



Report on Maize (*Zea mays* L.): Collection Status, Diversity Mapping and Gap Analysis



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This report includes unprocessed/ semi-processed data compiled from various sources for assessment of gaps on collection and conservation of *Zea mays*. The material contents in the report therefore should not be used without prior permission of the Director, NBPGR.

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1. Introduction

Maize is one of the three important cereal crops after wheat and rice consumed as staple food (Mukherjee 1989). It has high grain yield and used globally for food, feed, fodder and a very large number of industrial uses. Due to wider adaptability to varied agro-ecology this multipurpose cereal crop is cultivated globally (Ahloowalia and Dhawan 1963; Iltis and Doebley 1980). The center of origin for maize has been established as the Mesoamerican region, now Mexico and Central America (Iltis and Doebley 1980). Cultivated maize was introduced into the old world in the sixteenth century (Beadle 1980; Doebley and Iltis 1980) and in India by the Portuguese during the seventeenth century (Mukherjee et al. 1971; Mangelsdorf 1974; Wilkis 1981).

In this report, after four decades of active collection and conservation, gaps were identified and areas were prioritised for future collection. This report includes information compiled for diversity analysis on collected and conserved using germplasm of maize. It also includes the information on specific traits which were later validated through the published Crop Catalogues on evaluation and other sources.

2. Origin and taxonomy

The common maize has evolved from three different ancestors, namely: (i) wild maize (a form of pod-popcorn native to the lowlands of South America), (ii) teosinte originated from hybrids between maize and *Tripsacum*, and (iii) modern varieties of maize originated from introgressive hybridization of maize and teosinte. Teosinte is the progenitor of maize and the closest living relative as evident from morphology, physiology, crossability, chromosome morphology, cytogenetics and molecular genetics (Iltis 1972, 1983; Dhillon et al 2005). Different geographical regions for origin of maize are Mexico, Andean highlands of Peru, Bolivia and Ecuador and Himalayan region. Teosinte differs from maize in less specialized female inflorescence/ear, ability to survive in nature, kernel not protected by husks, and natural seed dispersal without the aid of humans. In India, it has been speculated that maize was first introduced in the North-West Himalayas by traders from where it spread to the Himalayan region (Dowswell et al. 1996); this includes introduction of primitive forms in the old world including the Himalaya in pre-Columbian period (Marszewski 1978).

Taxonomically maize (tribe Maydeae, family Poaceae; $2n = 20$) and its related taxa (*Tripsacum*, *Coix*, *Polytoca*, *Chionachne*, *Sclerachne* and *Trilobachne* and its closest relative, teosinte) were grouped in two separate genera (*Zea* and *Euchlaena*). Evidences from cytogenetics and molecular study classified maize and teosinte in genus *Zea* (Reeves and Mangelsdorf 1942; Doebley 1990a, b). The section *Zea* ($2n = 20$) includes maize (*Z. mays* ssp. *mays*), annual Mexican teosinte (*Z. mays* ssp. *mexicana*). Crossing of maize with *Coix* and *Polytoca* and with sorghum were unsuccessful but successful with relatively distant genus *Saccharum*.

3. Maize gene pool (GP)

The gene pool of maize consists of primary (GP-1 with all cultivars of maize and diploid teosintes), secondary gene pool [GP-2: *Zea perennis* (perennial, tetraploid) and *Tripsacum* (can cross with maize with difficulty, and the offspring show varying degree of sterility)], tertiary gene pool (GP-3: distant wild relatives/species or even different genera of the cultivated species (Zeven and de Wet 1971). Teosinte received greater attention from maize researchers because of its presumed role in the origin, evolution and generating genetic variability (races) in cultivated maize (Mangelsdorf and Reeves 1939; Wilkes 1979).

4. Distribution and diversity

Maize crop is grown in the warmer parts of temperate regions and in humid-subtropical climate across the world. Maize occupies an important place in Indian agriculture. Among the important maize growing countries India ranks third in area and fourth in production. The important maize growing states are Rajasthan, Uttar Pradesh, Madhya Pradesh, Karnataka, Bihar and Andhra Pradesh jointly accounting for over 95% of the national maize production (Dhillon et al. 2005). Maize is traditionally grown during the summer (monsoon) season across all the states, more so in the north-east hill (NEH) region and north-western Himalaya. During this period, it is accompanied by high temperatures (35 degree) and rains. Rabi (winter) cultivation of maize is a relatively new introduction started in mid-sixties in some pockets of Bihar and South India, but now in the country as a whole. Rabi maize has comparative advantage of low incidence of diseases and insect pests, due to less rainfall, slow growth of weeds, etc. and hence, preferred by the farmers. Though, the area under maize has shown an increasing trend, with maize emerging as a competitive crop, the level of production has to be substantially raised to meet growing demand of maize for human food, animal feed, poultry feed, as well as industrial processing to produce value added products. Other traits such as high lysine content, amylase enzyme, phytase enzyme, drought tolerance etc. are also being incorporated in maize.

Racial diversity in maize

Based on kernel types maize is classified into six types (flint, dent, flour, pop, pod, sweet). Globally a systematic programme was carried out on collection from all parts of Mexico (including farmers' varieties), and their characterization. The study on origin and evolution of maize through collection, classification and description of the races in the Americas (Mangelsdorf, 1974; Wellhausen *et al.*, 1951, 1952) led to the recognition of races. Large number of races in Mexico and Peru were considered to be endemic. Similar to other crops in many parts of the world in Mexico and Colombia, also improved varieties and hybrids have replaced the native varieties landraces.

Most of the races of maize are derived from prototypes developed by early native Indian farmers of Mexico and central and South America. In Asia the most widely cultivated maize types are the Caribbean-type flints maize introduced recently. In the Indian region rich diversity of maize is mainly concentrated in the North-eastern Himalaya, which supports Asiatic origin of maize; Sikkim Himalaya to be the secondary centre of diversity and have landraces known as Sikkim Primitives with primitive characteristics (popcorn characteristics and prolificacy) (Dhawan 1964; Bhag Singh 1977; Wilkes 1981; Rahman and Karuppaiyan 2011). Collection and evaluation programme for Indian germplasm primarily focussed on North-eastern Himalayan Region (Bhag Singh 1977; Bhag Singh et al. 1990) identifying distinct races under four categories: (i) Primitive group, (ii) Advanced or derived group, (iii) Recent introductions, and (iv) Hybrid races. Several local varieties (named after the region where predominantly cultivated) were studied from this region.

Area under cultivation and production

Globally, maize has estimated total world production (as per 2012) of 875,226,630 t (United States, China, and Brazil: 31%, 24%, and 8% of total production) (Ann NY Acad. Sci. 2014). It ranks first for production and productivity and second with respect to area among field crops. About 8.12 million hectares having production of 19.77 million tonnes with average productivity of 2.4 tonnes/ha during 2007-08 were reported. For India, the estimate of maize production (state wise) cultivation is given in table 1.

Table 1: State-wise maize cultivation

State	Area under cultivation (Mn hectares)	In %	Production (Mn tonne)	Yield (Tonnes / hectare)
Karnataka	1.3	15.47	4.4	3.5
Rajasthan	1.1	13.09	2.1	1.8
Maharashtra	0.9	10.71	2.6	2.9
Madhya Pradesh	0.8	9.52	1.0	1.2
Uttar Pradesh	0.8	9.52	1.1	1.5
Andhra Pradesh	0.7	8.33	4.0	5.3
Bihar	0.6	7.14	1.4	2.2
Gujarat	0.5	5.95	0.8	1.6
Tamil Nadu	0.2	2.38	1.0	4.5
Others	1.5	17.85	3.3	2.1
All India	8.4	100	21.7	2.6

Source: Directorate of Economics and Statistics ((2013-14), Department of Agriculture Cooperation (Data includes approximate area under single cross hybrid, three way cross and double cross hybrids seeds)

Unique topographic conditions growing regions, socio-economic attributes among the ethnic groups, seed movement among farmers, cultural knowledge and use have greatly influenced the pattern of diversity distribution in different regions beyond their primary habitats. Consequent upon cultivation over long period amazing diversity has got developed in different growing regions of India.

5. Materials and Methods

Collection mission data including eco-geographic, environmental, biotic, climatic, use pattern of the accessions facilitates in utilization of germplasm (Thormann et al. 2012). Keeping in view the best utilization of collected germplasm work on gap identification of maize genetic resources was undertaken based on information on distribution and collection of maize diversity in light of efforts made by the National Bureau of Plant Genetic Resources (NBPGR) through the collecting missions undertaken during last three decades upto 2015.

Passport data of maize accessions collected so far by the Bureau and other Institutes, SAUs, NGO or the accessions deposited by any other agency were taken as source material. To analyse collection and conservation status of each accession, vigorous checking was done using other published data. The data on collection and conservation of germplasm was validated for specific traits through the Crop Catalogues that were published on this crop after due evaluation/ characterization.

Collecting mission (passport data) data of 13,059 accessions collected from over 2,050 collection sites under different agro-ecological regions during last three decades were examined based on information available in published literature (Annual Reports 1976-2015; Singh et al. 1990; Plant Germplasm Reporter 2000-13; Plant Exploration Databases up to 2012-14). Short-listed germplasm (6,585) with details on state, district, village, collector number and latitude (N) - longitude (E) of collection sites were validated for mapping of collection sites. DIVA-Geographical Information System (GIS) tool was used to analysis passport data to generated maps on distribution pattern and survey, collection sites, altitudinal variation pattern with the help of point to grid analysis using simple methods (Hijmans et al. 2000; 2001).

Information on names of local cultivars/landraces, known traits and ethno-botanical knowledge was drawn mainly from passport data records and feedback information. In view of fast movement of cultivars from region to region and phenotypic variation developed under different climatic

conditions, distinct cultivars were identified with variable local names and henceforth treated as local cultivars in the report which included local/landrace diversity. In addition, many non-descriptive cultivars without specific name were also considered in general.

6. Germplasm exploration and collection of diversity

Areas of collection and mapping of diversity: Eco-geographic mapping of the collection sites and overall topographic configurations have been depicted agro-ecological areas of concentration of diversity were arbitrarily classified into five major zones (Fig. 1a, b). DIVA- GIS tool was used to analysis passport data to reveal eco-geographic patterns of distribution of crops and wild species by various workers (Hijmans et al. 2001; Dutta 2008; Sunil et al. 2009; Abraham et al. 2010).

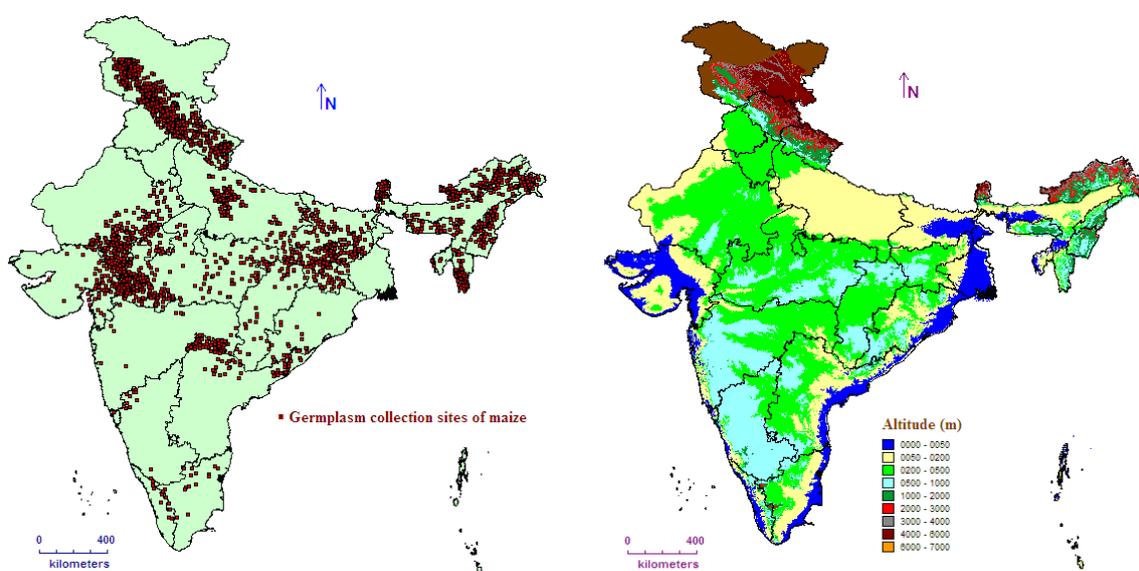


Fig.1a Germplasm collection sites; **b** Altitudinal range of germplasm collection sites of *Zea mays* in India

Diversity assembled in maize: Since 1976-2016, a total of 13,059 accessions of indigenous maize germplasm have been collected by NBPGR through crop-specific and multi-crop explorations in collaboration with crop-based institutes of Indian Council of Agricultural Research (ICAR) and State Agricultural Universities (SAUs). A total of 30 states covering nearly 388 districts in five major agro-ecological regions of the country were explored (Table 2).

Table 2: Germplasm accession collected from different states (districts#) of the country

States (districts)	No. accn.	States	No. accn.
Andhra Pradesh (5)	181	Maharashtra (22)	124
Andaman & Nicobar (2)	987	Manipur (9)	365
Arunachal Pradesh (15)	1013	Meghalaya (7)	638
Assam (15)	149	Mizoram (8)	644
Bihar (29)	188	Nagaland (11)	472
Chhattisgarh (12)	127	Odisha (14)	170
Goa (1)	2	Punjab (3)	47
Gujarat (19)	259	Rajasthan (24)	447
Haryana (6)	107	Sikkim (4)	599

Himachal Pradesh (12)	1973	Tamil Nadu (11)	67
Jammu & Kashmir (17)	505	Telangana (9)	279
Jharkhand (20)	443	Tripura (4)	53
Karnataka (16)	87	Uttar Pradesh (30)	447
Kerala (4)	9	Uttarakhand (14)	738
Madhya Pradesh (39)	569	West Bengal (4)	60
Total Germplasm Collected = 13,059		Total Districts = 388	Total States: 30

Districts in parenthesis

Among these states (accessions collected in parenthesis) of Himachal Pradesh (1973), Arunachal Pradesh (1013), Mizoram (644), Uttarakhand (738), Jammu & Kashmir (505), Rajasthan (447), Meghalaya (638), Madhya Pradesh (569), Uttar Pradesh (447), Nagaland (472), Jharkhand (443), Sikkim (599) and Gujarat (259) were well-explored. Trend of germplasm collections *viz-a-viz.* agro-ecological zone showed that the highest number of accessions representing local cultivar diversity were gathered from the north-eastern hill (NEH) regions and western Himalaya (WH) followed by the western and central plains (WP), eastern plains (EP) and the peninsular region (PR) (Fig. 1).

Local cultivars/ landrace diversity collected

Collection, characterization and classification of maize diversity are the foremost and time consuming activities that are essentially required for assessment of quality germplasm utilization. Number of landraces described globally for maize collections from different regions may be very high but estimated to be lesser (Brown and Goodman 1977). Characterization activity has received little attention for Asian and African germplasm. Characterization of maize from the Indian region mainly from NEH region have been done using morphological as well as molecular tools (Prasanna and Sharma 2005; Prasanna et al. 2009 a, b). Accessions collected from important maize-growing regions of India were classified into distinct races, sub-races and also primitive, advanced or derived types, recent introductions, and hybrid races (Singh 1969) that confirmed to the three out of six lineages postulated by Mangelsdorf (1974).

During the period under report, over 280 accessions of local cultivars/ landraces were collected from different diversity rich regions. Majority of the germplasm was named after locality name (Jaunpur local, Bhagalpur local, Jalandhar local, etc.), kernel colour (yellow, black, white, red) and by the maturity period (number of days; Sathi matures in 60 days), month in which crop matures (Asaujya, Katigya are late maturing types).

Indigenous variability was observed for plant height, adaptation to varying altitudinal ranges, leaf orientation, height at which ear arise, silk colour, cob size, cob orientation, shank colour, number of kernel rows/cob, kernel type (dent, flint, waxy, popping type, etc.), kernel shape/ size and colour and crop maturity period (Plant Germplasm Reporter 2000-13). Variation in traits like lodging resistance, stiffness of straw and including that of rachilla and crude protein content was sporadically represented in the collected germplasm. Considerable polymorphism and variations in grain size, shape and colour was reported in cob characters (Singh et al. 1990; Prasanna and Sharma 2005; Plant Germplasm Reporter 2000-14). Regional variation in traits was apparent among the collected diversity. North-eastern hill region was richer in popcorn, flint corn and dent corn, sweet corn, sticky and waxy type. Mostly the popcorn type kernels, big-smallest cob size, early to medium types, tall-dwarf types were more prevalent. In the north-western Himalayan region mostly flint kernel type (sometimes dent), late maturing, tall types and medium cob size were common. Table 3 gives data on diversity collected from different parts of India.

Table 3: Data compiled from diversity collected from different parts of India

Region	States	Plant traits
North-eastern Region (NER)	Arunachal Pradesh, Assam, Sikkim, Manipur, Meghalaya, Mizoram, Nagaland, Tripura	Plant height: 120-180cm; cob size:7-30cm; cob/plant: 2-6; seed colour: black, brown, cream, dark red, deep brown, light yellow, light brown, light purplish, milky white, orange, purple black, purple, purple-white, red, cream, white yellow red brown, purple milky white, white purple, white red, white black, yellow brown, orange, yellow orange, yellow red, yellow white; maturity: 90-100 days
North-western Himalaya (NW)	Himachal Pradesh, Jammu and Kashmir, Uttarakhand	Plant height: 45-360cm; cob size: 4-20 cm; cob/plant:1-4; cob colour: shades of white, yellow, red, orange, black, brown; mixed shades of black-red, orange-yellow, yellow-brown, white-red, red-yellow, orange-white, yellow-orange; maturity: 60-150days
Western and eastern plains (WEP)	Rajasthan, Gujarat, Punjab, Uttar Pradesh, Haryana, Madhya Pradesh, Odisha, West Bengal, Bihar, Chhattisgarh, Jharkhand	Plant height: 90-240cm; cob size: 12-15 cm; cob/plant: 1-12; seed weight: 11-22; seed colour: shades of yellow, orange, brown, purple, black; mixed colour-red-orange, white-orange, red- yellow, red-black, yellow-black, yellow-white-black, cream- white-yellow; maturity: 60-100days
Peninsular region (PR)	Andhra Pradesh, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu	Plant height: 190-225cm; cob size: 10-15 cm; cob/plant: 1-2; seed colour: yellow, yellow-orange, red, white; maturity: 90-100 days

7. Trait specific germplasm identified

A total of 39 trait-specific germplasm have been identified for seven economically important traits– early maturity types, late maturity types, stay green habit, dual types, dwarf type, number of cobs/plant and cob length (>30cm). Table (4) below lists some of the trait specific germplasm with desirable traits for maize were identified and IC and states of occurrences/ availability of the material.

Table 4: Areas identified for trait-specific germplasm of maize (*Zea mays*)

Trait	Accessions	State(s)
Early maturity types	IC 339677, IC 339681, IC 339685, IC 339687, IC 339697, IC 568220, IC 568221, IC 568222, IC 568224, IC 568225, IC 568230, IC 568245, IC 568246	Jammu & Kashmir,
Late maturity types	IC 369982, IC 345996, IC 538749, IC 548610, IC 568254, IC 568269	Himachal Pradesh, Uttar Pradesh
Stay green habit	IC 568251, IC 568254, IC 568269, IC 568283, IC 568299, IC 568302	Himachal Pradesh, Jharkhand, Uttar Pradesh
Dual types	IC 568235, IC 568251, IC 568269, IC 568282	Bihar, Jharkhand
Dwarf type	IC 547811, IC 547816, IC 344596	Himachal Pradesh

No. of cobs/plant	IC 526653, IC 557492, IC 560800, IC 564944	Mizoram, Nagaland,
Cob length (>30cm)	IC 396868, IC 538954, IC 557464	Sikkim, Arunachal Pradesh, Nagaland

8. Mapping of collected diversity (region-wise) The collected diversity was depicted in the maps (region-wise). The region wise maps are presented below.

North-eastern hill region

In the north-eastern hill (NEH) region intensive collections were made during crop specific exploration (Fig. 2). Collected diversity from this region represented 36 per cent of the total collection. Maximum collections (accessions in parenthesis) were made from Arunachal Pradesh (1013). In district level maximum accessions were from West Kameng (215) followed by West Siang (187) and East Siang (183) districts. Other states of the NEH region explored for collection of diversity were Manipur (365), Assam (149) and Tripura (53). In general the diversity collection sites were located in the altitude range from 50m (Assam, Tripura) to 2500m (Arunachal Pradesh) with intensive collection at 100m (Tripura) to 2000m (Arunachal Pradesh) (Fig. 2).

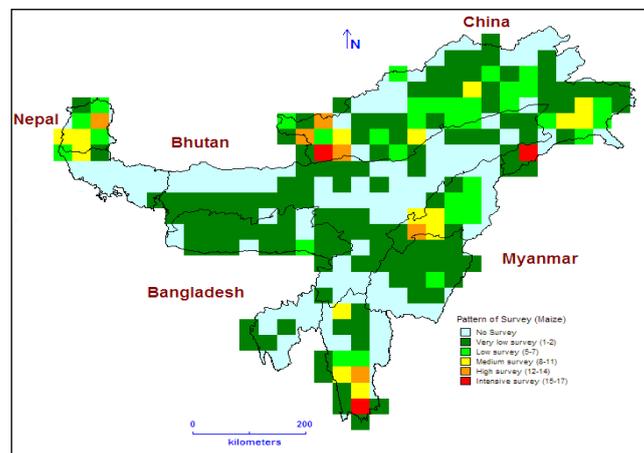


Fig. 2 Survey pattern and germplasm collection sites of maize from north-eastern hill region of India

Out of 165 local cultivars/landraces of maize reported from this region- *Ambo*, *Badam*, *Chujak*, *Fingdong*, *Finthang*, *Mimban*, *Mimpui*, *Murli*, *Nabo*, *Oshum*, *Poakzo*, *Riewhadem*, *Sappa*, *Seti*, *Tanee*, *Tepeh*, *Topo* and *Viamin* were most common. Highest numbers of landraces were collected from Lohit, Tawang and West Kameng district in Arunachal Pradesh. Tribal areas of Arunachal Pradesh, Nagaland, Assam, Manipur and Tripura had interesting variability especially of the primitive cultivars. These materials consisting of remarkable variability in primitive popping type of kernels, smaller and more number of ears and relatively high placed ears, fewer kernel rows, prolific tillering, tassel with fewer branch, smaller internodes and narrower leaves. Variability in primitive local-maize called *Murli* and *Darikincho* (medium tall, high tillering, 4-5 cobs/ plant, short cobs-6cm, small yellow elongated, hard kernels) and *Phensong* (cob upto 30cm long) was recorded from north Sikkim. Among local landraces, Sikkim Primitive maize (locally called *Murli*) was very distinct having characteristic small lemon yellow popcorn type kernels arranged in cob of 3-6cm, prolific bearing, prolificacy (multiple-ear bearing) and has its religious importance among the Buddhist community. Sikkim Primitive maize strains (Sikkim Primitive-1 and Sikkim Primitive-2) were reported to be different from the primitive Mexican races (Mukherjee et al. 1971; Prasanna 2005). Some of the *Sethi* and *Pahenli* had thick husk coverage and oblong cob orientation which impart resistance against ear rot in rainy season. Extra-earliness is a rare trait in mid and high altitude maize. The high altitude maize Tempo Ringing attains maturity in 85-90 days in mid-hills before the

other maize cultivars complete silking. Very interesting local germplasm with potential traits- *Murli*, Tempo Ringing and *Sethi* are being utilized in on-going breeding programme at the ICAR, Sikkim Centre, Tadong (Rahman and Karuppaiyan 2011).

Some of the interesting trait-specific local types/ landraces reported from this region were: aromatic and sticky kernel- *Fingdong* (aromatic popcorn), *Chujak* (aromatic, popcorn), *Chakhou chujak* (aromatic, soft, sticky), *Kholakitthi* (sticky); popcorn type- *Badam topo*, *Tanee*; flint- *Kukidolong*, *Kuchungdari*, *Bacherey*, *Kuchungtamar*, *Kukharey* (dwarf, high altitude); dent kernel-, *Gadbade*, *Seti*, *Chaptimakai* (soft opaque cap), *Pahenli* (light dent). Sporadic collection of early local types- *Ambo*, *Riewhadem* (early maturing), *Vaimin* (three months), *Pahari makai* (adapted to mid-to high-altitude, cold hardy), *Nepali Sappa* (3 cobs/plant) and modern cultivars/new introduced landraces (*Mampokmendi*, *Taminlamendi*, *Maromendi*) were also made. *Lachung* maize exhibited paramutation (multi coloured cob, tolerant to cold weather). Some outstanding landraces from this region *Sikkim Primitive*, *Tirap*, *Naga Sahyup* (Arunachal Pradesh), *Tistamehdi* (Sikkim) were earlier collected and evaluated (over 200) by others (Prasanna 2005).

North-western Himalayan region

In the north-western Himalayan region the surveyed areas are given in Figure 3. More than 31 per cent accessions of the total diversity were collected from Himachal Pradesh (1973), Uttarakhand (738) and Jammu & Kashmir (505). Highest collections were made from Chamba (449), Sirmaur (355) and Mandi (228) districts of Himachal Pradesh. In Uttarakhand mainly two districts viz. Almora (195) and Dehradun (150) had maximum collections whereas in Jammu and Kashmir Jammu (57), Poonch (38) and Kathua (35) districts were explored well (Fig. 3). The collection sites were located between the altitudinal range 500m (Himachal Pradesh) to 1800m in Uttarakhand with intensive collections made from 700-1800m (Jammu & Kashmir, Uttarakhand).

A total of 54 local cultivars/landraces *Chirku*, *Mishri makki* and *Sathu* were most commonly reported from this region. Within the area highest numbers of landraces were collected from Chamba and Mandi districts in Himachal Pradesh and Almora and Chamoli districts of Uttarakhand. Maize is cultivated in this region from foothills to high hills at an elevation of about 2500 m.

Distinct local types/ landraces collected from the region were popcorn type- *Chitku/chitkanu* (small white kernel), *Pinjori*, *Mudhe-ke-Makki*; dent type- *Gada* (greenish yellow kernel); flint- *Rhodu*, *Bachheli local*, *Jaunsari* maize (early type); sweet kernel-*Mishri makki*; tolerance/resistance to biotic/ abiotic stresses- *Pahari makki* (resistance/tolerance to lodging and insect pests), *Bhogru* (tall plant, resistant to diseases), *Chhoti Panjabi* (dwarf, lodging resistance, pest resistant); early

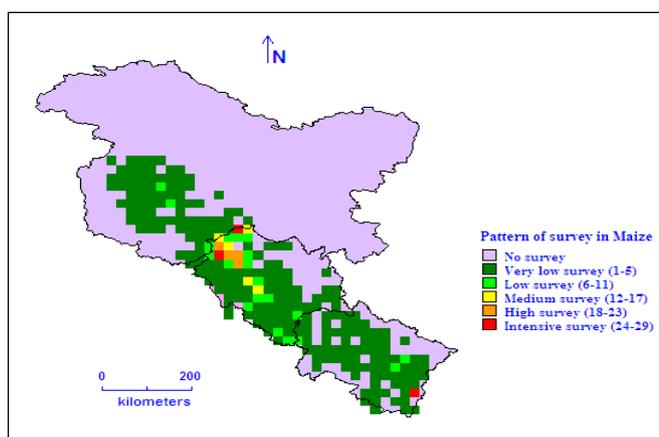


Fig. 3 Survey pattern and germplasm collection sites of maize from North-western Himalayan region of India

type- *Chhoti pinjori*, *Lal kukudi*, *Sathu/ Sathi* and fodder type- *Chari* (*Zea mays* spp. *mexicana*) (in tribal tracts of Tharus, Buxas in Uttarakhand). In Uttarakhand region, a local cultivar named ‘*Murli*’ with distinctly 3-6cm sized cobs with small kernel from Pithoragarh and Almora districts was interesting due to its similarity with a primitive landrace from NEH (also called in NEH region as ‘*Murli*’). Improved maize hybrids (Ganga-1, Ganga-5, Vijay, Pratap, Himsuper, composite-123) were not much popular in the area (Plant Germplasm Reporter 2000-2010a). In general local tall types showed lodging susceptibility, borer attack and sporadic incidence of loose smut. The maize landraces diversity collected from this region was mainly of the flint and dent types (Chandel and Bhat 1989; Dhillon et. al. 2006). Landrace *Chitkanu* was suspected to be no more under cultivation in the Himachal Pradesh (State of Plant Genetic Resources for Food and Agriculture in India- 1996-2006: A Country Report 2007).

North-western and central plains

Areas surveyed and diversity collected from the north-western and central plains are given below (Fig.4). In north-western and central plains collection sites were located in the range 50m (Gujarat) to 800 (Rajasthan) with intensive areas falling between altitudinal range of 100-800m. Out of the total germplasm collection, nearly 15 percent accessions were collected from five states viz. western parts of Madhya Pradesh (569) and Uttar Pradesh (447), Rajasthan (447), Gujarat (259) and Haryana (107). Maximum collections were made from Udaipur (86), Banswara (68), Rajsamand (51) and Bundi (43) districts of Rajasthan. While in Gujarat major variability was collected from Narmada district (83) followed by Panchmahal (Godhra) (31) district.

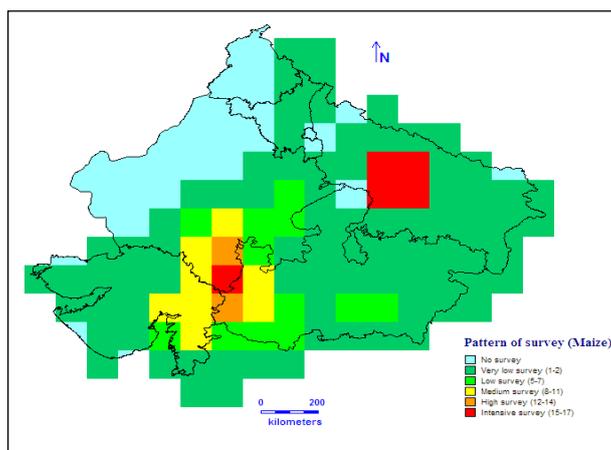


Fig. 4 Survey pattern and germplasm collection sites of maize from north-western plains

A total of 32 local cultivars/landraces were collected from this region; most commonly represented types included *Bharda*, *Dudhmogar*, *Malan*, *Pilli* and *Sathi makki*. Within the area highest numbers of landraces were collected from Dungarpur, Rajsamand and Udaipur districts of Rajasthan. Exploratory studies showed that north-western plains had moderate diversity in maize with traits that were different from those available in other part of India. Local types collected with traits like stay green habit/ fodder type (Jharkhand, Uttar Pradesh) and dual types (Bihar, Jharkhand) were interesting genetic resources collected from this region (Plant Germplasm Reporter 2000-2010). Cultivar ‘*Sathi local*’ was collected across different maize growing regions indicating its wider preference and adaptiveness. Recently, promising germplasm of landraces *Malan makki-4* and *Sathi makki- 5* were collected from Rajasthan under the National Agriculture Innovation Project (NAIP) executed by the NBPGR. *Sathi* and *Basi local* (Rajasthan) were earlier collected and evaluated (Prasanna 2005).

Some of the significant local cultivars/landraces collected from the region included: flint types- *Doodhmogar* (early maturity, drought tolerant), *Sameri* (early maturity, drought tolerant), *Gulla* (drought hardy); early types- *Chandan* (drought tolerant), *Sathi* (insect-pest resistance), and *Bari hati* and *Malan* (kernel arranged in zig-zag manner). Dhillon et al. (2006) have reported significant landraces from this region- *Sathi* local (Punjab) with very early maturing (65-75 days), heat and drought tolerance, excellent yield and high adaptability, *Basi local* (Rajasthan) with drought tolerance trait and *Dausa local* (Rajasthan) excellent yield characters and wider adaptability.

Eastern plains

In the eastern plains most of the region was broadly surveyed but intensive collections were made only from few districts (Fig. 5). Maize was collected from the altitudinal range 50- 800m but intensive collection sites were located between 200-400m. Diversity collected from this region represented nearly 14 per cent of total collected diversity. Germplasm was assembled (accessions in parenthesis) mainly from Jharkhand (443), Bihar (188) Chhattisgarh (127) and West Bengal (60).

Out of 43 local cultivars/landraces of maize collected from this region, *Deshila*, *Dhibria* and *Jondra* were the most common types. Within the area, highest numbers of landraces were collected from Katihar and Bhagalpur districts in Bihar, Chapra and Hazaribagh districts in Jharkhand and Bastar and Sarguja districts of Chhattisgarh.

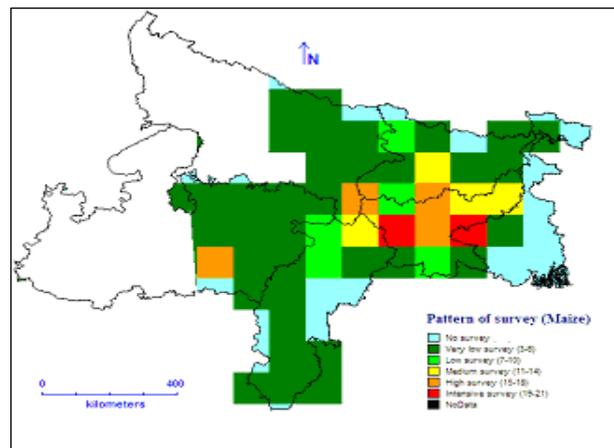


Fig. 5. Survey pattern and germplasm collection sites of maize from north-eastern regions

Some significant local types/ landraces collected from this region included *Jaunpuria local* (resistant to stalk rot, tolerant to excess water and drought) from Uttar Pradesh, *Tinpakhiya local* and *Tulbulia local* (both with extra early maturity) from Uttar Pradesh and Bihar respectively. These landraces have been earlier collected and evaluated from this region (Prasanna and Sharma 2005). The characteristic known traits in some of these were- popcorn types- *Bhadra* (irregular shape kernels, 100 days maturity); *Jharkhand tipri* (white-cream-yellow, angular shaped kernels), *Tinpakhiya* (very sweet kernel, extra early maturity); flint type- *Desi purple* (anthocyanin colouration on tassel and silk); early maturing types- *Ushvan*, *Mamu-bhaigna makka* (white-violet kernel, very old cultivar from last 80 years); medium maturity- *Jaunpuria local* (maturity 80-90 days), late maturing type- *Chhota safed* (small, round shaped kernels), *Deshila* (tasty, medium sized kernel); resistant/tolerant to biotic and abiotic resistance- *Akbarnagar local* (drought, water logging, diseases and insects, maturity in 75 days); *Bhagalpur local* (resistant/tolerant to drought, water logging, pests, maturity 75 days); *Jethualal* (highly tolerant to water logging), *Kabri* (maturity 90 days); *Sabour local* (resistance to drought, water logging, diseases/insects, maturity early); *Sonatikkar* (drought and water logging tolerant, maturity 80-90 days); *Tilbulia* (tolerant to water logging); and *Putali* (transposon-induced pericarp variegation).

Peninsular region

This region is a major site of production of maize. In the Peninsular region, only few districts were surveyed (Fig.6). Altitudinal range from 100-1000m was covered for collection of maize with intensive collections made from 200- 500m. From genetic resources collection point only 4 per cent of the germplasm was collected from six states representing Telangana (279), Andhra Pradesh (181) followed by Odisha (170), Maharashtra (124), Karnataka (87),Tamil Nadu (67) and Kerala (10). Maximum accessions were collected from tribal tracts of Adilabad (54) district.

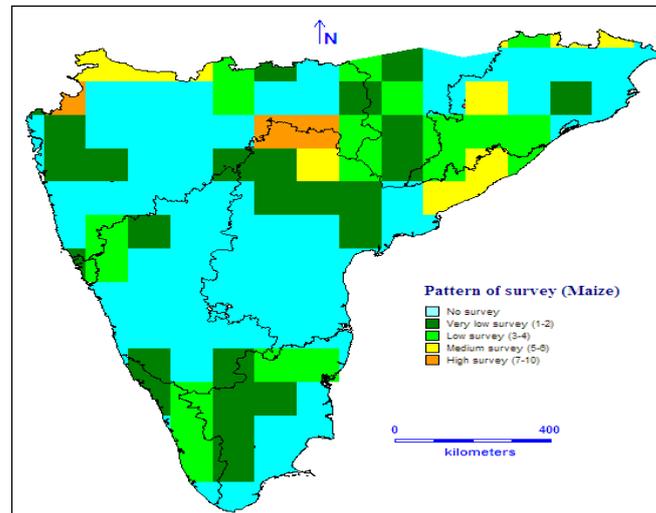


Fig. 6 Survey pattern and germplasm collection sites of maize from peninsular regions

Out of 22 local types/ landraces Jonna pottulu and Makka jonna were the most common types reported from this region, mainly from Vishakhapatnam district in Andhra Pradesh, Wayanad district in Kerala and Coimbatore district in Tamil Nadu. Maize is mostly cultivated around 1000-1600m altitude and landraces grown in the foothills of south India are early maturing types (Prasanna and Sharma 2005). They are popular among tribal people of Andhra Pradesh and Odisha (called “hungry children food”). This appears to be the potential area for higher adaptability and tolerance to fungal diseases as compared to other growing regions (Prasanna and Sharma 2005).

Among landraces diversity collected from this region, *Beli Govina jola* (a 40 year old local cultivar), cold tolerant types- *Kattu cholam*, *Kullan cholam*, *Kathiru*; hill maize (drought tolerant); rainfed type-*Mokka jonna* and *Nattumakka cholam* (suitable to poultry feeds) were the most interesting. Besides improved/ newly introduced types- *Baby corn* (released type), *Paras local-2*; *Deccan-1* and *Deccan-2* were available in the region especially in Kerala and Karnataka.

9. Germplasm collected and conservation

The National Genebank (NGB) is the largest ex situ seed repository in India and third largest in the World (after USA and China) having base collection of landraces, traditional and rare cultivars, released varieties, breeding lines, genetic stocks of crop plants. A total of 13,059 accessions of maize germplasm were collected through crop-specific and multi-crop explorations from different diversity rich areas of the country during 1976-2015. On the basis of rigorous screening, 10,589 accessions were short-listed with details on state, district, village, collector number, Latitude (N) and Longitude (E) of the collection sites for geo-referencing. Of 13,059 accessions of maize germplasm collected, only 5584 accessions of maize germplasm with complete passport information have been conserved in National Genebank (NGB) for long term storage and sustainable utilization (upto 2015) (Annexure D).

This includes a total of 687 exotic collections (Plant Germplasm Reporter 2000-2010b) including trait-specific materials (landraces, elite material, varieties, obsolete cultivars, elite populations, synthetics and lines). List of accessions collected vs conserved are given in Annexure 1.

10. Gap analysis and conclusions

The gap analysis data on collecting mission of maize genetic resources would enhance utilization of accessions through quality passport data, eco-geographic location, availability of germplasm site description, geographic coordinates, use pattern in crop improvement programme. Identification of collection sites located in distribution maps would allow: pinpointing of directed collection plans in under-represented areas and sites identified for rich landraces/ trait-specific diversity. Since these sites are highly vulnerable to genetic erosion due to spread of hybrids/ genetically modified crops (GM), etc. such areas need to be given special attention in genetic resource management.

Based on gap analysis salient points emerged in this report are:

- Broadly all maize growing areas have been surveyed in the past and diversity augmented from different parts of the country.
- Germplasm needs to be collected especially from the following:

Under represented/ poorly represented (states/ districts)-

Andhra Pradesh: Chinthapalli, Srikakulam; **Arunachal Pradesh** (East Kameng, Tawang, Tirap); **Assam** (Kachar, Dibrugarh, Goalpara, Lakhimpur, Tinsukhiya); **Bihar** (Deogarh, Arrah, Madhubani, Motihari, Munger, Nalanda, Nawada, Vaishali); **Chhattisgarh** (Dhantevada, Rajgarh, Rajnandgaon); **Gujarat** (Banaskantha, Bharuch, Panch Mehals, Sabarkantha); **J&K** (Doda, Ramban, Rajori); **Jharkhand** (Chatra, Gumla); **MP** (Dewas, Jabalpur, Morena, Sagar, Panna); **Meghalaya** (East K. hills, Jaintia Hills, Ri-Bhoi, West G. Hills, West Khasi Hills); **Mizoram** (Chaphai, Serchhip); **Nagaland** (Tuensang, Wokha); **Rajasthan** (Swai Madhopur, Alwar, Ajmer); **West Bengal** (Purulia and adjoining region)

- Based on gaps identified in the collections vs genebank holdings need based trait-specific germplasm and unique should be augmented through future exploration plan to the following:

Arunachal Pradesh (Lohit, Lower Subansiri, Upper Siang, Upper Subansiri, West Kameng, West Siang); **Assam** (Tinsukia, Sonitpur); **Manipur** (East Imphal, West Imphal, Senapati); **Mizoram** (Lunglei Saiha); **Sikkim** (North Sikkim); **HP** (Himgiri-Chamba), Lahul Spiti; Gujarat (Narmada, Sabarkantha); **UP** (Mirzapur); **MP** (Jhabua); **Bihar** (Bhagalpur, Begusarai, Siwan, Muzaffarpur).

- Grouping of local cultivars/ landraces of maize based on geographical distribution, morphology, field and molecular characterization is a major challenge that needs special address by the maize breeders and users.

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Collected vs conserved germplasm analysis

States	Districts	Acc. Coll.	Acc. Cons.				
Andhra Pradesh		181	113		East Champaran	4	4
	Chittoor	1	-		Gaya	6	6
	East Godavari	3	-		Gopalganj	8	5
	Srikakulam	2	1		Jamui	3	3
	Vijayanagaram	10	1		Katihar	4	-
	Visakhapatnam	55	14		Khagaria	2	-
Andaman & Nicobar		15	12		Lakhisarai	4	3
	North Andaman	1	-		Madhubani	1	1
	South Andaman	2	-		Motihari	5	1
Arunachal Pradesh		1013	492		Munger	5	5
	Changlang	30	3		Muzaffarpur	13	11
	E. Kameng	30	1		Nalanda	13	11
	Dibang Valley	25	-		Nawada	1	1
	Lower Dibang Valley	06	-		Patna	11	8
	E. Siang	183	105		Purnia	1	-
	Kurung kumey	18	13		Rohtas	8	1
	L. subansiri	88	56		Sahebganj	1	1
	Lohit	55	12		Samastipur	12	11
	Papumpare	26	21		Saran	10	7
	Tawang	43	5		Sekhpura	2	2
	Tirap	7	2		Sitamarhi	3	-
	Upper Siang	32	8		Siwan	4	1
	Upper Subansiri	42	34		Vaishali	8	3
	W. Kameng	215	119		W. Champaran	15	10
	W. Siang	187	107	Chhattisgarh		127	28
Assam		149	81		Baster	77	2
	Barpeta	1	1		Barsur	4	-
	Cachar	31	15		Bilaspur	11	2
	Darrang	10	2		Dhantevada	8	1
	Dhemaji	23	21		Jashpur	6	-
	Dhubri	5	2		Korba	1	1
	Dibrugarh	2	1		Durg	8	2
	Goalpara	3	2		Koriya	15	1
	Kamrup	8	5		Rajgarh	2	2
	Jorhat	13	3		Raipur	1	-
	Karbi Anglong	39	18		Rajnandgaon	2	1
	Lakhimpur	4	2		Sarguja	84	27
	Nagaon	2	1	Gujarat		259	165
	Sibsagar	1	1		Ahmedabad	33	33
	Sonitpur	7	2		Amreli	3	1
	Tinsukia	7	3		Banaskantha	19	4
Bihar		188	173		Baroda	1	1
	Arrah	5	1		Bharuch	3	2
	Aurangabad	1	-		Bhavnagar	1	-
	Begusarai	9	9		Dahod	26	9
	Bhagalpur	20	20		Dangs	3	-
	Darbhanga	1	1		Jamnagar	2	1
					Junagadh	3	1
					Kachchh	1	-
					Narmada	83	83
					Kheda	6	-

	Navasari	8	-
	Panch Mehals	30	11
	Rajkot	24	
	Sabarkantha	9	6
	Surat	8	7
	Vadodara	34	31
Haryana		107	91
	Ambala	35	25
	Gurgaon	9	8
	Hisar	11	11
	Karnal	37	35
	Panchkula	3	-
	Rewari	1	-
Himachal Pradesh		1973	961
	Bilaspur	94	52
	Chamba	449	273
	Hamirpur	70	38
	Kangra	136	32
	Kinnaur	39	11
	Kullu	184	63
	Lahaul & Spiti	17	8
	Mandi	228	125
	Shimla	149	52
	Sirmaur	355	163
	Solan	67	27
	Una	163	85
J & K		505	300
	Baramula	73	46
	Doda	40	40
	Bondipora	1	1
	Jammu	52	41
	Anantnag	24	18
	Budgam	29	10
	Kathua	35	18
	Kistwar	5	5
	Kashmir	2	-
	Kupwara	27	23
	Poonch	38	8
	Pulwama	22	14
	Rajouri	45	6
	Ramban	10	9
	Srinagar	23	15
	Shopian	2	-
	Udhampur	34	24
Jharkhand		443	191
	Bokaro	29	21
	Chatra	3	3
	Daltenganj	2	2
	Deogarh	27	21
	Dhanbad	8	7
	Dumka	23	13
	E.Singhbhum	11	3
	Garhwa	21	10
	Giridih	29	20
	Godda	13	12

	Gumla	5	4
	Hazaribagh	64	37
	Jamtara	11	6
	Kodarma	9	7
	Lohardaga	29	22
	Pakur	8	3
	Palamu	49	15
	Ranchi	40	18
	Sahibganj	2	-
	W. Singhum	4	4
Karnataka		87	53
	Bangaluru	42	31
	Belgaum	13	1
	Bagalkot	1	-
	Bellary	2	-
	Bidar	2	-
	Chamarajanagar	1	-
	Chikkaballapur	2	2
	Chitradurga	1	-
	Dharwad	3	3
	Hassan	1	-
	Haveri	1	-
	Kodagu	3	3
	Kodagu	1	-
	Mysore	4	-
	Raichur	2	-
	Tumkur	2	-
Kerala		9	5
	Idukki	4	4
	Palakkad	2	1
	Malappuram	1	-
	Wayanad	2	-
Madhya Pradesh		569	291
	Anuppur	4	-
	Balaghat	5	4
	Barwani	42	33
	Betul	2	1
	Chhatarpur	2	-
	Chhindwara	8	-
	Damoh	5	5
	Dewas	4	4
	Dhar	47	43
	Dindori	39	16
	East Nimar	37	34
	Guna	5	1
	Hoshangabad	2	-
	Indore	12	14
	Jabalpur	12	4
	Jhabua	61	41
	Khandawa	37	25
	Khargone	33	32
	Mandla	34	5
	Mandsaur	3	-

	Morena	1	1
	Narsinghpur	6	6
	Rajgarh	22	4
	Panna	2	-
	Raisen	1	-
	Ratlam	18	13
	Sagar	8	3
	Satna	4	-
	Seoni	2	1
	Sehore	1	-
	Shahdol	19	3
	Shajapur	3	3
	Shivpuri	7	3
	Siddhi	10	3
	Singrauli	4	-
	Ujjain	11	8
	Umariya	9	1
	Vidisha	8	-
	West Nimar	37	-
Maharashtra		124	58
	Ahmadnagar	5	3
	Akola	4	3
	Amravati	4	1
	Aurangabad	1	1
	Beed	2	-
	Chandrapur	3	-
	Dhula	2	2
	Gadchiroli	9	-
	Jalna	5	5
	Kolhapur	16	9
	Latur	3	-
	Mumbai	4	3
	Nagpur	1	1
	Nandurbar	19	20
	Nashik	7	4
	Osmanabad	3	-
	Parbhani	2	-
	Pune	2	-
	Raigarh	1	-
	Sangli	16	3
	Satara	5	-
	Solapur	4	-
Manipur		365	84
	Chandel	44	7
	Churachandpur	81	1
	East Imphal	23	7
	Kohima	1	-
	Senapati	73	35
	Tamanglong	62	13
	Thoubal	17	9
	Ukhrul	28	7
	West Imphal	9	3

Meghalaya		638	339
	E. Garo Hills	11	6
	East K. hills	215	102
	Jaintia Hills	14	8
	Ri-Bhoi	8	4
	South Garo hills	24	21
	W G. Hills	314	191
	West Khasi Hills	14	3
Mizoram		644	259
	Aizawal	257	113
	Champhai	66	5
	Kolasib	61	29
	Lunglei	83	22
	Lawngtlai	12	6
	Mamit	31	23
	Saiha	54	46
	Serchhip	60	7
Nagaland		472	303
	Dimapur	40	22
	Kiphire	19	14
	Kohima	165	87
	Longleng	6	6
	Mokokchung	56	44
	Peren	21	20
	Phek	44	24
	Tuensang	38	24
	Wokha	31	22
	Zunheboto	33	33
	Mon	15	6
Orissa		170	26
	Bolangir	5	1
	Cuttuck	1	1
	Dhenkanal	1	1
	Gajapati	3	1
	Ganjam	7	3
	Kalahandi	1	1
	Keonjhar	1	1
	Kandhamal	75	9
	Koraput	10	1
	Malakangiri	3	-
	Mayurbhanj	6	4
	Nabarangpur	7	2
	Puri	1	1
	Rayagada	16	2
Punjab		47	42
	Hoshiyarpur	1	1
	Ludhiana	34	33
	Ropnagar	3	1
Rajasthan		447	347
	Ajmer	9	8
	Alwar	6	6
	Baran	5	5
	Banswara	30	22
	Bharatpur	3	2
	Bhilwara	21	15

	Bikaner	2	1
	Bundi	43	9
	Chitaurgarh	22	14
	Dausa	8	9
	Dungerpur	19	18
	Jaipur	8	8
	Jhalawar	15	14
	Jhunjhun	1	1
	Jodhpur	3	-
	Nagaur	3	-
	Karauli	4	4
	Kota	3	2
	Pali	14	11
	Raj Samand	51	46
	Sawai Madhopur	6	6
	Sirohi	28	20
	Tonk	17	15
	Udaipur	86	66
Sikkim		559	275
	East Sikkim	158	91
	North Sikkim	151	74
	South Sikkim	122	57
	West Sikkim	123	49
Tamil Nadu		67	43
	Coimbatore	36	32
	Dharmapuri	3	1
	Dindugul	1	1
	Erode	1	1
	Madurai	2	-
	Nilgiris	5	-
	Salem	5	-
	Theni	1	1
	Tirupur	1	1
	Thiruvannamalai	4	2
	Vellore	1	1
Telangana		279	178
	Adilabad	54	33
	Hyderabad	131	105
	Karimnagar	11	9
	Khammam	13	3
	Mahbub nagar	2	-
	Medak	9	1
	Ranga Reddy	29	19
	Vishakhapatnam		1
	Warangal	30	7
Tripura		53	2
	Dhalai	6	1
	North Tripura	5	-
	South Tripura	22	-
	West Tripura	16	1
Uttar Pradesh		447	398
	Allahabad	1	1

	Azamgarh	5	-
	Bahraich	8	4
	Ballia	3	2
	Bareilly	9	2
	Basti	2	1
	Bijnor	7	3
	Chandauli	2	2
	Deoria	3	-
	Faizabad	1	1
	Farrukhabad	52	47
	Gazipur	1	1
	Gonda	3	-
	Gorakhpur	6	-
	Hardoi	46	40
	Jaunpur	9	5
	Kannauj	104	94
	Kanpur	38	35
	Lakhimpur Kheri	52	23
	Lucknow	7	5
	Maharajganj	1	1
	Mirzapur	19	11
	Muzafar nagar	13	10
	Pilibhit	3	3
	Rampur	5	2
	Sahajahanpur	5	-
	Shrawasti	2	2
	Sitapur	1	1
	Sonbhadra	13	5
	Varanasi	13	4
Uttarakhand		738	407
	Almora	195	147
	Bageshwar	21	19
	Chakrata	1	-
	Chamoli	32	21
	Champawat	37	31
	Dehradun	150	104
	Haridwar	1	-
	Nainital	89	21
	Pauri Garhwal	22	20
	Pithoragarh	93	59
	Rudraprayag	8	6
	Tehri Garhwal	23	18
	Udham S.Nagar	25	10
	Uttarkashi	30	23
West Bengal		60	1
	Darjeeling	49	-
	Kalimpong	4	-
	Nadia	1	-
	Purulia	14	1

Total collected = 10,589

Total conserved = 5,527

Others = 2,470

Annexure II

Cultivar/ landrace/ local type collected from different states with characteristic traits

North Eastern Hill region

Accessions No.	Cultivar/ landrace/ local type name	Districts	State	Remarks
IC-319592, 433834, 433884, 319529, 319490, 433760, 433785, 435879,	Baw , Tapoi, Khaufa, Makoie, Tanet, Nabu, Kwfal, Tambo, Ambo, Sapa	Lohit	Arunachal P.	Seed dark red colour, white, red -violet, bold seed, 3-4" long cob
IC-447401, 447436, 538993, 447251, 447141	Tanee, Paputan, Nime, Topo, Orsha	Lower Subansiri	Arunachal P.	Bold seed, very bold seed; long cob length, Popcorn type
IC-372216, 447077, 329959, 350181, 350191, 416908, 417089, 447245, 447161, 267238, 352966, 267283, 262351, 352982, 400594, 284567	Ohsum, Fidong, Poma, Phangong, Kumdham, Roksin, Achem, Badam, Finthang, Mitcha, Tepeh, Bremu Sang, Michi Lasa, Michi, Pinang, Jylon, Hapa,	Papumpare Tawang, Tirap, Upper Dibang Valley, Upper Siang, Upper Subansiri, West Kameng	Arunachal P.	Seed dark –yellow coloured; 2-3 cobs/plant, bitter taste
IC-417054	Nepali sappa,	West Siang	Arunachal P.	Three cobs/plant
IC-332988, 394361, 332929, 396657, 396658, 264521, 394187, 330099, 394427	Makoyijowa, Gomdhan, RongaMaoizowa, Lal makai, Safed makai, Pokhra makai, Gom Dhan, Thinth, Jati Tapa,	Dhemaji , Dhubri, Gom Dhan, Karbi Anglong, Sonitpur Tinsukia	Assam	Grain bold yellowish, plant upto one m tall, 2 cobs/plant
IC-556988, 556989, 556997, 556990, 556993	Mawok, Haotheikachik, ChujakAngouba, Kumathe, Tharathei,	East Imphal, West Imphal Tamenglong, Thoubal	Manipur	Scented, soft, glutinous.
IC-521526, 352941	Chahouchutak, Kabok	Tamenglong, Thoubal	Manipur	Soft, glutinous, small yellow flint corn, used as popcorn; aromatic
IC- 330332, 410329, 410339, 410330, 410353	Pithetho, Kita, Hannoba Kajiba Kida, Thoumangle, Abami Kide, Riewhadem,	Senapati	Manipur	Tall, hardy, high yield, aromatic dark red grain cobs
IC-330419, 330375	Mizachui, Khamathei	Ukhrul	Manipur	
IC-410353, 350779, 297916, 297880, 297884, 297885, 297891	Riewhadem saru , Yangpanah, Hadem, Mirakhu, Pathur, Vorm, Sarangi	East Khasi Hill, Jaintia Hill, Ri-Bhoi, West Garo Hills	Meghalaya	Different coloured grains
IC-265498, 278094, 265494, 374476, 297798, 297773, 297799, 297805, 297858	Hmingbar, Puakza, Hinban, Vamin, Mimitlore, Mimbanvar, Rumthimoei, Mimban (White), Mimpui, Charei,	Aizawl, Champhai	Mizoram	Intense purple kernel with white base, popcorn type maturity in 3 months
IC-265363, 369385, 297810	Lalchawngi, Mui, Mimban (Brown)	Kalasib, Lunglei Saiha	Mizoram	Whole plant/food, Forage type.
IC-422926, 265350, 422806, 326219	Pastor, Chare, Projekwimin, Engte		Mizoram	Yellow medium seed, cob 5-6 " long.
IC-326220	Puakzo	Saiha	Mizoram	Cob 3-4 long, yellow & small seed
IC-297839, 297807	Kutabimim, Mimban (White), Projek,	Saiha, Serchhip	Mizoram	Cob length 6-10 inch, creamy & medium seed

IC-447194, 339724, 591232, 339728, 419743, 540278, 419484, 339722, 419463, 419529, 419633, 340029, 340033, 447194	Suko, Seinya ketei, Kalbuman Kang Seinya kemeno, Kola khati, Manji, Mang Nemai, Kolbueng, Manzi Bera, Seti Ashur, Tsungro, Kohu, Zharsi Suko,	Dimapur, Kohima	Nagaland	Cobs purple colour, medium-dwarf size (12 cms ht) plants, seed yellow and orange, early maturing
IC-591234	Zarosi	Kohima	Nagaland	Yellow reddish, black seeds
IC-540192, 540236, 540190, 540202, 423346, 591226, 591229, 591227, 423324	Maibok Manti, Sangtam manti, Tagokla, Tsumar, Memda, Taminla, Gongliak, Maro Mendi, ampokmendi	Mokokchung	Nagaland	Cobs brownish, Cobs purplish to black
IC-557490, 423196, 423197, 591225, 591224, 591230, 423226	Teipeui, Puisang, Tepui Nei, Mekuta, Kore, Makeriei, Thwuii	Peren	Nagaland	Cobs brownish, dark, dwarf
IC-540274, 540241, 540243, 540178, 540265, 591238, 591240, 540199	Tsasu, Yempusantia, Sangti, Aniung manji, Thesu mutri, Hongei, Chisu, Ruppap, ,	Tuensang	Nagaland	Two cob/ per plant.
IC-423122, 423123, 423124, 423125, 591228, 423279	Chutum, Moro, Yalum, Kuki dolong, Rangvalak, Agri	Wokha	Nagaland	Cobs brownish to dark coloured
IC-423280, 423301, 423302, 423307, 423265	Kithoii, Aizu, Amoa, Kalakiti, Mashu	Zoneheboto	Nagaland	Sticky seeds
IC-351678, 351613, 396874, 351616, 351683	Seti makai, Paho makai ,Pali Seti, Khosalto makai, Lama makai	East Sikkim	Sikkim	Yellow kernels
IC-351692	Paheli makai	East Sikkim	Sikkim	Yellow kernels with (light dent).
IC-565882	Murli makai (Sikkim Primitive)	North sikkim	Sikkim	Prolificacy (multiple-ear bearing) plants; lemon yellow, popcorn type
IC-396875, 396881, 396880, 396877, 396885, 351692, 565867, 565889, 565892	Kin-cho-srepo, Sebo kinchon, Sathia, Dari kincho, Kunchung dori, Paheli makai, Kuchungtamar, Rathi makai, Paheli makai	North Sikkim	Sikkim	Lemon yellow, popcorn type, yellow/orange flint and dark purple kernels, prolificacy (multiple-ear bearing), cylindrical ear
IC-565892, 565872	Kaali makai, Gadbade makai	South Sikkim	Sikkim	Dark purplish black kernels, Mix of white flint and purple kernels.
IC-565880, 565878, 565876, 565887, 565879, 565877, 565872	Saathiya makai, Kukharey makai, Bancharey makai, Kaali makai, Putali makai, Chaptey makai, Gadbade makai	West Sikkim	Sikkim	White flint with a few purple colored kernels; chaptey makai, White flint/dent type with a few purple kernels, cylindrical ear; yellow flint kernels

North Western Himalaya

Accessions No.	Cultivar/ landrace/ local type name	Districts	State	Remarks
IC-313166	Chirku	Bairagarh (Chamba)	Himachal P.	Red colour cob, yellow seeds, flat dent seed.
IC-594384, 398132, 273245	Kukdi, Kanak, Sathi Makki	Bilaspur Chamba	Himachal P.	Plant height 12 feet, large grains Yellow coloured seed White, round grains small grains.
IC-594417, 467762, 279902, 279928	Sathu, Phapra, Chitti Kukari, Shathinu	Chamba	Himachal P.	Yellow seeded small cobs. White seeds Flint type, red colour white colour, Zenia effect, dent kernel
IC-328979	Gorkhall Makki	Chamba	Himachal P.	White seeds.
IC-313186	Chirku Makki	Hingiri (Chamba)	Himachal P.	Cooked and eaten as rice
IC-328376	Sukad chali	Kullu	Himachal P.	Sweet corn type, dwarf plant
IC-262858	Chhalli Bhogadu	Lahaul & spiti	Himachal P.	Fodder type, disease resistant.
IC-328321	Safed challi	Mandi	Himachal P.	Resistant to diseases; grown as rain fed crop
IC-328329	Lal challi	Mandi	Himachal P.	High production
IC-328329	Safed challi	Mandi	Himachal P.	Very hard seed, but resistant to diseases
IC-362116, 362117, 328321, 362123, 262799, 262804, 280159, 262808, 274547, 362115, 262800	Burfi, Sathu, Safed challi, Gada, Bada sarathu, Bhojari Makki, Makki sath,i Sathadu, Chhalada, Rhodu, Garda	Mandi	Himachal P.	White/yellow seeded, hard seed, medium plant height; early maturing.
IC-328415, 274553, 262806, 381306, 362121	Safed challi, Tarambalu, Chitti Makki, Makki Sathu, Maroani	Mandi	Himachal P.	Tall, resistant.
IC-278647	Chhoti Panjori/Lal Kukudi	Sirmour	Himachal P.	Landrace, 60 days crop, red seeded medium size ear
IC-278652	Panjori Makki,	Sirmour	Himachal P.	Lal makki, dwarf, good taste, 2-3 cobs/plant.
IC-321122	Safed Makki	Sirmour	Himachal P.	Good for sattu preparation
IC-321132	Kheelki Makki	Sirmour	Himachal P.	Cobs and seeds small, popcorn.
IC-327006	Pahari Makki	Sirmour, Solan	Himachal P.	Tall, 7-8 ft, less yield, good taste. Tall plant, less affected by insects.

IC-363791	Mudhe-ke-Makki	Sirmour	Himachal P.	White medium, size seeds popping type
IC-321126	Choti panjabi	Sirmour	Himachal P.	Dwarf, no lodging, pest resistant.
IC-321133	Badi Panjri	Sirmour	Himachal P.	Bold seeds, large cobs, 90 days crop.
IC-397360	Safed makki	Sirmour	Himachal P.	Tall, lodging prone, good taste, big cobs.
IC-328570, 328583, 411747	Pahari Makka, Paru makka, Double makai	Kathua	J & K	Local type.
IC-411762, 361540, 326608	Franchy maki, Mishri makki Jawar kannu	Kupwara , Pulwama	J & K	Better in yield also used as fodder.
IC-565899, 565904, 565903, 565902,	Bachheli local, Bahadarabad local, Bageswar local, Karuli local	Bageshwar local	Uttarakhand	Orange flint kernels.
IC-362271, 281792	Murli Ghwag	Almora, Pihoragarh	Uttarakhand	Yellow, cobs with kernel 10- 12 rows, cobs 4- 6 cm long
IC-281792	Ghwag	Bageshwer	Uttarakhand	Yellow white, small. Orange yellow, medium. White yellow, medium.
IC-266115, 279425	Mungari/ Mugari	Chamoli	Uttarakhand	Yellow, small Orange, medium.
IC-538053	Kakoni	Champawat	Uttarakhand	Orange white, small; kernel rows 14 nos.
IC-281792	Ghwag	Champawat, Pithoragarh	Uttarakhand	Orange, small.
IC-594381	Kukadi	Dehradun	Uttarakhand	Orange, medium, light orange
IC-316082, 338596	Kakuni, Mungari	Pauri	Uttarakhand	Yellow colour seeds, small size cobs. Medium size, 3-4 cobs/plant
IC-406712	Dhan bhutta	Pithoragarh	Uttarakhand	Smoll cob, small grains
IC-263217, 266881, 382653	Lal makka, Ghoga Ghwag, Mungri	Pithoragarh	Uttarakhand	Bold seeded
IC-400123, 263204	Red Makka, Safed Makka	Tehri	Uttarakhand	Red colour, White colour

North western plains

Accessions No.	Cultivar/ landrace/ local type name	Districts	State	Remarks
IC-396068	Badi Piyaree	Sidhi Gazipur Sonbhadra	Madhya Pradesh	Bold grains, orange colour, early duration, Checks biles, rain fed crop
IC-273304, 273329, 273322	Bari hati , Bari sardi, Bara safed	Jhabua	Madhya Pradesh	Very early maturing
IC-280434	Bharda	Baran	Rajasthan	yellow

IC-273242	Bhodu	Khandwa	Madhya Pradesh	White seeded.
IC-337446	Chandan	Dohad	Gujarat	Grains flint types, early, drought tolerance materials.
IC-273236	Choti Safed Desi	Khandwa	Madhya Pradesh	White seeded.
IC-273258	Choti sathi lal	Khargaon	Madhya Pradesh	Seeded Yellow
IC-298589	Deshi makai	Narmada ,Sabarkantha	Gujarat	Early maturity, drought tolerant, variegated drought tolerant.
IC-280177	Desi safed makki	Ahmedabad	Gujarat	Cobs small thin, have small yellow- or white seeds.
IC-273316	Dhawal matali	Jhabua	Madhya Pradesh	
IC-333120	Dhola makki	Barwani	Madhya Pradesh	White grains
IC-280427	Diri bhutta	Jhalawar	Rajasthan	white seeds
IC-331028	Doda	Vadodara	Gujarat	
IC-273354	Dokar makka	Bamwara	Rajasthan	
IC-351475	Doodh mogar	Dohad	Gujarat	Flint types, extra early maturity for marginal farming, drought tolerance, best storability for insect-pest resistant
IC-298554	Ghatdi makai	Sabarkantha	Gujarat	Black & yellow grain
IC-273311	Hameri nani hati	Jhabua	Madhya Pradesh	Super white kernel
IC-273238	Harwa maka	Khandwa	Madhya Pradesh	White seeded
IC-273366	Hati	Rajsamand	Rajasthan	
IC-273359	Hati Tegani	Bamwara	Rajasthan	
IC-274628	Johaudi	Umaria	Madhya Pradesh	
IC-320591	Jondra	Dindori	Madhya Pradesh	Yellow.
IC-396070	Jonhari	Sidhi and Surguja	Madhya Pradesh	Orange medium size grains
IC-263048	Junheri	Mirzapur	Uttar Pradesh	For rainfed type
IC-273336	Kathodi choti	Dahod	Gujarat	
IC-273340	Kathoodi	Dahod	Gujarat	
IC-351468	Kathudi	Vijay Nagar	Gujarat	Grains flint types, extra early suited to marginal
IC-298555	Khichdi makai	Sabarkantha	Gujarat	Black-yellow & black-white grain.
IC-273260	Khokari pili	Khargaon	Madhya Pradesh	Yellow seeded
IC-298557	Lal makai	Sabarkantha	Gujarat	Drought tolerance, early maturity.
IC-437070, 437069	Mahi dhawal, Mahi Kanchan	Udaipur	Rajasthan	
IC-333193	Makak pyontor	Dhar	Madhya Pradesh	White coloured small grain

IC-280429	Makiya, bharla	Jhalawar	Rajasthan	Grain yellow and black mixed
IC-280438	Makka (Gulla)	Baran	Rajasthan	Grain white and black mixed
IC-273222	Makki godhak	Shivpuri	Madhya Pradesh	Yellow grain
IC-273274	Makki safed	Barwani	Madhya Pradesh	White seeded
IC-280158	Malan	Rajsamand	Rajasthan	
IC-594438	Malan (White)	Udaipur Rajsamand	Rajasthan	
IC-280187	Malan makki	Dungerpur Chittaurgarh Rajsamand	Rajasthan	Cob narrow
IC-594440	Malan (yellow)	Rajsamand	Rajasthan	
IC-273295	Moti Hameri/Sameri	Jhabua	Madhya Pradesh	Good yield
IC-273298	Nani hameri	Jhabua	Madhya Pradesh	Storage pest resistant compared to others
IC-273297	Nani Pili	Jhabua	Madhya Pradesh	Early maturing
IC-336991	Pili makai	Narmada	Gujarat	Yellow grain, drought tolerant
IC-273275	Pili chot maki	Barwani	Madhya Pradesh	Very only type
IC-280170	Pili makki	Chittaurgarh Dungerpur Rajsamand Udaipur (Raj.) Vadodara (Guj.)	Rajasthan	Cobs very thin, small size grains; rainfed, plants tall, disease free
IC-273256	Pili sathi	Khargaon	Madhya Pradesh	Yellow seeded
IC-396069	Purpuriya	Sidhi	Madhya Pradesh	Yellow small-medium grains
IC-280404	Rati makai	Ajmer Bhilwara	Rajasthan	Redish yellow small
IC-273326	Safed Baoti	Jhabua	Madhya Pradesh	
IC-273305	Safed choti desi	Jhabua	Madhya Pradesh	Super white type
IC-273224	Safed godhak	Shivpuri	Madhya Pradesh	White maize
IC-280206	Safed makki (Malan)	Udaipur Chittaurgarh Rajsamand	Rajasthan	Mature in 90 days, grains arranged in straight line
IC-273228	Safed Sathi	Rajgarh	Madhya Pradesh	White seeded.
IC-280207	Safed Sathi makki	Udaipur	Rajasthan	Small size cobs have small grains
IC-351489	Sameri	Dohad	Gujarat	Grains flint types, marginal farming also drought tolerance materials and storability/insect-pest resistant.
IC-273327	Sameri choti	Jhabua	Madhya Pradesh	
IC-273294	Sameri	Jhabua	Madhya	Early maturing, good for

			Pradesh	popping
IC-351472	Sathi	Sabarkantha	Gujarat	Grains are flint types extra early
IC-273229	Sathi (Pili)	Indore	Madhya Pradesh	White seeded.
IC-280204, 594443, 594433	Sathi makka Sathi (white) Sathi (Yellow)	Kota Udaipur Chittaurgarh Dungerpur Rajsamand	Rajasthan	
IC-273286	Sathi Pili	Dhar	Madhya Pradesh	Different shades of yellow
IC-273269	Sathi safed	Bajwani	Madhya Pradesh	White seeded
IC-280212	Sathi safed makki	Udaipur	Rajasthan	Mixed type of cob with mixed type of seed
IC-333112	Satlu makki	Barwani	Madhya Pradesh	White grains
IC-333111	Sattu makki	Barwani	Madhya Pradesh	Early maturing whitish and grains.
IC-280408, 273358, 273351, 273348	Setriya makki, Tegari, Telani dholi, Telani ghangari	Bhilwara	Rajasthan	Yellow, 2-3 cobs / tiller
IC-273303	Uttavali	Jhabua	Madhya Pradesh	Very easily maturing
IC-273243	Zadau makka	Khandwa	Madhya Pradesh	White seeded.

Eastern plains

Accessions No.	Cultivar/ landrace/ local type name	Districts	State	Remarks
IC-283372	Local makka	Bhagalpur	Bihar	Resistance to drought, water logging, diseases and insects. Yield 25-30 q/ha, maturity 75 days, grown as kharif crop
IC-334244	Baisakha, Ashari, Dngwa makka	Vaishali Chapra	Bihar	Creamy white, 20.9g/100 seed.
IC-406412	Baraka jonhari	Jamtara	Jharkhand	White yellow kernel.
IC-361451, 334239	Bhadaiya makka/ Bhadra makai	West Champaran Nalanda Girdih Vaishali	Bihar	Kernel colour yellow along with mixture of red colour, maturity 100 days, good for propping.
IC-283374	Diara local makka	Bhagalpur	Bihar	Resistance to drought, water logging, diseases and insects; yield 25-30 q/ha, maturity 75 days, grown as kharif crop
IC-406418	Cholki makka	Deogarh	Jharkhand	White yellow kernel.
IC-283471	Deshila makai/	Katihar	Bihar	Maturity 90 days, grown in kharif season. Maturity 60-75 days, Kernel white-yellow,

				tolerant to water logging
IC-283432	Dhibariya jorra	Deogarh	Bihar	Kernel colour deep yellow.
IC-332068	Dhibiria makai	Chatra	Jharkhand	Cream colour seed coat, Diameter = 3.86 mm.
IC-369200	Dhibri	Giridih	Jharkhand	
IC-406421	Dibari makai	Deogarh	Jharkhand	Red-orange & small seed.
IC-406414	Garma makai	Jamtara	Jharkhand	Bold yellow colour.
IC-283518	Jaunpuria kachbachia	Khagaria	Bihar	Maturity 80-90 days.
IC-283517	Jaunpuria safed makai	Khagaria	Bihar	Maturity 80-90 days.
IC-334248	Jethua	Gaya	Bihar	Orange seed 23.03g/100 seed.
IC-283393	Jethua lal makai	Katihar	Bihar	Grain colour deep red, highly tolerant to water logging.
IC-283555	Jogia makai	Samastipur	Bihar	Maturity 90 days.
IC-277148	Jondra	Bastar	Chhattisgarh	Yellow corn.
IC-396000	Jonhari/ Jonhra	Korba , Godda, Pakud, Raigarh and Surguja	Chhattisgarh, Jharkhand	Very small cobs, medium-small yellow grains, grains irregular shape
IC-274720	Kachbachia Jaunpuria	Samastipur	Bihar	Mixture of white and violet colour of grain.
IC-406419	Kanchan	Deogarh	Jharkhand	Bold seed yellow kernel.
IC-447913	Kheri	Betia	Bihar	Small grain, yellow white tip
IC-331570	Kuari makka	Chapra	Bihar	
IC-342534	Kutki makai	Surguja	Chhattisgarh	Cream Colour Grains
IC-406420	Majhila makai	Deogarh	Jharkhand	Local material, long oval kernel, cob length 17-18 cm, compact, filled completely, small seed, deep yellow, compact,
IC-351559	Paphopaheli	Darjeeling	West Bengal	
IC-351585	Pathorangit	Darjeeling	West Bengal	
IC-351548, 351558	Peheli thulo, Pheli reli	Darjeeling	West Bengal	
IC-417848	Phuchakiya makka	Gopalganj	Bihar	
IC-260057	Piyarka , Rasto local	Madhubani/ East Champaran	Bihar	
IC-283375	Sabour local makka	Bhagalpur	Bihar	Resistance to drought, water logging, diseases and insects. Yield 25-30 q/ha, maturity 75 days, grown as kharif crop
IC-283574	Sanatikkar makka	Purnia	Bihar	Maturity 90 days.
IC-420918	Lakshmi	Muzaffarpur	Bihar	Tall

IC-283380, 420901	Sonatikkar makka, Suwan	Bhagalpur	Bihar	Drought and water logging tolerant, kernel yellow; maturity 80 days, tolerance to heavy rainfall, kernel colour yellow-white
IC-347881	Tapri makai	Hazaribagh	Jharkhand	White maize, tetragonal shape seed.
IC-334247	Tarun thulo local	Nalanda East Champaran	Bihar	Orange seed of tetragonal shape. 23.0g/100 seed.
IC-283427	Tilbulia makai	Lakhisarai Katihar	Bihar	Kernel colour white or mixture of white and yellow, maturity 75 days, yield 35-40 q/ha. kernel colour yellow, deep red; maturity 90 days; water logging tolerant.
IC-283627	Tinpakhiya makai	Muzaffarpur	Bihar	Maturity 75-80 days, small kernel, all puffing corn, puffs are sweet and tasty
IC-342911	Tipri	Hazaribagh	Jharkhand	Creamy yellow seed, Tetra angular seed,
IC-	Ushvan makai	Palamau	Jharkhand	Early maturing variety, small cob, orange colour

Peninsular region

Accessions No.	Cultivar/ landrace/ local type name	Districts	State	Remarks
IC-282534	Aswini	Visakhapatnam	Andhra Pradesh	Duration is 90-100 days and yield up to 18-29q/hac
IC-425053, 335916, 335917, 335918, 425057, 370762	Ambresh Beli Govina jola, Haladi Govinazola, Govin jola, Kerur local, Jolam	Belgaum, Bagalkot	Karnataka	This variety is 40 yrs grown and maintained by the farmer
IC-372410	Cholam	Idukki, Wynad, Palghat	Kerala	baby corn or flour purpose
IC-382853, 382825, 369632, 257918	Jonna Jonnapattu; Karra Jonna Jonna pottulu Korra jomalu,	Vishakha patnam, Vizianagaram	Andhra Pradesh	Rainfed
IC-353197, 330540	Kattu cholam, Kullam cholam kathiru	Coimbatore, Salem	Tamil Nadu	Cold tolerant
IC-353811	Makka cholam	Thiruvannamalai	Tamil Nadu	Three-four cobs/plant, seeds yellow; more suitable to poultry feeds; resistant to pest and diseases.
IC-430586	Mami Jonna	Khammam	Andhra Pradesh	Plants are medium in height, seed yellow

IC-430587	Mokka jonna	Adilabad; Chittoor; Chinthapalli ; East Godavari; Khammam; Visakhapatnam	Andhra Pradesh	Medium grain size; plant height 7.5 feet
IC-309334, 591713	Nokka jonna, Potta jonna, Punasa jonna	Visakhapatnam	Andhra Pradesh	Rain fed, cob small; plant 197 cm and has 1 cob/plant
IC-430635	Padda mokka jonna	Khammam	Andhra Pradesh	Seeds medium, yellowish
IC-420908	Panchganga	Kolapur	Maharashtra	Medium grain size
IC-536583	Pothi cholam	Malappuram	Kerala	Crop duration 80-100 days

