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BHAG SINGH

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

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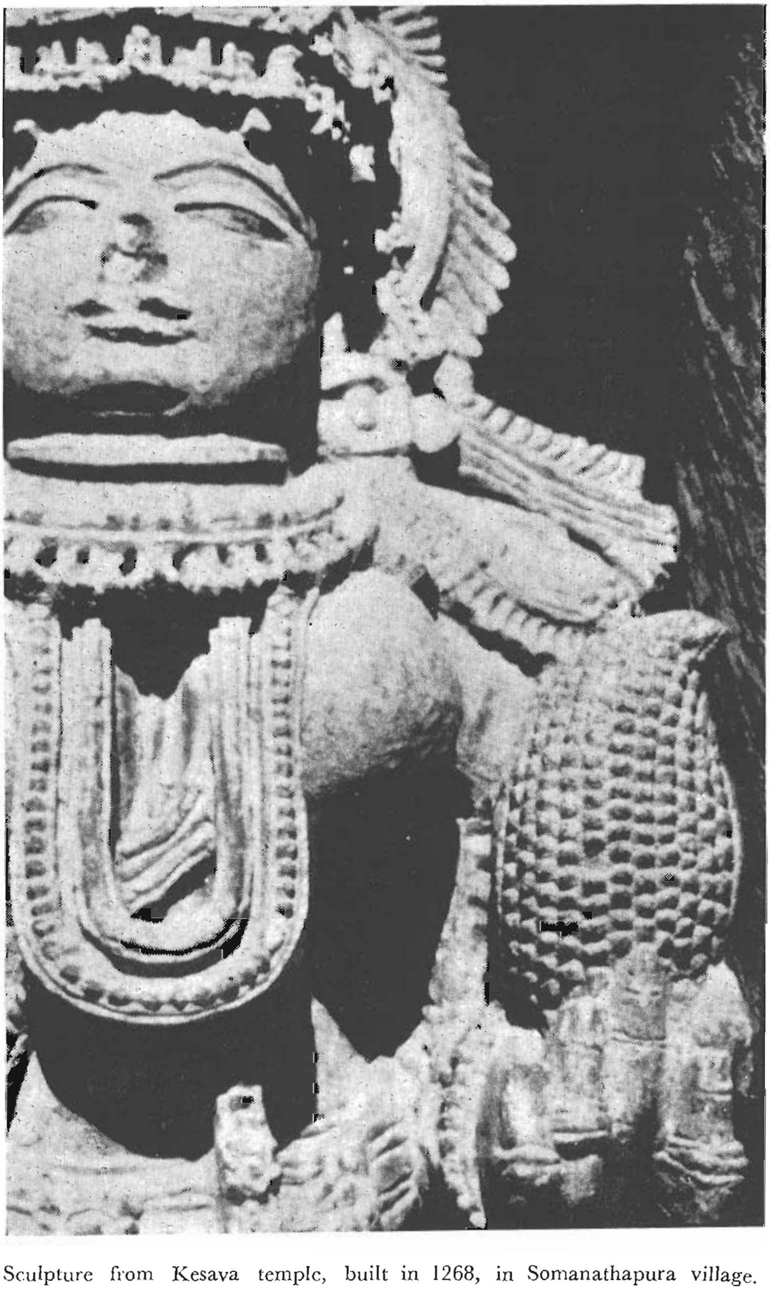

Sculpture from Kesava temple, built in 1268, in Somanathapura village. Could the object in the hand of the deity be a cob of maize?

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BHAG SINGH
Indian Agricultural Research Institute, New Delhi

ICAR

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FOREWORD

Although maize is essentially a crop of the New World, a surprising degree of diversity occurs in this crop in India, particularly in the North-Eastern Himalayan region. Unfortunately, there have been very few systematic attempts to collect and classify the primitive cultivars of maize found in several parts of Asia and Africa. Dr Edgar Anderson has drawn pointed attention to the presence of striking variability in maize in the North-Eastern Himalayan region. Dr N. L. Dhawan and his colleagues found that some of the strains from Sikkim have characteristics which bear resemblance to the postulated ancestors of maize. In fact, such strains raise the question whether maize came into India in the post-Columbus period as commonly believed or much earlier.

The Indian Council of Agricultural Research is deeply concerned about the problems of gene erosion and hence has started projects for the systematic collection, conservation, classification, assessment and utilization of germplasm material of economic plants. More recently, a National Bureau of Plant Genetic Resources has been set up for this purpose.

The present Monograph written by Dr Bhag Singh is the outcome of an ICAR-sponsored project executed by the Indian Agricultural Research Institute, New Delhi, on the collection and description of races of maize in India. Dr Bhag Singh has taken considerable pains to collect material from a region inhabited by people of varied ethnic groups, rich in culture and tradition. He has studied this material at Delhi and compiled the information contained in this Monograph. A similar Monograph on the rice strains of the North-Eastern Region will also be published by the ICAR. I hope this Monograph will be found useful not only by maize research workers but by all those interested in the fascinating world of crop diversity and evolution.

M. S. SWAMINATHAN

PREFACE

The information given in this publication was collected under the scheme 'Studies on Collection and Classification of the Races of Maize in India', financed by the Indian Council of Agricultural Research.

The Project was conceived by Dr M. S. Swaminathan, former Director of the Indian Agricultural Research Institute, New Delhi. It is mainly due to his keen interest and encouragement that this task of classification has been possible.

This work would not have been possible but for the keen interest, guidance and constant encouragement of Dr H. K. Jain, Head of the Division of Genetics, and Dr Joginder Singh, Project Co-ordinator for Maize, Indian Agricultural Research Institute, New Delhi.

I wish to express my gratitude to the various state departments of agriculture, in particular to the officials of Arunachal Pradesh, Nagaland, Assam, Sikkim, Bhutan, Manipur, Tripura and West Bengal, for their co-operation, help and guidance in collecting the large number of maize varieties.

Thanks are due to the Statistical Adviser and the staff of the Mechanical Tabulation Unit of the Institute of Agricultural Research Statistics for the computer facilities, to the photographic section of the Indian Agricultural Research Institute for the illustrations, and to Mr R. N. Sharma, Mr H. C. Bhattacharjee, Mr Gurmit Singh and Mr O. P. Bhagat for their help and assistance.

Grateful acknowledgement is also due to Dr A. B. Joshi, Director, Indian Agricultural Research Institute, New Delhi, for facilities and encouragement.

1 August 1975 BHAG SINGH

CONTENTS

1. INTRODUCTION

Maize varieties under cultivation in the Indian subcontinent are distinctive in being early in maturity. Most of them have yellow to light-yellow grain. These varieties have undergone natural as well as intensive human selection during the past five centuries (or more, if the hypothesis of pre-Columbian introduction is accepted). The variability in plant, tassel and ear characters is much greater in the north-eastern and north-western highlands of India, in contrast to the varietal diversity available in the plains, which at present account for over 80% of the area and production of maize in the country. In the early twentieth century, several introductions have been made by the central and state governments and individuals to identify more productive varieties, but these attempts have not contributed much towards broadening the spectrum of variability of maize grown in the plains of India.

Grant and Wellhausen (1955) observed that the local maize varieties in the plains of India were fairly uniform and lacked adequate variability necessary for the production of high-yielding hybrids of potential commercial value. These observations have been supported in several maize-improvement programmes.

The varieties of maize found in India seem to be of two general types, according to Grant and Wellhausen (1955). "One is an early yellow flint with a long slender ear somewhat enlarged at the butt, light-yellow endosperm, and shallow grain. This type closely resembles the early yellow flints that are grown in the north-eastern part of the United States. The other general type is a flint with short compact ears, deep-yellow-orange endosperm and shallow grain. This type looks very much like some of the Cuban yellow flints found throughout the Caribbean region."

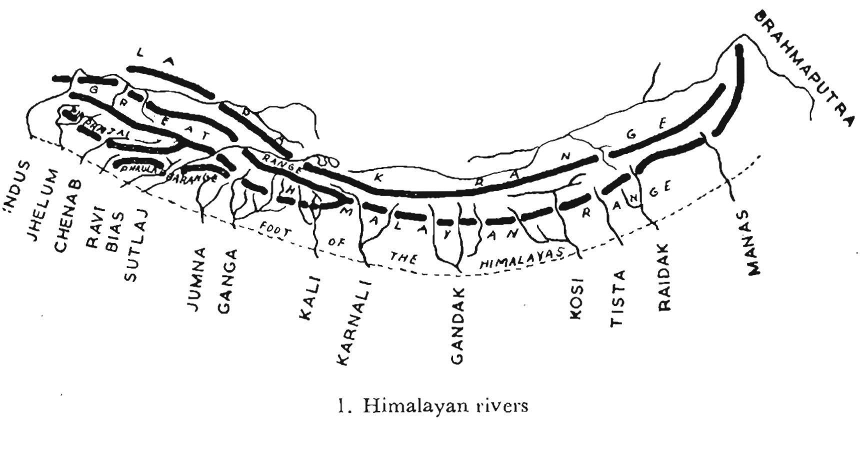
Under the Co-ordinated Maize-Improvement Scheme, a wide spectrum of germplasm has recently been collected from the major maize-growing countries of the world. These introductions in judicious combination with the Indian germplasm have led to the production of highly productive disease- and pest-resistant hybrids and composites. A number of them are already under commercial cultivation.

The importance of local germplasm which has undergone three to four centuries of natural selection cannot be overemphasized not only for direct cultivation but also as a source material for handling the problems of tomorrow. A number of Indian maize varieties like 'Rudrapur' have shown a high degree of resistance to the bacterial stalk-rot and other diseases to which a majority of the exotic varieties are highly susceptible. As the available indigenous variability in the plains is not extensive, particularly in regions where the bulk of maize is located, it is important that the available variability is conserved. In contrast to the Indo-Gangetic plains, extensive variability for plant and ear characters as well as for other traits becomes apparent to anyone travelling through the north-eastern Himalayan region comprising Arunachal Pradesh, Assam, Meghalaya, Mizoram, Tripura, Manipur, West Bengal, Bhutan and Sikkim and the Chamba Valley of Himachal Pradesh. Anderson (1945), Stonor and Anderson (1949), Ono and Suzuki (1956), Dhawan (1964) and Thapa (1966) were struck by the wide variability of maize in this region. Thapa (1966) collected maize varieties having marked resemblance in general plant morphology to that of the hypothetical progenitor of maize described by Mangelsdorf *et al.* (1964). So impressive is this variability that it led Anderson (1945) and Stonor and Anderson (1949) to propose an Asiatic origin to maize. Except for these stray studies no systematic attempts have so for been made on the range of variability in this important indigenous wealth. Not only can germplasm be of direct value, it can also provide, if properly mobilized along with other exotic materials, very useful populations for upgrading and stabilizing the present yield levels. Some of the pop-corn varieties in this collection are not only highly prolific and tiller profusely, they also have fairly narrow upright leaves and medium to short stature—a group of characters considered desirable under intensive agriculture. These medium- to low-yielding varieties of maize will not be able to withstand in their present form the onslaught of the high-yielding commercial hybrids; yet they constitute a distinct gene pool of importance for the improvement of maize. It was in this context that the present project on collection, evaluation and classification of the Indian germplasm of maize, particularly from north-eastern India, was undertaken. It is hoped that this classification of a rich reservoir of genetic variability will lead to a more effective utilization and would also contribute to a better understanding of the evolution and migration of the maize plant under human influence.

2. GEOGRAPHY AND CLIMATE OF INDIA

The Indian subcontinent is bounded by Burma in the east, Tibet and China in the north-east and Pakistan in the north-west. The country has vast montanous tracts to the north and a peninsula in the south, separated by the fertile Indo-Gangetic plains. To the south of the Indo-Gangetic plains lies the hill plateau of peninsular India, which is skirted by the narrow coastal strips, washed by the Arabian Sea to the west, the Bay of Bengal to the east, and the Indian Ccean to the south. On the north, along its entire length, the country is bounded by the lofty Himalayan mountains, which surround the plains in the west, north and east. To the south of this barrier are the alluvial plains of northern India, extending from Punjab to Assam, fed by the Indus, the Ganga and the Brahmaputra. The Indus and Gangetic river systems are separated by the Aravalli Hills and the adjoining deserts and semi-deserts of Rajasthan. Because of the varieties of soils at different elevations from sea-level to more than 6,000 m within a latitude of 8°-36°N, there exists a tremendous variation in climate.

The country has several rivers originating from the Himalayas



1. Himalayan rivers

(Fig. 1). On the basis of the rivers, the Himalayan mountains have been divided into 4 sections—the PUNJAB HIMALAYAS from the Indus to the Sutlej, KUMAON HIMALAYAS from Sutlej to Kali, NEPAL HIMALAYAS from Kali to Tista, and ASSAM HIMALAYAS from Tista to Brahmaputra (Randhawa, 1958). The most important rivers of the northern India are Ganga and Jamuna. Tista and Brahmaputra are important in the east.

The Indian soils have been classified into 4 major types: Indo-Gangetic alluvium, black cotton (or *regur*) soils, red soils lying on metamorphic rocks and laterite soils. The Indo-Gangetic alluvium is a very important and by far the largest soil group of India. A majority of the soils are loams or sandy-loams with a soil crust of varying depth. They are distributed mainly in the northern, north-western and north-eastern parts, including Punjab, Uttar Pradesh, Bihar, Bengal and parts of Assam and Orissa. Black cotton soils are common in Bombay, western parts of Madhya Pradesh, Mysore* and some parts of Tamil Nadu. These soils have generally a high degree of fertility. Red soils extend over the whole basement of peninsular India, from Bundelkhand to the extreme south, embracing south Bengal, Orissa, parts of Madhya Pradesh, Andhra Pradesh, Mysore and Tamil Nadu. The soils grade from poor, thin gravelly and light-coloured varieties of the uplands to the fertile, deep, dark varieties of plains and valleys. They are generally poor in nitrogen, phosphorus and humus. Laterites are specially well developed on the summits, hills of Deccan, Mysore, Kerala, Madhya Pradesh, coastal region of Orissa, Malabar and parts of Assam. All lateritic soils are generally very poor in lime and magnesia and deficient in nitrogen.

India is truly the land of monsoons. With the exception of Kashmir and south-eastern Tamil Nadu, much of the annual rainfall over the country occurs during the south-west monsoon period (June to September). In the extreme north a good proportion of the annual rainfall is contributed by winter precipitation, while in south-eastern Tamil Nadu nearly half the annual rainfall occurs during the retreating monsoon period, i..e, after September.

The areas of very heavy rainfall are to the windward side of the Western Ghats, the hills of Assam and the great Himalayan barrier. These are the watersheds from which originate the major river systems. Elsewhere, in the plateau of the Deccan, the Gangetic plains of northern India, and the plains of southern

*Renamed Karnataka.

India, the effects of orography are less pronounced or are completely absent, and rainfall is only moderate. Punjab, Rajasthan and the adjoining tracts to the north and west constitute the driest area of the country. The distribution of rainfall varies greatly, being as high as 400 cm over the Khasi hills and as low as 20 cm in western Rajasthan.

In India the success of agriculture, particularly of the rainy-season (*kharif*) crops like maize, depends principally on the monsoon. Generally, maize is planted at the onset of the monsoon (end of June) and harvested in October. In the hilly regions of north-eastern and north-western India maize is planted from March to May. The crop matures in 120–140 days and is harvested from August to September. In Andhra Pradesh and Maharashtra there are two crop seasons. *Kharif* planting starts by about the middle of June. The varieties mature in 110 to 120 days and come to harvest in September. A considerable area of maize is grown in the *rabi* season, when the crop is planted in November and harvested from March to April.

Winter begins earlier and lasts longer in northern India than in the central and southern tracts; the duration as well as the intensity of the cold decreasing rapidly as one moves towards the Equator. In north-eastern India and the maritime tracts of the peninsula, seasons of high humidity are long.

3. PLACE OF MAIZE IN INDIAN AGRICULTURE

A number of authors have favoured the observation of Watt (1893) that maize was introduced into India in the 16th century by the Portuguese, following the discovery of trade-routes by Vasco da Gama in 1498. This contention is primarily based on the lack of reference to maize in Indian history and literature before 1492. Even a Sanskrit equivalent of maize is not available. The presence of maize in pre-Columbian era, according to this view point, is not tenable. More recently the question of pre-Columbian contacts with the New World has received some attention (Lal, 1956; Suto and Yoshida, 1956; Sauer, 1960; Jeffreys, 1954, 1965; Thapa, 1966; Miracle, 1966; Hayerdahl, 1971).

The introduction of maize in the pre-Columbian era would have taken place through the usual land trade-routes in operation between the East and the West. This probably would support the presence of variability at higher elevations, unlike in peninsular India, particularly the coastal regions. Maize in the eastern Himalayan region is used by several tribes as offerings to the deity before harvest. The crop is preferred to the more extensively grown cereals (Thapa, 1966). In northern plains also, an offering of popped corn to bonfires lit on the occasion of *Lohri*, a peak winter festival, is well established and is observed till today.

Several tribes in the foothills and higher elevations of the Himalayas, Panch Mahal district of Gujarat and Udaipur district of Rajasthan exclusively depend on maize as the chief source of energy. In these regions, crops other than maize would probably give better yields; but the local population has a decided preference for maize, probably because of their long association with it. The precise length of association of maize with Indian culture and the acceptance of maize as a food cannot definitely be ascertained from the information available.

In terms of acreage, maize ranks next to rice, wheat, sorghum and millets, while in terms of production it exceeds millets. Annually, maize is planted in 5·8 million hectares and the production is over 6 million tonnes. Uttar Pradesh, Bihar, Rajasthan, Punjab, Madhya Pradesh, Himachal Pradesh and Jammu and Kashmir account for over 80% of the area and production. The particulars of the production and area in 1971–72 and 1972–73 are given in the Table 1. Most of the maize varieties grown in India are of the yellow flinty type.

Over 80% of the maize produced in India is used directly as human food. Nearly 10% of the produce is utilized by the starch industry, and as a poultry and cattle feed. The bulk of the maize is consumed in the form of unleavened bread, similar to Mexican ' tortillas ' but thicker and bigger. Much of the maize produced in the latter part of the rainy season is consumed in winter, along with green-leaf preparations of *Brassica* and curried pulses, particularly *Vigna radiata* L., in most of the northern plains. In Rajasthan it is consumed with green-leaf preparations of *Amaranthus*. The flint varieties meet the requirements of pop-corn and flour-corn of the New World, and the green flint ears are roasted or cooked as a vegetable. A porridge made in butter-milk and *rabdi* is favoured in Rajasthan.

TABLE 1. All-India final estimates of maize, 1971–72 and 1972–73

State	Area (thousand hectares) 1971–72	1972–73	Production (thousand tonnes) 1971–72	1972–73
Uttar Pradesh	1,479·0	1,470·3	842·6	1,297·6
Bihar	823·4	855·0	132·5	800·0
Rajasthan	763·4	801·3	751·0	660·8
Madhya Pradesh	596·6	591·9	484·3	578·8
Punjab	547·8	558·0	857·0	898·0
Jammu and Kashmir	282·2	276·3	363·3	380·3
Andhra Pradesh	271·0	247·3	293·6	229·3
Gujarat	268·5	250·8	432·0	255·8
Himachal Pradesh	246·1	251·1	330·3	392·8
Haryana	114·0	113·0	139·0	127·0
Karnataka	80·3	119·7	308·4	424·5
Orissa	74·8	66·5	63·1	54·9
West Bengal	45·1	46·9	38·0	38·3
Maharashtra	26·1	21·2	18·2	15·8
Meghalaya	14·9	14·9	7·5	7·5
Tamil Nadu	13·6	14·6	14·9	15·5
Assam	11·7	10·7	6·4	5·9
Manipur	6·6	14·0	17·1	22·0
Delhi	1·9	1·1	...	0·7
Mizoram	0·8	0 9	0 5	0·5
Total	5,667·6	5,725·5	5,100·5	6,206.0

In the north-eastern Himalayan region, maize is extensively used for brewing. The beer is made by several tribes with a mixture of maize, rice and millets, boiled in an earthen pot. A bamboo sieve covered with a muslin cloth at the upper end is placed in the centre of the pot. A little quantity of a starter extracted from a locally available fern is also added. The drink forms a regular part of the diet and is commonly used along with boiled meat of a variety of wild animals. Some of the tribes like Wancho and Chang Nagas are mostly dependent on maize.

A mixture of maize and rice is ground, boiled and served as one of the items of breakfast among the Garo tribes. Maize grains are sometimes parched or fired and ground to make *sattu*. Different types of preparations of *sattu* are occasionally used by the hill tribes like the Mikir tribes. They are also common in eastern Uttar Pradesh. In Madhya Pradesh, maize grain is used in the preparation of puddings, *pakori* and *barfi*. Similar types of preparations are not uncommon in parts of central Assam.

In the hills maize is grown mixed with millets or as a pure crop, usually in small plots in the immediate vicinity of the village. Nocte, Wancho and Khasi tribes in the north-eastern Himalayas dibble maize seeds in holes made with small bamboo sticks. The area of cultivation is shifted after some time, a process called *jhumb* cultivation. In the *sealing* method practised in Kashmir, the seedlings are thinned and organic matter is incorporated into the soil.

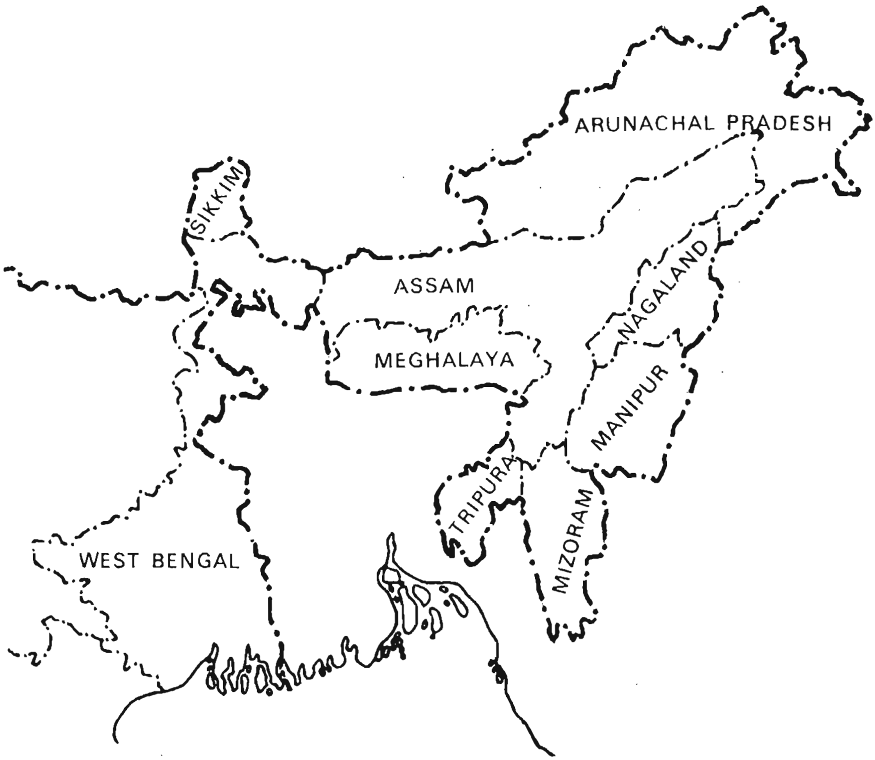
4. COLLECTION PROCEDURES

The majority of collections in this study were made directly from farmers' fields during the harvest season. An effort was made to obtain a minimum of 15 ears from each field and to include in this number as much variation as possible in respect of ear and plant type available in the crop. Notes were recorded on the locality, altitude, local name of the variety, rainfall and temperature. The full particulars of the localities of north-eastern region, from which most of the collections were made, are shown in Fig. 2.

The collections were dried, catalogued and photographed, and data on the ear and kernel characters recorded. A museum sample of ears of each collection was selected, and the remaining ears were shelled and the seed was mixed. These seed samples were put in cold storage for maintenance.

CHARACTERS USED IN CLASSIFICATION

The characters used in the classification are (*a*) vegetative characters of plant, (*b*) characters of the tassel, and (*c*) characters of the ear, both external and internal. The data (Tables 3-22) characterizing a race were taken from a selected group of collections, chosen after much study as being the most typical of that particular race. The number of collections selected as being typical of a given race varied from 1 to 59 (Table 2). The data in Tables 3–22 are averages based on the measurements of the collections for each given race. The column immediately following the mean values represents the standard deviation of the race. The number and identity of the collections used as being the most representative of each race are given in Table 2. The characters employed in this classification and the methods by which they were studied are described on the following pages.



2. Map showing details of north-eastern Himalayan region

The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

Based upon Survey of India map with the permission of the Surveyor-General of India. © Government of India. Copyright, 1977.

The boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas (Reorganisation) Act, 1971, but has yet to be verified.

5. VEGETATIVE CHARACTERS

Vegetative characters are strongly influenced by environmental variation. The varieties and races may be compared in an environment to which most of them are unadapted. Alternatively, they may be compared as they grow in their own different environments. A combination of data from both sites of environments would be more desirable. In the course of the present study, observations were recorded on all the collections grown under uniform environmental conditions at the experimental farm of the Indian Agricultural Research Institute, New Delhi. A brief summary of the characters used for the purpose of classification and the methods by which they were studied is given below.

Adaptation to altitude: Altitude is the dominant factor influencing the distribution of Indian races of maize. While maize is found growing in India from the sea-level to altitudes higher than 3,000 m, each particular race is adapted to a relatively small range. Adaptation to altitude is undoubtedly dependent upon many factors. One of the most important of these is temperature, which in a country like India is almost directly related to the altitude. It is largely for this reason that any given race can only be moved up and down within a certain range of altitude and can still remain well adapted to the environment. Hence the altitudes for all the collections were recorded.

Data were recorded on 10 competitive normal plants taken at random in each plot for all the characters, except days to flower.

Plant height: The measurements were uniformly made on the main stalk from the ground level to the base of the tassel. The mean height of the plant for each collection is the average of the measurements of the 10 normal plants chosen at random in the field plot.

Ear height: The measurements were uniformly taken from the ground to the uppermost ear on the main stalk. The means for this character were derived in the same manner as for the height of the plant. These heights may not agree with the ear heights represented on the internode diagram, since the latter represent plants with the modal number of internodes only.

Stem diameter: The means for this character are the averages of measurements made at the mid-point of the first internode above the ground on the main stalk.

Number of leaves above ear: The number of leaf bearing nodes above the uppermost ear was counted.

Leaf length: The leaf arising just above the uppermost ear-bearing node was measured from the ligule to the tip.

Leaf width: The same procedure was followed as for the length of the leaf, the measurements being made at the mid-point in the length of each leaf.

Leaf area: It was calculated as leaf length × leaf width.

Leaf angle: The leaf angle is arbitrarily scored from 1 to 3 as follows: 1 = erect leaf, 2 = semi-erect leaf, and 3 = flat leaf.

Internodal pattern: The pattern for a particular race was determined by measuring the length of each successive internode on each of the 10 plants. The results were averaged and depicted in a diagram showing the pattern of relative internode lengths. The diagram also indicates the position of the average number of ears and tassels. The numbers on the vertical scale in the diagram represent the lengths of each internode. The numbers at the base of the diagram represent the order of the internodes from the base upwards. The tassels are represented by circles and the ears by solid circles.

Ear number: The mean number of ears in a plant for each collection is the average of 10 representative plants.

Total leaf surface 'area' above ear: It was calculated as the number of leaves above the ear × leaf 'area'.

Brace root position: The position of the brace root is a visual estimate scored from: none = 0, arising from first node = 1, arising from the second node = 2, and arising from the third node = 3.

Pilosity: Pubescence is arbitrarily scored from 1 to 3 for both frequency and intensity, the lower number indicating stronger pubescence.

6. CHARACTERS OF THE TASSEL

The tassel is an extremely useful structure in classification. Several tassel characters found to be closely correlated with characters of the ear were not used since detailed data on various characters of the ear were taken.

Tassel emergence: This is a visual estimate recorded on 10 plants of each collection on an arbitrary scale: 1=flag-leaf covering the lowermost branch, 2=flag-leaf covering point of origin of the lowermost branch, and 3=flag-leaf below the lowermost branch.

Tassel length: The length was measured from the point of origin of the lowermost branch to the tip of the central spike. The average for each collection is based on measurements of 10 tassels.

Peduncle length: The distance was measured from the upper node of the stalk to the lowermost branch in the tassel. The average for each collection is based on 10 plants.

Central spike length: The distance between the uppermost primary branch and the apex of the tassel was measured.

Length of branching space of tassel: The distance between the basal and uppermost primary branches of the tassel was measured.

Total number of tassel branches: All branches, primary and secondary, were counted in the tassel on the main stalks of 10 plants from each collection.

Number of primary branches: All primary branches were counted in the tassel on the main stalk.

Number of secondary branches: All secondary branches were counted in the tassel on the main stalk.

Pollen diameter: The average pollen diameter for each collection is based on 100 pollen-grains.

7. CHARACTERS OF THE EAR

The ear would offer more useful diagnostic characters than any part of the plant since it is the most highly specialized organ which distinguishes *Zea mays* L. from all other grasses. Wellhausen *et al.* (1952) emphasized that the characters of the ear must be employed as fully as possible in any system of classification since the ear is frequently the only part available for collection and study. Hence particular attention has been devoted to external and internal characters.

EXTERNAL CHARACTERS

The external characters of the ear with one exception are a matter of simple measurement or counting. The description of the characters of ear employed in this classification is given below.

Ear length: The measurements were made on 10 normally developed ears. The same ears were employed for all the ear characters.

Ear diameter at base: The diameters were measured with callipers at the base of the ear.

Ear diameter at mid-point: The diameters of the ears were measured at the mid-point of their length.

Ear diameter at tip: The diameters were measured at the tip of the ear.

Row number: Actual counts were made of the number of rows of the kernel.

Kernel number/row: Actual counts were made of one row of each ear under study.

Row regularity: This is a visual estimate recorded on an arbitrary scale: 1=regular, 2=irregular to base, 3=irregular to tip, 4=irregular from base to middle of the ear, and 5=totally irregular.

Total ear surface: It was calculated as $3{\cdot}1416 \times$ ear diameter $\times$ ear length.

KERNEL CHARACTERS

Kernel thickness: The thickness of 10 consecutive kernels in a row near the mid-point of the ear was measured with callipers, when the kernels were on the ear.

Kernel width: The same 10 kernels used to determine kernel thickness laid side by side were measured.

Kernel length: The same 10 kernels were measured when laid end to end.

100-*grain weight*: With a Mattler microbalance 100 grains from the middle of the ear were weighed.

100-*grain volume*: The volume of the same 100 grains was measured in a measuring cylinder.

INTERNAL CHARACTERS

The same 10 ears used to determine the external characters were used to determine each of the internal characters described below.

Cob diameter: This was measured from the centre of upper surface of the upper glume on one side of the cob to the corresponding point on the upper surface of a glume directly opposite.

Rachis diameter: This was measured with callipers on the lower half of the broken ear. The measurement was made from the base of an upper glume on one side of the cob to the base of an upper glume directly opposite. Since the base of the glume is usually somewhat below on the rim of the cupule, this measurement does not represent the maximum diameter of the rachis but represents its diameter to the point at which the upper glume arises.

Rachilla length: Accurate measurements of rachilla length can be made only in histological sections, but a reasonably accurate estimate of rachilla length can be obtained from the data already available. The diameter of the rachis is subtracted from the diameter of the ear and divided by 2. From the figure so obtained is subtracted the average length of the kernel. The difference represents the average length of the rachilla from the base of the glume to the base of the kernel.

The indices were calculated as follows:

Venation index: It consists of the quotient of the average number of veins counted at mid-point in the length of the leaf just above the upper ear-bearing node and the average width at the same point. The counts and measurements were made on all plants scored in each collection.

Percentage branching space: This is the percentage derived by dividing the average length of that part of the central axis on which branches occurred by the total average length of the tassel.

Percentage of primary branches in tassel: The total number of primary branches in the tassel was divided by the total number of branches in the same tassel.

Percentage of secondary branches in tassel: The total number of secondary branches in the tassel was divided by the total number of branches in the same tassel.

Cob/rachis index: It is computed by dividing the diameter of the cob by the diameter of the rachis.

Glume/kernel index: It is computed by subtracting the diameter of the rachis from the diameter of the cob and dividing the figure obtained by twice the average length of the kernel.

Exposure index: It is computed as 100 times the ratio of the differences between ear and cob diameters and ear and rachis diameters.

Kernel density: It is computed by dividing the weight of 100 grains by the volume of the same 100 grains.

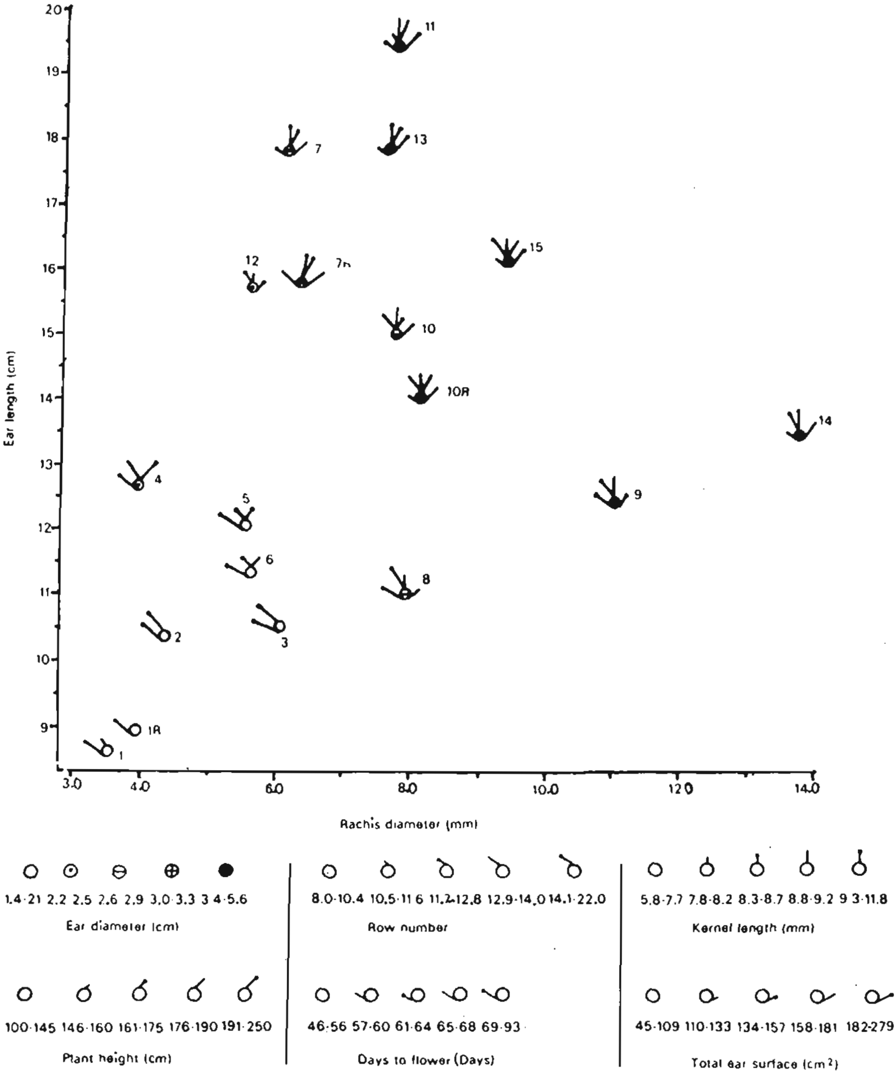
All other indices were calculated as x/y, where x and y are population means measured in the same units when possible.

8. IDENTIFICATION OF THE RACES

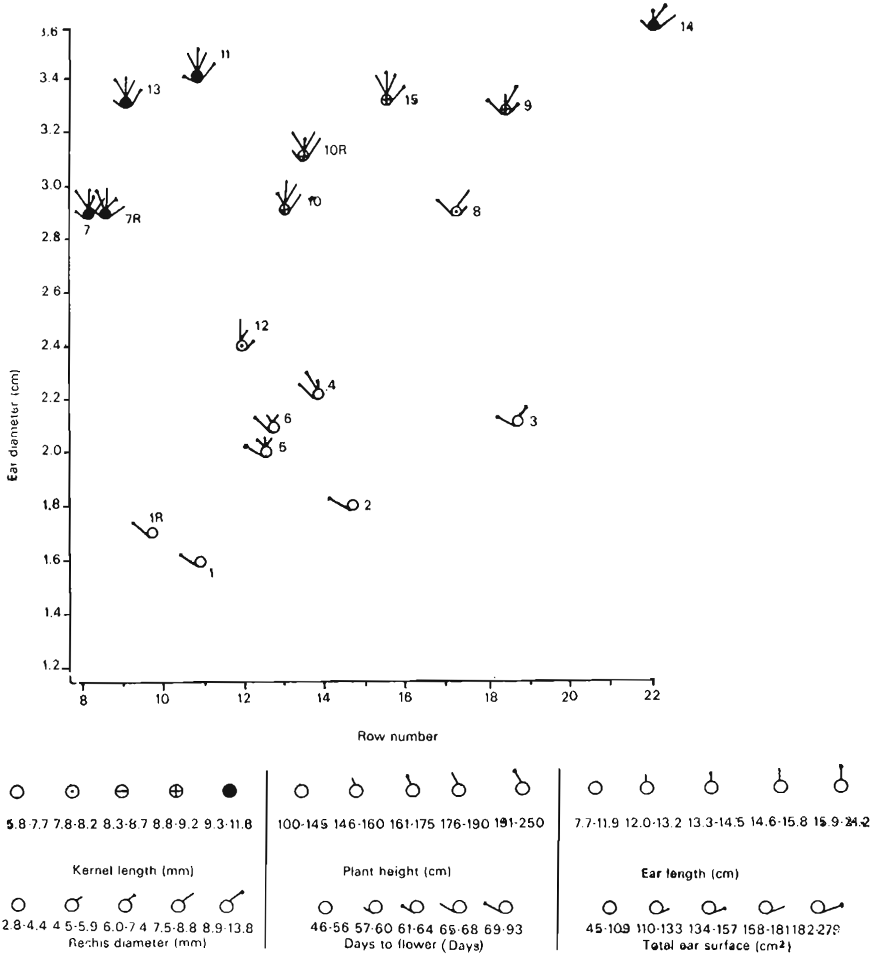
Fearing the erosion of locally adapted maize germplasm by high-yielding hybrids, and realizing its importance for future use, the National Research Council of the USA and the Rockefeller Foundation, in collaboration with the Mexican Government, initiated a systematic collection programme in Mexico in 1943. These varietal collections have since been systematically classified (Wellhausen *et al.*, 1952) into 25 racial and 4 sub-racial well-defined groups on the basis of a number of morphological plant and ear characters. Encouraged by the Mexican pioneering work, the collection and classification of local maize germplasm was extended to other Latin American countries like Colombia, Cuba, Peru, Ecuador and Bolivia (Roberts *et al.*, 1957; Hatheway, 1957; Brieger *et al.*, 1958; Brown, 1960; Ramirez *et al.*,1960; Grobman *et al.*, 1961; Timothy *et al.*, 1961, 1963; Grant *et al.*, 1963). These monographs, published from Latin American countries, provide voluminous useful information on the type of variability already available and the varietal groups that would be suitable for meeting the needs of a specific breeding programme. These treatises, however, lack detailed information on the procedure used in arriving at a specific number of races.

Goodman (1968) studied the relative stability of the plant and ear characters in various environments. His data suggested that ear and grain characters in general showed a better stability than vegetative traits. Data from the north-eastern Himalayan region compiled for the current study, in progress at the Indian Agricultural Research Institute during the past 3 years, are in agreement with those of Goodman (1968). Data on stable traits were used for the primary classification of varieties into racial groups.

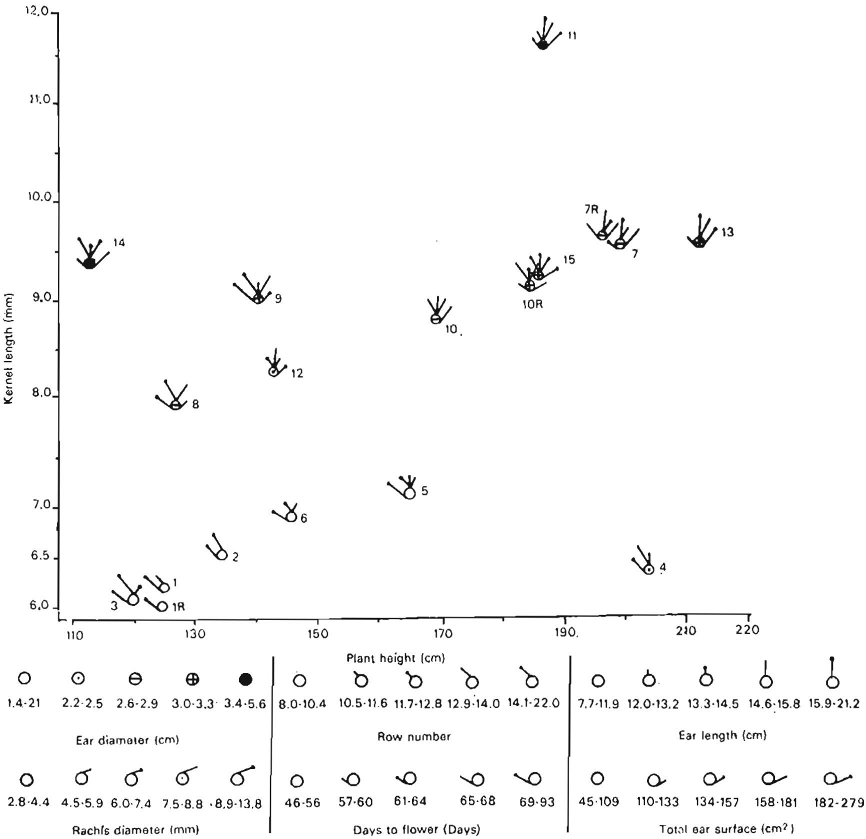
The pictorial scatter diagram of Anderson (1957) was used in the present classification, wherein several stable characters showing significant variation were utilized. Rachis diameter, row number, ear diameter, kernel length, ear length, total ear surface, plant height and days to flower were used. A number of scatter diagrams were developed with various character combinations as primaries represented by abscissa and ordinate. In



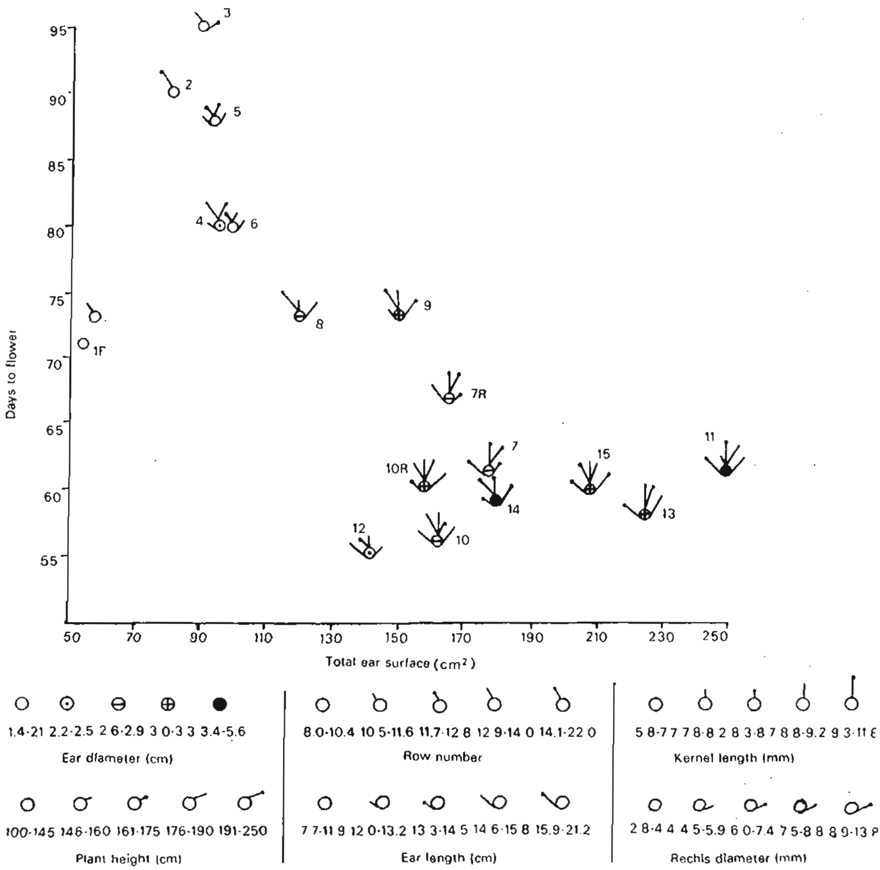
3. Pictorialized scatter diagram I



4. Pictorialized scatter diagram II



5. Pictorialized scatter diagram III



6. Pictorialized seatter diagram IV

the scatter diagrams (Figs 3–6) a nearly consistent racial pattern was observed.

Each of the characters was divided into 5 class intervals—low, low-medium, medium, high-medium, and high—on the basis of $\mu \pm 2\sigma$, where μ represents the mean value of the character and σ represents the standard deviation. The class intervals of each character are indicated in Figs 3–6. The class intervals of ear diameter in Figs 3, 5 and 6 and kernel length in Fig. 4 are represented by the structure of the circle as indicated in the figures. The ranges in the remaining characters have been represented by different lengths combined with terminal dots of the ray, and the different characters are represented by different positions of rays on the glyph. For each character a long ray with a terminal dot indicates that the individual has the highest value, a simple long ray indicates that it has high-medium value, a short ray with a terminal dot indicates that it has medium value, a simple short ray indicates that it has low-medium value, and no ray indicates that it has low value. For convenience and better understanding, overcrowding has been avoided by representing each race with a single glyph. Each ray of the glyph represents the mean value of the race and the numerical value around the glyph represents the race. Numbers 1 to 15 indicating the races are in similar order as enlisted in the Tables 3–22, whereas 1R, 7R and 10R used in pictorial diagrams represent the sub-races of the respective numbers.

Fig. 3 represents the pictorialized scatter diagrams, where the x-co-ordinate of each circle is the rachis diameter and the y-co-ordinate is the ear length of each race. The index scores for these characters have been obtained by assigning values to the 5 grades with equal weight to all the characters. Though the total magnitude of the indices of races 4 and 8 was similar, the races were different in all the characters except maturity. The situation was the same for races 11 and 15 belonging to another similar group. Of the 8 characters under consideration, these groups differed from each other in 4 characters: ear diameter, row number, kernel length and rachis diameter. The situation was similar for other races.

To overcome this difficulty and to understand the situation more clearly, several characters in combination were tried to study the distribution pattern. The choice of 2 characters as x-abscissa and y-ordinate is of primary consideration. Three more pictorialized scatter diagrams with different combinations of x-abscissas and y-ordinates, as indicated in Figs 4–6, were used. Each of x-abscissa and y-ordinate were divided into 5 class intervals, as explained above, and a number of cells, each categorizing a distinct group, were obtained. If we consider the 2 characters as denoted by x-abscissa and y-ordinate in each of the 4 figures, we find that no race maintains its individuality by differentiating itself from the rest of the races for all the 8 characters. On the other hand, race Shyam Nahom, indicated by number 8, in 3 of the 4 figures maintains itself in different cells. Thus this race differs significantly from all the other races in at least 3 of the 8 characters under consideration. This is true also of races numbered 4, 7, 9, 10, 11 and 14. Moreover, Shyam Nahom differs significantly in at least 4 characters from all the races except from Silken Tipang. Race number 8 (Shyam Nahom) differs from the race number 12 (Silken Tipang) in at least 3 characters. Similar types of conclusions were drawn for different characters.

Conclusions could be erroneous if the score index is calculated by giving equal weight to different characters and by simply adding the values of different characters as seen from Fig. 3. The situation remains more or less the same with the differential weightage. But when results from all the 4 figures (Figs 3–6) were considered simultaneously, with 2 characters as denoted by x-abscissa and y-ordinate from each, the situation became clearer and easily understandable. The races could be compared with one another more conclusively and with greater reliability. In the present publication, it was only by analysing and integrating the results from the above figures, and from other sources like geographical distribution, that a valid and natural classification has been made.

9. DESCRIPTION OF THE RACES

In the present study, 15 races of Indian maize are described. These are arranged from primitivity to advancement, roughly according to the characters of the plant, ear and tassel. The present classification into more or less distinct races should in no way be considered the final answer to the race problem in Indian maize.

Most of the previous studies in this series in the world have placed considerable emphasis on the origins and relationships of the races described. These subjects are either omitted in the present study or are treated in a very tentative manner, because I feel that our knowledge of these races of maize is as yet incomplete for effective discussion of the origin of the Indian races.

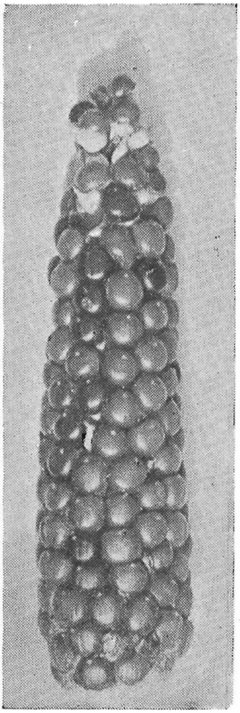
The description of the different races has been summarized in a tabular form. In addition each race is described for its characteristic morphological features for kernel, ear, tassel and plant. This description is supplemented with a distribution map, a photograph of a typical ear, and cross-sectional diagrams of ear and internode. The description of the races follows.

1. POORVI BOTAPA

Plants: Very short; maturity late; leaves very few, short, narrow, semi-erect with smaller surface area; pubescense slight; poorly developed brace roots emerge from first 2 nodes from the base of the plant; venation index high; LE/PHE index low; ears high-placed; EH/PH index 0·72; ear number/plant high, 3·4.

Tassels: Branches arise from $\frac{1}{3}$ of central axis, few; secondary branches few; condensation low; flag-leaf almost covers the lowermost branch of the tassel; pollen diameter 75·6 μ.

Ears: EXTERNAL CHARACTERS (Fig. 7): Very short and small, mostly highly conical; EDB/EDT index 1·5; irregular rows common; row number 10, each row with 20 kernels; kernel density high, 1·4; mean area of ear surface low, 58·2 cm²; kernels short, 6·2 mm, small, of medium thickness and width, rounded; KW/KL index 0·91; marked striations; endosperm flinty, pop-type. INTERNAL CHARACTERS (Fig. 10): Average ear diameter 2·0 cm; average cob diameter 1·6 cm; average rachis diameter



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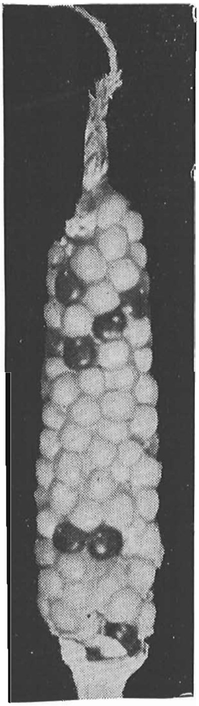
7. Ear of Poorvi Botapa



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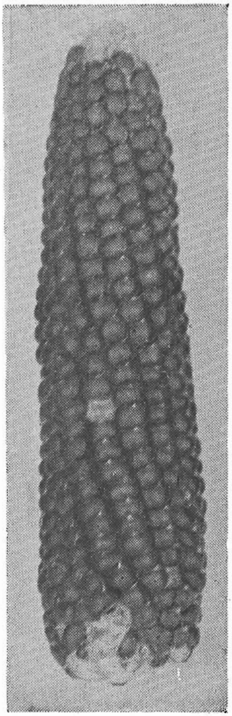
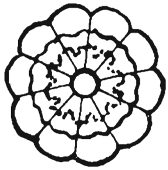
8. Ear of Murli sub-race of Poorvi Botapa



9

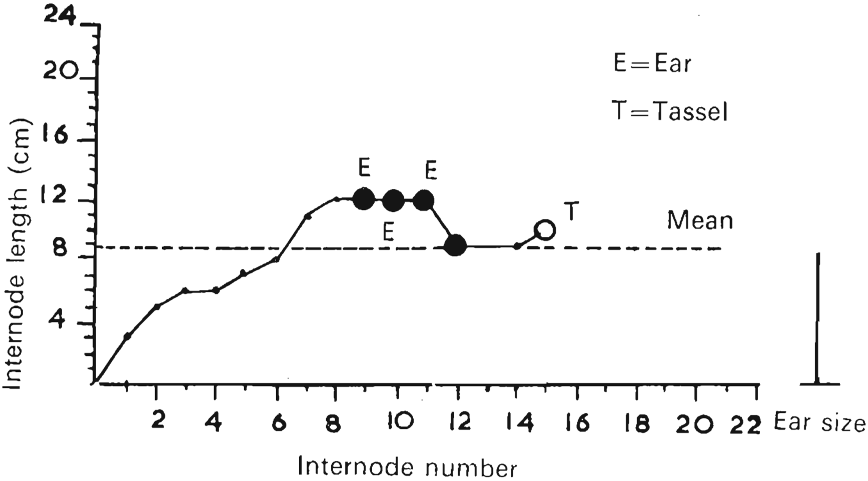
9. Ear of Tirap Nag-Sahypung

3·9 mm; estimated rachilla length 2·4 mm; cob/rachis index high, 4·5; glume/kernel index medium, 0·97; rachilla/kernel index



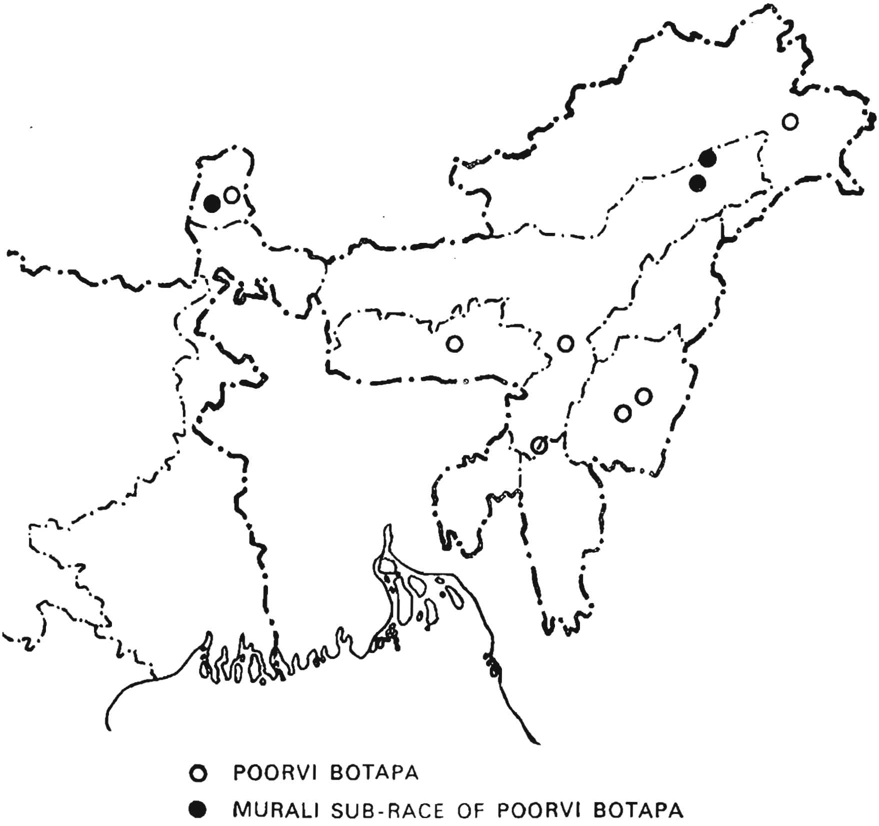
10. Cross-section of the ear of Poorvi Botapa

medium, 0·54; mean exposure index very low, 28·3; rachis tissue spongy.



11. Internodal pattern of Poorvi Botapa

Other characteristic indices (Fig. 11) of the race are: EDC/EL medium, 0·23; CD/EL high, 0·17; RD/EDC low, 0·18; RL/RD medium, 0·68; RL/CD low, 0·13; KL/EDC very high, 0·30; KL/EL high, 0·07. Mean values of indices of characters from different parts of maize plants are: ear diameter at centre as denominator of tassel length 14·4, of peduncle length 5·1, of central spike



12. Distribution of Poorvi Botapa and Murli sub-race of Poorvi Botapa

The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

Based upon Survey of India map with the permission of the Surveyor-General of India.

The boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas (Reorganisation) Act, 1971, but has yet to be verified.

length 9·5, of total tassel branches 7·2, of primary branches 5·9, and of secondary branches 1·2. Cob diameter and ear length are 11·6 and 65·8% of the total number of branches.

Distribution: Poorvi Botapa is adapted to medium to high elevations, 600-1,500 m (Fig. 12). It is still found in its pure form. It is common in the Mikir and Cachar hills of Assam, in some parts of Bhutan, Sikkim, central Manipur and the Tirap district of Arunachal Pradesh.

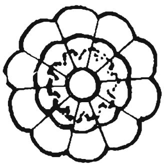
Derivation of name: 'Poorvi' means east. 'Botapa' is the name commonly used for this type of maize in the eastern region.

MURLI, SUB-RACE OF POORVI BOTAPA

Plants: Ears placed very high in collection No. 9-A, even along with the lowest branch of the tassel; mean ear number highest, 4·0/plant.

Tassel: Flag-leaf covers the lowermost branch of the tassel.

Ears: EXTERNAL CHARACTERS (Fig. 8): The most conspicuous feature of this sub-race is that the tassel of 2–6 cm is attached at the terminal portion of the tip of ears. Ears conical; EDB/EDT index 1·4; irregular rows common; mean kernel density1·5; kernels

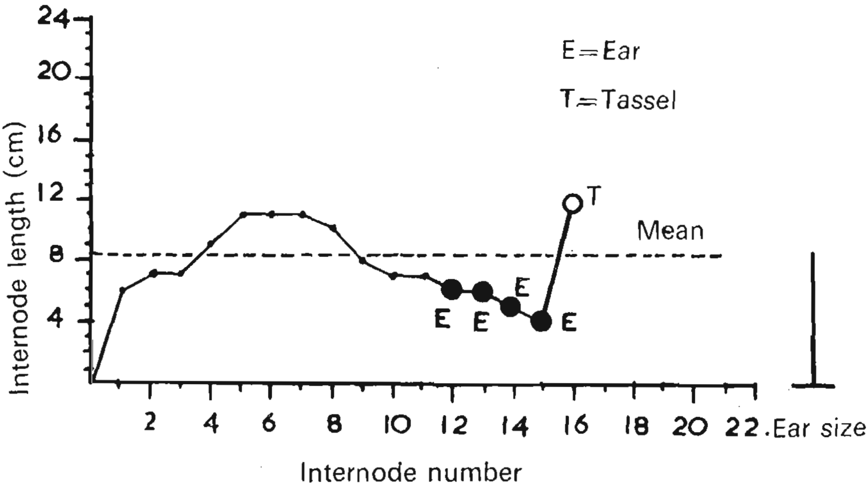


13 Cross-section of the ear of Murli sub-race of Poorvi Botapa

round; KW/KL index 0·92; endosperm flinty; ears pop-type. INTERNAL CHARACTERS (Fig. 13): Average ear diameter 1·9 cm; cob diameter 1·5 cm; rachis diameter 3·5 mm; estimated rachilla length 2·0 mm; cob/rachis index high, 4·2; glume/kernel index high, 0·95; rachilla/kernel index low, 0·40.

Other characteristics of plants, tassels and ears of this sub-race (Fig. 14) are similar to those of Poorvi Botapa.

Distribution: Murli is commonly adapted to medium to high elevation, 600–1,500 m (Fig. 12). It is found in pure form as well as mixed with Poorvi Botapa. It is common in the Mikir and Cachar hills of Assam and in northern Sikkim.



14. Internodal pattern of sub-race Murli

Derivation of name: Murli is the name commonly used for this type of maize in the eastern region.

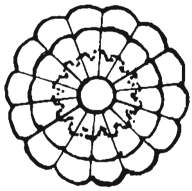
2. TIRAP NAG-SAHYPUNG

Plants: Short, 133 cm; maturity late, 90 days (days to 75% silk); average number of leaves above ear highest (6·6) of all races; leaves broad in relation to length, LW/LL 0·16; average length 50·0 cm, average width 7·9 cm; venation index low, 2·8; strongly pubescent leaves; erect; poorly developed brace roots emerge from first 3 nodes; internodes many (19), very short towards tassel; ear number/plant high, 3·7; ear high-placed, EH/PH 0·73.

Tassels: Short; medium number of branches arise in little less than ½ of central axis; secondaries medium in number, but prominent; condensation light to medium; flag-leaf covers the lowermost branch of tassel; pollen size medium.

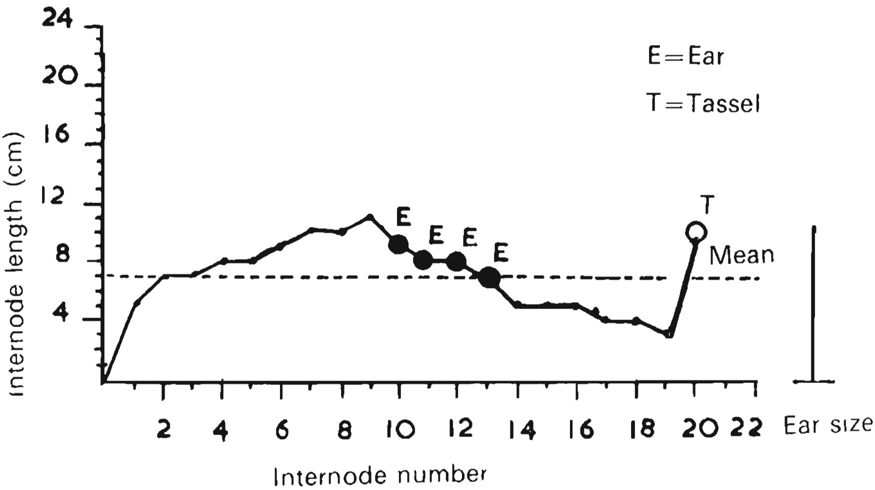
Ears: EXTERNAL CHARACTERS (Fig. 9): Short and small, mostly slender; slightly taper from base to tip; EDB/EDT index 1·2; irregular rows common; row number usually 14 (average

14·7); each row averages 24·7 kernels; kernel density high, 1·3; ear surface low, 76·5 cm²; kernel small, 6·5 mm, rounded, long;



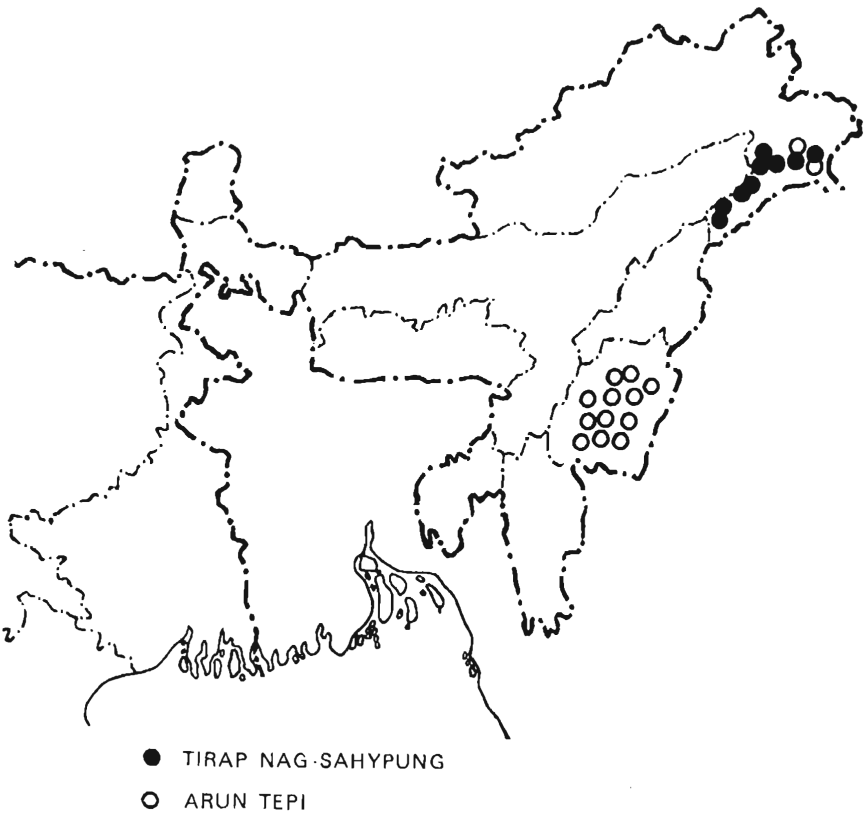
15. Cross-section of the ear of Tirap Nag-Sahypung

prominent striations; endosperm hard, pop-type. INTERNAL CHARACTERS (Fig. 15): Average ear diameter 2·3 cm; average cob diameter 1·7 cm; average rachis diameter 4·3 mm; estimated rachilla length 2·9 mm; cob/rachis index medium, 3·8; glume/kernel index medium, 0·95; rachilla/kernel index low, 0·44; exposure index low, 32·3; rachis tissue spongy.



16. Internodal pattern of Tirap Nag-Sahypung

Other characteristic indices (Fig. 16) of the race are: EDC/



17. Distribution of Tirap Nag-Sahypung and Arun Tepi

The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

The boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas (Reorganisation) Act, 1971, but has yet to be verified.

EL medium, 0·23; CD/EDC high, 0·73; RD/EDC low, 0·20; RL/RD medium, 0·66; KL/EDC high, 0·27. Mean values of indices of characters from different parts of maize plants are: ear diameter at centre as denominator of tassel length 13·2, of peduncle length 4·4, of central spike length 6·5, of total tassel branches 8·9, and of secondary branches 1·9. Cob diameter and ear length are 8·9 and 51·1% of the total number of branches.

Distribution: Tirap Nag-Sahypung is adapted to medium to high elevations, 600–1,500 m (Fig. 17). It is still found in pure form. It is found in the Tirap district of Arunachal Pradesh.

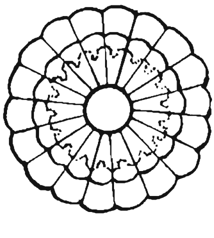
Derivation of name: The spread of broad leaves approaching the tassel gives the appearance of ' nag phan ', a type of spreaded head of cobra. Sahypung is the name used for this type of maize in Tirap, where it is most commonly found.

3. ARUN TEPI

Plants: Short, 120 cm; stalks slender; maturity latest among all races; a large number of leaves are broad in relation to length; LW/LL 0·16; average length 39·4 cm; average width 6·6 cm; venation index medium, 3·0; strongly pubescent; leaves erect; brace roots emerge from third node, poorly developed root system. Average ear number/plant low, 1·8; ears high-placed, EH/PH 0·79.

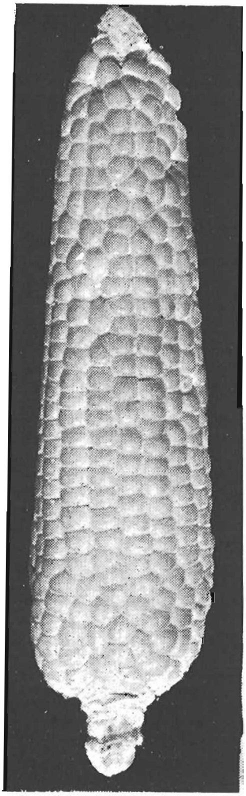
Tassels: Long, medium number of branches arise from little less than $\frac{1}{2}$ of central axis; peduncle short; secondaries few; flag-leaf covers the complete lowermost branch of tassel; mean pollen size 81·9 μ.

Ears: EXTERNAL CHARACTERS (Fig. 20): Short and small;



18. Cross-section of the ear of Arun Tepi

average length 10·5 cm; average diameter at base, centre and tip, 3·1, 2·7 and 2·1 cm; butt enlarged with strong taper from base to



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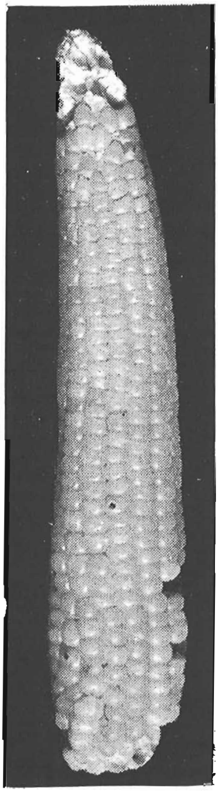

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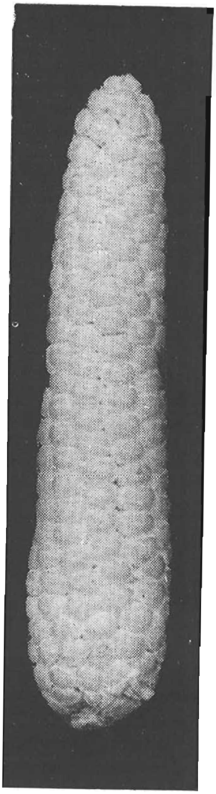

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20. Ear of Arun Tepi

21. Ear of Alok Sapa

22. Ear of Manipuri Chujak

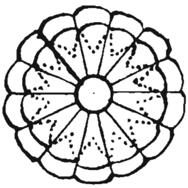
Derivation of name: The small kernels of the race are bright. Arun means sun, and Tepi means maize, the word taken from the regional language of the Gallong tribe of Arunachal Pradesh where it is most commonly found.

4. ALOK SAPA

Plants: Very tall, 204 cm; maturity late; leaf number high to medium; leaves long, narrow; LW/LL 0·08; venation index medium 3·0; sparse and drooping; pilosity weak; poorly developed root system; ear number medium, 2·2; ear placement low in relation to plant height; EH/PH 0·55.

Tassels: Long; very high number of branches arise from about ½ of central axis; secondaries numerous; flag-leaf below the lowest branch; pollen size small.

Ears: EXTERNAL CHARACTERS (Fig. 21): Short to intermediate in length, with slight gradual taper from base to tip; butt often slightly enlarged; EDB/EDT index 1·2; irregular rows common at base; row number usually 14 (average 13·9); kernels small, 6·3 mm, round, narrow; KT/KL 0·71; kernel density high, 1·3;

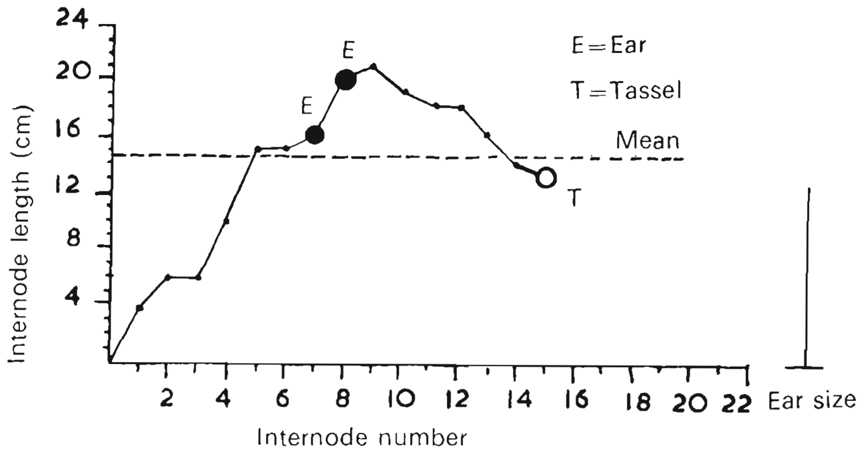


23. Cross-section of the ear of Alok Sapa

pronounced striations on the kernels; endosperm hard, pop-type; pericarp colour lacking. INTERNAL CHARACTERS (Fig. 23): Average ear diameter 2·4 cm; average cob diameter 2·1 cm; average rachis diameter 3·9 mm; estimated rachilla length 3·7 mm; rachis tissue spongy. Indices of cob/rachis (5·5) and glume/kernel (1·3) are highest of all races; exposure index lowest, 15·8.

Other characteristic indices (Fig. 24) of the race are: KL/CD ow, 0·30; RL/KL high, 0·58; EDT/EL low, 0·17; CD/EDC high, 0·87; KW/RD high, 1·6. Mean values of characters from different parts of the plant are: ear diameter at centre as denominator of tassel length 15·6, of peduncle length 5·5, of central spike length

7·4, of total tassel branches 12·0 and of primary branches 8·8. Cob diameter and ear length are 7·3 and 46·4% of the total number of branches, lowest of all races.



24. Internodal pattern of Alok Sapa

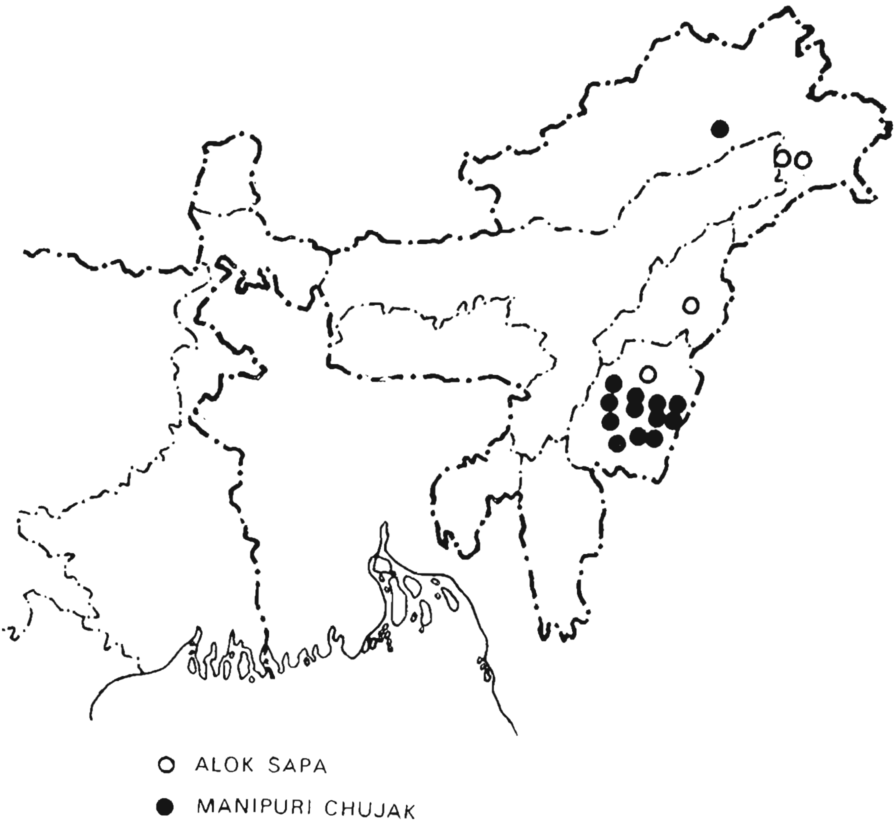
Distribution: Alok Sapa is adapted to high elevations, 1,500 m and above (Fig. 25). In its pure form, it is commonly found in the Tirap district of Arunachal Pradesh. It is also found in central Manipur and parts of Nagaland.

Derivation of name: The small, hard, pop kernels are pure white. Alok means day-light and Sapa means maize, a word taken from the regional language of the Pasi tribe of Arunachal Pradesh, where it is most commonly found.

5. MANIPURI CHUJAK

Plants: Medium to tall; maturity very late; medium number of broad leaves of medium length; sparse and drooping; venation index high, 3·2; pilosity weak; ear number medium, 2·0; ear placement medium; EH/PH 0·67.

Tassels: Medium to high number of branches arise from about $\frac{2}{5}$ of central axis; secondaries high, 27% of the total number of branches; flag-leaf almost covers the lowermost branch of tassel; pollen size medium.



25. Distribution of Alok Sapa and Manipuri Chujak

The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

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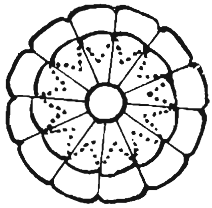
The boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas (Reorganisation) Act, 1971, but has yet to be verified.

Ears: External characters (Fig. 22): Short to medium. mostly slender, with slight taper from base to tip; EDB/EDT index 1·2; multiplication of rows at base; average row number 12·6; average kernel length 7·1 mm; kernels round; kernel density 1·0; endosperm medium-hard flint type. Internal characters



26. Cross-section of the ear of Manipuri Chujak

(Fig. 26): Average ear diameter 2·5 cm; average cob diameter 1·8 cm; average rachis diameter 5·5 mm; average estimated rachilla length 2·6 mm; cob/rachis index low-medium, 3·3; glume/kernel index low, 0·88; rachilla/kernel index low, 0·36; exposure index medium, 36·8.

Other characteristic indices (Fig. 27) of the race are: KL/CD high, 0·40; RL/RD low, 0·49; RL/EDC medium, 0·09; KL/EDC high, 0·29. Mean values of indices of characters from different parts of plants are: TL/EDC medium, 13·8; BL/EDC high, 5·1; TTB/EDC high-medium, 9·8; SB/EDC high, 2·2; CPL/EL medium, 1·8.

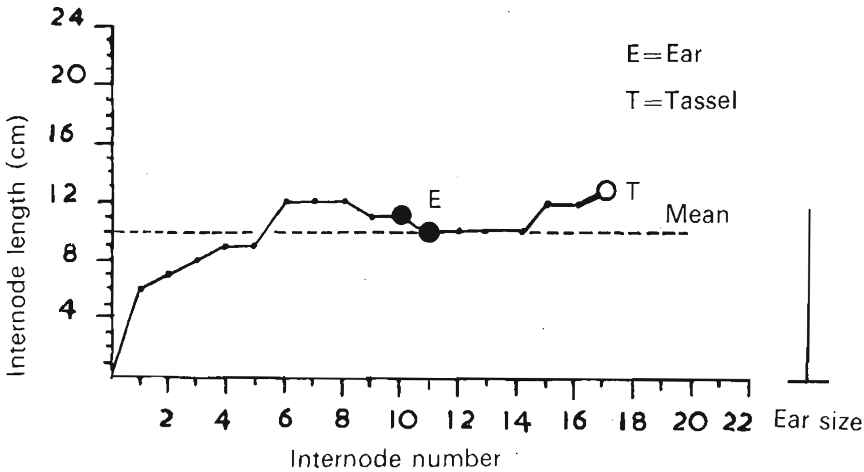
Distribution: Manipuri Chujak is adapted to high elevations, 1,500 m and above (Fig. 25). It is commonly found in central Manipur and in parts of the Lohit district of Arunachal Pradesh.

Derivation of name: Chujak is the word used for maize in Manipur, where it is primarily found.

6. MAYONG SA-AH

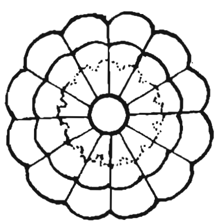
Plants: Short; maturity late; very few semi-erect, broad leaves of medium length; venation index medium, 3·0; pilosity intermediate; ear number low to medium; ear placement high in relation to plant height.

Tassels: Short; medium number of branches arise in $\frac{1}{3}$ of central axis, secondaries medium, 19·2% of the total number of branches; flag-leaf covers the point of origin of lowermost branch of tassel; pollen size small.



27. Internodal pattern of Manipuri Chujak

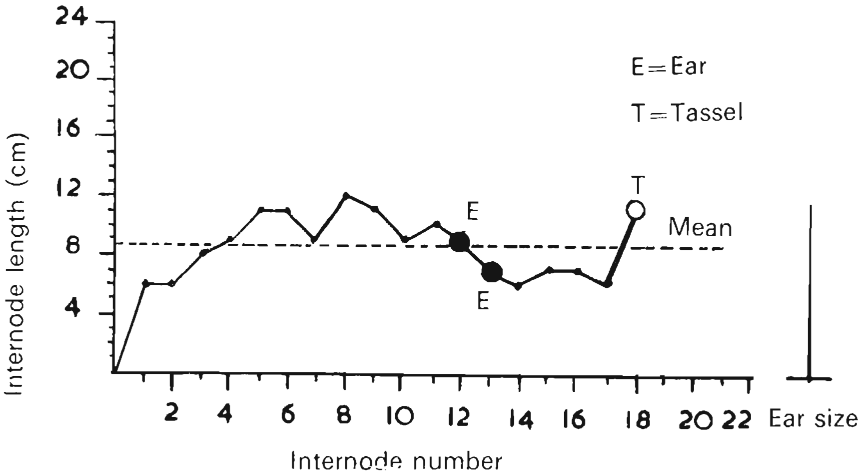
Ears: External characters (Fig. 33): Short, enlarged, strongly tapering from base to tip; EDB/EDT 1·4; EDB/EDC 1·1; EDC/EDT 1·3; irregular rows common; average row number 12·8; average kernel length 6·9 mm; kernels round; kernel density



28. Cross-section of the ear of Mayong Sa-ah

1·1; endosperm hard, flint-type. Internal characters (Fig. 28): Average ear diameter 2·6 cm; average cob diameter 2·0 cm;

average rachis diameter 5·6 mm; average estimated rachilla length 3·5 mm; cob/rachis index medium, 3·9; glume/kernel medium, 0·96; rachilla/kernel index high, 0·57; exposure index low, 27·5.



29. Internodal pattern of Mayong Sa-ah

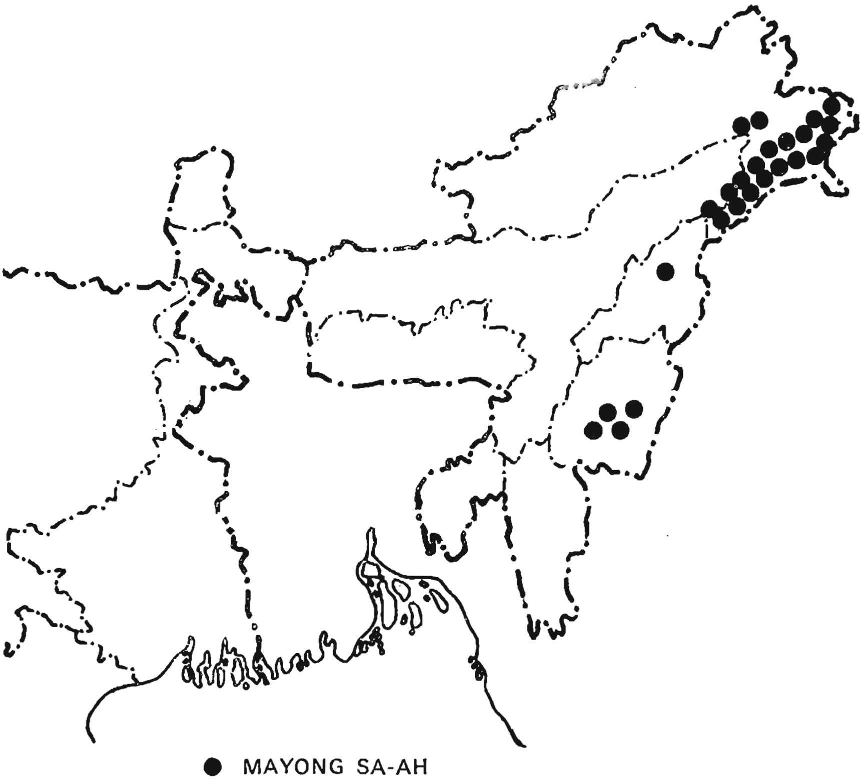
Other characteristic indices of the race (Fig. 29) are: KL/CD medium, 0·34; RL/RD high, 0·69; RL/EDC low, 0·12; KL/EDC medium, 0·22. Mean values of indices of characters from different parts of plants are: TL/EDC low-medium, 12·2; BL/EDC low, 3·4; TTB/EDC medium, 8·1; SB/EDC medium, 1·6; CPL/EL medium, 1·7.

Distribution: Mayong Sa-ah is adapted to high elevations, 1,500 m and above (Fig. 30). It is commonly found in Tirap and in parts of the Lohit district of Arunachal Pradesh. It is also found in parts of Nagaland and central Manipur.

Derivation of name: Sa-ah means maize, a word taken from the regional language of the Mayong tribe of Arunachal Pradesh, where it is most commonly found.

7. ASHT SAMSUNG

Plants: Tall; maturity medium; intermediate number of broad and relatively long sparse and drooping leaves. Venation



30. Distribution of Mayong Sa-ah

The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

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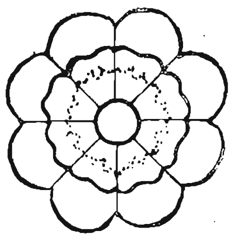
The boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas (Reorganisation) Act, 1971, but has yet to be verified.

index low, 2·8; pilosity medium; very few leaves above ear; EH/LE 26·9; internode long; ear number 1 to 2 (average 1·5); ear placement medium; EH/PH 0·68.

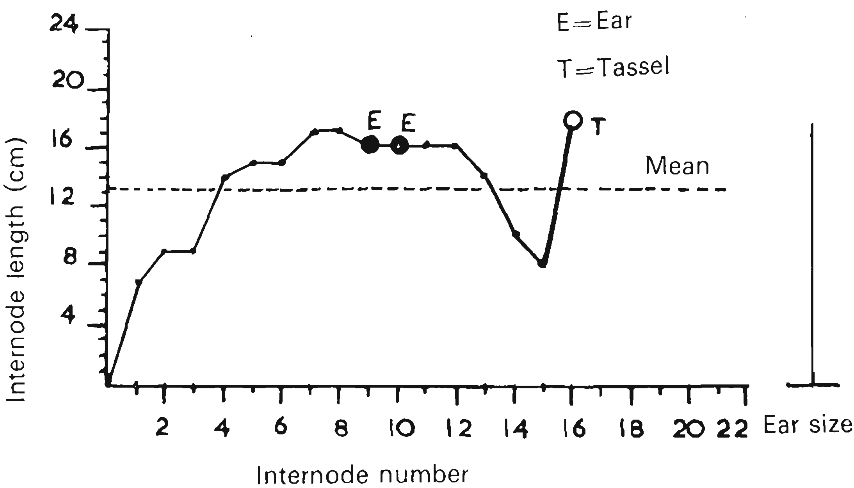
Tassels: Long; medium number of branches arise from ½ of central spike; secondaries medium; flag-leaf below the lowermost branch of tassel.

Ears: External characters (Fig. 34): Long; average length 17·8 cm; average diameter 3·1 cm; slender, cylindrical,

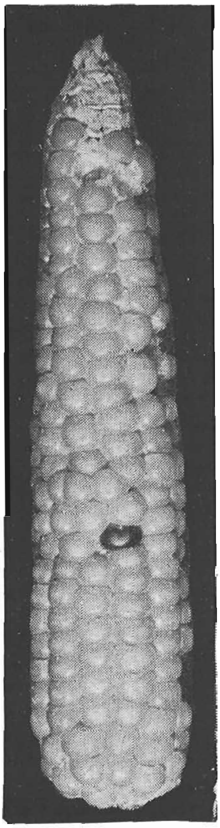


31. Cross-section of the ear of Asht Samsung

except for a slight taper at tip; EDB/EDT 1·1; average row number (8·3) least of all races; kernels wide, very thick, long, round; KW/



32. Internodal pattern of Asht Samsung



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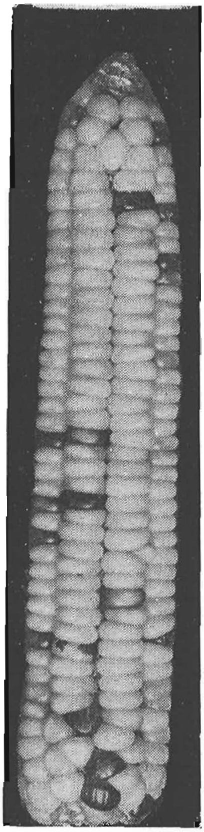

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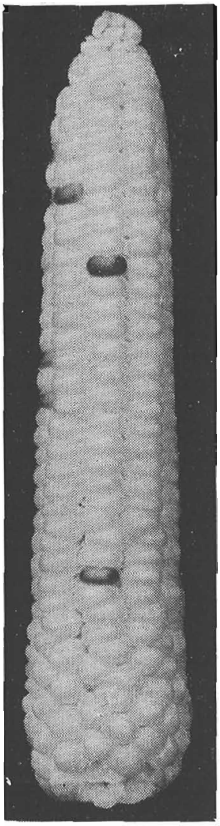

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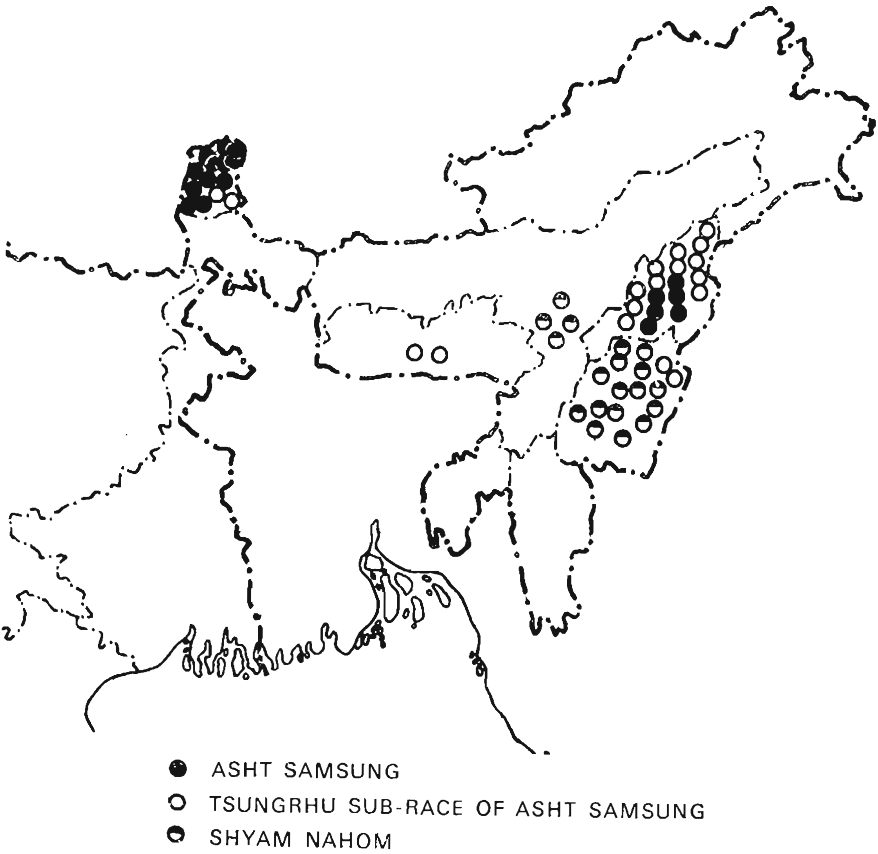
33. Ear of Mayong Sa-ah

34. Ear of Asht Samsung

35. Ear of Tsungrhu sub-race of Asht Samsung



36. Distribution of Asht Samsung, Tsungrhu sub-race of Asht Samsung and Shyam Nahom.

The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

The boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas (Reorganisation) Act, 1971, but has yet to be verified.

KL 1·0; kernel density 1·1; endosperm flinty. INTERNAL CHARACTERS (Fig. 31): Average ear diameter 3·1 cm; average cob diameter 2·1 cm; average rachis diameter 6·2 mm; average estimated rachilla length 3·4 mm; of all races indices for glume/kernel (0·75) and RL/KL (0·40) are lowest, and indices for KL/CD (0·48), KL/RN (1·12) and KW/RD (1·6) are highest. Exposure index high, 43·7.

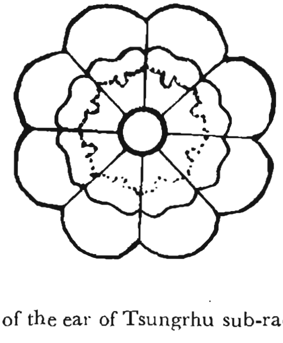
Other characteristic indices (Fig. 32) of the race are: kernel volume high in relation to ear diameter; KV/EDC 0·13; of all races, ear length is highest in relation to row number; EL/RN, 2·00; RL/RD high, 0·60; kernel length high in relation to ear diameter; KL/EDC 0·29; cob diameter and ear length are 11·5 and 95·7% of the total number of branches.

Distribution: Asht Samsung is adapted to high elevations, above 1,500 m (Fig. 36). It is commonly found in Sikkim and in parts of Nagaland.

Derivation of name: Asht, Sanskrit word for eight, refers to the eight rows of kernels typical of this race. Samsung is the place in Sikkim where this race is most commonly found.

TSUNGRHU, SUB-RACE OF ASHT SAMSUNG

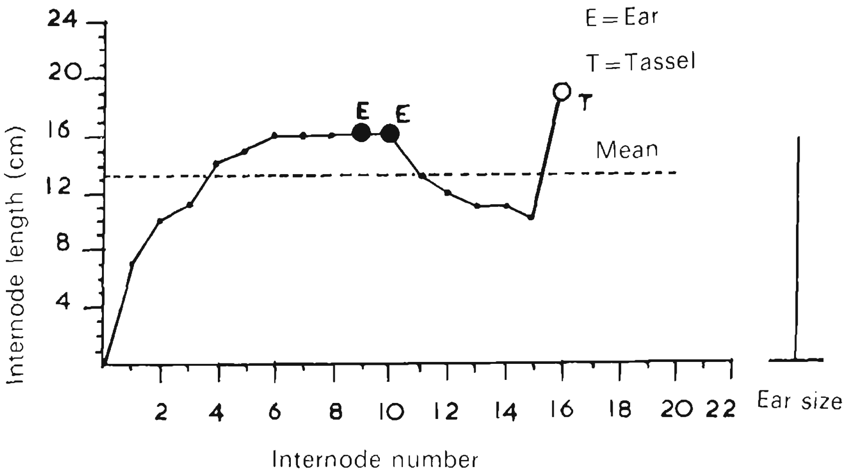
Plants: Tall, maturity medium; stem stout; average stem diameter 2·5 cm; average leaf length 78·4 cm; average leaf width 8·0 cm; venation index low; 7th to 10th internodes are longest and of nearly same length.



37. Cross-section of the ear of Tsungrhu sub-race of Asht Samsung

Tassels: Long; many branches arise from ½ of central spike; pollen size large, 83·4 μ.

Ears: External characters (Fig. 35): Length medium, 15·8 cm; slender, tapering slightly from base to tip; EDB/EDT 1·2; row number 8–10, average 8·5; kernels round, broad in relation to length; KW/KL 1·10; average kernel length 9·6 mm, average kernel width 10·1 mm. Internal characters (Fig. 37): Average ear diameter 3·3 cm; average cob diameter 2·2 cm; average rachis diameter 6·3 mm; exposure index high, 42·6.



38. Internodal pattern of Tsungrhu sub-race of Asht Samsung

Other characteristic indices (Fig. 38) are: EL/RN high, 1·80; KL/RN high, 1·10; SB/EDC high, 1·7. Other characters of plants, tassels and ears of Tsungrhu sub-race are similar to those of Asht Samsung.

Distribution: Tsungrhu sub-race is mostly adapted to high elevations, above 1,500 m (Fig. 36). It is commonly found in Nagaland and in parts of Sikkim.

Derivation of name: Tsungrhu, meaning maize, is a word taken from the regional language of the Lotha tribe of Nagaland, where it is commonly found.

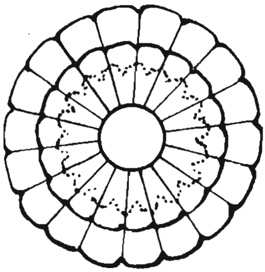
8. SHYAM NAHOM

Plants: Short, 127 cm; maturity late; leaves few, short, broad; LW/LL index 0·14; venation index high-medium, 3·1;

pilosity weak; average ear number 1·7; ears high-placed; EH/PH index 0·67; internodes 13 to 15 have almost the same internodal value as the mean of the race.

Tassels: Short; few branches arise from $\frac{1}{3}$ of central axis; secondaries few; flag-leaf covers the point of origin of lowermost branch.

Ears: EXTERNAL CHARACTERS (Fig. 40): Short and thick; slight taper from base to tip; EDB/EDT 1·2; average row number 17·4; irregular rows common; kernel small, round; average kernel length 7·9 mm; average kernel width 6·9 mm; KW/KL index 0·87; kernel density 1·0; kernels soft, flinty, with purple-blackish



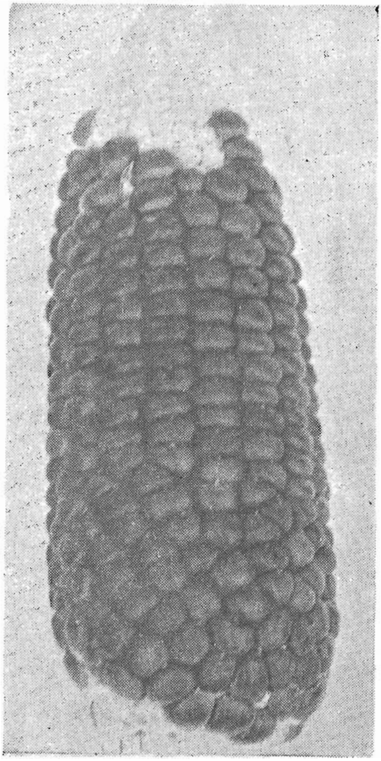
39. Cross-section of the ear of Shyam Nahom

endosperm. INTERNAL CHARACTERS (Fig. 39): Average cob diameter 2·5 cm; average rachis diameter 7·9 mm; average estimated rachilla length 5·2 mm; glume/kernel index high, 1·10; RL/KL index 0·70, highest of all races; rachis tissue spongy.

Mean values of characteristic indices (Fig. 42) of the race are: kernel volume very low in relation to ear diameter; KV/EDC 0·06; KL/RN very low, 0·45; EDB/EL high, 0·34; CD/EL 0·24, highest of all races; RL/EL high, 0·04; CPL/EL high, 2·3; TTB/EDC (0·38) and PB/EDC (3·4) are lowest of all races. Cob diameter and ear length are 20·4 and 86·3% of the total number of branches.

Distribution: Shyam Nahom is adapted to medium to high elevations, 600–1,500 m (Fig. 36). It is commonly found in Manipur and the Mikir and Cachar hills.

Derivation of name: Shyam, a Sanskrit word meaning black, refers to the blackish grain colour, typical of this race. Nahom



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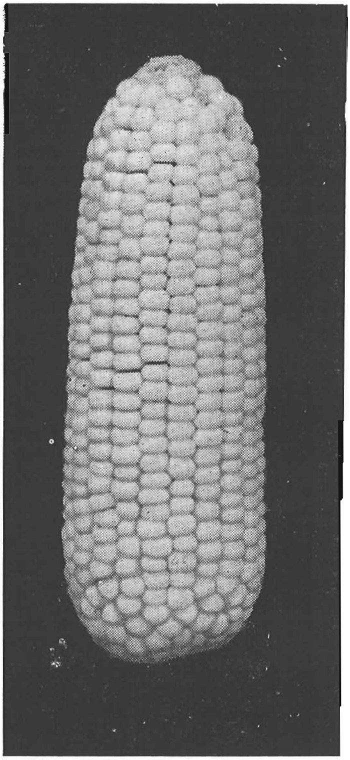
40. Ear of Shyam Nahom



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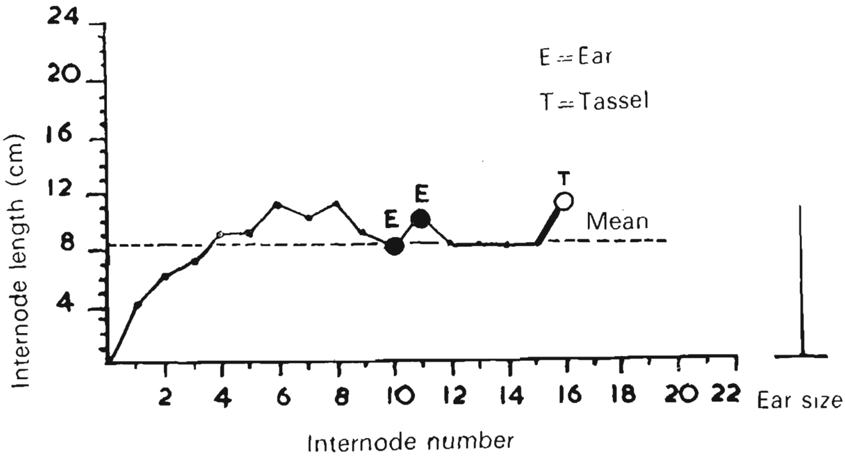
41. Ear of Cachar Gomdhan

means maize, a word taken from the regional language of Manipur, where it is most commonly found.



42. Internodal pattern of Shyam Nahom

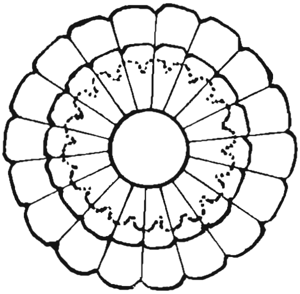
9. CACHAR GOMDHAN

Plants: Short, 139 cm; maturity late; leaves few, long, broad; LW/LL index 0·11; venation index low, 2·7; LL/PH high, 0·52; pilosity intermediate; stem stout, 2·4 cm in diameter; average ear number 2·5; ears high-placed.

Tassels: Long; low-medium number of branches arise from less than ⅓ of central axis; flag-leaf covers the point of origin of lowermost branch.

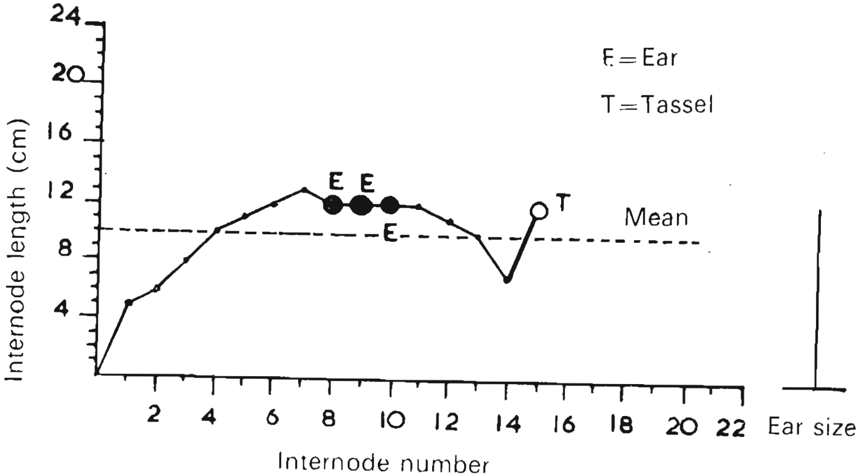
Ears: External characters (Fig. 41): Length low-medium, 12·3 cm; thick; average diameter at centre 3·8 cm; slight taper from base to tip; high row number, 18–20 (average 18·3); irregular rows common; kernel length more in relation to width; KW/KL index 0·75; average length 9·0 mm; average width 6·8 mm; average thickness 3·8 mm; kernel thickness less in relation to length; KT/KL 0·43; kernel density 1·1; kernels soft and waxy. Internal characters (Fig. 43): Average cob diameter high, 2·7 cm; average rachis diameter very high, 11·0 mm; estimated rachilla length medium, 4·6 mm; exposure index 44·7, highest of all races; CD/RD index very low, 2·6.

Other characteristic indices of the race (Fig. 44) are: RL/KL index low, 0·54; KV/EL medium, 0·01; KL/CD low, 0·29;



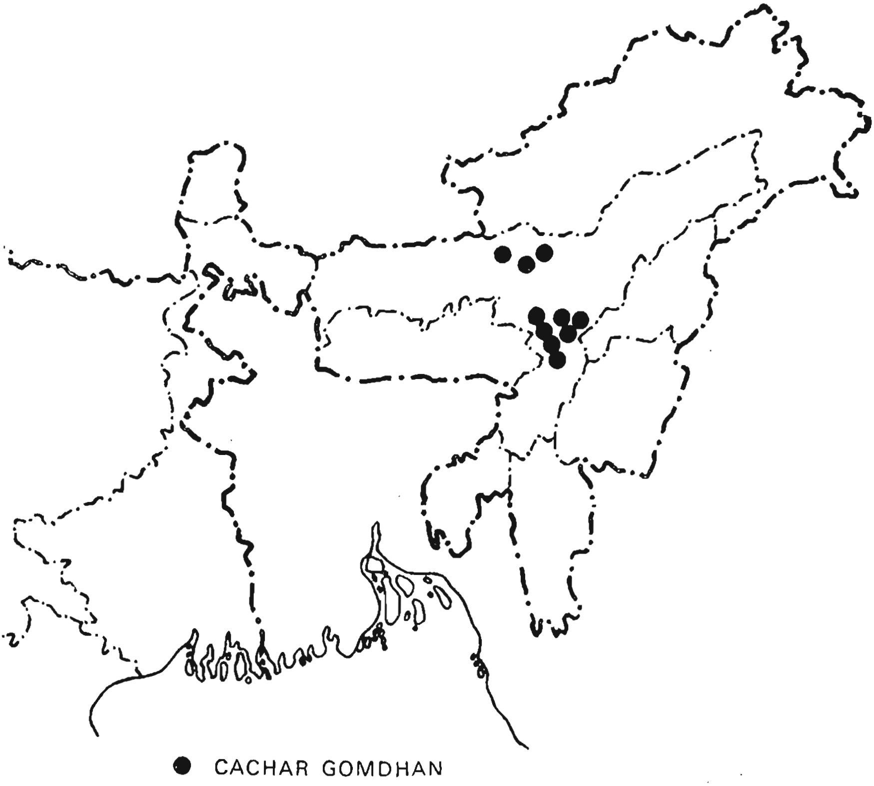
43. Cross-section of the ear of Cachar Gomdhan

RD/EL high, 0·09; RL/EL medium, 0·03; KL/RD very low, 0·9; of all races KL/EL index (0·08) is highest and BL/EDC (2·9) is



44. Internodal pattern of Cachar Gomdhan

lowest. Cob diameter and ear length are 16·6 and 76·0% respectively of the total number of branches.



45. Distribution of Cachar Gomdhan

The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

Based upon Survey of India map with the permission of the Surveyor-General of India.

The boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas (Reorganisation) Act, 1971, but has yet to be verified.

Distribution: Cachar Gomdhan is adapted to low elevations, up to 600 m (Fig. 45). It is most commonly found in the Cachar and Mikir hills of Assam.

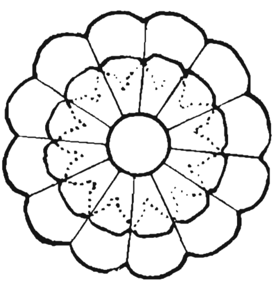
Derivation of name: Gomdhan means maize, a word taken from the regional language of the Cachar hills, where this race is most commonly found.

10. MAIDANI MAKKA

Plants: Height medium, 169 cm; maturity early; medium number of long leaves; LW/LL index 0·11; average leaf length 71·3 cm; average leaf width 7·9 cm; venation index low, 2·8; pilosity slight; average ear number 1·5; ear placement low; EH/PH 0·53.

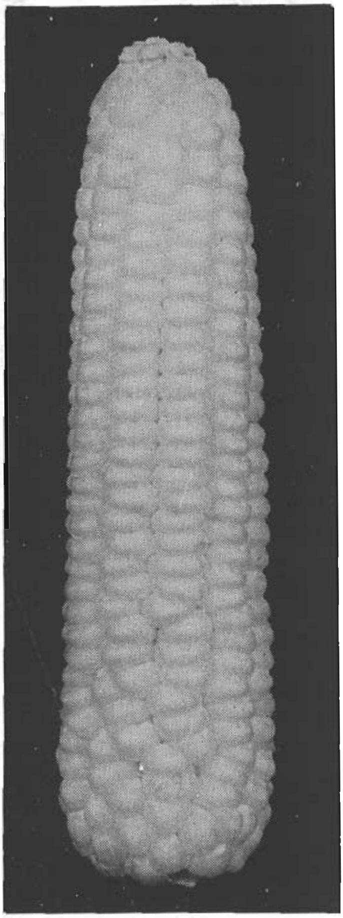
Tassels: Medium number of long branches arise from about ½ of central axis; secondary branches small and many, forming 21·8% of the total number of branches; flag-leaf below the lowermost branch.

Ears: External characters (Fig. 47): Length medium; slender; enlarged butt with strong taper from base to tip; EDB/EDT 1·3; row regular; multiplication of rows at base common; rows 12 to 14 (average 13·0), average number of kernels/row 31·2; kernels round; KW/KL index 0·91; kernel density 1·1; endosperm medium-hard, flinty. Internal characters (Fig. 46): Average



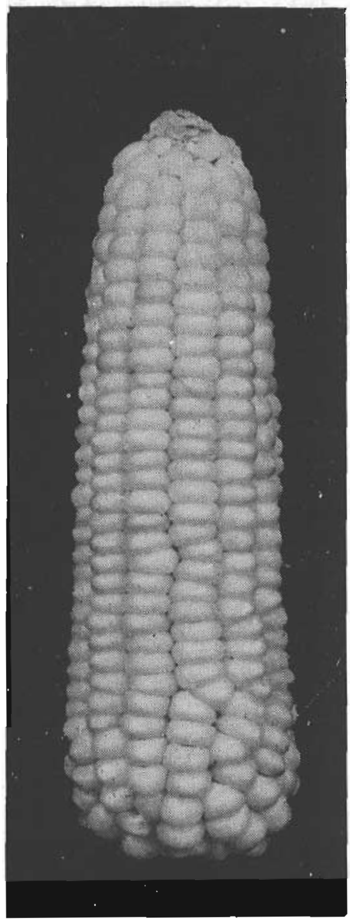
46. Cross-section of the ear of Maidani Makka

ear diameter 3·4 cm; cob diameter 2·4 cm; rachis diameter 7·7 mm; average estimated rachilla length 4·6 mm; glume/kernel index medium, 0·96; exposure index medium, 35·7.



47

47. Ear of Maidani Makka



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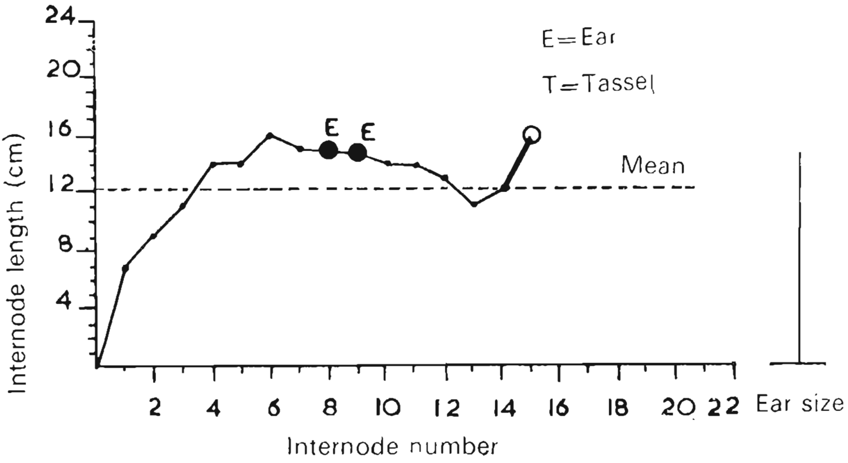
48. Ear of Ganga sub-race of Maidani Makka

Mean values of characteristic indices of the race (Fig. 49) are: KL/RN medium, 0·50; RD/EDC medium, 0·22; SB/PH



49. Internodal pattern of Maidani Makka

medium, 0·02; cob diameter and ear length are 12·7 and 76·4% of the total number of tassel branches.

Distribution: Maidani Makka is commonly adapted to low elevations up to 600 m (Fig. 50). It is scattered over almost all the plains of India, including north-eastern India.

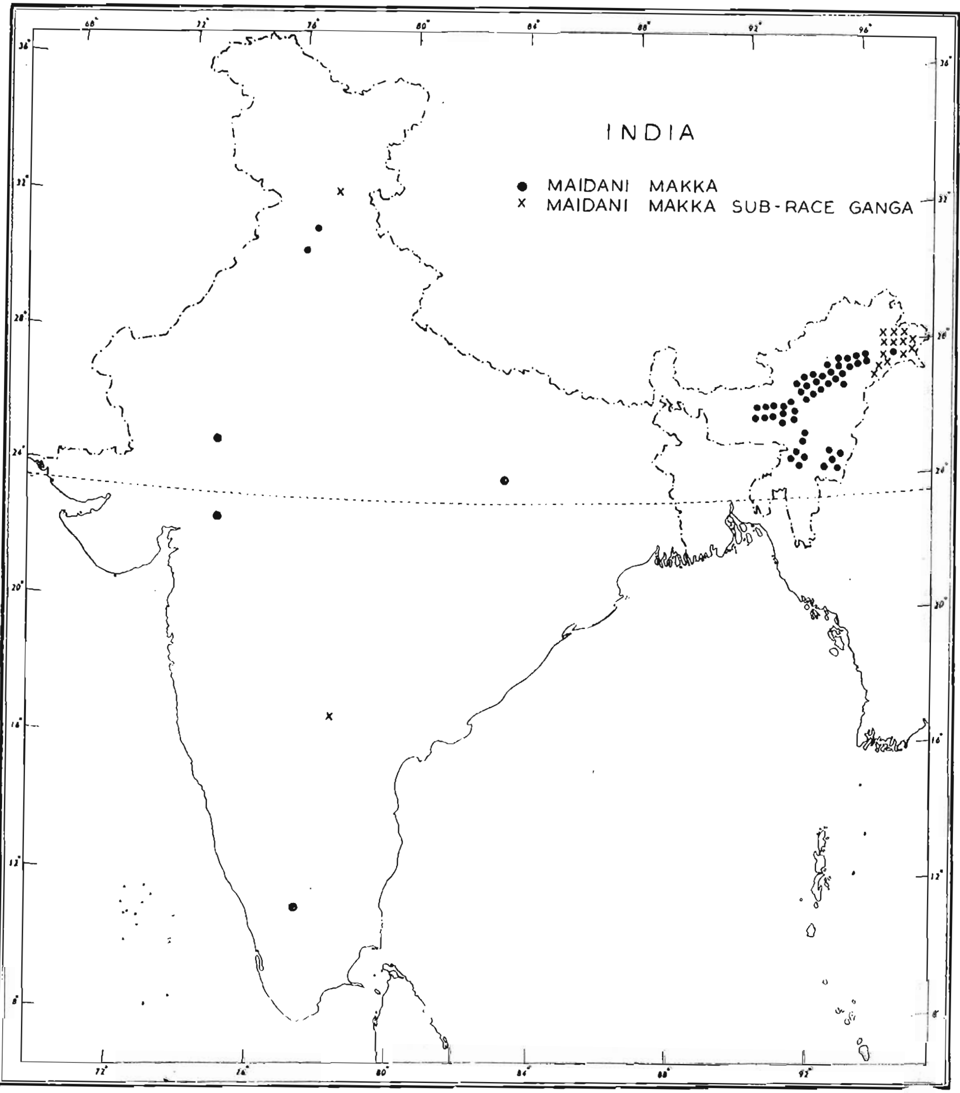
Derivation of name: This race is prevalent in low elevations throughout India, including north-eastern India. Maidani means plains, and makka means maize, both from Hindi.

GANGA, SUB-RACE OF MAIDANI MAKKA

Plants: Tall; maturity medium; leaves long, broad; venation index medium, 3·0; ear placement low in relation to plant height.

Tassels: Long; medium number of branches arise from about $\frac{1}{3}$ of central axis; pollen size large, 84·4 μ.

Ears: External characters (Fig. 48): Low, medium length; thick enlarged butt; slight taper from base to tip; row number commonly 14 (average 13·5); kernels bold, round; average kernel length 9·1 mm; endosperm hard flinty. Internal characters

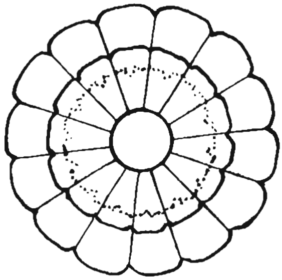


50. Distribution of Maidani Makka and Ganga sub-race of Maidani Makka

The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

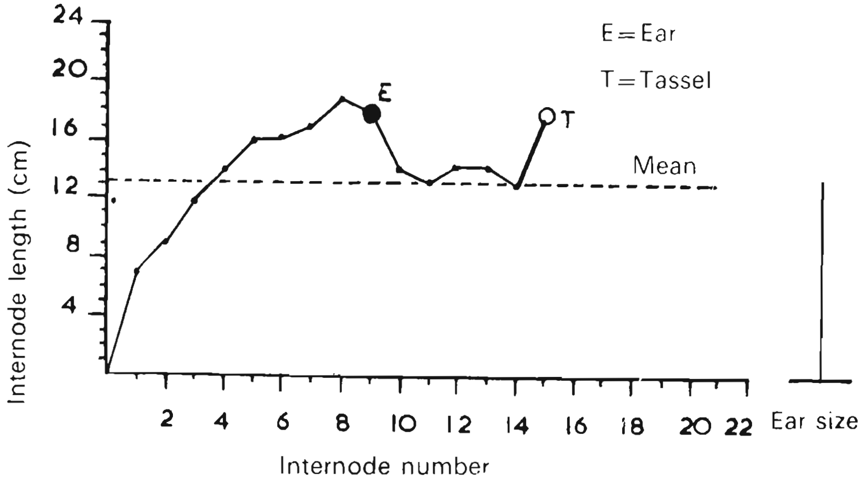
Based upon Survey of India map with the permission of the Surveyor-General of India.

(Fig. 51): Average ear diameter 3·5 cm; average cob diameter 2·4 cm; average rachis diameter 8·1 mm; average estimated rachilla length 4·8 mm; exposure index low, 30·6.



51. Cross-section of the ear of Ganga sub-race of Maidani Makka

Mean values of characteristic indices (Fig. 52) of the sub-race are: KL/RN high, 0·67; RD/EDC high, 0·32; SB/PH low, 0·01.



52. Internodal pattern of Ganga sub-race of Maidani Makka

Other characters of plants, tassels and ears of the sub-race Ganga are similar to those of Maidani Makka.

Distribution: Ganga is commonly adapted to medium to high elevations, 600–1,500 m (Fig. 50). It is found most commonly in Himachal Pradesh and the Tirap district of Arunachal Pradesh. It is also found in Andhra Pradesh.

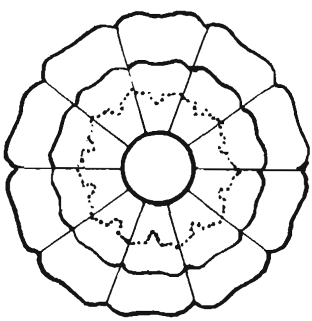
Derivation of name: This sub-race has been named Ganga because it is as popular as the river Ganga among Indians.

11. TISTA MENDI

Plants: Tall; maturity medium-early; medium number of very broad, long leaves; average leaf length 77·5 cm; average leaf width 8·8 cm; venation index low, 2·9; pilosity strong. Internode just below second ear longest; ear number low (average 1·2/plant).

Tassels: Long, medium number of branches arise from $\frac{2}{5}$ of central axis; flag-leaf usually below the lowermost branch of tassel.

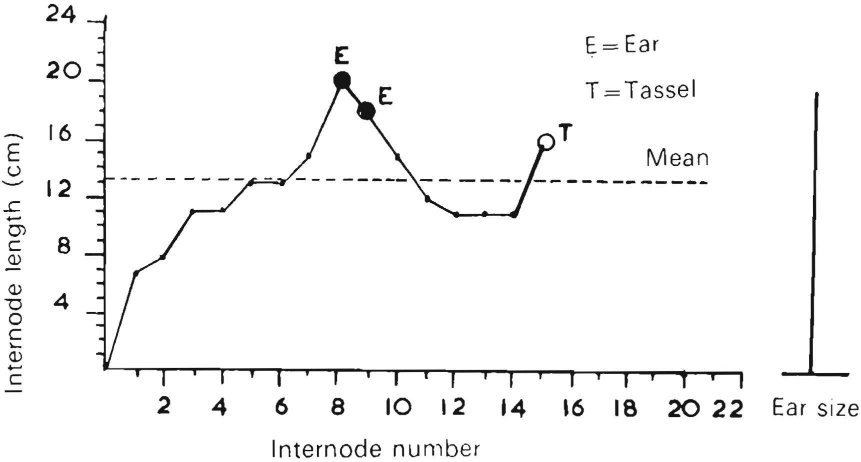
Ears: EXTERNAL CHARACTERS (Fig. 56): Total ear surface 250·3 cm^2, highest of all races; ears very long, thick; slight taper from base to tip; EDB/EDT 1·2; irregularity towards base common; row number 10–12 (average 10·5); kernels wide, long; average kernel length 11·7 mm; average kernel width 11·4 mm; of all races kernel thickness lowest in relation to length and width; KT/KL 0·39; KT/KW 0·40; kernel density low, 1·1; endosperm



53. Cross-section of the ear of Tista Mendi

soft, semi-dent. INTERNAL CHARACTERS (Fig. 53): Average ear diameter 4·1 cm; average cob diameter 2·6 cm; average rachis diameter 7·6 mm; average estimated rachilla length 5·0 mm;

cob/rachis index medium, 3·6; glume/kernel index low, 0·8; rachilla/kernel length low, 0·40; exposure index high, 42·9.



54. Internodal pattern of Tista Mendi

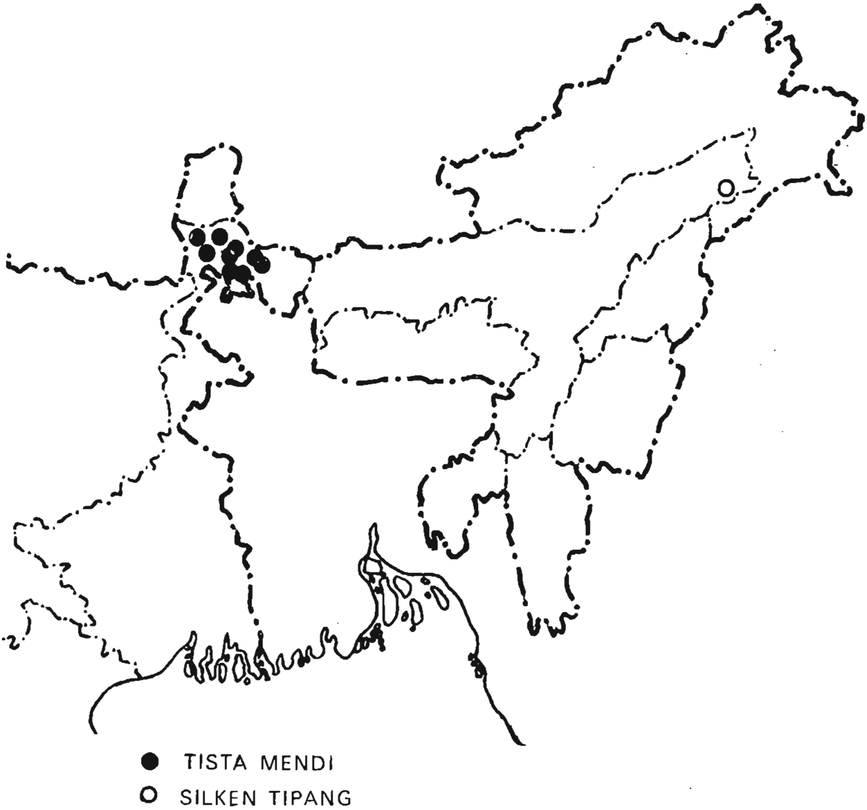
Other characteristic indices of the race (Fig. 54) are: kernel volume highest (0·14) of all races in relation to ear diameter; KL/CD high, 0·44; KL/RN very high, 1·10; EDC/EL low, 0·21; CD/EDC low, 0·64; RD/EL low, 0·03; RL/RD high, 0·72; KW/RD high, 1·5; tassel length lowest of all races in relation to ear length (2·1). Cob diameter and ear length are 13·2 and 95·6% of the total number of branches.

Distribution: Tista Mendi is adapted to high elevations, above 1,500 m (Fig. 55). It is commonly found in West Bengal.

Derivation of name: This race is commonly found in areas surrounded by the famous river Tista in the north-eastern region of India. Mendi means maize.

12. SILKEN TIPANG

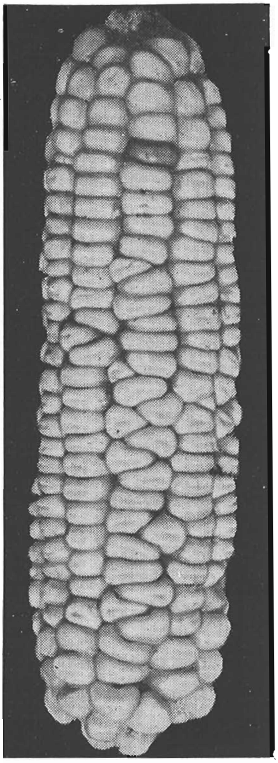
Plants: Height short to medium; maturity early; medium number of broad, long leaves; venation index low, 2·8; pilosity weak; average ear number 1·7/plant; ears high-placed in relation to plant height; EH/PH 0·70.



55. Distribution of Tista Mendi and Silken Tipang

The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

The boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas (Reorganisation) Act, 1971, but has yet to be verified.



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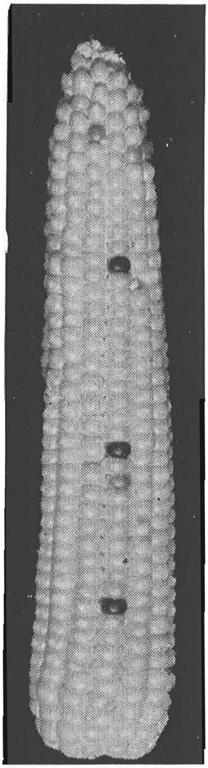
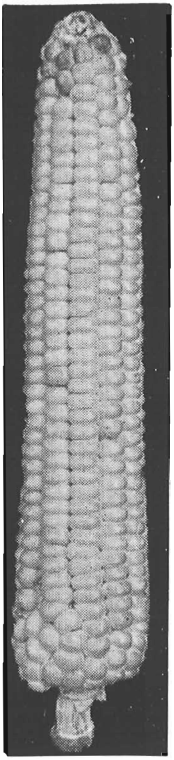
56. Ear of Tista Mendi



57

57. Ear of Silken Tipang

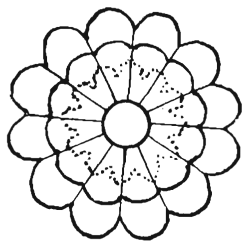


58

58. Ear of Khasi Riewhadem

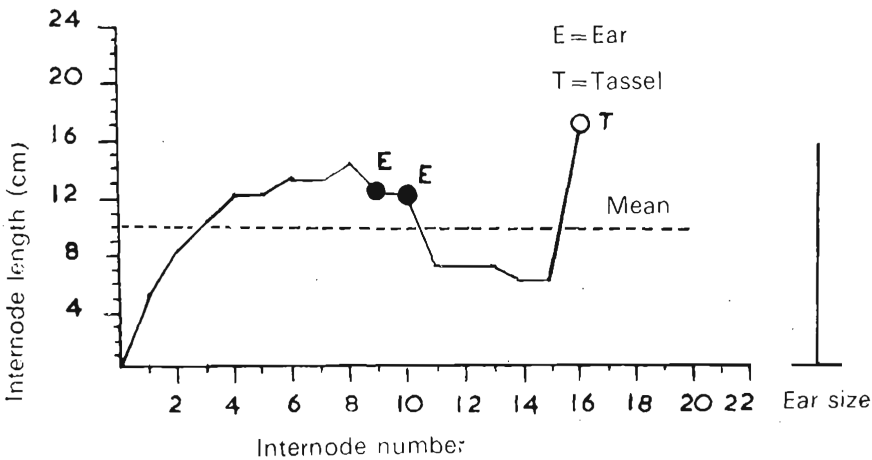
Tassels: Length medium; very few branches arise from $\frac{1}{2}$ of central axis; flag-leaf usually below the lowermost branch of tassel.

Ears: EXTERNAL CHARACTERS (Fig. 57): Length medium; strong taper toward tip; EDB/EDT 1·4; average number of rows low, 11·9; number of kernels/row high, 36·2; kernels long in relation to width; KW/KL index 0·81; average kernel thickness 4·0 mm; kernel density 1·3; slight striations on the kernels;



59. Cross-section of the ear of Silken Tipang

endosperm hard, pop-type. INTERNAL CHARACTERS (Fig. 59): Average ear diameter 2·9 cm; average cob diameter 2·2 cm;



60. Internodal pattern of Silken Tipang

average rachis diameter 5·6 mm; average estimated rachilla length 3·5 mm; cob/rachis index high, 4·0; glume/kernel index high, 1·0; rachilla/kernel index low, 0·46; exposure index low, 29·6; rachis tissue spongy to horny.

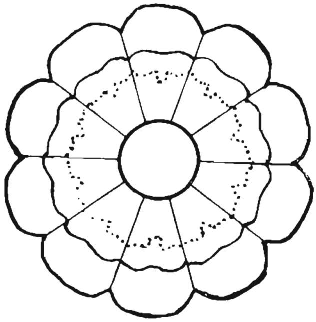
Mean values of the other characteristic indices (Fig. 60) are: KL/RN low, 0·43; EDT/EL 0·15; SB/EDC 0·6, lowest of all races; RD/EDC low, 0·19; KL/EL low, 0·05; PL/EDC high, 5·9; BL/EDC high, 5·7; TTB/EDC low, 4·0; EL/PH high, 0·10; cob diameter and ear length are 16·4 and 112·4% of the total number of branches.

Distribution: Silken Tipang is adapted to medium to high elevations, 600 – 1,500 m (Fig. 56). It is found in Arunachal Pradesh.

Derivation of name: Tipang means maize, a word taken from the regional language of the Mishing tribe of Arunachal Pradesh, where it is commonly found. Silken is the famous highway.

13. KHASI RIEWHADEM

Plants: Tall; maturity medium-early; leaves medium in number, long, broad; venation index low, 2·8; pilosity weak; stem stout; average stem diameter 2·5 cm; internodes long; average ear number 1·6/plant; placement of ear low in relation to plant height; EH/PH 0·56; of all races leaf number above ear is lowest



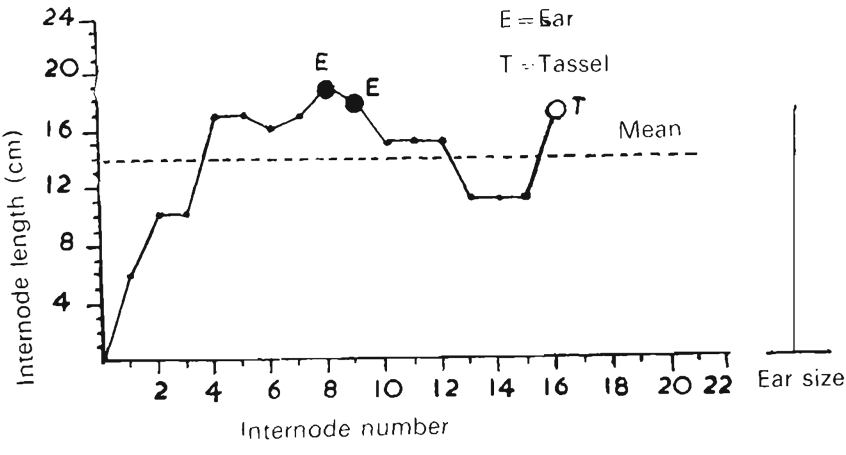
61. Cross-section of the ear of Khasi Riewhadem

in relation to days to flower; DF/LE 10·7; total leaf surface above ear highest, 61·0 cm^2.

Tassels: Tassel longest of all races; numerous branches arise from about ½ of central axis; flag-leaf usually below lowermost branch of tassel; pollen size medium.

Ears: External characters (Fig. 58): Long and thick; slight taper from base to tip; row number usually 8 to 10 (average 9·1); average kernel thickness 4·9 mm; average kernel width 10·8 mm; average kernel length 9·5 mm; of all races kernel width highest in relation to kernel length; KW/KL index 1·14; kernel density medium, 1·2; endosperm hard, flinty. Total ear surface high, 223·3 cm². Internal characters (Fig. 61): Average cob diameter 2·6 cm; average rachis diameter 7·5 mm; average estimated rachilla length 6·3 mm; cob/rachis index 3·7; exposure index high, 42·2.

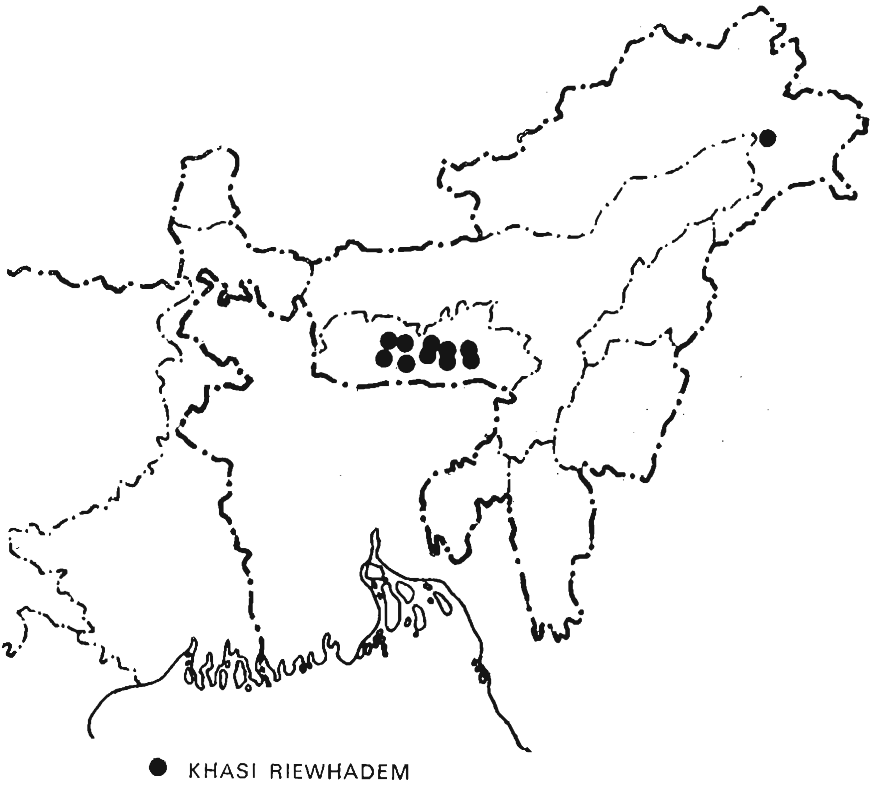
Mean values of characteristic indices (Fig. 62) of the race are: RL/KL high, 0·66; KV/EL high, 0·02; KV/EDC 0·13; EL/



62. Internodal pattern of Khasi Riewhadem

RN 2·0; KL/RN very high, 1·1; of all races cob diameter highest in relation to kernel length; KL/CD 0·27; ear diameter highest in relation to cob diameter; CD/EDC 0·54; RD/RN (0·90) and RL/CD (0·24) highest of all races.

Distribution: Khasi Riewhadem is adapted to high elevations, above 1,500 m (Fig. 63). It is most commonly found in the Khasi



63. Distribution of Khasi Riewhadem

The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

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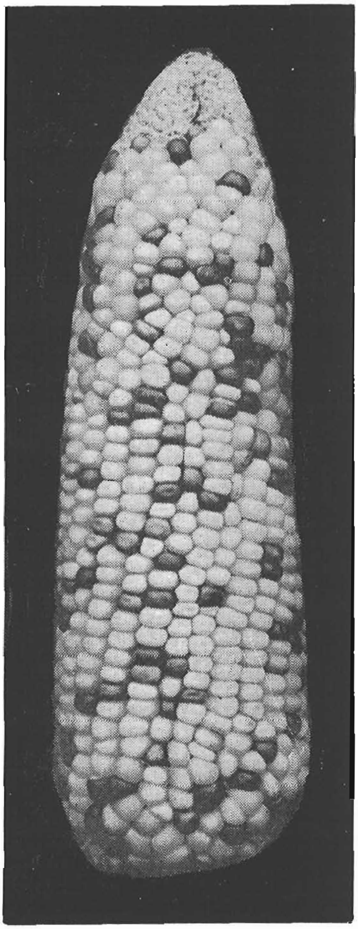
The boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas (Reorganisation) Act, 1971, but has yet to be verified.



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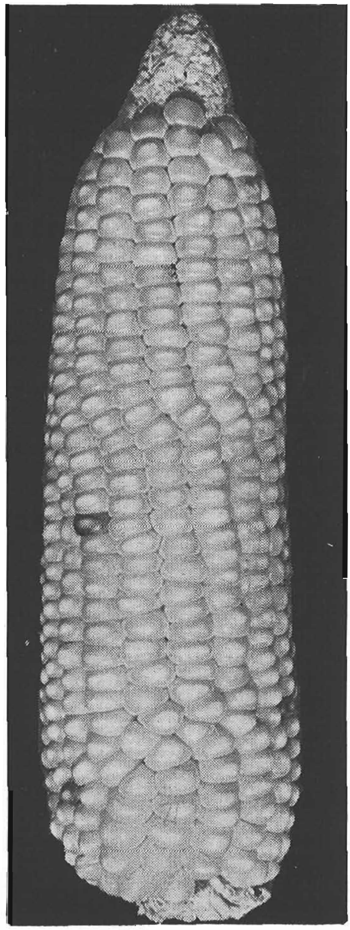


65

64. Ear of Mikir Merakku

65. Ear of Nilip Mekop

hills of Meghalaya. It is also found in the Lohit district of Arunachal Pradesh.

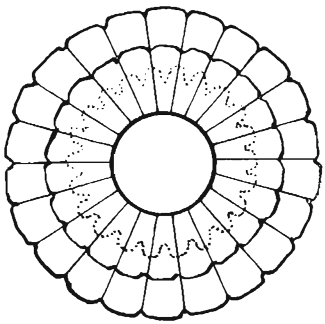
Derivation of name: Riewhadem means maize, a word taken from the regional language of the Khasi hills of Meghalaya, where it is most commonly found

14. MIKIR MERAKKU

Plants: Short; maturity medium-early; leaves very broad, of medium length; average width 8·9 cm; average length 67·7 cm; leaf length highest in relation to plant height; LL/PH 0·62; venation index 2·5, lowest of all races; leaves semi-erect; pilosity weak; internodes short, few; ear number low; placement of ears low in relation to plant height; EH/PH 0·53.

Tassels: Short; numerous branches arise from a little less than $\frac{1}{2}$ of central axis; flag-leaf usually below the lowermost branch of the tassel.

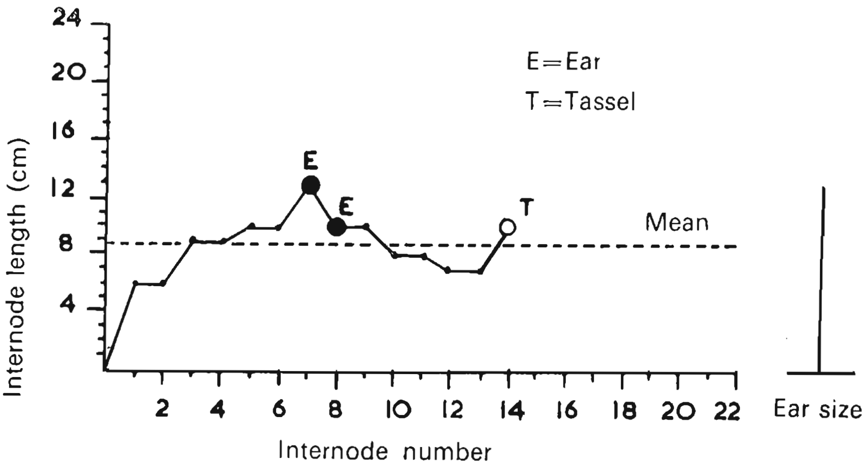
Ears: EXTERNAL CHARACTERS (Fig. 64): Short-medium length, very thick; slight taper from base to tip; EDB/EDT 1·2; irregular rows common. Ear diameter 4·5 cm at base; average kernel rows 22·0; ear diameter at base highest in relation to ear length; EDB/EL 0·36, highest of all races; kernels very long in relation to width; KW/KL 0·73; average kernel length 9·4 mm; average kernel width 6·9 mm; kernel density 1·2; endosperm soft, flinty. INTERNAL



66. Cross-section of the ear of Mikir Merakku

CHARACTERS (Fig. 66): Average cob diameter (3·1 cm) and average rachis diameter (13·8 mm) largest of all races. Estimated average rachilla length 4·0 mm; rachilla length lowest in relation to rachis diameter; RL/RD 0·35.

Of all races, rachis diameter in relation to ear length, ear diameter at centre, kernel length and kernel width largest; RD/EL 0·10; RD/EDC 0·32; KL/RD 0·7; KW/RD 0·5; tassel length and peduncle length in relation to ear diameter lowest of all races; TL/EDC 7·7; PL/EDC 2·3 (Fig. 67).



67. Internodal pattern of Mikir Merakku

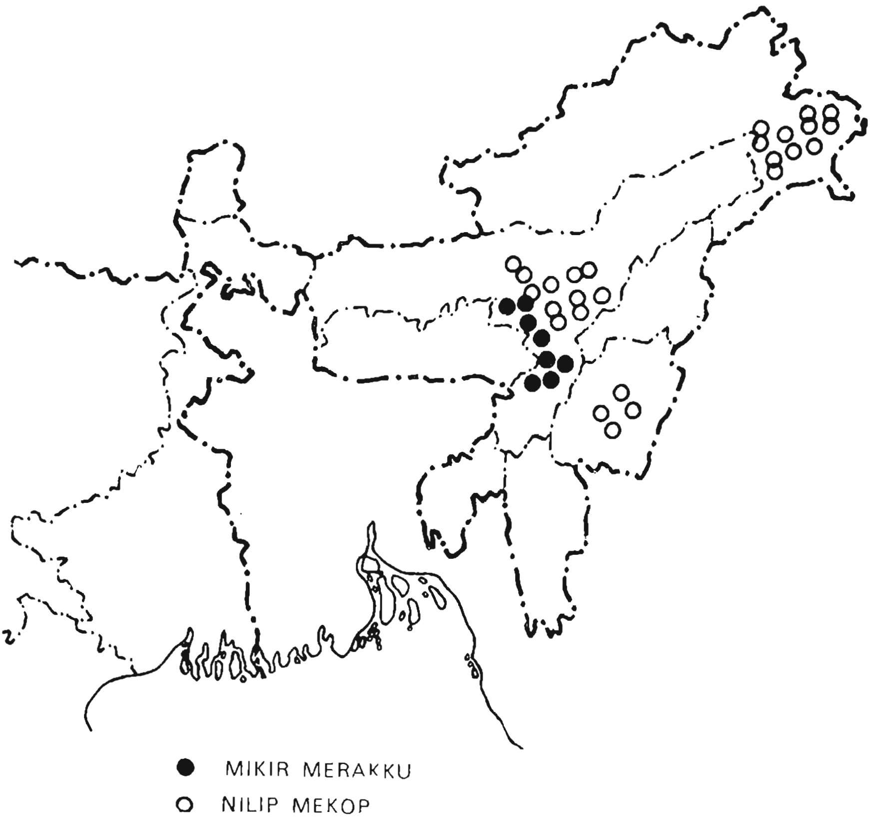
Distribution: Mikir Merakku is adapted to low elevations, up to 600 m (Fig. 68). It is most commonly found in the Mikir hills of Assam.

Derivation of name: This race is most commonly found in the Mikir hills. Merakku means maize.

15. NILIP MEKOP

Plants: Tall; maturity medium-early; leaves long, broad; average leaf length 77·4 cm; average width 8·6 cm; venation index low, 2·8; pilosity medium; average ear number 1·6/plant; placement of ears low; EH/PH index 0·57.

Tassels: Short; numerous branches arise from ½ of central axis; flag-leaf usually arises below the lowest branch of the tassel; pollen size medium.



68. Distribution of Mikir Merakku and Nilip Mekop

The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

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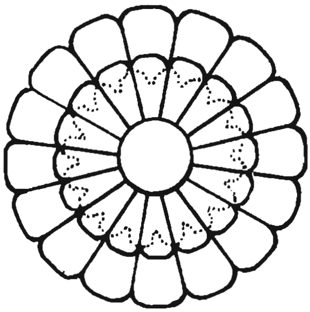
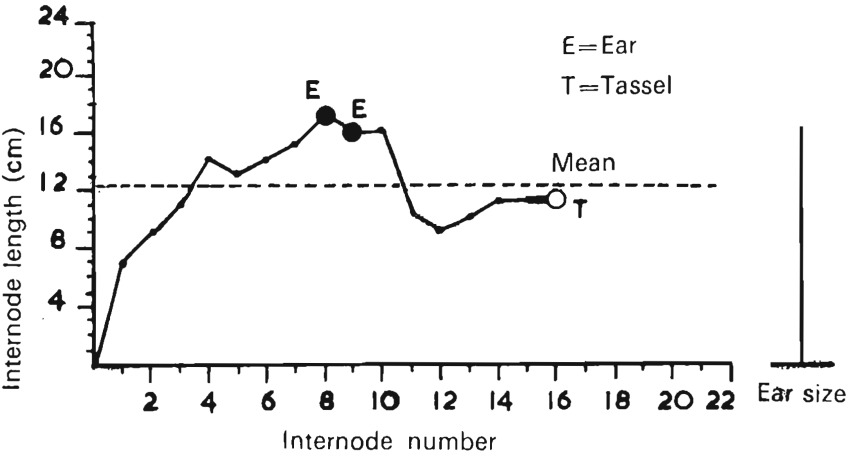
The boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas (Reorganisation) Act, 1971, but has yet to be verified.

Ears: EXTERNAL CHARACTERS (Fig. 65): Length 16·3 cm; average ear diameter 3·9 cm; slight taper from base to tip; EDB/EDT 1·2; rows regular; multiplication of rows at base common; number of rows 14 to 16 (average 15·6); kernels long in relation to width; KW/KL index 0·86; kernel volume low in relation to ear length; KV/EL 0·01; endosperm hard, flinty. INTERNAL



69. Cross-section of the ear of Nilip Mekop

CHARACTERS (Fig. 69): Average cob diameter 2·7 cm; average rachis diameter 9·4 mm; estimated average rachilla length 5·6 mm;



70. Internodal pattern of Nilip Mekop

RL/RD index intermediate, 0·67; rachilla length high in relation to cob diameter; RL/CD 0·21.

Mean values of characteristic indices (Fig. 70) of the race are: RL/KL very high, 0·60; CD/EL medium, 0·18; RD/EL low, 0·05; RD/EDC medium, 0·24; RL/EDC high, 0·14; EL/PH medium, 0·08; CPL/EDC (3·8) lowest of all races.

Distribution: Nilip Mekop is adapted to medium to high elevations, 600–1,500 m (Fig. 68). It is commonly found in the Mikir and Cachar hills, particularly in the Nilip area.

Derivation of name: Mekop means maize in the Nilip area of the Mikir hills.

10. DISCUSSION

It has been known for a long time that the north-eastern Himalayan states of India and parts of Nepal, China and Indonesia are endowed with a considerable genetic diversity in the maize crop. Among those who have drawn attention to this variability, Anderson (1945) and Stonor and Anderson (1949) deserve particular mention. They carried out very exhaustive studies on the variability of maize in the erstwhile Assam, comprising the present states of Assam, Meghalaya, Arunachal Pradesh, Mizoram and Nagaland. Not only did they draw attention to the immense genetic variability in this region but they also emphasized that some of this variability represented maize types of a very primitive kind. Indeed, they considered that maize might have originated in Asia or, at least, that the migration from the American continent took place much earlier than has been commonly believed.

There has been an obvious need for undertaking a systematic study of the entire genetic variability found in this part of India. Anderson (1945) and Stonor and Anderson (1949) were able to sample only a fraction of this total wealth of genetic material. The present study was planned to undertake a survey of this kind and to classify the different maize races existing in the region.

Although this survey is by no means complete, it has provided full support for the views of Anderson regarding the extent of variability present in the region. Thus, it has been possible to identify as many as 15 distinct races, each with characteristic complex of traits associated with it. The region is not only having this immense genetic variability, but it is clear that this diversity falls in distinct groups, whose identity has been preserved over hundreds of years. In a crop as highly cross-pollinated as maize, the conservation of these different complexes of characters in a relatively pure form should normally be difficult to explain. However, if one considers the geography of the region, its remoteness, and the poor communication facilities even to this date, it is not very surprising that the different tribes have been able to maintain their own maize types over the centuries.

Maize is a crop whose history in countries outside the American continent should be easy to understand. The most widely accepted and also perhaps the most logical interpretation has been that the maize plant had its origin in Mexico and that it was introduced into Asia and other parts of the world in the post-Columbian period. There is no doubt that the present-day high-yielding commercial varieties of maize, which are widely cultivated in many parts of the world, represent relatively recent introductions from America during the past four hundred years or so. There is evidence that the Portuguese introduced maize from Europe into India during the early part of the 16th century (Watt, 1893). Maize was not widely cultivated in India during the Mughal period, and this fits in with the theory of post-Columbian introduction.

If this theory of post-Columbian introduction of maize in India is accepted, the question is: What is the basis for the occurrence of so much genetic variability in some of these remote parts of India, while most of the advanced maize-growing states have hardly any variability in the local material? In explaining the occurrence of this immense variability in the Himalayan material, we may consider the possibility that the 15 races which have now been identified represent genotypes that have acquired their distinct characteristics largely as a result of adaptation to variation in the environment and the soil conditions in the region. While this possibility cannot be ruled out, it does not seem to be likely. For one thing, the environmental and soil variations are larger in other parts of the country. For another, the opportunities for such adaptive selections would have been greater in the plains of India, where introductions must have been first made through the sea-ports of Bombay, Calcutta and Madras.

If we rule out the possibility that these 15 races represent divergence of basically the same genetic material during the last four hundred years, then it follows that the introduction of maize in India in the post-Columbian period has been on a scale more comprehensive than has been visualized so far. It should be emphasized that some of the races described here are of a very primitive kind. For some of them, it is possible that the equivalent counterparts exist in the American continent.

The basic question is: If all this variability has been introduced in the post-Columbian period, why has it been localized in its distribution to a small, inaccessible and remote part of the country, where conscious efforts to introduce maize have been few? These considerations lead to a re-examination of the introduction of maize in Asia in regard to time-scale. This suggests that maize might have reached this part of India and other parts of Asia in pre-Columbian periods by routes that normally received little attention from scientists who have worked on the history of the maize plant. In this context it is significant that the part of India that shows the largest variability described here lies closer to China and other parts of Asia, from which primitive forms have been reported by other authors (Collins, 1909; Ono and Suzuki, 1956).

More recently, Dhawan (1964) and Thapa (1966) have described primitive varieties of maize from Sikkim. Under the project for the collection of maize and millets jointly sponsored by the Indian Council of Agricultural Research and the Rockefeller Foundation, local maize varieties were collected from different states in India during 1959–62. Rachie (1964) has tried to group these maize collections in a number of ways, each one primarily based on one factor like ear size, combined with grain colour, adaptability and utility. Most of the collections were obtained from Bihar, Madhya Pradesh, Jammu and Kashmir, Uttar Pradesh and Punjab, and relatively few were made from Assam, West Bengal and Himachal Pradesh. Singh and Singh (1967) indicated that the collections from Himachal Pradesh were outstanding, whereas varieties from Assam, Tripura and Manipur showed impressive plant type, even though some of them were quite late in maturity.

The question has been often asked: What should be the relative weightage attached to the characteristics of the plant, tassel, ear and grain in classification studies? Opinions on this aspect vary. Some authors have made use of the various characters of 'hierarchy'. On the other extreme, some have used multivariate analysis and Anderson's pictogram technique. Goodman (1969) has studied as many as 110 different characters in large collections of maize varieties. Edwards and Leng (1965) classified maize varieties of southern and south-western Europe, using the pictorialized scatter-diagram technique of Anderson. The details of the classification of large number of collections made by Brandolini (1970) are awaited. In the present study, a large number of meteric traits of various parts of the plant, tassel, ear and grains were recorded. The pictorialized scatter-diagram technique was used as the basis of classification. The basic information on the characteristics of different groups of varieties was obtained according to the technique suggested by Anderson (1957). Of the several characters found significant, 8 characters were selected. Six of them—rachis diameter, row number, ear diameter, kernel length, ear length and total ear surface—relate to the ears and grains; the other 2 were plant height and maturity. The characters used in pictorialized scatter diagram were selected on the basis of their larger range. In addition, greater emphasis was given to ear and grain characters that were observed to be more stable and least variable, in contrast to vegetative characters. Similar results were obtained by Goodman and Paterniani (1969).

The index scores of the 8 characters were obtained by assigning values to the 5 grades with equal weight to all the characters. It was observed that some of the races with similar magnitude were remarkably different from each other. The situation remained more or less the same with differential weightage. However, it led us to a more natural, clear, precise and comparable situation when 4 such diagrams with different combinations of x-abscissas and y-ordinates were prepared. It was observed that the 2 races Tista Mendi (11) and Nilip Mekop (15) with equal index score differ considerably in important ear and grain characters, each located in different cells, thus indicating different groups in all the 4 pictorialized scatter diagrams (Figs 3–6). When 2 characters as indicated by x and y co-ordinates in each of the 4 figures were considered, it was found that (*i*) the race Tista Mendi differs in at least 4 characters from all other races except the race Khasi Riewhadem (13); (*ii*) races Tista Mendi and Khasi Riewhadem in the pictorialized scatter diagram I (Fig. 3) are located in the same cell, thus indicating that Tista Mendi differs at least in 3 characters from the race Khasi Riewhadem; (*iii*) the race Nilip Mekop differs at least in 4 characters from all other races except races Cachar Gomdhan (9), Khasi Riewhadem and Ganga sub-race of Maidani Makka, (10R); and (*iv*) the race Nilip Mekop differs at least in 3 characters from each of the races Cachar Gomdhan, Khasi Riewhadem and Ganga sub-race of Maidani Makka. Similar types of conclusions were drawn from the diagrams. Thus, the 4 diagrams (Figs 3–6) are more informative than the single pictorialized scatter diagram. The erroneous conclusions caused by simple addition could also be checked and avoided if all the 4 diagrams are simultaneously considered.

The plant, tassel, and ear indices suggested by Goodman and Paterniani (1969) were also calculated and used in the description of races. Although the use of these relative indices did not materially change the picture based on individual characters, it did help in a better understanding of the collections. Special consideration has also been given to geographical distribution, which is of great importance in recognizing the races. It is only by analysing and integrating the evidence from various sources that a valid and natural classification has been possible. This classification into more or less distinct races should in no way be considered the final answer to the problem of racial diversity. The classification presented here is based on numerous measurements recorded in one year, and may have to be changed to some extent when information based on inbreeding and outbreeding is available.

To facilitate the comparison of the relative magnitudes of variability for various characters in different groups, the coefficients of variation are presented in Tables 23-26. For some important characters like ear length, the coefficient of variation in the race Khasi Riewhadem is 0·1% only, where as it is as high as 20 1% in the race Maidani Makka, which is distributed throughout the plains of India. Similar is the situation with regard to several other characters like ear diameter, kernel number, kernel rows, total ear surface, kernel length and tassel branches. This type of information is useful in selecting a race for specific characters for use in various plant-improvement programmes.

The races described here could be grouped for convenience into 4 categories: primitive, advanced or derived, recent introductions and hybrid races. The primitive group comprises several races of pop-corn which had become differentiated at various altitudes and under diverse conditions. These are Poorvi Botapa, Murli sub-race of Poorvi Botapa, Tirap Nag-Sahypung, Arun Tepi and Alok Sapa. These races have been placed under the primitive group because they are characterized by popping type of grains, prominent striations on the kernels, fewer kernel rows, smaller ears, more ears, tassel with fewer branches, smaller internodes, narrower leaves, shorter height and relatively high-placed ears. They are distributed throughout the eastern Himalayan region, particularly Assam, Nagaland, Manipur, Arunachal Pradesh, Sikkim and Bhutan. They are found at elevations from 600 m to more than 2,000 m, under conditions of traditional cultivation. An interesting feature of Murli sub-race of Poorvi Botapa is that it showed marked resemblance in its general plant type to the reconstructed ancestral form of maize reported by Mangelsdorf and his collaborators (Mangelsdorf, 1958; Mangelsdorf *et al.*, 1964). Further, there is evidence that the cytoplasm of primitive types of sub-race Murli and evolved types is highly differentiated, as indicated by reciprocal differences for a number of characters (Bhat and Dhawan, 1969). It has been found in Sikkim and Assam. The race Tirap Nag-Sahypung has several peculiar characteristics, including the size, shape, arrangement and number of leaves. The leaves are erect, small, numerous and clustered towards the tassel.

In the second group have been placed Manipuri Chujak, Mayong Sa-ah, Asht Samsung, Tsungrhu sub-race of Asht Samsung, Shyam Nahom, Cachar Gomdhan, Maidani Makka and Ganga, its sub-race. These are characterized by large flinty grain, with endosperm colour ranging from white, cherry, red, purple and their various grades. They have few but large ears, and they mature earlier than the races in the primitive group. They have semi-erect to flat leaves. Most of the varieties collected from the plains do not have much variability. They are mostly early flints and closely resemble Cuban flints and northern flints and hence have been grouped under the race Maidani Makka and its sub-race Ganga.

The third group consists of races Tista Mendi and Silken Tipang. Tista Mendi, found at high elevations, has semi-dent, yellow-and-red grains with few but large ears. It is probably a recent introduction, and had not only established itself as a pure race but had also hybridized with older races to form new hybrid races. Silken Tipang has pop grains, combined with few ears. It has larger ear surface and bolder grains than the primitive group. Probably a recent introduction from adjacent countries like Burma, it is confined in the specific pockets of Arunachal Pradesh, adjoining Burma.

Khasi Riewhadem, Mikir Merakku and Nilip Mekop constitute the fourth group. This group consists of races which are the result of hybridization of primitive types with advanced races. Some of the collections belonging to races Tista Mendi and Tirap

Nag-Sahypung have shown high resistance to the corn-borer, *Chilo zonellus* Swin. under natural infestation. Arun Tepi, Alok Sapa and all collections belonging to the race Tirap Nag-Sahypung show high resistance to leaf-blight caused by *Helminthosporium maydis* Nisikado & Miyake. In addition, all the entries belonging to the race Manipuri Chujak, Mayong Sa-ah and all the collections forming the race Tirap Nag-Sahypung show high resistance to downy-mildew caused by *Sclerospora philippinensis* Weston. These need further confirmation. The present study has thus helped to locate some of the most valuable genetic stocks which we in India need for the continued improvement of the maize crop. The collections showing resistance to stem-borer and downy-mildew are of particularly great value. The collection also consists of races like Tista Mendi which have shown an outstanding yield potential, with thick stem and high resistance to the corn-borer. The variety Malan, characterized by white, semi-dent grains, recently reported from Rajasthan, is similar to Maidani Makka.

Although considerable amount of improvement work on maize has been done, the yield levels have not exceeded 5 tonnes/ha, particularly in the low-land tropics. A number of ways of overcoming this yield-barrier have been suggested from time to time, and the development of varietial populations that would be able to withstand high population densities appears to be the most promising approach. The plant characters required for such populations have been discussed by several authors (Bleasdale and Nelder, 1960; Pendleton *et al.*, 1968; Hunter *et al.*, 1969; Frey and Jenick, 1971). Among the large number of collections from the north-eastern Himalayan region, the race Tirap Nag-Sahypung shows most of the characters desired for high yields under high population densities. The important characters of the race are: medium height, numerous leaves above the main ear, erect leaves, small tassels, numerous ears that are high-placed, and high resistance to corn-borer, leaf-blight and downy-mildew. Notwithstanding its late maturity, this race has the group of characters that could be most profitably utilized for a major advance in yield. These stocks with ideal plant type would be of utmost value in refashioning the maize plant of the future.

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TABLE 2. List of collections studied as representative of each race of Indian maize

1. Poorvi Botapa	A 35, A 94 BH 27 M 13 MR 43, MR 71 NA 16 SK 10
Sub-race Murli	A 96, A 97 SK 9A
2. Tirap Nag-Sahypung	NA 33, NA 34, NA 35, NA 36, NA 37, NA 38, NA 39, NA 40, NA 41
3. Arun Tepi	MR 10, MR 11, MR 12, MR 13, MR 14, MR 15, MR 16, MR 17, MR 18, MR 19, MR 22, MR 37 NA 31, NA 32
4. Alok Sapa	MR 63 N 2 NA 42, NA 43
5. Manipuri Chujak	MR 7, MR 8, MR 9, MR 32, MR 48, MR 51, MR 58, MR 62, MR 64, MR 68, MR 69, MR 70 NA 55A
6. Mayong Sa-ah	MR 6, MR 65, MR 66, MR 72 N 1 NA 9, NA 10, NA 13, NA 14, NA 15, NA 17, NA 18, NA 19, NA 20, NA 21, NA 22, NA 23, NA 44, NA 45, NA 46, NA 47, NA 48, NA 49, NA 66, NA 67
7. Asht Samsung	N 3, N 4, N 5, N 6, N 10, N 11 SK 1, SK 2, SK 3, SK 4, SK 5, SK 6, SK 7, SK 8, SK 9, SK 24, SK 84
Sub-race Tsungrhu	M 1, M 2 N 13, N 14, N 15, N 16, N 17, N 18, N 19, N 20, N 21, N 23, N 24, N 25 SK 14, SK 26
8. Shyam Nahom	A 38, A 48, A 49, A 50 MR 28, MR 29, MR 30, MR 31, MR 33, MR 34, MR 36, MR 41, MR 42, MR 44, MR 45, MR 46, MR 50, MR 54, MR 56
9. Cachar Gomdhan	A 21, A 22, A 23, A 40, A 41, A 42, A 43, A 45, A 51, A 52
10. Maidani Makka	A 3, A 4, A 6, A 7, A 9, A 12, A 13, A 16, A 24, A 25, A 27, A 28, A 54, A 55, A 56, A 57, A 58, A 59, A 60, A 61, A 62, A 63, A 64, A 65, A 66, A 71, A 73, A 74, A 82, A 86, A 87, A 88, A 89, A 92, A 95, A 98, A 104, A 106, A 107, A 108, A 127, A 130

	BH 3, BH 4, BH 5, BH 6, BH 20
	GT 1
	HP 2
	MR 1, MR 2, MR 3, MR 4, MR 5
	NA 30
	PB 1
	RJ 1
	TU 1
	UP 1
Sub-race Ganga	HD 1
	HP 1
	NA 1, NA 2, NA 3, NA 4, NA 5, NA 6, NA 7, NA 8, NA 25, NA 26, NA 27, NA 28
11. Tista Mendi	WB 4, WB 5, WB 6, WB 7, WB 8, WB 9, WB 10, WB 11, WB 12
12. Silken Tipang	NA 32A
13. Khasi Riewhadem	M 3, M 4, M 5, M 6, M 7, M 8, M 9, M 10, M 11, M 12
	NA 60
14. Mikir Merakku	A 32, A 34, A 36, A 39, A 44, A 46, A 47, A 53
15. Nilip Mekop	A 117, A 118, A 119, A 120, A 121, A 122, A 123, A 124, A 126, A 128, A 129
	MR 24, MR 25, MR 26, MR 27
	NA 54, NA 55, NA 56, NA 57, NA 58, NA 59, NA 61, NA 62, NA 63, NA 64, NA 65

TABLE 3. Races of maize in India: Vegetative characters of the plant

Race	No. of collections studied	Altitude (m)	Days to flower (75% silk) (DF)†		Plant height (cm) (PH)†		Ear height (cm) (EH)†		Stem diameter (cm) (SD)†		Number of leaves above ear (LE)†		Leaf length (cm) (LL)†	
1. Poorvi Botapa	9	600–1500	73	5·00	125	9·59	101	13·57	1·6	0·31	2·7	0·73	51·8	9·81
Sub-race Murli	3	600–1500	71	3·00	124	1·24	106	1·00	1·5	0·00	1·4	0·58	43·1	5·56
2. Tirap Nag-Sahypung	9	600–1500	90	6·39	133	12·10	110	17·80	2·1	0·54	6·6	1·30	50·0	13·50
3. Arun Tepi	15	above 1500	95	6·90	120	2·45	95	7·39	2·4	0·22	5·7	0·84	39·4	9·02
4. Alok Sapa	4	above 1500	80	6·41	204	6·54	98	1·02	2·0	0·44	5·6	0·43	82·3	6·01
5. Manipuri Chujak	13	above 1500	88	6·63	164	10·00	106	15·86	2·1	0·20	4·8	0·25	65·9	8·48
6. Mayong Sa-ah	21	above 1500	80	5·08	146	16·79	111	15·48	2·2	0·45	4·0	0·56	62·9	8·96
7. Asht Samsung	16	above 1500	62	2·66	199	12·32	138	11·40	2·0	0·20	5·0	0·14	74·4	6·32
Sub-race Tsungrhu	16	above 1500	67	0·50	197	9·27	125	0·20	2·5	0·24	5·0	0·00	78·4	1·34
8. Shyam Nahom	19	600–1500	73	9·22	127	21·30	95	14·88	1·9	0·11	4·0	0·81	51·4	6·67
9. Cachar Gomdhan	10	0–600	73	4·47	139	3·46	96	2·44	2·4	0·05	4·0	0·63	73·3	1·41
10. Maidani Makka	59	0–600	56	3·87	169	18·22	97	23·80	2·1	0·65	5·0	0·73	71·3	3·97
Sub-race Ganga	15	600–1500	60	5·81	185	10·00	99	8·81	1·9	0·18	5·2	0·37	72·2	3·67
11. Tista Mendi	8	above 1500	61	0·00	186	9·48	119	13·01	2·5	0·05	4·9	0·02	77·5	0·94
12. Silken Tipang	1	600–1500	55	*	143	*	112	*	1·8	*	5·0	*	70·5	*
13. Khasi Riewhadem	11	above 1500	58	2·23	211	15·64	118	5·09	2·5	0·23	5·4	0·14	78·0	5·65
14. Mikir Merakku	8	0–600	59	1·01	113	0·34	60	0·90	1·9	0·04	4·9	0·07	67·7	0·22
15. Nilip Mekop	27	600–1500	60	4·78	186	9·11	111	19·39	2·2	0·10	5·4	0·10	77·4	5·27

* One collection represents the race. † Abbreviated form of the characters.

TABLE 4. Races of maize in India: Vegetative characters of the plant

Race	Leaf width (cm) (LW)†		Leaf area (cm) (LR)†		Leaf angle (1–3) (LA)†		Ear number per plant (EN)†		Total leaf surface area above ear (cm) (LS)†		Brace root position (0–3) (BR)†		Pilosity (1–3) (PS)†	
1. Poorvi Botapa	5·4	1·14	16·7	3·24	2·3	0·45	3·4	0·57	27·0	6·21	1·9	0·25	2·1	0·30
Sub-race Murli	4·3	0·56	13·8	2·44	2·0	0·51	4·0	0·50	15·6	4·69	1·7	0·19	2·1	0·21
2. Tirap Nag-Sahypung	7·9	0·14	19·8	1·47	1·3	0·30	3·7	0·33	51·5	7·40	3·0	0·53	1·5	0·30
3. Arun Tepi	6·6	0·31	16·1	1·30	1·5	0·24	1·8	0·22	38·4	0·50	3·3	0·21	1·4	0·41
4. Alok Sapa	6·8	0·35	23·6	0·24	3·0	0·00	2·2	0·05	56·0	2·44	2·7	0·46	3·0	0·00
5. Manipuri Chujak	7·1	1·18	21·7	0·92	3·0	0·00	2·0	0·21	47·8	0·75	2·0	0·31	2·4	0·36
6. Mayong Sa-ah	7·2	0·56	21·2	2·13	2·0	0·37	1·5	0·27	43·7	4·46	2·3	0·41	1·7	0·42
7. Asht Samsung	7·6	0·64	23·7	1·92	3·0	0·00	1·5	0·05	53·5	5·38	1·5	0·14	2·0	0·02
Sub-race Tsungrhu	8·0	0·49	25·1	0·28	3·0	0·21	1·6	0·22	56·4	0·51	1·7	0·30	2·6	0·28
8. Shyam Nahom	7·2	0·49	19·1	2·14	2·2	0·22	1·7	0·22	38·3	4·12	1·4	0·30	2·3	0·19
9. Cachar Gomdhan	7·0	0·14	24·2	0·57	2·0	0·10	2·5	0·01	49·2	3·46	1·4	0·20	1·9	0·10
10. Maidani Makka	7·9	1·95	23·7	4·79	3·0	0·00	1·5	0·44	53·4	3·93	1·4	0·33	3·0	0·70
Sub-race Ganga	7·7	0·52	23·5	1·61	3·0	0·00	1·2	0·22	54·4	5·09	1·7	0·38	3·0	0·00
11. Tista Mendi	8·8	0·16	26·2	0·40	3·0	0·00	1·2	0·00	58·4	1·02	2·1	0·30	1·5	0·05
12. Silken Tipang	7·9	*	23·5	*	3·0	*	1·7	*	52·8	*	0·9	*	2·5	*
13. Khasi Riewhadem	8·8	0·70	26·0	1·41	2·7	0·31	1·6	0·05	61·0	2·82	1·6	0·03	2·2	0·22
14. Mikir Merakku	8·9	0·60	24·6	1·01	2·1	0·43	1·5	0·08	54·6	2·01	1·0	0·02	3·0	0·00
15. Nilip Mekop	8·6	0·57	25·8	0·42	2·9	0·14	1·6	0·45	60·0	1·24	1·4	0·40	2·0	0·44

* One collection represents the race. † Abbreviated form of the characters.

TABLE 5. Races of maize in India: Tassel characters

Race	Tassel emergence (1–3) (TE)†		Tassel length (cm) (TL)†		Peduncle length (cm) (PL)†		Central spike length (cm) (CPL)†	
1. Poorvi Botapa	1·5	0·39	29·1	3·94	10·3	2·60	19·3	3·69
Sub-race Murli	1·2	0·24	30·2	2·34	11·6	0·21	20·7	0·17
2. Tirap Nag-Sahypung	1·1	0·05	31·2	8·50	10·2	2·60	15·3	3·50
3. Arun Tepi	1·0	0·24	38·8	3·48	7·5	1·15	15·0	1·96
4. Alok Sapa	3·0	0·34	37·5	2·01	13·2	0·51	17·9	2·01
5. Manipuri Chujak	1·5	0·56	34·4	1·41	12·3	1·77	21·3	0·81
6. Mayong Sa-ah	1·9	0·50	30·1	1·96	11·5	3·23	20·2	4·74
7. Asht Samsung	2·5	0·00	38·9	0·10	17·7	0·10	20·1	2·89
Sub-race Tsungrhu	2·7	0·02	38·6	0·05	19·0	0·11	19·2	2·58
8. Shyam Nahom	1·6	0·24	28·5	3·87	11·6	2·31	24·4	3·92
9. Cachar Gomdhan	1·9	0·20	37·2	0·50	12·1	1·37	25·9	0·34
10. Maidani Makka	2·7	0·54	36·3	5·56	16·4	2·68	20·3	0·88
Sub-race Ganga	2·7	0·14	40·5	3·42	17·5	2·28	22·6	3·37
11. Tista Mendi	2·5	0·27	40·1	0·74	15·5	0·44	22·7	1·83
12. Silken Tipang	3·0	*	33·3	*	16·7	*	17·1	*
13. Khasi Riewhadem	2·5	0·15	40·8	1·16	17·0	0·91	21·5	2·50
14. Mikir Merakku	2·5	0·01	32·5	0·10	9·5	1·91	18·0	0·90
15. Nilip Mekop	2·7	0·01	39·3	3·16	16·2	0·62	18·6	0·63

* One collection represents the race.   † Abbreviated form of the characters.

TABLE 6. Races of maize in India: Tassel characters

Race	Branching space length (cm) (BL)†		Total number of tassel branches (TTB)†		Primary branches (PB)†		Secondary branches (SB)†		Pollen diameter (μ) (PD)†	
1. Poorvi Botapa	9·7	5·07	14·4	2·53	12·0	0·85	2·4	1·10	75·6	8·64
Sub-race Murli	9·6	0·86	14·8	0·50	12·2	0·24	2·5	0·60	73·9	0·57
2. Tirap Nag-Sahypung	10·2	4·52	20·8	2·10	16·3	1·60	4·3	1·00	78·7	1·66
3. Arun Tepi	11·1	0·09	22·3	2·21	18·5	0·14	3·8	0·51	81·9	0·57
4. Alok Sapa	19·6	1·41	28·8	4·26	21·2	3·02	7·5	1·42	75·6	0·72
5. Manipuri Chujak	13·0	3·31	24·1	2·15	17·6	0·17	6·5	1·26	78·7	0·65
6. Mayong Sa-ah	11·6	3·43	22·2	4·51	17·8	3·45	4·3	1·06	75·6	1·18
7. Asht Samsung	18·7	2·01	19·4	3·16	14·9	2·02	4·4	1·31	80·6	0·77
Sub-race Tsungrhu	18·4	2·12	23·4	0·24	17·6	2·24	5·7	0·11	83·4	1·22
8. Shyam Nahom	10·1	1·86	13·7	2·61	12·0	1·78	1·7	0·58	81·3	1·46
9. Cachar Gomdhan	11·2	1·10	16·6	1·48	14·1	1·02	2·5	0·30	80·0	0·72
10. Maidani Makka	16·0	0·88	20·5	0·87	15·8	2·10	4·6	0·58	78·8	3·60
Sub-race Ganga	17·9	2·25	20·2	3·34	16·2	2·12	3·9	1·17	84·4	1·10
11. Tista Mendi	17·4	0·52	20·6	0·62	16·1	0·54	4·5	0·05	76·8	0·12
12. Silken Tipang	16·2	*	13·7	*	12·0	*	1·7	*	73·8	*
13. Khasi Riewhadem	19·3	3·80	24·2	1·73	18·3	0·07	5·9	1·52	78·7	1·39
14. Mikir Merakku	14·5	0·84	23·9	1·02	18·0	1·02	5·9	0·31	82·5	0·05
15. Nilip Mekop	20·6	0·63	23·8	0·80	18·6	1·72	5·1	0·81	81·3	1·10

* One collection represents the race. † Abbreviated form of the characters.

TABLE 7. Races of maize in India: External ear characters

Race	Ear length (cm) (EL)†		Ear diameter at base (cm) (EDB)†		Ear diameter at centre (cm) (EDC)†		Ear diameter at tip (cm) (EDT)†	
1. Poorvi Botapa	8·9	0·83	2·4	0·15	2·0	0·14	1·6	0·17
Sub-race Murli	8·5	0·17	2·4	0·10	1·9	0·21	1·7	0·20
2. Tirap Nag-Sahypung	10·3	0·78	2·6	0·10	2·3	0·20	1·8	0·10
3. Arun Tepi	10·5	0·94	3·1	0·13	2·7	0·05	2·1	0·80
4. Alok Sapa	12·6	1·48	2·6	0·40	2·4	0·32	2·2	0·24
5. Manipuri Chujak	12·0	1·91	2·8	0·18	2·5	0·28	2·0	0·37
6. Mayong Sa-ah	11·3	1·26	2·8	0·18	2·6	0·08	2·1	0·14
7. Asht Samsung	17·8	0·31	3·3	0·14	3·1	0·01	2·9	0·22
Sub-race Tsungrhu	15·8	0·34	3·5	0·05	3·3	0·31	2·9	0·20
8. Shyam Nahom	11·0	1·45	3·6	0·02	3·4	0·01	2·9	0·02
9. Cachar Gomdhan	12·3	2·14	4·1	0·05	3·8	0·05	3·3	0·05
10. Maidani Makka	14·9	3·00	3·8	0·54	3·4	0·24	2·9	0·54
Sub-race Ganga	14·0	0·94	4·0	0·07	3·5	0·14	3·1	0·10
11. Tista Mendi	19·5	1·41	4·3	0·05	4·1	0·10	3·4	0·10
12. Silken Tipang	15·6	*	3·2	*	2·9	*	2·4	*
13. Khasi Riewhadem	17·9	0·02	4·1	0·09	3·9	0·03	3·3	0·22
14. Mikir Merakku	13·5	0·13	4·5	0·34	4·2	0·35	3·6	0·24
15. Nilip Mekop	16·3	1·45	4·1	0·30	3·9	0·24	3·3	0·20

* One collection represents the race. † Abbreviated form of the characters.

TABLE 8. Races of maize in India: External ear characters

Race	Row number (RN)†		Kernel number/row (KN)†		Row regularity (1–5) (KR)†		Total ear surface (cm²) (TES)†	
1. Poorvi Botapa	10·9	1·40	19·6	2·47	2·1	0·58	58·2	8·91
Sub-race Murli	9·9	1·38	17·7	1·09	2·7	0·22	53·1	4·47
2. Tirap Nag-Sahypung	14·7	0·89	24·7	2·70	2·8	1·00	76·5	6·40
3. Arun Tepi	18·7	1·41	22·6	0·79	3·2	0·22	89·3	4·47
4. Alok Sapa	13·9	1·24	21·0	5·02	2·5	0·20	95·4	17·49
5. Manipuri Chujak	12·6	0·84	23·2	5·29	1·8	0·41	93·7	11·86
6. Mayong Sa-ah	12·8	0·51	23·0	2·34	3·0	0·85	97·8	9·65
7. Asht Samsung	8·3	0·24	30·4	3·89	1·0	0·02	178·7	3·01
Sub-race Tsungrhu	8·5	0·21	30·0	1·04	1·0	0·05	167·6	19·49
8. Shyam Nahom	17·4	0·70	25·6	4·58	3·0	0·53	120·2	1·83
9. Cachar Gomdhan	18·3	1·04	27·4	5·48	3·0	0·50	150·3	26·09
10. Maidani Makka	13·0	1·73	31·2	6·40	1·5	0·45	163·3	49·10
Sub-race Ganga	13·5	1·18	26·9	3·89	1·7	0·51	158·6	11·90
11. Tista Mendi	10·5	0·23	36·6	0·20	1·5	0·11	250·3	27·41
12. Silken Tipang	11·9	*	36·2	*	1·0	*	140·9	*
13. Khasi Riewhadem	9·1	0·46	31·1	1·41	1·0	0·04	223·3	6·89
14. Mikir Merakku	22·0	2·38	29·5	3·01	3·9	0·59	178·4	14·01
15. Nilip Mekop	15·6	0·70	32·5	5·46	1·4	0·41	203·6	28·46

* One collection represents the race. † Abbreviated form of the characters.

TABLE 9. Races of maize in India: Kernel characters

Race	Kernel thickness (mm) (KT)†		Kernel width (mm) (KW)†		Kernel length (mm) (KL)†		100-grain weight (g) (KWT)†		100-grain volume (ml) (KV)†	
1. Poorvi Botapa	4·1	0·14	5·7	0·19	6·2	0·28	10·6	1·95	8·2	1·62
Sub-race Murli	4·2	0·07	5·6	0·01	6·0	0·20	8·9	0·10	6·4	0·10
2. Tirap Nag-Sahypung	3·7	0·28	5·5	0·31	6·5	0·30	7·6	1·28	6·0	1·50
3. Arun Tepi	3·3	0·40	5·5	0·30	6·2	0·64	8·3	1·04	6·8	1·53
4. Alok Sapa	4·5	0·12	6·0	0·90	6·3	1·30	8·4	1·50	6·6	1·48
5. Manipuri Chujak	4·4	0·21	6·3	0·46	7·1	0·08	10·7	2·01	11·1	1·80
6. Mayong Sa-ah	4·6	0·06	6·3	0·33	6·9	0·45	10·0	0·26	11·0	1·49
7. Asht Samsung	4·8	0·62	9·9	0·21	9·5	0·71	26·9	3·31	23·9	0·51
Sub-race Tsungrhu	4·7	0·12	10·1	0·80	9·6	0·39	29·2	5·47	24·9	4·35
8. Shyam Nahom	4·2	0·20	6·9	0·23	7·9	0·61	12·3	0·81	11·6	0·14
9. Cachar Gomdhan	3·8	0·34	6·8	0·94	9·0	0·91	17·4	2·44	15·4	4·24
10. Maidani Makka	4·2	0·50	8·0	1·37	8·8	1·72	19·2	3·09	16·9	6·48
Sub-race Ganga	4·6	0·04	8·6	0·52	9·1	0·10	21·4	1·34	18·1	0·63
11. Tista Mendi	4·5	0·11	11·4	0·12	11·7	0·05	34·8	1·61	31·0	1·41
12. Silken Tipang	4·0	*	6·6	*	8·1	*	14·3	*	11·0	*
13. Khasi Riewhadem	4·9	0·10	10·8	0·02	9·5	0·01	36·1	1·46	29·1	1·51
14. Mikir Merakku	4·0	0·10	6·9	0·10	9·4	0·94	16·3	1·22	13·3	0·83
15. Nilip Mekop	4·3	0·44	7·9	0·28	9·2	1·42	21·3	0·37	18·8	3·53

* One collection represents the race. † Abbreviated form of the characters

TABLE 10. Races of maize in India: Internal ear characters

Race	Cob diameter (cm) (CD)†		Rachis diameter (mm) (RD)†		Rachilla length (mm) (RL)†	
1. Poorvi Botapa	1·6	0·43	3·9	0·80	2·4	0·40
Sub-race Murli	1·5	0·20	3·5	0·07	2·0	0·01
2. Tirap Nag-Sahypung	1·7	0·14	4·3	0·20	2·9	0·20
3. Arun Tepi	2·2	0·05	6·5	0·40	4·1	0·30
4. Alok Sapa	2·1	0·05	3·9	0·50	3·7	0·50
5. Manipuri Chujak	1·8	0·24	5·5	0·10	2·6	1·30
6. Mayong Sa-ah	2·0	0·39	5·6	0·30	3·5	0·50
7. Asht Samsung	2·1	0·01	6·2	0·10	3·4	0·50
Sub-race Tsungrhu	2·2	0·10	6·3	0·11	3·9	0·60
8. Shyam Nahom	2·5	0·02	7·9	0·70	5·2	0·70
9. Cachar Gomdhan	2·7	0·10	11·0	0·01	4·6	0·10
10. Maidani Makka	2·4	0·41	7·7	0·13	4·6	0·90
Sub-race Ganga	2·4	0·07	8·1	0·20	4·8	0·80
11. Tista Mendi	2·6	0·05	7·6	0·03	5·0	0·30
12. Silken Tipang	2·2	*	5·6	*	3·5	*
13. Khasi Riewhadem	2·6	0·10	7·5	0·10	6·3	0·20
14. Mikir Merakku	3·1	0·34	13·8	1·20	4·0	0·20
15. Nilip Mekop	2·7	0·14	9·4	1·40	5·6	1·20

* One collection represents the race.   † Abbreviated form of the characters.

TABLE 11. Races of maize in India: Plant indices

Race	Venation index		DF/LE		LW/LL		LL/PH	
1. Poorvi Botapa	3·7	0·96	35·5	26·40	0·10	0·03	0·43	0·06
Sub-race Murli	4·1	0·64	52·5	15·49	0·09	0·00	0·40	0·00
2. Tirap Nag-Sahypung	2·8	0·26	14·2	3·30	0·16	0·10	0·37	0·14
3. Arun Tepi	3·0	0·09	16·8	2·01	0·16	0·03	0·32	0·07
4. Alok Sapa	3·0	0·21	14·3	0·05	0·08	0·01	0·41	0·01
5. Manipuri Chujak	3·2	0·42	17·8	2·24	0·10	0·03	0·41	0·01
6. Mayong Sa-ah	3·0	0·48	20·2	2·92	0·11	0·02	0·43	0·06
7. Asht Samsung	2·8	0·01	12·4	0·01	0·10	0·00	0·37	0·01
Sub-race Tsungrhu	2·8	0·10	13·2	0·10	0·10	0·01	0·39	0·01
8. Shyam Nahom	3·1	0·17	19·7	2·50	0·14	0·05	0·41	0·07
9. Cachar Gomdhan	2·7	0·01	18·0	3·02	0·11	0·10	0·52	0·02
10. Maidani Makka	2·8	0·48	11·0	2·20	0·11	0·02	0·42	0·15
Sub-race Ganga	3·0	0·12	11·3	0·75	0·10	0·01	0·39	0·03
11. Tista Mendi	2·9	0·19	11·9	0·05	0·11	0·00	0·42	0·03
12. Silken Tipang	2·8	*	11·0	*	0·11	*	0·49	*
13. Khasi Riewhadem	2·8	0·01	10·7	0·08	0·10	0·01	0·36	0·01
14. Mikir Merakku	2·5	0·09	12·0	0·01	0·13	0·01	0·62	0·20
15. Nilip Mekop	2·8	0·14	11·6	0·83	0·10	0·01	0·41	0·05

* One collection represents the race.

TABLE 12. Races of maize in India: Plant indices

Race	EH/PH		EH/LE		LW/LE		LE/Plant height above ear (PHE)†	
1. Poorvi Botapa	0·72	0·04	42·8	31·50	2·4	1·02	0·11	0·01
Sub-race Murli	0·75	0·07	75·0	27·00	4·2	1·59	0·08	0·02
2· Tirap Nag-Sahypung	0·73	0·17	15·6	4·10	1·2	0·26	0·28	0·03
3. Arun Tepi	0·79	0·09	16·6	1·08	1·2	0·14	0·23	0·03
4. Alok Sapa	0·55	0·01	19·7	0·16	1·2	0·15	0·05	0·01
5. Manipuri Chujak	0·67	0·05	22·6	2·01	1·4	0·16	0·08	0·01
6. Mayong Sa-ah	0·77	0·30	23·8	3·74	1·7	0·28	0·12	0·02
7. Asht Samsung	0·68	0·01	26·9	2·12	1·5	0·05	0·08	0·00
Sub-race Tsungrhu	0·60	0·01	23·8	0·21	1·5	0·05	0·07	0·00
8. Shyam Nahom	0·67	0·10	21·9	3·31	1·8	0·33	0·12	0·05
9. Cachar Gomdhan	0·69	0·03	23·8	3·01	1·9	0·10	0·09	0·00
10. Maidani Makka	0·53	0·14	17·9	2·28	1·5	0·30	0·06	0·01
Sub-race Ganga	0·52	0·02	18·7	1·73	1·4	0·01	0·06	0·00
11. Tista Mendi	0·60	0·08	21·9	0·64	1·7	0·02	0·07	0·03
12. Silken Tipang	0·70	*	14·6	*	1·6	*	0·17	*
13. Khasi Riewhadem	0·56	0·04	22·3	0·73	1·6	0·04	0·05	0·01
14. Mikir Merakku	0·53	0·01	12·2	0·20	1·8	0·14	0·09	0·00
15. Nilip Mekop	0·57	0·05	19·8	2·00	1·5	0·14	0·07	0·01

* One collection represents the race. † Abbreviated form of the characters.

TABLE 13. Races of maize in India: Tassel indices

Race	Percentage of branching space		Precentage primary branches		Percentage secondary branches	
1. Poorvi Botapa	33·4	14·60	82·9	10·40	17·1	10·40
Sub-race Murli	32·7	10·42	82·8	1·01	17·2	0·90
2. Tirap Nag-Sahypung	42·8	10·10	78·5	4·70	21·3	4·70
3. Arun Tepi	42·2	3·04	83·4	0·50	16·6	0·78
4. Alok Sapa	52·9	8·96	73·8	3·12	26·2	3·24
5. Manipuri Chujak	38·9	2·89	73·0	4·11	27·0	3·48
6. Mayong Sa-ah	35·6	13·04	80·8	4·05	19·2	1·64
7. Asht Samsung	48·1	5·56	77·5	2·46	22·4	3·00
Sub-race Tsungrhu	49·5	5·47	75·5	1·48	24·3	1·50
8. Shyam Nahom	35·7	7·35	83·9	1·63	12 0	1·67
9. Cachar Gomdhan	29·7	0·14	84·7	0·20	10·2	0·20
10. Maidani Makka	43·6	6·83	78·0	8·10	21·8	8·10
Sub-race Ganga	43·8	5·47	81·4	5·38	18·4	5·47
11. Tista Mendi	42·2	2·02	78·4	0·51	21·5	0·50
12. Silken Tipang	48·0	*	87·8	*	12·2	*
13. Khasi Riewhadem	47·5	7·74	75·7	5·14	24·2	5·51
14. Mikir Merakku	44·6	3·02	75·6	0·10	24·3	0·14
15. Nilip Mekop	51·1	9·74	78·7	4·24	21·2	3·43

* One collection represents the race.

TABLE 14. Races of maize in India: Ear indices

Race	EDB/ EDT		EDB/ EDC		EDC/ EDT		Exposure index		Glume/ kernel		CD/RD	
1. Poorvi Botapa	1·5	0·15	1·2	0·06	1·3	0·10	28·3	5·19	0·97	0·08	4·5	0·25
Sub-race Murli	1·4	0·01	1·1	0·01	1·1	0·01	28·0	4·47	0·95	0·07	4·2	0·00
2. Tirap Nag-Sahypung	1·2	0·03	1·0	0·02	1·2	0·02	32·3	4·49	0·95	0·02	3·8	0·45
3. Arun Tepi	1·4	0·12	1·1	0·01	1·3	0·01	27·0	1·41	1·20	0·10	3·3	0·14
4. Alok Sapa	1·2	0·01	1·1	0·02	1·1	0·05	15·8	3·44	1·30	0·10	5·5	0·74
5. Manipuri Chujak	1·2	0·12	1·1	0·01	1·2	0·08	36·8	9·70	0·88	0·21	3·3	0·20
6. Mayong Sa-ah	1·4	0·09	1·1	0·02	1·3	0·17	27·5	5·04	0·96	0·11	3·9	0·04
7. Asht Samsung	1·1	0·02	1·0	0·04	1·1	0·08	43·7	1·01	0·75	0·06	3·4	0·05
Sub-race Tsungrhu	1·2	0·02	1·1	0·00	1·1	0·01	42·6	4·47	0·80	0·09	3·4	0·05
8. Shyam Nahom	1·2	0·03	1·0	0·01	1·2	0·05	33·0	4·99	1·10	0·10	3·8	0·17
9. Cachar Gomdhan	1·2	0·00	1·1	0·00	1·1	0·00	44·7	1·98	0·86	0·10	2·6	0·24
10. Maidani Makka	1·3	0·10	1·1	0·22	1·2	0·20	35·7	5·22	0·96	0·12	3·2	0·23
Sub-race Ganga	1·2	0·01	1·1	0·01	1·1	0·01	30·6	2·19	0·92	0·03	3·1	0·01
11. Tista Mendi	1·2	0·01	1·0	0·01	1·2	0·01	42·9	3·31	0·80	0·04	3·6	0·10
12. Silken Tipang	1·4	*	1·1	*	1·2	*	29·6	*	1·00	*	4·0	*
13. Khasi Riewhadem	1·2	0·06	1·0	0·01	1·2	0·08	42·2	3·02	0·96	0·07	3·7	0·56
14. Mikir Merakku	1·2	0·04	1·0	0·04	1·2	0·03	39·5	1·02	0·91	0·03	2·2	0·13
15. Nilip Mekop	1·2	0·04	1·0	0·02	1·2	0·06	38·7	4·69	0·98	0·01	3·2	0·26

* One collection represents the race.

TABLE 15. Races of maize in India: Ear indices

Race	RL/KL		Kernel density		KW/KL		KT/KL		KT/KW		KV/EL	
1. Poorvi Botapa	0·54	0·01	1·4	0·10	0·91	0·04	0·66	0·05	0·73	0·03	0·01	0·001
Sub-race Murli	0·40	0·10	1·5	0·10	0·92	0·02	0·70	0·02	0·76	0·01	0·01	0·001
2. Tirap Nag-Sahypung	0·44	0·10	1·3	0·12	0·84	0·04	0·57	0·03	0·68	0·04	0·01	0·001
3. Arun Tepi	0·60	0·01	1·3	0·05	0·88	0·00	0·58	0·02	0·61	0·05	0·01	0·001
4. Alok Sapa	0·58	0·08	1·3	0·05	0·94	0·01	0·71	0·21	0·75	0·16	0·01	0·001
5. Manipuri Chujak	0·36	0·01	1·0	0·57	0·88	0·07	0·63	0·14	0·70	0·07	0·01	0·001
6. Mayong Sa-ah	0·57	0·02	1·1	0·04	0·91	0·03	0·66	0·02	0·72	0·02	0·01	0·004
7. Asht Samsung	0·40	0·09	1·1	0·12	1·00	0·06	0·51	0·07	0·49	0·07	0·02	0·001
Sub-race Tsungrhu	0·40	0·00	1·1	0·04	1·10	0·04	0·50	0·01	0·48	0·04	0·02	0·005
8. Shyam Nahom	0·70	0·13	1·0	0·04	0·87	0·05	0·52	0·05	0·60	0·03	0·02	0·008
9. Cachar Gomdhan	0·54	0·12	1·1	0·00	0·75	0·03	0·43	0·07	0·64	0·17	0·01	0·005
10. Maidani Makka	0·51	0·08	1·1	0·26	0·91	0·06	0·49	0·11	0·53	0·11	0·02	0·007
Sub-race Ganga	0·56	0·09	1·1	0·01	0·94	0·12	0·50	0·04	0·53	0·06	0·02	0·007
11. Tista Mendi	0·40	0·00	1·1	0·01	0·98	0·04	0·39	0·01	0·40	0·00	0·03	0·001
12. Silken Tipang	0·46	*	1·3	*	0·81	*	0·49	*	0·61	*	0·01	*
13. Khasi Riewhadem	0·66	0·12	1·2	0·21	1·14	0·01	0·56	0·01	0·46	0·01	0·02	0·001
14. Mikir Merakku	0·50	0·10	1·2	0·11	0·73	0·08	0·42	0·05	0·58	0·03	0·01	0·007
15. Nilip Mekop	0·60	0·00	1·1	0·14	0·86	0·09	0·47	0·10	0·54	0·06	0·01	0·001

* One collection represents the race.

TABLE 16. Races of maize in India: Ear indices

Race	KV/EDC		KL/CD		EL/RN		KL/RN		RD/RN		EDB/EL	
1. Poorvi Botapa	0·06	0·01	0·39	0·02	0·75	0·09	0·54	0·04	0·42	0·02	0·26	0·01
Sub-race Murli	0·07	0·00	0·40	0·02	0·07	0·00	0·60	0·05	0·31	0·07	0·27	0·01
2. Tirap Nag-Sahypung	0·05	0·01	0·38	0·03	0·70	0·03	0·44	0·03	0·31	0·00	0·25	0·02
3. Arun Tepi	0·04	0·01	0·30	0·02	0·57	0·14	0·33	0·06	0·40	0·00	0·30	0·03
4. Alok Sapa	0·07	0·02	0·30	0·09	0·80	0·30	0 45	0·05	0·61	0·01	0·20	0·00
5. Manipuri Chujak	0·07	0·01	0·40	0·14	0·90	0·19	0·57	0·01	0·40	0·05	0·24	0·01
6. Mayong Sa-ah	0·07	0·01	0·34	0·03	0·90	0·03	0·54	0·04	0·40	0·01	0·24	0·03
7. Asht Samsung	0·13	0·01	0·48	0·05	2·00	0·21	1·12	0·11	0·80	0·05	0·19	0·01
Sub-race Tsungihu	0·13	0·01	0·45	0·05	1·80	0·00	1·10	0·02	0·70	0·01	0·22	0·02
8. Shyam Nahom	0·06	0·01	0·32	0·03	0·60	0·02	0·45	0·02	0·50	0·02	0·34	0·04
9. Cachar Gomdhan	0·05	0·00	0·29	0·05	0·72	0·18	0·43	0·09	0·61	0·04	0·35	0·05
10. Maidani Makka	0·08	0 02	0·37	0·04	1·14	0·05	0·50	0·08	0·61	0·04	0·25	0·06
Sub-race Ganga	0 09	0·01	0·36	0·01	1·07	0·16	0·67	0·10	0·60	0·06	0·28	0·01
11. Tista Mendi	0·14	0·01	0 44	0·01	1·60	0·16	1·10	0·02	0·71	0·01	0·22	0·02
12. Silken Tipang	0·08	0·00	0·34	0·06	1·00	0·01	0·43	0·09	0·60	0·08	0·25	0·02
13. Khasi Riewhadem	0·13	0·01	0·27	0·10	2·00	0·10	1·10	0·10	0·90	0·04	0·22	0·00
14. Mikir Merakku	0·06	0·00	0·30	0·00	0 60	0·02	0·43	0·05	0·61	0·01	0·36	0·01
15. Nilip Mekop	0·08	0·00	0·34	0·06	1·00	0·01	0·60	0·10	0·62	0·08	0·25	0·02

TABLE 17. Races of maize in India: Ear indices

Race	EDC/EL		EDT/EL		CD/EL		CD/EDC		RD/EL		RD/EDC	
1. Poorvi Botapa	0·23	0·01	0·18	0·01	0·17	0·02	0·76	0·05	0·04	0·009	0·18	0·040
Sub-race Murli	0·22	0·01	0·19	0·02	0·17	0·02	0·77	0·04	0·04	0·000	0·19	0·005
2. Tirap Nag-Sahypung	0 23	0·02	0·17	0·02	0·17	0·01	0·73	0·03	0·04	0·009	0·20	0·001
3. Arun Tepi	0·26	0·01	0·25	0·03	0·21	0·02	0·79	0·20	0·06	0·010	0·24	0·010
4. Alok Sapa	0·19	0·00	0·17	0·00	0·16	0·02	0·87	0·11	0·03	0·000	0·16	0·010
5. Manipuri Chujak	0·21	0·05	0·18	0·05	0 15	0·04	0·70	0·08	0·04	0·010	0 21	0·010
6. Mayong Sa-ah	0·23	0·03	0·17	0·01	0·17	0·02	0·77	0·01	0·04	0·006	0·20	0·010
7. Asht Samsung	0·18	0·00	0·16	0·02	0·11	0·07	0·65	0·01	0·03	0·000	0·18	0·005
Sub-race Tsungrhu	0·21	0 02	0·18	0·02	0 13	0·02	0·64	0·04	0·03	0·007	0·18	0·010
8. Shyam Nahom	0·31	0·04	0 28	0·04	0·24	0·05	0·74	0·03	0·06	0·010	0·22	0 030
9. Cachar Gomdhan	0·33	0·50	0 28	0·05	0·23	0·04	0·69	0·03	0·09	0·010	0·29	0·007
10. Maidani Makka	0·23	0·05	0·19	0·04	0·16	0·03	0·72	0·14	0·05	0·010	0·22	0·050
Sub-race Ganga	0·26	0·02	0·22	0·02	0·17	0·01	0·69	0·02	0·05	0·004	0·32	0·010
11. Tista Mendi	0·21	0·02	0·17	0·01	0·13	0·01	0·64	0·04	0·03	0·005	0·18	0·005
12. Silken Tipang	0·18	*	0·15	*	0·14	*	0·76	*	0·03	*	0·19	*
13. Khasi Riewhadem	0·21	0·01	0·18	0 01	0·14	0·00	0 54	0·01	0·04	0·000	0·18	0·010
14. Mikir Merakku	0·34	0·01	0·30	0·01	0·23	0·00	0·73	0·02	0·10	0·050	0·32	0·020
15. Nilip Mekop	0·23	0·01	0·19	0·01	0·18	0·03	0·70	0·08	0·05	0·010	0·24	0·050

* One collection represents the race.

TABLE 18. Races of maize in India: Ear indices

Race	RL/RD		RL/CD		RL/EL		RL/EDC		KL/RD	
1. Poorvi Botapa	0·68	0·22	0·13	0·04	0·02	0·002	0·09	0·03	1·7	0·34
Sub-race Murli	0·55	0·02	0·12	0·01	0·01	0·005	0·09	0·01	1·6	0·10
2. Tirap Nag-Sahypung	0·66	0·22	0·16	0·03	0·02	0·008	0·12	0·02	1·4	0·19
3. Arun Tepi	0·63	0·01	0·19	0·01	0·04	0·007	0·15	0·01	0·9	0·15
4. Alok Sapa	0·95	0·10	0·18	0·00	0·03	0·007	0·15	0·02	1·6	0·01
5. Manipuri Chujak	0·49	0·20	0·14	0·05	0·02	0·010	0·09	0·05	1·3	0·33
6. Mayong Sa-ah	0·69	0·22	0·16	0·02	0·02	0·006	0·12	0·02	1·3	0·16
7. Asht Samsung	0·60	0·14	0·17	0·04	0·01	0·005	0·10	0·03	1·5	0·01
Sub-race Tsungrhu	0·63	0·01	0·17	0·01	0·02	0·000	0·11	0·01	1·6	0·20
8. Shyam Nahom	0·67	0·15	0·19	0·02	0·04	0·008	0·14	0·01	1·1	0·38
9. Cachar Gomdhan	0·54	0·21	0·16	0·03	0·03	0·010	0·11	0·03	0·9	0·01
10. Maidani Makka	0·62	0·05	0·18	0·01	0·03	0·008	0·13	0·07	1·2	0·31
Sub-race Ganga	0·62	0·10	0·18	0·02	0·03	0·004	0·12	0·03	1·2	0·06
11. Tista Mendi	0·72	0·04	0·18	0·01	0·02	0·000	0·11	0·01	1·6	0·12
12. Silken Tipang	0·64	*	0·16	*	0·02	*	0·12	*	1·4	*
13. Khasi Riewhadem	0·94	0·17	0·24	0·01	0·03	0·000	0·15	0·01	1·4	0·12
14. Mikir Merakku	0·35	0·07	0·15	0·03	0·03	0·010	0·11	0·01	0·7	0·01
15. Nilip Mekop	0·67	0·16	0·21	0·03	0·03	0·000	0·14	0·01	1·1	0·07

* One collection represents the race.

Table 19. Races of maize in India: Ear indices

Race	KW/RD		KL/EDC		KL/EL	
1. Poorvi Botapa	1·6	0·330	0·30	0·020	0·07	0·006
Sub-race Murli	1·5	0·140	0·30	0·140	0·07	0·000
2. Tirap Nag-Sahypung	1·2	0·240	0·27	0·020	0·06	0·001
3. Arun Tepi	0·8	0·100	0·23	0·010	0·06	0·000
4. Alok Sapa	1·6	0·030	0·26	0·001	0·05	0·003
5. Manipuri Chujak	1·2	0·220	0·29	0·050	0·06	0·006
6. Mayong Sa-ah	1·2	0·160	0·22	0·006	0·06	0·007
7. Asht Samsung	1·6	0·001	0·29	0·020	0·05	0·007
Sub-race Ganga	1·6	0·150	0·28	0·005	0·06	0·001
8. Shyam Nahom	1·0	0·300	0·23	0·002	0·07	0·004
9. Cachar Gomdhan	0·7	0·010	0·23	0·030	0·08	0·005
10. Maidani Makka	1·1	0·290	0·25	0·040	0·06	0·012
Sub-race Ganga	1·1	0·080	0·25	0·010	0·07	0·004
11. Tista Mendi	1·5	0·010	0·28	0·007	0·06	0·006
12. Silken Tipang	1·2	*	0·28	*	0·05	*
13. Khasi Riewhadem	1·5	0·140	0·24	0·020	0·05	0·001
14. Mikir Merakku	0·5	0·080	0·22	0·007	0·07	0·000
15. Nilip Mekop	0·8	0·240	0·24	0·010	0·06	0·002

* One collection represents the race.

TABLE 20. Races of maize in India: Miscellaneous indices

Race	TL/EDC		PL/EDC		CPL/EDC		BL/EDC		TTB/EDC		PB/EDC	
1. Poorvi Botapa	14·4	2·24	5·1	1·31	9·5	1·77	5·2	2·61	7·2	1·48	5·9	1·47
Sub-race Murli	14·5	0·51	5·9	0·26	10·4	1·95	5·0	1·48	7·6	1·04	6·3	0·60
2. Tirap Nag-Sahypung	13·2	2·09	4·4	1·60	6·5	1·53	4·8	1·94	8·9	1·70	6·7	1·40
3. Arun Tepi	14·3	1·29	2·7	0·54	5·5	0·91	4·1	0·07	8·3	0·68	6·8	0·48
4. Alok Sapa	15·6	1·48	5·5	0·78	7·4	0·34	8·1	1·01	12·0	2·89	8·8	1·44
5. Manipuri Chujak	13·8	2·44	4·9	0·89	8·6	0·85	5·1	1·45	9·8	1·79	5·1	1·45
6. Mayong Sa-ah	12·2	0·11	4·2	1·86	8·3	1·89	3·4	0·42	8·1	1·18	6·5	1·34
7. Asht Samsung	12·1	0·30	5·5	0·30	6·2	0·31	5·8	1·87	6·0	0·98	4·6	0·64
Sub-race Tsungrhu	11·7	0·10	5·8	0·90	5·7	0·24	5·9	1·08	7·2	1·48	5·4	1·14
8. Shyam Nahom	8·3	0·81	3·1	0·39	7·1	1·58	3·0	0·30	3·8	0·34	3·4	0·60
9. Cachar Gomdhan	9·7	0·01	3·2	0·41	6·7	0·00	2·9	0·05	4·3	0·10	3·6	0·24
10. Maidani Makka	10·6	0·65	4·8	0·78	6·0	0·94	4·7	0·70	5·9	0·61	4·4	0·48
Sub-race Ganga	11·4	1·18	4·9	0·77	6·3	1·01	5·0	0·64	5·6	1·01	4·5	0·61
11. Tista Mendi	9·8	0·44	3·8	0·67	5·5	0·50	4·2	0·00	5·0	0·00	3·9	0·41
12. Silken Tipang	11·8	*	5·9	*	6·1	*	5·7	*	4·0	*	4·2	*
13. Khasi Riewhadem	10·5	0·42	4·2	0·10	5·5	0·64	4·9	0·99	6·2	0·42	4·7	0·00
14. Mikir Merakku	7·7	1·30	2·3	0·64	4·3	1·14	3·5	1·02	5·7	0·64	4·3	0·60
15. Nilip Mekop	10·2	0·35	4·1	0·42	3·8	1·40	5·2	0·78	6·7	0·50	4·8	0·24

* One collection represents the race.

TABLE 21. Races of maize in India: Miscellaneous indices

Race	SB/EDC		TL/EL		EL/PH		CPL/EL		TL/PH		PB/PH	
1. Poorvi Botapa	1·2	0·51	3·3	0·45	0·07	0·007	2·2	0·46	0·23	0·020	0·09	0·010
Sub-race Murli	1·3	0·24	3·3	0·00	0·06	0·005	2·4	0·51	0·22	0·005	0·09	0·000
2. Tirap Nag-Sahypung	1·9	0·31	2·4	0·03	0·08	0·003	1·5	0·34	0·19	0·020	0·12	0·001
3. Arun Tepi	1·4	0·14	2·5	0·05	0·08	0·007	1·4	0·08	0·21	0·010	0·15	0·020
4. Alok Sapa	3·1	0·95	3·0	0·41	0·06	0·010	1·4	0·03	0·19	0·010	0·11	0·020
5. Manipuri Chujak	2·2	0·63	2·9	0·37	0·06	0·005	1·8	0·24	0·21	0·010	0·11	0·010
6. Mayong Sa-ah	1·6	0·31	2·6	0·33	0·07	0·010	1·7	0·40	0·22	0·070	0·12	0·020
7. Asht Samsung	1·3	0·52	2·2	0·11	0·08	0·007	1·2	0·02	0·19	0·010	0·07	0·010
Sub-race Tsungrhu	1·7	0·24	2·4	0·05	0·07	0·007	1·1	0·10	0·19	0·010	0·08	0·004
8. Shyam Nahom	0·6	0·17	2·6	0·51	0·08	0·010	2·3	0·81	0·22	0·030	0·09	0·010
9. Cachar Gomdhan	0·7	0·07	3·1	0·06	0·08	0·010	2·1	0·04	0·26	0·010	0·10	0·010
10. Maidani Makka	1·3	0·26	2·4	0·54	0·08	0·030	1·3	0·22	0·21	0·060	0·09	0·030
Sub-race Ganga	1·1	0·47	2·9	0·23	0·07	0·006	1·6	0·01	0·21	0·020	0·08	0·010
11. Tista Mendi	1·1	0·00	2·1	0·21	0·10	0·020	1·1	0·14	0·21	0·010	0·08	0·007
12. Silken Tipang	0·6	*	2·2	*	0·10	*	1·1	*	0·23	*	0·08	*
13. Khasi Riewhadem	1·5	0·42	2·3	0·11	0·08	0·000	1·2	0·14	0·19	0·010	0·09	0·010
14. Mikir Merakku	1·4	0·02	2·4	0·30	0·12	0·020	1·3	0·02	0·29	0·002	0·06	0·010
15. Nilip Mekop	1·4	0·20	2·4	0·08	0·08	0·000	1·2	0·42	0·21	0·010	0·09	0·010

* One collection represents the race.

TABLE 22. Races of maize in India: Miscellaneous indices

Race	SB/PH		CD/TTB × 100		EL/TTB × 100		TTB/PH	
1. Poorvi Botapa	0·02	0·010	11·58	2·34	65·8	13·66	0·11	0·010
Sub-race Murli	0·01	0·005	10·40	1·18	58·1	3·01	0·11	0·005
2. Tirap Nag-Sahypung	0·03	0·002	8·90	1·21	51·1	5·53	0·16	0·003
3. Arun Tepi	0·03	0·007	9·95	0·95	48·4	10·48	0·18	0·020
4. Alok Sapa	0·04	0·010	7·30	1·89	46·4	14·52	0·15	0·030
5. Manipuri Chujak	0·03	0·010	8·70	1·27	50·0	3·74	0·15	0·010
6. Mayong Sa-ah	0·02	0·007	10·00	2·34	57·4	13·36	0·15	0·030
7. Asht Samsung	0·01	0·007	11·50	1·94	95·7	17·31	0·09	0·010
Sub-race Tsungrhu	0·03	0·000	9·90	1·22	70·1	9·91	0·11	0·010
8. Shyam Nahom	0·01	0·001	20·40	1·60	86·3	1·04	0·10	0·005
9. Cachar Gomdhan	0·01	0·005	16·60	0·92	76·0	13·08	0·11	0·010
10. Maidani Makka	0·02	0·010	12·70	1·70	76·4	11·22	0·12	0·040
Sub-race Ganga	0·01	0·002	13·30	2·04	72·7	8·77	0·10	0·010
11. Tista Mendi	0·02	0·001	13·20	0·68	95·6	6·06	0·11	0·010
12. Silken Tipang	0·01	*	16·40	*	112·4	*	0·09	*
13. Khasi Riewhadem	0·03	0·010	10·80	1·59	74·6	5·94	0·11	0·000
14. Mikir Merakku	0·05	0·007	13·00	0·50	55·9	2·01	0·21	0·020
15. Nilip Mekop	0·02	0·001	11·80	0·08	70·0	6·16	0·12	0·010

* One collection represents the race.

TABLE 23. Races of maize in India: Coefficient of variation of vegetative characters of the plant

Race	DF	PH	EH	SD	LE	LL	LW	LR	LA	EN	LS	BR	PS
1. Poorvi Botapa	6·8	7·7	13·4	19·4	27·0	18·9	21·1	19·4	19·5	14·2	23·0	13·1	14·2
Sub-race Murli	4·2	1·0	0·9	0·0	41·4	12·9	13·0	17·6	25·5	14·7	30·0	11·2	10·0
2. Tirap Nag-Sahypung	7·1	9·1	16·1	25·7	19·6	27·0	1·7	7·4	23·0	8·9	14·3	17·6	20·0
3. Arun Tepi	7·2	4·9	7·8	9·2	14·7	22·9	4·7	8·0	16·0	12·2	1·3	6·4	29·3
4. Alok Sapa	8·0	3·1	1·0	22·0	7·7	7·3	5·1	1·0	0·0	2·3	4·4	17·0	0·0
5. Manipuri Chujak	7·8	6·2	15·0	9·5	5·2	12·9	16·6	13·4	0·0	10·5	1·6	14·1	18·9
6. Mayong Sa-ah	6·1	11·5	13·9	20·4	13·3	14·2	7·8	10·0	16·8	13·5	10·2	17·8	24·7
7. Asht Samsung	4·3	6·2	8·3	10·0	2·8	8·5	8·4	8·1	0·0	3·3	10·0	9·3	0·7
Sub-race Tsungrhu	0·7	4·7	0·2	1·9	0·0	1·7	6·1	1·1	6·5	13·7	0·9	17·6	10·7
8. Shyam Nahom	12·6	16·8	15·7	5·8	20·2	12·9	6·8	1·1	10·0	12·9	10·8	21·4	8·2
9. Cachar Gomdhan	6·1	2·5	2·5	2·1	15·8	1·9	2·0	2·4	5·0	0·4	7·0	14·2	5·2
10. Maidani Makka	6·9	9·6	24·5	30·9	14·6	5·6	24·7	20·2	0·0	29·3	7·4	23·5	23·3
Sub-race Ganga	9·7	5·4	11·2	9·5	7·1	5·1	6·8	6·8	0·0	18·3	9·4	22·3	0·0
11. Tista Mendi	0·0	5·1	10·9	2·0	0·4	1·2	1·8	1·5	0·0	0·0	1·7	14·2	1·7
12. Silken Tipang	*	*	*	*	*	*	*	*	*	*	*	*	*
13. Khasi Riewhadem	3·8	7·4	4·3	9·2	2·6	7·2	7·9	5·4	11·4	3·1	4·6	1·8	10·0
14. Mikir Merakku	1·7	0·3	1·5	2·1	0·1	0·3	6·7	4·1	20·4	5·3	3·7	2·0	0·0
15. Nilip Mekop	7·6	4·9	18·5	4·5	1·8	6·8	6·6	1·7	4·8	28·1	2·1	28·6	15·7

* One collection represents the race.

TABLE 24. Races of maize in India: Coefficient of variation of tassel characters

Race	TE	TL	PL	CPL	BL	TTB	PB	SB	PD
1. Poorvi Botapa	26·0	13·5	25·2	19·1	52·3	17·6	7·1	45·8	11·4
Sub-race Murli	20·0	7·7	1·8	0·8	9·0	3·4	2·0	24·0	6·9
2. Tirap Nag-Sahypung	4·5	27·2	25·5	22·9	44·3	10·1	9·8	23·2	21·1
3. Arun Tepi	2·4	8·9	15·3	13·1	0·8	9·9	0·8	13·4	6·9
4. Alok Sapa	11·3	5·4	3·9	11·2	7·2	14·8	14·2	18·9	9·5
5. Manipuri Chujak	37·3	4·1	14·4	3·8	25·5	8·9	0·9	22·9	0·8
6. Mayong Sa-ah	26·3	5·9	28·1	23·5	29·6	20·3	19·4	24·6	1·6
7. Asht Samsung	0·0	0·3	0·6	14·4	10·7	16·3	13·5	29·8	1·0
Sub-race Tsungrhu	0·7	0·1	0·6	13·4	11·5	1·0	12·7	1·9	1·5
8. Shyam Nahom	15·0	13·6	19·9	16·1	18·4	19·1	14·8	34·1	1·8
9. Cachar Gomdhan	10·5	1·3	11·3	1·3	9·8	8·9	7·2	12·0	0·9
10. Maidani Makka	20·0	15·3	16·3	4·3	5·5	4·2	13·2	12·6	4·6
Sub-race Ganga	5·2	8·4	13·0	14·9	12·6	16·5	13·1	30·0	1·3
11. Tista Mendi	10·8	1·8	2·8	8·1	3·0	3·0	3·4	1·1	0·2
12. Silken Tipang	*	*	*	*	*	*	*	*	*
13. Khasi Riewhadem	6·0	2·8	5·4	11·6	19·7	7·1	0·4	3·9	5·7
14. Mikir Merakku	0·4	0·3	20·1	5·0	5·8	4·3	5·6	5·3	0·6
15. Nilip Mekop	0·4	8·0	3·8	3·4	3·1	3·3	9·2	15·9	1·4

* One collection represents the race.

TABLE 25. Races of maize in India: Coefficient of variation of ear characters

Race	EL	EDB	EDC	EDT	RN	KN	KR	TES
1. Poorvi Botapa	9·3	6·2	7·0	10·6	12·8	12·6	27·6	15·3
Sub-race Murli	2·0	4·2	11·0	11·7	13·9	6·2	8·1	8·4
2. Tirap Nag-Sahypung	7·6	3·8	8·7	5·5	6·1	10·9	35·7	8·3
3. Arun Tepi	8·9	4·5	1·9	3·8	7·5	3·5	6·8	5·0
4. Alok Sapa	11·8	15·3	1·3	10·9	8·9	23·9	8·0	18·3
5. Manipuri Chujak	16·2	6·4	1·1	18·5	6·7	22·8	22·7	12·6
6. Mayong Sa-ah	11·0	6·4	3·1	7·0	4·0	10·2	38·2	9·9
7. Asht Samsung	1·8	4·2	0·3	7·6	2·9	12·8	2·0	1·7
Sub-race Tsungrhu	2·2	1·4	9·4	6·8	2·5	3·5	5·0	11·6
8. Shyam Nahom	13·2	0·6	0·3	0·7	4·0	17·9	17·7	1·5
9. Cachar Gomdhan	17·5	1·2	1·3	1·5	5·7	20·0	16·7	17·4
10. Maidani Makka	20·1	14·2	7·1	18·6	13·3	20·5	30·0	30·0
Sub-race Gănga	6·8	1·8	4·0	3·2	8·7	14·5	30·0	7·5
11. Tista Mendi	7·3	1·3	2·4	2·9	2·2	0·5	10·0	10·9
12. Silken Tipang	*	*	*	*	*	*	*	*
13. Khasi Riewhadem	0·1	2·2	0·8	6·7	5·1	4·5	4·0	3·1
14. Mikir Merakku	1·0	7·6	8·3	6·7	10·8	10·2	15·1	7·8
15. Nilip Mekop	8·9	7·3	6·2	6·0	4·4	16·8	29·3	14·0

* One collection represents the race,

TABLE 26. Races of maize in India: Coefficient of variation of kernel and ear (internal) characters

Race	Kernel characters					Ear (internal) characters		
	KT	KW	KL	KWT	KV	CD	RD	RL
1. Poorvi Botapa	3·4	3·3	4·5	18·4	19·8	26·9	2·1	16·6
Sub-race Murli	1·7	0·2	3·3	1·1	1·6	13·3	2·0	0·5
2. Tirap Nag-Sahypung	7·6	0·6	4·6	19·4	25·0	8·2	4·7	6·9
3. Arun Tepi	12·1	5·5	10·3	19·6	22·5	2·3	6·2	7·3
4. Alok Sapa	2·7	15·0	20·6	17·9	22·4	2·4	12·8	13·5
5. Manipuri Chujak	4·8	7·3	1·1	18·8	16·2	13·3	1·8	5·0
6. Mayong Sa-ah	1·3	5·2	6·5	2·6	15·7	19·5	5·4	14·3
7. Asht Samsung	12·9	2·1	7·5	12·3	2·1	0·5	1·6	14·7
Sub-race Tsungrhu	2·6	7·9	4·1	1·7	19·9	4·5	1·7	15·3
8. Shyam Nahom	4·8	3·3	7·7	6·6	1·3	1·3	8·9	13·5
9. Cachar Gomdhan	8·9	13·8	10·1	14·0	12·6	3·7	0·9	2·2
10. Maidani Makka	11·9	17·1	2·0	16·1	26·7	17·1	1·7	19·6
Sub-race Ganga	0·9	6·0	1·1	6·3	3·5	2·9	2·4	16·7
11. Tista Mendi	2·4	1·0	0·4	4·6	4·5	1·9	0·4	6·0
12. Silken Tipang	*	*	*	*	*	*	*	*
13. Khasi Riewhadem	2·0	0·2	0·1	4·0	5·2	3·8	1·3	3·1
14. Mikir Merakku	2·5	1·4	10·0	7·5	6·2	11·0	8·7	5·0
15. Nilip Mekop	10·2	3·5	15·4	1·7	18·8	5·2	14·8	21·4

* One collection represents the race.