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VARIATION IN COB MORPHOLOGY AMONG CERTAIN ARCHAEOLOGICAL AND ETHNOLOGICAL RACES OF MAIZE

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INTRODUCTION

Zea Mays L., one of the most highly evolved of all grasses, is still botanically much of an enigma. Commonly known as Indian corn or maize, it was a very important plant to the peoples of the New World long before the arrival of Columbus. It formed the basis of the highly developed Inca, Maya, and Aztec civilizations and was the staple crop from Canada to Chile for several thousand years. It is, of course, quite important to the present-day inhabitants of Central and South America, and agriculture and industry in the United States uses three and one-quarter billion bushels annually.

Botanists have until recently followed almost exclusively Sturtevant's (1899) classification of contemporary races of maize by kernel types. Although this classification is an artificial one, it has proven to be of practical commercial worth. Archaeologists have long known the value of maize kernels found at excavation sites for determining types of maize grown and the uses to which they were put. Until the last few years, other parts of the maize plant have been quite generally neglected as a source of historical data, chiefly because of the complexities involved in determining and evaluating such evidence as they contain. Evidence from maize tassels has been used with promising results (Alava, 1952; Anderson, 1944b, 1944c, 1949a, 1951; Anderson and Brown, 1948; Anderson and Cutler, 1942; Brown *et al*, 1952; Cutler, 1946; Wellhausen *et al*, 1951, 1952). Prat (1948) showed that in maize and other grasses hairs and other epidermal emergences can be used as a basis for identification and classification. Internode patterns have been studied by several workers (Anderson, 1943, 1949a; Anderson and Brown, 1948; Anderson and Schregardus, 1944; Stonor and Anderson, 1949; Wellhausen *et al*, 1951, 1952). Ear and tassel ontogeny have been studied by Bonnett (1940, 1948) and Kiesselbach (1949). Esau studied the ontogeny of the maize vascular bundle.

Surprisingly little has been done to measure and evaluate those morphological structures which are present on a maize cob after the kernels have been removed. Weatherwax, a pioneer in the study of the maize cob, pointed out (1918) the need and value of accurate morphology in understanding this structure, and demonstrated (1920) the orderly spikelet behavior underlying changes in kernel rowing. Fujita (1939) observed that an even number of pairs of kernels resulted in straight rows, and an odd number in spiral rows. Cutler (unpublished work) made many histological studies of the cobs of both North and South American maize, as well as of several closely related genera. Lenz (1948) indicated the types

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maize samples from Asia were responsible. Cobs studied were those grown by Stonor in Asia; varieties involved were described by Stonor and Anderson (1949).

The most striking features of the Asian corn cobs were their extremely deep cupules and their particular form of sclerenchymatization. The rachis tissue and lower glumes of all Asian cobs studied were quite hard, but their hardness was not identical with that of "bony" rachis tissue described by Mangelsdorf and Smith (1949) in connection with teosinte introgression. Whatever its cause, the end product was an extremely stiff, light-weight bulky cob. Studies by Lenz (1948) did not indicate that cell wall thickness had much to do with degree of sclerenchymatization among various races of maize. A deep cupule could possibly be interpreted as a condition which showed little if any "Tripsacoid influence" (Cutler, 1946). An inference cannot be drawn that all Asian maize varieties are alike in this respect, but for both Assam and Lushai samples, this conclusion seems justified.

The nine characters employed in constructing text-fig. 2 showed a strong tendency for association at both extremes. A strong overall association between all sample averages as well as within each sample is clearly shown by comparing the average of any sample in text-fig. 2 with its appropriate population diagram in text-figs. 3, 4, or 5. Individual cobs in the upper right-hand area of each population diagram consistently showed more and longer rays than did those from other parts of the same diagram. This similarity of separation patterns in the several diagrams emphasizes the fact that those limits employed in separating sample averages, while originally chosen in a subjective taxonomic fashion (Stebbins, 1952), were also working within each sample in such a way that morphological trends associated with a particular race of maize were associated with each other.

The diagram as constituted contains samples of rather diverse races of maize; closeness of position on the diagram and similarity of glyphs indicate similar morphology but do not necessarily imply close relationship. Weatherwax (1936) stated that no sound basis exists for any attempt to trace maize origin by arranging varieties from different localities in an evolutionary sequence. Introduction of the dimension of time in the form of archaeological material, however, allows the investigator to arrange maize varieties of both present and past according to cultural succession; the result may or may not be an evolutionary sequence, but such an arrangement is the strongest means available for documenting maize history and has therefore been employed in this investigation whenever possible.

Results obtained in this investigation are compared below with those obtained in three other independently conducted investigations. A high degree of correlation is found in each instance, a fact which indicates a basic soundness in methods employed for cob analysis in this investigation.

Brown *et al* (1952) have discussed relationships among three varieties of Hopi maize, two of which, Hopi White Flour and Hopi Blue Flour, were included in the present study. These workers found that the two varieties had certain re-

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semblances to Basketmaker and Eastern maize as well as to each other. Unfortunately, it was not possible to obtain a large enough sample of Kokoma, the variety they reported as resembling Basketmaker most closely, to warrant its inclusion here. Text-fig. 2 indicated that Hopi Blue Flour was basically similar to Basketmaker, differing in cupule width, wide lower glumes, heavy shanks, and presence of 8-rowed cobs. It should be noted that there has been no change in cupule depth and predominance of cigar-shaped ears in development of Hopi Blue Flour from Basketmaker maize.

Hopi White Flour was found by Brown *et al* (1952) to contain an admixture of both Eastern and Mexican germ plasm. The Mexican complex (Carter and Anderson, 1945), known to be present on the Mesa Central of Mexico, is characterized by strongly tapered cobs with high row numbers, thick kernels, and small shanks. This conclusion was borne out by text-fig. 2, which showed Hopi White to have all the characters associated with the Eastern complex with the exception of row number and cob shape; tapered cobs of high row number may be attributed to Mexican influence. Cobs of these two Hopi Flour maizes differed from each other in cupule depth (text-fig. 2 indicates this to be the strongest character contributed by the Eastern complex), cob shape, shank diameter, rachis-flap height, and row number.

In the correlation between results obtained in the present investigation and those of Wellhausen *et al* (1951, 1952) which are listed in Table II, the number of characters used was less than the number employed to separate the samples listed in Table I; yet, a pictorialized scatter diagram (text-fig. 6), using five measurements, presented essentially the same variation pattern as did text-fig. 2, in which nine measurements were employed. It should be noted that the basic pattern of maize cob variation was not altered by using measurements of a different character for the abscissa of text-fig. 6 than that employed in text-fig. 2. If a sample on text-fig. 6 has any real affinity to races with which it may be allied on other grounds, the fact should be shown by its position on the diagram. Text-fig. 6 should also lend further confirmation to the genealogies postulated by Wellhausen *et al* for several hybrid races of maize. That these confirmations are indeed possible was shown quickly and easily. The four races classified by these workers as Ancient Indigenous Races (Palomero Toluqueño, Arocillo Amarillo, Chapalote, Nal-Tel) were closely grouped; moreover they were all placed in the lower left-hand corner of the diagram and all had few to no rays. Thus their characters of small cupules, narrow lower glumes, high row numbers, thin kernels, and small shanks, all believed to indicate primitiveness in relation to other races of maize here considered, were strikingly indicated by text-fig. 6.

Three of the four races classified as Pre-Columbian Exotics (Cacahuazintle, Harinoso de Ocho, Olotón, Maíz Dulce) formed a consistent graded series along the lower edge of the upper region of text-fig. 6. They were placed in a separate class because of their antiquity and resemblance to South American maize. While

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