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Review Article

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Maize Scenario in Haryana: A Brief Review

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ABSTRACT

The importance of maize crop lies in the fact that it has been widely used in diversified sectors like food, feed and ethanol production and its demand is increasing every year due to growth in poultry industry and expansion of maize based industries. The cultivation of specialty corn viz., quality protein maize and baby corn and its value addition by establishing industries in rural area are also gaining importance in market driven farming which in turn may be helpful to the Haryana's farmers in crop diversification and generation of employment in rural area. No land race of maize is popular in Haryana. CCS HAU, Regional Research Station, Karnal has developed more than 450 inbred lines of normal maize and specialty corn (QPM, baby corn, sweet corn and popcorn) with different desirable traits and maturity groups. Approximately 3940 experimental hybrids have been developed and tested at the station. Sixteen single cross hybrids of maize have been developed and released from the centre. For baby corn cultivation and QPM, hybrid HM 4 and HQPM 1 developed from the centre are most popular cultivars among the farmers. Among the QPM, the HQPM 1 is the most popular hybrid. Taken into insight of the changing scenario of cropping system, diseases and insect/pest, the main challenge for the centre is to develop high yielding normal maize hybrids which may give grain yield more than 10 t /ha and specialty corn comparable with the private companies. Efforts will be there to promote area under maize cultivation and also for the establishment of maize based industry particularly baby corn, sweet corn and QPM.

Key words: *Maize, Hybrid, Baby corn, Dalia, Sattu*

INTRODUCTION

Maize (Zea mays L.) is an important cereal crop, belongs to the tribe Maydeae, of the grass family, Poaceae and is widely cultivated crop throughout the world and its suitability to diverse environments is unmatched by any other crop. Maize has gained tremendous importance due to rising demand from diversified sectors like food, feed and ethanol production. It is one of the major food crops in India where it is used as human food and animal feed. About 50 to 60 per cent of maize production in India is consumed as food for humans and feed for cattle, 30 to 35 per cent goes to poultry, piggery and fish meal, 10 to 12 per cent in wet milling industry e. g. in starch and oil and about 3 per cent in dry milling for traditional requirements like Dalia, Sattu and other food products such as corn bread corn chips[7]. It is one of the major fodder crops in north-west India during summer season.

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Use of maize for direct human consumption has reduced over the years and most of its produce goes to livestock as feed. However, it is one of the most important food, feed, fodder and industrial crop in Haryana and is also cultivated in all the three seasons (*kharif*, *rabi* and *spring*). It was cultivated on 6 thousand hectares in *kharif* season with average productivity of 2.83 t / ha during 2015-16. The maize is also increasing in spring season which was grown on ~ 7 thousands hectare with productivity of 4.5 t / ha. The specialty corn (baby corn and sweet corn) is also grown in > 5 thousand hectare area of Haryana in national capital region. Major breakthrough in yield of maize came with the release of hybrids with high yield potential. The single cross hybrids including quality protein maize hybrids have become popular among farmers due to their high yield potential and excellent uniformity[6]. The demand of maize is increasing every year due to growth in poultry industry and expansion of maize based industries. There is a good scope of cultivation of specialty types of corn (baby corn, quality protein maize and sweet corn) in Haryana as it is very near to national capital, Delhi. The cultivation of specialty corn and its value addition by establishing industries in rural area may be helpful to the Haryana's farmers in crop diversification, generation of employment in rural area, solving the problem of green fodder and earning foreign currency.

Major maize growing districts in Haryana

The dramatic increase in production and yield levels of maize during the last four decades is mostly due to genetic improvement of hybrids and better production technology[5]. As maize has been the source of nutrient for human as cereal crop and animals as fodder, the improvement of maize in terms of its protein quality mainly lysine and tryptophan is very important. Therefore, the QPM may be helpful in food and nutritional security, nutritious feed and promoting maize based entrepreneurship in the country[2]. However, the area and production of maize in Haryana decreased over the years but productivity increased during 1966 to 2015 (Fig. 1).

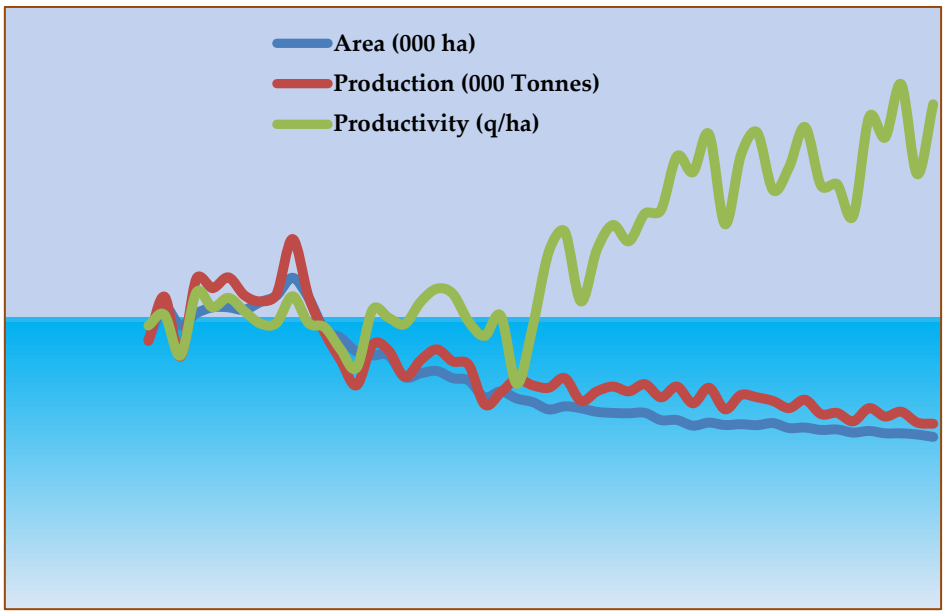

Fig. 1: Decadal seasonal trends in APY of maize in the Haryana from 1966 to 2016

Major industries utilizing maize in the Haryana

There are two starch industries viz., Bharat Starch Industries, Yamunanagar and Sada Sat Corn Product Pvt. Ltd. Garhi Singha, Kurukshetra. These industries utilize approximately 200 and 75 tonnes corn grain, respectively on daily basis. In addition to these , there are four baby corn industries *viz.* Pratibha Foods, Village Aterna, Sonepat; Shimla Farm, Village Aterna, Sonepat; Gulab Fruit and vegetable Growers & Marketing Co-

operative Society Ltd., Food Park, HSIIDC Rai, Sonepat and Integrated Unit for Mushroom Development, Kundli, Sonepat in the state, each of these industries are processing approximately 150 -200 tonnes baby corn every year.

Rainfall pattern: month-wise *kharif* and *rabi* separately for Haryana

Haryana state is considered the breadbasket of India along with the Punjab. The effects of drought and mitigation of those effects are therefore of considerable importance for the state. Haryana has a semiarid climate in the southwest and a Gangetic plain environment in the rest of the state. About 50% of the state has a moisture deficit. One of the reasons for adverse crop production in the state during June–September is the early withdrawal or late onset of monsoon rains, which contribute nearly 80% of the state's annual rainfall. The monsoon rain during June–September ranges from 284 mm to 521 mm in the drier western and southern plains and from 333 mm to 721 mm in the eastern districts of the state.

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Major cropping systems and production ecologies

Recently, due to changing scenario of natural resource, maize based cropping system become essential in Haryana state. In *peri*-urban interface sweet corn, baby corn and

maize based high value intercropping systems are also gaining importance due to market driven farming. 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, 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. The major cropping systems in the state are rice-wheat, cotton-wheat, pearlmillet-wheat, fallow-rapeseed & mustard and sugarcane. There is considerable decline in water table in rice-wheat areas in the north eastern zone of Haryana. The delay in planting and low yield of wheat in cotton based cropping system is some of the important issues related to these cropping systems and diversification. Inadequate availability of quality seeds of vegetables, flowers, spices, planting material for fruits, their higher cost and timely availability are some major constraints, to avoid these constraints there is a need of different types of maize in the Haryana state.

Different maize based cropping systems in Haryana are:

- Maize(*kharif*)- wheat
- Maize (*spring*) - paddy-potato
- Maize(*kharif*) - potato- sunflower
- Maize (*kharif*)- potato/ mustard/ maize (*spring*)
- Maize (*kharif*)-wheat-urdbea / mungbean

Coverage of cultivars

During spring season maize is grown in approximate area of 7000 ha with productivity of 4.5 t/ha. Almost whole of the cultivated area during spring season is under single cross hybrids while in *kharif* season from 6000 ha cultivated area approximately ~ 30 % area is under single cross hybrids and rest of the area is multi-parent hybrids. However, in specialty corn 100% area is under single cross hybrids[1].

Popular cultivars of maize in Haryana

No land race of maize is popular in Haryana. The maize hybrids *viz*. DKC 9125, Hyshel, DKC 7074, P 3408 and PAC 740 are popular in *kharif* while maize hybrids 31Y45, P 1844 and DKC 9108 are most popular in spring season. For baby corn cultivation, hybrid HM 4, Syn 5414 and NK6414 are most popular cultivars among the farmers. Among the QPM, the HQPM 1 is the most popular hybrid among the farmers while in sweet corn N 75 is most popular cultivar.

Key maize production problems in state.

- Subsidy on electricity by state Govt. is the key factor responsible for promoting rice cultivation and exploitation of underground water in the state which decreased the area under maize cultivation in the state.
- Increased population of blue bulls is another factor for reduction of area under maize in the state.
- Poor marketing of maize is also a limiting factor for maize cultivation. There is good scope of specialty corn (QPM, baby corn and sweet corn) but sufficient processing industries i.e. QPM based food and feed industries and baby corn and sweet corn processing industries are not there in the state.
- Seed of recommended hybrids is not available in sufficient amount to the farmers while the seed of private companies is very costly.

Cultivars released from Karnal

CCS HAU, Regional Research Station, Karnal has developed more than 450 inbred lines of normal maize and specialty corn (QPM, baby corn, sweet corn and popcorn) with different desirable traits and maturity groups. Approximately 3940 experimental hybrids have been developed and tested at the station. The superior experimental hybrids have been submitted for testing in different coordinated trials. The single cross hybrids of maize developed and released from the centre are given in Table 1.

Table 1: Maize hybrids developed and released from the Karnal centre

Cultivar	Year	Released by	Other /Characteristics
Yellow maize hybrids			
HHM 1	2000	SVRC	Early maturing yellow, dent grain, drought tolerant SCH for *kharif* and *rabi* season, Matures in 83-84 days in *kharif* with average grain yield during *kharif* is 53-55 q/ha while 60-65 q/ha during *rabi* season.
HM 4	2005	CVRC	First baby corn SCH in the country, attractive colour of grain and baby corn, released for *rabi* and *kharif*, matures in 84-86 days in *kharif* season. Average grain yield during *kharif* is 55-60 q/ha and 67-72 q/ha during *rabi* season. Baby corn average yield is 13-15 q/ha.
HM 8	2007	CVRC	Attractive orange and flint grains, SCH released for peninsular zone resistant to TLB, SDM and PFSR, tolerant to cold. Matures in 85-86 days in *kharif* season and yield 55-62 q/ha while gives and 67-72 q/ha during winter.
HM 9	2007	CVRC	Attractive orange and flint grains, SCH released for North Eastern Plain zone resistant to MLB and common rust, tolerant to frost/cold, matures in 85-88 days and grain yield is 57-62 q/ha during *kharif* and 70-75 q/ha during winter.
HM 10	2008	CVRC	Yellow semi dent grain, SCH for winter season, resistant to common rust, MLB, stem borer and cold, released for whole country , matures in 88-90 days in *kharif* season, average grain yield during *kharif* is 57-60 q/ha and 70-75 q/ha during *rabi* season.
HM 11	2011	CVRC	Semi dent, yellow grain SCH *kharif* season, responsive to high dose of nutrient, high level of resistance against MLB and common rust, matures in 88-90 days in *kharif* season ,average grain yield during *kharif* is 57-60 q/ha and 67-70 q/ha during *rabi* season.
HM 13	2014	CVRC	High starch, yellow grain SCH recommended for Northern hill zone for cultivation in *kharif* season, resistance against MLB, common rust, BLSB and TLB. Matures in 82-85 days in *kharif* season. Average yield during *kharif* is 55-60 q/ha and 65-68 q/ha during *rabi* season.
White maize hybrids			
HHM 2	2000	SVRC	First white shining flint grain, medium maturing SCH in the country released for *rabi* and *kharif* season for cultivation in the state, matures in 88-90 days in *kharif* season, average grain yield during *kharif* is 54-55 q/ha and 65-67 q/ha during *rabi* season.
HM 5	2005	SVRC	Very productive white dent maize hybrid, suitable for intercropping, released for *rabi* and *kharif* season, tolerant to common rust, MLB and cold, matures in 88-90 days in *kharif* season, average grain yield during *kharif* is 60-65 q/ha and 70-75 q/ha during *rabi* season.
HM 12	2012	CVRC	First white SCH recommended for North Eastern plain zone for cultivation in *kharif* season, resistant to MLB and common rust, matures in 85-87 days in *kharif* season, average grain yield during *kharif* is 55-60 q/ha and 63-68 q/ha during *rabi* season.
Quality protein maize hybrids			
HQPM 1	2006	CVRC	Yellow grain, SCH of QPM released for *rabi* and *kharif* season in the whole country, resistant to MLB and common rust, matures in 88-90 days during *kharif* season, grain yield is 57-62 q/ha during *kharif* and 65-70 q/ha during winter.
HQPM 4	2011	CVRC	QPM, SCH attractive light orange semi dent grain, released across the country, matures in 90-93 days during *kharif* season, resistant to MLB and tolerant to stem borer, grain yield is 58-62 q/ha during *kharif* and 65-72 q/ha during winter season.
HQPM 5	2007	CVRC	QPM SCH with attractive orange flint grain released for cultivation across the country, resistant to MLB, common rust, BLSB and PFSR, matures in 88-91 days, grain yield is 60-62 q/ha during *kharif* and 67-72 q/ha during winter season.
HQPM 7	2008	CVRC	QPM SCH released forpeninsular zone, grain is light orange, resistant to MLB and stem borer, matures in 88-91 days, grain yield is 60-64 q/ha during *kharif* and 67-72 q/ha during winter season.
Baby corn hybrid			
HM 4	**2004**	CVRC	Dual purpose SCH used for both baby corn and grain purpose. The grain is flint and orange in colour. The hybrid is resistant to MLB, stem borer and rust. It is harvested in appox. 60 days during *kharif* season, baby corn average yield is 13-15 q/ha and released for central western zone of India.
Sweet corn hybrid			
HSC 1	2011	CVRC	First public sector bred single cross sweet corn hybrid, released for cultivation in hilly zone (Jammu, Himachal Pradesh and Uttarakhand) for *kharif* season, average yield of green cobs 120 q/ha, ready to harvest in 80-82 days, resistant to MLB and common rust.

Changes in cropping system over the years

Haryana is predominantly an agriculture economy with preponderance of wheat, rice, bajra, mustard, sugarcane and cotton. In the recent years, commercial orientation of the state agriculture is more associated with mustard, vegetables, fruits etc. and the area under pulses declined considerably. Among the cereals, the annual compound growth rates for fine cereals, *viz*. wheat and rice were 3.7 % and 2.4 % while for coarse cereals, *viz*. maize, bajra and jowar the growth rates were 1.4 % and -0.76 % during the period 1976-77 to 2011-12, respectively. These changes in cropping pattern have especially marked in the regions, which have witnessed the advent of green revolution. For example, the pulses production in Haryana has declined alarmingly from 952.0 thousand t in 1975-76 to 100 thousand t in 2015-16. Contrary, during last four decades, wheat production in the state increased about eleven fold; from 1059 thousand tons in 1966-67 to 11352 thousand t in 2015-16. Similarly, the rice production has increased from 223 thousand t to 4145 thousand t during the same period, which is more than eighteen-fold. The indices of cropping intensity in the state have increased from 1975-76 from 121.02 in 1975-76 to 181.47 in 2015-16. Sangwan[4] reported that changes in the state cropping pattern resulted from increase in irrigation facilities to a large extent. Considering the diversity of soil, agro-climatic conditions and availability of canal irrigation and infrastructure services (e.g., roads and regulated markets) across the sub-regions, potentiality to cultivate varied types of crops exists in the state.

Ramphul[3] reported that the cropping pattern and performance of different districts in growing different crops like maize in Ambala and Yamunanagar, cotton in Hisar, sugarcane in Yamunanagar and Ambala, mustard in Rewari and Mahendragarh, gram in Mahendragarh, bajra in Rewari were the highest. The specialization of wheat in Panipat, Hisar and Faridabad, rice in Kurukshetra, Kathal and Karnal, jowar in Rohtak and Faridabad is highest area under this crop. The highest specialization of bajra was observed in Mahendragarh, Rewari and Gurgaon.

Changes in Disease scenario over the years

Among the factors adversely affecting productivity, incidence of diseases in pre-harvest stage is prominent. Considering the losses caused by diseases in Haryana from last ten years, five diseases *viz*., maydis leaf blight (*Bipolaris maydis*), banded leaf and sheath blight (*Rhizoctonia solani*f. sp. *sasakii)*,common rust (*Puccinia sorghi*), bacterial stalk rot (*Erwini acrysanthemi* pv. Zeae) and pythium stalk rot (*Pythium aphanidermatum*) are of economic importance. However, incidence of Curvularia leaf spot is also increasing from last few years and posing new threat to maize crop in Haryana. Banded leaf and sheath blight (BLSB) and maydis leaf blight (MLB) diseases were found most important diseases in maize growing area during *kharif* and common rust during *rabi* season. Maydis leaf blight appears every year and incidence ranges from 20-85%. Banded leaf and sheath blight observed in severe form every year and losses up to 100% causes if continuous rain prevails during July- August. Common rust ranging from 5-60 % also noticed during February-March.

Epidemiology

Prevalence and severity of different diseases in research and farmers field trials were recorded during both the seasons. More than 80 % prevalence and 42 % severity of MLB was recorded in non-recommended varieties grown on farmers' fields. Incidence of BLSB was recorded in severe form during 2009 and 2010 due to continuous rains in the months of July and August. Banded leaf and sheath blight disease appears at pre-flowering stage on leaf and sheath in 40 to 45 days old plants. Out of three dates of sowing of maize, the highest banded leaf and sheath blight disease intensity was observed in 1st date of sowing (29 June) followed by 2nd date of sowing (13July) and least disease intensity in 3rd date of sowing (28 July). Maximum temperature range of 31.9-32.3 ^{0}C, and minimum temperature 24.6-25 ^{0}C with relative humidity morning (94-95%) and

evening (69-83%), sunshine (2-7.7 hrs) per day and rainfall (34.6-55.8 mm) were most congenial for BLSB disease. However, temperature and relative humidity plays important role in BLSB progression. Regression equations on relationship between disease development and weather parameter have been developed for five maize hybrids / inbreds.

The *rabi* crop gets infected with rust during the month of February and March. Moderate temperature ranging from 16-25 ^{0}C and high relative humidity favours rust development and spread**.**

Changes in pest scenario over the years

Among the major factors of low productivity is the infestation by different insect–pests at various stages of crop. Different species of insect-pests infest maize crop during *kharif*, *rabi* and spring seasons. In India, 130 species of insect pests have been reported to damage this crop. Amongst these, the most serious pests are the maize stem borer, *Chilo partellus* (Swinhoe), the key pest throughout during rainy season, pink stem borer, *Sesamia inferens* (Walker), serious in peninsular India in post rainy season and two species of shoot fly, *Atherigona soccata* Rund and *Atherigona nuquii* Steyskal, serious in spring maize in Northern India, which cause economic yield losses[8].

Recently, *S. inferens* has emerged as a new pest and is likely to pose serious threat to the successful cultivation of maize in the north-western plains of India under largely adopted rice-wheat/maize cropping system[9]. *S. inferens* has also been reported to infest maize during *Rabi* season in Haryana[10]. Pink stem borer infestation in hybrid HQPM 1 ranged from 3.2 to 8.4% and 5.6 to 17.6% from November end to March at an average temperature of 10-25 ^{o} C during 2014-15 and 2015-16, respectively.

Chaffer beetle, *Chiloloba acuta* (Weidemann) is a serious pest in maize seed production area. It was first time observed in August 2002 at Research Farm, CCS HAU Regional Research Station Karnal. It appears in first fortnight of August and feeds on pollen grain and hence causes serious problems in seed setting. It prefers to lay eggs on organic matter in soil and larvae/grubs remain in soil till the emergence in next rainy season. There is only one generation in a year.

Cob borer **(***Helicoverpa armigera*) is also a regular occurrence in maize at silking/ tasseling stage during last decade in Haryana. Female moths lay eggs on the stem, leaves (both sides), tassels, silks and husks on the upper two-thirds of plants. Caterpillars hatching prior to silking cause little damage to tassels but may cause damage when migrating to cobs. Per cent incidence and severity of infestation by cob borer was reported as 3.9 and 0.61%, respectively. Often the damage to the grain is not much yet the infestation marks reduces the market value of green cobs.

Post harvest management

Maize can store for a considerable period in unprocessed form without undergoing deterioration. Its shelf life greatly depends on the prevailing ambient temperature and relative humidity, and other factors like the inherent moisture, pests and diseases. Therefore, recommended post harvest handling and managing operations involve the manipulation of the above factors in order to obtain high quality maize grains. Quality control starts with harvesting. The optimum time of harvesting maize is when the stalks have dried and moisture of grain as about 17-20%.

Future research and development strategy

- Development of maize hybrids with grain yield of 10 t/ ha during *kharif* season.
- Development of cultivars responsive to high density.
- Development of specialty corn (baby corn. Sweet corn and pop corn) hybrids for better income and solution to fodder problem.
- Development of nutritional rich value added products from QPM, baby corn, sweet corn and pop corn to double the income of farmers.
- To develop hybrids tolerance to extreme moisture conditions during *kharif* season.
- Enhancing water use efficiency in spring maize by breeding, resource conservation, etc.

- Development of fodder maize varieties.
- Development of QPM hybrids for silage purpose.
- Improving performance of parental lines *per se* (Breeding, production and protection).
- Emphasis on management of emerging pests and diseases like banded leaf and sheath blight and bacterial leaf streak virus.
- Improvement in mechanization of maize cultivation.
- Strengthening of the seed production programme public breed hybrid.

Future approach in research and development will focus on development of superior single cross hybrids. Priority will be given on evolving hybrids not only with high yield potential but also for specialty corn like quality protein maize, baby corn, sweet corn, pop corn and for specific industrial application. The mission for future research activities will be increasing the productivity and profitability of maize and maize based cropping system with socio-economic upliftment and conservation of natural resources leading to generation of wealth and employment in farming and industrial sector.

SUMMARY

CCS Haryana Agricultural University has developed very good hybrids of normal maize and specialty corn but now it is challenge for the center to develop normal maize hybrids which may give grain yield more than 10 t /ha and specialty corn comparable with the private companies. Efforts will be there to promote area under maize cultivation replacing paddy.
Establishment of maize based industry particularly baby corn, sweet corn and QPM may be helpful in doubling the income of the farmers.

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