# The Breeding and Cultivation of Maize

BY

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## INTRODUCTION

BOTANICALLY catalogued as *Zea Mays*, and variously known as Indian corn, maize and mealies, this high yielding cereal is believed to have originated in Central or South America. The only known relatives of maize are teosinte (*Euchlena mexicana*) and gama grass (*Tripsacum* spp.). It is thought that maize developed as a cross between one of these and an unknown grass of the Andropogoneae, or as postulated by another school of thought it may have arisen from a wild pod corn. But as no wild or uncultivated maize is known among present or ancestral types its origin remains a matter for speculation.

Although maize was only introduced into the old world after the discovery of America, it can now claim to be one of the world's most widely cultivated crops; its distribution being chiefly confined within the fortieth parallels of latitude. Its uses both as a food and as a base for industrial preparations are varied and numerous, so much so that in America much money and time have been devoted to the evolution of new hybrid varieties with excellent yields. But in Asian countries where rice is the staple diet, maize is only casually cultivated and hence has received serious impetus towards improvement. This lethargic attitude is for the most part due to the fact that those accustomed to rice find maize hard to digest, and moreover, food preparations from maize take twice as long to cook as rice. Furthermore the peoples of the East have not yet realized the immense value of maize as fodder and silage for livestock.

With the ever-growing food shortage all over the world, however, and the increasing difficulty to procure rice imports, the accent has at last been placed on subsidiary food crops, and as such maize should take prominence in the future.

## THE POSITION

The cultivation of maize in Ceylon has all along been restricted to the chenas of the Dry Zone, where it is grown chiefly as a mixed crop with kurakkan, and to small peasant holdings in the wetter highland districts. These maizes are all indigenous flint varieties of which there may be said to be three distinct types—red, yellow and white, yellow being the most common. However since no effort is made by the cultivator to select seasonally for seed and owing to the prevalent practice of growing numerous



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varieties concurrently in adjoining chenas and lots, natural hybridization over a period of very many years has almost obliterated all trace of definite varieties. Maize is normally cross fertilized and owing to the peculiar double fertilization which affects the endosperm, seeds show an immediate influence of a foreign pollen parent. A single crop will therefore exhibit a variety of differences in endosperm colour. Individual ears too will show colour combinations of yellow, red, purple and white.

The total accumulation of genes, however, in indigenous material seems to be disappointingly low, and flints as a rule are not heavy yielders. On an average the ears are large, but the seeds being round and shallow and the cob forming a comparatively large part of the ear, the shelling percent is invariably as low as 50-60, which compares most unfavourably with American dent corns that have shelling percents of 70-80. These factors taken all in all and enhanced by indifferent cultivation and manurial practices have resulted in poor quality maizes with notoriously low yields. Average yields of 15-20 bushels show up miserably when compared with bumper harvests of 40-60 bushels reaped in America, Europe and parts of Australia.

## IMPROVEMENT

The immediate problem that confronts the breeder, therefore is the production of high-yielding, quality-grain maizes. Two obvious avenues of approach are suggested viz :

(1) The introduction of high-yielding maizes from other countries.

(2) The improvement of indigenous material.

## THE CULTIVATION OF INTRODUCTIONS

In considering the feasibility of this approach, there arises the significant question of a adaptability. Maize though tolerant of a wide climatic range seems to be " latitude bound," and when transported outside its own latitude deteriorates in yield at once or over a few seasons.

The Department of Agriculture has experimented with such introductions from time to time with discouraging results. Of ten inbred lines obtained from Maryland, U.S.A., only four adjusted themselves to the new environment and the double hybrids derived from these inbreds have not proven themselves superior in yield to the local varieties. Three types of Italian flints were also tried in various parts of the Dry Zone with disappointing results. Recently four Javanese selections were grown at Agricultural stations, Katugastota and Tabbowa, and although high shelling percents and uniformly attractive ears, were very much in evidence, yields were not superior to outstanding local varieties of a comparable age. The

only introduction that seems to be thriving under local conditions is Australian Improved Yellow Dent, which has been grown very successfully since its introduction in 1948.

It is too early yet to attribute definite reasons for the success of this one variety in the face of the very mediocre performances of the others, but it will not be far wrong to surmise that maizes like Australian Yellow Dent derived from a more proximate latitude are able to adapt themselves to local conditions without a significant diminution in yield.

## IMPROVEMENT OF INDIGENOUS MAIZES

The unflattering performance of the majority of introduced maizes focuses the attention of the breeder on the improvement of indigenous stock, which, though poor in quality and yield, is characterised by a high degree of vigour and resistance to unfavourable conditions. Stout culms and lush leaves are a feature of all Ceylon maizes. Three methods of improvement are possible :

### (A) Selection

Firstly there is straight selection, where seasonal identification and isolation of promising plants within a local type is carried on till eventually an improved selection which is higher yielding and more uniform than the original local is produced. As a matter of fact such a selection known as " yellow maize " has long been recommended by the Department, and though it is superior in quality, yields are often only moderately better than local material. The paucity of genes in indigenous material restricts the value of this method and no striking results can hope to be achieved.

### (B) Varietal Crossing

Secondly there is the method of varietal crossing on the American pattern, which consists of identifying pure lines by a system of inbreeding local material for several seasons till the desirable germ plasm is made known. Thus highly superior strains may be determined and used to produce either first-cross seed from two pure lines, or a double hybrid from four pure lines. If the inbred purelines are not closely related improved yields may be expected on account of the phenomenal hybrid vigour that is imparted to the maize in the event of crossing.

But once again the efficacy of the system is impaired by two major limitations. Hybrid maize as such owes its superiority to the ephemeral expression of hybrid vigour. Hence the constant production of first cross or double-cross seed, which has to be frequently made available to the cultivator requires a considerable commercial organisation. An idea of the labour involved may be obtained from the estimate that only 0.1 per cent. of the inbreds tested in the U.S.A. have proved suitable for the production of commercial hybrids. Success was not attained until co-operative programmes

involving several states were launched. The cost of breeding and maintaining the production of hybrid seed corn, therefore, may well be entirely uneconomic for a country like Ceylon with only a small maize acreage. Furthermore the low gene complex of indigenous material presents a poser to the evolution of strikingly high yielders by this method.

(C) **Top Crossing**

It is very evident then that any system which hopes to attain economically important results must involve a process, whereby the local material is graded up by an infusion of fresh germ plasm. It is here that introductions prove particularly valuable as reservoirs of genes.

This in fact is what is being attempted by the Division of Botany. Promising open-pollinated strains are being top crossed with introduced material with a view to combining potentialities for yield and quality derived from the introductions, with the high degree of vigour and adaptability that characterises the local flints. The ensuing hybrids are being rigorously tested on the following criteria :—

(i) Large, well filled and completely covered ears with not less than 14 regular rows.

(ii) Ears of uniform endosperm colour.

(iii) Superior yields with a shelling percent of not less than 70.

(iv) Increased vigour and a high degree of resistance to lodging, wind and stem borer.

Hybrids that show promise, but are deficient in any one or more of these requirements are further top-crossed to correct or improve such tendencies. Since the *yala* season of 1951, one hundred and eleven top crosses have been effected, of which the best that conform with the above standards are selected from time to time for further trial in the major maize growing areas.

It is too early yet to make any definite recommendations, but preliminary trials indicate a marked improvement in yields, uniformity of endorsperm colour, shelling percentage and the almost total eradication of ear-tip sterility. A reduction in age too has been achieved by crossing certain longer-aged local types with early Javanese varieties and American inbreds. The earlier types of maizes are particularly profitable for cultivation in the wet zone where shorter spells of dry weather obtain.

As yet only four Javanese varieties Stbno 1, 4, 7 & 124 and four American inbreds P 8, T 8, Tr & 38-11 and their derivatives (i.e. F1's three-way and double crosses) have been used in combinations with local material. It is proposed to include Australian Yellow Dent and Italian Yellow in

future breeding programmes. Since the encouraging results obtained so far augur well for future top-crossing, the introduction of fresh breeding stock from other countries is being considered.

Top-crossing, however, is considered a mere stop gap in America. When the demand for hybrid corn exceeds the supply, top-crosses are issued temporarily. For countries like Ceylon, however, where immediate increases in yield are sorely needed, but uniformity is of less importance at present, this method offers plenty of scope—till such time as superior local inbreds have been identified and successfully combined with foreign inbreds to give prosperous commercial hybrids. The production of indigenous hybrids must be the ultimate aim of any country hoping to obtain maximum benefit from the use of hybrid maize.

There is a popular fallacy that hybrids are extraordinary crops capable of high productivity even in poorly tilled and spent soils, so much so that when disappointing yields are realized under these conditions the faith of the peasant in the breeder is irrevocably shaken. It should be thoroughly appreciated by the cultivator that hybrids are not infallible productions against the usual deficiencies of soils and agricultural practice. In fact the heavier yielding hybrid maizes make greater demands on soil fertility and moisture than the open pollinated varieties. Where crop yields are limited by these factors the introduction of improved varieties would offer little advantage unless the existing primitive methods of cultivation give way to improved practices. Varietal improvement can find its fullest expression only under improved agronomic conditions. A general outline therefore of the more important agronomic aspects of the crop will not be out of place.

## PREPARATORY TILLAGE

This will to a large extent depend on the nature of the soil, but as a rule a deep early ploughing, well in advance of the onset of the rains is advocated. Heavy clays and ill drained land should be avoided as much as possible, but, if used, should be ploughed to a depth of eight to ten inches.

But more important than soil type is tilth and soil structure. A fine seed bed ensures uniform stand and even maturity, and since there is an interaction between soil and climate, good soil conditions will protect the crop against adverse weather. This effect is further enhanced by the application of organic manures. The organic matter requirement of maize is high, hence a basic organic dressing should always be included in the preparation of the land.

The recommended practice is to harrow into the soil about five tons of compost or farmyard manure. But in the Dry Zone, where such bulky organics are scarce or are reserved for the cultivation of money crops like chilli and tobacco, a beneficial rotation should be implemented, whereby a green manure crop like cowpea, green gram or sun hemp alternates with the maize—the green crop being turned into the soil.

## SEEDING TIME AND RATES

Maize needs a well distributed rainfall during its vegetative phase, with intermittent spells of warm, bright weather, and should therefore be planted with the first rains, or dry-sown early in expectation of the rains. Late-planted maize is invariably stunted and less vigorous. During its reproductive phase, however, dry weather is essential to ensure maximum seed set and proper ripening. Wet weather during the period of maturity facilitates the spread of disease, besides causing the crop to lodge. Tassel smuts (*Sorosporium reilianum*) and stalk and ear rots (*Diplodia zeae* and *Gibberella saubenetii*) can become quite troublesome as a result of late planting, causing an appreciable reduction in market value.

For *maha*, both in the Dry and Wet Zones, planting with the first rains in October is best. In *yala* (Wet Zone only), sowing should be done in April or early May depending on the advent of the rains.

The spacing of the crop will be largely controlled by the nature of the soil, age of the crop and the machines used for intercultivation. Longer aged varieties and richer soils demand a wider spacing. But, as a general rule, the following recommendations may be adhered to in average soils.

Grain maize (Drilled)—3′ between rows and the drills so adjusted as to drop seed at a spacing of 6″-9″ in the row.

Grain maize (Dibbled)—2′ × 1′ with one seed per hill or $2\frac{1}{2}$′-3′ × 1′ with two seeds per hill.

Seed rate—15-20 pounds per acre.

Fodder maizes are either broadcast or drilled in rows one foot apart. The plants in the row should be as close as possible. 30-40 pounds of seed per acre should suffice.

## INTERCULTIVATION

This is a much neglected agricultural practice, though of the gravest importance if maximum yields are to be realized. Even more important than the actual stirring of the soil is the control of weeds, till such time as the crop is established well enough not to be seriously affected.

At least two intercultivations should always be given. In very weedy areas, however, a third may be necessary. The number and interval between intercultivations will vary with different localities, but the following schedule may serve us a guide.

(i) Two weeks after sowing (plants 6″-9″ high)—First intercultivation and thinning of plants.

(ii) Four weeks after sowing (plants about 1′ high)—Second intercultivation.

(iii) Six weeks after sowing—Earthing up with the Lister plough or with mamoties.

Earthing round the plants prevents lodging and in the case of listed areas conserves water, for although rain is detrimental to the crop during its later stages, a fairly high soil water requirement is necessary.

## FERTILIZER PRACTICE

Maize is a very exhaustive feeder and the nutrient status of local soils being poor, it is very evident that spasmodic organic dressings and crop rotations are not alone sufficient to ensure maximum yields per acre. The incorporation with the soil of supplementary fertilizers to those who can afford it is therefore well worth the extra trouble and expense. The cost of purchasing fertilizers has been prohibitive to the cultivator in the past, but under the present Government subsidy it should be easier to popularise their use.

Ceylon soils generally lack nitrogen and phosphoric acid, but potash is found to appreciable extents except in the sandier areas. Hence a fertilizer mixture should include approximately equal proportions of nitrogen and phosphoric acid, and in sandy districts a small proportion of potash in the form of muriate of potash.

Proper fertilizer practice is a tricky business; the cultivator is therefore warned to seek technical advice as to the composition and method of application of mixtures in his particular area. Fertilizers may be applied broadcast along with the organic dressing or they may be given as split doses at the time of preparatory tillage and earthing up. The placement method is recommended in preference to broadcast applications, since fertilizer nutrients are made more easily available to the crop at the critical times when they are required. Further. the loss of nitrogen by leaching is minimised. In the placement method, the mixture is applied as a split dose in a band about two inches away from each row of plants, at the time of sowing and immediately before flowering. This method is particularly suitable for adoption in small holdings.

As a general rule the following mixtures may be considered for an acre of maize :

### Dry Zone

1-1½ cwt. ammonium sulphate

½-¾ cwt. superphosphate (concentrated).

**Wet Zone**

$1\frac{1}{2}$-2 cwt. ammonium sulphate

$\frac{3}{4}$-1 cwt. saphosphosphate or hyperphosphate.

In sandy districts $\frac{1}{4}$ cwt. of muriate of potash may be added to the mixture.

Nutrient deficiencies may be gauged from the behaviour of the crop. A cultivator who is capable of distinguishing the symptoms of such deficiencies is able to vary the proportions of a mixture to meet the demands of his crop. Premature yellowing or firing of the lower leaves from the tips downward is indicative of nitrogen deficiency. On the other hand purple colouring of leaves and stunted growth may be due to a lack of phosphoric acid. Potash deficiencies are not so easily discerned, but burning around the outer edges of leaves, a somewhat stunted growth and chaffy, poorly filled ears may point to the need for potash.

## SEED SELECTION

The following season's seed should be selected within the standing crop from plants representative of the variety and area. Vigorous plants with stout straight culms should be favoured. Double eared plants bear more grain per plant than single eared plants, but the proportion is not double. One good ear per plant is certainly better than two mediocre ears, but where possible it is best to select from plants with two good ears. Ears should be completely covered by husks and borne on strong stalks. This if chiefly a selection against bird damage and unfavourable weather.

It has been found that longer ears yield more seed and that long, narrow grains are always associated with greater shelling per cent. The number of rows per ear seems to be immaterial as shown by research workers in other countries, who claim that the yield per row does not necessarily increase with number of rows in the ear. The ideal of selection therefore will be a long ear with large flat and deep kernels, borne in not less than fourteen regular rows.

## LIST OF LITERATURE

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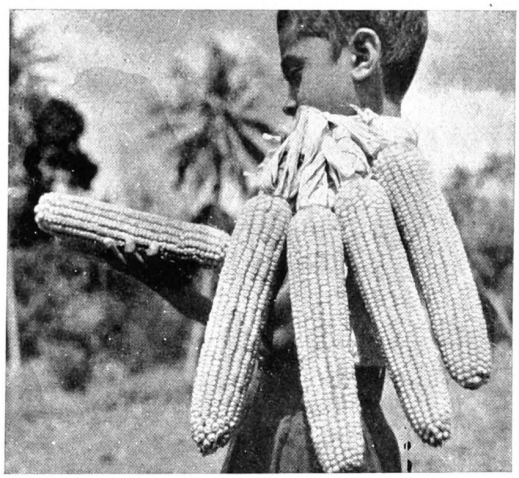

Fig. 1.—A fine example of hybrid maize obtained by top-crossing local material with introduced maizes.

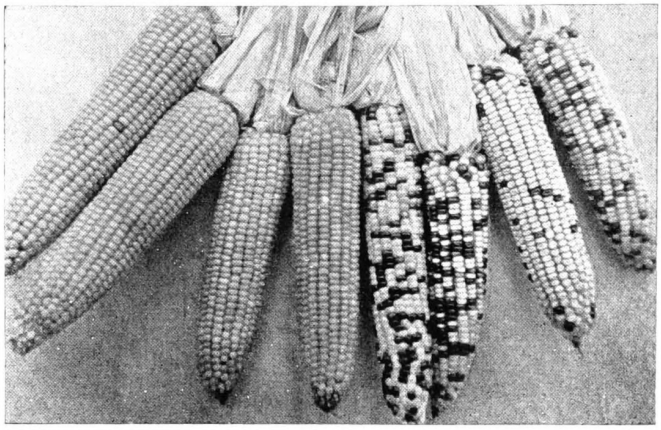

Fig. 2.—A comparative study of selected and unselected maize showing the elimination of endosperm colour differentiation achieved by crossing.

Fig. 3.—Another comparative study of improved and indigenous maize.

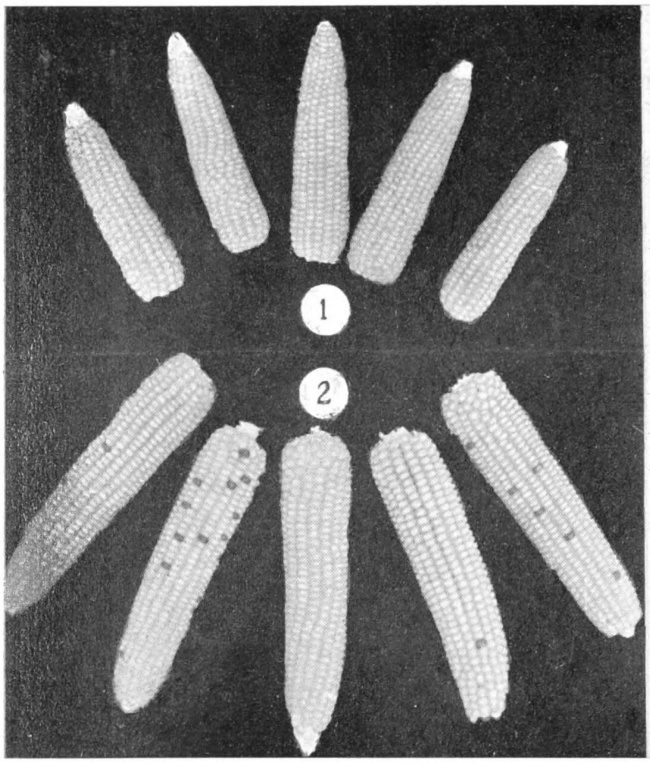


Fig. 4.—Hybrid flint maize (2) produced by top-crossing a local variety—W 1, with a Javanese strain—Stbno. 124 (1).

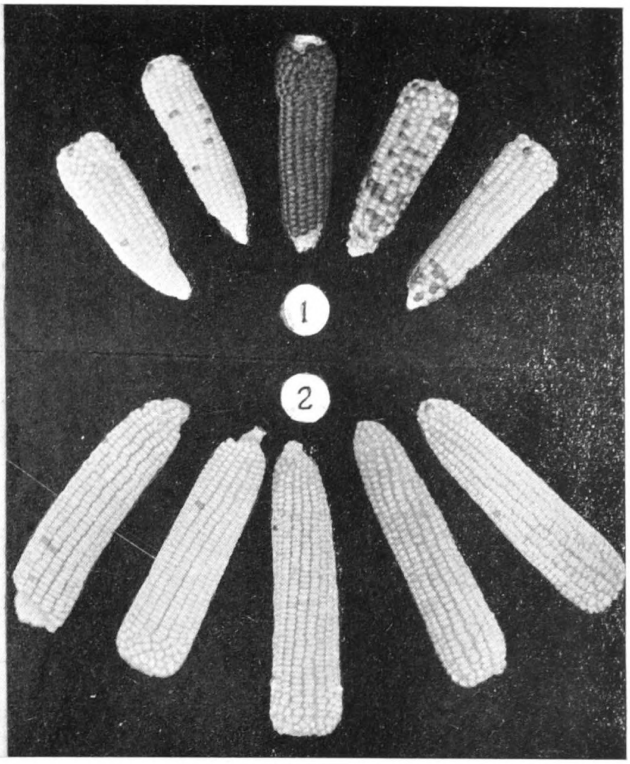


Fig. 5.—Hybrid dent maize (2) produced by top-crossing a local variety—M 2 (1), with introduced American inbred—TR.

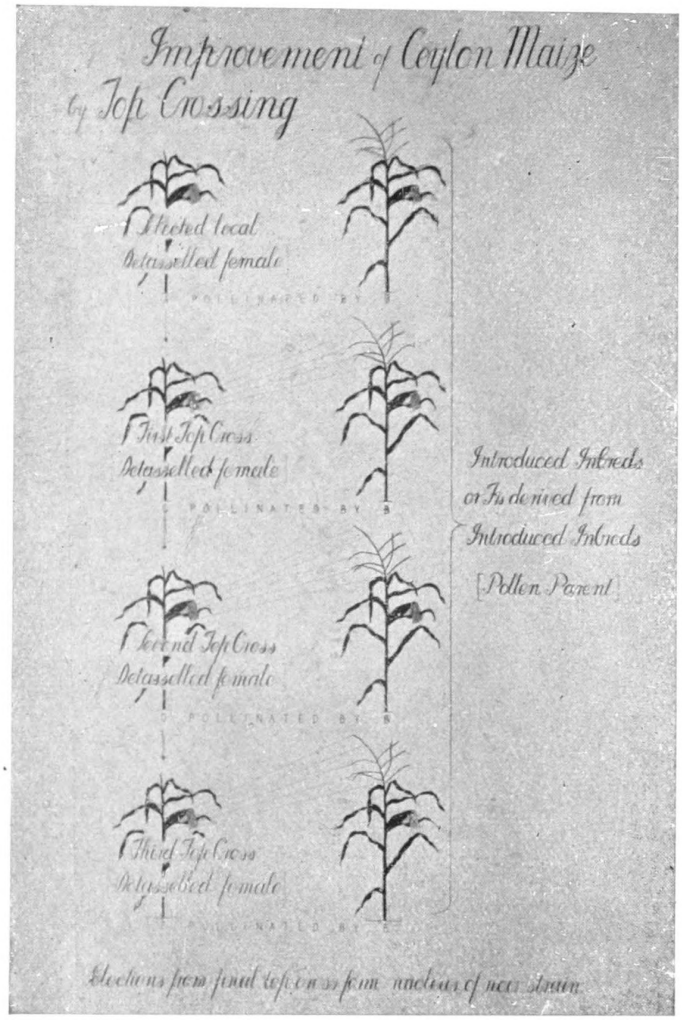


Fig. 6.—A diagramatic representation of the method being adopted by the Division of Botany to improve indigenous maizes.