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THE EFFECT OF DROUGHT AND HEAT IN 1936 ON THE FUNCTIONING OF THE STAMINATE FLOWERS OF MAIZE

J. N. Martin

During the season of 1936, the extreme drought and heat very noticeably interfered with the normal functioning of maize flowers, making it difficult in many cases to obtain satisfactory results in the breeding plots. Both staminate and pistillate flowers were affected, but this discussion is confined to observations of the effect on the functioning of the staminate flowers.

In the functioning of the staminate flowers of maize, and of the grasses in general, four processes are involved, of which three are thought to depend upon a water relationship. These processes, given in the order of their succession, are as follows: The swelling of the lodicules which thereby force apart the outer glumes and the lemmas and paleas, and thus provide openings through which the anthers are pushed upward by the elongation of the filaments (fig. 1, a and b); the elongation of the filaments of the stamens which results in the elevation of the anthers beyond the glumes where they can tilt (figs. 1 and 2); the formation of the dehiscing pores at the outer ends of the anthers by the functioning of the annuli (fig. 5); and the tilting of the anthers and the falling out of the pollen through the dehiscing pores by the force of gravity. If anyone of these processes is omitted from the series of events preliminary to the shedding of the pollen, pollination either fails or is not normal in efficiency.

The physiology of the swelling of the lodicules, elongation of the filaments and the functioning of the annuli in forming the dehiscing pores is not definitely known, but it may be inferred that it is similar to that in other plant structures where it is known that swelling, elongation, and most movements depend upon water relationships that affect turgor and the stresses and strains in cell walls.

In the swellings of the lodicules, which is normally very rapid, covering a period of minutes rather than hours, these structures are enlarged to several times their initial size. This enlarging of the lodicules, remarkable both in rapidity and degree, is attributed to

EXPLANATION OF FIGURES

PLATE I

Fig. 1. a. spikelet with the two flowers opened in the normal way, namely. the glumes are well separated by the swelling of the lodicules, the filaments have elongated and pushed the anthers out beyond the glumes, the dehiscing pores have been provided and the pollen is falling out through the pores. b. spikelet with empty glumes and lemmas removed to show the lodicules. In the flower at the right in which the filaments have elongated, note that the lodicule (at the end of the arrow) is much swollen, while in the flower at the left in which opening had not taken place the lodicule (at the end of arrow) is still inconspicuous.

Fig. 2. In the stamen at the left in which the filament has elongated, compare the length of the filament with length of the filaments of the two stamens at the right in which no elongation has occurred.

Figs. 3 and 4. Spikelets which are several days past their stage for dehiscing as indicated by the drying of the glumes. The lodicules are swollen but the stamens did not elongate their filaments nor provide the dehiscing pores.

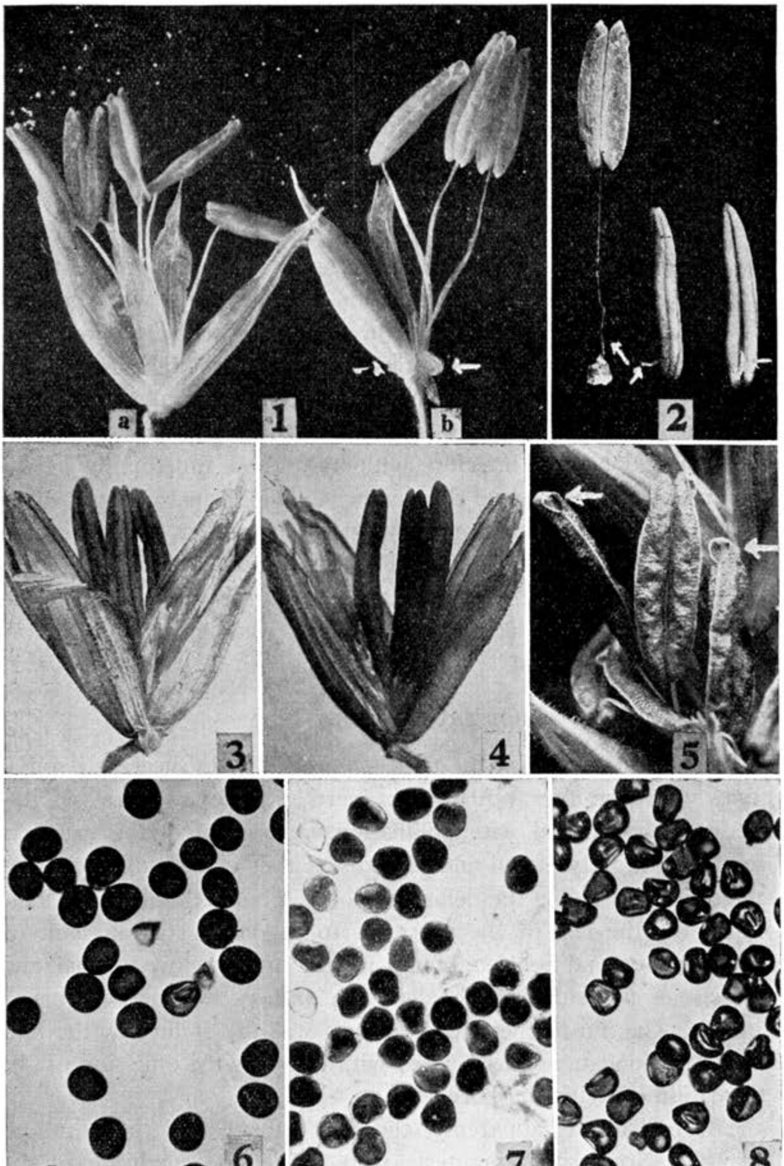
Fig. 5. The dehiscing pores (indicated by the arrows), two in each anther.

Fig. 6. Maize pollen, treated with iodine, showing shape and much starch. Taken from spikelets like those in figs. 3 and 4. The pollen grains are normal in appearance.

Fig. 7. Maize pollen treated as in fig. 6, but from spikelets more severely affected by the heat and drought. Considerable abnormality in content and shape.

Fig. 8. Maize pollen taken from the anthers and allowed to dry six hours during one of the hot dry August days in 1936. Note that there is no regular way the walls fold as the pollen shrinks. These pollen grains resumed their normal shape when dropped in water or exposed to moist air.

PLATE I



a change in osmotic activity that greatly increases turgidity, and therefore depends upon a ready supply of water (fig. 1, b).

In the elongation of the filaments by which the anthers are elevated to a position beyond the glumes, a process which also involves only a period of minutes, there is an increase in the length of the filaments to many times that of their initial length. This elongation is also attributed to turgor pressure and therefore necessitates a ready supply of water (fig. 2).

The activity of the annulus in the dehiscing of the anthers is probably similar to that of the annular mechanism in fern sporangia, where the loss of water following the death of the annular cells is accompanied by the formation of water films with tensions that bring about movements in the cell walls of the annulus and thereby a rupture in the sporangial wall. Although the proper functioning of the annulus presumably depends upon a loss of water and not upon a ready supply there is ample opportunity for drought and heat to interfere with its normal functioning by interfering with its normal development. The formation of the annulus occurs late in the development of the anther, and when the tassel is emerging from the envelope of leaves shortly before the pollen is ready to be shed, and thus at a time when its development can easily be affected by the adverse weather conditions near the pollination period.

Observations in 1936

In all cases in which the tassels were killed by heat and sometimes when the effects of drought were extreme, all processes immediately associated with pollination were omitted, the spikelets remaining tightly closed and stamens neither elongating their filaments nor providing the dehiscing pores. The swelling of the lodicules was the last of the processes to be omitted as a result of the adverse conditions, although it was often below normal and sometimes not sufficient to allow the anthers to emerge (figs. 3 and 4). The most general consequence was the failure of the filaments to elongate and associated with this was the omission of the formation of dehiscing pores.

The pollen was apparently the least affected by the heat and drought. No germinating tests were made, the condition of the pollen being judged by its plumpness and content, features that are not very reliable, however. More reliable and practicable tests of pollen viability than we now have would be welcomed.

Unlike the pollen of most plants, the pollen of maize and of grasses in general have only one germ pore and no sutures. Lacking sutures the pollen grains of the grasses are slow to show dessication by an infolding of the walls as do the pollen grains that have sutures. (Fig. 8.) Any noticeable shriveling in maize pollen, therefore, is an indication of rather severe dessication, whereas in the pollen with sutures, such as those of the legumes, in which the walls fold inward in a regular way along the sutures almost immediately on exposure to the air, a shriveled condition is a normal method of protection against further loss of water, and is not an indication of injury. On the other hand, plumpness of pollen grains can not always be taken as evidence of viability, for pollen subjected to killing temperatures and much shriveled becomes turgid and normal in appearance again when moisture is obtainable.

The pollen grains of nearly all varieties of field corn are normally well filled with starch when mature and are plump and almost globular in form. (Fig. 6.) Only in the extreme cases where the tassels were almost or entirely killed by heat did the pollen grains show shriveling, lack of starch, or other abnormal features (fig. 7). That the pollen is not readily affected by heat and drought, can be attributed to the fact that the pollen grains practically complete their development early in the life cycle of the plant, and commonly before the adverse conditions attain their greatest severity and while the anthers are still well protected by the leaves.

Summary

The normal functioning of the staminate flowers of maize in pollination involves four processes — the swelling of the lodicules, elongation of the filaments of the stamens, formation and opening of dehiscing pores, and tilting of anthers and falling out of pollen.

The drought and heat of 1936 interfered greatly not only by killing staminate spikelets but by inhibiting the swelling of lodicules, elongation of filaments, and the formation and opening of pores in many spikelets not so severely affected that they were killed or pollen apparently injured.

If the condition of maize pollen can be judged by its plumpness and content, it is able to survive amazingly well the extremes of drought and heat, a feature attributable to the fact that the pollen is formed early and while the tassel is still enveloped by the leaves.

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