Souvenir

National workshop on "Scientific Maize Cultivation in North East India"

March 05, 2019
Aizawl, Mizoram

Venue
Sameti Training Hall, Aizawl

Jointly Organized by
ICAR Research Complex for NEH Region, Mizoram centre, Kolasib-796081
In collaboration with
ICAR-Indian Institute of Maize Research, PAU Campus, Ludhiana, Punjab-141004
and
Directorate of Agriculture (Research & Extension), Government of Mizoram, Aizawl -796001

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at

SAMETI Training Hall, Aizawl

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Mizoram Centre, Kolasib-796081

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ICAR-Indian Institute of Maize Research, PAU Campus,

Ludhiana, Punjab-141004

and

Directorate of Agriculture (Research & Extension),

Government of Mizoram, Aizawl -796001

Souvenir

National workshop on
Scientific Maize Cultivation in North East India, March 05, 2019, Sameti Training Hall, Aizawl, Mizoram.

March, 2019

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Preface

The National workshop on 'Scientific Maize Cultivation in North East India' on March 05, 2019 is aimed for the knowledge dissemination and recent updates for tested technologies related to maize cultivation in the North East India. Maize (*Zea mays* L.) is the third important cereal crop in the world after wheat and rice with respect to area and production with very high productivity than any other cereals. In North East India, the percentage share in area coverage becomes second highest after rice. It shares the common jhum agro ecosystems in North East India.

The crop is mostly grown under rainfed condition. Being a C4 crop, maize has the wide adaptability for subsistent level cultivation and suitable for the traditional farmers facing capital inadequacy and habituated with low input agriculture. The technological interventions are required for the challenges lied with higher erosion potential from maize based cropping systems, quality seed availability in time and post-harvest management for maize products. The workshop will also give a special focus on finding ways and solutions to sustain income security from prevalent traditional maize based agriculture systems and also initiate the steps for increasing the maize farmers' income in Mizoram.

In this souvenir, all the literatures were assimilated to make a ready reckoner for the technology available for maize cultivation with a special focus on maize genetic resources available in North East Indian hills. We hope that the documented information will be useful to both central and state level policy planners, students and extension workers, who are presently working in this region.

We convey our sincere thanks to Director, ICAR Research Complex for NEH Region (Umiam, Meghalaya) and Director, ICAR- Indian Institute of Maize Research (PAU, Ludhiana) for their gracious support to organize the programme.

We are thankful to Director, Department of Agriculture, Govt. of Mizoram for coordinating the venture and all the Department officials for their support.

We are looking forwards for effective implementation of agricultural technologies for facilitating maize production in North East India, particularly in Mizoram.

Editors

Kummanam Rajasekharan
GOVERNOR OF MIZORAM

RAJ BHAVAN
Aizawl, Mizoram - 796001

सत्यमेव जयते

MESSAGE

I am pleased to learn that ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram in collaboration with ICAR- Indian Institute of Maize Research, PAU Campus, Ludhiana, Punjab as prime sponsor is jointly organizing the one day National workshop on 'Scientific maize cultivation in north east India' on March05, 2019 at Aizawl (Mizoram) and a Souvenir is being brought out to commemorate the event.

Maize (*Zea mays* L.) is one of the principle cereal crops having wide adaptability in the hill agro-ecosystem. In Mizo language, it is commonly known as 'Vaimim'. The crop is widely grown under shifting cultivation, as one of the principal staple food crop in the steep slopes of Lusai hills in Mizoram. Versatile uses of maize have been under practice over the years among the native tribal population. The green cobs are consumed extensively as roasted and steamed. It is an important source of animal feed and often used in other miscellaneous practices. However, the lower crop productivity is a major concern for maize cultivation in Mizoram. Therefore, the national workshop will provide a platform for many eminent scientists, academicians, extension functionaries, State officials, agro-industries, students and progressive farmers for exchange of their valuable ideas will be better equipped to increase maize production and better sustainable livelihood for the maize growers in Mizoram.

I offer my wholehearted support to the ICAR RC for NEH Region, Mizoram Centre, Kolasib and others involved in the organization of the event. Wish you a great success.

Dated 19th February, 2019

(Kummanam Rajasekharan)

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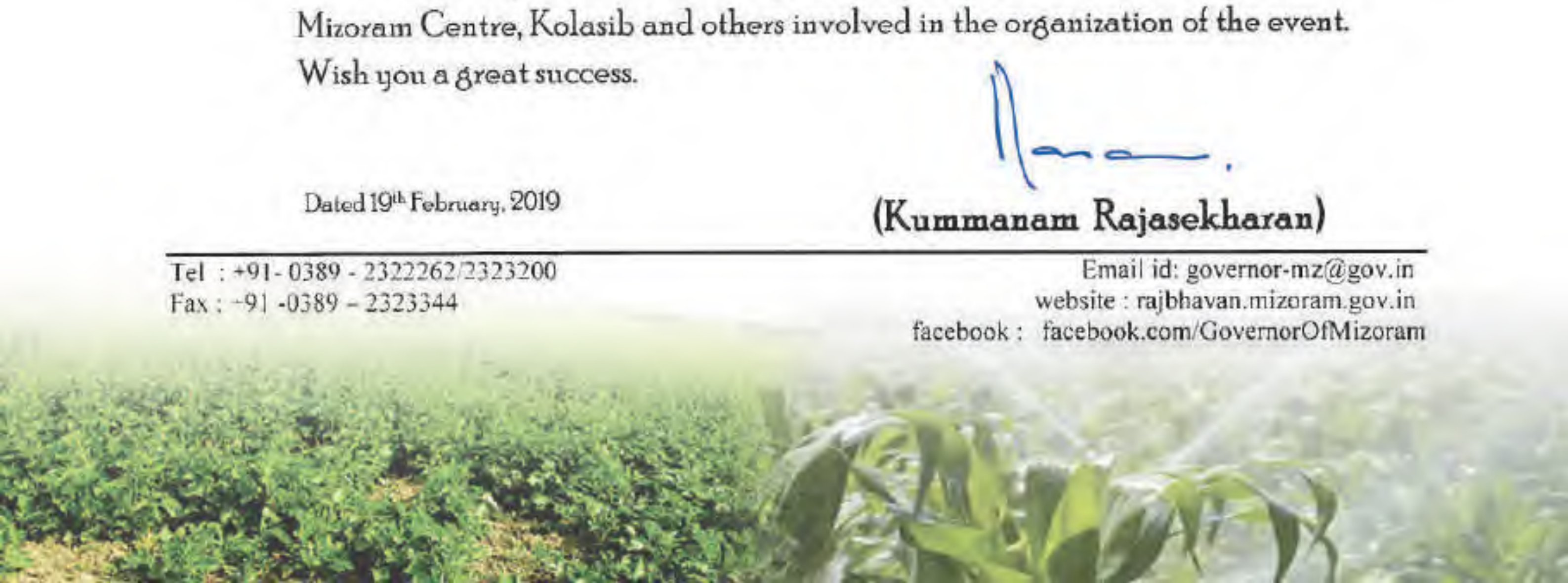

परशोत्तम रूपाला
PARSHOTTAM RUPALA

राज्य मंत्री
कृषि एवं किसान कल्याण मंत्रालय
और पंचायती राज मंत्रालय
भारत सरकार
Minister of State
Ministry of Agriculture & Farmers Welfare
Ministry of Panchayati Raj
Government of India

सत्यमेव जयते

Dated, the 19th February, 2019

MESSAGE

I am very happy to learn that ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram is jointly organizing **one day National Workshop on 'Scientific Maize Cultivation in North East India'** on March 05, 2019 at Aizawl (Mizoram) in collaboration with ICAR- Indian Institute of Maize Research, PAU Campus, Ludhiana, Punjab as the Prime Sponsor. A Souvenir is also being brought out to commemorate this event.

Maize has shifted from Traditional Food Crop to Industrial Commodity as the use of maize by the Food and Processed Food Industry has steadily increased over the years. In recent decade, major maize producing countries reduced their export due to increased domestic demand for Ethanol Industry. This has adversely affected availability and supply of maize in the global trade. To counter this, we have made substantial progress in the production of maize in the North Eastern Hill Region. The success is mainly attributable to the adoption of improved technologies resulted from Research and Development. The development of Quality Protein Maize, rich in essential amino acids, has put forth several steps towards achievement of our nations' Nutritional Security. It is realized that the role of the Maize workforce including Researchers, Extensions, Policy Makers and Industries is commendable in the increased production of Quality Protein Maize in the NEH Region.

I earnestly hope that this National Workshop on 'Scientific Maize Cultivation in North East India' would bring out the critical issues confronting the farming community of the NEH region in the context of the agricultural production and suggest appropriate strategies to accomplish the **Mission of Livelihood Security through Sustainable Farming Practices.**

I wish the National Workshop on 'Scientific Maize Cultivation in North East India' a Grand success.

(PARSHOTTAM RUPALA)

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Gajendra Singh Shekhawat

कृषि एवं किसान कल्याण
राज्य मंत्री
भारत सरकार
Minister of State for Agriculture & Farmers Welfare
Government of India

Dated - 19th February, 2019

MESSAGE

It gives me immense pleasure to note that the ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram in collaboration with ICAR- Indian Institute of Maize Research, PAU Campus, Ludhiana, Punjab as prime sponsor is jointly organizing a one day National workshop on 'Scientific maize cultivation in North East India' on March 05, 2019 at Aizawl (Mizoram) and a Souvenir is being brought out to commemorate the event.

Maize is a multi-faceted crop used as food, feed and industrial crop globally. Currently this coarse grain is cultivated in about 10.2 Million hectares in India. 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. In the NEH region, maize production plays a significant role in ensuring food security and is used both for direct consumption as well as for second cycle produce in livestock, piggery and poultry farming. The average productivity of maize in the region is very low (<1.5 t ha-1) than national average productivity (2.6 tonnes/ha) and other potential maize growing states (> 4.0 t ha-1 Andhra Pradesh, Karnataka and sometimes from Bihar). In NEHR of Mizoram, area under production by productivity increase and also reorient value chain if it is to serve the basic goal of remunerative prices for farmers.

I am sure that this National workshop on 'Scientific maize cultivation in North East India' will be successful in discussing various issues and bringing up strategies to enhance production of maize and its utilization in sustainable manner in this North Eastern Himalayan Region. I am looking forward for the roadmap for maize in NEH Region as recommendations in the workshop.

I extend my warm wishes to the organizers for a successful and fruitful event.

(Gajendra Singh Shekhawat)

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MESSAGE

I am happy to learn that ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram in collaboration with ICAR – Indian institute of Maize Research, PAU Campus, Ludhiana, Punjab as prime sponsor, is jointly organizing a one day National Workshop on "Scientific maize cultivation in north east India on 5th March, 2019 at Aizawl, Mizoram and that a Souvenir is being released to commemorate the event.

Maize is considered the third most important cereal crop in the world after rice and wheat and the most important emerging crop in the Eastern Himalayan Region. However, the average productivity in Mizoram is still below the national average and there is an urgent need to address the farmer's requirement for enhancement of its productivity. Popularization of improved technologies of maize to a particular agro-ecological condition is an utmost priority to valve hidden productivity potential. High yielding varieties (HYVs) of maize are widely adopted in other parts of the country but most of the farmers in this region are growing low yielding local varieties, less adaptive to changing climate particularly rainfall and temperature trend. It is anticipated that HYVs of maize with better management practices have immense potential to increase the existing production level in the hilly ecosystem of the north eastern hill region.

I am sure that all these aspects will be covered in this workshop on maize production in Mizoram and formulate a suitable solution apart from enlightening farmers of the region.

I convey my best wishes to the organizers of the workshop and wish it a grand success.

Dated Aizawl,
the 12th February, 2019

(ZORAMTHANGA)

C. Lalrinsanga
Minister
Agriculture, Cooperation
Irrigation & Water Resources

Dated Aizawl, the 19th February, 2019

MESSAGE

I am elated to know that ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram in collaboration with ICAR- Indian Institute of Maize Research, PAU Campus, Ludhiana, Punjab as prime sponsor is jointly organizing the one day National workshop on 'Scientific maize cultivation in north east India' on March 05, 2019 at Aizawl (Mizoram) and a Souvenir is being brought out to commemorate the event.

We need to double maize production and productivity in NEH Region through multi-institutional, multi-pronged strategies. This can be achieved through plant breeding for abiotic stress tolerance, plant phenotyping, precision agriculture and improved management practices. Popularization of advanced maize production technologies to a particular agro-ecological condition is at utmost priority for getting potential productivity and exploring maximum production potential of maize in the shifting cultivation lands of North eastern hill region.

Given this background, formulating suitable technologies of maize to increase the jhum productivity is the need of the hour. I feel very proud for the praiseworthy initiatives taken by ICAR Research Complex for NEH Region, Mizoram Centre, ICAR-Indian Institute of Maize Research (PAU Campus, Ludhiana) and Directorate of Agriculture (Research & Extension) to organize the workshop at Aizawl.

I wish the national workshop on maize production in Mizoram be very successful with great satisfaction.

(C. LALRINSANGA)

LALHMINGTHANGA, IAS
Commisioner & Secretary,
Government of Mizoram
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MESSAGE

It gives me immense pleasure to note that the ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram in collaboration with ICAR- Indian Institute of Maize Research, PAU Campus, Ludhiana, Punjab as prime sponsor is jointly organizing a one day National Workshop on 'Scientific Maize Cultivation in North East India' on March 05, 2019 in Aizawl (Mizoram) and a Souvenir is being brought out to commemorate the event.

Maize is an important crop of North Eastern Region with a very high potential for increase in production. The Region is also very rich in genetic diversity of maize. Many famous maize varieties exeunt in this region. The technology breakthrough in maize has made it possible to achieve great heights in yield through Quality Protein Maize hybrids (QPM). However, the popularity of hybrids in the NEH Region is yet to catch-up. I believe that this brain storming session will help to create awareness for the improved maize varieties a long with their improved agronomic practices. This will go a long was in the co-evolution of maize and piggery industry in the region, which was envisaged long back.

I am sure that this National Workshop on Scientific Maize Production in Mizoram will be successful in discussing various issues and bringing up strategies to enhance production of maize and its utilization in a sustainable manner in this North Eastern Himalayan Region. I am looking forward to the roadmap for maize in NEH Region as recommendations in this Workshop.

Dated: 27th February, 2019

(Lalhmingthanga)

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Dated - the 19th February, 2019

MESSAGE

It is my great pleasure to learn that ICAR Research Complex for NEH Region, Mizoram Centre and Indian Institute of Maize Research, PAU Campus, Ludhiana, Punjab are jointly organizing one day National workshop on 'Scientific maize cultivation in north east India' on March 05, 2019 at Aizawl, Mizoram.

In the North Eastern Himalayan Region (NEHR) of India, maize is the second most important crop after rice. The crop is widely adapted to grow under hill agro-ecosystem and played a major role for ensuring regional food security and also for rearing livestock (pigs and poultry). The average productivity of maize is far below than the national average. Our present effort is concentrated on multi-institutional, multi-pronged strategies for doubling maize production in North East Indian hills through technological intervention and development of suitable extension strategies. Development of composites and hybrids from plant breeding, biotic and abiotic stress phenotyping and precision farming are sought to be the most convenient option to achieve our goal. Quality Protein Maize (QPM) rich in carbohydrates, fats, better quality proteins, some of vitamins and minerals have glittering opportunity for development of pig and poultry farming in integrated farming system mode. Lysine and tryptophan fortification has also ensured our nutritional security" Therefore, effective dissemination of tested maize production technologies is at utmost priority to increase the net production and productivity of maize in north east India.

I earnestly hope that the National Workshop would highlight the critical issues of maize production in North East Indian hills and the recommendations of the work shop will serve as the guidance force for the farming community, policy makers and other stakeholders involved in maize production over the north east Indians hills.

I wish the event at grant success.

(N. Prakash)

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Dated : 27th February, 2019

Message

It gives me immense pleasure to note that the ICAR Research Complex for NEH Region, Meghalaya in collaboration with ICAR-Indian Institute of Maize Research, Ludhiana organizing a State level training on "State level interaction meeting of scientific maize production in Mizoram" on 5th March, 2019 at Aizol, Mizoram.

Maize being a queen of cereals and grown in all the NEH states have immense potential for its cultivation in this ecologies. The favorable rainfall and high organic matter soil provided good opportunity of the cultivation of this crop in these ecologies specially in Mizoram by adoption of high yielding maize cultivars specially hybrids that can tolerate biotic and abiotic stresses for providing resilience and enhancing profitability in the maize systems in Mizoram. Despite this, state is net importer of maize having competitive demands from poultry, piggery, fishery etc. for feed and thus, enhancing production in the Mizoram will further boost these sectors in this important strategic region of the country. The cultivation of the quality protein maize (QPM) can address the issue of the food, feed and nutritional security of this region.

The cultivation of the specialty corns like waxy maize, baby corn, sweet corn and pop corn have potential for enhancing the profitability of the maize cultivation in this state where land holding is limited with enough work force engaged in agriculture. This state and neighboring state have lack of the feed industries which enhances the feed cost enormously and in turn consumer have to pay higher prices for meat and other animal products. The establishments of the small processing industries for these specialty corns as well as for feed production have potential to further growth of maize in this state. Growing of these specialty corns will also boot up the animal sector growth and will help in realizing the doubling farmer income, the agenda of Government of India. The state can also take up seed production for own consumption and towards export of seed to the neighboring states of the region and other countries.

I am sure that this interaction meeting with stakeholders will be successful in discussing various issues and bringing up strategies to enhance production of maize and its utilization in sustainable manner in Mizoram. I am looking forward for the roadmap for maize in Mizroam as recommendations in this workshop of this meeting

I extend my warm wishes to the organizers for a successful and fruitful event.

(S. Rakshit)

MESSAGE

Message I am very happy to learn that ICAR Research Complex for NEI.I Region. ivlizoram Centre, Kolasib. Mizoram in collaboration with ICAR- Indian Institute of Maize Research, PAt1 Campus. Ludhiana. Punjab as prime sponsor is jointly organizing a tine day National workshop on 'Scientific maw: cultivation in north east India' on March 05. 2019 at Aizawl (Mizoram) and a Souvenir is being brought out to commemorate the event.

Maize is the second most important cereal crop after rice in Mizoram, mostly cultivated under shifting cultivation. Now•a-days. maize has become an important livestock feed both as silage and as crop residue grain and is also used industrially for starch and oil extraction. The production of maize in the state is highly deficit to meet the internal requirement of the state for both livestock feed and human consumption. This will undoubtedly open up opportunities for the region to tap its immense potential of maize in agricultural production. This National Workshop is a welcome step to congregate a large number of researchers. extension workers. policy planners, agro-industries, marketing agencies, AT A. NGOs and progressive farmers to discuss and conceptualize a meaningful strategy pertaining to development of maize production sector in the North East Region in particular for Mizoram, in the context of changing climate.

I believe that this National Workshop on scientific maize cultivation in N.E India would bring out the critical issues confronting the farming community of the North East Indian Hill region in context of the agricultural production and suggest appropriate strategies to accomplish the mission of livelihood security through sustainable farming practices.

I extend my best compliments to ICAR and wish the National Workshop on scientific maize cultivation in NiE India a grand success.

30/1/19

(Dr. H. SAITHANTLUANGA)
Director of Agriculture (Research & Extension)
Mizoram : Aizawl

Dated 30th January, 2019

MESSAGE

I am very happy to learn that ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram in collaboration with ICAR-Indian Institute of Maize Research, PAU Campus, Ludhiana, Punjab as prime sponsor is jointly organizing a one day National Workshop on 'Scientific Maize Cultivation in North East India' on 5th March, 2019 at Aizawl, Mizoram and a Souvenir is being brought out to commemorate the event.

Maize being one of the important crops cultivated by hill farmers of the North Eastern Region both as kharif and rabi crop. The productivity of the crop in North East is reported to be very low (< 1.5 T/Ha.) as compared to the national average (2.5 T/Ha.). The livestock, poultry and fishery sectors in the North East are growing at a faster pace resulting more demand for maize based livestock and poultry feeds. Increasing local demand for maize grain necessitates enhancement of productivity of the crop in the region.

I believe that this National Workshop on 'Scientific Maize Cultivation in North East India' would bring out the critical issues confronting the farming community of the NEH region in context of the agricultural production and suggest appropriate strategies to accomplish the mission of livelihood security through sustainable farming practices.

I extend my best compliments to ICAR and wish the National Workshop on 'Scientific Maize Cultivation in North East India' a grand success.

(ROHMINGTHANGA COLNEY)
Director of Agriculture
(Crop Husbandry)
Mizoram, Aizawl

Dated 28th February, 2019

भारतीय कृषि अनुसंधान परिषद
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Ph: 03837 220041, E-Mail: jdicarmizoram@gmail.com

Dated the 27 February, 2019

MESSAGE

I am very thankful to the Indian Institute of Maize Research, PAU Campus, Ludhiana, Punjab and Directorate of Agriculture (R &E), Govt. of Mizoram for jointly organizing one day National workshop on 'Scientific maize cultivation in north east India' on March 05, 2019 at Aizawl (Mizoram).

Maize (Zea mays L.) is widely grown in the uplands of the Eastern Himalayan Region (EHR); commonly known as 'Vaimin' in Mizoram. Many of the local maize landraces have a major share in shifting agriculture productivity in the Lusai hills of Mizoram. The crop is considered to be second most important after maize, due to its extensive use as food for human consumption and feed for livestock, animal, fish, and poultry birds. Quality protein maize is presently occupying its pace to fulfill the demand of feed. The average productivity of maize in Mizoram is low with less than 1.75 t/ha as against national average of 2.43t/. The lower crop productivity and high soil erosion potential are the major challenges for the maize based cropping systems in the jhum lands; in order to attain a sustainable productivity of maize in Mizoram.

There is an urgent need to address the farmers' requirement for enhancement of their productivity, quality improvement with proper technological backup for popularization and further expansion of maize area in this region along with strengthening in value addition and market chain development. I hope that the National Workshop will provide a great opportunity to bring together the multidisciplinary scientific team, academicians, policy makers, line departments, financial institutions, Krishi Vigyan Kendras, NGOs, Students, Farmers, Media and other stakeholders to a common platform for sharing their problems, finding ideas to formulate a fruitful strategies for sustainable way for harnessing the hidden potential of maize production in NEH Region. The recommendations derived out of this event will be published as policy document for sustainable maize production and value addition for the North Eastern Hill Region in particularly for the Mizoram state

I extend my heartfelt gratitude to our sponsors, invited speakers, experts, delegates, and representatives from NGOs, media and specially our farmer friends for their valuable contributions to the workshop.

(I Shakuntala)
Convener, Organising Committee

भाकृअनुप-भारतीय मक्का अनुसन्धान संस्थान
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Scientist & NEH Coordinator

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19th February, 2019

From the Desk of NEH Coordinator

It gives me a feeling of joy and pride to share that the ICAR- Indian Institute of Maize Research, PAU Campus, Ludhiana, Punjab sponsor the collaborative programme on Promoting improved technology of maize production in NEH Region to harness the hidden potential of NEH region in doubling the maize productivity. I respectfully appreciate the efforts of ICAR Research Complex for NEH Region, Meghalaya and its Regional Centre for implementation of the said programme in every NEH states and organization of a State level training on "State level interaction meeting of scientific maize production in Mizoram" on 5th March, 2019 at Aizol, Mizoram.

In the North Eastern Himalayan Region of India, maize occupies considerable acreage after rice but despite high demand maize is not adopted in Mizoram states and thus the state is importing maize for meeting the domestic demand. Despite of several problems (Acidic soil, High Rainfall, macro and micronutrients deficiency etc.), state has hidden potential of high maize production (Soil enrich in organic carbon, better biological properties etc.). This is possible only through suitable technological transformation at farmer's field. In the Mizoram, poultry, fishery and piggery farming is the prioritized activities, here maize grain may utilized for the second cycle produce and stalk may utilized for cattle. There is also opportunity of value addition industries for baby corn, QPM and sweet corn. Therefore, attention is required to be given not only to technological backup, but also to make roadmap for technologies transformation to the farmer's field along with strengthening in value addition.

The organic maize production, hybrid maize seed production, sweet corn and baby corn production could be a better option for enhancing profitability of maize farming the Mizoram. For this all stakeholders must come together to devise an institutional framework and infrastructure (road, processing industries) development for implementation of the overall maize programme in the state towards making it as a export hub for neighboring states and countries.

I am very much confident that this interaction meeting with stakeholders will brings a common platform for sharing their problems and finding roadmap to formulate a meaningful strategies for harnessing the hidden potential of maize production in Mizoram.

(S. L. Jat)

भारतीय कृषि अनुसंधान परिषद

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Dated , 27th February, 2019

MESSAGE

Maize is a multi-faceted crop used as food, feed and industrial crop globally. Currently this coarse grain is cultivated in about 10.2 Million hectare in India. 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. Similarly, In the NEH region, maize production plays a significant role in ensuring food security and is used both for direct consumption and as well as for second cycle produce in livestock, piggery and poultry farming. In NEH Region, area under maize cultivation is 0.23 million ha with production 0.37 million tonnes production with a very low productivity 1.47 Mt/ha than national average productivity (2.6 tonnes/ha) and other potential maize growing states (> 4.0 t ha^{-1} Andhra Pradesh, Karnataka and sometimes from Bihar).

It is in response to such increasing demand, NEHR needs to plan production by productivity increase and also reorient value chain if it is to serve the basic goal of remunerative prices for farmers. This time the driver of change is surge in demand for Maize from Maize based businesses, be it poultry, feed, starch or processed food. High yielding varieties (HYV) of maize widely adopted in other parts of country, but in the NEHR, most of the farmers are growing low yielding local genotypes. It is anticipated that HYVs of maize with better management practices have immense potential to increase the existing production level by 2-3 times in the hilly ecosystem of NEHR. To achieve sustainable double maize yield and enhance the farmer's income five pillars move together Linkage and aggregation with all stakeholders, enabling infrastructure at grassroots level, forging PPP, Policy framework and technological intervention.

In this backdrop, objective of the National Workshop on Scientific maize cultivation in North East India" on 5th March, 2019 at Kolasib, Mizoram is to create awareness among various stakeholders of agriculture especially farmers, policy makers and to identify possible reasons for low productivity of maize through participatory interaction. All researchers, policy makers, extension functionaries and farmers come together and put forth all ideation, deliberate and brainstorming to bring out the sustainable, feasible and acceptable strategies to for the doubling of the maize production and farmer's net income with harnessing the hidden potential of maize production in NEH Region.

(M. A. Ansari)

Contents

Nutrient Deficiency Induced Abiotic Stress to Maize in Northeast India: Detection and Assessment by Drone-based Aerial Imaging

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Introduction:

Maize (*Zea mays L.*) is the third major cereals in the world after rice and wheat. In India alone during 2015-16, 8.69 million ha net sown area was under maize crop. In the Northeast India, it is the second most important crop after rice, mostly grown in upland acid soils of the region (Marwein *et al.,* 2016). In many occasions, severe soil acidity led fertility stress often causes partial to complete crop failures. Occurrence of phosphorus (P) deficiency due to high P fixation by iron and aluminum oxides in the strong acid soils (pH <4.5) of the region limited the productivity of maize crop (<1.5 t ha^{-1}) (Marwein *et al.,* 2016). Despite rich in soil organic carbon, the upland cereal crops including maize of the region also often suffer from the inadequacy in soil nitrogen (N) availability to meet the crop uptake at peak crop growth stages. Soil test values also signify the prevalence of available N-deficiency in organic carbon rich upland soils of the hill region. Low mineralization rate in cold environment might be one of the reasons for low available N.

The upland agricultural fields in the region are mostly acidic in reaction (pH<5.0) and located in the undulating topography with inaccessible terrains. Small and sloppy agricultural land-holdings, sparsely distributed patches in-between inter-mountains and predominance of marginal, resource poor land-holders of these uplands further complicates in periodic monitoring, on-field detection of stresses, and diagnostic measures (amelioration, external nutrient supplementations from organic/inorganic/both etc.). As a result, sub-optimal crop productivity and occasional partial to complete crop failure is a major concern for the region. With the progress in proximal remote sensing particularly, low-flying high-resolution aerial imaging (Unmanned Aerial Vehicle, UAV or Drone), rapid detection, cost-effective and accurate evaluation procedure over manual survey of conventional, subjective, time consuming, expensive and inaccurate methods of abiotic crop (maize) stress detection and damage assessment in the inaccessible agricultural fields across hilly terrains.

Aerial imaging using UAV/drone for detection of nutrient stresses in maize crop:

Four consecutive field experiments (*kharif* and *rabi* seasons; since October 2016 till September 2018) on maize as test crop (variety: RCM-1-76) were carried out at the experimental research farm of ICAR Research Complex for NEH Region. We imposed three different abiotic stresses- soil acidity (pH was maintained at < 4.30), nutrients- Nitrogen and Phosphorus stresses. Standard irrigation scheduling was followed (as recommended for the region). Based on critical soil test values, we imposed the treatments. Details of the experimental details are given below (Fig. 1).

Maize at peak vegetative stages of growth (85 days old) : 3-D view of UAV image

Winter maize: Abiotic (nutrient) stress

Kharif maize: Abiotic (nutrient) stress

Fig. 1: Pictorial view of the experimental farm (imposed abiotic stresses on maize crop)

The multi-spectral UAV/drone (Model DJI Matrice 600; Table 1) fly was made periodically during crop growth periods (till harvest) covering multi-date (20 days interval) for both the consecutive seasons (*kharif* & *rabi*). Data acquisition and pre-processing from the onboard multispectral and RGB camera were done following standard procedures. After pre-processing of the UAV data, the different reflectance bands (Red, Green, Red edge and Near Infra-red band) were generated. These bands were used to obtain different indices like Normalized Difference Vegetation Index (NDVI), Normalized Difference Red Edge Index (NDRE), Green Normalized Difference Vegetation Index (GNDVI) etc. These indices were analyzed further to correlate it with the ground obtained parameters for all the treatment combinations.

Table 1: Technical specification of aircraft and the camera of the UAV (Source: ww.dji.com)

Model	**DJI Matrice 600**
Weight (battery included)	9.1 kg
Dimensions	640 mm x 582 mm x 623 mm (Frame arms and GPS mount folded)
Hovering accuracy (GPS mode)	Vertical: 0.5 m horizontal: 2.5 m
Hovering accuracy (P-Mode, with	Vertical: ±0.5 m,
GPS)	Horizontal: ±1.5 m
Max angular velocity	Pitch: 300°/s,
Max speed of ascent	Yaw: 150°/s
Max speed of descent	5 m/s
Max speed	3 m/s
	18 m/s (No wind)
Max flight time	Approximately 45 minutes
Max range	5000 m radius (with line of sight)

The four bands (Green, Red, Red edge, NIR) were stacked and used for NDRE and GNDVI profiling for three growth stages of *kharif* maize-2017 (30 days, 60 days and 90 days old crop). Analysis revealed that with the increase in nitrogen fertilizer doses from 0 kg/ha till 80 kg/ha in the form of urea, both GNDVI and NDRE were increased consistently. However, beyond 80 kg/ha, further increase in doses of N-fertilizer to 120 kg/ha, both the indices reflected a decreasing trend (Fig. 2). Similarly, moving from extremely phosphorus deficient soil (P_0: 0 kg/ha) to moderate (P_{30} - P60) and highly P sufficient soils (P_{120}: kg/ha) through external supplementation of P-fertilizers in the form of single super phosphate (SSP), an inconsistent increase in both GNDVI and NDRE were observed. This was also corroborated with the visual image analysis and digital image classification of the corresponding period's UAV images. Linking with measured leaf N and P content for the same period also reflected a good correlation (r = 0.55 to 0.62) with these indices. Other plant pigmentation and bio-physical parameters also revealed similar trends. Soil acidity ameliorated soils (by applying lime) and nutrient stress free crops (NPK + lime) had relatively higher GNDVI and NDRE values over acidity and nutrient stressed crops (alone lime/NPK applied plots) (Fig. 2).

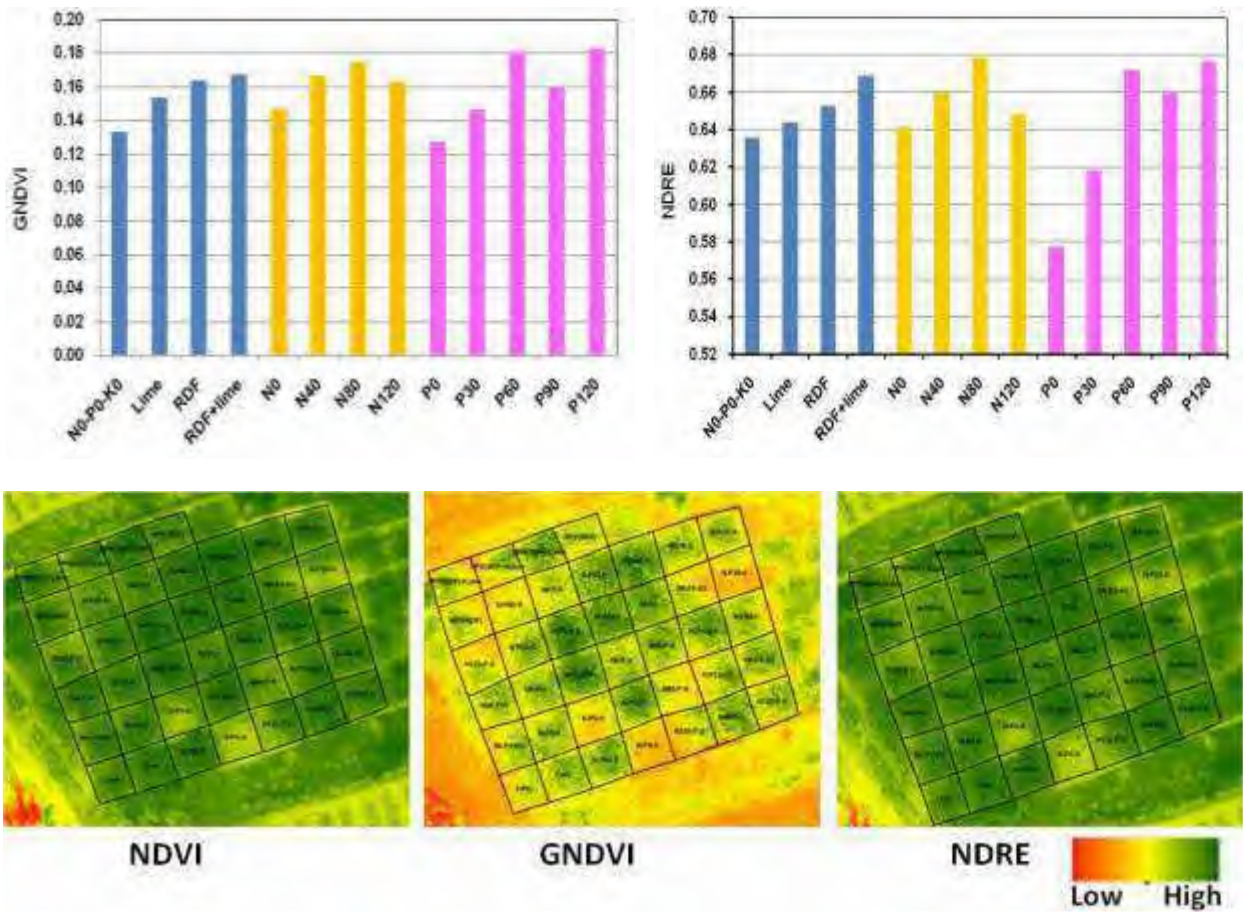
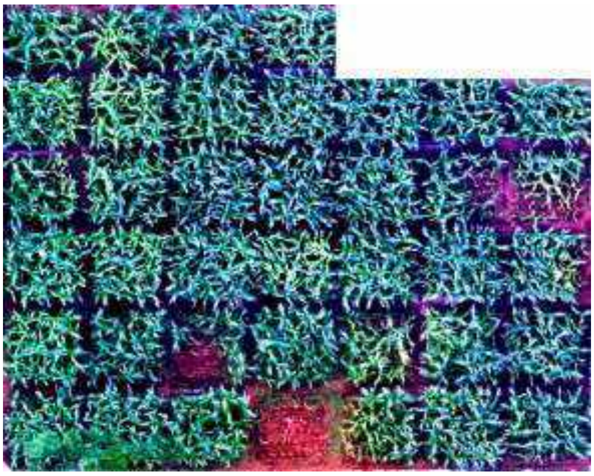
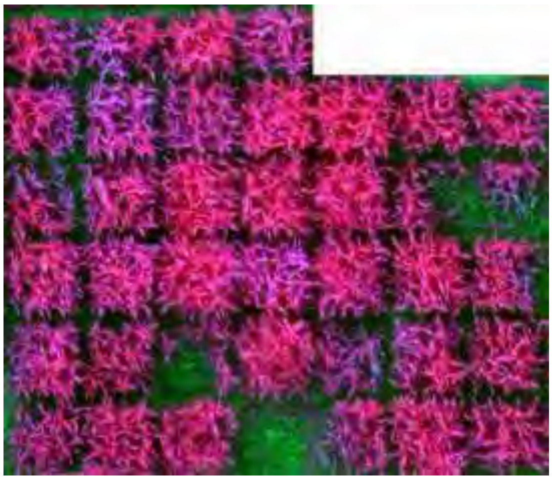


Fig. 2: Spectral indices (NDVI, GNDVI & NDRE) from UAV images of maize field

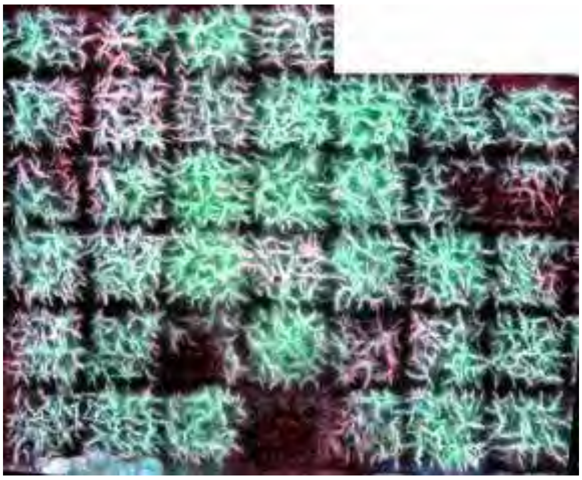
Similarly, two sets (*kharif*-2017 & *rabi*-2018) of UAV multispectral land cover data has been classified into 4 different classes for improving the classification accuracy in identifying /detecting stress-free and stressed maize crops as well as nutrient (N/P) specific stress (Figs. 3 & 4). Four advanced machine learning supervised classifiers (Support Vector Machine, Random Forest, Random Committee & Artificial Neural Network) were used to perform classification on the data. The multi-spectral UAV image from peak vegetative growth stages (60 days old) of maize crop grown in *kharif* season of 2017 was used for detection of stress-free and stressed crops using all these four classifiers. The four advanced machine learning classification techniques *viz.* Random Forest (RF), Random Committee (RC), Support Vector Machine (SVM) with polynomial kernel and artificial neural network (ANN) were used for classification of UAV data to detect the crop conditions (stress free vs. stressed) (Fig. 4). All the four methods of classification could able to identify/detect stress-free vs. stressed (N & P deficiency induced) crops at satisfactory level. However, stresses developed in the crops from specific nutrient deficiency (whether due to N or P deficiency) could not be segregated at satisfactory level by all the classifiers. Among the classifiers, RF registered relatively higher overall accuracy (accuracy= 86.47%, kappa index analysis = 0.80) with shorter training time (0.08 seconds) than other three classifiers. Artificial neural network took longest training time with low overall accuracy and kappa index than RC and SVM**.**



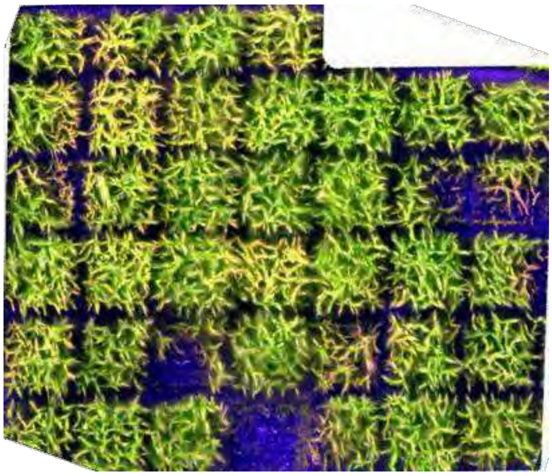
Maize with N/P deficiencies (RGB-UAV Image)



Maize with N/P deficiencies (Band-1234 UAV)



Maize with N/P deficiencies (Band-143 UAV)



Maize with N/P deficiencies (Band 132 UAV)

Fig. 3: Maize crops under abiotic stress-free and stressed induced regimes – UAV images

Similarly, we also tried to detect and periodical monitoring of stress-free vs. nutrients (N & P) deficiency induced stressed *rabi* maize crops grown during October 2017 to April-2018. Three dates of UAV-multispectral images of standing maize crops were taken in the month of November-2017 (30 days old crop), December-2017 (60 days old crop) and March (120 days old) -2018 (Figs. 4 & 5). There was severe hoar frost incidence, occurred in the month of January -10, 2018, therefore, images of November and December, 2017 were before frost occurrence and March-2018 is the aftermath of frost occurrence (Fig. 5). We used random forest classifier (which was relatively better in accuracy) to detect the stress free vs. stressed crops along with temporal variation in percent cropped area under different categories (Table 2). In the initial stages of crop growth (30 days old), nearly 29% area had healthy stress free crops which with the advancement of growth stages (on 60 days old), reached to 36% of the total area (600 sq. m). Generally, maize reaches it's peak vegetative stages at 90 days (falling in January end) and that time, canopy ground coverage also increases significantly. However, due to severe frost occurrence at peak vegetative stages of growth (10th January, 2018), frost induced injury resulted in partial failure/ death of crops at many plots (Fig.5).

As a result, during March-2018 (120 days old), health cropped area decreased by 11% over December-2017 (before frost occurrence). Similarly, area under stressed (unhealthy due to N & P deficiency) crops increased from 7.9% in November 2017 to over 17% in December and after frost injury, many plots experienced complete crop failure. As a result, post-frost stressed crop area increased further (>17% with partial stress while >39% area with complete crop failures). This was evident from the significant increase in non-cropped area from 12.77% in December- 2017 to 51.74% in March-2018 (Table 2).

Table 2: Temporal variation in area under nutrient stressed maize crops from multi-date UAV image analysis

Class	Percent area (%)		
	November, 2017	December, 2017	March, 2017
Healthy	28.838	36.01	25.036
Stressed	7.944	17.55	17.497
Weed	28.531	33.67	5.728
Border	34.687	12.77	51.739

Conclusion: The drone/UAV based aerial imaging can be used in detection of stress-free and nutrient stressed (nitrogen & phosphorus) maize crops. All the four advance machine learning classifiers namely random forest, random community, support vector machine and artificial neural network could able to identify / detect stress-free vs. stressed (N & P deficiency induced) crops at satisfactory level. Among all the four classifiers, random forest registered higher overall accuracy (overall accuracy= 86.47%, Kappa index analysis = 0.80) with shorter training time (0.08 seconds) than other three classifiers. However, stresses developed in the crops from specific nutrient deficiency (whether due to N or P deficiency) could not be segregated at satisfactory level using the multispectral camera born drone used in the present study. Use of hyperspectral camera born drone/UAV would be more precise in detection of nutrient(s) specific abiotic stresses in demarcating affected areas and accurate quantification across farmers' field in the hilly terrain of NE hill regions of India.

Acknowledgement:

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Suggested Readings:

Marwein, M.A., Choudhury, B.U., Chakraborty, D., Kumar, M., Das, A. and Rajkhowa, D.J. 2016. Response of water deficit regime and soil amelioration on evapotranspiration loss and water use efficiency of maize (*Zea Mays* L.) in subtropical Northeastern Himalayas". *International Journal of Biometeorology*, 61(5): 845-855, DOI: 10.1007/s00484-016-1262-4.

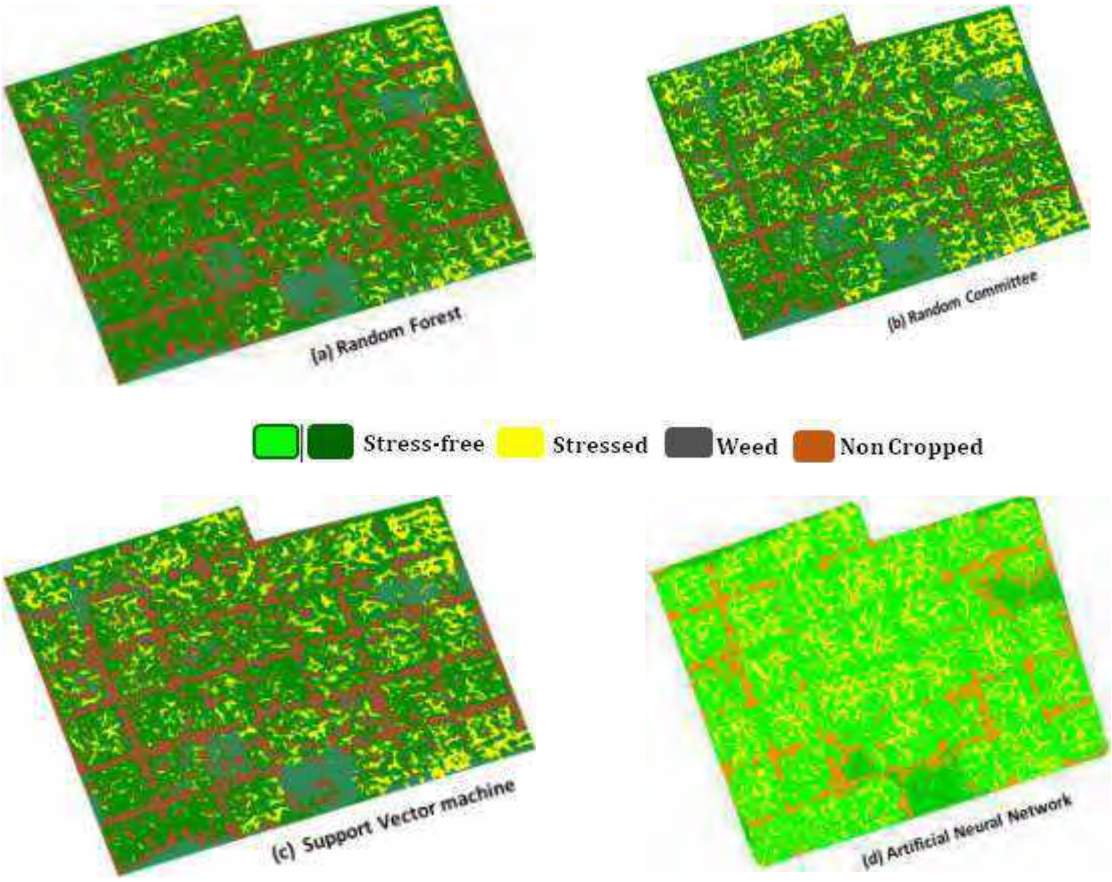

Fig. 4: Supervised classfied UAV-multispectral images of stress-free and stressed (N & P) maize

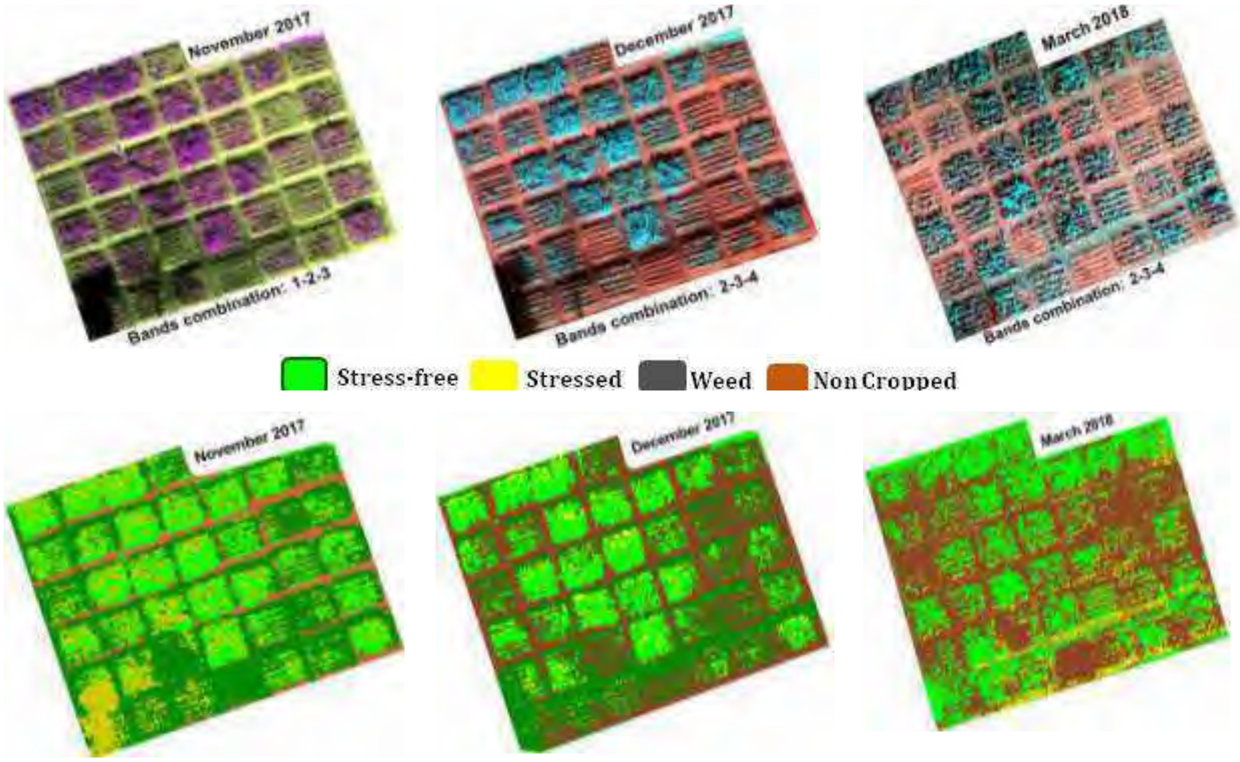

Fig. 5: Multi-date UAV images (RGB & classified using random forest classifier) of abiotic stressed maize fields

Baby Corn and Sweet Corn Production Technologies for Mizoram

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Introduction:

Specialty corns have several health benefits along with a delicious taste of their own. Specialty corn types (QPM, sweet corn, popcorn, baby corn) are rich in essential nutrients. Further nutritional improvement using traditional and modern breeding approaches can be the best option for ensuring nutritional vitamin A etc. will increase levels of several micronutrients that are insufficient to meet daily requirements at no additional cost. These specialty maize types must be grown in time isolations of 10-15 days or in space isolation of at least 250 meter for getting desired quality specialty maize. It means there is need to go for the baby corn and sweet corn village clusters for making quality production in NEH regions. In this chapter, quality of specialty maize and their production technology along with challenges and opportunities discussed in details with special reference to NEH regions of the India.

Baby corn

Baby corn is the ear of maize (*Zea mays* L.) plant harvested young, especially when the silks have either not emerged or just emerged, and no fertilization has taken place, depending on the cultivar grown. The dehusked young ears of baby corn can be eaten as vegetable, whose delicate sweet flavor and crispiness are much in demand. Importantly is free from pesticides and its nutritional value is comparable to popular vegetables like cauliflower, cabbage, tomato, eggplant and cucumber. It's by products such as tassel, young husk, silk and green stalks provide good cattle feed.

What baby corn is?

- Unfertilized cobs
- 6-11 cm long; 1.0-1.5 cm thickness
- Cream to light yellow
- Regular row arrangement
- Harvested 1-3 days silk emergence.
- 3-4 crops in a year
- Uses: salads, chutney, vegetables, Pickles, soup and several recipes, corn pakoda, etc.

Baby corn is a young finger like unfertilized cob with one to three centimeter emerged silk preferably harvested within 1-3 days of silk emergence depending upon the growing season. The desirable size of baby corn is 6 to 11 cm length and 1.0 to 1.5 cm diameter with regular row/ ovule arrangement.

The most preferred colour by the consumers / exporters is generally cream to very light yellow. Baby corn is nutritive and its nutritional quality is at par or even superior to some of the seasonal vegetables. Besides proteins, vitamins and iron, it is one of the richest sources of phosphorus. It is a good source of fibrous protein and easy to digest. The nutritive value of the baby corn is comparable with most of the common vegetables (Table 1). It is good source of carbohydrate, thiamine and phosphorus compared to other vegetables.

Table 1: Nutritive values of baby corn in comparison to common vegetables (per 100 g of edible portion)

Content	Baby corn	Cauliflo-wer	Cabb-age	Tomato	French bean	Lady's finger	Radish	Brinjal	Spinach
Moisture (%)	89.10	90.80	91.90	93.10	91.40	89.60	94.40	92.70	92.10
Carbohydrates (g)	8.20	4.00	4.60	3.60	4.50	6.40	3.40	4.00	2.90
Protein (g)	1.90	2.60	1.80	1.90	1.70	1.90	0.70	1.40	2.00
Calcium (mg)	28.00	33.00	18.00	20.00	50.00	66.00	50.00	18.00	73.00
Phosphorus (mg)	86.00	57.00	47.00	36.00	28.00	56.00	22.00	47.00	21.00
Iron (mg)	0.10	1.50	0.90	1.80	1.70	1.50	0.40	0.90	10.90
Thiamine	0.50	0.04	0.04	0.07	0.08	0.07	0.06	0.04	0.03
Riboflavin	0.08	0.10	0.11	0.01	0.06	0.01	0.02	0.11	0.07
Ascorbic Acid	11.00	56.00	12.00	31.00	11.00	13.00	15.00	12.00	28.00

Baby corn is nutritive and its nutritional quality is at par or even superior to some of the seasonal vegetables. Besides proteins, vitamins and iron, it is one of the richest sources of phosphorus. It is a good source of fibrous protein and easy to digest (Table 2). It is the most "safe" vegetable to eat as it is almost free from residual effects of pesticides as the young cob is wrapped up with husk and well protected from insects and diseases.

Table 2: Nutritional composition of baby corn on dry matter basis

Particulars	Baby corn hybrid (HM-4)
Moisture [g/100g]	7.37
Crude protein [g/100g]	10.04
Crude fat [g/100g]	4.43
Crude fiber [g/100g]	2.4
Ash [g/100g]	1.34
Total carbohydrates	81.97
Energy [Kcal/100g]	375.67
Total soluble sugars [g/100g]	0.14
Calcium [mg/100g]	17.76
Phosphorous [mg/100g]	197.89
Iron [mg/100g]	2.73

(Source: Kawatra and Sehgal, 2007)

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

Uses of baby corn:

Baby corn is a popular vegetable in USA, Europe and Southeast Asia. The demand for baby corn is rapidly increasing in urban areas in India. Baby corn is not a separate type of corn like sweet corn or popcorn and hence any corn type can be used as baby corn. It is delicacy, which can be profitably used in prolific types of corn i.e. those types, which bear two or more ears per plant. The cob with non-pollinated silk is baby corn. The economic product is harvest just after the silks emerge (1-2 cm long). Baby corn has immense potential as a salad and as cooked vegetable. It is used as an ingredient in ChopSuey (Chinese dish), soups, deep fried baby corn with meat, rice and other vegetables. Large number of dishes may be prepared from baby corn as discussed subsequently. Baby corn is highly nutritive. The nutritive value of baby corn is comparable to any common vegetable (Table 1). Since only immature cob is harvested as the economic produce, the crop meant as baby corn can be harvested within 50-55 days after sowing. Thus in the areas adjoining cities or other urban areas (peri-urban agriculture) multiple crop of baby corn can be raised which would fetch greater income to the farmers. Baby corn can be effectively used as both a nutritious vegetable and as an export crop to earn valuable foreign exchange. After harvest, the still young plants may be used as fodder for cattle.

In general, the cultivation practices of baby corn are similar to grain crop except

(i) Preference for early maturing single cross hybrid with multiple cob bearing ability and regular row arrangement

(ii) Higher seed rate with (22-25 kg/ha) with high plant population (more than 83,000/ha)

(iii) Higher dose of nitrogen application (150 to 180 kg/ha)

(iv) Detasseling just after tassel emergence

(v) Harvesting unfertilized tender cobs within 1-3 days of silk emergence

Major baby corn in world:

It has great potential both for internal consumption as well as for export round the year as 3-4 crops of baby corn can be taken in one year. Thailand is the major baby corn producing and exporting country in the world. In recent past, India also emerged as major baby corn exporting country due to lower cost and quality baby corn production and now it is preferred in the European market.

Advantages of baby corn cultivation:

1. **Diversification-** The maize is least attractive to the pest as compared to the vegetables. It can be grown round the year and promotes diversification in vegetable cultivated areas where pest and diseases are major problems due to mono-cropping. Hence, it is suited for peri-urban agriculture diversification.

2. **Intensification-** The crops of baby corn can be harvested earlier than the normal maize crop and 3-4 crops can be taken in a year. It can be grown in the narrow window of two main crop and thus intensifies the cropping. In the scenario of the expanding imbalance of land to human resources the baby corn can be a best bet for enhancing productivity and profitability of existing cropping system.
3. **Employment generation-** It provides employment in the form of cultivation, marketing, processing and export. The cultivation of the baby corn is labour intensive.
4. **Earning money in shortest possible time-** Generally, farmers have to wait for a longer time for the income from their crops. Being a short duration crop, farmers can earn money in the shortest possible time.
5. **Potential for export-** Baby corn has a great demand in the international market. The foreign exchange can be earned by exporting baby corn and its products.
6. **Quality fodder for livestock-** Green fodder obtained after the harvesting of baby corn can be used as a feed to livestock throughout the year. The farmers can save their land used for green fodder cultivation.
7. **Value addition-** Value addition of baby corn is possible through preparation of several recipes *viz*. soup, salad, pakora, vegetables, pickles, candy, murabba, jam, laddoo, burfy, etc.
8. **Intercropping-** Intercropping of vegetables, pulses, flowers, etc. can be done with baby corn in *rabi* to ensure additional income to the farmers. The baby corn hybrid (HM-4) based high value (beet root, peas, potato, coriander, fenugreek, radish, cabbage) intercropping systems were evaluated with raised bed planting system at DMR, New Delhi during winter 2007-08 and 2008-09. Results revealed that the baby corn yield under intercropping systems was comparable with sole baby corn. However, the net returns varied significantly under different cropping systems. The increase in profitability of intercropping systems varied from Rs. 146900 under baby corn+ pea, Rs. 133750 under baby corn + potato, Rs. 125700 under baby corn + coriander, Rs. 96500 under baby corn + beetroot, and Rs. 79950 under baby corn + radish. The profitability of other systems was either at par or less than sole baby corn systems due to their non-compatibility. Other than profitability, there was remarkable advantage on water productivity and employment generation under intercropping systems compared to sole cropping of baby corn or other winter crops.

Production technology of baby corn

In general, the cultivation practices of baby corn are similar to grain crop except some special operation of detasseling and picking of tender cob. However, to achieve higher productivity, following package should be adopted:

1. Selection of suitable varieties:

Being a commercial crop, selection of variety is most important in the baby corn production. The preference should be given for early maturing single cross hybrid with multiple cob bearing ability and regular row arrangement in baby corn production. The hybrids like HM-4, Central Maize VL baby corn 2, VL Baby corn 1, COBC-1, IMHB1532, IMHB1539 etc. are suitable hybrids for baby corn. The variety should have following characteristics in order to fetch better commercial value in the market. Traits contributing to higher baby corn yield are as follows:

i) Early maturating single cross hybrids- To earn better returns in shortest period from baby corn crop, early maturing single cross hybrids are suggested with silking period of 45-50 days in *kharif*, 75 to 80 days in spring and 120-130 days in winter in North Indian states.
ii) Medium height and lodging resistance- Baby corn is cultivated with high plant populations. In general, with high plant density, lodging has been observed. Therefore, hybrid with strong plant type and better root system is preferred.
iii) Prolific- Cultivars producing more than one ear per plant are desirable for higher yield of baby corn.
iv) Responsive to high dose of fertilizers- As baby corn is cultivated in higher plant density, fertilizer responsive cultivars are more suitable for the purpose.
v) No barrenness- Varieties possessing no barrenness trait are desirable for proper yield.
vi) Stay green- For getting better fodder quality, genotypes grown for baby corn cultivation must possess the stay green traits. After the picking of baby corn, left over plant material is used as green fodder.
vii) Erect leaves- To accommodate more plant per unit area, erect leaves is a desirable trait. This allows better light interception and hence, enhances net photosynthesis and ultimately increases productivity under high density.
viii) Length of dehusked ear- Preferably not exceeding 10 cm with 1.0¬-1.5 cm diameter. **ix) Husked to dehusked ratio-** It should be 5-6 : 1.
x) Harvesting period- Harvesting period should be within 10- 12 days in *kharif* /spring and 20 days during winter.
xi) Deformity: Each plant should give 3-4 pickings of baby corn. Each baby corn should maintain desirable size and colour.
2. Sowing time: It can be sown round the year except the highly low temperature days during winter season in NEH states. Generally, August to November planting yields best quality baby corn.
3. Sowing method: In case of the big size of the field the sowing should be done in blocks with 7 days' time interval. It will enhance the period of baby corn availability and also the efficient utilization of the farm resources. Baby corn should be sowed in the centre of the ridges made at 60 cm apart during monsoon season. Sowing should be done on southern side of the ridges during winter depending upon plant type (erect/spreading). For 60 cm apart ridges, plant must be sowed at 10-15 cm row spacing. Furrow sowing should be adopted for baby corn production during summer to enhance the water-use efficiency.

4. Seed rate and plant population: A little higher seed rate than normal maize is required for baby corn production due to more plant population requirement. A seed rate of 22-25 kg/ha is recommended for baby corn production depending on the seed size of the cultivars. An optimum plant population of 83,333 to 1,11,111 is to be maintained for higher and quality baby corn yield by keeping 15 to 20 cm distance between plants after thinning.

5. Seed treatment: Seeds should be treated with fungicides and insecticides before sowing to protect it from seed and soil borne diseases and some insect-pests. The following pesticides should be used for the respective pests and diseases:

Disease/insect-pest	Fungicide/Pesticide	Application rate (kg^{-1} seed)
Seed borne diseases	Bavistin/Captan	2.0 g
Termite and shoot fly	Imidacloprid	6.0 ml

6. Nutrient management- Nutrient application should be based on soil test basis. Generally 120:60:0:25 kg/ha N, P, K and $ZnSO_4$ with 8-10 tons/ha FYM should be applied for realizing potential yield of baby corn hybrids. Full dose of phosphorus, potash and zinc and 30% N should be applied as basal dose. The remaining dose of nitrogen should be applied in two-splits at knee high and tasseling to avoid losses and to meet the requirement throughout the crop cycle. After first/second picking apply 30 kg N/ha for harvesting good yield in subsequent pickings of the baby corn.

7. Weed management- Broad leaf weeds and most of the grasses can be controlled by pre-emergence spray of Atrazine @1.0-1.5 kg/ ha in 500-600 L of water. While spraying, the person doing spray should move backward so that the Atrazine film on the soil surface may not be disturbed. Preferably, three nozzle booms may be used for proper ground coverage and saving of time.

One to two hoeing are recommended for aeration and uprooting of the remaining weeds. While doing hoeing, the person should move backward to avoid compaction of soil and to facilitate better aeration.

Herbicides for weed control in maize are as follows:

Name	Dose (a.i. /ha)	Time of application	Remarks
Atrazine	1000 -1500 g	Apply with 500 litre/ha of water before emergence of crop as well as weeds	Control all weeds except *Dactyloctenium aegyptium* (Makra) and *Cyprus rotundus*
Pendimethalin	1000 ml	Apply with 500 litre/ha of water before the emergence of crop as well as weeds. Suitable for application in intercropping.	Control all weeds except *Commelina benghalensis* (Cana) and *Cyprus rotundus*
Atrazine + Pendimethalin	500 g + 750 ml	Apply tank mix with 500 litre/ha of water before emergence of crop as well as weeds	Control all weeds except *Cyprus rotundus*
Tembotrione	120 ml	It can be applied as post emergence up to 25-30 days in heavily broadleaf weed infested fields.	It is effective against all weeds.

Name	Dose (a.i. /ha)	Time of application	Remarks
Topramezone	25 g	It can be applied as post emergence up to 25-30 days in heavily broadleaf weed infested fields.	It is effective against all weeds.
2,4-D	500 ml	It can be applied as post emergence up to 25-30 days in heavily broadleaf weed infested fields.	It is not effective against sedges and grassy weeds.

8. Water management: First irrigation should be applied very carefully. Water should not overflow on the ridges to avoid the runoff and exposure of the seed for prey to the birds. The irrigation should be applied in furrows up to 2/3rd height of the ridges. Irrigation should be given as and when required by the crop depending upon the rains and moisture holding capacity of the soil. Young seedlings, knee high stage, silking and picking are the most sensitive stages for water stress for crops and irrigation should be ensured at these stages. Light and frequent irrigations are desirable for crop. During winter (mid-December to mid-February) soil should be kept wet to avoid frost injury in the baby corn.

9. Intercropping: Baby corn is more remunerative, if it is cultivated with intercrop in winter season. As many as 20 crops, namely potato, green pea, rajmah for green pods, palak, cabbage, cauliflower, sugar beet, green onion, garlic, methi, coriander, knol-khol, broccoli, lettuce, turnip, radish, carrot, french bean, celery, gladiolus, etc. have been successfully tried in the winter season (Fig.1). Since, the season is long therefore, farmers can utilize his lean period and get additional income through intercropping in baby corn. There is no adverse effect of intercrops on baby corn and vice-versa, rather, some of the intercrops help in improving soil fertility and protect the baby corn crop from cold injury. Intercrops protect the baby corn from northern cold wind because baby corn is planted on southern side and intercrops in northern side of the ridge. In general, short duration varieties of intercrops are preferred for intercropping with baby corn. Recommended dose of fertilizers of intercrops should be applied in addition to the recommended dose of fertilizers of baby corn. In *kharif* season, cowpea for green pods and fodder purposes, urdbean, mungbean, etc. can be intercropped with baby corn. Number of intercrops are option for the farmers but for commercial purpose, pea and potato can be taken on large scale during winter season.

In the experiment conducted at DMR, the increase in profitability of intercropping systems varied from Rs. 1,46,900 under baby corn+ pea, Rs. 1,33,750 under baby corn + Potato, Rs. 1,25,700 under baby corn + coriander, Rs. 96,500 under baby corn + beetroot, and Rs. 79,950 under baby corn + radish. The profitability of other systems was either at par or less than sole baby corn systems due to their non-compatibility. Other than profitability, there was remarkable advantage on water productivity and employment generation under intercropping systems compared to sole cropping of baby corn or other winter crops.

Baby corn + Sugar beet

Baby corn + Cabbage

Baby corn + Cauliflower

Baby corn + Spinach

Baby corn + Potato

Baby corn + Pea

Baby corn + Carrot

Baby corn + Gladiolus

Fig. 1: Suitable intercrops with baby corn in winter season

10. Protection from serious insect pests: Stem borer (*Chilo partellus*), Pink borer (*Sesamia inferens*) and Sorghum shoot fly (*Atherigona* spp.) are serious problems in *kharif*, *rabi* and spring seasons, respectively. Stem borer can be controlled by 1-2 spray of Carbaryl after 10 and 20 days of germination. Spraying should be done in the central whorl of plant.

11. Detasseling: To maintain the quality of baby corn, detasseling is an essential operation. It is done by removing the tassel of the plant as soon as it emerges from the flag leaf. It should be practiced row-wise. While detasseling, leaf should not be removed which will otherwise affect net photosynthesis and ultimately reduce average baby corn yield. It has been observed that the removal of 1 to 3 leaves along with tassel reduces 5-15% yield of baby corn. The removed tassel should not be thrown in the field as it is nutrient rich and should be fed to the cattle.

12. Harvesting: The ears are harvested (45-50 days after emergence) when the silks are 1-2 cm long, i.e. within 1-2 days after silk emergence. Feed corn varieties are harvested at silking, while super sweet varieties may be harvested up to the time silks are about 5 cm long but still fresh. Ears quickly become too long and tough. Suitable time for harvesting of ears may be determined by sampling for size. Harvesting is usually done in the morning when the moisture is high and the temperatures are low. The picking of baby corn is to be done once in three days and generally 7-8 pickings are required depending on genotypes used. Picking should be done daily in *kharif* and on alternate days in winter season within 1-3 days of silk emergence from the leaf sheath depending upon the variety. Harvesting should be done when baby corn silk comes out 2.0-3.0 cm from the top of ears, preferably in the morning or evening, when the baby corn moisture is highest and ambient temperature is low. In single cross hybrid plant, 3-4 pickings may be obtained.

In a good crop on an average 15-19 q/ha baby corn can be harvested. Additional income may also be obtained through sale of green fodder, which may yield up to 250-400 q/ha. The husk is to be carefully removed so as not to break or damage the ear. Ears intended for processing must be carefully hand husked and de-silked. Subsequent to the removal of the ear husks, the cobs are cleared of the silks. Then the cobs are graded based on their size and colour and packed in polythene sheets before marketing. In many cases baby corn for vegetable use is marketed without dehusking of the cobs. This reduces labour involved in processing but fetches less market price. Optimum size for market and cannery industries is 4.5-10 cm long and 7-17 mm diameter of dehusked cobs. Yellow coloured cobs with regular row arrangement fetch better market price. Harvested baby corn may be stored for 3-4 days at 10^0C without much effect on its quality. For long term storage and distant transport, baby corn is canned in brine solution (3%), sugar (2%) and citric acid (0.3%) solution and stored under refrigerated conditions. Baby corn may also be stored in vinegar. Baby corn pickle is also gaining popularity in Indian market and it already has an established international market, particularly in Europe.

13. Yield: It depends on potential of genotypes and climatic conditions. In a good crop, on an average 15-19 q/ha dehusked baby corn can be harvested. Green fodder yield is about 300-400 q/ha that gives additional income to the growers.

The effort should be made to peel the baby corn on the same day and stored in a cool and dry place. It should be carried out in shady places having good ventilation and air circulation. De-husked baby corn should be put in containers like plastic baskets, bags, sacks and ensure that they are not heaped. Baby corn should be transported to the processing unit at the earliest. Following are the quality traits of baby corn needed to be considered for higher market price:

- Baby corn should be uniform in color, shape and size.
- Color of baby corn should be creamish or light yellow.
- Ears should be straight.
- Ears should not have slitting marks
- Ears should be fresh, free from defects like rotting, over dryness, over ripening and water soaking. Trimming of baby corn should be neat and leave no scars on ears.
- Ovule/row arrangement should be regular and straight.

14. By-products: Following by-products obtained by the baby corn production:

1. Tassels
2. Silks
3. Husks
4. Green plant material after harvest

All these by-products are highly nutritive and can be fed to the cattle that increase milk yield.

Sweet corn

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

- A delicious and rich source of energy, vitamin C and A used in preparation of soup, salad, pizza and other recipes
- Varieties: HSC1 for J&K and HP & Madhuri, Win orange, Priya for other states
- Seed rate: 8 kg/ha
- Spacing: 75 cm X 25-30 cm
- Green cobs are harvested after 18-20 days of pollination during *kharif* season
- Picking should be done in evening
- Generally sweet corn is early in maturity & harvested in 70-75 days during *kharif* season

- At the harvest time the moisture is generally 70 % in the grain and sugar content varies from 11 to more than 20%

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

Precaution: Its picking should be done in the morning or evening time. Green cobs should be immediately transported to the cold storage in refrigerated trucks to avoid the conversion of sugar to starch. It loses flavor if kept in high temperature after picking. Sweet corn with high sugar content should not be planted, when temperature is below 16 °C.

Package of practices for sweet corn cultivation in NEH region

Choice of cultivar:

Maturity group/type	Hybrids/cultivar
Sweet corn	Hybrids: Hi Brix 53, Hi Brix 39, Central Maize VL Sweet corn 1, Candy, Mishti Composites: Priya, Madhuri, Win orange

Time of sowing: Optimum temperature for maize growth and development is 18 to 32 °C, with temperatures of 35 °C and above considered inhibitory. The sweet corn sowing could be avoided in the period expecting heavy rainfall or temperature more than 30 °C after 40-50 days of planting.

Seed treatment:

Disease/insect-pest	Fungicide/pesticide	Application rate per kg seed
Seed borne diseases (TLB, MLB, CLS)	Bavistin/ Captan	2.0 g
Termite and shoot fly	Imidachlorpid	3.0-4.0 ml

Seed rate and plant population:

Type/purpose	Seed rate (kg ha^{-1})	Plant geometry (plant x row, cm)	Plant population per ha
Sweet corn	8	75 x 25; 75 x 30	44444 to 53333

Nutrient management:

- Seeds treatment with three packets of *Azospirillum*
- Application of 10-15 t ha^{-1} FYM
- 120 kg N, 60 kg P_2O_5 ha^{-1} for hybrid sweet corn
- Apply 1/3rd of N each at basal, knee high and tasseling stage; splitting of potassium is beneficial
- Or apply 25% N as basal and rest 75% N in four splits as top dressing as follows:

S. No.	Crop Stage	Nitrogen rate (%)
1.	V_4 (four leaf stage)	25
2.	V_8 (eight leaf stage)	30
3.	V_T (tasseling stage)	20

- *Azotobacter/Azospirillum* + *Phosphobacteria* 2 kg each/ha along with FYM application in case of no seed treatment with biofertilizer.

Weed management: please follows as written for the baby corn earlier.

Insect management:

- For *Chilo and Sesamia* control, foliar spray of **Carbaryl @ 2.5 g/litre** at 10 days after germination.
- The *Chilo* can be controlled by release of **8 Trichocards per ha** at 10 days after germination.
- Intercropping of maize with cowpea is an eco-friendly option for *Chilo* control.

Disease management:

- **TLB, MLB:** Need based sprays of **Mancozeb @ 2.5 g/l**.
- **BLSB**: *Stripping of lower 2-3 leaves* along with their sheath & **tolcofos-methyl @ 1g/ l or Validamycin @ 2.7ml/l.**
- **Downy mildew: Metalaxyl** @ 2-2.5g/l is recommended at first appearance.

Harvesting: 20 days after pollination (Green cobs: 40-50 q/acre & green fodder: 120-150 q/acre)

Opportunities for the specialty corn in NEH region:

1. **Availability of the soil and water-** The north eastern hill regions hosts the soil having high organic matter which is very much suitable for the low input requiring baby corn crop and for even sweet corn as well. The water is also of good quality and available in the Mizoram. The villages of the baby corn and sweet corn may be established in all the state to cater the domestic needs and for export to the Japan and other countries.

2. **Sufficient work force-** The country is facing shortage of the employment generation and especially in this state due to less industrialization. In this scenario, the traditional agriculture sector could be revived by introduction of the high value crops like baby corn and sweet corn for employment generation. This will also help in checking the migration of the rural youth and will improve the livelihood security of the farmers.

3. **Tourism promotion-** In recent past and with future project of road linkage by government of India, the unexplored NEH region of the country is going to tourist hub in the country due to attraction of scenic natural beauties. In the tourist areas, the cultivation and sale of the raw and processed baby corn and sweet corn product like baby corn *pakora*, baby corn mixed vegetable and salad, steamed sweet cob and sweet corn soup will have great promise for generation of the income to the farmers.

4. **Value addition and processing industries -** Due to good availability of water sources in the flood plains of the Brahamputra river and the energy availability provides enough opportunity for the establishment of the baby corn and sweet corn processing plants. These plants also require very less energy and can be run on biomass energy as well.

5. **Employment generation** -There is great opportunity to engage more people in the baby corn cultivation and processing as this is the labour intensive and provides employment to all stage people, youth and women.

6. **Livestock promotion -** The green fodder and the cob sheath generated by the cultivation of baby corn and sweet corn are very nutritious. This could help in the bridging the gap for fodder requirements of the livestock and hence will help in improving productivity of this sector as well.

7. **Organic specialty corn -** The importer of the baby corn and sweet corn are the high-income economies of Northern America, Japan and Europe. The NEH soils are in general rich in the organic matter as well as there is not much requirement of nutrients in baby corn as there is no need to go for the seed. Hence, this crop could be an important candidate for the organic cultivation. These can be exported for the earning of forex and will also lead to increased employment and livelihood security of the farmers in the NEH region.

8. **Availability of cultivars -** There is enough technological intervention in terms of high yielding cultivars available for specialty corn in NEH states. The cultivars of the baby corn like HM-4, VL Baby corn 1, etc. and in sweet corn Hi Brix 53, Hi Brix 39, Central maize VL Sweet corn 1, Candy, Mishti, etc. These cultivars can be grown successfully in the Mizoram.

Challenges for specialty corn in NEH states:

a) **Establishment of the market linkages-** Being a difficult terrain and the less connection of hinterlands of NEH region warrants the establishment of the seed to marketed product linkages in the value chain. Further, these personnel in entire value chain must/will be from the NEH regions and thus requires intensive trainings on the various aspects of the specialty maize production. These trainings could be the part of the RKVY projects and NHM projects of this region. Establishments of the seed hubs, baby corn and sweet corn processing and processing plants will add up towards making success of the specialty maize cultivars in NEH regions.,

b) **Training to the producers-** The cultivation of these specialty types of the maize is not penetrated in NEH region and hence the farmers are mostly friendly with traditional maize growing.

c) **Trainings to the trainers-** As the baby corn and sweet corn are the specialty type of maize and hence if produced with the normal maize practices could not be remunerative. Hence, intensive class room and on farm trainings of the state government officials and other trainers of the ICAR is needed for the proper dissemination of the knowledge about these specialties maize types.

d) **Assured seed supply at affordable prices-** The government of the states can help by establishing the seed villages under the RKVY scheme. The current price of the available seed of the baby corn is Rs. 350 to 550 while for sweet corn it is much higher up to Rs. 2250 to 2500 per kg.

e) **Transportation-** The baby corn and sweet corn being a perishable commodity needs a transport network that is faster to fetch the appropriate prices in the market. In NEH region of difficult terrain this is relatively slow and hence will be a challenge for its wider adaptability amongst the hinterland farmers. However, the areas near cities could go for it easily. For hinterland, the air-conditioned transport system or the processing industries establishment could be a solution where villages of the baby corn and sweet corn could be established like a business module.

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Germplasm Conservation and Utilization in Maize

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Introduction:

Maize is typically a cross pollinated crop due to its monoceious and protandrous nature. It is being grown in more than 165 countries of the world under different agro-climatic conditions up to 50^0 N and S from the equator to more than 3000msl. In the past, it was mainly confined to food in India and many other countries however now it has become an industrial crop throughout the world. Being a cross pollinated crop, it has enormous genetic diversity that offers incredible opportunities for genetic enhancement. Worldwide, the heterosis phenomenon has been well utilized in maize for its yield enhancement due to availability of high genetic variability. Genetic diversity provides options to develop through selection and breeding of new and more productive crops, tolerant to various abiotic and biotic stresses. The available genetic variation need to be conserve for its continuous future use. The conservation of germplasm involves the preservation of the genetic diversity of a particular plant or genetic stock so that it can be used at any time in future. The sum total of genes in a crop species is referred to as gene pool. The gene pool is the basic material with which a plant breeder initiates their plant breeding programme. A better understanding of genetic diversity and its distribution is essential for its conservation and use. It will help in determining what to conserve as well as where to conserve. It will also help in understanding of the taxonomy, origin and evolution of important plant species. A detail on germplasm contains the information for a species genetic makeup and valuable natural resource of plant diversity. Conservation of plant genetic resources is necessary for food security and agro-biodiversity. The benefits from plant genetic resources have been enormous over the last century. Plant breeders have been able to produce new varieties with improved yields, quality and adaptation. Germplasm diversity could be valuable aid in crop improvement strategies. Diversity studies can be exploited to strengthen pre-breeding programmes. The erosion of these resources poses a severe threat to the world's food security. Climate change scenarios show agriculture production will largely be affected (Lobell *et al.,* 2008). The diversity of several important crops, including maize, spread across the world is under the threat due rapid urbanization and unpredictable and extreme climatic events, such as drought, heat and flooding. It is important to conserve the valuable genetic traits present in the existing and primitive plants.

Plant genetic resources for food and agriculture could be conserved by various methods. The Germplasm has to be maintained in such a state that there is minimum risk for its loss and that either it can be planted directly in the field or it can be prepared for planted for planting with relative ease. The most common and most economic method to conserve germplasm is to store as seed. However, not all plant germplasm can be stored conveniently in the seed form. In many cases it is convenient to conserve the germplasm by other methods. Each method has its advantages and its limitations. There are two basic types of conservation, namely *in situ* and *ex situ* conservation.

Of the major cereals, maize presents the most convincing prospect for some degree of *in situ* conservation on-farm. Advancement in the plant science has resulted in development of high yielding hybrids worldwide but still coverage is an issue particularly in India where only around 25-30% area is under improved single cross hybrids cultivation. This may due to problem of accessibility to hybrids seed as well as also from farmer preference for landraces, particularly in low-productivity conditions. The open-pollinated varieties (OPVs), landraces, and wild relatives represent an extraordinary genetic resource of the species with significant allelic diversity, much of which has not been incorporated into improved varieties due to the ‘bottleneck’ effects created by artificial selection. However, there conservation in *In/Ex-situ* is a prime responsibility of very individual who are dealing with it. Both in situ and ex situ conservations are vital to preserve the enormous genetic diversity present in maize, as these approaches are complementary (Maxted *et al.,* 1997). In situ approaches are best suited for conservation of landraces or traditional varieties that have high value to the farmers as well as high genetic diversity (Smale and Bellon, 1999), and those biodiversity-rich areas where farmers are less likely to substitute traditional varieties for improved ones for various socioeconomic, cultural or ethnic reasons (Smale *et al.*, 2004).

***In-situ* conservation** is the conservation of germplasm in its natural habitat or in area where it grows naturally. ***Ex-situ* conservation** is the conservation of components of biological diversity outside their natural habitats.

In situ conservation:

There are different methods *viz.* Biosphere reserves, National Park, Gene Sanctuaries and On-Farm Conservation for *In-situ* conservation. In maize, the most common method is On-Farm conservation. To maintenance of domesticates such as landraces or local crop varieties in farmers’ fields often referred to as on-farm conservation (Maxted *et al.,* 2002). At national level, there are several examples for on-farm *in-situ* conservation of maize e.g. **Gurez** and **Anantnag** local land races of maize which are being grown and conserve since long back at very high altitude areas of Jammu & Kashmir. These land races have been naturally conserved due to their adaptability and in-built tolerance to cold stress. Similarly, an orange color local land race of Himachal (**Chamba local**), and **Malan** (drought tolerant) **Telani** (high oil content) and **Sathi** (very early maturing) of Rajasthan, **Sikkim primitives** (highly prolific) of Sikkim and **Mimban'** landrace from Mizoram are the few of the examples of *in-situ* conservation of maize in India**.** At International level, Mexico and Guatemala, remained significant areas of landrace production, populations found closest to wild relatives of maize, and the annual and perennial teosintes (Dempsey, 1996).

Advantages *of In-situ* conservation-

- It allows the possibility of conserving a large range of potentially interesting alleles and genotypes.
- It allows natural evolution to continue, providing breeders with a dynamic source of resistance and other traits.
- It facilitates research on species in their natural habitats.
- It assures protection of associated species.

***Ex situ* conservation:**

Ex situ conservation approach generally comprises the following methods: seed storage, field gene banks, *in vitro* storage, pollen storage and DNA storage. **Seed Gene Bank**: A place where germplasm is conserved in the form of seeds is called seed bank. In seed banks there are three types of conservation *viz*. Short term (working collections) (>3-5 years) at 10-15^0 C at 10% moisture. Medium term (active collections) 10-15 year at temperature 15^0 C with 5% moisture. Long term (base collections) 50 years more stored about -20^0 C with 5% moisture content. b) **Field Gene Bank**: Field gene banks also called plant gene bank are area of land in which germplasm collections of growing plants are assembled. It is also called *ex-situ* conservation of germplasm. **DNA Bank:** Where DNA can be stored as extracted uncut genomic DNA. Such efforts have led to storage of total genomic information of germplasm in the form of DNA libraries. **Pollen Bank**: Pollen can be preserved limited space. Pollen preservation may be useful for base collections of species that do not produce orthodox seeds.

Advantage of *ex-situ* conservation-

- It is possible to preserve entire genetic diversity of crop species at one place.
- Less interaction with environment, so less chance to loss of genetic resources.
- Handling germplasm is easy.
- Small propagules stored in less space no need to generate plants every season.
- This is a cheap method of germplasm conservation.

Utilization of maize germplasm resources:

Maize has enormous genetic diversity that offers incredible opportunities for genetic enhancement. The diverse maize germplasm may be utilized for several purposes likely,

1. Development of new maize genotypes- The diverse germplasm of maize can be utilized for development of new inbred lines through selection followed by selfing of suitable plants and their advancement through ears to row method till their fixation. Several inbred lines have been developed from diverse maize germplasm which have been utilized for the development of productive hybrids. In India around 25-30% area have been covered under improved single cross hybrids which in results has helped in the increase of national maize productivity and production.

2. Broadening the genetic base of elite germplasm- There is no lack of favourable alleles in the global maize germplasm that contribute to higher yield, abiotic stress tolerance, disease resistance or nutritional quality improvement. However, these desirable alleles are often scattered over a wide array of landraces or populations. There is need to highlight the enormous genetic diversity in maize, especially in the landraces and the wild relative, teosinte, and the need for novel and systematic initiatives to understand and utilize the genetic diversity. Multi-institutional efforts are required at the global level to systematically explore the maize germplasm to diversify the genetic base of elite breeding materials, create novel varieties and counter the effects of global climate changes. Gurez local (land race) endemic to Gurez has a high level of cold tolerance and has been utilized in a crossing programme with CIMMYT pools to develop diverse varieties for high land ecologies of Kashmir. At the beginning when maize hybrids breeding were started, the inbred lines were not so much productive. Thereafter, by utilization of diverse maize germplasm coupled with systematic breeding improvement programme had resulted in development of productive maize inbred lines which has further made seed production economic and more viable.

3. For study of maize molecular genetic diversity- Molecular characterization of maize landraces of different countries (Warburton *et al.,* 2011; Prasanna, 2010; Sharma *et al.,* 2010) have provided new insights into domestication events in maize (Matsuoka *et al.,* 2002), understanding phylogenetic relationships and gene flow between maize landraces and the wild progenitor, teosinte (Warburton *et al.,* 2011), assessing the patterns of genetic diversity in the maize gene pool, identifying genes of agronomic importance in maize and tracking the migration routes of maize from the centres of origin.

4 Next-generation sequencing and high-density genotyping- The genome sequencing is important landmarks in maize genome research. It has contributed significantly for understanding of the maize genome organization and evolution, as well as to formulate strategies to utilize the genomic information in maize breeding. With next-generation DNA sequencing technology (Shendure and Ji, 2008), it will be possible to sequence the whole gene bank collection. Maize is the first plant species with a haplotype map (HapMap) constructed. The available diverse maize germplasm has been proven as assets for all these studies.

5. Seeds of Discovery (SeeD) - A new initiative of CIMMYT, titled 'Seeds of Discovery' (SeeD), aims to discover the extent of allelic variation in the maize genetic resources. It has helped to make available the favourable alleles and haplotypes associated with important traits to the breeders in an usable form, identification for desirable QTLs, donors for various abiotic and biotic stresses in maize.

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Quality Seed Production of Maize in Mizoram

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1. Hybrid maize technology:

Hybrid maize was one of the first example of genetic theory successfully applied to food production. The concept of Hybrid vigour was given by G.H. Shull in maize in 1908; which is still considered one of the greatest achievements in the history of plant breeding. Heterosis has been successfully exploited by maize breeders worldwide to adapt and improve germplasm sources for desirable traits. Hybrid varieties are made by crossing of selected parents (inbred lines) in the field. Maize hybrid seed has improved combination of traits such as high yield potential and ability to cope with biotic and abiotic stresses. However, the quality of hybrid seed depends greatly on field production methods, both in adherence to quality assurance standards and implementation of appropriate agronomic management. Hybrid maize seed production involves deliberately crossing a female parent population with a male parent in isolated fields. Thus, from the very start of hybrid seed production, the identity and arrangement of the two parent populations determine the outcome. Each hybrid variety is composed of a specific combination of a female (seed bearing) and male (pollen providing) parents. The field management of the two parents is also important and requires attention to timing of planting, elimination of off-types, removal of tassels from the females before pollen shedding, separate harvesting of the female seed and careful shelling and processing of the seed to maintain seed quality. The sequentially dependent nature of the process means that any errors in earlier stages have a significant impact on following stages and major errors or problems can result in complete failure or rejection of the crop.

2. Different types of hybrid in maize:

Crosses between males and females can be made in different ways to give rise for different kinds of hybrids:

i) Conventional hybrids: Conventional hybrids have all parents as inbreds

a) **Single cross hybrids-** Two unrelated inbred parents are crossed to produce single cross hybrid. The two parents of a single-cross hybrid, which is also known as a F1 hybrid, are inbreds. Plants of a single-cross hybrid are more vigorous than the parental inbred plants. The increase in vigour of a hybrid over its two parents is known as hybrid vigour. If a single-cross hybrid is allowed to open-pollinate, each of the plants grown from the resulting seed will be genetically unique.

b) **Double cross hybrids-** In this type of hybrid cross, both parents are single-cross hybrids. As the name implies, producing a double-cross hybrid requires two stages of crossing involving two pairs of inbreds. In Step 1, two pairs of inbreds, A and B and C and D are crossed to produce single-cross hybrids, A × B and C × D. In Step 2, the two single-cross hybrids produced in Step 1 are crossed to produce the double cross. Unlike a single-cross hybrid, plants of a double-cross hybrid are not genetically uniform.

c) **Three-way cross hybrids-** Three parents are involved in a three-way cross hybrids. The female of a three-way hybrid is a single-cross hybrid, while the male is an inbred line.

ii) Non-conventional hybrids: Non-conventional hybrids have at least one non-inbred parent. Among the several possible non-conventional hybrid combinations, two parent hybrids that involve one narrow-base seed parent and a male inbred parent in particular, offer great scope for exploitation of heterosis as well as significantly superior seed yield as compared to inbred seed parent. Genetic base of two-parent hybrids is much broader than conventional hybrids and hence are less vulnerable to pest and disease epidemics.

a) Top-cross- Obtained from a cross between a single cross or an inbred line and an open pollinated varieties**.**

b) Double top cross hybrids- Progeny of a single cross and a variety.

c) Inter-varietal hybrids- Formed by inter-crossing of two varieties.

3. Single cross hybrid maize:

Maize is highly cross pollinated crop which upon continuous selfing/inbreeding (process of taking the pollen from tassel of a plant and applying this pollen to the silks of the same plant) generates phenotypically weak, low productive but uniform inbred lines. However, when two diverse inbred lines are crossed, the vigour is restored in the resulting seed, and the yield of the plants grown from the seed is greatly increased. This is called *hybrid vigour*. It occurs as a result of the interaction between the sets of genes obtained from the two different inbred lines. Maize crop improvement have passed through the adoption of several genetic and agro-technique improvement strategies *viz.* open pollinated varieties(OPVs), composites, double top cross, double cross, three way crosses, four way crosses etc., however none of these strategies were able to harness heterosis at its fullest in maize. Hence, single cross hybrid technology having highest heterotic potential have been advocated. The impact of single cross hybrid technology was clearly visible in USA, China, Canada and many other countries. In India the productivity stagnated under 1 t/ha for many decades due to cultivation of open pollinated varieties and multi parent hybrids. However, later the adoption of SCH technology had a greater impact which can be witnessed in form of present growth rate of area (2.6%), production (6.4%) and productivity (3.6%) of maize. By extending the area under SCH technology by hardly 20% the productivity of maize was increased by 425 kg/ha from 2007 to 2008. This huge increase in a single year is a landmark in Indian maize scenario. Therefore, by covering 100% area under single cross hybrids, the production and productivity can be doubled within no time. Therefore development of single cross hybrids and their adoption in farmers' field should become the min strategy to ensure food and feed security of the developing world. The advantages of Single Cross Hybrid Maize have been mentioned below:

i. Tolerant to biotic and abiotic stresses and decreases the vulnerability to recurrent droughts and climate change.
ii. Nutrient responsive (low/high) due to profuse root system
iii. Faster growth and most uniform
iv. Low cost of production
v. Export potential

vi. Hybrids are generally higher yielding than open pollinated varieties, if grown under suitable conditions.
vii. Hybrids are uniform in colour, maturity, and other plant characteristics, which enables farmer to carry out certain operations, such as harvesting at the same time.
viii. The uniformity of the grain harvested from hybrids can also have marketing advantages when sold to buyers with strict quality standards.
ix. High acceptability among the farmers and require only two parents.
x. Require less number of isolation i.e. only three

4. Prerequisites for hybrid seed production:

i. Good compatible, uniform, productive and diverse parents
ii. Proper site selection, avoid the sites where preceding crop was maize.
iii. Fertile and quality land with good quality and assured irrigation.
iv. Proper isolation distance.
v. Knowledge of recommended package of practices.
vi. Technically experienced manpower.
vii. Stress free season.

5. Important considerations for hybrid seed production:

i. Isolation distance-

Seed production should be taken in fertile well drained, weed and disease free soil and preferably the fields where preceding crop was not maize to minimize rouging and maintain the genetic purity. Isolation is the first and foremost requirement of hybrid seed production which can be achieved through isolation by time i.e. temporal isolation or through isolation by space i.e. spatial isolation. At least 400-500m distance is required to avoid any contamination. Foundation seed requires 400 m and certified seed production requires 200 m isolation distance.

Isolations blocks need if all three generation of seed multiplication are being taken at one place-

Hybrid type		**Number of isolations**
Single cross (A x B)	Three	First two isolations for two inbreds, breeder seed and foundation seed production Third isolations for certified seed production (A x B)
Three-way cross (A x B) x C	Five	Three isolations for three inbreds (breeder seed and foundation seed production). One isolation for F_1 seed production (A x B) as foundation seed. One isolation for producing certified seed production.

Double top cross (A x B) x OPV	Five	Three isolations for two inbreds and one OPV (Breeder and foundation seed production). One separate isolation for producing F_1 *i.e.*, (A x B) Crossed foundation seeds. One isolation for production of certified seed [(A x B) x OPV].
Double cross (A x B) x (C x D)	Seven	Four isolations for seed production of the four inbred lines *i.e.* A, B, C and D (breeder and foundation seed production). Two isolations for seed production of the two parental single-cross hybrids (foundation seed), *i.e.* (A x B) and (C x D). One isolation for certified double cross hybrid *i.e.* (A x B) x (C x D)

ii. Maintenance of inbred line and seed production-

Maintenance and seed production of inbred line is an important consideration in hybrid seed production. Each inbred lines are maintained in proper isolation as well as seed of different classes are produced as per prescribed standards. Inbred line is a nearly homozygous line developed by continuous inbreeding, usually selfing, accompanied by selection. The maintenance may be done by planting ear to row or by mixing seeds from ears of individual plant of inbred line for increase and may be maintained by self-pollination, full sib-pollination by hands. Very often, in many maintenance programmes parental lines are maintained by alternate selfing and sibbing from one generation to the next.

For hybrid seed production, parental seeds are multiplied by four stage of seed chain.

Nucleus Seed-------Breeder Seed-------Foundation Seed--------Certified Seed

Breeder seed and Foundation seed should never be used for commercial hybrid seed production

Seed production stages and production of parental lines / hybrids

Stage of seed	Single cross	Double cross	Three way cross	Double top cross	Top cross
Breeder seed	A, B	A, B, C, D	A, B, C	A, B, variety	A, variety
Foundation seed	A, B	(AxB), (CxD)	(AxB), C	(AxB), variety	A, variety
Certified seed	A X B	(AxB) x (CxD)	(AxB) x variety	(AxB) x variety	A, variety

iii. **Male: female ratio-**

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

Fig. 1: Seed production- sowing of male: female parents

iv. Time of sowing-

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

v. Method of sowing and layout-

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

vi. Seed rate-

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

vii. Seed treatment-

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

Disease/insect-pest	Fungicide/pesticide	Rate of application (g kg^{-1} seed)
Turcicum leaf blight, Banded leaf and Sheath blight, Maydis leaf blight	Bavistin + Captan in 1:1 ratio	2.0
Brown strip downey mildew (BSMD)	Apran 35 SD	4.0
Pythium stalk rot	Captan	2.5
Termite and shoot fly	Imidachlorpid	4.0

viii. Fertilizer application-

The available quantity of the farmyard manure should be incorporated into the field before sowing. A combination of organic manure and chemical fertilizer is known to give better yield. A balanced application of 120-150kg N, 60-75 kg P,60-75kg K per hectare and 25 kg Zinc sulphate /ha is recommended. 1/3rd of total nitrogen and the entire quantity of phosperous, potash and zinc should be applied in bands 5-7 cm deep before sowing. The rest of the nitrogen should be applied in two doses as mentioned below as top dressing.

Plant stage	6-8 leaf stage	flowering stage
Quantity	50%	50%

ix. Removal of off-type plants and thinning (rouging)-

- After 12-15 days of sowing: off-type and excess plants should be removed. Proper plant to plant distance should be maintained
- At knee high stage, all the dissimilar plants should be removed.
- At flowering, remove dissimilar tassel bearing plant before anthesis from the male.

x. Water management-

Water management in maize is a very important task because maize is a crop which can neither tolerate much water nor do drying. Therefore, proper drainage should be there in the seed production area and irrigation should be done only when the crop needs water at the right time. Mainly water management depends on the crop sowing season. Because about 80 percent of maize crop is grown in India especially in rain-fed areas. If rainfall is occurring on normal and correct time, then the crop does not need irrigation. First irrigation needs to be done very carefully. Because this irrigation does not increase the growth of small plants with more water. Therefore, water in the first irrigation should not be flown over the ridges. Generally water should be given to 2/3rd of the height of the ridge in the drains. Water requirement is high in heavy soils, whereas in the light soil the crop requires less water. The following crop stages are sensitive for irrigation in maize:

1. Seedling stage
2. Knee height stage
3. Flowering stage
4. Grain filling stage

xi. Weed management-

Weed management in maize crop is a big problem and it is major problem in *kharif* season. They compete for the nutrition, water and light in the crop which bring unexpected loss in yield. Therefore, the control of weeds is very important in order to take good yield of maize. The following weeds are mainly found in maize crop *viz.* Cyonodon, Dactyloctenium, Echinocloa, Cyperus, Amaranthus, Chenopodium, Parthenium, Trianthema etc.

Control: Both chemical and mechanical methods are used to destroy weeds grown in maize field.

1. Atrazin: Broad spectrum pre-emergent herbicide. @1-1.5 kg a.i. /ha.
2. Laudis is a broad spectrum post emergence herbicide recommended for use along with surfactant for control of broad leaf and grassy weeds in corn
3. Manual weeding

xii. Detasseling-

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

Fig. 2: Correct stage and method of de-tassseling

xiii. Harvesting-

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

xiv. Stages of crop inspection-

At the time of sowing, we have to monitor the land, isolation distance, planting ratio of male: female, proper sowing time, seed treatment.

- During pre-flowering/vegetative stage: to verify the rouging and removal of off type plants
- During flowering stage: to check disease and pest infestation
- During post-flowering and pre-harvest stage: to remove the late and diseased plants differential type of tassel/silk plants, harvesting time: to see the proper time of harvesting

xv. Drying and sorting of seed parent cobs-

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

xvi. Shelling-

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

xvii. Seed processing-

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

xviii. Storage and marketing-

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

6. Disease and insect pest management in maize:

Maize is one of the most important grain crops in the world. The main season of maize cultivation is rainy season and hence prone to many diseases and pests. The management of important disease and pests are briefly discussed below:

A. Disease management:

(i) Turcicum leaf blight (TLB): This is one of the most important diseases in Northern and North-eastern hills and peninsular India and is caused by *Exserohilum turcicum*. If not controlled at proper time, it has the potential to cause yield reduction up to 70%. Two to four applications of Maneb or Zineb @ 2.5-4.0 g/L of water at 7-10 days interval provide good control of the disease.

(ii) Maydis leaf blight (MLB): MLB is caused by *Bipolaris maydis* and generally appears in warm tropical and sub-tropical areas to wet temperate climate. It has the potential to cause as high as 70% yield loss. Application of 2-4 sprays of Diathane M-45 or Zineb @ 2.0-2.5 gm/litre of water at 7-10 days interval from the first appearance of disease controls the spread of pathogen.

(iii) Polysora rust (PR): Polysora rust or Southern rust caused by *Puccinia polysora* is prevalent in penninsular India and can cause substantial damage. Spray of Diathane M-45 @2-2.5 g/L at the beginning of appearance of symptoms provides good control. However, additional 1-2 sprays may be provided depending upon the intensity of infestation.

(iv) Post flowering stalk rot (PFSR): PFSR is prevalent mainly in Rajasthan, UP, Bihar and AP; although it may appear in other maize growing areas in North and South India. It is one of the most destructive diseases and is caused by complex association of multiple pathogens; among them *Fusarium moniliforme*, *Macrophomina phaseolina* and *Cephalosporium maydis* are commonly associated. The symptoms start appearing during senescence and it commonly affects roots, crown region and lower internodes. Application of potassium fertilizer minimizes the incidence of disease. Avoidance of water stress at flowering stage and crop rotation also reduces the incidence of the disease to a greater extent. Further, application of bio-control agent such as *Trichoderma* formulation in furrow @ 10g/kg of FYM at 10 days prior to sowing provides good control.

(v) Banded leaf and sheath blight (BLSB): BLSB caused by *Rhizoctonia solani f. sp. sasakii* has recently emerged as an important disease in Asia and South East Asia and can cause substantial loss to grain yield and fodder quality. The disease is very difficult to control. Removing lower 2-3 leaves, application of *Pseudomonas fluorescens* culture @16g/kg of seeds (as seed treatment) or 7g/L of water for soil application coupled with foliar spray of Sheethmar or Validamycin @ 2.5-3.0 ml/L of water provides reasonable control on the spread of the disease.

B. Insect management:

(i) Stem borer: Stem borer or *Chilo partellus* is a major insect pest in India and infest maize crop during the *kharif* season all over India. Spray of Cholopyriphos @ 1-1.5 ml/L of water at 10-12 days after germination provides good control. The insecticide should be mixed in 800- 1000 L of water and evenly sprayed over the canopy per hectare. Additional 1-2 sprays after 7-10 days intervals further restricts the insect infestation. Alternatively, application of Carbofuron G 3% @ 0.6 kg a. i. / ha in the leaf whorls after 15-20 days after germination, provides protection against stem borer.

(ii) Pink borer: Pink borer or *Sesamia inference* affects maize crop during the *rabi* season and mainly restricted to Peninsular India. The larvae enter the plant at base by making a hole and damages the inside portion of the stem. This makes the plant stem weak and mild to heavy wind leads to the falling of the plants. The control measure is similar to stem borer as mentioned above.

(iii) Shoot fly: Shoot fly (*Atherigona sp.*) is a serious pest in peninsular India, but can affect summer or spring crop in North Indian states as well. It affects the maize plants at the seedling stage and leads to drying of the seedlings or 'dead heart'. Seed treatment with Imidacloprid @ 6 ml/kg of seeds provides good control of the shoot fly. Early sowing during first fortnight of February avoids buildup of shoot fly population.

(iv) Termites: Termite (*Odontotermes obesus*) is a major problem in the some fields. If not controlled, it can cause substantial damage to the maize crop. Since they establish colonies much deep into the soil, it is very difficult to get rid of the problem completely. Frequent irrigation before land preparation and during the crop growth reduces its infestation. Application of Fepronil granules @ 20 kg/ha followed by light irrigation controls termites to a reasonable extent. If the infestation occurs in patches, applying few granules of Fepronil on and around the patches control termite infestation

(v) Fall armyworm: Fall Armyworm (FAW) (*Spodoptera frugiperda*) is a polyphagous insect pest that feeds on more than 80 crop species, causing damage to economically important cultivated cereals such as maize, rice, sorghum, and also to legumes as well as vegetable crops and cotton. Late planted fields and later maturing hybrids are more likely to become infested. Fall armyworm causes serious leaf feeding damage as well as direct injury to the ear. While fall armyworms can damage corn plants in nearly all stages of development, it will concentrate on later plantings that have not yet silked. Like European corn borer, fall armyworm can only be effectively controlled while the larvae are small. Early detection and proper timing of an insecticide application are critical. The best and most effective strategy for managing FAW is taking preventive measures and immediate action when the fall armyworm is detected. Different Control measures can be used to control FAW like - seed treatment and use of resistant varieties, avoiding late planting and staggered planting will reduce pest incidence. It is observed that the infestation is more in mono-cropping of maize so growing of inter crops like legumes will reduce infestation, remove and destroy all crop residues after harvest. Collection and destruction of egg masses and young larvae can be taken up. Application of sawdust or sand into the whorls leads to the aberration and desiccation of the young larvae. Different chemicals –Barazide, Karate, Carbofuran-3G, Coragen, Curacron etc. may be used to control the FAW.

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Post-Harvest Processing and Fodder from Maize

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Introduction:

The maize is being utilized primarily of industrial purposes in India and the world as more than 80 % used for feed, starch and ethanol purposes. This is the only a billion ton food grain crop having highest production (1.064 billion tonnes) and productivity in the world (>5 t/ha). Through the adoption of improved maize production technologies focused on 'Single Cross Hybrids' has also lead to enhanced maize production in India. The country also start exporting maize to neighboring and south Asian countries including Bangladesh, Nepal, Bhutan, Pakistan, Indonesia etc.. Maize is doing wonders in daily life and directly or indirectly involved in following:

- Food we eat: corn flakes, chapattis, porridge, chips and other value added products.
- Milk we drink: Used to feed cattle and thus makes it as indirect part of it.
- Chocolates/Biscuits we take: To give crispiness in these product corn starch used.
- Clothes & shoes we wear: To give smoothening and softness to clothes and leather products corn starch (malt) is used.
- Paper we read: Corn starch used to give strength to the paper we read and use in our daily life.
- Medicines we take: The various forms of corn starch used as constituents as well as coating agent of medicines and syrups.
- Eggs and chicken we consume: More than 70% of the chicken food comes from the maize and thus it become an indirect constituent for these products.
- In India >1000 products and in the world >3000 products are being made by using maize directly or indirectly.

Post-harvest processing of maize:

After harvesting of the maize cobs having 20-25% moisture content in the grain must be dried in sun for 4-5 days before shelling. The shelling to be done around 15% moisture content. After shelling, the grain to be dried up to 12 moisture content before storage to avoid contamination of the fungus and to safeguard from storage pests. The high moisture attracts fungus *Aspergillus* that in turn produces aflatoxin. Thus toxin have bad effect on human and animal health. The storage to be done in the bins for better quality. The maize uses for making various products are as follows:

1.1. Quality protein maize or normal maize: Normal maize has high zein fraction (60%) and deficient in essential amino acids *viz.* lysine and tryptophan. Normal maize also have imbalance leucine: isoleucine ratio that affects niacin (essential vitamin) biosynthesis and thus these reasons makes its low biological values and digestibility. QPM is a cheap and natural source of quality protein and it provides solution to the malnutrition of Indian poor masses. Quality of QPM green cob is better than normal maize and nutritionally superior as it has double lysine and tryptophan than normal maize

This QPM can be used as food for nutritionally disadvantageous population of the country especially tribals whose primary food is maize. Beside this QPM can be used as nutritionally superior food for children's, pregnant and lactating women, adolescent and old age population of the country. Being low cost quality protein compared to milk it meet the energy and protein needs of infants and children and thereby improves growth rates in young children and also fulfill protein requirements of adults. Thus, it prevents and cure protein deficiency diseases, Kwashiorkor in young children and marasmus in old. Many value added products of QPM can be prepared *viz.* biscuits, kheer, chakli, chips, kurkure, porridge/cheela, sattu, kheer, halwa, upama, malt mix, health mix, rab, khichadi, chakli, sev, ribbon, murukku, muffins, ladoo,,mathari, fryams, bakli, pasta,,cake, etc. Hence this will help in increasing productivity of the human in the country.

1.2. **Industrial use of sweet corn:** Sweet corn is nutritious as compare to normal maize green cob. Its pericarp is thin and easily digestible. It is very popular in USA and many other countries. Now a day's, its use in India is increasing and can be cultivated around the year in south and in central India and 2-3 crops can be taken in north. It has other various direct consumption and uses mention below:

- Sweet corn provides material for glue, fiber, paper, fuel, oil, sweetener, bedding, weaving, and apparel used in condiments, beverages, appetizers, side dishes, main courses, desserts, salads, snacks and breads.
- Use in bath and beauty products that contain derivatives from sweet corn.
- Dried cob usage for fuel, animal fodder, basket making, and in the outhouse.
- Stems and seed husks contain fiber used in paper making.

1.3. **Industrial and food products of baby corn:** Baby Corn has become very popular in the urban and semi-urban population of India. Its major cultivation was started in Thailand in late sixties and today Thailand is the major exporter of baby corn in the world. The canning industries in *peri*-urban will be a viable unit as raw materials will be available at the door steps of industry. This will create employment generation and promote dairy industries because of continuous supply green fodder to their milk cattle. Baby corn can be eaten as raw, salad, pickle, pakora and many more products. The cost of production of baby corn is lowest in India; therefore India can also be potential country for its export. Presently India is exporting baby corn to UK and USA and earning foreign exchanges.

2. **Corn silk uses:** It is a diuretic and used for curing bladder infections, inflammation of the urinary system, prostate, kidney stones, and bedwetting. It is also used to treat congestive heart failure, diabetes, high blood pressure, fatigue, and high cholesterol levels.

3. **Maize in industrial security**: In addition to staple food for human being and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products in the world that includes starch, oil, protein, alcoholic beverages, food sweeteners, biofuel, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc. In India, presently 3.0 Mt of maize is used for industrial purpose which includes 2 Mt for starch industries and 1.0 Mt for ethanol and beverage industries. In India more than two dozen starch industries (Punjab, Haryana, Himachal, Gujarat, Madhya

Pradesh, Karnataka, Andhra Pradesh and Tamil Nadu) and around one dozen biofuel industries (Maharashtra and Andhra Pradesh) and other hundreds of maize based industries are operating.

3.1. Maize starch industry:

Products/byproducts

Maize kernel has approximately 70% of the starch which is found mainly in endosperm and it constitutes 83% of the kernel weight (Table 1). This endosperm starch can be easily separated by either wet or dry milling process. Corn starch have advantage over other starch of tapioca and potato as it takes relatively short time to form viscous and opaque paste having low ash and protein content. It doesn't thin down appreciably during process of sizing and can be transformed into very smooth paste in lesser time. No antifoaming agents while working with maize starch due to neutral pH range and it is also easily dispersed in hydrophilic media.

Table 1: Composition of maize seed component part in percent of dry basis.

Component	Kernel percent	Starch	Protein	Oil	Ash	Sugars	Fiber
Endosperm	82.9%	88.4%	8.0%	0.8%	0.3%	0.6%	1.9%
Germ	11.0%	11.9%	18.4%	29.6%	10.5%	10.8%	18.8%
Bran coat	5.3%	7.3%	3.7%	1.0%	0.8%	0.3%	86.9%
Tip cap	0.8%	5.3%	9.1%	3.8%	1.6%	1.6%	78.6%
Whole kernel	100%	75.0%	8.9%	4.0%	1.5%	1.7%	8.9%

During maize processing the maize grain is passed through a series of steeping and grinding process and gives starch, gluten and corn germ meal (Fig. 1).

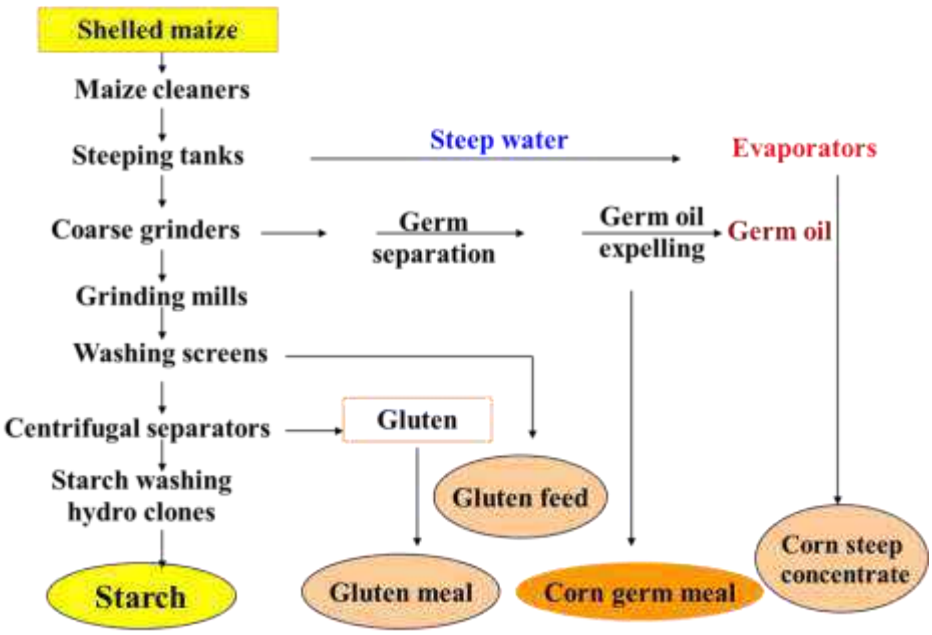

Fig. 1: Schematic diagram of maize processing starch industries

The main products and by-products of the corn starch industries are as follows:

- Corn starch powder: soups, sauces, gravies & custard
- Liquid glucose: to keep food products soft and fresh,
- High Maltose Corn Syrup (HMCS) : sweetener & preservative,
- Dextrose Monohydrate: food industry,
- Maltodextrin: pharmaceutical & confectionery industries as coating material,
- Modified starches,
- Dextrose syrup
- By-products are like corn germ, corn gluten, corn fiber

Package of practices for QPM/normal & fodder maize cultivation:

Maize is considered ideal fodder crop grown throughout the country. Since ages, maize straw is being used as animal fodder. It is quick growing, high yielding, and supplies highly palatable, succulent and nutritious forage which can be fed at any stage of growth and helps to increase body weight and milk quality in cattle. Among the cultivated non-legume fodders, maize is the most important nutritious fodder crop that can be grown round the year under irrigated conditions and contains relatively high concentrations of protein and minerals and have better digestibility. Maize can be feed as green or dry and makes excellent silage. Its quality is much better than sorghum and pearl millet, since both sorghum as well as pearl millet possess anti-quality components such as hydrocyanic acid and oxalate, respectively causing adverse effect on animal health. On an average, it contains 9-10% CP, 60-64% NDF, 38-41% ADF, 23-25% hemicellulose, and 28-30% cellulose on dry matter basis when harvested at milk to early-dough stage. Thus, forage maize has become a major constituent of ruminant rations in recent years, as its inclusion as dairy cow diets improves forage intake, increases animal performance and reduces production costs. With increasing standard of living and greater cash availability, shifting food habits towards livestock products particularly meat, there will be continued diversion of maize grain for livestock feed.

1. Soils-

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

2. Suitable varieties-

The suitable cultivars for fodder maize are J1006, African Tall and Pratap Chari 6.

3. Seed rate and plant geometry-

Optimum plant density is the key for achieving higher productivity and resource use efficiency. The seed rate depends on purpose, seed size, plant type, season, sowing methods, planter etc. For different purposes of maize cultivation, the following crop geometry and seed rate should be adopted.

Purpose	Seed rate (kg/ha)	Plant geometry (plant x row, cm)	Plant population
Fodder	50	30 x 10	333333

4. Nutrient management-

Seeds treatment with three packets of *Azospirillum*

- Application of 10-15 t ha^{-1} FYM
- 120 kg N, 60 kg P_2O_5 ha^{-1} for hybrid maize.
- Apply 1/3rd of N each at basal, knee high and tasseling stage; splitting of potassium is also found beneficial
- *Azotobacter/Azospirillum* + *Phosphobacteria* 2 kg each/ha along with FYM application in case of no seed treatment with biofertilizer.

5. Weed management-

Broad leaf weeds and most of the grasses can be controlled by pre-emergence spray of Atrazine @1.0-1.5 Kg/ ha in 500-600 L of water. While spraying, the person doing spray should move backward so that the Atrazine film on the soil surface may not be disturbed. Preferably, three nozzle booms may be used for proper ground coverage and saving of time.

One to two hoeing are recommended for aeration and uprooting of the remaining weeds. While doing hoeing, the person should move backward to avoid compaction of soil and to facilitate better aeration. Herbicides for weed control in maize are as follows:

Name	Dose (a.i./ha)	Time of application	Remarks
Atrazine	1000 - 1500 g	Apply with 500 L/ha of water before emergence of crop as well as weeds	Control all weeds except *Dactyloctenium aegyptium* (Makra) and *Cyprus rotundus*
Pendimethalin	1000 ml	Apply with 500 L/ha of water before the emergence of crop as well as weeds. Suitable for application in intercropping.	Control all weeds except *Commelina benghalensis* (Cana) and *Cyprus rotundus*
Atrazine + Pendimethalin	500 g + 750 ml	Apply tank mix with 500 litre/ha of water before emergence of crop as well as weeds	Control all weeds except *Cyprus rotundus*

6. Water management-

First irrigation should be applied very carefully. Water should not overflow on the ridges to avoid the runoff and exposure of the seed for prey to the birds. The irrigation should be applied in furrows up to 2/3rd height of the ridges. Irrigation should be given as and when required by the crop depending upon the rains and moisture holding capacity of the soil. Young seedlings, knee high stage, silking and picking are the most sensitive stages for water stress for crops and irrigation should be ensured at these stages. Light and frequent irrigations are desirable for crop. During winter (mid- December to mid-February) soil should be kept wet to avoid frost injury in the baby corn.

7. Insect management-

- For *Chilo and Sesamia* control, foliar spray of Carbaryl @ 2.5 g/L at 10 days after germination.
- The *Chilo* can be controlled by release of 8 Trichocards per ha at 10 days after germination.
- Intercropping of maize with cowpea is an eco-friendly option for *Chilo* control and helps in achievement goal of quality fodder production as cereal legume mixture.

8. Harvesting-

Fodder maize: The fodder maize is to be harvest at the silking stage to have maximum palatability and nutritional value. However, for silage purposes it is to be done at the milking stage for high quality silage that can also supplements the feed need of the animals.

Hydroponics maize fodder production:

In India, success of hydroponic fodder production was noticed in Goa while ICAR-Research Complex for Eastern region working on a Rashtriya Krishi Vikash Yojna (RKVY) funded project. In this project necessary infrastructure and technical support was provided to co-operative dairies of Goa. Interestingly, they found that maize can successfully grow through hydroponics technology for green fodder. For this purpose, a 1.25 Kg disease free seed of maize was soaked for a period of 4 hours. Soaked seed loaded in a 90 cm x 32 cm aluminum tray. Hydroponics green fodders look like a mat consisting of roots, seeds and plants. In comparison to conventional green fodders, hydroponics green fodders contained more crude protein (13.6 v/s 10.7%) and less crude fiber (14.1 v/s 25.9%).

Table 2: Chemical composition (%) on dry matter of maize green fodder grown as conventional and hydroponically.

Nutrients	Conventional fodder	Hydroponics fodder
Protein	10.67	13.57
Ether extract	2.27	3.49
Crude fibre	25.92	14.07
Nitrogen free extract	51.78	66.72
Total ash	9.36	3.84
Acid insoluble ash	1.40	0.33

*(**Source:** RKVY; Goa State Co-Operative Milk Producers' Union Ltd.)*

Table 3: Conventional fodder production v/s Hydroponics Maize Fodder Production (600 Kg /day/unit).

S. No	Attributes	Conventional fodder	Hydroponics	Savings on
1.	Area	10000 sq, mts.	50 sq. mts.	Land
2.	Time required	60-70 days	7 days	Time saved
3.	Water requirement	Very high	Very low	Water saving
4.	Land fertility	Essential	Not essential	Soil conditioning
5.	Fertilisers required	Required	Not required	Saving on fertilisers
6.	Dependency	On climate rain , water etc.	In controlled environment	No dependency
7.	Fodder utilisation	Partial	Complete	Conserve fodder
8.	Fencing and Protection	Required	Not required	Saving on fencing cost
9.	Feeding practices	By chopping	Not required	Time and labour
10.	Electricity	Very High	Very low	Energy saving

*(**Source:** RKVY; Goa State Co-Operative Milk Producers Union Ltd.)*

Pros of hydroponic fodder technology:

While hydroponic fodder may not become a major source of fodder for commercial livestock, it could be feasible under certain circumstances with following advantages.

1. **Ensure efficient use of resources (land, water and nutrients):** As compare to conventional system of fodder production there is little waste water, as animals consume the re-circulated water along with the feed. Another side in hydroponic fodder production system there is no chance of losses of nutrients through leaching so this system makes efficient use of all the applied nutrients. Compare to conventional system of fodder production hydroponic production system requires considerably less land to produce same quantity of fodder.
2. **Suitable for arid and semiarid drought-prone regions:** Due to less requirement of water, this system of fodder production is probably best-suited for drought-prone regions. By growing fodder crops as indoors, crop failures would no longer be a risk just because of their less dependence on outside weather.

3. **Limited and costly land:** Places where land values are extremely high or land is not readily available, hydroponic fodder has obvious advantages, as it can be produced in a small footprint. Because the fodder is produced continuously, there is no need for long-term feed storage and no nutrient losses that can be associated with feed storage.
4. **Minimising loss of fodder**: Green fodder produced from hydroponics will be fully utilised as there won't be loss of the fodder during feeding as compared towastages of chopped traditional grasses during consumption by the animal.
5. **Small-scale producers:** Requiring smaller amounts of fodder, small-scale producers may be able to build their own fodder systems. When the investment is low and labor is unpaid, the cost of hydroponic fodder is considerably less.
6. **Non-ruminants:** Hydroponic fodder may be best-suited to non-ruminants which would benefit more from the changes in the feed due to sprouting (e.g. less starch, more sugars) as compared to ruminants which are less efficient at digesting high quality feed.
7. **Organic:** Hydroponic fodder production seems particularly well-suited to organic producers, who already pay high prices for feed or have difficulty sourcing organic feed stuffs.
8. **Green fodder round the year**: Technology is capable to make provision for the green fodder round the year, as per demand. Constant supply can be organised irrespective of rain, storm, sunshine or drought.
9. **Reduction in growth time of green fodder**: To obtain nutritious fodder requires just over 7 days from seed germination to fully-grown plant of 25–30 cm height. Biomass conversion ratio is as high as 7-8 times to traditional fodder grown for 60-80 days.
10. **Increasing nutritive value of fodder**: Through hydroponics, it is possible to enhance the nutritive value by adding additional growth promoters, nutrients, etc to have quality milk from the dairy animals.

Future perspectives for fodder maize improvement:

To meet the future demand of livestock production, the deficit in all components of fodder, dry crop residues and feed has to be met by either increasing productivity, utilizing untapped feed resources**,** increasing land area or through adoption of innovative strategies. The future breeding strategies should focus on developing high yielding and better quality dual type (grain-cum-fodder)single cross hybrids, introgression of apomixis, tillering and ratooning from *Teosinte* ssp., manipulation of ploidy levels to develop high biomass possessing amphiploids and promoting the baby corn and sweet corn based cropping system. The idealistic ideotype for fodder maize should have the combination of traits *viz.* multi-cut, tillering, erect leaves for high density planting, better digestibility and stay greeness traits.

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Evaluation of Nutrient Management on Three Major Maize Landrace Characteristics of Mizoram

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Introduction:

Shifting cultivation popularly known as *jhum* cultivation is a system where plant biomass is slashed and burnt followed by cultivation of crops and left for regeneration of plants. While this system can be ecologically and economically viable with a long fallow, having the capacity to recover the soil fertility through nutrient fixation and transformation from non-available to available forms (Grogan *et al.*, 2012). The fallow period have been drastically reduced to 3-6 years (Borthakur, 1992) due to increasing population thus creating a negative balance to the biodiversity and ecology (Singh *et al.*, 2010). The negative effects also include soil erosion further lowering the soil fertility (Ziegler *et al*., 2009). Shifting cultivation has been the foundation of agriculture in Mizoram which is engulfed as a culture. Selection of site starts before or at December by entire village headed by the chief or village council on the basis of rotation of fields; cleaning of forest during December to January till February; burning the dried debris during mid-March and sowing seeds of various crops. Rice or maize as a main crop or mixed with sesamum and vegetables like brinjal, wild coriander, pumpkin, chilli, ginger etc. is a common practice. Harvesting is done in the month of September to October and the land is kept for regeneration of forest. However, some farmers utilize the second year by reburning the left biomass from the first year. The general perception of shifting cultivation is that economic yield reduces with short fallow due to enhance soil erosion (Toky and Ramakrishnan, 1981). With many potentials options for improving this system (Grogan *et al*., 2012), one of the major problem and most important is low soil fertility. If nutrient management with a proper method is applied, it can be a promising option for utilizing low fertile soils with short fallow period and even up to third year of cultivation.

From time to time, potential options for shifting cultivation has always been evaluated and one such option is terrace cultivation, where with proper soil fertilization can be economical and reduces soil erosion. Permanent terrace structures have been used in most part of hilly areas and have been found to be suitable for agricultural, horticulture and forest plantations. At the initial stage soil fertility usually decline however, with proper management with soil amendments and proper leguminous crop for few years can be economical.

Mizoram is blessed with rich diversity of local germplasm. There are several local landraces of maize and these are classified into three categories based on taste and use; *Mimpui* (tall height with long cobs/roasted/feed), *Mimban* (sticky/starchy) and *Puakzo* or *Mimpuak* (popcorn, Singh *et al.*, 2016). These local landraces are grown in *jhum* fields but the yields are not high. Fertilizers or other production technologies are not usually used in *jhum* fields. Therefore, as cited above, we tested the response of three maize local landraces of Mizoram on application of fertilizer to ascertain the extent of difference on their yield parameters under *jhum* and terrace condition.

Materials and Methods:

The study was conducted at ICAR Research Complex for the North Eastern Hill Region, Mizoram Centre, Kolasib farm. The terrace selected was permanent terrace where rice and maize were grown from time to time. The *jhum* site has a slope percentage of 18 whereas terrace was 3 %. The *jhum* site had been used to grow ginger and rice in the year 2011and therefore designated as a three year *jhum* as the experiment was done on May, 2014. The site was covered with thatch grass (*Imperatacyl indrica*) and wild sugarcane (*Saccharum arundinaceum*). The slash vegetation was burned and after 45 days of burning, soil samples were collected and analyzed with standard methods to ascertain the fertility status of the site. Three local maize landraces namely *Mimpui* (IC0612948, MZM-MP-12), *Mimban* (MZM-MB-02) and *Puakzo* (IC 611485, MZM-Pz-29) were randomly selected from the collected maize from different parts of Mizoram. An area of 9 m^2 was selected randomly four times as a replicate for each plot to take the readings where four plants were selected for each sub plot. Fertilizer at a dose of (80:60:40) through Urea, SSP and MOP as a source of nitrogen, phosphorus and potassium, was applied to a depth of 10 cm at the lower end and upper side of maize stalk in the *jhum* slope of each plot. Similarly 9 m^2 plot was used in the terrace with four replication. Both the fields were design to fit in a randomized complete block design. Half dose of nitrogen and full dose of phosphorus and potassium was applied during sowing and remaining 1/4th of nitrogen was given at knee height stage and tasseling stage. Harvesting was done and yield parameters as such were taken with standard methods. The data was analyzed according to factorial randomize complete block design (RCBD) with least significant difference (LSD) at 5% level of significance. The analysis was performed with SAS 9.3 version software.

Table 1: Initial soil parameters of the site

Soil parameters	***jhum***	**terrace**
pH (1:2.5)	5.2	5.23
Organic carbon (%)	0.84	1.6
Available N (mg kg^{-1})	84.7	160
Available P (mg kg^{-1})	1.87	15.3
Available K (mg kg^{-1})	45.6	130

Results and Discussion:

The results of initial soil analysis are presented in Table 1. The soil fertility was low and slightly acidic in nature. The response to fertilizer application and variability between the three maize landraces are presented in Table 2 and Table 3. The plant height differs significantly between the different landraces and fertilizer application. Among the landraces, *Mimpui* recorded the highest plant height (249.13 cm and 281.85 cm) followed by *Mimban* (216.38 cm and 229.55 cm) and *Puakzo* (201.25 cm and 207.64 cm) for *jhum* and terrace. Application of fertilizer significantly increased the plant height by 11.83% and 9.78% over the unfertilized control for *jhum* and terrace respectively. The weight of cobs per plant also differs significantly in both ways. *Mimpui* and

Mimban (114.04 g, 122.42 g and 92.11 g, 90.4 g) recorded heavier cobs per plant than *Puakzo* (59.34 g and 65.44 g) for both the *jhum* and terrace. Fertilizer application increased the weight of cob per plant by 26.33% and 28.05% over the control. The cob length differs significantly in both ways. While, *Mimpui* recorded the longest cob length (15.5 cm and 15.55 cm) followed by *Mimban* (12.1 cm and 12 cm) and *Puakzo* (9.81 cm and 8.94 cm) and increase by 22.86% and 17.4% over the control. The cob diameter differs significantly in both ways with *Mimban* recording the longest cob diameter (47.74 mm and 48.42 mm) followed by *Mimpui* (42.2 mm and 43.9 mm) and *Puakzo* (32.6 mm and 33.35 mm). Fertilizer application increased the cob diameter by 9.65 and 5.42 % respectively for *jhum* and terrace. The number of lines per cob differs significantly only for the maize varieties where *Mimban* recorded more lines (18.63 and 15.5) than *Puakzo* (14.25 and 14.63) and *Mimpui* (12.75 and 16.88). The number of seeds per line differs significantly in maize varieties for *jhum* with *Mimpui* recording more seeds per line (30.5 and 31.66) than *Mimban* (25 and 24.6) and *Puakzo* (20.25 and 24.36). Grain yield differs significantly in both ways. *Mimpui* recorded the highest grain yield (2.43 t/ha and 2.73 t/ha) followed by *Mimban* (2.17 t/ha and 2.4 t/ha) and *Puakzo* (0.86 t/ha and 1.28 t/ha). Fertilizer application increased the grain yield in *jhum* by 27.7% while in terrace it was at par over the unfertilized plot.

Compared to the yield of improved varieties, yield of local maize landraces are usually less (Sibiya *et al.*, 2013). Many authors from different regions (Ramakrishnan and Toky, 1981; Bruun *et al*., 2009) and from the study region, Koalsib district (Lungmuana *et al.*, 2017) have reported lower soil fertility associated with shorter fallow period than longer *jhum* fallow. The low yield characteristics of *jhum* as compared to terrace could be attributed to the above points as the site is a short fallow *jhum* with low soil fertility where all the major nutrients are deficient while the terrace condition has better soil fertility (Table 1).The results obtained from this study revealed that fertilizer can improve the three local landraces of maize significantly. In terrace or lowland condition, fertilizers can be broadcasted or simply applied near the root zone, while in upland *jhum* areas, proper placement of fertilizers is required which is also attributed to the fertilizer response in this experiment. In general, the response of fertilizer to the growth and yield attributes of maize were better in *jhum* compared to terrace. *Mimpui* appeared to be superior landrace among the cultivar however; *Mimban* has the highest potential for increasing the productivity through proper fertilizer application as the increase in the grain yield (33.2% and 14.32%) were higher compared to the other landraces for *jhum* and terrace condition.

This study further confirm the importance of nutrient management for plant nutrition in a young slash and burn cultivation for local landraces of maize, having a profound influence on the yield characters. The different yield characters may be better in other *jhum* sites depending on the fallow and site. As already cited, *jhum* occupies an integral part of life for the *Mizo* farmers which will continue. However, if more scientific cultivation practices like inclusion of nitrogen fixers, anti-erosion plants or erosion resistant crops, terracing and planting of improve varieties are adopted in the present farmer practice of *jhum* cultivation, better crop production, productivity and improvement of the existing cultivation is inevitable. We therefore strongly recommend that similar studies with more diverse treatment and improve techniques may be initiated in such a short fallow *jhum* with more local landraces.

Table 2: Growth and yield parameters of local maize varieties with and without fertilizers in *jhum* field.

	Plant height (cm)	Cob weight per plant (g)	Cob length (cm)	Cob diameter (mm)	No. of lines	No seeds per line	Grain yield (tonnes/ha)
***Mimpui*(C)**	234.75	105.47	12.88	40.07	12.00	26.25	2.18
***Mimpui*(F)**	263.50	122.61	18.13	44.34	13.50	34.75	2.68
***Puakzo* (C)**	192.00	51.03	9.50	31.21	13.75	18.75	0.76
***Puakzo*(F)**	210.50	67.66	10.13	34.05	14.75	21.75	0.97
***Mimban*(C)**	202.75	78.11	11.20	45.64	17.75	25.25	1.87
***Mimban*(F)**	230.00	106.11	13.00	49.83	19.50	24.75	2.48
CD (5%)							
Maize	14.24	12.9	1.97	2.15	1.86	4.67	0.17
Fertilizer	11.62	10.6	1.6	1.76	NS	NS	0.14

*(F-Fertilizer; C-Control; *Factorial effect is not significant)*

Table 3: Growth and yield parameters of local maize varieties with and without fertilizers in terrace land.

	Plant height (cm)	Cob weight per plant (g)	Cob length (cm)	Cob diameter (mm)	No. of lines	No seeds per line	Grain yield (tonnes/ha)
***Mimpui*(C)**	263.51	110.05	13.90	43.11	16.25	28.19	2.58
***Mimpui*(F)**	300.19	134.80	17.19	44.71	17.50	35.14	2.87
***Puakzo* (C)**	199.82	57.78	8.73	31.77	14.00	22.43	1.25
***Puakzo*(F)**	215.47	73.09	9.16	34.93	15.25	26.30	1.30
***Mimban*(C)**	222.18	76.21	10.94	47.50	14.25	24.03	2.24
***Mimban*(F)**	236.91	104.60	13.07	49.35	16.75	25.30	2.56
CD (5%)							
Maize	12.29	10.98	1.93	2.4	2.78	2.8	0.29
Fertilizer	10.03	8.96	1.58	1.96	NS	2.3	NS

*(F-Fertilizer; C-Control; *Factorial effect is not significant)*

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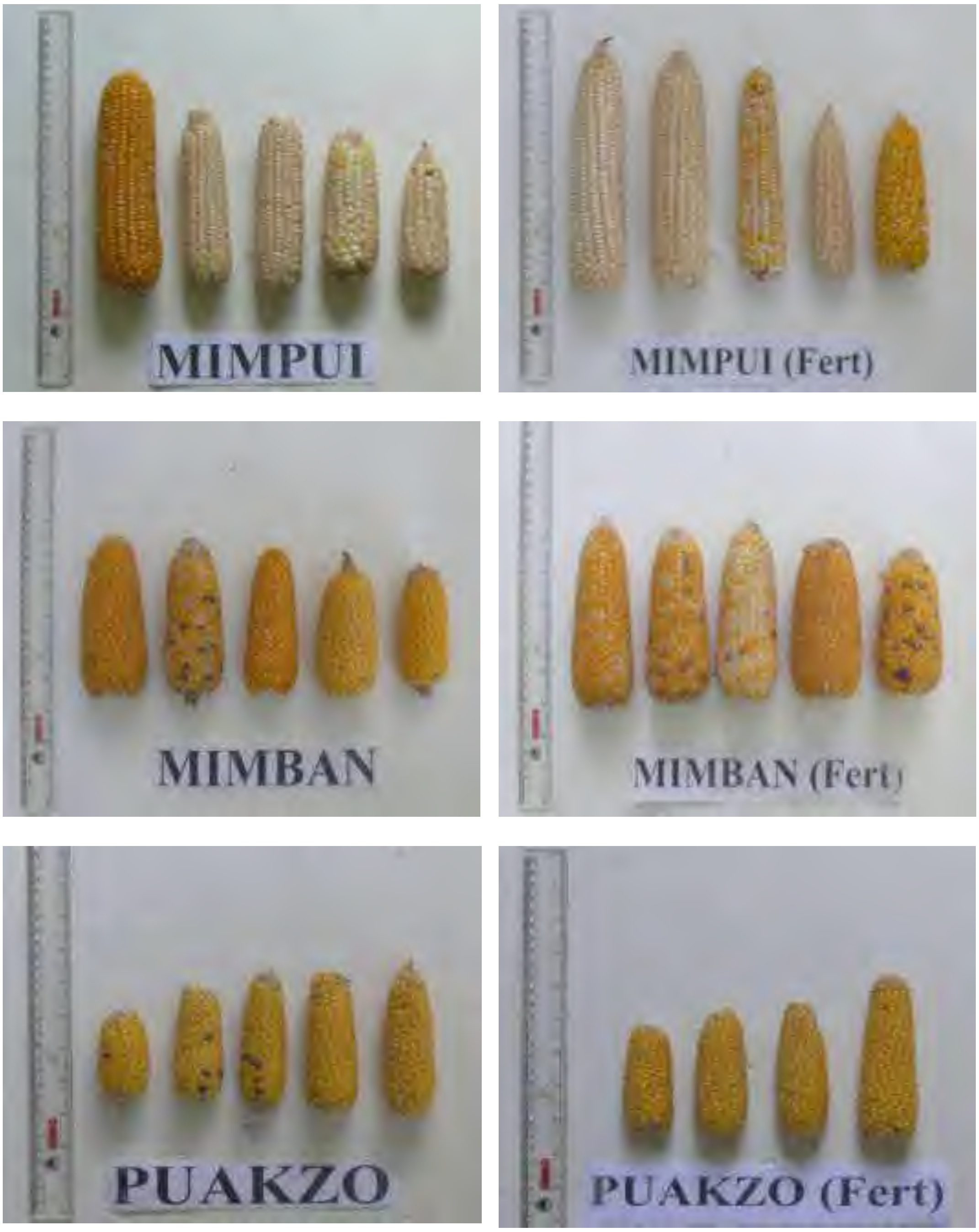

Fig. 1: Variation and response of different maize to nutrient management practices

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Integrated Nutrient Management on Maize

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Introduction:

Globally, maize is a staple crop, and many people rely on it as a primary source of nutrition. In addition to playing a major role in the human diet, maize is also used as livestock fodder. Maize is processed to make an assortment of products ranging from high fructose corn syrup to bio-fuels, all of which play important roles in human society. Oddly enough, maize is at the forefront of the green revolution with byproducts like compostable containers and bio-fuel, while simultaneously being used as a controversial food additive in the form of corn syrup and other derivatives. Maize is considered a promising option for diversifying agriculture in upland areas of India. It now ranks as the third most important food grain crop in India. The maize area has slowly expanded over the past few years to about 6.2 million ha (3.4% of the gross cropped area) in 1999/2000. Paroda and Kumar (2000) predicted that this area would grow further to meet future food, feed, and other demands, especially in view of the booming livestock and poultry producing sectors in the country. Since opportunities are limited for further expansion of maize area, future increases in maize supply will be achieved through the intensification and commercialization of current maize production systems. In India, maize is grown in a wide range of environments, extending from extreme semi-arid to sub-humid and humid regions. The crop is also very popular in the low- and mid-hill areas of the western and northeastern regions. Broadly, maize cultivation can be classified into two production environments: (1) traditional maize growing areas, including Bihar, Madhya Pradesh, Rajasthan, NEH region and Uttar Pradesh (BIMARU), and (2) non-traditional maize areas, including Karnataka and Andhra Pradesh (KAP). In traditional areas, the crop is often grown in marginal eco-regions, primarily as a subsistence crop to meet food needs. In contrast, maize in the non-traditional areas is grown for commercial purposes–i.e. mainly to meet the feed requirements of the booming poultry sector.

The changing global scenario is compelling policymakers to adhere to the regulations and obligations set by the World Trade Organization (WTO). The resulting new economic regime is expected to alter the economics of existing cropping systems, including maize, in terms of production, value added, and trade. The question often raised is how research and development efforts can efficiently contribute to intensifying maize production in upland areas while protecting the interests of poor maize producers. To answer the question, it is necessary to study and characterize maize production systems, and future policy and technology interventions like integrated nutrient management need to be formulated accordingly.

Integrated nutrient management:

Among all the cereals, maize in general and hybrids in particular are responsive to nutrients applied either through organic or inorganic sources. The rate of nutrient application depends mainly on soil nutrient status/balance and cropping system. For obtaining desirable yields, the doses of applied nutrients should be matched with the soil supplying capacity and plant demand (site-specific nutrient management approach) by keeping in view of the preceding crop (cropping system). Response of maize to applied organic manures is notable and hence integrated nutrient management (INM) is very important nutrient management strategy in maize based production systems. Organic manures, particularly FYM and vermicompost, not only supply macronutrients but also meet the requirements of micronutrients, besides improving soil health. The use of organics plays a major role in maintaining soil health due to buildup of soil organic matter, beneficial microbes. To sustain the soil fertility and crop productivity the role of organic manures and fermented organic nutrients are very important. The organic fertilizers in addition to nutrients contain microbial load and growth promoting substances which helps in improving the plant growth, metabolic activity and resistance to pest and diseases. Boosting yield, reducing production cost and improving soil health are three inter -linked components of the sustainable triangle. Therefore, suitable combination of chemical fertilizer and organic manures cultures need to be developed for particular cropping system and soil. The combined use of organic and inorganic sources of plant nutrient not only pushes the production and profitability of field crops, but also it helps in maintaining the permanent fertility status of the soil. It is highly desirable to make massive efforts to adopt organic sources as a source of plant nutrients as well as soil productivity in the developing countries.

In India, there is sufficient availability of organic manures like animal dung manure (791.6 Mt), crop residues (603.5 Mt), green manure (4.50 m ha), rural compost (148.3 Mt), city compost (12.2 Mt) and biofertilizer (0.41 Mt) and these may become a good substitute of chemical fertilizers to maintain the soil physico-chemical and biological properties. The incorporation of organic manures improves the nutrient content and uptake. Although organic manures contain plant nutrients in small quantities as compared to the fertilizer, the presence of growth promoting principles like enzyme and hormones besides plant materials make them essential for improvement of soil fertility and productivity. The fertilizer management, therefore, is of paramount importance in the crop cultivation, Nutrient requirement of maize and its mode of application is however, governed by a number of factors, *viz.* soil type, planting season, preceding crop, methods and time of fertilizer application etc. Maize requires a regulated and assured supply of nutrients particularly nitrogen throughout its growing period right from seedlings to grain filling stages. The major nutrient deficiency symptoms for maize are

1. **Nitrogen deficiency:** Leaves become yellow, older leave show drying at the tips which progress along mid veins, stalk become slender.
2. **Phosphorous deficiency:** Leaves are purplish green during early growth, growth spindly, slow maturity and irregular ear formation.
3. **Potassium deficiency:** Leaves shows yellow or yellowish green steak, become corrugated. Tips and marginal Scorch. Tips ends in ears are poorly filled. Stalks have short internodes. Plant become weak and may fall down.
4. **Magnesium deficiency:** Older leaves are first to become chloritic at margins and between veins. Steaked appearance of leaves. Necrotic or chlorotic spots seen in leaves.
5. **Zinc deficiency:** Older leaves become yellow steak or chlorotic striping between veins. In several cases unfolding of young leaves which may be white or yellow.

The nitrogen utilization pattern is found to be increased from seedling of knee- height and reaches to the peak at tasseling stage when the plant removes nearly 4-5 kg N $ha^{-1}day^{-1}$. It is interesting to note that the response of applied nitrogen is highest in poor fertility soil condition than the normal ones. Under an ideal fertility management it is noticed that the new plant types yield 15-25 kg grain per kg of applied N. Phosphorous, as usual helps in development of all phases of maize plants and its deficiency leads to purpling of leaves and tends to delay maturity. The potassium is essential for translocation of water and photosynthates within the plant body. Higher dose of nitrogen and phosphorous in hybrids and composites varieties make it essential to apply potassium. Therefore, the fertility management of maize is very critical. However, the basic management practices are as follows:

Irrigated maize:

1. **Application of FYM or compost**: Spread 12.5t /ha of FYM or compost coir pith on the unplowed field along with 10 pockets of *Azospirillium* (2000 g/ha) and incorporate in soil.
2. **Field preparation**: Plough the field with disc plough once followed by cultivator ploughing twice after spreading FYN till a fine tilth is obtained.

Application of fertilizers:

1. Apply NPK fertilizers as per soil test recommendation as far as possible if soil test recommendation is not available apply 135: 62: 50 kg NPK per ha.
2. Apply quarter of the dose of N; full dose of P and K basally before sowing.
3. In case of ridge planted crop open a furrow 6 cm deep on the side of the ridge at two third of the distance from the top of the ridge.
4. Apply the fertilizer mixture along the furrow and cover to a depth of 4cm with soil.
5. If bed system of planting is followed, open furrows 6 cm deep at a distance of 6cm apart.
6. Place the fertilizer mixture along with the furrows evenly and cover to a depth of 4cm with soil.

When Azospirillium is used as seed and soil application apply 100 kg N/ha (25% reduction on the total N recommendation by soil test)

Application of micronutrients:

1. 12.5 kg micronutrients mixture formulation mixed with sand to make a total quantity of 50 kg/ha to be applied.
2. Apply Mn mixture @30kg/ha as enriched FYM (prepare enriched FYM at 1:10 ratio mineral mixture (MN); mix at friable moisture and incubate one month in shade.
3. 5kg Zn + 40 kg S and 1.5 kg B in deficient soil
4. Zinc sulphate @37.5 Kg is recommended in Zn deficient soil.
5. Apply the mixture over the furrow and two third in the top of ridge, if ridge planting is followed.
6. If bed system of sowing is followed apply the micronutrient mixture over the furrow.
7. Do not incorporate micronutrient mixture in Soil.

Drip fertigation technology:

1. Methods of planting : paired row planting (60/90 x30 cm)
2. Fertilizer dose : 150:75:75 Kg NPK per ha

3. Drip fertigation with Water Soluble Fertilizers (WSF)

N	Polyfeed	19-19-19
P	MAP	12-61-00
K	KNO_3	13-00-45

Fertigation device: Ventury Assembly (3/4”) with injector pump (0.5 HP)

***Rainfed* maize:**

1. Application of FYM or Compost**:** Spread 12.5 t/ha of FYM or Compost coir evenly on the unploughed field along with 10 pickets of *Azospirullium* (2000 g/ha) and incorporate in the soil.
2. Apply NPK as per soil test recommendation as far as possible. If soil test recommendation is not available, adopt blanket application of 60:30:30 NPK kg/ha for alfisols and 40-20-0 NPK kg/ha for vertisols.
3. Apply half of N and full dose of P&K with enriched FYM as basal along with *Azospirillium* (10 pockets/ha).
4. Top dress remaining half of N at tasseling.
5. Apply MN mixture @ 7.5 kg/ha as enriched FYM (prepare FYM at 1:10 ratio of MN mixture & FYM; mix at friable moisture & incubate for one month in shade).

Conclusion: Maize has high genetic yield potential than other cereal crops. Hence, it is called as ‘miracle crop’ and also as ‘queen of cereals’. Being a C_4 plant, it is very efficient in converting solar energy in to dry matter. As heavy feeder of nutrients, maize productivity is largely dependent on nutrient management. Therefore, it needs fertile soil to express its yield potential. Ideal soils are rarely found in nature. Anthropogenic factors such as inappropriate land use systems, mono-cropping, nutrient mining and inadequate supply of nutrients are aggravated the situation. To alleviate the problem, INM is an option as it utilizes available organic and inorganic nutrients to build ecologically sound and economically viable farming system. Intensive cultivation, growing of exhaustive crops, use of unbalanced and inadequate fertilizers accompanied by restricted use of organic manures have made the soils not only deficient in the nutrients, but also deteriorated the soil health resulting in decline in crop response to recommended dose of N – fertilizer in the region under such situation, Integrated Plant Nutrient System (IPNS) has assumed a great importance and has vital significance for the maintenance of soil productivity. Recently there has been a renewed interest in use of farmyard manure. This interest is attributed to concerns for maintaining sustainable agricultural production while preserving the environment. For better utilization of resources and to produce crops with less expenditure, INM is the best approach. In this approach all the possible source of plant nutrients are applied based on economic consideration and the balance required for the crop is supplemented with chemical fertilizers.

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Resource Conservation Technologies in Maize-based Cropping Systems

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Introduction:

Maize (*Zea mays* L) is a potential and predominant pre-rainy and rainy season crop on the hill ecosystems of North Eastern Region (NER) of India. Maize requires humid climate from the time of sowing to the end of its reproductive phase. Therefore, there is need to intensify existing maize–fallow systems with the inclusion of more number of crops per unit area. The NER has a potential to revolutionize the maize production of the country, given its naturally fertile soil having high organic carbon content (1-3.5%), a wide range of pH, diverse micro flora and fauna, and a good amount of drainage, the abundant water resources from the plenty of rainfall and a coordinal climatic conditions from an altitude of 20 m to more than 3000 m from sea level (Ansari *et al.,* 2015). A wide pedo-climatic variation provides an opportunity for year round cultivation of maize in NER. However, to boost up production under maize based cropping systems, an approach based capacity building of farmers through introduction of high yielding maize varieties/hybrids, conservation agriculture based production system, adequate and timely supply of quality seed and mechanization is the need of hour. For realizing actual potential, adequate emphasis must be given on resource conservation technology in maize based cropping systems to enhancing farmers' income and attract youths in farming (Yadav *et al.,* 2018a).

Continuous use of conventional farming practices with excessive tillage and burning crop residues/ improper management of available biomass has degraded the soil resource base and intensified soil degradation with concomitant decrease in crop production capacity. Further, escalating fuel, fertilizers and other input costs; necessitates the effective use of resources in agriculture. Resource Conservation Technologies (RCTs) including Conservation Agriculture (CA) with its four principles: (i) minimizing mechanical soil disturbance and seeding directly into untilled soil, (ii) using cover crops and/or crop residues (mainly residue retention), (iii) diversification of crops in associations, sequences and rotations and (iv) integrated nutrient management. These well-known practices have recently been packaged and promoted under the label 'RCTs' by global level organizations. According to its promoters, the overall goal of conservation agriculture is to make better use of agricultural resources (than does conventional agriculture) through the integrated management of available soil, water and biological resources such that external inputs can be minimized. Its primary feature, and indeed central tenet, is the maintenance of a permanent or semi-permanent soil cover, be it a live crop or dead mulch, which serves to protect the soil from sun, rain and wind, and feed soil biota. This biotic community is essential as it provides a 'biological tillage' that serves to replace the functions of conventional tillage. However, in the absence of specific information on RCTs in the north east India, the policies and efforts are inadequate and ineffective to achieve the desired results in this direction. It is, therefore, imperative now to promote these alternative technologies in north east India that would help conserve the much needed but gradually depleting natural resources while boosting productivity growth in the long-run by maintaining soil health and production environment. This indicates, there is a large knowledge gap in CA based technologies which indicate there is a need to develop, refine, popularize and disseminate these technologies in maize based cropping systems on a large scale (Kandpal *et al.,* 2018).

Effect of RCTs on plant growth:

No-till and raised bed (NT-RB) planting reported to increase the leaf area index (LAI) and dry biomass accumulation (DBA) recorded at 15, 30, 45, 60 and 75 days after sowing (DAS) by following a sigmoidal growth pattern in all the tillage and land configuration systems. It may be due to the higher amount of water under the no-tillage and raised bed systems, which improves the leaf area and dry mass production of maize. Therefore, the manipulation of NT with suitable land configuration system increased the leaf area index (LAI) and DBA over conventional system of cultivation (Yadav *et al.*, 2018b).

Effect of RCTs on root growth and development:

Root development and its distribution in the soil profile have great impact on the crop's potential capacity for nutrient and water uptake, and also on plant growth and crop yields. Tillage practices are important components of soil management systems which influence root attributes. Root length density (RLD) and root mass density (RMD) are critical parameters for characterizing root systems. Root length density (RLD) was significantly affected by tillage and land configuration, year and soil depth. Tillage effects on root length density (RLD) varied with depth. The RLD was greater under NT than under CT in the top 0–15 cm soil depth. However, from 15 cm to 60 cm soil depth, the RLD was smaller in NT than under CT up to 60 cm soil depth reported by Yadav *et al.* (2018b). Greater soil bulk density and resistance under NT may reduce the RLD in deeper layer. The manipulation of tillage with land configuration had increased the RLD in all the layer of soil in their respective tillage systems. Adoption of NT–RB recorded had significantly more RLD than all other tillage and land configuration system in the top 30 cm soil depth; whereas down to 30 cm soil layer. Root mass density (RMD) was also affected by tillage and land configuration. Significantly higher value of RMD was under NT–RB than under all other tillage and land configuration system in top 30 cm soil layer; whereas down to 30 cm soil depth, conventional tillage with raised bed (CT–RB) was recorded higher value of RMD then all other treatments at both the crop stages (Yadav *et al.,* 2018b).

Effect of RCTs on yield attributes and yield of maize:

Tillage and land configuration management in maize markedly regulated the maize yield and yield components. NT–RB showed the significantly maximum values of green cob yield and yield components including number of cobs $ha^{-1}$and cob weight over CT–RF and CT–FB (Yadav *et al.,* 2018b). In the years with erratic rainfall, no till with residue retention is reported to perform better. However, there was no significant difference within NT–RB, NT–RF and NT–FB treatments. Maize grown in NT–RF yielded approximately 14.5% more green cob than CT–FB. Tillage practices markedly influence root attributes, and significant interactions between tillage and year are presented for RLD, dry matter and yield. There was significant positive relationship soil moisture content, root growth and yield in both the years. Therefore, higher the RLD, RMD and soil moisture content led to greater biomass and yield NT–RB and NT–RF than other tillage and land configuration (Yadav *et al.,* 2018b). Broad bed and furrow system with 10 tonnes FYM/ha gave higher plant growth, dry matter accumulation and lower weed population, which indicate the higher crop growth that ultimately may give more yield of maize. Broad bed and furrow method of planting produced significantly higher yield as compared to flatbed method, which was on par with ridge and furrow method of planting. Application of FYM @ 10 t/ha produced significantly more yield as compared to other treatments. Hence, growing of maize on broad bed and furrow system with FYM application had gave more yield compared to other methods of planting. In another study at ICAR, Lembucherra, Tripura, 6 tillage based resource conservation measures *viz.* conventional tillage with flatbed planting (CT-FB), conventional tillage with ridge and furrow planting (CT-RF), conventional tillage with raised bed planting (CT-RB), no-till with flatbed planting (NT-FB), no-till with ridge and furrow planting (NT-RF) and no-till with raised bed planting (NT-RB) were tested. Green cobs yield of summer maize was 25.3–27.4% and field pea seed yield was 17.9–32.2% higher under NT-RF and NT-RB than CT-RF. Rainy season (*kharif*) maize grown under NT-RF recorded 12.66% less grain yield than the CT-RF. The NT-RB resulted in the maximum system productivity to the tune of 16.34 and 14.55 t/ha in 2012–13 and 2013–14, respectively. The average system productivity was 6.1% higher under systems than to CT systems (Yadav *et al.,* 2015).

In another experiment the maize-maize-field pea cropping system was grown under different treatment combinations of tillage and land configuration. All the yield attributes of summer maize were higher in broad bed and furrow system under conventional tillage. Green cob yield of summer maize was not significantly affected by tillage; however land configuration had a significant effect on green cob yield over tillage system. The highest green cob yield was recorded with broad bed and furrow system with conventional tillage (BBFCT), which was at par with Ridge and furrow system with convention system (RFCT) over rest of the treatments (Fig. 1A). The green fodder yield after harvest of green cobs was not affected by tillage as well as land configuration. However, *kharif* maize showed the different trend as compared to summer maize. In *kharif* season tillage had significant effect yield attributes and grain yield of maize. Among the tillage treatment conventional tillage (CT) recorded significantly higher yield attributes and grain yield as compared to zero tillage (ZT). The effect of zero tillage was also not overcome by land configuration. However, highest yield attributes and yield was recorded with BBFCT, which at par with RFCT and CT and significantly superior over rest of the treatments (Fig. 1B). Reduction in yield under zero tillage condition was mainly due infestation of plant with disease at silking to maturity stage. Zero tillage plot recorded higher number of infected plant and percentage plant mortality at maturity stage. After harvest of *kharif* maize, Field pea was sown to evaluate the effect of tillage and land configuration on yield field pea (TRCP-8). There was no significant differences among the growth parameter of field pea due tillage. However, broad bed and furrow system with convention tillage recorded higher value of all the growth parameters. Broad bed and furrow system with Zero tillage recorded higher seed yield and harvest index compared to all other treatments.

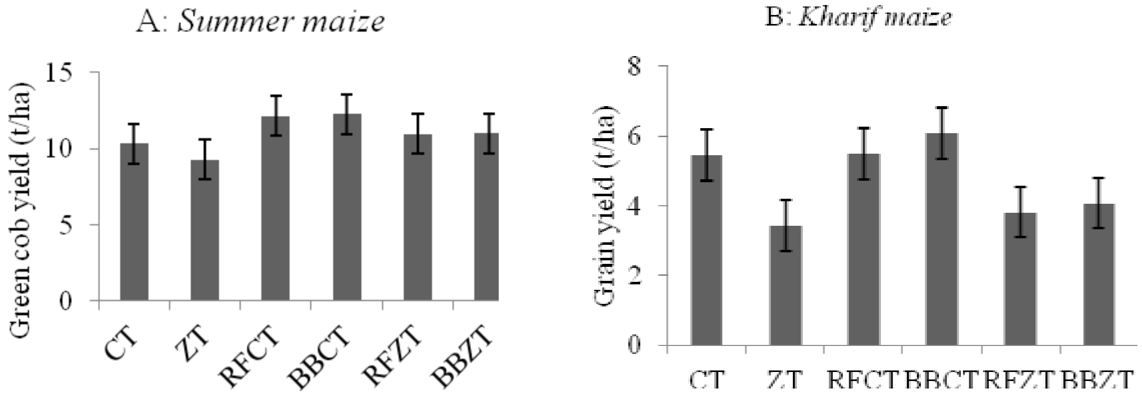

Fig. 1: Effect of tillage and land configuration on green cob yield of summer maize (A) and grain yield of *kharif* maize (B)

Moisture conservation in maize based cropping system:

No-till planting is well proven technology for maize in different regions of the world where soil erosion, runoff and moisture stress are major production constraint. Water is the primary limiting factor in crop production for *rainfed* agricultural system. Crop management and tillage practices strongly affected the characteristics of the macropore in soil system and thus affect soil moisture conservation and distribution. Soil moisture characteristics are significantly affected by tillage methods because of their impact on water infiltration, surface runoff and evaporation. It is well documented that the intensive tillage practices increase the soil bulk density at the ploughing depth (20 to 30 cm), decreases aggregation, deplete soil organic matter (SOM) and reduce crop productivity. Soil moisture deficit is also caused by high evaporation rates, high runoff and soil erosion rates. Hence, moisture conservation is needed to improve the yield of summer crops grown under limited irrigation facilities. The necessities of moisture conservation practices are more where frequent dry spells causes moisture stress in crop. Conservation tillage management systems are effective means of improving soil moisture regimes. Therefore, adoption of conservation tillage practices during summer may be a viable alternative for better resource and moisture conservation. No-till with residue retention can change the capability of soil surface to intercept rainfall by affecting hydraulic conductivity of the top soil, soil roughness, and soil surface porosity. It is renowned technique for conserving water by reducing direct evaporation and escalating water storage. Furthermore, sometime heavy rain fall may cause the excess moisture leading to water stagnation, reduction in root aeration and effects the crop growth and productivity. Therefore, it is necessity to identify suitable land configuration practices for moisture conservation and removal of excess water.

In Sikkim, crop production is entirely *rainfed* and depends upon the rainfall and natural sources of water. Rainfall mostly occur during monsoon season (May to September) and partially in post rainy season (October to March); hence, no water is available for crop production in post rainy season (Babu *et al.,* 2016). In these circumstances, diversification of maize based cropping system through in-situ moisture conservation practices seems to be the only way to enhance the productivity and sustainability in the state. In order to meet the demand of pulses in the state, short duration pulse crop rajmash (*Phaseolus vulgaris* L.) variety which will fit in maize-fallow under *rainfed* condition is demanded by the farmers in the state. Short duration rajmash variety can escape the drought during early winter season may enhance the cropping intensity after harvest of maize crop in the state. Keeping these points in view, ICAR-NOFRI Sikkim initiated research strategies for growing pulses in *rabi* season by using locally available biomass and 30 per cent maize stover as mulch for conservation of soil moisture. The end of September month is best suited for sowing of rajmash after maize (Babu *et al.,* 2016). A good seed bed should consist of 5 to 7 cm of fine firm soil that is free from weeds. Apply vermin-compost @ 2.0 t/ha + neem cake @ 1.0 t/ha + FYM @ 5.0 t/ha in furrows open for sowing of the seeds. VL Rajma-63, VL Rajma-125, IPR 98-5 (Utkarsh), HUR-15, HUR-137 and SKR-57 is suitable for cultivation in Sikkim. Seed should be inoculated with Rhizobium culture @ 20 g/ kg seed and the seed rate is 100-125 kg/ha. Sowing should be done in furrows at a spacing of 30 cm x 10 cm with 3-5 cm depth. Two hand weeding, first at 15-20 DAS and second at 40-45 DAS should be done to get the optimum yield. Spraying of Spinosad 45 SC @ 0.3 ml/l and second spraying at 20 days interval is effective to control gram pod borer and legume pod borer. Harvesting should be starts at 90 -95 days after sowing. In the study, Raj-2 recorded significantly higher grain yield (1.73 t/ha) over Raj-1, SKR-57 and Tripura Raj Sel-1 but remained at par with Raj-3 and Raj-4 (Singh *et al.,* 2018).

Soil moisture content (SMC) was measured during crop period, when there was no or very negligible rain at least during a period of week (considered as dry spell). The SMC was varied over the years due to variable rainfall before moisture estimation. Evidently, the soil moisture content was lower in the surface layer (0–15 cm) than in the sub–surface layers, but the differences due to tillage and land configuration treatments were more pronounced in the surface layer. The soil moisture conservation was more under NT based systems than under CT systems. The soil moisture content was further increased when tillage was manipulated with land configuration. Significantly higher soil moisture content was found in NT–RB system in all the period of moisture estimation in all the soil layers. The manipulation of tillage with land configuration increased the soil moisture content in both tillage however, the increased in soil moisture content was more in NT than under CT. The NT maintains the soil surface roughness, conserving natural soil structure and bio–pores (from earthworms and dead roots) thereby increasing infiltration. This pattern of water conservation in NT systems has frequently been observed when there is no long drought period. The occurrence of dry spell time and duration was different in both years. Based on the average of all 4 dry spells, the total soil moisture storage in 0–60 cm depth was 19.8% and 20.6% higher in NT–RB over CT–FB in both years 2012 and 2013, respectively. In sub–soil layers the soil moisture content was not significantly different in among the tillage and land configuration except in conventional tillage. The pattern of increased soil moisture with soil depth was similar in all the treatments (Yadav *et al.,* 2018b).

Impact of various resource conservation measures soil health:

A 4-year field study (2006-10) was conducted at the ICAR Research Complex for the NEH Region, Umiam, Meghalaya, India with No-till (NT) and residue mulching under maize –*toria* (*Brassica campestris* L.) system. Bulk density and SOC improved under NT and residues managed plots, compared to the CT. Among the mulch treatments, maize stalk cover (MSC) + *Ambrosia* @ 10 t/ha and MSC + *Ambrosia* @ 5t/ha + poultry manure @ 5 t/ha recorded the higher seed yield of *toria*. The yield of both maize and *toria* crop under conventional tillage remained similar to NT.

Available N and P was maximum in MSC + *Ambrosia* 5 t/ha + poultry manure 5 t/ha (Das *et al.*, 2010). The study indicated that effect of soil moisture conservation measures on soil hydro-physical characters, SOC and biological activity was more pronounced under zero tillage than under conventional tillage. Adaption of NT increased mean SOC by 6%, water stable aggregate by 9.3%, mean weight diameter 42.6%, available soil moisture by 20%, SMBC by 66.8% over CT system. The temperature under conservation tillage was marginally higher. Similarly, moisture conservation measure MSC + *Ambrosia* 5 t/ha + poultry manure 5t/ha enhanced mean SOC by 30.4%, soil available N by 54.8%, mean weight diameter by 100%, hydraulic conductivity by 76% and SMBC by 100 % (Das *et al.*, 2017). Such improvements in soil properties have a direct bearing on long-term sustainability and soil quality in a fragile hilly ecosystem. Therefore, zero tillage and residue management promoted positive changes in SOC, soil physical and microbial properties and improved soil quality. In another study at ICAR, Lembucherra, Tripura, 6 tillage based resource conservation measures *viz.* conventional tillage with flatbed planting (CT-FB), conventional tillage with ridge and furrow planting (CT-RF), conventional tillage with raised bed planting (CT-RB), no-till with flatbed planting (NT-FB), no-till with ridge and furrow planting (NT-RF) and no-till with raised bed planting (NT-RB) were tested. Under the NT-FB, soil organic carbon was 13.2% higher than CT-FB. However, the CT-RB recorded higher soil pH as compared to all the other treatments. The available nitrogen, phosphorus and potassium were higher with NT systems compared to CT systems (Yadav *et al.*, 2015).

Conclusions: Maize is having very good potential as food-feed crop in NER under upland and *jhum* land fields as pre-*kharif* and *kharif* season crop whereas in lowland it may be a very good option after rice. Diversification/Intensification of maize based system along with need based location specific resource conservation technologies under both irrigated and *rainfed* ecosystems may enhance the productivity, profitability and resource use efficiency in the region in changing climatic conditions.

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Diseases and Insect Pests in Maize Cultivation: Approaches to Their Management in NEH Region

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Introduction:

Maize is an important cereal crop in India. It is estimated that by the year 2020, demand for maize in developing countries will surpass demand for both wheat and rice. India ranks fifth in total area and third in production and productivity. In North Eastern Himalayan region of India, maize is the second most important crop, next to rice and mostly grown in *rainfed* conditions. This level of production has to be substantially raised to meet growing demand of maize for human food, animal and poultry as well as industrial processing by the wet and dry millers to produce value added products. The national average yield of maize is low compared to other leading maize growing countries of the world. Among the factors adversely affecting productivity, ubiquitous prevalence of disease and insect pests in the pre harvest stage are predominant. The total economic loss of the crop in India due to insects and pests in the pre-harvest stage are prominent. The total economic loss of the maize crop in India due to disease and insect pests has been estimated to be of the order of 13.2%. Since there is practically no possibility of increasing maize area, the productivity can only be raised by providing seed of improved cultivars, better agronomic practices and protection against disease and pests.

Maize diseases:

A. Turcicum Leaf Blight (TLB):

The disease is caused by the fungus *Exserohilum turcicum.* An early symptom is easily recognized, by slightly oval, water-soaked, small spots produced on the leaves. These grow into elongated, spindle-shaped necrotic lesions. They may appear first on lower leaves and increase in number as the plant develops, and can lead to complete burning of the foliage. It has the potential to cause yield reduction up to 70%.

Fig. 1: Characteristic symptoms of turcicum leaf blight

Management

- Rotating maize with non-host crops can reduce disease pressure
- Management of overwintering infected crop residue will reduce the amount of available inoculum at the onset of the subsequent growing season
- Fungicide should be applied when lesions first become visible on the lower leaves. Two to four applications of Maneb or Zineb @ 2.5-4.0 gm/litre of water at 7-10 days interval provide good control of the disease

B. Downy Mildews:

Downy mildews cause considerable losses to the yield under favourable conditions of fungal growth. These diseases cause severe damage to hybrid maize cultivars. Several mildews are known as mentioned below:

Several species of the genera *Peronosclerospora*, *Sclerospora*, and *Sclerophthora* are responsible for downy mildews: Crazy top downy mildew (*Sclerophthora macrospora*), brown stripe downy mildew (*Sclerophthora rayssiae* var. *zeae*), green ear disease (*Sclerospora graminicola*), Philippine downy mildew (*Peronosclerospora philippinensis*), sugarcane downy mildew (*Peronosclerospora sacchari*) and sorghum downy mildew (*Peronosclerospora sorghi*).

The symptoms appear on younger leaves as white or light green stripes which soon become white or light yellow on most of the leaves of affected plants. The sporangia develop on branched sporangiophores which emerge in groups from the plant tissues through stomata. A white mat of the fungal growth can be seen on the lower or both the surfaces of leaves during wet weather. The stem may also be affected if infection occurs during early stages of plant growth.

Fig. 2: Characteristic symptoms of downy mildew

Management

- The best control is to use resistant varieties or hybrids, if available
- Spraying with systemic fungicides such as metalaxyl and propamocarb etc. can be used to manage the disease.

C. Maydis Leaf Blight (MLB):

MLB is caused by fungus *Bipolaris maydis.* It has the potential to cause as high as 70% yield loss. Young lesions are small and diamond shaped. As they mature, they elongate. Growth is limited by adjacent veins, so final lesion shape is rectangular and 2 to 3 cm long. Lesions may coalesce, producing a complete burning of large areas of the leaves.

Fig. 3: Symptoms of maydis leaf blight

Management

Application of 2-4 sprays of Diathane M-45 or Zineb @ 2.0-2.5 gm/litre of water at 7-10 days interval from the first appearance of disease controls the spread of pathogen.

D. Common Rust:

Common rust is caused by *Puccinia sorghi*. The disease is recognised by the abundant oval-elongate, red-brown pustules up to 2 mm long, which erupt through both leaf surfaces in scattered groups. This distinguishes common rust from polysora rust, which has little development of rust pustules on the lower leaf surface. The pustules contain numerous powdery spores that can be spread long distances by wind. Common rust survives between seasons only on living maize plants.

Fig. 4: Symptoms of common rust

Management

The only practical control measure is to plant resistant hybrids.

E. Polysora Rust:

Polysora rust is caused by the fungus *Puccinia polysora*. Small red-brown or orange pustules develop evenly over the upper leaf surfaces, and larger elongated ones may also develop on the midribs, ear husks and tassels. Polysora rust survives between seasons only on living maize plants. Polysora rust survives between seasons only on living maize plants.

Fig. 5: Symptoms of polysora rust

Management

- Spray of Diethane M-45 @ 2-2.5 gm/litre at the beginning of appearance of symptoms provides good control.

F. Post Flowering Stalk Rot (PFSR):

It is one of the most destructive diseases and is caused by complex association of multiple pathogens, among which *Fusarium moniliforme*, *Macrophomina phaseolina* and *Cephalosporium maydis* are commonly associated. The symptoms start appearing during senescence and it commonly affects roots, crown region and lower internodes. The disease symptoms manifest after flowering and gets severe under moisture stress/ high soil temperature conditions. Being soil borne, its transmission occurs through contaminated seeds, biological culture, infected crop residue and movement of agricultural equipment.

Fig. 6: Symptoms of post flowering stalk rot

Management

- Application of potassium fertilizer minimizes the incidence of disease.
- Avoidance of water stress at flowering stage and crop rotation also reduces the incidence of the disease to a great extent.
- Application of bio-control agent such as *Trichoderma* formulation in furrow @ 10 g/kg of FYM at 10 days prior to sowing provides good control.

G. Bacterial Stalk Rot:

Bacterial stalk rot caused by *Erwinia chrysanthemi*. The basal internodes develop soft rot and give a water soaked appearance. A mild sweet fermenting odour accompanies such rotting. Leaves some time show signs of wilting or water loss and affected plants within a few days of infection lodge or topple down. Ears and shank may also show rot. They fail to develop further and the ears hang down simply from the plant

Fig. 7: Symptoms of post bacterial stalk rot

Management

- Use of disease resistance varieties, i.e. Hybrids Ganga Safed-2, DHM 103, show significantly less disease incidence than other hybrids.
- Avoid waterlogging and poor drainage.

H. Banded Leaf and Sheath Blight (BLSB):

BLSB caused by *Rhizoctonia solani* f. sp. *sasakii* has recently can cause substantial loss to grain yield and fodder quality. The disease develops on leaves and sheaths and can spread to the ears. Characteristic symptoms include concentric bands and rings on infected leaves and sheaths that are discoloured, brown, tan or grey in colour. Typically, disease develops on the first and second leaf sheath above the ground and eventually spreads to the ear causing ear rot. Ear rot is characterized by light brown, cottony mycelium on the ear and the presence of small, round, black sclerotia (compact mass of hyphae that can survive in unfavourable conditions). Ears dry prematurely and caking of the ear sheaths is common.

Fig. 8: Symptoms of banded leaf and sheath blight

Management

- Fields should be well drained prior to planting.
- Treatment of the soil with fungicide prior to planting can reduce survival of the pathogen and reduce disease severity.

• Removing lower 2-3 leaves, application of *Pseudomonas fluorescens* culture @16 g/kg of seeds (as seed treatment) or 7 g/litre of water for soil application coupled with foliar spray of Sheethmar or Validamycin @ 2.5-3.0 ml/litre of water provides reasonable control on the spread of the disease.

I. Maize Streak Disease:

Maize streak disease is caused by maize streak virus (MSV). The virus is transmitted by *Cicadulina* spp. leafhoppers'. *Cicadulina mbila* is the most prevalent vector, and transmit the virus for most of its life after feeding on an infected plant. Early disease symptoms begin within a week after infection and consist of very small, round, scattered spots in the youngest leaves. The number of spots increases with plant growth; they enlarge parallel to the leaf veins. Severe infection causes stunting, plant will not develop cobs and plants can die prematurely. Many cereals crops and wild grasses serve as reservoirs of the virus and vectors.

Fig. 9: Symptoms of maize streak disease

Management-

Cultivars possessing resistance should be planted. Avoid planting before early October or after mid-December. Keep the maize field and surrounding border free of grass and weeds. Remove infected maize stalk from the field or bury burn them. Planting should be done in moist soil that is tilled well to improve uniform germination.

Integrated Disease Management (IDM) in maize:

Maize diseases constitute an important production constraint because they reduce yield and quality of grain and silage. Downy mildews, Maydis leaf blight and stalk rot are some of the major diseases affecting maize in North Eastern Region of India. An integrated disease management approach using several practices is usually recommended in maize production. Integrated disease management is a knowledge approach for managing diseases by combining compatible cultural, physical, biological and chemical tools in a way that minimize economic, health and environment risk. The most commonly recommended tactics involves the selection of hybrids with genetic resistance to diseases (always opt for hybrid with high yield potential, good resistance to leaf and stalk diseases, and good emergence and seedling vigour traits), application of seed fungicides, the adoption of sound crop management practices which includes rotation with non-host crops of pathogen, cropping sequence, selection of planting site, seedbed preparation, date of planting , varietal maturity and the occasional application of foliar fungicides when warranted by disease risk (field must be scouted regularly to determine if fungicide application is needed and the appropriate time for application).

Cultural Practices-

- Crop rotation.
- Follow recommended planting dates and plant population.
- Ensure proper drainage for managing stalk rot and avoid moisture stress at flowering stage.
- Fertilize crop as per recommendation.
- Manage the crop residue (plough down or recycling after proper composting.

Genetic Management-

Use of resistant/ tolerant hybrids/composites.

Mechanical Control-

- Rogue and destroy infected plants.
- Stripping of two lower leaves along with leaf sheath.
- Use bird scarer to prevent seed damage.

Biological and Chemical control-

- Seed treatment with Thiram 75% WS @ 1.5-2.5 g/kg seed or *Trichoderma harzianum* 2% WP @ 20g/kg seeds.
- Add *Trichoderma harzianium* formulation 2% WP in furrow at the time of sowing prior mixing with FYM @10 g/kg FYM.
- Spray Macozeb 75% WP @1.5-2 kg/L water or Zineb 75%WP @1.5-2 kg/ha after first appearance of disease followed by 2-4 application at 10-15 days interval.
- Soil drenching of bleaching powder containing 33% chlorine @10 kg/ha at pre flowering stage.

Major Insects:

1. **Maize cob borer or sorghum ear-head caterpillar, *Stenachroia elongella* Hampson**

This pyralid insect can be considered to be most important insect pest of maize in the NE region, ahead of another well-known cob borer i.e. *Helicoverpa armigera.* In this region, the importance of *Helicoverpa armigera* as a cob borer is not as dominating as in other parts of the country. The adult moths of *Stenochroia elongella* emerge after mid-June and egg laying starts on growing corn cobs. About 60-70 eggs are laid singly on the cobs between two cob sheaths. Eggs are small cream coloured and hatches in 5-8 days. The caterpillar on hatching bore into the corn cobs and create characteristic punctured holes on the corn cobs. There excrements coming out from these holes along with the punctured holes are the characteristic symptoms of the cob borer damage. Presence of 3-5 borers in a single cob can completely damage the cob. The puncture holes and their excrements also leads to the secondary infection by fungus. There were found to be four larval instars over a period of 28-30 days. Pupal duration was observed to be about 6-7 days and found to occur within the cob or between cob sheaths. Three to

Fig. 10: Cob borer damage symptoms in maize cob

four overlapping generations from July to end of September were recorded (Pathak, 2004). As is observed in borers, late sown crop suffers more damage than early sown crop. The adult moths prefer sorghum crop to maize for oviposition and sorghum can be used as a trap crop to lure away the adult moths.

2. **Maize stalk/stem borer, *Chilo partellus* (Swinhoe)**

Another major pest of maize in the region is the maize stem borer. It is devastating because it can affect the crop in early stages and destroy the crop completely if not controlled. In different agro-climatic regions of India, *C. partellus* has caused damage of 26.7-80.4% to sorghum. It is the principal pest in lowland areas. After hatching, the young larvae crawl and feeds on tender folded leaves causing typical **"shot hole"** symptom. Then, larvae mines the midrib enter the stem and feeds on the internal tissues. Bore holes are visible on the stem near the nodes. During the vegetative stage, it causes "**dead heart**" where the central portion of the growing shoot is killed and as a result the whole plant dies. Affected parts of stem may show internally tunnelling caterpillars.

Fig. 11a: Characteristic symptom of maize stalk borer with shot holes

Fig. 11b: Newly hatched stem borer larvae scrapping on leaf

Fig. 11c: Shot holes on leaf

Fig. 11d: Dead heart of central shoot

Fig. 12: Important green pesticides for managing insect pests

Minor insects:

3. Maize shoot fly/ stem fly, *Atherigona soccata* Rondani

The insect attacks the young crop when it is in the six leaf stage. Six weeks after planting, the crop is seldom attacked. Maggots are cylindrical, tapering towards head, pale yellow or dirty white in colour. The adults are dark grey coloured, housefly-like but much small flies (5 mm long). As the maggots feed on the main shoot, the growing point is destroyed and by the time they pupate, the plant is almost dead. They feed inside the main shoot for 6-10 days and, when full grown, they may pupate either inside the stem or come out and pupate in the soil. The young plants show typical dead-heart symptoms. The total loss in yield is sometimes as high as 60 per cent. Cloudy weather favors the multiplication of this insect and it is believed that infestation is also higher in irrigated fields. The high-yielding hybrids are more susceptible to the attack of this fly.

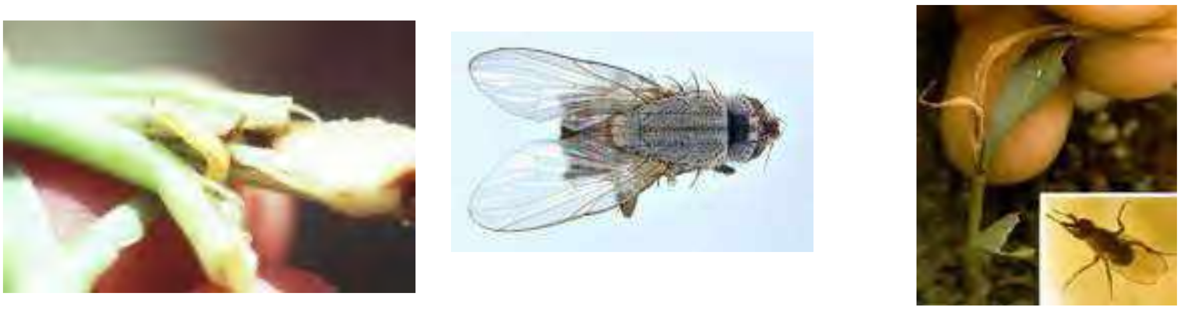

Fig. 13: Maize shoot fly adult and its damage symptom

4. Maize aphid, *Rhopalosiphum maidis* Fitch

Maize aphids are Oval-shaped, with soft bodies and a pair of cornicles protruding from the end of their abdomen. They are olive green to bluish-green in colour, and have short antennae and dark legs. Both winged and wingless forms occur. Both apterus and pterous aphids infest the upper half of the plant. Nymphs and adults suck the sap from the leaves / shoots and exude honeydew, on which a sooty mould grows, giving the leaves a black appearance and thus affect photosynthesis badly resulting in yellowing of leaves.



Fig. 14: Aphids and their damage symptoms on maize

Integrated Pest Management (IPM) in maize:

Cultural practices-

i). Deep summer ploughing and leave the field to expose to hot sunshine to kill the resting stages of pests and to destroy the stubbles and perennial weeds by allowing farm animals to graze on it to destroy overwintering larvae.
ii). Timely sowing of crop and maintain proper spacing
iii). Intercrop with legumes like soybean, cowpea and green gram to reduce the incidence of borer.
iv). Balanced use of manures and fertilizers to reduce pests' infestation.
v). Proper irrigation management and avoidance of moisture stress at the time of flowering to grain filling stage.
vi). Planting Sorghum as a trap crop for managing cob borer.

Genetic management-

i). Use certified seeds of recommended varieties

Mechanical practices-

i). Manual weeding at 2-3 and 6 weeks to prevent the shelter of insect pests.
ii). Removal of dead hearts and diseased plants or alternate hosts will help to reduce second generation infestation.
iii). Use of bird scarer prevents seed damage.
iv). Manual collection and destruction of white grubs and chaffer beetle during adult emergence period reduces the pest population.
v). Use of pheromone traps from one-month crop stage @ 4–6/acre to control pest at early stage.
vi). Installation of light trap to attract adult moths @1 trap /acre for monitoring and mass trapping.
vii). Stripping of two to four lower leaves along with leaf sheath to reduce oviposition of maize stem borer.

Bio-control and chemical control-

i). Seed treatment with imidacloprid 70 WS 10 g/kg of seeds. Farmers following organic practice/farming can use *Trichoderma viride* or *T. harzianum* for seed treatment @ 2ml/litre of water (for 1 acre) and soak the seeds in this solution for 30 minutes, shade dry the seeds and sow them.
ii). Soil application of phorate 10%CG @ 10 kg/ha at the time of sowing.

iii). Spray the crop 2-3 weeks after sowing as soon as borer injury to the leaves is noticed with *Bacillus thuringensis* var. *kurstaki* @ 1.5 kg/ha (5ml/litre) or application of *Ha*NPV @ 500 ml/ha (250 LE) with adjuvant like teepol, jaggery, tinopal or coragen 18.5 SC (chlorantraniliprole) @ 30 ml or deltamethrin 2.8 EC @ 80 ml using 60 litres water per acre with knap-sack sprayer.

iv). For sucking insect pests, spray oxydemeton methyl or dimethoate 30EC @ 200 ml per acre in 50 litres of water with manually operated knap-sack sprayer.

v). Spraying of neem pesticides @ 3ml/ litre or annonin extract @2ml/litre at silking stage effectively helps to reduce cob borer population

vi). Whorl application of Carbaryl 3G or Phorate 10G @ 2-3 granules per whorl at 28-30 days after germination effectively kills the borers and cutworms.

vii). The hairy caterpillars can be destroyed by crushing the grown up caterpillars under feet or by picking and putting them into kerosenized water. If the population is high, control it by spraying 500 ml of Quinalphos per acre in 100 litres of water with a manually operated knap-sack sprayer.

viii). Farmers following organic farming/practice can use *Beauveria bassiana* @5ml/litre water for managing lepidopteran caterpillars and even sucking pests too. The common trademark name of *B. bassiana* is Green Racer.

ix). For termites and white grub infestation, frequent irrigation before land preparation and during the crop growth reduces its infestation. Application of Fipronil granules @ 20 kg/ha followed by light irrigation controls soil insects to some extent. Farmers following organic farming/practice can use *Metarhizium anisopliae* @ 5ml/litre for foliar application and soil drenching around the root zone. However, in case of termite infestation, destroy the termitarium first and it should be used at 10ml/litre and applied liberally in and around the termitarium. The common trade names of *M. anisopliae* is Green Muscle or Green Pacer.

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Soil Health Assessment in Maize (*Zea mays* L.) Based Cropping System in Arunachal Pradesh, India

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Status of maize cultivation in Arunachal Pradesh:

In Arunachal Pradesh, out of the total geographical area 8374 '000 ha, the net sown area is 211 '000 ha and only 5000 ha is under maize with a production and productivity of 80000 MT and 417 kg/ha (2009-2010). The productivity is far below the national average due to *rainfed* cultivation and predominance of low yielding local cultivars. The cause of low maize productivity is absence of location specific varieties, low use of organic manure and unfavorable climatic conditions particularly during the pre-*kharif* and post-*kharif* seasons when heavy rain with turbulent storms occur. Maize is cultivated mainly for food and feed purpose. Maize is cultivated in *jhum* mostly during the summer or pre-*kharif* season under *rainfed* condition. In some districts maize is grown as *rabi* crop during September- October. Sowing of maize is done by random dibbling at a depth of 20-30 cm depth. The intercultural activities like weeding are done as and when required. The crop is completely rainfall dependent. The common varieties grown are Novjot, Nabin in eastern Arunachal, RCM-1-75, RCM-1-76 (early maturing) in Western Arunachal and Pedi red, DA-61A, Zero local, Tapoli and Tago local in central Arunachal. The maize variety HQPM-1 was tried in ICAR Basar under FASAL project in 2011. In this project it was observed that HQPM-1 showed 100% germination in date of sowing 20/4/2011 while Pedi Red (local variety) germination rate was only 75%. As HQPM-1 maize variety, showed 100% germination rate it is a promising maize variety to improve the production and productivity. In 2015, baby corn varietal evaluation was undertaken at ICAR Basar and it was found that DA-61A had the highest plucking of baby corn among RCM-1, Vijay, RCM-1-76, RCM-1-75, RCM-1-3, RCM-1-3.

Maize base cropping system in Arunachal Pradesh:

Maize is common crop grown after rice. Likewise, some of the major cropping systems practiced in Arunachal Pradesh are: maize- rice –mustard, maize- rice- potato, maize- rice-turmeric/ginger. Intercropping of maize with cowpea, frenchbean, blackgram, soyabean and local herbs is also a common cropping system in *jhum* land. As maize is nutrient exhaustive crop and Arunachal Pradesh soil is commonly acid soil, maize-leguminous crops is a potential cropping system. Again worth mentioning is, as vegetable particularly legumes crops are sparsely available in local markets here, Maize-legume cropping system can meet the vegetable market demands whilst maintaining the fertility of the soil.

Soil fertility status of Arunachal Pradesh:

Arunachal Pradesh is dissected by many rivers and nallas and consist large boulder of quartzite, gneisses, schist, etc., bedded in sandy matrix. The soils are sandy loam to sand and very low water holding capacity. The soil has acidic pH ranging from 3-6. Due to heavy rainfall of approx. >4000 mm annually, the soil base saturation is low while aluminum and iron toxicity are prevalent. It is well established that acidic pH causes soil nutrient imbalance and fixation of soil available phosphorous. Soils are virgin with SOC ranging from 2-4%. However, this fact is soon to be a history due to unscientific agricultural practices carried out by the farmers in the region.

It is increasingly evident that declining soil fertility is the most widespread, dominant limitation on yields of most field crops including maize and on the sustainability of maize-based cropping systems in Arunachal Pradesh. In addition, Arunachal Pradesh is vulnerable to soil erosion and landslides due its undulating topography that rise to an altitude of 3000 m above msl. Thereby, there is a need to promote soil conservation. But, low cost soil conservation and soil fertility improvement technology that financially poor farmers can use are relatively scarce.

Holistic soil management practices for maize in Arunachal Pradesh:

Though maize has high nutritionally value, it is a genetically nutrient exhausting crop. Thereby, a strategic soil management practices suitable to the soil condition of Arunachal Pradesh needs extensive study and research. Alike Sikkim, Government of Arunachal Pradesh is moving with a target to declare it the total organic state. Some of the organic soil management practices shall be discussed below:

1. **Soil conservation methods-** Contour ploughing orients furrows following the contour lines of the farmed area. Furrows move left and right to maintain a constant altitude, which reduces runoff. Contour plowing can increase crop yields from 10 to 50 percent, partially as a result of greater soil retention. Terracing is the practice of creating nearly level areas in a hillside area. The terraces form a series of steps, each at a higher level than the previous. Terraces are protected from erosion by other soil barriers. Terraced farming is more common on small farms and in underdeveloped countries, since mechanized equipment is difficult to deploy in this setting. Half-moon terrace are mostly employed in steep slopes where terracing is difficult. Stone dykes are pile of stones staked up to prevent soil erosion and landslides.

2. **Application of organic manure-** Application of FYM, vermin-compost, poultry litters, pig litter, bone meal, ash etc not only increases the soil fertility status but also improves the soil physical condition.

3. **Green manuring-** Green manuring improves the soil fertility and the soil physical condition.
4. **Mulching-** Soil mulching with straws of plant material prevents soil moisture evaporation and also controls the weed population.
5. **Cover crop-** Cover crop are grown in between rows or across the slopes to prevent runoff loss.
6. **Intercropping-** Intercropping of leguminous crops between maize increases the soil nitrogen content and beneficial microorganism. Economically, it is profitable as it provide additional income to the farmers.
7. **Liming-** Application of lime in acid soils is beneficial to increase the soil pH which eventually makes the soil nutrient available to the plants. As lime contains Ca and Mg it will increase the soil base saturation percentage and also improve the soil stability.

8. **Zero tillage-** It is a practice where no tillage is done before planting a crop. The advantages of zero tillage are:
    a. Reduction in the crop duration and thereby early cropping can be obtained to get higher yields.
    b. Reduction in the cost of inputs for land preparation and therefore a saving of around 80%.
    c. Residual soil moisture can be effectively utilized and number of irrigations can be reduced.
    d. Dry matter and organic matter get added to the soil.
    e. Environmentally safe - Greenhouse effect will get reduced due to carbon sequestration.
    f. No tillage reduces the compaction of the soil and reduces the water loss by runoff and prevents soil erosion.
    g. As the soil is intact and no disturbance is done, no till lands have more useful flora and fauna.

Conclusion: Maize base cropping system in Arunachal Pradesh needs strategic soil management packages of practices to improve the yield and productivity. Intercropping of vegetables with Maize is an additional source of income for the farmers. There is need to impart the awareness of benefit of soil conservation to increase the soil fertility among the farmers and go beyond Rice terrace system. Though, maize is not a grown in large scale, it has the potential to expand in Arunachal Pradesh due to its wide adaptability and large germplasm.

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Maize-based Cropping Systems in North East Hill region of India

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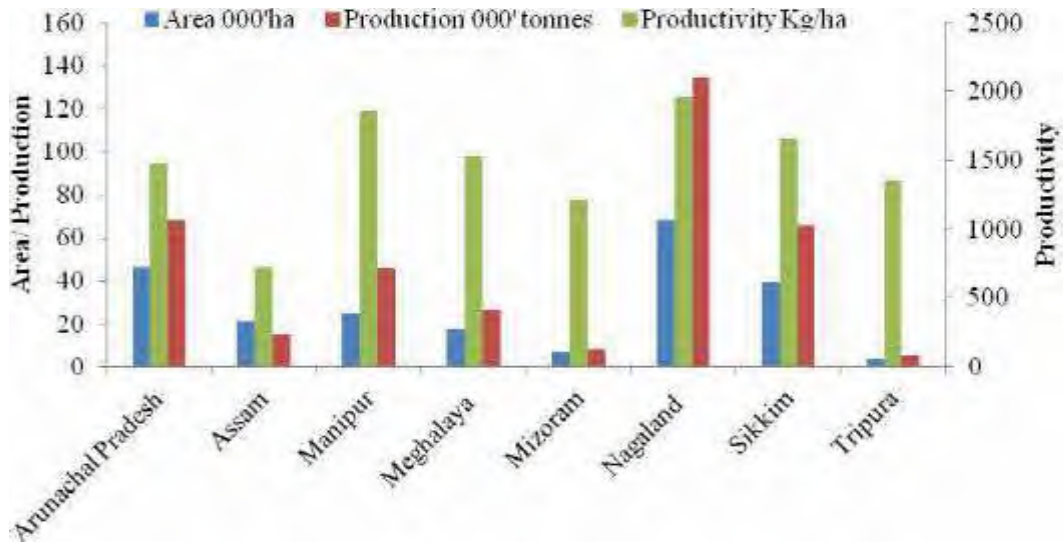
Introduction:

The maize is grown in a wide range of environments, extending from extreme semi-arid to sub-humid and humid regions of India. Maize is considered a promising option for diversifying agriculture in upland areas of India. It is now rank as the third most important food grain crop in India. The crop is also very popular in the low- and mid-hill areas of the western and north eastern hill (NEH) regions. It is a potential crop after rice in the NER (Ansari *et al.*, 2015). In NEH region of India, maize is primarily grown under *jhum* land and terraced area. The area, production and productivity of maize crop in all NE states are shown in the Fig. 1. Maize usually grows under the temperature 21ºC to 27 ºC. Because of growing market demand as well as fodder demand in the region, the farmers are growing maize in all the seasons. However, the productivity in the region is low (<1.5 t/ha) due to lack of assured irrigation and low residual soil moisture (Yadav *et al.*, 2018a). Therefore, to enhance overall system productivity there is need to intensify the existing cropping systems with inclusion of legumes, oilseed and other suitable high value crops.

Fig. 1: Area, production and productivity of maize crop in NE India



(***Data Source:*** *Basic statistics of North Eastern Region, 2015)*

Scope of maize cultivation in NEH region:

- In addition to being staple food maize has range of multiple uses. It has been a part of diet of the NE region as well as serves as basic material for various industrial products like alcoholic beverages, ethanol, plastic, pharmaceuticals and paper industries etc.
- Range of climate and seasons provides year round cultivation of maize along with that region is blessed with great diversity of leguminous crop with vital potential of nitrogen fixation.

- NER provides good scope for maize based cropping system, additional crops in the systems such as vegetables, legumes, high value crops *etc. enhance*
- In India, the primary source of starch is maize which is highly demand in the textile industry. Many processed products like food ingredients, boot polishes, cosmetic products derived from maize are part of our daily life.
- Further, North East India has wide scope for establishment of value addition chain. It predominantly offers a means to increase and stabilize farm income through assured trading of the row produce at better price. Value addition units /project could create employment generation in area which can lead to rural as well as social development.
- The use of maize in livestock and poultry feed is getting remarkable importance and there is good scope for developing the feed industry in North East India.
- There is need to identify and analyse strategies for value addition and processing.
- Commercialization, promotion and adaption of maize based value added food produces will not only ensure higher return to farmers but also generate employment for local people. Other diversified uses could be as popcorn, baby food, corn flacks, corn oil, which offer possibilities for start-ups.

Gap analysis/ constraints/needs in the maize production:

- Hill agriculture ecosystems have some constraints of remoteness and problems in terms of moisture stress, poor soil condition and small land holdings etc.
- Farmers in the region generally adopt maize-fallow cropping system which results in the lower cropping intensity. Therefore, there is need to enhance the productivity crop in Sikkim to meet the rising demand for the food and feed grains. The maize-based cropping systems with incorporation of intercrops or sequential crops should be practiced in the hilly ecosystems of the Sikkim.
- The soils of the Sikkim are mainly acidic in nature. Therefore, suitable cultivars/varieties should be identified which acclimatize with the soil properties such acid tolerant varieties.
- Maize is nutrient exhaustive crop which consumes the soil nutrients more aggressively, therefore, there is need of maintaining the soil fertility.
- Seed is the main basic inputs of the crop production. Improved, HYVs seeds may not reach the farmers on time, especially in the remote and less accessible areas of the hilly regions.
- Pest and diseases are the other major hurdle in the crop stands. Non-availability of effective organic pesticides and bio control agents is also major constraint in the region.
- Low cost farm machinery for tillage practices, intercultural operations, harvesting and processing, exclusively suitable for hilly landscapes are not available.
- In spite of consistent functioning of various extension organizations, majority of the farmers of the region is far away from knowledge and adoption of improved organic practices. The farmers are cultivating maize traditionally with their own way.
- Regulated market, processing and storage facilities which ensure farmers for the economic benefit are lacking in the region.

Maize-based cropping systems in NER India:

Maize-based cropping systems for Arunachal Pradesh-

The common maize based cropping systems grown in Arunanchal are maize + cowpea, maize + urdbean/green gram, maize-mustard, maize-vegetable pea and maize-french bean.

Maize based cropping systems for Meghalaya-

High altitude:

- Maize + soybean

Mid and low altitude:

- Maize-french bean
- Maize-vegetables
- Maize- pea (for vegetable purpose, 70 days duration)
- Maize (fodder) + rice (early variety sown at the end of June)
- Maize + soybean (2:2)-mustard
- Maize + groundnut (2:2) - toria
- Maize + groundnut (2:2) - carrot
- Maize-mustard
- Maize + french bean-mustard
- Maize + soybean 2:2 (*kharif*) - mustard (*rabi*)
- Maize+ soybean 2:2 (*kharif*) - french bean (pre-*rabi*)
- Maize + groundnut 1:2 (*kharif*) - mustard (*rabi*)
- Maize - carrot-french bean (upland)
- Maize - french bean - tomato (upland)
- Maize - french bean - toria (upland)
- Maize - tomato

Maize-based cropping systems for Manipur-

Maize based sequential cropping:

- Maize - pea
- Maize - rapeseed and mustard
- Maize -lentil
- Maize - lathyrus
- Maize - vegetables
- Maize - beans

Maize-based intercropping:

- Maize + groundnut
- Maize + rice bean
- Maize + soybean
- Maize + mungbean/ urdbean

Maize cropping systems for Mizoram-

Most popular maize based cropping systems grown in Mizoram are maize + cowpea, maize + uradbean/ greengram, maize-mustard and maize-french bean.

Maize based cropping systems for Nagaland-

Maize is also important crop in Nagaland. Here, it mostly grown with rice under *jhum* system. But in valley areas, crops like mustard, field pea, vegetable pea, french bean are grown after harvest of maize. During rainy season, crops such as groundnut, green gram etc. can be grown as intercrop to enhance the productivity and profitability of the farmers.

Maize-based systems for Sikkim-

Existing cropping systems:

- Maize - fallow
- Maize – rice
- Maize - buckwheat

Diversified / intensified cropping systems:

- Maize + beans-vegetable pea
- Maize + pahenlo dal - cole crops
- Maize + pahenlo dal - coriander
- Maize (green cobs) - pahenlo dal- fenugreek (leafy vegetable)
- Maize-french bean - vegetables (cauliflower/broccoli/cabbage/spinach)
- Maize (green cobs) - pahenlo dal/kalo dal-vegetable pea
- Maize (green cobs) - rice-vegetable pea/coriander/fenugreek (leaves)
- Maize- pahenlo dal - leafy mustard

ICAR-National Organic Farming Research Institute designed the following diversified/ intensified cropping systems with zero irrigation having 200-300% cropping intensity for profit maximization per unit of land and input applied for *rainfed* ecosystems of Sikkim (Singh *et al.,* 2018).

- Maize (green cobs) - pahenlo dal- buckwheat toria
- Maize + beans-vegetable pea
- Maize + beans - rajmash
- Maize + beans- buckwheat
- Maize - black gram/green gram/french bean

Maize-based cropping systems for Tripura-

ICAR-NEH Tripura designed the following diversified/ intensified cropping systems and identified their economic performance in the region (Yadav *et al.,* 2018b).

- Green cob maize-grain maize-field pea
- rice-vegetable
- Reduced tillage cultivation of hybrid maize in rice fallow land (rice-maize)

Scope for value addition of maize:

In addition to being staple food maize has range of multiple uses. It serves as basic material for various industrial products like alcoholic beverages, ethanol, plastic, pharmaceuticals and paper industries *etc*. In India, the primary source of starch is maize which is highly demand in the textile industry. Many processed products like food ingredients, boot polishes, cosmetic products derived from maize are part of our daily life. Further, along with Sikkim the whole North East India has wide scope for establishment of value addition chain. It predominantly offers a means to increase and stabilize farm income through assured trading of the row produce at better price. Value addition units /project could create employment generation in area which can lead to rural as well as social development. The use of maize in livestock and poultry feed is getting remarkable importance and there is good scope for developing the feed industry in North East. There is need to identify and analyse strategies for value addition and processing. Commercialization, promotion and adaption of maize based value added food produces will not only ensure higher return to farmers but also generate employment for local people. Other diversified uses could be as popcorn, baby food, corn flacks, corn oil, which offer possibilities for start-ups.

Conclusion: In NEH Region of the parts maize crop has great scope and opportunities in cereal based production systems. However, there are several threats and weaknesses. Various factors influence the economic returns through maize production. Sustainable crop production has positive impact on the socio-economic status of the farmers. There is need to bridge the gaps between the adaptation of techniques of sustainable maize production at farmers' field in terms of production and productivity. The present evidences suggest research and extension efforts are essential for the wider adoption of improved cultivation strategies. Also it is important to examine the status and feasibility of different farming practices in different production systems and agro-climatic situations in NEH region.

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Quality Maize Fodder Production and Management in Hydroponic Green House

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Introduction:

On worldwide basis, much of the maize produced is fed to livestock, whereas only a small portion goes directly to human food. Maize contributes greatly in meeting the energy requirements of livestock. Their quality depends on seasonal and storage conditions. Poor growing or storage conditions can lead to grains with a lower than expected energy content or contamination with mycotoxins or toxin-producing organisms. Environmental factors also affect the nutrient content in grains and the digestibility of nutrients contained in an ingredient. The grain provides the world with 19% of its food calories and 15% of its annual production of food crop protein. Maize provides more feed for livestock than any other cereal grain. For instance, 65% of the maize grown worldwide is used for livestock feed, of which the United States is the highest consumer. Also, rapid increase in poultry production in developing countries in Latin America, Africa and Asia is a major factor contributing to the increased use of maize for livestock feeding. In fact, maize is the preferred grain for feeding domestic birds, because its dietary energy value is the highest among cereals with very low variability between years for a given region (Sonia *et al.*, 2018).

The North-Eastern Region (NER) of India comprising the states of Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura occupies about seven per cent of total land area and four per cent of total population of the country. About fifty-seven per cent of the geographical area of NER is covered by forests, which are mostly under private or community ownership. Agriculture is the prime source of livelihood for the majority (85%) of rural population in this region. Although cereals dominate the cropping pattern in this region, livestock are an important component of mixed farming system and dependence on livestock as an alternative source of income. Maize, also known as corn (*Zea mays* L), has been recognised worldwide as a major energy feed ingredient in the diets of livestock. Protein and carbohydrate are by far the two most important nutrients in livestock diets, but also the fact that they represent approximately 90% of the total cost of the ingredients in a ration. Maize grains constitute a large proportion (>50%) of animal diets and contribute largely carbohydrates and to some extent proteins.

Importance of maize grain in livestock:

As livestock feed, it is the grain that is most important. The stalks, leaves and immature ears are used as forage for ruminants. Maize grain is recognized as giving the highest conversion of dry matter into meat, milk and eggs in relation to other cereal grains. It is used extensively as the main source of calories in the feeding of poultry, pigs and cattle. Maize provides more feed for livestock than any other cereal grain. Maize is the preferred grain for feeding domestic animals, because its dietary energy value is the highest among cereals. Maize grain has a digestible energy content of 3.75–4.17 kcal/g. For chicken and pigs, the metabolisable energy values recorded when maize was fed were 3.6 and 3.8 kcal/g and corresponding gross energy digestibilities were 86% in chickens and 92% in pigs. Maize is popular for feeding monogastric animals, particularly poultry.

Quality Maize fodder Production in Hydroponic Green House:

Fresh Green fodder is an important component in the diet of livestock. Due to droughts, floods and other adverse climatic factors, the production to meet the demand of the fodder has become a challenge among livestock farmers. In recent years, the production of green fodders has decreased affecting livestock production and health. As the demand and supply of the green fodder for livestock is increasing, there is a need for alternative method for fodder production which would ensure fodder production throughout the year for betterment of livestock production (Sailo *et al.*, 2018).

The word hydroponics has been derived from the Greek word. Hydro means 'water' and ponos means 'working' and it is growing of fodder without soil but in water for a maximum of 6 days. The water must be safe for human drinking. You can sprout seeds of barley, maize, oats, wheat or sorghum to obtain fodder for cattle, pigs or poultry.

Benefits of Hydroponics grown fodder:

1. Fodder is produced within a short a time and in a small area.
2. Fodder is completely edible to livestock –they eat the entire mat, roots and green growth. There is no wastage of feed.
3. Water requirement is less (70-80 % less than conventional farming) and can be recycled.
4. Minimal running costs; soil preparation, weed control and post-harvest loss.
5. Minimal incidences of pests and diseases.
6. Temperature control is automated in hydroponic green house.
7. Labour cost is low.
8. Requires less space.
9. Soil is not required for growing fodder.
10. Budgeting is easier than conventional farming.

Current status of green fodder production in the country and the state:

Category	India (Million hectares)
Total geographical area	328.7
Fodder crops	8.3
Green fodder deficit	60 – 65%

Protocol for producing green fodder in Seven days cycle in Hydroponic Green House:

1. Select seeds without overgrowths and free of chemicals
2. Disinfect seeds by soaking in diluted chlorine solution (similar to what is used to disinfect drinking water) for 2 hours to prevent mould/fungus growth.

3. Drain chlorinated water and rinse grains then soak the grains in water for 24 hours to promote water uptake by the grains.
4. For grain sowing, measure 2kg of grains for each tray that measures 80cm by 40cm
5. Spread the grains on the trays evenly (not over 3cm deep) to provide enough space for each seed to sprout.
6. Ensure your tray has holes that are evenly spread at the bottom for proper drainage of water.
7. Transfer the trays to the hydroponic unit. Germination of seeds begins at this point and is considered day 1.
8. Irrigate from day 1 to day 6 at intervals of 4 hours in every 24 hours (30 seconds for automated system and 1 minute for manual system).

Fig. 1: Select good quality maize grain

Fig. 2: Rinse and clean the maize grain with clean water

Fig. 3: Disinfect the grains by adding bio fungicide and soaking for 24 hour

Fig. 4: Measure approx. 750-800 grams of the grain to be kept in each tray

Fig. 5: Spread the grains evenly on the trays

Fig. 6: Cover the trays with a black polythene sheet and keep overnight

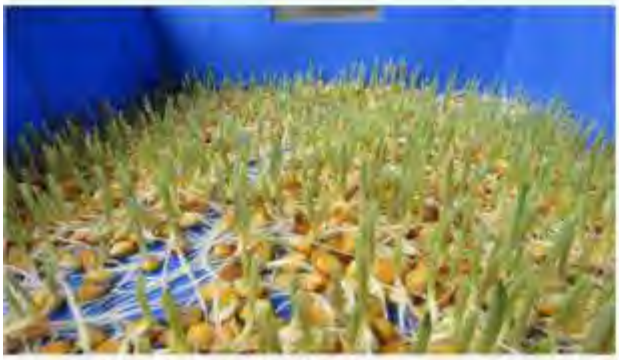

Fig. 7: Two days old Maize fodder

Fig. 8: Fully grown Maize fodder (8 days old)

Fig. 9: Hydroponic grown maize fodder (Single tray)

Fig. 10: Hydroponic grown maize fodder

Fig. 11: Grower pigs relishing hydroponic maize fodder

Fig. 12: Cattle relishing hydroponic maize fodder

Feeding Hydroponics grown fodder to livestock:

Cattle: Provide 8kg of the hydroponic barley to replace 2.5kg dairy meal in addition to hay and silage.

Pigs: At fattening stage provide 3kg of hydroponic fodder and 2kgs of dry feed.

Poultry: For 100 layers provide 8kg of hydroponic fodder in addition to 4kg of layers mash per day.

Nutritional content of Hydroponics grown maize:

Particulars	% on as such basis	% on dry matter basis
Moisture	86.75	-
Crude Protein	1.90	14.35
Crude fibre	1.79	13.54
Ether Extract	0.48	3.64
NFE	8.62	65.08
Ash	0.45	3.39

Hydroponics vs Conventional farming:

Parameters	Hydroponics	Conventional farming
Control on Environment	Effective control	No control
Yield	Predictable	Not predictable
Budgeting	Easier	Not effective
Aeration of Root	Can ensure adequate aeration of root zone	Cannot ensure
Pest and Diseases	Controlled	Not controlled
Temperature & Humidity	Automated	Not automated
Water Recycling	Can be recycled	Cannot be recycled
Labour costs	Low	High
Soil	Not required	Required
Water consumption	Low (70 t0 80 % lower than conventional farming)	High
Space requirement	less space	More space

Low cost Hydroponics Green House:

There was a perception that hydroponics fodder can only be grown under Hi-tech nursery and green houses. However, the unit can be made using low cost locally available materials. The low cost unit can be fabricated with Bamboo and wood, MS or GI pipes and plastic pipes. For irrigation: Micro sprinklers (automatic or manually) or a Knapsack sprayer can be used at regular intervals. The cost of Greenhouse unit (30-350 kg fresh fodder capacity daily) made of shade net and wooden material is approximately Rs. 6000-50,000.00. The cost of Greenhouse unit (150-750 kg fresh fodder capacity daily) made of shade net and MS pipe material is approximately Rs. 25,000-1,50,000.00. Home grown or locally available seeds of maize, wheat etc., can be used in this low cost unit (Naik *et al.*, 2013).

Prospects of Hydroponics grown fodder:

Hydroponics unit can be incorporated in livestock based Integrated Farming Systems (IFS) as:

- ✓ Dairy cattle based IFS Model
- ✓ Piggery based IFS Model
- ✓ Buffalo based IFS Model
- ✓ Goat based IFS Model

There is a huge prospect for low cost hydroponics unit for dairy cattle and goat farmer's as the market cost of concentrated feeds is high. The hydroponics grown fodder can be used as a supplement in the diet of livestock's and poultry during scarcity season to increase the milk production, to minimize the cost of concentrated feeds and to improve the livelihood of small and marginal farmers (Sailo *et al.*, 2017).

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Strategies for Intensification of Maize based Cropping System in North East Indian Region

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Introduction:

Corn is one of the major cereal grains grown in the world, exceeded only by rice and wheat in terms of quantity produced. India is the fifth largest producer of maize in the world, contributing 3% of the global production, though productivity is much lower (2.60 t ha^{-1}) than global productivity (5.6 t ha^{-1}) and other potential maize growing countries like USA (12.08 t ha^{-1}), Canada (10.33 t ha^{-1}), Australia (8.3 t ha^{-1}), Argentina (8.20 t ha^{-1}) and China (6.55 t ha^{-1}) (FAOSTAT, 2016). The North Eastern Hill (NEH) region of India, comprises of eight states (Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura and the hilly tracts of Assam) and covers about 18 million hectare (M ha) area which is ~5.47% of total geographical area of India (329 M ha). In the uplands of Eastern Himalayan Region (EHR) of India, maize is the second most important crop and occupying considerable area. In NEH Region, area under maize cultivation is 0.23 million ha with production 0.37 million tonnes production with a very low productivity 1.47 Mt/ha as compared to average productivity of country. North Eastern Region of India having a wide number of germplasm is considered to be the secondary origin of maize. Since, maize is an essential ingredient for feeds of animal, fish, poultry and cost of feed has soothe up very high, its importance is increasing day by day. Thus, maize is the most important emerging crop in the EHR. The average productivity of maize in Manipur is low with less than 1.5 t/ha as against national average of 2.60 t/ha. Thus, there is an urgent need to address the farmers' requirement for enhancement of their productivity.

In the North Eastern Himalayan Region (NEHR), maize production plays a significant role in ensuring food security and is used both for direct consumption and as well as for second cycle produce in piggery and poultry farming. In NEHR, most of the area is comprises with Terrace and sloppy lands, where, land productivity and resource use efficiency (water and nutrient productivity; other resources and energy efficiency) is very less. The diverse and complex North Eastern Himalayan Region (NEHR) climate allows for *rainfed* cropping, which differed in crop phenology from other part of the country. With the increasing evidence of less seasonal rainfall, terminal heat, frequent occurrence of extreme weather events coupled with intensive rainfall pattern across the region, the resource use efficiency vs. productivity can be analyze utmost. However, successful maize production depends on the appropriate technology and accurate application of production inputs that will sustain the environment as well as agricultural production. The success and level of profit from maize depend on the choice of technologies to be adopted (Ansari *et al.,* 2016; 2017). Spatial and temporal management practices are capable to produce 2 to 3 times more yields with better management practices over farmers practice.

Status of maize production in NEH:

The total maize area and production in north east Indian states contributes about 229.2 thousands ha with 370.2 thousands metric tonnes production with 1.5 t/ha productivity. The highest area comprises by Nagaland 68.5 thousands ha with 134.3 thousands metric tonnes with 1.96 t/ha productivity.

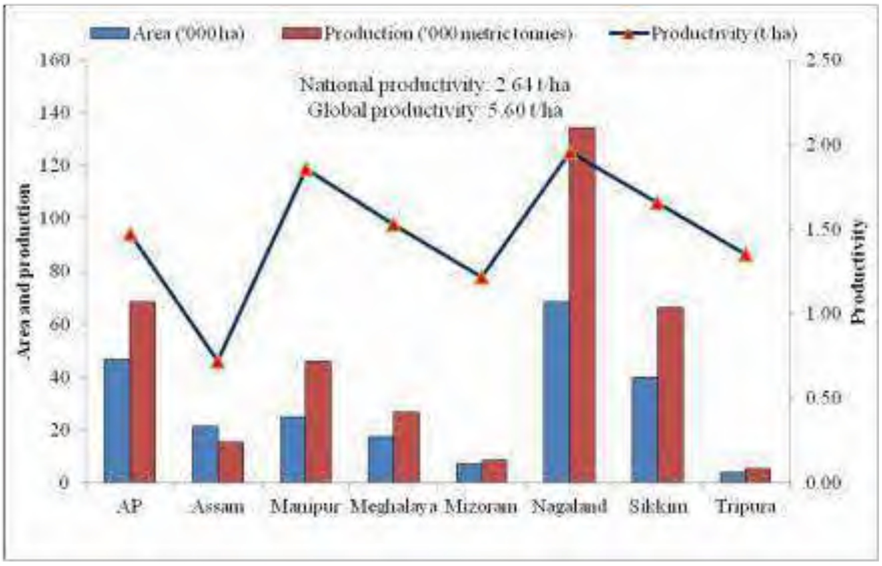

Fig. 1: Maize production statistics in North East Indian states

Strategies for intensification:

A. Horizontal intensification: Cropping system is broadly grouped into sequential cropping and intercropping. It may be a regular rotation of different crops in which the crops follow a definite order of appearance on the land or it may consist of only one crop grown year after year on the same area. To enhance the pulses production, it must be included in cropping system either in sequential (horizontal) or intercropping (vertical). The prominent sequential cropping systems involving different pulses have been discussed crop wise.

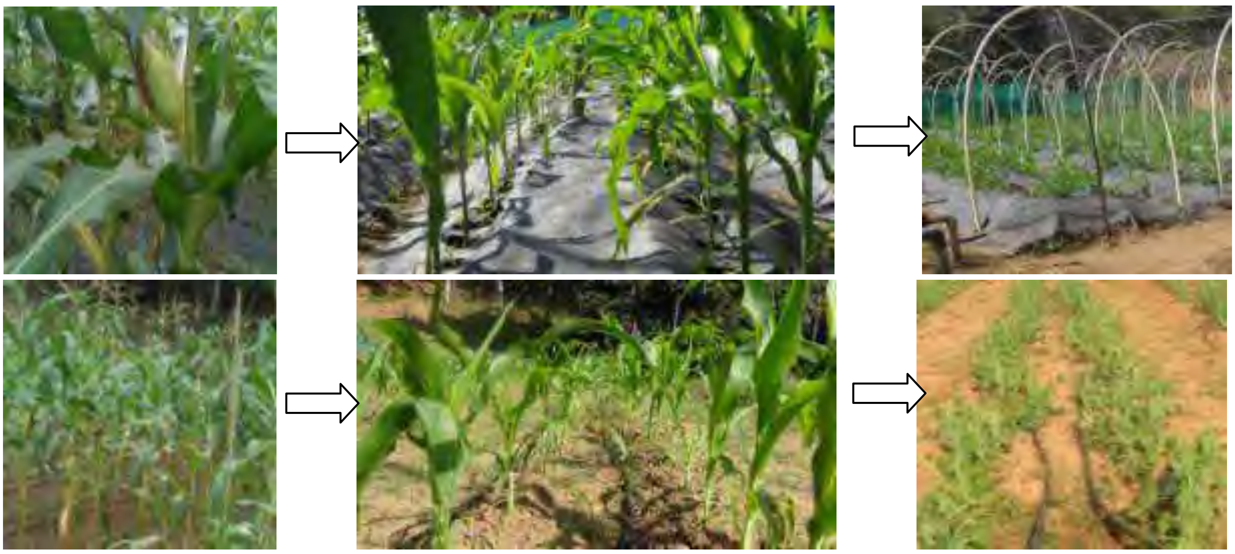

Fig. 2a: Maize (HQPM-5) grown in April- August; sweet corn grown in August- November; vegetable pea (Arkel) grown in November- February under ground cover and open field at ICAR Langol farm (hill) at Imphal, Manipur

Fig. 2b: Maize (HQPM-5) grown in April- August; sweet corn/baby corn grown in August- November; vegetable pea (Arkel) grown in November- February under ground cover and open field at ICAR Lamphel farm (valley) at

1. Maize-sweet corn-pea cropping system: ICAR Research complex for NEH Region, Manipur Centre conducted an experiment on maize based cropping system (maize-sweet corn-pea) with 300% cropping intensity under agro-textiles based ground cover and open field. We observed that 60, 34 and 36 percent higher yield of maize, sweet corn and pea under ground cover crop than open field, respectively. The system productivity in terms of maize was recorded 15.2 tonnes/ha in ground cover as compared to 10.7 tonnes/ha under open field. Under ground cover higher water use efficiency and very less weed infestation were recorded as compared to open field.

2. Maize-baby corn-pea cropping system: ICAR Research complex for NEH Region, Manipur Centre conducted an experiment under collaborative project with ICAR-IIMR, PUA Campus, Ludhiana of “Promoting improved technology of maize production in NEH Region” on maize based cropping system (maize/QPM-1-baby corn/sweet corn- vegetable pea) at ICAR Lamphel with 300% cropping intensity and recorded more than 18 t/ha Maize Equivalent Yield (MEY).

3. Maize- vegetable pea cropping system: ICAR Research complex for NEH Region, Manipur Centre demonstrated the maize-vegetable pea cropping system in collaboration with ICAR-IIMR, PAU Punjab, at farmers field and farmers yield varied from 8 to 11 t/ha MEY.

4. Maize- rapeseed and mustard cropping system: ICAR Research complex for NEH Region, Manipur Centre demonstrated the maize- vegetable pea cropping system in collaboration with ICAR-IIMR, PAU Punjab, at farmers field and farmers’ yield varied from 7 to 10 t/ha MEY.

5. Maize- vegetable cropping system: ICAR Research complex for NEH Region, Manipur Centre demonstrated the maize- vegetable pea cropping system in collaboration with ICAR-IIMR, PAU Punjab, at farmers field and farmers produced more than 14 t/ha MEY.

Fig. 3: Maize- vegetable pea cropping system demonstrated in farmers' field at Kanglatombi (Imphal West, Manipur)

Fig. 4: Maize- rapeseed and mustard cropping system demonstrated in farmers' field at Ukhongshang, (Thoubal, Manipur)

Fig. 5: Maize- cabbage cropping system demonstrated in farmer's field at T. Champhai, (Churachandpur, Manipur)

B. Vertical intensification: In intercropping, the crops are arranged in definite rows. Sowing of both crops may be done simultaneously or in staggered manner. Similarly harvesting time may also differ. Intercropping is an improved system of mixed cropping which ensures desired plant stand, ease in cultural operation, spraying of chemicals and harvesting, and higher returns. The major considerations for intercropping are the contrasting maturities, growth rhythm, height and rooting pattern and variable insect pest and disease associated with component crops so that these complement each other rather than compete for the resources and guard against weather adversities. Growing of crops in intercropping systems is found more productive particularly under *rainfed* conditions. More than 70% area of pulses in India is covered under intercropping systems. Pulses are intercropped with oilseeds, cereals, coarse grains and commercial crops. Maize is the most suitable crops to intercrops with pulses and oilseeds. Intercropping of pulses with maize is more popular in terrace cultivation and mixed cropping of pulses with rice/maize is more popular in *jhum* cultivated areas of Manipur. Maize + rice bean, Maize + soybean, Maize + urdbean/mungbean and are more remunerative in *kharif* season.

ICAR Research complex for NEH Region, Manipur Centre demonstrated the maize based intercropping system on farmer's field in various districts of Manipur. Among the various maize based cropping system, on an average maximum maize equivalent yield was found in maize + groundnut (R) (6.33 t/ha) followed by maize + soybean (A) than maize sole cropping (3.4 t/ha) (Fig. 1). Maize + groundnut (A), maize + greengram (A), maize + urdbean (A), maize + rajma (R), and maize + ricebean (R) were fetched higher economic returns as compared to sole cropping of maize. Based on Minimum Support Price (MSP), as fixed by Govt. of India across the targeted area farmers earned net returns from Rs. 25410 to 60555 per ha from HYVs (after deducting the cost of cultivation) as compared to farmers grown local genotype Chaochujak (1.9 t/ha).

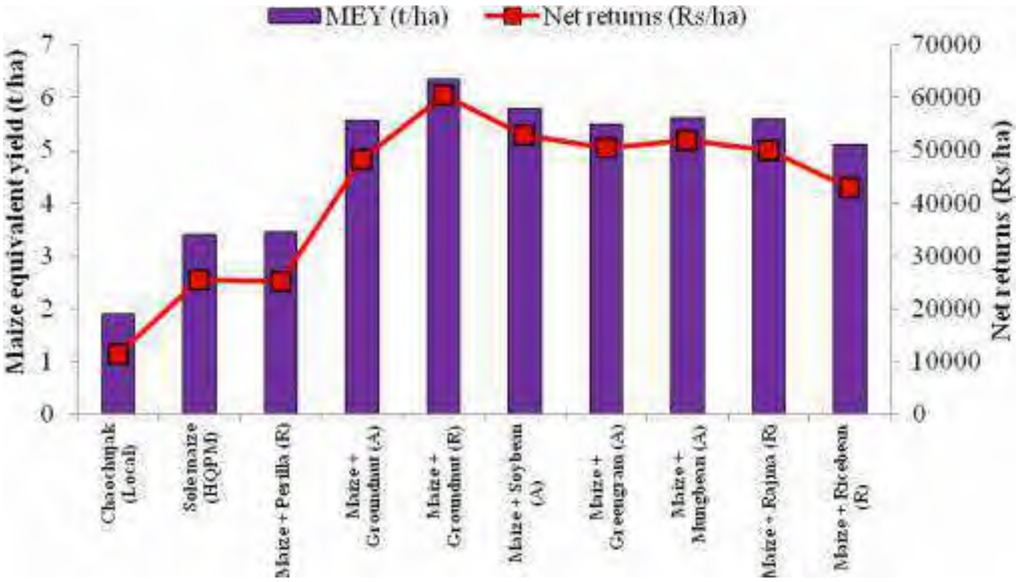

Fig. 6a: Groundnut grown under additive and replacement series with maize at Churachandpur

Fig. 6b: Soybean and ricebean grown under replacement series with maize at Chandel

Other promising maize based intercropping system:

Maize + Soybean intercropping

Maize + Carrot intercropping

Maize + Beans intercropping

Maize + Sunflower intercropping

Maize + Sweet potato intercropping

Maize + Cowpea intercropping

Fig. 7: Other promising maize based intercropping system

Challenges for intensifying the corn based cropping system in NE Indian states:

1. **Establishment of the market linkages-** Being a difficult terrain and the less connection of hinterlands of NEH region warrants the establishment of the seed to marketed product linkages in the value chain. Further, these personnel in entire value chain must/will be from the NEH regions and thus requires intensive trainings on the various aspects of the specialty maize production. These trainings could be the

part of the RKVY projects and NHM projects of this region. Establishments of the seed hubs, baby corn and sweet corn processing and processing plants will add up towards making success of the specialty maize cultivars in NEH regions.

2. **Training to the producers-** The cultivation of these specialty types of the maize is not penetrated in NEH region and hence the farmers are mostly friendly with traditional maize growing.
3. **Trainings to the trainers-** As the baby corn and sweet corn are the specialty type of maize and hence if produced with the normal maize practices could not be remunerative. Hence, intensive class room and on farm trainings of the state government officials and other trainers of the ICAR is need for the proper dissemination of the knowledge about these specialty maize types.
4. **Assured seed supply at affordable prices-** The government of the states can help by establishing the seed villages under the RKVY scheme. The current price of the available seed of the baby corn is Rs. 350 to 550 while for sweet corn it is much higher up to Rs. 2250 to 2500 per kg.
5. **Transportation-** The baby corn and sweet corn being a perishable commodity needs a transport network that is faster to fetch the appropriate prices in the market. In NEH region of difficult terrain this is relatively slow and hence will be a challenge for its wider adaptability amongst the hinterland farmers. However, the areas near cities could go for it easily. For hinterland, the air-conditioned transport system or the processing industries establishment could be a solution where villages of the baby corn and sweet corn could be established like a business module.

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Impact of biochar on maize growth behaviour in North East India

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Introduction:

Rising carbon dioxide (CO_2) concentrations in the atmosphere and consequent concerns about climate change make it imperative to reduce greenhouse gas (GHG) emissions (Lehmann, 2007). However, in today's modern world including NE India, climate change pose a serious threat in agriculture due to its increase in temperature with an unprecedented rate (Houghton, 2001) and has been one of the favorite topics to be debated among scientists, policy makers and organizations. The continuous increase in the atmospheric concentration of greenhouse gases (GHGs) due to anthropogenic emissions can lead to a significant change in climate (Houghton *et al.*, 1996). Around 90% of the soils of NE India are known to be acidic in nature (Sharma and Singh, 2002). Soil acidity lowers the soil physical, chemical and biological properties causing nutrient imbalance for the uptake of plants and thus pose severe impacts on crop production. Presence of threshold level of organic matter in the soil is essential in order to maintain the equilibrium functioning of soil physical, chemical and biological integrity as well as carrying out agricultural production and environmental functions of soil (Izaurralde, 2001). To adequately address the above issues, the scientific communities and several other policy makers pose a challenging task a head in developing efficient strategies and methods to sustain the degrading environments through sustainable approach. Biochar, the solid product of pyrolysis is highly heterogeneous material with chemical composition that varies widely depending on feedstock and pyrolysis conditions (Spokas, 2010). The biochar is a thermo-chemical process where biomass is heated in the absence of oxygen. Bio char is a highly porous substance, and somewhat similar to charcoal in its appearance produced by natural burning. Biochar is sterile, odorless, high carbon solid that may be produced from a variety of organic feedstock which can be tailored to suit the crop, soil type and management system to reach maximum benefit. The longevity of charcoal in soil has led to the suggestion that the production of chars through the pyrolysis of biomass and its incorporation into soils lead to be a feasible method of sequestering carbon (Lehmann *et al.,* 2006). It can play a potential role in sequestering carbon from the atmosphere in the NE hill region where, farmers can adapt “slash and char” instead of “slash and burn” practice. The practice can recover 190-213 Tg of carbon from atmosphere (Srinivasarao *et al.*, 2013) and sequester more than 50% of the C in a highly stable form in the soil. The added advantage of North East region of India having vast expansion of vegetation and unused waste material also provides large scope and opportunity for biochar production.

Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under various agro-climatic conditions. It is the second most important crop in the North Eastern Hill (NEH) region of India after rice and cultivated in an area of about 0.17 m ha in NEH region with productivity of 1.50 tonnes/ha, which is lower than the India's national average productivity of 1.84 tonnes/ha (Layek *et al.*, 2015). In India, majority amount of maize produced (48%) used as poultry feed, while about 28% of maize is used for food purpose. Because of its unique adaptability to wide range of climatic conditions including varied altitudes ranging from low (up to 800m), medium (800-1300m) to high (above 1300 m) and ease of growing as rain fed mono or mixed crop in both the upland and *jhum* land (leaflet ICAR-Umiam) turns it into crop of choice for cultivation in marginal soils of NER region. By virtue of its *rainfed* nature and poor fertility, the hilly regions of NER pre-dominantly practices maize-vegetable cropping systems since many years. However, it is observed that a large part of the arable area after harvesting of maize remain uncultivated and wasted in the NER (Das *et al.*, 2010). This creates window of opportunity for introduction of frenchbean (*Phaseolus Vulgaris* L.) in the maize fallows. Moreover, frenchbean well known for its nutrient richness and profitablility which is mostly grown and consumed in the form of tender pods and shelled green beans having a high demand in the market. Its dry seed contains 21.1% protein, 69.9% carbohydrates, 1.7% fat, 381 mg calcium, 425 mg phosphorous and 12.4 mg iron per 100 g of edible part (Ali and Kushwaha, 1987). Considering the above points, cultivation of frenchbean in the maize fallows under "no till" conditions along with standardized technologies can help in enhancing the farm income, cropping intensity as well as system productivity in the region. This unique crop can also act as tenable cover crop to protect the soil from erosion and physical degradation like aggregate destruction, top soil compaction and surface sealing (Baets *et al*., 2011). As frenchbean is grown after maize under no-till and with residual soil moisture without any addition of irrigation, Biochar can play a significant role in optimum growth of frenchbean through modification and soil properties and water regime. The role of biochar on enhancing soil moisture status can indirectly help in better crop establishment and frenchbean productivity.

Incorporation of biochar in the soil is reported to alter various soil physical properties such as soil structure, pore size distribution etc. and have positive implications for soil aeration, water holding capacity and plant growth (Downie *et al.*, 2009). Therefore, the bio char application can reduce the overall total bulk density of the soil which is generally desirable for most plant growth and increased water holding capacity (Chan and Xu, 2009). The increased in surface area, porosity, and lower bulk density in mineral soil with bio char could be alter water retention, soil aggregation, and decrease. The effect of biochar was positive additions may be on moisture content found in coarse-textured soils (Glaser *et al.*, 2002). Van Zwieten *et al.* (2010) suggest that while biochar may not provide a significant source of plant nutrients but they can improve the nutrient assimilation capability of crops by positively influencing the soil environment. Biochar plays a significant role in improving the soil chemical properties which includes raising of pH, organic carbon and exchangeable cations (Chan and Xu, 2009). Most studies reports increase in soil pH upon biochar additions (Laird *et al.*, 2010) which is very much necessary for North East India where most of the soils re highly acidic. Biochar have high amount on its surfaces and thus helps in retaining nutrients in soil. This negative charge on biochar surfaces can also buffer acidity in the soil. CEC is one of many factors involved in soil fertility. "Cations" are positively charged ions, in this case. Organic matter and some clay soil adsorb these positively charged nutrients like Ca, Mg etc. because they have negatively charged sites on their surfaces, and opposite charges attract each other. The soil can then "exchange" these nutrients with plant roots. Most biochar trials have been done on acidic soils, where biochar with a high pH (e.g. 6 – 10) were used. Adding biochar to soil caused increases in pH which had a detrimental effect on yields, because of micronutrient deficiencies which occur at high pH (>6.0). P is the major limiting elements in the plant in acid soils of North East India and better uptakes of P may lead to a better crop health. Major (2010) found that total nutrient uptake increased with biochar amendments, whereas, Biederman and Harpole (2013) also found a positive increase in tissue P concentration after biochar addition. Burgeon and Tech (2017) concluded that, the increase in total above ground biomass is mainly accredited to increased nutrient availability in soils, which is through the addition of biochar and the pH increase in soil solution. Effect of year after year addition of biochar in the field would allow understanding the effects of and on additional biochar to a soil with already modified physico-chemical and biological activity. Lastly, the behaviour of biochar on the long term is possibly the biggest and most important source of uncertainty in biochar science.

Role of biochar on productivity, nutrient use efficiency and C Sequestration potential of maize based cropping system: a case study from Meghalaya

An experiment on maize-frenchbean cropping system was conducted for consecutive two years in ICAR Research Complex for NEH Region, Umiam, and Meghalaya with different doses of biochar and nutrient management options to know the role of biochar in improving productivity and soil health under acidic soils. Altogether three doses of biochar (0, 2.5 and 5.0 t/ha) and four nutrient management options (100% RDF, 75% RDF, 50% RDF and 75% RDF + 4t FYM/ha. The main objective of the study was to evaluate the role of biochar in improving the soil quality and yield of maize and also to know as biochar can minimize the amount of fertilizer needed for maize growth. After harvest of maize, frenchbean was grown under zero tillage with four levels of fertilizers under residual effect of three biochar levels. As frenchbean is grown after maize under no-till and with residual soil moisture without any addition of irrigation, Biochar can play a significant role in optimum growth of frenchbean through modification and soil properties and water regime. The role of biochar on enhancing soil moisture status can indirectly help in better crop establishment and frenchbean productivity.

Fig. 1: Biochar experiment in ICAR Umiam

Application of biochar significantly increased the grain yield of maize and green pods yield of frenchbean with the increased rate of application over no biochar (Table 1). The maximum maize grain yield (4376 kg ha^{-1}) and frenchbean green pods (5194 kg ha^{-1}) were obtained with the application of biochar at 5.0 t ha^{-1}. In nutrient management practices, integrated approach of 75 per cent NPK and 4 t ha^{-1} FYM recorded higher grain yield in maize. However, in frenchbean, 100 per cent NPK alone produced significantly higher pod yield over other treatments. The kernel weight cob^{-1} was significantly higher among the nutrient management treatments, maximum with the application of 75 per cent NPK and 4 t ha^{-1} FYM (94.9 g) and biochar levels (94.4 g) with the application of 5.0 t ha^{-1} biochar. There was no significant effect on 100 seeds weight in both biochar and nutrient management levels. However, maximum 100 seed weight (29.7 g) was obtained with the application of 75 per cent NPK and 4 t ha^{-1} FYM. The pod length of frenchbean was significantly higher with the application of biochar at 5.0 t ha^{-1}(15.3 cm), and treatments with 100 per cent NPK (14.7 cm).

Table 1. Yield and yield attributes of maize and frenchbean as influenced by different levels of biochar and nutrient management practices.

Treatments	**Maize**			**Frenchbean**	
	Grain yield (kg/ha)	**Kernel wt/cob (g)**	**Seed index (g)**	**Pod Yield (kg/ha)**	**Pod length (cm)**
Biochar dose					
No biochar	2368	82.9	28.0	2765	13.3
2.5 t/ha biochar	3296	87.7	28.4	3890	14.0
5.0 t/ha biochar	4376	94.4	28.5	5194	15.3
Sem ±	**59.4**	**3.08**	**0.77**	**28.20**	**0.11**
CD (*p=0.05*)	**174.3**	**9.04**	**NS**	**82.70**	**0.31**
Nutrient Management					
100% RDF	3570	92.6	28.8	4372.9	14.7
75 % RDF	3272	86.9	27.7	3871.2	14.0
75 % RDF+ 4 t/ha FYM	3631	94.9	29.7	4070.5	14.3
50% RDF	2914	78.9	27.0	3486.5	13.7
Sem ±	**68.6**	**3.56**	**0.89**	**32.56**	**0.12**
CD (p=0.05)	**201**	**10.4**	**NS**	**95.49**	**0.36**

Soil pH is increased with increased rate of application of biochar at 0-15 cm soil depth (Fig. 2). Effect of application of biochar with 5.0 t/ha found higher pH in comparison to other treatments. Soil organic carbon (SOC) at 0-15 cm soil depth was found positively improved with the application of biochar. The highest SOC was observed with biochar application at 5.0 t/ha and was statistically superior over no biochar and biochar application with 2.5 t/ha after two seasons of crop growth (Fig. 3). Soil moisture profile study at 0-15 cm and 15-30 cm depth showed higher soil moisture content under biochar applied with 5.0 t/ha as compared to application of biochar at 2.5 t/ha and no biochar application in both the layers of soil.

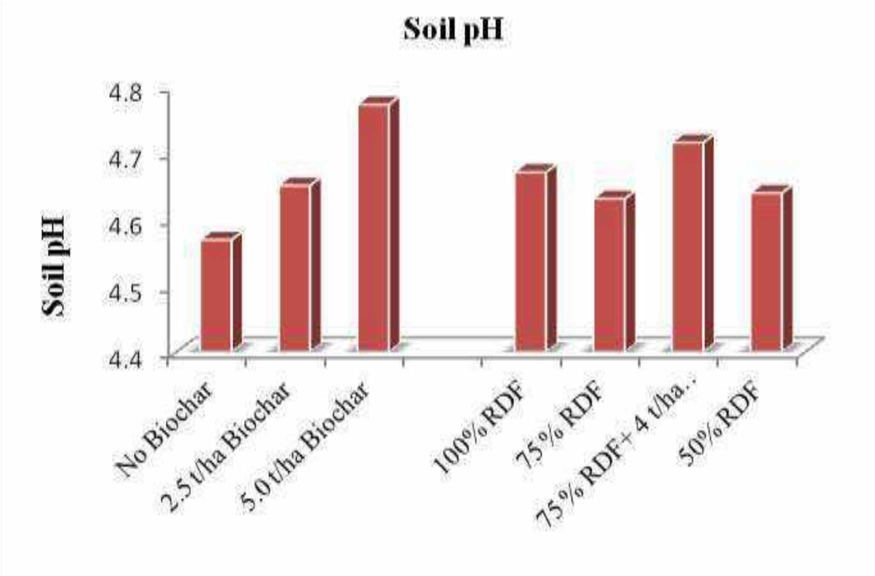

Fig. 2: Soil pH as influenced by different levels of biochar and nutrient management practices (0-15 cm soil depth**)**

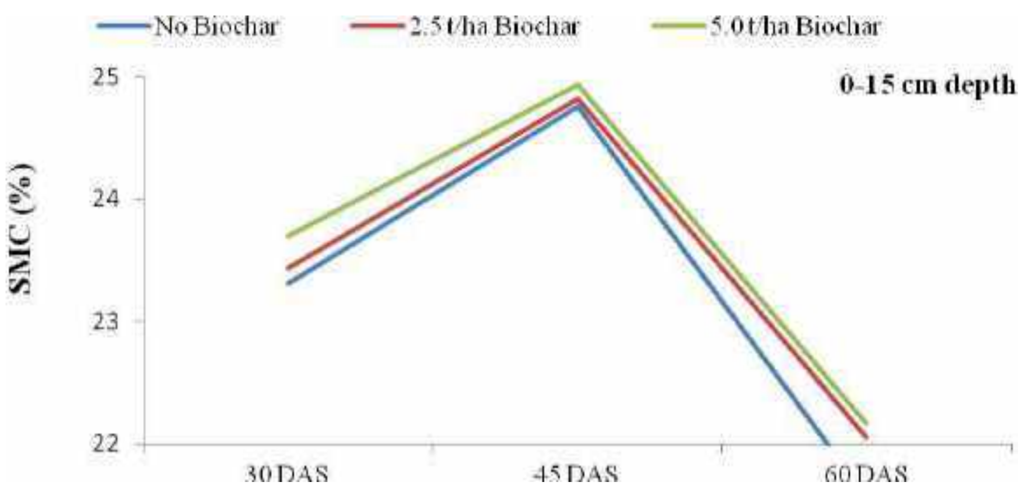

Fig. 3: Soil moisture content in soil profile at 0-15 cm and 15-30 cm depth

Another field experiment is being conducted in rice and maize based cropping systems to study the impact of biochar on various soil physical and hydrological properties, soil carbon stock,

Fig. 4: Application of Biochar in soil

Fig. 5: Maize crop under Biochar

liming potential and GHG emission. Biochar has been prepared from weed biomass, maize stalk and pine wood in biochar unit of the Institute and applied in soil as per treatments. Maize-frenchbean and rice-toria cropping was followed for different source and doses of biochar treatments. Characterization of bio char has been done in Scanning electron microscope (SEM) and Transmission electron microscopy (TEM) for Surface area and pore size analysis, particle size etc. Biometric observations like, plant growth, Physiological characters (chlorophyll content, photosynthetic rate, transpiration rate, leaf area index, transpiration rate etc.) and yield attributes were taken for all the crops. GHG gas emission studies undertaken for all the crops under different biochar treatments periodically. The yield of maize and frenchbean was recorded to be higher in biochar treated plot as compared to no biochar plots. This is mainly due to improved soil properties and moisture holding capacity of soil positively impacted by biochar application

Fig. 6: PP system reading in maize

Conclusion: It can be concluded that biochar can potentially improve soil properties and growth and productivity of maize and succeeding crops in the hilly region of NE India in addition to mitigating climate change through carbon sequestration. However, suitability of biochar type and dose for specific crop like maize need to be identified before application.

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Diversity of Landraces Maize in Mizoram: Prospect, Challenges and Opportunities

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Introduction:

Mizoram is a mountainous region situated in *Lushai* hill ranges which is sandwiched between Myanmar in the east and south and Bangladesh in the west, Mizoram occupies an area of great strategic importance in the north-eastern corner of India. It has a total of 630 miles boundary with Myanmar and Bangladesh. The hills are very steep and are separated by rivers (*Tlawng, Tlua, Kalodyne, Tuirial*, *Serluii* etc.) which flow either to the north or the south creating deep gorges between the hill ranges. The average height of the hills is about 900 metres. Mizoram has a pleasant climate throughout the year, generally cool in summer and not very cold in winter. During winter, the temperature varies from 11^{o}C to 21^{o}C and in the summer it varies between 20^{o}C to 29^{o}C. The entire area is under the direct influence of the monsoon. It rains heavily from May to September and the average rainfall in Aizawl is 208 cm. Mizoram has great natural beauty and endless variety of landscape and is very rich in flora and fauna.

Fig. 1: MZM-31 (IC-611490): a multi cob bearing maize of Mizoram (5 dark red cobs at maturity stage)

Maize (*Zea mays* L.) (locally known as *Vaimim*) is the 2nd most important cereal crop after rice in Mizoram and is grown in varied agro ecosystems as sole crop or in combination with other crops and trees. About 9005.00 ha land (Statistical abstract 2011-2012, Directorate of Agriculture –CH, Aizawl, Mizoram) is reported to have been brought under maize cultivation in the state of Mizoram during the year 2011-2012. In the world, Maize is the third most important cereal grown after wheat and rice is known as the 'king of grain crops' (Anon, 2006). The level of production is somewhat moderate in Mizoram and it needs to be substantially increased to meet the growing demand for human food, animal and poultry feed. Many landraces grew well during rainy (*kharif*), winter (*rabi*) and summer (*zaid*) crop seasons. Because of its divergent types, it can be grown over a wide range of climatic conditions and can be grown under a wide variety of soil but adapted to well drained mildly alkaline at a soil pH range of 7.5 to 8.5 and requires light (sandy), medium (loamy) and heavy (clay) soil. Maize are the mostly grown in *rainfed* condition and it grows best in range of 600-1500 mm rainfall and is known to susceptible to water logging as well as soil moisture stress throughout its life cycle. *Vaimim* are grown as either sole cropping under *jhum* or with mixed cropping successfully intercropped with paddy, turmeric, ginger, other vegetables (brinjal, chilli, bittergourd, pumpkin, cucumber, melon) and pulses (greengram, blackgram, cowpea) and oilseeds (groundnut, soybean, sesame etc.). Maize is also found to be cultivated under different tree species in agroforestry system *viz.* leucaena, jack fruit, tree bean, etc. at a definite spacing and does not lower the yield than that of pure maize, while intercrop would be a bonus. Cultivation of high-yielding hybrids and improved composites like Shakti-1, RCM-75 and RCM-76 is widely practiced in Mizoram. Recently, cultivation of HQPM for green cobs; single cross hybrids (e.g. Vivek-9, Vivek-21) for grain and for quality feed production has been taken up by government in order to promote commercial diary and pig farming. The crop has manifold uses *viz*. as food, feed, fodder and serves as a source of basic raw materials for a number of industrial products like starch, protein, oil, food sweeteners, alcoholic beverages, cosmetics, bio-fuel etc. (Langade *et. al.*, 2013, Kumari *et al.,* 2015).

Traditional uses of maize:

Maize in Mizoram is widely used in various ways likely as a of human food source, livestock feed, and meagre in industrial processing. As a source of food, it is used in many ways. The sweet and sticky cobs (*Mimbam*) are boiled in hot water along with husk. The green ears are roasted on coals or boiled in water, and are eaten immediately on the cob. Mature dry grains are boiled and eaten whole, preferably mixed with pulses and vegetables, to produce a grain is also soaked and cooked in water, and is then ground to make dough that is converted into a sweet drink or an alcoholic drink by fermentation. *Mimpui*, bigger in cobs size are used for flour or feed preparation in Mizoram. *Puakzo* (popcorn) kernels are subjected to high temperatures of about in a hot plate to make them pop, since popcorn is a popular snack in Mizoram (Ratankumar *et al.,* 2016). Baby ear shoots (baby corn) are also cultivated and harvested when the silk is about to emerge above the leaves, and are used fresh as a soup and salad vegetable. High quality protein maize (HQPM) has also much better protein quality than normal maize, and its nutritional superiority has been repeatedly demonstrated in the diet of infants, small children, and also adults, particularly women (Vasal, 1994). However, this type of corn is not yet a common crop in Mizoram.

The maize plant provides excellent fodder for livestock, particularly from the tasseling stage onwards. Maize whose ears are at the doughy stage of grain development provides the best fodder; at this stage, maize surpasses all other fodder crops in dry matter production and digestible nutrients per hectare. This is also the best stage for preparing maize silage. Stover left after harvesting of the grain is also used as fodder. Maize gives a higher conversion ratio than other grains to produce meat, milk, and eggs. Its high starch and low fibre content make it a highly concentrated source of energy for livestock. Precise statistics on the use of maize for livestock and poultry feed are not available, but government researchers in the livestock industry believe that the largest proportion is used as poultry feed. Industrial processing of maize through wet or dry milling is used industrially to create various food, feed, and industrial products. The wet milling process is used to produce pure starch, sweeteners (e.g. dextrose, fructose, glucose, and syrups), high-protein industrial starch, fibre, ethanol, maize oil, sweet corn milk, and creamed corn. Maize starch is the most important product of the wet milling process, and it is used for numerous food and industrial applications. The dry milling process is used to produce corn meal and other whole maize meals that are rich in bran and germ. Whole kernels are also used in the brewing industry to produce beer and distilled liquors. This industry is the largest consumer of the dry milled products.

Types of Maize in Mizoram:

Many exploration was undertaken during last two decades for collection of local maize from the Mizoram state. Since 1976, in the north-eastern hill (NEH) region intensive collections of

Fig. 2: A *Mizo* farmer preserved the maize cobs for the next season sowing

landraces maize were made by ICAR-NBPGR, New Delhi and diversity from this region comprised 36 per cent of the total collection representing the highest number of accessions (Pandey *et al.*, 2014). Locally, Mizoram maize are mainly classified into three groups based on taste and uses i.e. *Mimban* (Sticky/starchy), *mimpui* (large cob/roasted/feed) and *puakzo* (popcorn type) (Ratankumar *et al.*, 2014). *Jhumia* used to categorised the landarces based on the grain colour like (*sen*-red, *eng*-yellow, *var*-white, *dum*-black, and *tial*-variegated). Sweet corn maize (*Mim thlum*) landraces were also grown in many interior places of Mizoram. Short duration crop/early maize crop are also cultivated in Mizoram like *Liam diak, Tharrang, Mimdum* (Roy *et al.*, 2015). Local maize of Mizoram has tremendous variability in plant type, kernel color, texture, nutrient composition and appearance. Mostly, maize exists in a continuum of plant types ranging from wild relatives and primitive races to more advanced landraces, varieties maintained by farmers for generations, genetically improved cultivars, but professionally bred improved cultivars based on open pollination using many parent lines. The original landraces, including varieties preserved by individual farmers and local varieties, were largely grown by *jhumia*, which generally produce round, hard, and smooth grains. Flint maize also grown usually matures earlier, and dries faster after reaching physiological maturity. It is less prone to damage in the field and during storage. However, its yield is lower than that of dent types. Most of the flint maize grown commercially has a wide range of colors, including yellow, orange, white or cream, green, purple, red, blue, and black.

Fig. 3: Samples from the tribal saved maize landraces in Mizoram

Breeding prospects of maize in north east India:

North eastern part of India is a biodiversity hub for many crops including maize. There are diverse maize germplasm found in these regions. Genetic improvement of local germplasm and its further utilization in various breeding programmes will help a lot in a successful crop improvement programme. There is an ample scope for breeding maize in north- east India. The landraces maize that have been maintained by tribal farmers of Mizoram based on their perception of their own needs, their experience and natural skills have not been subjected to selection and improvement by professional breeders. The breeding prospects include breeding for high yield, quality, waxiness, biotic and abiotic stress etc.

a. *Breeding for high yield through genetic improvement of local germplasm-*

Availability of diverse germplasm is a pre-requisite for undertaking a successful crop improvement programme. Since local germplasm were evolved in balance with the prevalent agro-ecological conditions of the region and, therefore, they are expected to possess better adaptation to regional stresses. Indigenous germplasm can be used to develop populations, heterotic pools and inbreds (Yadav *et al.*, 2015). Such inbreds can be used as parents in development of hybrids, which has potentially enhanced yield than those of local landraces.

b. *Breeding for quality-*

North eastern parts of India have a unique preference for taste and aroma. The local people prefer waxy maize which have high amylopectin content and also aromatic maize. Even though high yielding normal maize hybrids were introduced in these regions, it is not yet popularized for consumption purpose except for animal feed or other purpose. Therefore, taking into consideration the local preference, there is a high need for breeding maize with high amylopectin content for these regions.

c. *Breeding for biotic stress-*

Turcicum leaf blight and Maydis leaf blight are two common diseases prominent in north-east India. Common insect pests of these regions include stem borer, cob borer and aphids. Landraces maize may contain many traits that are not available in the improved varieties developed by professional breeders, for whom yield is the most important trait; in addition, these commercial varieties are most suitable for use in favorable environments where better management and cultivation practices are available. Breeding maize tolerant to these diseases and pests may be very beneficial to the maize growers of these regions. Moreover, local germplasm can be evaluated under artificial inoculation/ infestation to identify resistant sources against these diseases and insect pests. Some local cultivars are excellent sources of genes for disease and insect resistance and for resistance to other stresses.

d. *Breeding for abiotic stress-*

North eastern regions are prone to heavy rainfall (during monsoon months) as well as drought condition (during *rabi* season). Maize is largely grown as *rainfed* crop during rainy season. Maize is also prone to face contingent/ intermittent water logging or drought at critical growth stages and occasionally both within same crop season (Yadav *et al.*, 2015). Diverse germplasm which are well adapted in these regions can be screened and evaluated for tolerance to cold, waterlogging and drought. Mapping of QTL associated with drought and waterlogging can be done and this will provide useful information for marker-assisted selection (MAS) and further genetic studies on maize drought and waterlogging tolerance.

Constraints of maize production in Mizoram:

- **Acid soil-** Mizoram soils are acidic in nature Therefore, suitable cultivars of maize need to be identified. *Jhumia* are using their own saved seed for sowing every each season in Mizoram.
- **Seed replacement-** The seed replacement with improved varieties is need of hour for *jhumia* on time. The farmers in the remote areas do not get seeds and other critical inputs like plant health management, nutrient, weed management inputs etc.
- **Farm mechanization-** Mizoram hills are acute steep in nature, option for farm mechanization is almost impractical and availability of low cost farm machineries and implements for these hilly terrains are still meagre.
- **Hybrid seed-** Apart from the technological stagnation, reluctant of the farmers in adopting new hybrids or high yielding varieties, intervention of biotic and abiotic factors play a major role in limiting the production of maize in north eastern hill region.
- **Lack of linkage with financial institutes-** Majority of the farming community is small and marginal. They do not have access to easy credit from the banking institutions, as a result of which they are compelled to continue with small scale household production system. There is a lack of regulated market and retail chain to sell the produce at a profitable price. The farmers resort to distress sale of their produce.
- **Traditional farming and marginal farmer-** *Jhum*/shifting cultivation of maize is widely predominant in the Mizoram. In Mizoram, maximum areas under maize crop is growing by marginal farmers along with different crops i.e. diversification. This land use pattern which

leads to both land and environmental degradation moreover, productivity in such areas is very low.

- **Value addition of maize-** In spite of having enormous livestock population in Mizoram, value addition of maize crop is not harness like feed, popcorn, flour etc. Good transportation and communication system play a vital role for such development in the state but transport network in the Mizoram is still in a poor shape. Procurement, processing, value addition and storage infrastructure is still considered constraint (Ansari *et al.*, 2015).

Conclusion: Landraces maize of Mizoram may also represent a reservoir of genetic diversity as large as they are considered for sources of traits that are important to farmers for local adaptation, economic stability, and sustainability. There is an increasing appreciation among maize professionals of the need to broaden the search for useful genes and to augment genetic variability to increase the likelihood of sustainable productivity. Since Mizoram has a diverse maize germplasm which are tolerant to biotic and abiotic stress, screening and genetic improvement of these germplasm can be very useful for further breeding program. Local germplasm can be used to develop populations, heterotic pools and inbreds. Molecular breeding tools can be used for mapping of QTL associated with abiotic and biotic stresses. Marker-assisted introgression of desirable gene(s) like *waxy1* gene can be introgressed into the already improved lines for used as parents in hybrid breeding program. Breeding for high nutritional quality maize (lysine, tryptophan and pro- vitamin A) can also be given due focused keeping in view the poor nutritional status of most of the local people. There is an increased research need to conserve traditional genetic resources for future use.

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Organic Farming in North East of India

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Introduction:

The concept of organic farming builds on the idea of the efficient use of locally available resources for generating income and improving environmental quality. It is based on a system-oriented approach and can be a promising option for sustainable agricultural intensification in the tropics, as it may offer several potential benefits (Kilcher 2007, Valkila 2009, Eyhorn *et al*., 2007, Mendez *et al*., 2010) such as: (i) A greater yield stability, especially in risk-prone tropical ecosystems, (ii) higher yields and incomes in traditional farming systems, once they are improved and the adapted technologies are introduced, (iii) an improved soil fertility and long-term sustainability of farming systems, (iv) a reduced dependence of farmers on external inputs, (v) the restoration of degraded or abandoned land, (vi) the access to attractive markets through certified products, and (vii) new partnerships within the whole value chain, as well as a strengthened self-confidence and autonomy of farmers. There may by differing management approaches for organic cultivation under different climates, locations and cropping systems but one thing they all have in common is the desire to develop a method of production capable of generating safe and healthy food and fibre, with minimum or no adverse effects on the environment and resources. Over the years it has been scientifically proven, beyond doubt, that organic farming systems are most productive environment-friendly system of growing crops, promising environmental preservation, protection of variety and species, protecting the soil, keeping the water clean and reducing the impact of agriculture on the atmosphere. The system may not be emphasizing on maximization of yields and profits from one or two particular crops but ensures that the total productivity and benefits (including environmental and resource conservation) from the farm as a whole are far more than the productivity and economic benefits from one single crop. Critics contend that organic farming is associated with low labour productivity and high production risks (Trewavas 2002, Nelson *et al*. 2004), as well as high certification costs for smallholders (Makita 2012), but, the main criticism reflected in the scientific literature is the claim that organic farming is not able to meet the world's growing food demand, as yields are on average 10% to 25% lower than in conventional agriculture (de Ponti *et al*. 2012, Seufert *et al*. 2012). It should however be taken into account, that yield deviations among different crops and regions can be substantial depending on system and site characteristics. In a meta-analysis by Seufert *et al.* (2012) it was shown that yields in organic farming systems with good management practices can nearly match conventional yields, whereas under less favourable conditions or under simple nutrient replacement models they cannot. Results from 8 years of research project at UAS Dharwad show that the organic and integrated systems had comparable yields and superior over the conventional inorganic systems in all crops under study (Babalad 2016). Reganold (2012) pointed out that while making comparisons productivity is not the only goal that must be met in order for agriculture to be considered sustainable: The maintenance or enhancement of soil fertility and biodiversity, while minimizing detrimental effects on the environment and the contribution to the well-being of farmers and their communities are equally important and need to be given due importance while making such comparisons.

Status of organic farming in India:

As on March 2016, India has brought 57.0 lakh ha area under organic certification process, which includes 14.8 lakh ha cultivated agricultural land and 42.2 lakh ha of wild harvest collection area in forests. Reduction in the area during the period from 2009-10 to 2012-13 was attributed to the loss of area under cotton due to introduction of BT cotton. During 2015-16, India exported 2.64 lakh MT of organic products belonging to 135 commodities valuing at US$ 285 million (approximately INR 1900 crore). Domestic market is also growing at an annual growth rate of 15-25%. The major share of exports was oilseeds, cereals and millets and processed foods with a combined share of around 91%. In the oilseeds category, soybean with exports of 1.26 lakh tons during 2015-16 had a share of about 95%. In cereals and millets category, rice, maize, wheat and coarse millets are being exported. In the rice category the quantity of basmati rice exported was around 10300 tons.

Table 1: State-wise area under certification process and state-wise certified organic production available for sale as organic commodities (production excludes quantity sold locally or for home consumption)

Sl. no.	State	Organic Area (ha)	In Conversion area (ha)	Total area (ha)	Total production available for sale
1.	Andhra Pradesh	7710.127	10541.459	18251.586	6565.491
2.	Arunachal Pradesh	221.250	3964.010	4185.26	0
3.	Assam	5092.332	23340.912	28433.244	9543.558
4.	Bihar	0.000	91.700	91.7	0
5.	Chhattisgarh	1930.214	8654.725	10584.939	5847.675
6.	Goa	15377.853	1579.740	16957.593	4815.761
7.	Gujarat	46498.560	30314.504	76813.064	55466.237
8.	Haryana	4469.581	399.467	4869.048	5133.963
9.	Himachal Pradesh	4590.531	8168.594	12759.125	1329.243
10.	Jammu & Kashmir	6599.795	18915.215	25515.01	15784.198
11.	Jharkhand	100.706	30263.027	30363.733	0
12.	Karnataka	26438.320	67525.020	93963.34	280935.789
13.	Kerala	12350.178	13549.217	25899.395	10574.544
14.	Lakshadweep	895.332	0.189	895.521	42.180
15.	Madhya Pradesh	198460.263	263314.463	461774.726	364088.178
16.	Maharashtra	74100.761	124251.528	198352.289	361565.693
17.	Manipur	0.000	251.400	251.4	0
18.	Meghalaya	1410.882	3198.540	4609.422	772.293
19.	Mizoram	0.000	213.800	213.8	906.087
20.	Nagaland	991.660	5195.274	6186.934	40788.120
21.	New Delhi	10.800	12.230	23.03	0
22.	Odisha	38614.932	57282.049	95896.981	0
23.	Pondicherry	0.000	2.835	2.835	0
24.	Punjab	500.398	460.805	961.203	107.300

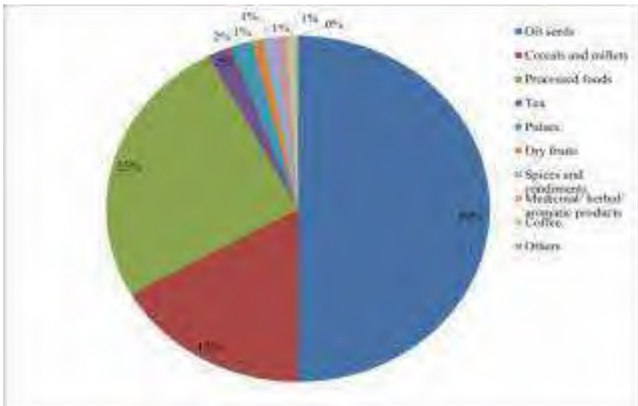
25.	Rajasthan	56106.747	98913.526	155020.273	51629.983
26.	Sikkim	42605.547	33245.664	75851.211	109.263
27.	Tamil Nadu	7773.220	6683.280	14456.5	14392.022
28.	Telangana	2934.651	7420.936	10355.587	796.708
29.	Tripura	203.560	0.000	203.56	309.197
30.	Uttar Pradesh	29972.525	31109.303	61081.828	51399.651
31.	Uttarakhand	20597.850	16623.537	37221.387	20464.387
32.	West Bengal	14728.264	3162.148	17890.412	12411.647
	Total	**621286.839**	**868649.097**	**1489935.936**	**1315779.168**

*(**Source:** APEDA, 2017)*

Table 2: Category wise production (2015-16)

Crop category	Production in tonnes		
	Organic	**In-conversion**	**Total Certified**
Cereals and millets	199448.640	9254.095	208702.735
Dry fruits	8613.647	0.675	8614.322
Fiber crops	156361.635	7248.192	163609.827
Fodder crops	19.527	0	19.527
Fresh Fruits	24636.401	94.513	24730.914
Medicinal/herbal/aromatic plants	34819.252	124.45	34943.702
Ornamental plants/ flowers	1922.938	0	1922.938
Plantation crops	37656.668	2.00	37658.668
Processed foods (wheat)	0	117.200	117.2
Pulses	36438.7299	16.04	36454.7699
Oil seeds/ oil crops	251978.625	0	251978.625
Spices and condiments	22484.636	1494.64	23979.276
Sugar crops and Cocoa	530749.303	1697.00	532446.303
Tuber crops	1471.751	0	1471.751
Vegetables	8692.742	0	8692.742
Others	485.068	1.8	486.868
Total	**1315779.5629**	**3193.44**	**1335830.1679**

*(**Source:** APEDA, 2017)*



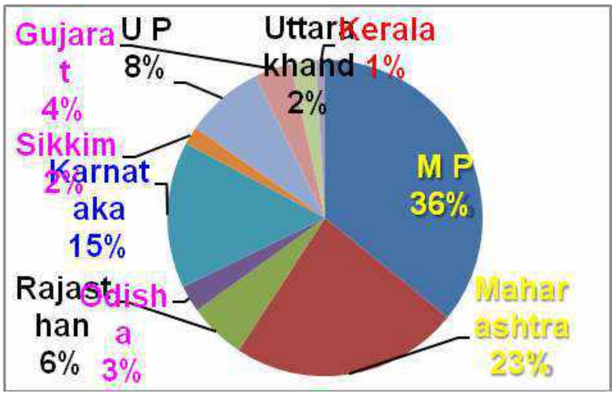


Fig. 1: Category-wise export share of commodities (2015-16)

Fig. 2: Major State players in of Organic Farming in India (% share in area)

As per the survey conducted by ICCOA, Bangalore domestic market during the year 2012-13 was worth INR 600 crore which has now grown to more than 1000 crore during 2014-15. The share of commodities in total organic export in India and organic area share is presented in Fig. 1 and 2.

Organic farming and profitability:

Recently a study was conducted in Maharashtra to study the impact of organic farming on economics of sugarcane cultivation in Maharashtra (Kshirsagar, 2007). The study was based on primary data collected from two districts covering 142 farmers, 72 growing Organic Sugarcane (OS) and 70 growing Inorganic Sugarcane (IS). The study finds that organic cultivation enhances human labour employment by 16.90 per cent and its cost of cultivation was lower by 14.24 per cent than conventional farming. Although the yield from organic was 6.79 per cent lower than the conventional crop, it was more than compensated by the lower cost and price premium received and yield stability observed on organic farms. The organic farming gives 15.63 per cent higher profits and profits were also more stable on organic farms than the conventional farms. Tej Pratap and Vaidya (2009) in a nationwide survey of organic farmers suggest that "The cost-benefit analysis indicates favourable economics of organic farming in India. Farmers in 5 out of 7 states are better placed, so far as organic farming is concerned. The returns are higher in Himachal Pradesh, Uttaranchal, Karnataka, Maharashtra and Rajasthan. In Karnataka organic farmers had 4-35% higher returns than inorganic farmers. In Kerala the differentials ranged between 4-37% in favour of inorganic farmers. In Maharashtra the difference in net profit was more than 100% in case of organic soybean. Organic cotton farmers were enjoying comfortable profit margin. The profit differential in Rajasthan ranged from 12-59% in favour of organic farmers. In Tamil Nadu organic farmers were better placed with two crops, while inorganic farmers were at slight advantage in other two crops. In another study by Ramesh *et al*. 2010, it has been reported that on an average, the productivity of crops in organic farming is although lower by 9.2% compared to conventional farming. There was a reduction in the average cost of cultivation by 11.7% compared to conventional farming. However, due to the availability of premium price (20-40%) for organic produce in most cases, the average net profit was 22.0% higher in organic compared to the conventional farming. In traditional rainfed agriculture (with low external inputs), organic agriculture has shown the potential to increase yields and profits. The economics of organic cotton cultivation over a period of six years indicated that there is a reduction in cost of cultivation and increased gross and net returns compared to conventional cotton cultivation in India.

The north east of India:

The North East (NE) of India comprising of eight states *viz*., Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim lies between 22°05′ and 29°30′ N latitudes and 87°55′ and 97°24′ E longitudes. The region is characterised by diverse agro-climatic and geographical situations. The region has the unique combination of various ecosystems with rich diversity. The region is endowed with a varied topography and agro-climactic conditions which offer vast potential for agriculture, horticulture and forestry. The NE region has been represented in six agro-climatic zones. Out of the total geographic area, about 54.1 per cent area is under forests, 16.6 per cent under crops, and the remaining land either under non-agricultural uses or uncultivated land (Saha *et al.,* 2012). The socio-economy of the NE peoples is mainly rural and agrarian. The population of the NE states is diverse, and comprises various tribal ethnic peoples. The large extent of the communities are continue to depend on the local resources and natural services. More than 70% of population is engaged either directly or indirectly in agriculture and allied sectors. The holding pattern in the region is mainly marginal and small comprising 69.66% of the farming families. The average monthly income is the maximum in Meghalaya (Rs. 11792) while minimum in Tripura (Rs. 5429). Full potential of organic farming in North East India can never be realised, until practiced in clusters or on group basis. Organic (certified/not certified) commodities in North East India are usually in organized markets esp. on highways, road/street vends or through local ferries at low prices. However, other outlets such as supermarkets, hotels, hospitals, restaurants and fast-food chains are fast emerging. These institutional buyers need reliable, regular supply of organic commodities especially vegetables for their menus and scout for suppliers of good quality organic commodities at reasonable better price. However, reliability of supply and logistics are the major problems for most smallholder farmers because individually the requirements of the institutional buyers are difficult to be met. Most of the growers in the North East India are small-scale producers and the producer organizations must collaborate to consolidate the farm products. Small-scale farmers, and the rural communities in which they live, are imprisoned within a “cycle of equilibrium” of low margins, resulting in low risk-taking ability and low investment, which leads to low productivity, low market positioning and low value addition which, in turn, nets low margins. To participate in the emerging markets, the small farmers need to unite and adjust to the new environment to avoid marginalization. One such consolidation effort that may prove to be useful is cluster farming. Cluster farming is simply a concentration of producers, agro-industries, traders and other private and public actors engaged in the same business and building value networks, either formally or informally, when addressing common challenges and pursuing common opportunities. They include, for example, suppliers of specialized inputs, such as organic manures, seeds, and other crop management inputs, machinery, and services, and providers of specialized infrastructure. The soils of North East of India are widely distributed over the hills, mountain and plain land which are highly susceptible and sensitive to landslides. However, in the North East the magnitude of man induced activities is lower than other part of India. The ICAR-National Bureau of Soil Survey and Land Use Planning, Nagpur reported five soil orders among NE states as Inceptisols, Entisols, Alfisols, Ultisols and Mollisols. Land degradation in the region is 36.64% of the total geographical area which is almost double than the national average of 20.17% (Anonymous, 2000). The problem of land degradation is much serious in the states like Manipur, Nagaland, and Sikkim.

The North East of India has vast physiographical variations, which have been represented in six agro-climatic zones. The total geographical area is 262,179 sq km. The net area sown (all NE states) is estimated as 6259 thousand ha. Among the states of NE of India, Assam accounts maximum cultivable area (3357000 ha) while Sikkim has the lowest (77000 ha).

Organic farming with special reference to north eastern hill region of India:

The north eastern hill (NEH) region of India consists of eight states *viz.*, Assam, Nagaland, Mizoram, Meghalaya, Tripura, Manipur, Sikkim and Arunachal Pradesh. Out of 21 agro-ecological zones of the country, four zones are covered exclusively by NEH region. In this region, around 56 per cent of the area is under low altitude (valley or lowland), 33 per cent mid-altitude (flat-upland) and the rest under high altitude (upland terrace) (Das *et al*., 2011). Agriculture production in these areas is still almost on the traditional eco-friendly lines and making the farmers aware of the methods of organic farming may not be very difficult. Most of the upland areas and areas under shifting cultivation (*jhum*) are organic by default. The region wise average fertilizer consumption is around 33.3 kg/ha. Most of chemical fertilizers are used in valley ecosystem but upland ecosystem is free from use of chemical fertilizers. Similarly, the use of pesticides in the region is very low because the farmers are practicing traditional methods for controlling of insect pests and diseases. Bujarbaruah (2004) reported that the region has a potential of about 47 million tonnes of organic manure including 37 million tonnes from animal excreta and 9 million tonnes from crop residues. Moreover, there is profuse production of biomass including weeds, shrubs and herbs due to occurrence of high rainfall (2000 mm to 11000 mm per annum). Some of these species could be efficiently used in organic production. All these make the region suitable to trigger India's second Green Revolution.

Research results of organic farming experiments conducted at ICAR:

Keeping in view, the prospective role of organic farming in mitigating the problems of resource (soil, water, and bio-diversity) degradation and minimize the implications of climate change on agriculture, Indian Council of Agricultural Research took up a research programme on organic farming during 10th Five-Year Plan, by establishing a 'Network Project on Organic Farming (NPOF)', to study some agronomic aspects of organic farming and develop package of practices in arable crops. Analysis of research data from various centres revealed the following:

- ❖ Yield advantage (after 8th cycle across the locations): Basmati rice, soybean, garlic, groundnut, cauliflower, tomato (4-6 %) and green gram, onion, chilli, cabbage, turmeric (7-14 %).
- ❖ Yield reduction (after 8th cycle across the locations): wheat, mustard, lentil, potato, french bean (5-8%).
- ❖ Soil organic carbon increased by 22 % under organic production over inorganic in 6 years.
- ❖ Increase in soil microbes (fungi, bacteria, actinomycetes) was observed.
- ❖ Slight improvement in nutritional quality was observed in soybean, turmeric, and ginger under organic production.

During initial conversion from inorganic conventional management to organic management, there was a decrease in yield but later yield increased has been reported. The per cent change in the yield of major crops over the years is given in Table 4. Integrated organic farming system model involving animal husbandry, poultry, fisheries, etc. along with crops is being developed at Meghalaya and Coimbatore centres under Network Project on Organic Farming. The models could improve the net returns by 3 to 7 times compared to existing systems (Coimbatore: finger millet-cotton-sorghum; Meghalaya: rice-fallow). Higher levels of organic carbon, available nitrogen (N), soluble phosphorus (P) and microbial activity were reported from organic soils than from non-organic soils (Saha, *et al.,* 2007).

Table 3: Mean yield of crops tested in cropping systems under organic input management and yield trend over the years

Crop	No. of observa tions	Mean yield (kg/ha) under organic input management	Yield trend under organic system over the years (%increase (+) or decrease (-) over inorganic input management)						
			1st year	2nd year	3rd year	4th year	5th year	6th Year	7th year
Basmati rice	67	3099	-13	-14	-3	2	2	8	7
Rice	56	3639	-12	-13	5	2	1	2	1
Wheat	56	2952	-15	-9	-7	-3	-7	-13	-4
Maize	55	4541	-5	9	4	0	3	10	16
Green gram	12	905	-	-4	-	-9	3	13	13
Chickpea	25	1269	-10	5	9	3	0	1	5
Soybean	58	1697	1	1	5	0	3	0	12
Cotton	29	1243	8	9	11	12	11	14	12
Garlic	9	7878	-10	-19	8	15	-	-	-
Cauliflower	12	10683	-8	-8	4	2	-	-	-
Tomato	11	20577	-13	-13	-30	-28	35	26	20
Mean			**-6.7**	**-4.8**	**0**	**1**	**8.4**	**5.6**	**9.0**

(http://icar.org.in/files/Base-Paper-Organic-Farming-%20Base-16-03-2015.pdf)

Potential benefits of organic farming:

Benefits of organic farming are manifold (Table 4). Organic farming systems are inherently less risky in all respects than conventional systems. In fact, organic systems tend to be more drought tolerant and organic farms have a larger mix of crops (and often of livestock) than do conventional farms. Both of these features tend to make the economics of organic farms less risky than conventional farms.

Table 4: Benefits of organic farming

Parameter	Potential benefits
Agriculture	Increased diversity, long-term soil fertility, high food quality, reduced pest/disease, self-reliant production system, stable production
Environment	Reduced pollution, reduced dependence on non-renewable resources, negligible soil erosion, wildlife protection, resilient agro-ecosystem, compatibility of production with environment
Social conditions	Improved health, better education, stronger community, reduced rural migration, gender equality, increase employment, good quality work
Economic conditions	Stronger local economy, self-reliant economy, income security, increase returns, reduced cash investment, low risk
Organizational/institutional	Cohesiveness, stability, democratic organizations, enhanced capacity

(**Source**: *Singh, 2009; Stoll, 2002; Crucefix, 1998)*

Risk associated with organic farming-

Some of the risks associated with organic farming are as follows:

1. Risks of contamination of organic crops by genetically modified organisms (GMOs)
2. Shortages of particular inputs such as certified organic seeds and biological pesticides
3. Access to capital, because banks are sometimes unfamiliar with organic production systems
4. Instability of organic price premiums; and
5. Some crops in organic rotations do not benefit from USDA commodity program price and income protection (Hansen *et al.*, 2004).

Organic farming status in north east of India:

The NE of India has tremendous potential in organic farming production. The NE region has the largest number of organic producers with small holdings largely practicing with traditional agriculture which is organic by-default. Sikkim was also traditional agriculture practicing state with crops' grown with low external inputs; however, officially the state was declared organic from 2003 and attained fully organic status by December 2015. For systematic promotion of organic farming, Government of India has initiated programs like National Program for Organic Production (NPOP) and National Project on Organic Farming (NPOF) in project mode different NE states (Anonymous, 2017). Several forms of organic farming are successfully practiced in diverse agro-climates, particularly in rainfed, mountains and hilly and tribal areas of the region (Mitra and Devi, 2016). Many of the forest products of economic importance, such as herbs and medicinal plants are in this category as components of "wild collections". As per the available statistics, the total area under organic certification is 118084 ha (Table 5). The cultivation is not limited to the edible sector but also produces organic cotton fiber, other fiber crops, wild harvest products *etc.*

Table 5: Area under organic certification process (2016-17)

State	Organic area (ha)	In conversion area (ha)	Total farm area (ha)	Wild harvest area (WH) (ha)	Total WH+ Farm
Arunachal Pradesh	21.4	3989.7	4011.2	68300.0	72311.2
Assam	2544.0	21326.3	23870.3	60.0	23930.3
Manipur	0.0	241.4	241.4	0.0	241.4
Meghalaya	1414.8	8214.7	9629.5	0.0	9629.5
Mizoram	0.0	210.0	210.0	0.0	210.0
Nagaland	1508.6	3191.2	4699.9	0.0	4699.9
Sikkim	72145.4	3072.8	75218.2	0.0	75218.2
Tripura	203.5	0.0	203.5	0.0	203.5
Total	**77837.7**	**40246.1**	**118084.0**	**68360.0**	**186444.0**

*(**Source:** Yadav, 2017)*

Prospects of organic farming in North East of India:

There is tremendous scope for organic farming in NE of India, because the use of inorganic fertilizers and chemicals is least in the region. Farming practices remain low input-low yield based and the average yield of most of the crops is far behind national averages. Moreover, the region receives plentiful rainfall leading to profuse biomass production which may be utilized as valuable sources of organic nutrients for sustainable crop production. The region has tremendous potential towards increasing farm income, reducing rural poverty and enhancing food and nutritional security. There is lot of scope for expansion of horticulture crop for yield maximization under organic production systems. A number of horticulture-based industries are also being developed on the product lines such as fruit based alcoholic beverages, ginger processing/dehydration, apple cultivation and processing, processing of citrus fruits, tapioca production unit for production of sago and starch, cold storages, and multipurpose fruit and vegetables processing. Such efforts can change the face of the state and bring economically sound population to the forefront. The region has most of the area under *jhum* land, which can be utilized for cultivation of organic tea, coffee, and medicinal, aromatic and dye plants. These crops have immense potential for employment and income generation which can be an economic boon among the farmers and workers of the state. Similarly, speciality rice and other nutritionally rich minor millets which can also be produced organically on commercial scale for profit maximization. There is also scope for dairy processing and poultry processing in the NER. There is huge demand for dry fish, which processing is not capital intensive. Various underutilised fruits, vegetables and wild harvest can be tapped by setting-up small-scale processing units at the local level which will boost the rural employment.

Organic farming for doubling farmers' income in cluster approach:

Real potential of organic farming in North East of India is not realised due to the resource poor farmers. Majority growers in the North East of India are small-scale; hence, the appropriate size of holding is not available to provide suffcicient surplus amount of produce for marketing proposes in and out of the region. The timely availability of organic input in these areas is also an area of concern for the government agencies and policy planners. Similarly, the oraganic input outlets and their accesibility to the farming community are also lacking in the region. Under such circumstances the government may have to take the responsibility for ensuring the timely availability of inputs. Hence, cluster-based approach may be beneficial for the resource poor small and marginal faremrs to take the advantage of adopting the organic farming for doubling their income in the region.

Organic farming business ideas:

There are still plenty of opportunities for agriculture businesses to profit from the organic farming market. If one is interested in getting involved with this growing niche industry, here are some organic farming business ideas to consider.

1. Organic produce farm-

One of the most popular ways one can get into the organic farming business is to grow organic produce. This is similar to regular produce farming by adopting the National Standards for Organic Production under the NPOP Guidelines, 2014 issued by APEDA, GoI.

2. Organic dairy farm-

Similarly, one may start a dairy farm where natural processes and organic feed for the cows are used.

3. Organic livestock/poultry farm-
Or one could even start a livestock farm where also natural materials and processes are used to raise the livestock and poultry.

4. Organic fish farm-
There's some debate about how can organic fish really be farmed? But one can stay away from pesticides and follow the National Standards for Organic Production for aquaculture under the NPOP Guidelines (2014) issued by APEDA, GoI.

5. Organic grocery wholesaler-
Whether one grows one type of organic food item or has a whole farm, one option for selling those items is to be a wholesaler for large chains like Walmart/Big Bazar *etc*.

6. Organic market-
One could also open up own organic food market or shop where organic items are sold directly to the consumers.

7. Niche organic store-
Another retail type option would be to open up a small shop that focuses on a specific niche like an organic tea and coffee shop or a health food store that sells indigenously inspired options.

8. Roadside farm stand-
If one has a small farm, one can also sell the products directly to consumers with a roadside farm stand that can be set up during busy seasons.

9. Farmers market vending-
There are also plenty of farmers markets around the country that one can rent space from to sell the organic foods.

10. Organic farmers' market-
Or else one could actually organize one's very own farmers market and just work with organic farmers.

11. Organic feed for livestock-
Organic livestock farmers need to use organic animal feed, there's another opportunity for agriculture business to provide that product to farming customers.

12. Herb growing-
If one has a smaller space to work with, one can also grow herbs that are actually high value and in great demand to package for sale to consumers or retail outlets or high-end restaurants/hotels.

13. Organic bath and body products-
Various plants like lavender, aloe vera, jasmine, mint, and Hibiscus can also be grown to use in bath and body products that can then be sold to cosmetic and toiletries industry.

14. Organic canning-
Fruits or vegetables grown organically can create jams, salsas or other products that can be packaged in cans or jars to sell online or in stores again by adopting the NPOP Guidelines (2014) issued by APEDA, GoI.

15. Organic baby food sales-
One can also use the organic produce and process it into packaged baby food to sell to the health conscious parents.

16. Supplement production-

Certain plants like turmeric, ginger, sage, coriander (cilantro), Ocimum, (Holy basil, tulsi) or beets could also be grown that can be processed into organic supplements and packaged for sale at retail outlets or outlets in shopping malls.

17. Natural cleaning products-

Some organic items like lemon juice or olive oil can even be used to create natural cleaning products that appeal to health and eco-conscious families.

18. Organic restaurant wholesaler-

For businesses that want to sell organic foods on wholesale basis, one could actually sell right to restaurants rather than retail stores.

19. Farm to fork restaurant-

Another option would be to grow organic food on a rooftop or nearby farm and then use those organic items in a farm to fork restaurant menu.

20. Organic juice bar-

A variety of organic produce can also be used in juices and smoothies that can be sold at a specialty juice bar.

21. Organic gardening service-

If one is looking to start a service business, gardening services could be offered to people desiring to grow their own vegetables or other plants without the use of synthetics.

22. Organic compost sales-

Composting materials can also be collect and then sold as organic compost to farmers or gardeners that want to use only natural materials.

23. Urban rooftop garden-

One no longer needs acres to start a farm or grow food items. An urban garden could be started on a rooftop or in a small lot and the items are then sold to visitors or nearby business houses.

24. Organic farm consultant-

Finally, if one has enough expertise of organic farming, business can be launched as consultant where other agriculture businesses looking to go organic can be provided with the technological backup.

Conclusions: The real potential of organic farming is yet to be harnessed especially in NE region where most of the farmers'are under small and marginal category (69.66%). Ensuring the timely availability of organic inputs, making clusters of the farmers' based on common interest and proper marketing facilities, encompassing farmers from doorstep can lead to enhanced income which may lay the foundation for doubling the farems' income by 2022. Similarly, the combined efforts of the Central Government and farmers centric schemes with proper implementation through the involvement of the State Governments of NE Region can certainly double the income of the resource poor farmers in the region.

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Innovative Maize-based Cropping System under *Jhum* Improvement with Special Reference to Serchhip District, Mizoram

(Additional income generation through maize cultivation)

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1. **Challenge:** The farmers of Hualtu village under District Agriculture Office, Serchhip district are predominantly engaged in *jhum* cultivation where various types of crops like paddy, maize, pulses, oilseeds, chilies, tobacco etc., are grown as mixed crop in an area of about 2-3 acres of land per individual farmers. The economic needs of the farmers are therefore met through cultivation of various kinds of crops to sustain their livelihood. The farmers of the village have felt that cultivation of various kinds crops in the same area without proper marketing system gradually becoming non- viable and also observed that the cost benefit ratio was sometimes not in their favor. Therefore, the village council members of Hualtu village approached DAO, Serchhip and discussed about suitable alternate crops which will bring them a good return.

2. **Intervention:** After several discussion between the stakeholder and Agriculture Department, it was decided to introduce maize based cropping. System in *jhum* land during *kharif* season. The department conducted training and awareness campaign among the stakeholder and finally decided to grow hybrid maize as a sole crop which will be followed by sowing of soybean as a second crop (relay cropping system) after harvesting of maize crop.

   Finally, 32ha land was made available for cultivation of maize with 80 number of farmers @ 1 acre of land per farmers. DAO Serchhip provided the farmers with 4 (four) quintals of hybrid maize (variety HQPM-5) seeds under the scheme NFSM – coarse cereals (2017-2018). However, for the second crop i.e. soybean, farmers suggested to grow their own local variety seeds (small seeds in size) since the market demand is high where they can sell their harvested crop in the local market @ Rs 100-120/- per kg.

   Maize sees are sown soon after burning of *jhum* land i.e., during the first week of April and the crops are ready for harvest during the last week of July which was followed by sowing of soybean (local) as a succeeding crop. Periodic supervision and visit by Departmental Official encouraged the farmers to adopt maize-based cropping system in *jhum* land during *kharif* season.

3. **Key results**: From 32 ha land, the production of maize is recorded as 480 quintals with an average productivity of 15 quintal per ha. Due to the department initiatives and interventions, there is a ready market for selling of farmers' product @ Rs.18/- kg without the interference of the middlemen. Besides this, the production of soybean (local) is also recorded as 192 quintals with an average productivity of 6 (six) quintal per ha. Farmers are aware that there is a ready market for selling soybean in the local market itself by getting Rs. 100-120/- per kg of soybean.

4. **Impact**: Due to the introductions of maize- based cropping system in *jhum* land during *kharif* season, farmers get dual benefits and doubling their income by selling of maize as well as soybean with a reasonable price. The adoption of maize - based cropping system gradually increases the level of income of farmers which will ultimately stabilize the savings of farmers. The success story of this initiatives have a great impact on the farmer's communities. The Department projected in collaboration with the concerned village councils, to covered 11 (eleven) villages to introduced Maize – soybean or Maize - arhar based cropping system in *jhum* land this *kharif* season under different schemes like NFSM - Coarse Cereals, NFSM-Oilseeds and NEDP (State Plan Fund).

5. **Lesson learned:** If extension machinery delivers effectively, farmers can be easily motivated to adopt maize - based cropping system from traditional method of mixed cropping system or choice of variety. Adoption of maize - based cropping system will pave a new road towards self-sufficiency and sustainability. Collectivizing the farmers' products and direct sale of the farmers produce will also help the farmers to increase in income levels, thereby reducing the burden of marketing on the farmers.

Clearing of *jhum* land for maize

Maize cultivation on *jhum*

Maize cultivation on *jhum*

Harvested dry cob of maize

Harvested dry cob of maize

Harvested dry cob of maize

Harvested dry cob of maize

Harvested dry cob of maize

Drying of maize grain

Mini maize sheller

Maize grain

Grinding of maize grain

Soybean in *jhum* after maize

Soybean in *jhum* after maize

Impact of Different Vegetables Crops Intercropping on Sweet Corn Yield at Farmers field at Aizawl District, Mizoram

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Introduction:

Mizoram has an unprecedented topographical feature with tough hilly terrain. Further heavy rainfall during monsoon and severe scarcity of water during off monsoon season, a dual affect of water has greatly impounded an immense effect on the declining cultivable agricultural land. In a dire need to increase and uplift the agricultural food grain and vegetable production, a judiciously designed intercropping system of practices can be introduced in the region. Intercropping practices allows growing of two or more crops in a specific area of cultivable land in specified time. It also provides stability in the soil fertility, mitigates soil erosion and arrest spread of weeds. Therefore, it is essential to introduce and propagate wide adoption of intercropping system in the region. Maize (*Zea mays*) is one of the most vital cereal crops that contribute as a food security and socio economic capsule for many developing countries around the globe. In India, being the third most important crop after rice and wheat, it gives high biological yield as well as grain yield relatively in a short period of time because of its unique photosynthetic mechanism as C_4 plant (Hatch and Slack, 1996). Sweet corn is known as sugar corn is hybridize version of maize specifically breed to increase the sugar content (Chuadhary *et. al.*, 2018). Maize as wider spaced plant offers some component crops to grow together without economic loss sacrificing small maize yield with greater total production in respect of land and time. This practice offers considerable yield advantages and higher economic return over sole intercropping because of its efficient utilization of growth resources (Faruque *et al.*, 1996). Sweet corn is a highly remunerative successfully cultivated in peri-urban agriculture. However, instead of cultivating sweet corn as sole crop it may be intercropped with other highly remunerative crops like vegetables, flower crops etc. This provides additional income to the farmers from unit area and makes agriculture more sustainable. Sweet corn (*Zea mays* saccharata L.) is as hybridized version of maize as to increase the sugar content may also be introduced coupling with vegetable crops like pumpkin, broccoli, etc. that is prevailing in the region. Considering the above entities discussed herein, in the present study attempt has been made as to find out a suitable intensive multiple vegetable cropping pattern under the umbrella of intercropping practices for Aizawl district in Mizoram, NEH Region of India.

Material and methods:

The present study was conducted at farmers filed at three different villages namely Sihphir Mual Veng, Venghlun and Sairang of Aizawl district in Mizoram during the *rabi* season 2017-18. The seed and others critical inputs were provided by the ICAR-RC for NEH Region Kolasib, Mizoram. The soil samples for the fields were collected and tested at soil laboratory, Krishi Vigyan Kendra Aizawl, C.V.Sc. & A. H., Central Agricultural University (I), Selesih, Mizoram. The experiment consisted under intercropping system with most prevailed and highly preferred vegetables of this region namely, i) sweet corn + broccoli ii) sweet corn + pumpkin, iii) sweet corn sole iv) broccoli sole v) pumpkin sole. The variety hybrid sweet cornSV6881SN, Fantancy, local were used for sweet corn, broccoli and pumpkin respectively. All vegetables were sown/planted in lines in between the sweet corn row with maintain the standard spacing of the respective vegetables.

Result and discussion:

A comparison of yield performance between intercropping practices and sole crops is shown in Table 1. Results indicated that, the sweet corn intercropping with broccoli practices recorded (33+164) identical yield when compared to sole practices which were (40+179) recorded highest. The results of economic analysis of broccoli production revealed that mean cost of cultivation increased in intercropping practices as compared to sole shown in Table 2 and it was recorded highest mean gross return (Rs. 575000 /ha) and mean net returns (Rs. 440000 /ha) with sweet corn and broccoli whereas among sole practice the highest mean gross returns (Rs 447500 /ha) and net returns (Rs 337500 /ha) were recorded with broccoli crops.

Table 1: Intercrop yield and sweet corn yield

Treatments	**Yield (Q/ha)**	
	Intercrop yield	**Sweet corn Yield**
Sweet corn + broccoli	164	33
Sweet corn + pumpkin	169	24
Sweet corn sole	-	40
Broccoli sole	179	-
Pumpkin sole	175	-

Total 2: Cost, gross income, net income and B: C ratio of sweet corn +intercropping system

Treatments	**Total cost (Rs./ha)**	**Gross income (Rs./ha)**	**Net return (Rs./ha)**	**B: C ratio**
Sweet Corn + broccoli	1, 35,000	575000	440000	3.2
Sweet Corn + pumpkin	75,000	2,89,000	214000	2.8
Sweet corn sole	80,000	2,00,000	1,25,000	1.4
Broccoli sole	1,10,000	447500	337500	3.0
Pumpkin sole	50000	170000	120000	2.4

Conclusion: The study concluded that the intercropping is an effective tool for increasing the production and productivity of sweet corn and changing the knowledge, attitude and skill of the farmers. This has not only resulted in socio-economic security but also helped in attaining food and nutrition security to the community. This will subsequently increase the income as well as the livelihood of the farming community. The benefit cost (B: C) ratio in yield of sweet corn + broccoli intercropping was highest (~ 3.2) compare among alone and its combination. The intercropping demonstration over the sole practice created greater awareness and motivated the other farmers to adopt the improved cropping system of sweet corn + broccoli. The concept of demonstration may be applied to all farmer categories including progressive farmers for speedy and wider dissemination of the recommended practices to other members of the farming community.

Acknowledgement:

The authors are thankful to the Joint Director and Scientists from ICAR-RC NEH Region, Mizoram Centre (Kolasib) for providing all critical inputs and guidance assistance towards conducting this demonstration.

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Fig. 1: Sweet corn intercropping with

Fig. 2: Sweet corn intercropping with

Fig. 3: Sole crop of sweet corn

Fig. 4: Sweet corn intercropping with

भारतीयकृषिअनुसंधानपरिषद
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Agresearch with a human touch

National Workshop on Scientific Maize Cultivation in North East India

Jointly Organized by
ICAR Research Complex for NEH Region, Mizoram centre, Kolasib-796081
in collaboration with
ICAR-Indian Institute of Maize Research, PAU Campus, Ludhiana, Punjab-141004
and
Directorate of Agriculture (Research & Extension), Government of Mizoram, Aizawl -796001

Date: 05th March, 2019

Venue: SAMETI training hall, Aizawl

Inaugural Session	
9:30 to 10:00 a.m.	Registration of the delegates
10: 00 to 11:30 am	**Inaugural session:** **Chief Guest: Pu C. Lalrinsanga (Cabinet Minister, Agriculture Dept., Irrigation & Water Resources and Co-operation Department)** **Guest of honor: Pu Lalhmingthanga (Commissioner and Secretary, Agril. & RD Department)**
10:00– 10:05 a.m.	• Entry of Chief Guest, Guest of Honor and all the dignitaries • ICAR theme song • Felicitation of the guests
10:05– 10: 15a.m.	Welcome and introductoryspeech by Dr. N Prakash(Director, ICAR Research Complex for NEH region, Umiam)
10:15- 10:20a.m.	Greeting and release of publications
10:20-10.30a.m.	Speech from Director ICAR-IIMR
10.30-10.40a.m.	Speech from Director of Agriculture (R & E), Govt. of Mizoram
10:40-11:00 a.m.	Speech from Guest of Honor
11:00 -11:25 a.m.	Speech from Chief Guest
11:25 -11.30 a. m.	Vote of Thanks by Dr. I. Shakuntala (Joint Director, ICAR Kolasib)
11:30 – 11:45 a.m.	**High tea**

Technical Session: **Chairman: Dr. N. Prakash (Director, ICAR Research Complex for NEH region, Umiam)** **Co-Chairman: Dr. H. Saithantluanga (Directorate of Agriculture, Govt. of Mizoram)** **Rapporteurs:** Dr. S.L. Jat (Scientist, ICAR-IIMR) Dr. Mukesh Choudhary(Scientist, ICAR-IIMR) Dr. M.A. Ansari (Scientist, ICAR- NEH-Manipur Centre)	
11:45 a.m.–12:00p.m.	Quality seed production of maize in Mizoram Speaker: Dr. Mukesh Choudhary(Scientist, ICAR-IIMR)
12:00– 12:30 p.m.	Baby corn and sweet corn production technologies for Mizoram Post-harvest processing and fodder from maize Speaker: Dr. S.L.Jat (Scientist, ICAR-IIMR)
12:30– 12:45 p.m.	Resource conservation technologies suitable for maize based cropping systems in NE India Speaker: Dr. G.S. Yadav (Scientist, ICAR- NEH-Tripura Centre)
12:45 – 01:00 p.m.	Evaluation of Maize landraces for their yield production potential in Mizoram Speaker: Dr. M.A. Ansari (Scientist, ICAR- NEH-ManipurCentre)
01:00–01:15 p.m.	Organic maize production in NE India – prospects and potentials Speaker: Dr.Subhash Babu (Scientist, ICAR- NEH-Umiam)
01:15 -01:30 p.m.	Fodder maize production in hydroponics Speaker: Dr. Blessa Sailo (Scientist, ICAR- NEH-Manipur Centre)
01.30 -02.30 p.m.	**Lunch**
02:30– 02:45 p.m.	Evaluation of nutrient management on three major maize landrace characteristics of Mizoram Speaker: Dr. Lungmuana (Scientist, ICAR- NEH-Mizoram Centre)
02:45 – 03:00 p.m.	Diversity of maize landraces in Mizoram Speaker: Dr. A.R. Singh (Scientist, ICAR- NEH-Umiam)
03.00 -03:15 p.m.	Current status of maize cultivation in Mizoram with special reference to Serchhip District Speaker: K. Laltlanmawia, SDAO, Serchhip district (Mizoram)
03:15 -.03:30 p.m.	Impact of Different Vegetables Crops Intercropping on Sweet Corn Yield at Farmers field at Aizawl District, Mizoram Speaker: Lalvensanga Pachuau, Farm Manager (CAU- Seilesh)
03:30 - 03:45 p.m.	Presentation from NEIDA (TATA Trust and Department of Animal Vety., Govt. Mizoram)
03:45– 04:00 p.m.	Presentation on maize silage production- A success story (IMA dairy) from Manipur
04: 00-04:30 p.m.	**Valedictory session**
04.30 -05.30 p.m.	**Project meeting**

ORGANISING COMMITTEE

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