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DEPARTMENT OF AGRICULTURE
GOVERNMENT OF PUNJAB



CROP DIVERSIFICATION WITH MAIZE





IN PUNJAB

SUSTAINABLE AGRICULTURE CONCLAVE

DECEMBER 10, 2019 | TAJ HOTEL, CHANDIGARH

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Sh. J.P.S Bindra, Chief General Manager, NABARD Punjab

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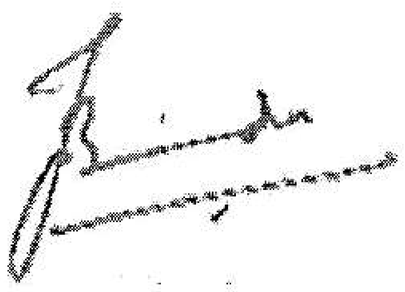
Foreward

A much highlighted issue of Punjab and many parts of Northern India today is of stubble burning of crops, mainly, of paddy. Agencies from centre, state as well as different institutions including NABARD are engaged in working out a viable solution to address this menace. While awareness creation is one end of it, a comprehensive solution can come only by promoting alternative crops that can help break the paddy-wheat cycle. Maize is one such crop that has the potential to emerge as a feasible alternative to paddy in *kharif*.

Besides, the very fact that maize requires much less water than paddy in cultivation signifies the role it can play in a state like Punjab, when the water tables are receding at an alarming rate. Developing proper marketing facilities and establishing a profitable value chain are vital for fostering an ecosystem conducive for cultivation of maize.

I am glad that FICCI is organizing a Maize Conclave bringing together subject and industry experts as well as farmers from the field level under a single roof. I look forward to the interactions and hope that the collective wisdom of the congregation will be able to chart a new road ahead for the success of maize as a *kharif* crop in Punjab.

I wish every success to the event.



(J P S Bindra)
Chief General Manager
NABARD Punjab Regional Office

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FROM THE CHAIRMAN'S DESK

Punjab's struggle with groundwater depletion has not remained unknown. It is well-established that paddy-dominant agriculture in Punjab (39.64% of total crop production) has ripped the State of its valuable water resources, so much so that the groundwater level now remains at a critical edge.

To address the concern, State-Government as well as State offices of Central bodies have explicitly explored the array of available solutions in various committee meetings and panel discussions, post which crop diversification with less-water intensive crops like maize was accepted as the best suited option in hand. Converting this solution into a reality, NABARD Punjab has been incentivising Punjab farmers for 'shifting from paddy to maize cultivation' under its project, that covered 1000 acres in its first year of implementation itself. Punjab Government too has been actively pursuing this agenda. In July 2019, Hon'ble Chief Minister of Punjab, Capt. Amarinder Singh called for crop diversification models. From then till now, farmer-sensitization workshops have been organized and other initiatives have been taken. Though highly appreciable, most, if not all, of these measures are supply-sided. Effective demand sided measures are also needed to expand market for maize produce.

As an industry chamber, FICCI strives to fill the demand gap by bringing maize-allied industries on-board for this agenda. Maize, as a commercial crop, has a strong industry linkage, such as in poultry and cattle feed, starch, ethanol, silage etc. We believe that this could be leveraged into boosting demand of maize, thus creating sufficient market for farmers' to sell their produce and at a beneficial rate. This program, *Crop Diversification with Maize in Punjab* marks the beginning of our contribution in closing the demand-supply gap and enhancing maize value-chain.

We are pleased to have support of Government and industry stakeholders for this initiative, and we look forward to many such collaborative efforts towards achieving sustainable agriculture in Punjab.

RAJINDER GUPTA
Regional Chairman, FICCI

SUSTAINABLE AGRICULTURE CONCLAVE

December 10, 2019 | Chandigarh

CROP DIVERSIFICATION WITH MAIZE

ROADMAP FOR PUNJAB

Crop Diversification with Maize in Punjab is an initiative under FICCI Regional Agri & Agro-Allied Committee, is being organized in collaboration with NABARD Regional Office Punjab and Department of Agriculture, Government of Punjab. It aims at identifying key detriments to growth in farming, livestock, agro-business & entrepreneurship and other segments of/related to the agriculture domain while at the same time, undertaking corrective measures towards ensuring progressive and sustainable operations. The regional coverage of this initiative is North India, with special focus on States of Punjab, Haryana and Himachal Pradesh.

This year's program is focused on the issue of groundwater depletion and need of crop diversification in Punjab, providing maize as an answer to it. With a gathering of 150+ progressive farmers, agri-industry (animal feed, starch, ethanol and silage manufacturers, seed and agri-tech providers etc) and subject-matter experts, the program will provide a common platform for drafting a roadmap to make shift-to-maize feasible for farmers. It will also take into account crop-related issues of maize consuming industry and will strive towards developing a dialogue between farming sector and industry to address such concerns.

150+

PARTICIPANTS FROM



Farmers & FPO



Agriculture Experts & Consultants



Water Management Industry



Maize Consuming Industry

Poultry & Cattle Feed, Starch & Ethanol, and Silage, among others



Agri-Tech Industry

Seed & Agri-Machinery, pesticide, fertilizers and other chemicals

PROGRAM **AGENDA**

09:00 – 10:00 Hrs *(Duration: 60 minutes)*	**Registration & Tea**
10:00 – 11:00 Hrs *(Duration: 60 minutes)* ***INAUGURAL SESSION*** ***Context Setting: Groundwater Depletion & Crop Diversification with Maize in Punjab***	The issue of groundwater depletion runs deep in the State of Punjab. Due to paddy-dominant agriculture and consequent high groundwater consumption, the State's groundwater level has reached a point where in absence of remedial measures, in the next 15-20 years, there wouldn't be sufficient water to sustain life, let alone agriculture. Catering to this clarion call, Government of Punjab is promoting crop diversification wherein farming community is encouraged to shift from high water-demanding crops (such as paddy) to those with low water requirements (such as maize and cotton). The inaugural session will witness sincere representation from different stakeholders – Government, farmers, industry and subject matter experts, to map criticality of the issue of groundwater depletion in the State. The session also explored crop diversification as the solution to the issue, presents measures that have already been taken in this context as well as possible initiatives that could be taken to boost the agenda. **Opening Address**: *Need for Crop Diversification & Maize as a Way Forward* Dr. Sujay Rakshit, Director, Indian Institute of Maize Research (IIMR), ICAR **Industry's Perspective**: Mr. Sriram Kannan, Managing Director, CLAAS India Pvt Ltd **Special Address** Dr. Balwinder Singh Sidhu, Commissioner-Agriculture, Punjab **Address**: Mr. Inderjit Singh, Director-Dairy, Government of Punjab **Address:** *State's Perspective* Mr. K.S. Pannu, IAS, Secretary, Department of Agriculture, Government of Punjab **Inaugural Address** Mr. J.P.S Bindra, Chief General Manager, NABARD Regional Office-Punjab ***Release of Souvenir & Closing Brief***
11:00 – 11:15 Hrs *(Duration: 15 minutes)*	**Networking Tea**

11:15 – 12:30 Hrs *(Duration: 75 minutes)* ***SESSION 1*** ***Maize Cultivation: Challenges & Opportunities***	Maize has stood out as the most fitted crop for diversification in the State of Punjab. It is less water-demanding, implying less groundwater consumption for production purposes, and produces higher yield per hectare. Then it is also a commercial crop, pointing to higher economic value to the State. Despite such advantages, Punjab has been unable to register any significant progress in increasing area under maize cultivation, which has remained more or less constant. It is due to reasons ranging from qualitative and quantitative challenges to maize cultivation, to low knowledge dissemination on available technologies and successful cultivation modals for adaptation purposes. Maize-experts from institutes such as PAU, IIMR-ICAR and others will join farmer representative and agri-industry leaders to reflect upon, • Prospects of maize cultivation • Challenges to maintaining quality and quantity • Suggestive measures **Session Moderator:** Dr. Sujay Rakshit, Director, Indian Institute of Maize Research (IIMR), ICAR **Panelists:** • Dr. SK Sandhu, Senior Maize Breeder, Punjab Agricultural University (PAU) • Dr. Manju Wadhwa, Senior Nutritionist and Former Head-Animal Nutrition, GADVASU • Mr. J.S. Nagi, Proprietor, Kulwant Nutritions • Mr. Kannan, Managing Director, CLAAS India Limited • Mr. Rahul Shrivastava, Senior Vice President (Grains), COFCO International • Mr. Govind Sharma, Head of Agronomy, Syngenta India **Sum-Up by Moderator**
12:30 – 12:40 Hrs *(Duration: 10 minutes)* ***Individual Address/ Presentation 1***	***Commodity Exchange for Better Crop Pricing*** Mr. Deepak Gupta, Deputy Manager, National Commodity & Derivative Exchange (NCDEX)
12:40 – 12:50 Hrs *(Duration: 10 minutes)* ***Individual Address/ Presentation 2***	***Crop Protection for Maize: Losses due to Crop Disease & Measures to Minimize it*** By Mr. Malwinder Malhi, Program Lead-North Region, Syngenta India
12:50- 13:00 Hrs *(Duration: 10 minutes)* ***Individual Address/ Presentation 3***	***Economic Potential of Maize Processing, special reference to Crop Residue Management*** By Dr Sudesh Kumar, Scientist 'F', CIAB-NABI
13:00 – 14:00 Hrs *(Duration: 60 minutes)*	**Lunch**

14:00 – 15:15 Hrs

(Duration: 75 minutes)

SESSION 2

Maize in Industry: Mapping Demand Patterns

Maize, being a commercial crop, has far-reaching application in industry. Serving as a raw material, maize has sustained poultry and cattle feed (63% consumption share), starch & ethanol (22% consumption share), silage businesses. However, in Punjab, there is a mismatch between demand and supply side in maize value-chain. Due to high moisture content of Punjab-grown maize, majority of maize-consuming industry in the State consumes produce of other States and/or countries. Apart from it, high level of aflatoxin is another concern for maize dealers/traders and results in non-procurement of in-grown crop. This diversion of demand outside the State has contracted the market for Punjab's maize, further discouraging the farmers to shift from paddy to maize.

This session targets to establish a dialogue between supply side (farmers) with demand side (maize-consuming industry) to map loopholes in the maize value-chain. Discussion will pursue on,

- Current consumption and prospects in
  - Cattle Feed and Poultry Industry
  - Starch and Ethanol Industry
  - Corn-processing industry (producing corn syrup, cornmeal etc)
- Challenges in qualitative and quantitative procurement of maize
- Suggestive measures, if any

Session Moderator: Dr. Jaswinder Singh Bhatti, President, Fodder Manufacturer Association (FMA)

Panelists

- Mr. Harsh Rawat, Purchase Manager, Cargill Pvt Ltd
- Mr. Naresh Mehta, Owner, Kanchan & Leader Cattle Feed
- Mr. Inderjit Singh, Director-Dairy, Government of Punjab
- Mr. Harinder Khanna, Indian Fodder Industries Association
- Mr. Kushal Mittal, AMD, BCL Industries Limited
- Mr. Siddharth Mundeja, General Secretary, Fodder Manufacturer Association (FMA)

Sum-Up by Moderator

15:15 – 15:25 Hrs

(Duration: 10 minutes)

Individual Address/ Presentation 4

Enhancing Global Competitiveness of Maize

By Mr. Taranjeet Singh Bhamra, CEO, AgNext Technologies-Mohali

15:25 Hrs onwards

<u>Closing Session</u>

Program Sum-Up by FICCI Team
Vote of Thanks & Closing

AGRICULTURE IN PUNJAB

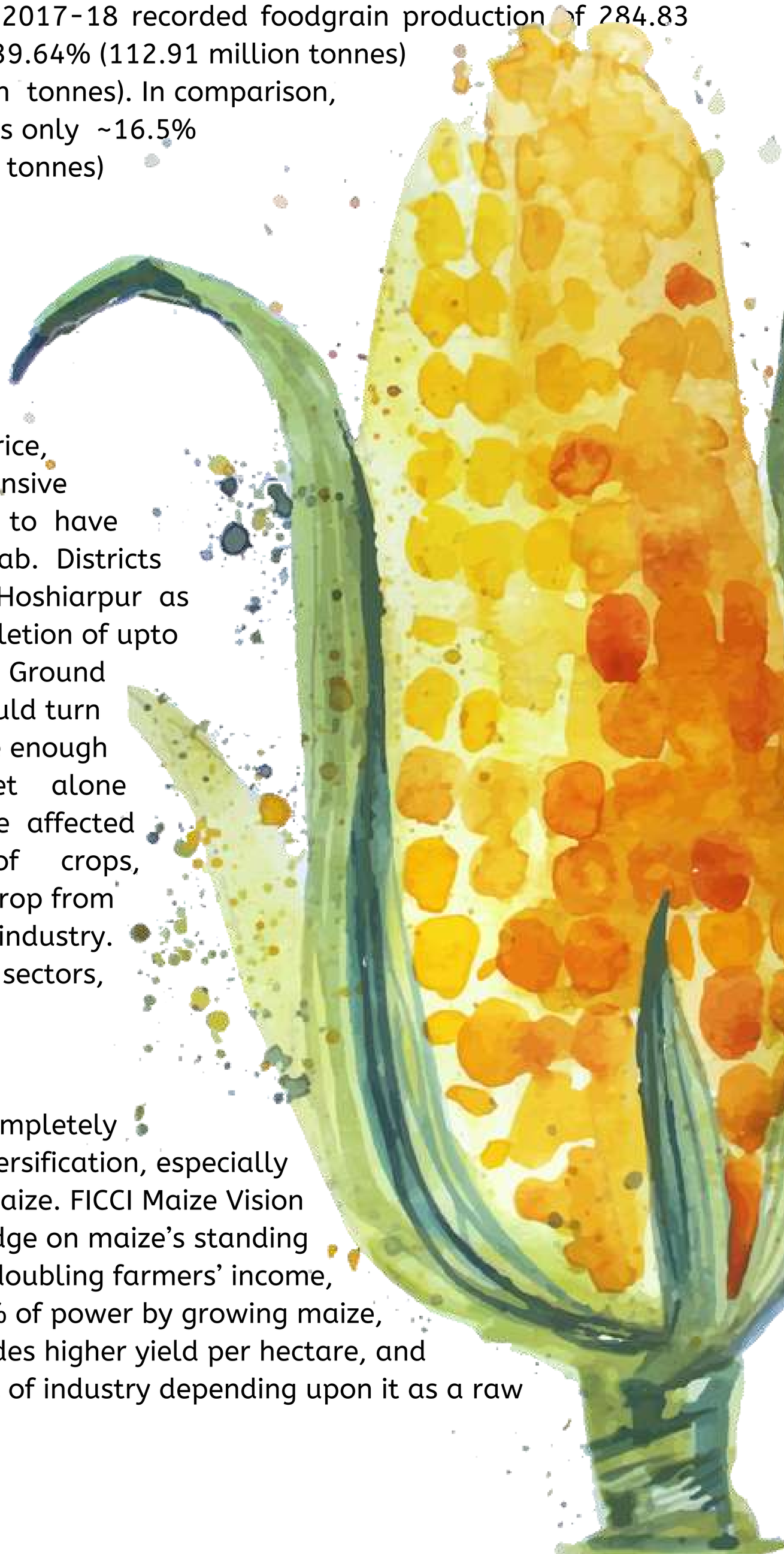
WHY CROP DIVERSIFICATION WITH MAIZE?

Agriculture Trend

Punjab is an agriculture-centric State and a leading crop-producer in India. It accounts for 1.5% (5033 hectare) of the nation's geographical area, of which 83% is under cultivation. In terms of food-grain production, it ranks third in the nation and is often termed as 'Granary of India'. Majority of Punjab's agriculture production comprises of rice and wheat. According to the 4th Advance Estimates by Government of Punjab, the year 2017-18 recorded foodgrain production of 284.83 million tonnes, of which the share of rice was 39.64% (112.91 million tonnes) and that of wheat was 35.003% (99.70 million tonnes). In comparison, contribution of nutri/coarse cereals and pulses was only ~16.5% (46.99 million tonnes) and ~8.879% (25.23 million tonnes) respectively.

Paddy-Cycle & Groundwater Depletion

While it might seem harmless, rice dominated production is ripping the State of its resources, especially groundwater. About 2500-5500 litres of water is required to produce one kilogram of rice, which for wheat is between 1200-2000 litres. Extensive irrigation requirement of rice alone is believed to have already depleted groundwater in 80% of Punjab. Districts including Mansa, Sangrur, Ludhiana, Bathinda, Hoshiarpur as well as Moga have been hit the hardest with depletion of upto 40-50 metres. According to a report by Central Ground Water Board, if the trend continues, the State would turn into a desert in next 25 years and would not have enough water resources to sustain any crop-production, let alone rice and wheat. Agri-allied sectors would too be affected in a massive way. With no local availability of crops, animal feed producers would have to import crop from other States, so would have to food-processing industry. And since griculture forms the backbone of other sectors, overall economy of Punjab would fall.



Crop Diversification with Maize

Though production of rice and wheat cannot be completely erased, the adversity can be averted with crop diversification, especially by shifting to less-water intensive crops like maize. FICCI Maize Vision 2022, a report providing comprehensive knowledge on maize's standing in Indian agriculture and mapping an agenda for doubling farmers' income, states that "a farmer saves 90% of water and 70% of power by growing maize, in comparison to paddy." In addition, it also provides higher yield per hectare, and being a commercial crop, has a complete segment of industry depending upon it as a raw material or for consumption.

WHERE DOES PUNJAB STAND ON MAIZE?

Department of Agriculture, Government of Punjab

01 Presently State of Punjab is facing serious problem of depleting ground water due to predominance of Paddy Crop. During 1960-61 area under Paddy 2.27 million hectare that has swelled to 31.03 million hectare during 2018-19. For Sustainable Agriculture in Punjab the area under Paddy must be restricted to 18 to 20 lakh hectare. The area 10-12 lakh hectare has to be shifted to Maize, Cotton, Pulses and other less water consuming crops.·

02 Maize Crop was grown on 3.72 lakh hectare during 1960-61. This has been reduced to 1.09 lakh hectare during 2018-19. Due to the efforts of Department of Agriculture the area under Maize Crop has increase to 1.60 lakh hectare during 2019-20. The Punjab has potential of growing 5.00 lakh hectare of Maize.

03 Over exploitation of ground water has led to other serious natural problems in this state. As per the latest report the ground water level is depleting at the rate of 49 centimeter per year. Out of 149 Blocks of the State 109 blocks are over exploited in terms of ground water usage.

04 Water draft through tubewell for many districts are very high, viz. Sangrur (260 %), Patiala (217%), Jalandhar (239%), Kapurthala (224%) are in great danger. This is only because of Paddy cultivation and urgently needs corrective measure in terms of Crop diversification through Maize.

05 To save the State from further degradation of its natural resources Maize seems to be the best possible option as this will check the issues of ground water depletion, straw burning and air pollution. Its various usage feed, fodder, food and fuel makes it best suitable in the state of Punjab.

06 Over 120 different products having wide range of usage could be prepared from Maize. It also implies great potential of export to other country, given its industrial. This will lead to increase to foreign exchange earnings.

07 Ethanol processed from Maize can be blended with Petrol and Diesel will further reduce dependence on non-renewable sources of energy. Tractors, Diesel Engines and various vehicles can make use of Ethanol. To further boost maize-based ethanol production, ethanol processing plants should be sanctioned on subsidized and appropriate terms. Terms and condition for Ethanol production/processing should be relaxed.

08 State needs assured buy-back of maize at MSP through any notified agency.

NEED FOR CROP DIVERSIFICATION WITH MAIZE IN PUNJAB: A WAY FORWARD

DR. SUJAY RAKSHIT, CHIKKAPPA GK AND SL JAT
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During the 1960s, before the era of green revolution, Punjab was one of the major maize growing states in India. Punjab constituted 9% of the total maize area of the country with 13% production during mid 1960s. However, over a period of 50 years from 1966-2016 the trend has changed completely. Currently Punjab contributes 1.5% of the total maize produced in India from little over one per cent (1.2%) maize area of 9.8 mha in the country. In 1966, the total maize area in Punjab was around 4.44 lakh hectares which increased to 5.77 lakh hectares in 1975-76. Subsequently from 1975 onwards the maize area was decreasing gradually and currently it is around 1.14 lakh hectares. On the contrary, the area under rice mainly during kharif season has increased significantly from 2.85 lakh hectares in 1966-67 to 30.65 lakh hectares (2017-18) which is whopping 74.41% of the net sown area (41.45 lakh ha) of Punjab. The above statistics indicate that Punjab is predominantly under rice-based cropping system during kharif season with extremely less area under other crops. Thus, the state of Punjab has slowly shifted from the traditional crops like maize, pearl millet, pulses and oilseeds to mainly rice with little or negligible area under other traditional crops. The shift was mostly driven by unfavourable policy support to the other crops and non-availability of high yielding cultivars in these crops. In fact the adoption of the high-yielding rice cultivars in 1970s with expansion of irrigation facilities and usage of fertilizer and pesticide brought green revolution in Punjab. This increased adoption of rice in Punjab and Haryana helped in ensuring food security of the country.
Further, the favourable government policies of establishment of storage, marketing, milling industry with no pricing for water and electricity and assured purchase of rice have given impetus to increase its acreage at very fast rate.

The extremely large area under rice during kharif season in Punjab over a period of 5 decades has led to one of the major serious ecological imbalance in the region like lowering water table. In addition, the agriculture sector in Punjab is also facing other challenges like increasing imbalances soil fertility, appearance of new pests and weeds, escalation in costs of production, falling profitability in farming, increasing incidence of landlessness and indebtedness among the farmers etc. Further, there are emerging uncertainties of weather, climate change and global warming for which impact on agriculture of Punjab is yet to be foreseen. The above scenarios indicate that the state of Punjab is facing he challenge of long-term sustainability of agriculture. Therefore, diversification of the rice with maize could address sustainability of agriculture in Punjab.

Maize for diversification

The major advantages of shifting from rice to maize is that, maize being less water demanding crop than rice (almost half) could immediately address the issue of lowering water table. The other major issue maize could address immediately is the current issue of increased air pollution in Punjab and nation as a whole due to burning of rice-straw. Further, maize cultivation can address several other issues which promote ecological balance and environmental sustainability like maintaining the soil fertility and soil eco-system through maize based conservation agriculture. The adoption of zero-tillage resource conservation crop production practices could reduce green house gas emission substantially which will further improve environmental quality. In addition several ancillary advantages can be reaped by farmers through maize cultivation like saving of electricity on water pumping, advancing wheat panting

which will help in increased wheat productivity by minimizing risk of terminal heat stress, less use of pesticide in maize production will reduce the ground water pollution and related effects. The required technologies like suitable high-yielding single cross hybrid maize cultivars (7-10 t/ha), efficient weed management system, machineries for mechanized cultivation of maize and conservation agriculture practices are available to promote maize as alternative crop for crop diversification in Punjab.

Strategies for maize based crop diversification in Punjab

Mapping of target area

Identification of ecologically vulnerable pockets of the state should be the priority to target the most appropriate technology like single cross hybrid technology. Several high yielding single cross hybrids have been released for commercial cultivation for the state of Punjab. Targeting such hybrids to divert rice-dominated cropping system could be one strategy to prevent further ecological imbalances. The mapping could be as precise as possible at Tehshil to block level using most advanced information and data like satellite images.

Policy intervention

The combination of push and pull factors has to be implemented by government to convince farmers to shift from rice cultivation to alternative crops like maize. The following intervention from the government could certainly create an impact to bring crop diversification in Punjab through maize.on water pumping, advancing wheat panting which will help in increased wheat productivity by minimizing risk of terminal heat stress, less use of pesticide in maize production will reduce the ground water pollution and related effects. The required technologies like suitable high-yielding single cross hybrid maize cultivars (7-10 t/ha), efficient weed management system, machineries for mechanized cultivation of maize and conservation agriculture practices are available to promote maize as alternative crop for crop diversification in Punjab.

a. Procurement of farm produce – Government has to ensure procurement of maize at minimumsupport price (MSP) just like rice or wheat from the farm gate of farmers. The policy would encourage farmers to go for maize cultivation as final disposal is ensured.

b. Specialty corn and livestock production – The demand for specialty corns like sweet corn, baby corn and popcorn is increasing. Presently in Punjab baby corn industry in Ludhiana is already exporting processed and fresh packed baby corn in large quantity to other countries. Considering the availability of required infrastructure, like airports with direct cargo flights to European countries there is scope to promote specialty corn cultivation to bring maize led diversification in existing cropping system of Punjab. Further, it is known fact that Punjab has organized livestock / dairy farms. Establishing linkages between specialty corn cultivation like baby corn and sweet corn with dairy farms could further boost livestock industry.

c. Silage maize – Maize is one of the best crops for silage making. The organized dairy industry in Punjab could be better supplied with high quality maize silage by promoting maize cultivation for fodder and silage making. The cultivation of fodder and silage maize is another avenue to bring diversification in the existing un-sustainable rice-based cropping system of Punjab.

d. Arrangement of community based machineries – What and rice are cultivation is largely mechanized; in order to promote maize cultivation in the state, government has to encourage and support to create facilities like community based machineries to undertake mechanized cultivation of maize. Combined harvester, dehusker and maize sheller may be made available to the farmers on custum-hire basis. Maize grain dryers and silos need to be made available at block level, while small scale storage bins need to be provided to small farmers.

e. Development of value chain – The government support to establish end-user industries like food, feed and starch industries and also storage facilities would certainly encourage entrepreneurship and attract investment in agriculture and create competition in the market.

f. Crop insurance and differential price support – The government has to create competitive crop insurance comparable with rice encourage maize cultivation. Since a organized market for maize is yet to be established and the current economics of maize cultivation vis-a-vis rice cultivation favours rice, the differential profit may be compensated to the farmers growing maize for incentivising maize cultivation in the state. Savings on account ofelectricity and ground water may diverted to the maize growers.

DESIGNING MAIZE USING NOVEL TECHNIQUES FOR PRODUCTIVITY ENHANCEMENT IN PUNJAB STATE

SURINDER K. SANDHU, MAHESH KUMAR AND JS CHAWLA
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With the menace of paddy straw burning issues and hence environmental consequences coupled with depletion of underground water, maize crop has more strongly emerged as a candidate for crop diversification during kharif season in Punjab. Maize is likely to gain importance in the context of climate change also. Being C4, maize can assimilate more CO2 than C3 crops like rice and wheat, and can become driving force for crop diversification in the North-western Indian states of Punjab and Haryana in the existing rice-wheat cropping system. Under Punjab state crop diversification program, it is planned to expand maize cultivation from 1.1 lakh ha to 5.5 lakh ha in the next few years. To comprehend this vision, concerted research and policy measures are required to make maize crop as a viable alternative to shift some area from rice to maize. Punjab Agricultural University (PAU)'s maize research group is commited to address issues of productivity enhancement in maize and accelerated adoption of associated improved technologies. Major areas of intention are:

Designing new plant architecture for high density planting:

The wide gap in potential and actual productivity of maize hinders the economic viability and consequently wider adoption by the farmers. High-density planting which envisages higher productivity by increased plant population per unit area has undergone a constant evolution over the years, with the purpose of enhancing the crop yield and has been documented as is one of the research interventions to break the maize productivity plateau. Earlier studies in this domain indicated that crowding stress reduced the ability of plants to use soil N prominently during the post-silking period. The increased incidence of lodging and biotic stresses has also been indicated. Recently, PAU, Ludhiana has up designing plant architecture amenable to high density planting. It is expected that the high density apposite inbred lines would generate high density responsive hybrids. The identification of efficient inbred lines, with key variants which may facilitate to cope up crowding stress viz.,altered plant height, leaf angle and area, ear placement, ear and kernel traits, root structure and maturity patterns, has been carried out. Maize kernels with a rapid filling speed, easy threshing characteristics as well as lodging resistance upon maturity for maize production mechanization are also being considered. The lines with a few but long lateral roots is another selection target for superior water capture, growth, and high yield under moisture stress. The evaluation of hybridsfrom new plant type inbreds under different planting patterns are expected toharness higher productivity. Currently, with recommended row to row and plantto plant distance of 60 cm x 20 cm, respectively, the optimally 33,333plants/acre are raised. Efforts are being made to raise this plant populationto about 40,000 plants/acre with expected 10-12% yield enhancement. Modifiedplant architecture coupled with optimization of fertilization under high plantdensity may prove as a sustainable approach to elevate maize yield.

Exploring novel variants for biotic stresses using wild resources:

The availability of new molecular tools with the potential to accelerate introgression breeding programs have aggravated interest to exploit potential value of novel traits from wild progenitors. Teosinte (Z. mays ssp. mexicana) is a valuable source for maize breeding, and can be used to broaden and enrich the maize germplasm. It has excellent potential to produce high biomass and can expand the fodder production potential of maize as forage crop.

Teosinte has special merits over fodder maize including multiple cutting, high nutritive value and ease of production. Teosinte differs from corn by abundant tillering which results in tufted plants, and many studies reported good level of heterosis in maize x teosinte hybrids. Efforts have been made to generate variants through hybridization of elite maize inbred maize lines and Zea mays ssp. mexicana accession. Efforts are being made to develop alien introgression lines using teosinte to introgress biotic stress in these productive lines. Resistant plants obtained for various insect pests and diseases are under large scale evaluation for validation.

Accelerated breeding:

Development of inbred lines in maize and their maintenance requires a lot of time, labour, resources etc. Doubled haploid (DH) technology using inducer lines can cut short the time span by two generations to get advanced generation uniform inbred lines. The development of lots of inbreds through DH technology will provide new combination of genes within a very short duration to the breeders to be used in single cross hybrids development programme. It is important to select the breeding materials in relation to various abiotic/ biotic stresses, in addition to grain yield and other desirable agronomic traits. At PAU, haploid inducer stock was procured from CIMMYT in 2013. The centre has standardized the DH technology and developed doubled haploid lines for further evaluation. PAU is also regularly using off-season facility at Hyderabad to gear up its hybrid development programme.

Besides major goal of high productivity late maturing hybrids, the work on conversion of normal maize inbred lines to its quality protein maize (QPM) version, development of quality baby corn using cytoplasmic male sterility (CMS) source, breeding for higher biomass for fodder purpose, breeding for waxy maize and improvement of germplasm for heat stress and water use efficiency has already been taken up. QPM can be promoted for nutritional security of poor masses whereas pop corn, baby corn and sweet corn can help in increasing the farm income due to high market value.

Agronomic recommendations for yield enhancement:

Improved agronomic practices recommended by PAU, Ludhiana has addressed the major productivity constraints of maize cultivation. Kharif maize being a rainy season crop gets infested with variety of weeds and subjected to heavy weed competition, which often inflicts huge losses. The farmers principally adopt the herbicides recommended by PAU for the control of weeds. The pre-emergence herbicide i.e., Atrazine is supplemented by the recommendation of new group of post emergence weedicides. For the control of dila/motha (Cyperus rotundus), spray 2, 4-D amine salt 58SL@400 ml/acre at 20-25 days after sowing by using 150 liters of water. Laudis 420 SC is a new herbicide for the selective control of broad leave weeds and annual grasses in maize. The active ingredient of Laudis 420 SC is tembotrione, a member of the triketone class of herbicides is recommended by PAU for Punjab. Weeds can also be controlled through cultural and mechanical methods. Growing one or two rows of cowpea in between maize rows, due to high foliage of cowpea, it competes with weed flora for space, light and suppress the weed growth. Harvest the cowpea crop at 35 to 45 days after sowing before it starts twining the maize plants. The water logging is another major constraint in kharif season. To avoid the flooding, earthing up of crop is recommended. In case of flooding, two sprays of 6 kg urea/acre (3% solution) at weekly interval or broadcasting of additional nitrogen @ 12 to 24 kg (25-50 kg urea) per acre is recommended.

Strengthening partnership with private stakeholders:

PAU has strong linkage with private sector in exchange evaluation of hybrids. Quality seed production of public sector hybrids always remain a limiting factor. PAU has signed MoU with Maharashtra Seed Corporation to fasten the large scale production of quality seed and hence, its distribution to farmers. University has also licensed private companies for production and marketing of PAU bred hybrids. A revised MoU has been floored to facilitate the testing of hybrids. There is also a proposal for testing of PAU developed pre-release hybrids by private sector to smooth the progress of quality seed production and improved marketing of hybrids.

ROLE OF MAIZE IN ANIMAL NUTRITION

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Maize grain has high starch content (65-70%), about 2.5% oil and a low fibre content (10% NDF). Proteins in maize grain are mainly zein and glutelin, and are situated in the endosperm and germ respectively. Zein, the most important, is deficient in lysine and tryptophan so amino acid supplementation is often necessary. Corn grains are excellent source of rumen undegradable protein. These are used along with other cereal grains, protein supplements, brans and minerals for formulating compounded feed or in the formulation of total mixed ration. These can be fed to all categories of livestock and poultry and are highly palatable. It is preferred over other cereal grains and fed at high levels in poultry. Maize oil is a good source of polyunsaturated fatty acids (linoleic acid). Yellow maize contains more carotene and cryptoxanthin which are beneficial to yolk pigmentation.

Maize By-Products

Dried distillers grain with soluble (DDGS):

DDGS is a co-product in bio-fuel industry. Raw materials used for distillation include maize, wheat, rice, tapioca and sweet potato. DDGS contains 27-35% protein, but a low energy content and is used in livestock, poultry and fish feeds. A metric ton of DDGS can replace, on average, 1.22 metric tons of feed consisting of maize and soybean meal. It can be incorporated up to 25% in ruminants. Conservatively, DDGS can be added at 5-8% of starter diets for broilers and turkeys. DDGS can be added to poultry diets at 25% for layers and broilers to achieve excellent performance and egg and meat quality when diets are formulated on a digestible amino acids (AAs) basis. Adding 10% DDGS to all aquaculture feeds can result in excellent performance. For normal inclusion levels of DDGS in animal diets, the limiting essential AAs are lysine and tryptophan for maize DDGS. While formulating diet with DDGS level of sulphur must be considered and ensure that total dietary sulphur content does not exceed 0.40%.

Corn gluten

The CP content in CGM depends on type of extraction used if dry extraction then it contains 45% CP and if by wet extraction then around 65-70%. It contains about 8% of residual starch in the DM and limited amounts of fibre (crude fibre 1% DM), fat (3-5% DM) and minerals (2%). However, like maize grain, its amino acid profile is low in lysine (1.7% of the protein vs. 6.3% for soybean meal and 7.5% for fish meal) and tryptophan (0.5% vs. 1.4% for soybean meal and 1.1% for fish meal). It also contains more methionine (2.4%) than lysine, resulting in an unbalanced profile for many livestock species, though the relatively good methionine content is valuable for laying hens. Corn gluten meal is a good source of bypass protein for ruminants. A constraint is its moderate palatability in land-based livestock. Corn gluten meal is particularly rich in yellow xanthophylls (between 200 and 500 mg/kg DM) that are useful for pigmentation in poultry where high-colour chickens and eggs are prized by consumers.

Maize germ meal

Maize germ meal obtained from the wet milling process for starch production has a relatively high protein content (22-31% DM). The crude fibre content is moderate (10% DM) but the NDF content is high and variable (30-60% DM). Residual oil ranges from less than 3% to more than 10%, reflecting differences in oil extraction efficiency. Oil-rich maize germ meal from wet milling is slightly poorer in protein than well defatted maize germ meal (25-32% vs. 22-30% DM). All the by-products of maize can be used in animal feed. Maize bran has a relatively low protein content varying between 9 and 15% of DM, higher than maize grain but lower than corn

distillers and corn gluten feed. Fibre content (NDF 20-60% DM) tends to be higher than for other maize by-products, and much more variable. Maize cobs are a feed ingredient of low nutritive value, roughly similar to straw. Maize cobs contain little protein (about 5% DM) and are mostly composed of fibre (NDF more than 80% DM).

Maize fodder

Maize green forage has a relatively low protein content (7-8% of DM) and a high fibre content (19-36% of DM). Depending on the stage of harvesting, it can be rich in starch (up to 30% of DM or more) and, therefore, a source of energy. In India, it is reported to have a higher nutritional quality than sorghum and pearl millet, with none of antimetabolites, such as HCN in sorghum or oxalates in pearl millet.

Maize silage is a heterogeneous fodder that includes both starchy material (from the grain) and fibre (cell walls from stalks and leaves) in variable proportion, depending on genetics, stage of maturity and growing conditions. Maize silage contains about 25-35% dry matter. The protein content varied between 8-10% of DM and rich in fibre (15-27% of DM), with a highly variable starch content (18-37% of DM). It is low in lignin and lipids (about 2-3% of DM each).

B*aby corn* is cultivated throughout the year in India. In India, the average baby corn production is about 7.5–8.7 tonnes/ha. Of this the human-edible husked baby corn cob is only 15%, while the remaining 85% constitutes of outer peel/husk with a silky thread-like structure called baby corn husk with silk (Photo 1). Another byproduct is green stalks with leaves, also called baby corn fodder. Baby corn crop after 55-60 days of sowing is ready for picking baby corn cobs for human consumption. Three to four baby corn ears are hand-picked as soon as 2-3 cm silk emerges from the ear tips. The husk and silk are removed from the baby corn cob. The husked cobs are used for human consumption. The husk with silk constitutes 85-90% of the ear. The average yield of baby corn husk with silk is 5-5.5 tonnes/ha. Baby corn husk with silkis chopped for feeding to livestock.

Fresh baby corn husk with silk and conventional maize fodder contain 94.3 and 91.8%organic matter (OM), 11.7 and 8.6% crude protein (CP), 62.0 and 68.0% neutral detergent fibre (NDF), 27.0 and 41.5% acid detergent fiber (ADF), 24.0 and 33.0% cellulose, and 35.0 and 26.0% hemicellulose, respectively (Bakshi and Wadhwa, 2012). Fresh baby corn husk and silk portion is highly relished by animals and an adult large cow can consume 45-50 kg/day. As compared to conventional maize fodder, fresh baby corn husk has higher (P<0.05)digestibility of nutrients, N-retention and efficiency of N-utilization in buffalo calves.

E*nsiled baby corn husk with silk* can been siled after wilting for few hours during summers or 1-2 days during winters.After wilting, these are chopped and ensiled for 42 days in a low density polyethylene tube of approximately 6 feet diameter and 10-12 feet length. After thorough pressing the chopped husk with clean feet, the polyethylene tube is tied with nylon string at the top. After 42 days, the tube silo is opened from the top and the ensiled husk with silk is taken out as per the daily requirement, and the tube is tied again. The spraying of water soluble silage inoculum containing lactobacillus spp. (1×1011 colony forming units (cfu)/ g) hastens pH drop during ensiling. It is beingused at 1 g/tonne of the green fodder by some farmers. The ensiled baby cornhusk can be incorporated in the total mixed ration (TMR) of ruminants up to 30%on dry matter basis.

Baby corn fodder

After taking 3-4 baby corn ears, the leftover byproduct available is the young green fodder, which can also be used for animal feeding. The yield of green baby corn fodder varies between 30-35 tonnes/ ha, depending on the type of cultivar. An adult cow can consume 40-45 kg fresh, chaffed green fodder. The baby corn fodder and conventional maize fodder have comparable chemical composition except that the former has higher CP (10-11% vs. 9.2-10%) and OM (92.4% vs.91.5%). The in vitro evaluation revealed that baby corn fodder had higher (P<0.05) digestibility of nutrients, total volatile fatty acid (VFAs) production and metabolizable energy (ME)

availability as compared with the conventional maize fodder. The baby corn fodder has higher digestibility and nutritional value than conventional maize fodder.

Small farmers harvest the baby corn fodder manually and leave them in the field for wilting and then subject it to chaffing. Large farmers harvest baby corn fodder by using a tractor operated single-row or self-propellant multiple-row harvester. Besides harvesting the fodder, these machines chaff the fodder and shred the corn grains simultaneously. The only difference is that the single-row harvester has a capacity of harvesting 0.1-0.3 hectare/day, and the multiple-row harvester has a capacity of harvesting 7.-8 hectare/day. The chaffed fodder is simultaneously loaded in a tractor trolley. The trolley is unloaded by hydraulic system. The chaffed fodder is then transferred to the hopper of a semi- or fully automatic baling machine for making bales. These bales are highly compact with high density (450 to 500 kg/m3) and are kept for 42 days ensiling. This automatic baler can make 30-40 bales/hour of 450 to 500 kg each. The costs in US$ of these single-row and multiple-row harvesters and automatic baling machine are approximately 5,000; 230,000 and 190,000 respectively.

The ensiled baby corn fodder is mixed with other feedstuffs such as straw, green fodder, concentrate ingredients and feed additives and fed as TMR round the-year. The ensiled baby corn fodder can be incorporated up to 30% in the ration of ruminants. The TMR containing ensiled baby corn fodder had nutritive value comparable with that of conventional maize fodder, when tested in male buffalo calves. In dairy animals, it resulted in higher milk yield and higher solid-not-fat compared with that obtained on feeding conventional maize silage. The baby corn cultivation serves as a dual-purpose crop. The cultivation of baby corn has been highly remunerative to the farmers: besides selling baby corn cobs for human consumption, they can use/sell baby corn husk with silk, and baby corn fodder as animal feed.



Baby Corn



Baby Corn Husk



Baby Corn Husk Silage

APPLICATION OF REMOTE SENSING IN SOIL HEALTH STUDIES

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Since time immemorial, agriculture has been the mainstay of man's food requirements apart from hunting. History has enough shreds of evidence to show and prove that all great civilisations prospered in river valleys for meeting their demands of water for irrigation and depended heavily on agriculture for food. Even today, for a country like India which is still an agrarian economy in terms of labour (53.4% workforce of the country indulged in agriculture and related activities), it becomes crucial to ensure food security for a huge and increasing population. In the State of Punjab, this objective takes a critical turn. Struggling with the issue of groundwater depletion on account of paddy dominant cultivation, Punjab stands at the threshold of becoming a barren land with no water resources to sustain agriculture. If that happens, the State would be pushed years back in terms of food sercutiy and self-sufficiency. Catering to it, the State is promoting crop diversification with less water-intensive crops like maize. Though effective, this can only produce optimum results, if pursued alongwith measures to rejuvenate soil health that has deteriorated due to injudicious chemical consumption and low water content in soil.

Proper and scientific management of agriculture, in form of soil health study and mapping, offers a solution. In the last century, the soil was studied and researched upon along with crop and precision agriculture studies and there was a lack of dedicated efforts to study soil in an elaborate way. Though studies on soil date back to some eighty years old when first studies were carried out. But eventually, it was only in 1941 when it was published. Such preliminary studies were mostly in-situ soil characterisation studies based on field studies and sampling.

With the advent of remote sensing and Geographical Information System (GIS) in early seventies, there was a paradigm shift in mapping and remote analysis of several fields of knowledge, and even agriculture and soil weren't left untouched. Remote sensing proved to be time-saving as well as non-evasive technique of study and analysis, and made data availability easy and within real time reach of researchers worldwide. With remote sensing, it became possible to map different soil types, monitor any change in soil properties as well as a regular study of soil erosion, owing to the high temporal data availability.

Early remote sensing studies were mostly classification studies aimed at qualitative domain but with the addition of statistical tools and people from various domains of knowledge contributing, it tended towards a more qualitative analysis tool. Slowly, different satellite and airborne remote sensing imageries were used to model and calculate various soil health parameters like- soil moisture, soil salinity, soil NPK values, soil temperature, soil organic content and many more. Initial studies and many more being done now a days as well use optical multispectral datasets both airborne and spaceborne for the study. Later more complex data like thermal and hyperspectral datasets took over. But as these sensors were all passive sensors, they relied upon the Sun's illumination of the target and captured the reflected spectra. Moreover, they don't have an all-weather availability and it was difficult to conduct studies in monsoon months when there is dense cloud cover. But the advantage is that this data set is freely available in coarse and medium spatial resolutions (10m-30m). To overcome this, the need for an all-weather data was felt. It is

this what brought microwave/RADAR remote sensing into use. It has an all-weather availability and penetration abilities with which it can penetrate through clouds and doesn't depend upon Solar illumination of the studied target.

A pilot study conducted at IIT Ropar preliminarily for Rupnagar District of Punjab and at a later stage for some districts of Uttar Pradesh, aims to study and analyse soil health status at present time using optical and RADAR data. The RADAR data to be used here is from Sentinel-1A satellite which was launched in 2014 by the European Space Agency (ESA) as a part of the Copernicus mission. It has dual linear polarisation channels VV and VH. Apart from this, Sentinel-1 has a 12-day repeat pass that makes regular monitoring easy with 14m spatial resolution. It is by now, the only active freely available RADAR data. The main objectives of the study are as follows-

- Modelling for Soil Moisture estimation and prediction
- Modelling for Soil Salinity estimation from soil electrical conductivity and RADAR backscatter values
- Modelling for Soil Organic content estimation from the field as well as Optical and RADAR data
- Modelling and prediction of soil Nitrogen (N), Phosphorus (P) and Potassium (K) values
- Using all the parameters for crop yield estimation using a simple but robust machine learning model
- Developing a mobile app – 'M-SAHBHAGITA' for use by farmers wherein they can feed the soil parameters and get an estimate of yield predicted in coming seasons. Following are NDMI (Normalized Difference Moisture Index) maps, as shown in Fig.1 -

Work done so far-

- A simple linear regression model developed using moisture indices obtained from Optical and RADAR data, which gave good results in soil moisture prediction, even though due to unavailability of field data. The results are expected to improve once field data for soil moisture is supplemented.
- After getting the field equipment, field validation is underway and same model would be used with adding actual moisture values from field and results would be compared.
- The Root Mean Squared Error (RMSE) and R2-statistics values for this unsupervised modelling approach were found to be 0.24 and 0.72 respectively for more than a lakh data points in Ropar area- 72% prediction accuracy. Soil electrical conductivity and soil temperature data are also being collected to be used for modelling for soil salinity. The results are given as below in Fig.2.

In this age of cyber-savvy necessity, it is important to be technology-oriented. With new remote sensors coming up in the horizon and Machine learning and Artificial Intelligence being used hand in hand, we continue to move to an era of technological agricultural management. Where like other things, agricultural and soil preparation practices would be a fire and forget system. The need is to bring the end results of researches to the end-users- the Farmers on ground, rather than shelving the research. With industry and academia working together, food security and climate change challenges can be met easily.

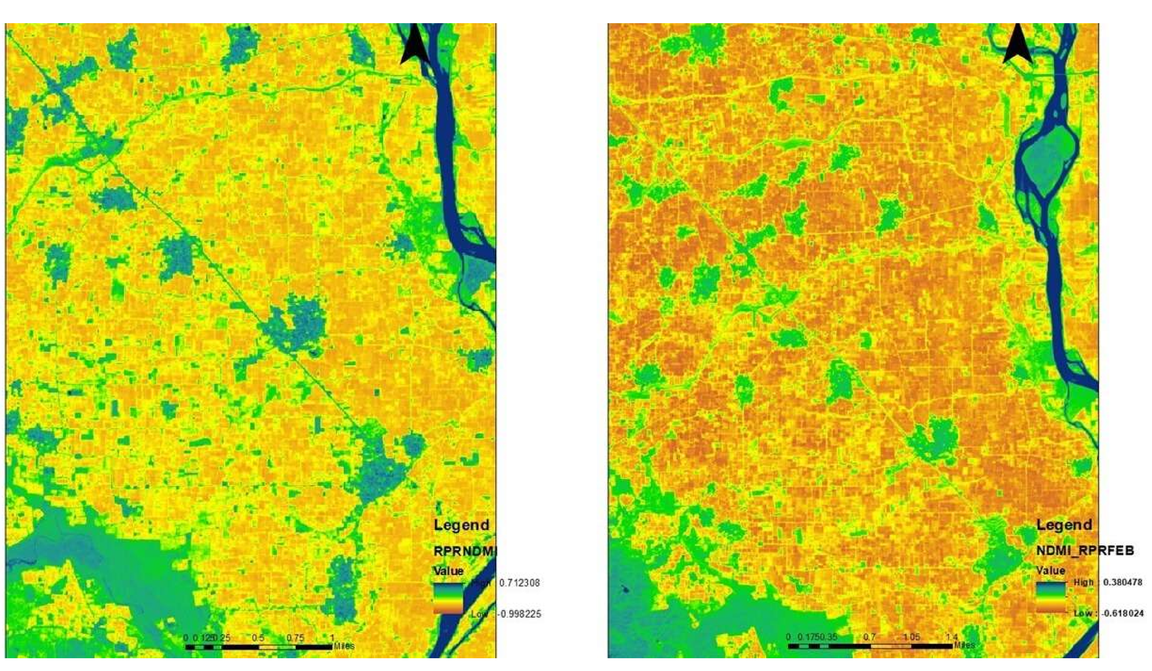
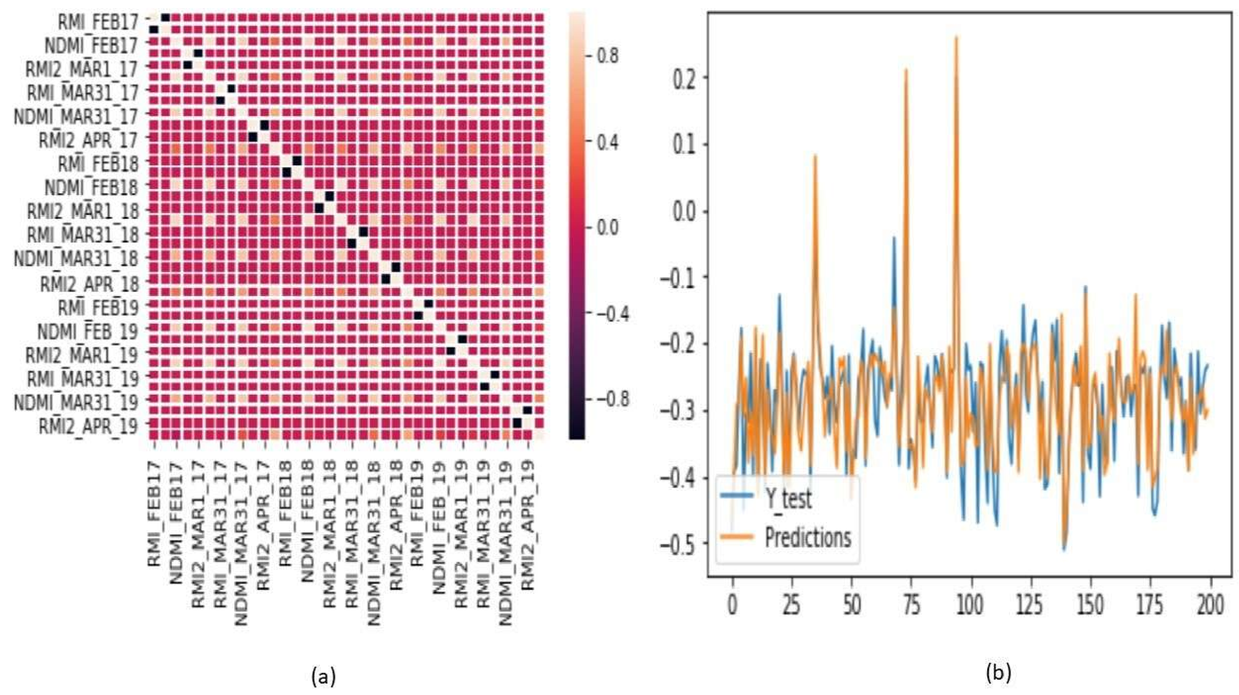


Fig.1. NDMI Map from Sentinel-2



(a) (b)

FIG.2. (a) Correlation Heat Map, (b) Fitting plot for Predicted Vs Actual Values of NDMI for April 2019

FARMERS' PERSPECTIVE ON MAIZE CULTIVATION: FEW CHALLENGES, BIG OPPORTUNITIES

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Agricultural security is as important as national security for a populous country like India. The Indian farming community]exercised their voting right to be part of the world's largest democratic exercise. The farmer and agriculture related industry hope that the new legislature will move away from current indifference, towards a more open, technology driven, futuristic approach for the agriculture sector.

Our crops' yields are quite low compared to other countries and climatic change will further lead agricultural productivity to reduce by 20-30%. We need to adopt modern science and technology like plant breeding, biotechnology and digital technology to improve our seed quality as well include farm mechanization to modernize farming and make agriculture profitable. Profitability enhancement will also require a change in our crop portfolio to optimize water, climatic change, market demand patterns, international stocks and prices and other considerations. This will need support from policy makers.

The climate resilient agriculture is a big challenges and big business opportunity which industry can leverage. The need is to go in for indigenous seeds that will be more suitable to the maize producing States.

In a big to break the wheat-paddy cropping cycle and promote crop diversity in Punjab, the State Government is trying to encourage the cultivation of maize, which relatively consumes less water. This might help contain the steady decline in the water table in the State and restore the natural resource base, which is being eroded by this cropping pattern.

To encourage the cultivation of these alternative crops, the Department proposed a few initiatives including a remunerative Minimum Support Price (MSP), subsidy on seeds to cover production risks and to incentivise the farmers to shift to other crops and the creation of an efficient marketing infrastructure & mechanism for crops other than paddy.

The maize breeding programme plays a key role in facilitating deployment of improved maize seed in the tropics, especially targeting women farmers and disadvantaged groups to maximum impact. Works includes identifying easy-to-produce, best-bet hybrids & improved open-pollinated varieties, seed production research & recommendations, promoting scale-up and delivery of new & promising products through seed company partners.

Maize consumption in Punjab has a salient, established, urban consumers market which is increasing many folds every year.

Challenges and Potential

Baby corn, sweet corn, popcorn and Quality Protein Maize (QPM) are well established markets with bottlenecks, due to absence of any contract farming act. Baby corn is produced by 600-700 farmers around field fresh company near Ludhiana. Raw yield is 4 M.T. and recovery is 12% cobs. PAU was successful in producing basic baby corns through common grain varieties, but could not produce male sterile seed which has no tasseling. The rate of baby corn seed of a private company is Rs 650/Kg for optimum 35000 plants per acre, nearly 7 Kg seed is required which costs Rs. 4500/- per acre with zero subsidy on seed.

Sweet corn has a big market with many restaurants, domestic consumers nd export orders with Pagro Foods Ltd, near Rajpura. The cost of sweet corn seed is Rs. 2400/- per Kg with 3Kg seed requirement per acre which costs Rs 7200/-.

Pop corn has a very big market in all malls and cities of the State, selling nearly Rs 50,000/- in 24 hours. The seed is procured from private players at Rs. 250/- per KG and selling at Rs 1000/- per Kg.

QPM, Quality Protein Maize, needs to be promoted link zinc wheat. The research on zinc maize is required to align with consumers' changng mindset.

State Government must chalk out long range policies for industrial usage of maize like pharmaceutical products (Sorbitol etc), modified starches, maize starch powder, liquid glucose, high maltose corn syrup, dextrose monohydrate, dextrose anhydrous, corn steep liquor and other co-products.

For India, CIMMYT has focused on developing climate reilient maize hybrids that are tolerant to heat and drought. It also focuses on breeding quality protein maize that produces competitive yield under optimal consitions and superior yield under abiotic and biotic stresses.

As a member in Global Farmers Network and Cornell Alliance for Science, we are committeed to eradcate nutritional hunger in India and South Asia by 2022, towards the agenda of doubling the farmers' income as adopted by the present Government.



Image 1: Baby Corn Cobs



Image 2: Sweet Corn Cobs



Image 3: Popecorn as a Usage of Corn

CONTAMINATION CONTROL STRATEGIES FOR MAIZE

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Promotion of cultivation of Maize in Punjab seems to be the best way to curb serious issues prevailing in the state, such as over-exploitation of water tables, stubble burning and in-turn decreasing farmer income. Maize requires less-than-half water per hectare and would in-turn yield ~20% more money for farmer per hectare. Promoting production would also require government to ensure safeguarding on crop in terms of damage due to fungi and pests, which requires immediate attention. Mycotoxins and aflatoxins have chronic toxicity that cause serious health hazards, hence the concentration needs to be regulated strictly.

Fungus Occurs

- If the produce is not handled properly to minimize the thriving of the fungal are most severe when crops are caught by rain just prior to or during harvest.
- In feedlot manure(Hendrickson and Grant, 1971)
- When conditions in the storage are favorable
- Combination of moisture content and temperature favours fungal/molds infection as a result increased aflatoxin contamination.
- During high humidity, initially dry seed develops water content conducive to contamination.

Alfatoxin Contamnation

- Fungi Aspergillus is responsible for aflatoxin contamination in maize grains.
- It endangers the food supplies and health of both people and livestock, threatens the economic livelihood of farmers, commercial feed users, and numerous feed and food industries.
- In developing countries like India, drought stress is particularly important in terms of food security. For example, marginal land where stress tolerant sorghum was previously grown is being replaced with maize in Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh etc.
- Maize is prone to infection when water stress periods occur, leading to increased aflatoxin contamination of such crops pre-harvest and post-harvest and can significantly impact on the ability to export the crop and also on the nutritional quality when consumed in rural subsistence communities.

Post-Harvest Strategies

- Proper monitoring of temperature and relative humidity.
- Dry grains to obtain moisture contents below 14% immediately after harvest.
- Maintain hygiene and sanitation from harvest to storage Segregate foreign materials and broken grains Storage should be sealed, airtight container or structure to limit the presence of aerobic organisms Clean, fumigate, or segregate maize grain as and when insects and molds are noticed.
- In conclusion, climate change will add new challenges related to the dynamics of patho-systems and future food security, need for continuous monitoring of the climatic changes and its interaction with aflatoxin producing fungi and host.
- If the current climatic patterns continue in this century, aflatoxin concentrations in maize will likely to be increased, whereas some other toxins viz., DON levels may decrease.
- However, climate change-induced alterations in cropping patterns or shifts in pathogen populations could create new opportunities for DON risk in areas where maize currently is not grown or is a minor crop, and where new, more aggressive isolates of F. graminearum occur. Overall it will increase the economic and health risks with consumption of aflatoxin infected maize.

MAIZE PROCESSING: POTENTIAL FOR VALUE ADDED PRODUCTS AND ECONOMIC GAIN

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Maize being high in yield potential is known to be queen of cereals and is third leading crop after rice and wheat around the world. Unlike other major cereals, it finds complete utilization either as food and feed without any costlier modifications in fibre or other polymers. The edible and inedible portions of crop are used commercially in food processing, dairy, poultry, meat and ethanol industry. The dry and wet milling of corn generates a number of products underpinning potential of various uses in food and feed industry. Dry milling generates larger and smaller grits generally used for breakfast cereals, a newer and demandable processed food product. Maize flour is used in household cooking for a number of dishes and breads as well as bakery products such as bread, muffins, doughnuts, infant foods, biscuits, filler and binder in meat products etc. Maize germ is rich in oil containing essential fatty acids which is refined to use for cooking and as salad oil or mayonnaise. Wet milling of maize yields industrially targeted ingredients such as starch, corn syrup, corn sugar, dextrin and industrial starch. The starch finds its uses in paper, textile, adhesives and packaging industries. The distiller's dried grains, by-product of ethanol from maize, can be used for livestock. Glucose and dextrose are used in beer, cider, confectionary and bakery products. The inedible portions of maize i.e. straw or stover act as good substrate for large-scale lignocellulosic biorefinery for biofuel production. The corn stover is also directly used by manufacturers for insulating materials and chemicals. It is also a direct feed for livestock cattle in western countries. The lower lignin content requires less bleaching than wood pulp, therefore, corn stover is an economic and environmentally sustainable substitute to wood for pulp and paper industry. Corn stover mulch is also known to prevent soil erosion. Being rich in pentosans, corn cobs yield higher furfurals and derivatives on hydrolysis, which finds uses in food and pharmaceuticals. Corn cobs can also be valorized for endoglucanases and other enzymes for bio-ethanol production, thus, reducing cost in comparison to cellulase. Green composites based on corn cob and polypropylene can partially replace plastic and functions similar to wood plastic composites. Apart frombeing an economic entrepreneurial crop, it is cultivated on a small scale and contributes to only 6% of total cereal production. Therefore, the cultivation and utilization of maize crop as food, feed and other industrial applications should be promoted more to achieve food security and environmental sustainability.

FUTURE IS BRIGHT FOR MAIZE CONSUMPTION IN ETHANOL INDUSTRY

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Maize is being used worldwide for bio-ethanol production. The United States is the largest ethanol producer globally and devotes about 40% of its cultivated maize to production of bio-ethanol. Moreover, about 85% of the US maize is the GMO variety which offers the farmers 40 – 50% more yield in comparison to the regular one, something that can be replicated in India as well.

Maize stands to be a great wealth-generator for farmers, all thanks to its many industrial applications. Being a commercial crop lends it a high market demand, which ensures that the farmer's produce is quickly sold at a good price. This is evident from the last harvesting season, when the prices for maize were at an all time high, fetching the farmers a great value. In comparison, the rice being procured by the FCI has been sitting in storage and going to waste. This is missed opportunity as the land being used to cultivate paddy which currently is facing a demand glut can be diversified for crops like maize that high a higher commercial value addition.

Another way to view the market opportunity for maize and maize-based ethanol is to look at energy targets. India is currently importing crude oil to meets its energy demand. Ethanol is not only a greener form of energy but also allows India to reduce its energy import. The current blending targets for ethanol set by the OMC's are not being met. Last year the OMC's required 326 cr liters of Ethanol for 5.5% blending but the tendered ndered amount was only 250 cr liters. This year they require 511 cr liters of ethanol but have only received the tender for 146 cr liters. This won't even meet 3% of the current blending target, whereas the blending targets are set to 20% by 2020. This further highlights the point that there is a huge demand for ethanol and consequently, of maize, in the coming years. India should focus on producing import substitute goods and ethanol production will help cut imports, increase farmer wealth and promote local industry.

Additionally the cultivation of maize will also save the state on electricity subsidy for the running of tube wells. We learn that the annual subsidy is currently close to 8000 cr and will sharply decline if maize is promoted as it requires less water.

Over and above, there are ample avenues for maize consumption, especially in context to ethanol industry. The only requirement is of right set of measures from Government to support the supply.

"We at BCL Industries are willing to set up an additional maize based 200 KLPD distillery plant in Punjab, if the cultivation of maize is to increase. This will be an investment of around 170 cr. We also know other entrepreneurs in the State who are willing to invest in maize based distilleries too."

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