CHROMOSOME POLYMORPHISM OF TEOSINTE

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ABSTRACT

Florida teosinte from Honduras and Guanajuato teosinte have most of their knobs internally located and a common inversion in the short arm of chromosome *8*. Teosintes from northern Guatemala, Huixta and Monajil, have all their knobs terminally located and do not have any inversions. Therefore, Florida teosinte from Honduras appears to be phylogenetically closer to Guanajuato teosinte than it is to Guatemalan teosintes.——The presence of B chromosomes and an *In 8* in Guanajuato teosinte and Florida teosinte from Honduras may constitute evidence of introgression between maize and teosinte.

TEOSINTES, *Zea mexicana* (Schrad.) Kuntze, or *Euchlaena mexicana* (Schrad.) from southern Guatemala have, on the average, two more paracentric inversions and six more chromosome knobs than those from northern Quatemala. In all Guatemalan teosintes, except in Florida teosinte (from southern Guatemala), chromosome knobs are exclusively terminal. These findings were reported by TING (1969) in a paper which also reviewed previous studies of teosinte chromosomes and discussed the relationship between maize (*Zea mays*) and teosinte.

Additional research has now been carried out with the view of resolving the following questions: (1) To what extent do the chromosomes in teosinte vary geographically in terms of knobs and inversions? (2) Are the *B* chromosomes in teosinte the same as those in maize? Did they originate in teosinte or in maize?

MATERIALS AND METHODS

Four teosinte varieties were employed in this study. Seeds of one of them came from Urianato, elevation 1850 m., Guanajuato Province (Department), Mexico. Hence it is called Guanajuato teosinte. Seeds of two Guatemalan teosintes came from San Antonio Huixta, elevation 1240 m., and Monajil, elevation 1030 m., Hue-huetenanago Province, northern Guatemala. These two teosintes are distinct and are thereafter designated Huixta teosinte and Monajil teosinte. They are geographically more than seven miles apart and differ in time of blooming by three weeks. Seeds of these above three teosintes were provided by DR. H. G. WILKES of the University of Massachusetts in Boston. Seeds of the fourth teosinte came from Florida, and were originally provided by PROFESSOR (emeritus) P. C. MANGELSDORF, Harvard University. Since this teosinte came to Florida from Honduras in late last century, it is named Florida teosinte from Honduras. However the history of the introduction of this teosinte to Florida, U.S.A., is uncertain, as discussed by WILKES (1967. All these teosintes were crossed with a standard inbred maize, New England Wilbur's Flint, in which there are no large chromosome knobs or aberrations of any kind. The procedures and methods are given in TING (1969).

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OBSERVATIONS AND EXPLANATIONS

None of the species involved was completely dominant over the other in any of the maize-teosinte hybrids reported here. Plant height, leaf-width response, degree of glume and rachis induration, of the hybrid plants were practically intermediate between those of the parental species. The characteristic behavior, morphology and types of chromosomes of different teosintes as revealed during meiosis of the microsporocyte divisions of maize-teosinte hybrids are as follows:

(i) Florida teosinte from Honduras

The gross morphology of this material was similar to that of the other Florida teosinte when grown in the Boston area. For instance, it had narrow leaves and short stalks, and under short-day condition, such as in October in Boston, it flowered profusely. The knob constitution of this material as determined from pachytene analysis of five F_1 maize-Florida teosinte hybrids is shown in Figure 1.

A practically terminal inversion involving more than 60% of the short arm of chromosome *8* was consistently observed and it frequently showed inversion loop pairing (Figure 5a). Asynaptic fork-configurations and foldback nonhomologous associations were also observed. The short arm of chromosome *6* of this teosinte was shorter than that of its maize homolog by about one-third.

Among 152 F_1 cells counted at diakinesis, 13% had two univalents and nine bivalents. The univalent chromosomes were short and resembled chromosome *8*. Presumably the inverted segment of the short arm interfered with effective pairing and chiasma formation. At anaphase I, cells having a bridge with a fragment (Figure 5b), and cells having only a fragment were observed.

(ii) Mexican teosinte

Nine F_1 plants of maize × Guanajuato teosinte were cytologically examined, and the knob constitution is given in Figure 2. In addition a second type of chromosome *4* with two large terminally located knobs was observed. A paracentric inversion which occupied 60% of the short arm of chromosome 8 was identified and designated *In 8* of Guanajuato teosinte. WILKES (1967) observed the same rearrangement in his study on F_1 hybrids of maize—Guanajuato teosinte. However, he did not think that it was due to inversion. The average length of four separate measurements of this inversion was 8.6 μm at pachytene (Figures 2 and 6a). At anaphases I and II, bridges and fragments were observed.

The *B* chromosomes (Figure 6b), varying from three to six per plant, are morphologically the same as those found in maize by MCCLINTOCK (1933). At pachytene, the average length of the *B*'s was 25.0 μm, and they form multivalent associations when three or more are present.

FIGURES 1–4.—The pachytene chromosomes of (1) Florida teosinte from Honduras, (2) Guanajuato teosinte, (3) Monajil teosinte, and (4) San Antonio Huixta teosinte. The chromosomes are arranged in order of decreasing size (1–10). Dashed lines represent inversions, gaps indicate centromeres and the nucleolar organizers are outlined. The knobs (solid) are enlarged for clarity but three sizes (large–small) are represented.

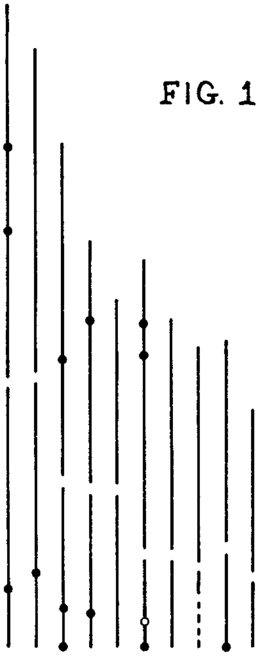

FIG. 1

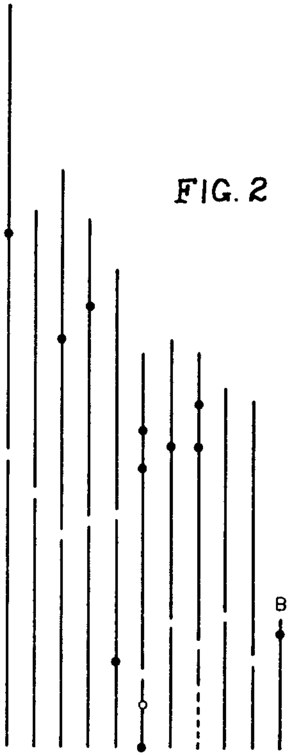

FIG. 2

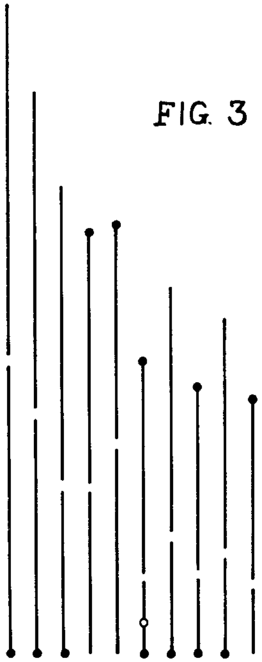

FIG. 3

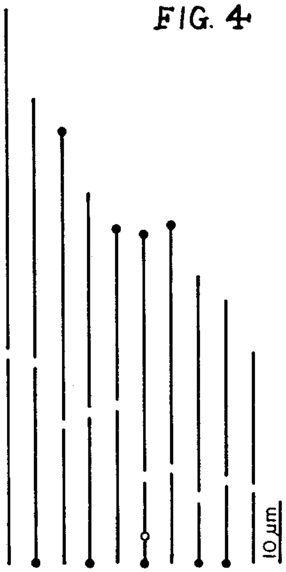

FIG. 4

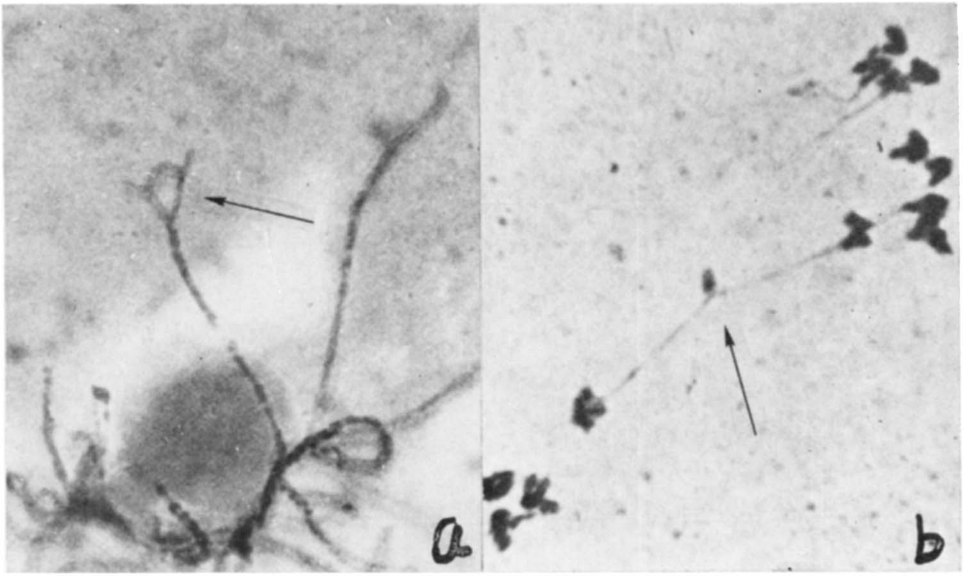

FIGURE 5.—Microsporocyte divisions in F_1 hybrids between maize and Florida teosinte from Honduras. Magnification: 1600×.

a. Pachytene configuration of a paracentric inversion in the short arm of chromosome *8* (arrow).

b. Anaphase I with chromatid bridge and fragment (arrow).

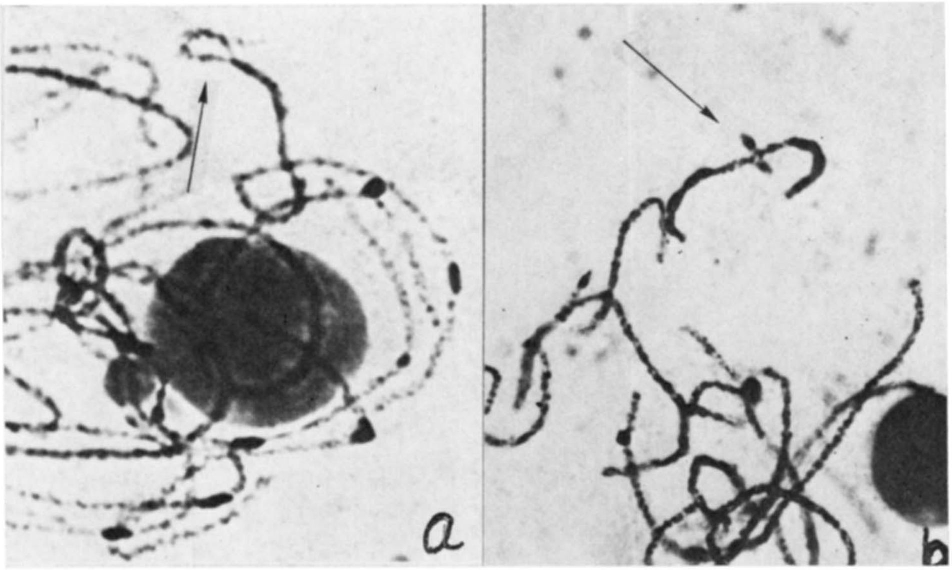

FIGURE 6.—Pachytene in the F_1 hybrids between maize and Guanajuato teosinte. Magnification: 1600×.

a. Paracentric inversion in the short arm of chromosome *8* (arrow).

b. Multivalent *B* chromosomes (arrow).

(iii) Guatemalan teosinte

(a) Monajil teosinte. Fifteen maize-Monajil teosinte F_1 hybrids were studied. The pachytene chromosomes were generally well-spread, and identification of individual chromosomes and their knob endowments were made without difficulty (Figure 3). This teosinte must have been homozygous for the knobs indicated because they were found in all the hybrid plants examined.

In these hybrids, asynapses involving one-third of the long arm of chromosome *3* were observed at pachytene several times. Whether these were caused by an inversion was uncertain since there were no anaphase bridges or fragments among more than 500 randomly chosen sporocytes examined.

(b) Huixta teosine. Seventeen maize-Huixta teosinte F_1 hybrids were cytologically examined and the findings with regard to knob number differed from those reported previously (LONGLEY 1937; TING 1969). Both chromosomes *1* and *10* were knobless. There was a large knob on the short arms of chromosomes *2* and *4*. The long arm of chromosome *3* had also a large knob. Chromosome *5* had a large knob on the long arm. Both long arms of chromosomes *6* and *7* contained a medium-sized knob. On the short arm of chromosome *9* there was a small knob. A large knob was present on the short arm of chromosome *8*. In total, there were eight terminal knobs, excluding the small knob (satellite) on the short arm of chromosome *6* (Figure 4).

No inversions or any other structural changes of the chromosomes were observed. The chromosome pairings in these hybrids were as close as those found in either parents. In addition, chromosome behavior at anaphases I and II was regular.

DISCUSSION

(a) Relationship between maize and Florida teosinte from Honduras.

Florida teosinte from Honduras resembles Florida teosinte from Guatemala in morphology and physiology. For instance, both have short stature and many tillers, and both respond similarly to photoperiodic changes. However, contrary to expectation, Florida teosinte from Honduras has the same *In 8* as found in the majority of Mexican teosintes and certain races of maize, but *In 8* has not been found in any of the Guatemalan teosintes. In addition, Florida teosinte from Honduras has most of its chromosome knobs, except those on the short arms of chromosomes *3* and *9*, internally located, again suggesting a closer relationship with maize and Mexican teosintes than Guatemalan teosintes.

(b) Introgression between maize and teosinte

The *In 8* of Guanajuato teosinte cannot be distinguished from an inversion in chromosome *8* found in various strains of maize (McCLINTOCK 1959; TING 1967). The *B* chromosomes of the two groups are likewise similar. These observations suggest introgression, which has already been proposed on the basis of gross morphological characteristics by MANGELSDORF and REEVES (1959) and by MANGELSDORF (1974). *B* chromosomes have been found in many maize strains occupying a wide geographical area. The interchange of germ plasm could have taken place a long time ago when maize was limited to a small area, in which case the direction of flow of this type of chromosome, maize to teosinte or *vice versa*, would be uncertain. On the other hand, the interchange of germ plasm could have taken place in an isolated area long after maize was widely dispersed geographically, in which case it must be argued that the *B* chromosome moved from maize to teosinte.

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