Maize Production Technologies in India

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Preface

Since 1950-51, the area, production and productivity of maize have increased by more than 3.4, 12 and 4.5 times from 3.2 m ha, 1.7 m t and 547 kg ha^{-1} to current level of 8.17 m ha, 19.33 m t and 2414 kg ha^{-1}, respectively due to increasing maize demand for diversified uses. The introduction of single cross hybrid which now covers 20% area under maize cultivation making good dent on Indian scenario.

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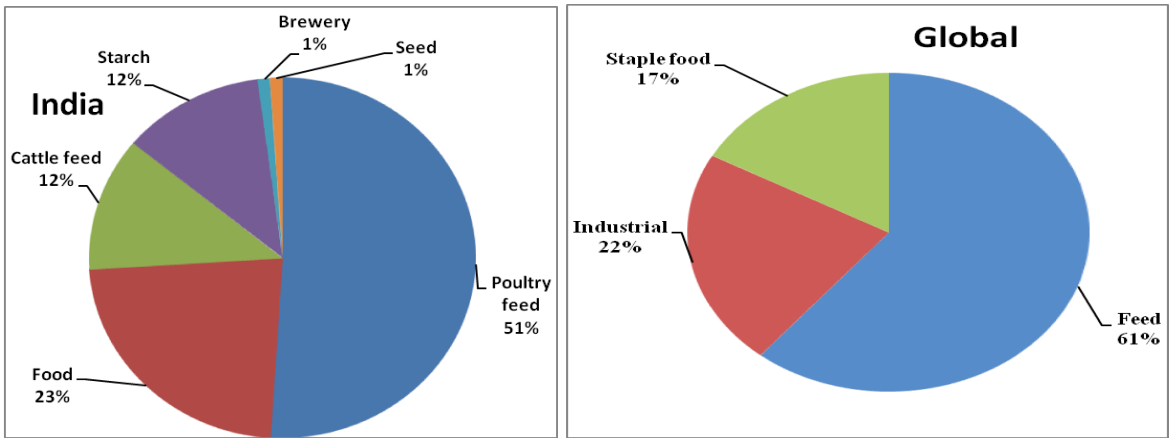
Maize Production Technologies in India

1. Introduction

Maize (*Zea mays* L) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. It is cultivated on nearly 150 m ha in about 160 countries having wider diversity of soil, climate, biodiversity and management practices that contributes 36 % (782 m t) in the global grain production. The United States of America (USA) is the largest producer of maize contributes nearly 35 % of the total production in the world and maize is the driver of the US economy. The USA has the highest productivity ($\geq$ 9.6 t ha^{-1}) which is double than the global average (4.92 t ha^{-1}). Whereas, the average productivity in India is 2.43 t ha^{-1}.

In India, maize is the third most important food crops after rice and wheat. According to advance estimate it is cultivated in 8.7 m ha (2010-11) mainly during *Kharif* season which covers 80% area. Maize in India, contributes nearly 9 % in the national food basket and more than Rs. 100 billion to the agricultural GDP at current prices apart from the generating employment to over 100 million man-days at the farm and downstream agricultural and industrial sectors. In addition to staple food for human being and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc.

Recent trends (2003-04 to 2008-09) in growth rate of area (2.6 %), production (6.4 %) and productivity (3.6 %) of maize in India has been of high order and experienced highest growth rate among the food crops. Since 1950-51, the area, production and productivity of maize have increased by more than 3.4, 12 and 4.5 times from 3.2 m ha, 1.7 m t and 547 kg ha^{-1} to current level of 8.17 m ha, 19.33 m t and 2414 kg ha^{-1}, respectively due to increasing maize demand for diversified uses. In India, the maize is used as human food (23%), poultry feed (51 %), animal feed (12 %), industrial (starch) products (12%), beverages and seed (1 % each). With the increasing trends of maize production, the projected demand of maize (22.73 m t) by the end of XIth five year plan (2011-12) will be achieved through improved maize production technologies focused on 'Single Cross Hybrids'.



Current maize utilization pattern

The maize is cultivated throughout the year in all states of the country for various purposes including grain, fodder, green cobs, sweet corn, baby corn, pop corn in peri-urban areas. The predominant maize growing states that contributes more than 80 % of the total maize production are Andhra Pradesh (20.9 %), Karnataka (16.5 %), Rajasthan (9.9 %), Maharashtra (9.1 %), Bihar (8.9 %), Uttar Pradesh (6.1 %), Madhya Pradesh (5.7 %), Himachal Pradesh (4.4 %). Apart from these states maize is also grown in Jammu and Kashmir and North-Eastern states. Hence, the maize has emerged as important crop in the non-traditional regions i.e. peninsular India as the state like Andhra Pradesh which ranks 5th in area (0.79 m ha) has recorded the highest production (4.14 m t) and productivity (5.26 t ha^{-1}) in the country although the productivity in some of the districts of Andhra Pradesh is more or equal to the USA.

2. Soils

Maize can be grown successfully in variety of soils ranging from loamy sand to clay loam. However, soils with good organic matter content having high water holding capacity with neutral pH are considered good for higher productivity. Being a sensitive crop to moisture stress particularly excess soil moisture and salinity stresses; it is desirable to avoid low lying fields having poor drainage and also the field having higher salinity. Therefore, the fields having provision of proper drainage should be selected for cultivation of maize.

3. Time of sowing

Maize can be grown in all seasons viz; *Kharif* (monsoon), post monsoon, *Rabi* (winter) and spring. During *Rabi* and spring seasons to achieve higher yield at farmer's field assured irrigation facilities are required. During *Kharif* season it is desirable to complete the sowing operation 12-15 days before the onset of monsoon. However, in rainfed areas, the sowing time should be coincided with onset of monsoon. The optimum time of sowing are given below.

Season	Optimum time of sowing
Kharif	Last week of June to first fortnight July
Rabi	Last week of October for inter cropping and up to 15th of November for sole crop
Spring	First week of February

4. Seed rate and plant geometry

To achieve higher productivity and resource-use efficiencies optimum plant stand is the key factor. The seed rate varies depending on purpose, seed size, plant type, season, sowing methods etc. The following crop geometry and seed rate should be adopted.

S. No.	Purpose	Seed rate (kg ha^{-1})	Plant geometry (plant x row, cm)	Plant population
1	Grain (normal and QPM)	20	60 x 20 75 x 20	83333 66666
2	Sweet corn	8	75 x 25 75 x 30	53333 44444
3	Baby corn	25	60 x 20 60 x 15	83333 111111
4	Pop corn	12	60 x 20	83333
5	Green cob (normal maize)	20	75 x 20	66666

			60 x 20	83333
6	Fodder	50	30 x 10	333333

5. Seed treatment

To protect the maize crop from seed and major soil borne diseases and insect-pests, seed treatment with fungicides and insecticides before sowing is advisable/ recommended as per the below given details.

Disease/insect-pest	**Fungicide/Pesticide**	**Rate of application (g kg^{-1} seed)**
Turcicum Leaf Blight,, Banded Leaf and Sheath Blight, Maydis Leaf Blight	Bavistin + Captan in 1:1 ratio	2.0
BSMD	Apran 35 SD	4.0
Pythium Stalk Rot	Captan	2.5
Termite and shoot fly	Imidachlorpit	4.0

6. Tillage and crop establishment

Tillage and crop establishment is the key for achieving the optimum plant stand that is the main driver of the crop yield. Though the crop establishment is a series of events (seeding, germination, emergence and final establishment) that depends on interactions of seed, seedling depth, soil moisture, method of sowing, machinery etc but, the method of planting plays a vital role for better establishment of crop under a set of growing situation. Maize is mainly sown directly through seed by using different methods of tillage & establishment but during winters where fields are not remain vacant in time (till November), transplanting can be done successfully by raising the nursery. However, the sowing method (establishment) mainly depends on several factors *viz* the complex interaction over time of seeding, soil, climate, biotic, machinery and management season, cropping system, etc. Recently, resource conservation technologies (RCTs) that include several practices viz. zero tillage, minimum tillage, surface seeding etc. had came in practice in various maize based cropping system and these are cost effective and environment friendly. Therefore it is very important that different situations require different sowing methods for achieving higher yield as described below:

(i) Raised bed (ridge) planting: Generally the raised bed planting is considered as best planting method for maize during monsoon and winter seasons both under excess moisture as well as limited water availability/rainfed conditions. Sowing/planting should be done on the southern side of the east-west ridges/beds, which helps in good germination. Planting should be done at proper spacing. Preferably, the raised bed planter having inclined plate, cupping or roller type seed metering systems should be used for planting that facilitates in placement of seed and fertilizers at proper place in one operation that helps in getting good crop stand, higher productivity and resource use efficiency. Using raised bed planting technology, 20-30 % irrigation water can be saved with higher productivity.

Moreover, under temporary excess soil moisture/water logging due to heavy rains, the furrows will act as drainage channels and crop can be saved from excess soil moisture stress. For realizing the full potential of the bed planting technology, permanent beds are advisable wherein sowing can be done in a single pass without any preparatory tillage. Permanent beds are more beneficial under excess soil moisture situations as the infiltration rate is much higher and crop can be saved from the temporary water logging injury.

(ii) Zero-till planting: Maize can be successfully grown without any primary tillage under no-till situation with less cost of cultivation, higher farm profitability and better resource use efficiency. Under such condition one should ensure good soil moisture at sowing and seed and fertilizers should be placed in band using zero-till seed-cum-fertilizer planter with furrow opener as per the soil texture and field conditions. The technology is in place with large number of farmers particularly under rice-maize and maize-wheat systems in peninsular and eastern India. However, use of appropriate planter having suitable furrow opener and seed metering system is the key of success of the no-till technology.

(iii) Conventional till flat planting: Under heavy weed infestation where chemical/herbicidal weed management is uneconomical in no-till and also for rainfed areas where survival of crop depends on conserved soil moisture, in such situations flat planting can be done using seed-cum-fertilizer planters.

(iv) Furrow planting: To prevent evaporative losses of water during spring season from the soil under flat as well as raised bed planting is higher and hence crop suffers due to moisture stress. Under such situation/condition, it is always advisable to grow maize in furrows for proper growth, seed setting and higher productivity.

(v) Transplanting: Under intensive cropping systems where it is not possible to vacate the field on time for planting of winter maize, the chances of delayed planting exists and due to delay planting crop establishment is a problem due to low temperature so under such conditions transplanting is an alternative and well established technique for winter maize. Therefore, for the situation where fields are vacated during December-January, it is advisable to grow nursery and transplant the seedlings in furrows and apply irrigation for optimum crop establishment. Use of this technique helps in maintenance of temporal

isolation in corn seed production areas for production of pure and good quality seed as well as quality protein maize grain. For planting of one hectare, 700 m^2 nursery area is required and the nursery should be raised during second fortnight of November. The age of seedlings for transplanting should be 30-40 days old (depending on the growth) and transplant in the month of December-January in furrows to obtain higher productivity.

7. Nutrient management

Among all the cereals, maize in general and hybrids in particular are responsive to nutrients applied either through organic or inorganic sources. The rate of nutrient application depends mainly on soil nutrient status/balance and cropping system. For obtaining desirable yields, the doses of applied nutrients should be matched with the soil supplying capacity and plant demand (Site-specific nutrient management approach) by keeping in view of the preceding crop (cropping system). Response of maize to applied organic manures is notable and hence integrated nutrient management (INM) is very important nutrient management strategy in maize based production systems. Therefore, for higher economic yield of maize, application of 10 t FYM ha^{-1}, 10-15 days prior to sowing supplemented with 150-180 kg N, 70-80 kg P_2O_5, 70-80 kg K_2O and 25 kg $ZnSO_4$ ha^{-1} is recommended. Full doses of P, K and Zn should be applied as basal preferably drilling of fertilizers in bands along the seed using seed-cum-fertilizer drills. Nitrogen should be applied in 5-splits as detailed below for higher productivity and use efficiency. N application at grain filling results in better grain filling. Therefore, nitrogen should be applied in five splits as per below mentioned for higher N use efficiency.

S. No	Crop Stage	Nitrogen rate (%)
1	Basal (at sowing)	20
2	V_4 (four leaf stage)	25
3	V_8 (eight leaf stage)	30
4	V_T (tasseling stage)	20
5	GF (grain filling stage)	5

Nutrient deficiencies in crops reduce yields, quality and profits to the farmer. Yield can often be reduced 10-30% by deficiencies of major nutrients before any clear symptoms of deficiency are observed in the field. The photographs of common nutrient deficiency symptoms in maize are given in Appendix II.

8. Water management

The irrigation water management depends on season as about 80 % of maize is cultivated during monsoon season particularly under rainfed conditions. However, in areas with assured irrigation facilities are available, depending upon the rains and moisture holding capacity of the soil, irrigation should be applied as and when required by the crop and first irrigation should be applied very carefully wherein water should not overflow on the ridges/beds. In general, the irrigation should be applied in furrows up to 2/3rd height of the ridges/beds. Young seedlings, knee high stage (V_8), flowering (V_T) and grain filling (GF) are the most sensitive stages for water stress and hence irrigation should ensured at these stages. In

raised bed planting system and limited irrigation water availability conditions, the irrigation water can also be applied in alternate furrow to save more irrigation water. In rainfed areas, tied-ridges are helpful in conserving the rainwater for its availability in the root zone for longer period. For winter maize, it is advisable to keep soil wet (frequent & mild irrigation) during 15 December to 15 February to protect the crop from frost injury.

9. Weed Management

Weeds are the serious problem in maize, particularly during *kharif* /monsoon season they competes with maize for nutrient and causes yield loss up to 35 %. Therefore, timely weed management is needed for achieving higher yield. Atrazine being a selective and broad-spectrum herbicide in maize checks the emergence of wide spectrum of weeds. Pre-emergence application of Atrazine (Atratraf 50 wp, Gesaprim 500 fw) @ of 1.0-1.5 kg a.i ha^{-1} in 600 litre water, Alachlor (Lasso) @ 2-2.5 kg a.i ha^{-1}, Metolachlor (Dual) @ 1.5-2.0 kg a.i ha^{-1}, Pendamethalin (Stomp) @ 1-1.5 kg a.i. ha^{-1} are effective way for control of many annual and broad leaved weeds. While spraying, following precautions should be taken care by the person during spray, he should move backward so that the Atrazine film on the soil surface may not be disturbed. Preferably three boom flat fan nozzle should be used for proper ground coverage and saving time. One to two hoeing are recommended for aeration and uprooting of the remaining weeds, if any. While doing hoeing, the person should move backward to avoid compaction and better aeration. For areas where zero tillage is practiced, pre-plant application (10-15 days prior to seeding) of non-selective herbicides viz., Glyphosate @ 1.0 kg a.i. ha^{-1} in 400-600 litre water or Paraquat @ 0.5 kg a.i. ha^{-1} in 600 litre water is recommended to control the weeds. Under heavy weed infestation, post-emergence application of Paraquat can also be done as protected spray using hoods.

The photographs of the common weed flora in maize are given in Appendix III.

10. Crop protection

A. Insect-pest management

i. Stem Borer (*Chilo partellus*)

Major pest of maize in India is Stalk borer. *Chilo partellus*, popularly known as stalk borer that occurs during monsoon season is a major pest throughout the country. *Chilo* lays eggs 10-25 days after germination on lower side of the leaves. The larva of the *Chilo* enters in the whorl and cause damage in the leaves

ii. Pink Borer (*Sesamia inference*)

Sesamia inference occurs during winter season particularly in peninsular India. The moth of the *Sesamia* is nocturnal and lays eggs on lower leaf sheath. The larvae of the *Sesamia* enter the plant near the base and cause damage to stem.

Control of *Chilo and Sesamia*: For control of *Chilo and Sesamia*, foliar spray of 0.1 % Endosulfan {700 ml (35 EC) in 250 litre water} 10 days after germination is very effective. The *Chilo* can also be controlled by release of 8 Trichocards (*Trichogramma chilonis*) per hectare at 10 days after germination. Intercropping of maize with suitable varieties of cowpea is an eco-friendly option for reducing the incidence of *Chilo* on maize.

iii. Shoot fly *(Atherigona* sp.)

In South India it is a serious pest but it also appears on spring and summer maize crop in North India. It attack mainly at seedling stage of the crop. The tiny maggots creep down under the leaf sheaths till they reach the base of the seedlings. After this they cut the growing point or central shoot which results in to dead heart formation.

Control of Shootfly:

- Sowing must be completed before first week of February so that the crop will escape shootfly infestation.
- Spring sowing must be accompanied with seed treatment with Imidacloprid @ 6ml/kg seed.

iv. Termites *(Odontotermes obesus*)

Termite is also an important pest in many areas. For control of termite fepronil granules should be applied @ 20 kg ha^{-1} followed by light irrigation. If the termite incidence is in patches, than spot application of fepronil @ 2-3 granuled/plant should be done. Clean cultivation delays termite attack.

v. Other emerging pests:

Recently some other non-traditional pests are also causing damage to maize crop viz. larvae of American Bollworm (*Helicoverpa armigera*) which causes damage to cob in Southern part of India while the Chaffer beetle (*Chiloloba acuta*) feeds on maize pollen which adversely affects pollination in northern part of India.

American bollworm

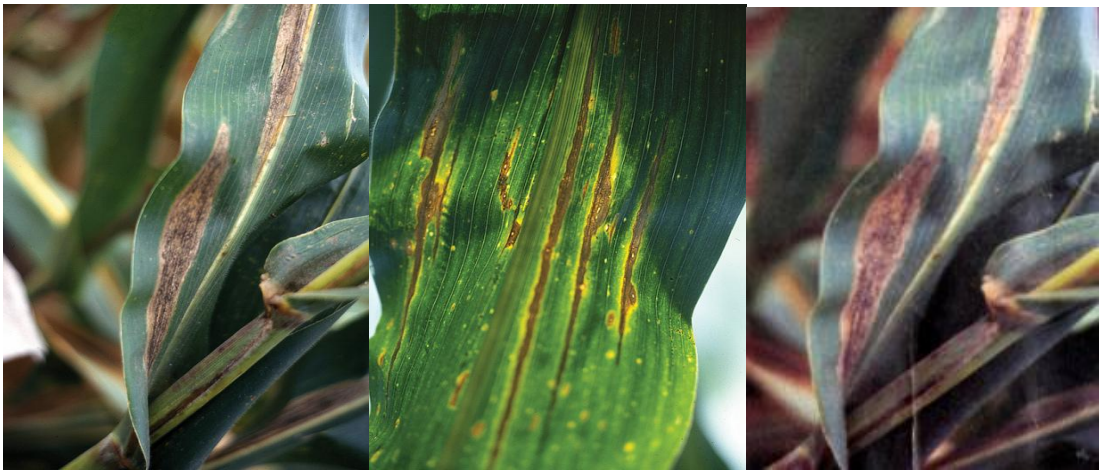
Chaffer beetle

B. Disease management

Across the country several diseases occurs during different seasons, if they are not managed at proper time than they leads to yield loss. Estimated losses due to major diseases of maize in India is about 13.2% of which foliar diseases (5 %), stalk rots, root rots, ear rots (5 %) cause major yield losses. The major diseases and their management practices are described as below:

i. Turcicum leaf blight (TLB)

This disease is distributed in Jammu & Kashmir, Himachal Pradesh, Sikkim, West Bengal, Meghalaya, Tripura, Assam, Uttar Pradesh, Uttarakhand, Bihar, Madhya Pradesh, Gujarat, Karnataka and Tamil Nadu. At its appearance, it shows long, elliptical, grayish-green or tan lesions ranging from 2.5 to 15 cm in length on the leaves. For control of TLB, spray Zineb/Meneb @ 2.5-4.0 g/liter of water (2- 4 applications) at 8-10 days interval. The crop debris should be ploughed down. Also, the resistant cultivars should be grown.



ii. Maydis leaf blight (MLB)

MLB also occurs in wide range of maize growing states like Jammu & Kashmir, Himachal Pradesh, Sikkim, Meghalaya, Punjab, Haryana, Rajasthan, Delhi, Uttar Pradesh, Bihar, Madhya Pradesh, Gujarat, Maharashtra, Andhra Pradesh, Karnataka & Tamil Nadu. It shows the symptoms as lesions on the leaves elongated between the veins, tan, 2-6 x 3-22 mm with limited margins with buff to brown borders. For effective control of this disease, spray of Dithane Z-75 or Zineb @ 2.4 – 4.0 g/liter of water (2-4 applications) at 8-10 days interval after first appearance of symptoms of disease. In addition, the crop debris should be ploughed down. Also, the resistant cultivars should be grown.

iii. Polysora Rust

This disease appears mainly in peninsular India i.e Andhra Pradesh, Karnataka and Tamil Nadu. The main symptoms of the disease shows appearance of circular to elongate light cinnamon brown, circular to oval 0.2-2.0 mm long densely scattered legions on the upper leaf. The uredospores are yellowish to golden in colour. For effective control of polysora rust, three sprays of Dithane M-45 @ 2-2.5 gm/liter beginning from first appearance of symptoms at 15 days interval are required. It is always advisable to use resistant varieties.

iv. Banded leaf and sheath blight (BLSB)

This disease mainly occurs in Jammu and Kashmir, Himachal Pradesh, Sikkim, Punjab, Haryana, Rajasthan, Madhya Pradesh, Delhi, Uttar Pradesh and Bihar. At appearance of the disease, white lesions develops on leaves and sheath. Purplish or brown horizontal bands present on white lesions characterize the disease. Seed treatment with peat based formulation (*Pseudomonas fluorescence)* @ 16 g/kg of seed or as soil application @ 7g/liter of water (soil drenching) or foliar spray of Sheethmar (Validamycin) @ 2.7 ml /liter water provides effective control of the disease. Stripping of 2 lower leaves along with leaf sheath also gives effective control of the disease.

v. Post Flowering Stalk Rot of Maize (PFSR)

The PFSR occurs mainly in Rajasthan, Uttar Pradesh, Bihar and Andhra Pradesh. Disease appears when the crop enters in senescence phase. The pathogen commonly affects the roots crown regions and lower internodes. When split open, the stalk shows pink-purple dis-colouration. For effective control of the disease, water stress at flowering should be avoided. Use balance dose of nutrients wherein potassium application helps in minimizing the disease. Use of bio-control agents (*Trichoderma* formulation) in furrows mixed with FYM @ 10g/kg at 10 days prior to its use in the field. It always advisable to practice crop rotation to minimize the disease incidence.

vi. Downy mildews (DM)

Himachal Pradesh, Sikkim, West Bengal, Meghalaya, Punjab, Haryana, Rajasthan, Delhi, Uttar Pradesh, Bihar, Madhya Pradesh and Gujarat are prone to downy mildews. The main symptoms of downy mildew are legends developing on lower leaves as narrow chlorosis strips. Strips extend in parallel fashion, well defined margined delimited by veins. Downy whitish to creamy growth usually on the ventral surface of the infected leaves appears corresponding to stripes. For control of downy mildew, the infected plants should be rogue out and destroyed. The planting of crop before onset of rains minimizes the incidence of mildew. Seed treatment with fungicides like Apron 35 WS @ 2.5 g/kg seed. Also the resistant varieties should be used.

11. Maize based cropping systems in India

As maize has wide adaptability and compatibility under diverse soil and climatic conditions and hence it is cultivated in sequence with different crops under various agro-ecologies of the country. Hence, it is considered as one of the potential driver of crop diversification under different situation. Among different maize based cropping systems, maize-wheat ranks 1st having 1.8 m ha area mainly concentrated in rainfed ecologies. Maize-wheat is the 3rd most important cropping systems after rice-wheat and rice-rice that contributes about 3 % in the national food basket. The other major maize systems in India are maize-mustard, maize-chickpea, maize-maize, cotton-maize etc. Recently, due to changing scenario of natural resource base, rice-maize has emerged a potential maize based cropping system in peninsular and eastern India. In peri-

urban interface, maize based high value intercropping systems are also gaining importance due to market driven farming. Further, maize have compatibility with several crops of different growth habit that led to development of various intercropping systems. Studies carried out under various soil and climatic conditions under All India Coordinated Research Project on Cropping Systems revealed that compared to existing cropping systems like rice-wheat and rice-rice, maize based cropping systems are better user of available resources and the water use efficiency of maize based cropping systems was about 100 to 200 % higher at different locations.

Table 1. Maize based sequential cropping systems in different ago-climatic zones of India

Agro-climatic region	Cropping system	
	Irrigated	Rainfed
Western Himalayan Region	Maize-wheat Maize-potato-wheat Maize-wheat-greengram Maize-mustard Maize-sugarcane	Maize-mustard Maize-legumes
Eastern Himalayan Region	Summer rice-maize-mustard Maize-maize Maize-maize-legumes	Sesame-Rice+maize
Lower Gangetic Plain region	Autumn rice-maize Jute-rice-maize	Rice-maize
Middle Gangetic Plain region	Maize-early potato-wheat-mungbean Maize-wheat Maize-wheat-mungbean Maize-wheat-urdbean Maize-sugarcane-mungbean	Maize-wheat
Upper Gangetic Plain region	Maize-wheat Maize-wheat-mungbean Maize-potato-wheat Maize-potato-sunflower Maize-potato-onion Maize-potato-sugarcane-ratoon Rice-potato-maize	Maize-wheat Maize-barley Maize-safflower
Trans Gangetic Plain region	Maize-wheat Maize-wheat-mungbean Maize-potato-wheat Maize-potato-sunflower Maize-potato-onion Mungbean-maize-toria-wheat Maize-potato-mungbean	Maize-wheat
Eastern plateau & hills region	Maize-groundnut-vegetables Maize-wheat-vegetables	Rice-potato-maize Jute-maize-cowpea
Central plateau & hills region	Maize-wheat	Maize-groundnut
Western plateau & hills region	Sugarcane + Maize	
Southern plateau & hills region	Rice-maize	Sorghum-maize

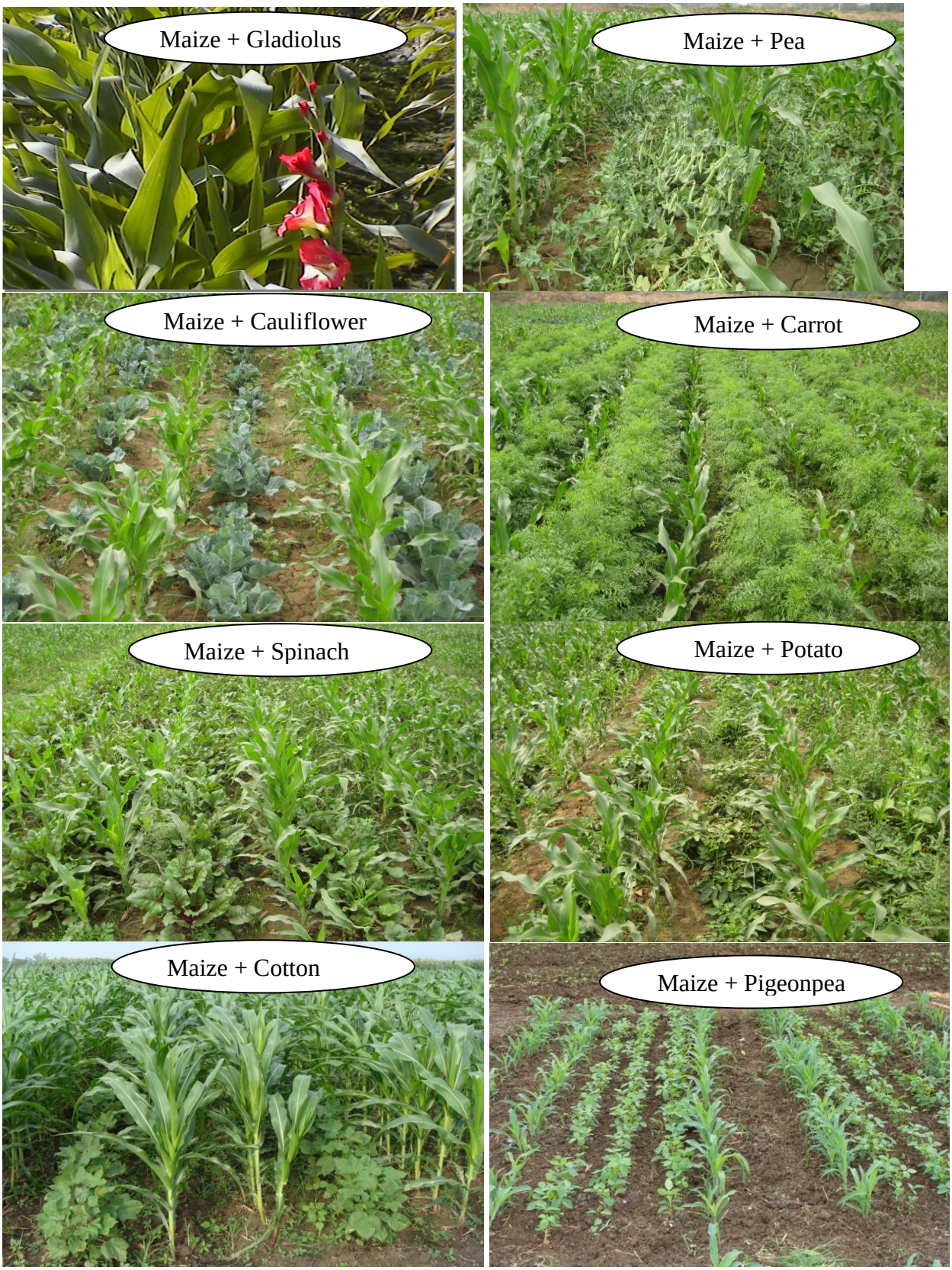
	Maize-rice	Maize-sorghum-Pulses Maize-potato-groundnut
East coast plain and hills region	Rice-maize-pearlmillet Maize-rice Rice-maize Rice-rice-maize	Maize-maize-pearlmillet Rice-maize + cowpea
West coast plain and hills region	Maize-pulses Rice-maize	Rice-maize Groundnut-maize
Gujrat plains and hills region	Maize-wheat	Rice-maize
Western dry region	Maize-mustard Maize-chickpea	Maize+legumes
Island region	Rice-maize	Maize-rice Rice-maize + cowpea Rice-maize-urdbean Rice-rice-maize

Table 2 Maize based intercropping systems

Intercropping systems	Suitable area/situation
Maize + Pigeon pea Maize + Cowpea Maize + Mungbean Maize + Urdbean Maize + Sugarcane Rice + Maize Maize + Soybean	All maize growing areas
Maize + high value vegetables Maize + flowers Baby corn + vegetables Sweet corn + vegetables	Peri-urban interface

12. Maize and climate change

Under the changing climate scenario the limitations of rising temperature during grain filling of wheat particularly in eastern India, and declining yield of boro rice in West Bengal and Orissa, water scarcity areas in peninsular India (AP and Tamil Nadu) affecting yield of *Rabi* rice, maize being a photo-insensitive crop has better options for adaptation and mitigation of these climatic changes. Peninsular India is considered to be a neutral environment for maize wherein maize can be cultivated in either of the seasons. Therefore, it is emerging as a potential driving force for diversification i.e. diversification of rice-rice with rice-maize and other maize based high value cropping systems in water scarcity/lowering of water table is a major concern in rice growing belt of India and making rice cultivation non-remunerative. Hence, maize has emerged as a potential as well as profitable crop in these areas. The rabi rice in Peninsular India and upland rice in Odisha and NEH region has low productivity. Therefore maize is only suitable alternative crop and more area is likely to shift towards maize cultivation in near future in these non-traditional areas. Wheat crop adversely affected with terminal heat due to sudden rise in temperature during crop growth and maturity but this favours maize crop positively.



Maize based intercropping systems

Therefore, in view of the changing farming scenario in the country, maize has been emerging as one of the potential crops that addresses several issues like food and nutritional security, climate change, water scarcity, farming systems, bio-fuel etc. Further, a recent study by National Centre for Agricultural Economics and Policy Research (NCAP) has showed that there is an increasing demand for maize in the industry sector which caters to consumer needs like textiles, paper, glue, alcohol, confectionery, food processing and pharmaceutical industry etc., of which the demand keeps on increasing with population pressure.

13. Quality Protein Maize, Specialty and other Corn types production technology

Other than grain, maize is also cultivated for various purposes like quality protein maize and other special purposes known as 'Specialty Corn'. The various specialty corn types are quality protein maize (QPM), baby corn, sweet corn, pop corn, waxy corn, high oil corn etc. In India, QPM, baby corn and sweet corn are being popularized and cultivated by the large number of farmers. The brief summary of different type of specialty maize is as follows –

i. Quality Protein Maize

As more than 85 % of the maize is used directly for food and feed, the quality has a great role for food and nutritional security in the country. In this respect, discovery of Opaque-2 (O2) and floury-2 (F2) mutant had opened tremendous possibilities for improvement of protein quality of maize which later led to the development of "Quality Protein Maize (QPM). QPM which is nutritionally superior over the normal maize is the new dynamics to signify its importance not only for food and nutritional security but also for quality feed for poultry, piggery and animal sectors as well. Quality Protein Maize has specific features of having balanced amount of amino acids with high content of lysine and tryptophan and low content of leucine & isoleucine. The balanced proportion of all these essential amino acid in Quality Protein Maize enhances the biological value of protein. The biological value of protein in QPM is just double than that of normal maize protein which is very close to the milk protein as the biological value of milk and QPM proteins are 90 and 80 % respectively. Whereas it is less than 50 % in normal maize protein. There are 9 QPM hybrids of different grain colours have been developed and relased in India for their cultivation in different agro-climatic conditions across the country. The production technology of QPM is same as of normal grain maize except isolation as to maintain the purity of QPM, it should be grown in isolation with normal maize.

ii. Baby corn

Baby corn is a young finger like unfertilized cobs with one to three centimeter emerged silk preferably harvested within 1-3 days of silk emergence depending upon the growing season. It can be eaten raw as salad and in preparation of different recipes such as chutney, pakora, mix vegetables, pickles, candy, murabba, kheer, halwa, raita, Chinese preparations, etc. The desirable size of baby corn is 6 to 11 cm length and 1.0 to 1.5 cm diameter with regular row/ ovule arrangement. The most preferred colour by the consumers / exporters is generally creamish to very light yellow. Baby corn is nutritive and its nutritional quality is at par or even superior to some of the seasonal vegetables. Besides proteins, vitamins and iron, it is one of the richest sources of phosphorus. It is a good source of fibrous protein and easy to digest. It is

almost free from residual effects of pesticides. It can be cultivated round the year therefore, three to four crops of baby corn can be taken in a year. Cost of cultivation of baby corn in India is lowest in the world therefore; India can become one of the major baby corn producing country. It has great potential both for internal consumption and export.

In general, the cultivation practices of baby corn are similar to grain crop except (i) higher plant population (ii) higher dose of nitrogen application because of higher plant population (iii) preference for early maturing single cross hybrid and (iv)harvesting within 1-3 days of silk emergence.

iii. Sweet corn

Sweet corn is one of the most popular vegetables in the USA, Europe and other developed countries of the world. It is a very delicious and rich source of energy, vitamin C and A. It is eaten as raw, boiled or steamed green cobs/ grain. It is also used in preparation of soup, salad and other recipes. It is becoming very popular in urban areas of country therefore, its cultivation is remunerative for peri-urban farmers. Besides green cobs the green fodder is also available to the farmers for their cattle. Generally sweet corn is early in maturity. It is harvested in 70-75 days during kharif season. Green cobs are harvested after 18-20 days of pollination during kharif but the duration may varies season to season. At the harvest time the moisture is generally 70 % in the grain and sugar content varies from 11 to more than 20 %.

Color: Sweet corn is generally dull yellow and white but dull yellow color is preferred.

Precaution: Its picking should be done in the morning or evening time. Green cobs should be immediately transported to the cold storage in refrigerated trucks to avoid the conversion of sugar to starch. It loses flavor if kept in high temperature after picking.

Sweet corn with high sugar content should not be planted when temperature is below 16^{o}C.

iv. Pop Corn

Popcorn is one of the common snack items in many parts of the world, particularly in cities and is liked because of its light, porous and crunchy texture. The popcorn flour can also be used for preparing many traditional dishes.

It is consumed fresh, as it has to be protected against moisture absorption from the air. It is hard endosperm flint maize. Kernels of pop corn are very small and oval/round in shape. When heated at about 170^{0}C, the grains swell and burst, turning inside out. Quality of pop corn depends on popping volume and minimum number of non pop corn.

v. Waxy corn

It is originated in China but largely used in USA. Grain gives wax-like appearance and having 100 **%** amylopectin starch**.** While in normal maize, the starch is nearly 30 percent amylose and the remaining 70 % is amylopectin. Waxy corn is mainly used for food and industrial purposes.

vi. High oil corn

Most of the normal maize lines have 3- 4 % oil content. In general, lines with more than 6 % oil are considered high oil lines. 95 % of the total oil is in the germ. When the oil percent increases the starch decreases. The wet milling industries are still in advantage with high oil content corn. In USA the high oil corn is cultivated on contractual basis and remunerative price is paid to the farmers. In India its cultivation is not economical because it is not sold on premium basis. Generally in normal maize crop, 15-20 % population of high oil hybrids is used as pollen parent and there is detasseling of the normal corn plant. Due to xenia effect there is an increase of oil in normal maize and its cultivation is done in isolation. The corn oil has low content of saturated fatty acid and is considered to be one of the best quality cooking oil. In India more than 60000 tonnes of corn oil is made available for various uses.

vii. Fodder maize

Maize fodder can be used at any crop growth stage. Its quality is adversely affected after anthesis. To maintain the fodder quality the detasseling is advised to the farmers for better digestibility and palatability. By grazing this fodder to the milch cattle, their milk is increased. The tall, leafy and longer duration cultivars are most preferred for maize fodder cultivation. The cultivation of maize for fodder can be done round the year. Very high seed rate is used. Generally the farmers grow composite varieties or advance generation of hybrid seed which is economical to the farmers.

Table 3 Quality Protein Maize, specialty and other corn type cultivars

S. No.	Corn type	Cultivars
1	Quality Protein Maize	H*:HQPM 1 & HQPM 5 (all states of India), HQPM 7, Vivek QPM 9 (Peninsular India), C**:Shaktiman1,2,3& 4 (Bihar)
2	Baby corn	H:HM-4, C: VL Baby Corn 1
3	Sweet corn	H:HSC1 for J&Kand HP C:Madhuri, Win orange, Priya
4	Pop corn	C: Jawahar, Amber, Pearl &VL pop corn
5	Fodder	C: African tall, J 1006 & Pratap chari-6

*H=hybrid and **C=composite

14. Single Cross Hybrid Maize Seed production

i. Isolation Distance

Seed production should be taken in fertile well drained, weed and disease free soil and preferably the fields where preceding crop was not maize to minimize rouging and maintain the genetic purity. At least 400-500 metre distance is required to avoid any contamination.

ii. Male: female ratio

The male: female ratio depends on (a) pollen shedding potential and duration of male parent; (b) male: female synchrony : for better seed setting flowering of female should be earlier than male or male pollen dehiscence should coincide with female silking and (c) season. In general the male: female ratio should be 1:2 or 1:3 or 1:4.

iii. Time of Sowing

To avoid flowering from heavy rains during *kharif* and low/high temperature during winter season the optimum time of sowing is first week of July during *kharif* and first week of November during winter.

iv. Method of sowing and layout

It is desirable to plant the crop on ridges. Depending upon the plant type the row and plant spacing should be kept at 60-75 cm and 20 cm, respectively. Identification labels/ tags should be put on the male and female lines to distinguish between them.

v. Seed Rate

The seed rate depends on size of seed/ test weight, plant type and male: female ratio. 15 kg ha^{-1} for female and 10 kg ha^{-1} for male is recommended.

vi. Removal of off-type plants and thinning

i) After 12-15 days of sowing: off-type and excess plants should be removed. Proper plant to plant distance should be maintained

ii) At knee high stage all the dissimilar plants should be removed.

iii) At flowering remove dissimilar tassel bearing plant before anthesis from the male.

vii. Detasseling

- Detasseling in female should be done before anthesis.
- It should be practiced row-wise.
- One person should follow to monitor the each row to check that no part of the tassel is left inside.
- The process of detasseling should continue for 8-10 days.
- While detasseling, leaf should not be removed which will reduce the yield. It has been observed that the removal of 1 to 3 leaves along with tassel reduces 5-15 % yield.
- The removed tassel should not be thrown in the field but fed to the cattle as it is nutritive fodder.

viii. Harvesting

If possible male parent should be harvested after pollination. Optimum moisture content in grain at harvesting should be around 20 %. The harvested cobs should spread evenly instead of making heap.

ix. Stages of crop inspection

- At the time of sowing: to monitor the land, isolation distance, planting ratio of male: female, proper sowing time, seed treatment
- During pre-flowering/vegetative stage: to verify the rouging and removal of off type plants
- During flowering stage: to check disease and pest infestation
- During post-flowering and pre-harvest stage: to remove the late and diseased plants
- Differential type of tassel/silk plants
- Harvesting time: to see the proper time of harvesting

x. Drying and sorting of seed parent cobs

The drying of the cobs should not be done either on the kuccha or pucca flour, rather it should be dried on tarpoline sheets to avoid seed injury and during night the cobs should be kept covered. To maintain the purity, dissimilar, diseased and pest infested cobs should be removed before shelling. The female cobs should be dried up to 13-14 % moisture content before shelling.

xi. Shelling

Shelling of female parent should be done earlier than male to avoid mechanical mixture**.** Shelling can be done manually or by power operated maize Sheller.

xii. Seed processing:

All under size, broken, damaged etc seeds should be removed for maintaining the quality of seed.

xiii. Storage and marketing

Seed drying should be done till the moisture content of the seed is reduced to 8 % and it should be kept in aerated jute bags. Seed should be stored at cool and dry place preferably in cold storage. Poor storage conditions will lead to loss of vigour and poor germination. Marketing should be done with specifications and standards.

15. Value addition

Value addition in maize has a great potential and there are several value added products of maize particularly QPM and baby corn that not only increase the farm income but also provides employment to rural youth and farm women. Value added products developed using normal maize, QPM are:

- Baked products: Bread and cake
- Extruded products: Vermicelli and pasta
- Convenience foods: Instant idli and dhokla mix, porridge mix and sprouted chaat
- Popped products: Popcorn and popped laddoo
- Traditional products: Laddoo, halwa, Kheer, chapatti, sev, mathi, pakora and cheela

A wide range of products from baby corn have been developed as mentioned below:

- Sweet Products: Halwa, kheer, barfi
- Preserved Products: Jam, chutney, pickle, candy, murrabba
- Chinese Products: Soup, manchurian, babycorn chilly, chowmein sweet and sour vegetables
- Traditional Products: Pakoda, cutlet, chaat, salad,dry vegetables, kofta, mixed vegetable, raita

Appendix I. Maize varieties of different maturity suitable for various states and seasons

A. List of hybrids (H) and composites(C) varieties of different maturity groups for different states for *kharif* season

States	Extra early maturity	Early maturity	Medium maturity	Late maturity
Delhi	H:Vivek 17 &21, PMH 2	H:PAU 352, PEH 3, Parkash, X 3342	H:HM4, HM 8 10, DK 701	H:PMH 3, Buland, NK 61, Pro 311, Bio 9681, Seed Tech 2324
Punjab	H:Vivek 17& 21, PEEH 5	H:PAU 352, PEH 3, JH 3459, Parkash, PMH 2, X 3342	H:HM4, HM 8& 10, DK 701	H:PMH 3, PMH-1 , Buland, Pro 311, Bio 9681 , NK 61, Pro 311, Seed Tech 2324
Haryana	H:Vivek 17 &21, PMH 2, PEEH 5	H:HHM 1,PAU 352, Pusa Early Hybrid 3, JH 3459 Parkash, X 3342	H:HM 2, HM 4,8 &10 DK 701	H:PMH 3, Buland, ,HM 5, NK 61, Pro 311, Bio 9681, Seed Tech 2324
Uttar Pradesh	H:Vivek 5, 15, 17, 21 & 27 PMH 2,	H: JH 3459, Parkash,PEH 2, X 3342 C: Pusa Composite 4,	H:HM 8& 10, Malviya hybrid makka 2, Bio 9637 ,DK 701	H:PMH 3, Buland, Pro Agro 4212, Pro 311, Bio 9681, NK 61,Seed Tech 2324
Rajasthan	H:Pratap hybrid 1, Vivek 4 & 17,	H: PEHM 2 ,Parkash ,Pro 368, X 3342 C: Pratap Makka 3, Aravali Makka 1, Jawahar Makka 8,Amar, Azad Kamal, Pant Sankul Makk 3,	H: HM 10, NK 21 C: Pratap Makka 5	H: Trishulata, Pro 311, Bio 9681, Seed Tech 2324
Madhya Pradesh	H:Vivek 4 & 17	H: PEHM 2, Parkash, Pro 368, X 3342 C: Jawahar Makka 8, Jawahar composite 12, Amar, Azad Kamal, Pant Sankul Makka 3, Chandramani, Pratap Makka 3	H: HM 10, NK 21 C: Pratap Makka 5	H: Trishulata , Pro 311, Bio 9681, Seed Tech 2324
Gujarat	H:Vivek 4 &17	H: PEHM 2, Parkash, Pro 368, X 3342 C: Jawahar Makka 8,Pant Sankul Makka 3, Pratap Makka 3, G M 2,4 & 6 Aravali Makka 1, Narmada Moti	H: HM 10, NK 21 C: Pratap Makka 5	H:Trishulata , Pro 311, Bio 9681, Seed Tech 2324 C: G M 3,
Andhra Pradesh	H:Vivek 9, 15, 17& 27, PEEH 5	H:PEHM 1, PEHM 2, DHM 1, BH- 2187, Parkash, JKMH 1701, X 3342	H:HM 8& 10, DHM111,DHM117	H:DHM113,Kargil 900 M, Seed Tech 2324, Pro 311, Bio 9681, Pioneer 30 v 92, Prabal, 30 V 92,
Tamil Nadu	H:Vivek 9, 15, 17, 21& 27, PEEH 5	H:PEHM 2 , Parkash, X 3342 JKMH 1701	H:HM 8& 10, COHM 4	H:COHM 5, Prabal , Pro 311, Bio 9681, Seed Tech 2324, 30 V 92,
Maharashtra	H:Vivek 9, 15,17, 21& 27, PEEH 5	H: PEHM 1& 2, Parkash, X 3342 , JKMH 1701	H:HM 8& 10	H: Prabal, Pro 311, Bio 9681, Seed Tech 2324, 30 V 92,
Karnataka	H:Vivek 9, 15, 21& 27, PEEH 5	H: PEHM 2 , Parkash, X 3342 JKMH 1701 C: NAC 6002	H:HM 8& 10	H:Nithya Shree,EH434042, DMH 1, DMH 2, Bio 9681, Prabal, Pro 311, Seed Tech 2324 C: NAC 6004, 30 V 92

States	Extra early maturity	Early maturity	Medium maturity	Late maturity
Jammu & Kashmir	H: Vivek 15, 21, 25 &33, PEEH 5 C: Pratap Kanchan 2, Shalimar KG 1 & 2,Vivek 35,and 37	H: Vivek 33, Parkash, JKMH 1701, X 3342 C: C 8,14 & 15	H: HM 10 C: C 6	-
Uttarakhand	H: Vivek 5, 9, 21& 25 PEEH 5 C: Pratap Kanchan 2,Vivek 35 and 37	H:Vivek hybrid 33, Vivek hybrid 23, Parkash	H: HM 10 C: Bajaura Makka	-
Bihar	H: Vivek 27 C: D 994	H: Parkash, X 3342 C: Dewaki, Birsa Vikas Makka 2	H:HM 9, Malviya hybrid makka 2	H: Pro 311, Bio 9681, Seed Tech 2324, 30 V 92, 900 M C: Hemant, Suwan & Lakshmi
Jharkhand	H: Vivek 27 C: D 994,	H: Parkash, X 3342 C: Dewaki, B V M 2, B M 1	H:HM 9, Malviya hybrid makka 2, DK 701	H: Pro 311, Bio 9681, Seed Tech 2324 C: Suwan
Orissa	H: Vivek 27 C: D 994,	H: Parkash, HIM 129, X 3342	H:HM 9, Malviya hybrid makka 2, DK 701, DMH 115, Pro 345	H: , Pro 311, Bio 9681, Seed Tech 2324 , PAC 705
West Bengal	H:Vivek 27	H: Parkash, X 3342	H:Malviya hybrid Makka 2	H: Pro 311, Bio 9681, Seed Tech 2324
Himachal Pradesh	H:Vivek 15, 21& 25, PEEH 5	H: Parkash, X 3342	C: Bajaura Makka, Pratap Makka 4	H: Pro 311, Bio 9681, Seed Tech 2324
NEH Region	H:Vivek 21& 25, PEEH 5	H: Parkash , JKMH 1701, X 3342	C: Pratap Makka 4	H: Pro 311, Bio 9681, Seed Tech 2324 C: NLD white
Chhattisgarh	H:Vivek 27	H: Parkash, X 3342	C: Pratap Makka 5	H:PEHM 1, Pioneer 30 V 92 & 30 R 26, Bio 9681, Pro 4640 & 4642,
Assam	-	H:Parkash, X 3342	H: DK 701 C: Pratap Makka 4	C: Vijay ,NLD white,

B. List of hybrids (H) and composites (C) varieties of late maturity groups for different states for *rabi* season

STATES	Late maturity
Delhi	H: PMH 3, Buland, NK 61, Pro 311, Bio 9681, Seed Tech 2324,HM11,HM8
Punjab	H: PMH 3, PMH-1 , Buland, Sheetal , Pro 311, Bio 9681 , NK 61, Pro 311, Bio 9681, Seed Tech 2324,HM11,HM8
Haryana	H: PMH 3, Buland, ,HM 5, NK 61, Pro 311, Bio 9681, Seed Tech 2324,HM11,HM2,HM1,HM8
Uttar Pradesh **Rajasthan**	H: PMH 3, Buland, Pro Agro 4212, Pro 311, Bio 9681, NK 61,Seed Tech 2324,HM8 H: Pro 311, Bio 9681, Seed Tech 2324, HM8
M.P.	H: Pro 311, Bio 9681, Seed Tech 2324
Gujarat	H: Pro 311, Bio 9681, Seed Tech 2324 C: G M 3, Ganga safed 2
Andhra Pradesh	H: The late maturing hybrids of Kharif e.g. Kargil 900 M, Seed Tech 2324, Pro 311, Bio 9681, Pioneer 30 v 92, Prabal, 30 V 92, 900 M
Tamil Nadu	H: COHM 5, Prabal , Pro 311, Bio 9681, Seed Tech 2324, 30 V 92, 900 M
Maharashtra	H: Prabal, Pro 311, Bio 9681, Seed Tech 2324, 30 V 92, 900 M
Karnataka	H: Nithya Shree, DMH 1, DMH 2, 900 M, Bio 9681, Prabal, Pro 311, Bio 9681, Seed Tech 2324 C: NAC 6004, 30 V 92
Jammu & Kashmir	-
Uttarakhand	-
Bihar	H: Rajendra Hybrid 2, Rajendra Hybrid 1, Pro 311, Bio 9681, Seed Tech 2324, 30 V 92, 900 M C: Hemant, Suwan & Lakshmi
Jharkhand	H: Pro 311, Bio 9681, Seed Tech 2324 C: Suwan
Orissa	H: Pro 311, Bio 9681, Seed Tech 2324 , PAC 705
West Bengal	H: Pro 311, Bio 9681, Seed Tech 2324
Himachal Pradesh	H: Pro 311, Bio 9681, Seed Tech 2324
NEH Region	H: Pro 311, Bio 9681, Seed Tech 2324 C: NLD white
Chhattisgarh	H: PEHM 1, Pioneer 30 V 92 & 30 R 26, Bio 9681, Pro 4640 & 4643, 900 M
Assam	C: NLD white,

C. List of hybrids (H) and composites(C) varieties of different maturity groups for different states for *spring* season

States	Extra early maturity	Early maturity
Delhi	H:Vivek 17 &21, PMH 2	H: PAU 352, PEH 3, Parkash, X 3342
Punjab	H:Vivek 17& 21, PEEH 5	H:PAU 352, PEH 3, JH 3459, Parkash, PMH 2, X 3342
Haryana	H:Vivek 17 &21, PMH 2, PEEH 5	H: HHM 1,PAU 352, Pusa Early Hybrid 3, JH 3459 Parkash, X 3342
Uttar Pradesh	H: Vivek 5, 15, 17, 21 & 27 PMH 2,	H: JH 3459, Parkash,PEH 2, X 3342, C: Pusa Composite 4, Gaurav, Azad Uttam, Surya, Kiran, Tarun
Rajasthan	H:Pratap hybrid 1, Vivek 4 & 17,	H: PEHM 2 ,Parkash ,Pro 368, X 3342 C: Pratap Makka 3, Aravali Makka 1, Jawahar Makka 8, Amar, Azad Kamal, Pant Sankul Makk 3, Mahi Kanchan, Mahi Dhawal
M.P.	H: Vivek 4 & 17	H: PEHM 2, Parkash, Pro 368, X 3342 C: Jawahar Makka 8, Jawahar composite 12, Amar, Azad Kamal, Pant Sankul Makk 3, Chandramani, Pratap Makka 3
Gujarat	H: Vivek 4 &17	H: PEHM 2, Parkash, Pro 368, X 3342 C: Jawahar Makka 8,Pant Sankul Makka 3, Pratap Makka 3, G M 2,4 & 6 Aravali Makka 1, Narmada Moti
Andhra Pradesh	H: Vivek 9, 15, 17& 27, PEEH 5	H:PEHM 1, PEHM 2, DHM 1, BH- 2187, Parkash, JKMH 1701, X 3342
Tamil Nadu	H: Vivek 9, 15, 17, 21& 27, PEEH 5	H: PEHM 2 , Parkash, X 3342
Maharashtra	H:Vivek 9, 15,17, 21& 27, PEEH 5	H: PEHM 1& 2, Parkash, X 3342 , C:, JKMH 1701
Karnataka	H:Vivek 9, 15, 21& 27, PEEH 5	H: PEHM 2 , Parkash, X 3342, C: NAC 6002
Jammu & Kashmir	H: Vivek 15, 21, 25 &33, PEEH 5 C: Pratap Kanchan 2, Shalimar KG 1 & 2	H: Vivek 33, Parkash, JKMH 1701, X 3342, C: C 8,14 & 15
Uttarakhand	H: Vivek 5, 9, 21& 25 PEEH 5 C: Pratap Kanchan 2	H:Vivek hybrid 33, Vivek hybrid 23, Parkash
Bihar	H: Vivek 27 C: D 994, Gujarat Makai 6	H: Parkash, X 3342, C: Dewaki, Birsa Vikas Makka 2
Jharkhand	H: Vivek 27, C: D 994,	H: Parkash, X 3342, C: Dewaki, B V M 2, B M 1
Orissa	H: Vivek 27, C: D 994,	H: Parkash, HIM 129, X 3342
West Bengal	H: Vivek 27	H: Parkash, X 3342
Himachal Pradesh	H: Vivek 15, 21& 25, PEEH 5	H: Parkash, X 3342, C:
NEH Region	H: Vivek 21& 25, PEEH 5	H: Parkash ,JKMH 1701, X 3342
Chhattisgarh	H:Vivek 27	H:Parkash, X 3342
Assam	-	H:Parkash, X 3342

Appendix II. Common nutrient deficiency symptoms in maize

Nitrogen Deficiency

Phosphorus Deficiency

Potassium Deficiency

Zinc Deficiency

Sulphur Deficiency

Copper Deficiency

Iron Deficiency

Magnesium Deficiency

Manganese Deficiency

Appendix III. Common weed flora in maize

1. **Narrow Leaved Weeds:**

Sanva (*Echinochloa crusgalli*)

Goosegrass (*Acrachne racemosa*)

Crowfootgrass (*Eleusine indica*)

Viper grass (*Dinebra retroflexa*)

Dactyloctenium aegyptium

Green bristlegrass (*Setaria viridis*)

Banchari (*Sorghum halepense*)

Bandra (*Setaria glauca*)

Doob (*Cynodon dactylon*)

Narkul (*Phragmites karka*)

Crabgrass (*Digitaria sanguinalis*)

Little Lovegrass (*Eragrostis tenuifolia*)

2. Broad Leaved Weeds:

Kundra (*Digera arvensis*)

Cholai (*Amaranthus spp.*)

Desert horsepurslane (*Trianthema portulacastrum*)

Day Flower (*Commelina benghalensis)*

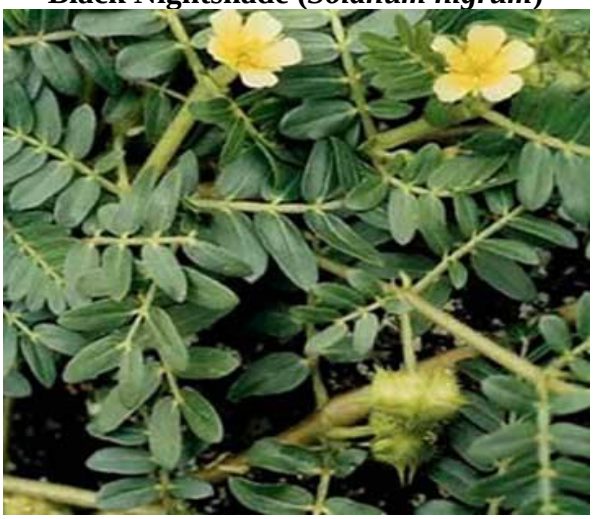
Hazardana(Phyllanthus niruri)

Jungli Jute (*Corchorus acutangulus*)

White cock's comb (*Celosia argentina*)

Black Nightshade (*Solanum nigrum*)

Hulhul (*Cleome viscosa*)



Puncture vine (*Tribulus terrestris*)

Congress grass (*Parthenium hysterophorus*)

Wildflower (*Xanthium strumarium)*

Creeping Woodsorrel (*Oxalis corniculata*)

Chikweed (***Stellaria media***)

Gajari (*Fumeria parviflora*)

Lambsquarters (***Chenopodium album***)

3. Sedges:

Motha (*Cyprus rotondus*)

Yellow nutsedge (C*yprus esculentus*)