

greatest importance, and such a house would allow utilization of the full supply. The results of Garner and Allard² suggest, too, that artificial lighting may be used to supplement the natural supply, and to obtain the optimum relation between periods of light and dark.

The details are for the future. For the present it seems enough to point out the advantages of speeding up the progress by growing two crops a year, and the desirability of determining the best practice in greenhouse corn culture as well as the possibilities and limitations of such a method in corn breeding.

WAXY ENDOSPERM IN COIX AND SORGHUM

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IN THE endosperm of maize seeds, a layer of compact starch cells, variable in thickness, encloses the loose or soft starch cells that occupy the center of the seed adjacent to the embryo. This layer of compact or hard starch cells is found in three visibly different, genetically distinct types, commonly known as horny, sweet, and waxy. Each of these types is distinguished easily from the others and from the soft type or central starch. The horny type is coextensive with maize and is the common form of endosperm, not only in maize but in most grasses. The sweet and waxy types have been reported only in maize and are restricted in distribution—the former in the Americas, and the latter in Asia. Sweet endosperm is distinguished from the common, horny form, chiefly in the wrinkling of the seed caused by the drying of imperfect starch cells. In the smaller seeded grasses, this characteristic wrinkling might be overlooked easily, or be attributed to immaturity or imperfect fertilization. However, crosses between maize with sweet endosperm and *Euchlaena*, the nearest American wild relative, have given only horny seeds in the first generation, indicating that the sweet type of endosperm is not common in *Euchlaena*.

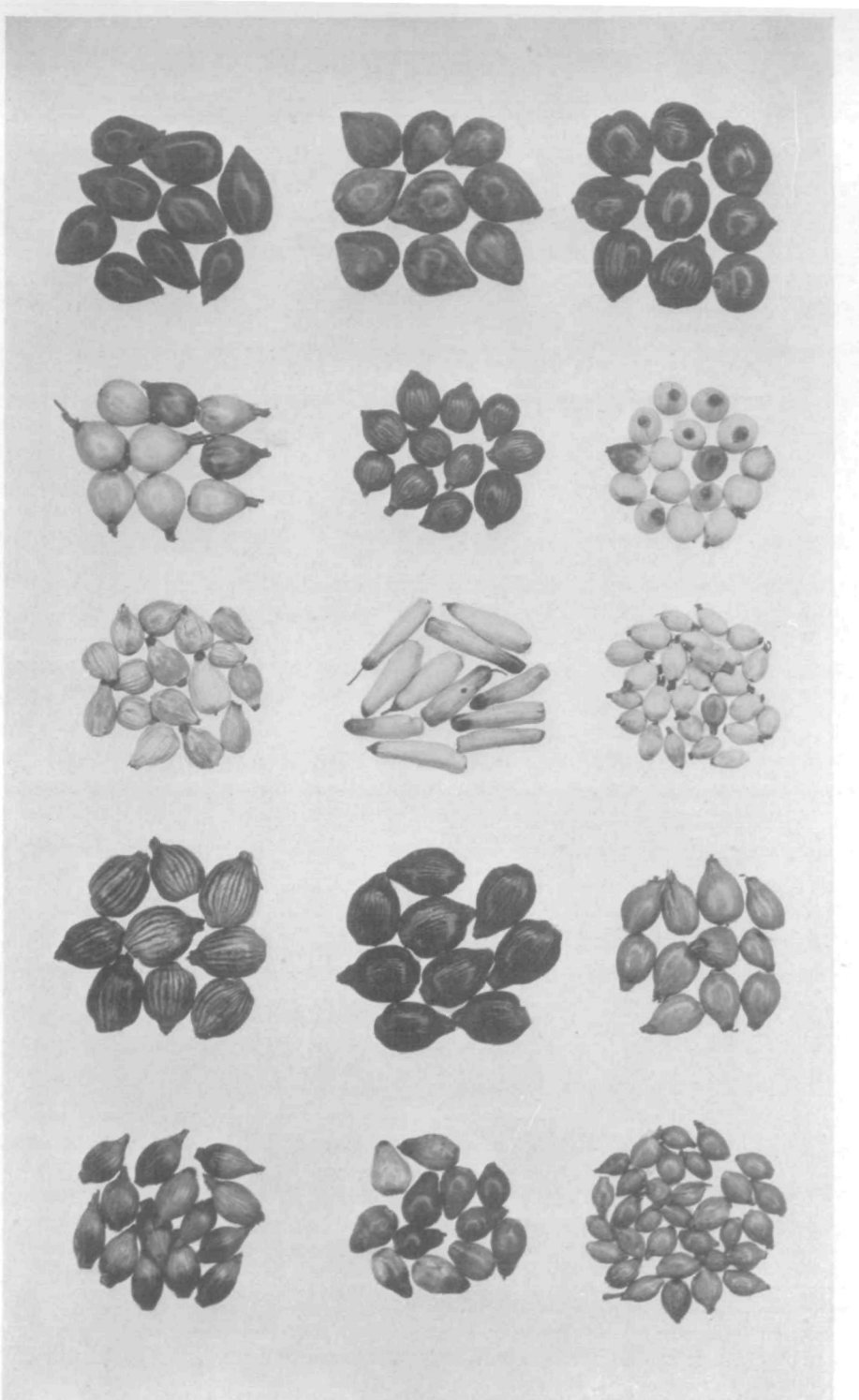
Waxy endosperm differs from the horny in texture and in being opaque

instead of translucent. It was found first in maize from China and later in maize from Burma and the Philippines. Maize varieties from other parts of the world have been scrutinized carefully for this type of endosperm, but thus far it has been found only in the three widely separated regions of Eastern Asia. The common occurrence of waxy endosperm in the Shan states of upper Burma with an extensive vocabulary of native maize names has led Collins to the conclusion that this type of endosperm originated in Burma and was distributed from there to China and thence to the Philippines.¹

A waxy type of endosperm has been found now in several varieties of Coix (*Job's tears*) and also in one variety of sorghum. In appearance this type of endosperm in Coix is entirely similar to the waxy endosperm of maize, and presents the same sharp contrast with the horny endosperm as well as with the loose, or floury portion of the kernels. It may be expected that in Coix as in maize the waxy endosperm will behave as a definitely, alternative character, recessive to the horny form. From the standpoint of the origin of waxy endosperm in maize it seems suggestive that waxy endosperm in Coix is found in the same isolated regions in Eastern Asia, and as with maize, Burma seems to be the most important center.

² Garner, W. W., and Allard, H. A. Effect of the relative length of day and night and other factors of the environment on the growth and reproduction in plants. In *Journ. Agr. Res.*, v. XVIII, no. 11, pp. 553-606. 1920.

¹ Collins, G. N. Waxy maize from upper Burma. *Science*, N.S., Vol. LII 770 1333 pp. 48-51, July 16, 1920.



VARIOUS TYPES OF JOB'S TEARS

The plant known as Job's tears (*Coix lachryma-jobi*), an Asiatic relative of maize, is grown not only as a source of beads, but also as a cereal. The seeds of the lower six groups shown in this photograph have the waxy type of endosperm first found in maize from China. Most of the samples which have waxy endosperm are soft-shelled, the one exception being the central group in the lower row, which is hard-shelled. The central group in the upper row is the form commonly cultivated in Europe and America as a source of beads.

Beginning at the upper left-hand corner, the sources of seed and localities from which they came will be found in the table in the following order: 34, 49, 4, 37, 43, 27, 18, 21, 11, 8, 13, 45, 33, 36, 45. The seeds are natural size. (Fig. 6.)

	<i>Locality</i>	<i>Variety</i>	<i>Source of Seed</i>	<i>Type of Shell</i>	<i>Type of Endosperm</i>
1	So. Shan States, Burma		S.P.I. ² 38870	Hard	Horny
2	"		" 38871	Soft	Waxy
3	"	Ma Yuen	" 38873	"	"
4	"	Ma Yuen	" 38874	"	Horny
5	"	Stenocarpa	" 38875	Hard	"
6	"	"	" 38876	"	"
7	"	Ma Yuen	" 38877	Soft	"
8	"	"	" 38878	"	Waxy
9	"	"	" 38879	"	"
10	"	"	" 38872	"	Horny
11	"	Monilifer	" 38880	Hard	"
12	"	Ma-Yuen	" 44813	Soft	Waxy
13	"	"	F.H.B. ³ 28926	"	"
14	No.	"	S.P.I. 37945	"	"
15	"	Stenocarpa	" 37946	Hard	Horny
16	"	Typica	" 38476	"	"
17	"	"	" 38474	"	"
18	"	Ma Yuen	" 38473	Soft	Horny
19	"	Gigantea	" 38475	Hard	"
20	"	Stenocarpa	F.H.B. 28920	"	"
21	"	"	" 28921	"	"
22	"	"	" 28922	"	"
23	"	"	" 28923	"	"
24	"	Ma Yuen	" 28924	Soft	Waxy
25	"	"	" 28925	"	Waxy-Horny
26	Mongpai, Burma	Stenocarpa	" 28878	Hard	Horny
27	"	"	" 28879	"	"
28	"	"	" 28880	"	"
29	"	Ma Yuen	" 28884	Soft	Waxy-Horny
30	"	Stenocarpa	" 28882	Hard	Horny
31	Lauksauk, Burma	Ma Yuen	" 28883	Soft	Horny
32	"	Stenocarpa	" 28881	Hard	"
33	Kachin Hills				
	Myitkyina, Burma	Ma Yuen	" 28919	Soft	Waxy
34	Pegu, Burma	Gigantea	S.P.I. 38868	Hard	Horny
35	"	"	" 38869	"	"
36	Poona, India	Ma Yuen	F.H.B. 35933	"	Waxy-Horny
37	Saigon, Cochin-China		S.P.I. 36994	"	Horny
38	Buitenzorg, Java		" 37120	"	"
39	Singapore, Siam		" 37609	"	"
40	Mauritius		" 37227	"	"
41	Laguna, P. I.		" 47324	"	"
42	Los Baños, P. I.		" *	"	"
43	Tangkulan Mindanao, P. I.	"	" *	Soft	"
44	Kalasangay Mindanao, P. I.	"	" *	"	"
45	Subanus, P. I.	"	" *	"	Waxy-Horny
46	China	"	" †	"	"
47	China		S.P.I. 49345	Hard	Horny
48	Brazil		" 47617	"	"
49	U.S.A. Thorburn Seed Co.			"	"
50	U.S.A. Santa Barbara, Calif.			"	"

² The numbers following S.P.I. are the serial numbers of the importations made by the Office of Foreign Seed and Plant Introduction, Bureau of Plant Industry, U. S. D. A.

³ The numbers following F.H.B. are the serial numbers of the importations examined by the Federal Horticultural Board, U. S. D. A.

*Samples presented by Dr. William Weston, Jr.

†Sample presented by Dr. Yam Yei Kin.

Forty seven samples of *Coix lachryma jobi* L. from Eastern Asia have been examined, as well as three samples from the American hemisphere. These samples embrace several varieties of this species and include many of cultivated forms. The seeds vary greatly in size, shape, color, and hardness of shell, and the plants of those we have been able to grow are little less variable, some being grass-like, with numerous stalks and narrow leaves, while others with a few and thick culms and long broad leaves have more the appearance of maize or sorghum.

Although the diversity in Coix is great and it is possible to separate the seeds into widely different types, even the most extreme forms are said by Watt⁴ to intergrade under cultivation. Several species of Coix have been described, but Watt accepts only two, *Coix gigantea* Koen., and *Coix lachryma-jobi*-L., while other authorities consider all the known forms as varieties of *C. lachryma-jobi*. All cultivated forms are considered generally as varieties of *C. lachryma-jobi*, and those with a thin, loose and easily broken shell are known under the varietal name of Ma-Yuen. Practically all of the hard shell forms of *C. lachryma-jobi* are duplicated in the soft shelled series and Watt states that under continued cultivation, the hard shelled forms gradually become thin and papery. Coix has been cultivated for centuries, not only as a source of beads, but also as an important cereal in Burma, Assam, and northern India. As in maize, cross pollination is the rule, and it is not surprising, therefore, that with soft and hard shell forms growing side by side, few true breeding types are found. That interbreeding is the explanation of the change from hard to soft shells under continued cultivation is indicated by the hard shelled strain of *C. lachryma-jobi* which has been cultivated for centuries in Europe and America without losing to a noticeable degree the hardness of the shell.

The varietal names of the fifty samples examined, as well as the sources of the seed, the localities from which they came, and the type of shell and endosperm are shown in the preceding table:

Of the fifty samples, fourteen were found to contain seeds with waxy endosperm and of these eleven were from Burma, one from China, one from India, and one from the Philippines. Thirteen of the fourteen were of the soft shell type, but differed greatly in other respects. Ten of the samples from Burma contained waxy seeds only, two contained but a small percentage of horny seed, while in the samples from China, India, and the Philippines waxy and horny seeds were more nearly in equal numbers.

The discovery of waxy endosperm in Coix suggested the examination of the seeds of a Chinese sorghum received from Dr. Yam Yei Kin. This sample proved to have both waxy and horny seeds. A single panicle of *Andropogon sorghum* va. *negrosense* furnished by Dr. Weston had waxy seeds only. This sample was from Talim Island, Lak of Bay, Laguna Prov., P. I., and Dr. Weston states that the cultivation of this variety is restricted to the southern islands of the Philippines. No attempt has been made to canvass the other sorghums for this character, although an examination of two or three of the commercial varieties showed only seeds with horny endosperm. The desirability of determining whether the waxy texture of the endosperm is confined to the Asiatic varieties of sorghum needs no emphasis, and it is important also that the wild species of *Andropogonae* be examined since this type of endosperm has been found thus far only in cultivated forms. Neither *Tripsacum* nor *Euchlaena*, the two American wild relatives of maize, seem to have waxy endosperm, and its occurrence in the *Andropogonae* and the *Tripsaceae* of Eastern Asia may add to other indications of the close relationship of these families.

⁴ Watt, Sir George. Coix spp or Job's tears. A review of all available information. Vegetable Product Series No. 88. The Agri. Ledger No. 13, 1804, pp. 513-553.

In addition to the differences in endosperm texture the seeds of coix differ also in the color of the pericarp. The seeds of most of the hard shelled forms have a dark red pericarp while the pericarp color of many of the soft shelled seeds is a very light brown. Both red and brown pericarp colors are found in maize though by far the most common form is colorless, a form as yet not found in coix, while the only pericarp color known in *Tripsacum* and *Euchlaena* is a dark red. There is nothing to indicate whether the association in coix of the light brown pericarp with the soft shelled seeds is genetic or due simply to a discrimination against red pericarp in the cultivation of edible forms.

In maize the waxy texture of the endosperm has been found to be associated with the color of the aleurone cells of the seeds and also with a form of seed known as shrunken.⁵ None of the samples examined had colored aleurone or shrunken endosperm but it is conceivable that with a larger series or by appropriate crosses these characters would be found, making it possible to compare their linkage relations in maize and coix. Even without this possibility coix should appeal to geneticists since the variability in seed and plant characters is great and the genus presents interesting morphological features.

INHERITANCE OF WEBBED TOES

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IN THE family of the writer there occurs a curious type of webbed toes. The digits affected are the two nearest to the large toe on each foot, which are joined together by a webbed skin that persists as far out as the last joint. This webbing appears only in the skin and the superficial fascia, and in no way affects the bones. Sometimes the web extends a trifle beyond the last joint on the right foot, and in other cases it does not extend as far as the joint on the left foot. However this may be in any one case, it is found that the web persists always to a greater degree on the right than on the left foot. There is no noticeable inability to move either or both digits on account of the web of skin. The condition prevails at birth, not increasing as the individuals grow older.

The character always appears in the male sex, is transmitted only thru the male lineage, and it is never concealed in the males of this lineage. The daughter of an affected male may transmit the trait to her sons if this character behaved in no unusual manner, but as is shown in the accompanying chart this never occurs. Also it



DIAGRAM OF WEBBED TOES. (Fig. 7.)

will be noted that it is never handed down to a daughter by an affected male.

This peculiar hereditary trait is apparently inherited as a secondary sex character. Since this condition prevails in the family of the writer, there has been ample opportunity to examine the females equally as well as the males, and all conditions noted and given here have been verified.

⁵ Hutchison, C. B. Heritable Characters of Maize—VII. Shrunken Endosperm. *JOURNAL OF HEREDITY*, Vol. XII, No. 2, Feb., 1921, pp. 76-83.