DEVELOPMENT OF THE STAMINATE AND PISTILLATE INFLORESCENCES OF SWEET CORN[1]

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INTRODUCTION

Studies of the morphology of the corn plant have led, according to Weatherwax (*17*),[2] to clearer and simpler explanations of the results of certain experiments with corn. It should be expected that further studies of the developmental morphology might prove to be equally helpful. Variations from the normal sequence of development which lead to abnormalities of the tassel and ear and variations in such characters as length of ear, number of rows of kernels on the ear, irregularities in the straightness of the rows of kernels, and correlation in the development of the ears of multiple-eared types, to mention a few examples, can be better understood by studying the developmental morphology. By means of frequent observations during the development of the growing points it is possible to see whether the variations observed in the mature plant are the result of variation in the pattern of differentiation and development or are the result of growth responses to changes in the environment.

While excellent descriptions of the morphological development of certain of the parts of the inflorescences have been written, some of which will be cited later, few workers have attempted to describe and illustrate all of the steps in the ontogeny of the staminate (tassel) and pistillate (ear) inflorescences. In this paper the major steps in the development of the tassel and ear from the undifferentiated growing points of the shoots to the fully differentiated flowers and flower parts are described and illustrated with photomicrographs.

LITERATURE REVIEW

Only a few of the publications dealing with the morphology of the corn plant will be reviewed. Most of the authors cited have made extensive reviews of the literature. In this connection special attention is called to the publications of Weatherwax (*15*), Miller (*8*), Randolph (*11*), and Arber (*1*).

The general morphology of the tassel and ear of the corn plant has been described by Collins (*5*), Weatherwax (*15, 16, 18*), and Arber (*1*). A clear understanding of the development of the pistillate spikelet is given by Miller (*8*), and Randolph (*11*) has described and illustrated the development of the pistillate spikelet and the caryopsis. Schuster (*12*) has described and illustrated some of the early stages of spikelet development.

Noguchi (*9*) is the only one of those cited who has described some of the beginning stages in the development of the ear and tassel, and he has illustrated a few of these stages with drawings.

[1] Received for publication May 22, 1939.

[2] Italic numbers in parentheses refer to Literature Cited, p. 36.

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Descriptions of many-flowered spikelets, seeds in the tassel, and other variations from normal development in the inflorescences have been published by Kempton (*6*), Stratton (*13*), and Weatherwax (*18*).

MATERIALS AND METHODS

First-generation hybrids, Golden Cross Bantam (Purdue Bantam 39 × Purdue 51) and a Country Gentleman hybrid (Illinois 8 × Illinois 6) were used in these studies. Sweet corn (*Zea mays* var. *rugosa* Bonafous) was used because it could be easily grown in the greenhouse and, with an early-maturing type like Golden Cross Bantam, it was possible to get the various stages of development in a relatively short time. Another reason for using hybrids was that there would probably be less variation in development among individual plants which would make it easier to follow the developmental sequences.

In a study of the developmental morphology of the caryopsis, Randolph (*11*) found no significant differences among dent, flint, and sweet corn. Likewise, no essential differences were noted in the morphological characteristics of the inflorescences of dent and sweet corn. Therefore, it seems reasonable to expect that whatever is found out regarding the ontogeny of the inflorescences of sweet corn would also apply to dent corn.

The corn plants were grown in the greenhouse, without artificial lights, in glazed 2-gallon gars, filled with a mixture of sand, soil, and well-rotted stable manure.

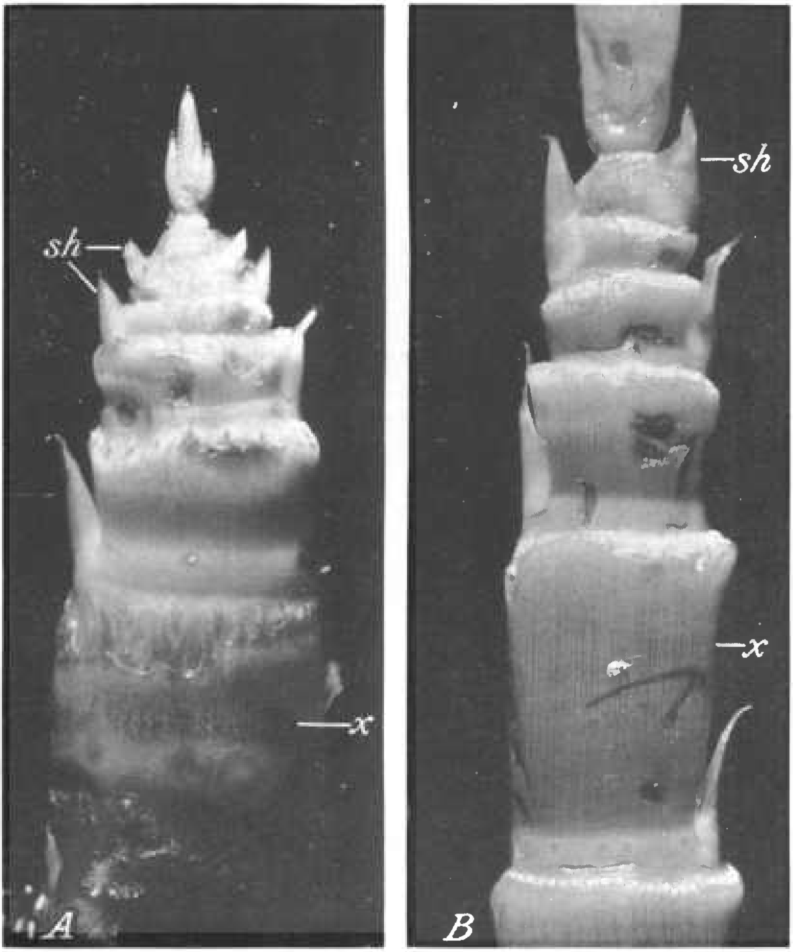
Growing points at successively later stages of development were removed from the plants and photomicrographs were taken. The photographic set-up was essentially the same as one already described (*2*). Photomicrographs were taken with an upright camera and special microlenses having focal distances of 16, 24, 32, and 48 mm. Light for photographing was obtained from a microscope lamp fitted with a 200-watt bulb. A Florence flask filled with distilled water was used as a condenser.

In order to bring out the morphological details in some of the specimens, a stain composed of a mixture of 90-percent alcohol, a small amount of glycerin, and basic fuchsin was applied. The alcohol quickly evaporated, leaving the stain and glycerin in the folds of the various structures which made them more easily seen.

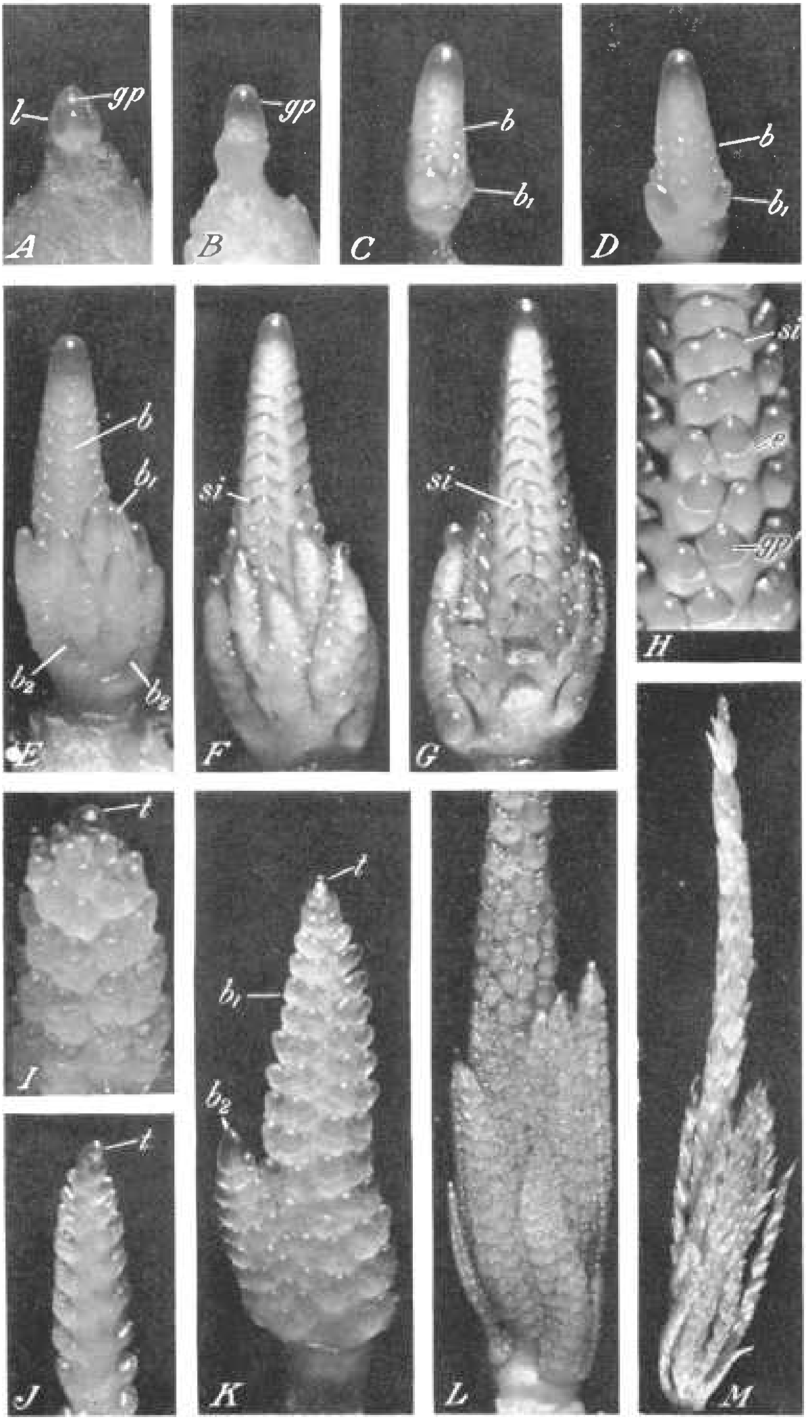
DEVELOPMENT OF THE INFLORESCENCES

Usually when the plants had 8 to 10 leaves, the ear shoot and tassel had begun to form (fig. 1). However, the number of leaves that a plant has is not a reliable guide to the stage of development of the inflorescence. Plants with the same number of leaves may differ to a considerable extent in the degree of development of the growing points owing to differences in growing conditions, differences in variety, and other factors.

Tassel and shoot development in a plant that was at the same stage of development as those shown in figure 1 is illustrated in plate 1, *A*. The tassel has formed, the axillary shoots from which the ears will develop (pl. 1, *A*, *sh*, and *B*, *sh*) can be seen on the upper part of the stem, and the basal internodes of the stem have begun to elongate (pl. 1, *A*, *x*, and *B*, *x*).



Stems of Golden Cross Bantam sweet corn with leaves removed to show the tassel, shoots, nodes, and internodes. *A* is an earlier stage than *B*; *x*, Internodes; *sh*, axillary shoot. × 5.



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TASSEL AND STAMINATE SPIKELET DEVELOPMENT

The shoot of the corn plant, like that of other cereals (*2, 3, 4*) and grasses (*20*), passes through two stages in its development from germination to the dehiscence of the anthers. During the first stage, leaf fundaments, leaves, and axillary shoots are produced and the internodes of the stem remain short. During the second stage the internodes of the stem elongate, the tassel and its parts differentiate and develop, and the axillary shoot or shoots (ear or sucker) pass through their various stages of development.

Two growing points (pl. 2, *A* and *B*) represent the appearance of the shoot in the first stage of development. The growing point (pl. 2, *A*, *gp*) is partly enclosed by two leaf initials. At this stage of development the growing point is much smaller in relation to the diameter of the stem than the growing point of either wheat, oats, or barley at a similar stage of development.

Two processes, which occur simultaneously, indicate the beginning of the second stage of development. (1), The internodes of the stem begin to elongate (pl. 1, *A*, *x*, and *B*, *x*), and (2) the growing point elongates in preparation for the differentiation of the tassel and its parts. During the second stage the growth activities are internode elongation and the differentiation of the tassel and its parts. Tassel development is completed when the anthers dehisce.

Branch primordia are the first of the tassel parts to differentiate (pl. 2, *C*, *b*, and *D*, *b*). They arise in acropetal succession as lateral projections from all sides of the elongated central axis. Some of the branch initials at the base of the central axis elongate and become the lateral axes of the tassel (pl. 2, *E*, b_1). The other initials arising from a point higher on the central axis are the initials from which the spikelet initials originate (pl. 2, *C*, *b; D*, *b; E*, *b; F*, *si* and *G*, *si*).

It should be noted that, in the early stages of development of the tassel, so far as external appearances indicate, there are no differences between those initials that become the lateral branches of the first order and those from which the spikelet initials differentiate. Therefore all of the first initials to appear are branch initials.

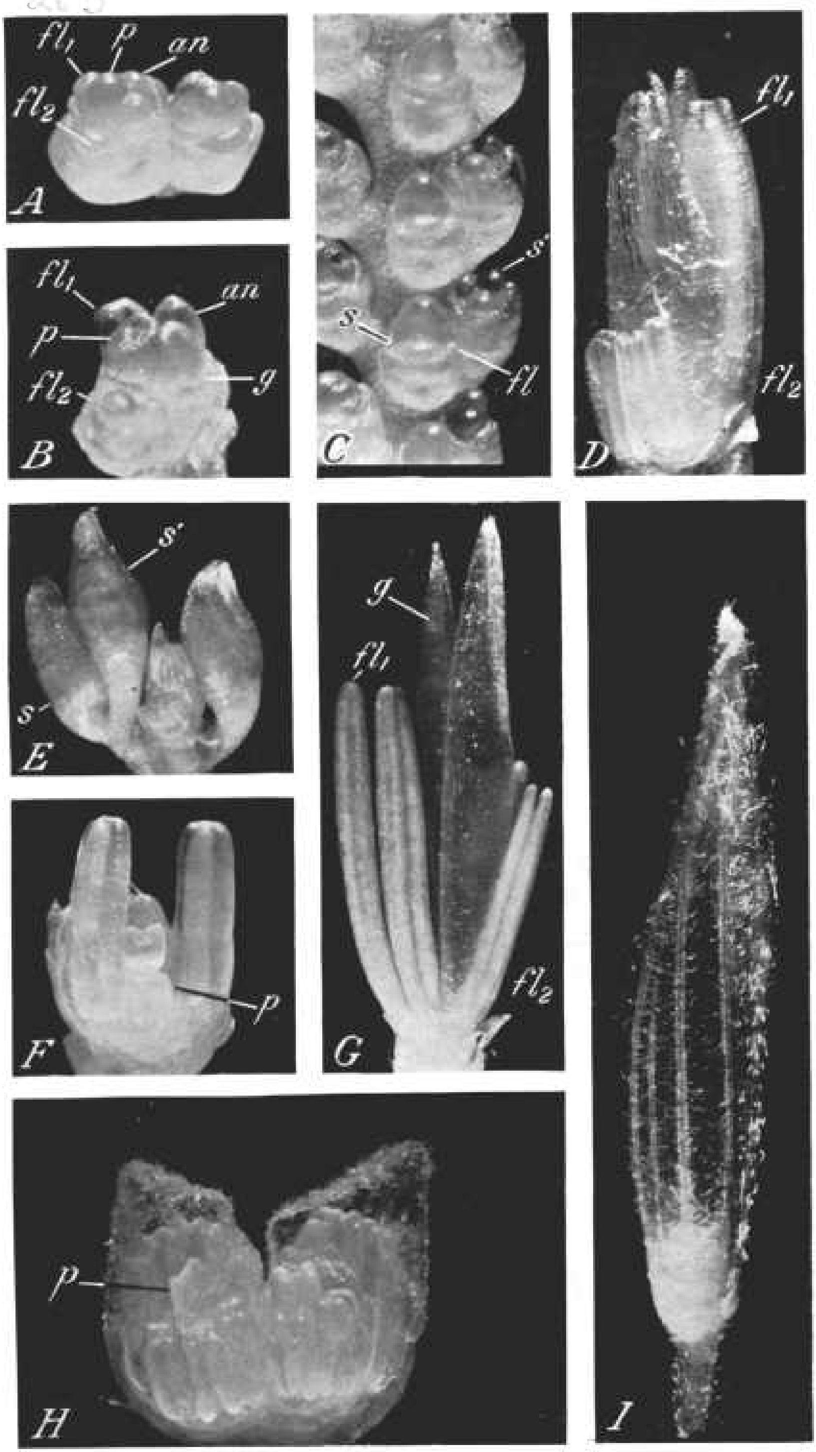
EXPLANATORY LEGEND FOR PLATE 2

A.—Growing point of a corn plant having four leaves visible. × 22.
B.—Beginning of the elongation of the growing point just before tassel differentiation. × 22.
C and *D*.—Differentiation of the branches of the tassel × 22.
E.—Elongation of the basal branches of the tassel. × 22.
F.—Beginning of the differentiation of the spikelet initials on the central axis of the tassel. × 22.
G.—A stage similar to *F* with some of the basal branches removed to show spikelet differentiation on the central axis. × 22.
H.—Differentiation of spikelets and empty glumes on a portion of the central axis of the tassel. × 35.
I.—Portion of the tip of the central axis of the tassel. × 25.
J.—Adaxial side of a branch of the tassel. × 22.
K.—Abaxial side of tassel branches of the first and second orders. × 25.
L.—A more advanced stage of tassel development. × 22.
M.—Fully differentiated but not full-sized tassel. × 8.
b. Branch initial from which spikelets differentiate; b_1, basal branch of the first order; b_2, branch of the second order; *e*, empty glumes; *gp*, growing point; *gp'*, growing point of the spikelet; *l*, leaf initial; *si*, spikelet initial; *t*, undifferentiated tip of an axis.

FIGURE 1.—Plants of Golden Cross Bantam sweet corn at the same stage of development as the dissected plants shown in plate 1, A and B.

As has been described for oats (*4*), branches of the second order may rise by budding from the base, and at the lateral margins, of the branches of the first order (pl. 2, *E*, b_2, and *K*, b_2). As has already been stated for the central axis, those initials of the lateral axes above the most basal ones are the primordia from which the spikelet initials differentiate.

In studies made on barley, wheat, and oats (*2*, *3*, *4*) there was always an indication of leaf fundaments on the central axis in the axils of which the lateral shoots of the inflorescence were formed. There is, however, no indication of leaf fundaments subtending the initials



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of the lateral shoots of the tassel, but, as will be pointed out later, there are structures apparently homologous with leaf initials, subending the lateral shoots of the ear (pl. 4, *C, l*).

All the branches of the tassel are indeterminate. Neither the central axis (pl. 2, *I, t*) nor the lateral axes (pl. 2, *J, t*, and *K, t*) of the tassel terminate in apical spikelets. Primordia from which the spikelet initials differentiate are produced acropetally as long as the axes increase in length.

In the beginning of spikelet development the branch initial divides into two unequal parts, the spikelet initials (pl. 2, *F, si; G, si;* and *H, si*). The spikelet that develops from the larger spikelet initial is pediceled (pl. 3, *E, s'*) and the spikelet from the smaller spikelet initial is sessile (pl. 3, *E, s*). The larger initial is always in advance of the smaller in its development. This is shown by the beginning of development of the empty glume on the larger initial in plate 2, *H, e*, and the lack of such development in the smaller initial and by the beginning of anther differentiation in the larger spikelet in plate 3, *C, s'*, and the lack of anthers in the smaller spikelet plate 3, *C, s*.

Several of the early stages of development of the spikelets can be seen in plate 2, *H*, which shows a group of spikelets from the central axis of the tassel. The stages of development beginning at the top of the photograph range from an undifferentiated lateral shoot initial, through the various stages of division into spikelet initials, to the beginning of development of the empty glumes. The empty glumes are the first of the spikelet parts to form and are first seen as transverse ridges across the spikelet initial (pl. 2, *H, e*). They grow in length and finally enclose the flowers (pl. 3, *I*).

Spikelet initials develop from all sides of the central axis of the tassel (pl. 2, *G*) but only on the abaxial side of the lateral branches. The abaxial side of branches of the first and second order are shown in plate 2, *K*, b_1, b_2, and the adaxial side of a branch is shown in plate 2, *J*. Two rows of lateral shoot primordia develop and they divide into two pairs of spikelet initials.

At any stage of development the central axis of the tassel is in advance of the branches (pl. 2, *F, L*, and *M*). This is what should be expected since the central axis is formed first and the branches

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EXPLANATORY LEGEND FOR PLATE 3

A.—Two spikelets of the tassel at the beginning of the development of the flower parts of the upper flowers and the more advanced stage of development of the spikelet at the left. × 56.

B.—Two flowers of a spikelet of the tassel showing the more advanced stage of development of the upper flower. × 56.

C.—Part of a branch of the tassel showing a more advanced stage of development of the pedicled spikelet. × 40.

D.—Staminate spikelet with the empty glumes removed to show the difference in the size of the anthers of the upper and lower flower. × 20.

E.—Two pairs of spikelets, one member of each pair is pediceled and the other sessile, the empty glumes have been removed from one spikelet. × 25.

F.—Staminate flower with one anther removed to show the partly developed pistil. × 20.

G.—Later stage of spikelet development in which the anthers of the lower flower are approaching the size of those of the upper flower. × 10.

H.—Pair of spikelets both sessile. × 28.

I.—Fully differentiated spikelet. × 10.

an, Anther; *fl*, flower initial; fl_1, upper flower; fl_2, lower flower; *g*, palea; *p*, pistil; *s*, sessile spikelet; *s'*, pediceled spikelet.

differentiate from it. The branches increase considerably in size before the initials from which the spikelets differentiate are produced.

In each staminate spikelet two flowers develop from the meristem located above the empty glume initials (pl. 2, *H*, *gp'*). The meristem divides into two unequal parts. The larger part gives rise to the upper flower (pl. 3, *A*, fl_1, and *B*, fl_1) and the smaller part develops into the lower flower (pl. 3, *A*, fl_2, and *B*, fl_2. These flowers differ in their rates of development. The anthers of the upper flower (pl. 3, *A*, fl_1; *B*, fl_1; *D*, fl_1; and *G*, fl_1) differentiate first and in their development are always ahead of the corresponding parts of the lower flower (pl. 3, *A*, fl_2; *B*, fl_2; *D*, fl_2; and *G*, fl_2). As the flowers approach maturity the anthers of the lower flower attain nearly the same size as the anthers of the upper flower (pl. 3, *G*, fl_1, and fl_2).

Anther initials are the first of the flower parts to differentiate (pl. 3, *A*, *an*, and *B*, *an*). Since the tassel flowers are staminate, anther differentiation and development are the principal growth activities within the flower.

Pistils may develop from the meristem located above the anther initials (pl. 3, *A*, *p*) but they usually remain rudimentary (pl. 3, *B*, *p*). Under certain conditions of growth the pistil may show considerable development (pl. 3, *F*, *p*) and may become fully developed and functional (pl. 7, *E*, *p*).

Flowering glumes develop for each flower, but they are so thin (pl. 3, *G*, *g*) that they are difficult to distinguish at the beginning of their development. The lemma and palea begin their development as thin ridges at a point on the meristem just below the anther initials (pl. 3, *B*, *g*) at about the same time that the anther initials begin to differentiate.

Deviations from the normal development under field conditions are often seen in plants grown in the greenhouse. Normally one spikelet is sessile and the other pediceled (pl. 3, *E*), but both spikelets may be sessile (pl. 3, *H*). Another type of deviation which will be described later is the development of functional pistils in the tassel.

EXPLANATORY LEGEND FOR PLATE 4

A.—Axillary shoot in which the ear develops, enclosed in the prophyllum. × 13.

B.—Side view of an axillary shoot. × 17.

C.—Beginning of the differentiation of the ear. × 25.

D.—Ear development showing a more advanced stage of branch differentiation. × 25.

E.—Beginning of spikelet differentiation by an unequal division of the branch initials. × 22.

F.—Development of the empty glumes. × 22.

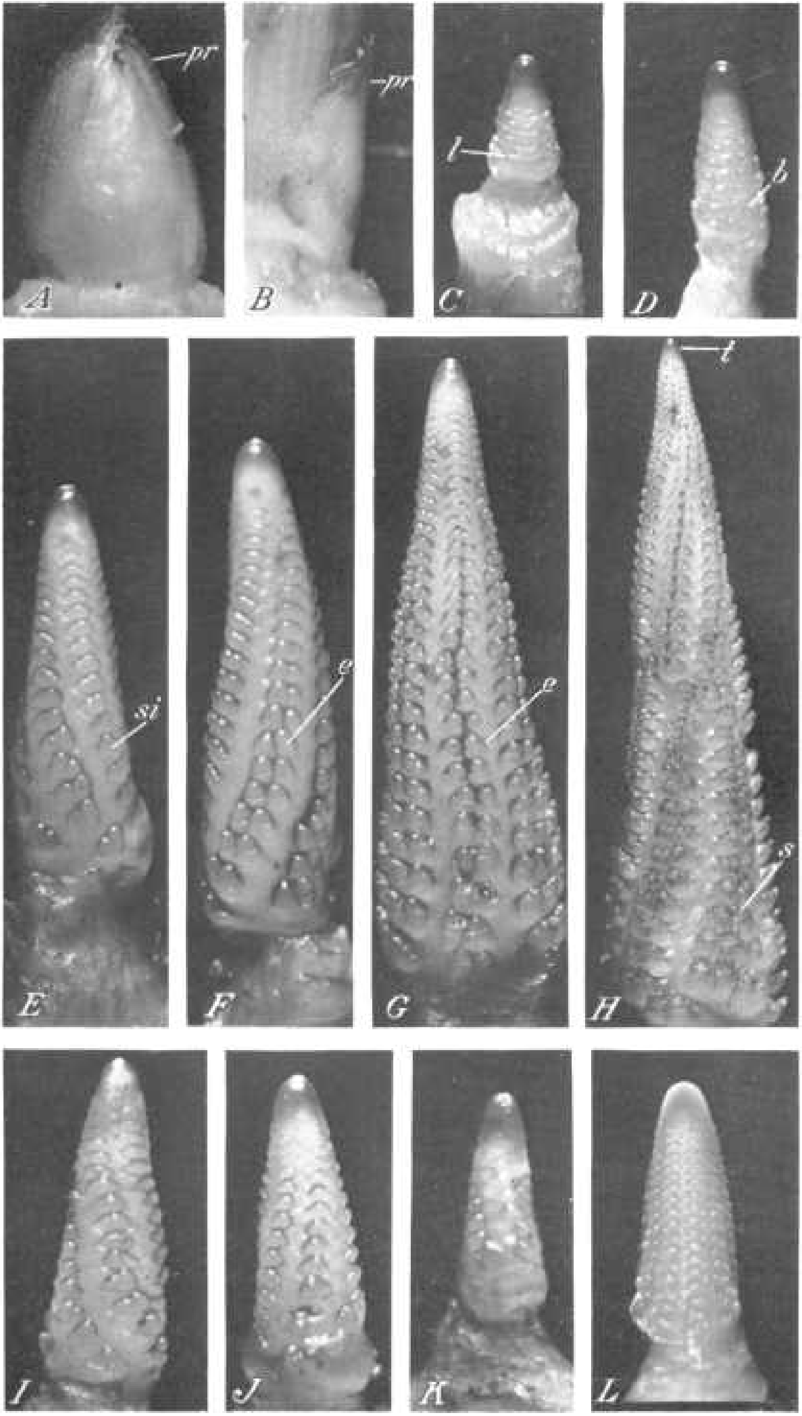
G.—Paired rows of the ear and a more advanced stage of the development of the empty glumes. × 17.

H.—The differentiation and development of the silks can be seen at the base of the ear. × 17.

I, *J*, and *K*.—Topmost, second, and third ears, respectively. All × 22.

L.—Young ear of Country Gentleman sweet corn. × 17.

b, Branch initial from which spikelet initials differentiates; *e*, empty glumes; *l*, leaf fundament; *pr*, prophyllum; *si*, spikelet initial; *s*, silk initial; *t*, undifferentiated tip of the ear.



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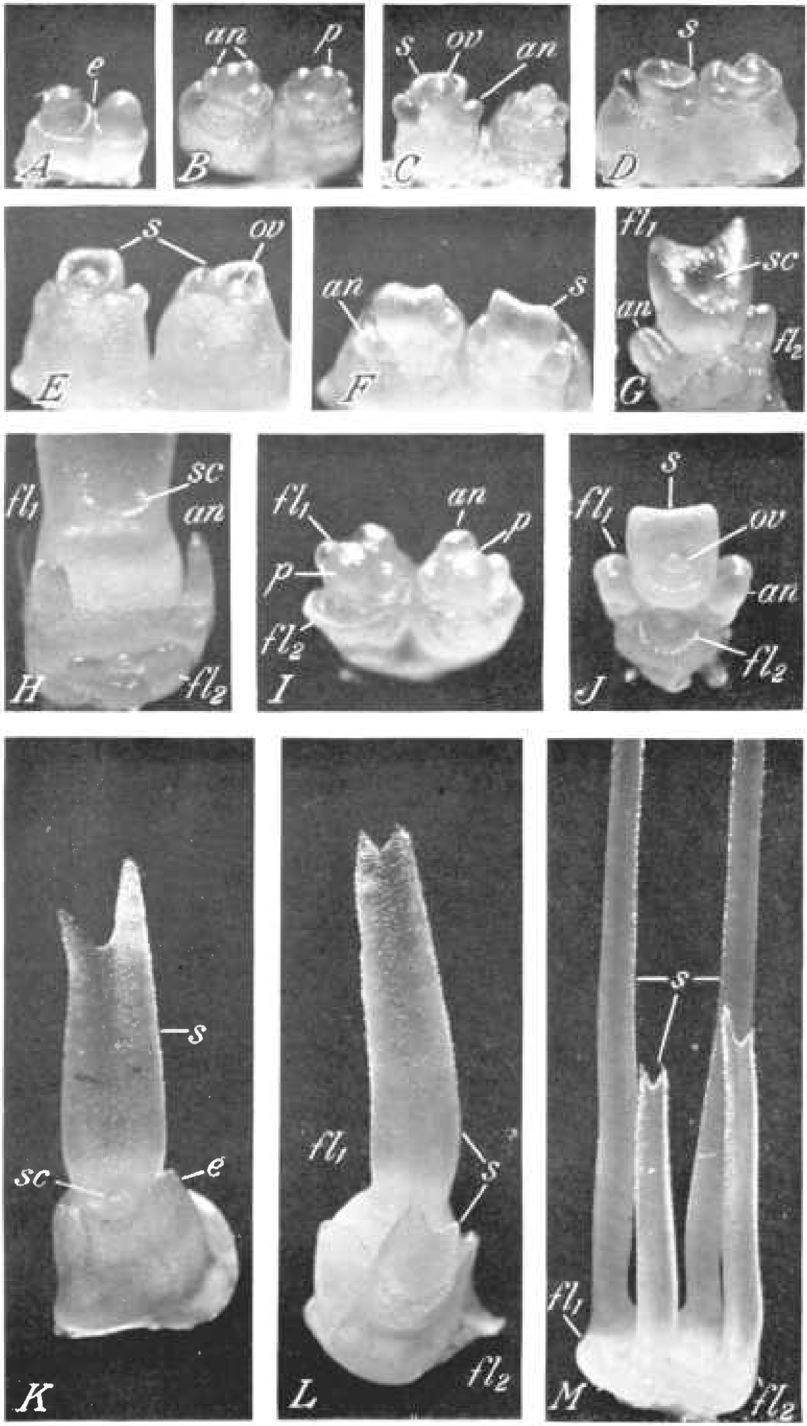

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EAR AND PISTILLATE SPIKELET DEVELOPMENT

In the early stage of stem development a shoot is produced in the axil of each leaf (pl. 1, *A*, *sh*, and *B*, *sh*), but at a later stage of development axillary shoots are no longer produced. The cessation of axillary shoot development seems to be associated with the elongation of the internodes of the stem and the development of the tassel. This is in agreement with observations made by Percival (10) on the cessation of axillary shoot (tiller) development in wheat and the same thing has been observed regarding axillary shoot development in barley.[3]

Ears develop from the upper one or more axillary shoots of the stem. Those shoots formed at the base of the stem may remain nonfunctional or develop into suckers. If an examination is made at the time the topmost shoots are producing ear initials, it will be found that the growing points of the basal shoots are producing only leaf fundaments; but they are more and more advanced in development from the base to the top of the stem.

Axillary shoots develop in acropetal succession and during the early stage of stem development the axillary shoots became larger in succession from the apex to the base of the stem (pl. 1, *A*). Later when the ears begin to develop, the size sequence changes, so that the topmost shoot is the largest and the shoots become smaller from the top to the base of the plant (pl. 1, *B*). The topmost shoot or the topmost two or three shoots, depending upon whether they are single- or multiple-eared types, in turn take precedence in their development or they may inhibit the development of the shoot immediately below. This difference in development is shown by the size of the ear initials in plate 4, *I*, *J*, and *K*, which are the ear initials from the topmost, second, and third shoots, respectively.

[3] BONNETT, O. T. TILLERING IN BARLEY AS INFLUENCED BY CERTAIN PLANT CHARACTERISTICS. 1933. (Abstract of doctor's thesis, Univ. Ill.)

EXPLANATORY LEGEND FOR PLATE 5

A.—Pair of pistillate spikelets at an early stage of development. × 40.

B.—Beginning of the differentiation of anthers in the upper flower of a pair of spikelets. × 40.

C.—Differentiation of a silk, the first stage of pistil development. × 40.

D.—Silk development. × 40.

E.—Silks partly enclosing the ovules. × 40.

F.—Silk development from the adaxial side. × 40.

G.—Spikelet showing the comparative development of the upper and lower flowers. × 40.

H.—Functional upper flower and a sterile lower flower of the spikelet are illustrated. × 40.

I.—Pair of spikelets of Country Gentleman at an early stage of development. × 40.

J.—Spikelet of County Gentleman comparing the development of the functional upper and lower flowers. × 40.

K.—Silk development of the functional flower of a spikelet having only one functional flower. × 28.

L.—Comparison of the silk development of the lower and upper flowers of a spikelet having two functional flowers. × 28.

M.—A more advanced stage in the development of spikelets having two functional flowers. × 10.

an, Anther initial; *e*, empty glumes; fl_1, upper flower; fl_2, lower flower; *ov*, ovule; *p*, pistil initial; *s*, silk initial; *sc*, stylar canal.

The axillary shoot is enclosed in a strongly keeled prophyllum (pl. 4, *A*, *pr*, and *B*, *pr*) which may be entire or divided. Leaf initials that develop into the husks are covered by the prophyllum.

Ear differentiation is indicated by an elongation of the growing point of the axillary shoot and the differentiation of lateral projections from the central axis of the ear initial (pl. 4, *C*, and *D*). The lateral projections are the initials from which the spikelet initials differentiate and correspond to the initials that first appear on the central axis and branches of the tassel. Subtending each initial, as has already been mentioned, are ridges (pl. 4, *C*, *l*) which are similar to the subtending leaf initials that appear in the differentiation of the inflorescences of barley, oats, and wheat. These ridges increase in size and form the cuplike depressions in which the spikelets occur (pl. 6, *B*, *x*).

Spikelet initials are produced in pairs by the division of the preceding initial into two unequal parts (pl. 4, *E*, *si*). While the parts of the larger of the pair of spikelet initials begin to differentiate before those of the smaller spikelet initial, the difference in their development is not so great as was pointed out for the spikelet initials of the tassel.

The empty glumes are the first of the spikelet parts to form and can be seen as transverse ridges across the spikelet initial (pls. 4, *F*, *e*, and 5, *A*, *e*). More advanced stages of development of the glumes are shown in plate 4, *G*, *e*. As the empty glumes increase in length, they enclose the ovary, but the silk extends beyond them (pl. 5, *K*, e).

Straightness of row and the number of rows of kernels per ear are characteristics of the ear that are determined when the spikelets differentiate. Variations in the straightness of row can be seen in plate 4, *E*, *F*, *G*, and *H*. The rotation to the left or right (pl. 4, *E* and *F*) and the regularity or irregularity in the placement of the spikelets (pl. 4, *G* and *H*) can be seen. Row number is determined by the number of rows of branch initials around the ear initial (pl. 4, *D*, *b*) from which a pair of spikelets differentiates. Each spikelet has a fertile flower from which the kernels are produced.

The ear as well as the tassel is indeterminate in its growth and continues to elongate at the tip (pl. 4, *H*, *t*), but many of the flowers at the tip of the ear remain rudimentary (pl. 6, *C*, *t*). Since the spikelets arise in acropetal succession they are successively younger from the base to the tip of the ear (pl. 4, *G* and *H*).

Two flower initials are produced in each spikelet, but in most corn varieties only one flower is functional. In a few types like Country Gentleman sweet corn both flowers are functional.

The two flowers of the ear develop from an unequal division of the meristem of the spikelet just as was pointed out for the flowers of the tassel. The flower differentiating from the larger mass of meristem

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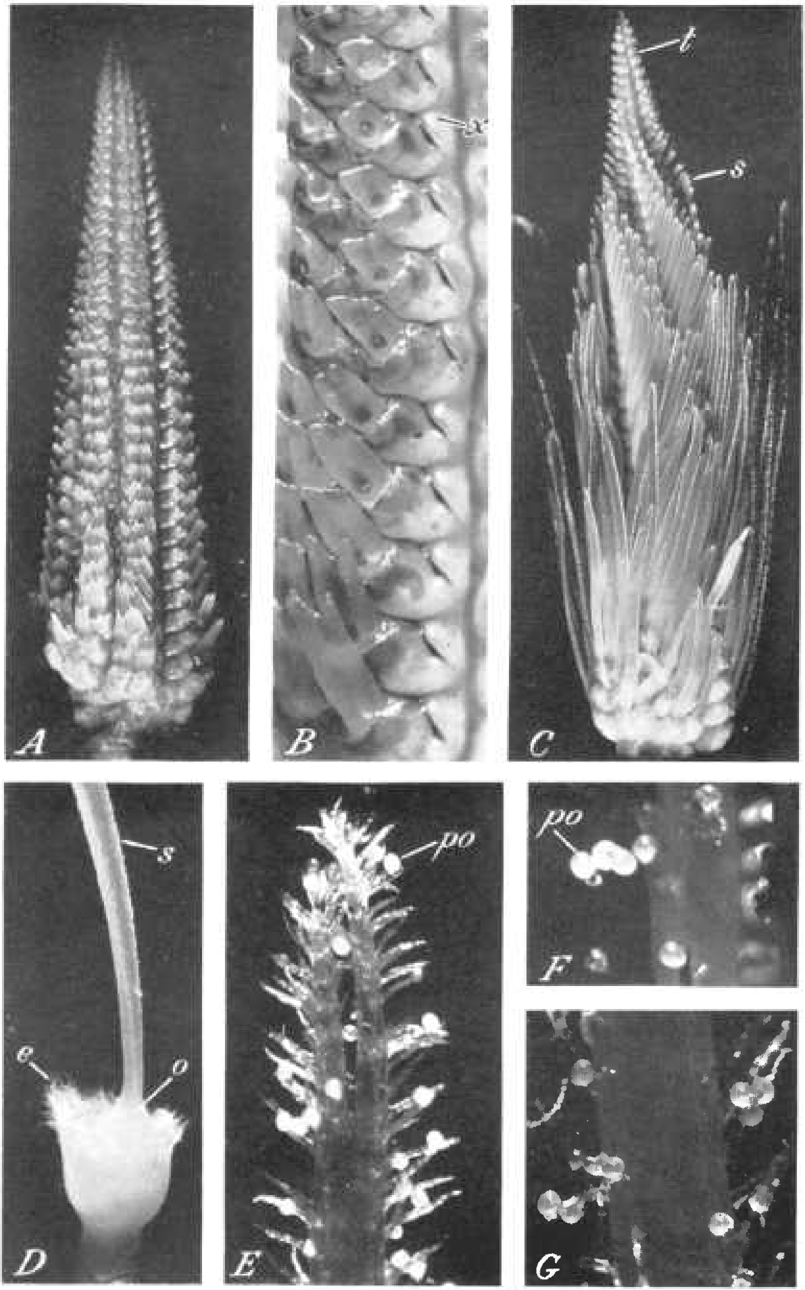
Explanatory Legend for Plate 6

A.—Ear showing different stages of silk development. × 6.5.
B.—Section of an ear. × 19.
C.—Variation in silk development. × 6.5.
D.—Pistil from the tassel. × 14.
E.—Tip of a mature silk with pollen grains germinating on it. × 26.
F and *G*.—Pollen grains germinating on the silk. × 38.
e, Empty glumes; *o*, ovary; *po*, pollen grain; *s*, silk; *t*, tip of ear; *x*, enlargement of ridge subtending the spikelets of the ear.



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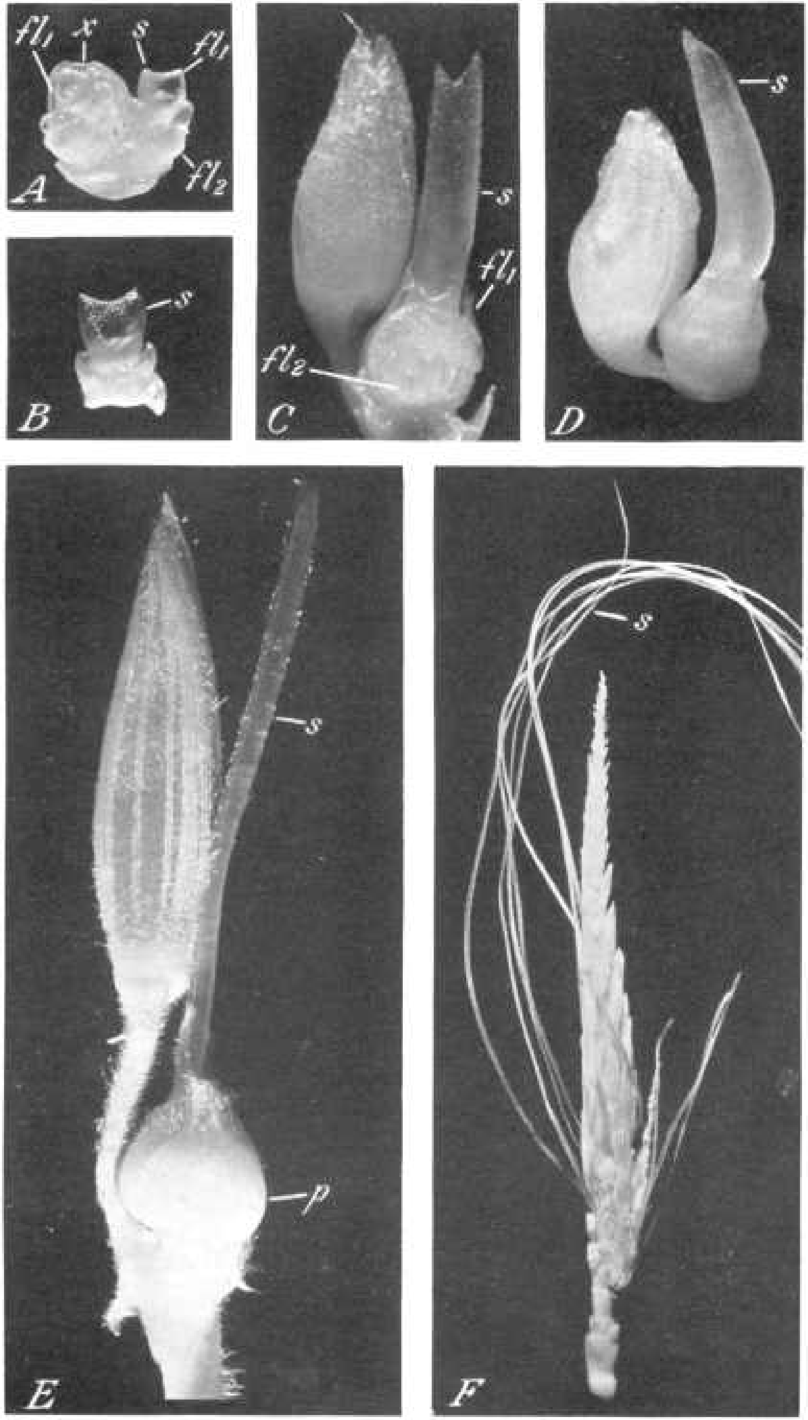

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(the upper flower) takes precedence in its development over the flower from the smaller mass of meristem (the lower flower). The larger flower is the functional flower in those types of corn that have only one functional pistillate flower per spikelet. In these types of corn having two functional pistillate flowers per spikelet, the larger flower is more advanced at every stage in its development than the smaller flower.

Anther initials are the first of the reproductive parts of the flower to differentiate (pl. 5, *B*, *an*). In the pistillate flower the anthers begin differentiation but usually remain small and nonfunctional. Under certain growth conditions and in the genetic type, anther ear, the anthers of the pistillate flower may attain full development. Anthers well enough developed to show the locules are shown in plate 5, *G*, *an*, and *J*, *an*.

The pistil initial develops from the apex of the growing point which is located between the anther initials (pl. 5, *B*, *p*, and *I*, *p*). Development begins with the formation of a ridge, the silk initial, which partly encircles the tip of the growing point (pl. 5, *C*, *s*, and *D*, *s*). The ovule differentiates from the meristem which is partly enclosed by the developing silk initial (pl. 5, *C*, *ov*, and *E*, *ov*).

The margin of the silk initial grows more rapidly on one side than on the other (pl. 5, *E*, *s*). Soon two distinct points appear (pl. 5, *F* and *G*) which continue to elongate (pl. 5, *G* and *K*) and which finally result in the biparted tip of the mature silk (pl. 6, *E*). Unequal growth rates of the margins of the silk initial result in the development of a tubelike structure, partly enclosing the ovule (pl. 5, *E*, *ov*). The opening above the ovule gradually closes and becomes the stylar canal (pl. 5, *G*, *sc*; *H*, *sc*; and *K*, *sc*).

As the silk elongates it becomes covered with hairs, the structure of which has been described by Weatherwax (*16*). Hairs are just beginning to appear as fine points upon the silk in plate 5, *K*, *s*, and *L*, *s*, and they are shown, fully developed, with pollen grains germinating upon them, in plate 6, *E*, *F*, and *G*.

The ovary is shown in plate 6, *D*,*o*, with the silk attached and partly enclosed by the flowering glumes. At this stage of pistil development all of the external parts have differentiated but the pistil has not attained full size.

Silks begin to develop first at the base of the ear (pl. 6, *A*), and at later stages of ear development a marked contrast in the length of the silks at the tip and the base of the ear can be seen (pl. 6, *C*).

EXPLANATORY LEGEND FOR PLATE 7

A.—A staminate (left) and pistillate (right) spikelet from the tassel. ×20.
B.—Silk development in a pistillate spikelet from the tassel. ×28.
C.—Glumes removed from the pistillate spikelet to show the abortive lower flower. ×20.
D.—Staminate and pistillate spikelets of the tassel. ×15.
E.—A fully differentiated staminate and a pistillate spikelet of the tassel, the pistillate spikelet being sessile and the staminate spikelet pediceled. ×10.
F.—A tassel showing silks from pistillate spikelets at the base of the tassel. ×10.
fl_1, Upper flower; fl_2, lower flower; *p*, pistil; *s*, silk; *x*, upper flower of the staminate spikelet.

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An enlargement of a section of the ear at the same stage of development as the ear in plate 6, *A*, is shown in plate 6, *B*. The attachment of the spikelets, variation in the length of the silks, and the size of the stylar canal can all be seen in plate 6, *B*.

Very soon after pollen grains lodge upon the silk they germinate and the pollen tube grows down the hair into the silk (pl. 6, *F* and *G*). This process has been described by Miller (*8*) and Randolph (*9*).

DEVIATIONS FROM NORMAL FLOWER DEVELOPMENT

Two deviations from normal flower development will be illustrated and described. The first is the development of two fertile flowers in a pistillate spikelet and the second is the development of pistillate spikelets in the tassel. Illustrations for the first deviation were taken from Country Gentleman sweet corn and are shown in plate 5, *I*, *J*, *L*, and *M*. Illustrations for the second deviation were taken from Golden Cross Bantam and are shown in plate 7.

It will be recalled that in those types of corn that have only one fertile flower per spikelet, the sterile flower begins but does not complete its development. The sterile flower develops from the smaller of the two divisions of the growing point of the spikelet initial. Anther initials and the pistil initial of the sterile flower differentiate (pl. 5, *G*, fl_2) but do not complete their development (pl. 5, *H*, fl_2). The pistil of the fertile flower develops as has been described, but the anthers do not, so that in examining a spikelet of the ear of those types of corn having one fertile flower per spikelet, all that can be seen after the silk has begun to elongate are the empty glumes (pl. 5, *K*, *e*) and the silk of the fertile flower extending beyond them (pl. 5, *K*, *s*).

When two fertile flowers develop in a pistillate spikelet each flower goes through the same sequence of development that has been described, but the rates of development are different. The upper flower arising from the larger of the two divisions of the growing point develops more rapidly than the lower flower. This was also pointed out for the development of the two flowers of the spikelet in the tassel.

The differences in rates of development of the upper and lower flowers can be seen by comparing the development of the upper flower in plate 5, *I*, fl_1; *J*, fl_1; *L*, fl_1; and *M*, fl_1, with the development of the lower flower designated as fl_2 in the photographs just mentioned. While the upper flower develops first, the lower flower gradually overtakes the upper flower as the ear approaches maturity, so that at pollination, the silks of both flowers are approximately the same length.

Paired grains of corn result when two fertile flowers are produced per spikelet. The germ of the upper flower faces the tip of the ear and the germ of the lower flower faces the base of the ear, resulting in the kernels being placed back to back. With the development of two grains per spikelet the kernels may be crowded out of line so that there are irregular rows or a lack of rows as shown in Country Gentleman sweet corn.

Development of paired grains, according to Randolph (*11*), was first described in pod corn by Sturtevant (*14*), and Kempton (*6*) was the first to interpret correctly the development of paired grains as being the result of the development of two fertile flowers per spikelet. Weatherwax (*18*), Stratton (*13*), and others have also described the development of double kernels.

The development of pistillate spikelets in the tassel is an interesting deviation from normal development. Kempton (*6*) has pointed out that if there are pistillate flowers in the staminate inflorescence, it is the upper flower of the sessile spikelet that is pistillate and both of the flowers of the pediceled spikelet are staminate.

Spikelet differentiation and the first stages in the development of the flowers are the same in both the staminate and the pistillate spikelets of the tassel. The essential difference lies in the degree of development of the anthers and pistils. In the pistillate flowers both the anthers and the pistil differentiate but the pistil takes precedence in development; in the staminate flowers both the anthers and pistil differentiate but the anthers develop instead of the pistil.

In Golden Cross Bantam only one flower, the upper one, of the spikelets of the ear is fertile and the same is true of the pistillate spikelet produced in the tassel. Consistent with the development of the flowers of the ear of this type, the upper flower (pl. 7, *A*, fl_1, and *C*, fl_1) developed and the lower flower was abortive (pl. 7, *A*, fl_2, and *C*, fl_2).

Pistil differentiation and development were the same as previously described for the pistillate flower of the ear. The various stages in the development of the silk are shown in plate 7, *A*, *s*, to *F*, *s*, inclusive, and it can be seen that they are essentially the same as already described.

The development of the flowers of the staminate spikelet shows no deviation from normal development except that the pistil is a little further developed than in the tassels having only staminate spikelets. But the example shown in plate 7, *A*, *x*, should not, perhaps, be considered as typical because even in those plants that did not have pistillate spikelets, a considerably greater degree of pistil development was noted (pl. 3 *F*, *p*, and *H*, *p*) than would be expected in plants grown in the field. However, this is what should be expected of corn plants grown in the greenhouse under certain conditions of temperature and light.

SUMMARY

The developmental morphology of the tassel, the ear, and their parts were studied by dissecting them from the stem of the corn plant at the different stages of development. Photomicrographs were taken of the various stages.

From germination to the dehiscence of the anthers, the shoot of the corn plant passes through two stages of development. In the first stage leaves and axillary shoots are produced, and in the second stage the internodes of the stem elongate and the tassel, ear, and their parts differentiate and develop.

Tassel differentiation begins with the appearance of lateral projections, branch initials, which arise acropetally from the growing point of the central axis. The first initials to appear at the base of the central axis elongate to produce branches of the first order. Those above develop into two spikelet initials.

Branches of the second order arise as buds from the base and at the margins of the branches of the first order.

Differentiation of the ear also begins with the appearance of lateral projections which arise acropetally from the growing point.

In both the tassel and ear the spikelet-forming branch initials divide into two unequal parts to form the spikelet initials and in turn the spikelet initials divide into two unequal parts to form the flower initials.

In the tassel the spikelet developing from the larger division of the branch initial is pediceled and the spikelet from the smaller division is sessile. In the ear and tassel the larger initial begins the development of its parts ahead of the smaller initial.

Differences in the size of the flower initials in the tassel are correlated with a difference in the size and rate of development of the anthers. The larger (upper) flower initial is ahead of, and larger than, the anthers of the smaller (lower) flower initials, but as the flowers approach maturity the anthers of the lower flower are almost as large as the anthers of the upper flower.

In the ear the flower developing from the larger (upper) of the two flower initials becomes the fertile flower and the smaller (lower) flower initial the abortive flower in those types of corn that have only one fertile flower per spikelet. In those types that have two fertile flowers per spikelet the flower from the upper initial is larger and develops before the flower from the lower initial.

The empty glumes are the first of the spikelet parts to differentiate in the spikelets of the tassel and the ear.

Flower parts of the flower of the tassel and of the ear differentiate in the following order: Lemma and palea, anthers, and pistil. In the pistil the ovary, silk, and hairs on the silk develop in the order named.

Pistillate spikelets which develop in the tassel follow the same sequence in their development as the pistillate spikelets of the ear.

When two fertile flowers develop in the pistillate spikelet of the ear both flowers follow the normal sequence of development, but the upper flower develops ahead of the lower flower.

Because they do not terminate in apical spikelets the ear and tassel are indeterminate inflorescence.

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