AGRICULTURAL EXPERIMENT STATION
KANSAS STATE COLLEGE OF AGRICULTURE
AND APPLIED SCIENCE
MANHATTAN, KANSAS

A STUDY OF THE MORPHOLOGICAL NATURE AND PHYSIOLOGICAL FUNCTIONS OF THE AWNS OF WINTER WHEAT

PRINTED BY KANSAS STATE PRINTING PLANT
LEONARD McCALLA, STATE PRINTER
TOPEKA, 1944
20-3882

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A STUDY OF THE MORPHOLOGICAL NATURE AND PHYSIOLOGICAL FUNCTIONS OF THE AWNS OF WINTER WHEATS [1]

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INTRODUCTION

The function of the awns of cereals has long been of interest. Although their exact function is unknown, it is agreed that they are useful to the plant because the awned varieties, under certain conditions, outyield the awnless ones. Some investigational work has been done relative to the physiological function, effect, inheritance, and morphology of the awns, but the results obtained are somewhat contradictory. In an attempt to clarify and supplement the known facts and perhaps to find new ones, studies were conducted on several varieties of bearded winter wheat growing in the field at Manhattan, Kansas, during the years 1936, 1937, and 1938.

REVIEW OF LITERATURE

MORPHOLOGY OF THE SPIKELET OF WHEAT[2]

According to Fittbogen (10) it was noted by Grönland that the glumes and awns of little barley *(Hordeum vulgare)* had only rudimentary stomata on their surfaces or none at all.

Hayes and Garber (21) stated that the awn is an extension of the flowering glume. They also stated that the common wheats, as Marquis and Bluestem, are not truly awnless for there is a short extension of the awn, particularly in the spikelets at the top of each spike.

Scarth (34) reported that cells injured by cutting caused the stomata in the immediate vicinity of the wound to close. In such a case, the loss of turgor in the guard cells is accompanied by an increase of starch in the cells.

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1. Contribution No. 448 from Department of Botany.
Acknowledgment is due C. O. Johnston, pathologist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, United States Department of Agriculture, and J. C. Frazier, assistant plant physiologist, Kansas Agricultural Experiment Station, for their advice and criticism in the preparation of this publication.

2. Considerable work was done on the morphology of the spikelet while the experiment was in progress. Since this part of the experiment has been so thoroughly studied by many other investigators, it was considered best to include with the review of literature the discussion of the various parts which make up the head or spike. The descriptions of the various parts of the spikelet are taken mostly from the monograph, "The Wheat Plant" by Percival.

Percival (30) defines the inflorescence of wheat as "a distichous, compound spike, the primary axis bearing two opposite rows of lateral, secondary spikelets and a single, fertile, terminal spikelet, except in the case of *Triticum monococcum* in which the latter is rudimentary and barren, or missing." In America the spike is frequently referred to as the "head," and in Europe, as the "ear."

A lemma, palea, and the sexual organs constitute a floret, of which there may be from three to nine in a spikelet. (Fig. 1, A.) One or more of the upper florets in a spikelet are usually sterile. Each

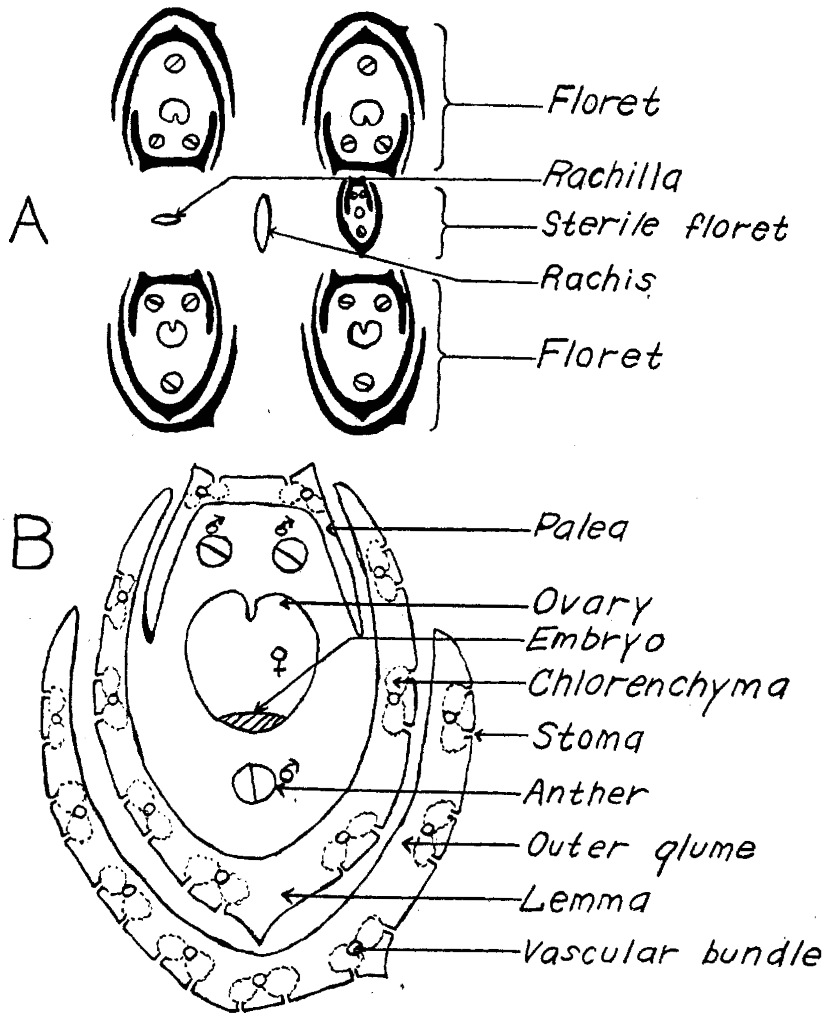

FIG. 1.—(A) Diagrammatic cross section of a wheat spike showing the arrangement of florets and floret parts; (B) detailed diagrammatic drawing of a floret showing the arrangement of its various parts.

spikelet consists of a delicate, flattened and jointed rachilla which bears two, opposite rows of alternately solitary flowers between chaffy bracts or outer glumes. The florets of a spikelet are thus

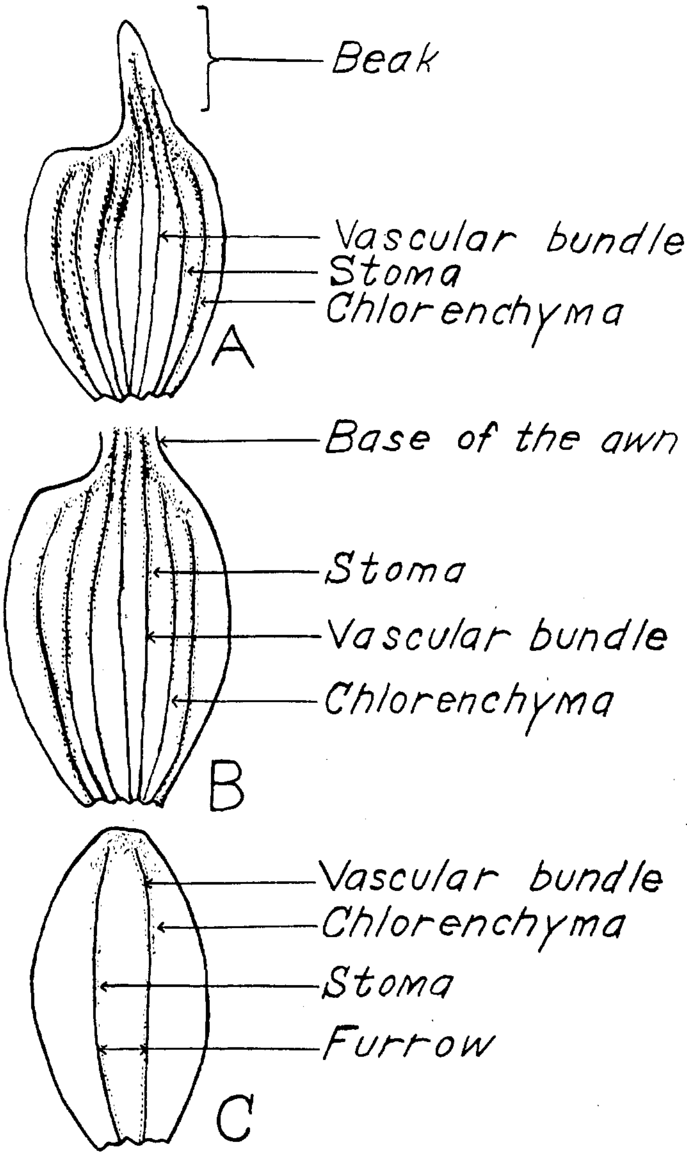

FIG. 2.—Diagrammatic drawings: (A) Outer glume of wheat spikelet, showing outer (lower) surface view; (B) basal part of lemma (flowering glume), or palea inferior, showing outer (lower) surface; and (C) palea in outer (lower) surface view, palea superior. Redrawn from Perlitius.

subtended by two outer glumes, one being attached to the rachilla at a slightly higher level than the other.

Outer Glumes.—The outer glumes are variously designated as "empty glumes," "bracts," "first and second bracts," "first and second scales," "first and second glumes," "Gluma," and "Hullspelze." They are the two opposite, rigid, boat-shaped structures subtending the spikelet. The outer glumes are shorter than the rest of the spikelet and in lateral spikelets the parts on the right and left of the midrib are dissimilar in size and shape. (Figs. 1, B and 2, A.) The form of the apex varies from a blunt extension (beak) of the midrib to a terminal, scabrid awn with a length of 2 to 5 cm. The shape of a cross section of this beak differs slightly from that of the awn, but as shown in Figure 3, A and B, their general anatomy is the same. The outer glumes of the terminal spikelet differ from those of the lateral in that the former are rarely keeled and always symmetrical. The midrib may be well defined or missing in which case two, strong, lateral veins are present, one on each side of the central line, the apex being notched or divided sometimes to near the base of the glume. In the glumes of lateral spikelets, there are eight bundles with five in the larger side and three in the smaller. The stomata are in double rows over the chlorenchymatous strands, the latter being in contact with a vascular bundle. (Figs. 1, B, and 2, A.) On the peripheral strands, stomata extend from the apex to the base but approaching the midrib, the stomata extend down the bundles progressively shorter distances. There are a few stomata on the inner (upper) surface near the apex. According to Perlitius (31, 32) there are approximately 1000 stomata on each outer glume of wheat. As previously mentioned, Fittbogen (10) stated that, according to Dr. Gronland, the glumes and awns on barley are devoid of stomata or have them in only the rudimentary form. Observations on the varieties of wheat used in these experiments showed the presence of stomata in approximately the numbers given by Perlitius (31, 32).

Lemmas or Flowering Glumes.—Inserted alternately on opposite sides of the short rachilla are the lemmas, or the flowering glumes, in the axils of which the flowers arise. (Figs. 1, B, and 2, B.) The lemma is boat-shaped, many-nerved, and without a keel, the upper part notched and ending in a beak with awnless wheats and in an awn in the awned varieties. The synonyms for the lemma include the following: "flowering glume," "inner glume," "palea inferior," "third scale," "bract," "third bract," and "Deckspelze."

Only from one-sixth to one-fourth of the stomata of the lemma are on the basal or leaf-like part, while the rest of them are on the awn. Perlitius (31, 32) cites the case of a winter wheat with a total of 3,086 stomata on the lemma; of this number 686 were on the basal part of the lemma, while 2,400 were on the awn.

In the strictly awnless types the lemma or flowering glume consists of only a leafy portion with a beak or very short extension.

There are seven vascular bundles present, the three central ones continuing into the awn on the awned types. The stomata are in double rows associated with the chlorenchymatous strands which in turn adjoin the vascular bundles. The stomata that are located on the periphery of the bract, but approaching the center of the lemma, extend down the bract shorter distances. (Fig. 2, B.) According to Schmid (35) stomata when present on the inside surface of the

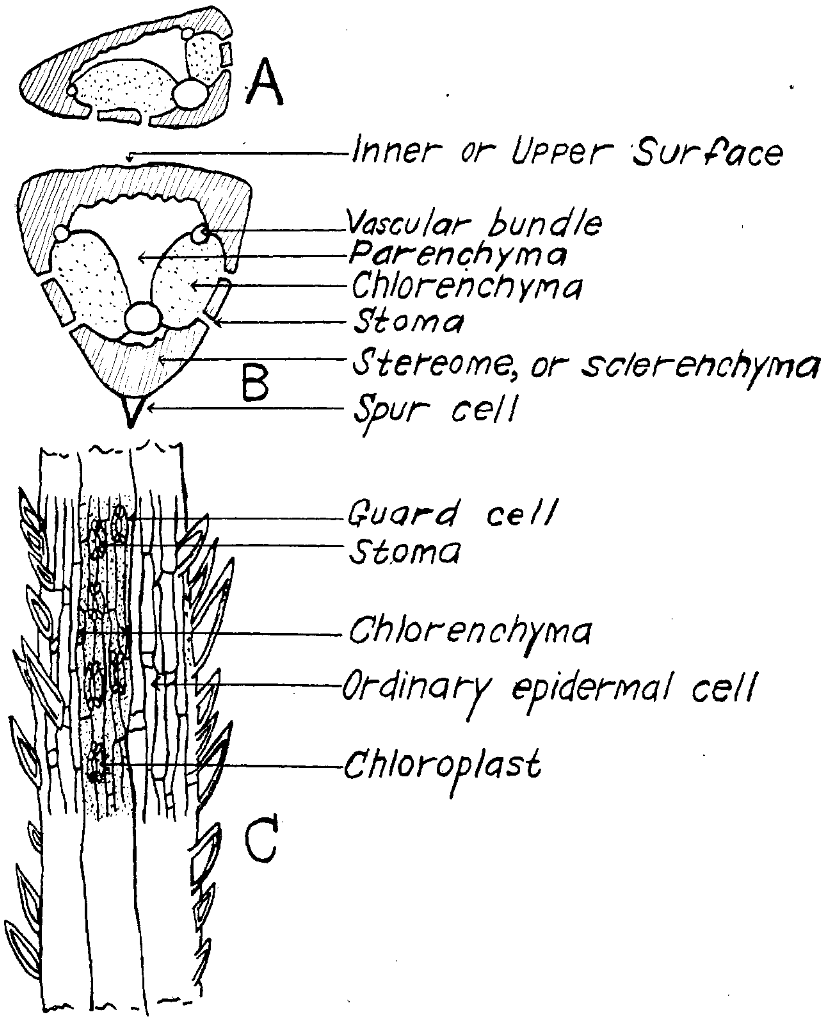

FIG. 3.—Diagrammatic drawings: (A) Cross section of beak on outer glume of wheat; (B) cross section of the awn of wheat showing the location of its various tissues; and (C) longitudinal surface view of the awn of wheat. C only is redrawn from Percival.

lemma do not extend downward from the apex more than one-third of its length.

Palea.—Opposite each lemma or flowering glume, but attached to the very short floral branch with its back to the rachilla, is the palea. The palea has been called by various names including "palea superior," "bract," "fourth bract," "scale," "fourth scale," "palet," and "Vorspelze." It is a symmetrical, thin, membranous glume with two prominent lateral veins, along which runs a line of stiffish hairs. The part between these two veins is called the furrow and is concave. The two semitransparent margins of this glume turn inwardly around the flower. (Fig. 1, B.) Plant breeders often experience difficulty in removing the two stamens that are located within the enclosure of the margins of the palea as they approach maturity. The palea is of simple structure, the tissue adjoining the furrow being only two or three cells in thickness. The epidermis of the palea is composed chiefly of elongated cells and circular "dwarf" cells with sinuous walls; over the keels, margins, and surfaces of the apical portions of the palea are simple hairs 50 to 130μ in length.

Double rows of stomata serve the two strands of chlorenchyma which, in turn, are in contact with vascular strands. There are numerous stomata at the apex on the outside (lower) surfaces and also rows of stomata extend down each of the two bundles, the two inner rows (in the furrow) extending to the base of the palea, and the two outer rows extending about two-thirds of the way from the apex to the base. (Fig. 2, C.) There are no stomata on the inner (upper) surface of the palea.

Rachis.—Although the vascular bundles are arranged in a circle in the rachis, the chlorenchymatous strands and stomata occur only on the convex side; the more or less flattened side is underlaid with a thick schlerenchymatous layer, the stereome.

Rachilla.—The rachilla is delicate and flattened with an arrangement of tissue similar to that found in the rachis. The epidermal cells of the rachilla have straight cell walls that are not greatly thickened. Numerous hairs are usually present. There are usually three slender vascular bundles running through the thin-walled ground tissues.

Awn.—Hayes and Garber (21) define the awn or "beard," as an extension of the flowering glume. (Fig. 3, B and C.) Schmid (35) and other workers considered it to be a metamorphosed leaf, particularly because of the presence of stomata. Other investigators contend that the presence of stomata cannot be used as a criterion of a foliar structure since organs of the plant other than leaves have stomata. The awns are tapering and triquetrous, with forward-pointing, scabrous projections running longitudinally along the angles. Percival (30) stated that they are usually straight but may be sinuous or even bent into the form of a hook or spiral, as in some Asiatic forms of *Triticum vulgare.* Frequently the side of the awn turned toward the rachis is somewhat flattened. This irregularity is mostly in the lower portion of the awn and does not occur in the upper part, Percival (30) stated that in a Persian form of *Triticum vulgare* the awn has a pair of thin membranous and colorless outgrowths which are leaf-like in appearance. Schmid (35) and the authors of this bulletin observed that the awns are formed early, so that by the time the ovary is beginning to differentiate, the awns are as long as the spikelets.

In truly awned spikes or heads, the awns are uniformly distributed from the top to the bottom of the spike with the longest never at the apex. In the heads or spikes that are classified as awnless, whatever awns are present are longest near the apex of the spike. The rest of these awns rapidly diminish in length towards the base, where they rarely exceed 1 to 3 mm. in length. The length of the awns on the heads of the commonly-grown, awned varieties of wheat in Kansas varies from 2.5 to 11.1 cm., depending on the location of the awn on the spike and the variety of wheat.

Percival (30) describes the awn as consisting of four types of tissue, viz., epidermis, mechanical tissue or stereome, vascular bundles, and chlorenchyma. (Fig. 3, B.) The epidermis is composed of three types of cells (a) narrow, elongated cells with walls showing wavy thickenings and numerous simple pits, (b) small, oval or squarish, "dwarf" cells often projecting as papillae, and (c) short, thick-walled, unicellular hairs with fine points which are directed forward and give the awn its rough character. All epidermal cells have a high content of silicon, and by careful handling a portion of this tissue will keep its skeletal form when ashed on a platinum wire with sulfuric acid. The outside of the epidermal cell is very thick-walled and frequently perforated with canals or pits, which extend to the cuticle. In the epidermis of the two outer faces of the awn are longitudinal rows of stomata which communicate with the chlorenchymatous strands within the awn. Near the base of the awn, there may be three to five rows of stomata, over each of the two chlorenchymatous strands, while near its tip they are reduced to one row. Thus for most of the length of the chlorenchymatous strands in the awn, the stomata are in double rows, one of which is associated with each chlorenchymatous strand. The long axis of the stomatal pore is always parallel to the long axis of the awn. (Fig. 3, C.)

The cells of chlorenchyma are densely packed with chloroplasts. This tissue consists of two separate strands of chlorophyllous parenchyma, which traverse the awn from its base to near its apex where they unite into a single central strand. Immediately within the epidermis, at the three angles and around the inner part of the awn, is strongly-developed stereome, while the center is occupied by thin-walled parenchyma. The stereome is especially well silicified. According to Schmid (35) the stereome has two functions: (a) Those cells nearest the epidermis have a mechanical function; (b) the mechanical cells toward the center, because of their numerous pits, serve to conduct substances, especially water.

Three vascular bundles occur in each awn for a considerable portion of its length. There is one large bundle, which is really the midrib of the leafy part of the lemma, in the angle between the two strands of chlorenchyma, and, at the two sides, two smaller bundles which come from either side of the midrib of the lemma or flowering glume. Only the central, large bundle continues to the very tip of the awn. Schmid (35) stated that the middle vascular bundle is of the typical monocotyledonous type, while the two smaller ones, especially in the upper parts of the awn, are often reduced to but a few cells.

Schmid also mentioned that some awns are colored and that the coloring matter is in the cell sap. He added that it is not known whether the coloring matter acts as a protection against light, intense heat, or has some other function. The awns may be white, red, or black. The first two colors are found only on white or red glumes, while the last color may occur on the lemma or flower glume whether they are white, red, or black.

PHYSIOLOGICAL FUNCTIONS

The first observations relative to the influence of the awns on the yields of wheat were reported by Hickman (25) in 1889, Ohio. He found for that year that the average yield per acre of 31 varieties of awned wheats was 40.5 bushels while that for 36 varieties of awnless wheats was 37.4 bushels. The following year, however, he (25) reported the results for 10 years in which 162 awned varieties were compared with 234 awnless varieties. The average difference in yield during that time was only 0.6 bushel per acre in favor of the awned varieties. As the result of these studies Hickman stated that the awnless wheats were equal to the awned types in productivity in Ohio.

Zoebl and Mikosch (41) found that the awns of barley are organs of transpiration because heads that were deprived of their awns by clipping transpired only one-fifth to one-fourth as much water as intact heads under the same conditions. Transpiration from the awns was most intense when the movement of materials into the head was at its maximum. Hence, the rate of transpiration from the awns was in direct relationship to the intensity of metabolism in the head.

An unsigned article in a German publication (2) stated that the rate of transpiration from barley heads is decreased by the removal of the awns.

Vasilyev (40) used *Stipa capillata,* rye and various varieties of barley and wheat to verify the conclusions of Zoebl and Mikosch (41). In *Stipa capillata,* 67 percent of the total water transpired from the heads was lost through the awns. In Byeloturka wheat it was found that 63.3 percent, and in another variety of wheat 60.3 percent, of the water transpired by the spike was from the awns.

The maximum transpiration from the awns was at the time of flowering. In one experiment, the removal of the awns from a portion of the spike lowered the weight of grain produced by the head as much as 9 percent. This seems to indicate that the presence of the awns is favorable to the proper filling of the grain. Vasilyev concluded that when the awns are fully developed, they transpire the greater amount of water that is lost from the heads and that the removal of the awns strikingly diminishes the amount of water transpired from this part of the plant.

Schmid (35) presented data on the work that he had done relative to the origin, structure, transpiration, assimilation, and respiration of the awns of barley, wheat, rye, oats, and allied wild plants. He also studied the effect of awns upon the ash content in the various parts of these plants. In many regards his data on the morphology and the physiological role of these parts are the most thorough that have been reported. His work concerning the origin and morphology of the awns has been discussed under that heading. He found that the deawning of a wheat plant lowered its transpirational rate 10 to 30 percent. The awned spikes transpired relatively more by night than by day, while with awnless spikes, as well as with the lamina of the leaf, the reverse was true. Since both the awn and the lamina have numerous stomata, he considered that the stomata of the awn did not open so widely during the day as did those of the latter. The weight of the grain was decreased 6 to 8 percent by total deawning.

Deawning on one side of the spike did not reduce these values one half, and it was considered that the deawned side received some nourishment from the awned side of the spike. The decrease in weight of the grain was directly proportional to the length of the awn removed by deawning. Little or no starch was found in the chlorenchyma of the wheat or barley awns. Based on dry weight, grain from awned spikes had 0.05 percent more nitrogen than grain from deawned spikes, but Schmid could not deduce a relationship between awnedness and the content of protein. He concluded that, in general, awns have a biological and physiological role: the first manifest in seed dispersal and protection against grazing; the second shown in the production of a larger, heavier grain. He also concluded that the importance of the awn in the metabolism of the plant is in direct proportion to its size.

Treyakov (39) studied the influence of the awns on the development of the awned wheats at the Poltava experimental field. The awns were removed from all the plants on one plot as soon as they appeared, while on another plot they were allowed to remain intact. Ripening began two days earlier on the deawned plants. The absence of awns was accompanied by a smaller grain with a lower weight. The grain from spikes of deawned varieties was richer in ash but poorer in nitrogen and phosphorus. The author concluded that awned varieties give smaller yield of grain but that the grain possessed a higher absolute weight. The fluctuations in the size of the grains of the awned wheats were less than those of the awnless varieties.

Perlitius (31, 32) concluded that the awns of winter wheat, spring wheat, and barley have a decided influence upon the size and weight of kernels and that this influence is manifested shortly before the kernels are in the milk stage. Chemical analyses indicated that the grain of awned varieties was lower in nitrogen but higher in starch and ash than those of the awnless or deawned varieties. He concluded that the awned varieties ripened earlier than awnless types. Observations made to determine the activity of the awns of wheat and barley showed that a considerable portion of the water transpired by the spike passes through the awns and that the quantity of water lost increases with their length. Awned wheat spikes transpired in some cases twice as much as did awnless heads or those from which the awns had been removed. The period of maximum transpiration varied with the different types of spikes but it always occurred before the grains had reached the milk stage in their development.

Freeman (11) revived and modified a method for obtaining the amount of water lost through transpiration with the parts yet intact on the plant. This method was used by Gauch and Miller (12) in determining the effect on the rate of transpiration after the removal of the awns.

In 1911, an unknown Italian writer (3) reported the analyses for starch and wet gluten for two varieties of bearded wheats and two that were beardless. His conclusion was that the difference between these two kinds of wheat was not sufficient to justify any prejudice against the bearded varieties on the markets.

Schulze (36) in experiments with barley plants found that the awned plants transpired much more than those whose heads had been deawned or were naturally awnless. The peak of transpiration was reached at the milk stage of development of the grain.

Grantham and Groff (15) noted that the awned varieties of wheat as a class have a higher percentage of sterile spikelets than the awnless varieties. Of the 108 awned varieties and 80 awnless ones, the average percentage of sterile spikelets was 17.8 for the latter and 24.1 percent for the former. There was a distinct correlation between the length of the spike, as measured by the number of spikelets and the number of sterile spikelets. In 1917 Grantham (16) noted that the awned varieties tiller more than the awnless wheats. This probably accounts for the fact that the awned varieties yield more per unit of area than the awnless types. In 26 tests in Delaware (17) over a period of 10 years with 1986 varieties and strains, the awned varieties outyielded the awnless ones by 3.3 bushels per acre. Grantham (18) substantiated his earlier findings that the awned wheats outyielded the awnless types. The grain of awned and awnless wheats was taken at random from farms in the state of Delaware, and it required 285 grains from the awned spikes and 412 from the awnless spikes to weigh 10 grams. An excess of nitrogen in the soil affected the awnless wheats more adversely than the awned types.

Tedin (38) compared the time of maturity and the weight of the grain of eight varieties of barley, which had the awns blown off before ripening, to plants with intact awns in the same field. The deawned spikes ripened earlier and produced kernels whose average weight was 10 percent less than those produced on normal spikes.

Harlan and Anthony (19) worked with Manchurian barley in 1915 at Minneapolis, Minnesota, and with Hannchen barley at Aberdeen, Idaho, in 1916. The results given here are mostly from the experimental work at Aberdeen, Idaho. They found that the grain from deawned spikes had a smaller volume and a lower weight of dry matter than did those from awned spikes. This difference in yield was not thought to be due to injury or to the shock of removing the awns because development of the grain proceeded normally after the deawning. One week after flowering, which is near the time that rapid starch infiltration begins, the accumulation of dry matter in the grain of the awned spike began to exceed that in the grain of the deawned spike. The daily deposit of nitrogen and ash was more nearly equal in the two types of spikes than was the deposit of starch. In the awned spikes at Aberdeen barley awns contained more than 30 percent of ash at maturity. When the awns were removed, a part of this ash was deposited in the rachis. This probably made the rachis easier to break and increased shattering. According to these writers, hooded and awnless barleys generally yield less and shatter more than awned varieties, which seems to indicate that the awns of barley have some physiological function.

Harlan and Pope (20) studied the amount of ash in the awns and various other parts of the spike of barley. They obtained their samples from a wide range of territory. They obtained two samples from Aberdeen, Idaho, two from Chico, California, and one each from St. Paul, Minnesota, and Arlington, Virginia. The awns of barley have a high proportion of ash which is deposited mainly during the time that the kernel is developing. The content of ash in the awns at flowering time and for a few days immediately following was usually from 4 to 8 percent of the dry matter. The increase in ash in these parts after flowering is uniform and samples taken when growth had ceased had from 13 to over 35 percent of ash in their dry matter. The rachises had from 4.8 to 13.6 percent and the grain from 2.3 to 3.8 percent of ash. The heavy deposit of ash in the awns indicates that they are a depository for the excess ash absorbed by the roots. The fact that some varieties contain much more ash in the awns and rachises than others is due to difference in the amount of water transpired and to a difference in the selective functions of the roots of different varieties. The rachises of hooded and awnless varieties are usually high in ash and this increases their brittleness and promotes shattering.

It was stated by Aumüller (4) that the awns of barley possess transpirational and assimilatory functions.

Hayes (22) used Marquis X Preston hybrids and found in each of the generations from the F_3 to the F_5, that the awned types gave a higher yield per plant than the awnless ones. In Minnesota during the seasons of 1918 and 1920, which were favorable for the development of wheat, the awned varieties yielded 7 to 8 percent more than the awnless varieties, while in the unfavorable season of 1919, the difference in yield was 17 percent in favor of the awned varieties. The grain of the awned varieties exceeded the awnless varieties somewhat in length, plumpness, and yield per plant. From these data, Hayes believed that the awn of wheat is an important organ, and that the tendency to breed only awnless wheats should not be adopted in entirety without further experimental studies.

From a cross between Marquis and Kota wheats, Hayes, Aamodt and Stevenson (23) showed, from a study of spring and winter wheats, that awned strains on the average excelled in plumpness of grain. Because plumpness of grain and yield are strongly correlated, it seems that awned wheats yield better on the average than awnless wheats when grown under the conditions prevailing in southern Minnesota.

Clark (7) found that there is a direct relation between the length of the awn and the yield. Thus the difference in favor of the yield of awned types of wheat in the F_2 generation was 15 percent in 562 cases at St. Paul, Minnesota, and 11 percent in 1,143 cases at Mandan, North Dakota. In the F_3 generation for 900 plants the difference in yield was 18 percent in favor of the awned hybrids.

Meister, Shekhurdin and Plotnikov (27), working in Russia, reported that the removal of the awns after the wheat is fully headed had no influence on the dry matter in the grain of *Triticum durum*. Goulden and Neatby (14), Canadian workers, studied the association between awns and grain yield in rod-row trials of awned and awnless strains of H-44-24 X Marquis wheats. The results indicated a very high probability of association between the presence of awns and high grain yield.

It was reported by Conti (9) in Italy that the awns of durum wheats consume some food in their development. The contributing factors toward this were considered to operate through the increased transpiration of the awns.

It was reported by Barre of the South Carolina Agricultural Experiment Station (5) that some of the awnless types of barley showed only a slightly lower yield, less than 1.5 bushels per acre, than the awned varieties. They were also more desirable to handle.

Moskalenko (28) studied the hybrids of winter wheats relative to the relationship between awnedness and the "element of productivity." From data obtained 1922-'27, inclusive, he found no relationship between the presence of awns and productivity under the conditions of the Ukrainian steppe.

Stevens (37) made some comparisons of the hybrids of wheat of awned and awnless segregates in the F_2 generation growing in the crop-improvement nursery at Manhattan, Kansas, in 1929. He observed that, under the prevailing conditions, these segregates of the awned types excelled the awnless ones by 7.8 percent in plumpness of grain, by 0.9 gram of grain per plant, and by 3.4 bushels per acre.

Gemmell (13) in 1921 (published 1933) compared the weight of grain from totally deawned and partially deawned spikes to that from fully awned spikes. Deawning was performed at the blooming stage, June 1; one week later, June 8; and four days before harvest, June 16. His data show that the awned spikes and spikelets yielded more than those from which all or half of the awns had been removed. The differences were always less, the nearer the time of deawning approached maturity. Parker (29) later reported a review of these results in a popular form.

Rosenquist (33) found that the kernels from clipped spikes uniformly weighed less than those from intact heads. Those from the clipped heads weighed only 82.7 percent as much as those from the awned ones. Also, the spikelets on one side of several spikes were clipped at pollination, while those on the opposite side of the same spikes were left untreated. The kernels from the clipped spikelets weighed 85.1 percent of those from the unclipped part of the same head. He believed that part of this difference in weight was due to the injury suffered by the spike by the removal of the awns. He considered this fact as the probable reason why so many investigators have reported that the deawned heads ripened sooner than those from which the awns were not removed. To avoid the injury caused by the removal of the awns by clipping, Rosenquist worked with segregates of the F_2 generation of a cross between Garnet, a variety that may be classed as awnless, and Prelude, a fully awned variety. This cross produced spikes that could be placed into three categories—awnless, intermediate, and awned. Because of the fact that grain size is dependent upon its position in the spike, it is necessary to compare only grains from the same location on the head. Comparable grains from the awned florets averaged about 1.4 percent heavier than those from awnless florets in the same spike. Grains from intermediately awned, F_2 spikes averaged 3.2 percent heavier than those from awnless, F_2 spikes while the grain from fully awned, F_2 spikes were 4.9 percent heavier than those from awnless heads. He concluded that the presence of awns on the florets of wheat tended toward the production of heavier grains.

Aamodt and Torrie (1) working at the University of Alberta in Canada and using a number of F_2 hybrids of Reward X Caesium, an awned and awnletted strains of Marquillo X Marquis-Kanred, did not find a significant relationship between the presence of awns and grain yield.

Lamb (26) reviewed critically much of the work that had been done to that time relative to the yields from awned and awnless varieties of wheat. In Ohio, as well as in other states, farmers have an antipathy to awned varieties of wheat because they are unpleasant to handle and because they do not shock so well as the awnless varieties. In Ohio a study was made of 3695 awned and 4590 awnless heads from eight segregating populations in three seasons. The indications were that there was probably a slight increase in yield resulting from the presence of the awns. The author considered that for practical purposes, however, the advantage was negligible and he considered that there seemed no reason for carrying awned selections in the nursery.

Lamb suggested, on purely theoretical grounds, that a function of the awn that affects yield may be its role in removing from the translocating system of the plant, when the grain is being filled, substances which otherwise might interfere with the rapid movement of materials into the grain. He tried six hybrids for three years and two for one year, using the F_3, F_4 and F_5 generations. The data in general suggest that there is no basis to assume that awned segregates have any advantage in length of straw, head, or in the number of kernels per head. The data do not indicate a serious bias in favor of the beardless groups so far as these measurements are concerned. Therefore any increase in yield must come from the better filling of the grain in the awned heads. In five cases the beardless types had the heavier kernels. Lamb concluded that the awned types gave a slight increase over the awnless segregates in kernel weight. The increase of 1.4 percent in grain weight was not characterized as to significance.

Bayles and Suneson (6) obtained data from composite populations of awned and awnletted segregates from two crosses, one between two winter wheat varieties, Triplet X Oro; and the other between two spring varieties, Baart X Onas. They grew composited populations of homozygous awnless or awnletted and of awned plant segregates from these two crosses in adjacent, replicated nursery plots for four and five years, respectively, at several, widely distributed, western, experiment stations. The grain from the composite of awned plants was superior to that from the composite of awnless or awnletted plants in both kernel weight and test weight per bushel for each cross regardless of the environment. The increase in yield of the awned over the awnless composites from the winter wheat cross was not statistically significant but the difference between the awned and the other two composite types of spring wheat was highly significant.

Gauch and Miller (12) reported on the rate of transpiration from the awned and deawned heads of Pusa 52 X Federation from flowering to maturity. They obtained the amount of transpiration from the heads by an adapted Freeman (11) method. The transpiration rate was determined as early as two minutes after deawning and as late as 34 days afterwards. The deawned heads transpired, from the average of a large number of determinations, 38.9 percent less water than the awned heads. Deawning thus decreased the rate of transpiration. Although the awns of wheat are active in the transpiration of the spike, the head does not ordinarily transpire more than 1 to 5 percent of the total amount of water lost from the plant.

Clark and Quisenberry (8) studied crosses of the spring wheats Marquis, awnless, and Kota, an awned type, in Montana and reported an imperfect dominance of awnlettedness. In the F_2 generation the average yield of the awnletted hybrid plants exceeded that of the awned plants by 1.30 ± 0.33 grams. Shattering estimates taken on a row basis at harvest time showed that the awnletted strains shattered 8.25 percent whereas the awned types shattered 14.38 percent. The difference in yield was due in part to greater shattering among the awned plants, although if no shattering had occurred, the awnletted strains apparently still would have outyielded the awned. The grain of Kota, the awned parent, had a slightly higher crude-protein content than that of Marquis, the awnless parent.

METEOROLOGICAL DATA

A summary of the climatic conditions at Manhattan, Kansas, for the years 1935 to 1938, inclusive, is given in Tables 1 and 2. The total precipitation for each of the four years was 37.71, 24.54, 21.81, and 28.87 inches, respectively. The average precipitation for 81 years to the end of 1938 was 31.04 inches. Thus during 1935 precipitation was 6.67 inches over the average for 81 years, while during the other three years, it was, respectively, 7.5, 9.23 and 2.17 inches lower than the average for that period. The precipitation in 1934 was only 19.38 or 11.66 inches below the normal rainfall. The moisture content in the soil, however, was sufficient at all times to mature a crop of wheat.

TABLE 1.—*Monthly precipitation for the years 1935 to 1938 and the 81-year period, 1858-1938, inclusive.*

MONTH.	1935.	1936.	1937.	1938.	Average for 81 years.
January	0.21	1.03	1.76	0.18	0.75
February	1.12	0.30	0.91	0.75	1.14
March	0.21	0.19	1.75	2.52	1.48
April	1.05	1.40	0.54	1.11	2.66
May	7.62	5.78	2.42	7.99	4.34
June	6.79	0.75	3.39	3.27	4.48
July	0.04	1.78	4.39	4.54	4.32
August	8.79	2.19	2.05	4.43	3.85
September	5.34	7.55	1.52	0.79	3.47
October	3.41	2.29	2.15	0.42	2.18
November	2.54	0.02	0.67	2.56	1.53
December	0.59	1.26	0.26	0.31	0.83
Totals	37.71	24.54	21.81	28.87	31.04

TABLE 2.—*Monthly mean, maximum and minimum temperatures for the years 1935 to 1938 and the 47-year period, 1892-1938, inclusive.*

MONTH.	Average for 47 years.		1935.		1936.		1937.		1938.	
	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
January	39.6	18.0	45.2	21.3	31.5	13.2	31.2	12.0	45.5	21.5
February	43.8	20.6	48.6	27.3	30.7	8.0	40.2	21.0	48.0	25.9
March	56.4	31.2	64.3	39.4	64.0	33.0	50.0	29.3	63.4	39.4
April	68.2	42.4	64.4	40.6	69.8	39.4	66.7	42.8	67.7	43.5
May	76.9	52.5	69.2	51.2	80.0	58.0	79.8	54.5	75.0	53.5
June	82.7	62.4	82.0	59.9	93.2	63.0	88.3	63.7	85.9	63.0
July	92.9	67.0	100.5	72.8	104.3	71.7	97.2	68.6	95.6	68.6
August	92.0	65.0	95.0	67.7	101.7	70.7	98.4	70.7	97.2	71.2
September	83.8	57.6	82.3	58.2	84.7	63.1	86.5	58.6	88.0	58.2
October	71.4	44.8	67.5	44.7	67.5	44.1	70.2	43.1	83.1	50.3
November	55.9	31.3	48.9	32.5	57.0	28.0	51.6	29.5	56.1	31.2
December	42.6	21.5	42.0	24.0	49.1	28.2	39.7	21.5	48.5	22.5
Mean	67.5	42.9	67.5	45.0	69.5	43.4	66.6	42.9	71.2	45.7

The various tables show that the climatic conditions that prevailed during the years 1935 to 1938, inclusive, were not exceptional from the average of 81 years of precipitation and 47 years during which the maximum and minimum temperatures were recorded.

EXPERIMENTAL METHODS

METHOD OF GROWING THE PLANTS

The plants used in the experiment herein reported were grown in the field during the three growing seasons of 1936-'38, inclusive. They were grown in an experimental plot at Manhattan, Kansas, which had been sown to small grains at least 10 years. The soil is

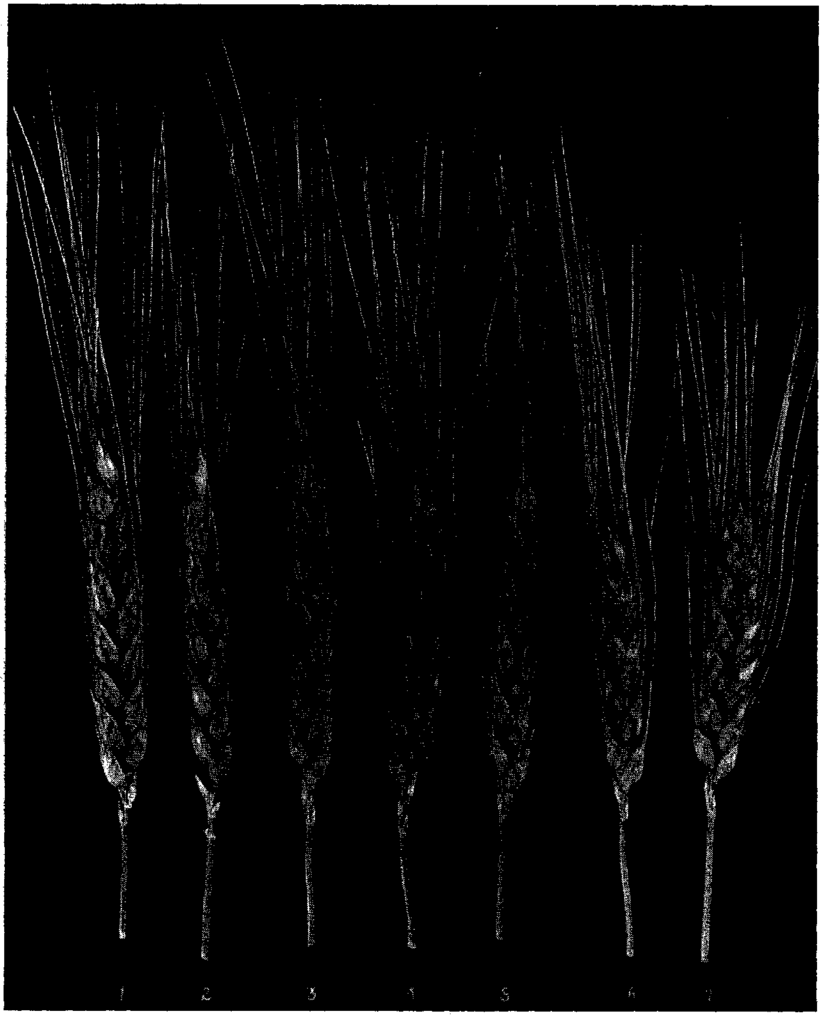

FIG. 4.—Representative spikes (heads) of the varieties of wheat used in these studies: (1) Kawvale; (2) Fulcaster; (3) Kanred; (4) Tenmarq; (5) Turkey; (6) Early Blackhull; and (7) Kanred × Hard Federation. Length of the Kawvale spike from the base to the tip of the longest awn is 6½ inches.

a fertile, sandy loam that is characteristic of the lowland areas of this region. Each year soon after the wheat was harvested the ground was plowed and cultivated, and was in good tilth when the wheat was sown. It was planted October 11, 1935; October 5, 1936; and October 1, 1937.

The wheat was sown with a small, single-row, nursery drill in rows one foot apart at the approximate rate of one and one-half bushels to the acre, with the different varieties sown in random arrangement with seven replications. Good stands were obtained each year and the crop made an excellent fall growth. There was sufficient moisture in the soil at all times for the needs of the plant.

The following varieties were grown each of the three years: Kanred, Turkey, Kanred X Hard Federation, Tenmarq, Kawvale, Fulcaster, and Early Blackhull. All of these selections were red winter wheats. Representative spikes or "heads" of each of these varieties are shown in Figure 4. Kawvale is a semihard wheat, Fulcaster is a soft wheat, and the other five varieties are representative of the awned hard red wheats grown in Kansas.

TECHNIQUE OF DEAWNING

The method used for the selection of heads for the deawning experiments, each of the three seasons, was as follows: Two stalks or culms in close proximity to each other that seemed to be the same in general appearance and from the same or different plants were selected at random at or before the "boot" stage. On one of these stalks a colored tag was attached that distinguished it as a control plant. A tag of another color was attached to the other stalk to mark it as an experimental plant. The same process was repeated for a given variety until 150 experimental and an equal number of control stalks were so tagged. The 300 tagged stalks were in close proximity to one another, occupying only a small proportion of a given row and were called a set. Eight sets of a given variety were tagged on the same or replicate rows and thus, for the seven varieties, 56 sets or about 16,800 culms were tagged during each of the three years.

Deawning was accomplished by clipping the awn at the apex of the lemma with small, sharp-pointed scissors. Care was exercised at all times not to cut or injure the rest of the lemma. The beak of the outer glume was removed at the same time as the awn. The same technique of removing the awns was followed during the three years.

The experiments in which all the awns were removed from the spike are herein designated as "totally deawned" and when the awns were removed from only one side of the spike the treatment is called "partially deawned." (Fig. 5.)

The heads or spikes were deawned at four stages, viz., seven to 10 days before blooming, at blooming, one week after blooming, and two weeks after blooming.

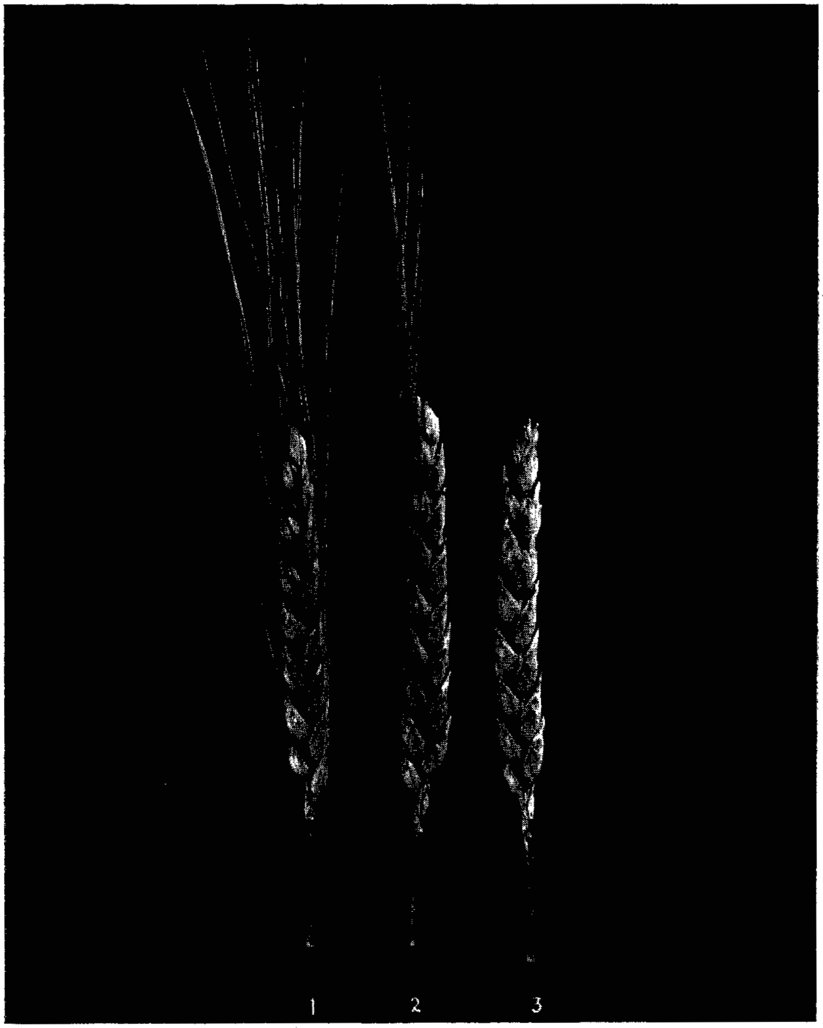

FIG. 5.—Sample of the control, partially deawned, and totally deawned spikes of Kawvale wheat: (1) Typical awned spike (control); (2) partially deawned spike; and (3) totally deawned spike. The length from the base of the spike to the tip of the longest awn is 6 inches.

Deawning of each variety at the four different periods was both total and partial. There were thus performed eight experiments each year on each variety: Table 3 gives the times at which the heads of the various varieties were deawned and the dates on which they were harvested. Table 4 shows the number of heads or spikes that were recovered from each experiment. The failure to recover all of the 150 tagged plants was due to lodging, to inability to locate the tagged stalks, and to other unavoidable circumstances.

TABLE 3.—*Dates of deawning and of harvesting wheat heads, 1936-1938.*

VARIETY.	Deawning.*				Harvesting.*			
	BB.	B.	1-B.	2-B.	BB.	B.	1-B.	2-B.
1936	May	May	June	June	June	June	June	June
Kanred	27	29	4	9	20	21	20	22
Turkey	22	27	1	10	21	20	20	22
Kanred × Hd. Fed	19	20	†	8	17	17	17	17
Tenmarq	25	25	3	9	24	20	20	22
Kawvale	28	29	5	......	22	18	18	......
Fulcaster	28	29	......	6	21	24	......	22
Early Blackhull	20	19	†	8	22	22	19	22
1937								
Kanred	28	31	4	10	25	25	25	25
Turkey	28	31	3	10	25	25	25	25
Kanred × Hd. Fed	21	27	1	7	25	25	25	25
Tenmarq	28	29	3	10	25	25	25	25
Kawvale	27	29	3	10	24	24	24	24
Fulcaster	27	29	3	10	24	24	24	24
Early Blackhull	21	22	1	7	21	21	21	21
1938								
Kanred	25	28	4	11	23	23	23	23
Turkey	26	30	6	13	23	23	23	23
Kanred × Hd. Fed	17	21	‡	4	20	20	20	20
Tenmarq	19	24	§	6	22	22	22	22
Kawvale	24	27	3	10	22	22	22	22
Fulcaster	24	26	2	9	22	22	22	22
Early Blackhull	11	14	‖	‡	19	19	19	19

* BB, before blooming; B, blooming; 1-B, one week after blooming; 2-B, two weeks after blooming.
† May 30.
‡ May 28.
§ May 31.
‖ May 21.

HARVESTING

To prevent shattering, the entire culm or stalk was cut at the stage of early ripening, brought into the laboratory, and the intact culms permitted to ripen on drying racks. This treatment did not induce any apparent shriveling of the grain. Each series of plants was harvested at as nearly the same stage of ripening as possible and treated in the same manner before threshing. Table 3 gives date of harvesting. In 1936 the plants were harvested from June 17 to June 24. During the next two years, as shown in Table 3, the heads were harvested four days earlier as a result of experience gained the first year.

THRESHING

Each group of spikes was threshed separately by hand in a small head thresher so that no grain was lost. In the experiments with Tenmarq and Kanred in which the spikes were separated into grain, chaff (glumes), awns, and rachises, all remaining awns were removed by clipping before threshing. The rachises were sorted from the chaff and grain mixture and the chaff was separated from the grain

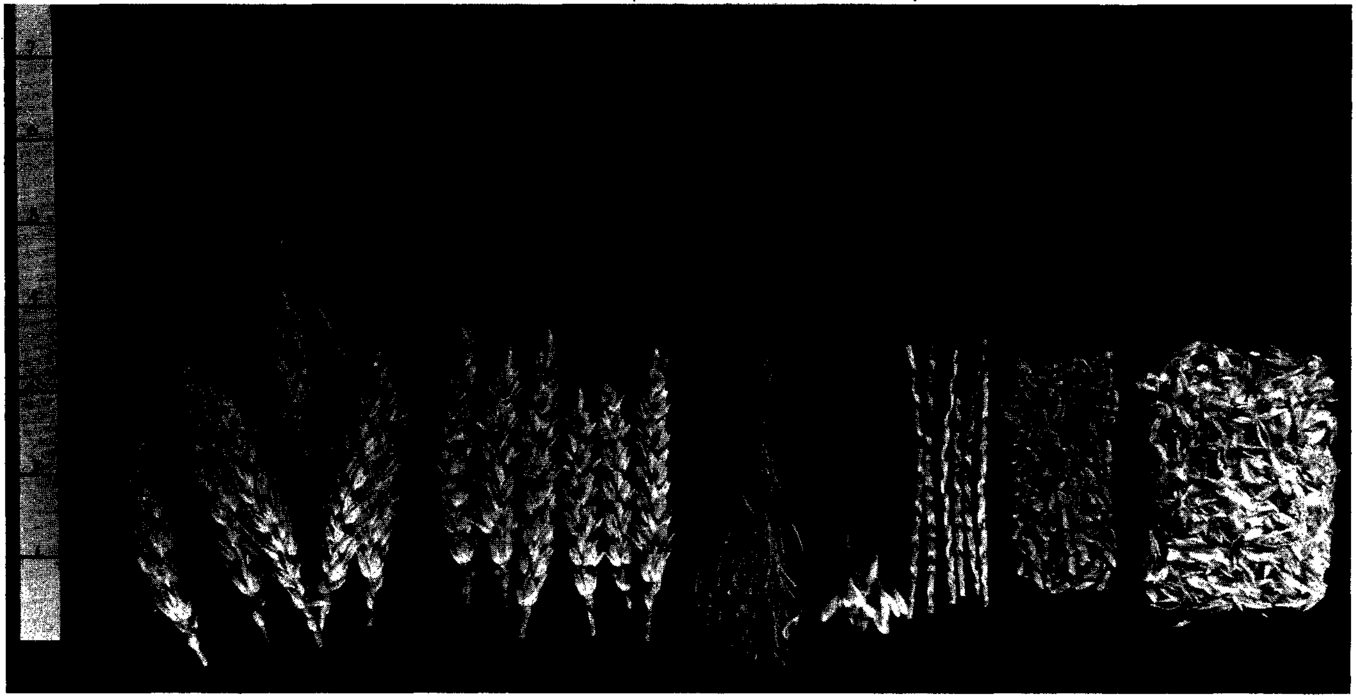

Fig. 6.—Intact awned spikes, totally deawned spikes, and the parts into which they were separated for the various determinations. Proceeding from left to right are shown intact, awned spikes, totally deawned spikes, awns without the glumes, awns attached to glumes, rachises, grain, and glumes.

by light blasts of air. As a rule the rachises remained intact but all the segments of the broken ones were carefully removed. The spikes and parts into which the varieties were resolved are shown in Figure 6.

TABLE 4.—*Number of heads harvested from the various sets of treatments, 1936-1938.*

VARIETY.	Stage of deawning.*							
	BB-T.	BB-P.	B-T.	B-P.	1-T.	1-P.	2-T.	2-P.
1936								
Kanred	137	140	145	140	139	144	152	158
Turkey	125	139	136	137	146	129	132	139
Kanred × Hd. Fed	120	140	135	140	148	140	145	137
Tenmarq	135	133	141	144	147	143	140	144
Kawvale	131	137	135	141	148	145	......	......
Fulcaster	145	144	134	143	......	......	143	145
Early Blackhull	126	132	118	92	146	138	142	145
1937								
Kanred	118	115	121	114	114	114	108	120
Turkey	114	120	117	115	100	115	115	119
Kanred × Hd. Fed	122	121	120	121	104	112	119	109
Tenmarq	112	115	122	119	111	117	117	117
Kawvale	122	123	123	118	120	116	112	110
Fulcaster	120	119	121	115	117	108	111	120
Early Blackhull	120	114	120	121	114	105	114	115
1938								
Kanred	130	130	130	130	130	130	130	130
Turkey	130	140	125	130	130	145	145	135
Kanred × Hd. Fed	140	150	130	145	140	140	135	150
Tenmarq	140	130	130	130	130	135	130	130
Kawvale	140	145	135	125	135	145	135	140
Fulcaster	145	145	125	145	130	145	150	145
Early Blackhull	140	150	135	145	130	135	135	145

* BB-T = before blooming, totally deawned; BB-P = before blooming partially deawned; B-T = blooming, totally deawned; B-P = blooming, partially deawned; 1-T = one week after blooming, totally deawned; 1-P = one week after blooming, partially deawned; 2-T = two weeks after blooming, totally deawned; 2-P = two weeks after blooming, partially deawned.

DISCUSSION OF EXPERIMENTAL DATA

EFFECT OF DEAWNING ON THE WEIGHT OF GRAIN IN 100 HEADS

Table 5 shows the fresh weight of the grain obtained from 100 heads of wheat that were totally or partially deawned in comparison to the weight of grain from the same number of control heads. These results are expressed in the number of grams from each head and in percentage of the control plants.

As a rule there was a progressive decrease in the extent of loss in weight of the grain when the deawning was performed before blooming and continuing to the stage two weeks after blooming. (Fig. 7.) There were 82 experiments in which the heads were totally deawned during the three years. During this time there were only two instances where the grain from 100 totally deawned heads had a greater weight than the grain from the same number of control heads. This increase was for the variety Tenmarq in 1937 and 1938. In 1937 it amounted to 1.7 grams or 2.63 percent above the yield of the grain from the control heads. In 1938 it amounted to an increase of only 0.1 gram or 0.17 percent above that of the control heads. In 1937 the variety Kawvale (one week after blooming) and in 1938 the variety Turkey (two weeks after blooming) did not depart from the controls. The average loss of the seven varieties

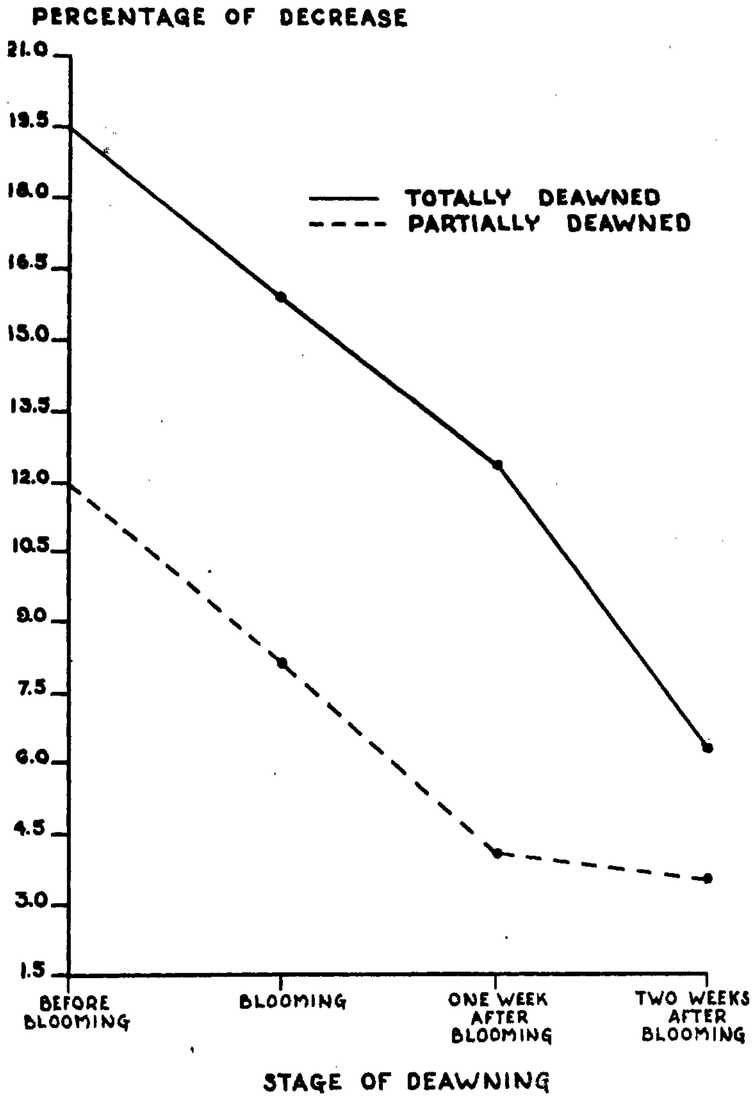

FIG. 7.—Percentage loss in weight of grain from 100 each of totally and partially deawned heads at four stages of development as shown by the grand weighted average (Table 5).

TABLE 5.—*Effect of total and partial deawning of wheat heads on weight of grain on a basis of 100 heads. 1936-1938*. Weights are in grams.*

VARIETY.	100 totally deawned heads.				100 partially deawned heads.			
	Controls.	Experimental.	Decrease.	Percent decrease.	Controls.	Experimental.	Decrease.	Percent decrease.
Before Blooming, 1936								
Kanred	57.1	47.3	9.8	*17.16*	58.2	55.9	2.3	*3.95*
Turkey	55.9	44.9	11.0	*19.68*	52.9	47.1	5.8	*10.96*
Kanred × Hd. Fed.	45.4	37.3	8.1	*17.84*	42.7	38.8	3.9	*9.13*
Tenmarq	73.6	63.7	9.9	*13.45*	69.8	58.1	11.7	*16.76*
Kawvale	71.6	59.8	11.8	*16.48*	64.5	59.9	4.6	*7.13*
Fulcaster	58.1	50.0	8.1	*13.94*	66.0	61.5	4.5	*6.82*
Early Blackhull	43.7	34.5	9.2	*21.05*	51.4	44.9	6.5	*12.66*
Average				*17.09*				*9.63*
Weighted average†				**16.75**				**9.69**
Before Blooming, 1937								
Kanred	29.0	23.4	5.6	*19.12*	32.8	27.8	5.0	*15.24*
Turkey	31.2	24.7	6.5	*20.88*	31.6	21.8	9.8	*31.41*
Kanred × Hd. Fed.	55.9	47.1	8.8	*15.74*	53.7	49.4	4.3	*8.01*
Tenmarq	28.1	22.6	5.5	*19.66*	33.4	29.4	4.0	*11.95*
Kawvale	52.4	45.2	7.2	*13.03*	58.8	56.9	1.9	*3.23*
Fulcaster	48.8	40.5	8.3	*17.01*	45.0	40.8	4.2	*9.33*
Early Blackhull	62.7	52.3	10.4	*16.59*	61.9	53.9	8.0	*12.92*
Average				*17.43*				*13.16*
Weighted average				**16.98**				**11.73**
Before Blooming, 1938								
Kanred	40.5	31.4	9.1	*22.47*	37.7	35.9	0.8	*2.12*
Turkey	42.9	24.5	18.4	*42.89*	40.3	33.2	7.1	*17.62*
Kanred × Hd. Fed.	41.5	37.3	4.2	*10.12*	48.5	43.9	4.6	*9.49*
Tenmarq	69.7	49.1	20.6	*29.60*	67.3	59.4	19.6	*29.12*
Kawvale	80.1	62.1	18.0	*22.47*	73.9	64.4	9.5	*12.86*
Fulcaster	71.2	53.3	17.9	*25.14*	71.0	59.7	11.3	*15.92*
Early Blackhull	40.9	34.6	6.3	*15.40*	45.2	40.9	4.3	*9.51*
Average				*24.01*				*13.81*
Weighted average				**24.43**				**14.90**
Grand weighted average‡				**19.51**				**12.07**
Blooming, 1936								
Kanred	63.4	54.8	8.6	*13.56*	66.3	66.3	0.0	*0.00*
Turkey	58.2	50.1	8.1	*13.92*	72.8	70.6	2.2	*3.02*
Kanred × Hd. Fed.	56.5	47.4	9.1	*16.11*	58.9	54.4	4.5	*7.64*
Tenmarq	69.5	60.2	9.3	*13.38*	66.0	60.7	5.3	*8.03*
Kawvale	75.3	61.6	13.7	*18.19*	59.6	58.9	0.7	*1.17*
Fulcaster	76.1	66.3	9.8	*12.88*	73.1	68.5	4.6	*6.29*
Early Blackhull	52.8	43.0	9.8	*18.56*	47.9	42.4	5.5	*11.48*
Average				*15.23*				*5.38*
Weighted average				**15.14**				**5.13**

* The data in tables 5 to 8, inclusive, are based on the airdry weight of the grain.

† This value is obtained by multiplying the number of times the observations were made by the average percentage of each variety. These figures were then added and divided by total number of observations.

‡ This value is obtained by finding the sum of the weighted averages for the three years and dividing this by the total number of observations made.

TABLE 5.—*Effect of total and partial deawning of wheat heads on weight of grain on a basis of 100 heads. 1936-1938*. Weights are in grams*—CONTINUED.

VARIETY.	100 totally deawned heads.				100 partially deawned heads.			
	Controls.	Experimental.	Decrease.	Percent decrease.	Controls.	Experimental.	Decrease.	Percent decrease.
Blooming, 1937								
Kanred	55.8	48.8	7.0	*12.55*	53.3	44.6	8.7	*16.32*
Turkey	47.7	39.5	8.2	*17.19*	33.4	27.9	5.5	*16.47*
Kanred × Hd. Fed.	44.7	40.8	3.9	*8.72*	44.7	40.7	4.0	*8.95*
Tenmarq	69.0	59.8	9.2	*13.33*	73.2	63.6	9.6	*13.12*
Kawvale	73.4	67.7	5.7	*7.76*	75.5	67.2	9.8	*12.98*
Fulcaster	56.2	47.9	8.3	*14.77*	52.3	46.9	5.4	*10.33*
Early Blackhull	80.4	69.8	10.6	*13.18*	73.9	67.4	6.5	*8.79*
Average	....	....	....	*12.50*	....	....	....	*12.42*
Weighted average	....	....	....	**12.38**	....	....	....	**12.18**
Blooming, 1938								
Kanred	38.5	30.7	0.8	*2.08*	36.5	37.4	+ 0.9	+ *2.47*
Turkey	44.8	26.1	18.7	*41.74*	34.5	29.5	5.0	*14.49*
Kanred × Hd. Fed.	53.6	44.9	8.7	*16.23*	45.9	43.2	2.7	*5.88*
Tenmarq	66.9	53.8	13.1	*19.58*	60.2	53.2	7.0	*11.63*
Kawvale	71.7	56.4	15.3	*21.34*	64.6	66.2	+ 1.6	+ *2.48*
Fulcaster	69.4	55.8	13.6	*19.60*	69.9	61.2	8.7	*12.45*
Early Blackhull	42.4	31.0	11.4	*26.87*	39.0	34.0	5.0	*12.82*
Average	....	....	....	*21.06*	....	....	....	*7.47*
Weighted average	....	....	....	**21.07**	....	....	....	**7.39**
Grand weighted average	....	....	....	**16.02**	....	....	....	**8.17**
One week after blooming, 1936								
Kanred	57.7	49.9	7.8	*13.52*	62.4	58.7	3.7	*5.93*
Turkey	69.4	63.2	6.2	*8.93*	65.3	60.2	5.1	*7.81*
Kanred × Hd. Fed.	48.7	44.9	3.8	*7.80*	57.1	56.4	0.7	*1.23*
Tenmarq	58.2	52.2	6.0	*10.31*	62.4	59.6	2.8	*4.49*
Kawvale	....	....	....	....	....	....	....	....
Fulcaster	69.6	65.7	3.9	*5.60*	69.3	68.0	1.3	*1.88*
Early Blackhull	61.4	55.4	6.0	*9.77*	59.0	56.0	3.0	*5.08*
Average	....	....	....	*9.32*	....	....	....	*4.40*
Weighted average	....	....	....	**9.23**	....	....	....	**4.42**
One week after blooming, 1937								
Kanred	47.7	44.6	5.1	*10.26*	49.6	48.8	0.8	*1.61*
Turkey	48.0	38.8	9.2	*19.17*	48.1	46.2	1.9	*3.95*
Kanred × Hd. Fed.	54.0	49.2	4.8	*8.89*	52.3	52.0	0.3	*0.57*
Tenmarq	58.0	70.7	12.7	*21.90*	65.0	65.0	0.0	*0.00*
Kawvale	71.6	71.6	0.0	*0.00*	73.6	74.8	+ 1.2	+ *1.63*
Fulcaster	58.4	57.0	1.4	*2.40*	60.0	59.4	0.6	*1.00*
Early Blackhull	69.6	61.4	8.2	*11.78*	71.0	67.0	4.0	*5.63*
Average	....	....	....	*10.63*	....	....	....	*1.59*
Weighted average	....	....	....	**10.17**	....	....	....	**1.53**
One week after blooming, 1938								
Kanred	39.9	35.0	4.9	*12.28*	41.5	41.0	0.5	*1.20*
Turkey	39.2	33.0	6.2	*15.82*	56.2	53.9	2.3	*4.09*
Kanred × Hd. Fed.	31.7	29.5	2.2	*6.94*	54.7	51.3	3.4	*6.22*
Tenmarq	59.5	47.8	11.7	*19.66*	65.3	61.9	3.4	*5.21*
Kawvale	70.0	58.3	11.7	*16.71*	82.4	71.3	11.1	*13.47*
Fulcaster	62.4	50.9	11.5	*18.42*	71.3	69.3	2.0	*2.81*
Early Blackhull	42.9	35.0	7.9	*18.41*	44.1	40.1	4.0	*9.07*
Average	....	....	....	*15.46*	....	....	....	*6.01*
Weighted average	....	....	....	**16.23**	....	....	....	**6.43**
Grand weighted average	....	....	....	**12.35**	....	....	....	**4.11**

TABLE 5.—*Effect of total and partial deawning of wheat heads on weight of grain on a basis of 100 heads. 1936-1938.* Weights are in grams*—CONCLUDED.

VARIETY.	100 totally deawned heads.				100 partially deawned heads.			
	Controls.	Experimental.	Decrease.	Percent decrease.	Controls.	Experimental.	Decrease.	Percent decrease.
Two weeks after blooming, 1936								
Kanred	63.4	58.8	4.6	7.26	64.3	61.6	2.7	4.20
Turkey	59.5	54.7	4.8	8.07	60.9	59.3	1.6	2.62
Kanred × Hd. Fed.	43.9	43.2	0.7	1.59	45.8	43.2	2.6	5.68
Tenmarq	65.6	59.8	5.8	8.84	69.4	67.4	2.0	2.88
Kawvale	....	....	....	....	....	....	....	....
Fulcaster	69.0	63.8	5.2	7.54	69.3	67.4	1.9	2.74
Early Blackhull	56.2	51.9	4.3	7.65	56.4	54.1	2.3	4.08
Average	....	....	....	6.83	....	....	....	3.73
Weighted average				**7.10**	....	....	....	**3.58**
Two weeks after blooming, 1937								
Kanred	53.3	47.9	5.4	10.13	61.7	58.3	3.4	5.51
Turkey	44.0	39.8	4.2	9.55	50.1	48.0	2.1	4.19
Kanred × Hd. Fed.	57.6	52.6	5.0	8.68	53.0	47.7	5.3	10.00
Tenmarq	64.7	66.4	+ 1.7	+ 2.63	67.3	64.1	3.3	4.90
Kawvale	66.6	63.8	2.8	4.28	70.0	66.7	3.3	4.71
Fulcaster	61.4	59.6	1.8	2.93	65.9	60.0	5.9	8.95
Early Blackhull	67.0	63.2	3.8	5.67	65.8	64.6	1.2	1.82
Average	....	....	....	5.52				5.73
Weighted average				**5.14**	....	....	....	**5.65**
Two weeks after blooming, 1938								
Kanred	53.0	47.5	0.5	0.94	46.7	50.8	+ 4.1	+ 9.78
Turkey	54.5	54.5	0.0	0.00	47.6	49.1	+ 1.5	+ 3.15
Kanred × Hd. Fed.	48.0	43.6	4.4	9.17	52.7	50.7	2.0	3.80
Tenmarq	60.4	60.5	+ 0.1	+ 0.17	71.5	68.1	3.4	4.76
Kawvale	70.8	68.1	2.7	3.81	76.7	71.7	5.0	6.52
Fulcaster	68.9	64.7	4.2	6.10	74.8	75.1	+ 0.3	+ 0.40
Early Blackhull	61.1	44.7	16.4	26.84	43.5	43.4	0.1	0.23
Average	....	....	....	6.67	....	....	....	0.28
Weighted average				**6.74**	....	....	....	**1.11**
Grand weighted average				**6.29**	....	....	....	**3.48**

in the weight of the grain from 100 heads was statistically significant[3] in all cases.

In the case of the partially deawned heads, the average of the losses in weight of the grain of the seven varieties was statistically significant in 10 of the 12 cases studied. The exceptions were one week after blooming in 1937, and two weeks after blooming in 1938.

There were increases in the weight of the grains of the partially deawned heads over that from the control heads only six times in 82 experiments. These increases ranged from 0.3 to 4.1 grams, or expressed on a percentage basis, from 0.4 to 9.78 percent above the weight of grain derived from 100 control heads. Two of these increases occurred at the stage of blooming in 1938, one at the stage one week after blooming in 1937, and three at the stage two weeks after blooming in 1938. In 1936 the variety Kanred at blooming, and in 1937 the variety Tenmarq one week after blooming, showed no departure from the controls.

There was no regularity relative to the weight of grain produced by any variety during any year or period. The weights of the grain from the controls and the experimental plants at a given stage would have been about the same, because these plants were grown within a short distance in the same row in close proximity to each other, and were thus under comparable conditions of soil fertility.

The percentages of the decreases in the weight of grain from 100 totally deawned and 100 partially deawned heads as compared with the weight of grain produced from 100 control heads are given in Table 5. With the exception of the partially deawned heads at the stage before blooming, the decrease in weight of the partially deawned heads as compared with the totally deawned heads is approximately 50 percent. At that stage the weight of the grain was much greater than 50 percent. The reason is not known.

The decrease in the weight of grain produced by 100 of the totally deawned heads of the seven varieties was greater the earlier they were deawned. (Fig. 7.) Thus the grand weighted average decreases in the percentage of grain from deawned heads before blooming were 19.51, at blooming 16.02, one week after blooming 12.35, and two weeks after blooming 6.29. (Table 6.)

The decrease of the weight of grain produced varied markedly for the various years. This variation is due to certain factors that are now unknown. (Table 6.) Thus in 1936 and 1937 total deawning before blooming caused a decrease in the weight of grain produced of 16.75 and 16.98 percent, respectively, while in 1938 the decrease amounted to 24.43 percent. When the total deawning was performed at blooming, the decrease in the weight of the grain produced amounted to 15.14 percent in 1936, 12.38 percent in 1937, and 21.07 percent in 1938. When total deawning was performed one week after blooming, the average decrease in the percentage of the weight of grain produced by these totally deawned heads was 9.23, 10.17,

3. In all these experiments the statistical significance of the average results for each year for the seven varieties was determined by the T-test, using the 5 percent level of significance.

and 16.23, respectively, for the years 1936, 1937 and 1938. When total deawning was done two weeks after blooming, the percentage decrease in the weight of grain produced amounted to 7.10, 6.74 and 6.74, respectively, for each of the three years.

The effect of stage of growth at time of deawning varied considerably with different years. Thus, in 1936, the difference between the percent decrease in weight of the grain produced by 100 heads when the deawning was performed before blooming was 1.61 percent more than that from the same number of heads that were totally deawned at blooming. This was the least difference in percentages of the nine comparisons for deawning observed in the three years. The next year this difference amounted to 4.60 percent, which almost equaled the greatest percentage difference of that year. In 1936 the percentage difference between the decreased grain production when the total deawning was performed at blooming and one week after blooming was 5.91, the greatest difference between the various stages during that year. In 1936, 1937, and 1938 the percentage difference

TABLE 6.—*Yearly average percentage decrease in the weight of grain from 100 heads of seven varieties of winter wheat that were totally and partially deawned in 1936-1938, inclusive.*

Date.	TYPE OF AVERAGE.	Stages of total deawning.						
		BB-T.	B-T.	Difference between BB-T and B-T.	1-T.	Difference between B-T and 1-T.	2-T.	Difference between 1-T and 2-T.
1936	Average	17.09	15.23	1.86	9.32	5.91	6.83	2.49
	Weighted average	16.75	15.14	1.61	9.23	5.91	7.10	2.13
1937	Average	17.43	12.50	4.93	10.63	1.87	5.52	5.11
	Weighted average	16.98	12.38	4.60	9.23	2.95	5.14	4.09
1938	Average	24.01	21.06	2.95	15.46	5.60	6.67	8.79
	Weighted average	24.43	21.07	3.36	16.23	4.84	6.74	9.49
1936 1937 1938	**Grand weighted avg.**	**19.51**	**16.02**	**3.49**	**12.35**	**3.69**	**6.29**	**5.06**
		Stages of partial deawning.						
		BB-P.	B-P.	Difference between BB-P and B-P.	1-P.	Difference between B-P and 1-P.	2-P.	Difference between 1-P and 2-P.
1936	Average	9.63	5.38	4.25	4.40	0.98	3.73	0.67
	Weighted average	9.69	5.13	4.56	4.42	0.71	3.58	0.84
1937	Average	13.16	12.42	0.74	1.59	10.83	5.73	+ 3.14
	Weighted average	11.73	12.18	+ 0.45	1.53	10.65	5.65	+ 4.12
1938	Average	13.81	7.47	6.34	6.01	1.46	0.28	5.73
	Weighted average	14.90	7.39	7.51	6.43	0.96	1.11	5.32
1936 1937 1938	**Grand weighted avg.**	**12.07**	**8.17**	**3.90**	**4.11**	**4.06**	**3.48**	**0.63**

between the weight of grain produced from heads that were totally deawned one week after blooming and two weeks after blooming were 2.13, 3.43 and 9.49, respectively.

The decrease in weight of the grain was greatest the earlier the heads were partially deawned. Thus the average percentage of decrease was 12.07 when the deawning was performed before blooming, 8.17 percent when deawning was at blooming, 4.11 percent when the deawning was performed one week after blooming, and 3.48 percent when this process was done two weeks after blooming.

EFFECT OF DEAWNING ON THE WEIGHT OF 1,000 GRAINS

Table 7 shows the weight of 1,000 grains produced by the control plants, the weight of 1,000 grains from the experimental plants, and the decrease in weight of 1,000 grains from the experimental plants. The experiments for the seven varieties were averaged for each year and for each of the four different periods at which the experiments were performed. There were 12 averages each for the totally and partially deawned plants. In all 12 cases, the totally deawned heads showed losses in weight which were statistically significant. In the 82 experiments of total deawning performed during the three years, there was an increase in weight in only two cases. These involved the variety Tenmarq in 1937 when the deawning was performed one week after blooming and the increase was 3.5 grams or 11.56 percent. Again in 1938 for the variety Turkey when deawning was performed two weeks after blooming, the increase in weight was 0.5 grams or 2.1 percent over the controls.

In case of the partially deawned heads there were two instances where the yearly average losses were not statistically significant, both in 1937, one week after blooming and two weeks after blooming. In the 82 experiments performed with the various varieties, there were 11 cases where there was an increase in the weight of 1,000 grains from experimental heads as compared with the same number of controls. These increases ranged from 0.6 to 4.46 percent of the weight of the controls.

The decrease in the weight of 1,000 grains represents approximately 50 to 80 percent of the decrease in yield due to deawning. This fact shows that the effects of deawning are not manifest alone in the weight of the grain but other effects must be considered also.

The averages of the percentage decreases or increases in the weight of 1,000 grains from the totally and partially deawned heads, together with the percentage difference between the weight of the grains at the different stages of deawning, are given in Table 8. In 1937 and 1938 the greatest percentage decrease in the weight of 1,000 grains occurred at the earliest time that the heads were deawned. The highest decrease in percentage during 1936 was one week after blooming when it amounted to 8.70 percent. At the blooming stage it amounted to 8.38 percent.

From Table 7 it is observed that heads which were totally deawned weighed more than those from the heads deawned at the

TABLE 7.—*Effect of total and partial deawning of wheat heads on weight of 1,000 grains. 1936-1938. Weights are in grams.*

Variety.	Total deawning.				Partial deawning.			
	Controls.	Experimental.	Decrease.	Percent decrease.	Controls.	Experimental.	Decrease.	Percent decrease.
Before Blooming, 1936								
Kanred	28.0	26.1	1.9	*6.79*	28.2	27.2	1.0	*3.55*
Turkey	25.0	24.6	0.4	*1.60*	27.4	25.3	2.1	*7.66*
Kanred × Hd. Fed.	24.2	21.2	3.0	*12.40*	25.9	24.8	1.1	*4.25*
Tenmarq	31.7	30.3	1.4	*4.42*	29.9	28.2	1.7	*5.69*
Kawvale	30.0	28.9	1.1	*3.66*	29.8	28.7	1.1	*3.83*
Fulcaster	29.9	28.7	1.2	*4.01*	32.6	32.0	0.6	*1.84*
Early Blackhull	25.5	22.5	3.0	*11.76*	30.3	29.3	1.0	*3.30*
Average				*6.38*				*4.30*
Weighted average				**6.18**				**4.21**
Before Blooming, 1937								
Kanred	14.1	12.3	1.8	*14.46*	14.1	12.6	1.5	*10.88*
Turkey	14.1	13.1	1.0	*6.98*	14.0	10.7	3.3	*23.17*
Kanred × Hd. Fed.	27.3	24.0	3.3	*12.12*	26.7	26.4	0.3	*1.14*
Tenmarq	15.9	15.1	0.8	*5.55*	15.4	16.3	+ 0.9	+ *5.77*
Kawvale	24.2	22.8	1.4	*5.77*	25.3	25.3	0.0	*0.00*
Fulcaster	22.6	20.2	2.4	*10.66*	25.3	24.2	1.1	*4.41*
Early Blackhull	34.0	30.6	3.4	*9.94*	25.4	23.9	1.5	*5.82*
Average				*9.07*				*5.69*
Weighted average				**9.27**				**4.67**
Before Blooming, 1938								
Kanred	18.9	17.4	1.5	*7.89*	17.9	17.3	0.6	*3.81*
Turkey	22.2	15.5	6.7	*29.87*	17.5	15.6	1.9	*11.20*
Kanred × Hd. Fed.	22.8	21.4	1.4	*6.06*	23.6	22.3	1.3	*5.47*
Tenmarq	25.5	21.2	4.3	*17.18*	24.4	21.7	2.7	*10.96*
Kawvale	28.6	25.5	3.1	*10.85*	26.4	24.1	2.3	*8.99*
Fulcaster	28.8	25.5	3.3	*11.43*	27.0	25.2	1.8	*6.45*
Early Blackhull	19.8	18.7	1.1	*5.52*	22.5	21.3	1.2	*5.24*
Average				*12.69*				*7.45*
Weighted average				**12.83**				**7.47**
Grand weighted average*				**9.43**				**5.45**
Blooming, 1936								
Kanred	29.6	27.0	2.6	*8.78*	31.0	30.1	0.9	*2.90*
Turkey	28.5	26.3	2.2	*7.72*	30.9	29.6	1.3	*4.21*
Kanred × Hd. Fed.	28.4	25.0	3.4	*11.98*	31.7	29.9	1.8	*5.68*
Tenmarq	32.0	29.5	2.5	*7.81*	33.2	30.9	2.3	*6.93*
Kawvale	31.6	28.8	2.8	*9.72*	29.9	28.9	1.0	*3.46*
Fulcaster	36.5	35.1	1.4	*3.84*	36.4	34.8	1.6	*4.39*
Early Blackhull	26.9	23.9	3.0	*11.15*	26.5	25.1	1.4	*5.28*
Average				*8.71*				*4.72*
Weighted average				**8.38**				**4.69**
Blooming, 1937								
Kanred	28.3	26.0	2.3	*7.89*	24.5	23.0	1.5	*6.27*
Turkey	23.9	23.6	0.3	*1.05*	16.3	14.3	2.0	*12.20*
Kanred × Hd. Fed.	27.4	26.6	0.8	*2.98*	30.0	30.6	+ 0.6	+ *1.99*
Tenmarq	33.7	30.5	3.2	*9.69*	32.3	30.9	1.4	*4.36*
Kawvale	34.1	30.9	3.2	*9.33*	32.2	30.2	2.0	*5.97*
Fulcaster	24.9	22.9	2.0	*7.67*	22.1	21.4	0.7	*2.92*
Early Blackhull	34.3	31.6	2.7	*7.85*	34.9	33.5	1.4	*3.77*
Average				*6.64*				*4.79*
Weighted average				**6.94**				**4.28**

* See footnote for Table 5.

TABLE 7.—*Effect of total and partial deawning of wheat heads on weight of 1,000 grains. 1936-1938. Weights are in grams*—CONTINUED.

VARIETY.	Total deawning.				Partial deawning.			
	Con-trols.	Experi-mental.	De-crease.	Percent decrease.	Con-trols.	Experi-mental.	De-crease.	Percent decrease.
Blooming, 1938								
Kanred	18.1	16.7	1.4	7.82	18.2	17.5	0.7	4.16
Turkey	17.0	15.3	1.7	10.03	15.9	14.5	1.4	8.64
Kanred × Hd. Fed.	25.1	23.5	1.6	6.05	23.5	22.6	0.9	3.70
Tenmarq	24.7	22.3	2.4	9.77	21.9	20.3	1.6	6.98
Kawvale	25.2	23.4	1.8	7.49	23.3	22.6	0.7	3.17
Fulcaster	27.6	27.1	0.5	1.77	27.0	25.9	1.1	3.16
Early Blackhull	20.6	18.2	2.4	11.81	20.6	20.1	0.5	2.21
Average				7.82				4.57
Weighted average				**7.49**				**4.36**
Grand weighted average				**7.60**				**4.41**
One week after blooming, 1936								
Kanred	28.8	25.0	3.8	13.19	29.2	27.7	1.5	5.14
Turkey	28.8	26.7	2.1	7.29	30.5	29.3	1.2	3.93
Kanred × Hd. Fed.	25.8	24.0	1.8	6.98	30.3	30.0	0.3	0.99
Tenmarq	27.5	24.6	2.9	10.55	30.6	28.6	2.0	6.54
Kawvale	31.8	29.7	1.9	6.40	32.2	31.5	0.7	2.22
Fulcaster	.....	.....	.....	.....	.....	.....	.....	.....
Early Blackhull	33.1	30.3	2.8	8.46	33.1	31.9	1.2	3.63
Average				8.81				3.72
Weighted average				**8.70**				**3.71**
One week after blooming, 1937								
Kanred	22.7	20.0	2.7	11.18	22.8	22.5	0.3	1.51
Turkey	23.1	20.0	3.1	13.28	22.8	22.2	0.6	2.70
Kanred × Hd. Fed.	28.4	26.1	2.3	8.20	29.1	29.3	+ 0.2	+ 0.60
Tenmarq	30.2	33.7	+ 3.5	+11.66	30.1	28.4	1.7	5.58
Kawvale	31.4	30.1	1.3	4.03	32.4	33.2	+ 0.8	+ 2.68
Fulcaster	29.4	28.4	1.0	3.13	30.3	29.7	0.6	2.23
Early Blackhull	29.8	26.7	3.1	10.49	33.0	34.3	+ 1.3	+ 4.12
Average				5.54				1.42
Weighted average				**5.08**				**0.43**
One week after blooming, 1938								
Kanred	20.1	17.2	2.9	14.46	19.4	19.7	+ 0.3	+ 1.67
Turkey	17.3	16.1	1.2	7.13	25.9	24.7	1.2	4.62
Kanred × Hd. Fed.	19.1	18.0	1.1	5.69	25.8	23.4	2.4	9.08
Tenmarq	24.0	20.1	3.9	15.94	23.9	22.8	1.1	4.66
Kawvale	26.8	23.3	3.5	12.90	27.1	24.1	3.0	9.72
Fulcaster	23.9	23.0	0.9	3.86	27.8	27.7	0.1	0.37
Early Blackhull	20.7	18.0	2.7	13.22	21.2	20.4	0.8	3.93
Average				10.46				4.39
Weighted average				**10.64**				**4.61**
Grand weighted average				**8.14**				**2.92**
Two weeks after blooming, 1936								
Kanred	31.5	29.6	1.9	6.03	31.5	30.0	1.5	4.76
Turkey	28.5	26.8	1.7	5.96	30.3	29.4	0.9	2.97
Kanred × Hd. Fed.	26.0	24.9	1.1	4.23	28.8	28.1	0.7	2.43
Tenmarq	30.0	28.3	1.7	5.66	32.3	31.2	1.1	3.41
Kawvale	.....	.....	.....	.....	.....	.....	.....	.....
Fulcaster	36.4	33.5	2.9	8.66	36.5	35.7	0.8	2.24
Early Blackhull	32.5	31.0	1.5	4.62	32.1	31.7	0.4	1.25
Average				5.86				2.84
Weighted average				**5.84**				**2.82**

previous stage in three instances. Two of these cases were in 1936 when the heads were deawned, before and at blooming. The increase was 2.20 per cent when deawning was performed at blooming time, and one week after that time the difference was 0.32 percent. In 1938 the difference in percentage of weight was 3.15 and occurred between the blooming stage and one week after blooming.

TABLE 7.—*Effect of total and partial deawning of wheat heads on weight of 1,000 grains. 1936-1938. Weights are in grams*—CONCLUDED.

VARIETY.	Total deawning.				Partial deawning.			
	Controls.	Experimental.	Decrease.	Percent decrease.	Controls.	Experimental.	Decrease.	Percent decrease.
Two weeks after blooming, 1937								
Kanred	24.1	22.7	1.4	*6.14*	29.0	30.0	+ 1.0	+ *5.19*
Turkey	21.5	19.9	1.6	*7.44*	24.0	23.1	0.9	*3.88*
Kanred × Hd. Fed.	27.6	26.7	0.9	*3.09*	25.2	26.3	+ 1.1	+ *4.46*
Tenmarq	29.8	29.4	0.4	*1.61*	32.8	30.9	1.9	*6.00*
Kawvale	30.3	28.4	1.9	*6.08*	30.2	30.5	+ 0.3	+ *0.90*
Fulcaster	29.7	29.1	0.6	*1.86*	30.5	30.0	0.5	*1.68*
Early Blackhull	26.8	25.3	1.5	*5.33*	29.7	30.4	+ 0.7	+ *2.37*
Average	....	....	....	*4.49*	....	....	....	*0.06*
Weighted average				**4.32**	....	....	....	+ **0.09**
Two weeks after blooming, 1938								
Kanred	22.3	21.2	1.1	*4.86*	21.9	22.4	+ 0.5	+ *2.12*
Turkey	23.9	24.4	+ 0.5	+ *2.10*	23.4	23.2	0.2	*0.75*
Kanred × Hd. Fed.	23.1	21.5	1.6	*6.73*	26.1	25.4	0.7	*2.64*
Tenmarq	23.8	23.1	0.7	*2.78*	27.2	25.9	1.3	*4.91*
Kawvale	26.6	25.5	1.1	*4.01*	27.2	26.2	1.0	*3.66*
Fulcaster	28.2	27.4	0.8	*2.81*	32.2	31.2	1.0	*0.32*
Early Blackhull	23.5	20.4	3.1	*13.12*	22.5	21.1	1.4	*5.88*
Average	....	....	....	*4.60*	....	....	....	*2.29*
Weighted average				**4.52**	....	....	....	**2.81**
Grand weighted average				**4.73**	....	....	....	**1.91**

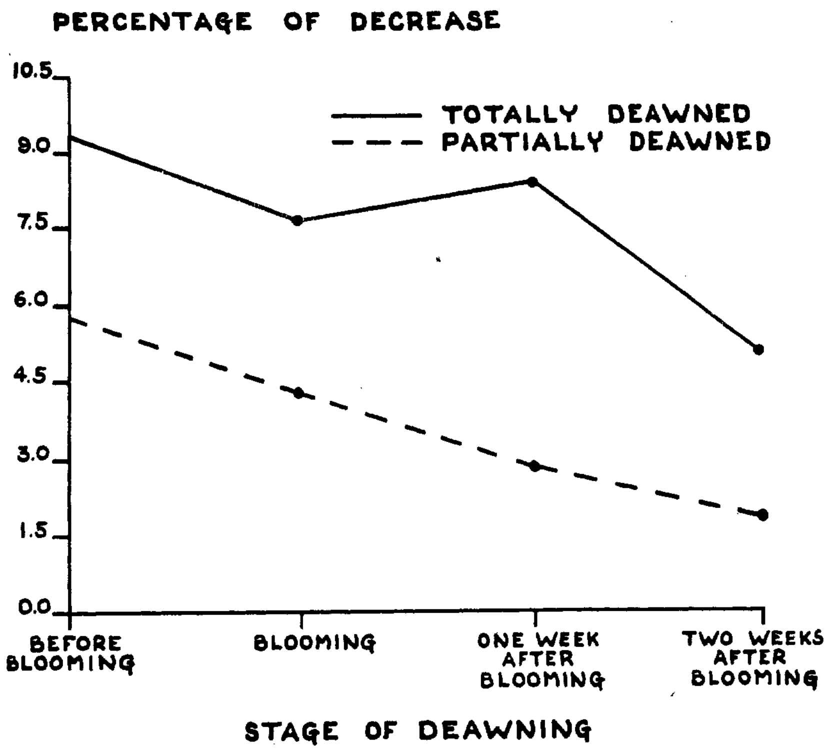

FIG. 8.—Percentage loss in weight of 1,000 grains from each of the totally and partially deawned heads at four stages of development as shown by the grand weighted average (Table 7).

The percentage decrease for partial deawning in 1936 was higher when the plants were deawned at blooming than when they were deawned before blooming. During the years 1937 and 1938, however, the earlier the heads were deawned the greater the decrease in the weight of 1,000 grains. In 1936 the weight of the grain increased by 0.48 percent at the stage of blooming, and in 1937 the weight of the grain increased by 0.09 percent at the stage two weeks after blooming. These were the only instances in the 24 experiments that the weight of 1,000 grains showed an increase compared to the preceding stage. Except in 1936, the greatest percentage decrease in the weight of 1,000 grains occurred the earlier the deawning was performed. The greatest variation in percentage loss of weight between the various stages occurred at the stages when deawning was performed one week after blooming and two weeks after blooming. This is as one would expect because deawning at the last-named stage has little effect on the yield of grain.

TABLE 8.—*Yearly average percentage decrease in the weight of 1,000 grains of seven varieties of winter wheat that were totally and partially deawned in 1936-1938, inclusive.*

Date.	TYPE OF AVERAGE.	BB-T.	B-T.	Difference between BB-T and B-T.	1-T.	Difference between B-T and 1-T.	2-T.	Difference between 1-T and 2-T.
		Stage of total deawning.						
1936	Average	6.38	8.71	+2.33	8.81	+0.10	5.86	2.95
	Weighted average	6.18	8.38	+2.20	8.70	+0.32	5.84	2.84
1937	Average	9.07	6.64	2.43	5.54	1.10	4.49	1.05
	Weighted average	9.27	6.94	2.33	5.08	1.86	4.32	0.76
1938	Average	12.69	7.82	4.87	10.46	+2.64	4.60	5.86
	Weighted average	12.83	7.49	5.34	10.64	+3.15	4.52	6.12
1936 1937 1938	**Grand weighted avg.***	**9.43**	**7.60**	....	**8.14**	....	**4.73**	....
		Stage of partial deawning.						
		BB-P.	B-P.	Difference between BB-P and B-P.	1-P.	Difference between B-P and 1-P.	2-P.	Difference between 1-P and 2-P.
1936	Average	4.30	4.72	+0.32	3.72	1.00	2.84	0.88
	Weighted average	4.21	4.69	+0.48	3.71	0.98	2.82	0.89
1937	Average	5.69	4.79	0.90	1.42	3.37	0.06	1.36
	Weighted average	4.67	4.28	0.39	0.43	3.85	+0.09	0.52
1938	Average	7.45	4.57	2.88	4.39	0.18	2.29	2.10
	Weighted average	7.47	4.36	3.11	4.61	+0.25	2.81	1.80
1936 1937 1938	**Grand weighted avg.***	**5.45**	**4.41**	....	**2.92**	....	**1.91**	....

* This grand weighted average is obtained by adding the weighted average for the three years and dividing the result by 3, as the number of cases had not been recorded.

EFFECT OF DEAWNING ON THE NUMBER OF GRAINS PRODUCED IN 100 HEADS

Table 9 shows the effect of total and partial deawning of the heads of wheat at the various stages upon the number of grains produced by the various varieties at the different stages during the three years. Of the 82 experiments in total deawning, 15 show an increase in the number of grains over the controls. This increase ranged from 1 to 347 grains. The last-named number is apparently abnormal in some way for the next-greatest increase amounted to only 96 grains. Exclusive of this large increase, the percentage ranged from 0.05 to 4.0. In the exceptional case the increase amounts to 21.47 percent, the highest percentage of either increase or decrease in the number of grains in the 82 cases examined. The average of all the varieties for the three years shows that in five examples of the 12, or in 42 percent of the cases, the results were not statistically significant.

TABLE 9.—*Effect of total and partial deawning of wheat heads on number of grains. 1936-1938. Weights are in grams.*

VARIETY.	100 totally deawned heads.				100 partially deawned heads.			
	Controls.	Experimental.	Decrease.	Percent decrease.	Controls.	Experimental.	Decrease.	Percent decrease.
Before Blooming, 1936								
Kanred	2035	1814	221	*10.86*	2061	2059	2	*0.10*
Turkey	2235	1826	409	*18.30*	1930	1856	72	*3.88*
Kanred × Hd. Fed.	1877	1759	118	*6.29*	1651	1566	85	*5.15*
Tenmarq	2320	2100	220	*9.48*	2336	2064	272	*11.64*
Kawvale	2387	2072	315	*13.20*	2164	2084	80	*3.70*
Fulcaster	1939	1743	196	*10.11*	2025	1924	101	*4.99*
Early Blackhull	1715	1532	183	*10.67*	1694	1531	163	*9.62*
Average	....	....	....	*11.27*	....	....	....	*5.58*
Weighted average	....	....	....	**11.46**	....	....	....	**5.59**
Before Blooming, 1937								
Kanred	2059	1898	161	*7.82*	2319	2209	110	*4.76*
Turkey	2210	1882	328	*14.84*	2264	2024	240	*10.60*
Kanred × Hd. Fed.	2045	1966	79	*3.89*	2056	1835	221	*10.73*
Tenmarq	1764	1500	264	*14.98*	1913	1806	107	*5.59*
Kawvale	2162	1979	183	*8.41*	2324	2273	51	*2.17*
Fulcaster	2161	2006	155	*7.17*	1775	1687	88	*4.97*
Early Blackhull	1843	1706	137	*7.41*	2442	2255	187	*7.65*
Average	....	....	....	*8.89*	....	....	....	*6.49*
Weighted average	....	....	....	**9.19**	....	....	....	**6.65**
Before Blooming, 1938								
Kanred	2142	1800	342	*15.95*	2101	2082	19	*0.92*
Turkey	1937	1639	298	*15.41*	2297	2133	164	*7.15*
Kanred × Hd. Fed.	1820	1741	79	*4.36*	2059	1972	87	*4.24*
Tenmarq	2716	2318	398	*15.81*	2764	2739	25	*0.92*
Kawvale	2802	2436	366	*13.08*	2795	2681	114	*4.10*
Fulcaster	2471	2090	381	*15.43*	2631	2364	267	*10.14*
Early Blackhull	2066	1851	215	*10.49*	2007	1915	82	*4.08*
Average	....	....	....	*12.93*	....	....	....	*4.70*
Weighted average	....	....	....	**13.03**	....	....	....	**4.55**
Grand weighted average	....	....	....	**11.29**	....	....	....	**5.56**
Blooming, 1936								
Kanred	2143	2032	111	*5.18*	2135	2204	+69	+ *3.23*
Turkey	2043	1903	140	*6.85*	2358	2381	+23	+ *0.97*
Kanred × Hd. Fed.	1993	1899	94	*4.95*	1856	1817	39	*2.10*
Tenmarq	2172	2043	129	*5.94*	1990	1967	23	*1.15*
Kawvale	2383	2138	245	*10.28*	1994	2037	+43	+ *2.16*
Fulcaster	2086	1893	193	*9.25*	2007	1972	35	*1.74*
Early Blackhull	1959	1795	164	*8.37*	1812	1691	121	*6.68*
Average	....	....	....	*7.25*	....	....	....	*0.75*
Weighted average	....	....	....	**7.28**	....	....	....	**0.59**
Blooming, 1937								
Kanred	1974	1876	98	*5.00*	2177	1945	232	*10.68*
Turkey	1818	1671	147	*8.09*	2050	1951	99	*9.36*
Kanred × Hd. Fed.	1632	1538	94	*5.77*	1658	1333	325	*19.59*
Tenmarq	2046	1964	82	*4.01*	2265	2058	207	*9.13*
Kawvale	2155	2193	+38	+ *1.74*	2348	2223	125	*5.34*
Fulcaster	2261	2085	176	*7.79*	2371	2187	184	*7.77*
Early Blackhull	2342	2205	137	*5.87*	2120	2008	112	*5.26*
Average	....	....	....	*5.25*	....	....	....	*9.59*
Weighted average	....	....	....	**4.89**	....	....	....	**8.57**

TABLE 9.—*Effect of total and partial deawning of wheat heads on number of grains. 1936-1938. Weights are in grams*—CONTINUED.

VARIETY.	100 totally deawned heads.				100 partially deawned heads.			
	Controls.	Experimental.	Decrease.	Percent decrease.	Controls.	Experimental.	Decrease.	Percent decrease.
Blooming, 1938								
Kanred	2119	1835	284	13.43	2004	2139	+135	+ 6.76
Turkey	2634	1704	930	35.29	2196	2030	166	7.56
Kanred × Hd. Fed.	2140	1909	231	10.82	1955	1908	47	2.40
Tenmarq	2713	2419	394	10.83	2752	2615	137	5.00
Kawvale	2840	2413	427	15.03	2772	2934	+162	+ 5.81
Fulcaster	2520	2062	458	18.16	2617	2367	250	9.56
Early Blackhull	2059	1707	352	17.09	1895	1690	205	10.78
Average	...	...	...	17.23	...	...	...	3.24
Weighted average				**18.07**	...	...	...	**3.14**
Grand weighted average				**10.53**	...	...	...	**4.14**
One week after blooming, 1936								
Kanred	2004	1999	5	0.25	2138	2118	20	0.94
Turkey	2408	2366	32	1.33	2139	2054	85	3.97
Kanred × Hd. Fed.	1890	1870	20	1.06	1887	1884	3	0.16
Tenmarq	2117	2118	+ 1	+ 0.05	2038	2078	+40	+ 1.96
Kawvale	2188	2214	+26	+ 1.19	2154	2158	+ 4	+ 0.19
Fulcaster	...	...	...	...	...	...	...	...
Early Blackhull	1855	1829	26	1.40	1783	1754	29	1.63
Average	...	...	...	0.40	...	...	...	0.65
Weighted average				**0.45**	...	...	...	**0.77**
One week after blooming, 1937								
Kanred	2194	2228	+34	+ 1.56	2174	2172	2	0.08
Turkey	2077	1936	141	6.79	2107	2079	28	1.32
Kanred × Hd. Fed.	1901	1887	14	0.76	1799	1775	24	1.34
Tenmarq	1923	1878	45	2.35	2159	2286	+127	+ 5.86
Kawvale	2283	2379	+96	+ 4.20	2425	2124	301	12.41
Fulcaster	1989	2005	+26	+ 1.37	1978	2001	+23	+ 1.17
Early Blackhull	2337	2302	35	1.50	2156	1951	205	9.50
Average	...	...	...	0.61	...	...	...	2.51
Weighted average				**0.54**	...	...	...	**2.77**
One week after blooming, 1938								
Kanred	1980	2033	+53	+ 2.68	2139	2076	63	2.90
Turkey	2269	2055	214	9.42	2170	2189	+19	+ 0.86
Kanred × Hd. Fed.	1664	1641	23	1.38	2121	2187	+66	+ 3.10
Tenmarq	2477	2372	105	4.26	2730	2710	20	0.70
Kawvale	2614	2498	11	4.45	3046	2955	91	3.01
Fulcaster	2609	2215	394	15.09	2563	2501	62	2.45
Early Blackhull	2070	1949	121	5.87	2075	1964	111	5.36
Average	...	...	...	5.39	...	...	...	1.49
Weighted average				**5.87**	...	...	...	**1.55**
Grand weighted average				**2.70**	...	...	...	**1.75**
Two weeks after blooming, 1936								
Kanred	2011	1985	26	1.29	2040	2049	+ 9	+ 0.44
Turkey	2087	2042	45	2.16	2006	2016	+10	+ 0.50
Kanred × Hd. Fed.	1688	1737	+ 9	+ 2.90	1587	1539	48	3.02
Tenmarq	2184	2114	70	3.21	2149	2163	+14	+ 0.65
Kawvale	...	...	...	...	...	...	...	...
Fulcaster	1896	1906	+10	+ 0.53	1900	1888	12	0.63
Early Blackhull	1727	1675	52	3.01	1756	1708	48	2.73
Average	...	...	...	0.89	...	...	...	0.68
Weighted average				**1.16**	...	...	...	**0.66**

TABLE 9.—*Effect of total and partial deawning of wheat heads on number of grains. 1936-1938. Weights are in grams*—CONCLUDED.

VARIETY.	100 totally deawned heads.				100 partially deawned heads.			
	Controls.	Experimental.	Decrease.	Percent decrease.	Controls.	Experimental.	Decrease.	Percent decrease.
Two weeks after blooming, 1937								
Kanred	2210	2118	92	*4.19*	2166	1946	220	*10.20*
Turkey	2046	2001	45	*2.21*	2084	2077	7	*0.32*
Kanred × Hd. Fed.	1620	1968	+347	*+21.47*	2103	1811	292	*13.88*
Tenmarq	2169	2261	+92	*+ 4.22*	2049	2077	+28	*+ 1.37*
Kawvale	2200	2242	+42	*+ 1.91*	2316	2191	145	*5.39*
Fulcaster	2070	2048	22	*1.09*	2161	2000	161	*7.44*
Early Blackhull	2505	2498	7	*0.28*	2214	2123	91	*4.12*
Average				*+ 2.83*				*5.47*
Weighted average				**+ 2.13**				**5.88**
Two weeks after blooming, 1938								
Kanred	2380	2244	136	*5.72*	2128	2265	+137	*+ 6.47*
Turkey	2190	2235	+45	*+ 2.05*	2035	2114	+79	*+ 3.90*
Kanred × Hd. Fed.	2074	2022	52	*2.50*	2017	1995	22	*1.06*
Tenmarq	2539	2619	+80	*+ 3.12*	2629	2636	+ 7	*+ 0.29*
Kawvale	2660	2665	+ 5	*+ 0.20*	2816	2733	83	*2.97*
Fulcaster	2441	2358	83	*3.39*	2323	2408	+85	*+ 3.65*
Early Blackhull	2604	2194	410	*15.73*	1938	2052	+114	*+ 5.91*
Average				*3.13*				*+ 2.57*
Weighted average				**3.26**				**+ 2.00**
Grand weighted average				**0.85**				**1.52**

The decreases in the number of grains was the highest when the heads were deawned before blooming. At blooming there was only one case in which the deawned head showed an increase over the control and this amounted to only 1.74 percent.

The results show that deawning of the heads one and two weeks after blooming has little or no effect on the production of the number of grains. In five out of six yearly averages of the seven varieties, the differences were not statistically significant; also, in 14 of the 15 cases in these two stages, the number of grains increased instead of decreased. In 1937 the average for all varieties at the last stage of deawning increased in number over the controls. In all other cases the results showed a smaller number of grains than the controls, although some were not statistically significant.

When the heads were partially deawned, the effects as a rule were much less marked than when they were totally deawned. At the stage before blooming there were decreases only in the number of grains produced by deawned heads. At the stage of blooming there were five cases, as compared to one in the total deawning of the 21, where there was an increase in the number of grains that were produced. In the stage one week after blooming, there were six cases of the 20, or practically one third, in which there was an increase in the number of grains produced. At the stage two weeks after blooming, an increase in the number of grains occurred nine times, or approximately one-half the cases under observation. In only one case, however, were the averages of the results for each year for the seven varieties greater than those of the controls. In 1938 in five cases out of seven, there was an increase in the number of grains rather than a decrease. In all other cases the results were not statistically significant, but the average of the seven varieties for each year showed a decrease over those of the control. Thus, after blooming, deawning of the heads, both total and partial, had little or no influence on the number of grains produced. (Fig. 9.)

Table 10 shows the percentage increase or decrease in the number of grains. From the grand weighted average in this table it can be seen that the average percentage decreases are greater than the controls for the three years in all cases.

During the stages before blooming, at blooming, and one week after blooming, the variety Kanred X Hard Federation was less affected by the total deawning of the heads than any other. Thus in seven of the nine cases during these stages this variety was the lowest in the percentage decrease and it was second in the other two cases. There was, however, no regularity regarding the percentage decrease relative to this or any other variety when the heads

TABLE 10.—*Yearly average percentage decrease in the number of grains produced by each of the seven varieties of winter wheat that were totally and partially deawned in 1936-1938, inclusive.*

Date.	TYPE OF AVERAGE.	Stages of total deawning.						
		BB-T.	B-T.	Difference between BB-T and B-T.	1-T.	Difference between B-T and 1-T.	2-T.	Difference between 1-T and 2-T.
1936	Average	11.27	7.25	4.02	0.40	6.88	0.89	+0.49
	Weighted average	*11.46*	*7.28*	*4.18*	*0.45*	*6.83*	*1.16*	*+0.71*
1937	Average	8.89	5.25	3.64	0.61	4.64	+2.83	3.42
	Weighted average	*9.19*	*4.89*	*4.30*	*0.54*	*4.35*	*+2.13*	*2.67*
1938	Average	12.93	17.23	+4.30	5.39	11.84	3.13	2.16
	Weighted average	*13.03*	*18.07*	*+5.04*	*5.87*	*12.20*	*3.26*	*2.61*
	Grand weighted avg.	**11.29**	**10.03**	....	**2.70**	....	**0.85**	....
		BB-P.	B-P.	Difference between BB-P and B-P.	1-P.	Difference between B-P and 1-P.	2-P.	Difference between 1-P and 2-P.
1936	Average	5.58	0.75	4.83	0.65	0.10	0.68	+0.03
	Weighted average	*5.59*	*0.59*	*5.00*	*0.77*	*+0.18*	*0.66*	*0.11*
1937	Average	6.49	9.59	+3.10	2.51	7.08	5.47	+2.96
	Weighted average	*6.65*	*8.57*	*+1.92*	*2.77*	*5.80*	*5.88*	*+3.11*
1938	Average	4.70	3.24	1.46	1.49	1.75	+2.57	4.60
	Weighted average	*4.55*	*3.14*	*1.41*	*1.55*	*1.59*	*+2.00*	*3.55*
	Grand weighted avg.	**5.56**	**4.14**	....	**1.75**	....	**1.52**	....

were partially deawned. Kanred X Hard Federation has a shorter fruiting period than any of the other varieties. This might account for this behavior but it is not definitely known.

Apparently the determiner of the number of grains in a head is very sensitive and the effect of deawning will depend on whether it is performed at the critical stage in the production or development of the grain. The greatest reduction in the number of grains is produced by deawning before flowering. It is a moot question, however, whether the failure to set fruit is due to the injury shock or to a change in the nutrition occasioned by the removal of the awns. Table 10 shows that the percentage increase or decrease in the number of grains produced by each of the seven varieties of winter wheat that were totally and partially deawned in the three years that the experiment was conducted.

By noting the location of each grain in the head or spike, it was possible to determine which florets are most affected by deawning. It has been stated previously that each spikelet may consist of three to nine florets, but the usual number is two and sometimes three. This third floret, which sometimes develops, is the central, small, upper floret which ordinarily produces a smaller sized grain than the side florets. Usually the two side florets produce grain and the fertility of the central floret ultimately determines the number of grains to be set by the individual spike. It is the production of the grain by this floret that is affected by deawning. This is shown by the following example: In 1936 the heads of the variety Kanred were totally deawned at flowering on May 29. One hundred awned or control heads produced 68 middle florets while 100 of the deawned heads produced only six middle florets. This is apparently the reason for the difference in volume of the grain at the stages of deawning shown in Figures 10 and 11. Figures 12 and 13, however, show no effects of partial deawning on the volume of the grain of Kanred wheat.

EFFECT OF DEAWNING ON THE AMOUNT IN GRAMS AND PERCENTAGE OF ASH IN THE GRAIN

In the 82 experiments on total deawning performed on seven varieties of wheat during three years, it was observed in 45 cases that the percentage of ash in the grain increased over the controls, that in 27 observations the percentage of ash decreased, and that in 10 cases there was no change in the ash content. (Table 11.) Total deawning of the heads thus increased the percentage of ash in the grain in 55 percent of the cases, while in 45 percent, the results were either negative or showed no change.

In 59 experiments in which the heads were partially deawned, 68 percent showed a percentage increase in their content of ash in the grain, while 32 percent of the cases had a decrease or no change in the percentage of ash in the grain.

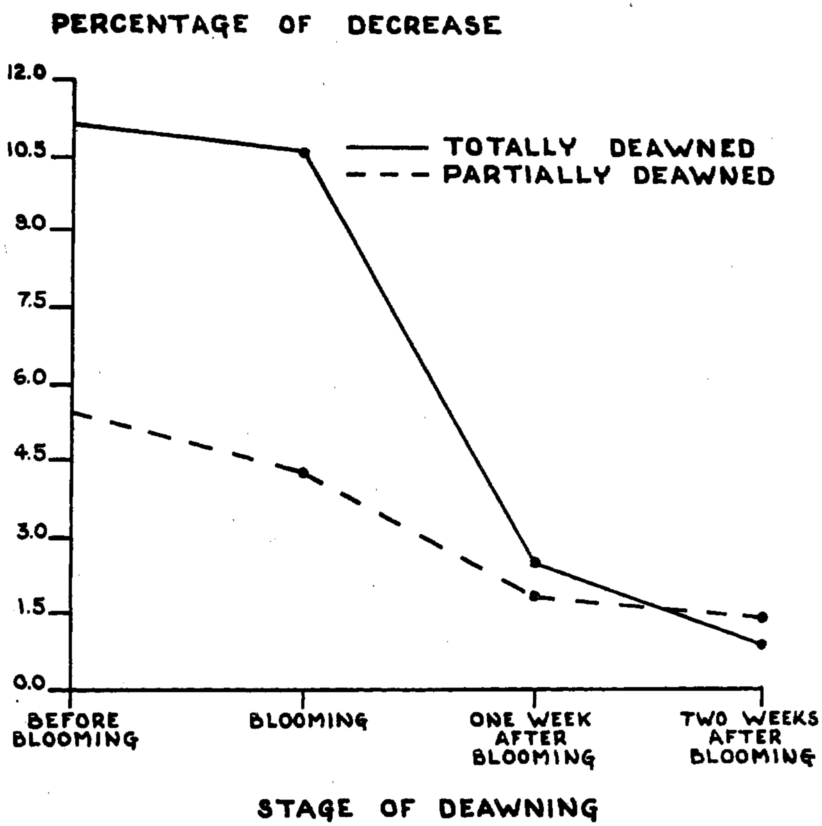

FIG. 9.—Percentage decrease in the number of grains from 100 each of totally and partially deawned heads at four stages of development as shown by the grand weighted average (Table 9).

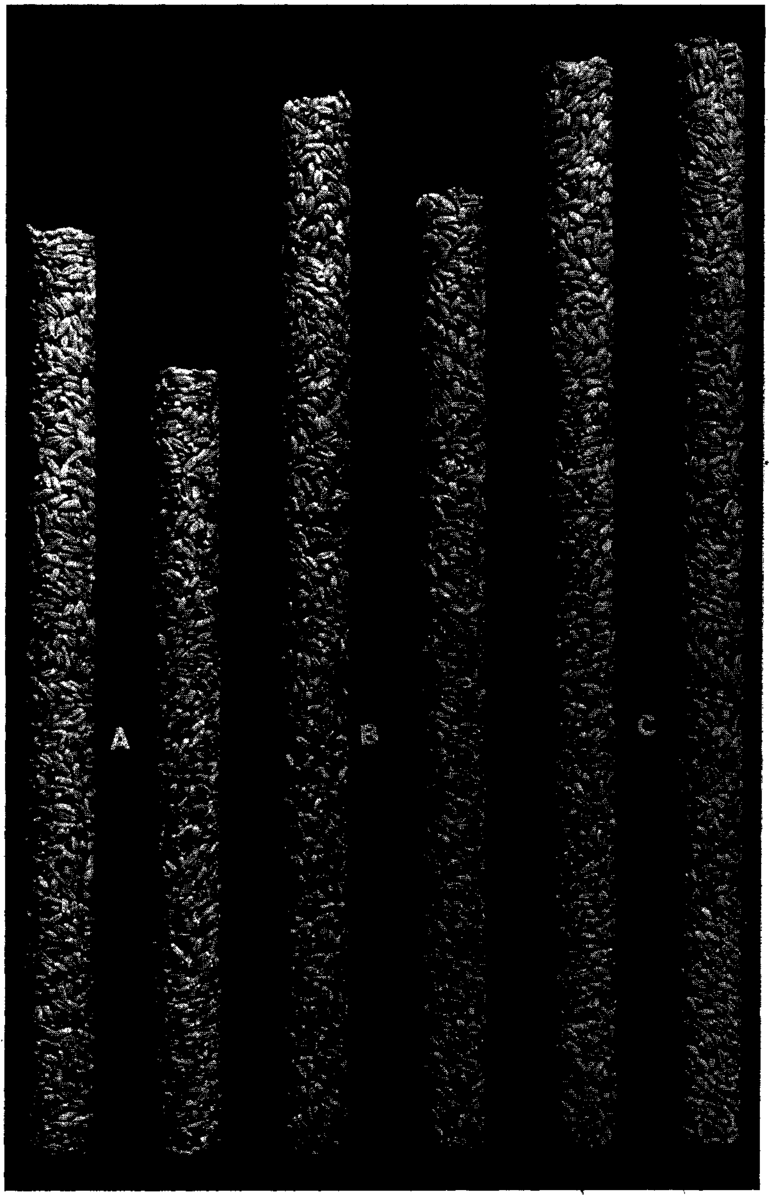

FIG. 10.—Volumetric comparison of the grain from awned and totally de-awned spikes of Kanred wheat grown at Manhattan, Kansas. The sample on the left of each pair is the control. The right sample of pair A shows the effect of deawning before blooming; the right sample of pair B shows the effect of deawning at blooming; and the pair C shows that deawning two weeks after blooming has no reductional effect on yield.

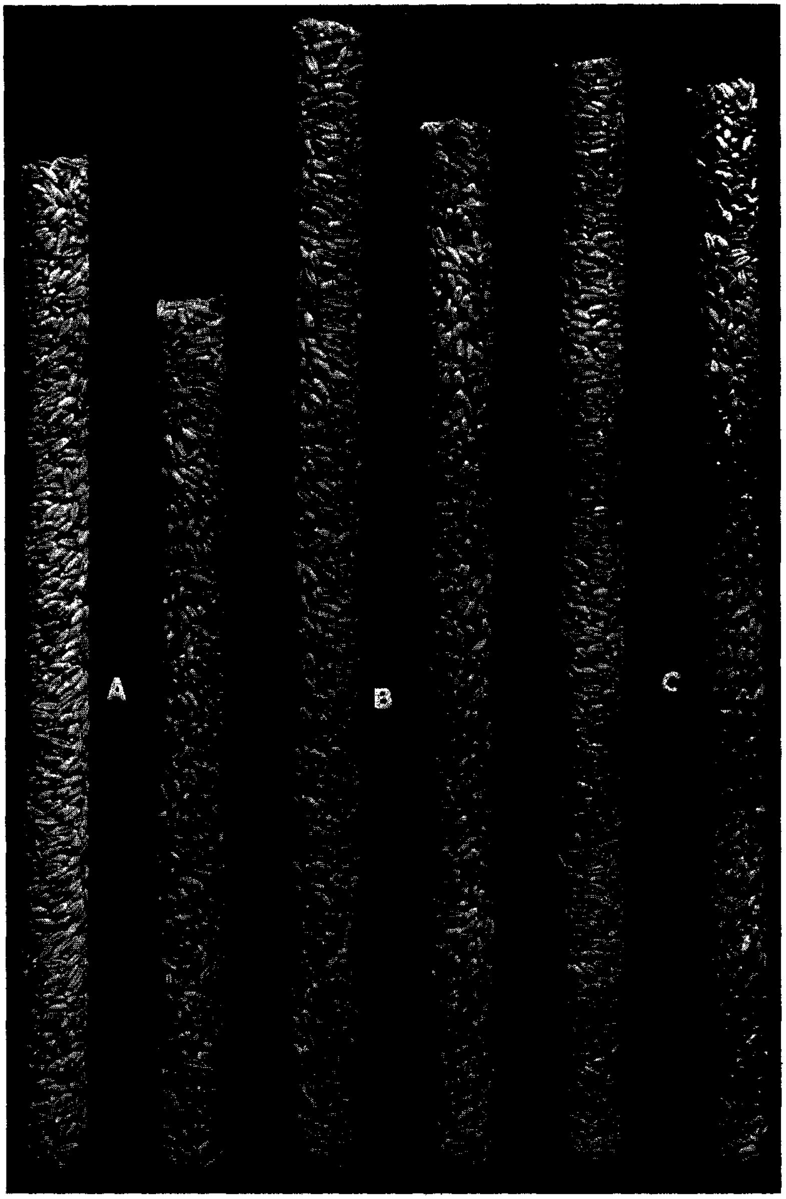

FIG. 11.—Volumetric comparison of the grain from awned and totally deawned spikes of Fulcaster wheat grown at Manhattan, Kansas. The sample on the left of each pair is the control. The right sample of pair A shows the effect of deawning before blooming time; of pair B, the effect of total deawning at blooming; and of pair C, the effect of total deawning between one and two weeks after blooming. The volume evidently is decreased to the greatest extent the earlier the total deawning is performed.

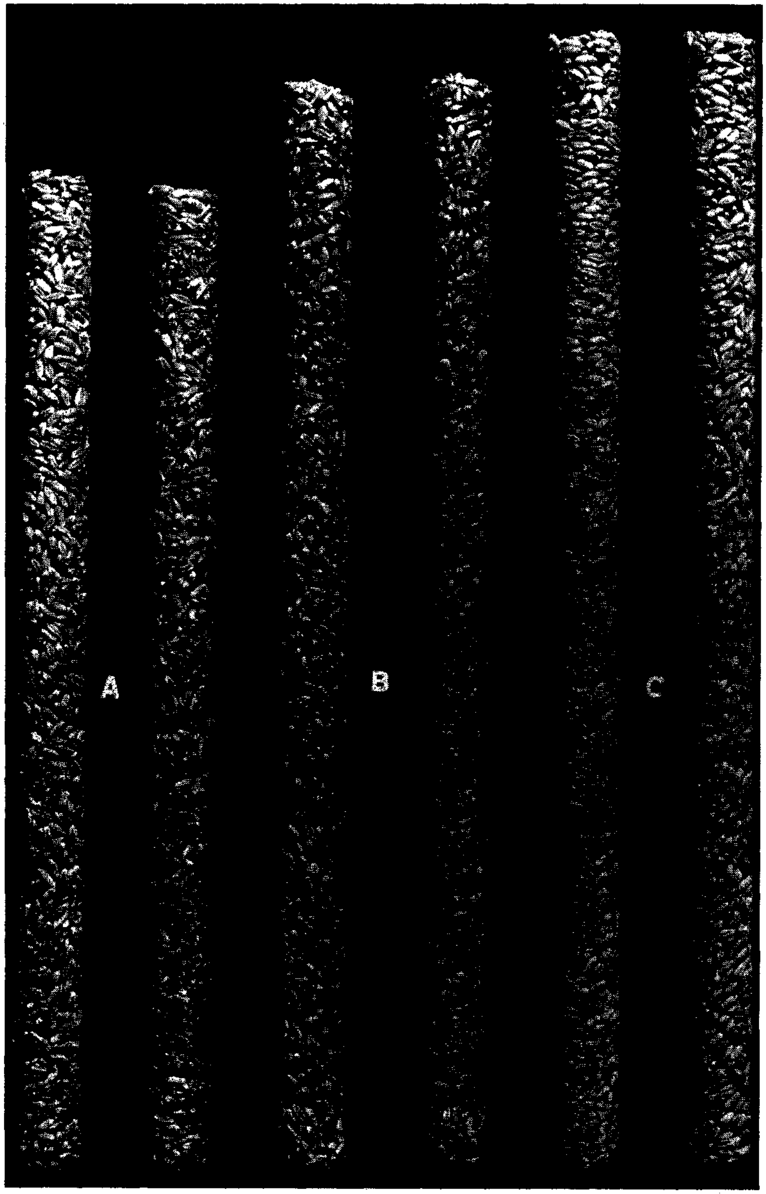

FIG. 12.—Volumetric comparison of the grain from awned and partially deawned spikes of Kanred wheat grown at Manhattan, Kansas. This figure shows that there is little or no difference in the volume of the grain from the heads that have been only partially deawned compared to controls.

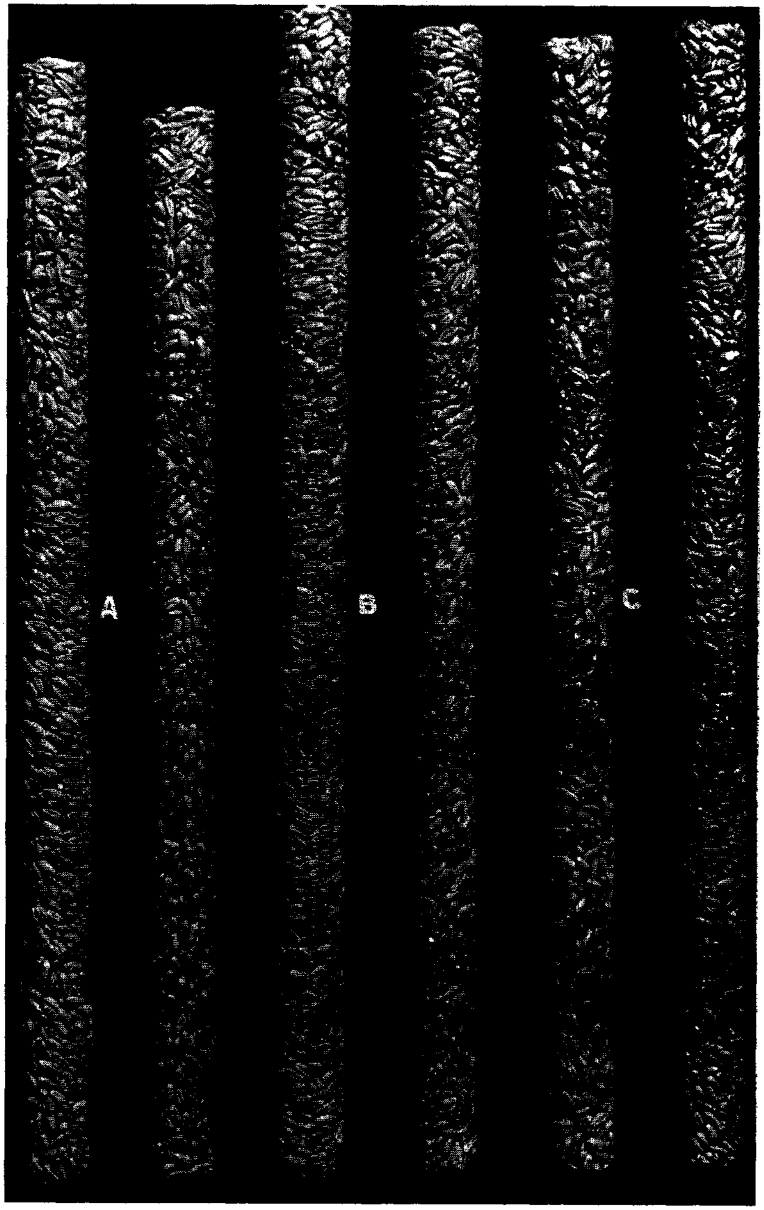

FIG. 13.—Volumetric comparison of the grain from awned and partially de-awned spikes of Fulcaster wheat grown at Manhattan, Kansas. The figure shows that there is no effect on the volume of the grain of the partially de-awned heads, compared to the controls, except when the process was performed before blooming.

TABLE 11.—*Effect of total and partial deawning on the amount of ash in grains of control and experimental heads of wheat. 1936-1938. Weights in grams.*

VARIETY.	100 totally deawned heads.				100 partially deawned heads.			
	Controls.	Experimental.	Increase.	Percent increase.	Controls.	Experimental.	Increase.	Percent increase.
Before Blooming, 1936								
Kanred	2.22	2.31	0.09	*4.054*	1.96	1.90	-0.06	-*3.061*
Turkey	2.42	2.49	0.07	*2.892*	......	......	......	......
Kanred × Hd. Fed.	3.31	3.52	0.20	*6.184*	2.00	2.06	0.06	*3.000*
Tenmarq	1.69	1.68	-0.01	-*0.591*	1.83	1.80	0.03	*1.639*
Kawvale	2.67	2.57	-0.10	-*3.745*	......	......	......	......
Fulcaster	2.26	2.22	-0.04	-*1.769*	2.18	2.25	0.07	*3.211*
Early Blackhull	2.22	2.23	0.01	*0.450*	2.68	2.64	0.04	*1.492*
Before Blooming, 1937								
Kanred	2.60	2.65	0.05	*1.923*	2.79	2.83	0.04	*1.433*
Turkey	2.35	2.35	0.00	*0.000*	......	......	......	......
Kanred × Hd. Fed.	3.31	3.52	0.20	*6.184*	2.74	2.81	0.07	*2.554*
Tenmarq	2.50	2.58	0.08	*3.200*	2.25	2.32	0.07	*3.111*
Kawvale	2.01	2.06	0.05	*2.487*	......	......	......	......
Fulcaster	2.21	2.19	-0.02	-*0.904*	2.03	2.03	0.00	*0.000*
Early Blackhull	1.96	1.98	0.02	*1.020*	1.97	2.09	0.12	*6.091*
Before Blooming, 1938								
Kanred	2.09	2.09	0.00	*0.000*	2.39	2.31	-0.08	-*3.347*
Turkey	2.29	2.28	-0.01	-*0.436*	......	......	......	......
Kanred × Hd. Fed.	2.78	2.76	-0.02	-*7.190*	2.07	2.12	0.05	*2.415*
Tenmarq	2.21	2.31	0.10	*4.524*	2.45	2.30	-0.15	-*6.122*
Kawvale	1.91	1.91	0.00	*0.000*	......	......	......	......
Fulcaster	2.12	2.04	-0.08	-*3.773*	2.28	2.32	0.04	*1.754*
Early Blackhull	2.18	2.25	0.07	*3.211*	2.10	2.13	0.02	*0.952*
Blooming, 1936								
Kanred	1.91	1.93	0.02	*1.047*	1.78	1.81	0.03	*1.685*
Turkey	1.81	1.85	0.04	*2.209*	......	......	......	......
Kanred × Hd. Fed.	1.86	1.88	0.02	*1.075*	2.92	2.99	0.07	*2.397*
Tenmarq	1.98	1.94	-0.04	-*2.020*	1.89	1.79	-0.10	-*5.291*
Kawvale	2.33	2.25	-0.08	-*3.433*	......	......	......	......
Fulcaster	2.09	2.09	0.00	*0.000*	1.90	1.88	-0.02	-*1.052*
Early Blackhull	3.42	3.45	0.03	*0.877*	2.23	2.30	0.07	*3.139*
Blooming, 1937								
Kanred	1.89	1.99	0.10	*5.291*	2.07	1.95	-0.12	-*5.797*
Turkey	2.02	1.99	-0.03	-*1.485*	......	......	......	......
Kanred × Hd. Fed.	1.85	1.90	0.05	*2.702*	2.02	2.03	0.01	*0.495*
Tenmarq	1.84	1.91	0.07	*3.804*	1.73	1.76	0.03	*1.734*
Kawvale	2.33	2.25	-0.08	-*3.433*	......	......	......	......
Fulcaster	2.19	2.22	0.03	*1.369*	2.38	2.35	-0.03	-*1.260*
Early Blackhull	2.27	2.35	0.08	*3.404*	1.94	1.94	0.00	*0.000*
Blooming, 1938								
Kanred	2.18	2.27	0.09	*4.128*	12.97	13.09	0.12	*0.925*
Turkey	2.47	2.46	-0.01	-*0.404*	......	......	......	......
Kanred × Hd. Fed.	2.17	2.17	0.00	*0.000*	2.09	2.10	0.01	*0.478*
Tenmarq	2.18	2.22	0.04	*1.834*	1.94	2.00	0.06	*3.092*
Kawvale	2.29	2.26	-0.03	-*1.310*	......	......	......	......
Fulcaster	2.18	2.14	-0.04	-*1.834*	2.20	2.25	0.05	*2.272*
Early Blackhull	2.53	2.55	0.02	*0.790*	2.08	2.21	0.13	*6.25*

TABLE 11.—*Effect of total and partial deawning on the amount of ash in grains of control and experimental heads of wheat. 1936-1938. Weights in grams* —CONCLUDED.

VARIETY.	100 totally deawned heads.				100 partially deawned heads.			
	Controls.	Experimental.	Increase.	Percent increase.	Controls.	Experimental.	Increase.	Percent increase.
One week after blooming, 1936								
Kanred	1.91	2.02	0.11	5.759	1.85	1.88	0.03	1.621
Turkey	1.90	1.81	—0.09	—4.736	......	......	......	......
Kanred × Hd. Fed.	2.16	2.09	—0.05	—2.314	1.85	1.84	—0.01	—0.540
Tenmarq	1.99	2.00	0.01	0.502	1.68	1.67	—0.01	—0.595
Kawvale	1.78	1.80	0.02	1.123	......	......	......	......
Fulcaster	......	......	......	......	......	......	......	......
Early Blackhull	2.25	2.27	0.02	0.888	2.01	2.08	0.07	3.482
One week after blooming, 1937								
Kanred	1.88	1.99	0.11	5.851	1.91	1.82	—0.09	—4.712
Turkey	1.97	2.05	0.08	4.060	......	......	......	......
Kanred × Hd. Fed.	1.60	1.60	0.00	0.000	1.65	1.74	0.09	5.454
Tenmarq	2.04	2.04	0.00	0.000	2.00	2.05	0.05	2.500
Kawvale	2.01	2.09	0.08	3.980	......	......	......	......
Fulcaster	2.04	2.03	—0.01	—0.490	2.05	2.02	—0.03	—1.463
Early Blackhull	1.86	1.92	0.06	3.225	2.15	2.05	—0.10	—4.872
One week after blooming, 1938								
Kanred	2.52	2.56	0.04	1.587	2.13	2.07	—0.06	—2.816
Turkey	2.41	2.43	0.01	0.621	......	......	......	......
Kanred × Hd. Fed.	2.49	2.40	—0.09	3.614	2.02	2.10	0.08	3.960
Tenmarq	2.40	2.45	—0.05	2.083	1.89	1.96	0.07	3.703
Kawvale	2.01	1.98	—0.03	—1.492	......	......	......	......
Fulcaster	3.20	3.20	0.00	0.000	2.38	2.30	—0.08	—3.361
Early Blackhull	2.18	2.27	0.09	4.128	2.28	2.24	—0.04	—1.754
Two weeks after blooming, 1936								
Kanred	1.93	1.89	—0.04	—2.072	1.88	1.95	0.07	3.723
Turkey	1.97	1.94	—0.02	—1.269	......	......	......	......
Kanred × Hd. Fed.	2.21	2.26	0.05	2.262	2.05	2.19	0.14	6.829
Tenmarq	1.71	1.77	0.05	3.206	1.82	1.84	0.02	1.098
Kawvale	......	......	......	......	......	......	......	......
Fulcaster	2.03	1.94	—0.09	—4.433	2.06	2.11	0.05	2.427
Early Blackhull	2.11	1.99	—0.12	—5.687	2.08	2.11	0.03	1.442
Two weeks after blooming, 1937								
Kanred	1.85	1.87	0.02	1.081	1.65	1.75	0.10	6.060
Turkey	2.06	2.10	0.04	1.941	......	......	......	......
Kanred × Hd. Fed.	1.92	1.94	0.02	1.041	1.80	1.85	0.05	2.777
Tenmarq	1.86	1.86	0.00	0.000	1.91	1.99	0.08	4.188
Kawvale	5.47	5.28	—0.19	—3.470	......	......	......	......
Fulcaster	2.09	2.04	—0.05	—2.392	2.04	1.98	—0.06	—2.94
Early Blackhull	2.01	2.08	0.07	3.482	2.01	2.08	0.07	3.482
Two weeks after blooming, 1938								
Kanred	2.03	2.02	0.01	0.492	2.33	2.29	—0.04	—1.927
Turkey	2.16	2.18	0.02	0.925	......	......	......	......
Kanred × Hd. Fed.	2.18	2.10	—0.08	—3.669	2.01	1.99	—0.02	—0.995
Tenmarq	2.04	2.09	0.05	2.450	1.85	1.86	0.01	0.540
Kawvale	1.94	1.91	—0.03	—1.546	......	......	......	......
Fulcaster	2.29	2.29	0.00	0.000	2.08	2.12	0.04	1.923
Early Blackhull	2.19	2.15	—0.04	—1.826	1.89	1.92	0.03	1.587

There were 12 averages or means for the totally deawned and the same number for the partially deawned heads. However, in only two cases of each of the totally and partially deawned heads were the means or averages statistically significant. These were the instances when the heads were totally deawned before blooming and one week after blooming in 1937. The averages that were significant when the heads were partially deawned were before blooming in 1937 and two weeks after blooming in 1938.

The results show that deawning has no significant effect in increasing the percentage weight of ash in the grain of wheat.

SOME EFFECTS OF PARTIAL DEAWNING ON HEAD CHARACTERS OF THE VARIETIES TURKEY AND KAWVALE

During each of the three years, the effects of partial deawning were studied relative to certain changes in the head. The grains from the deawned portion of each head were obtained and kept separate from those of the awned, intact portion of the head. The varieties Turkey and Kawvale were used for this purpose. The number of the varieties used in the experiment was limited to two because of the tediousness of the processes involved. The four determinations made on the grain for these two varieties were, (a) the weight of the grain from the awned and deawned portions of 100 heads, (b) the weight of 1,000 grains from each portion of the heads, (c) the number of grains produced in the awned and deawned portions of 100 heads, and (d) the ash content of the grain.

Effect of partial deawning on weight of grains from 100 heads.—Table 12 shows the weight of grain from the deawned portion of 100 heads and that from the awned, intact portion of the same heads. There was a decrease in the weight of grain from the deawned portions of the head over that from the intact parts at all four stages that the experiments were performed. (Fig. 14.)

There are frequent irregularities in the decrease in weight, of the deawned portions, but from Table 12 it is observed from the grand weighted average that the losses are the greatest at the stage before flowering, and they decrease in magnitude to the stage when the deawning was performed two weeks after blooming.

The decrease of the weight of grain from the deawned portion of the head was always much greater for the variety Turkey than for Kawvale. Thus the decrease in the weight of the grain of the variety Turkey ranged from 1.3 times to over 5 times as much as for the variety Kawvale.

Effect of partial deawning on the weight of 1,000 grains.—Table 13 shows the decrease in grams and the percentage decrease in the weight of 1,000 grains from the deawned portions of the heads as compared to the intact or awned portions of the same heads. The percentage decrease in weight was obtained by dividing the loss

TABLE 12.—*Effect of partial deawning on weight of grain produced by 100 awned halves and 100 deawned halves of the same heads of wheat. 1936-1938.*

STAGE OF DEAWNING.	Weight of grains per 100 heads.										
	Turkey.				Kawvale.				Average.	Weighted average.	Grand weighted average.
	Weight in grams.			Percent decrease.	Weight in grams.			Percent decrease.			
	Awned half.	Deawned half.	Decrease.		Awned half.	Deawned half.	Decrease.				
1936											
BB-P	26.3	20.7	5.6	*21.29*	32.7	27.2	5.5	*16.82*	*19.06*	*18.81*	....
B-P	39.6	30.9	8.7	*21.97*	31.1	27.7	3.4	*10.93*	*16.45*	*17.11*	....
1-P	33.5	26.7	6.8	*20.30*	34.8	33.2	1.6	*4.60*	*12.45*	*12.30*	....
2-P	32.4	26.9	5.5	*16.98*	....	....	....	....	*16.98*	*16.98*	....
1937											
BB-P	14.2	7.6	6.6	*46.48*	29.8	27.2	2.6	*8.72*	*27.60*	*20.91*	....
B-P	15.3	12.6	2.7	*17.65*	34.8	32.4	2.4	*6.90*	*12.28*	*10.18*	....
1-P	24.4	21.8	2.6	*10.66*	38.2	36.6	1.6	*4.19*	*7.43*	*6.71*	....
2-P	25.5	22.5	3.0	*11.77*	34.1	32.5	1.6	*4.69*	*8.23*	*7.72*	....
1938											
BB-P	19.4	13.8	5.6	*28.87*	34.7	29.7	5.0	*14.41*	*21.64*	*19.59*	**19.67**
B-P	17.0	12.5	4.5	*26.47*	36.8	29.4	7.4	*20.11*	*23.29*	*22.12*	**16.70**
1-P	29.3	24.6	5.7	*19.45*	38.1	33.2	4.9	*12.86*	*16.16*	*15.73*	**11.70**
2-P	26.1	23.0	3.1	*11.88*	36.6	35.1	1.5	*4.10*	*7.99*	*7.34*	**9.50**

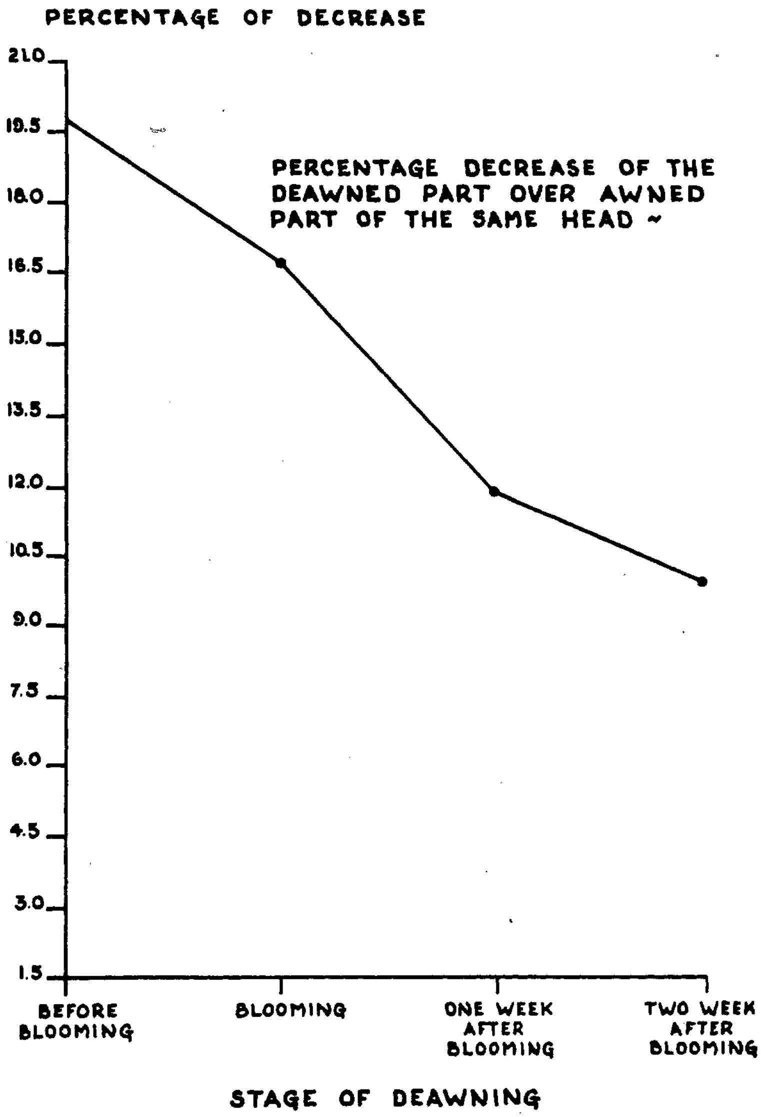

FIG. 14.—Percentage decrease in weight of the grain from the deawned half of 100 heads as compared to that portion of the head on which the awns were left intact.

TABLE 13.—*Effect of partial deawning on weight of grain produced by the awned and deawned halves of the same heads of wheat. 1936-1938.*

Stage of Deawning.	Weight of 1000 grains.										
	Turkey.				Kawvale.				Average.	Weighted average.	Grand weighted average.
	Weight in grams.			Percent decrease.	Weight in grams.			Percent decrease.			
	Awned half.	Deawned half.	Decrease.		Awned half.	Deawned half.	Decrease.				
1936											
BB-P	26.3	24.2	2.1	*7.98*	29.0	28.4	0.6	*2.07*	*5.03*	*4.88*	....
B-P	30.5	28.6	1.9	*6.23*	29.9	27.8	2.1	*7.02*	*6.63*	*6.62*	....
1-P	29.7	28.8	0.9	*3.03*	31.8	31.2	0.6	*1.89*	*2.46*	*2.44*	....
2-P	29.5	29.3	0.2	*0.68*	....	....	....	....	*0.68*	*0.68*	....
1937											
BB-P	14.2	7.6	6.6	*46.46*	25.8	24.3	1.5	*5.82*	*26.14*	*26.03*	....
B-P	15.3	12.6	2.7	*17.65*	31.5	28.9	2.6	*8.26*	*12.95*	*11.31*	....
1-P	24.4	21.8	2.6	*10.65*	30.7	29.9	0.8	*2.72*	*6.68*	*6.52*	....
2-P	25.5	22.5	3.0	*11.76*	30.2	30.7	+0.5	*+1.75*	*5.00*	*6.08*	....
1938											
BB-P	16.6	14.3	2.3	*13.85*	25.7	22.4	3.3	*12.76*	*13.30*	*13.25*	**11.15**
B-P	15.6	13.2	2.4	*15.39*	23.9	21.1	2.8	*11.74*	*13.57*	*13.18*	**9.37**
1-P	25.3	23.9	1.4	*5.54*	25.0	23.2	1.8	*6.88*	*6.21*	*6.21*	**4.37**
2-P	23.5	23.0	0.5	*2.12*	26.3	26.2	0.1	*0.38*	*1.25*	*1.26*	**3.18**

in weight in grams by the weight of 1,000 grains from the intact portions of the heads. The average of the loss in weight in grams and in percentage decrease for each of the four stages was significant for each of the three years. With one exception there was a decrease in the weight of 1,000 grains from the deawned portion. That exception was for the variety Kawvale in 1937 at the stage two weeks after blooming.

The percentage decrease in the weight of 1,000 grains from the deawned portions of the heads was greatest the earlier the heads were deawned. The grand weighted average of the percentage decrease was 11.15, 9.37, 4.37 and 3.18 percent, respectively, for the four stages for the three years.

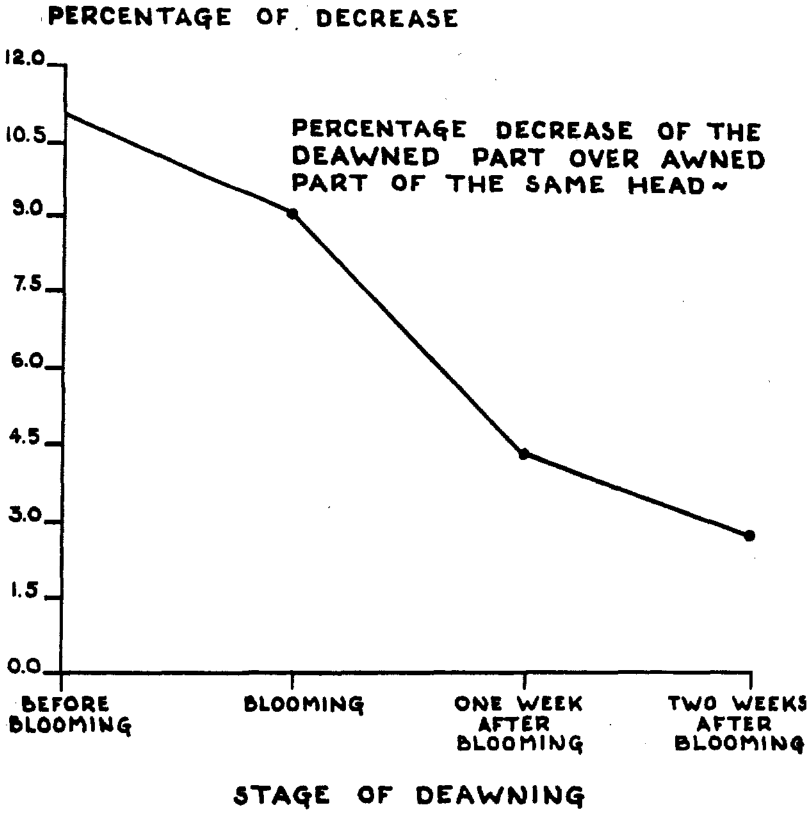

FIG. 15.—Percentage decrease in the weight of 1,000 grains from the deawned half of the head as compared to the awned half of the same heads.

TABLE 14.—*Effect of partial deawning on the grain produced by the awned and deawned halves of the same heads. 1936-1938.*

STAGE OF DEAWNING.	Number of grains per 100 heads.										
	Turkey.				Kawvale.				Average.	Weighted average.	Grand weighted average.
	Awned half.	Deawned half.	Decrease.	Percent decrease.	Awned half.	Deawned half.	Decrease.	Percent decrease.			
1936											
BB–P	1002	856	146	*14.57*	1126	958	168	*14.92*	*14.75*	*14.76*	....
B–P	1300	1081	219	*16.85*	1041	996	45	*4.32*	*10.59*	*11.28*	....
1–P	1127	927	200	*17.75*	1092	1066	26	*2.38*	*10.07*	*10.18*	....
2–P	1098	918	180	*16.39*	....	....	....	....	*16.39*	*16.39*	....
1937											
BB–P	1063	961	102	*9.64*	1155	1119	36	*3.10*	*6.37*	*6.22*	....
B–P	960	904	56	*5.79*	1104	1119	+15	*+1.30*	*4.49*	*4.48*	....
1–P	1055	1024	31	*2.89*	1243	1226	17	*1.38*	*2.14*	*2.09*	....
2–P	1082	996	76	*7.00*	1132	1059	73	*6.42*	*6.71*	*6.73*	....
1938											
BB–P	1169	964	205	*17.48*	1352	1328	24	*1.78*	*9.63*	*9.08*	**9.92**
B–P	1088	942	146	*14.20*	1541	1393	148	*9.61*	*11.91*	*11.18*	**8.52**
1–P	1159	1030	129	*11.07*	1527	1428	99	*6.50*	*8.79*	*8.49*	**6.97**
2–P	1112	1002	110	*9.87*	1392	1341	51	*3.69*	*6.78*	*6.43*	**8.43**

Effect of partialdeawning on the number of grains produced by 100 heads.—Table 14 gives the decrease in the number of grains from the deawned parts of the heads as compared to the number from the awned parts of the same heads of the varieties Turkey and Kawvale. The difference is expressed in the decrease in the number of grains produced by 100 heads and in the percentage decrease as based on the number of grains from the intact parts of the heads. The results show that with one exception the number of grains produced in the deawned portion was decreased. This exception is for the variety Kawvale and occurred in 1937 at the blooming stage. When the results of the seven varieties were averaged for each of the three years, they were statistically significant.

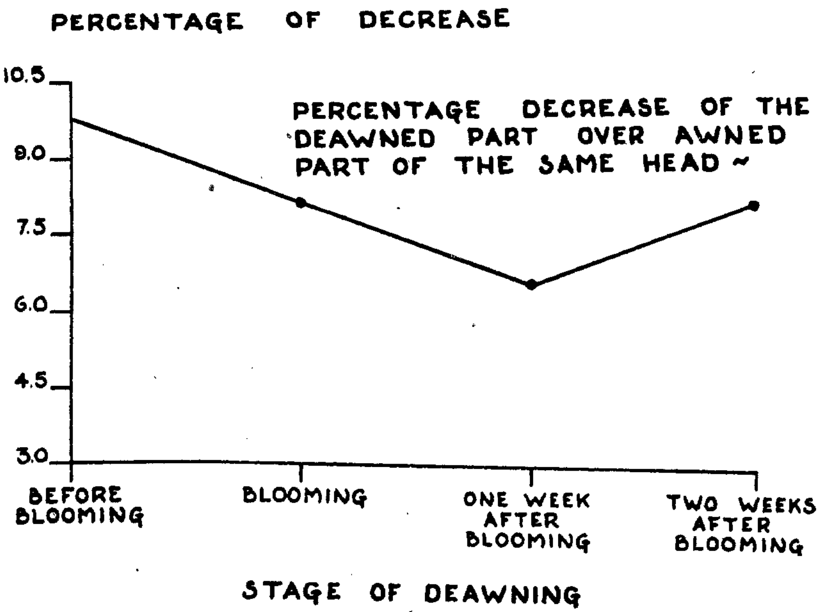

FIG. 16.—Percentage decrease in the number of grains from the deawned half of 100 heads compared to the awned half of the same heads.

With one exception, the percentage decrease in the number of grains from the deawned parts of the head was much higher for the variety Turkey than for Kawvale. The average percentage decrease in the number of grains produced in the deawned half of 100 heads for the three years was for Turkey 13.90, 12.28, 10.57, 11.09, and for Kawvale 6.60, 4.64, 3.42, and 3.37, respectively, for each of the four stages at which deawning was performed. To obtain these results, the percentage decreases at each stage of deawning for the years were added and the sum divided by three. On

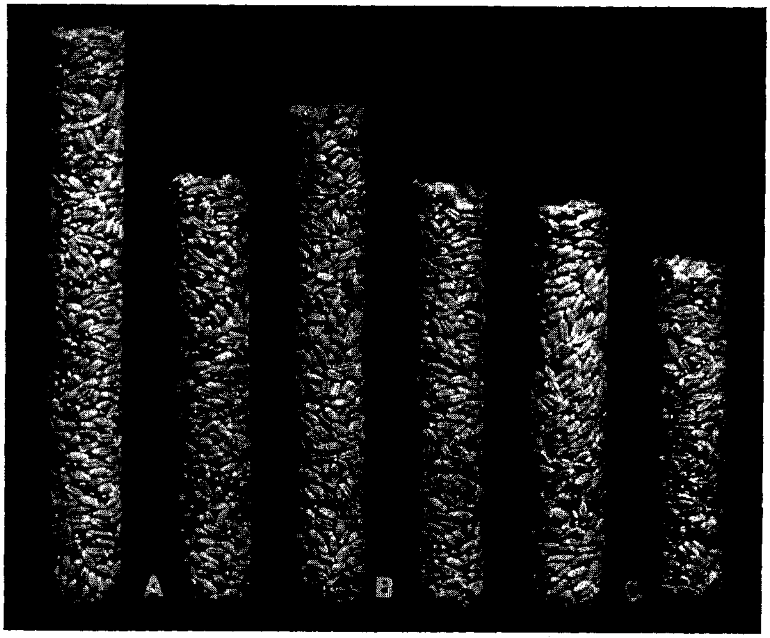

FIG. 17.—Volumetric comparison of the grain from the awned and deawned florets of the same 100 partially deawned spikes of Turkey wheat grown at Manhattan, Kansas. The sample on the left of each pair is the grain from the awned portion of the head; that on the right, from the deawned. (A) Before blooming; (B) at blooming; and (C) one week after blooming.

the average the percentage decrease of the number of grains produced was over 2.5 times higher for the variety Turkey than for Kawvale. One reason that the volume of the grain from the deawned portions of the heads is lower than those from the intact parts of the same heads is the fewer grains in the former. (Fig. 17.)

The number of grains from the deawned portion of the heads and the number from the intact part of the same head were added together and were used as the number of grains produced by the partially deawned heads or spikes in Table 14. In this table the number of grains produced by these partially deawned spikes are compared with a like number of control plants.

EFFECT OF PARTIAL DEAWNING ON THE PERCENTAGE WEIGHT OF ASH IN THE GRAIN

Table 15 shows the effect of the awned and deawned portions of the same heads on the percentage increase in ash of the varieties Turkey and Kawvale. In the variety Turkey the percentage contents of ash in the grain were decreased eight times and increased four times.

TABLE 15.—*Effect of partial deawning on the weight of ash in the grain produced by the awned and deawned halves of the same heads of wheat. 1936-1938.*

STAGE OF DEAWNING.	Turkey. Weight in grams of ash in 100 gm. sample. Awned half.	Deawned half.	Increase in wgt.	Percent increase.	Kawvale. Weight in grams of ash in 100 gm. sample. Awned half.	Deawned half.	Increase in wgt.	Percent increase.
1936								
BB-P	1.840	1.820	—0.020	*—1.098*	1.915	1.820	—0.095	*—5.219*
B-P	1.750	1.790	0.040	*2.234*	1.865	1.860	—0.005	*—0.268*
1-P	1.840	1.760	—0.080	*—4.545*	2.220	2.260	0.030	*1.351*
2-P	1.910	1.940	0.030	*1.546*	....	....	....	....
1937								
BB-P	2.620	2.650	0.030	*1.145*	1.970	1.930	—0.040	*—2.030*
B-P	2.190	2.210	0.020	*0.904*	1.720	1.650	—0.070	*—4.069*
1-P	1.980	1.940	—0.040	*—2.020*	1.850	1.820	—0.030	*—1.621*
2-P	2.390	2.250	—0.140	*—5.857*	1.960	1.900	—0.060	*—3.061*
1938								
BB-P	2.420	2.400	—0.020	*—0.833*	2.250	2.150	—0.100	*—4.444*
B-P	2.480	2.400	—0.080	*—3.333*	1.940	1.990	0.050	*2.577*
1-P	2.010	1.980	—0.030	*—1.492*	1.900	1.980	0.080	*4.210*
2-P	2.070	2.040	—0.030	*—1.449*	2.060	2.010	—0.050	*—2.487*

In the variety Kawvale, in which no sample was obtained two weeks after blooming in 1936, the percentages of ash in the grain should be a decrease eight times and an increase three times. The results of studies on these two varieties shows that the partial deawning of the heads has little or no effect on the percentage ash content of the grain in these two varieties.

From the grand weighted average it is observed that the percentage of reduction in the number of grains produced by the stage one week after blooming is 6.97 and is surpassed 1.46 percent by the stage designated as two weeks after blooming which is 8.43. This difference apparently is due to the fact that in 1936 only the variety Turkey was used in the first experiment. No sample was obtained from Kawvale partially deawned two weeks after blooming.

SOME EFFECTS OF DEAWNING ON THE HEADS OF THE VARIETIES KANRED AND TENMARQ

The total dry weight of the glumes, awns, and rachises together with the amount of ash of these parts was determined for the varieties Kanred and Tenmarq for the awned and deawned portions of the same head. Only two varieties were taken because of the extra work involved. These varieties were taken for no special reason. From Table 16 it is seen that in the 21 cases observed during the three years the variety Kanred showed a decrease in the weight of the glumes of the experimental plants twice and the variety Tenmarq showed in the same number of observations a decrease five times. Thus in the total number of cases observed, one-seventh of them showed a decrease in the weight of the glumes of the deawned

TABLE 16.—*Effect of total and partial deawning of wheat heads on average increase in weight of glumes per 100 heads. 1936-1938.*

STAGE OF DEAWNING.	Average weight increase in the glumes in 100 heads.										
	Kanred.				Tenmarq.				Average.	Weighted average.	Grand weighted average.
	Weight in grams.			Percent increase.	Weight in grams.			Percent increase.			
	Control.	Experi-mental.	Increase.		Control.	Experi-mental.	Increase.				
1936											
BB-T	12.01	12.08	0.07	*0.58*	15.87	16.11	0.24	*1.51*	*1.05*	*1.11*	....
BB-P	11.74	12.43	0.69	*5.88*	15.93	14.47	—1.46	*—9.17*	*—1.65*	*—2.78*	....
B-T	11.45	12.63	1.18	*10.31*	13.42	14.16	0.74	*5.51*	*7.91*	*7.72*	....
B-P	12.28	13.44	1.16	*9.45*	12.83	13.51	0.68	*5.30*	*7.37*	*7.33*	....
1-T	11.33	11.75	0.42	*3.71*	12.96	13.54	0.58	*4.48*	*4.10*	*4.12*	....
1-P	12.15	12.31	0.16	*1.32*	12.66	12.72	0.06	*0.47*	*0.90*	*0.89*	....
2-T	11.09	11.18	0.09	*0.81*	14.69	14.60	—0.09	*—0.61*	*0.10*	*0.00*	....
2-P	11.25	11.45	0.20	*1.78*	14.78	14.81	0.03	*0.20*	*0.99*	*0.88*	....
1937											
BB-T	8.72	9.74	1.02	*11.76*	8.19	8.65	0.46	*5.58*	*8.67*	*8.75*	....
BB-P	10.15	10.38	0.23	*2.25*	9.03	9.25	0.22	*2.40*	*2.33*	*2.35*	....
B-T	10.25	11.21	0.96	*9.43*	12.07	12.91	0.84	*6.93*	*8.18*	*8.06*	....
B-P	10.58	9.91	—0.67	*—6.29*	13.31	13.10	—0.21	*—1.60*	*—3.95*	*—3.68*	....
1-T	9.84	11.64	1.80	*18.26*	11.16	11.65	0.49	*4.42*	*11.34*	*10.90*	....
1-P	10.89	11.50	0.61	*5.62*	12.46	13.71	1.25	*10.01*	*7.82*	*7.97*	....
2-T	11.08	11.48	0.40	*3.62*	12.00	13.97	1.97	*16.42*	*10.02*	*10.27*	....
2-P	11.67	11.74	0.07	*0.59*	12.50	12.74	0.24	*1.90*	*1.25*	*1.28*	....
1938											
BB-T	9.10	9.61	0.51	*5.58*	13.77	14.22	0.45	*3.25*	*4.42*	*4.20*	**4.06**
BB-P	9.27	10.07	0.80	*8.69*	13.97	14.60	0.63	*4.48*	*6.59*	*6.15*	**1.58**
B-T	9.28	10.01	0.73	*7.82*	14.77	15.35	0.58	*2.36*	*5.09*	*5.45*	**7.06**
B-P	8.73	9.56	0.83	*9.60*	13.37	13.32	—0.05	*—0.34*	*4.63*	*3.53*	**2.45**
1-T	8.04	9.42	1.38	*17.17*	12.86	12.60	—0.26	*—1.98*	*7.60*	*5.36*	**6.66**
1-P	8.67	9.15	0.48	*5.59*	14.01	14.17	0.16	*1.11*	*3.35*	*2.82*	**3.84**
2-T	11.02	10.48	—0.54	*—4.91*	12.95	14.69	1.74	*13.44*	*4.27*	*5.01*	**4.91**
2-P	9.58	10.25	0.67	*6.99*	13.84	14.18	0.34	*2.47*	*4.73*	*4.31*	**2.11**

heads over that of the controls. The difference in weight between the control and experimental heads was relatively small, but the average weights of these two varieties for each of the three years were always greater than the weight of the controls. The differences for each of the three years were statistically significant, and for the partial deawning they were significant in the years 1937 and 1938, but nonsignificant in 1936. From the grand weighted average of Table 16 it is apparent that although the results for each stage are positive, there is no correlation between the time that total and partial deawning were performed and the percentage increase in the weight of the glumes. (Fig. 18.)

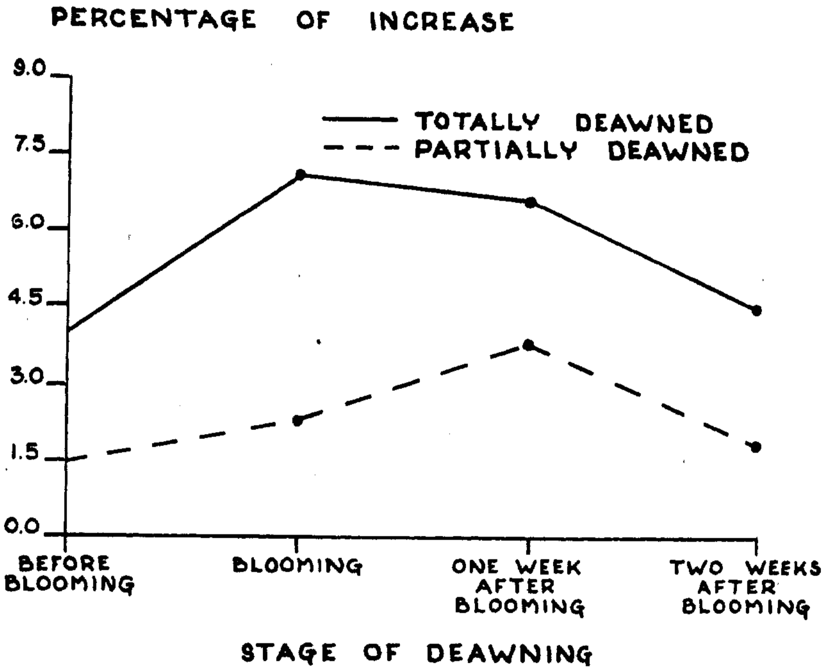

FIG. 18.—Percentage increase in weight of the awns from 100 each of totally and partially deawned heads at four stages of development as shown by the grand weighted average (Table 16).

Effect of total and partial deawning on the amount of ash in the glumes.—Table 17 shows the amount and increase in the ash content of the glumes of 100 awned and deawned heads of Kanred and Tenmarq varieties. The percentage increase in the amount of ash of the experimental plants is shown by both the actual increase in grams and in percentage. There was one comparison in each variety in which there was a decrease in the amount of ash in the glumes of the experimental plants. With Kanred this loss in the weight of ash in the glumes from 100 heads amounted to only 0.102 grams or 4.27

TABLE 17.—*Effect of total and partial deawning of wheat heads on increase in weight of ash in the glumes. 1936-1938.*

STAGE OF DEAWNING.	Control weights in grams.			Experimental weights in grams.			Difference.		Average*	Weighted* average.	Grand* weighted average.
	Weight of glumes of 100 heads.	Weight of ash.	Percent ash.	Weight of glumes of 100 heads.	Weight of ash.	Percent ash.	Increase of ash.	Percent increase.			
KANRED											
1936											
BB-T	12.01	2.168	*18.05*	12.08	2.585	*21.40*	0.417	*19.23*	*19.72*	*19.77*	....
BB-P	11.74	2.157	*18.37*	12.43	2.421	*19.48*	0.264	*12.24*	*3.98*	*3.04*	....
B-T	11.45	2.137	*18.66*	12.63	2.751	*21.78*	0.614	*28.73*	*28.22*	*28.19*	....
B-P	12.28	2.310	*18.81*	13.44	2.723	*20.26*	0.413	*17.88*	*13.97*	*13.91*	....
1-T	11.33	2.109	*18.61*	11.75	2.484	*21.14*	0.375	*17.78*	*20.26*	*20.35*	....
1-P	12.15	2.264	*18.63*	12.31	2.452	*19.92*	0.188	*8.30*	*8.17*	*8.18*	....
2-T	11.09	2.288	*20.63*	11.18	2.578	*23.06*	0.290	*12.67*	*13.50*	*13.56*	....
2-P	11.25	2.392	*21.26*	11.45	2.533	*22.12*	0.141	*5.89*	*5.25*	*5.20*	....
1937											
BB-T	8.72	1.297	*14.87*	9.74	1.554	*15.95*	0.257	*19.85*	*15.87*	*15.94*	....
BB-P	10.15	1.599	*15.75*	10.38	1.618	*15.59*	0.019	*1.19*	*5.23*	*4.82*	....
B-T	10.25	1.830	*17.85*	11.21	2.245	*20.03*	0.415	*22.68*	*22.99*	*23.00*	....
B-P	10.58	1.752	*16.56*	9.91	1.758	*17.74*	0.006	*0.34*	*1.39*	*1.48*	....
1-T	9.84	1.755	*17.84*	11.64	2.213	*19.01*	0.458	*26.01*	*24.32*	*24.34*	....
1-P	10.89	1.764	*16.20*	11.50	1.996	*17.36*	0.232	*13.15*	*11.19*	*11.02*	....
2-T	11.08	1.917	*17.30*	11.48	2.125	*18.51*	0.208	*10.85*	*19.76*	*20.21*	....
2-P	11.67	2.067	*17.71*	11.74	2.200	*18.74*	0.133	*6.43*	*5.28*	*5.26*	....
1938											
BB-T	9.10	1.764	*18.39*	9.61	1.912	*19.90*	0.148	*8.39*	*7.81*	*7.71*	**14.57**
BB-P	9.27	1.747	*18.85*	10.07	1.963	*19.49*	0.216	*12.36*	*8.88*	*9.27*	**5.32**
B-T	9.28	1.880	*20.26*	10.01	2.165	*21.63*	0.285	*15.16*	*14.58*	*14.48*	**21.76**
B-P	8.73	1.621	*18.57*	9.56	1.835	*19.19*	0.214	*13.20*	*10.27*	*9.68*	**8.75**
1-T	8.04	1.495	*18.60*	9.42	1.990	*21.12*	0.495	*33.11*	*19.47*	*16.54*	**20.32**
1-P	8.67	1.739	*20.06*	9.15	1.941	*21.21*	0.202	*11.62*	*7.98*	*7.13*	**8.67**
2-T	11.02	2.391	*21.70*	10.48	2.289	*21.84*	—0.102	*—4.27*	*7.77*	*7.67*	**13.48**
2-P	9.58	2.087	*21.79*	10.25	2.328	*22.71*	0.241	*11.55*	*7.43*	*7.05*	**5.82**

* These averages are for Kanred and Tenmarq combined.

TABLE 17.—*Effect of total and partial deawning of wheat heads on increase in weight of ash in the glumes. 1936-1938*—CONCLUDED.

Stage of Deawning.	Control weights in grams.			Experimental weights in grams.			Difference.		Average*	Weighted* average.	Grand* weighted average.
	Weight of glumes of 100 heads.	Weight of ash.	Percent ash.	Weight of glumes of 100 heads.	Weight of ash.	Percent ash.	Increase of ash.	Percent increase.			
Tenmarq *1936*											
BB-T	15.87	2.753	*17.35*	16.11	3.309	*20.54*	0.556	*20.20*			
BB-P	15.93	2.705	*16.98*	14.47	2.589	*17.89*	—0.116	*—4.29*			
B-T	13.42	2.332	*17.38*	14.16	2.978	*21.03*	0.646	*27.70*			
B-P	12.83	2.377	*18.53*	13.51	2.616	*19.36*	0.239	*10.05*			
1-T	12.96	2.269	*17.51*	13.54	2.785	*20.57*	0.516	*22.74*			
1-P	12.66	2.053	*16.22*	12.72	2.218	*17.44*	0.165	*8.04*			
2-T	14.69	2.640	*17.97*	14.60	3.018	*20.67*	0.378	*14.32*			
2-P	14.78	2.785	*18.84*	14.81	2.913	*19.67*	0.128	*4.60*			
1937											
BB-T	8.19	1.237	*15.10*	8.65	1.384	*16.00*	0.147	*11.88*			
BB-P	9.03	1.305	*15.56*	9.25	1.426	*15.42*	0.121	*9.27*			
B-T	12.07	1.914	*15.86*	12.91	2.468	*19.12*	0.446	*23.30*			
B-P	13.31	2.090	*15.72*	13.10	2.143	*16.36*	0.051	*2.44*			
1-T	11.16	1.803	*16.16*	11.65	2.211	*18.98*	0.408	*22.63*			
1-P	12.46	2.091	*16.78*	13.71	2.284	*16.66*	0.193	*9.23*			
2-T	12.00	2.116	*17.63*	13.97	2.723	*19.49*	0.607	*28.67*			
2-P	12.50	2.153	*17.22*	12.74	2.242	*17.60*	0.089	*4.13*			
1938											
BB-T	13.77	2.476	*17.98*	14.22	2.655	*18.67*	0.179	*7.23*			
BB-P	13.97	2.487	*17.80*	14.60	2.621	*17.95*	0.134	*5.39*			
B-T	14.77	2.706	*18.32*	15.35	3.085	*20.10*	0.379	*14.01*			
B-P	13.37	2.427	*18.15*	13.32	2.605	*19.56*	0.178	*7.33*			
1-T	12.86	2.314	*17.99*	12.60	2.449	*19.44*	0.135	*5.83*			
1-P	14.01	2.794	*19.94*	14.17	2.915	*20.57*	0.121	*4.33*			
2-T	12.95	2.352	*18.16*	14.69	2.818	*19.18*	0.466	*19.81*			
2-P	13.84	2.511	*18.14*	14.18	2.594	*18.29*	0.083	*3.31*			

percent. This was in 1938 at the stage two weeks after blooming when the heads were totally deawned. In Tenmarq a reversal occurred in 1936 during the stage before blooming and with a partial deawning of the heads. This decrease amounted to 0.116 grams or 4.29 percent.

The grand weighted average shows that total deawning had its greatest influence on the increase of the ash in the glumes when performed at blooming, followed by the stages one week after blooming, before blooming, and two weeks after blooming. Partial deawning of the heads had the same influence on accumulation of ash except that the stage before blooming came at the end of the list rather than next to the end of this list as in the case of total deawning. (Fig. 19.)

Effect of partial deawning on weight of the awns of 100 heads.—Table 18 shows the effect of partial deawning on the dry weight of the awns of 100 heads of the two varieties Kanred and Tenmarq for each of the three years. Since half of the awns had been removed, weight of the awns from the experimental heads is multiplied by two to compare it with the total weight of the awns of the control heads. The dry weight of the awns of the controls of the totally deawned heads is also given. This facilitates comparison of the dry weight of the awns of the controls for partially deawned heads.

The increase in the weight of the awns for the variety Kanred is negative in four of the 12 cases, once during the year 1936 at the stage two weeks after blooming, and three times during the year 1937 at the stages before blooming, at blooming, and two weeks after blooming. In seven of the 12 cases with the variety Tenmarq the results were negative. These cases were so well scattered at the various stages and during the three years that one concludes that the weight of the remaining awns of these varieties was not increased by partial deawning.

The grand weighted average is greater than the controls in all cases, but for three of the four cases it is very small and probably of no significance.

Effect of partial deawning on the weight of ash in the awns.—Table 19 shows the effect of partial deawning of heads on the weight of the ash in the awns of 100 heads for the varieties Kanred and Tenmarq for three years. The figures representing the total dry weight of the awns from 100 heads are the same as those given in Table 19, which show the increase or decrease in weight of the awns due to partial deawning. The weight of the awns and also the amount of ash in the awns of the partially deawned heads are doubled to compare them with the control plants. The percentage of ash based on the dry weight of 100 heads is obtained in each case. The percentage of ash was always higher for the experimental plants than those of the control except in one case of Kanred and two cases of Tenmarq. In the three exceptions the amount in grams and in percentage is low. Thus in Kanred the decrease which occurred in 1937 amounted to only 1 milligram in weight as compared with the

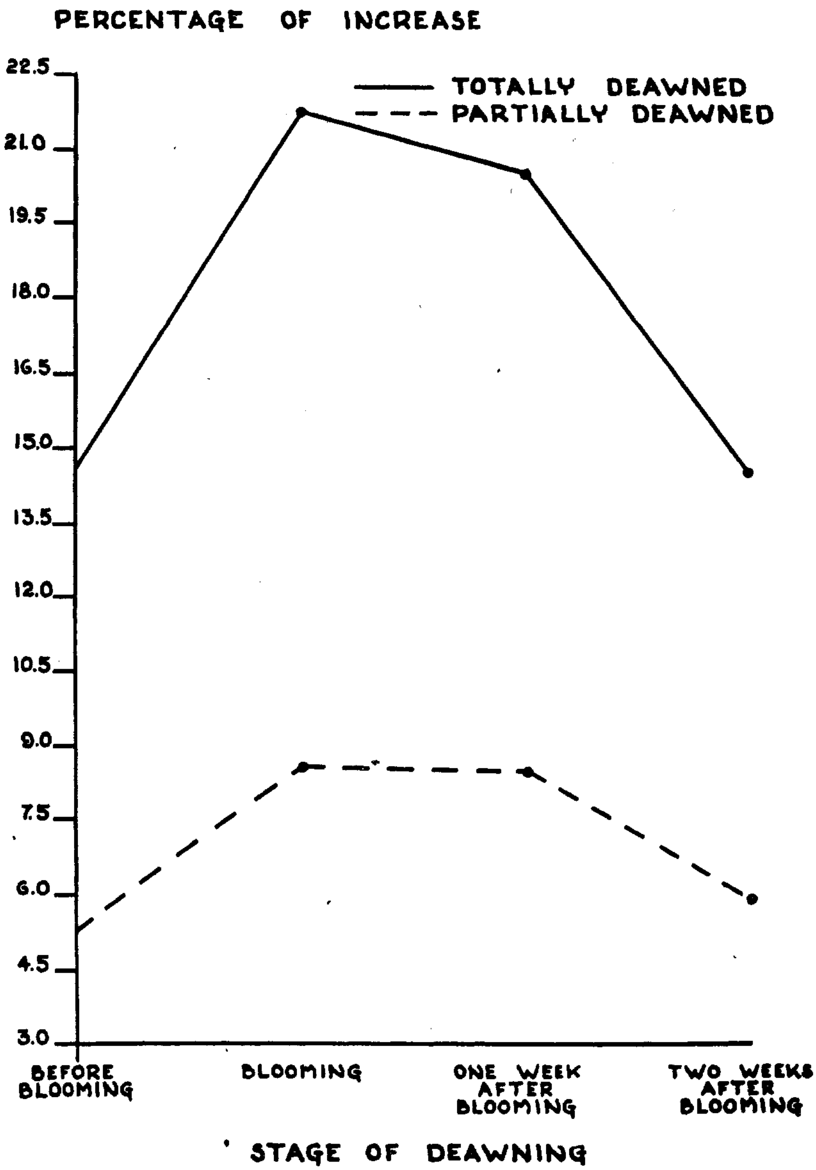

FIG. 19.—Percentage increase in the weight of ash in the glumes from 100 each of totally and partially deawned heads at four stages of development as shown by the grand weighted average (Table 17).

TABLE 18.—*Effect of partial deawning of wheat heads on the increase in weight of remaining awns per 100 heads. 1936-1938. Weights are in grams.*

STAGE OF DEAWNING.	Kanred.				Tenmarq.				Average.	Weighted average.	Grand weighted average.
	Control.	Experi-mental.	Increase.	Percent increase.	Control.	Experi-mental.	Increase.	Percent increase.			
1936											
BB-T	9.15				11.46						
BB-P	9.58	10.23	0.65	6.78	11.44	10.87	—0.57	—5.03	0.90	0.38	
B-T	10.99				10.71						
B-P	10.49	11.73	1.24	11.82	11.09	10.83	—0.26	—2.40	4.71	4.54	
1-T	9.54				9.89						
1-P	9.82	10.13	0.31	3.16	9.71	9.85	0.14	1.47	2.32	2.30	
2-T	8.87				10.66						
2-P	9.25	9.20	—0.05	—0.56	10.99	11.45	0.46	4.26	1.85	2.03	
1937											
BB-T	6.16				5.22						
BB-P	7.41	6.91	—0.50	—5.83	6.04	6.16	0.12	1.85	—1.99	—1.83	
B-T	8.03				7.84						
B-P	8.18	7.79	—0.39	—4.11	10.41	10.09	—0.32	—3.03	—3.57	—3.82	
1-T	8.79				8.40						
1-P	8.26	8.58	0.32	3.37	9.45	9.71	0.26	2.77	3.04	3.27	
2-T	9.00				9.66						
2-P	9.20	9.10	—0.10	—0.92	9.80	9.19	—0.61	—6.22	—3.56	—3.74	
1938											
BB-T	7.52				9.82						
BB-P	7.19	7.64	0.45	6.26	10.82	10.71	—0.11	—0.97	2.64	1.89	**0.08**
B-T	8.02				11.13						
B-P	6.88	7.45	0.57	8.27	10.44	9.70	—0.74	—7.11	0.58	0.98	**0.17**
1-T	6.92				8.92						
1-P	6.18	6.28	0.10	1.59	8.78	9.79	1.01	11.47	6.53	7.42	**4.10**
2-T	6.84				8.84						
2-P	6.88	7.68	0.80	11.51	9.62	9.17	—0.45	—4.63	3.44	2.12	**0.09**

TABLE 19.—*Effect of partial deawning of wheat heads on weight of ash in awns of 100 heads. 1936-1938. Weights in grams.*

STAGE OF DEAWNING.	Control.			Experimental.			Difference.		Average*	Weighted* average.	Grand* weighted average.
	Weight of awns.	Weight of ash.	Percent ash.	Weight of awns.	Weight of ash.	Percent ash.	Increase of ash.	Percent increase.			
KANRED *1936*											
BB-T	9.15	1.994	*21.79*	.....	.....	.....	.....	.....	.....	.....	.....
BB-P	9.58	2.169	*22.64*	10.23	2.494	*24.38*	0.325	*14.98*	*8.40*	*8.05*	.....
B-T	10.99	2.346	*21.35*	.....	.....	.....	.....	.....	.....	.....	.....
B-P	10.49	2.317	*22.09*	11.73	2.857	*24.36*	0.540	*23.31*	*11.77*	*10.89*	.....
1-T	9.54	1.961	*20.56*	.....	.....	.....	.....	.....	.....	.....	.....
1-P	9.82	2.290	*23.32*	10.13	2.528	*24.96*	0.238	*10.39*	*9.78*	*9.84*	.....
2-T	8.87	2.267	*25.56*	.....	.....	.....	.....	.....	.....	.....	.....
2-P	9.25	2.467	*26.67*	9.20	2.547	*27.69*	0.080	*3.24*	*5.31*	*5.37*	.....
1937											
BB-T	6.16	1.014	*16.46*	.....	.....	.....	.....	.....	.....	.....	.....
BB-P	7.41	1.263	*17.04*	6.91	1.262	*18.26*	—0.001	*—0.08*	*7.41*	*6.80*	.....
B-T	8.03	1.674	*20.85*	.....	.....	.....	.....	.....	.....	.....	.....
B-P	8.18	1.483	*18.13*	7.79	1.558	*20.00*	0.075	*5.06*	*6.16*	*6.27*	.....
1-T	8.79	1.645	*18.72*	.....	.....	.....	.....	.....	.....	.....	.....
1-P	8.26	1.576	*19.08*	8.58	1.785	*20.81*	0.209	*13.26*	*11.92*	*11.31*	.....
2-T	9.00	1.609	*17.88*	.....	.....	.....	.....	.....	.....	.....	.....
2-P	9.20	1.987	*21.60*	9.10	2.118	*23.18*	0.131	*6.59*	*1.94*	*1.93*	.....
1938											
BB-T	7.52	1.359	*18.07*	.....	.....	.....	.....	.....	.....	.....	.....
BB-P	7.19	1.293	*17.99*	7.64	1.539	*20.15*	0.246	*19.03*	*12.43*	*10.83*	**8.68**
B-T	8.02	1.663	*20.73*	.....	.....	.....	.....	.....	.....	.....	.....
B-P	6.88	1.181	*17.17*	7.45	1.374	*18.44*	0.193	*16.34*	*9.99*	*8.57*	**8.92**
1-T	6.92	1.348	*19.48*	.....	.....	.....	.....	.....	.....	.....	.....
1-P	6.18	1.361	*22.02*	6.28	1.418	*22.58*	0.057	*4.19*	*13.82*	*14.69*	**11.69**
2-T	6.84	1.646	*24.06*	.....	.....	.....	.....	.....	.....	.....	.....
2-P	6.88	1.695	*24.63*	7.68	1.949	*25.38*	0.254	*14.99*	*6.38*	*5.35*	**4.30**

* These averages are for Kanred and Tenmarq combined.

TABLE 19.—*Effect of partial deawning of wheat heads on weight of ash in awns of 100 heads. 1936-1938. Weights in grams*—CONCLUDED.

STAGE OF DEAWNING.	Control.			Experimental.			Difference.		Average*	Weighted* average.	Grand* weighted average.
	Weight of awns.	Weight of ash.	Percent ash.	Weight of awns.	Weight of ash.	Percent ash.	Increase of ash.	Percent increase.			
TENMARQ											
1936											
BB-T	11.46	2.377	*20.74*								
BB-P	11.44	2.416	*21.12*	10.87	2.460	*22.63*	0.044	*1.82*			
B-T	10.71	2.239	*20.91*								
B-P	11.09	2.698	*24.33*	10.83	2.704	*24.97*	0.006	*0.22*			
1-T	9.89	2.023	*20.46*								
1-P	9.71	1.898	*19.55*	9.83	2.072	*21.08*	0.174	*9.17*			
2-T	10.66	2.346	*22.01*								
2-P	10.99	2.619	*23.83*	11.45	2.812	*24.56*	0.193	*7.37*			
1937											
BB-T	5.22	0.944	*18.08*								
BB-P	6.04	1.064	*17.62*	6.16	1.223	*19.86*	0.159	*14.94*			
B-T	7.84	1.621	*20.68*								
B-P	10.41	1.849	*17.76*	10.09	1.983	*19.65*	0.134	*7.25*			
1-T	8.40	1.575	*18.75*								
1-P	9.45	1.765	*18.68*	9.71	1.934	*19.93*	0.169	*9.58*			
2-T	9.66	1.956	*20.25*								
2-P	9.80	1.996	*20.37*	9.19	1.942	*21.13*	—0.054	*—2.71*			
1938											
BB-T	9.82	1.768	*18.00*								
BB-P	10.82	2.113	*19.53*	10.71	2.236	*20.88*	0.123	*5.82*			
B-T	11.13	2.240	*20.13*								
B-P	10.44	1.866	*17.87*	9.70	1.934	*19.94*	0.068	*3.64*			
1-T	8.92	1.705	*19.11*								
1-P	8.78	1.634	*18.61*	9.79	2.017	*19.58*	0.383	*23.44*			
2-T	8.84	1.712	*19.37*								
2-P	9.62	2.156	*22.41*	9.17	2.108	*22.99*	—0.048	*—2.23*			

controls or 0.08 percent of the controls and occurred at the stage before blooming. In Tenmarq the decrease occurred once in 1937 and again in 1938. Both exceptions occurred at the stage two weeks after blooming. In the former case the decrease was 0.054 grams or 2.71 percent as compared with the controls and in the latter case this decrease was 0.048 grams or 2.33 percent. The increase of ash in the glumes is one of the most striking facts observed in deawning and has been reported by numerous investigators.

The increase in the amount of ash in grams in the awns of 100 heads of the experimental plants over that of the controls is shown in the next to the last column in Table 19. The increase of ash in percentage is obtained by dividing the increase in the amount of ash in the awns of the experimental heads by the amount of ash in the controls.

Both the average and weighted averages for the two varieties for each year show an increase in the ash at all times. The grand weighted average shows that the greatest percentage increase in ash of the awns occurred at the deawning period designated as one week after blooming. The next greatest increase was at the blooming stage followed by the increase two weeks after blooming. The increase was the least at the period before blooming.

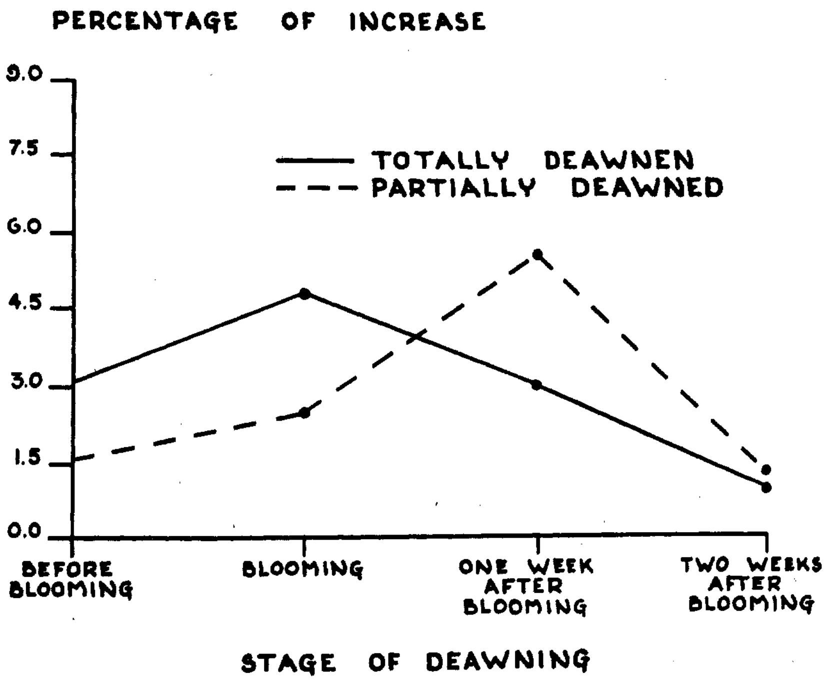

FIG. 20.—Percentage increase in the weight of the rachises from 100 each of totally and partially deawned heads in comparison to the controls at four stages of development (Table 20).

Effect of total and partial deawning on weight of the rachises.—Table 20 shows the effect of total and partial deawning of 100 experimental heads on the weight of the rachises. With the variety. Kanred there were eight times out of the 24, or one-third of the cases in which the rachises from the experimental heads weighed less than those from the controls. In the variety Tenmarq there were five instances out of the 24 which showed this same trend. In Tenmarq there were two cases in which there was neither an increase nor a decrease in the weight of the rachises. One of the cases was in 1937 at total deawning, one week after flowering. The other example was in 1938 when the head was only partially deawned at blooming time. But in more than two-thirds of the cases the weight of the rachises increased in the experimental plants over those of the control. It is likely that one of the effects of deawning of heads was to increase the weight of the rachises of the deawned heads.

Both the average and weighted average of the deawned portions of the heads of the two varieties of wheat were less than the awned, portions four times out of eight in 1937 and twice in 1938. The grand weighted average showed that in all cases the weight of rachises was not raised as much by partial as by total deawning but in either case deawning consistently increased the weight of the rachises more in the deawned part than in the awned portion. The most striking increase in weight in this grand weighted average was 4.64 percent, at the blooming stage of total deawning. The next most significant increase in weight of the rachises due to total deawning is at the stage before blooming where it amounts to 3.09 percent. The next percentage increase was 3.02 at one week after blooming. The most striking increase in the weight of the rachises in the partially deawned heads was 5.25 percent at the stage one week after blooming. There was not one case at that stage in any of the three years when the results showed a decrease in weight. The increase in weight of the rachises was in the following order for the three treatments: at blooming, before blooming, and two weeks after blooming.

Effect of total and partial deawning on the amount of ash in the rachises.—Table 21 shows the effects of the total and partial deawning of the heads on the weight of ash in the rachises. These results are shown in the total amount of ash present and the percentage increase based on the dry weight and on the ash content. In only four cases out of the 24 for the variety Kanred and only once for the variety Tenmarq was there a decrease in the amount of ash in the rachises and usually this decrease was only slight. From the grand weighted average of the totally deawned heads, the increase in the percentage of ash in the rachises stood in the following order: at blooming, before blooming, one week after blooming, and two weeks after blooming. With the partially deawned heads the percentage of the ash content of the rachises was the highest at the period one week after blooming, at blooming, two weeks after blooming, and before blooming. At all times, however, the partially

TABLE 20.—*Effect of total and partial deawning of wheat heads on average increase in weight of rachises. 1936-1938. Weights are in grams.*

STAGE OF DEAWNING.	Average weight increase in the rachises in 100 heads.										
	Kanred.				Tenmarq.				Average.	Weighted average.	Grand weighted average.
	Control.	Experi-mental.	Increase.	Percent increase.	Control.	Experi-mental.	Increase.	Percent increase.			
1936											
BB-T	2.66	2.65	-0.01	*-0.40*	3.19	3.74	0.55	*17.24*	*8.42*	*9.23*	....
BB-P	2.71	3.08	0.37	*13.65*	3.29	2.95	-0.34	*-10.30*	*1.68*	*0.50*	....
B-T	2.99	3.10	0.11	*3.68*	2.98	3.14	0.16	*5.37*	*4.53*	*4.52*	....
B-P	2.99	3.32	0.33	*11.04*	2.83	2.92	0.09	*3.18*	*7.11*	*7.22*	....
1-T	2.91	2.94	0.03	*1.03*	2.80	2.93	0.13	*4.64*	*2.84*	*2.80*	....
1-P	2.92	2.97	0.05	*1.71*	2.90	2.97	0.07	*2.41*	*2.06*	*2.06*	....
2-T	2.70	2.80	0.10	*3.70*	3.20	3.16	-0.04	*-1.25*	*1.23*	*1.02*	....
2-P	2.72	2.80	0.08	*2.94*	2.82	3.20	0.38	*13.48*	*8.21*	*8.30*	....
1937											
BB-T	2.35	2.40	0.05	*2.13*	1.82	1.90	0.08	*4.40*	*3.27*	*3.12*	....
BB-P	2.80	2.65	-0.15	*-5.36*	2.19	2.13	-0.06	*-2.74*	*-4.05*	*-4.21*	....
B-T	2.42	2.49	0.07	*2.89*	2.74	2.85	0.12	*4.38*	*3.64*	*3.68*	....
B-P	2.64	2.47	-0.17	*-6.44*	2.88	2.95	0.07	*2.43*	*-2.01*	*-1.81*	....
1-T	2.67	2.76	0.09	*3.37*	2.44	2.44	0.00	*0.00*	*1.69*	*1.76*	....
1-P	2.67	2.88	0.21	*7.87*	2.89	3.07	0.18	*6.23*	*7.05*	*7.01*	....
2-T	2.82	2.68	-0.14	*-4.96*	2.72	2.85	0.13	*4.74*	*0.11*	*0.18*	....
2-P	2.78	2.72	-0.06	*-2.16*	2.90	2.75	-0.15	*-5.17*	*-3.67*	*-3.70*	....
1938											
BB-T	2.30	2.29	-0.01	*-0.43*	3.19	3.01	-0.18	*-5.64*	*-3.04*	*3.46*	**3.09**
BB-P	2.43	2.62	0.19	*7.82*	3.09	3.32	0.23	*7.44*	*7.63*	*7.61*	**1.45**
B-T	2.34	2.48	0.14	*5.98*	3.11	3.28	0.17	*5.47*	*5.73*	*5.69*	**4.64**
B-P	2.43	2.51	0.08	*3.29*	3.08	3.08	0.00	*0.00*	*1.65*	*1.45*	**2.37**
1-T	2.01	2.13	0.12	*5.97*	2.74	2.84	0.10	*3.65*	*4.81*	*4.63*	**3.02**
1-P	1.94	2.06	0.12	*6.19*	3.07	3.30	0.23	*7.49*	*6.84*	*6.99*	**5.25**
2-T	2.39	2.19	-0.20	*-8.37*	2.78	3.06	0.28	*10.07*	*0.85*	*1.55*	**0.78**
2-P	2.16	2.05	-0.11	*-5.09*	2.82	2.86	0.04	*1.42*	*-1.84*	*-1.41*	**1.11**

TABLE 21.—*Effect of total and partial deawning of wheat heads on the increase in weight of ash in the rachises. 1936-1938. Weights are in grams.*

STAGE OF DEAWNING.	Control.			Experimental.			Difference.		Average*	Weighted* average.	Grand* weighted average.
	Weight of rachises per 100 heads.	Weight of ash.	Percent ash.	Weight of rachises per 100 heads.	Weight of ash.	Percent ash.	Increase of ash.	Percent increase.			
KANRED *1936*											
BB-T	2.66	0.177	*6.66*	2.65	0.146	*5.51*	0.031	*17.51*	*30.85*	*30.66*	....
BB-P	2.71	0.181	*6.67*	3.08	0.197	*6.39*	0.016	*8.84*	*5.01*	*5.11*	....
B-T	2.99	0.161	*5.37*	3.10	0.205	*6.61*	0.044	*27.33*	*25.56*	*25.54*	....
B-P	2.99	0.183	*6.12*	3.32	0.230	*6.94*	0.047	*25.68*	*15.34*	*16.03*	....
1-T	2.91	0.173	*5.94*	2.94	0.208	*7.08*	0.035	*20.23*	*20.37*	*20.36*	....
1-P	2.92	0.163	*5.60*	2.97	0.186	*6.26*	0.023	*14.11*	*13.70*	*13.73*	....
2-T	2.70	0.166	*6.16*	2.80	0.181	*6.45*	0.015	*9.04*	*10.88*	*10.95*	....
2-P	2.72	0.152	*5.59*	2.80	0.169	*6.02*	0.017	*11.18*	*15.53*	*15.46*	....
1937											
BB-T	2.35	0.128	*5.45*	2.40	0.144	*6.02*	0.016	*12.50*	*20.61*	*19.65*	....
BB-P	2.80	0.134	*4.78*	2.65	0.133	*5.01*	—0.001	*—0.75*	*1.95*	*1.90*	....
B-T	2.42	0.138	*5.70*	2.49	0.162	*6.50*	0.024	*17.39*	*19.46*	*19.59*	....
B-P	2.64	0.155	*5.86*	2.47	0.147	*5.94*	—0.008	*—5.16*	*5.39*	*4.78*	....
1-T	2.67	0.145	*5.42*	2.76	0.159	*5.77*	0.014	*9.66*	*8.73*	*8.74*	....
1-P	2.67	0.144	*5.39*	2.88	0.162	*5.61*	0.018	*12.50*	*10.60*	*10.64*	....
2-T	2.82	0.149	*5.28*	2.68	0.165	*6.16*	0.016	*10.74*	*9.82*	*9.83*	....
2-P	2.78	0.135	*4.86*	2.72	0.139	*5.12*	0.004	*2.96*	*0.86*	*0.37*	....
1938											
BB-T	2.30	0.188	*8.18*	2.29	0.197	*8.61*	0.009	*4.79*	*7.35*	*7.50*	**18.61**
BB-P	2.43	0.212	*8.72*	2.62	0.232	*8.85*	0.020	*9.43*	*10.30*	*10.37*	**6.59**
B-T	2.34	0.194	*8.27*	2.48	0.227	*9.14*	0.033	*17.01*	*16.08*	*16.07*	**20.13**
B-P	2.43	0.182	*7.51*	2.51	0.195	*7.75*	0.013	*7.14*	*6.70*	*6.64*	**9.17**
1-T	2.01	0.147	*7.33*	2.13	0.162	*7.60*	0.015	*10.20*	*10.63*	*10.67*	**13.47**
1-P	1.94	0.149	*7.69*	2.06	0.159	*7.73*	0.010	*6.71*	*7.79*	*8.06*	**10.55**
2-T	2.39	0.177	*7.40*	2.19	0.160	*7.31*	—0.017	*—9.60*	*2.59*	*2.77*	**7.68**
2-P	2.16	0.151	*7.01*	2.05	0.144	*7.03*	—0.007	*—4.64*	*3.21*	*4.11*	**6.78**

* These averages are for Kanred and Tenmarq combined.

TABLE 21.—*Effect of total and partial deawning of wheat heads on the increase in weight of ash in the rachises. 1936-1938. Weights are in grams*—CONCLUDED.

STAGE OF DEAWNING.	Control.			Experimental.			Difference.		Average*	Weighted* average.	Grand* weighted average.
	Weight of rachises per 100 heads.	Weight of ash.	Percent ash.	Weight of rachises per 100 heads.	Weight of ash.	Percent ash.	Increase of ash.	Percent increase.			
TENMARQ *1936*											
BB-T	3.19	0.172	*5.38*	3.74	0.248	*6.64*	0.076	*44.19*	....	....	....
BB-P	3.29	0.171	*5.20*	2.95	0.173	*5.87*	0.002	*1.17*	....	....	....
B-T	2.98	0.164	*5.51*	3.14	0.203	*6.45*	0.039	*23.78*	....	....	....
B-P	2.83	0.160	*5.67*	2.92	0.168	*5.75*	0.008	*5.00*	....	....	....
1-T	2.80	0.156	*5.57*	2.93	0.188	*6.42*	0.032	*20.51*	....	....	....
1-P	2.90	0.143	*4.93*	2.97	0.162	*5.45*	0.019	*13.29*	....	....	....
2-T	3.20	0.181	*5.66*	3.16	0.204	*6.44*	0.023	*12.71*	....	....	....
2-P	2.82	0.152	*5.40*	3.20	0.182	*5.69*	0.030	*19.87*	....	....	....
1937											
BB-T	1.82	0.101	*5.57*	1.90	0.130	*6.85*	0.029	*28.71*	....	....	....
BB-P	2.19	0.129	*5.91*	2.13	0.135	*6.35*	0.006	*4.65*	....	....	....
B-T	2.74	0.158	*5.77*	2.85	0.192	*6.72*	0.034	*21.52*	....	....	....
B-P	2.88	0.138	*4.79*	2.95	0.160	*5.43*	0.022	*15.94*	....	....	....
1-T	2.44	0.141	*5.78*	2.44	0.152	*6.23*	0.011	*7.80*	....	....	....
1-P	2.89	0.138	*4.76*	3.07	0.150	*4.89*	0.012	*8.70*	....	....	....
2-T	2.72	0.146	*5.38*	2.85	0.159	*5.58*	0.013	*8.90*	....	....	....
2-P	2.90	0.134	*4.61*	2.75	0.131	*4.76*	—0.003	*—1.24*	....	....	....
1938											
BB-T	3.19	0.212	*6.65*	3.01	0.233	*7.73*	0.021	*9.91*	....	....	....
BB-P	3.09	0.251	*8.11*	3.32	0.279	*8.39*	0.028	*11.16*	....	....	....
B-T	3.11	0.198	*6.38*	3.28	0.228	*6.94*	0.030	*15.15*	....	....	....
B-P	3.08	0.240	*7.79*	3.08	0.255	*8.28*	0.015	*6.25*	....	....	....
1-T	2.74	0.181	*6.62*	2.84	0.201	*7.07*	0.020	*11.05*	....	....	....
1-P	3.07	0.248	*8.09*	3.30	0.270	*8.18*	0.022	*8.87*	....	....	....
2-T	2.78	0.184	*6.63*	3.06	0.211	*6.89*	0.027	*14.67*	....	....	....
2-P	2.82	0.190	*6.73*	2.83	0.211	*7.38*	0.021	*11.05*	....	....	....

deawned heads showed a smaller percentage increase than the totally deawned heads. (Fig. 21.)

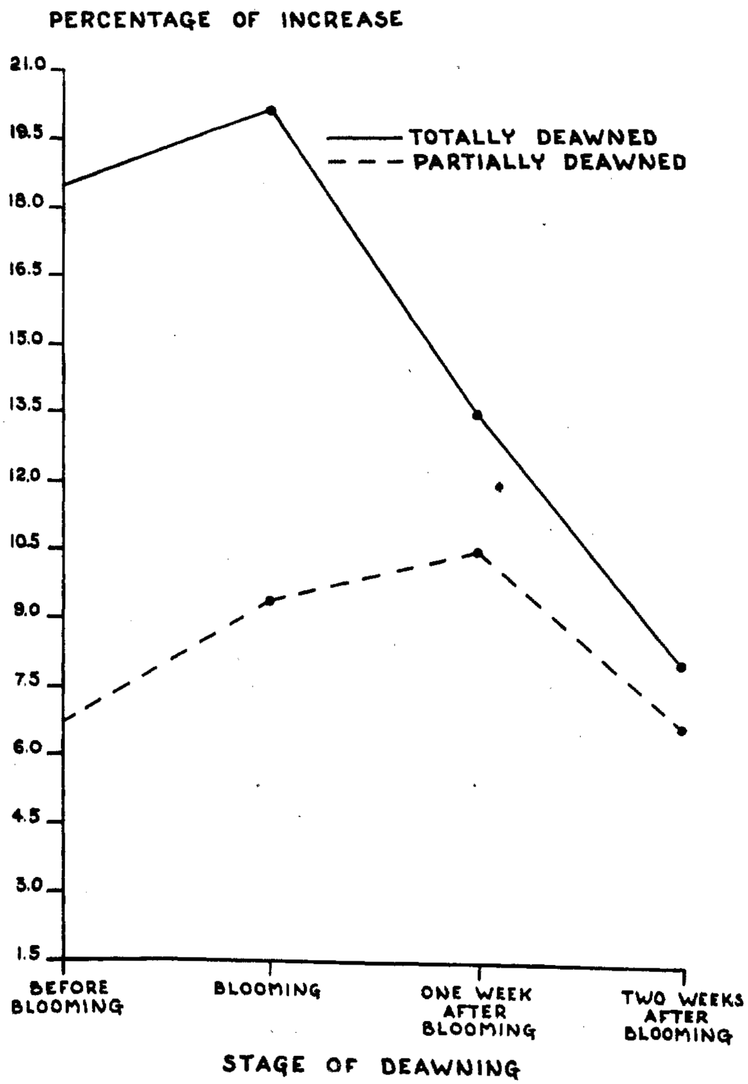

FIG. 21.—Percentage increase in the weight of ash in the rachises of 100 each of the totally and partially deawned heads at four stages of development as shown by the grand weighted average (Table 21).

SUMMARY

1. Varieties Studied.—Seven varieties of awned or bearded wheats were grown in different rows at Manhattan, Kansas, during the growing seasons of 1935-'36, 1936-'37; and 1937-'38 for determining some of the effects of the removal of the awns. The varieties grown were all red winter wheats and included Kanred, Tenmarq, Early Blackhull, Turkey, Kanred X Hard Federation, Kawvale and Fulcaster. The last named is a soft wheat, Kawvale is a semihard wheat, and the first five named are hard wheats.

2. Methods of Labeling.—At or before the "boot stages," two stalks of the same or different plants were selected and to one of these a tag was attached that distinguished it as a control stalk. A tag was attached to the other stalk that designated it as an experimental stalk. This process of tagging was repeated until 150 each of the control and experimental stalks were labeled. The process of tagging was repeated at four stages of development of the seven varieties of wheat used. There were tagged during each growing season approximately 16,800 plants or 50,400 for the experiments during the three years.

3. Methods of Deawning.—The heads of the experimental plants were deawned in two ways: (a) Those totally deawned, which involved severance with small pointed scissors of all the awns of the head as well as the beaks of the outer glumes, and (b) those partially deawned, which involved complete severance by the same method of only one-half of the awns of the head. Care was exercised that the clipping did not damage the plants beyond removing the awns.

4. Stages of Deawning.—The awns were removed from the heads of the experimental stalks at four different times: (a) Before blooming, at which time the head was fully out of the "boot," this was from four to seven days previous to blooming, (b) at blooming, (c) one week after blooming, and (d) two weeks after blooming.

5. Tagged Plants Recovered.—The dates on which the plants were harvested and the number of experimental plants recovered at each of the four stages at which deawning was performed were recorded. The number of plants recovered varied from 92 to 150 but the average of the seven varieties for the 24 different experiments ranged from 112 to 146. The failure to recover all of the 150 tagged stalks was due to lodging, failure to locate the stems, and to other unavoidable factors. As many plants were recovered as possible of the 150 tagged stalks in each case because the more specimens that were recovered the more representative the results were assumed to be.

6. Methods of Separating and Studying.—Each lot of spikes was threshed separately by hand in a small head thresher. In certain of the experiments with the varieties Kanred and Tenmarq the heads or spikes were separated into grain, chaff (glumes), awns, and rachises.

7. Climatic Data.—The precipitation is given for each month of each year and for the 81-year period ending 1938, with the annual rainfall expressed in inches. Likewise the mean, maximum, and minimum temperatures are given for each month of the four years and the average for the 47 years for which records are available.

8. Weight of Grain from 100 Heads.—Total and partial deawning in general decreased the weight of grain as determined from a study of 100 heads. Partial deawning as a rule decreased the weight of grain by approximately one-half that of the totally deawned. The decrease in the weight of grain was usually greatest when the heads were deawned before blooming. The effects of deawning tended to be less and less as the length of time increased following the deawning.

9. Effect on Weight of 1,000 Kernels.—Total and partial deawning generally decreased the weight of 1,000 grains. In total deawning there were only two of the 82 experiments in which there was an increase in the weight of 1,000 grains over the same number from the controls. When the heads were partially deawned, there were 11 cases of the 82 where there was an increase in the weight of 1,000 grains from the experimental plants over that of the same number of grains from the controls. There was one case in which there was no change in weight so that between 84 and 85 percent of the experiments with partially deawned heads showed a decrease in the weight of 1,000 grains over the dry weight of the same number of grains from the control heads. The decrease in the weight of 1,000 grains represents approximately 50 to 80 percent of the decrease in yield due to deawning. This shows that the effects of both total and partial deawning are not manifest alone in the weight of the grain but other effects must also be prominent.

10. Grains per Head.—The number of grains produced by 100 heads was determined for plants that had been totally, and partially deawned. The number of grains formed was reduced by both types of deawning. The more striking reductions were obtained when the heads were totally deawned. The earlier the deawning was performed, the greater the reduction in the number of kernels. Thus deawning that was performed before blooming brought about the greatest reduction in the number of grains, whereas the process performed two weeks after blooming showed little or no influence on the number of grains produced.

11. Ash Increase.—There was no percentage increase in the ash of the grain for either the totally or partially deawned heads.

12. Effect of Partial Deawning.—During each of the three years the effects of partial deawning were studied in relation to changes in the nature of the grain produced from the same head. The three changes studied were: (a) The effect on the weight of grain from the awned parts of 100 heads, (b) the weight of 1,000 grains from each part of the heads, and (c) the number of grains produced in the deawned and in the awned portions of 100 heads. This phase of the study involved only two varieties, viz., Turkey and Kawvale. The number of varieties was limited to two because of the labor involved in threshing the seed from the two portions of the heads.

13. Deawning Reduced Weight of Grain per Head.—There was always a decrease in the weight of grain that was produced by the deawned portion of 100 heads as compared to the intact portions of the same heads. The percentage decrease was obtained by dividing the decrease in weight of the deawned portion by the weight of the grain from the intact portions of the same 100 heads. The decrease obtained amounted to as much as 46.48 percent and as little as 4.10 percent. The differences although varying somewhat with the stage at which the deawning occurred, were approximately one-half of the maximum for the variety Turkey and for the variety Kawvale. As a rule, the earlier the deawning was performed, the greater the percentage decrease in the weight of the grain produced.

14. Deawning Reduced the Weight of 1,000 Grains.—The weight of 1,000 grains from the deawned portions of the heads of the two varieties Turkey and Kawvale, with one exception, was less than the weight of 1,000 grains obtained from the intact portions of the same heads. The exception was for the variety, Kawvale, in 1937, when deawning was performed two weeks after blooming. In that case, however, the increase amounted to only 0.5 grams, or 1.75 percent, of the grain produced by the intact parts of the heads. The percentage decrease was greater in amount on the average the earlier the deawning was performed. Thus the grand weighted average of the percentage decreases for the three years was 11.15, 9.37, 4.37, and 2.33, respectively, for the four stages of deawning.

15. Decrease of Grains per Head.—A study was made of the percentage decrease of the number of grains produced in the deawned portions of 100 heads relative to intact portions of the same heads. It was found that there were fewer grains produced in the deawned portions than in the intact portions of the same heads. It was found also that the decrease in the number of grains formed varied markedly between the two varieties. Generally, the number of grains produced by the deawned spikelets of Turkey was 2.5 times greater than the deawned spikelets of the variety Kawvale. It was also found that the decrease in the number of grains in the deawned parts of the heads became greater the earlier the process of deawning was performed.

16. Effects of Deawning on Weight of Glumes.—The effects of total and partial deawning on the weight of the glumes of 100 heads were determined during the three years for the two varieties Kanred and Tenmarq. In most cases the weights of the glumes were increased in both of these varieties by both total and partial deawning of heads. The glumes of Kanred showed a decrease in weight twice in the 24 observations of that variety, five times in the 24 observations on Tenmarq.

17. Ash Content of Glumes as Result of Deawning.—The amount of ash in grams and in percentage by weight was determined each of the three years at the four stages at which deawning was performed for Kanred and Tenmarq. Except in two cases the results showed slight increase over the controls. One of the exceptions was in 1938 with the variety Kanred, for the stage two weeks after blooming, and the other was in 1936 with the variety Tenmarq for the deawning stage one week before blooming.

18. Weight of Awns.—The effect of partial deawning on the weight of awns from 100 heads was studied at the four stages during the three years for the varieties Kanred and Tenmarq. The results show that in one-third of the cases with Kanred and in over one-half those with Tenmarq the awns on the unclipped side of the head weighed less than the controls. The decreases in the weights of the awns were so well scattered throughout the various stages of deawning during the three years that one is forced to conclude that the weight of the awns was not increased in the partial deawning of these heads at the four stages at which deawning was performed. The average weight during the years 1936 and 1938 was greater than the controls in all cases as the grand weighted average for the three years shows.

19. Weight of Ash in Awns.—The influence of total and partial deawning on the weight of ash in the awns of 100 heads was studied. The results are striking in that, with one exception for Kanred and two for Tenmarq, the results show that the percentage of ash in the awns on the deawned portion of the heads is always more than the percentage of ash in the controls. The increase of the amount of ash in the awns is one of the most striking results of deawning. This fact has been reported by many of the investigators who have worked on the effect of deawning on the physiology of the cereals.

20. Effect of Deawning on Weight of Rachises.—The effects of total and partial deawning on the weight of the rachises of 100 heads were studied for the three years and for the four different stages at which deawning was performed. The rachises of the variety Kanred decreased in weight in one-third of the 24 cases, while in Tenmarq there were five cases out of the 24 in which there was a decrease in the weight of the rachises and two cases in which there was no change at all. Thus in more than two-thirds of the cases the weight of the rachises was increased by the deawning of the heads.

21. Ash in Rachises as Affected by Deawning.—There was an increase in the weight of the ash of the rachises with exception of four of the 24 cases of Kanred and only one of the 24 in Tenmarq and the results in these five exceptions were slight.

22. Conditons under which Experiments were Performed.—The results reported herein were observed under the conditions of a specific method of deawning, temperature, moisture and numerous other factors that prevailed when the experiments were performed and the results taken. They may vary markedly if the conditions under which they are conducted are varied. These results thus hold only for the conditions of this experiment.

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