Grain	66.48	182.77	64.20	61.78
14	36	Grain	75.54	13.62	71.52	11.42
21	37	Grain	100.00	32.39	100.00	39.81

TABLE XXIII.—*Concluded*

DATE.	Age of plants, weeks.	Plant parts.	Kanred.		Harvest Queen.	
			Percentage of total potassium at various stages, based on maximum.	Weekly percentage increase or decrease of total potassium, based on the previous sample.	Percentage of total potassium at various stages, based on maximum.	Weekly percentage increase or decrease of total potassium, based on the previous sample.
1933-'34.						
May 9....	31	Stems and leaves..	100.00	.....	100.00	.....
16....	32	Stems and leaves..	73.30	—26.70	97.49	—2.51
23....	33	Stems and leaves..	76.02	3.72	96.89	—0.62
30....	34	Stems and leaves..	66.25	—12.85	91.18	—5.89
June 6....	35	Stems and leaves..	62.29	—5.98	83.23	—8.72
13....	36	Stems and leaves..	46.71	—25.01	58.75	—29.41
20....	37	Stems and leaves..	38.65	—17.25	51.03	13.14
May 9....	31	Heads.....	18.15	.....	.....	.....
16....	32	Heads.....	36.65	101.99	35.45	.....
23....	33	Heads.....	47.67	30.05	44.20	24.68
30....	34	Heads.....	.....	.....	57.30	29.63
June 6....	35	Heads.....	85.98	.....	91.49	59.68
13....	36	Heads.....	100.00	16.31	100.00	9.30
20....	37	Heads.....	73.24	—26.76	65.37	—34.63
May 30....	34	Chaff.....	90.37	.....	88.74	.....
June 6....	35	Chaff.....	98.66	9.17	100.00	12.69
13....	36	Chaff.....	100.00	1.36	89.00	—11.00
20....	37	Chaff.....	65.15	—34.85	30.63	—65.58
May 30....	34	Grain.....	.....	.....	36.01	.....
June 6....	35	Grain.....	75.63	.....	81.02	125.00
13....	36	Grain.....	100.00	32.23	100.00	23.43
20....	37	Grain.....	79.85	—20.15	80.91	—19.09

* Harvest Queen not grown during 1931-'32.

TABLE XXIV.—Percentage and actual amount in grams per 100 plants of the reducing sugars, nonreducing sugars, and total sugars at various stages of growth of Kanred wheat during four seasons. Manhattan, Kan.

DATE.	Age of plants, weeks.	Plant parts.	Sugars.					
			Reducing.		Nonreducing.		Total.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
1931-'32.				*Gms.*		*Gms.*		*Gms.*
Oct. 1	Seed	Seeds	0.00	0.000	0.00	0.000	0.00	0.000
29	4	Total	1.20	0.307	5.20	1.334	6.40	1.641
Nov. 11	6	Total	0.75	0.507	2.70	1.791	3.40	2.298
25	8	Total	0.62	0.623	4.90	4.904	5.50	5.527
Dec. 9	10	Total	1.87	2.693	11.10	15.883	12.90	18.576
23	12	Total	1.65	2.730	12.40	20.958	14.10	23.688
Jan. 5	14	Total	3.70	6.253	10.60	17.914	14.30	24.167
19	16	Total	3.12	6.084	9.00	17.511	12.10	23.595
Feb. 10	19	Total	2.95	6.578	13.10	29.102	16.00	35.68
24	21	Total	1.30	2.899	13.80	30.771	15.10	33.67
Mar. 16	24	Total	2.85	7.324	5.80	15.026	8.70	22.35
29	26	Total	3.00	9.180	3.30	14.350	7.30	23.33
Apr. 13	28	Total	3.20	19.456	2.60	15.704	5.80	35.26
27	30	Total	1.80	16.200	0.00	0.00	1.80	16.20
May 4	31	Total	3.30	46.662	0.00	0.00	3.30	46.66
11	32	Total	4.60	85.10	0.30	5.55	4.90	90.65
18	33	Total	3.60	78.48	2.50	54.50	6.10	132.98
25	34	Stems and leaves	4.20	98.28	2.50	58.50	6.70	156.78
		Heads	4.90	15.97	9.30	30.22	14.20	46.29
		Total		114.25		88.72		203.07

TABLE XXIV.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Sugars.					
			Reducing.		Nonreducing.		Total.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*
1931-'32.								
June 1	35	Stems and leaves	3.40	83.64	4.90	120.54	8.30	204.18
		Heads	2.45	12.98	7.65	40.55	10.10	53.53
		Total		96.62		161.09		257.71
8	36	Stems and leaves	3.05	72.22	0.95	22.50	4.00	94.72
		Heads	1.90	16.05	1.43	12.08	3.33	28.13
		Total		88.27		34.58		122.85
15	37	Stems and leaves	2.45	52.95	0.00	0.00	2.45	52.94
		Heads	1.85	22.53	1.55	18.59	3.40	41.12
		Total		75.48		18.59		94.06
22	38	Stems and leaves	2.15	43.58	0.00	0.00	2.15	43.58
		Heads	1.95	26.92	0.00	0.00	1.95	26.92
		Total		70.50		0.00		70.50

TABLE XXIV.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Sugars.					
			Reducing.		Nonreducing.		Total.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*
1932-'33.								
Oct. 5	Seed	Seeds	0.27	0.007	5.70	0.148	5.97	0.155
Nov. 2	4	Total	0.67	0.046	14.10	0.959	14.77	1.004
16	6	Total	1.31	0.198	15.71	2.372	17.02	2.570
30	8	Total	1.56	0.335	21.74	4.674	23.30	5.010
Dec. 22	11	Total	1.75	0.418	16.30	3.896	18.05	4.314
Jan. 4	13	Total	1.76	0.539	20.29	6.209	22.03	6.741
17	15	Total	3.83	1.287	4.75	1.596	8.58	2.883
Feb. 2	17	Total	2.11	0.842	12.30	4.908	14.41	5.749
16	19	Total	3.18	1.282	8.29	3.341	11.47	5.831
Mar. 2	21	Total	1.63	0.660	5.03	2.037	6.66	2.697
16	23	Total	1.26	0.877	3.80	2.645	5.06	3.522
30	25	Total	0.98	0.979	1.82	1.818	2.80	2.797
Apr. 14	27	Total	1.38	2.397	5.95	10.335	7.33	12.732
27	29	Total	0.93	2.483	2.40	6.408	3.33	8.891
May 4	30	Total	1.36	4.829	2.91	10.333	4.27	15.163
11	31	Total	1.48	8.433	2.74	15.613	4.22	24.046
18	32	Stems and leaves	1.25	8.182	3.47	22.713	4.72	30.894
		Heads	4.01	2.096	13.18	6.889	17.19	8.985
		Total		10.278		29.602		39.879

TABLE XXIV.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Sugars.					
			Reducing.		Nonreducing.		Total.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*
1932-'33.								
May 25	33	Stems and leaves	0.85	5.952	4.29	30.043	5.14	35.995
		Heads	1.26	1.362	9.15	9.891	10.41	11.253
		Total		7.314		39.934		47.248
31	34	Stems and leaves	1.25	9.909	5.81	46.056	7.06	55.965
		Chaff	1.26	1.459	5.35	6.194	6.61	7.653
		Grain	2.35	1.511	19.45	12.502	21.80	14.013
		Total		12.879		64.752		77.631
June 7	35	Stems and leaves	1.38	10.466	2.56	19.416	3.94	29.883
		Chaff	1.33	1.584	4.28	5.098	5.61	6.683
		Grain	0.78	1.765	4.07	9.212	4.85	10.977
		Total		13.815		33.726		47.443
14	36	Stems and leaves	0.65	4.896	0.98	7.382	1.63	12.279
		Chaff	0.83	0.920	2.28	2.526	3.11	3.446
		Grain	0.65	1.767	2.98	8.100	3.63	9.866
		Total		7.583		18.008		25.591
21	37	Stems and leaves	1.10	8.258	0.06	0.450	1.16	8.708
		Chaff	0.81	0.873	2.13	2.296	2.94	3.169
		Grain	1.03	2.881	1.63	4.559	2.66	7.440
		Total		12.012		7.305		19.317

TABLE XXIV.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Sugars.					
			Reducing.		Nonreducing.		Total.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*
1933-'34.								
Oct. 4	Seed	Seeds	0.46	0.010	2.98	0.066	3.44	0.076
Nov. 1	4	Total	0.76	0.052	3.99	0.271	4.75	0.323
15	6	Total	0.95	0.129	13.19	1.789	14.14	1.917
29	8	Total	1.48	0.545	14.60	5.380	16.08	5.925
Dec. 13	10	Total	1.88	1.063	17.34	9.802	19.22	10.865
Jan. 17	15	Total	1.83	1.592	18.81	16.365	20.64	17.957
31	17	Total	1.48	1.351	15.35	14.015	16.83	15.366
Feb. 14	19	Total	1.41	1.488	14.22	15.002	15.63	16.490
Mar. 7	22	Total	1.16	1.455	8.37	10.496	9.53	11.951
21	24	Total	0.85	1.105	2.84	3.692	3.69	4.797
Apr. 4	26	Total	0.25	0.614	1.05	2.578	1.30	3.192
11	27	Total	0.13	0.458	2.17	7.643	2.30	8.101
18	28	Total	0.33	1.684	4.67	23.836	5.00	25.520
25	29	Total	0.91	6.658	7.56	55.317	8.47	61.975
May 2	30	Total	0.28	3.010	4.00	43.004	4.28	46.014
9	31	Stems and leaves	0.33	4.365	2.89	38.266	3.22	42.591
		Heads	3.10	1.587	16.19	8.289	19.29	9.876
		Total		5.952		46.555		52.467

TABLE XXIV.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Sugars.					
			Reducing.		Nonreducing.		Total.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*
1933-'34.								
May 16	32	Stems and leaves	1.16	16.107	5.14	71.369	6.30	87.476
		Heads	2.51	3.765	6.82	10.230	9.33	13.995
		Total		19.872		81.599		101.471
23	33	Stems and leaves	1.33	22.377	7.81	131.403	8.14	136.955
		Heads	1.60	4.280	10.59	28.328	12.19	32.608
		Total		26.657		159.731		169.563
30	34	Stems and leaves	1.70	28.773	7.18	121.522	8.88	150.294
		Chaff	1.03	2.611	6.91	17.517	7.94	20.128
		Grain	0.40	0.808	10.68	21.574	11.08	22.382
		Total		32.192		160.613		192.804
June 6	35	Stems and leaves	1.45	22.432	3.60	55.692	5.05	78.124
		Chaff	0.40	1.030	5.10	13.133	5.50	14.164
		Grain	0.28	1.354	2.88	13.925	3.16	15.279
		Total		24.816		82.750		107.566
13	36	Stems and leaves	0.43	5.831	0.90	12.204	1.33	18.035
		Chaff	0.11	0.281	3.89	9.920	4.00	10.200
		Grain	0.36	2.200	2.28	13.931	2.64	16.130
		Total		8.312		36.055		44.365
20	37	Stems and leaves	0.46	6.309	0.32	4.389	0.78	10.698
		Chaff	0.26	0.585	0.40	0.900	0.66	1.485
		Grain	0.28	1.662	1.69	10.030	1.97	11.641
		Total		8.556		15.319		23.824

TABLE XXIV.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Sugars.					
			Reducing.		Nonreducing.		Total.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*
1934-'35.								
Oct. 5	Seed	Seeds	0.13	0.003	1.42	0.034	1.55	0.037
Nov. 9	5	Total	0.52	0.093	10.84	1.937	11.36	2.030
23	7	Total	0.60	0.170	6.12	1.763	6.72	1.935
Dec. 20	11	Total	1.20	0.522	3.82	1.662	5.02	2.184
Jan. 11	14	Total	0.88	0.357	18.54	7.524	19.42	7.881
Feb. 1	17	Total	1.38	0.598	13.54	5.867	14.92	6.465
21	20	Total	0.72	0.285	9.95	3.943	10.67	4.229
Mar. 14	23	Total	0.19	0.113	4.48	2.654	4.67	2.767
28	25	Total	0.11	0.110	5.00	5.020	5.11	5.100
Apr. 11	27	Total	0.29	0.592	4.32	8.813	4.61	9.404
18	28	Total	0.90	2.678	4.85	14.434	5.75	17.112
25	29	Total	0.12	0.595	1.21	5.899	1.33	6.593
May 2	30	Total	0.87	6.441	3.82	28.283	4.69	34.725
9	31	Total	0.66	6.864	2.53	26.312	3.19	33.176
16	32	Total	0.35	4.365	2.15	26.811	2.50	31.175
23	33	Stems and leaves	0.41	6.342	3.09	47.796	3.50	54.138
		Heads	4.82	4.338	5.79	5.211	10.61	9.549
		Total		10.680		53.007		63.687

TABLE XXIV.—*Concluded*

DATE.	Age of plants, weeks.	Plant parts.	Sugars.					
			Reducing.		Nonreducing.		Total.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*
1934-'35.								
May 30	34	Stems and leaves	0.92	14.617	4.47	71.019	5.39	85.636
		Heads	1.33	2.234	3.92	6.586	5.25	8.820
		Total		16.851		77.605		94.456
June 6	35	Stems and leaves	1.10	18.581	4.92	83.109	6.02	101.690
		Chaff	0.52	1.310	3.34	8.417	3.86	9.727
		Grain	2.86	1.647	29.80	17.165	32.66	18.812
		Total		21.538		108.691		130.229
13	36	Stems and leaves	0.87	14.188	5.66	92.303	6.53	106.491
		Chaff	0.21	0.517	2.12	5.215	2.33	5.732
		Grain	1.07	1.913	8.37	14.966	9.44	16.879
		Total		16.618		112.484		129.102
20	37	Stems and leaves	1.29	20.078	3.10	48.248	4.39	68.326
		Chaff	0.76	2.362	1.79	5.563	2.47	7.677
		Grain	0.43	2.270	2.29	12.091	2.72	14.362
		Total		24.710		65.902		90.365

TABLE XXV.—Percentage and actual amount in grams per 100 plants of the reducing sugars, nonreducing sugars, and total sugars at various stages of growth of Harvest Queen wheat during three seasons. Manhattan, Kan.

DATE.	Age of plants, weeks.	Plant parts.	Sugars.					
			Reducing.		Nonreducing.		Total.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*
1932-'33.								
Oct. 5	Seed	Seeds	0.13	0.003	5.12	0.133	5.25	0.137
Nov. 2	4	Total	1.40	0.106	13.15	0.999	14.55	1.106
16	6	Total	1.50	0.257	15.58	2.664	17.08	2.910
30	8	Total	2.35	0.597	20.03	5.088	22.38	5.685
Dec. 22	11	Total	1.18	0.337	17.48	4.999	18.66	5.337
Jan. 4	13	Total	2.10	0.714	20.21	6.871	22.31	7.585
17	15	Total	2.93	1.078	9.68	3.562	12.61	4.640
Feb. 2	17	Total	2.30	1.083	12.47	5.873	14.77	6.957
16	19	Total	3.43	1.653	8.34	4.020	11.77	5.673
Mar. 2	21	Total	1.90	1.009	5.15	2.735	7.05	3.744
16	23	Total	1.10	0.913	3.78	3.137	4.88	4.050
30	25	Total	0.93	1.064	2.98	3.409	3.91	4.473
Apr. 14	27	Total	0.57	1.031	2.76	4.993	3.33	6.023
27	29	Total	0.95	2.865	2.05	6.183	3.00	9.048
May 4	30	Total	1.33	6.304	2.08	9.859	3.41	16.163
11	31	Total	2.05	13.173	3.01	19.342	5.06	32.516
18	32	Stems and leaves	1.41	10.820	3.59	27.550	5.00	38.370
		Heads	3.51	1.764	12.46	6.367	15.97	8.161
		Total		12.614		33.917		46.531

TABLE XXV.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Sugars.					
			Reducing.		Nonreducing.		Total.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*
1932-'33.								
May 25	33	Stems and leaves	0.85	7.069	2.65	22.040	3.50	29.110
		Heads	1.31	1.062	9.24	7.494	10.55	8.556
		Total		8.131		29.534		37.666
31	34	Stems and leaves	1.46	13.041	5.17	46.178	6.63	59.219
		Chaff	1.13	0.950	4.95	4.163	6.08	5.113
		Grain	2.68	1.943	17.37	12.593	20.05	14.536
		Total		15.934		62.934		78.868
June 7	35	Stems and leaves	1.10	9.334	1.87	15.869	2.97	25.203
		Chaff	1.91	1.824	4.23	4.040	6.14	5.864
		Grain	0.46	0.922	2.18	4.371	2.64	5.293
		Total		12.080		24.280		36.360
14	36	Stems and leaves	0.68	5.847	1.40	12.037	2.08	17.834
		Chaff	0.83	0.718	2.08	1.799	2.91	2.517
		Grain	0.53	1.406	2.77	7.349	3.30	8.755
		Total		7.971		21.185		29.106
21	37	Stems and leaves	0.95	8.700	0.18	1.648	1.13	10.349
		Chaff	0.88	0.831	2.06	1.945	2.94	2.775
		Grain	1.13	2.917	1.67	4.310	2.80	7.227
		Total		12.448		7.903		20.351

TABLE XXV.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Sugars.					
			Reducing.		Nonreducing.		Total.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*
1933-'34.								
Oct. 4	Seed	Seeds	0.40	0.011	1.32	0.035	1.72	0.046
Nov. 1	4	Total	0.45	0.037	3.88	0.317	4.33	0.354
15	6	Total	1.56	0.251	13.58	2.188	15.14	2.439
29	8	Total	1.93	0.861	14.60	6.515	16.53	7.376
Dec. 13	10	Total	1.86	1.244	17.25	11.540	19.11	12.785
Jan. 17	15	Total	1.75	1.582	18.83	17.022	20.58	18.604
31	17	Total	1.78	2.230	14.41	18.056	16.19	20.286
Feb. 14	19	Total	1.43	2.055	14.65	21.052	16.08	23.107
Mar. 7	22	Total	0.81	1.284	8.55	13.552	9.36	14.836
21	24	Total	0.91	1.407	2.84	4.391	3.75	5.798
Apr. 4	26	Total	0.38	1.054	0.87	2.413	1.25	3.468
11	27	Total	0.14	0.554	0.02	0.079	0.16	0.634
18	28	Total	0.50	2.975	3.88	23.086	4.38	26.061
25	29	Total	0.55	5.004	5.83	53.041	6.38	58.045
May 2	30	Total	0.55	6.941	2.59	32.686	3.14	39.627
9	31	Stems and leaves	0.30	4.598	2.53	38.777	2.83	43.375
		Heads	3.52	1.204	26.01	8.895	29.53	10.099
		Total		5.802		47.672		53.474

TABLE XXV.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Sugars.					
			Reducing.		Nonreducing.		Total.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*
1933-'34.								
May 16	32	Stems and leaves	1.33	26.221	4.31	84.972	5.64	111.193
		Heads	2.81	3.681	8.85	11.594	11.66	15.275
		Total	.....	29.902	.....	96.566	.....	126.468
23	33	Stems and leaves	1.86	42.966	3.47	80.157	5.33	123.123
		Heads	1.41	3.793	9.92	26.685	11.33	30.478
		Total	.....	46.759	.....	106.842	.....	153.601
30	34	Stems and leaves	2.16	49.399	4.92	112.520	7.08	161.920
		Chaff	1.86	4.752	7.80	19.929	9.66	24.681
		Grain	0.78	1.548	10.75	21.339	11.53	22.887
		Total	.....	55.699	.....	153.788	.....	209.488
June 6	35	Stems and leaves	0.68	15.504	2.51	57.228	3.19	72.732
		Chaff	0.40	1.072	5.32	14.258	5.72	15.330
		Grain	0.18	1.058	2.65	15.569	2.83	16.626
		Total	.....	17.634	.....	87.055	.....	104.688
13	36	Stems and leaves	0.60	13.092	1.12	24.438	1.72	37.530
		Chaff	0.83	2.208	3.94	10.480	4.77	12.688
		Grain	0.20	1.531	2.18	16.688	2.38	18.219
		Total	.....	16.831	.....	51.606	.....	68.437
20	37	Stems and leaves	0.61	12.791	0.19	13.984	0.80	16.776
		Chaff	0.20	0.502	0.44	1.104	0.64	1.606
		Grain	0.26	1.932	1.62	12.037	1.88	13.968
		Total	.....	15.225	.....	27.125	.....	32.350

TABLE XXV.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Sugars.					
			Reducing.		Nonreducing.		Total.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*
1934-'35.								
Oct. 5	Seed	Seeds	0.13	0.003	1.23	0.031	1.36	0.035
Nov. 9	5	Total	0.37	0.084	8.71	1.968	9.08	2.052
23	7	Total	0.51	0.179	6.41	2.247	6.92	2.425
Dec. 20	11	Total	1.05	0.572	13.03	7.092	14.08	7.664
Jan. 11	14	Total	0.77	0.428	15.98	8.886	16.75	9.315
Feb. 1	17	Total	1.57	0.795	12.29	6.226	13.86	7.021
21	20	Total	0.59	0.284	6.80	3.268	7.39	3.552
Mar. 14	23	Total	0.13	0.096	3.70	2.736	3.83	2.832
28	25	Total	0.25	0.248	5.19	5.154	5.44	5.402
Apr. 11	27	Total	0.17	0.345	5.16	10.464	5.33	10.809
18	28	Total	0.82	2.722	7.35	24.402	8.17	27.124
25	29	Total	0.23	1.182	2.02	10.377	2.25	11.558
May 2	30	Total	0.53	4.278	2.72	21.956	3.25	26.234
9	31	Total	1.23	14.386	3.66	42.807	4.89	57.193
16	32	Total	0.73	10.459	2.41	34.530	3.14	44.990
23	33	Stems and leaves	0.72	11.753	2.59	42.279	3.31	54.032
		Heads	6.50	3.705	1.63	0.929	8.13	4.634
		Total		15.458		43.208		58.666

TABLE XXV.—*Concluded*

DATE.	Age of plants, weeks.	Plant parts.	Sugars.					
			Reducing.		Nonreducing.		Total.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*
1934-'35.								
May 30	34	Stems and leaves	1.55	28.726	3.42	63.383	4.97	92.109
		Heads	1.25	2.056	4.19	6.893	5.44	8.949
		Total	.....	30.782	.....	70.276	.....	101.058
June 6	35	Stems and leaves	1.47	29.804	3.14	63.664	4.61	93.468
		Chaff	0.77	1.484	3.20	6.166	3.97	7.650
		Grain	3.20	1.466	29.02	13.291	32.22	14.757
		Total	.....	32.754	.....	83.121	.....	115.875
13	36	Stems and leaves	1.20	25.030	6.55	136.620	7.75	161.650
		Chaff	0.67	1.356	2.64	5.343	3.31	6.699
		Grain	1.32	2.986	7.65	17.304	8.97	20.290
		Total	.....	29.372	.....	159.267	.....	188.639
20	37	Stems and leaves	1.13	23.229	1.95	40.086	3.08	63.316
		Chaff	0.72	1.768	2.28	5.597	3.00	7.365
		Grain	0.37	1.791	2.05	9.922	2.42	11.713
		Total	.....	26.788	.....	55.605	.....	82.394

TABLE XXVI.—The weekly increase or decrease in grams per 100 plants of the total sugars and starch in the stems and leaves and heads of Kanred and Harvest Queen wheats during four seasons. Manhattan, Kan.

WEEK ENDING.	Kanred.		Harvest Queen.	
	Stems and leaves.	Heads.	Stems and leaves.	Heads.
	Gms.	*Gms.*	*Gms.*	*Gms.*
1931-'32.				
June 1	+39.8	+73.7	*	*
June 8	—159.0	+60.7		
June 13	—44.8	+152.1		
June 20	—9.7	—19.6		
1932-'33.				
May 25	—8.2	+2.2	—22.8	0.0
May 31	+21.5	+6.9	+31.0	+24.4
June 7	—25.4	+79.2	—32.5	+16.1
June 14	—18.0	+14.4	—6.7	+58.1
June 21	—3.0	+1.8	—6.4	—5.8
1933-'34.				
May 16	+42.6	+4.3	+71.4	+5.9
May 23	+50.0	+19.0	+12.0	+15.0
May 30	+12.4	+64.3	+37.8	+72.9
June 6	—65.7	+90.0	—86.0	+120.9
June 13	—65.9	+46.0	—38.0	+57.3
June 20	—6.3	—22.4	—18.1	—29.5
1934-'35.				
May 30	+31.9	—1.0	+39.0	+4.4
June 6	+17.3	+24.3	+1.6	+17.5
June 13	+21.3	+23.9	+90.7	+48.2
June 20	—37.5	+120.9	—98.4	+92.2

* Harvest Queen not grown during 1931-'32 season.

TABLE XXVII.—Percentage and actual amount in grams per 100 plants of the total sugars, starch, hemicellulose and total carbohydrates at various stages of growth of Kanred wheat during four seasons. Manhattan, Kan.

DATE.	Age of plants, weeks.	Plant parts.	Carbodydrates.							
			Total sugars.		Starch.		Hemicellulose.		Total carbohydrates.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*		*Gms.*
1931-'32.										
Oct. 1	Seed	Seeds	0.0	0.000	46.2	1.35	6.2	0.18	52.4	1.53
29	4	Total	6.4	1.641	0.0	0.00	9.4	2.41	15.8	4.051
Nov. 11	6	Total	3.4	2.298	0.0	0.00	12.1	8.18	15.5	10.478
25	8	Total	5.5	5.527	0.3	0.30	13.0	13.06	18.8	18.887
Dec. 9	10	Total	12.9	18.576	0.6	0.86	13.4	19.29	26.9	38.726
23	12	Total	14.1	23.688	2.96	4.97	13.2	22.17	30.26	50.828
Jan. 5	14	Total	14.3	24.167	7.0	11.83	12.9	21.80	34.2	57.797
19	16	Total	12.1	23.595	7.3	14.23	12.9	25.15	32.3	62.975
Feb. 10	19	Total	16.0	35.68	9.7	21.63	12.3	27.42	28.0	84.73
24	21	Total	15.1	33.67	8.4	18.73	11.0	24.52	34.5	76.92
Mar. 16	24	Total	8.7	22.35	1.9	4.88	8.5	21.84	19.1	49.07
29	26	Total	7.3	23.33	2.1	6.42	11.6	35.50	21.0	65.25
Apr. 13	28	Total	5.8	35.26	1.9	11.55	14.8	89.98	22.5	136.79
27	30	Total	1.8	16.20	2.1	18.90	19.1	171.90	23.0	207.00
May 4	31	Total	3.3	46.66	2.6	36.76	18.1	255.93	24.0	339.35
11	32	Total	4.9	90.65	0.3	5.55	17.7	327.45	22.9	423.65
18	33	Total	6.1	132.98	1.1	23.98	19.9	433.82	27.1	590.78
25	34	Stems and leaves	6.7	156.78	1.4	32.86	20.3	475.02	28.4	664.66
		Heads	14.2	46.29	3.5	11.41	18.4	59.98	36.1	117.68
		Total		203.07		44.27		535.00		782.34

TABLE XXVII.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Carbohydrates.							
			Total sugars.		Starch.		Hemicellulose.		Total carbohydrates.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*		*Gms.*
1931-'32.										
June 1	35	Stems and leaves	8.3	204.18	2.4	59.04	17.6	432.96	28.3	696.18
		Heads	10.1	53.53	8.3	43.99	17.1	90.63	35.5	188.15
		Total		257.71		103.03		523.59		884.33
8	36	Stems and leaves	4.0	94.72	0.4	9.47	21.8	615.22	26.2	719.41
		Heads	3.33	28.13	15.4	130.13	14.1	119.14	32.83	277.40
		Total		122.85		139.60		734.36		996.81
15	37	Stems and leaves	2.45	52.94	0.3	6.48	22.9	494.86	25.65	554.28
		Heads	3.4	41.12	22.1	269.17	12.8	155.90	38.3	466.19
		Total		94.06		275.65		650.76		1,020.47
22	38	Stems and leaves	2.15	43.58	0.3	6.08	22.5	456.07	24.95	505.73
		Heads	1.95	26.92	19.1	263.77	13.0	179.53	34.05	470.22
		Total		70.50		269.85		635.60		975.95

TABLE XXVII.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Carbodyrates.							
			Total sugars.		Starch.		Hemicellulose.		Total carbohydrates.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*		*Gms.*
1932-'33.										
Oct. 5.....	Seed	Seeds.....	5.97	0.155	35.13	0.913	6.13	0.159	47.23	1.228
Nov. 2.....	4	Total.....	14.77	1.004	1.80	0.122	2.03	0.138	18.60	1.265
16.....	6	Total.....	17.02	2.570	1.85	0.279	7.96	1.202	26.83	4.051
30.....	8	Total.....	23.30	5.010	2.00	0.430	8.30	1.784	33.60	7.224
Dec. 22.....	11	Total.....	18.05	4.314	1.83	0.437	6.41	1.532	26.29	6.283
Jan. 4.....	13	Total.....	22.03	6.741	2.01	0.615	4.08	1.248	28.12	8.605
	15	Total.....	8.58	2.883	0.75	0.252	15.78	5.302	23.61	7.933
Feb. 2.....	17	Total.....	14.41	5.749	0.81	0.323	15.88	6.336	31.10	12.409
16.....	19	Total.....	11.47	5.831	0.81	0.326	16.08	6.480	28.36	11.429
Mar. 2.....	21	Total.....	6.66	2.697	0.83	0.336	16.05	6.500	23.54	9.534
16.....	23	Total.....	5.06	3.522	0.66	0.459	18.73	13.036	24.45	17.017
30.....	25	Total.....	2.80	2.797	0.66	0.659	20.06	20.040	23.42	23.397
Apr. 14.....	27	Total.....	7.33	12.732	0.20	0.347	14.63	25.412	22.16	38.492
27.....	29	Total.....	3.33	8.891	0.33	0.881	15.26	40.744	18.92	50.516
May 4.....	30	Total.....	4.27	15.163	0.33	1.172	14.76	52.413	19.36	68.747
11.....	31	Total.....	4.22	24.046	2.38	13.561	15.76	89.800	22.36	127.407
18.....	32	Stems and leaves..	4.72	30.894	2.60	17.018	15.90	104.072	23.22	151.984
		Heads.....	17.19	8.985	2.60	1.359	16.70	8.729	36.49	19.073
		Total.....	.....	39.879	.....	18.377	.....	112.801	.....	171.057

TABLE XXVII.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Carbohydrates.							
			Total sugars.		Starch.		Hemicellulose.		Total carbohydrates.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*		*Gms.*
1932-'33.										
May 25	33	Stems and leaves	5.14	35.995	0.53	3.712	17.90	125.353	23.57	165.061
		Heads	10.41	11.253	1.23	1.330	19.36	20.928	31.00	33.511
		Total		47.248		5.042		146.281		198.572
31	34	Stems and leaves	7.06	55.965	0.65	5.152	16.90	133.966	24.61	195.083
		Chaff	6.61	7.653	0.82	0.949	21.80	25.240	29.23	33.842
		Grain	21.80	14.013	16.83	10.818	7.06	4.538	45.69	29.370
		Total		77.631		16.919		163.744		258.295
June 7	35	Stems and leaves	3.94	29.883	0.78	5.916	17.80	135.002	22.52	170.801
		Chaff	5.61	6.683	0.46	0.548	20.83	24.813	26.90	32.043
		Grain	4.85	10.977	35.53	80.419	6.43	14.554	46.81	105.950
		Total		47.543		86.883		174.369		308.794
14	36	Stems and leaves	1.63	12.279	0.73	5.499	19.06	143.579	21.42	161.357
		Chaff	3.11	3.446	0.76	0.842	24.36	26.990	28.23	31.279
		Grain	3.63	9.866	36.38	98.881	6.76	18.374	46.77	127.121
		Total		25.591		105.222		188.943		319.757
21	37	Stems and leaves	1.16	8.708	0.88	6.606	20.20	151.641	22.24	166.956
		Chaff	2.94	3.169	1.10	1.186	24.33	26.228	28.37	30.583
		Grain	2.66	7.440	36.51	102.118	6.36	17.789	45.53	127.347
		Total		19.317		109.910		195.658		324.886

TABLE XXVII.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Carbodydrates.							
			Total sugars.		Starch.		Hemicellulose.		Total carbohydrates.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
1933-'34.				*Gms.*		*Gms.*		*Gms.*		*Gms.*
Oct. 4	Seed	Seeds	3.44	0.076	31.80	0.703	7.03	0.155	42.27	0.934
Nov. 1	4	Total	4.75	0.323	0.16	0.011	9.56	0.649	14.47	0.983
15	6	Total	14.14	1.917	0.25	0.034	9.96	1.351	24.35	3.302
29	8	Total	16.08	5.925	0.68	0.251	10.40	3.832	27.16	10.008
Dec. 13	10	Total	19.22	10.865	0.15	0.085	9.96	5.630	29.33	16.580
Jan. 17	15	Total	20.64	17.957	1.10	0.957	11.06	9.622	32.80	28.536
31	17	Total	16.83	15.366	1.08	0.986	11.93	10.892	29.84	27.244
Feb. 14	19	Total	15.63	16.490	1.31	1.382	12.76	13.462	29.70	31.334
Mar. 7	22	Total	9.53	11.951	1.10	1.379	13.81	17.318	24.44	30.648
21	24	Total	3.69	4.797	0.78	1.014	16.06	20.878	20.53	26.689
Apr. 4	26	Total	1.30	3.192	0.33	0.810	15.46	37.954	17.09	41.956
11	27	Total	2.30	8.101	0.10	0.352	13.40	47.195	15.80	55.648
18	28	Total	5.00	25.520	0.08	0.408	14.60	74.518	19.68	100.447
25	29	Total	8.47	61.975	0.05	0.366	14.33	104.853	22.85	167.193
May 2	30	Total	4.28	46.014	0.00	0.000	16.30	175.241	20.58	221.256
9	31	Stems and leaves	3.22	42.591	0.32	4.233	16.46	217.716	20.00	264.540
		Heads	19.29	9.876	0.07	0.036	11.13	5.699	30.49	15.611
		Total	.....	52.367	.....	4.269	.....	223.415	.....	280.151

TABLE XXVII.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Carbohydrates.							
			Total sugars.		Starch.		Hemicellulose.		Total carbohydrates.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*		*Gms.*
1933-'34.										
May 16	32	Stems and leaves	6.30	87.476	0.14	1.944	15.40	213.829	21.84	303.248
		Heads	9.33	13.995	0.16	0.240	22.36	33.540	31.85	47.775
		Total		101.471		2.184		247.369		351.023
23	33	Stems and leaves	8.14	136.955	0.14	2.355	15.60	262.470	21.88	368.131
		Heads	12.19	32.608	0.24	0.642	20.30	54.302	32.73	87.553
		Total		169.563		2.997		316.772		455.684
30	34	Stems and leaves	8.88	150.294	0.09	1.523	16.33	276.385	25.30	428.203
		Chaff	7.94	20.128	1.23	3.118	21.10	53.489	30.27	76.734
		Grain	11.08	22.382	25.20	50.904	6.73	13.595	43.01	86.880
		Total		192.804		55.545		343.469		591.817
June 6	35	Stems and leaves	5.05	78.124	0.52	8.044	15.83	244.890	21.40	331.058
		Chaff	5.50	14.163	0.31	0.798	20.90	53.818	26.71	68.778
		Grain	3.16	15.279	32.33	156.315	6.53	31.573	42.02	203.167
		Total		107.566		165.157		330.281		603.003
13	36	Stems and leaves	1.33	18.035	0.16	2.170	19.36	262.522	20.85	282.726
		Chaff	4.00	10.200	0.59	1.505	22.30	56.865	26.89	68.570
		Grain	2.64	16.130	33.66	205.662	6.60	40.326	42.90	262.119
		Total		44.365		209.337		359.713		613.415
20	37	Stems and leaves	0.78	10.698	0.16	2.194	19.60	268.814	20.54	281.706
		Chaff	0.66	1.485	0.08	0.180	25.46	57.285	26.20	58.950
		Grain	1.97	11.691	33.33	197.814	6.63	39.349	41.93	248.855
		Total		23.874		200.188		365.448		589.511

TABLE XXVII.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Carbodydrates.							
			Total sugars.		Starch.		Hemicellulose.		Total carbohydrates.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*		*Gms.*
1934-'35.										
Oct. 5.....	Seed	Seeds.....	1.55	0.037	30.40	0.717	6.90	0.163	38.85	0.917
Nov. 9.....	5	Total.....	11.36	2.030	0.48	0.086	9.87	1.764	21.71	3.880
23.....	7	Total.....	6.72	1.935	0.05	0.014	12.30	3.542	19.07	5.492
Dec. 20.....	11	Total.....	5.02	2.184	1.27	0.552	11.27	4.902	17.56	7.639
Jan. 11.....	14	Total.....	19.42	7.881	1.13	0.459	12.53	5.085	33.08	13.424
Feb. 1.....	17	Total.....	14.92	6.465	1.18	0.511	13.43	5.819	29.53	12.795
21.....	20	Total.....	10.67	4.229	0.21	0.083	14.87	5.893	25.75	10.205
Mar. 14.....	23	Total.....	4.67	2.767	0.09	0.053	14.10	8.354	18.86	11.175
28.....	25	Total.....	5.11	5.100	0.04	0.040	12.73	12.705	17.88	17.844
Apr. 11.....	27	Total.....	4.61	9.404	0.18	0.367	13.63	27.805	18.42	37.577
18.....	28	Total.....	5.75	17.112	0.17	0.506	12.67	37.706	18.59	55.324
25.....	29	Total.....	1.33	6.593	0.08	0.397	13.93	69.051	15.34	76.040
May 2.....	30	Total.....	4.69	34.725	0.11	0.814	13.03	96.474	17.83	132.013
9.....	31	Total.....	3.19	33.176	0.08	0.832	15.90	165.360	19.17	199.368
16.....	32	Total.....	2.50	31.175	0.09	1.122	15.57	194.158	18.16	226.455

TABLE XXVII.—*Concluded*

DATE.	Age of plants, weeks.	Plant parts.	Carbohydrates.							
			Total sugars.		Starch.		Hemicellulose.		Total carbohydrates.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*		*Gms.*
1934-'35.										
May 23	33	Stems and leaves	3.50	54.138	0.13	2.011	16.17	250.118	19.80	306.266
		Heads	10.61	9.549	0.41	0.369	19.97	17.973	30.99	27.891
		Total		63.687		2.380		268.091		334.157
30	34	Stems and leaves	5.39	85.636	0.15	2.383	14.60	231.965	20.14	319.984
		Heads	5.25	8.820	0.10	0.168	19.40	32.592	24.75	41.580
		Total		94.456		2.551		264.557		361.564
June 6	35	Stems and leaves	6.02	101.690	0.21	3.547	14.77	249.495	21.00	354.732
		Chaff	3.86	9.727	1.08	2.722	21.60	54.432	26.54	66.881
		Grain	32.66	18.812	3.66	2.108	7.20	4.147	43.52	25.068
		Total		130.229		8.377		308.074		446.681
13	36	Stems and leaves	6.53	106.491	1.23	20.059	14.13	230.432	21.89	356.982
		Chaff	2.33	5.732	1.22	3.001	20.37	50.110	23.92	58.843
		Grain	9.44	16.879	17.66	31.576	7.63	13.642	34.73	62.097
		Total		129.102		54.636		294.184		477.922
20	37	Stems and leaves	4.39	68.326	1.34	20.856	16.00	249.024	21.73	338.206
		Chaff	2.47	7.677	1.18	3.667	19.63	61.010	23.28	72.354
		Grain	2.72	14.362	28.87	152.434	7.17	37.858	38.76	204.653
		Total		90.365		176.957		347.892		615.213

TABLE XXVIII.—Percentage and actual amount in grams per 100 plants of the total sugars, starch, hemicellulose and total carbohydrates at various stages of growth of Harvest Queen wheat during three seasons. Manhattan, Kan.

DATE.	Age of plants, weeks.	Plant parts.	Carbodydrates.							
			Total sugars.		Starch.		Hemicellulose.		Total carbohydrates.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*		*Gms.*
1932-'33.										
Oct. 5.....	Seed	Seeds.....	5.25	0.137	33.53	0.872	6.30	0.164	45.08	1.172
Nov. 2.....	4	Total.....	14.55	1.106	1.60	0.122	1.12	0.085	17.27	1.313
16.....	6	Total.....	17.08	2.910	1.75	0.299	7.45	1.274	26.28	4.494
30.....	8	Total.....	22.38	5.685	1.93	0.490	4.78	1.214	30.09	7.643
Dec. 22.....	11	Total.....	18.66	5.337	1.90	0.543	6.81	1.948	27.37	7.828
Jan. 4.....	13	Total.....	22.31	7.585	1.96	0.666	9.95	3.383	34.22	11.635
17.....	15	Total.....	12.61	4.640	0.78	0.287	15.36	5.652	28.75	10.580
Feb. 2.....	17	Total.....	14.77	6.957	0.70	0.330	16.11	7.588	31.58	14.874
16.....	19	Total.....	11.77	5.673	0.83	0.400	15.88	7.654	28.48	13.727
Mar. 2.....	21	Total.....	7.05	3.744	0.75	0.398	17.41	9.245	25.21	13.387
16.....	23	Total.....	4.88	4.050	0.80	0.664	18.56	15.405	24.24	20.119
30.....	25	Total.....	3.91	4.473	0.66	0.755	18.46	21.118	23.03	26.346
Apr. 14.....	27	Total.....	3.33	6.023	0.33	0.597	14.00	25.326	17.66	31.947
27.....	29	Total.....	3.00	9.048	0.20	0.603	15.53	46.838	18.73	56.490
May 4.....	30	Total.....	3.41	16.163	0.33	1.564	15.90	75.366	19.64	93.094
11.....	31	Total.....	5.06	32.516	0.46	2.956	15.06	96.776	20.58	132.247
18.....	32	Stems and leaves..	5.00	38.370	2.25	17.267	18.50	141.969	25.75	197.606
		Heads.....	15.97	8.161	2.65	1.354	20.10	10.271	38.72	19.786
		Total.....	.....	46.531	.....	18.621	.....	152.29	.....	217.392

TABLE XXVIII.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Carbohydrates.							
			Total sugars.		Starch.		Hemicellulose.		Total carbohydrates.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*		*Gms.*
1932-'33.										
May 25	33	Stems and leaves	3.50	29.110	0.46	3.826	17.80	148.043	21.76	180.978
		Heads	10.55	8.556	1.25	1.014	21.50	17.436	33.30	27.006
		Total		37.666		4.840		165.479		207.984
31	34	Stems and leaves	6.63	59.219	0.53	4.734	16.60	148.271	23.76	212.224
		Chaff	6.08	5.113	0.68	0.572	24.40	20.520	31.16	26.206
		Grain	20.05	14.536	19.28	13.978	7.63	5.532	46.96	34.046
		Total		78.868		19.284		174.323		272.476
June 7	35	Stems and leaves	2.97	25.203	0.73	6.195	17.10	145.111	20.80	176.509
		Chaff	6.14	5.864	0.90	0.860	22.56	21.545	29.60	28.268
		Grain	2.64	5.293	18.95	37.995	3.53	7.078	25.12	50.366
		Total		36.360		45.050		173.734		255.143
14	36	Stems and leaves	2.08	17.834	0.80	6.878	18.50	159.063	21.38	183.825
		Chaff	2.91	2.517	0.68	0.588	24.33	21.045	37.92	32.801
		Grain	3.30	8.755	36.28	96.251	7.56	20.057	47.14	125.062
		Total		29.106		103.717		200.165		341.688
21	37	Stems and leaves	1.13	10.349	0.86	7.876	19.60	179.496	21.57	197.538
		Chaff	2.94	2.775	0.91	0.859	24.66	23.279	28.51	26.913
		Grain	2.80	7.227	35.40	91.367	6.93	17.886	45.13	116.481
		Total		20.351		100.102		220.661		340.932

TABLE XXVIII.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Carbodydrates.							
			Total sugars.		Starch.		Hemicellulose.		Total carbohydrates.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*		*Gms.*
1933-'34.										
Oct. 4	Seed	Seeds	1.72	0.046	33.06	0.879	7.73	0.206	42.51	1.131
Nov. 1	4	Total	4.33	0.354	0.26	0.021	9.96	0.815	14.55	1.190
15	6	Total	15.14	2.439	0.23	0.037	9.26	1.492	24.63	3.968
29	8	Total	16.53	7.376	0.86	0.384	9.86	4.399	27.25	12.159
Dec. 13	10	Total	19.11	12.785	0.18	0.120	9.10	6.088	28.39	18.993
Jan. 17	15	Total	20.58	18.604	1.15	1.040	11.43	10.333	33.16	29.977
31	17	Total	16.19	20.286	1.20	1.504	12.03	15.074	29.42	36.863
Feb. 14	19	Total	16.08	23.107	1.03	1.480	12.73	18.293	29.84	42.880
Mar. 7	22	Total	9.36	14.836	1.13	1.791	13.80	21.873	24.29	38.500
21	24	Total	3.75	5.798	0.71	1.098	14.43	22.308	18.89	29.204
Apr. 4	26	Total	1.25	3.468	0.25	0.694	15.06	41.776	16.56	45.937
11	27	Total	0.16	0.634	0.16	0.634	14.30	56.630	14.62	57.895
18	28	Total	4.38	26.061	0.13	0.774	14.13	84.074	18.64	110.908
25	29	Total	6.38	58.045	0.07	0.637	14.30	130.101	20.75	188.784
May 2	30	Total	3.14	39.627	0.05	0.631	16.03	202.298	19.22	242.556
9	31	Stems and leaves	2.83	43.375	0.00	0.000	16.83	257.953	19.66	301.329
		Heads	29.53	10.099	0.15	0.051	7.16	2.449	36.84	12.599
		Total		53.474		0.051		260.402		313.928
16	32	Stems and leaves	5.64	111.193	0.18	3.549	15.56	306.765	21.38	421.507
		Heads	11.66	15.275	0.61	0.799	22.10	28.951	34.37	45.025
		Total		126.468		4.348		335.716		466.532

TABLE XXVIII.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Carbohydrates.							
			Total sugars.		Starch.		Hemicellulose.		Total carbohydrates.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*		*Gms.*
1933-'34.										
May 23	33	Stems and leaves	5.33	123.123	0.16	3.696	15.16	350.196	20.65	477.015
		Heads	11.33	30.478	0.21	0.565	21.33	57.378	32.87	88.420
		Total		153.601		4.261		407.574		565.425
30	34	Stems and leaves	7.08	161.920	0.12	2.744	16.80	384.216	24.00	548.880
		Chaff	9.66	24.681	1.90	4.855	21.30	54.422	32.86	83.957
		Grain	11.53	22.887	25.93	51.471	7.06	14.014	44.52	88.372
		Total		209.488		59.070		452.652		721.209
June 6	35	Stems and leaves	3.19	72.732	0.26	5.928	15.83	360.924	19.28	439.584
		Chaff	5.72	15.330	0.40	1.072	19.90	53.332	26.02	67.734
		Grain	2.83	16.626	32.66	191.878	7.30	42.888	43.79	257.266
		Total		104.688		198.878		457.144		766.584
13	36	Stems and leaves	1.72	37.530	0.14	3.055	19.03	415.235	20.89	455.820
		Chaff	4.77	12.688	0.09	0.239	24.40	64.904	29.26	77.831
		Grain	2.38	18.219	32.80	251.084	7.10	54.351	42.28	323.653
		Total		68.437		254.378		534.490		857.304
20	37	Stems and leaves	0.80	16.776	0.28	5.872	20.33	426.320	21.41	448.968
		Chaff	0.64	1.606	0.14	0.351	26.63	66.841	27.41	68.799
		Grain	1.88	13.968	31.86	236.720	7.03	52.233	40.77	302.921
		Total		32.350		242.943		545.394		820.688

TABLE XXVIII.—*Continued*

DATE.	Age of plants, weeks.	Plant parts.	Carbodydrates.							
			Total sugars.		Starch.		Hemicellulose.		Total carbohydrates.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*		*Gms.*
1934-'35.										
Oct. 5.....	Seed	Seeds.....	1.36	0.035	26.06	0.665	7.17	0.183	34.59	0.882
Nov. 9.....	5	Total.....	9.08	2.052	0.32	0.072	9.87	2.231	19.27	4.355
23.....	7	Total.....	6.92	2.425	0.29	0.102	9.33	3.270	16.54	5.797
Dec. 20.....	11	Total.....	14.08	7.664	0.16	0.087	11.23	6.1112	25.47	13.863
Jan. 11.....	14	Total.....	16.75	9.315	0.68	0.378	12.60	7.007	30.03	16.700
Feb. 1.....	17	Total.....	13.86	7.021	0.67	0.339	13.17	6.672	27.70	14.033
21.....	20	Total.....	7.39	3.552	0.53	0.255	14.40	6.921	22.32	10.727
Mar. 14.....	23	Total.....	3.83	2.832	0.44	0.325	14.13	10.449	18.40	13.607
28.....	25	Total.....	5.44	5.402	0.14	0.139	12.67	12.581	18.25	18.122
Apr. 11.....	27	Total.....	5.33	10.809	0.34	0.690	13.00	26.364	18.67	37.863
18.....	28	Total.....	8.17	27.124	0.33	1.096	11.80	39.176	20.30	67.396
25.....	29	Total.....	2.25	11.558	0.20	1.027	13.37	68.682	15.82	81.267
May 2.....	30	Total.....	3.25	26.234	0.17	1.372	13.93	112.443	17.35	140.049
9.....	31	Total.....	4.89	57.193	0.16	1.871	14.67	171.580	19.72	230.645
16.....	32	Total.....	3.14	44.990	0.11	1.576	15.40	220.651	18.65	267.217

TABLE XXVIII.—*Concluded*

DATE.	Age of plants, weeks.	Plant parts.	Carbohydrates.							
			Total sugars.		Starch.		Hemicellulose.		Total carbohydrates.	
			Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.	Percentage dry basis.	Amount per 100 plants.
				Gms.		*Gms.*		*Gms.*		*Gms.*
1934-'35.										
May 23	33	Stems and leaves	3.31	54.032	0.13	2.122	15.20	248.125	18.64	304.279
		Heads	8.13	4.634	0.53	0.302	15.57	8.875	24.23	13.811
		Total		58.666		2.424		257.000		318.090
30	34	Stems and leaves	4.97	92.109	0.16	2.965	14.90	276.142	20.03	371.216
		Heads	5.44	8.949	0.19	0.313	19.40	31.913	25.03	41.174
		Total		101.058		3.278		308.055		412.390
June 6	35	Stems and leaves	4.61	93.468	0.16	3.244	14.77	299.462	19.54	396.174
		Chaff	3.97	7.650	1.23	2.370	23.33	44.957	28.53	54.977
		Grain	32.22	14.757	4.13	1.892	7.20	3.298	43.55	19.946
		Total		115.875		7.506		347.717		471.097
13	36	Stems and leaves	7.75	161.650	1.23	25.655	13.87	289.300	22.85	476.605
		Chaff	3.31	6.699	1.25	2.530	21.73	43.982	26.29	53.211
		Grain	8.97	20.290	20.13	45.534	7.23	16.354	36.33	82.178
		Total		188.639		73.719		349.636		611.994
20	37	Stems and leaves	3.08	63.316	1.25	25.696	14.97	307.738	19.30	396.750
		Chaff	3.00	7.365	1.30	3.192	23.00	56.465	27.30	67.022
		Grain	2.42	11.713	29.93	144.861	6.67	32.283	39.02	188.857
		Total		82.394		173.749		396.486		652.629