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Maize Research in Chhattisgarh: Status and Progress

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A B S T R A C T

Chhattisgarh, the 26th state of the Indian Union came into existence on November 1st, 2000. In Chhattisgarh, maize is a *kharif* season crop and second most important crop next to paddy in terms of both area and production. The state has got very good potential for maize but the productivity is very low due to cultivation of open pollinated varieties (OPVs) and improper input management practices. The real potential can be realized by the adoption of hybrid maize especially single cross hybrids with full package of practices. As the major chunk of maize acreage of the state is rainfed, there is a need to popularize single cross hybrids which have better adaptability under stress environments. Maize crop can also be extended from upland to midland situation in the state and it can hold better promises than rice in drought and prolonged dry spell condition. In Chhattisgarh AICRP maize research program has been started in Kharif at Indira Gandhi Krishi Vishwavidyalaya, RMD college of Agriculture Research Station, Ambikapur-497001. With the inception of project farmers of the state initiate adoption of high yielding cultivars (composites/ hybrids) and scientific crop management practices resulting in continued growth in maize production and productivity. Public sector as well as private sector companies play important role in supply of hybrid seeds to the farmers. Government of Chhattisgarh also launched different special programs for increasing the production and productivity of the maize in state. The Agriculture department is involved in the rapid growth in output and popularity of the maize crop among the farmers in Chhattisgarh. Various demonstrations on improved maize cultivation have been conducted under ISOPOM, BGREI, TSP & RKVY and also with new approach like Cluster demonstration etc. Efforts made to enhance the area and productivity of maize crop in the state is summarized in this article.

Introduction

Father of green revolution, renowned Noble Laureate Dr Norman E. Borlaug was of the view "after the last two decades saw the revolution in rice and wheat, the next few decades will be known as maize era". Maize (*Zea mays* L.) is an exciting and leading crop contributing significantly to world agriculture and more importantly to world's food basket of roughly 2000 million metric tons. Maize crop is one of the world's important food crop, which supplies >5% dietary energy. The wider adaptability and high yield potential of maize and its utility as food, feed and forage crop signifies the importance of maize. Maize (*Zea mays* L.) 2n = 20 belongs to poaceae family is the third most important crop of India after rice and wheat. It was first adopted and cultivated by the Latin American countries and was first introduced in India by the Portuguese during the 17th century. It is cultivated round the year, though more than 80% is grown in rainy or *kharif* season (July to October).

Globally, maize is known as "Queen of cereals" because of its highest genetic yield potential. Maize is the only food cereal crop that can be grown in diverse seasons, ecologies and uses. Besides this maize have many types like normal yellow/ white grain, sweet corn, baby corn, popcorn, waxy corn, high amylase corn, high oil corn, quality protein maize *etc*.

In India, the production of maize witnessed a significant increase of more than 14 times from a mere 1.73 million tons in 1950-51 to 24.17 million tons in 2014-15. Presently it occupies 9.23 million hectare area with the mean yield of 2.56 tons/hectare. Maize grain is gaining popularity in our country due to huge demand, particularly for poultry feed industry. The most important maize growing states are Karnataka, Andhra Pradesh, Maharashtra, Tamil Nadu, Rajasthan, Bihar, Uttar Pradesh, Gujrat and Madhya Pradesh, which account for more than 80% of the total maize area of the country and also account for similar share in production. Both area and production of maize have been steadily increasing. Apart from uses as food and feed, maize has great demand in the development of various products in different industries viz; pharma, textile, paper, film, tyre, biofuel etc. Maize is utilized domestically for poultry and cattle feed, food, manufacturing of starch and other industrial purposes. Being a potential crop in India, maize occupies an important place as a source of human food (25%), animal feed (12%), poultry feed (49%), industrial products mainly as starch (12%) and 1% each in beverages and seed. In the last few years, good quantity of maize is also being exported from India to different countries. It is understood that with the increasing demand for value added foods and industrial requirements, from a growing economy and population, maize will hold its share as an important cereal crop.

Chhattisgarh, the 26th state of the Indian Union came into existence on November 1st, 2000. The state is geographically situated in the central part of India, between the latitudes of 17° 46'N - 24° 5' N and the longitudes of 80° 15' E - 84° 20' E. Its proximate position with the Tropic of Cancer has a major influence on its climate. The total geographical area is around 137.90 lakh ha of which cultivable land area is 46.77 lakh ha & forest land area is 63.53 lakh ha with more than 2.55 crore population. In Chhattisgarh region about 22% of net cropped area was under irrigation. About 80 percent of the population in the state is engaged in agriculture and 43 percent of the entire arable land is under cultivation. Paddy is the principal crop and the central plains of Chhattisgarh are known as rice bowl of central India. Other major crops are coarse grains, wheat, maize, groundnut, pulses and oilseeds.

Agro-climatically, Chhattisgarh is divided into 3 distinct zones with immense potential for agricultural development. Out of these three zones climate of the two zones Bastar Plateau and Northern hills are very much suitable for maize crop production.

Chhattisgarh Plains: The plains cover districts of Raipur, Mahasamund, Dhamtari, Durg, Rajnandgaon, Kabirdham, Bilaspur, Korba, Janjgir-Champa, Balod, Baloda Bajar, Bemetara, Gariyaband, Mungeli and a part of Kanker district (Narharpur & Kanker blocks) along with a part of Raigarh district.

Bastar Plateau: Bastar plateau region comprises of Baster, Bijapur, Dantewada, Kondagaon, Narayanpur, Sukma and the remaining part of Kanker district.

Northern Hills: It covers districts of Sarguja, Surajpur, Balrampur, Korea, Jashpur and Dharamjaigarh Tehsil of Raigarh district.

In Chhattisgarh maize occupies 111.1 thousands hectare land with the productivity of 2062 Kg/ha in *Kharif* 2013-14. It is a *kharif*

season crop in Chhattisgarh and second most important crop next to paddy in terms of both area and production. Though the productivity of maize in the state is quite low in comparison to All India and states like Tamil Nadu, Andhra Pradesh, Karnataka, West Bengal, Punjab, Odisha, Bihar etc. (Fig.-2) but there is also immense possibility to increase this. It is cultivated mainly in Bastar, Bijapur, Dantewada, Sukma, Gariyabhand, Kondagaon, Kanker, Korea, Korba, Surajpur, Balrampur and Sarguja districts. These are pre-dominantly tribal regions. Maize yield had significantly improved in Balrampur, Surajpur, Surguja, Kanker, Bastar and Jashpur districts in the recent past. The *rabi* maize accounts less than 5% of total area and production of the State. *Rabi* maize was also gaining popularity in few districts like Balrampur, Surajpur, Korba and Kanker with slight improvement in yield. Balrampur district is the leading maize growing district of the state. The state has got very good potential for maize but the productivity is very low due to cultivation of open pollinated varieties (OPVs) and improper input management practices. The real potential can be realized by the adoption of hybrid maize with full package of practices. As the major chunk of maize acreage of the state is rainfed, there is a need to popularize single cross hybrids which have better adaptability under stress environments.

Climate

The climate of Chhattisgarh is tropical. It is hot and humid (Fig.-3) because of its proximity to the Tropic of cancer and its dependence on the monsoons for rains. Summer in Chhattisgarh temperatures can reach 45 °C (113 °F). The monsoon season is from late June to October and is a welcome respite from the heat. Chhattisgarh receives an average of 1,292 millimetres (50.9 in) of rain. Winter is from November to January. Though weather varies from region to region, it's warm in most of the places. Like any other part of India, Chhattisgarh enjoys three seasons, summers, winters and monsoons. During summers (April-June), the temperature sometimes goes up to 45°C (max) whilst the sun shines brightly over heads. Late in the month of June, Monsoons (July-September) arrive in the state as a respite from the scorching heat. Chhattisgarh receives pretty decent amount of rainfall with an average of 1292 mm. Since it falls under the rice agro-climatic zone, rainfall proves to be the main source of irrigation. A significant variation in the annual rainfall adversely affects the harvest. The elevated regions in the north and south observe moderate climate round the year. In October, cool breeze envelops the entire state as if heralding the arrival of winters. The winter season (November-February) doesn't necessarily mean wearing loads of woolens in Chhattisgarh. At this time, the temperature even drops down to 10°C. The climate favours the maize crop production. The normal weather parameters of Northern hills are given in table 1.

Importance of Maize in Chhattisgarh State: Utilization Pattern and Value Addition in Chhattisgarh

Earlier maize was mainly cultivated in Surguja and Bastar division of Chhattisgarh but now it is emerging as main cash crop in entire Chhattisgarh state. The area and production has steady increasing trends. There had been an increase of 20 per cent in Maize crop acreage in Chhattisgarh during the past 10 years. It has the impressive growth rate. Now the farmers of the area are cultivating maize in lines, applying atrazin weedicide, full dose of chemical fertilizers etc. They are willing to buy the hybrid seed for cultivation from the market. Now they are taking maize as green cob and also utilizing the green parts as fodder. Maize threshers have been purchased by some farmers in the region which is an indicative of large maize production. For industrial utilization of the maize Chhattisgarh

state has "Raja Ram Maize Factory" in Rajnandgaon district. They are producing and supplying Maize starches, liquid glucose, dextrose mono hydrate, dextrin, maltose liquid, malto dextrin, maize oil, maize gluten, maize grit, maize husk etc under the company "Raja Ram Maize Products". But most of the maize production is used as poultry feeds in the state. Traders purchase corn directly from the farmers' fields in the villages. It is also exported to the neighboring states either as grain or green cob. Around 10-15% is retained by the farmers for own consumption and seed purpose.

Maize cultivated by farmers in Bastar is already being exported to USA, Malaysia, Hong Kong and Vietnam. In the Kharif season period more than six lakh quintals of Maize worth `85 crore was exported from Bastar. The maize area of the State has increased from 93.4 thousand ha in 2000-01 to 111.1 thousand ha in 2013-14, while the production has gone up from 125.7 thousand tons to 229.1 thousand tons. There is 1.5 times increase in productivity in the state. The yearly growth rate of maize area, production and productivity of the State since 2000-01 indicated that there is a steady increase over the years (Table 2; Figure 4a and 4b).

The continued growth in maize production and productivity over years is due to adoption of high yielding cultivars (composites/ hybrids) and scientific crop management practices. The greater part of produced maize is of high yielding varieties, which accounts around 85% of the total maize area. Private sector companies like Pioneer India Seeds, Monsanto, Syngenta Seeds, Nuziveedu Seeds, Advanta, Bio-seeds, Mahyco seeds, Rasi Seed etc play important role in supply of hybrid seeds to the farmers. Maize crop can be extended from upland to midland situation in the state and in drought and prolonged dry spell condition this crop can hold better promises than rice.

Major maize growing districts of Chhattisgarh

Maize is being cultivated almost in all the districts of Chhattisgarh (Table 3). However, districts of Northern hills and Bastar Plateau are important with a view of area and production. It is cultivated mainly in Bastar, Bijapur, Dantewada, Sukma, Gariyabhand, Kondagaon, Kanker, Korea, Korba, Surajpur, Balrampur and Sarguja districts. These are pre-dominantly tribal regions. Maize yield had significantly improved in Balrampur, Surajpur, Surguja, Kanker, Bastar and Jashpur districts in the recent past. Though the *rabi* maize accounts only less than 5% of total area and production of the State but is gaining popularity in few districts like Balrampur, Surajpur, Korba and Kanker with slight improvement in yield. Balrampur district is the leading maize growing district of the state. Among the districts Dhamtari has the highest productivity followed by Bijapur and Sukma (Fig.-5a &5b).

AICRP centre/s genesis and their mandate

Since time immemorial Indian farmers were growing land races/local cultivars of maize having low productivity which was a matter of concern at national level. To address the issue of low productivity systematic maize research in India was initiated in 1957 with the launch of All India Coordinated Maize Improvement Project (AICMIP), the first project in the series of Co-ordinated programmes in the country. After the inception of AICMIP, the focus was on multi-parent hybrid research and within a short span of 4 years, four hybrids namely, Ganga-1, Ganga-101, Ranjit and Deccan were released by project. The next step was to ensure the availability of seed of these hybrids to farmers and hence, the National Seeds Corporatin (NSC) was established mainly for maize hybrid seed production in the country. In 1961, the Indian

maize programme shifted emphasis from multi-parent hybrids to composite varieties. The composite varieties programme continued to dominate almost for 3 decades (till late 1990's) wherein the release of composites outnumbered the multi-parent hybrids. The farmers started growing improved varieties and the productivity also started increasing but no quantum jump was recorded in productivity. Realizing the importance of hybrid technology in crops, in 1989-90, ICAR launched the hybrid project in several crops including maize. Further, the liberalization of seed policy by the government of India, the multinational seed companies also focused their research and development on hybrids technology. In Chhattisgarh AICRP maize research program has been started in Kharif 1999 (ICAR F. No. 18-2/98-FFC; Dt. 05.12.99) at Indira Gandhi Krishi Vishwavidyalaya, RMD college of Agriculture Research Station, Ambikapur-497001. (C.G.) with the following mandate:

Collection, evaluation, utilization and documentation of the germplasm.
Development of single cross hybrids.
Development of early hybrids.
Development of specialty corn hybrids.
Standardization of agro techniques.
Dissemination of maize production technology.

State Govt. Effort for Increasing Maize Production in Chhattisgarh

Government of Chhattisgarh has launched different special programs for increasing the production and productivity of the maize in state. The Agriculture Department is involved in the rapid growth in output and popularity of the maize crop among the farmers in Chhattisgarh. Mini-kits are supplied to the farmers and technical advice is provided whenever it is deemed fit. Extension Reforms (Aatma) programme helped the farmers in getting details of the corn crop. There is huge potential for spreading corn crop in the entire state. Various demonstrations on improved maize cultivation have already been conducted under ISOPOM, BGREI, RKVY and with new approach like Cluster demonstration etc. Private sector people are also involved in transfer of technology for good maize crop harvest. In view of enormous prospect of promoting food processing units using Maize as raw material, the Chhattisgarh government signed Memorandum of Understanding (MoU) with three companies mainly- BMD Starch Pvt Ltd., Kakkad Udyog Ltd and Indian Agro and Food Industries recently. The aforesaid companies would establish their units in Bastar, Dhamtari and Rajnandgaon districts. The units would also establish their captive power units.

Reasons for low production/ productivity in Chhattisgarh

The productivity of maize in Chhattisgarh is quite low as compared to the National average. States like Tamil Nadu, Andhra Pradesh, West Bengal, Punjab, Haryana, Karnatak and Orissa are far ahead in terms of maize grain productivity. As the major chunk of maize acreage of the state is rainfed, there is a need to popularize single cross hybrids which have better adaptability under stress environments.

The main reasons for low production/ productivity of the state are:
Use of traditional local cultivars.
Cultivation of open pollinated varieties (OPVs).
Improper input management practices.
Maize hybrids have been adopted but could not exploit their potential:

Unavailability of suitable hybrids of rainfed condition such as drought due to prolonged dry spell. More concentration on rice as it is

the principal crop of *kharif* in CG.
Other reasons

Non-availability of seed in time
High cost of hybrid seed
Inadequate supportive irrigation
Lack of facilities for post-harvest primary processing
Lack of assured marketing
Lack of facilities for value addition of the produces

Maize production opportunities in Chhattisgarh

Maize production in Chhattisgarh can be increased by seeking and implementing opportunities through area expansion yield improvement, extension agencies and others etc.

Area Expansion

Substitution of upland non productive crops with Maize during *kharif.*
Substitution of paddy (Upland & Medium land) with Maize during *kharif.*
Increase in area under maize during *rabi and summer.*

Yield improvement

Minimizing / reducing the yield gap at farmer's level.
Minimizing / reducing the yield gap at Block and district level.
Availability and use of potent maize hybrids with full package of practices.
Availability and use of potent maize hybrids for biotic and abiotic stress environments.

Other measures

Implementation of district-wise, zone-wise plan through cluster-approach for yield enhancement.
Capacity building of the farmers through technology transfer for adoption of scientific crop management practices
Promotion of farm mechanization in maize cultivation.
Promotion of inter-cropping in maize system.
Market linkage for better price to the farmers.
Increase in irrigation facilities.
Promotion of high quality protein maize production.
Promotion of sweet corn and baby corn cultivation in peri-urban areas.
Crop insurance facility.

Future research strategy

Development and dissemination of potent hybrids resistant to biotic and abiotic stresses more particularly to drought, water logging etc. for cultivation in state.
Standardization of maize agro techniques for different agro climatic zone of the state.
Standardization of maize based intercropping for different agro climatic zone of the state.

AICRP technologies

Popular land races with their peculiar characteristics for their popularities

The exploration of maize germplasm can be worth, in transfer of the resistance to biotic and abiotic stress and also adoptability of the genotype for the region in concern. The state is characterized large number of local landraces, most of them with the tribal community. They are keeping these just for consumption purpose. These include flint, yellow to orange grained tall maize germplasms. Collection have been made and at present the centre has forty eight local maize germplasm.

Popular hybrids: Emphasis on the most popular hybrids (irrespective to private/public)

The state is dominated in use of maize hybrids most of them are from public sector including NK 30, Hishell, 900M Gold, Pro 4212, Pro 311, DHM 117 etc.

Coverage of cultivars: Approximate area under SCH/DCH/OPV

Earlier local landraces or cultivars were taken into large area cultivation but now-a-days even tribal farmers are also using single cross hybrids of various private sector. About 85% area is under hybrids (Mostly Single cross hybrid) and the rest are under local landraces or germplasm.

Cultivars released for state by AICRP

So far none of the hybrid / variety has been released from this centre however based on the performance of hybrids in various varietal evaluation trials of different maturity group of maize the following ones are recommended for cultivation in the state:

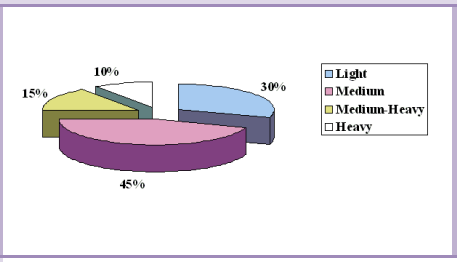
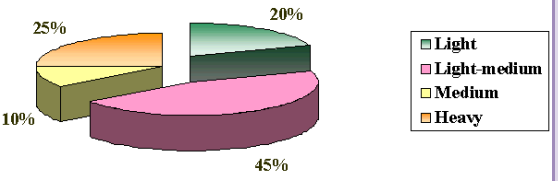
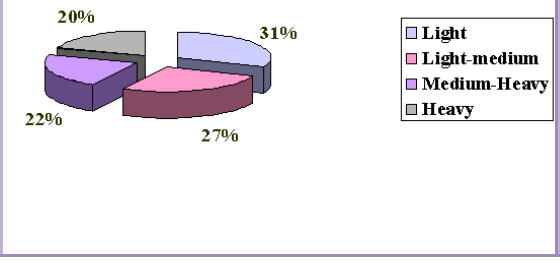
Full Season Maturity (95-110 days)	Hybrids	Bio 9681, 900M Gold, Hi-shell, NK 30, Seedtech 2324, PMH 3, PMH 1, NMH 731, DKC 9117
	Composites	Prabhat,
Medium Season Maturity (85-95 days)	Hybrids	Bio 9637, HM 10, DHM 117, HM 9, CMH 08-282
	Composites	Navjot,
Early & Extra Early Maturity (<85 days)	Hybrids	JH 3459, Prakash, Vivek 17,Pusa Hybrid 1, Vivek 21, Vivek 9, Pro 4212
	Composites	Jawaher Makka 216
Quality Protein Maize	Hybrids	HQPM 1, HQPM 5, Vivek QPM 9 Shaktiman 2, Shaktiman 4
Sweet Corn	Hybrids	HSC 1, Bisco Madhu.
Baby Corn	Hybrids	HM 4
Pop corn	Hybrids	VL Popcorn, Bajura Popcorn

Major cropping systems and production ecologies

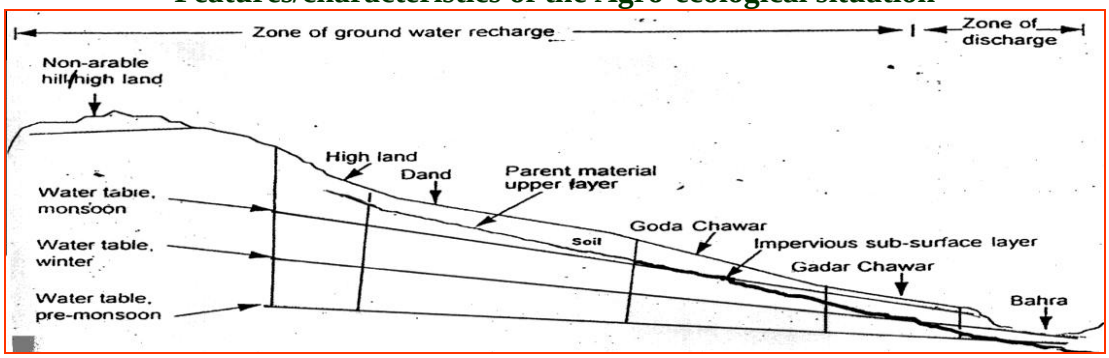
Chhattisgarh is agricultural chief land & due to large production of rice. Chhattisgarh is known as the "rice bowl". Chhattisgarh used to produce over seventy percent of the total paddy production in the state. Apart from paddy, cereals like maize, kodo-kutki and other small millets, pulses like arhar and kulthi and oilseeds like groundnut, soybean, niger and sunflower are also grown. The main rabi crops of Chhattisgarh are jowar, gram, urd, moong and moth. About 80 per cent of its population residing in villages depend mainly on agriculture and agro-based industry and 88% of the total cultivated area is un-irrigated and is under mono-cropping of which 72% of net sown area is under cereals (Rice, niger, maize and ragi), predominantly paddy followed by pulses (gram, arhar and urd). All these crops have productivity lower than the national average.

Chhattisgarh state has been divided into three Agro-climatic zones *viz*. Chhattisgarh plains, Bastar Plateau, and Northern Hills zone covering 51, 28 and 21 % of the geographical area, respectively. The location of the state is such that it is close to the Bay of Bengal,

which is instrumental in bringing monsoon in the Northern part of the country. Due to high average precipitation in the state and undulating topography in north & south hilly region and porous soil characteristic, it results in high runoff and leaching of available rainwater which leads to loss of scantily available soil nutrients. The soils are also left acidic with deficiency in micro-nutrients. Thus, soils do not retain adequate moisture even for *kharif* crop. *Rabi* crop becomes impossible without tapping ground and surface water, which is scarce.

	Soils Classification	Cropping system
Northern Hilly region of Chhattisgarh:		➢ Rice/ Maize-Fallow ➢ Kodo Kutki-Fallow ➢ Niger-Fallow ➢ Fallow-Niger/Horsegram ➢ Rice/ Maize-Ground nut ➢ Rice-Fallow
Plain region of Chhattisgarh:		➢ Rice/Maize/ Pigeon pea - Chickpea/ Lentil/Peas ➢ Rice/Maize-sarson/ Mustard/Linseed ➢ Rice/Maize-Potato/ Wheat ➢ Maize/ Soybean- Vegetable Wheat
Bastar Plateau Chhattisgarh:		➢ Rice/ Maize-Fallow ➢ Kodo Kutki-Fallow ➢ Niger-Fallow ➢ Fallow-Niger/Horsegram ➢ Maize/ Ground nut- Fallow

Features/characteristics of the Agro-ecological situation



The soils of Chhattisgarh state have been classified into two broad groups as per revenue class and productivity i.e. land on upper slope, Dand and Goda Chawar (Upland soils), and the land following called Gadar Chawar and Bahra (Lowland soils). Upland soils are usually red and acidic (pH 5.0-5.5), lighter in texture and water holding capacity is poor (25-30%). Upland soils are low in organic matter, nitrogen, available phosphorus, sulphur, calcium and magnesium. The medium land soils are yellowish and slightly acidic (pH 5.5-6.0) with considerable water holding capacity. These soils are poor in organic carbon, available nitrogen, calcium and magnesium. The lowland soils are grayish and neutral or slightly alkaline (pH-7.0-7.3). These soils are heavy textured with high water holding capacity and medium in organic carbon and available nitrogen. Due to the presence of high amount of iron oxides the soils become very hard when dry. The soils get very easily saturated during rains but at the same time release of moisture is also very fast for which soil moisture depletion occurs quite frequently and the upland crops have to face moisture stress and physiological dryness.

Changes in cropping system over the years

All the three zones of Chhattisgarh receive rainfall mainly through south west monsoon during kharif and very few through north east monsoon during rabi. Rice is a staple food and is grown in about 3.8 million hectare and out of which 80 per cent area is rainfed which suffers drought either at early or later stage of crop growth. There are several constraints of continuous rice cultivation over year of which insect-pest and weeds often pose a serious problem. Despite good amount of rainfall received in Chhattisgarh, most of the fields are monocropped usually with upland rice with very poor productivity (less than one ton). The area under cereal crop has been dropping over time and so is the share of cereal crops in the total output of the sector (in value terms). On the other hand the rural focus on fruits and vegetables is growing rapidly. Under the prevailing and changing agro-climatic conditions of northern hills of Chhattisgarh which experiences drought due to wide variation in yearly rainfall, the cultivation of maize may establish productivity and uplift the economic status of farmers.

Upland ecosystem

Previous system	Current system
Rice-Fallow Kodo- Kutki-Fallow Pigeon pea/Blackgram-Fallow Fallow-Niger/Horsegram	Rice/ Maize- Fallow Maize + Pigeonpea (1:2) - Fallow Pigeonpea + Rice (1:3)- Fallow Pigeonpea + Maize (1:1)- Fallow Maize + Blackgram (1:2)- Fallow Maize/ Niger/ Horse gram- vegetable

Midland ecosystem: (Rainfed/ irrigated)

Previous system	Current system
Rice-Chickpea/Lentil/Peas Rice - Mustard/Linseed Rice/Maize-Potato/Wheat	Rice/ Maize–Chickpea/ vegetable/peas Maize/ Moong/ Urd– Sarson/ Potato- Summer vegetable Ground nut- vegetable- vegetable Pigeonpea – Sarson- Summer Maize Maize + Blackgram (1:2) Maize/ Niger/ Horse gram- vegetable Til/ Soybean- Vegetable- Vegetable

Lowland

Previous system	Current system
Rice-Fallow	Rice – Wheat (surface seeded on wet soil) Rice – Sarson-Summer vegetable Kharif Rice – Winter rice- Summer rice Rice – Linseed/ Lathyrus

Production technologies recommended and package of practices

1.	**Suitable soil**					
		Upland and midland soils of Chhattisgarh are most suitable for cultivation of maize				
		Maize can be cultivated successfully on variety of soils ranging from well drained sandy loam to clay loam.				
		Soil pH: 5.5 to7.0 supports good crop growth				
		Hilly regions of Chhattisgarh soils are acidic in nature, at pH lower than 6.0 application of 2.5 quintal of lime/ha in furrows should be done before time of sowing				
2.	Land Preparation					
		2-3 ploughings followed planking				
		Fields should be free from weeds, clods and stubbles				
3.	Selection of cultivars					
		Full Season Maturity (95-105 days): Bio 9681, 900M Gold, Hi-shell, NK 30, Seedtech 2324, PMH 3, PMH 1, NMH 731, DKC 9117				
		suited for timely sowing in adequate rainfall areas				
		Medium Maturity (85-95 days): Bio 9637, HM 10, DHM 117, HM 9, CMH 08-282, KMH 3712				
		Suitable for rain fed areas and under delayed sowing				
		Early Maturity (80-85 days): Pro 4212, JH 3459, Prakash, Vivek 17,Pusa Hybrid 1, Vivek 21,, Pro 4212				
		Suited for intercropping in arhar and sugarcane				
		Extra Early Maturity (75-80 days): Vivek 21, Vivek 9				
		Suitable for growing as short duration catch crop or an intercrop				
		Babycorn: BVM-2 and HM-4				
		Sweetcorn: HSC 1, Bisco Madhu, Madhuri and Priya				
		Popcorn: VL Amber Popcorn, Bajura Popcorn				
4.	Time of Sowing					
		Season	**Optimum time of Sowing**			
		Kharif	25 June to 31 July (sowing time coincide with the monsoon)			
		Rabi	15 Nov to 30 November			
		Summer	1 Feb to 28 Feb			
5	**Seed Rate and Plant geometry**					
		S. No.	**Purpose**	**Maturity**	**Seed rate (kg/ha)**	**Plant geometry (row x plant, cm)**
		1	Grain and green cob (*Kharif*)	Full	20-25	75 x 20
				Medium	25	60 x 20
				Early	18-20	50 x 20
		2	Sweet corn		15	50 x 20
		3	Baby corn		20	50 x 20
		4	Pop corn		12	60 x 20
		6	Fodder		50	30 x 10
6.		Seed Treatment:				
		To protect seed from soil borne diseases and some insect-pests				
		Fungicide/Pesticide	**Appication rate (g/kg of seed)**	**Disease/Insect-pest**		
		Bavistin and Captan	2.0	BLSB, MLB Phythium stalk rot		

7.		**Sowing**			
		In mostly cases, Sowing is done with the help of plough. Sowing of seed and fertilizer application is done behind plough.			
8		**Manures and fertilizer**			
		Apply 4- 5 t/ha of farmyard manure at the time final land preparation10-15 before sowing			
			Nutrient applied (kg/ha)		
			N	**P_2O_5**	**K_2O**
		Hybrids (Early maturity)	100-125	50-60	30-50
		Hybrids (Medium maturity)	125-150	60-80	40-60
		Hybrids (Full maturity)	150-200	80-100	60-80
		Full dose of phosphorus and potassium along with 1/3rd of nitrogen is applied as basal			
		The remaining nitrogen is applied in two equal splits at knee high and tasseling stage			
9		**Water management**			
		kharif maize is grown as rainfed crop. In case of less rainfall irrigation should be applied at critical stages but in case of heavy rainfall drainage should be done to remove excess water.			
		Irrigation should be given if moisture stress at critical stages i.e. young seedling, knee high stage, tasseling, silking, grain filling stage happen			
		Rabi and *summer* maize are grown in irrigated condition and irrigation should be applied at critical stages.			
10		**Weed Management**			
		The critical period of crop-weed competition is 30-35 days after sowing			
		Application of atrazine @ 2.0 kg/ha as pre-emergence is effective for the control of weeds			
		2 hand weeding at 25 and 40 days after sowing may take care of weeds.			
11		**Harvesting**			
		Maize grown for Green fodder, the crop should be harvested at flowering stage.			
		Maize grown for Green cob, the cob should be harvested 20-25 days after pollination which is indicated by full sized cob with light green husk, dried silks, soft white kernels turning yellow that produce milky liquid when punctured			
		Harvesting of baby corn is done 1-2 days after silk emergence in morning or evening			
		Harvesting of sweet corn is done 21-22 days after silk emergence			
		Harvesting of cobs is done when husk around the cobs turns brown			
		The moisture content in grain at harvesting can be up to 25-30%.			
12		**Postharvest operations**			
		Harvested cobs should be dehusked and sun dried for about 4-5 days till the grain moisture decreases to 12-15%. Shelling can be done manually or by power operated shellers.			
		Shelled grain is dried for 2-3 days till moisture falls to 8-10% and then stored in gunny/ polythene bags and kept on wooden pallets in dry ventilated store.			

Changing diseases scenario and pest and disease management

In Chhattisgarh, stem borer is the major pest in *kharif* and *rabi* damaging the crop severely. Major diseases of maize in this state are Maydis Leaf blight and Banded leaf and sheath blight.

The important insect pests that affect maize crop in Chhattisgarh are as under:

Insect-pest	**Scientific name**	**Symptoms**	**Control**
Stem Borer	*Chilo partellus*	Central shoot withers and leading to "dead heart". Larvae mines the midrib enter the stem and feeds on the internal tissues. Bore holes visible on the stem near the nodes. Young larva crawls and feeds on tender folded leaves causing typical "shot hole" symptom. Affected parts of stem may show internally tunnelling caterpillars	Mix any of the following granular insecticides with sand to make up a total quantity of 50 kg and apply in the leaf whorls on the 20th day of sowing Phorate 10% CG10 kg/ha Carbaryl 4% G 20 kg/ha. For stem borer, release egg p[arasitoid *Trichogramma chilonis* @ 2,50,000 /ha coinciding egg laying period. Three releases at weekly interval are desirable. Third release is to be accompanied with larval parasitoid *Cotesia flavipes* @ 5000/ha If granular insecticides are not used, spray any one of the following: Carbaryl 50 WP 1 kg/ha on the 20th day of sowing (500 l of spray fluid/ha). Dimethoate 30% EC 660 ml/ha
Termite	*Odontotermes obesus*	Termite can cause substantial damage to the maize crop. They establish colonies much deep into the soil, it is very difficult to get rid of the problem completely..	Frequent irrigation before land preparation and during the crop growth reduces its infestation. Application of Fepronil granules @ 20kg/ha followed by light irrigation controls termites to a reasonable extent.

The major diseases prevalent in Chhattisgarh are as under:

Diseases	Causal Organism	Symptoms	Management
Maydis Leaf Blight	*Helminthosporium maydis*	Young lesion are small & diamond shape. As they mature they elongate. Growth is limited by adjacent veins so, final lesions shape is rectangular and 2 – 3 cm long, lesions may coalesce producing a large area. The fungus require slightly higher temperature for infection. Seedling from the infected kernels may wilt & die within 3 – 4 weeks of sowing. If the environment is warm with humidity than this is, unfavourable condition for the occurrence of this disease.	Field Sanitation: Ploughing down of crop debris may reduce early infection. Growing of resistant variety. Spray of diethane M – 45, Captan Zineb @ 2gm/ lit 2 to 4 application at 7- 10 days interval. Crop rotation for 2 – 3 years. Use of healthy & certified seed
Banded leaf and sheath blight	*Rhizoctonia sasakii*	Symptoms are first produced on lower leaves, the affected plants produces large gray or brown colored areas alternating with dark brown bands on infected leaves and sheath.Developing ear is completely damaged and dries of prematurely with cracking of the Husk leaves.Brown rotting of ears may develop which shows conspicuous light brown cottony mould with small round sclerotia	Deep summer ploughing Field sanitation Seed treatment with Pseudomonas fluroscense@16gm/kg of seed Rhizolex 50WP @1-2 g/litre when the crop is 30-40 days old

Extension: FLDs, yield gaps and exhibitions/farmer fairs

Front line demonstration

Front line demonstrations and trainings not only plays significant role in transfer of new technology to the farmer's field but they are also important from the point of betterment of the socio-economic status of the farmers. Farmers of the state started growing improved varieties/hybrids and now maize crop is emerging as main cash crops in the state as it gives good market price on trade either as green cob or grain. Large numbers of front line demonstration have been conducted by the centre. The details are as below:

Year & Season	No. of FLD	No. of Beneficiaries
Rabi 2000-01	40	46
Kharif 2001	100	115
Kharif 2002	100	117
Kharif 2003	100	112
Kharif 2004	477.5	441
Rabi 2004-05	100	106
Kharif 2005	422.5	413
Rabi 2005-06	85	87
Kharif 2006	400	390
Rabi 2006-07	100	116
Kharif 2007	400	432
Rabi 2007-08	300	300
Kharif 2008	375	407
Kharif 2009	525	546
Rabi 2009-10	100	114
Kharif 2010	80	97
Rabi/Summer 2010-11	100	118
Kharif 2011	200	201
Kharif 2012	50	50
Kharif 2013	50	50
Total	4105	4258

A total of 4105 demonstrations were conducted on hybrid varieties (Pro 4640, 900M gold, Pro 4212, DHM 117, HQPM 1, NK 30, Hishell) of maize from 2001 to 2013 at mostly tribal farmer's field of different agro-climatic situations of Chhattisgrh. These varieties gave an additional yield advantage of 50-200% over local check. The field day under demonstration has also been organized at FLD villages.

Front line demonstration (tsp)

In similar way TSP demonstration has also been conducted. The details are as below:

Year & Season	No. of FLD	No. of Beneficiaries
Kharif 2013	20	20
Summer 2015	20	20
Kharif 2015	32	36
Summer 2016	20	20
Total	92	96

Table.1 Monthly normal values of weather parameter

Monthly Normal Data (Based on 1991 to 2015)									
Month	T. Max	T. Min	Rainfall	RH1	RH2	Wind Speed	BSSH	Evap.	No. of Rainy Days
January	23.5	8.5	21.0	87	41	2.3	8.2	3.0	1.8
February	26.8	11.5	19.2	81	37	3.1	8.7	4.2	2.0
March	31.5	15.8	18.3	67	30	3.7	8.8	5.5	1.7
April	36.3	20.7	12.8	52	23	4.6	9.1	7.9	1.4
May	39.0	24.6	14.9	49	25	5.4	8.9	9.4	1.7
June	34.8	24.5	205.7	71	51	6.3	6.0	7.2	10.5
July	29.7	23.2	384.9	90	76	5.6	3.7	3.9	18.0
August	29.1	22.5	366.9	93	77	3.8	3.6	3.5	16.9
September	29.7	21.6	233.6	92	71	3.0	5.1	3.7	12.4
October	29.5	17.6	54.5	87	53	2.4	7.1	4.1	4.2
November	27.2	12.1	15.1	86	41	2.0	8.0	3.8	1.1
December	24.2	8.5	11.5	87	37	1.9	7.7	3.3	0.9
Annual	**30.1**	**17.6**	**1358.3**	**78**	**47**	**3.7**	**7.1**	**5**	**73.0**

Table.2 Area, production and productivity of maize in CG state (2000-01 to 2013-14)

Year	Area (000' hac)	Production (000' tonnes)	Productivity (kg/hac)
2000-01	93.4	125.7	1346
2001-02	93.8	69.7	743
2002-03	94.0	122.6	1304
2003-04	98.6	135.0	1369
2004-05	96.5	131.7	1365
2005-06	98.7	106.2	1076
2006-07	97.3	119.2	1225
2007-08	105.8	165.8	1567
2008-09	100.1	140.3	1402
2009-10	102.4	143.3	1399
2010-11	102.7	185.6	1807
2011-12	104.0	172.0	1654
2012-13	107.2	207.5	1936
2013-14	111.1	229.1	2062

Table.3 Crop production statistics (Maize-Kharif) for the Crop Year 2013-14 in CG

SN	State/Crop/ District	Area (Hectare)	Production (Tonnes)	Grain Yield (Tonnes/Hectare)
1	BALOD	258	415	1.61
2	BALODA BAZAR	86	150	1.74
3	BALRAMPUR	19661	39902	2.03
4	BASTAR	9503	22351	2.35
5	BEMETARA	24	21	0.88
6	BIJAPUR	580	1487	2.56
7	BILASPUR	3016	5654	1.87
8	DANTEWADA	3323	8515	2.56
9	DHAMTARI	2074	6090	2.94
10	DURG	184	202	1.10
11	GARIYABAND	10519	15934	1.51
12	JANJGIR-CHAMPA	364	819	2.25
13	JASHPUR	5563	12224	2.20
14	KABIRDHAM	2589	5071	1.96
15	KANKER	11511	25705	2.23
16	KONDAGAON	13586	31831	2.34
17	KORBA	4630	7233	1.56
18	KOREA	8148	14470	1.78
19	MAHASAMUND	109	191	1.75
20	MUNGELI	183	343	1.87
21	NARAYANPUR	1177	2759	2.34
22	RAIGARH	990	2105	2.13
23	RAIPUR	218	411	1.89
24	RAJNANDGAON	1338	2096	1.57
25	SUKMA	2640	6765	2.56
26	SURAJPUR	11661	22187	1.90
27	SURGUJA	9438	19156	2.03

Fig.1 Agro-climatic zones of Chhattisgarh State

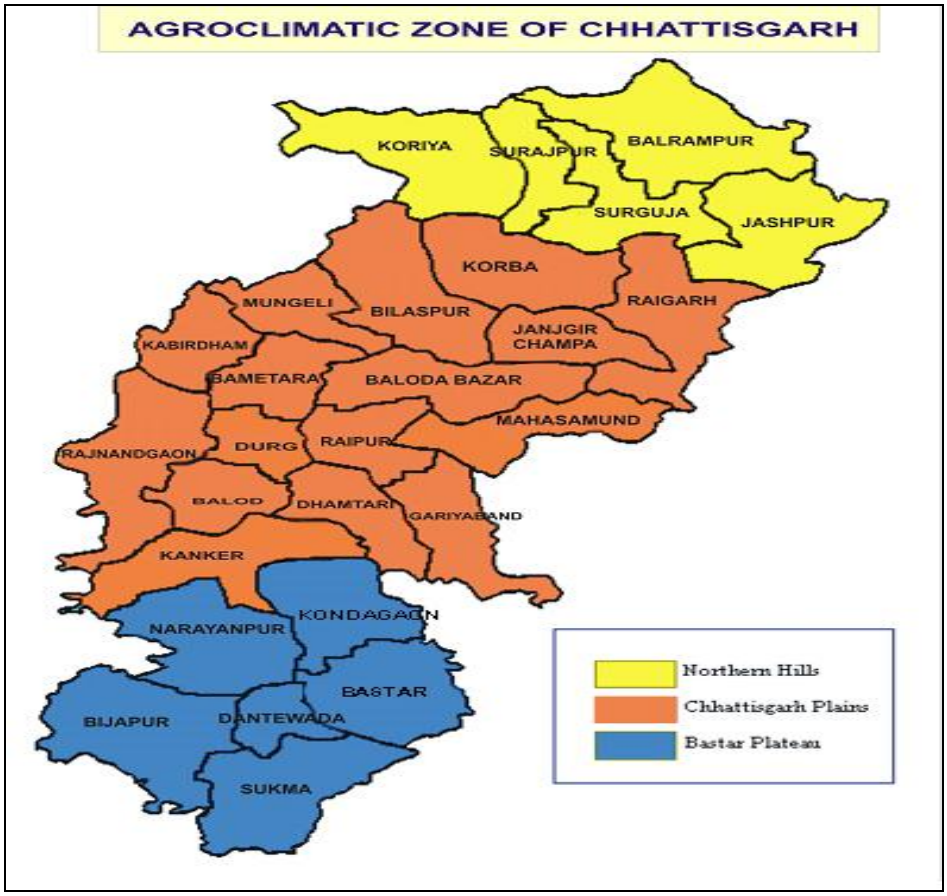


Fig.2 State-wise Normal Area, Production and Yield of Maize (Average of 2009-10 to 2013-14)

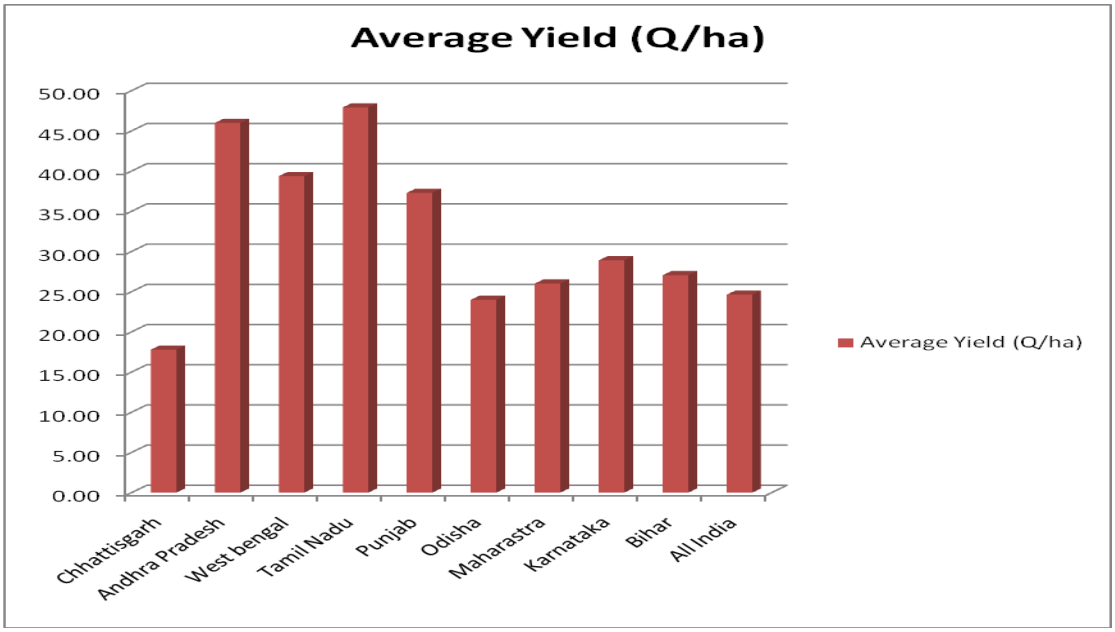


Fig.3 Climate type of Chhattisgarh State

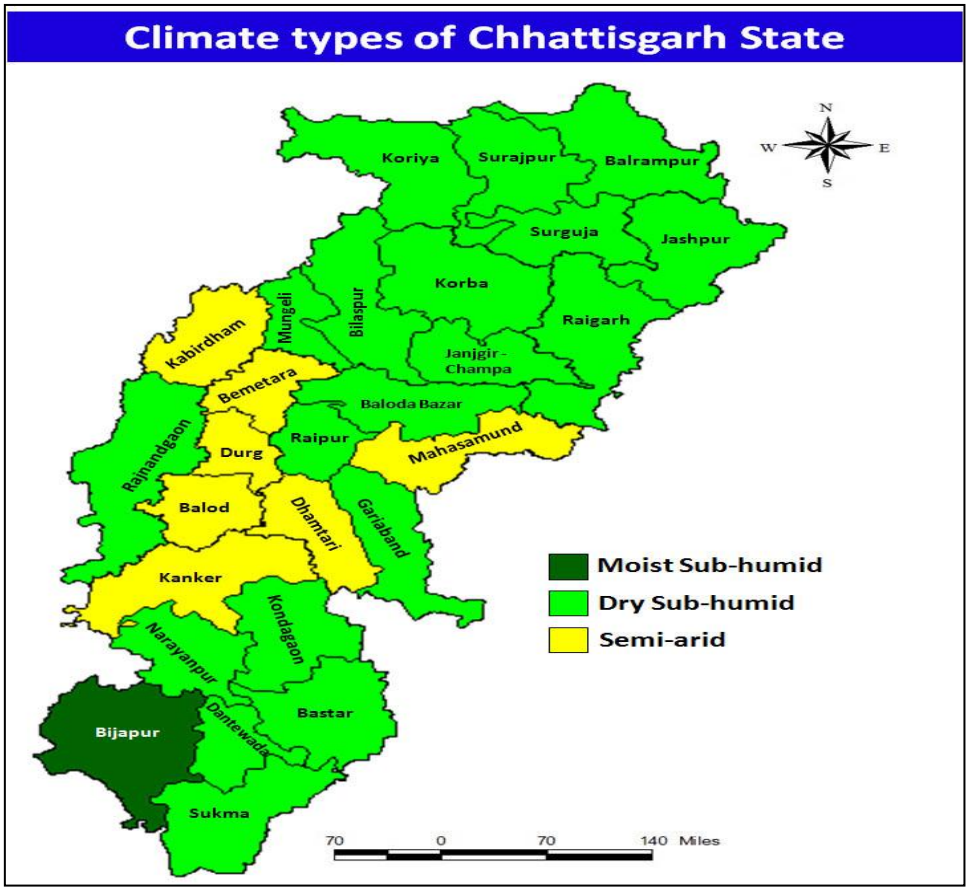


Fig.4a Year-wise area, production and productivity of maize in Chhattisgarh State

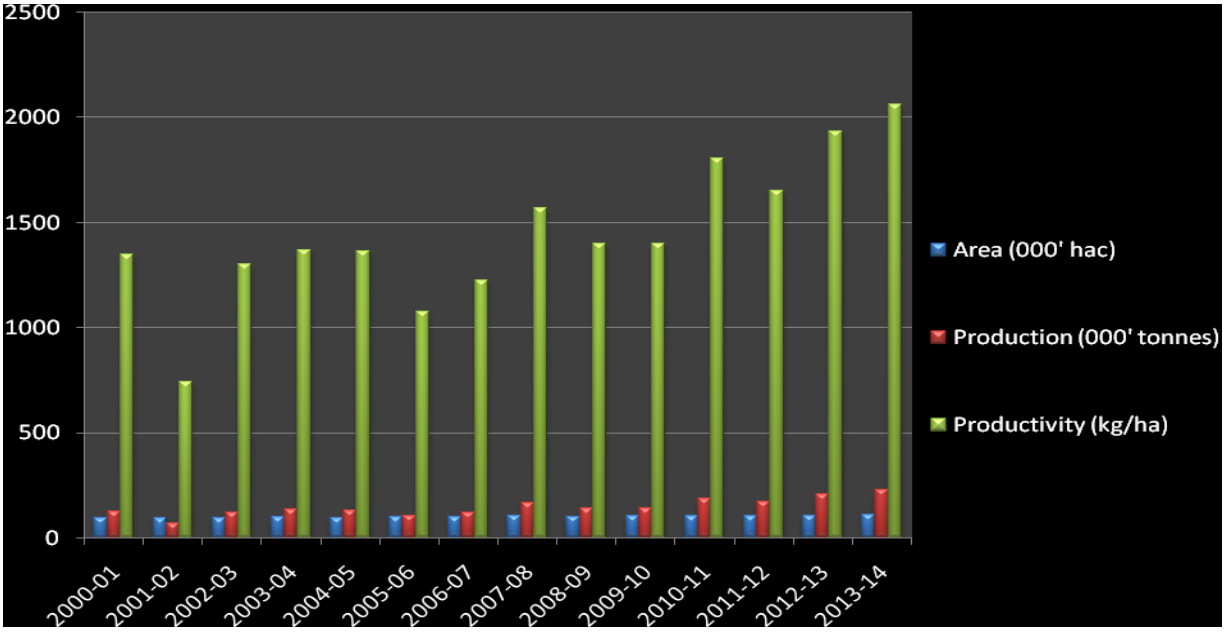


Fig.4b Year-wise area, production and productivity of maize in Chhattisgarh State

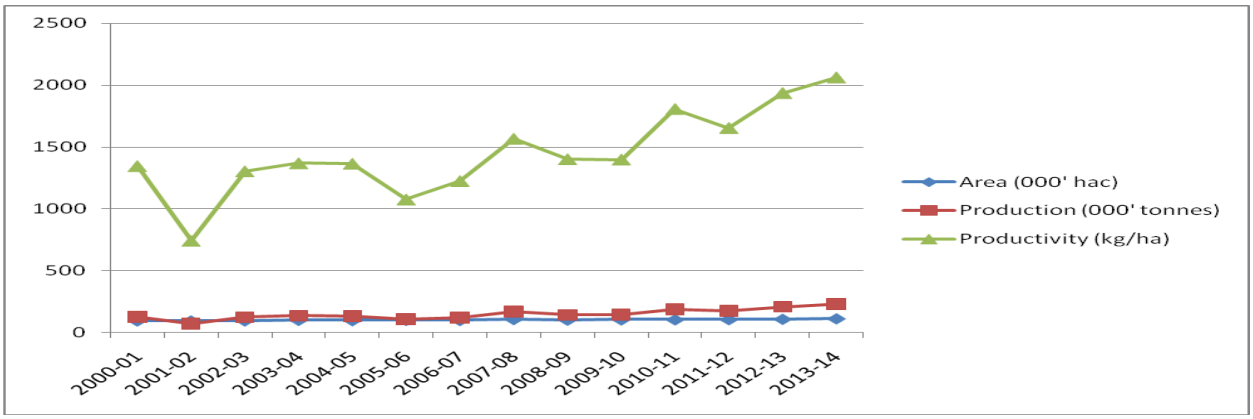


Fig.5a District-wise area, production and productivity of maize in Chhattisgarh State (2013-14)

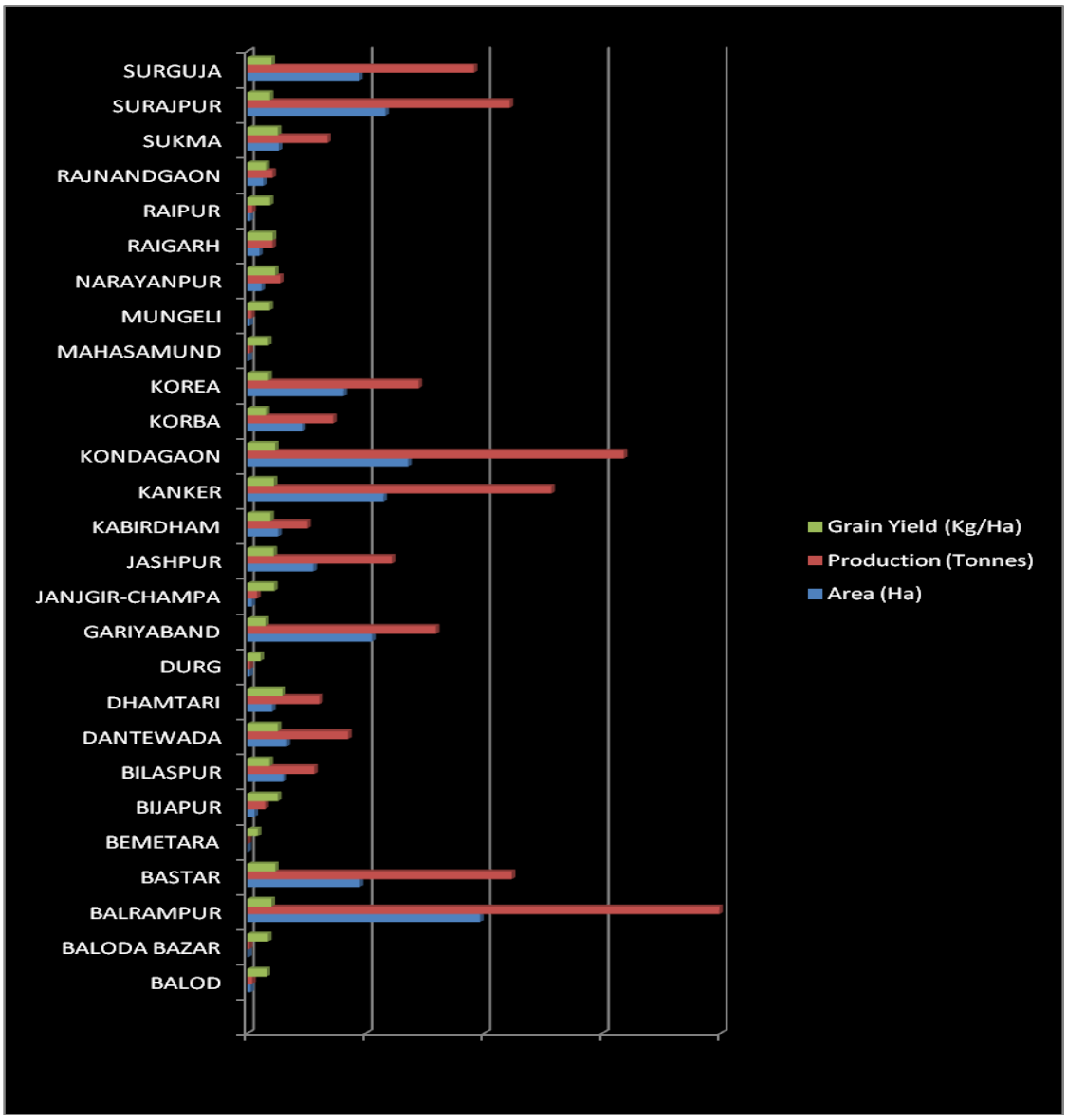
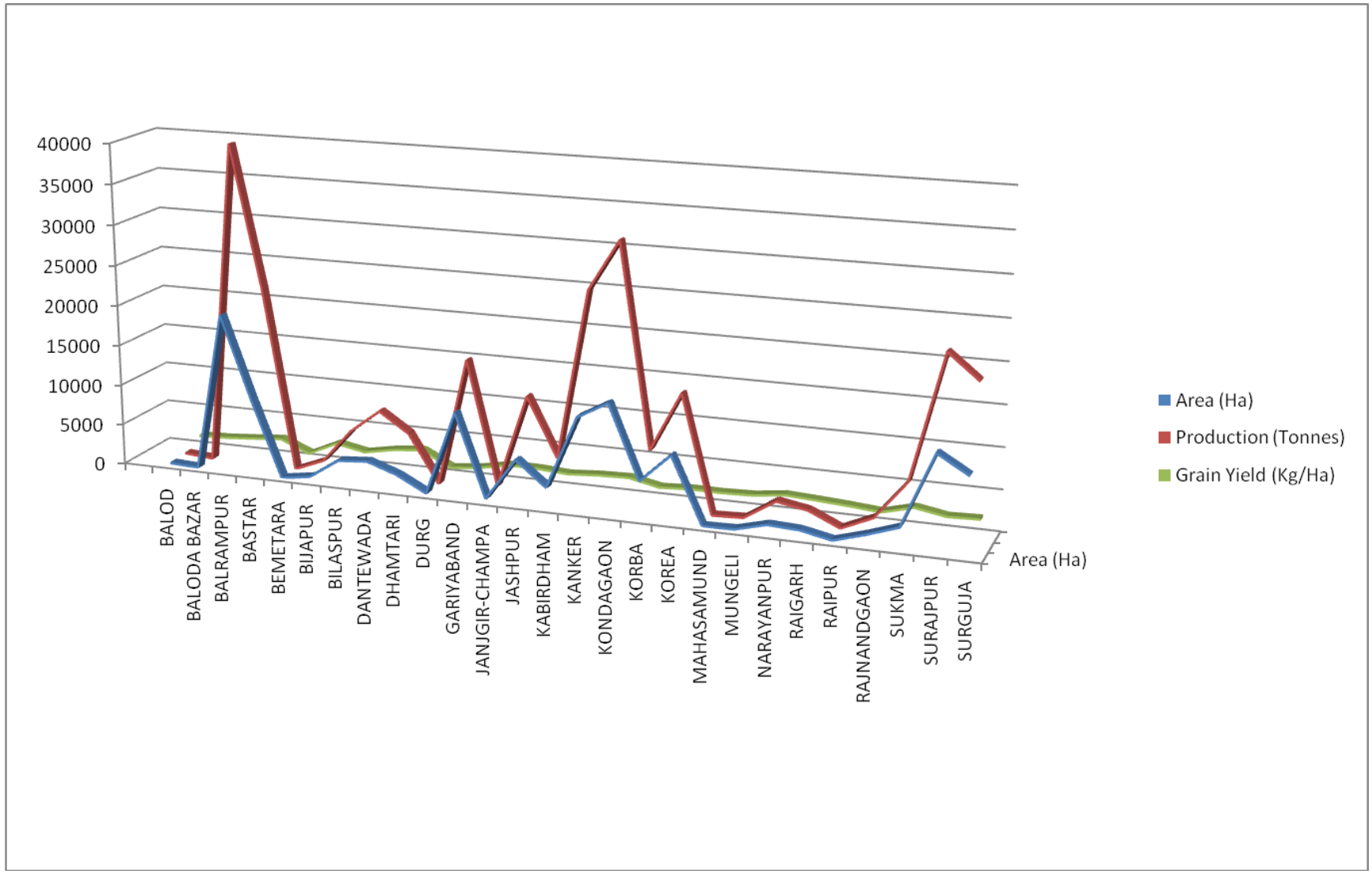


Fig.5b District-wise area, production and productivity of maize in Chhattisgarh State (2013-14)



Technologies transferred through FLD

Following technologies have been transferred among the farmers through FLD:

Single cross maize hybrid
Dry grain production technology
Green cob production technology
QPM production technology

Training programme

A sum of twelve training programmes has been conducted.

Training Conducted	-	12
No. of participants	-	18-43 (per training)
Participants	-	SADO's, ADO's, RAEO's & Farmers
Total participants	-	around 320

Kisan diwas / field day

Various field days have been organized. About 150-250 farmers were participated in each programme and interacted with the scientists of RMD CARS Ambikapur about maize production technologies.

Tribal farmers sent for training

A group of 5-10 tribal farmers of this region have been sent to IIMR New Delhi, frequently from 2011 to 2016 for training on various aspects of maize production technology and value addition. Total 95 tribal farmers of this region have been trained.

Acknowledgement

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