

Status of Corn Cultivation in Bihar: opportunities and future Challenges

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Introduction

Maize is the highest growing cereals among all other cereals around the world especially in India after rice and wheat production. Maize is the second most important cereal crop in the world in terms of acreage and is called the ‘**Queen of Cereals**’. Global maize production touched approx. 1040 million MT in 2016-17, wherein, US has been the leading producer, followed by China, accounting for about 38% and 23% respectively. India contributes around 2% of this production chart with a quantum of 26 million MT in 2016-17. The United States of America (USA) is the largest producer of maize contributes nearly 35% of the total production in the world and other important growing countries are China, Brazil, India, Argentina, Ukraine, and Mexico. In India, major maize growing states are Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Bihar, Uttar Pradesh, Apart from India, US stand uniquely by securing the highest position in the production of maize surplus which also makes it a world exporter of maize. The maximum number of maize are produced are used in the practice of feed and the rest is used for other food and industrial usages among the humans. In most of the developing countries, the production of maize crop is an essential food crop not only in India but around the world as well to a large extent significantly. The food crop supports major food security in most of the fast-growing developing countries across the globe. After the cereal production of wheat and rice, maize has significantly held a strong place in the third position out of the many crops production in India. The major usage of maize is just not limited to the use of humans and animals feed but also widely used in baby corn oil, corn starch, corn oil production, and much more. Maize is important to India as 15 million Indian farmers are engaged in Maize cultivation. Having realised the potential of maize in generating better income to farmers and providing gainful employment, maize qualifies as a potential crop for doubling farmer’s income. There is a tremendous potential of growth of the Maize value chain in the country. The consumption of Maize has increased at a CAGR of 11% in last five years. Today, Maize is a source of more than 3500 products including specialised Maize like QPM “Quality Protein Maize”. These trends open up vistas of opportunity for India’s Maize sector. However, it’s time to check if India is ready to capitalize on this opportunity. Although, India has received Maize production level of 26 Mn MT, it would require 45 Mn MT of Maize by the year 2022. The increasing interest of the consumers in nutritionally enriched products and rising demand for poultry feed which accounts 47% of total maize consumption are the driving forces behind increasing consumption of Maize in the country. As per the demand estimates, the Indian Maize production has to grow with CAGR of 15% in next 4-5 years. In the Indian context, not less than 15 Million farmers are engaged in maize cultivation and it generates employment for more than 650 million person-days at farming and its related business ecosystem levels. Importantly, maize contributes more than 2 per cent to the total value of output from all agricultural crops. The crop is less water demanding than other similar cereals and being a ‘C4’ as well as ‘day-neutral plant’, it gives higher yield per hectare in a shorter period and can be grown in any season. The multiple utilities of maize as a ‘food’, ‘fodder’ and ‘feed’ makes it further more demand friendly and insulates it against low demand situations. These unique characteristics of maize make the crop a suitable crop candidate for enhancing farmer’s income and livelihoods in India.

Background

Bihar has a total geographical area of 93.60 lakh hectares. Gross sown area in the State is 78.82 lakh hectares, while net sown area is 57.12 lakh hectares. There are around 1.61 crore

landholdings in the State of which 1.47 crore around 91.06 percent are marginal holdings of size less than 1 hectare 79% population of the state engaged in agriculture. Bihar with a geographical area of about 94.2 thousand square km is divided by river Ganges into two parts, the north Bihar with an area of 53.3 thousand square km and the south Bihar having an area of 40.9 thousand square km. Based on soil characterization, rainfall, temperature and terrain, four main agro-climatic zones in Bihar have been identified. These are: Zone-I, North Alluvial Plain, Zone-II, north East Alluvial Plain, Zone-III A South East Alluvial Plain and Zone-III B, South West Alluvial Plain, each with its own unique prospects. Agro climatic zone I and II is located north of the river Ganges whereas the Zone III is located south of the river Ganges. Zone I is situated in the north western part of the state whereas zone II is located in the north eastern part. Zone I and II are flood prone whereas zone III is drought prone. Potential wise all three agro climatic zones have vast untapped potential for increasing the productivity of food grain crops. Across the state soil texture is varies from sandy loam to heavy clay. However the majority type belongs to loam category which is good for crop cultivation. The natural precipitation varies from 990 to 1700 mm. Most of the precipitation is received during the month of July to September There are three crop seasons- Kharif, Rabi and Zaid. Rice, wheat and pulses are grown in all the districts. Being located between 25 to 27 degree North latitude the climate of Bihar is of mostly sub-tropical. Average temperature is 35-40 degree Celsius throughout the summer months. April and June are the hottest months of the year. December to January is the winter season in Bihar. The winter in Bihar is mild with average temperature being 5 to 10 degree Celsius. Bihar gets its maximum rainfall during South-West monsoon season which prevails from June to September. The average rainfall of Bihar is around 120 cm. (Source: <http://krishi.bih.nic.in/>)

Table 1: Name of the districts under each Agro-Climatic Zone

S.No.	Agro-climatic zone	Districts
1.	Agro- climatic zone I (Northern West)	West Champaran, East Champaran, Siwan, Saran, Sitamarhi, Sheohar, Muzaffarpur, Vaishali, Madhubani, Darbhanga, Samastipur, Gopalganj, Begusarai
2.	Agro-climatic Zone II (Northern East)	Purnea, Katihar, Saharsa, Supaul, Madhepura, Khagaria, Araria, Kishanganj.
3.	Agro-climatic zone IIIA (Southern East)	Sheikhpura, Munger, Jamui, Lakhisarai, Bhagalpur & Banka.
4.	Agro-climatic zone IIIB (Southern West)	Rohtas, Bhojpur, Buxar, Bhabhua, Arwal, Patna, Nalanda, Nawada, Jehanabad, Aurangabad, Gaya.

National Maize Production Scenario

Global maize production hovered around 1040 million MT of Maize in 2016- 17, however for the current year there are forecasts for a slightly lower Maize area, yield and production. In a global perspective, US has been the leading maize producer, followed by China, accounting for about 38% and 23% respectively. (Anonymous, 2018b). In last three years, in spite of drought-like conditions, the maize area has increased in Gujarat, Himachal Pradesh, Jharkhand, and west Bengal (Table 1). In addition the maize production has increased in Bihar, Himachal Pradesh, Jammu & Kashmir, Madhya Pradesh, Tamil Nadu and West Bengal. In spite of rought, the maize productivity has been increasing in Bihar, Jammu & Kashmir, Madhya Pradesh, Tamil Nadu, Uttar Pradesh and West Bengal (Table 2). As per the Compound Annual Growth Rate (CAGR) since 2001, the there is increase in area, production and productivity in both *kharif* and *rabi* season, however the growth rate was higher in *rabi* season than *kharif* season. Maize consumption

in India can broadly be divided into three categories viz. feed, food and Industrial non-food products (mainly starch). Total corn in India utilised in poultry feed (47%), livestock feed (13%), Food (13%), processed food (7%), starch (14%) and exports & others (6%). Overall consumption of Maize in last 5 years has increased with CAGR of 11%.

Table 2: Maize area, production and yield statistics in Indian states from 2013-14 to 2015-16

State/ UT	Area ('000 ha)			Production ('000 tonnes)			Yield (kg/ha)		
	2013-14	2014-15	2015-16 [#]	2013-14	2014-15	2015-16 [#]	2013-14	2014-15	2015-16 [#]
Andhra Pradesh	335.7	303.0	233.0	2087.5	1938.0	1414.0	6218	6396	6069
Arunachal Pradesh	47.0	48.0	*	69.0	75.0	*	1467	1563	*
Assam	24.1	28.0	25.0	21.6	93.2	64.0	898	3333	2560
Bihar	732.3	706.5	701.7	2112.1	2340.5	2397.2	2884	3313	3416
Chattisgarh	111.1	122.1	114.5	229.1	230.3	193.8	2062	1886	1693
Gujarat	461.0	382.0	387.0	681.0	631.0	572.0	1477	1652	1478
Haryana	9.0	8.0	6.0	27.0	18.0	17.0	3000	2250	2833
Himachal Pradesh	292.7	292.6	295.6	652.1	579.0	671.0	2228	1979	2270
Jammu & Kashmir	298.7	298.9	306.1	530.5	360.0	479.2	1776	1204	1566
Jharkhand	256.9	269.8	288.0	517.0	475.6	375.5	2012	1763	1304
Karnataka	1377.0	1337.0	1179.0	3984.5	4214.0	3269.0	2894	3152	2773
Kerala	0.1	0.1	0.1	0.1	0.1	0.1	2000	1000	1000
Madhya Pradesh	868.0	1132.0	1098.0	1534.0	2128.2	2580.3	1767	1880	2350
Maharashtra	1001.0	1077.0	1007.0	2729.4	2202.0	1511.0	2727	2045	1500
Manipur	26.1	26.2	*	58.6	58.8	*	2246	2243	-
Meghalaya	18.0	18.0	*	39.7	40.8	*	2200	2259	-
Mizoram	5.8	5.7	*	8.2	8.6	*	1420	1515	-
Nagaland	68.8	68.8	*	135.4	135.9	*	1969	1975	-
Orissa	95.1	91.7	55.6	263.6	188.2	110.8	2771	2053	1993
Punjab	130.0	126.0	115.0	507.0	460.0	424.0	3900	3651	3687
Rajasthan	926.7	891.5	881.1	1502.2	1551.2	1210.4	1621	1740	1374
Sikkim	39.9	39.9	*	68.8	68.9	*	1724	1727	*
Tamil Nadu	345.3	322.0	363.9	1855.1	2067.9	2383.3	5372	6423	6549
Telangana	670.3	692.0	573.0	2774.7	2308.0	1736.0	4140	3335	3030
Tripura	4.6	4.5	*	5.9	5.9	*	1279	1303	-
Uttar Pradesh	767.0	717.0	679.0	1306.2	1279.0	1255.0	1703	1784	1848
Uttarakhand	25.0	24.5	23.0	35.5	50.8	36.0	1419	2070	1565
West Bengal	128.7	152.4	156.0	522.4	663.1	720.0	4059	4350	4615
A & N Islands	0.1	0.2	-	0.3	0.6	-	2254	3529	-
D & N Haveli	0.1	0.1	-	0.1	0.1	-	1000	1100	-
Others	-	-	204.3	-	-	383.9	-	-	1879
All India	966.2	9185.3	8691.2	24259.5	24172.6	21806.5	2676	2632	2509

Status of maize in Bihar

Bihar stands uniquely in the 6th position in the top 10 list of the largest maize producing states in India. The state also remarkably stands in a powerful position in the production maize in a huge amount significantly. Bihar is thus eventually regarded as one of the largest producers in the production of the maize crop in India. It has recently emerged as the high-yielding maize crop with high potential in playing a dynamic role as an agricultural power house. Bihar is one of the largest maize growing state and the crop was grown primarily as a subsistence crop to meet food needs for a long time till recently. But now like in non-traditional areas (Karnataka and Andhra Pradesh), it is also grown for commercial purposes (i.e., mainly to meet the raw material requirements of the animal feed sector). It is third largest maize producing state contributing around 14 percent to national production. Around 0.72 million hectare is presently under maize cultivation, which is about 7.3 per cent of Gross Cropped Area (GCA) in the state and over 15 lakh farmers are engaged in maize cultivation. During 2016-17, the state produced about 3.84 million MT. Maize can be utilized in many different forms by

converting it into a variety of products, through grinding, alkali processing, boiling, cooking and fermenting, such as corn starch, corn flakes and cereals, ethanol etc. It also has many industrial applications, which can make it a profitable crop in the state. Maize processing and utilization pattern shows that in India, around 64 per cent of the total produce is for animal feed, 16 per cent for human consumption and 19 per cent is used by the industry (starch, brewery etc) seed and other miscellaneous 1%. In Bihar only 8-10% of maize (5% directly by the processors and another 3-5% is being used by road side snack joints etc.) is processed within the state despite the fact that the state has huge and rising marketable surplus. While the area under cultivation, maize production & yield has increased during 1977 to 2017, there are only 10-12 maize processing units in Bihar. They are mainly into milling of flour and production poultry feed. In absence of adequate processing facility in the state, result more than 80% of Bihar maize goes outside the state and gets processed there depriving it of value addition and higher income for the people in the state. The processed maize in the form of poultry feed and seeds then come back to the state. There is potential for processing of both high & low value added products in maize sector in the state itself. There are factors contributing to increase in the demand of processed maize. Some of them are (1) growing demand for eggs and chicken leading to increased demand for poultry feed in the state; (2) the state has nearly 8 lakh hectare land under water which is suitable for fish farming; (3) increased demand for ethanol as a fuel additive; (4) growing urbanization leading to increased demand for processed food like corn flakes etc; (5) dairy sector is on growth path and this sector can provide a good market for cattle feed products. Thus there is growing demand for processed maize in the state and there is also adequate supply of good quality maize in the state.

Although maize is growing in all three seasons (Kharif, Rabi and Spring/summer) in Bihar but major area is in rabi followed by kharif and spring. Highest productivity is also in rabi followed in spring and Rabi. Bihar is the 8th populous state in India and depends primarily on agriculture. It produces a variety of crops like maize, sugarcane, potato, jute and many other vegetables and fruits due to its soil fertility and climatic conditions. The geographical location and climatic condition of eastern part of Bihar namely Purnea, Katihar, Saharsa, Araria, Khagaria, districts are favourable for cultivation of rabi maize. Maize is thus an important crop in Bihar which is third largest producer of maize in the country after Karnataka and Madhya Pradesh and accounts for about 11% of national maize output (Anonymous, 2017). Cultivation of maize provides livelihood to about 1.3 million farmers in Bihar, majority of who are marginal and small farmers.

On the basis of 2016-17 data the maize growing districts can be divided into:

High productivity districts (productivity >6t/ha)	Katihar , Purnia, Darbhanga, Kishanganj, Araria and Khagaria
Medium productivity districts Productivity 3 to 6 t/ha)	Arwal, Saharsa, Supaul, Madhepura , Samastipur, Jahanabad, Siwan, Nalanda, Seohar, Saran, Sitamdhhi, Madubani, Vaishali, Begusarai, West Champaran, Bhgalpur, Banka and Gaya.
Low productivity districts (productivity <3 t/ha)	Nawada, Gopalganj, Jamui, East Champaran, Aurangabad, Buxer, Patna, Bhabhua, Mungesr, Bhojpur, Muzaffarpur, Sheikhpura, Rohtas and Lakhisara.

Table 2: District and Season wise maize area, production and productivity in Bihar during 2016-17

Sl.No.	Name of Districts	Autumun(Kharif) Maize			Rabi Maize			Summer Maize			Total Maize		
		Area (ha.)	Production (M.T.)	Yield (kg/ha.)	Area (ha.)	Production (M.T.)	Yield (kg/ha.)	Area (ha.)	Production (M.T.)	Yield (kg/ha.)	Area (ha.)	Production (M.T.)	Yield (kg/ha.)
1	Patna	4575	6598	1442	399	1127	2825	1366	6182	4526	6340	13907	2194
2	Nalanda	2304	4274	1855	1426	6280	4404	4323	26010	6017	8053	36564	4540
3	Bhojpur	2082	2542	1221	126	511	4056	428	2105	4918	2636	5158	1957
4	Buxar	1022	1639	1604	0	0	0	254	1369	5390	1276	3008	2357
5	Rohtas	74	110	1486	1	4	4059	5	19	3800	80	133	1663
6	Bhabhua	304	471	1549	0	0	0	42	255	6071	346	726	2098
7	Gaya	3512	9750	2776	120	898	7482	756	3059	4046	4388	13707	3124
8	Jahanabad	178	475	2669	53	397	7482	207	1209	5841	438	2081	4751
9	Arwal	149	397	2664	237	1773	7482	130	763	5869	516	2933	5684
10	Nawada	1110	2604	2346	0	0	0	395	1776	4496	1505	4380	2910
11	Aurangabad	1175	2837	2414	0	0	0	0	0	0	1175	2837	2414
12	Saran	14576	56112	3850	5277	23013	4361	5138	30290	5895	24991	109415	4378
13	Siwan	11875	32740	2757	4964	45788	9224	1176	6566	5583	18015	85094	4724
14	Gopalganj	5862	13406	2287	3923	9262	2361	1493	9076	6079	11278	31744	2815
15	Muzaffarpur	12711	19958	1570	10216	19227	1882	8454	17433	2062	31381	56618	1804
16	E.Champaran	38805	95066	2450	4588	16219	3535	3289	10994	3343	46682	122279	2619
17	W.Champaran	994	2913	2931	2064	8289	4016	2316	7191	3105	5374	18393	3423
18	Sitamarhi	1086	2824	2600	4016	18369	4574	278	633	2277	5380	21826	4057
19	Sheohar	212	552	2604	1195	5778	4835	97	346	3567	1504	6676	4439
20	Vaishali	15202	58262	3833	6548	37022	5654	10636	28193	2651	32386	123477	3813
21	Darbhanga	1565	5457	3487	12255	93408	7622	540	3092	5726	14360	101957	7100
22	Madhubani	21	65	3095	5	28	5560	60	247	4117	86	340	3953
23	Samastipur	11952	35927	3006	31580	150321	4760	18343	114143	6223	61875	300391	4855
24	Begusarai	30770	28743	934	22997	176663	7682	2676	5997	2241	56443	211403	3745
25	Munger	771	1163	1508	386	1098	2844	1032	2034	1971	2189	4295	1962
26	Sheikhpura	535	362	677	76	687	9035	66	141	2136	677	1190	1758
27	Lakhisarai	4439	1863	420	0	0	0	0	0	0	4439	1863	420
28	Jamui	3191	4605	1443	703	6352	9035	540	1034	1915	4434	11991	2704
29	Khagaria	16273	7992	491	38080	377563	9915	9181	19078	2078	63534	404633	6369
30	Bhagalpur	17182	29718	1730	18448	85636	4642	5066	23134	4567	40696	138488	3403
31	Banka	6348	17240	2716	1312	4318	3291	2714	12330	4543	10374	33888	3267
32	Saharsa	3109	12539	4033	11684	80304	6873	14883	72260	4855	29676	165103	5564
33	Supaul	2844	14937	5252	5258	39635	7538	7158	29215	4081	15260	83787	5491
34	Madhepura	3730	12307	3299	18027	135599	7522	19128	66558	3480	40885	214464	5246
35	Purnia	8574	22416	2614	11879	118042	9937	16481	145082	8803	36934	285540	7731
36	Kishanganj	359	1547	4309	1233	9386	7612	1913	12064	6306	3505	22997	6561
37	Araria	0	0	0	21244	124384	5855	21002	149750	7130	42246	274134	6489
38	Katihar	11979	113889	9507	44563	534132	11986	33011	280259	8490	89553	928280	10366
	Total	241450	624300	2586	284883	2131513	7482	194577	1089887	5601	720910	3845700	5335
											Source:- Directorate of Economics & Statistics		

**Included in others; #As per Fourth Advance estimates*

During 2016-17 food grains production in Bihar reached a record high, both in terms of total produce and per hectare yield. The state agriculture department said in its latest report that the total production of food grains in the state was 18.561 million tonnes in 2016-17, which is a record. Maize also played a great role to fill the food grain basket of the state. Maize is cultivated in all the 38 districts of the state in varying measures, the state's 'maize road' covers 11 districts, including Muzaffarpur, East Champaran, Vaishali, Katihar, Purnia, Samastipur, Begusarai, Khagaria, Bhagalpur, Araria and Madhepura," said agriculture scientist Anil Kumar Jha. The six districts on the maize road where the maize coverage was relatively higher in the 2015-16 season were Samastipur (63,594 hectares), Begusarai (56,499 hectares), Khagaria

(55,238 hectares), Bhagalpur (44,898 hectares), Araria (52,600 hectares) and Madhepura (45,523 hectares). The coverage in the remaining five districts was Katihar (45,603 hectares), Purnia (39,498 hectares), Muzaffarpur (39,164 hectares), East Champaran (46,507 hectares) and Vaishali (31,860 hectares). Maize produced in Bihar is being exported to Indonesia, Malaysia and Vietnam (Anonymous 2017b). Besides, Bihar is the third largest producer of maize after Karnataka and Madhya Pradesh in India, and accounts for 11% of the country's total yield (Anonymous, 2017b). According to a report of APEDA India has exported 7,05,513.8 MT of maize to the world for the worth of Rs. 1228.5 crores/ 190.3 USD Millions in 2017-18. Major Export Destinations in 2017-18 were Nepal, Bangladesh, Philippines, Myanmar, and Sri Lanka

Opportunities and Future Challenges

Maize is the major crop in Bihar, it can be grown in all three seasons in the state. To increase the production and productivity of maize in the state, opportunities to be searched and strategies to be made to meet the challenges.

Area expansion and diversification

Maize is considered to be a better alternative to wheat or *Rabi* rice due to several reasons: (a) wheat encounters several biotic stresses, and most importantly, abiotic stresses due to terminal heat stress in the IGP, wheat is often vulnerable to temperature fluctuation resulting in shrivelled grains and poor yield, (b) evidences of declining yield of *Boro* rice in eastern Bihar West Bengal and Orissa, and (c) water scarcity and high cost of water input in rice. In particular, maize has fewer pest and disease problems than *Boro* rice and wheat. There is a vast opportunity for intensification of winter maize in flood prone areas as to compensate for the loss during *Kharif* season with proper planning for seeds, inputs and improved management practices and crop diversification. The medium and uplands where subsistence yield of wheat, *Rabi* rice and other winter crops is obtained, could be substituted by winter maize in Bihar. In general, any late maturing single cross-bred variety of *Kharif* season is equally good for winter season. Winter maize (170-180 days duration) has the clear cut comparative advantages of low incidence of diseases and insect pests, is not affected by temperature rise during winter (as the wheat is) and do not suffer on account of heavy rainfall. In districts where land is kept fallow in *rabi* like in Lakhisarai district *rabi* maize cultivation can be taken up.

Improved management practices for crop production

There is huge variability in the productivity of maize from district to district in the state. For example average productivity of Katihar district in 2016-17 was 10.36t/ha whereas in Lakhisarai district it was 0.42 t/ha. There are many maize hybrids are available which have high yield potential and responsive to nutrients. There are several factors that affect the productivity of maize however, the fertilizer management is one of the most important factors that affect the growth and yield of maize. Maize is an exhaustive crop requires all types of macro and micro nutrients for better growth and yield potential. Among the various nutrients, nitrogen is the principal nutrients for better harvest require approximately 150 N20 kg ha⁻¹. However, high yielding R-M systems can also accelerate the problem of secondary and micronutrient deficiencies, not only because larger amounts are removed, but also because the application of high rates of N, P, and K to achieve yield targets often stimulates the deficiency of secondary and micronutrients. Proper nutrient management of exhaustive systems like R-M should aim to supply fertilisers adequate for the demand of the component crops, and apply those in ways that minimise loss and maximise the efficiency of use. Of all the nutrients, N, P, and K remain the major ones for increased and sustained productivity. Various improved agronomic and management practices like water, soil, nutrient, disease, insect/pest management practices can play a key role in increasing productivity

of maize in the low productivity districts. Farmers need to be made aware through training programmes or Frontline demonstration to attract the maize cultivation in these districts. Many districts have scarcity of water during rabi and summer season. Water is crucial input for augmenting agricultural production towards sustainability in agriculture. Scientific water management aims to provide suitable soil moisture environment to the crop to obtain optimum yield commensurate with maximum economy in irrigation water and maintenance of soil productivity. During the winter season less water is required at early stage of crop while, at later crop growth stages water requirement increases due to rapid increase in evapo-transpiration demand. Amongst the various irrigation scheduling approaches, climatological approach has been found to be better, since it integrates all the weather parameters giving them their natural weightage in a given climate-water-plant continuum. In these districts water management practices or drip/sprinkler irrigation methods need to be promoted to take up the maize crop. To improve soils, conservation agriculture is emerging as a big boost for maize production. Conservation agriculture is based on minimal soil disturbance (reduced or no tillage), combined with organic matter retention and diverse crop rotations. As well as reducing erosion and improving soil structure and soil water dynamics, this approach also saves on labour, time, fuel and machinery wear. A good example of the effectiveness of conservation agriculture is the rapid spread of 'Zero Tillage' technology in Andhra Pradesh's rice-maize system.

Mechanization- sowing to shelling

In every crop mechanization is essentially required to increase the productivity and decrease the cost of cultivation. Maize is a crop in which mechanization can be followed since sowing to harvesting/shelling. Keeping in view the small landholdings of majority of farmers in the state small machinery affordable to these farmers, should be promoted. High cost machineries like maize harvester/combine dryer should be set up or made available on custom hiring basis. In majority of areas farmers still following plough furrow sowing of maize. Utilization of seed drill for sowing of maize is lesser in comparison to wheat. Now a days irrigation is becoming costly input to every crop. Due to spacing of rows maize is suitable for drip irrigation mechanization. Sprinkler irrigation method also be useful in this crop. Weed management and inter-culture operation like earthing up have important role in the maize cultivation. Tractor run ridger provides best solution for this mechanization. Manual harvesting of maize is another costly operation in maize. Although combine harvesters are commonly used in wheat crop. But due to non-availability of such machines combine harvesters farmers still following manual harvesting. Although few maize combine harvester are available in Purnia and Katihar districts.

Drying and Storage to meet global market quality

Generally maize is harvested at a moisture level ranging 20-30% in the grain. Farmers use sun drying to lower the grain moisture but in kharif harvest maize and some time in rabi harvest this moisture is difficult to bring down from 14%. This high grain moisture of either fetch low price to the farmers and deteriorate the quality of grain during storage due to development of aflatoxins. Therefore, to meet the global marketing standards and quality of maize and also to fetch good returns from maize crop, mechanical dryers need to be utilized at large levels in the state. The National Collateral Management Services Limited (NCML), a leading warehouse service provider, has inaugurated its public silo complex of 36,000 tonnes for storing maize at Purnia in Bihar.

Breeding for Climate Resilient Maize Hybrids

Climate change is an important challenge that threatens the long-term production growth of cereals. Climate change also creates various abiotic stresses like drought, heavy rains/flooding, heat and cold stress. Changing climate has resulted in increase of abiotic stresses which limit the crop yields worldwide (Wani *et al.*, 2013).

a) Cold stress tolerance for rabi maize

In Indo- Gangetic Plains region and specially in Koshi regions of Bihar that includes Katihar, Khagaria, Purnia, Araria, Kishanganj and Sharsha also the regions of Samastipur and Begusarai where the winter season maize crop invariably face severe low temperature during winter months. The average minimum temperature may fall below 5°C or even less.. Adaptation of maize to winter season requires genetic improvement for cold tolerance, which implies vigorous seedling growth without suffering with cold injuries under low temperature conditions. Maize hybrid needs to be tolerant to cool temperature at pre-flowering and flowering stage. The extreme cool temperature affects the maize growth in a number of ways right from emergence till flowering and seed-setting. Low temperature at planting greatly affects germination. Prolonged exposure to low temperature during the vegetative phase results in reduction in plant height, yellowing of the leaf, chlorosis and tip firing due to the death of leaf tissues. Prolong cold stress occurring at flowering stage severely affects flowering leads to reduced tassel size, lesser tassel branches, poor tassel development, lesser anther, death of pollen which ultimately results into poor or no grain setting in the maize ear. The similar situation was faced by the farmers of koshi region of the state during early sown rabi 2017-18 maize crop. Breeding programme should be emphasized on the development of such hybrids that have in built mechanism to tolerate the cold stress.

b) Waterlogging stress tolerance for kharif maize

Waterlogging is another abiotic stress in bihar. Many district of Bihar including gangatic area of Patna, Begusarai, Khagaria, Bhagalpur and district of Koshi regions i.e. Katihar, Saharsa, Purnia, Khagaria, Madhepura, Kishanganj Araria and Supoul are flood prone. Kharif crop may face waterlogging at knee high stage, pre-flowering or flowring stage. Lack of oxygen supply for the plant is the main reason of damage in waterlogging condition, which hampers nutrient and water uptake, as a reason the plant shows wilting. In oxygen-deprived condition plants shift its metabolism to anaerobic from aerobic mode. Plants which can withstand waterlogging condition have mechanisms such as increased availability of soluble sugar, aerenchyma formation, greater activity of glycolytic pathway and fermentation enzymes. Historically large gains have been made through conventional breeding. Large volume of information is available on the responses of excessive moisture/waterlogging stress on maize; however, the major challenge is to identify the stress-adaptive traits among the various effects/changes under the stress on different stress responsive traits. The genotypes with inbuilt capacity to produce brace roots and morphological adaptation like air space (aerenchyma) formation in cortical region of brace roots on exposure to the stress, can tolerate excess water situation in rhizosphere up to some extent. (Zaidi, *et al.* 2010 & 2013). Teosinte the wild relave of maize have many superior features for waterlogging tolerance. Teosinte *Z. luxurians* and *Z. mays* ssp *huehuetenangensis* have been observed to exploit a higher capacity for adventitious root formation under extreme conditions of waterlogging than maize. *Z. luxuriance* was reported to develop well-formed aerenchyma in adult plants (Ray *et al.* 1999). Qiu *et al.*, (2007) Identified, several moderate effect QTLs for seedling stage tolerance to waterlogging. QTL mapping revealed five QTL on chromosomes 1, 3, 5, 7, and 10, which explained 30% of phenotypic variance for GY under waterlogged conditions and 13 QTL's were identified for various secondary traits associated with waterlogging tolerance, New genomic selection technologies have become available that allow the breeding cycle to be greatly reduced and that facilitate the inclusion of information on genetic effects for multiple stresses in selection decision (Heffner *et al* 2009). Three marker-based selection approaches are being utilized (F2 enrichment, MARS, and GWS), that aim at increasing desirable QTL allele frequencies in a population improvement context, either by utilizing the QTL information or without it, are increasingly gaining prominence.

c) **Drought and heat stress tolerance for summer maize**

Summer or spring maize is planted in many districts of Bihar. Low lying areas of koshi region including Khagaria, Saharsa Bhagalpur where flood water remain stagnant and dry up in December January, farmers cultivate summer maize. It is also cultivated in Samastipur, Vaishali and Patna districts. Summer or spring maize crop face extreame drought during April and May. Therefore, requiring water efficient plant type or drought tolerant genotypes. As early as the 1970s, the International Maize and Wheat Improvement Centre (CIMMYT) began a breeding approach for drought-tolerant maize lines and spent more than 30 years developing several drought-tolerant varieties (Ashraf, 2010). The responses to drought and/or heat stresses in plants are complex physiological and biochemical processes and involve changes in anatomic structures. These characteristics are determined by sets of genes within the maize genome. Thus, it is necessary to identify stress- related genes/proteins. A range of stress response-related proteins, such as heat shock proteins (HSPs), phyto-hormone regulators, signalling proteins, and protective enzymes, etc. (Gong *et al.*, 2014; Yin *et al.*, 2014; Hu *et al.*, 2015a,b) contribute to drought and heat stress tolerance in maize. Proteins HSP26 improves chloroplast performance under heat stress by interacting with specific chloroplast proteins in maize (Hu *et al.*, 2015b).

Fall Army Worm (*Spodoptera frugiperda*)- a new insect threat to maize production

Fall Army Worm (FAW) was first detected in a field of maize in Karnataka in May, Bangalore's National Bureau of Agriculture Insect Resource (NBAIR) confirmed presence of fall armyworm in Tamil Nadu, Karnataka, West Bengal, Telangana, Andhra Pradesh and now, in Maharashtra. Fall armyworm is native to the Americas and was first reported to have reached Africa in 2016. Centre for Agriculture and Biosciences International (Cabi) estimated in September that improper management of the armyworm could cost 10 of Africa's major maize producing economies etween \$2.2 billion and \$5.5 billion per year in lost maize harvests. Though known primary attacking maize fields, the fall armyworm also eats an additional 186 plant species, including sorghum and soya beans. Already, Maharashtra has detected a suspected fall armyworm attack on sugarcane in the state. "Armyworm has spread to almost all countries in sub Saharan Africa. Eradication is not feasible, so management is now required on a continuing basis to limit losses. The same situation is likely to occur in Asia. The yield of my maize crop can decline by about 25%," said Ganesh Babar, the first farmers on whose farm fall armyworm was detected in Maharashtra. However, government agencies have reported losses up to 70% in some of the fields in Karnataka. If the pestilence spreads, it is difficult to eradicate. Fall armyworm can cause significant yield losses if not well managed. Fall armyworm is a dangerous transboundary pest with a high potential to continually spread due to its natural distribution capacity and trade. Farmers will need significant support to sustainably manage fall armyworm in their cropping systems through Integrated Pest Management," said the Food and Agricultural Organisation (FAO): The incidence of FAW has been reported in some maizefields in purnia districts of Bihar

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