वार्षिक प्रतिवेदन
Annual Report
2021

भा.कृ.अनु.प.-भारतीय मक्का अनुसंधान संस्थान
पी.ए.यू. परिसर, लुधियाना - 141004 (भारत)

ICAR-Indian Institute of Maize Research
PAU Campus, Ludhiana-141004 (India)

Nurturing diversity, resilience, livelihood & industrial inputs

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Punjab Agricultural University Campus,
Ludhiana - 141004 (INDIA)

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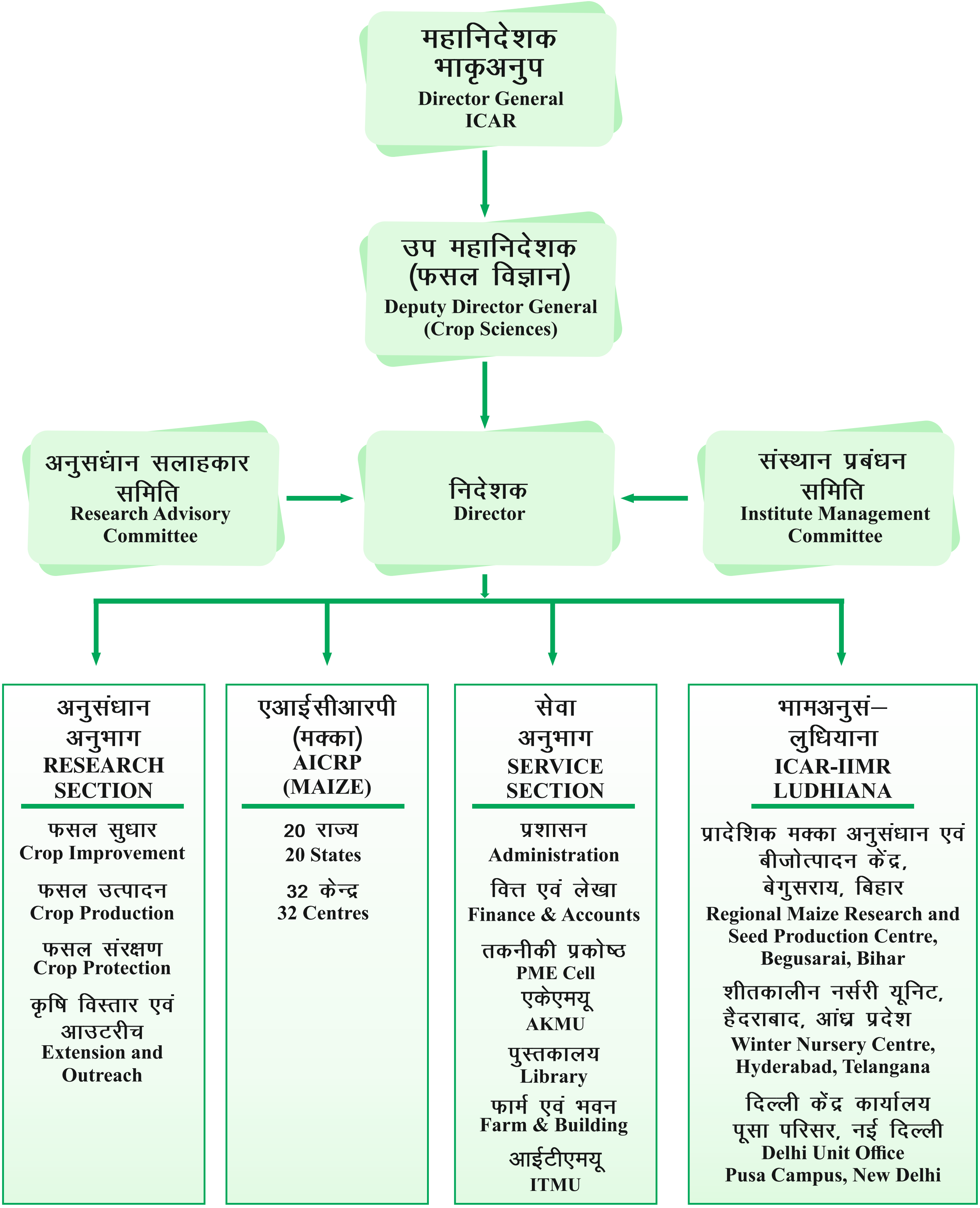


प्रस्तावना

भाकृअनुप–भारतीय मक्का अनुसंधान संस्थान (ICAR-IIMR) जिसका उद्भव अखिल भारतीय समन्वित मक्का अनुसंधान परियोजना (AICRP) से हुआ है, जोकि भारत में सबसे पुरानी समन्वित फसल सुधार अनुसंधान परियोजना हैं जो देशभर में फैले अखिल भारतीय समन्वित अनुसंधान परियोजना केन्द्रों के माध्यम से सम्पूर्ण राष्ट्र के लिए मक्का अनुसंधान एवं विकास से जुड़े मुद्दों को संबोधित करने वाला एकमात्र राष्ट्रीय संस्थान हैं मक्का अनुसंधान का प्रमुख ध्यान उपज के लिए मक्का का आनुवंशिक वृद्दि करने पर निरन्तर बना रहा हैं इसका ज्वलंत उदाहरण है कि जहां वर्ष 1950–51 में भारत में मक्का उत्पादन केवल 1.73 मिलियन टन था जो कि वर्ष 2020.21 में बढ़कर 31ण्65 मिलियन टन तक पहुंच गया हैं इसमें मक्का के एकल क्रास संकरों के रकबे और उत्पादकता में वृद्धि के साथ बेहतर फसल उत्पादन प्रथाओं का योगदान हैं यह गर्व की बात है कि दो गुणवत्ता वाले प्रोटीन मक्का (क्यूपीएम) संकर (आईक्यूएमएच 202 और आईक्यूएमएच 203) जिनकी पहचान 20–22 अप्रैल, 2020 के दौरान 64वीं वार्षिक मक्का कार्यशाला के दौरान की गई थी, को 1 जनवरी, 2021 को राजपत्र अधिसूचना के माध्यम से अधिसूचित किया गया थां इसके अलावा, मक्का के टरसिकम लीफ ब्लाइट (टीएलबी) रोग के विरूद्ध प्रतिरोध के स्रोत के रूप में चार मक्का इनब्रेड लाइनों, आईएमएल 11, आईएमएल 12, आईएमएल 13 और आईएमएल 21 को एनबीपीजीआर, नई दिल्ली में पंजीकृत किया गयां संस्थान बीज उत्पादन श्रृंखला के व्यावसायीकरण और सुदृढ़ीकरण के लिए लगातार प्रयास कर रहा हैं 19 समझौता ज्ञापनों के माध्यम से अब तक सात संकरों का व्यावसायीकरण किया जा चुका हैं वर्ष 2021 के दौरान 9 समझौता ज्ञापनों पर हस्ताक्षर किए गए हैं

उपज एवं तनाव अनुकूलनता के लिए मक्का फसल के आनुवंशिक आधार में सुधार लाने के प्रयास तेज करने की दिशा में संकरण के माध्यम से नवीन विभिन्नताओं को शामिल करके और उनका सृजन करके जननद्रव्य आधार को व्यापक बनाया गया हैं संस्थान ने बेगूसराय में सर्दियों के मौसम 2020 के दौरान मानव रहित हवाई वाहन का उपयोग करते हुए राष्ट्रीय जीन बैंक (एनजीबी) में संरक्षित सभी मक्का जर्मप्लाज्म (11,674) के उच्च–थ्रूपुट डिजिटल लक्षण वर्णन द्वारा फसल सुधार में कृत्रिम बुद्धिमत्ता को पेश करने के लिए एक बड़ा कदम उठाया हैं उपज एवं पोषणिक गुणवत्ता में सुधार लाने के अलावा, हालिया वर्षों में औद्योगिक जरूरतों के अनुसार उच्च एमॉयलोज मक्का का विकास जैसे सुधार किए जा रहे हैं पुनः उपज आधार को गहराई से समझने के लिए उन्नत टूल्स एवं प्रौद्योगिकियों के माध्यम से गुणवत्ता एवं तनाव अनुकूलनता को संबोधित किया जा रहा हैं जैव प्रौद्योगिकी अनुप्रयोगों के माध्यम से फसल सुधार कार्यक्रम को बढ़ावा देने के लिए, इस अवधि के दौरान परिपक्व बीज–व्युत्पन्न नोडल अन्वेषकों का उपयोग करके उष्णकटिबंधीय मक्का के लिए एक ठोस इन विट्रो पुनर्जनन और रूपांतरण प्रोटोकॉल विकसित और प्रकाशित किया गयां

हालांकि, भारत की 3.0 टन/हेक्टेयर उत्पादकता का स्तर 5.6 टन/हेक्टेयर के वैश्विक औसत से बहुत कम हैं भारत में इस उत्पादकता अन्तराल में बारानी वातावरण जहां मक्का उत्पादन के कृषि रकबे का लगभग चौथाई–पांचवां भाग आता है, की मौसम संबंधी अनियमितताओं का व्यापक योगदान हैं इस वास्तविकता से पोषक तत्व उपयोग प्रभावशीलता के लिए आनुवंशिक बढ़ोतरी, कीट, रोग, तापमान और नमी तनाव के प्रति सहिष्णुता, भूजल की कमी के प्रबंधन के लिए फसल विविधीकरण, सेंसर–निर्देशित नाइट्रोजन प्रबंधन जैसी सटीक संरक्षण कृषि प्रथाओं आदि के विकास से जलवायु स्मार्ट मक्का प्रौद्योगिकियों की शुरूआत करने को बढ़ावा मिलता हैं वर्ष के दौरान ऐसी प्रौद्योगिकियों पर की गई प्रगति से देश के विभिन्न भौगोलिक तथा जलवायु क्षेत्रों में फसल सघनीकरण और व्यापक अनुकूलनता में मदद मिलेगीं

वर्ष 1950 के दशक के दौरान अपनी प्रारंभिक अवस्था में इस परियोजना के अंतर्गत, मक्का की पारंपरिक अथवा किसानों द्वारा तैयार की गईं किस्मों में सुधार करने से लेकर वर्तमान में जैव– संवर्धित किस्मों सहित सामान्य तथा विशिष्ट मक्का एकल क्रास संकर किस्मों का विमोचन करने में संस्थान द्वारा 64 वर्षों से भी अधिक समय से राष्ट्र सेवा की जा रही है

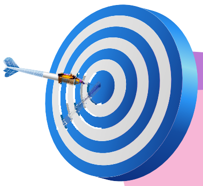
हितधारकों तक प्रमाणित प्रौद्योगिकियों का विस्तार करने के लिए, संस्थान द्वारा अग्रिम पंक्ति प्रदर्शनों एवं विभिन्न प्रायोजित कार्यक्रमों यथा अनुसूचित जनजातीय संघटक, पूर्वोत्तर पर्वतीय संघटक, अनुसूचित जाति उप–योजना तथा मेरा गांव–मेरा गौरव के माध्यम से जीवंत विस्तार एवं आउटरिच कार्यक्रम चलाए जाते हैं जिनसे जमीनी स्तर तक प्रौद्योगिकी को पहुंचाने में मदद मिलती हैं एग्री–बिजनेस इनक्यूबेशन (ABI) के तहत, कई मक्का आधारित उत्पाद बनाए गए और व्यावहारिक प्रशिक्षण आयोजित किए गएं वर्ष 2021 के दौरान, कोविड महामारी की गंभीर चुनौती के बावजूद संस्थान द्वारा मक्का अनुसंधान तथा इसके परिणामों को किसानों तक पहुंचाने के साथ–साथ उनके प्रशिक्षण एवं क्षमता निर्माण की दिशा में उल्लेखनीय प्रयास किया गया हैं संस्थान ने भारत में आक्रामक फॉल आर्मीवर्म कीट के प्रबंधन में जागरूकता पैदा करने के लिए विभिन्न एजेन्सियों जिनमें संयुक्त राष्ट्रसंघ का खाद्य एवं कृषि संगठन भी शामिल है, को जरूरत आधारित परामर्शी सेवाएं प्रदान के लिए सलाहकार के रूप में भी काम कियां

सुजय रक्षित

उद्देश्य और विज़न

Mission & Vision

भाकृअनुप–भा.म.अनु.सं.
ICAR-IIMR



आर्थिक एवं पर्यावरणीय स्थिरता के साथ मक्का और मक्का आधारित कृशि प्रणालियों की उत्पादकता, लाभप्रदता तथा प्रतिस्पर्धा को बढ़ाना।

Enhancing the productivity, profitability and competitiveness of maize and maize-based farming system with economic and environmental sustainability.

मक्का की खेती और उपयोग से प्रत्यक्ष या अप्रत्यक्ष रूप से जुड़े समस्त जनमानस के लिए कृषि और औद्योगिक क्षेत्रों में संपदा तथा रोजगार सृजन हेतु मक्का और मक्का आधारित उत्पादों के खाद्य, चारा (फीड) एवं औद्योगिक अनुप्रयोग में व्यापक रूप से वृद्धि करना।

Rapid growth in the food, feed and industrial application of maize and maize-based products, for generation of wealth and employment in farming and industrial sectors, and for all those who are directly or indirectly associated with maize cultivation and utilization.

Preface

ICAR-Indian Institute of Maize Research, born out of All India Coordinated Research Project on Maize (AICRP on maize), the oldest among the co-ordinated crop improvement research projects in India, is the sole national institute to address Maize for the entire nation through its AICRP centres distributed across the country. Genetic enhancement of maize for yield continued to be the major focus of maize research, due to which the production of 1.73 million tonnes (mt) during 1950-51reached 31.65 mt in 2020-21, a quantum jump. This can be attributed to an increase in area and productivity of single cross hybrids and adoption of improved crop production practices. It is a matter of pride that two Quality Protein Maize (QPM) hybrids (IQMH 202 and IQMH 203) which were identified during 64th Annual maize Workshop during April 20-22, 2020, were notified through gazette notification on January 1, 2021. In addition, four maize inbred lines, *viz*., IML 11, IML 12, IML 13 and IML 21 were registered in NBPGR, New Delhi as source of resistance against Turcicum Leaf Blight (TLB) of maize. The institute is continuously making efforts for commercialization and strengthening of seed production chain. So far seven hybrids have been commercialized through 19 MoUs. During the representing year, 9 MoUs have been signed.

To accelerate its stride to improving genetic base of the crop for yield and stress resilience, the germplasm base has been widened by new introductions and creation of new variations through heterosis. The institute has taken a massive step to introduce artificial intelligence in crop improvement by high-throughput digital characterization of all the maize germplasm (11,674) conserved at National Gene Bank (NGB), using Unmanned Aerial Vehicle during the winter season 2020 at Begusarai. In addition to improving yield and nutritional quality, improvement according to industrial needs is also being addressed in recent years such as the developing high starch maize. Further, in depth understanding of the basis of yield, quality and stress resilience is being addressed by basic research through advanced tools and technologies. To boost the crop improvement programme through biotechnology applications, a robust *in vitro* regeneration and transformation protocol for tropical maize using mature seed-derived nodal explants was developed and published during this period.

The average maize productivity in India of around three tons per hectare is far behind the global average of 5.6 t/ha, and is attributed largely to weather volatilities of rainfed environment, where the four-fifth of maize production area lies. This realization lead to inception of research on climate-smart maize technologies such as genetic enhancement for nutrient-use efficiency, tolerance to insect pests, diseases, heat, and moisture stress, crop diversification to manage ground water depletion, development of precision conservation agriculture practices like sensor-guided nitrogen management etc. The progress made on such technologies during the year would help in crop intensification and wider adaptability to different geographic and climatic regimes of the country.

The institute has evolved over 64 years of its service to the nation through AICRP on Maize from its initial agenda of improving land races during 1950s to the releasing of normal and specialty corn single cross hybrids, including bio-fortified varieties.

To extend the proven technologies to stake holders, the institute operates a vibrant extension and outreach programme though Frontline Demonstrations (FLDs) and various sponsored programmes such as Scheduled Tribe Component (STC), North Eastern Hill (NEH) component, Scheduled Caste Sub Plan (SCSP), NSFM, and *Mera Gaon Mera Gaurav* (MGMG), which helps to penetrate the technology to the grass root level. Under the Agri-Business Incubation (ABI), several maize-based products were made and hands-on trainings were conducted. During 2021, despite the COVID pandemic, the institute made significant progress strides in maize research and outreach of its outcomes to farmers, as well as training and capacity building. The institute also acted as the consultant for the Food and Agriculture Organization of the United Nations for its interventions to create awareness in managing the invasive pest fall armyworm in India.

Sujay Rakshit

अधिदेश

MANDATE

विशिष्ट मक्का सहित मक्का की उत्पादकता और उत्पादन को बढ़ाने के उद्देश्यसे मौलिक एवं कार्यनीतिपरक अनुसंधान करना।

Basic and strategic research aimed at enhancement of productivity and production of maize, including specialty corn.

विविध कृषि जलवायु परिस्थितियों के लिए उपयुक्त प्रौद्योगिकियों की पहचान करने हेतु बहुस्थानिक एवं बहुआयामी अनुसंधान में समन्वय करना।

Coordination of multi-disciplinary and multi-location research to identify appropriate technologies for variedagro-climatic conditions.

उन्नत प्रौद्योगिकियों का प्रसार, क्षमता निर्माण और विकासशील संपर्क स्थापित करना।

Dissemination of improved technologies, capacity building and developing linkages.

मक्का पर अखिल भारतीय समन्वित अनुसंधान परियोजना (एआईसीआरपी) का समन्वय और विस्तार एवं आउटरीच कार्यक्रम को कार्यान्वित करना

Coordination of the All india Coordinated Research Project (AICRP) on Maize and to carry out extension andoutreach programmes.

विशिष्ट सारांश

भाकृअनुप – भारतीय मक्का अनुसंधान संस्थान (ICAR-IIMR) द्वारा मक्का फसल के उत्पादन, उत्पादकता और दीर्घकालिकता को बढ़ाने के उद्देश्य से मूलभूत, कार्यनीतिपरक तथा प्रायोगिक अनुसंधान किया जाता है। संस्थान के अनुसंधान कार्यक्रम मुख्यतः तीन क्षेत्रों पर केन्द्रित हैं यथा फसल सुधार, फसल प्रबंधन एवं फसल सुरक्षा। विकसित प्रौद्योगिकियों का प्रमाणन अखिल भारतीय समन्वित मक्का अनुसंधान परियोजना के माध्यम से किया जाता है और प्रसार एवं आउटरिच कार्यक्रमों की मदद से प्रमाणित प्रौद्योगिकियों का विस्तार हितधारकों तक किया जाता है। वर्ष 2020 के दौरान, संस्थान द्वारा अनुसंधान, उत्पाद विकास, प्रौद्योगिकियों का व्यावसायीकरण तथा आउटरिच गतिविधियों के माध्यम से किसानों तक प्रौद्योगिकियों का विस्तार करने में उल्लेखनीय उपलब्धियां अर्जित की गई हैं।

फसल सुधार

एक फसल सुधार संस्थान होने के कारण भारतीय मक्का अनुसंधान संस्थान का मुख्य अनुसंधान मक्का के आनुवंशिक बढ़ोतरी पर केन्द्रित रहा है। फसल सुधार कार्यक्रम का फोकस संकर किस्मों एवं पैतृक वंशक्रमों की उत्पादकता को सुधारने, जैविक तथा अजैविक तनावों की प्रतिरोधिता एवं गुणवत्ता विशेषताओं हेतु जननद्रव्य वृद्धि पर केन्द्रित है। इसके अलावा, इस संबंध में फोकस का नया आयाम विकसित उत्पादों का व्यवसायीकरण करना है।

चिन्हित एवं अधिसूचित संकर

वर्ष 2020 के दौरान, दिनांक 10 जुलाई, 2020 को कृषि फसलों के लिए फसल मानक, अधिसूचना एवं किस्म निर्मुक्ति पर केन्द्रीय उप समिति की 84वीं बैठक में चार संकर किस्मों नामतः एलक्यूएमएच 1 (आईएमएचक्यूपीएम 1530), एलपीसीएच 2 (आईएमपीएच 1535), एलपीसीएच 3 (आईएमएचपी 1540) तथा एलबीसीएच 3 (डीएमआरएचबी 1305) को खेती प्रयोजन के लिए जारी एवं अधिसूचित किया गया। एलक्यूएमएच 1 एक क्यूपीएम संकर है जिसमें उच्च ट्रिप्टोफन (0.73%) तथा लाइसीन (3.03%) की मात्रा है। एलपीसीएच 2 एवं एलपीसीएच 3 पॉपकार्न किस्में हैं जिनमें उच्च पॉपिंग प्रतिशत है जबकि एलबीसीएच 3 एक बेबीकॉर्न संकर है जिसमें उच्च एवं संतुलित पैदावार (एसएसबी 1) पाई जाती है। इसके अलावा, दिनांक 20–22 अप्रैल, 2020 को आयोजित 63वीं वार्षिक मक्का कार्यशाला के दौरान दो क्यूपीएम संकरों की भी की गई। संस्थान द्वारा विकसित की गईं तीन जैव–संवर्धित (बायो–फॉर्टीफाइड) संकर किस्मों को दिनांक 16 अक्तूबर, 2020 को विश्व खाद्य दिवस के अवसर पर माननीय प्रधानमंत्री जी द्वारा राष्ट्र को समर्पित किया गया।

संकर मक्का किस्मों का बीज उत्पादन एवं व्यवसायीकरण

मक्का की संकर किस्मों यथा डीएमआरएच 1301, डीएमआरएच 1308, डीएमआरएच 1305 तथा आईएमएचबी 1539 के पैतृक वंशक्रमों का कुल 35.46 क्विंटल प्रजनक बीज उत्पादन किया गया और विभिन्न राज्यों, राष्ट्रीय एवं अन्य बीज उत्पादक एजेन्सियों को उनकी मांग के अनुसार आपूर्ति की गई। इसके अलावा, व्यवसायीकरण के प्रयोजन से एग्रीनोवेट इंडिया लिमिटेड के माध्यम से विभिन्न बीज कम्पनियों को इन संकर किस्मों का लाइसेंस प्रदान किया गया।

अखिल भारतीय समन्वित अनुसंधान परियोजना परीक्षण के अंतर्गत संकर किस्मों का प्रोन्नयन / योगदान

रबी 2019–20 के दौरान, सामान्य मक्का की पांच प्रविष्टियों को एवीटी–1 से एवीटी–2 में प्रोन्नत किया गया और मक्का की तीन प्रविष्टियों जबकि पॉपकार्न की दो संकर किस्मों को एनआईवीटी से एवीटी–1 में प्रोन्नत किया गया। खरीफ 2020 के दौरान, एक क्यूपीएम संकर किस्म को एवीटी–2 में परीक्षण हेतु प्रोन्नत किया गया जबकि सामान्य मक्का की चार प्रविष्टियों एवं चार क्यूपीएम को एनआईवीटी से एवीटी–1 में प्रोन्नत किया गया। उत्तर पश्चिमी मैदानी क्षेत्र (जोन 2) में एक स्वीट कॉर्न संकर किस्म को एनआईवीटी से एवीटी–1 में प्रोन्नत किया गया। मक्का की पंद्रह संकर किस्मों द्वारा खरीफ 2020 के दौरान और 25 प्रविष्टियों द्वारा रबी 2020–21 के दौरान अखिल भारतीय समन्वित अनुसंधान परियोजना परीक्षण में योगदान दिया गया। पुनः रबी 2020–21 के दौरान एआईसीआरपी चारा परीक्षण में चार प्रविष्टियों और खरीफ 2020 के दौरान मक्का की तीन संकर किस्मों द्वारा अखिल भारतीय समन्वित अनुसंधान परियोजना में योगदान दिया गया।

परीक्षणात्मक संकर किस्मों का मूल्यांकन

तीन स्थानों पर कुल चार चेक किस्मों (जाँच किस्मों) के साथ मक्का की 32 परीक्षणात्मक संकर किस्मों का मूल्यांकन किया गया। उच्च माध्य तथा स्थिरता के आधार पर दो परीक्षणात्मक संकर किस्मों की पहचान की गई। अगेती परिपक्वता में, खरीफ 2020 के दौरान कुल 38 नवीन क्रास का मूल्यांकन किया गया। दाना उपज के लिए 18 क्रास में चेक डीकेसी 7074 की तुलना में उल्लेखनीय श्रेष्ठता प्रदर्शित हुई। आरएमआर एंड एसपीसी, बेगुसराय में रबी मौसम के लिए सर्वश्रेष्ठ उच्च उपजशील संकर की पहचान करने के लिए 545 परीक्षणात्मक संकरों के एक सेट का मूल्यांकन किया गया। मध्यम परिपक्वता के अंतर्गत 121 संकर संयोजनों और पछेती परिपक्वता के तहत 10 संकर संयोजनों में संबंधित परिपक्वता समूहों की सर्वश्रेष्ठ चेक के मुकाबले बेहतर उपज प्रदर्शित हुई। खरीफ 2020 के दौरान, उत्पन्न किए गए 275 परीक्षणात्मक संकरों के एक सेट का मूल्यांकन बेगुसराय और लुधियाना में किया गया और बेगुसराय तथा लुधियाना में सर्वश्रेष्ठ चेक किस्म की तुलना में क्रमशः 12 एवं 17 परीक्षणात्मक संकरों में 10 प्रतिशत से अधिक की उपज प्रदर्शित हुई। लुधियाना में खरीफ 2020 के दौरान कुल चार

चेक किस्मों के साथ एक क्यूपीएम परीक्षण के 45 परीक्षणात्मक संकरों का मूल्यांकन किया गया। लोकप्रिय सामान्य संकर बायो 9544 की तुलना में दो परीक्षणात्मक संकरों ने बेहतर प्रदर्शन किया। लुधियाना में खरीफ 2020 के दौरान 15 परीक्षणात्मक बेबी कॉर्न संकरों के एक सेट का मूल्यांकन किया गया जिसमें दोनों चेक किस्मों की तुलना में एक संकर बेहतर पाया गया।

जननद्रव्य का समावेशन

बेबी कॉर्न कार्यक्रम को मजबूती प्रदान करने के प्रयोजन से रेशा रहित बेबी कॉर्न का विकास करने हेतु मक्का आनुवंशिक स्टॉक केन्द्र, इलिनॉइस विश्वविद्यालय, संयुक्त राज्य अमेरिका से अंतः प्रजात वंशक्रमों की नौ प्राप्तियों का आयात किया गया। पुनः सिम्मट (CIMMYT), भारत से विशिष्ट मक्का स्रोतों के 84 नए स्रोतों की खरीद की गई जिसमें स्वीट कॉर्न (55), पॉपकॉर्न (19) तथा बेबी कॉर्न (10) शामिल है।

जननद्रव्य का लक्षण वर्णन

अनुक्रमण द्वारा जीनोटाइपिंग करते हुए पहचाने गए कुल 60227 एसएनपी का उपयोग करके 350 विविध मक्का अंतः प्रजात वंशक्रमों के सम्बद्धता मानचित्रण पैनल (AMP) का लक्षणवर्णन किया गया। आबादी अथवा पापुलेशन संरचना का अध्ययन किया गया और सम्बद्धता मानचित्रण पैनल में छः संभावित उप संरचनाओं की पहचान की गई। प्रत्येक उप–वर्ग अन्य से भिन्न था और इस पर जीडब्ल्यूएएस के लिए विचार किया जा सकता है। पुनः तीन स्थानों पर 6527 बहुरूपीय एसएनपी के साथ–साथ एचकेआईपीसी 4 बी x सीएमएल 269 के मध्य क्रास से उत्पन्न 198 F 8 आरआईएल का लक्षणवर्णन बीज और पॉपिंग विशेषताओं के लिए किया गया। कुल 15 क्यूटीएल (पांच प्रमुख एवं दस गौण) का मानचित्रण पॉपिंग से जुड़ी विभिन्न विशेषताओं के लिए किया गया और गुणसूत्र 10 को छोड़कर सभी गुणसूत्रों में इनका वितरण है। पॉपिंग विशेषताओं के लिए मेटा क्यूटीएल विश्लेषण द्वारा दस मेटा क्यूटीएल तथा विभिन्न क्यूटीएल मानचित्रण प्रयोगों में सूचित किए गए क्यूटीएल से प्रकटन आधार पर (केईजीजी पाथवे का उपयोग करके चयनित 19 जीन) 229 जीन की पहचान की गई। एसएसआर मार्करों के साथ सफेद मक्का की कुल 27 आबादी अथवा पापुलेशन का लक्षणवर्णन उपज में योगदान करने वाले गुणों के लिए किया गया जिसमें प्रति बाली कतार की संख्या (NRPE), प्रति कतार बीज अथवा दानों की संख्या (NKPR) तथा सौ बीजों का भार (HSWT)। प्रति बाली कतार की संख्या (छत्च्म्) के लिए छः, प्रति कतार बीज अथवा दानों की संख्या (छझ्च्) के लिए तीन तथा सौ बीजों का भार (भ्ैॅज्) आदि शामिल थे के लिए पांच आबादी अथवा पापुलेशन की पहचान पुनः अध्ययन प्रयोजन हेतु की गई। एसएसआर प्रोफाइल के आधार पर आबादी अथवा पापुलेशन में कुल दो विषमजात समूह मौजूद थे। रबी 2019–20 के दौरान बेगुसराय में कुल 500 अंतः प्रजात वंशक्रमों का मूल्यांकन किया गया जहां सर्वश्रेष्ठ तुलनीय अंतः प्रजात (एचकेआई 193–2) की तुलना में बीस अंतः प्रजात वंशक्रमों में कहीं अधिक उपज पाई गई। पुनः खरीफ 2020 के दौरान लुधियाना में 400 अंतः प्रजात वंशक्रमों की जांच की गई जहां 11 वंशक्रमों में 75 क्विंटल/हे. की उच्च दाना उपज दर्ज की गई। इसके अलावा, 776 जीनप्ररूपों का लक्षणवर्णन किया गया और वर्ष 2014–15 से 2018–19 के दौरान उत्पन्न किए गए पासपोर्ट डाटा के आधार पर चुने गए 898 अंतः प्रजात वंशक्रमों का गुणनीकरण सीआरपी–एबी के अंतर्गत परियोजना में किया गया। अठावन संकरों के लिए प्रफुल्लनकाल हेतु बढ़वार डिग्री दिवस (GDD) का मानकीकरण किया गया। अधिकांश अगेती, मध्यम तथा पछेती वंशक्रमों के लिए जीडीडी में क्रमशः 800 से 900, 900 से 950 तथा 950 से 1000 जीडीडी के बीच भिन्नता थी।

आनुवंशिक संसाधनों का विकास, रखरखाव एवं विविधीकरण

रबी 2019–20 के दौरान, स्वः परागण के माध्यम से कुल 922 अंतः प्रजात वंशक्रमों का और बल्क परागण के माध्यम से 41 पापुलेशन अथवा संख्या का रखरखाव किया गया । वसंत 2020 के दौरान, लुधियाना में कुल 645 अंतः प्रजात वंशक्रमों का अनुरक्षित और गुणनीकरण किया गया। पुनः कुल 805 परिवारों को S3 अवस्था में और 289 पृथक्करण परिवारों को S2 अवस्था में विकसित किया गया। रबी 2018–19 के दौरान आरएमआर एंड एसपीसी, बेगुसराय में खेती के लिए विमोचित मक्का संकरों के 13 पैतृक जीनप्ररूपों एवं 140 अंतः प्रजात वंशक्रमों के एक सेट का मूल्यांकन किया गया और साथ ही तेरह आकारिकी एवं उपज संबंधित गुणों के लिए लक्षणवर्णन किया गया। D2 सांख्यिकी से पहचाने गए भिन्न जीनप्ररूपों के बीच 20 कलस्टर एवं क्रास द्वारा संकर ओज के व्यापक स्तर का सदुपयोग किया जा सकता है। आणविक स्तर पर आनुवंशिक विविधता अध्ययन भी किया गया और इस कार्य में 40 बहुरूपीय एसएसआर मार्करों की मदद ली गई। क्यूपीएम जननद्रव्य में विविधता लाने के लिए दो टेस्टर्स के साथ 24 क्यूपीएम और 24 सामान्य वंशक्रमों का क्रास कराया गया और आणविक प्रोफाइलिंग की गई। उपज एवं आणविक डाटा दोनों के आधार पर, इन जीनप्ररूपों को विभिन्न कलस्टरों यथा ए तथा बी में वर्गीकृत किया गया। विषमजात समूह ए तथा बी से जुड़े सामान्य वंशक्रमों का उपयोग श्रृंखला क्रासिंग के माध्यम से संबंधित समूह के क्यूपीएम जननद्रव्य में विविधता के लिए किया जाएगा।

विशेष मक्का प्रजनन

संकर ब्रेक–डाउन अथवा संतति क्रास से हासिल किए गए 126 F3–F5 पृथक्करण स्वीट कॉर्न परिवारों को स्व–परागण के माध्यम से आगे बढ़ाया गया। भुट्टे की लंबाई (EL), भुट्टे की परिधि अथवा घेरा (EG) तथा बीज कतारों की संख्या (NKR) के लिए पाई गई भिन्नता संकर से उत्पन्न अंतः प्रजात वंशक्रमों की तुलना में संतति क्रास में अपेक्षाकृत कहीं अधिक थी। पुनः विषमजात वर्गीकरण के लिए दो टेस्टर्स यथा एलएम 13 एवं एलएम 14 के साथ स्वीट कॉर्न अंतः प्रजात वंशक्रमों का क्रास कराया गया और उपज एवं उपज में सहायक लक्षणों के लिए टेस्ट क्रास (150) का मूल्यांकन किया जा रहा है। बेबी कॉर्न जननद्रव्य को

मजबूती प्रदान करने के लिए 82 नए अंतः प्रजात वंशक्रम उत्पन्न किए गए। एक जीनप्ररूप आईबीसीएल 36 में प्रति पौधा 3–4 छल्ली की उर्वरता अथवा उपज प्रदर्शित हुई और एक अन्य वंशक्रम आईबीसीएल 46 सीधी पत्ती के साथ लिग्यूल रहित था। सीएमएस आधारित बेबी कॉर्न संकर का विकास करने के प्रयोजन से प्रगत बैकक्रास पीढ़ियां विकसित की गईं। पुनः जी 5417 तथा अंतः प्रजात वंशक्रमों के बीच कुल 54 नए टेस्ट क्रास बनाए गए और खेत में नर मंजरी आकारिकी के आधार पर 14 अंतः प्रजात वंशक्रमों को B वंशक्रम के रूप में और 16 वंशक्रमों को R के रूप में वर्गीकृत किया गया जबकि 24 वंशक्रमों में आंशिक उर्वरता प्रदर्शित हुई। दो टेस्टर्स यथा एचकेआई 1105 एवं एचकेआई 323 के साथ क्रास कराकर 26 अंतः प्रजात वंशक्रमों का विषमजात वर्गीकरण किया गया। कुल 26 वंशक्रमों के बीच, 12 जीनप्ररूपों को वर्ग A (एचकेआई 323) में तथा 14 जीनप्ररूपों को वर्ग B (एचकेआई 1105) में वर्गीकृत किया गया। पूर्व–प्रजनन कार्यक्रम के तहत, उच्च उपजशील एवं जलवायु अनुकूल मक्का का विकास करने हेतु बैकक्रास तथा स्वः परागण के माध्यम से BC2F2 पापुलेशन अथवा आबादी का विकास करने के लिए एलएम 13 एवं एलएम 14 (संकर पीएचएम–1 का पैतृक वंशक्रम) का क्रास जिया पार्वीग्लूमिस के साथ कराया गया। पुनः दो चेक किस्मों नामतः जे 1006 एवं अफ्रीकन टॉल के साथ कुल 28 पापुलेशन अथवा आबादी का मूल्यांकन चारा विशेषताओं के लिए किया गया और पांच आबादी अथवा पापुलेशन को जे–1006 के समतुल्य पाया गया। एलएम 13 एवं एलएम 14 के साथ कुल 28 चारा अंतः प्रजात वंशक्रमों का क्रास कराकर चारा अंतः प्रजात वंशक्रमों का विषमजात वर्गीकरण भी किया गया। हरा चारा उपज के विशिष्ट संयोजन क्षमता (SCA) के आधार पर कुल 28 अंतः प्रजात वंशक्रमों को दो विषमजात वर्गों में वर्गीकृत किया गया जिसमें एलएम 13 के वर्ग A के तहत 16 वंशक्रम और एलएम 14 के वर्ग B में 12 वंशक्रम शामिल थे।

अजैविक तनाव के लिए जननद्रव्य की जाँच

वृद्धि पर बुवाई के समय और शीत तनाव की सम्बद्धता का अध्ययन करने के लिए रबी 2018–19 के दौरान 25 संकर किस्मों और रबी 2019–20 के दौरान 35 संकर किस्मों का मूल्यांकन बेगुसराय, बिहार में किया गया और इसके तहत दोनों वर्षों में बुवाई पांच भिन्न तारीखों यथा 25 अक्तूबर, 5 नवम्बर, 15 नवम्बर तथा 25 दिसम्बर को की गयी। अध्ययन से पता चला कि दिनांक 5 नवम्बर को मक्का की बुवाई करने पर अधिकतम उपज प्राप्त हुई और यह तारीख बिहार राज्य में रबी मक्का के लिए सर्वाधिक उपयुक्त थी। प्रयोग के एक अन्य सेट में, पांच चेक किस्मों के साथ कुल 137 क्रास को रबी 2019–20 के दौरान लुधियाना में खेत परिस्थितियों के तहत प्रारंभिक बढ़वार अवस्था और फूल आने से पहले वाली अवस्था में शीत तनाव दिया गया जहां मध्यम परिपक्वता अवधि वाले कुल 14 क्रास सर्वश्रेष्ठ चेक किस्म पी–3396 के मुकाबले में बेहतर पाए गए। इनमें से आईएमएलएसबी 274–1 x सीएमजी 240, आईएमएलएसबी 207–2 x आईएमएलएसबी 976–2 और आईएमएलएसबी 571–2 x आईएमएलएसबी 406–2 में चेक किस्म पी–3396 के मुकाबले में क्रमशः 18.2 प्रतिशत, 14.4 प्रतिशत और 14.0 प्रतिशत की अधिक उपज पाई गई। पुनः लुधियाना में रबी 2019–20 के दौरान कुल 500 अंतः प्रजात वंशक्रमों का प्रारंभिक बढ़वार और फूल आने से पहले वाली अवस्था में शीत तनाव के विरूद्ध मूल्यांकन किया गया। अंतः प्रजात नामतः आईएमएलएसबी 250–2 में सबसे अधिक उपज (27.0 क्विंटल/हे.) हासिल की गई। 20.0 से 30.0 क्विंटल/हेक्टेयर के बीच उपज दर्ज करने वाले शीर्ष 11 अंतः प्रजात वंशक्रम नामतः आईएमएलएसबी 250–2, सीएमजी 155, आईएमएलएसबी 2004, आईएमएलएसबी 274–1, आईएमएलएसबी 671–2, आईएमएलएसबी 885–2, आईएमएलएसबी 1296–1, आईएमएलएसबी 509–2, आईएमएलएसबी 733–1, आईएमएलएसबी 428–2 तथा आईएमएलएसबी 268–1 थे। प्रयोग के एक अन्य सेट में लुधियाना में रबी 2019–20 के दौरान कुल 350 अंतः प्रजात वंशक्रमों का मूल्यांकन किया गया जिनमें दाना उपज में 0.18 से 32.31 क्विंटल/हेक्टेयर तक की भिन्नता थी। दाना उपज के आधार पर जीनप्ररूपों को 6 विभिन्न वर्गों में वर्गीकृत किया गया जहां 17, 68, 21, 21 तथा पांच जीनप्ररूपों में क्रमशः 0.18 से 1.00 क्विंटल/हेक्टेयर, 1.01 से 5.0 क्विंटल/हेक्टेयर, 5.01 से 10.0 क्विंटल/हेक्टेयर, 0.01 से 20.0 क्विंटल/हेक्टेयर, 2.001 से 30.0 क्विंटल/हेक्टेयर तथा 30.0 क्विंटल/हेक्टेयर से अधिक की सीमा में दाना उपज दर्ज की गई।

गुणवत्ता लक्षणों के लिए प्रजनन

नवीन विकसित कुल 115 क्यूपीएम अंतः प्रजात वंशक्रमों के एक सेट का विश्लेषण प्रोटीन और ट्रिप्टोफन मात्रा का पता लगाने के लिए किया गया जहां डीक्यूएल 2760 और डीक्यूएल 2702 उच्च प्रोटीन (क्रमशः 10.7 प्रतिशत एवं 10.0 प्रतिशत) और ट्रिप्टोफन मात्रा (क्रमशः 1.0 प्रतिशत एवं 0.9 प्रतिशत) के साथ सर्वाधिक आशाजनक पाए गए। पुनः खरीफ 2020 के दौरान लुधियाना में दो चेक किस्मों (डीक्यूएल 2192 एवं एचकेआई 163) के साथ 30 अंतः प्रजात वंशक्रमों का मूल्यांकन किया गया ताकि इनके बीच समतुल्य प्रदर्शन का पता लगाया जा सके। इसमें दस अंतः प्रजात वंशक्रमों में सर्वश्रेष्ठ चेक किस्म डीक्यूएल 2192 की तुलना में बेहतर प्रदर्शन पाया गया।

अनुकूलनीय युग्मविकल्पी यथा opaque2, crtRB1 तथा Ipa2 का वहन करने वाले मार्कर सहायतार्थ सेलेक्शन के माध्यम से एलएम 13, एलएम 19, एलएम 14 और एलएम 17 के लिए विकसित किए गए निअर समजीनी वंशक्रमों (NILs) का मूल्यांकन सस्यविज्ञान व जैव–रासायनिक प्रदर्शन का पता लगाने के लिए किया गया। मक्का दाने में उच्चतर लाइसीन एवं ट्रिप्टोफन, बढ़े हुए प्रोविटामिन ए और कम फाइटिक अम्ल की पुष्टि के लिए opaque2, crtRB1 तथा Ipa2 के अनुकूलनीय युग्मविकल्पी जिम्मेदार हैं। मूल्यांकन आंकड़ों के आधार पर, तीन–चार सर्वश्रेष्ठ एनआईएल का चयन किया गया और एलएम 13 एवं एलएम 19, तथा एलएम 14 एवं एलएम 17 के एनआईएल का उपयोग करते हुए प्रयोगात्मक क्रास उत्पन्न किए गए।

जैव–रासायनिक लक्षणों का मूल्यांकन

रिपोर्टाधीन अवधि के दौरान, अधिकांशतः अंतः प्रजात को शामिल करते हुए कुल 81 जीनप्ररूपों का मूल्यांकन स्टार्च प्रोफाइल यथा स्टार्च, एमाइलोज़ तथा एमाइलोपेक्टिन के लिए किया गया। अधिकांश जीनप्ररूपों में एमाइलोज की मात्रा 20 से 30 प्रतिशत के बीच पाई गई जिससे प्राकृतिक जननद्रव्य में उच्च एमाइलोज़ उत्परिवर्ती की अनुपलब्धता का पता चलता है। क्यूपीएम प्रजनन कार्यक्रम के अंतर्गत, नवीन विकसित कुल 115 वंशक्रमों का मूल्यांकन प्रोटीन गुणवत्ता का पता लगाने के लिए किया गया और 34 सर्वाधिक आशाजनक वंशक्रमों के एक सेट का भी मूल्यांकन किया गया। इसके अलावा, मार्कर सहायतार्थ चयन (MAS) के माध्यम से क्यूपीएम में रूपांतरित 20 वंशक्रमों का विश्लेषण प्रोटीन गुणवत्ता के लिए किया गया तथा उच्च ट्रिप्टोफन मात्रा वाले वंशक्रमों की पहचान की गई। आशाजनक वंशक्रमों की पहचान करने हेतु रंगीन मक्का जननद्रव्य में एंथोसाइनिन, फ्लेवोनॉइड एवं फिनोलिक मात्रा का मूल्यांकन भी किया गया।

मक्का में स्वः पात्रे पुनर्जनन एवं रूपांतरण विधि की स्थापना

बायोलिस्टिक एवं एग्रोबैक्टीरियम मध्यस्थ रूपांतरण विधियों का उपयोग करते हुए नोडल कर्तोतक से उत्पन्न कैलाई में एक पुनरुत्पादनीय योग्य स्वः पात्रे पुनर्जनन विधि विकसित की गई। ग्लूकुरोनिडेज (GUS) प्रोटीन का उपयोग करके रूपांतरण प्रोटोकॉल की मानकीकरण प्रक्रिया का कार्य प्रगति पर है। ऊतक–रसायन तथा पीसीआर विश्लेषण से रूपांतरित ऊतकों में जीयूएस गतिविधि की मौजूदगी का पता चला।

अल्प फाइटेट वाली मक्का के लिए जीन लक्ष्य की इन सिलिको प्राथमिकता

प्लीओट्रॉपिक प्रभावों से बचने के साथ–साथ मक्का में फाइटिक अम्ल मात्रा को कम करने हेतु सर्वाधिक आशाजनक लक्ष्य इनोस्टिोल फॉस्फेट काइनेज 1 (IPK 1) पाया गया। इनोस्टिोल फॉस्फेट काइनेज 1 (IPK 1) एंजाइम संरचना और पोषाधार के साथ इसकी पारस्परिकता का कम्प्यूटेशनल रूप से निर्धारण किया गया। विशिष्ट अमीनो अम्ल पॉजीशन का खुलासा किया गया जहां प्रोटीन–प्रोटीन पारस्परिकता को प्रभावित किए बिना एंजाइम गतिविधि के अवरोध में उत्परिवर्तन होगा।

अल्प नाइट्रोजन तनाव में प्रमुख भिन्नात्मक प्रकटित जीनों (DEGs) का प्रमाणन

विषम अंतः प्रजात वंशक्रमों यथा डीएमआई 56 (नाइट्रोजन तनाव का सहिष्णु) एवं डीएमआई 81 (नाइट्रोजन तनाव के प्रति संवेदनशील) से पत्ती एवं जड़ ऊतकों का उपयोग करके ट्रांसक्रिप्टोम विश्लेषण के माध्यम से पहले पहचाने गए प्रमुख भिन्नात्मक प्रकटित जीनों का प्रमाणन qPCR द्वारा किया गया। नाइट्रोजन तनाव की प्रतिक्रिया में भिन्नात्मक प्रकटन के रूप में जीनों यथा Asn4, एचएटी 2.3, एनआरपी 1, बेसिक इण्डोकाइटीनेज, एएपी 3, जीटी 31, एमवाईबी 36 ट्रांसक्रिप्शन कारक, AP2-EREBP ट्रांसक्रिप्शन कारक और नाइट्रेट ट्रांसपोर्ट–1 की पहचान की गई।

फसल प्रबंधन

आनुवंशिकी जहां उच्च गुणवत्ता, उच्च उपजशील तथा तनाव प्रतिरोधी जीनप्ररूपों के विकास में महत्वपूर्ण भूमिका निभाती है वहीं वांछित फार्म उत्पादकता एवं दीर्घकालिकता हासिल करने में फसल प्रबंधन के तरीके महत्वपूर्ण भूमिका निभाते हैं। संस्थान के फसल प्रबंधन कार्यक्रम का मुख्य फोकस जुताई, पोषक तत्व एवं फसलचक्र प्रणाली प्रबंधन पर केन्द्रित है।

गंगा के मैदानी इलाकों में अनाज आधारित प्रणालियों में प्रेसीजन संरक्षित कृषि रीतियों का विकास

चावल–गेहूं फसलचक्र प्रणाली की तुलना में संरक्षित कृषि (CA) आधारित मक्का–गेहूं फसलचक्र प्रणाली के तहत उल्लेखनीय रूप से उच्चतर प्रणाली उत्पादकता दर्ज की गई। इसी प्रकार, एफएफपी, आरडीएफ तथा एसएसएनएम के साथ पारम्परिक मक्का–गेहूं–मूंग तथा चावल–गेहूं–मूंग फसलचक्र प्रणालियों की तुलना में ग्रीन सीकर (GS) सेंसर आधारित पोषक तत्व प्रबंधन वाली संरक्षित कृषि आधारित मक्का–गेहूं–मूंग फसलचक्र प्रणाली में अधिकतम शुद्ध लाभ और लाभ : लागत अनुपात पाया गया। विभिन्न फसलचक्र प्रणालियों में खरपतवार बीज बैंक अध्ययन किया गया और यह पाया गया कि पारम्परिक चावल–गेहूं–मूंग फसलचक्र प्रणाली में कुल बीज बैंक न्यूनतम था जबकि यह पारम्परिक जुताई तथा संरक्षित कृषि आधारित मक्का–गेहूं–मूंग फसलचक्र प्रणाली में उच्चतर था। इससे यह स्पष्ट तौर पर पता चलता है कि केवल समुचित खरपतवार प्रबंधन के साथ ही संरक्षित कृषि रीति सफल हो सकती है।

सामान्य मक्का एवं विशेष मक्का में विभिन्न जैविक पोषक तत्व स्रोतों का अध्ययन

जैविक परिस्थिति के तहत तीन वर्षीय प्रयोग को पूरा करने के उपरान्त चौथे वर्ष में, जैविक उपचारों के अंतर्गत बेबी कॉर्न, स्वीट कॉर्न तथा सामान्य मक्का की उपज उर्वरकों की संस्तुत मात्रा (RDF) का प्रयोग करने के समतुल्य पाई गई। सौ प्रतिशत गोबर की खाद (FYM) का प्रयोग करने पर बेबी कॉर्न की उपज उर्वरकों की संस्तुत मात्रा (RDF) का प्रयोग करने के समतुल्य पाई गई जबकि स्वीट कॉर्न के मामले में उर्वरकों की संस्तुत मात्रा (RDF) का प्रयोग करने पर हासिल की गई उपज के समतुल्य ही 100 प्रतिशत गोबर की खाद तथा 50 प्रतिशत गोबर की खाद + 50 प्रतिशत वर्मी कम्पोस्ट का प्रयोग करने पर उपज हासिल की गई । इसी प्रकार, सभी जैविक उपचारों में सामान्य मक्का की उपज को उर्वरकों की संस्तुत मात्रा (RDF) का प्रयोग करने पर हासिल की गई उपज के समतुल्य पाया गया।

चावल–गेहूं एवं मक्का–गेहूं फसलचक्र प्रणालियों का मृदा जीवाण्विक विविधता विश्लेषण

विभिन्न जुताई रीतियों के तहत चावल–गेहूं एवं मक्का–गेहूं फसलचक्र प्रणालियों में मृदा की जीवाण्विक विविधता की जांच क्रोमोजेनिक ऐगार मीडियम पर की गई। यह पाया गया कि स्थान विशिष्ट पोषक तत्व प्रबंधन के

तहत मृदाओं में नाइट्रोजन निर्धारण करने वाले जीवाणु का उच्चतर घनत्व था जैसा कि नाइट्रोजन की अल्पता वाली परिस्थितियों के तहत शानदार ढ़ंग से बढ़ने की इनकी क्षमता का आकलन करने से पता चला।

पारम्परिक एवं संरक्षित कृषि रीतियों के तहत मक्का आधारित फसलचक्र प्रणाली में सेंसर निर्देशित नाइट्रोजन प्रबंधन

पचास प्रतिशत आरडीएन + जीएस आधारित नाइट्रोजन प्रयोग करने पर संरक्षित कृषि के अंतर्गत कृषि अपशिष्ट को बनाये रखते हुए मक्का–गेहूं–मूंग फसलचक्र प्रणाली को अपनाकर प्रयोग किए गए नाइट्रोजन की आंशिक कारक उत्पादकता, उच्चतर प्रणाली उपज और शुद्ध लाभ को उल्लेखनीय रूप से हासिल किया जा सकता है। मक्का अपशिष्ट का प्रयोग करने पर परिपक्वता अवधि के दौरान गेहूं की फसल में कमतर कैनोपी तापमान उत्पन्न हुआ जिससे अंतस्थ ताप तनाव को कम करने में इस प्रौद्योगिकी की क्षमता का पता चला। मक्का की फसल में नाइट्रोजन की पहली विभाजित खुराक का उप–सतही बैण्ड प्लेसमेंट करने पर पारम्परिक सतही बैण्डिंग प्रयोग की तुलना में मक्का की उपज में उल्लेखनीय सुधार हुआ।

फसल सुरक्षा

फसल सुरक्षा कार्यक्रम के अंतर्गत परपोषी पादप प्रतिरोधिता और नाशीजीव व रोग प्रबंधन तकनीकों में एकीकृत युक्तियों पर बल दिया जाता है। वसंत 2020 के दौरान कुल 106 अंतः प्रजात वंशक्रमों की स्क्रीनिंग की गई जिसमें 35 अंतः प्रजात वंशक्रम चारकोल सड़न रोग के विरूद्ध प्रतिरोधी पाए गए। रबी 2019–20 और खरीफ 2020 के दौरान कृत्रिम संक्रमण के तहत छांटे गए कुल 46 अंतः प्रजात वंशक्रमों में क्रमशः गुलाबी तना वेधक के विरूद्ध पांच अंतः प्रजात वंशक्रम यथा VH12137F2-1-5-2-3-1-1-1#-2-1-1, ZH111688F2-2-5-3-2-1-1-2#-1-2-1, ZH116002F2-1-3-2-3-1-1-1#-2-1-1, ZH116117F2-1-2-1-1-2-1-1#-1-1-1 तथा ZH112656F2-1-2-2-1-1-1-1#-1-1-1 और धब्बेदार तना वेधक के विरूद्ध एक अंतः प्रजात वंशक्रम यथा 141167-2-PP-25-1-2-1आशाजनक पाया गया। खरीफ 2020 के दौरान लुधियाना में मेडिस पत्ती अंगमारी (MLB) के विरूद्ध विभिन्न रोग प्रबंधन माड्यूल्स यथा जैविक, रासायनिक तथा एकीकृत रोग प्रबंधन (IDM) को जांचा गया। दोनों रोगों की रोकथाम करने में उल्लेखनीय रूप से सबसे अधिक उपज को रासायनिक माड्यूल में एवं तदुपरान्त एकीकृत रोग प्रबंधन माड्यूल में पाया गया। टर्सिकम पत्ती अंगमारी रोगजनक, सिटोस्फीरिया टर्सिका की विविधता का अध्ययन करने के लिए नौ राज्यों नामतः मेघालय, उत्तराखण्ड़, हिमाचल प्रदेश, आन्ध्र प्रदेश, ओड़िशा, गुजरात, मध्य प्रदेश, जम्मू व कश्मीर तथा महाराष्ट्र से कुल 45 पृथक्कों को संकलित किया गया। पृथक्कों को शुद्धीकृत कर इनका लक्षणवर्णन किया जा रहा है।

मक्का–गुलाबी तना वेधक के बीच पारस्परिकता को समझने की दिशा में विभिन्न प्रकार के उपचारों को आजमाकर उत्पन्न रक्षा प्रतिक्रिया संबंधी अध्ययन किए गए। विभिन्न उपचारों में: कंट्रोल यथा अनुपचारित पौधे, पीएसबी फीडिंग, मैकेनिकल वाउन्डिंग, मैकेनिकल वाउण्डिंग प्लस पीएसबी उर्ध्वनिक्षेप तथा दो अवस्थाओं यथा अंकुरण के 5 एवं 15 दिन बाद (DAG) प्रतिरोधी (डीएमआरई 63, सीएम 500), संतुलित प्रतिरोधी (डब्ल्यूएनजेड विदेशी पूल) तथा संवेदनशील जीनप्ररूप (सीएम 202, बीएमएल 6) में मिथाइल जैस्मोनेट का बहिर्जात प्रयोग करना थे। यह पाया गया कि संवेदनशील जीनप्ररूपों के मुकाबले विशेषकर प्रतिरोधी और संतुलित रूप से प्रतिरोधी जीनप्ररूपों में अधिकांश घटनाओं में अंकुरण के 5 एवं 15 दिन बाद अल्प एवं दीर्घावधि प्रतिक्रियाओं में जब कीट द्वारा आक्रमण किया गया तब च.कॉमेरिक अम्ल (p-CA) तथा फेरूलिक अम्ल (FA) मात्रा स्वाभाविक रूप से ज्यादा थी।

फॉल आर्मीवर्म (FAW) का बेहतर प्रबंधन करने की दिशा में, बीज उपचार कीटनाशकों यथा 6 से 10 मिलि. की मात्रा में थियामिथॉक्सम 30 FS, इमिडाक्लोप्रिड 600 FS तथा फिप्रोनिल 5 Sc का मूल्यांकन भाकृअनुप–भारतीय मक्का अनुसंधान संस्थान, डब्ल्यूएनसी, हैदराबाद में खरीफ 2020 के दौरान फॉल आर्मीवर्म के विरूद्ध किया गया। इसमें नुकसान को कम करने और उपज वृद्धि हासिल करने के संबंध में 6–10 मिलि. /किग्रा. बीज की दर पर थियामिथॉक्सम 30 FS का प्रयोग करना बेहतर पाया गया। रबी 2019–20 के दौरान दिल्ली में विभिन्न जुताई रीतियों के तहत फॉल आर्मीवर्म के संक्रमण को दर्ज किया गया। सबसे कम संक्रमण को शून्य जुताई (ZT) प्रणाली में और सबसे अधिक संक्रमण को पारम्परिक रूप से जुताई (CT) वाली प्रणाली में पाया गया। खरीफ 2020 में, विभिन्न जुताई रीतियों और फसलचक्र प्रणालियों के तहत V 6.7 अवस्था वाली मक्का फसल में फॉल आर्मीवर्म का संक्रमण दर्ज किया गया जिसमें विशेषकर मक्का–चना–सेस्बेनिया (MCS), मक्का–सरसों–मूंग (MMuMb) फसलचक्र प्रणालियों में सबसे कम संक्रमण को शून्य जुताई (ZT) में और सबसे अधिक संक्रमण स्तर को पारम्परिक जुताई (ब्ज) में पाया गया।

अखिल भारतीय समन्वित मक्का अनुसंधान परियोजना

अपनी प्रमुख अनुसंधान गतिविधियों के अलावा, संस्थान द्वारा फसल सुधार, फसल उत्पादन एवं फसल सुरक्षा के अंतर्गत अखिल भारतीय समन्वित मक्का अनुसंधान परियोजना के माध्यम से विभिन्न कृषि विश्वविद्यालयों के मक्का अनुसंधान कार्यक्रमों का समन्वय भी किया जाता है।

फसल सुधार

रबी 2019–20 के दौरान, सामान्य मक्का, विशिष्ट मक्का के राष्ट्रीय पहल किस्मीय परीक्षण (NIVT), प्रगत किस्मीय परीक्षण–I (AVT-I) तथा प्रगत किस्मीय परीक्षण–II (AVT-II), क्यूपीएम परीक्षणों, कीटविज्ञान एवं रोगविज्ञान परीक्षणों की रूपरेखा तैयार की गई। प्रजनन परीक्षण के तहत एनआईवीटी में दो, एवीटी में तीन, क्यूपीएम में एक और पॉपकार्न में एक परीक्षण को शामिल किया गया। खरीफ 2020 के दौरान, 35 विभिन्न प्रजनन परीक्षणों की रूपरेखा बनाई गई। इनमें एक सेट जहां पूरी तरह से उत्तरी पर्वतीय जोन (छभ्) के लिए था वहीं अन्य सेट शेष जोन के लिए थे। इसके अलावा, विशेषतः वसंत मौसम के लिए भी एक नये परीक्षण की

रूपरेखा बनाई गई और उत्तरी भारत के राज्यों के चार केन्द्रों यथा लुधियाना, करनाल, दिल्ली और पंतनगर क्षेत्रों में वसंत मक्का की लोकप्रियता को ध्यान में रखते हुए इन परीक्षणों को आयोजित किया गया। रबी 2019–20 के दौरान, विभिन्न जोन यथा उत्तर पश्चिमी मैदानी क्षेत्र (छॅंचे), उत्तर पूर्वी मैदानी क्षेत्र (छम्चे), प्रायद्वीपीय क्षेत्र (चे), मध्य पश्चिमी क्षेत्र (ब्ँ) के लिए क्रमशः 91 प्रतिशत, 89 प्रतिशत, 100 प्रतिशत तथा 100 प्रतिशत की सफलता दर पाई गई। उत्तर पश्चिमी मैदानी क्षेत्र (छॅंचे) में वसंत परीक्षण आयोजित किए गए जिनमें कुल 11 प्रविष्टियों में से केवल दो प्रविष्टियों यथा वीएनआर 37753 तथा एचटी 20185 को परीक्षण प्रयोजन हेतु एवीटी–1 में प्रोन्नत किया गया।

फसल उत्पादन

रबी 2020–21 के दौरान, विभिन्न कृषि पारिस्थितिकी प्रणालियों में मक्का प्रणालियों की उत्पादकता एवं लाभप्रदता को बढ़ाने के लिए मक्का प्रणालियों में विभिन्न परिपक्वता अवधि वाले पहले विमोचित किए जा चुके जीनप्ररूपों के जुताई एवं पोषक तत्व प्रबंधन, सेंसर निर्देशित नाइट्रोजन प्रबंधन, एकीकृत पोषक तत्व प्रबंधन, पारिस्थितिक गहनता और खरपतवार प्रबंधन पर सस्यविज्ञान प्रयोग किए गए। सघनता एवं पोषक तत्व स्तरों के प्रति पहले विमोचित किए गए जीनप्ररूपों की प्रतिक्रिया की जांच करने के लिए प्रयोग किया गया जिसमें पता चला कि जीनप्ररूपों द्वारा उत्तर पश्चिमी मैदानी क्षेत्र (छॅंचे) में एवं सामान्य सघनता (करनाल) में उच्चतर पोषक तत्व की प्रति प्रतिक्रिया दी गई। प्रायद्वीपीय क्षेत्र (चे) में दीर्घावधि परिपक्वता वाले जीनप्ररूपों द्वारा उच्च पोषक तत्व स्तरों के प्रति प्रतिक्रिया की गई लेकिन ये चेक किस्मों के साथ दाना उपज के लिए आंकड़ों की दृष्टि से समान थे। मध्य पश्चिमी क्षेत्र (ब्ँ) में भी लंबी परिपक्वता अवधि वाले जीनप्ररूपों में उच्च सघनता के साथ उच्च उर्वरता के प्रति अच्छी प्रतिक्रिया देखी गई और सर्वश्रेष्ठ चेक किस्म के मुकाबले में पीएम 17201 एल में उल्लेखनीय रूप से कहीं उच्चतर उपज पाई गई। इसी प्रकार, मध्यम परिपक्वता अवधि वाले जीनप्ररूपों (4 + 2 तुलनीय) को उत्तर पूर्वी मैदानी क्षेत्र (छम्चे) में चार स्थानों पर जांचा गया और यह पाया गया कि 150 प्रतिशत आरडीएफ के साथ उच्च सघनता में उल्लेखनीय उपज सुधार हुआ। विभिन्न जुताई रीतियों के तहत मक्का–गेहूं–लोबिया फसलचक्र प्रणाली में पोषक तत्व प्रबंधन के लिए प्रयोग किया गया जिसमें पारम्परिक जुताई (ब्ज) के साथ 100 प्रतिशत आरडीएफ का उपयोग करने पर अधिकतम मक्का समतुल्य उपज दर्ज की गई । पंतनगर (उत्तर पश्चिमी मैदानी क्षेत्र (छॅंचे) में भी शून्य जुताई के साथ 100 प्रतिशत आरडीएफ का प्रयोग करने पर इसी प्रकार की समतुल्य उपज दर्ज की गई। हालांकि, शून्य जुताई के साथ 100 प्रतिशत आरडीएफ का प्रयोग करने पर प्रणाली में अधिकतम शुद्ध लाभ हासिल किया गया। परिणामस्वरूप आरडीएफ–शून्य जुताई के साथ अधिकतम लाभ : लागत अनुपात हासिल किया गया। विभिन्न जुताई रीतियों के अंतर्गत मक्का–गेहूं–मूंग फसलचक्र प्रणाली में पोषक तत्व प्रबंधन में यह देखने को मिला कि धोली (उत्तर पूर्वी मैदानी क्षेत्र (छम्चे) में अनुवर्ती गेहूं की उपज और शुद्ध लाभ पर जुताई का कोई विशेष प्रभाव नहीं पाया गया जबकि स्थान विशिष्ट पोषक तत्व प्रबंधन (ैछड) के साथ 60 प्रतिशत आरडीएफ + ग्रीन सीकर (ळै) का प्रयोग करने पर समतुल्य परिणाम प्राप्त किए गए जिनमें आरडीएफ की तुलना में कहीं उच्चतर उपज और शुद्ध लाभ हासिल किया गया। पुनः उभरती चावल–मक्का आधारित फसलचक्र प्रणाली में सर्वश्रेष्ठ पोषक तत्व एवं जुताई प्रबंधन रीतियों का पता लगाने के लिए उत्तर पूर्वी मैदानी क्षेत्र (छम्चे) के धोली एवं कल्याणी में एक प्रयोग किया गया। जुताई रीतियों के बीच, स्थायी क्यारी (च्ठ) के तहत मक्का फसल से उल्लेखनीय रूप से उच्चतर उपज और शुद्ध लाभ हासिल किया गया जो कि शून्य जुताई के समतुल्य था। पुनः धोली की रेतीली दुमटी मृदा में पारम्परिक जुताई के मुकाबले में दोनों रीतियां उल्लेखनीय रूप से बेहतर पाई गईं। इसके प्रतिकूल कल्याणी की चिकनी दुमटी मृदा में पारम्परिक जुताई और स्थायी क्यारी की तुलना में शून्य जुताई के तहत उल्लेखनीय रूप से कहीं उच्चतर उपज और शुद्ध लाभ मिला। हालांकि दोनों स्थानों पर ग्रीन सीकर निर्देशित नाइट्रोजन का प्रयोग करने पर उल्लेखनीय रूप से कहीं उच्चतर उपज और शुद्ध लाभ हासिल किया गया। मक्का–चना फसलचक्र प्रणाली में बांसवाडा (मध्य पश्चिमी क्षेत्र (ब्ँ) में विभिन्न जुताई रीतियों के अंतर्गत मक्का आधारित बारानी फसलचक्र प्रणाली में पोषक तत्व प्रबंधन के लिए प्रयोग किया गया। यह देखने में आया कि विभिन्न जुताई रीतियों का मक्का की उपज पर कोई विशेष प्रभाव नहीं था जबकि शून्य जुताई के तहत उल्लेखनीय रूप से उच्चतर चना उपज प्राप्त की गई जो कि स्थायी क्यारी रीति में हासिल की गई उपज के समतुल्य थी तथा ये दोनों रीतियां पारम्परिक जुताई (ब्ज) के मुकाबले में बेहतर थीं। पोषक तत्व प्रबंधन के बीच, स्थान विशिष्ट पोषक तत्व प्रबंधन (ैछड) आधारित पोषक तत्वों का प्रयोग करने पर अध्ययन में उपयोग किए गए अन्य विकल्पों की तुलना में दोनों फसलों की उल्लेखनीय रूप से कहीं उच्चतर उपज मिली। मक्का की फसल में जैविक खाद के प्रयोग को एकीकृत करने के प्रयोजन से एकीकृत पोषक तत्व प्रबंधन पर दीर्घावधि परीक्षण किया गया। मक्का–गेहूं प्रणाली में पंतनगर (उत्तर पश्चिमी मैदानी क्षेत्र (छॅंचे) तथा बांसवाडा (मध्य पश्चिमी क्षेत्र (ब्ँ) में 100 प्रतिशत आरडीएफ + 5 टन/हेक्टेयर की दर पर गोबर की खाद का प्रयोग करने पर उल्लेखनीय रूप से अधिकतम शुद्ध लाभ और लाभ : लागत अनुपात दर्ज किया गया। गोबर की खाद / 10 टन/हे. + एजोटोबैक्टर का प्रयोग करने पर मक्का + फली अंतर फसलचक्र में भी बांसवाडा और पंतनगर में हासिल की गई उपज के समतुल्य उपज दर्ज की गई। सेंसर आधारित नाइट्रोजन प्रबंधन पर आयोजित किए गए प्रयोग में यह देखने में आया कि ग्रीन सीकर सेंसर आधारित नाइट्रोजन का प्रयोग करने वाले उपचारों, 33 प्रतिशत नाइट्रोजन का आधारीय प्रयोग + घुटनों की ऊंचाई तक तथा नर मंजरी निकलने की अवस्था में ग्रीन सीकर आधारित नाइट्रोजन का प्रयोग करने अथवा 30 प्रतिशत नाइट्रोजन का आधारीय प्रयोग + बुवाई के 25 दिनों उपरान्त 30 प्रतिशत + नर मंजरी अवस्था में ग्रीन सीकर नाइट्रोजन का

प्रयोग करने पर आंकड़ों की दृष्टि से समान उपज हासिल की गई जबकि उच्चतर शुद्ध लाभ को आरडीएफ का प्रयोग करने पर हासिल किया गया। एसटीसीआर आधारित पोषक तत्वों का प्रयोग करने पर मक्का–गेहूं फसलचक्र प्रणाली में उल्लेखनीय रूप से कहीं अधिक उपज और लाभ अर्जित किया गया। विभिन्न मक्का आधारित फसलचक्र प्रणालियों में केवल उत्तर पर्वतीय क्षेत्र (छभ्) को छोड़कर अन्य चार क्षेत्रों में इकोलॉजिकल सघनीकरण (म्) के इष्टतमीकरण के माध्यम से उपज एवं लाभ अधिकता के लिए प्रयोग किया गया। सभी क्षेत्रों अथवा जोन में इकोलॉजिकल सघनीकरण के साथ फसल उपज आंकड़ों की दृष्टि से अधिकतम थी। बांसवाडा, पेड्डापुरम, करीमनगर, हैदराबाद तथा धोली में इकोलॉजिकल सघनीकरण माइनस खरपतवार प्रबंधन के लिए; वगारई, कोयम्बटूर तथा पंतनगर में इकोलॉजिकल सघनीकरण माइनस जल प्रबंधन के लिए जबकि कल्याणी, भुवनेश्वर एवं लुधियाना में इकोलॉजिकल सघनीकरण माइनस पोषक तत्व प्रबंधन के लिए कमतर उपज पाई गई। अतः मक्का प्रणाली की उपज को बढ़ाने हेतु इको–क्षेत्र विशिष्ट प्रौद्योगिकी पर ध्यान केन्द्रित करने की जरूरत है। मक्का प्रणालियों में खरपतवार प्रबंधन पर आयोजित किए गए प्रयोग में पता चला कि मक्का की फसल में खरपतवार निकलने के उपरान्त प्रयोग किए गए शाकनाशी जैसे कि टेम्बोट्रियोन अथवा टोपरामिजोन का रोटेशन में बोई गई अनुवर्ती गेहूं फसल पर कोई प्रतिकूल प्रभाव नहीं था। रबी की मक्का फसल में प्रयोग किए गए शाकनाशी उपचारों में खरपतवार निकलने से पूर्व 750 ग्राम/हे. की दर पर एट्राजिन एवं तदुपरान्त बुवाई के 25 दिनों बाद 25.2 ग्राम/हे. की दर पर टोपरामिजोन का प्रयोग करने पर कल्याणी (उत्तर पूर्वी मैदानी क्षेत्र) में उल्लेखनीय रूप से कहीं उच्चतर उपज और शुद्ध लाभ दर्ज किया गया।

फसल सुरक्षा

रबी 2019–20 एवं वसंत 2020 के दौरान अखिल भारतीय समन्वित मक्का अनुसंधान परियोजना के कीटविज्ञान प्रयोगात्मक परीक्षण आयोजित किए गए जिनका प्रयोजन मुख्यतः गुलाबी तना वेधक (पीएसबी : सिसेमिया इनफेरेन्स), धब्बेदार तना वेधक (एसएसबी : काइलो पार्टेलस), फॉल आर्मीवर्म (फॉल आर्मीवर्म : स्पोडोप्टेरा फ्रुजीपर्डा) तथा प्रोह मक्खी (एथरीगोना प्रजाति) के विरूद्ध प्रतिरोधिता का पता लगाना था।

हैदराबाद में पीएसबी के विरूद्ध, कोल्हापुर में एसएसबी के विरूद्ध, करनाल एवं लुधियाना में प्रोह मक्खी के विरूद्ध, कोयम्बटूर, हैदराबाद तथा कोल्हापुर में फॉल आर्मीवर्म के विरूद्ध एवीटी–1 तथा एवीटी–2 पछेती परिपक्वता समूह में कुल 17 प्रविष्टियों की छंटाई की गई। इसमें पता चला कि जहां 16 प्रविष्टियां पीएसबी के प्रति संतुलित प्रतिरोधी थीं वहीं एसएसबी के विरूद्ध सभी प्रविष्टियां संतुलित रूप से प्रतिरोधी थीं। प्रोह मक्खी के विरूद्ध सबसे कम मृत हृदय को पीएम 17201 एल (16.0) में एवं तदुपरान्त एनएमएच 4313 (17.1) में पाया गया। फॉल आर्मीवर्म के लिए डेविस स्कोर में बुवाई के 14 दिनों उपरान्त 2.4 (केएमएच 25 के 45) से लेकर 2.9 (पीएम 18206 एल) तक; बुवाई के 28 दिनों बाद 3.4 (पीएम 18204 एल) से 4.6 (पीएम 17208 एल) तक; तथा बुवाई के 60 दिनों उपरान्त 4.7 (एनएमएच 713) से 6.0 (पीएमएच 17208 एल) तक की भिन्नता देखने को मिली। पुनः हैदराबाद में पीएसबी के विरूद्ध, कोल्हापुर में एसएसबी के विरूद्ध, करनाल व लुधियाना में प्रोह मक्खी के विरूद्ध तथा कोयम्बटूर, हैदराबाद और कोल्हापुर में फॉल आर्मीवर्म के विरूद्ध एवीटी–1 एवं एवीटी–2 मध्यम परिपक्वता वर्ग में कुल 15 प्रविष्टियों की छंटाई की गई। इसमें सभी प्रविष्टियां पीएसबी और एसएसबी के विरूद्ध संतुलित प्रतिरोधी पाई गईं। प्रोह मक्खी के विरूद्ध समग्र न्यूनतम मृत हृदय (प्रतिशत) को आईएमएचएसबी 17 आर–16 (12.2) में पाया गया वहीं फॉल आर्मीवर्म के लिए डेविस स्कोर में बुवाई के 14 दिनों उपरान्त 2.7 (आईएमएचएसबी 17 आर–5) से 3.1 (आईएमएचएसबी 17 आर–9, एनएमएच 4140) तक, बुवाई के 28 दिनों उपरान्त 3.5 (आईएमएचएसबी 17 आर–16) से 4.4 (बीएलएच 139) तक तथा बुवाई के 60 दिनों उपरान्त 3.8 (आईएमएचएसबी 17 आर–8, डीएचएम 117) से 4.2 (एएच 8181, बीएलएच 139) तक की भिन्नता देखने को मिली। पुनः करनाल व लुधियाना में प्रोह मक्खी के विरूद्ध और कोयम्बटूर में फॉल आर्मीवर्म के विरूद्ध प्राकृतिक संक्रमण के तहत 42 मक्का प्राप्तियों का मूल्यांकन किया गया। प्रोह मक्खी के विरूद्ध सबसे कम औसत प्रतिशत मृत हृदय को डीएमआर ई 63/सीएमएल 287–4–6 (25.3) में पाया गया। फॉल आर्मीवर्म के मामले में, बुवाई के 28 दिनों उपरान्त सबसे कम औसत डेविस स्कोर को जहां बीएमएल 7 (1.4) में पाया गया वहीं सबसे अधिक मान को डीएमआरई 63/सीएमएल 287–3–61–2बी (4.2) में दर्ज किया गया। खरीफ 2020 के दौरान, इम्फाल, करनाल, लुधियाना, धोली, कोयम्बटूर, हैदराबाद, कोल्हापुर और उदयपुर सहित विभिन्न केन्द्रों पर एसएसबी तथा/अथवा फॉल आर्मीवर्म के विरूद्ध अखिल भारतीय समन्वित अनुसंधान परियोजना प्रविष्टियों का मूल्यांकन किया गया और प्रतिरोधी प्रविष्टियों की पहचान की गई। पुनः अखिल भारतीय समन्वित अनुसंधान परियोजना के विभिन्न केन्द्रों पर विभिन्न परीक्षण किए गए जैसे कि एनबीएआईआर मंद गति से जारी करने वाले डिसपेन्सर के साथ फिरोमॉन ट्रैप का उपयोग करके फॉल आर्मीवर्म की निगरानी; फिरोमॉन ट्रैप द्वारा छल्ली वेधक (हेलिकोवर्पा आर्मीजेरा) की निगरानी; फॉल आर्मीवर्म के विरूद्ध बीज उपचार के रूप में कीटनाशकों का मूल्यांकन; मक्का फसल में तना वेधक और फॉल आर्मीवर्म का प्रबंधन; तथा फॉल आर्मीवर्म के विरूद्ध जैव नाशकजीवनाशियों/जैव एजेन्टों का मूल्यांकन।

रबी 2019–20 के दौरान, देश के विभिन्न जोन में मेडिस पत्ती अंगमारी (डस्ठ), टर्सिकम पत्ती अंगमारी (ज्स्ठ), चारकोल सड़न (बिंत्) तथा सोरघम डाउनी मिल्डयू (ैक्ड) के विरूद्ध कुल 109 मक्का प्रविष्टियों का मूल्यांकन किया गया। मेडिस पत्ती अंगमारी (डस्ठ), टर्सिकम पत्ती अंगमारी (ज्स्ठ) तथा सोरघम डाउनी मिल्डयू (ैक्ड) के लिए एनआईवीटी पछेती परिपक्वता की कुल 36 संकर किस्मों का मूल्यांकन

किया गया। मेडिस पत्ती अंगमारी तथा सोरघम डाउनी मिल्डयू के लिए क्रमशः छः एवं एक प्रविष्टि संतुलित थी जबकि टर्सिकम पत्ती अंगमारी (ज्स्ठ) तथा चारकोल सड़न (बित) के विरूद्ध कोई भी प्रविष्टि प्रतिरोधी नहीं पाई गई। एनआईवीटी मध्यम परिपक्वता में कुल 52 प्रविष्टियों में से मेडिस पत्ती अंगमारी के लिए पांच प्रविष्टियां यथा एएच 8047, आईएमएचएसबी 19 आर–17, आईएमएचएसबी 19 आर–4, आईएमएचएसबी 19 आर–9 तथा एमएच 2047 और सोरघम डाउनी मिल्डयू के लिए तीन प्रविष्टियां यथा बीएयूएमएचआर 19–2, आईएमएचएसबी 19 आर–12 एवं आईएमएचएसबी 19 आर–14 प्रतिरोधी थीं जबकि टर्सिकम पत्ती अंगमारी (ज्स्ठ) तथा चारकोल सड़न (बित) के विरूद्ध कोई भी प्रविष्टि प्रतिरोधी नहीं पाई गई। पुनः मेडिस पत्ती अंगमारी (डस्ठ), टर्सिकम पत्ती अंगमारी (ज्स्ठ), चारकोल सड़न (बित) तथा सोरघम डाउनी मिल्डयू (ैक्ड) के विरूद्ध एवीटी–1–2 की कुल 22 प्रविष्टियों का मूल्यांकन किया गया। इस कार्य में मेडिस पत्ती अंगमारी के लिए एक प्रतिरोधी प्रविष्टि यथा आरएएसआई 4118 तथा सोरघम डाउनी मिल्डयू के लिए तीन प्रतिरोधी प्रविष्टियों यथा एडीवी 7043, पीएम 17205 एल और पीएम 18205 एल का पता चला। मेडिस पत्ती अंगमारी (डस्ठ), टर्सिकम पत्ती अंगमारी (ज्स्ठ), चारकोल सड़न (बित) तथा सोरघम डाउनी मिल्डयू (ैक्ड) के विरूद्ध एवीटी–1–2 मक्का संकरों की रोग स्क्रीनिंग करने पर मेडिस पत्ती अंगमारी के विरूद्ध तीन प्रतिरोधी प्रविष्टियों यथा आईएमएचएसबी 17 आर–16, आईएमएचएसबी 17 आर–8 तथा आईएमएचएसबी 17 आर–9 और सोरघम डाउनी मिल्डयू के विरूद्ध एक प्रतिरोधी प्रविष्टि यथा एएच 8181 की पहचान की गई। पॉपकार्न मक्का संकरों की रोग स्क्रीनिंग करने पर मेडिस पत्ती अंगमारी (डस्ठ), टर्सिकम पत्ती अंगमारी (ज्स्ठ), चारकोल सड़न (बित) तथा सोरघम डाउनी मिल्डयू (ैक्ड) के लिए किसी प्रतिरोधी स्रोत की पहचान नहीं की जा सकी जबकि क्यूपीएम परीक्षण में दो प्रविष्टियां यथा आईक्यूपीएमएच 19 आर–1 एवं आईक्यूपीएमएच 19 आर–3 मेडिस पत्ती अंगमारी के विरूद्ध प्रतिरोधी थीं। खरीफ 2020 के दौरान, कुल 269 परीक्षण आयोजित किए गए। इनमें से 196 समन्वित परीक्षण थे जबकि ट्रैप नर्सरी के लिए 20 परीक्षण आयोजित किए गए। इसके अलावा, विभिन्न श्रेणियों यथा प्रबंधन परीक्षण; सिम्मट से परीक्षण; टालने योग्य अथवा परिहार्य उपज नुकसान परीक्षण; एवं सर्वे एवं सर्विलांस के तहत क्रमशः 25, 6, 3 तथा 19 परीक्षण भी आयोजित किए गए।

प्रसार एवं आउटरिच

प्रसार कार्यक्रम

अनुसंधान जरूरतों का समाधान करने के साथ–साथ संस्थान द्वारा अपने हितधारकों तक पहुंच स्थापित करने के लिए जीवंत प्रसार एवं आउटरिच कार्यक्रम चलाया जाता है। विभिन्न कार्यक्रमों का आयोजन करके संस्थान अपने किसान हितधारकों तक अपनी पहुंच बनाता है। इन कार्यक्रमों में प्रमुख हैं : राष्ट्रीय खाद्य सुरक्षा मिशन (छथ्ैड) के अंतर्गत कृषि, सहकारिता एवं किसान कल्याण विभाग, भारत सरकार द्वारा प्रायोजित अग्रिम पंक्ति प्रदर्शन (थ्स्क्े); अनुसूचित जनजाति संघटक (ज्ैच्); पूर्वोत्तर पर्वतीय संघटक (छम्भ्); अनुसूचित जाति उप–योजना (ैब्ैच्); तथा मेरा गांव – मेरा गौरव (डळडळ)।

वर्ष 2019–20 के रबी मौसम में, कुल 295 किसानों को लाभ पहुंचाते हुए 100 हेक्टेयर कृषि क्षेत्रफल में अग्रिम पंक्ति प्रदर्शन लगाए गए। इस मौसम में, सात राज्यों में आठ केन्द्रों द्वारा किसानों के खेतों पर सूक्ष्म पोषक तत्व एवं एकीकृत नाशीजीव प्रबंधन जैसी प्रौद्योगिकियों, डीएमआरएच 1301, सीओ 6, जीएवाईएमएच–1 तथा जीएवाईएमएच–3 जैसे सार्वजनिक क्षेत्र के संकरों और मटर एवं आलू के साथ मक्का के अंतर फसलचक्र का प्रदर्शन किया गया। बेगुसराय, बिहार में 8.4 प्रतिशत से लेकर कोल्हापुर, महाराष्ट्र में 46 प्रतिशत तक उपज वृद्धि हासिल की गई। वसंत 2020 में, तीन केन्द्रों द्वारा 30.2 हेक्टेयर से अधिक कृषि रकबे में अग्रिम पंक्ति प्रदर्शन लगाए गए जिनमें सार्वजनिक क्षेत्र के उन्नत संकर (पीएमएच 10) तथा निजी क्षेत्र के संकर (डीकेसी 9108) की प्रौद्योगिकी और संस्तुत बुवाई समय का प्रदर्शन किया गया। इस मौसम में न्यूनतम उपज वृद्धि देखी गई और इस वृद्धि में 2.51 से 5. 68 प्रतिशत की भिन्नता थी।

खरीफ 2020 में, तेरह राज्यों में कुल 375 किसानों को लाभ पहुंचाते हुए 151.03 हेक्टेयर से भी अधिक कृषि रकबे में अग्रिम पंक्ति प्रदर्शन आयोजित किए गए। इनमें सार्वजनिक क्षेत्र द्वारा हालिया जारी की गई संकर किस्मों यथा डीएमआरएच–1301, एफक्यूएच 106, वीएमएच 45, पीएमएच 1, ब्व्भ्;डद्ध.8ए एमएएच–14–5, जीएवाईएमएच–1, जैव प्रबलित क्यूपीएम संकर शक्तिमान–5 तथा साथ ही निजी क्षेत्र की संकर किस्मों यथा बायो–9544, पीएम–3 तथा पीएम–9 आदि को प्रदर्शित किया गया। इन प्रदर्शनों में मांडया, कर्नाटक में 9.6 प्रतिशत से लेकर इम्फाल, मणिपुर में 103 प्रतिशत तक की उपज वृद्धि हासिल की गई। जलभराव के प्रति संवेदनशील उत्तर पूर्वी मैदानी क्षेत्र (छम्च्) में सपाट बुवाई की तुलना में उठी हुई क्यारियों में रोपण के तहत 73.1 प्रतिशत की उपज वृद्धि पाई गई। कोल्हापुर केन्द्र में फॉल आर्मीवर्म (थ्।ॅ) प्रबंधन अग्रिम पंक्ति प्रदर्शन आयोजित किए गए जिनमें 46.1 प्रतिशत की उपज वृद्धि की सूचना मिली। इसी प्रकार, छिंदवाडा, मध्य प्रदेश में सर्वश्रेष्ठ खरपतवार प्रबंधन वाले अग्रिम पंक्ति प्रदर्शनों में 44.8 प्रतिशत उपज अग्रता प्रदर्शित हुई।

अनुसूचित जनजाति संघटक (ज्ैच्) के अंतर्गत, देश के विभिन्न भागों में कुल 31 किसान प्रशिक्षण/प्रक्षेत्र दिवस/जागरूकता कार्यक्रम आयोजित किए गए। मक्का की वैज्ञानिक खेती के विभिन्न पहलुओं पर कुल 1486 जनजाति किसान लाभान्वित हुए। इन कार्यक्रमों में आदान वितरित किए गए जिससे 1259 किसान परिवार लाभान्वित हुए। केन्द्रीय कृषि विश्वविद्यालय, इम्फाल, मणिपुर; केन्द्रीय कृषि विश्वविद्यालय–सीपीजीएस, बारापानी, मेघालय; भाकृअनुप–राष्ट्रीय सूअर अनुसंधान केन्द्र, गुवाहटी, असम; भाकृअनुप–राष्ट्रीय यॉक

अनुसंधान केन्द्र, दिरांग, अरूणाचल प्रदेश; भाकृअनुप–राष्ट्रीय मिथुन अनुसंधान केन्द्र, दीमापुर, नागालैण्ड; तथा पूर्वोत्तर पर्वतीय क्षेत्र के लिए भाकृअनुप का अनुसंधान परिसर, उमियाम के साथ सहयोग करते हुए ''टिकाऊ पशुधन उत्पादन के लिए मक्का'' विषय पर पूर्वोत्तर पर्वतीय कार्यक्रम की परियोजना को लागू किया गया है। इस कार्यक्रम के अंतर्गत सूअरों और यॉक के उत्पादन प्रदर्शन पर क्यूपीएम मक्का चारा और सिलेज के अनुपूर्ति प्रभाव का मूल्यांकन किया गया। इसके अलावा, पूर्वोत्तर भारत में विभिन्न संस्थानों के साथ सहयोग करते हुए पूर्वोत्तर पर्वतीय क्षेत्र के मक्का किसानों के लिए कुल 15 प्रशिक्षण कार्यक्रम आयोजित किए गए और आदानों का वितरण किया गया । इन कार्यक्रमों में कुल 504 ग्रामीण परिवारों को लाभ पहुंचा।

अनुसूचित जाति उप–योजना (ैब्च्) के अंतर्गत, विभिन्न अखिल भारतीय समन्वित अनुसंधान परियोजना केन्द्रों द्वारा तीन प्रशिक्षण कार्यक्रम आयोजित किए गए और किसानों को कृषि आदान वितरित किए गए। इन कार्यक्रमों में कुल 117 किसान लाभान्वित हुए। निक्रा–अनुसूचित जाति उप–योजना के अंतर्गत, चौधरी सरवन कुमार हिमाचल प्रदेश कृषि विश्वविद्यालय (ब्ैज्ञभ्च्ज्ञट), पालमपुर, हिमाचल प्रदेश के साथ सहयोग करते हुए जिला चम्बा, हिमाचल प्रदेश में लगभग 200 किसान परिवारों को लाभ पहुंचाते हुए चार मक्का थ्रेसर वितरित किए गए।

इसके अलावा, कोविड–19 महामारी के दौरान समाचार–पत्रों, स्थानीय चैनल, ऑल इंडिया रेडियो, स्थानीय रेडियो स्टेशन, व्हाट्सऐप ग्रुप तथा फेसबुक आदि के माध्यम से कुल नौ भाषाओं में किसानों को परामर्श जारी किए गए।

भाकृअनुप–भारतीय मक्का अनुसंधान संस्थान के तीस वैज्ञानिकों की आठ टीमों द्वारा पंजाब, हरियाणा, बिहार और तेलंगाना के पांच ब्लॉक में अंगीकृत किए गए 29 गांवों में मेरा गांव–मेरा गौरव कार्यक्रम को क्रियान्वित किया गया है। गांव में दौरा करके, किसानों को संदेश, ई–मेल, फोन कॉल तथा संदेश आदि भेजकर किसानों को सर्वश्रेष्ठ मक्का उत्पादन रीतियां, फॉल आर्मीवर्म प्रबंधन, स्वच्छता और कोविड–19 के संबंध में सावधानी उपायों पर परामर्श प्रदान किए गए।

प्रशिक्षण एवं क्षमता निर्माण

अपने स्टाफ सदस्यों को तकनीकी एवं प्रशासनिक प्रशिक्षण के लिए भेजने के अलावा, भारतीय मक्का अनुसंधान संस्थान द्वारा अपने विभिन्न हितधारकों यथा अनुसंधान एवं प्रसार के क्षेत्र में अधिकारियों, प्रशासकों, किसानों और छात्रों के लिए मक्का की वैज्ञानिक खेती एवं नाशीजीव प्रबंधन पर तकनीकी प्रशिक्षण कार्यक्रम आयोजित किए गए।

Executive Summary

ICAR- Indian Institute of Maize Research (ICAR-IIMR) carry out basic, strategic and applied research aimed at enhancing production, productivity and sustainability of the maize crop. The research programmes of the institute are built around three major theme areas: Crop Improvement, Crop Protection and Crop Management. The technologies developed are validated through All India Coordinated Research Project (AICRP) on Maize and the validated technologies are extended to stakeholders through extension and outreach programmes. Further, we focus on commercialization of developed products so that it fulfils the ultimate goal of improving the national maize production and productivity. During 2021, the institute has made significant achievements in research, product development, commercialization and extending its technologies to farmers through outreach programmes.

CROP IMPROVEMENT

Being a crop science institute, the major research of ICAR-IIMR has mainly been focused to improve the national maize production and productivity through genetic enhancement of maize. The crop improvement programme is focused on introduction and characterization of germplasm, improving productivity of the hybrids and parental lines, germplasm enhancement for resistance to biotic and abiotic stresses and quality traits. Significant research progress under the crop improvement division has been achieved by the institute which are mentioned below:

Genetic stock registered

Four maize inbred lines, viz., IML 11, IML 12, IML 13 and IML 21 were registered in NBPGR, New Delhi as source of resistance against Turcicum Leaf Blight (TLB) of maize.

Hybrids release and notified

Two QPM hybrids (IQMH 202 and IQMH 203) which were identified during 64th Annual maize Workshop during April 20-22, 2020, were notified through gazette notification on January 1, 2021. IQMH 202 has been recommended for Punjab, Haryana, Delhi, Western UP and Plains of Uttarakhand with moderate resistance to MLB and spotted stem borer with yield potential 72 q/ha. IQMH 203 has been recommended for Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh with Resistant to Fusaruim stalk rot (FSR), moderately resistant to Curvularia leaf spot (CLS) and spotted stem borer with yield potential 63 q/ha.

Seed production and commercialization of maize hybrids

In the recent past ICAR-IIMR has developed and released total 12 maize hybrids through Central Variety Release Committee (CVRC) under different categories (three each in normal field corn, quality protein maize, baby corn and popcorn). These are recommended for different zones and seasons such as for rabi (02) and kharif (10 hybrids) season cultivation. Besides release, the institute is continuously making efforts for commercialize and strengthening of seeds production chain. So far seven hybrids have been commercialized through 19 MoUs. During the representing year, 9 MoUs have been signed.

Maize Genetic Resource Management

Twenty-four maize genotypes were introduced from USA to strengthen the high oil maize breeding (EC 1076082 to EC 1076105). Further, under CRP on Agro Biodiversity (CRPAB) of Maize the institute undertook the massive exercise and characterized all the maize germplasm (11674) conserved at National Genebank (NGB), during winter season of 2020 at Begusarai. Data on 78 traits and drone-based data capturing was also under taken as a part of high throughput data recording. At Hyderabad, during rabi 2020-21, 512 inbred lines were maintained in field and 465 inbred lines were maintained at Ludhiana during spring 2021. Twenty-nine pools were used to extract new inbred lines; plants were selfed to advance to S1 generation. These 29 pools were also grown for maintaining through bulk pollination. In kharif 2021, 368 families were advanced from S1 to S2 generation through selfing.

Specialty corn breeding

Fifteen sweet corn inbred lines with positive GCA for important yield contributing traits were identified.

Heterotic grouping of 55 sweetcorn inbred lines was carried out, of which 30 aligned with LM 13 and 25 aligned with LM 14. Thirty-six experimental crosses were evaluated during spring season 2021 and promising hybrids were identified. To develop the CMS based baby corn, a total of eight lines, viz., MLSP 10116, MLSP 10117, HKI323, HKI 1105, 1710410C2, IMR 284, IMR 331 and IML 127-1 were converted into CMS lines. Further, a set of eight experimental babycorn hybrids were developed through crossing of CMS lines which were evaluated during kharif season 2021 at Ludhiana. The silage quality of hybrid PMH 1 was analyzed for planting density and sowing date; for silage quality, all silages exhibited good ensiling characteristics at all dates of sowing and plant densities. However, improved nutritive profile, better feeding values, higher in vitro potential and good fermentation characteristics of hybrid was observed in July15 sowing.

Breeding for abiotic stress

A trial of 200 newly developed inbred lines including some released inbred lines was conducted at Begusarai under normal as well as drought conditions. Under managed drought environment, top 20 inbred lines recorded >2.29 t/ha grain yield whereas top eight inbreds yielded >3 t/ha grain yield under drought stress environment. Only seven inbred lines out yielded the best check inbred LM 13 under stress environment. A separate set of 196 experimental maize hybrids along with four check hybrids was evaluated under normal and drought environment at Begusarai during rabi 2020-21. Performance of two hybrids, viz., MIL 2-1062-1-2 × BML 7 and BML 6 × MIL 2-3470 was better in both normal and drought environment. Further, a set of 275 experimental maize hybrids along with five check hybrids was evaluated under normal and water logging environment at RMR&SPC, Begusarai during kharif 2020. Twenty hybrids under normal environment and 18 hybrids under water logging were superior to best check hybrid under normal (DKC 7074) and water logging environment (Bio 9544), respectively. A set of 275 experimental hybrids along with five standard checks were evaluated under optimum and heat stress environment. Under heat stress trial 68 entries out yielded the best check hybrid P 3522. Three experimental hybrids, viz., MIL 2-975-2 × MIL 2-571-1, MIL 2-406-2 × T3 and MIL 2-1298-1 × LM 13 showed good performance under normal and heat stress environments. However, as the stress was suboptimal the data need reconfirmation.

Further, 100 maize inbred lines were evaluated in replicated design to study the effect of two post emergence herbicides i.e. tembotrione and topramezone. Phytotoxicity of tembotrione was observed in some of the inbred lines after 7 days of spray and one inbred line (MIL 2-3492) showed severe toxicity.

Breeding for biotic stress

Two trials were conducted one with 60 lines (Trial 1) and other with 150 lines (trial 2) to screen against Turcicum leaf blight (TLB) under artificially inoculated field conditions. In trial 1, the following lines were found to be resistant (<3.0 rating) IMLSB 1041-4-1, IMLSB 446-2, IMLSB 343-2, DML 16, IML 15-113, KDM 71412, VL 1110195, JCY 2-7, KDM 71412, PFSR R3, NAI 178A at Mandya centre. In trial 2, four lines, viz., EC 619334, EC 672689, EC 612071 and CML269dv shown the rating <3.0 at both Mandya and Dharwad location. In a genome-wide association study (GWAS) for TLB resistance in tropical maize identified 22 significant SNPs associated with TLB resistance with maximum SNPs on chromosome no. 4. Screening of 200 maize inbred lines against MLB during kharif 2020 found one resistant inbred line at Karnal and one inbred line at Dholi centre. A set of 100 inbred lines were evaluated against fall armyworm (FAW) under natural infestation during kharif 2020. Fourteen inbred lines showed less incidence of ear damage along with high yield potential. MIL 2- 49-2 was one of the best performing inbred under FAW infestation. A set of 25 maize inbred lines along with three checks were evaluated against spotted stem borer during kharif 2020 at WNC, Hyderabad. Two inbred lines (MIL 2-882-1 and MIL 2-1043-1-1) were identified as moderately resistant.

Breeding for quality traits

A set of 224 lines was evaluated at Ludhiana and 40 most promising lines were identified with higher tryptophan content (>0.8%). Toward diversification of QPM germplasm, new QPM lines were developed by using the background of normal maize lines as one of the parents after crossing with QPM lines. A set of such newly derived 74 lines was tested for tryptophan content and out of these 74 lines, 40 most promising lines have been identified for high tryptophan content which are listed below. For enrichment of lysine, tryptophan and ?-carotene LM 13, LM14, LM 15 and LM 17 were targeted for introgression of opaque2 (o2) and crtRB1 allele independently. The NILs carrying o2 gene have shown higher tryptophan which varied from 0.56 to 1.10% of the total protein. Some of the converted NILs showed more than double the level of tryptophan as compared to its original parent. The provitamin-content in the reconstituted hybrids was 4.35 ppm (Improved PMH 3) to 5.44 ppm (Improved PMH 6). To develop the waxy maize, crosses were made between donor (Pusa Waxy 55411) and recurrent parents (UMI 1200, UMI 1201, UMI 1230) during kharif 2020. The confirmed F1 plants were crossed with respective recurrent parents to generate BC1F1 generation. To improve the amylose content in maize, parents of HM 5 (HKI 1344 × HKI 1348-6-2) and HM 12 (HKI 1344 × HKI 1378) were selected as recurrent parents, whereas PI643420 and 510B were used as donor parents. The individuals of BC1F1 generation from each family, viz., HK I1344, HK I1348-6-2 and HKI1378 were genotyped with the foreground marker (sbeII) and were advanced to BC2F1 generation. Foreground positive BC2F1 individuals with high background recovery were advanced o BC2F2 generation.

Pre-breeding

Two advanced backcross populations (BC2F3) were generated through crossing between LM 13 and LM 14 with Zea parviglumis. Molecular characterization of different accessions of 25 wild species of maize, viz., Zea maxicana (17), Zea luxurians (1), Zea dipploperennis (2), Zea nicaraguensis (2) and Zea parviglums (3) were collected from different sources to diversify the maize germplasm and six parental lines, viz., LM 13, LM 14, BML 6, BML 7, UMI 1230 and UMI 1201 were carried out using 37 SSR markers to characterize the wild and normal maize inbred. Based on the 37 SSR primers, 31 maize germplasm including wild and inbred lines were classified into two clusters. It indicates that wild species are distantly different from cultivated inbred lines.

Biochemical characterization of maize germplasm

Screening of germplasm for amylose to amylopectin ratio showed the non-availability of high amylose lines in Indian germplasm as most of the lines possess higher amylopectin content. Two high amylose mutants procured from USDA were analysed for starch digestibility characteristics. A positive correlation has been observed between amylose and resistant starch content. Scanning electron microscopy of high, low and moderate amylose samples showed that starch matrix of low amylose lines was scattered relative to high amylose which have dense matrix. The higher density leaves no room for enzymatic activity leaving indigested starch fractions in the high amylose genotypes. Diversity analysis was performed among amylose extender (ae) mutants and normal maize lines. Apart from this a single kernel rapid method named "Cut Grain Dip Method" was developed to analyse amylose content in a large set of maize lines. On the basis of regression equation the method was standardised as a successful preliminary method for the estimation of amylose content in maize. The regression equation depicted a significantly inverse relation between amylose content and time taken for maximum colouration to reach. A ready reckoner table was developed to analyse the amylose content through CGD method.

Extraction and stability analysis of maize anthocyanins

The tristimulus patterns (L, a, b) and other color attributes of kernel and flour of indigenous landraces and exotic maize lines was noted. Purple or dark maize has more polymeric density as compared to the yellow, orange or red maize. The antioxidant activity of purple maize was higher as compared to the blue and red maize germplasm. The anthocyanin content in freshly harvested silk and stored silk for 3 months in refrigeration were compared and it as found that the dried silk has substantially lower anthocyanin content. Preliminary results show that zinc supplementation has stabilizing effect on the anthocyanin.

Development of a robust in vitro regeneration and transformation protocol for tropical maize (Zea mays L.) using mature seed-derived nodal explants

The standardized protocol not only overcomes the major limitations associated with the existing and predominately used immature embryo-based protocol but it is easier, reproducible, and has either higher or comparable callusing, regeneration, and transformation efficiency. To the best of our knowledge, this is the first report of its kind in tropical maize.

Purification of extracellular ligninolytic enzymes from co-culture of Phanerochaete chrysosporium and Pleurotus ostreatus

Phanerochaete chrysosporium and Pleurotus ostreatus are two fungi with potential in bio-delignification. In order to purify the extracellular ligninolytic proteins, a co-culture of Phanerochaete chrysosium and Pleurotus ostreatus was grown using corn stover as the substrate. Phosphate buffer was used to extract the extracellular enzymes and an ion exchange chromatogerpahy procedure was standardize to purify the enzymes to homogeneity. Nanoformulation of the purified enzymes showed enhanced activity.

Meta-QTL (MQTL) analysis for biotic and abiotic stresses in maize

The MQTL analysis revealed the projection of 33.59 % (128) QTLs associated with resistance against 12 fungal disease across the maize genome. A total of 38 MQTL regions were identified on the 9 chromosomes of maize (Ch1 to Ch9) possessing 1910 putative candidate genes. Similarly, projection of 27.04% (53) QTLs associated with resistance against 11 viral diseases was observed. For abiotic stress response, total 32 MQTLs on six chromosomes were projected, possessing 1907 candidate genes against different stresses.

gRNA designing to initiate genome-editing programme

guideRNAs were designed for gene editing of ZmZb7 and wrky114 individually, which result in albino and salt resistance, respectively. Albino phenotype would be helpful for standardizing gene editing protocol in maize, while salt resistance would lead to increase in area under maize by enabling cultivation on stressed ecologies.

CROP PROTECTION

Crop protection research at the institute is being carried out in the disciplines of Entomology and Pathology to manage insect pests and diseases of maize. Though maize crop is stressed by large number of insects and pathogens, spotted stemborer (SSB), pink stemborer (PSB), FAW and shoot fly among insect pests, and charcoal rot, maydis leaf blight and turcicum leaf blight among diseases are of major concern in India. Host plant resistance (HPR) is the most economical way to manage any disease or insect pest. Towards this direction, identification of sources of resistance is a continuous process. In addition to HPR, management of biotic stresses by integrating cultural, biological and, chemical means is also being explored to prevent economic loss to the crop.

Management of maize pests

Among 170 inbred lines screened against SSB and PSB, the lines BM 1644 and DML 1931 for SSB and MIL 1-11 for PSB were identified as sources of resistance. Normalized Difference Vegetation Index (NDVI) was identified as a promising technique for SSB germplasm screening.

Management of maize diseases

Among 36 entries evaluated against maydis leaf blight, [(VQH9/VQH9)BIO9544]-5-1-1-1 was found resistant. To study the diversity in S. turcica, 61 isolates were collected and purified from Meghalaya, Uttarakhand, Himachal Pradesh, Andhra Pradesh, Odisha, Gujarat, Madhya Pradesh, Jammu & Kashmir, Gujarat, Tamil Nadu and Maharashtra and characterized them morphologically. Web forewarning models for BLSB and MLB were developed and validated.

CROP MANAGEMENT

While crop improvement programme plays a great role in development of high quality, high yielding, and stress resistant genotypes, the ways and means to manage the crop plays an important role in achieving desirable farm productivity and sustainability. The crop management programme of the institute is mainly directed at tillage, nutrient and cropping system management.

Development of precision conservation agriculture practices in the cereal-based systems in Indo-Gangetic Plains

The conventional rice-wheat-mungbean (RWMb) system was compared with the conventional and conservation agriculture (CA) based maize-wheat mungbean (MWMb) system. It was found that replacement of the RWMb with the MWMb system increased system productivity (up to 29%), net returns (up to 71 %) and also gave huge (80%) water-saving at Ludhiana. It was concluded that the maize-wheat-mungbean system can be grown on 5-6 times acreage with the same amount of water used to grow one cycle of the rice-wheat system.

Study of different organic nutrient sources in maize and speciality corn

In the fifth year, the yield of baby corn, sweet corn and normal maize in organic treatments was significantly lower as compared to RDF. However, the gap between RDF and organic treatment is narrowing down. The integrated use of the organic and inorganic fertilizer proved to be the best treatment for the realization of a higher yield of all types of maize studied.

Sensor guided nitrogen management in maize-based cropping system under conventional and conservation agriculture practices

The green seeker (GS) guided N dose optimization was integrated with the sub-surface banding (SSB) of the first split N application under conservation agriculture in maize. The improved N placement lead to a significant yield increase of 8.5 and 13.7% by GS-SSB and RDN-SSB, respectively over RDN-conventional. The subsurface banding of the first split dose of N fertilizer leads to enhanced agronomic efficiency of N by 18.3 and 30.7% under RDF and GS guided treatments, respectively over conventional-RDN. Irrespective of the cropping system, the gain due to residue retention was significant in maize yield (10.4%) over residue removal under CA.

EXTENSION AND OUTREACH

Extension programmes

The institute maintains a dynamic extension and outreach programme to reach out to its stakeholders in addition to fulfilling research needs. The institute reaches out to its farmer and other stakeholders through conducting programmes, viz., Frontline Demonstrations (FLDs) sponsored by the Department of Agriculture and Cooperation, Government of India under the National Food Security Mission (NFSM), the Scheduled Tribe Component (STC), North Eastern Hill (NEH) component, Scheduled Caste Sub Plan (SCSP), Agribusiness incubation centre (ABI) and Mera Gaon Mera Gaurav (MGMG). The NEH programme had a project on "Maize production in NEH region for sustainable livestock production" has been implemented in collaboration with CAU, Imphal (Manipur), CAU-CPGS, Barapani (Meghalaya), ICAR-National Research Centre on Pig, Guwahati (Assam), ICAR-National Research Centre on Yak, Dirang (Arunachal Pradesh), ICAR-National Research Centre on Mithun, Dimapur (Nagaland) and ICAR-Research Complex for North Eastern Hill Region, Umiam.

Rice vs maize demonstrations

A comparison of upland/midland rice vs maize was demonstrated in West Bengal, Uttarakhand, Odisha and Jharkhand in an area of 259 ha under SCSP/STC programme. In West Bengal, hybrid maize has a monetary gain of about Rs.42000/ha over upland rice. In Jharkhand and Odisha, the average monetary gain of hybrid maize over the midland paddy was about Rs. 52585/ha and Rs.18647/ha, respectively. In Uttarakhand, the average monetary gain of hybrid maize over the summer rice was Rs. 47422/ha. This showed that the maize ecosystems need to be developed in upland/midland paddy areas of eastern India and the summer rice areas in the foothill Himalayan region for the benefit of the farmers and agroecosystem sustainability.

Learning platform for diversification with maize in western IGP

In kharif 2021, ICAR-IIMR initiated a collaborative project with CIMMYT, SAUs and the state agricultural department on "Participatory Innovation Platform on Potential Yield Realization of Maize-based Cropping Systems in Punjab and Haryana". The 100 acres of learning platforms have been established in 7 districts of Punjab viz. Hoshiarpur, SBS Nagar, Jalandhar, Ludhiana, Pathankot and Rupnagar and 50 acres in three districts of Haryana (Karnal, Kurukshetra, and Ambala). Knowledge on improved agronomic production technologies and agro-inputs such as seeds of improved maize varieties, herbicides and pesticides to control fall armyworm have been distributed to the farmers. In the first year, the yield realized at the learning sites was upto75 q/ha which showed a hope that the maize can be inroads for diversification. State Level Maize day was organized in both the state for convincing the policy makers and all stakeholders. The district-level maize days in Kurukshetra, Ambala and Jalandhar were also held to create widespread awareness of maize cultivation as a profitable enterprise in the rice belts of Punjab and Haryana.

Frontline demonstration under NSFM

In rabi 2020-21, FLDs were conducted on 95.6 ha by 8 centres in 6 states, benefitting 376 farmers and the average yield gains in the season was 18.6% (6.7% in Kalyani to 38.5% in Gossaingaon). In spring 2021, the FLDs was done on 50 ha benefiting 120 farmers where a mean yield gain of 36.1% was recorded. In kharif 2020, FLDs were conducted on 144.0 ha benefiting 425 farmers in 11 states. This kharif season FLDs showed a yield gain of 44.2% with improved technology demonstrated which varied from 2.4% in Ludhiana to 127.2% in Karnal. The recently released public sector hybrids like DMRH 1301, GAWMH 2, PMH 13, Pant Sankar Makka 5, Shaktiman 5, Shalimar QPM 1, PJHM 1, DMRH 1308, VLQPMH 59, VL Maize Hybrid 57, etc. along with new hybrid varieties of private sector like CP 999, CP 838, DKC 9108 etc. were demonstrated under FLDs.

Maize demonstrations for disadvantaged areas/farmers

Under STC, in rabi season 2020-21, FLDs were taken up on 50.6 ha of land benefitting 125 farmers which gave an average yield gain of 28.8% (15.6% in Vagarai to 38.2% in Banswara). During kharif 2021, 502.8 ha FLDs were conducted under this STC component benefitting 1923 farmers and an average yield gain of 52.2% was recorded which varied from 17.0% in Vagarai to 161.0% in Ranchi. Under the SCSP, improved technologies of maize were demonstrated in 462.3 ha of the farmer's field and benefitted 1390 farmers. The result of the FLDs showed that an average yield of 25.7% was recorded, with a minimum yield gain of 7.4% in Jagtial and the highest in Rahuri with 82.9%. Under NEH, the FLDs were also taken up in 60.3 ha and benefitted 194 farmers of the NEH region. The average yield gain of 26.2% was recorded which ranged from 12.5% in Barapani to 53.1% in Imphal. In research for these areas, it was found that feeding green maize has decreased the population of methanobacteria in the gut of pigs, which in turn has limited the production of methane. Therefore, a fibre-rich diet being a good remedy to improve the intestine digestibility in pigs, can also be implemented as a strategy to lower the global warming impact worldwide.

Farmer led Innovations (FLI) and their Scaling up Mechanisms in Maize

Several farmers' led innovations were collected and documented on different aspects of maize farming from different part of the country. Some of the prominent innovations collected are wind operated bird scaring machine by using a cycle hub, cycle chain, and steel plate and table fan blades; indigenous storage technique of maize; maize sheller; indigenous practice of detasselling after pollination etc.

MGMG programme

Seven teams of ICAR-IIMR scientists performed the MGMG programme in 23 adopted villages across five blocks and 5 districts of Punjab, Haryana, Bihar and Telangana. Scientists were in regular touch with the farmers of these villages through visits, and ICT tools and organized several activities such as interface meeting/gosthies, input distributions, awareness creation and linkage with other agencies benefitting more than 801 farmers.

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Mera Gaon Mera Gaurav programme

Seven teams of ICAR-IIMR scientists performed the Mera Gaon Mera Gaurav (MGMG) programme in 23 adopted villages across five blocks and 5 districts of Punjab, Haryana, Bihar and Telangana. Scientists were in regular touch with the farmers of these villages through visits and ICT tools, and organized several activities such as interface meeting/kisan gosthies, input distributions, awareness creation and linkage with other agencies benefitting more than 801 farmers.

Entrepreneurship development under ABI

Under the Agri-Business Incubation (ABI), several maize-based products such as QPM Biscuit, QPM Cookies, QPM Burfi, Pop Corn Laddu, Pop Corn Ghachak, QPM Muffins, QPM Cakes, QPM & Normal Maize Pasta, QPM & Normal Maize Chapati etc. have been developed. In 2021, one agri. start-up has joined the ABI of ICAR-IIMR.

TRAINING AND CAPACITY BUILDING

Under the STC, 56 farmers' training/field day/awareness programmes were conducted in different parts of the country on various aspects of scientific maize cultivation, benefiting 2579 tribal farmers. 1548 households benefitted from the input distributions. The 37 trainings/ agricultural inputs distributions/ awareness/ field day programmes were also organized benefitting 2299 farmers under the SCSP programme. Various inputs including seed, fertilisers, chemicals, small farm implements and farm literature were also distributed to 1385 households under the SCSP programme. Under NEH, 17 training/ input distribution programmes/ field days/ awareness programmes were also organized benefitting 792 beneficiaries. Besides these, 1462 rural households also benefitted from input distribution programmes. Under ABI, two hands-on training were conducted on "Value addition in maize" for the popularization of technologies developed by ICAR-IIMR.

In addition to the technical trainings imparted on scientific maize cultivation to various stakeholders, the institute been deputing its staff for technical and administrative training too.

AICRP on MAIZE

All India Coordinated Research Project on Maize (AICRP on Maize) supported by the institute and co-ordinated through a network of state agricultural universities is the back bone of concerted maize research in India. Multi-location testing of maize technologies under crop improvement, crop production, crop protection, is the signature of AICRP on Maize. AICRP on Maize also made possible the dissemination of tested technologies to far flung places of the country.

Crop improvement

During Rabi 2020-21, 127 entries were received for multi-location evaluation in AICRP under the normal corn trials viz., NIVT (NIVT-Late: 34 and NIVT-Medium: 49), AVT-I (AVT-I-Late: 8 and AVT-I-Medium 4) and AVT-II (AVT-II-Late: 4 and AVT-II-Medium: 6), and specialty corn trials viz., QPM (13), popcorn (13), baby corn (2) and sweet corn (4). Out of the total 127 entries, 66 entries were contributed by the private sector (20 different firms) and 61 by the public sector. During spring 2021, 49 entries were received for evaluation in NWPZ under the normal corn trials viz., NIVT (NIVT-Late: 7 and NIVT-Medium: 40) and AVT-I-Medium (2). Success rate for the spring trial was 76.0%.

During kharif 2021, 269 entries were received for multi-location evaluation under the normal corn trials viz., NIVT (NIVT-Late: 40, NIVT-Medium: 60, NIVT-Early: 26), AVT-I trials (AVT-I-Late: 20, AVT-I-Medium: 27, AVT-1-Early: 7), AVT-II trials (AVT-II-Late: 4, AVT-II-Medium: 6 and AVT-II-Early: 2), specialty corn trials viz., QPM (40), baby corn (12), sweet corn (10) and popcorn (6), and 10 under open pollinated varieties (OPV). Out of the total 269 entries, 92 entries were contributed by the private sector (28 different firms) and the rest 177 came from 25 centres of AICRP on maize. Total 34 different breeding trials constituted, where, one set was exclusively for NHZ and the rest for across the zones. Total of nine trial, viz., NIVT-Medium, NIVT-Early, AVT-I-II-Early, AVT-I-II-Medium, QPM I-II-II, Sweet Corn I-II-III, Baby Corm I-II-III, Popcorn I-II-III and OPV trials were exclusively conducted in NHZ and total seven trials, viz., NIVT-Late, NIVT-Medium, NIVT-Early, QPM I-II-II, QPM quality, Sweet Corn I-II-III, Baby Corn I-II-III, AVT-II-R/F-Early and AVT-II-R/F-Medium were constituted across the zones. Ninety-one entries were promoted from the first and second year of testing.

Crop Protection

Maize AICRP entomology rabi 2020-21 and spring 2021 experimental trials were aimed mainly for screening resistance against pink stem borer (PSB) , spotted stem borer (SSB), fall armyworm (FAW) and shoot fly.

Under artificial infestation of PSB at Hyderabad location, the entries BIO 9544 (5.8), IMHSB 17R-16 (6.0) and IMHSB 19R-10 (6.0) out of 16 medium maturity and IT 8582 (5.2) out of 18 late maturity were found moderately resistant to PSB under AVT-I and AV-II trials. Among the nine popcorn I-II-III entries, only APCH 2 (5.4) was moderately resistant to PSB.

Under artificial infestation of SSB at Kolhapur, IMHSB 17R-8 (4.9), IMHSB 17R-14 (6.0) and IMHSB 17R-14 (6.0) out of 16 medium maturity and RASI 7044 (5.5), HKI 9569 (5.6), NMH 712 (5.8), IT 8582 (5.9), JKMH 4510 (5.9) and KMH 018 (6.0) of late maturity under AVT-I and AVT-II trials were found moderately resistant. Of the nine popcorn I-II-III entries screened against SSB, APCH 2 (5.4), BPCH 6 (5.5) and APCH 3 (6.0) were found moderately resistant.

In AVT-I and AVT-II medium maturity group, only one entry i.e. IMHSB 17R-17 (18.8) was moderately resistant against shoot fly of medium maturity group in AVT-I and AVT-II whereas at Karnal and Ludhiana centres during spring 2021. A total of 95 maize accessions were evaluated under natural infestation against fall armyworm in augmented design at Coimbatore and Kolhapur during rabi 2020-21. The lowest and highest Davis scores were recorded in IMLSB 208B (2.7) and IMLSB 800-1 (4.6). A total of 95 maize accessions were evaluated under natural infestation against shoot fly in augmented design at Karnal and Ludhiana during spring 2021. The following five entries, viz., IMLSB 807-1, UMI 1205, IMLSB 2160, BML 2 and E 9GoTC recorded mean percent dead heart less than 20.0.

During rabi2020-21, 127 maize entries were evaluated against Maydis leaf blight (MLB), Turcicum leaf blight (TLB), Charcoal rot (ChR) and Sorghum downy mildew (SDM) in different zones across the country. A total of 49 entries of medium maturity were evaluated for MLB, TLB, ChR and SDM across three zones (NEPZ, NWPZ and PZ) NIVT medium maturity. One entry (IV 8214) was found resistant against ChR in NWPZ. A total of 34 entries of late maturity were evaluated for MLB, TLB, ChR and SDM across three zones (NEPZ, NWPZ and PZ) in NIVT late maturity. One entry (GH 150125) was found resistant against ChR in NWPZ. A total of 10 entries of medium maturity were evaluated for MLB, TLB, ChR and SDM across three zones (NEPZ, NWPZ and PZ) in AVT-I-II medium maturity. The following five entries, viz., IMHSB 17R-16, IMHSB 17R-17, IMHSB 17R-8, IMHSB 19R-10 and IMHSB 19R-2 were found resistant against MLB in NEPZ. A total of 12 entries of late maturity were screened against MLB, TLB, ChR and SDM across three zones (NEPZ, NWPZ and PZ) in AVT-I-II late maturity. A total of six entries, viz., IT 8582, KMH 018, PM 18202L, PM 18204L, RASI 5278 and RASI 5640 were found resistant against MLB in NEPZ. A total of 22 entries from QPM and specialty corn were screened against MLB, TLB, ChR and SDM across three zones (NEPZ, NWPZ and PZ) in QPM and specialty corn. Only three QPM entries namely viz., BHQPM 418026, DZ-89, QPMMH 2155 were found resistant against MLB in NEPZ. A total of nine coordinated trials for screening of different diseases has been sent for kharif 2021.

Crop Production

In rabi 2020-21, experiments were conducted on the agronomy of pre-release genotypes of different maturity, tillage and nutrient management, integrated nutrient management, ecological intensification, weed management, crop residue management in traditional and emerging maize systems, enhancing water use efficiency in spring maize and agro-ecological options for Fall Armyworm (FAW) management in maize systems. The different hybrids of AVT-II in medium and late maturity were tested at fertility levels and density levels in four zones except NHZ. The NMH 4140 genotype showed significantly higher yield over best check at NWPZ, NEPZ and CWZ. The late maturity genotype PM 18202L responded to high nutrient levels and density but was on par for grain yield with checks in PZ. In CWZ, long duration genotypes tested at two locations and genotype responded to high fertility levels (150% RDF), however none was found superior over best check. In NWPZ, PM 18202L, PM 1824L, PM 18208L and IT 8582 gave significantly higher grain yield over check in late maturity. Nutrient management in maize-wheat-cowpea cropping system under different tillage practices revealed that different tillage practices had non-significant effect on wheat yield but the system yield and system net returns were significantly higher with zero tillage (ZT) in clay loam soil at Pantnagar which was at par with conventional tillage (CT). However, in nutrient management (100% RDF) showed significantly higher wheat and system yield as well as system net returns which was at par with site specific nutrient management (SSNM). Long-term trial on integrated nutrient management revealed that maize equivalent yield of system, net returns and benefit cost (BC) ratio were significantly highest with 100% RDF + 5 t/ha farm yard manure (FYM) which was at par with the 75% RDF + 5 t/ha at Pantnagar (NWPZ). FYM at Maize + legume intercropping (for economic produce) with FYM 10 t/ha + Azatobactor application produced highest yield which was statistically similar to the 100% RDF + 5 t/ha FYM treatment at Banswara. The experiment on ecological intensification for climate resilient maize-based cropping systems revealed that crop yield was statistically highest with ecological intensification (EI) at all seven locations. Th weed management in maize systems found superior performance of Atrazine 1000 g/ha (PE) followed by Tembotrione 120 g/ha at 25 DAS), Atrazine 750 g/ha (PE) followed byTopramezone 25.2 g/ha at 25 DAS and Atrazine 1000 g/ha (PE) followed by hand weeding at 25 DAS at Gossainagaon, Kalyani and Banswara.

During kharif 2021, evaluation of pre-release genotypes under varying planting density and nutrient levels identified KMH 8322, SYN 916801, HT 519074 in late maturity group in NWPZ, IMHSB-19-2 in medium maturity while genotype JKMH 1481 and BH 417182 in Peninsular zone and JKMH 1481in CWZ. IQPMH 18-2 was found superior over best check HQPM 5in CWZ whereas in sweet corn CP Sweet 2 and CPSC 301 was superior in NHZ and NEPZ, respectively. Long term trial on integrated nutrient management in maize system revealed that 100% RDF + 5 t/ha FYM resulted in the significantly higher maize yield at 9 locations except at Banswara.

Weed management in maize systems revealed that sequential application at 25 days after sowing (DAS) after 750 or 1000 g/a of pre-emergence atrazine application or as tank-mix application at 15 DAS for tembotrione (120 g/ha) or tompramezone (25.2 g/ha) along with 750 g/ha atrazine resulted in significantly higher or on par yield with recommended check (1000 g/ha atrazine as pre-emergence (PE) followed by hand weeding at 25 DAS) at most of the locations. The net returns were recorded significantly higher in selected post emergence herbicide-based weed management over check in all locations except at Peddapuram and Vagarai where it remained at par with some of the post emergence herbicidal based treatment. The organic polymer Fasal Amrit was tested at 8 locations for its efficacy in enhancing productivity of rainfed maize. The application of Fasal Amrit @ 20 kg/ha + RDF gave higher yield and net returns in kharif maize at 5 locations which was at par with Fasal Amrit @ 5/10/15 kg/ha + RDF except at Karimangar where it remained at par with only Fasal Amrit @ 15 kg/ha + RDF. At 3 locations (Ludhiana, Bhubaneswar and Godhra), it had non-significant on yield and economics of maize production. The experiment for enhancing sustainability of baby corn based intensive cropping system was started at two maize ecologies. In first year, there was non-significant amongst various treatments applied at Karnal on baby corn yield. At Kalyani, application of 20 t/ha organic manure/year + RDF continuous baby corn resulted in the maximum yield and returns which remained at par with continuous baby corn cultivation with 15 t/ha organic manure/year + RDF.

CROP IMPROVEMENT 1

Crop improvement discipline deals with the improvement of yielding ability of maize hybrids and its parental lines, germplasm enhancement for resistance to biotic and abiotic stresses and quality traits to meet the changing climate and market scenario.

Genetic stock registered

Four maize inbred lines, viz., IML 11, IML 12, IML 13 and IML 21 were registered in NBPGR, New Delhi as source of resistance against Turcicum Leaf Blight (TLB) of maize. The details of these inbred lines are given below:

IML 11 (INGR 21126): IML 11 is a late maturing high yielding line resistant to TLB (disease mean score 2.6 on the scale of 1 - 9) with short height, medium ear placement, straight attitude of lateral tassel branches, sparse spikelets of tassel, yellow round shaped and flint kernels. It was derived from normal maize segregating progeny by continuous selfing following pedigree breeding method. IML 11 has yield potential of 28.2 q/ha.

IML 12 (INGR 21209): IML 12 is a medium maturing high yielding inbred line resistant to TLB (disease mean score 2.5 on the scale of 1 - 9) with medium height and ear placement, straight attitude of lateral tassel branches, sparse spikelets of tassel, cylindrical ears with yellow round shaped and flint kernels. It was derived from normal maize segregating progeny by continuous selfing following pedigree breeding method. IML 12 has yield potential of 31.9 q/ha. It also has good seed setting potential to be used as seed parent for commercial seed production.

IML 13 (INGR 21210): IML 13 is a medium maturing high yielding line resistant to TLB (disease mean score 2.4 on the scale of 1 - 9) with short height, medium ear placement, curved attitude of lateral tassel branches, sparse spikelets of tassel, straight kernel rows, cylindrical ear with yellow round shaped and flint kernels. It was derived from normal maize segregating progeny by continuous selfing following pedigree breeding method. IML 13 has yield potential of 36.4 q/ha. It also has good seed setting capacity and can be used as seed parent under commercial seed production.

IML 21 (INGR 21208): IML 21 is a late maturing high yielding inbred line resistant to TLB (disease mean score 2.6 on the scale of 1 - 9) with medium height and ear placement, straight attitude of lateral tassel branches, sparse spikelets of tassel, straight kernel rows, cylindrical ear with yellow round shaped and semi-dent/ semi-flint kernels. It was derived from normal maize segregating progeny by continuous selfing following pedigree breeding method. IML 21 has yield potential of 33.1 q/ha. This inbred is suitable for cultivation during rabi season where climatic conditions are free from cold stress and can be used as seed parent under commercial seed production.

Hybrid development, seed production and commercialization

Hybrids release and notified

Two QPM hybrids which were identified during 64th Annual maize Workshop during April 20-22, 2020, were notified through gazette notification on January 1, 2021 (Table 1.1).

Table 1.1: The details of the hybrids notified

Sl. No.	Name of the hybrid	Notification no.	Recommended areas for cultivation	Yield (q/ha)	Specific traits
1.	IQMH 202	SO 500(E) Dated: 29.1.2021	Punjab, Haryana, Delhi, Western UP and Plains of Uttarakhand	72	Moderately resistance to Maydis leaf blight (MLB) and spotted stem borer, high lysine (3.04%) and tryptophan (0.66%).
2.	IQMH 203	SO 500(E) Dated: 29.1.2021	Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	63	Resistant to Fusaruim stalk rot (FSR), moderately resistant to Curvularia leaf spot (CLS) and spotted stem borer, high lysine (3.48%) and tryptophan content (0.77%).

Seed production and commercialization of maize hybrids

Breeder seed demand and commercialization of IIMR Hybrids

In the recent past ICAR-IIMR has developed and released total 12 maize hybrids through Central Variety Release Committee (CVRC) under different categories (three each in normal field corn, quality protein maize, baby corn and popcorn). These are recommended for different zones and seasons such as for rabi (02) and kharif (10 hybrids) season cultivation. Besides release, the institute is continuously making efforts for commercialize and strengthening of seeds production chain. So far seven hybrids have been commercialized through 19 MoUs. During the representing year, 9 MoUs have been signed. The year wise breeder seed indent received from Department of Agriculture& Farmers Welfare (DAC&FW) and total breeder seed sold for IIMR Hybrids have been given in Table 1.2 and 1.3.

Impact analysis of DMRH 1301 and 1308 hybrids

The rabi season maize contributes about 30% of India's maize production from total of 19% maize acreage. These both hybrids are recommended for rabi season cultivation in NEPZ and CWZ. Initially, DMRH 1308 was recommended for CWZ but after state evaluation in Bihar, the Govt. of Bihar has recommended this hybrid for cultivation in the state. Bihar and West Beal are the two important states of the NEPZ where rabi maize is cultivated extensively.

Table 1.2: Year wise DAC&FW breeder seeds demand received for ICAR-IIMR hybrids

Hybrids	DAC&FW breeder seeds indent received (kgs)				
	2018-19	2019-20	2020-21	2021-22	Total
DMRH 1301 (Male parent)	3	80	105	220	408
DMRH 1301 (Female parent)	5	140	150	380	675
DMRH 1308 (Male parent)	-	10	20	321	351
DMRH 1308 (Female parent)	-	20	35	642	697
DMRH 1305 (Male parent)	-	10	-	-	10
DMRH 1305 (Female parent)	-	20	-	-	20
LQMH 1 (Male parent)	-	-	5	14	19
LQMH 1 (Female parent)	-	-	10	28	38
Male and Female of IMHB 1532	-	-	40	-	40

Source: https://seednet.gov.in, MOA&FW, Govt. of India

Table 1.3: Year wise total Breeder seeds produced and supplied (kgs) for different hybrids of the institute

Parents of hybrids	Year wise breeder seeds produced and supplied (kgs)				Total
	2018-19	2019-20	2020-21	2021-22	
DMRH 1301 (Female parent) and 1308 (Female parent)	1110.0	188.0	2212.0	5542.0	9052.0
DMRH 1301 (Male parent)	295.0	60.0	725.0	200.0	1280.0
DMRH 1308 (Male parent)	-	-	429.0	1895.0	2324.0
DMRH 1305 (Female parent)	-	20.0	40.0	-	60.0
DMRH 1305 (Male parent)	-	10.0	20.0	-	30.0
LQMH 1 (Female parent)	-	-	-	30.0	30.0
Male of LQMH 1 (Male parent)	-	-	-	15.0	15.0
IMHB 1539 (Female parent)	-	-	10.0	-	10.0
IMHB 1539 (Male parent)	-	-	5.0	-	5.0
LPCH 3 (Female parent)	-	-	-	5.0	5.0
LPCH 3 (Male parent) -	-	-	2.5	2.5	
IMHB 1532 (Female parent)	-	-	30.0	-	30.0
IMHB 1532 (Male parent)	-	-	10.0	-	10.0

#The quantity supplied includes the total demand received (through DAC&FW + direct demand to the institute) from various states and national seeds producing agencies

Normally the seed production of hybrid maize is being carried out in peninsular India that involves high transportation and handling cost. However, the hybrids seed production for DMRH 1301 was first demonstrated in West Bengal in a participatory mode in collaboration with National Seed Corporation (NSC) and West Bengal State Seed Corporation (WBSSC) at farmer's field in 2018-19. The seed production on this alternate site for commercial production became successful in the first year itself with production of nearly 36 tones certified seed. After the successful seeds production and cultivation of DMRH 1301 in the West Bengal, now seed production is also going on for DMRH 1301 and DMRH 1308 on a large scale in nearly 280 acres land during rabi 2021-22. The entire seed produced is given to the famers for commercial production in Bihar and West Bengal through various government agencies. The seed was also distributed by the ICAR-IIMR in frontline demonstrations (FLDs) under National Food Security Mission in Bihar and West Bengal. Comparing to the pre-dominant long duration hybrids of private sector being cultivated in these ecologies, both DMRH 1301 and 1308 are of the medium duration and more suitable for the cropping system. At the farmers' and experimental fields, both the hybrids gave average yield of 9.0 t/ha (7.5 - 11.1 t/ha) and 7.7 t/ha (6.5 - 10.4 t/ha) in West Bengal and Bihar, respectively **(Figure 1.1).**

The farmers accepted these hybrids due to their better grain and water productivity, profitability, and best fitting into the cropping system because of medium duration. As a result, the seeds of these

Figure 1.1: Commercial cultivation of DMRH 1301 and DMRH 1308 hybrids (a to c) and seeds production of DMRH 1301 (d) in farmers field

hybrids are in great demand in recommended ecologies. This was also evident by receiving the highest DAC&FW breeder seed demand of these two hybrids (1563 kgs) in the country for the year 2021-22 which was 33.20% of the total breeder seeds demand for the year. Seeing the business opportunity and farmers' feedback on the hybrids performance, as of now total 12 companies have signed MoUs of worth Rs. 29.25 lakhs with ICAR-IIMR through Agri-Innovate. Through breeder seed sale of these two hybrids, a total of Rs. 42.77 lakhs revenue has been generated in the last four years. Considering the quantity of breeder seeds supplied, the coverage of these hybrids increased from mere 7,400 ha in 2018-19 to 1, 89,880 ha in 2021-22. If we take the DAC breeder seeds demand of these two hybrids received for year 2021-22 into account (15.63 q), in the time to come, these can go nearly in 5.0 lakhs ha acreage in the NEPZ and CWZ.

Hybrids promoted/contributed under AICRP testing

Hybrid promoted in AICRP- Normal

Two entries of filed corn contributed by the institute, viz., IMH 2-19R-2 and IMH 2-19R-10 NEPZ (Zone 3) have been promoted from AVT-I (medium) to AVT-II (medium) during rabi 2020-21. Two entries of filed corn, viz., IMH 2-20R-10 (for NEPZ), IMH 2-20R-7 (for NWPZ) and four entries, viz., IMH 2-20R-6, IMH 2-20R-11, IMH 2-20R-15 and IMH 2-20R-1 (for NEPZ) have also been promoted from NIVT (medium) to AVT-I (medium) during rabi 2020-21. During kharif season one entry IMH 2-19K-2 was promoted from AVT-I (medium) to AVT-

Table 1.4: Hybrid promoted (Normal maize) in different AICRP trials

Sl. No.	Name of hybrid	Type of hybrid	Trial	Promoted to	Maturity	Zone	Yield (q/ha)	Superiority (%)
1	IMH 2-20R-10	Field Corn	NIVT	AVT-I	Medium	NEPZ	94.97	7.79
2	IMH 2-20R-7	Field Corn	NIVT	AVT-I	Medium	NEPZ	94.41	7.16
3	IMH 2-20R-6	Field Corn	NIVT	AVT-I	Medium	NEPZ	100.74	13.52
4	IMH 2-20R-11	Field Corn	NIVT	AVT-I	Medium	NEPZ	100.47	13.22
5	IMH 2-20R-15	Field Corn	NIVT	AVT-I	Medium	NEPZ	99.64	12.29
6	IMH 2-20R-1	Field Corn	NIVT	AVT-I	Medium	NEPZ	99.06	11.64
7	IMH 2-19R-2	Field Corn	AVT-I	AVT-II	Medium	NEPZ	108.22	18.80
8	IMH 2-19R-10	Field Corn	AVT-I	AVT-II	Medium	NEPZ	104.90	15.15
Kharif 2020								
9	IMH 2-20K-12	Field Corn	NIVT	AVT-I	Medium	NEPZ	79.40	14.89
10	IMH 2-20K-13	Field Corn	NIVT	AVT-I	Medium	NEPZ	78.10	13.01
11	IMH 2-20K-10	Field Corn	NIVT	AVT-I	Medium	NEPZ	77.50	12.08
		Field Corn	NIVT	AVT-I	Medium	PZ	98.80	2.96
12	IMH 2-20K-11	Field Corn	NIVT	AVT-I	Medium	NEPZ	76.50	10.75
13	IMH 2-19K-2	Field Corn	AVT-I	AVT-II	Medium	NEPZ	77.00	24.34

Table 1.5: The detail QPM hybrid promoted in AICRP trials

Sl. No.	Name of hybrid	Type of hybrid	Trial	Promoted to	Maturity	Zone	Yield (q/ha)	Superiority (%)
1	IQPMH 2001	QPM	NIVT	AVT-I	81.26	Medium	CWZ	2.0%
2	IQPMH 2002	QPM	NIVT	AVT-I	73.32	Medium	NHZ	7.0%
3	IQPMH 2004	QPM	NIVT	AVT-I	74.03	Medium	NHZ	8.0%
4	IQPMH 2007	QPM	NIVT	AVT-I	10.25	Medium	NEPZ	9.3%
					88.32	Medium	CWZ	10.4%
5	IQPMH 2012	QPM	NIVT	AVT-I	82.36	Medium	CWZ	2.9%
					57.10	Medium	PZ	7.0%

Figure 1.2: Potential QPM hybrids promoted in AICRP

II (medium) for NEPZ. Further, four field corn hybrids (IMH 2-20K-10, IMH 2-20K-11, IMH 2-20K-12 and IMH 2-20K-13) and one normal hybrid (IMH 2-20K-10) were also promoted from NIVT (Medium) to AVT-I (Medium) for NEPZ and PZ, respectively (Table 1.4).

Hybrid promoted in AICRP- QPM

Five hybrids namely IQPMH 2001, IQPMH 2002, IQPMH 2004, IQPMH 2007 and IQPMH 2012 have been promoted for testing in advance trials (Table 1.5 and Figure 1.2).

Hybrid promoted in AICRP- Baby corn

Two Baby corn entries, viz., IMH 2-19KB-2 (NHZ, PZ and CWZ) and IMH 2-19KB-3 (NHZ) were promoted from NIVT to AVT-I. The list of promoted entries is given in Table 1.6.

Hybrids contributed under AICRP testing

Normal maize

The institute contributed 10 new field corn hybrids in NIVT (medium), five hybrids in AVT-I (Medium), one in AVT-II (Medium), two baby corn hybrids (AVT-I), two popcorn hybrids and four QPM hybrids in NIVT. During rabi 2021-21, 12 new entries in NIVT (medium), six entries in AVT-I (medium) and two entries in AVT-II (medium) were also contributed.

Multi-location testing of experimental hybrid

Evaluation of fresh crosses for yield and related traits- early maturity normal corn

A field trial comprising of 38 fresh crosses with one check PMH 2 was conducted in kharif 2021. None of crosses was significantly superior (LSD at P = 0.5) for grain yield in comparison to PMH 2. However, four crosses were numerically superior to PMH 2 (Table 1.7).

Screening of maize experimental hybrids to identify high yielding hybrids for rabi season

A set of 594 experimental maize hybrids along with six checks were evaluated in ?-lattice design during rabi 2020-21 at Begusarai. Out of these hybrids, 29 hybrids in medium maturity and 7 hybrids in late maturity group out yielded the best check hybrid i.e. P 3522 (Table 1.8). Further, 12 hybrids in medium maturity and two hybrids in late maturity recorded >10% yield superiority over best check hybrid.

Table 1.6: The detail baby corn hybrid promoted in AICRP trials

Sl. No.	Name of hybrid	Type of hybrid	Trial	Promoted to	Maturity	Zone	Yield (q/ha)	Superiority (%)
1	IMH 2-19KB-2	Baby Corn	NIVT	AVT-I	-	NHZ	5.40	17.39
		Baby Corn	NIVT	AVT-I	-	PZ	7.10	4.41
		Baby Corn	NIVT	AVT-I	-	CWZ	9.10	10.98
2	IMH 2-19KB-3	Baby Corn	NIVT	AVT-I	-	NHZ	5.20	13.04

Table 1.7: Details of numerically superior entries over check

Sl. No.	Crosses	Grain Yield (q/ha)	Superiority (%)	Days to anthesis	Days to maturity	Shelling Outturn (%)
1	MIL 5-11303 × LM 16	54.25	27	45	76	87
2	MIL 5-11289 × LM 16	52.07	22	44	76	79
3	MIL 5-11023 × LM 15	49.57	16	45	77	80
4	MIL 5-11359 × LM 15	48.97	14	48	77	81
5	PMH 2 42.84		47	77	80	
	CV (%)	19.9		2.29	1.94	5.37
	LSD (P = 0.5)	12.42		2	2.4	7

Table 1.8: Grain yield potential and superiority of medium and late maturity experimental maize hybrids in station trial during rabi 2020-21 at Begusarai

Hybrid	Pedigree	DTA	DTM	PH (cm)	HSW (g)	Shelling %	GY (t/ha)	% Sup.
Medium maturity								
IMH 2-20R-418	MIL 2-406-2 × BML 3	102	150	198	31	85.5	14.5	22.4
IMH 2-20R-425	MIL 2-406-2 × MIL 2-3470	103	152	216	37	86.2	14.2	20.0
IMH 2-20R-113	MIL 2-1292-1 × LM 13	102	153	209	43	83.6	14.2	19.7
IMH 2-20R-365	MIL 2-173-2 × BML 7	103	152	189	40	83.6	14.0	18.0
IMH 2-20R-536	MIL 2-2039 × BML 7	107	154	218	35	85.4	13.9	17.4
IMH 2-20R-531	MIL 2-1510 × BML 6	103	154	204	36	84.3	13.7	15.5
IMH 2-20R-451	MIL 2-571 × MIL 2-406-1	103	153	199	31	83.6	13.6	14.9
IMH 2-20R-506	UMI 1200 × BML 7	105	152	173	42	77.2	13.6	14.8
IMH 2-20R-364	MIL 2-164-1 × HKI 1128	104	154	200	34	87.8	13.6	14.5
IMH 2-20R-405	MIL 2-350 × MIL 2-1062-1-2	99	143	202	33	87.6	13.6	14.3
IMH 2-20R-377	MIL 2-219-2 × MIL 2-114-1	103	152	193	32	86.9	13.3	12.5
IMH 2-20R-385	MIL 2-274-1 × BML 7	103	152	174	31	80.7	13.2	11.6
Late maturity								
IMH 2-20R-511	MIL 2-1282-1 × BML 7	107	156	184	31.8	82.4	13.6	14.6
IMH 2-20R-441	MIL 2-457-2 × MIL 2-3240	104	156	166	29.1	86.0	13.6	14.3
IMH 2-20R-470	MIL 2-791-3 × BML 7	112	156	208	32.1	81.4	12.5	5.7
IMH 2-20R-379	MIL 2-231-2 × MIL 2-571-1	104	157	192	33.2	84.4	12.5	5.6
IMH 2-20R-523	MIL 2-1299-5 × MIL 2-406-1	104	156	196	37.2	84.2	12.4	4.9
IMH 2-20R-517	MIL 2-1298-8 × BML 7	107	156	194	34.4	83.3	12.1	1.9
IMH 2-20R-401	MIL 2-343-3 × MIL 2-1299-5	108	156	207	33.7	79.5	12.0	0.8
Check -5 (Late)	P 3522	110	159	232	32	84.2	11.9	
Check-6 (Medium)	DKC 9081	101	153	188	26	84.1	11.8	
Check-4 (Medium)	NMH 713	109	157	206	33	84.2	11.7	
Check- (Medium)	DHM 117	110	150	194	35	84.0	11.0	
Check-2 (Medium)	Bio 9544	111	148	179	28	79.1	10.1	
Check-3 (Medium)	DMRH 1301	99	140	180	25	81.9	7.7	
Mean		**102**	**146**	**183**	**34**	**82.2**	**7.7**	
CV		**7.84**	**8.10**	**14**	**14**	**13.40**	**14.6**	
CD (5%)		**5.82**	**10.56**	**12**	**11**	**9.40**	**1.23**	

DTA: Days to anthesis (DTA); DTM: Days to maturity; PH: Plant height, HSW: 100 Kernel weight; GY: Grain yield; % Sup: Superiority over best check

Evaluation of fresh crosses for yield and related traits - normal corn for kharif season

A set of 275 experimental maize hybrids along with five checks was evaluated at IIMR Ludhiana during kharif2020. Twenty nine hybrids out yielded the best check hybrids CMH 08-287, of which 17 hybrids recorded >10% yield superiority. Four top ranking hybrids recorded more than 8.0 t/ha yield with >20% yield superiority (Table 1.9).

Evaluation of experimental hybrids-QPM

A set of 150 experimental hybrids along with four checks (2 QPM and 2 Normal) were evaluated during kharif 2021 at ICAR-IIMR, Ludhiana and MPKV, Rahuri. Two experimental hybrids, viz., QIL 4-2513 × QIL 4-2709 and QIL 4-2490× QIL 4-2709 out-performed the best normal hybrid (DKC 9224) at Ludhiana location (Table 1.10) whereas, five hybrids (QIL 4-2262 × QIL 4-2743, QIL 4-2167 × QIL 4-

Table 1.9: Top ranking experimental maize hybrids during kharif 2020 at ICAR-IIMR, Ludhiana

Hybrid	Pedigree	DTA	PH (cm)	GY (t/ha)	% Sup.
IMH 2-20K-147	MIL 2-406-1 × LM 13	51	226	8.48	28.2
IMH 2-20K-145	MIL 2-387-1 × LM 13	51	222	8.27	25.1
IMH 2-20K-179	MIL2-1491 × LM 13	52	240	8.18	23.8
IMH 2-20K-60	MIL 2-571-1 × MIL 2-406-1	52	186	8.04	21.7
IMH 2-20K-251	MIL 2-2003 × LM 14	50	252	7.97	20.6
IMH 2-20K-78	MIL 2-976-2 × BML 7	53	236	7.92	19.8
IMH 2-20K-50	MIL 2-406-2 × MIL 2-388-1	50	230	7.86	18.9
IMH 2-20K-72	MIL 2-883-1 × MIL 2-388-1	51	209	7.82	18.3
IMH 2-20K-30	MIL 2-274-1 × BML 7	52	200	7.68	16.1
IMH 2-20K-152	MIL 2-537-2 × LM 13	51	243	7.62	15.3
IMH 2-20K-234	MIL 2-837-2 × LM 14	50	177	7.46	12.9
IMH 2-20K-246	MIL 2-1292-1 × LM 14	52	238	7.44	12.6
IMH 2-20K-75	MIL 2-975-2 × BML 6	52	210	7.43	12.4
IMH 2-20K-120	MIL 2-3-1 × LM 13	50	231	7.41	12.1
IMH 2-20K-22	MIL 2-173-3 × MIL 2-334B-1	54	214	7.41	12.1
IMH 2-20K-20	MIL 2-173-2 × BML 7	54	226	7.32	10.8
IMH 2-20K-68	MIL 2-814-2 × MIL 2-388-1	52	223	7.32	10.7
Check-4	CMH 08-28751	228	6.61	-	
Check-1	DKC 7074	50	175	5.23	-
Check-5	NK 6240	51	174	5.10	-
Check-2	Bio 9544	55	185	4.92	-
Check-3	DHM 121	55	177	2.76	-
	Mean	**50.9**	**187.2**	**3.68**	**-**
	CV	**10.8**	**12.8**	**16.8**	**-**
	CD (5%)	**5.9**	**13.9**	**0.39**	**-**

DTA: Days to anthesis; DTS: Days to silking; GY: Grain yield

2699, QIL 4- 2668 × QIL 4-2753, QIL 4-2513 × QIL 4-2698 and QIL 4-2064 × QIL 4-2709) out-performed the best check IQMH 1705 at Rahuri location (Table 1.10).

Heterotic grouping of white maize germplasm

Grouping of white testers

Three white testers, viz., HKI 1344, HKI 1348-6-2 and HKI 1378 were crossed with the known heterotic yellow tester, viz., LM 13 and LM 14. The crosses were evaluated during kharif 2020 and based on the yield and specific combining ability (SCA) effect (Table 1.11) HKI 1344 was grouped with LM 14 whereas; HKI 1348-6-2 and HKI 1378 were grouped with LM 13.

Heterotic grouping of white maize genotypes using test crosses

For hetrotic grouping of white maize genotypes, 38 white inbred lines were crosses with HKI 1344 and HKI 1378. These 76 crosses along with checks were evaluated in RCBD design in two replications during kharif 2021 at Ludhiana. Based on the mean yield and SCA effect total 23 inbred lines could be classified in opposite hetrotic groups (HG) of which 11 was classified as HG-A and 12 inbred lines were classified in HG-B (Table 1.12). Superior white hybrids were also identified from the trial which have been presented in Table1.13 (Figure 1.3).

Heterotic grouping of white maize genotypes using molecular marker

The sets of 87 white inbred lines along with the testers were characterized using 40 SSR markers. Based on the molecular data the genotypes could be classified in five broad groups (Figure 1.4).

Maize Genetic Resource Management

Introduction of germplasm

Twenty-four maize genotypes were introduced from

Table 1.10: Performance of QPM hybrids at Ludhiana and Rahuri

Sl. No.	Genotype	DTA	DTS	GY (q/ha)
	Ludhiana			
1	QIL 4-2513 ×QIL 4-2709	49	51	77.0
2	QIL 4-2490 × QIL 4-2709	56	58	76.4
3	DKC 9224 (Check)	53	54	68.4
4	QIL 4-2513 × QIL 4-2698	49	50	66.6
5	QIL 4-2646 × QIL 4-2753	54	55	64.3
6	QIL 4-2631 × QIL 4-2709	51	52	63.9
7	QIL 4-2325 × QIL 4-2743	54	56	62.9
8	QIL 4-2543 × QIL 4-2753	51	52	62.7
9	QIL 4-2631 × QIL 4-2699	50	51	61.8
10	QIL 4-2487 × QIL 4-2709	51	52	61.6
11	QIL 4-2513 × QIL 4-2751	50	51	61.6
12	Bio 9544 (Check)	52	53	77.0
	CD (5%)		**14.4**	
	CV (%)		**18.5**	
	Rahuri			
1	QIL 4-2262 × QIL 4-2743	53	55	57.1
2	QIL 4-2167 × QIL 4-2699	55	57	54.5
3	QIL 4-2668 × QIL 4-2753	53	54	54.1
4	QIL 4-2606 × QIL 4-2751	55	57	54.0
5	QIL 4-2064 × QIL 4-2709	51	53	53.7
6	Check IQPMH 1705	52	52	52.7
7	CLQRCY 40 × QIL 4-2698	56	57	52.5
8	QIL 4-2545 × QIL 4-2691	57	58	52.2
9	QIL 4-2668 × QIL 4-2751	51	53	52.1
10	QIL 4-2631 × QIL 4-2709	57	58	52.0
11	CLQRCY 40 × QIL 4-2743	58	59	51.9
12	QIL 4-2246 × QIL 4-2709	54	54	51.9
13	QIL 4-2513 × QIL 4-2698	58	60	51.8
14	QIL 4-2646 × QIL 4-2709	56	59	51.7
15	DKC 8221 (Check)	53	54	50.6
	CD (5%)		**6.42**	
	CV (%)		**11.94**	

DTA: Days to anthesis (DTA); DTM: Days to maturity; PH: Plant height, HSW: 100 Kernel weight; GY: Grain yield; % Sup: Superiority over best check

Table 1.11: Heterotic grouping of white testers

Line	Tester	Site mean	Yield (q/ha)	SCA	Heterotic group
HKI1344	LM13	84.11	100.63	16.26	LM14
HKI1344	LM14	84.11	69.00	-14.87	
HKI1378	LM13	84.11	65.60	-18.22	LM13
HKI1378	LM14	84.11	96.78	12.48	
HKI1348-6-2	LM13	84.11	80.66	-3.39	LM13
HKI1348-6-2	LM14	84.11	91.98	7.74	

Table 1.12: Heterotic grouping of white maize genotypes

Sl. No.	Genotype	Tester	Yield	SCA	HG
1	MIL 10-1575	HKI 1378	65.21	0.11	A
2	CML 275	HKI 1378	77.32	19.39	A
3	CML 492	HKI 1378	90.40	5.92	A
4	CML 498	HKI 1378	88.73	22.33	A
5	MIL 10-744	HKI 1378	73.62	3.51	A
6	CML 576	HKI 1378	106.22	15.95	A
7	MIL 10-696	HKI 1378	74.84	13.27	A
8	CML 90	HKI 1378	80.67	20.05	A
9	MIL 10-1357	HKI 1378	68.97	2.14	A
10	CML 208	HKI 1378	88.85	23.23	A
11	MIL 10-13	HKI 1378	64.61	2.92	A
12	MIL 10-2013	HKI 1378	70.42	8.33	A
13	MIL 10-209C3	HKI 1344	126.14	28.12	B
14	MIL 10-220	HKI 1344	69.00	0.73	B
15	MIL 10-1359	HKI 1344	94.12	7.16	B
16	MIL 10-1378	HKI 1344	61.64	2.60	B
17	CML 172	HKI 1344	92.30	5.17	B
18	CML 522	HKI 1344	75.54	5.64	B
19	MIL 10-95C6	HKI 1344	102.07	4.90	B
20	MIL 10-328C1	HKI 1344	71.03	6.22	B
21	MIL 10-95C5	HKI 1344	67.17	13.30	B
22	MIL 10-1940	HKI 1344	79.86	33.98	B
23	MIL 10-9C1	HKI 1344	82.67	9.25	B

Table 1.13: Superior white crosses identified

Sl. No.	Cross	Yield (q/ha)	Superiority
1	MIL 10-209C3 × HKI1344	126.14	32.18
2	MIL 10-576 × HKI1378	106.22	11.31
3	MIL 10-60 × HKI 1378	104.74	9.75
4	MIL 10-95C6 × HKI 1344	102.07	6.95
	Bio 9544 ©	95.43	-
	CD (5%)	14.38	-
	CV (5%)	18.06	-

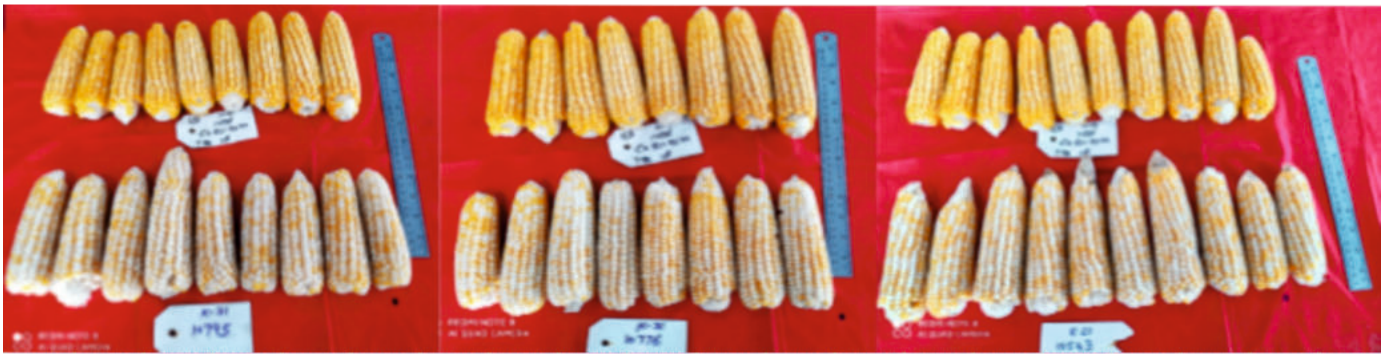


Figure 1.3: Superior white crosses identified

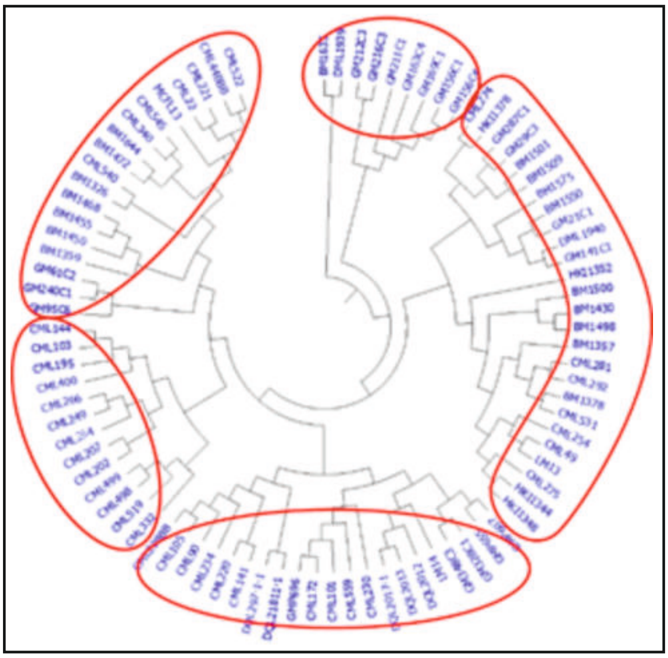


Figure 1.4: Grouping of white maize genotypes using SSR marker

USA to strengthen the high oil maize breeding. The genotypes were assigned exotic collection number as EC 1076082 to EC 1076105.

Characterization of germplasm

Germplasm characterization

As part of continuation of component-I of CRP on Agro Biodiversity (CRPAB) of Maize the institute undertook the massive exercise, to characterize all the maize germplasm conserved at National Genebank (NGB) at one location. The trial was conducted at Begusarai, during winter season of 2020 (Figure 1.5). The total numbers of accessions taken out from the NGB were 11674. The trial was conducted in augmented block design (ABD) using 12 check entries which comprised of four each of inbred lines, open pollinated varieties and single cross hybrids. The entire germplasm accessions were stratified at three levels into 170 classes based on the information available on each of the accessions conserved at NGB. The first level of stratification was carried out based on type of germplasm i.e. indigenous and exotic. The entire germplasm was further stratified in level two based on biological status, viz., landraces, folk cultivars, inbred lines, etc. The third level of stratification was carried out based on geographical region or collection site from where the germplasms were collected. Data on 78 traits were collected including 17 morphological traits, five each of agronomic and reproductive traits and three vegetative traits. Further, drone based data capturing was also under taken as a part of high throughput data recording to record data on traits like plant height, chlorophyll content which are also being verified using ground tooting data.

Maintenance and generation advancement-early

At Hyderabad, during rabi 2020-21, 512 inbred lines were maintained in field and 465 inbred lines were maintained at Ludhiana during spring 2021. Twenty-nine pools were used to extract new inbred lines; plants were selfed to advance to S1 generation. These 29 pools were also grown for maintaining through bulk pollination. In kharif 2021, 368 families were advanced from S1 to S2 generation through selfing.

Figure 1.5: The field view of characterization of maize germplasm conserved at NGB, NBPGR

Specialty corn breeding

Breeding for sweet corn

Identification of sweet corn inbred lines with good general combining ability (GCA)

One hundred ten test-crosses generated by crossing 55 promising sweet corn inbred lines with two inbred line tester, viz., LM 13 and LM 14 were evaluated during kharif 2020 at New Delhi in ?-design with two replications to understand the combining ability and also differentiate the sweet corn germplasm into different heterotic groups based on combining ability. The data on grain yield, ear length, ear diameter, number of kernel rows, and number of kernels per row along with other traits were analyzed for understanding the combining ability. The details of top 15 sweet corn inbred lines with positive GCA for important yield contributing traits are given in Table 1.14. Out of 55 inbred lines, 30 and 25 inbred line showed heterotic pattern by aligning with LM 13 and LM 14, respectively.

Identification of promising hybrid combinations

Thirty-six experimental crosses attempted between the selected inbred lines were evaluated during spring season 2021 at Mandya, Karnataka in randomized complete block design (RCBD) with two replications to identify the promising hybrids. The data was recorded on various morphological traits, viz., days to flowering, grain yield, fodder yield, ear height, plant height, harvest index etc. The details of promising cross combinations identified for green ear yield, the commercial product of sweet corn are given in Table 1.15.

Breeding for baby corn

Development of CMS based baby corn

To develop the CMS based baby corn hybrid, a total of eight lines, viz., MLSP 10116, MLSP 10117, HKI323, HKI 1105, 1710410C2, IMR 284, IMR 331 and IML 127-1 were converted into CMS lines. The converted lines were sent to six different locations (Mandya, Hyderabad, Karnal, Pantnagar, Begusarai and Peddapuram) to evaluate the persistence of sterility across the locations. Further, other backcrosses to convert the normal fertile baby corn into CMS version, two lines at BC3stage, seven at BC2stage and four at BC1 stage are available. Further, a total of 15 new test crosses were made between G 5417 and inbred lines to classify them into maintainer line (B) and restorer line (R) which were evaluated in kharif 2021. Based on the tassel morphology in the field, six inbred lines were classified as B lines and nine lines as R lines.

Table 1.14: Sweet corn inbred lines with positive general combining ability (top 15 lines)

Inbred Lines	Grain Yield	Ear Length	Ear Diameter	No. of kernels
	GCA	GCA	GCA	GCA
SIL 6-2-1	119.11	0.14	0.14	1.03
SIL 6-2	86.64	0.12	0.12	1.09
SIL 6-9-2	83.54	0.11	0.11	0.63
SIL 6-416084-2	82.18	0.14	0.14	1.33
SIL 6-11-5	65.23	0.01	0.01	0.91
SIL 6-3156	63.39	-0.07	-0.07	0.77
SIL 6-9-1	55.29	0.08	0.08	1.13
SIL 6-9-3	48.05	0.09	0.09	0.62
SIL 6-11-4	47.99	0.09	0.09	0.85
SIL 6-416084-1	40.16	0.08	0.08	0.66
SIL 6-20-2	33.33	0.06	0.06	1.09
SIL 6-11-7	32.53	-0.05	-0.05	-0.72
SIL 6-37-3-7	31.48	0.08	0.08	0.85
SIL 6-20-1	27.52	0.02	0.02	0.46
SIL 6-780	21.50	0.03	0.03	0.83

#SE for Grain Yield: 19.29; SE for Ear Length:0.57; SE for Ear Diameter: o.57; SE for No. of kernels: 1.14

Table 1.15: The details of selected experimental sweet corn hybrids identified for high yield

Experimental Crosses	GEwoH(kg/ha)	GEwH(kg/ha)	FWpP(kg/p)	EpP(No.)
SIL 6-12 × SIL 6-91-2	15925[a]	20834[a]	6[ab]	13[ab]
SIL 6-9 × SIL 6-91-2	13118[ab]	16950[ab]	4[ab]	18[a]
SIL 6-91-2 × SIL 6-37-3	13075[ab]	17153[a]	4[ab]	11[ab]
SIL 6-13-4 × SIL 6-12	11834[ab]	16889[ab]	6[a]	13[ab]
SIL 6-12 × SIL 6-14-11	11231[ab]	9458[ab]	5[ab]	13[ab]
SIL 6-13-6 × SIL 6-91-2	11173[ab]	14486[ab]	4[ab]	10[ab]
SIL 6-9 × SIL 6-12	10521[ab]	13896[ab]	3[ab]	11[ab]
SIL 6-12×SIL 6-1	10367[ab]	14389[ab]	4[ab]	11[ab]
SIL 6-14-11 × SIL 6-19	10248[ab]	14722[ab]	5[ab]	12[ab]

#GEwoH: Green ear weight without husk; GEwH: Green ear weight with husk; FWpP: Fresh weight per plot; EpP: Ear per plot; a and b represents significantly different crosses.

Testing of CMS based baby corn hybrids

A set of eight experimental baby hybrids were developed through crossing of CMS lines which were evaluated during kharif season 2021 at Ludhiana. The experiment was laid out in RCBD design with two replications. G 5417 was used as a check. Among the eight experimental hybrids, one hybrid was found numerically superior over the check which needs to be confirmed for one additional year of testing. The detail of superiority percentage has been given in Table 1.16.

Table 1.16: Superiority of IBCH 19 over G 5417

Hybrid	Yield (q/ha)	% Superiority over G 5417
IBCH 19	10.67	16.87[ns]
G 5414 (check)	9.13	-
CV 13.60	-	
CD (0.5)	1.11	-

Fodder maize breeding

Generation of fodder maize breeding population

A total of 121 inbred lines with high biomass were maintained. Further, to develop the silage-specific hybrids, a total of 502 families were generated through six crosses of leafy mutant line and high biomass lines. On the other hand, total of 14 F1 crosses were generated using Zea maxicana and Z. parviglumis with fodder inbred lines to explore the tillering ability.

Silage quality analysis of PMH 1 hybrid for different date of sowing

The silage quality of hybrid PMH 1 was analyzed. The treatments were consisted of two plant densities i.e. normal density, ND (60 × 20cm) and high density, HD (60 × 10cm), with four dates of sowing i.e. June 23, 2019 (DS-1), July 3, 2019 (DS-2), July 15, 2019 (DS-3) and July 26, 2019 (DS-4). The experiment was laid down in RBD factorial with three replications. Based on yield, feed values and NGP as well as Neutral detergent fibre (NDF) digestibility of forage it was concluded that the PMH 1, DS-3 is comparatively superior than other date of sowing at both the plant densities; however, in terms of forage yield, ND (60 × 20 cm) had an edge over the HD (60 × 10 cm). For silage quality, all silages exhibited good ensiling characteristics at all dates of sowing and plant densities. However, improved nutritive profile, better feeding values, higher in vitro potential and good fermentation characteristics of hybrid was observed in DS-3. Thus, July15 is more recommendable date of sowing for forage as well as for ensiling under given conditions at both ND and HD (Table 1.17).

Studies on grain opaqueness vs. digestibility traits

A total of 21 maize seed grain sample having opaqueness from 25 to 100% were analyzed for digestibility traits. All the treatments showed significant differences. The digestibility traits indicate that there is no correlation of opaqueness with digestibility (Table 1.18).

Hydroponics experiment

A hydroponics experiment was conducted using J 1007 fodder cultivar. The 1.80 kg seeds were soaked in water for 24 hours after that it was put in a jute bag

Table 1.17: Analysis of silage extracts of maize hybrid

Parameter	Date of sowing (DS)				p-value	Plant density (D) ND	HD		DS×D
	DS-1	DS-2	DS-3	DS-4					
pH	4.17^{b}	4.05^{a}	3.98^{a}	4.03^{a}	***	4.04	4.08	NS	NS
LA, % DM	4.05	4.15	4.0	3.85	NS	4.20	3.82	NS	NS
AA, % DM	1.25^{a}	1.42^{b}	1.12^{a}	1.15^{a}	**	1.30	1.20	NS	***
NH4-N,% of TN	6.43	6.35	5.00	6.54	NS	6.18	5.98	NS	***
Fleig point	100.2^{a}	106.8^{b}	108.0^{b}	108.6^{b}	**	106.5	105.3	NS	NS
Nutrient composition									
DM	31.10	31.90	31.20	32.40	NS	31.53	31.75	NS	NS
CP	8.43^{a}	8.21^{c}	7.64^{b}	7.38^{a}	***	7.82	7.67	NS	NS
EE	2.22	2.22	2.42	2.47	NS	2.29	2.39	NS	NS
NDF	52.00^{c}	54.00^{c}	47.60^{a}	50.10^{b}	***	50.60	51.30	NS	*
ADF	27.70^{b}	28.10^{b}	23.90^{b}	26.90^{b}	**	26.60	26.40	NS	NS
ADL	3.45^{b}	3.62^{b}	3.20^{a}	3.65^{b}	***	3.50	3.460	NS	*
Cellulose	24.60^{b}	24.70^{b}	22.50^{a}	24.40^{b}	**	24.10	24.0	NS	***
Ash	5.26^{ab}	5.54^{b}	4.40^{a}	5.12^{ab}	*	5.10	5.07	NS	***
Organic matter	94.70^{ab}	94.50^{a}	95.60^{b}	94.90^{ab}	*	94.90	94.93	NS	***
Feed values									
DMI (%) B.wt.	2.31^{b}	2.22^{a}	2.52d	2.39^{c}	***	2.38	2.35	NS	*
DDM (%)	67.30^{a}	66.90^{a}	70.30^{b}	67.90^{a}	**	68.20	68.10	NS	NS
TDN (%)	68.40^{a}	68.10^{a}	71.10^{b}	69.00^{a}	**	69.20	69.10	NS	NS
RFV	120.40^{a}	115.60^{a}	137.50^{c}	126.10^{b}	***	125.70	126.90	NS	*
RFQ	2.820^{a}	2.710^{a}	3.210^{c}	2.95^{b}	***	2.94	2.97	NS	*
NEL (M cal/kg)	1.56^{a}	1.55^{a}	1.62^{b}	1.570^{a}	**	1.58	1.57	NS	NS
In-vitro fermentation characteristics									
NGP (ml/g)	133.30^{a}	131.30^{a}	160.70^{b}	144.10^{ab}	**	142.20	142.60	NS	*
NDFD (%)	24.6^{b}	24.60^{b}	24.90^{b}	22.20^{a}	*	24.69	23.47	NS	NS
TOMD (%)	58.00	58.10	58.90	57.90	NS	58.53	57.95	NS	*
PF (mg/ml)	4.47	4.47	3.70	4.25	NS	4.34	4.10	NS	*
MBP (mg/g)	293.90	292.50	237.60	273.40	NS	284.60	264.10	NS	NS
ME (MJ/kg)	6.00	6.00	6.74	6.24	NS	6.16	6.34	NS	*

LA-Lactic acid, AA-Acetic acid, NH-N-Ammonical nitrogen, DDM-Digested dry matter, TDN-Total digestible nutrients, RFV-Relative feed value, RFQ-Relative feed quality, NE-Net energy lactation. Dry matter (DM), Crude protein (CP), Ether extract (EE), Neutral detergent fibre (NDF), Acid detergent fibre (ADF), Acid detergent lignin (ADL). Figures with different superscripts in a row differ significantly, *$p<0.05$, **$p<0.01$, ***$p<0.001$, ns-non significant.

Table 1.18: Proximate analysis range for digestibility traits

Trait	Mean Square	F Value	CD (5%)	CV %	Range
NGP (ml)	67.14	31.95**	3.01	1.32	99.00-123.75
NGP/g DM	477.49	31.95**	8.04	1.32	264.00-330.00
TDS	0.77	6.13**	0.74	0.10	365.25-367.97
OMD%	4.42	61.06**	0.56	0.29	89.75-95.50
NDFD%	79.00	35.99**	3.08	2.06	59.18-83.07
DMD%	4.35	117.42**	0.40	0.20	89.46-95.06

NGP = Net gas production, TDS = Truly degraded substrate, %OMD = Organic matter degradability, %NDFD = Neutral detergent fiber degradability and %DMD = Dry matter digestibility

Table1.19: Proximate analysis for digestibility traits in hydroponically grown fodder

Parameter %	Average
Fodder Weight, Kg	5.30
Nutrient composition	
Dry matter	17.24
Crude protein	10.70
Neutral detergent fibre	26.80
Acidic detergent fibre	7.97
Ash 1.86	
Organic matter	98.14
Digestible Dry Matter	82.70

Figure 1.6: Hydroponically grown fodder of J1006 cultivar

for another 24 hrs in three replications. Finally, germinated seeds were spread in the hydroponic trays (3 trays) and the trays were ready for harvesting after eight days. The final weight was gained almost three times in each tray after eight days. Further proximate analysis was carried out for digestibility traits. A higher proportion of crude protein, organic

Table 1.20: Yield performance of top 20 inbred lines under normal condition during rabi2020-21 at Begusarai

Sl. No.	Inbred line	DTA	ASI	Maturity	Plant height (cm)	GY (t/ha)	% sup. Over B. check	DSI
1	MIL 2-93-1	105	4	158	131	5.41	48.7	0.98
2	MIL 2-1587	105	3	156	203	5.27	44.8	0.76
3	MIL 2-49-2	104	3	161	154	5.20	43.1	0.39
4	MIL 2-591-2	104	4	157	146	5.08	39.7	0.99
5	MIL 2-37-2	99	4	155	162	5.08	39.7	1.18
6	MIL 2-719-2	104	2	154	136	5.07	39.6	1.48
7	MIL 2-301-1	105	3	159	138	4.99	37.3	0.64
8	MIL 2-2034	115	3	157	172	4.89	34.5	1.39
9	MIL 2-100104	4	152	129	4.72	29.9	1.65	
10	MIL 2-3711	101	3	156	173	4.65	28.0	1.85
11	MIL 2-1299-5	109	3	161	197	4.25	16.9	0.53
12	MIL 2-475-1	106	3	161	142	4.20	15.6	1.43
13	MIL 2-2119	104	5	161	150	4.06	11.7	1.47
14	MIL 2-13-2	99	4	153	118	4.06	11.7	1.82
15	MIL 2-763-2	107	3	155	124	3.99	9.8	1.34
16	MIL 2-2166	112	4	157	170	3.92	7.8	1.09
17	DML-2036	113	2	162	180	3.90	7.2	1.84
18	MIL 2-83-2	110	3	158	141	3.84	5.7	0.75
19	MIL 2-43-2	114	3	159	126	3.76	3.4	0.58
20	BML6	110	4	156	161	3.64	-	
	Mean	**102**	**3.1**	**146**	**137**	**2.34**	**-**	
	CV	**6.52**	**10.3**	**8.12**	**14.48**	**12.32**	**-**	
	CD	**4.63**	**0.34**	**9.78**	**11.79**	**0.537**	**-**	

DTA: Days to anthesis; ASI: Anthesis to silking interval; DSI= Drought Susceptibility index

Table 1.21: Yield performance of top 20 inbred lines under drought environment during rabi2020-21 at Begusarai

Sl. No.	Inbred line	DTA	ASI	Maturity	Plant height (cm)	GY (t/ha)	. DSI .
1	MIL 2-49-2102	4	154	158	3.89	0.39	
2	MIL 2-1587	104	4	149	162	3.88	0.76
3	MIL 2-301-1	107	4	156	129	3.74	0.64
4	MIL 2-1299-5	112	4	163	168	3.52	0.53
5	MIL 2-1255	101	5	152	150	3.45	0.09
6	MIL 2-93-1106	5	159	122	3.31	0.98	
7	MIL 2-591-2	104	7	151	136	3.09	0.99
8	LM 13 109	5	155	130	3.02	0.16	
9	MIL 2-43-2116	4	153	95	2.86	0.58	
10	MIL 2-37-299	4	153	158	2.81	1.18	
11	MIL 2-83-2108	6	155	143	2.81	0.75	
12	MIL 2-173-1	110	3	155	139	2.62	0.47
13	BML 15 113	4	157	157	2.60	0.24	
14	MIL 2-1297-1	113	4	165	134	2.55	0.40
15	MIL 2-618-1	101	5	147	130	2.52	0.25
16	MIL 2-406-2	115	6	148	111	2.43	0.65
17	MIL 2-2034	119	6	151	137	2.38	1.39
18	MIL 2-800-1	111	4	153	135	2.38	0.73
19	IML 2-2166	113	3	156	151	2.38	1.09
20	MIL 2-456-1	112	4	154	130	2.29	
	Mean	**105.1**	**4.5**	**145.6**	**126.2**	**-**	
	CV	**9.2**	**14.4**	**8.12**	**13.8**	**-**	
	CD	**6.1**	**0.34**	**9.78**	**10.1**	**-**	

DTA: Days to anthesis; ASI: Anthesis to silking interval; DSI= Drought Susceptibility index

matter and digestible dry matter were found in hydroponically grown fodder compared to silage and green fodder maize (Table 1.19; Figure 1.6).

Breeding for abiotic stress

Screening of maize inbred lines under normal and drought environment

A trial of 200 newly developed inbred lines including some released inbred lines was conducted at Begusarai. The trial was laid during first fortnight of November month. Observations on twelve traits including maturity traits, yield components and 19 DUS traits were recorded. Out of the 200 inbred lines only 19 inbred lines outyielded the best check inbred line BML 6 and yield of these 19 inbred lines ranged from 3.76 - 5.21 t/ha (Table 1.20).

he same set of 200 inbred lines which was evaluated under normal environment; was also evaluated under managed drought environment during rabi 2020-21. Drought stress was created by withholding irrigation before flowering stage which was continued for three-week duration up to grain filling stage. Top 20 inbreds lines recorded >2.29 t/ha grain yield whereas top eight inbreds yielded >3 t/ha grain yield under drought stress environment. Only seven inbred lines out yielded the best check inbred LM 13 under stress environment (Table 1.21).

Screening experimental maize hybrids under normal and managed drought environment

A set of 196 experimental maize hybrids along with four check hybrids was evaluated under normal and

Table1.22: Top twenty experimental maize hybrids under normal and drought stress during rabi 2020-21 at Begusarai

Experimental hybrid	ASI	GY (t/ha)	% Sup	DSI	Experimental hybrid	ASI	GY (t/ha)	% Sup	DSI	R
Normal environment					*Drought environment*					
MIL 2-54-2×LM 14	2	16.4	24.5	1.41	MIL 2-406-2×MIL 2-2039	4	11.1	17.7	0.42	1
MIL 2-1510×BML 6	2	16.2	22.8	1.23	BML 6×MIL 2-406-1	4	11.1	17.1	0.53	2
MIL 2-3470 × BML 6	2	15.8	20.3	1.91	MIL 2-406-2×MIL 2-3470	3	10.9	15.3	0.26	3
MIL 2-231-2×MIL 2 -571-1	4	15.3	16.5	1.32	MIL 2-125-1×HKI 1128	4	10.7	13.6	0.22	4
MIL 2-274-1×BML7	3	14.9	13.1	1.30	MIL 2-1062-1-2× BML 7	6	10.7	13.0	0.78	5
BML6 × MIL 2-3470	1	14.8	12.7	0.90	MIL 2-2077×LM 13	5	10.4	10.1	0.33	6
MIL 2-1062-1-2 × BML 7	2	14.6	11.0	0.78	MIL 2-119-1 × MIL 2-1062-1-2	3	10.	9.5	0.64	7
MIL 2-164-1 × HKI 1128	2	14.2	8.0	1.22	BML6 × MIL 2-3470	3	10.2	8.3	0.90	8
MIL 2-126-2×LM13	2	14.2	7.6	1.75	MIL 2-58 × MIL 2-428	3	10.2	7.7	0.27	9
MIL 2-334-B-2 × BML 7	3	14.1	6.7	1.87	HKI1128 × MIL 2-1062-1-2	4	10.2	7.7	0.43	10
MIL 2-310-1×BML7	4	13.9	5.9	1.21	HKI 1378 × LM 13	5	10.1	6.5	0.29	11
MIL 2-406-1×BML6	3	13.8	5.1	1.34	MIL 2-100 × LM 14	4	10.0	5.9	0.55	12
MIL 2-511-1×BML7	1	13.8	4.6	1.58	MIL 2-83-1 × BML 7	3	9.9	5.3	0.52	13
MIL 2-457-2 × MIL 2-406-1	3	13.8	4.6	1.27	MIL 2-49-2 × LM 13	4	9.9	4.8	0.71	14
MIL 2-173-2×BML7	2	13.7	4.2	1.33	MIL 2-114-1 × MIL 2-1062-1-2	3	9.8	4.2	0.42	15
MIL 2-457-2 × MIL 2-3470	2	13.7	3.8	1.48	MIL 2-800-1 × BML 6	4	9.7	3.0	0.23	16
MIL 2-3397×LM-14	2	13.6	3.4	1.35	MIL 2-1299-5×BML 7	5	9.7	3.0	0.40	17
MIL2-126-2×LM-14	4	13.6	3.0	1.26	MIL 2-244-1 × LM 13	4	9.6	1.8	0.29	18
BML-6 × MIL 2-406-1	4	13.5	2.5	0.53	MIL 2-100 × BML 15	3	9.5	0.6	0.77	19
MIL 2-975-2 × MIL 2-406-12-406-1	2	13.4	1.7	0.85	MIL 2-975-2 × MIL	4	9.4	0.1	0.85	20
DKC 9081	2	13.2	-	0.82	DKC 9081	4	9.4	-	0.82	-
P3522	3	12.8	-	1.13	P3522	4	8.9	-	1.13	-
Bio 9544	3	11.2	-	0.59	Bio 9544	5	7.8	-	0.59	-
DMRH 1301	2	10.6	-	0.96	DMRH 1301	5	7.1	-	0.96	-
Mean	**2.8**	**9.4**	**-**		**Mean**	**4.6**	**6.2**	**-**		**-**
CV	**12.1**	**13.2**	**-**		**CV**	**18.1**	**19.1**	**-**		**-**
CD	**0.4**	**0.8**	**-**		**CD**	**0.6**	**0.9**	**-**		**-**

ASI: Anthesis silking interval; R: Rank; % sup: Percent superiority; DSI= Drought Susceptibility index drought environment at Begusarai during rabi 2020-21. Drought stress was created by withholding irrigation before flowering which was continued for three-week duration up to grain filling stage. Twenty-one hybrids under normal environment and 20 hybrids under drought out yielded the best check hybrid DKC 9081 (Table 1.22). Performance of two hybrids, viz., MIL 2-1062-1-2 × BML 7 and BML 6 × MIL 2-3470 was better in both normal and drought environment.

Evaluation of inbred lines for drought and low nitrogen

In spring 2021, a set of 80 inbred lines were evaluated for their response to drought and low applied nitrogen. There were three treatments; T1 (drought with low nitrogen application), T2 (drought with recommended nitrogen application), and T3 (irrigated with recommended nitrogen application). In T1 and T2 drought were imposed for 20 days during flowering and post-flowering stage. In T1, 59 inbred lines could produce grains, and 21 inbred lines could not produce grain, whereas in T2, 79 inbred lines could produce grain. The range of grain yield per hectare was 0.8 to 10.1 q in T1, 1.2 to 29.8 q in T2 and 1.5 to 37.1q in T3. In T1, five inbred lines produced 5.0 to 10.1 kg grain yield; these were MIL 5-11347, MIL 5-11172, MIL 5-11470, MIL 5-11001, and MIL 5-11036. In T2, three inbred lines produced 20.0 to 30.0 kg grain yield; these were MIL 5-11347, MIL 5-11025, and MIL 5-11082, and five inbred lines produced 15.0 to 20.0 q grain yield, which were MIL 5-11001, MIL 5-11172, MIL 5-11123, MIL 5-11283, and MIL 5-11199. In T3, six inbred lines produced 30 to 40 q grain yield; these were MIL 5-11123, MIL 5-11347, MIL 5-11190, MIL 5-11172, MIL 5-11025, and MIL 5-11542. The best inbred line identified under drought and low nitrogen application is MIL 5-11347, which also performed better under drought and irrigated condition. In addition to grain yield, other yield attributes were also observed, viz., days to anthesis, silking and maturity, plant and cob placement height, cob length and diameter, grain-rows per cob and grains per row, and shelling outturn. Analysis of variance (ANOVA) showed sufficient

Table 1.23: Top five inbred lines under drought and low nitrogen application (T1) with their yield attributes

Inbred	GY/ha (Kg)	Days to anthesis	Days to maturity	Cob length (cm)	Cob diameter (mm)	Shelling outturn (%)
MIL 5-11347	1010	78	103	10.4	34	72
MIL 5-11172	639	78	103	10.4	28	82
MIL 5-11470	562	78	109	10.9	36	79
MIL 5-11001	549	78	106	12.3	32	73
MIL 5-11036	521	80	105	10.4	28	73

GY: Grain Yield

Table 1.24: Top five inbred lines under drought and recommended nitrogen application (T2) with their yield attributes

Inbred	GY/ha (Kg)	Days to anthesis	Days to maturity	Cob length (cm)	Cob diameter (mm)	Shelling outturn (%)
MIL 5-11347	2982	79	106	14.4	42	72
MIL 5-11025	2400	80	115	15.3	39	75
MIL 5-11082	2123	77	112	12.5	39	70
MIL 5-11001	1995	77	107	13.1	37	75
MIL 5-11172	1777	78	107	14.2	36	72

GY: Grain Yield

variation for all these observed traits in all three treatments. The top five inbreds for grain yield under T1 and T2 are being given in the Table 1.23 and 1.24 along with other yield attributes.

These inbred lines will be evaluated for drought and low nitrogen for one more season to consolidate results.

Screening experimental maize hybrids under normal and managed water logging environment

A set of 275 experimental maize hybrids along with five check hybrids was evaluated under normal and water logging environment at RMR&SPC, Begusarai during kharif2020. Water logging stress was given during knee height stage of the crop at 35

Table 1.25: Top twenty experimental maize hybrids under normal and water logging stress during rabi-2020-21 at Begusarai

Experimental hybrid	GY	% (t/ha)	DSI Sup	Experimental hybrid	GY (t/ha)	% Sup	DSI	R
Normal environment				*Water logging environment*				
MIL 2-119-2 × MIL 2-1062-1-2	6.90	24.6	1.14	IMH 2-207-1 × LM 13	5	2.14	0.69	1
MIL 2-1510 × BML 6	6.86	23.9	1.09	MIL 2- 58-2×MIL2-428-2	8	1.94	0.59	2
MIL 2 800-1 × MIL 2-406-1	6.81	22.8	1.15	MIL 2-114-1 × MIL 2-1062-1-2	6	1.89	0.76	3
MIL 2-2077 × BML 7	6.67	20.3	1.14	MIL 2-537-2 × LM 13	5	1.83	0.39	4
MIL 2-37-2 × LM 14	6.61	19.3	1.19	MIL 2-219-2 × LM 14	4	1.67	0.70	5
MIL 2-883-1×MIL 2-388-1	6.42	15.8	1.11	MIL 2-1210 × BML 7	5	1.61	0.20	6
MIL 2-334B-2 × LM 13	6.34	14.4	1.19	MIL 2-376-2 × LM 13	5	1.58	0.69	7
LM 14 × MIL 2-1299-5	6.38	15.1	1.09	MIL 2-883-1×MIL 2-3240	5	1.56	0.75	8
MIL 2-1011-2 × LM 13	6.32	14.0	1.01	MIL 2-801-1 × MIL 2-1299-5	4	1.50	0.80	9
MIL 2-1043-1-1 × BML 6	6.22	12.3	1.19	MIL 2-30-1 × LM 13	4	1.47	0.44	10
MIL 2-1041-4-2 × LM 13	6.18	11.6	1.11	MIL 2-43-2 × HKI1128	6	1.39	0.66	11
MIL 2-1527 × LM 14	6.12	10.5	1.19	MIL 2-207-2 × MIL 2-457-2	6	1.35	0.73	12
DKC 074	5.54	-	0.98	MIL 2-883-1 × MIL 2-207-2	5	1.33	0.91	13
CHM 08-287	4.76	-	1.02	MIL 2-1298-8 × BML 7	5	1.31	0.61	14
BIO 9544	4.47	-	0.89	EI 670 × LM 14	5	1.25	0.74	15
DHM 121	3.60	-	0.89	MIL 2-1292-1 × LM 14	6	1.22	0.65	16
NK 6240	2.92	-	0.89	MIL 2-1299-5 × MIL 2-406-1	5	1.17	0.82	17
Mean	**4.62**	**-**		MIL 2-1062-1-2 × LM 13	5	1.14	0.71	18
CV	**14.8**	**-**		BIO 9544	7	1.08	0.90	-
CD	**0.46**	**-**		DKC 7074	4	0.94	0.98	-
				DHM 121	5	0.89	0.89	-
				NK 6240	4	0.50	0.88	-
				CHM 08-287	6	0.67	1.02	-
				Mean	**3.4**	**0.58**		**-**
				CV	**14.5**	**28.8**		**-**
				CD	**3.8**	**1.07**		**-**

GY: Grain yield; ASI: Anthesis silking interval

Table 1.25: Top twenty experimental maize hybrids under normal and water logging stress during rabi-2020-21 at Begusarai

Experimental hybrid	GY (q/ha)	Experimental hybrid	GY (q/ha)	Rank Rank
Normal environment		***Heat stress environment***		
MIL 2-975-2 × MIL 2-571-1	13.08	MIL 2-1062-1-2 × MIL 2-310-1	9.14	1
MIL 2-406-2 × BML 6	12.96	MIL 2-1298-1 × LM 13	9.06	2
MIL 2-1299-5 × BML 6	12.06	MIL 2-406-2 × MIL 2-941-1	8.96	3
MIL 2-406-2 × MIL 2-883-1	12.04	MIL 2-133-1 × MIL 2-1062-1-2	8.94	4
MIL 2-204-2 × LM 13	11.97	LM 14 × MIL 2-1299-5	8.56	5
MIL 2-262-1 × LM 13	11.97	LM 13 × BML 7	8.51	6
MIL 2-83-3 × MIL 2-1062-1-2	11.75	MIL 2-406-1 × LM 13	8.43	7
MIL 2-83-1 × MIL 2-55-2	11.71	MIL 2-406-2 × BML 6	8.32	8
MIL 2-3240 × UMI 1200	11.33	MIL 2-975-2 × MIL 2-571-1	8.31	9
MIL 2-1298-1 × LM 13	11.29	MIL 2-488-1 × LM 14	8.22	10
MIL 2-883-1 × BML 7	11.17	MIL 2-333-2 × LM 14	7.99	11
MIL 2-1475 × LM14	11.15	HKI 1105 x MIL 2-917-1	7.89	12
MIL 2-3362 × LM13	11.08	MIL 2-1523 × LM 14	7.87	13
MIL 2-1299-5 × MIL 2-406-1	11.06	MIL 2-100 × MIL 2-55-2	7.87	14
Bio 9544 (Check)	11.04	MIL 2-3325 × LM 13	7.69	15
MIL 2-406-1 × MIL 2-941-1	11.00	MIL 2-282-2 × LM 14	7.58	16
MIL 2-2039 × MIL 2-1299-5	10.86	MIL 2-428 × MIL 2-1062-1-2	7.58	17
MIL 2-201-2 × MIL 2-173-2	10.83	BML 6 × MIL 2-1299-5	7.56	18
MIL 2-596-2 × LM 13	10.82	MIL 2-3240 × MIL 2-3470	7.28	19
KMH 25K45 (Check)	**11.36**	MIL 2-171-1 × LM 14	7.18	20
		P 3522 (Check)	**5.40**	**69**

GY: Grain yield

days after sowing with continuous flooding for seven days. Twenty hybrids under normal environment and 18 hybrids under water logging were superior to best check hybrid under normal (DKC 7074) and water logging environment (Bio 9544), respectively (Table1.25).

Evaluation of experimental hybrids under heat stress at ICAR-IIMR, Ludhiana

A set of 275 experimental hybrids along with five standard checks were evaluated under optimum and heat stress environment. The normal set of hybrids was planted on February 12, 2021 and stress set was planted on March 18, 2021, so that heat stress may coincide with flowering time. There were intermittent rains after the flowering; hence heat stress intensity was less than expected. Under optimum environment out of 275 hybrids eight hybrids out yielded the best check hybrid KMH 25K45 (Table 1.26). Under heat stress trial 68 entries out yielded the best check hybrid P 3522 (Table 1.26). Three experimental hybrids, viz., MIL 2-975-2 × MIL 2-571-1, MIL 2-406-2 × T3 and MIL 2-1298-1 × LM 13 showed good performance under normal and heat stress environments. However, as the stress was suboptimal the data need reconfirmation.

Screening maize inbred lines under salinity stress

A set of 20 inbred lines were tested under salinity stress under three EC levels 3, 6 and 9 dS m?1, at CSSR Regional Station Bharuch. Among the 20 genotypes three genotypes (HKI 163, IML 127-1 and IML 418-1) showed K/Na ratio more than one, hence these maybe considered as tolerant against the salinity as shown in Figure 1.7.

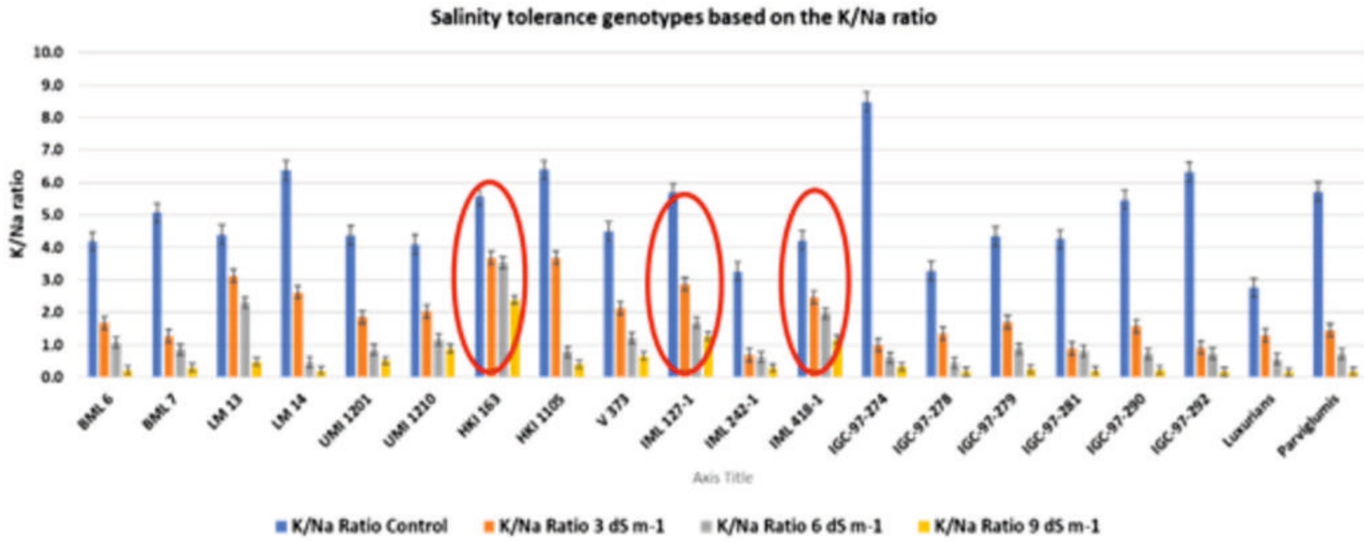


Figure 1.7: Salinity tolerance of twenty maize genotypes

Study the effect of herbicides on the growth and yield of maize inbred lines

One hundred maize inbred lines were evaluated in replicated design to study the effect of two post emergence herbicides i.e. tembotrione and topramezone along with control set (no herbicide with two manual weeding). Six genotypes did not germinate. Phytotoxicity of tembotrione was observed in some of the inbred lines after 7 days of spray. One inbred line (MIL 2-3492) showed severe toxicity (Figure 1.8A). No toxicity of topramezone was observed at growth stage on inbred lines. No significant difference on yield was observed among both the herbicide treatments and control. The mean grain yield of all inbred lines under different treatment was 19.1 q/ha (Tembotrione), 18.4 q/ha (Topramezone) and 19.0 q/ha (Control-two normal weeding) **(Figure 1.8B).**

Breeding for biotic stress

Screening of maize genotypes against TLB

Two trials were conducted one with 60 lines (Trial 1) and other with 150 lines (trial 2) to screen against TLB under artificially inoculated field conditions. Trial 1 was conducted at Mandya, Karnataka during kharif 2021, whereas trial 2 was conducted at both Mandya and Dharwad centre during kharif 2021.

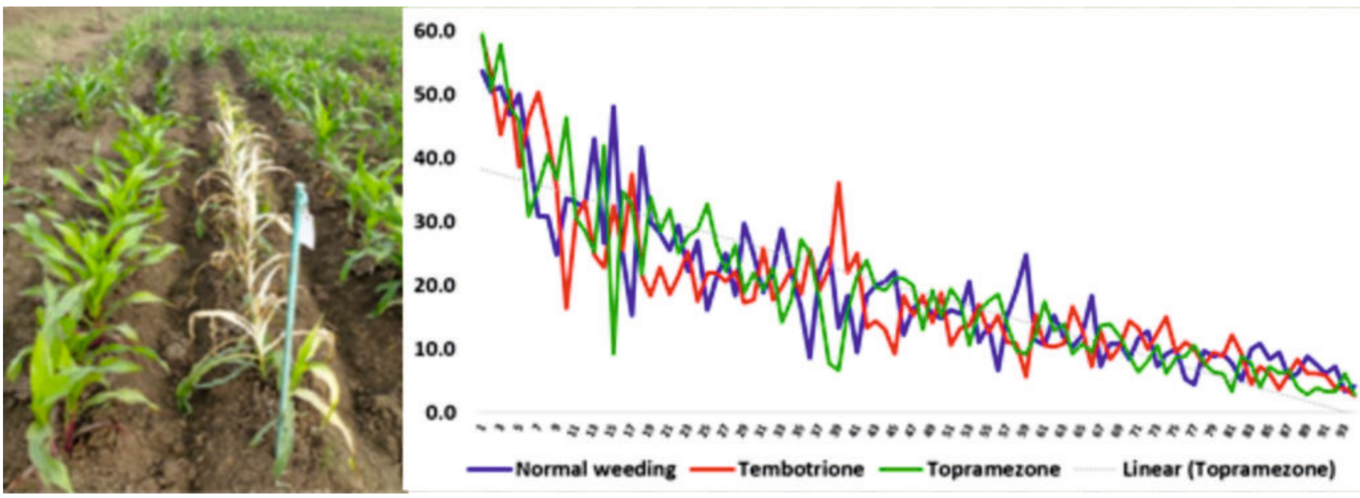


Figure 1.8: A. Highly tembotrine susceptible inbred line (IML 2-3492), B. Yield performance of maize inbreds under herbicide treatments

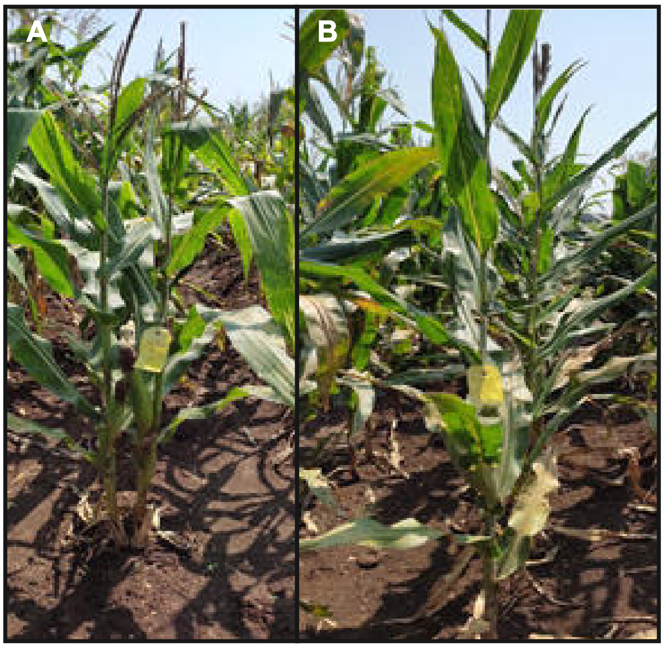


Figure 1.9: Resistant genotypes against TLB at both Mandya and Dharwad centre (A. EC 612071; B. CML 269 dv)

Trials were conducted in ?-lattice design with two replications. Artificial inoculation was performed by leaf whorl inoculation technique using grounded TLB mass multiplied on sorghum seeds and disease reaction was recorded using 1 to 9 scales. In trial 1, the following lines were found to be resistant (<3.0 rating) IMLSB 1041-4-1, IMLSB 446-2, IMLSB 343-2, DML 16, IML 15-113, KDM 71412, VL 1110195, JCY 2-7, KDM 71412, PFSR R3, NAI 178A at Mandya centre. In trial 2, four lines, viz., EC 619334, EC 672689, EC 612071 and CML269dv were shown the rating <3.0 at both Mandya and Dharwad location. EC 615249, BAJIM 08-26, PFSR 63, VS 162, IMLSB 376-2, IMLSB 380-1, HUZM 55, EC 646061, EC 611610(WS)B-1 and EC 615260 were resistant at Mandya centre alone whereas EC 646047, BLS 42048-2, IMLSB 274-1, IMLSB 282-2, JCY 3-7-1-2-1 and CM 213 were resistant at Dharwad location alone (Figure 1.9).

Genome-wide association studies (GWAS) for Turcicum leaf blight (TLB) resistance in tropical maize

A divers set of 384 inbred lines which has already been phenotyped for TLB under artificial inoculated conditions at four hot-spots locations, viz., Bajaura, Dharwad, Mandaya and Srinagar during 2018-2020 was genotyped by GBS. Total 60277 polymorphic SNPs were identified. The linkage disequilibrium (LD) as well as the population structure was studied to carry out the genome-wide association mapping for TLB resistance. Sufficient variability was observed in the panel for targeted parameters from phenotypic and genotypic data. The genome wide association mapping study was carried out to find out the SNPs associated with TLB disease resistance. The mapping was performed using both general linear model (GLM) as well as mixed linear model

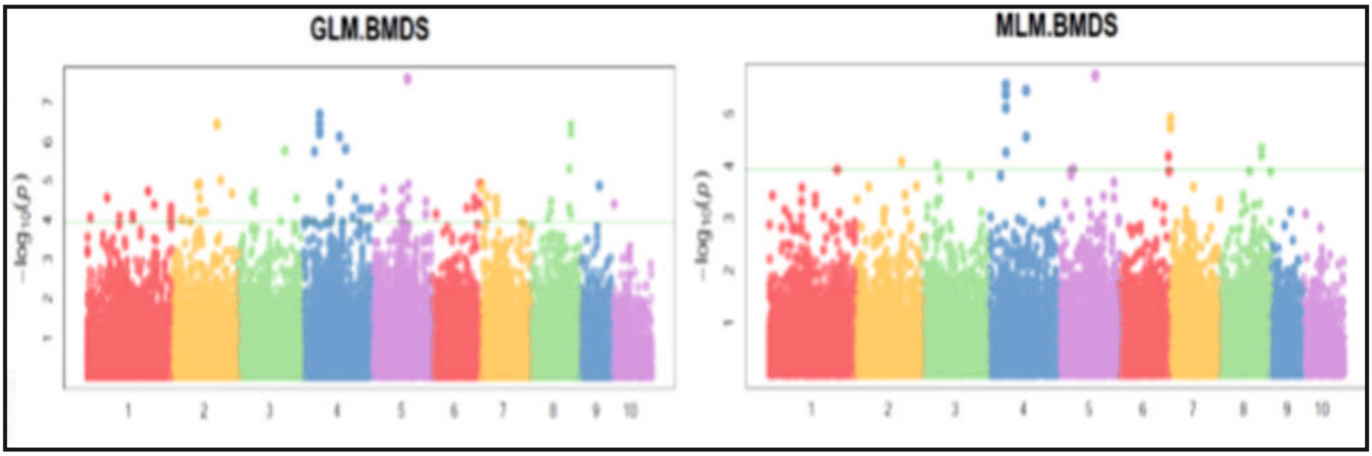


Figure 1.10: Manhattan plots representing the significant SNPs (above threshold lines) on different chromosomes which were found associated with mean disease score of TLB disease at Bajaura, Mandaya, Dharwad and Srinagar (BMDS). The association study was carried out using both GLM as well as MLM model

Table 1.27: Details of SNPs found associated with TLB resistance on the basis of both GLM as well as MLM

SNP	Chr.	Position (bp)	P value		R^2		Effect	
			MLM	GLM	MLM	GLM	MLM	GLM
SChr2_166580547	2	166580547	8.31E-05	3.71E-07	0.24	0.25	4.76	5.70
SChr2_166580547	2	166580547	2.69E-02	1.07E-02	0.29	0.28	6.70	6.61
SChr3_49666693*	3	49666693	9.69E-05	2.84E-05	0.24	0.23	4.49	4.60
SChr4_133011027	4	133011027	2.75E-05	1.23E-05	0.25	0.24	5.89	5.86
SChr4_133011115	4	133011115	3.55E-06	7.75E-07	0.26	0.25	6.50	6.58
SChr4_60643199	4	60643199	4.18E-06	3.59E-07	0.25	0.25	-5.56	-5.83
SChr4_60643265	4	60643265	2.80E-06	2.02E-07	0.26	0.25	-5.63	-5.93
SChr4_60643350	4	60643350	7.72E-06	6.37E-07	0.25	0.25	5.36	5.67
SChr4_60644158*	4	60644158	5.43E-05	5.47E-07	0.24	0.25	4.43	5.28
SChr4_133011027	4	133011027	9.95E-04	4.25E-04	0.29	0.27	7.40	7.12
SChr4_133011115	4	133011115	1.71E-02	1.59E-02	0.29	0.27	7.81	7.62
SChr5_133852353	5	133852353	1.88E-06	2.59E-08	0.26	0.26	4.88	5.33
SChr5_54792228*	5	54792228	0.000113	5.58E-05	0.24	0.23	5.67	5.57
SChr5_133852353	5	133852353	1.16E-02	1.50E-03	0.29	0.28	7.86	7.85
SChr6_171682925*	6	171682925	6.48E-05	1.20E-05	0.24	0.24	3.85	4.08
SChr7_4755874*	7	4755874	1.22E-05	1.14E-05	0.25	0.24	-4.78	-4.68
SChr7_4755895*	7	4755895	1.82E-05	1.56E-05	0.25	0.23	4.75	4.70
SChr8_148909020	8	148909020	4.72E-05	3.90E-07	0.24	0.25	3.22	3.75
SChr8_148909048	8	148909048	4.72E-05	3.90E-07	0.24	0.25	-3.22	-3.75
SChr8_148909176	8	148909176	6.38E-05	6.22E-07	0.24	0.25	3.12	3.63
SChr8_148909020	8	148909020	8.18E-03	2.43E-03	0.30	0.29	5.72	5.68
SChr8_148909048	8	148909048	8.18E-03	2.43E-03	0.30	0.29	-3.40	-3.41

*These are the SNPs found significantly associated on the bases of overall mean values of disease response at four locations, however rest of the SNPs were found associated in both, i) individual location as well as ii) on over all mean value basis of four locations. The lateral can be considered as important for further use.

Table 1.28: Disease score against MLB of best inbred lines

Inbred	Score	Reaction	Inbred	Score	Reaction
Ludhiana			Karnal		
MIL 2-43-2	3.9	MR	MIL 2-49-2	4.0	MR
MIL 2-173-2	3.9	MR	MIL 2-68-2	4.0	MR
MIL 2-173-3	4.0	MR	MIL 2-173-2	4.0	MR
MIL 2-801-1	3.8	MR	MIL 2-173-3	4.0	MR
MIL 2-976-2	3.7	MR	MIL 2-266-2	4.0	MR
MIL 2-3470	3.3	MR	MIL 2-592-2	3.5	MR
R. check	4.2	MR	MIL 2-1062-1-2	3.8	MR
Dholi			MIL 2-1298-8	3.5	MR
MIL 2-55-1	2.5	R	MIL 2-1300	3.5	MR
R. check	2.0	R	MIL 2-2166	3.8	MR
			MIL 2-3470	3.3	MR
			MIL 2-3701	3.0	R
			R. check	4.8	MR

(MLM). The SNPs found significantly associated with target trait using GLM and MLM which have been represented in Figure 1.10 and Table 1.27. There were total 22 significant SNPs found associated with TLB resistance with maximum SNPs on chromosome no. 4.

Screening maize inbred lines against MLB during kharif 2020

A set of 200 maize inbred lines were evaluated against maydis leaf blight (MLB) and banded leaf and sheath blight (BLSB) at Ludhiana, Karnal and Dholi. One inbred line at Karnal and one inbred line at Dholi centre

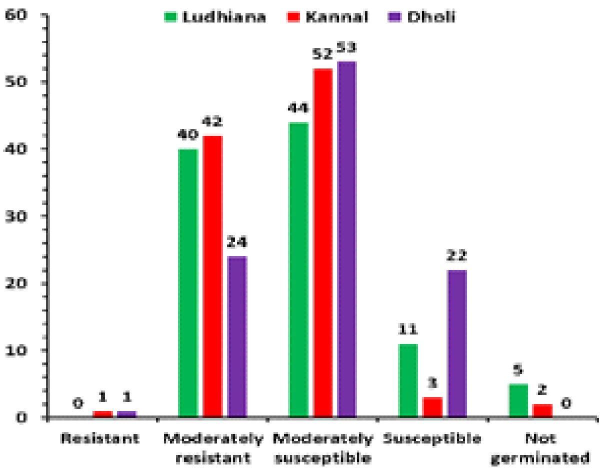


Table 1.29: Reaction of inbred lines against FAW incidence

Sl. No.	Treatment Name	LIRv3-6	LIRv 5-8	LIRvt-r2	LIRr3-5	INFv3-6	INFv 5-8	Yield/ear (g)	Ear Damage (%)
1	MIL 2-114-1	1.83^{ghijk}	2.78	4.36^{abcd}	$4.75^{abcdefg}$	$78.03^{abcdefgh}$	100	$32.80^{defghijkl}$	0.70^{cd}
2	MIL 2-119-1	$2.17^{bcdefghijk}$	2.2	4.14^{abcd}	$4.47^{abcdefg}$	$77.77^{abcdefghij}$	90.92	$37.89^{cdefghijkl}$	4.61^{bcd}
3	MIL 2-15-2	1.66^{hijk}	2.19	3.92^{abcd}	3.37^{efg}	$56.82^{bcdefghij}$	91.67	14.54^{kl}	1.10^{cd}
4	MIL 2-274-1	$2.32^{bcdefghijk}$	3.27	6.17^{abc}	7.09^{abc}	88.15^{abcde}	100	13.31^{kl}	58.65^{a}
5	MIL 2-291-1	$2.79^{abcdefgh}$	3.65	5.54^{abcd}	6.97^{abcd}	$78.03^{abcdefgh}$	100	48.50^{cdef}	4.62^{bcd}
6	MIL 2-342-1	$2.57^{abcdefghij}$	3.45	4.63^{abcd}	$5.66^{abcdefg}$	100.00^{a}	91.67	52.15^{cde}	4.22^{bcd}
7	MIL 2-350-1	$2.13^{cdefghijk}$	2.98	4.86^{abcd}	$5.38^{abcdefg}$	$79.17^{abcdefg}$	95.84	19.14^{jkl}	0.20^{d}
8	MIL 2-375-1	$2.09^{cdefghijk}$	3.29	5.14^{abcd}	$5.28^{abcdefg}$	$66.67^{abcdefghij}$	100	59.70c	4.70^{bcd}
9	MIL 2-376-2	$1.97^{defghijk}$	3.41	4.28^{abcd}	$4.79^{abcdefg}$	$62.50^{abcdefghij}$	100	$38.60^{cdefghijk}$	4.20^{bcd}
10	MIL 2-380-1	1.81^{ghijk}	3.2	5.86^{abcd}	6.62^{abcde}	$53.13^{cdefghij}$	86.67	$34.42^{cdefghijk}$	1.00^{cd}
11	MIL 2-387-1	$2.48^{bcdefghijk}$	3.19	5.60^{abcd}	6.37^{abcdef}	$75.30^{abcdefghi}$	100	$37.30^{cdefghijk}$	4.80^{bcd}
12	MIL 2-393-1	$2.90^{abcdefg}$	3.47	4.94^{abcd}	$5.07^{abcdefg}$	93.03^{ab}	100	$36.46^{cdefghijk}$	2.80^{bcd}
13	MIL 2-43-2	$2.06^{defghijk}$	2.36	3.71^{abcd}	$4.01^{abcdefg}$	$64.29^{abcdefghij}$	100	$37.85^{cdefghijk}$	2.60^{bcd}
14	MIL 2-483-1	$2.45^{bcdefghijk}$	3.34	5.20^{abcd}	$5.90^{abcdefg}$	88.54^{abcde}	100	$45.14^{cdefghi}$	5.40^{bcd}
15	MIL 2-49-2	$1.91^{efghijk}$	2.25	4.00^{abcd}	$3.91^{abcdefg}$	$58.57^{bcdefghij}$	80.56	59.70^{c}	2.20^{cd}
16	MIL 2-591-2	$2.06^{defghijk}$	3.01	4.91^{abcd}	$4.26^{abcdefg}$	50.00^{efghij}	90.63	45.50^{cdefgh}	7.60^{bcd}
17	MIL 2-801-2	1.90^{fghijk}	2.46	4.52^{abcd}	$5.03^{abcdefg}$	$68.57^{abcdefghij}$	93.34	$37.86^{cdefghijk}$	7.20^{bcd}
18	BML 6 (Check)	$2.73^{abcdefghi}$	3.62	5.85^{abcd}	6.69^{abcde}	$81.39^{abcdefg}$	100	14.19^{kl}	34.10^{abcd}
19	BML 7 (Check)	$1.96^{defghijk}$	2.5	3.72^{abcd}	$4.49^{abcdefg}$	$52.28^{defghij}$	100	$30.12^{defghijkl}$	5.37^{bcd}
20	Co-8 (Check)	$2.71^{abcdefghij}$	3.82	2.65^{d}	2.84^{g}	$70.98^{abcdefghij}$	100	152.30^{a}	4.80^{bcd}
21	DHM117(Check)	1.73^{ghijk}	2.15	2.57^{d}	3.20^{fg}	39.52^{hij}	88.73	92.10^{b}	8.53^{bcd}
22	E 63 (Check)	1.39^{k}	2.47	2.99^{bcd}	3.61^{defg}	36.07^{j}	100	8.241	26.50^{abcd}
23	IML127-1(Check)	1.89^{fghijk}	2.81	2.73^{cd}	$4.37^{abcdefg}$	45.59^{ghij}	100	$23.40^{fghijkl}$	24.10^{abcd}
24	IML418-1(Check)	1.57^{ijk}	2.46	5.18^{abcd}	6.49^{abcdef}	37.50^{ij}	100	19.40^{ijkl}	0.40^{d}
	General Mean	2.23	2.93	4.86	5.44	69.84	95.89	34.79	11.51
	p-Value<.0001	0.1093	<.0001	<.0001	<.0001	0.3201	<.0001	<.0001	
	F value8.25	1.41	3.8	5.58	8.12	1.14	32.83	4.71	
	CV (%)10.73	17.47	14.81	12.78	11.44	6.7	15.27	65.56	

Table 1.30: Reaction of maize inbred lines against spotted stem borer at WNC Ludhiana during kharif 2020

Sl. No.	Entry name	Insect score	Insect reaction	Sl. No.	Entry	Insect score	Insect reaction
1	MIL 2-807-1	6.6	S	15	MIL 2-1289-2	NG	-
2	MIL 2-874-2	7.5	S	16	MIL 2-1292-2	7.6	S
3	MIL 2-882-1	6.0	MR	17	MIL 2-1297-1	7.8	S
4	MIL 2-883-1	6.1	S	18	MIL 2-1298-6	6.9	S
5	MIL 2-955-1	8.3	S	19	MIL 2-1299-5	NG	-
6	MIL 2-975-2	6.3	S	20	MIL 2-2034	6.4	S
7	MIL 2-976-2	6.3	S	21	MIL 2-2039	7.0	S
8	MIL -1018-1	8.0	S	22	MIL 2-2051	8.0	S
9	MIL 2-1042-3-1	8.1	S	23	MIL 2-2068	6.8	S
10	MIL 2-1043-1-1	5.5	MR	24	MIL 2-2077	7.4	S
11	MIL 2-1053-2-2	7.1	S	25	MIL 2-2166	6.8	S
12	MIL 2-1060-8-1	8.0	S		E 63 (R Check)	3.3	MR
13	MIL 2-1063-1-2	7.9	S		CM 500 (R Check)	2.8	R
14	MIL 2-1281-3	6.9	S		BML 6 (S Check)	7.5	S

was found resistant against. Forty lines at Ludhiana, 42 lines at Karnal and 24 lines at Dholi were found moderately resistant. Resistant check at Ludhiana and Karnal showed the moderately score indicating high incidence of MLB at both the locations (Figure 1.11). Six lines at Ludhiana and 12 lines at Karnal as mentioned in Table 1.28 showed lower score than the resistant check.

Screening of inbred lines against Fall armyworm (FAW) in kharif 2020 at IIMR, New Delhi

A set of 100 inbred lines were evaluated against Fall Armyworm (FAW) under natural infestation during kharif 2020. Eight inbred lines were observed with Least Infestation Rate (LIR) at four different growth stages (Table 1.29). Fourteen inbred lines showed less incidence of ear damage along with high yield potential. MIL 2- 49-2 was one of the best performing inbred under FAW infestation.

Screening of maize inbred lines against spotted stem borer (Chilo partellus)

A set of 25 maize inbred lines along with three checks were evaluated against spotted stem borer during kharif 2020 at WNC, Hyderabad. Two inbred lines (MIL 2-882-1 and MIL 2-1043-1-1) were identified as moderately resistant (Table 1.30).

Breeding for quality traits

Promising QPM lines identified

A set of 224 lines was planted at Ldhiana experimental field and the selfed samples were used for biochemical analysis. Out of 224 lines, 40 most promising lines were identified with higher tryptophan content (>0.8%) which is given below in Table 1.31.

Diversification of QPM germplasm

Toward diversification of QPM germplasm, new QPM lines were developed by using the background of normal maize lines as one of the parents after crossing with QPM lines. A set of such newly derived 74 lines was tested for tryptophan content and out of these 74 lines, 40 most promising lines have been identified for high tryptophan content which are listed below (Table 1.32).

Breeding for high-lysine, tryptophan and ?-carotene

The inbred lines, viz., LM 13, LM14, LM 15 and LM 17 were targeted for introgression of opaque2 (o2) and crtRB1 allele independently. The stabilized near isogenic lines (NILs) with good agronomic performance were evaluated for quality traits. The NILs carrying o2 gene have shown higher tryptophan which varied from 0.56 to 1.10% of the total protein. Some of the converted NILs showed more than double the level of tryptophan as compared to its original parent (Figure 1.12).

Table 1.31: Identification of tryptophan rich germplasm

Sl. No.	Inbred Line	Tryptophan (% of protein)	Sl. No.	Inbred Line	Tryptophan (% of protein)
1	E 4-9-1C4	1.01	21	E 7-15-1	0.90
2	E 19-14-1-1	0.98	22	E 19-14-1-2-1	0.90
3	E 6-24-1-2-1	0.96	23	E 7-15-2-1-1	0.89
4	E 11-39-2	0.96	24	E 3-25-1-1-2	0.88
5	E 8-21-1-1-1	0.94	25	E 8-3-1-2	0.88
6	E 9-2-1-1	0.94	26	E 2-52-1	0.88
7	E 11-46-2-1	0.94	27	E 5-18-1-2	0.88
8	E 9-27	0.94	28	E 8-26	0.88
9	E 2-22-3-1	0.92	29	E 12-15	0.87
10	E 4-1-1-1	0.92	30	E 16-33	0.87
11	E 4-9-1-2	0.92	31	E 11-24-1-2	0.87
12	E 6-32-4	0.92	32	E 2-47-1	0.86
13	E 8-16-1-2-2	0.92	33	E 5-13-1	0.86
14	E 7-6-1	0.92	34	E 7-24-3-C1	0.86
15	E 8-20-4-1-2	0.92	35	E 11-25	0.86
16	E 8-21-3	0.91	36	E 14-37-1	0.86
17	E 11-35-0-2	0.91	37	E 25-13-1	0.86
18	E 8-16-1-2-1	0.91	38	E 6-36-1-C2	0.86
19	E 2-44-1	0.90	39	E 8-21-1-1	0.85
20	E 5-13-1-3	0.90	40	E 11-38	0.85

Table 1.31: Identification of tryptophan rich germplasm

Sl. No.	Inbred Line	Tryptophan (% of protein)	Sl. No.	Inbred Line	Tryptophan (% of protein)
1	E 4-9-1C4	1.01	21	E 7-15-1	0.90
2	E 19-14-1-1	0.98	22	E 19-14-1-2-1	0.90
3	E 6-24-1-2-1	0.96	23	E 7-15-2-1-1	0.89
4	E 11-39-2	0.96	24	E 3-25-1-1-2	0.88
5	E 8-21-1-1-1	0.94	25	E 8-3-1-2	0.88
6	E 9-2-1-1	0.94	26	E 2-52-1	0.88
7	E 11-46-2-1	0.94	27	E 5-18-1-2	0.88
8	E 9-27	0.94	28	E 8-26	0.88
9	E 2-22-3-1	0.92	29	E 12-15	0.87
10	E 4-1-1-1	0.92	30	E 16-33	0.87
11	E 4-9-1-2	0.92	31	E 11-24-1-2	0.87
12	E 6-32-4	0.92	32	E 2-47-1	0.86
13	E 8-16-1-2-2	0.92	33	E 5-13-1	0.86
14	E 7-6-1	0.92	34	E 7-24-3-C1	0.86
15	E 8-20-4-1-2	0.92	35	E 11-25	0.86
16	E 8-21-3	0.91	36	E 14-37-1	0.86
17	E 11-35-0-2	0.91	37	E 25-13-1	0.86
18	E 8-16-1-2-1	0.91	38	E 6-36-1-C2	0.86
19	E 2-44-1	0.90	39	E 8-21-1-1	0.85
20	E 5-13-1-3	0.90	40	E 11-38	0.85

Table 1.32: Promising tryptophan rich germplasm identified from diversification programme

Sl. No.	Inbred Line	Tryptophan (% of protein)	Sl. No.	Inbred Line	Tryptophan (% of protein)
1	QIL 4-67	0.98	21	QIL 4-305	0.84
2	QIL 4-301	0.98	22	QIL 4-378	0.84
3	QIL 4-51	0.96	23	QIL 4-226	0.82
4	QIL 4-261	0.96	24	QIL 4-254	0.81
5	QIL 4-77	0.95	25	QIL 4-376	0.81
6	QIL 4-157	0.95	26	QIL 4-264	0.81
7	QIL 4-224	0.94	27	QIL 4-227	0.8
8	QIL 4-252	0.94	28	QIL 4-388	0.8
9	QIL 4-143-1	0.93	29	QIL 4-186	0.79
10	QIL 4-23	0.92	30	QIL 4-332	0.79
11	QIL 4-1112	0.92	31	QIL 4-13	0.78
12	QIL 4-275	0.92	32	QIL 4-141-1	0.78
13	QIL 4-94	0.91	33	QIL 4-236	0.78
14	QIL 4-24	0.88	34	QIL 4-71	0.77
15	QIL 4-98	0.88	35	QIL 4-214	0.77
16	QIL 4-266	0.87	36	QIL 4-75	0.75
17	QIL 4- 81	0.86	37	QIL 4- 78	0.74
18	QIL 4- 113-1	0.86	38	QIL 4- 99	0.74
19	QIL 4- 163	0.86	39	QIL 4- 162	0.74
20	QIL 4- 233	0.86	40	QIL 4- 182	0.74

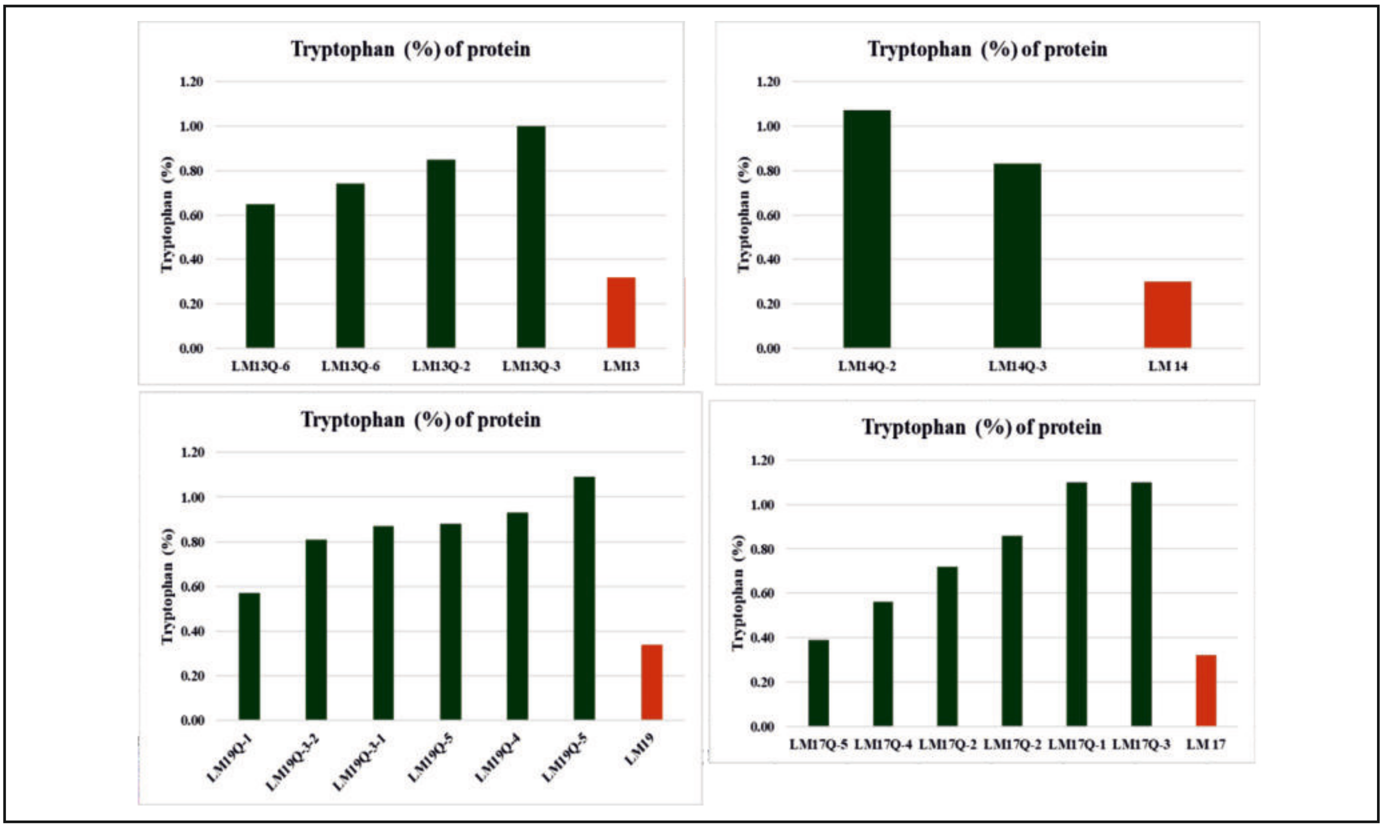


Figure 1.12: The comparison of tryptophan content in the original lines vis-à-vis converted NILs

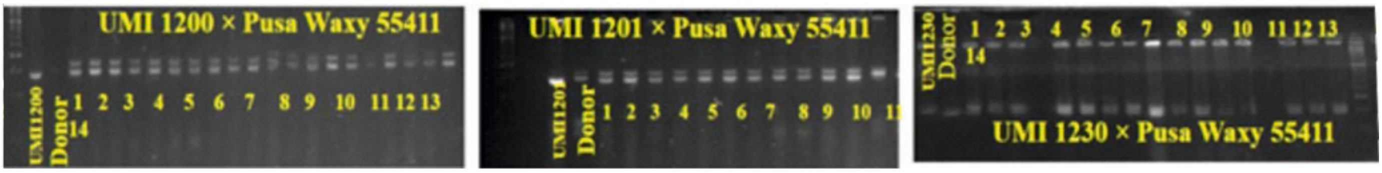


Figure 1.13: The confirmation of hybridity test in F1s

The biochemical analysis of reconstituted hybrids [PMH 3 (LM 17 × LM 14); PMH 6 ()] for provitamin-A was also carried out by following normal process of harvesting as practiced in farmer's field. The provitamin-A content in the reconstituted hybrids was 4.35 ppm (Improved PMH 3) to 5.44 ppm (Improved PMH 6).

Molecular breeding for high amylopectin/waxy maize

The crosses were made between donor (Pusa Waxy 55411) and recurrent parents (UMI 1200, UMI 1201, UMI 1230) during kharif 2020 at ICAR-IIMR Farm, Ladhowal and F1s (UMI 1200 × Pusa Waxy 55411, UMI 1201 × Pusa Waxy 55411, UMI 1230 × Pusa Waxy 55411) were grown at WNC, ICAR-IIMR, Hyderabad during rabi 2020-21and hybridity of the F1s were confirmed using foreground marker of waxy gene (Figure 1.13). The confirmed F1 plants were crosses with respective recurrent parents to generate BC1F1 generation. Further, polymorphic molecular markers between donor and recipient genome were identified for faster recovery of recurrent parents. The total number of polymorphic molecular markers identified between donor and recipient parents for background selection were 90-100 for each pair of donor and recurrent parents (Figure 1.14).

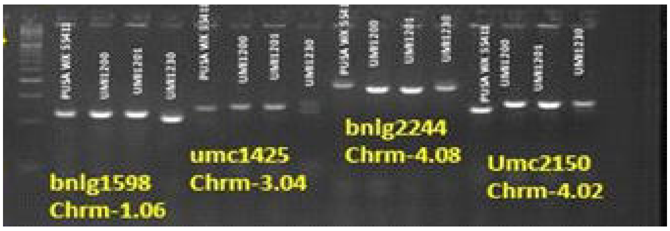


Figure 1.14: The Parental polymorphism survey between donor and recurrent parents using SSR markers

Molecular breeding for high amylose maize

Diversification the background of high amylose maize genotypes

Maize inbred lines with good agronomic performance (HKI 1344, HKI 1348-6-2, HKI 1352, HKI1378, MIL 10-22-6-1, BML 6, HKI 163, LM 13, LM 14, LM 15, LM 16, MIL 10-9C1, MIL 10-1519, MIL 10-1382, UMI 1200, UMI 1201 and UMI 1230) were selected for diversification of the narrow background of high amylose germplasm (EC 972407, EC 972391, EC 972408, EC 972405, EC 972403, EC 972401, PI 1643420) received from maize genetics stock centre, USA. All the 24 maize genotypes were characterized using 99 SSR markers which helped to group these genotypes into different clusters based on the genetic distance (Figure 1.15). Based on the clustering information crosses were made among the normal and imported high amylose lines to generate two MAGIC pool representing different heterotic pattern. To derive MAGIC pool-I, single crosses among LM 13 × EC 972405, HKI 1352 × EC 972408, LM 16 × EC 972405 and HKI 1344 × EC 972408 were derived. Crosses were further made among single crosses to generate double crosses ((LM 13 × EC 972405) × (HKI 1352 × EC 972408);

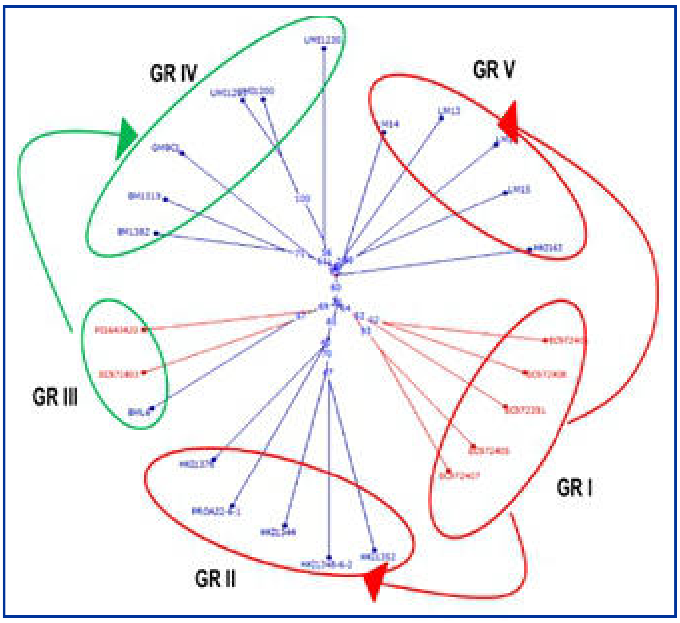


Figure 1.15: Crosses made among normal and ae mutant line based on clustering pattern

Figure 1.16: The individuals of BC2F1 generation were genotyped with the foreground marker (sbeII)

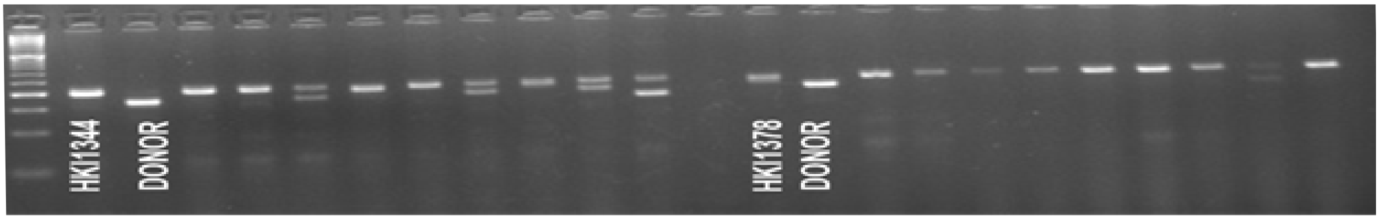


Figure 1.17: Background genotyping to BC2F1 individuals with bnlg2291 marker

(LM 16 × EC 972405) × (HKI 1344 × EC 972408)). To derive MAGIC pool-II, single crosses among UMI 1200 × PI 643420, UMI 1201× EC 972403, UMI 1230 × PI 643420 and MIL 10-9C1 × EC 972403. Further, crosses were made among single crosses to generate double crosses [(UMI 1200 × PI 643420) × (UMI 1201× EC 972403); (UMI 1230 × PI 643420) × (MIL 10-9C1 × EC 972403)].

Marker assisted introgression of high amylose allele (ae1) into parental lines of released hybrids

Parents of HM 5 (HKI 1344 × HKI 1348-6-2) and HM 12 (HKI 1344 × HKI 1378) have been selected as recurrent parents, whereas PI643420 and 510B were used as donor parents. Donor parent had the favourable allele for sbeII gene whereas in recurrent parents (HKI 1344, HKI 1378 and HKI

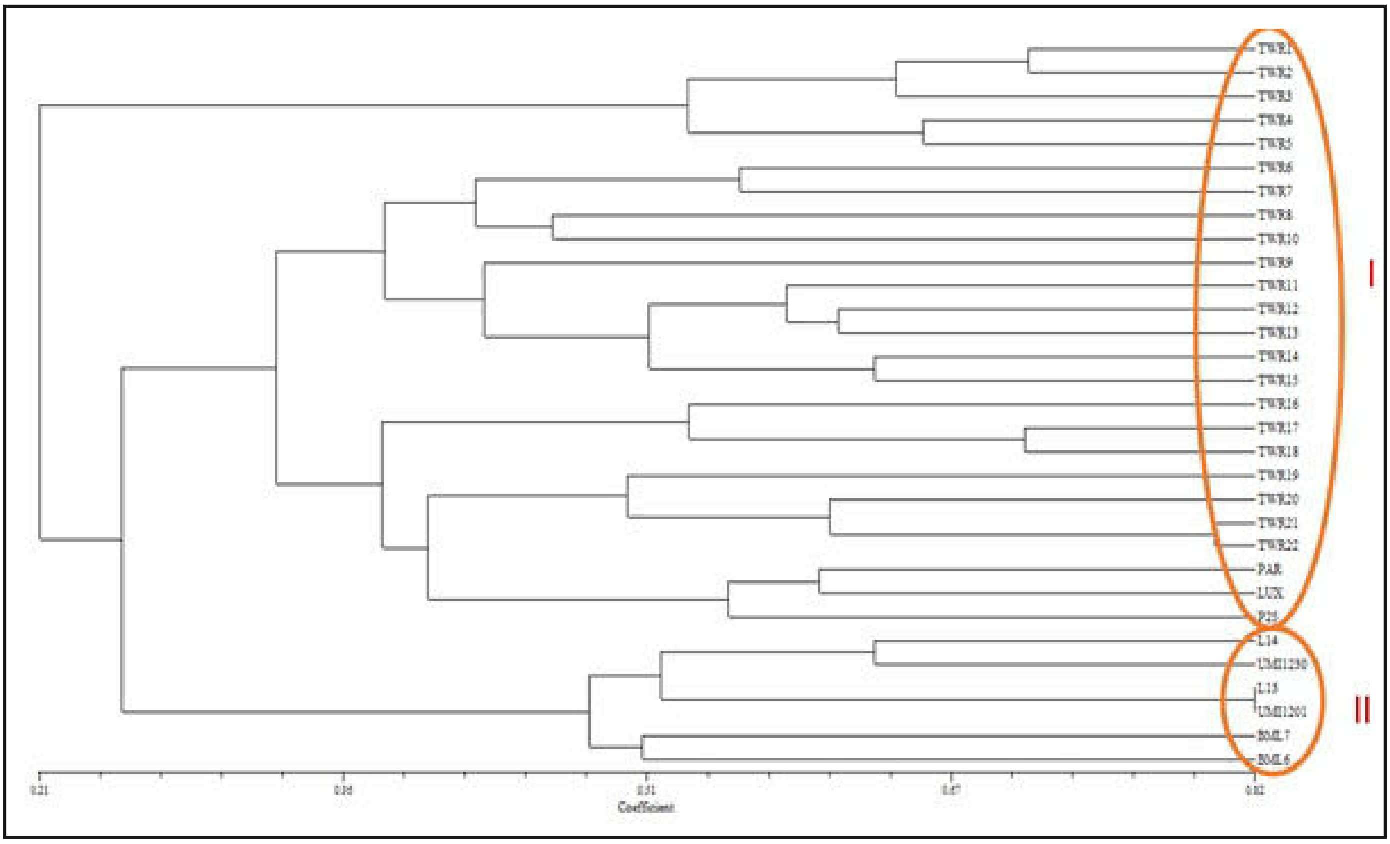


Figure 1.18: Dendrogram of wild species and cultivated inbred lines

1348-6-2) there was no amplification. The marker behaved as a dominant marker. Kernel starch content of HKI 1344, HKI 1348-6-2 and HKI 1378 was 60.26%, 60.70% and 57.65%, with kernel amylose content (of total starch) 26.39%, 23.29% and 22.25%, respectively. Parental polymorphism was also done among the donor and recurrent parents, and polymorphic SSR markers (>100) were identified for each of the pairs (recurrent and donor). The crosses were made between donor and recurrent parents and F1s were grown at WNC, Hyderabad. F1 plants were crosses with recurrent parents to generate BC1F1 generation and the BC1F1 generation was grown at Ludhiana. The individuals of BC1F1 generation from each family, viz., HK I1344, HK I1348-6-2 and HKI1378 were genotyped with the foreground marker (sbeII). Foreground selected positive plants for HKI 1344, HKI 1348-6-2 and HKI1378 were screened with the polymorphic SSR markers to determine the background recovery of the foreground selected plants in BC1F1 generation. The foreground selected individuals with background recovery >75 % [HKI 1344 (4), HKI 1348-6-2 (4) and HKI 1378 (4)] were advanced to BC2F1 generation. Further, individuals of BC2F1 generation from each family were genotyped (Figure 1.16) and positive individuals were selfed. Background recovery in BC2F1 generation ranged from 83-95% [HKI 1344 (4) (85-95%), HKI 1348-6-2 (4) (83-92%) and HKI 1378 (4) (86-93%)] (Figure 1.17). Foreground positive BC2F1 individuals with high background recovery were advanced o BC2F2 generation.

Pre-breeding

Molecular characterization

Two advanced backcross populations (BC2F3) were generated through crossing between LM 13 and LM 14 with Zea parviglumis. Molecular characterization of different accessions of 25 wild species of maize,

Table 1.33: Quality parameters in different set of maize germplasm

Genotype	Oil	Protein	Starch	Sugar	N Force
IC 6114290	3.54^{fg}	12.01^{efg}	70.84^{cd}	1.2^{cd}	467.48^{abc}
IC 564944	4.39^{cdefg}	10.87^{hi}	69.23^{def}	1.55^{a}	489.34^{ab}
IC 353811	5.52^{abc}	13.88^{bc}	70.17^{cd}	1.33^{b}	543.83^{a}
IC 396885	4.78^{abcde}	14.31^{abc}	67.04^{fgh}	1.61^{a}	575.36^{a}
BIL 1-56-11	5.16^{abcd}	10.40^{ij}	73.36^{ab}	0.91^{ij}	447.98^{abcd}
BIL 1-69-11	4.80^{abcde}	9.26^{k}	74.51^{a}	1.22^{bc}	375.88^{abcdef}
Z. parviglumis	3.41^{g}	11.56^{fgh}	45.45^{i}	0.74^{k}	552.17^{a}
C7 (J&K)	4.86^{abcde}	9.94^{jk}	73.6^{ab}	1.59^{a}	397.92^{abcde}
IMFP 21	5.43^{abc}	10.42^{ij}	69.8^{cde}	1.17^{cdef}	290.26^{bcdefg}
IMFP 23	3.77^{efg}	12.04^{ef}	71.84bc	1.07^{efgh}	405.85^{abcde}
FML 1-07-12	4.76^{abcde}	13.67^{c}	65.13hi	1.04^{gh}	540.20^{a}
LM 13	3.80^{efg}	12.86^{d}	65.73^{gh}	1.09^{defg}	268.12^{bcdefg}
LM 14	4.20^{defg}	12.01^{efg}	62.93ijk	1.15^{cdefg}	238.66^{defg}
BC_1F_2(LM 14 × *Z. parviglumis*)	5.91^{a}	14.87^{a}	61.29^{k}	1.26^{bc}	161.17^{fg}
BC_1F_2(LM 13 × *Z. parviglumis*)	5.12^{abcd}	14.49^{ab}	63.14^{ijk}	0.84^{jk}	140.9^{g}
BC_2F_2(LM 14 × *Z. parviglumis*)	5.04^{abcd}	12.91^{d}	62.65jk	1.26^{bc}	236.82^{defg}
BC_2F_2(LM 13 × *Z. parviglumis*)	5.02^{abcd}	12.67^{de}	64.79^{hij}	1.07^{efgh}	252.05^{cdefg}
BC_1F_1(LM 13 × *Z. mexicana*)	4.65^{bcdef}	12.74^{de}	64.69^{hij}	1.06^{fgh}	142.03^{g}
BML 6	3.98^{defg}	10.29^{ij}	64.98^{hij}	1.17^{cde}	195.22^{efg}
BML 7	5.81^{ab}	11.27^{gh}	67.78^{efg}	0.97^{hi}	403.56^{abcde}
P value	**0.0061 ****	**4.49e^{-12} *****	**9.87e^{-14} *****	**1.02e^{-11} *****	**0.003 ****
CV (%)	**12.21**	**2.93**	**1.71**	**4.52**	**30.56**
CD (5%)	**1.19**	**0.74**	**2.37**	**0.11**	**227.14**

viz., Zea maxicana (17), Zea luxurians (1), Zea dipploperennis (2), Zea nicaraguensis (2) and Zea parviglums(3) were collected from different sources to diversify the maize germplasm and six parental lines, viz., LM 13, LM 14, BML 6, BML 7, UMI 1230 and UMI 1201 were carried out using 37 SSR markers to characterize the wild and normal maize inbred. Based on the 37 SSR primers, 31 maize germplasm including wild and inbred lines were classified into two clusters. It indicates that wild species are distantly different from cultivated inbred lines (Figure 1.18).

Quality analysis

A total of 20 maize lines including six landraces, three inbred inbred lines, four parental lines of hybrids, five wild cross generations, one composite and one wild species (Z. parviglumis) were used for quality analysis, viz., oil, protein, sugar, hardness and starch.The result indicates that BC1F2(LM 14 × Z. parviglumis) population having more oil and protein percent compared to Z. parviglumis and LM 14.The BIL 1-69-11 having maximum starch percent and maximum hardness was observed in IC 353811, IC 396885, Z. parviglumis and FML 1-07-12 (Table 1.33). Further this needs to confirm through one more year testing. This results showed that wild species of maize having wider scope to enhance the quality traits.

BASIC SCIENCES

2

Characterization of maize amylose and development of rapid method for its categorization

A set of 200 nutritionally superior lines from Indian germplasm were evaluated for amylose content. The material was categorized into low, moderate and high amylose content. Maximum number of lines (147) contained moderate amylose content, whereas few lines contained high amylose category. Contrasting lines from all the three categories were selected for starch digestibility characters, including resistant starch (RS), slowly digestible starch (SDS) and rapidly digestible starch (RDS). A positive correlation was observed between amylose and resistant starch content (R=0.95). It was also observed that RDS slightly reduces in high amylose, whereas SDS content decreased with increasing amylose content. Therefore, SDS and amylose concentrations showed decreasing linear relationship. In order to study the binding properties of starch granuoles in high amylose maize, scanning electron microscopy was performed in high, low and moderate amylose samples. Scanning electron micrographs showed a visual difference between starch matrix of low and high amylose line at different magnifications (Figure 2.1). In low amylose lines, the matrix was scattered compared to high amylose, where the matrix was dense. Moderate lines' starch matrix density lied in between two extremes. In order to analyse amylose content in a large set of maize lines, a rapid method named "Cut Grain Dip Method" was developed (Figure 2.2). On the basis of regression equation derived from the set of 21 samples, the method was standardised as the successful preliminary method for the estimation of amylose content. The regression equation depicted a significantly inverse relation between amylose content and time taken for the development of maximum colouration. A ready reckoner table was developed to analyse the amylose content through CGD method.

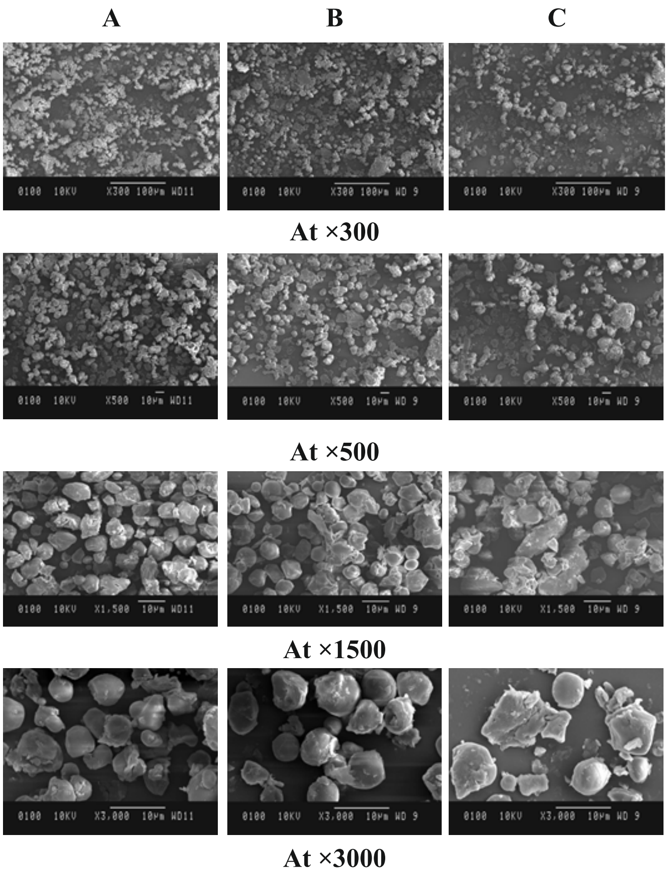


Figure 2.1: Scanning electron micrographs of (A) low, (B) moderate and (C) high amylose lines

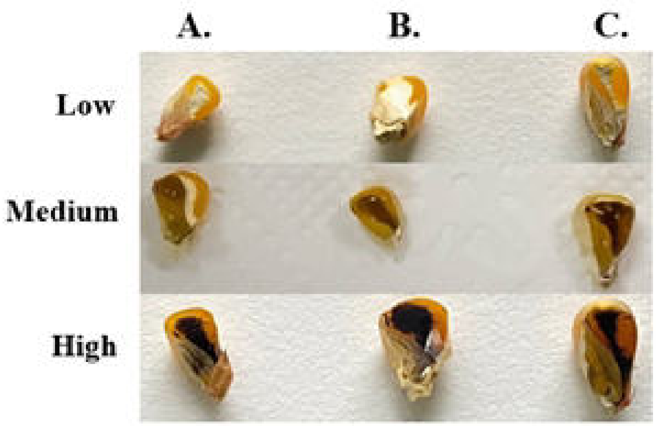


Figure 2.2: Time course evaluation of color development by CGD method after (A) addition of reagent, (B) 10 seconds, and (C) 50 seconds of color development.

Extraction and stability analysis of maize anthocyanins

The indigenous landraces and exotic maize lines from USDA and CIMMYT were collected. The lines vary in color i.e. purple, blue and red. The major color pigment in these lines is anthocyanin. The color maize germplasm according to their colors were grouped for measurement of Tristimulus patterns (L, a, b) and other color attributes of kernel and flour (Table 2.1). Value 'L' value indicates lightness (L = 100 means bright, L = 0 means dull). Values 'a' and 'b' indicate redness to greenness and yellowness to blueness color, respectively.

Table 2.1: Tristimulus pattern (L, a, b, c and h values) of colored maize

	O-Yellow	Red	Blue	Super Dark
L, Lightness	83.3	77.2	72.5	63.2
a, Redness	1.3	9.6	5.1	4.3
b, Yellow	43.7	16.9	-0.6	3.2
Chroma	32.3	17.5	5.1	9.9
Hue	88.1	74.6	7.1	19.1

The polymeric color percentage of different color maize samples (fresh and stored) was also measured. Lower amount of polymeric color is related to higher amount of freshness (Figure 2.3). Purple or dark maize has more polymeric density as compared to the yellow, orange or red maize.

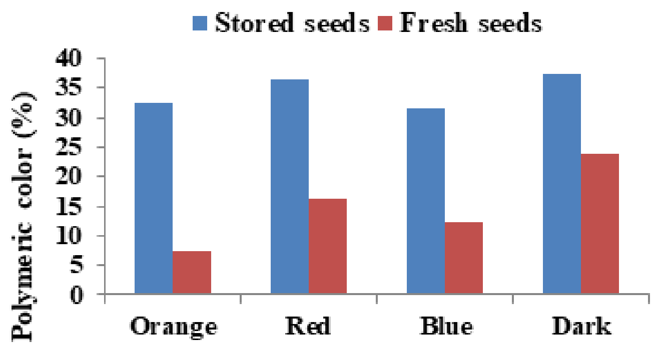


Figure 2.3: Polymeric color of fresh and stored seeds

The anthocyanins from the pericarp part (purple) as well as aleurone layers (blue) of selected colored maize germplasm was also determined. The antioxidant activity of colored maize was determined through various methods, viz., ORAC (Oxygen Radical Absorbance Capacity) and DPPH [(2,2-diphenyl-1-picryl-hydrazyl-hydrate) free radical method] . The antioxidant capacity of anthocyanin rich extract correlated well with the phenolic profile of set of colored maize germplasm (Figure 2.4). The antioxidant activity of purple maize was higher as compared to the blue and red maize germplasm. The phenolic and flavonoid content of maize germplasm

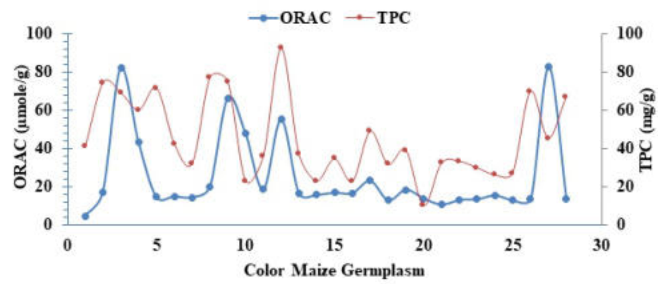


Figure 2.4: Correlation of antioxidant activity of maize germplasm with total phenolic

also has been evaluated in order to speculate the untapped potential for the pharmaceutical and nutritional/anti-nutritional properties.

Silk is also important resource material after maize harvest. It is beneficial to extract phenolic and flavonoids along with anthocyanins from the color silk. Anthocyanin contents in the silk of collected germplasm have been measured. The silk samples were harvested after 3 days of silk emergence. The anthocyanin content in freshly harvested silk and stored silk for 3 months in refrigeration were compared (Figure 2.5). The dried silk has substantially lower anthocyanin content as it is sensitive biomolecule.

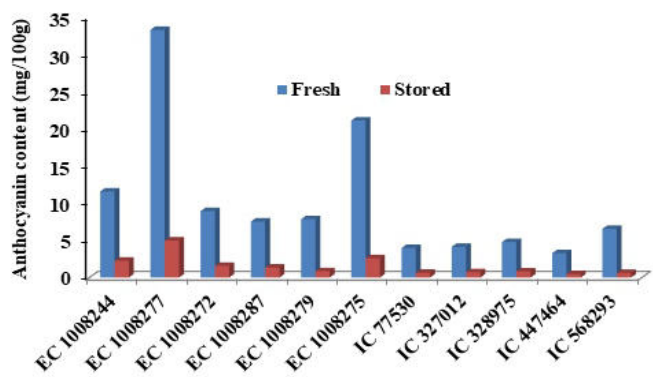


Figure 2.5: The impact of storage on anthocyanin content of silk from selected maize germplasm

Anthocyanin exists in carbocation, zwitter ion and anionic form at different pH. It can be protected from the severe pH change through the stabilizing effect of extraneous agents e.g. divalent metal ions. A preliminary trial to know the effect of metal ion on anthocyanin content has been conducted. It has been found that zinc supplementation has stabilizing effect on the anthocyanin. This could lead to observed higher anthocyanin content in the maize sample from metal treated plot (Figure 2.6).

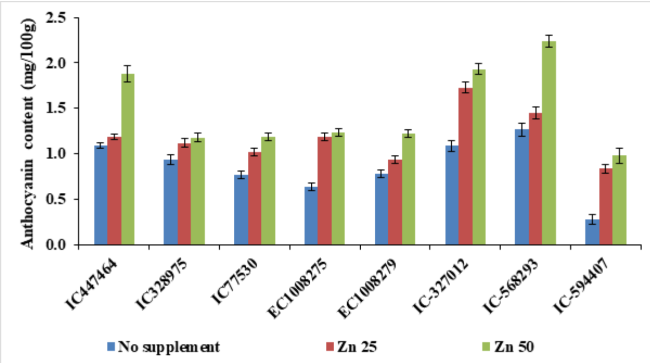


Figure 2.6: Effect of zinc towards more anthocyanin retention in kernel demonstrated the positive influence on anthocyanin stabilization. Zn 25 and Zn 50 represent supplementation with zinc sulphate concentration of 25 kg/ha and 50 kg/ha, respectively.

Development of an efficient and reproducible transformation protocol for tropical maize (Zea mays L.) using mature seed-derived nodal explants

During 2021, using the nodal explants-derived embryogenic calli, the genetic transformation was successfully carried out. The subcultured embryogenic calli from high yielding and popular maize cultivars i.e. DMRH 1301 and DMRH 1308 were subjected to particle bombardment-mediated transformation **(Figure 2.7A)**. The scrutiny of embryogenic (globular, friable, fast-growing, loose, nodular) calli from non-embryogenic (mucilaginous, fragile, slow-growing) ones was found to be a critical and essential step before in vitro regeneration and genetic transformation as this would affect the regeneration as well as transformation capability of the calli. . The histochemical staining of ?-glucuronidase (GUS) activity exhibited the presence of blue spots in the calli even ten days after biolistic transformation and hence indicated the expression of GUS protein within transformed cells **(Figure 2.3B)**. The healthy transformants were analyzed for their transgenic status via PCR analysis and histochemical staining of GUS expression. PCR analysis of putative maize transformants using ?-glucuronidase (gusA)

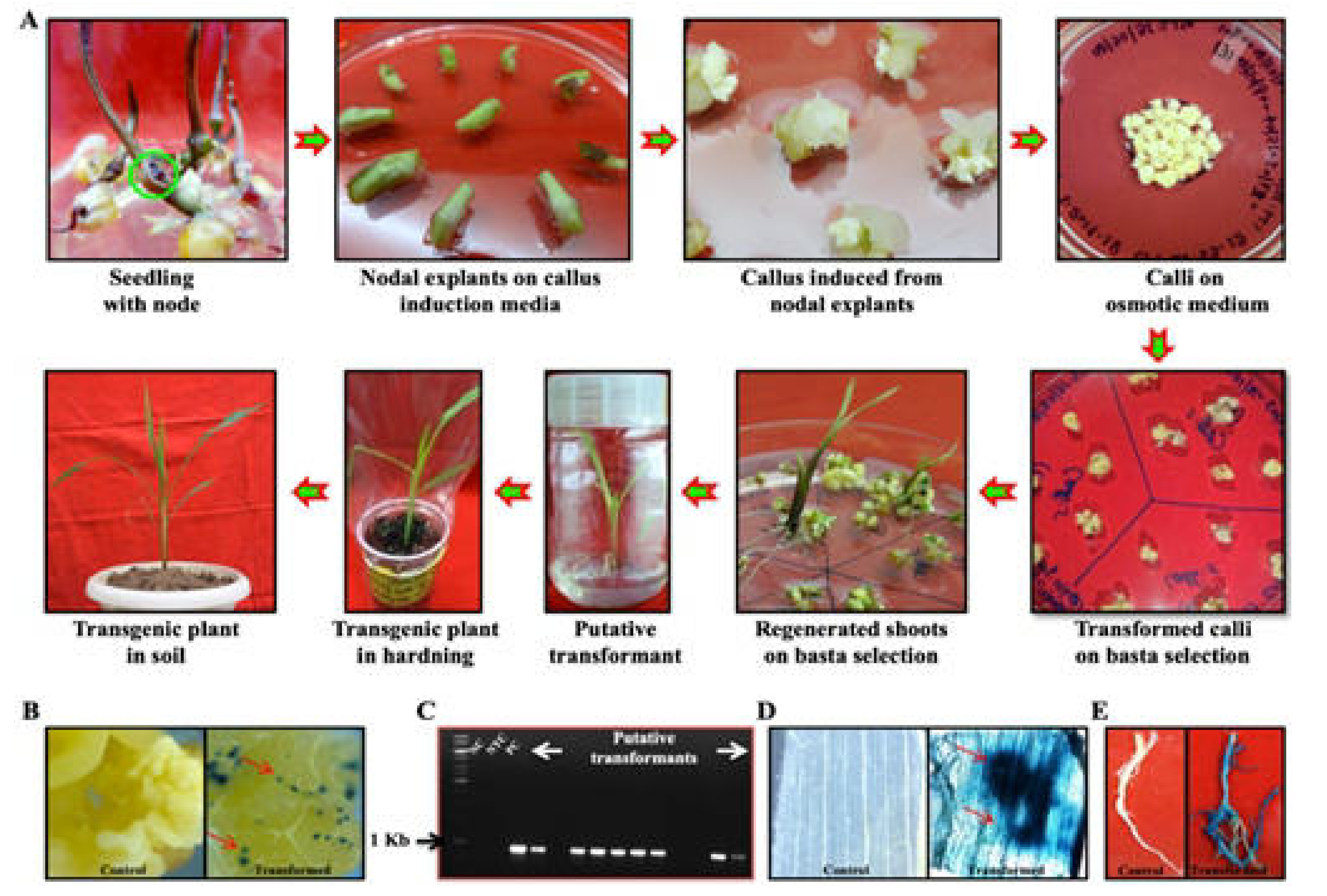


Figure 2.7: (A) Genetic transformation in tropical maize using mature seed derived-nodal explants based calli and (B-E) molecular confirmation of putative transformants. (B) GUS expression in calli 10 days after biolistic transformation. (C) PCR analysis using ?-gusA specific primers. GUS expression in leaves (D) and roots (E) from PCR positive plants.

specific primers confirmed the presence of the expected size band (~0.9 Kb) in many transformants as compared to untransformed maize plants (Fig. 2.7C). Further, histochemical analysis of PCR positive transformants exhibited the presence of GUS activity in the leaf and root tissues while no GUS activity was observed in these tissues from the non-transformed wild-type plant (Figure 2.3D-E). The molecular analysis confirms the integration of transgene and hence, the transgenic nature of putative transformants. The genetic transformation in both the genotypes has been repeated three times and transformation efficiency of 4.25% and 5.61% was achieved in DMRH 1301 and DMRH 1308, respectively. Despite using mature seeds as the starting material which is generally considered recalcitrant for tissue culture, the transformation efficiency achieved in our study is comparable with these reports on immature embryos.This robust and efficient regeneration and transformation protocol can overcome the major limitations associated with the existing immature embryo-based protocol in tropical maize as mature seeds can be obtained easily in ample quantities throughout the year and in a season-independent manner. In addition to this, mature seeds are easy to handle and store for a long time. Despite using hybrids as a source of explants, fixed events could be generated quickly by employing the Doubled haploid technique. Such an easy, generalized and reproducible protocol would facilitate the faster application of transgenic and genome-editing technologies for molecular breeding in maize. This will help in the augmentation of novel and economic traits, which are otherwise intractable through conventional breeding.

Purification of extracellular ligninolytic enzymes from co-culture of Phanerochaete chrysosporium and Pleurotus ostreatus

Phanerochaete chrysosporium and *Pleurotus ostreatus* are two fungi with potential in biodelignification. In order to purify the extracellular ligninolytic proteins, a co-culture of *Phanerochaete chrysosium* and *Pleurotus ostreatus* was grown using corn stover as the substrate. Ground corn stover was moistened with Lignin Modifying Enzyme Basal Medium (LBM) at the ratio of 1:4 (w/v) followed by autoclaving at 121°C for 15 min, inoculated with 10% (v/v) of spore suspension (1x108 spores/ml) and kept in a BOD incubator at 28±2°C. LBM included 1.0 ml of 20% (w/v) glucose (autoclaved separately) and solidified with 1.6% (w/v) agar was used as the screening media with the following g/L composition: Mono potassium phosphate, 1.0g/L; Ammonium tartrate, 0.5g/L; Magnesium sulphate heptahydrate, 0.5g/L; Calcium chloride dehydrate, 0.01g/L;Yeast extract, 0.01g/L; Copper sulphate pentahydrate, 0.001g/L; Ferric sulphate, 0.001g/L; Manganese sulphate monohydrate, 0.001g/L, with the pH of the media kept at 5.0.

Phosphate buffer was used to extract the extracellular enzymes produced by the co-culture of *Phanerochaete chrysosium* and Pleurotus ostreatus grown on corn stover. After acetone precipitation, the protein extract was purified using DEAE-cellulose. After binding on the column, the bound protein was eluted using 1M sodium chloride. Fractions of 0.5 ml were collected and tested using Bromophenol blue as the substrate. Decolorization of the dye was taken as the presence of enzymatic activity of ligninolytic enzymes (Figure 2.8). From one liter of initial protein extract, 5 ml of concentrated, purified ligninolytic enzyme preparation was obtained. Figure 2.3 shows the dye assay using different protein fractions collected upon elution of the bound protein using 1M sodium chloride. Fractions 19 to 28 showed high decoloration and were pooled together. This enzyme preaparation is under further testing.

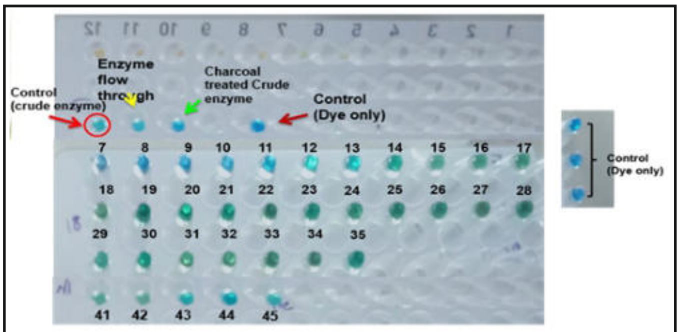


Figure 2.8: Evaluation of ligninolytic activity of protein fractions isolated from DEAE cellulose chromatography

Meta-QTL (MQTL) analysis for biotic and abiotic stresses in maize

Fungal disease resistance

A total of 128 research papers were assessed representing QTL information of 19 fungal diseases. A total of 82 QTL mapping experiments from 63 studies having required information were used for the study. The genetic map data were extracted from the MaizeGDB and the consensus map was constructed using a reference map. The information of 381 QTLs linked with resistance was summarized. Using MetaQTL software, the input text files of QTL and genetic map were converted into XML format, which were then used as input files in the BioMercator V4.2.3 software for MQTL analysis. The MQTL analysis revealed the projection of 33.59 % (128) QTLs associated with resistance against 12 fungal diseases (SLB, NCLB, BLSB, GLS, HS, FSR, FER, GER, AER, PLS, CS, SDM) across the maize genome. A total of 38 MQTL regions were identified on the 9 chromosomes of maize (Ch1 to Ch9) possessing 1910 putative candidate genes. The results revealed 5 MQTLs on Ch 1, 2, 3, 4, 6, and 8, 4 MQTLs on Ch 5, 2 MQTLs on Ch 7 and Ch9. In comparison to the initial CI of individual QTLs located in that MQTL region, CI value of each MQTL was dramatically reduced. The five MQTL regions (2_4, 1_4, 3_4, 3_2 and 5_4) were linked with multiple diseases which can be explored for marker-assisted breeding (MAB) for fungal resistance. Their validation with GWAS studies and constitutive gene network analysis is now being investigated.

Viral disease resistance

A total of 51 research papers were assessed representing QTL information of 14 viral diseases. A total of 39 QTL mapping experiments from 30 studies having required information were used for the study. The information of 196 QTLs linked with resistance was summarized and MQTL analysis was performed similarly as described for fungal resistance. The MQTL analysis revealed the projection of 27.04% (53) QTLs associated with resistance against 11 viral diseases (SCMV, BYDV, MSV, MMV, MCMV, MCDV, MLN, MRCV, FoMV, MSD and MRFV. The 14 MQTLs for viral resistance were projected on Ch1, Ch3 and Ch10 having average phenotypic variance ranges between 13-93%. The Ch1, Ch3 and Ch10 contained 6, 5 and 3 MQTL regions, respectively. The two MQTLs were associated with a maximum of three diseases, viz., 3_2 (MSV, SCMV, MLN); 3_4 (SCMV, MSD, MCDV) followed by six MQTLs associated with two diseases, viz., 1_1 (SCMV, MRCV); 3_1 (FoMV, MSV); 3_3 (MMV, MCMV), 3_5 (MSV, MLN); 10_2 (BYDV, SCMV) and 10_3 (MSV, MRFV) and rest six MQTLs were associated with the single disease. The average CI of MQTLs (7.48) and initial QTLs (15.23) for VDR demonstrated that the CI of MQTLs was greatly lowered, providing maize breeders with an opportunity to use them effectively in VDR breeding programmes. A total of 1715 candidate genes were present in 14 MQTL regions. The analysis regarding verification of the candidate genes with existing GWAS studies and identification of constitutive genes are being now investigated.

Abiotic stress resistance

A total of 542 QTLs were summarized from 33 published studies for tolerance to different abiotic stresses in maize to conduct MQTL analysis using BiomercatorV4.2.3 software. Among those, only 244 major QTLs with more than 10% phenotypic variance were preferably utilised to carry out the analysis. Total 32 MQTLs on six chromosomes, i.e., Ch1, Ch2, Ch4, Ch5, Ch7 and Ch9 were projected for various abiotic stresses possessing 1907 candidate genes against different stresses response. The MQTL2_1, MQTL5_1, MQTL5_2, MQTL5_6, MQTL7_1, MQTL9_1 and MQTL9_2 control different stress-related traits for combined abiotic stress tolerance so these can be simultaneously targeted for improvement of abiotic stresses tolerance in maize. The candidate genes for important transcription factor families such as ERF, MYB, bZIP, bHLH, NAC, NF-YA, NF-YB and WRKY have been detected for different stress tolerance. These identified MQTLs facilitate breeders to target these regions for further climate-resilient marker-assisted breeding programmes and functional validation of candidate genes.

gRNA designing to initiate genome-editing programme

gRNA-designing and selection

The maize gene Zmzb7 encodes the IspH protein plays important role in MEP (methyl-D-erythritol-4-phosphate) pathway. It has been reported that the loss of function of Zmzb7 resulted in the albino plant (Lu et al. 2012). This is a useful visual tool to standardize the gene editing protocol and estimate the amount of edited plants generated. Therefore, sgRNAs were designed from the 1st and 8th exon of the ZmZb7 gene using CRISPR-P V2 software to target particular gene.

Similarly, in order to impart salt tolerance in maize, gRNAs were designed to edit wrky 114 gene. which negatively regulates salt tolerance (Bo et al. 2020).

The restriction sites were also analyzed in the sgRNA sequence for primary screening of mutants (Table 2.3).

Table 2.2: Description of gRNA designed to target ZmZb7 gene of maize

S. No.	Name /ID	sgRNA(5'-3')	Restriction site
1	1.1	TCCTGCCGCCGAGCGCCACG	BssSI
2	1.2	CAAGGGGTTCGGGCACAAGA	HpyAV
3	8.1	ACAAGATGCTATGTATCAGC	PvuII
4	8.3	TTATTCTTGTTGTTGGAGGA	BccI

Table 2.3: List of gRNAs and their properties selected for restriction enzyme assay

S. No.	Name	sgRNA(5'-3')	Efficiency (%)	Restriction site
1	T2	TCAGAACAAAGCCCTGACGC	60.30	BsII
2	T4	GCAACCTCCAGCGCCGGACT	47.83	PleI
3	T14	TACCCCACGACGAGTACTCG	67.08	BssSI
4	Sg16/T90	TCGGCGATCTGCCCGAGCGG	58.35	BsrBI

CROP PRODUCTION 3

Development of precision conservation agriculture practices in the cereal-based systems in Indo-Gangetic Plain.

Rice-wheat (RW) cropping system in north-west India, although associated with food security in the country, has also led to soil degradation and over-exploitation of underground water resources. The diversification of RW systems with maize-based systems, alternate soil and crop management practices could help enhance the system productivity, sustain soil health and environment quality, save irrigation water and labour costs, provide palatable fodder and meet the increased demand of maize grains from the industry.

System productivity (tonnes/hectare) was higher under maize-wheat system compared to rice-wheat system. In comparison to the rice-wheat system, the system productivity was 28.72% and 9.64% higher in conservation and conventional maize-wheat system, respectively in the 4th year of experimentation **(Figure 3.1)**. Among different fertilizer management treatments, significantly higher system yield was obtained under Green Seeker-based (GS), Recommended Dose of Fertilizer (RDF) and Site-specific Nutrient Management (SSNM) over farmers fertilizer practice (FFP). Maize-wheat system was also found to be water-use efficient as it reduced water consumption by 80% as compared to the rice-wheat system. Maize-wheat system can be grown 5-6 times with the same amount of water that is used to grow one cycle of the rice-wheat system. So, replacement of the rice-wheat system with maize-wheat increased system productivity (up to 29%), profitability (up to71 %) and also resulted in huge (80%) water saving.

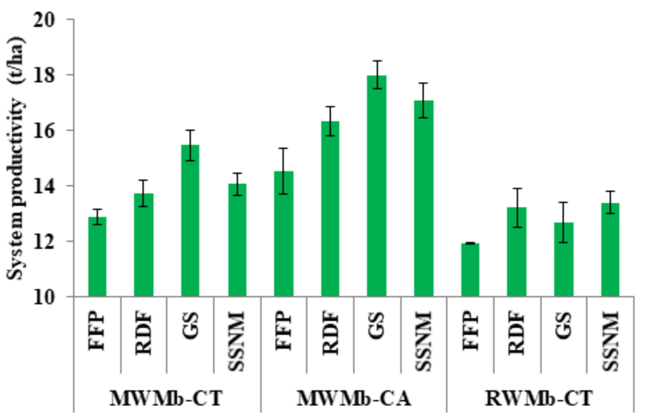


Figure 3.1:System productivity (t/ha) in the maize-wheat-mungbean and rice-wheat-mungbean system under different tillage and nutrient management practices during 2020-21.

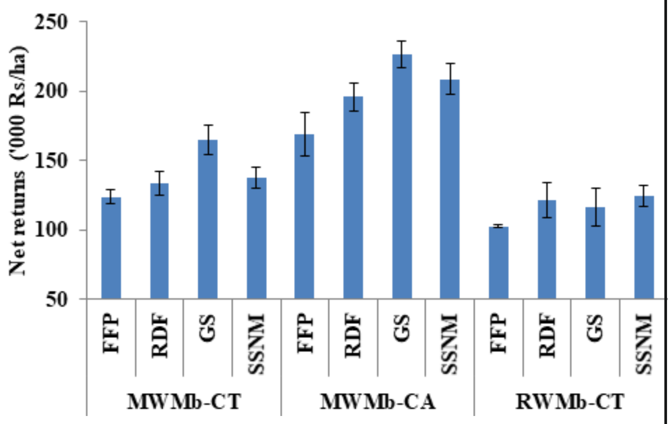


Figure 3.2: Net returns of different cropping system under various nutrient and tillage practices during 2020-21.

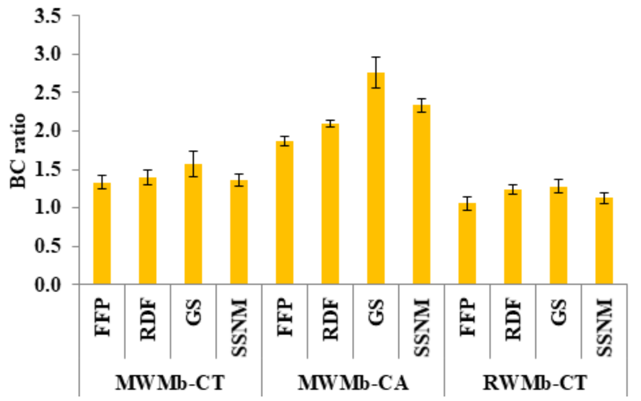


Figure 3.3: The benefit-cost ration of different cropping system under various nutrient and tillage practices during 2020-21.

Net return and Benefit to Cost (B:C) ratio was found to besignificantly higher with conservation maize-wheat-mungbean with the help of Green Seeker sensor **(Figure 3.2 and 3.3)** as compared to conventional maize-wheat-mungbean and rice-wheat-mungbean systems. A gain in net return of 64.4%, 60.7%, 94.8% and 67.0% was observed in conservation agriculture under FFP, RDF, GS, SSNM as compared with RW system. Similarly, highest B:C ratio (Rs 2.76) was also obtained with CA under Green Seeker sensor-based treatment.

Study of different organic nutrient sources in maize and specialty corn

Presently, there is an increased demand for organic produce due to its better nutritive value and quality. However, no concrete information is available for organic maize production with special reference to specialty maize. Hence, on a long term basis, one experiment has been conducted on a fixed-site to measure the effect fertilizer vis-a-vis different organic sources in maize and specialty corn i.e. baby corn and sweet corn (Table 2). After completion of four years of experimentation, the yields of baby corn, sweet corn and normal maize in organic treatments were significantly lower as compared with RDF. However, gap between RDF and organic treatment is narrowing down with progression of experiment.

Sensor guided nitrogen management in maize-based cropping system under conventional and conservation agriculture practices

Better nutrient management is the key to higher productivity with a lower environmental footprint in intensive cropping systems. Nitrogen is the most critical nutrient for enhancing productivity of the crop and determining the environmental footprint of crop production. The maximizing grain production with lesser use of nitrogen could lead to sustainability of a fast-emerging maize-based cropping system in India. In this direction, sensor-based in-season nitrogen management along with better placement methods in maize in conservation agriculture plots established at the fixed site in 2012 was evaluated. The benefits of residue retention were also estimated to evaluate the issue of residue burning and improvement in soil health.

In two treatments, i.e. 50% RDN + GS sub-surface banding (GS-SSB) and 30% RDN + sub-surface banding (RDN-SSB), the first split in

Table 3.1: *Effect of different organic nutrient sources in maize and specialty corn*

Maize type	Treatment	Maize (2017)	Maize (2018)	Maize (2019)	Maize (2020)	Maize (2021)
Baby corn	RDF	7570	8876	8750.0	4607.3	9848
	100% FYM	6585 (-13)	7721(-13)	6995.9	4674.0	7317
	50% FYM + 50% VC	6268 (-17)	7349 (-17)	6834.5	5173.8	6583
	25% FYM + 25% VC + 1/3 Straw	6598 (-12)	7736 (-12)	4095.5	2400.1	6496
	LSD (P=0.05)	NS	NS	2176.8	1432.2	1473.7
Sweat corn	RDF	9986	12642	10464.1	8597.5	12010
	100% FYM	9417 (-5)	8751 (-30)	5970.6	6998.7	10415
	50% FYM+ 50% VC	9121 (-8)	8510 (-32)	5709.6	5966.2	9363
	25% FYM + 25% VC + 1/3 Straw	8635 (-13)	7561 (-40)	2590.9	2634.7	5350
	LSD (P=0.05)	NS	1272.8	1260.8	1691.6	1591.2
Normal maize	RDF	6435	9706	8391	5388.7	6597
	100% FYM	4453 (-30)	6428 (-33)	6693	5098.1	4732
	50% FYM + 50% VC	4487 (-30)	5621 (-42)	6136	5378.7	4478
	25% FYM + 25% VC+ 1/3 Straw	4518 (-29)	5514 (-43)	5286	5068.8	3925
	LSD (P=0.05)	290.1	230.6	240.5	979.4	668.1

(Note: Data in parenthesis indicating per cent yield reduction as compared to RDF

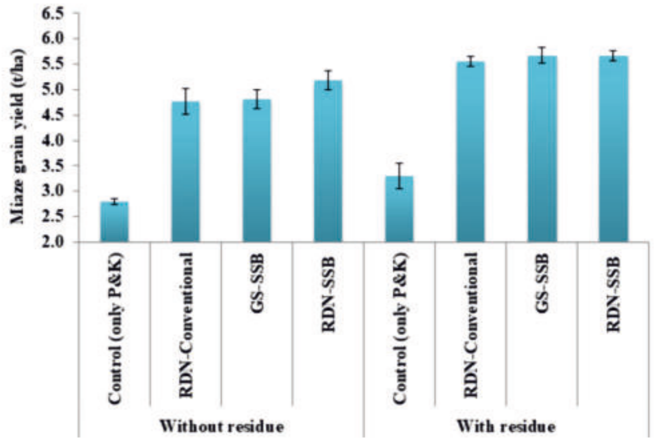


Figure 3.4: The yield of maize during Kharif 2021 as influenced by different residue and nitrogen management methods in the maize-mustard-mungbean system.

standing crop was drilled along the crop rows while the second split was surface band placed as per recommended practices. In the ninth maize crop under maize-mustard-mungbean (MMuMb) cropping system, the retention of crop residue lead to enhancement in maize yield significantly by 15.1% over residual removal **(Figure 3.4)**. The yield of maize in this system due to improved placement was 1.5 and 5.0% higher with RDN-SSB and GS-SSB, respectively irrespective of the residue management scenarios over the standard recommended practices of nitrogen management (RDN-conventional). However, the yield gains in placement differed according to the residue management scenario and the gains were 0.9 and 8.8 without residue while 2.0 and 1.8% with residue retention by GS-SSB and RDN-SSB, respectively over RDN-conventional.

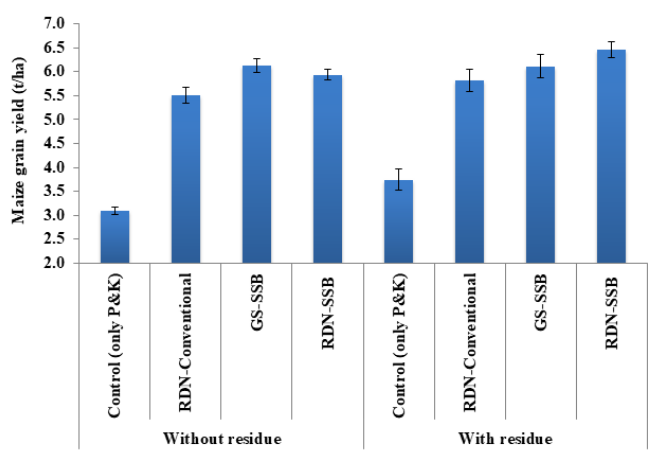


Figure 3.5: The yield of maize during Kharif 2021 as influenced by different residue and nitrogen management methods in the maize-wheat-mungbean system.

Similarly, in the ninth maize crop under the maize-wheat-mungbean (MWMb) cropping system, the retention of crop residue leads to enhancement in maize yield significantly by 7.1% over residual removal **(Figure 3.5)**. The yield of maize due to improved placement was 8.1 and 9.5% with GS-SSB and RDN-SSB, respectively irrespective of the residue management scenarios and was significantly superior over RDN-conventional. However, the yield gains in placement differed due to residue management scenario and the gains were 11.1 and 7.8% without residue while 5.2 and 11.1% with residue retention by GS-SSB and RDN-SSB, respectively over RDN-conventional.

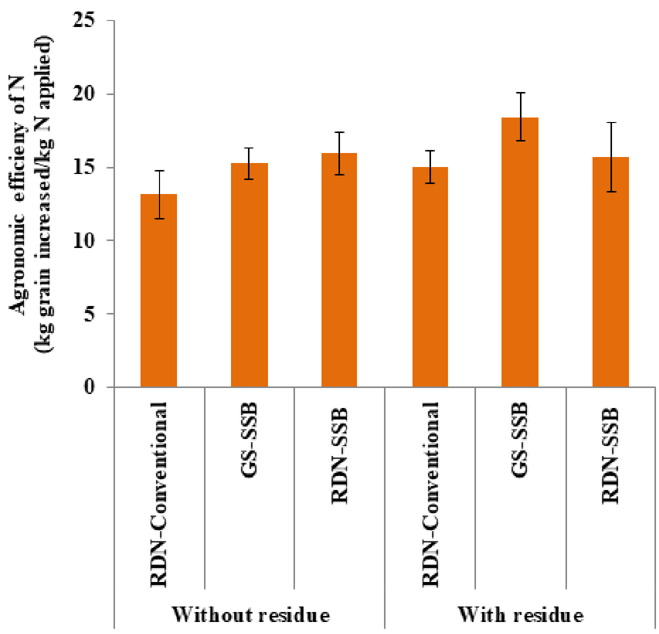


Figure 3.6.: Agronomic efficiency of nitrogen in maize during Kharif 2021 as influenced by different residue and nitrogen management methods in the maize-mustard-mungbean system.

The maize yield was significantly higher by 13.3% with the MWMb system over the MMuMb system. The gains due to the better placement of nitrogen were also higher under the MWMb system. Irrespective of the cropping system, the gain due to residue retention was significant in maize yield (10.4%), while the improved N placement lead to significant yield increase of 8.5 and 13.7% by GS-

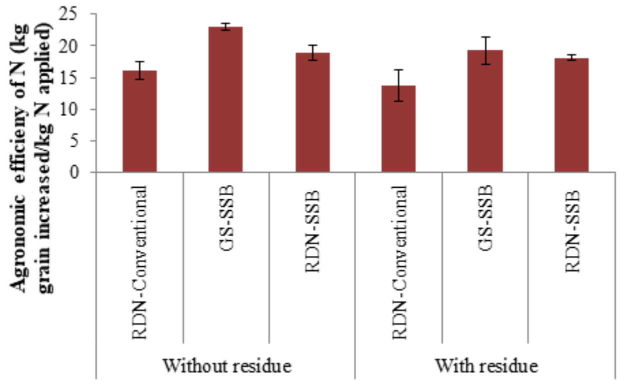


Figure 3.7: Agronomic efficiency of nitrogen in maize during Kharif 2021 as influenced by different residue and nitrogen management methods in the maize-wheat-mungbean system.

SSB and RDN-SSB, respectively over RDN-conventional. Thus, residue retention and improved N placement showed significant enhancement in maize yield.

The agronomic efficiency of applied nitrogen (AEN) in maize under MMuMb system was significantly higher with sub-surface banding of nitrogen, the SSB increased it by 16.0 and 21.2% in 'without residue', while 22.5 and 4.5% in 'with residue' over RDN-conventional, respectively under GS-SSB and RDN-SSB treatments **(Figure 3.6)**.

The AEN in maize under the MWMb system was significantly higher with sub-surface banding of nitrogen and it was higher than that of the MMuMb system. The SSB increased AEN by 42.8 and 17.8% in 'without residue', while an increase of 39.6 and 31.3% in 'with residue' over RDN-conventional respectively, was observed under GS-SSB and RDN-SSB treatments **(Figure 3.7)**. Overall, irrespective of the cropping systems, AEN in maize increased by 30.7 and 18.3% under GS-SSB and RDN-SSB over conventional-RDN, respectively.

CROP PROTECTION 4

Entomology

Management of maize stem borers through host plant resistance

Identification of resistant sources against spotted stem borer

Spotted stem borer [Chilo partellus (Swinhoe)] is the most important insect pest during kharif season causing 26-80% yield losses in different agro-climatic regions of India. In order to identify and breed SSB resistant sources, maize genotypes are screened at various locations under artificial infestation and categorized into resistant, moderately resistant and susceptible lines as defined by leaf injury rating scales (LIR) (Resistant: 1.0-3.0, Moderately Resistant: >3.1-6.0 and Susceptible: >6.1-9.0), respectively. Seventy-six inbred lines along with resistant (DMRE 63, CM 500) and susceptible checks (BML 6) were screened under artificial infestation against spotted stem borer (SSB) during kharif 2021 at Hyderabad. Among the lines screened, none of the genotypes were found promising against SSB, while 27 were moderately resistant **(Figure 4.1)**.

Identification of resistant sources against pink stem borer

Pink stem borer (Sesamia inferens Walker) is the most important pest of rabi maize distributed in almost all parts of India. Mild winter temperatures and high relative humidity favours the multiplication of PSB. Fifty four inbred lines along with resistant checks (DMRE 63 and CM 500) and susceptible check (BML 6) were evaluated under artificial infestation against pink stem borer during rabi 2020-21. The resistant, moderately resistant and susceptible lines were

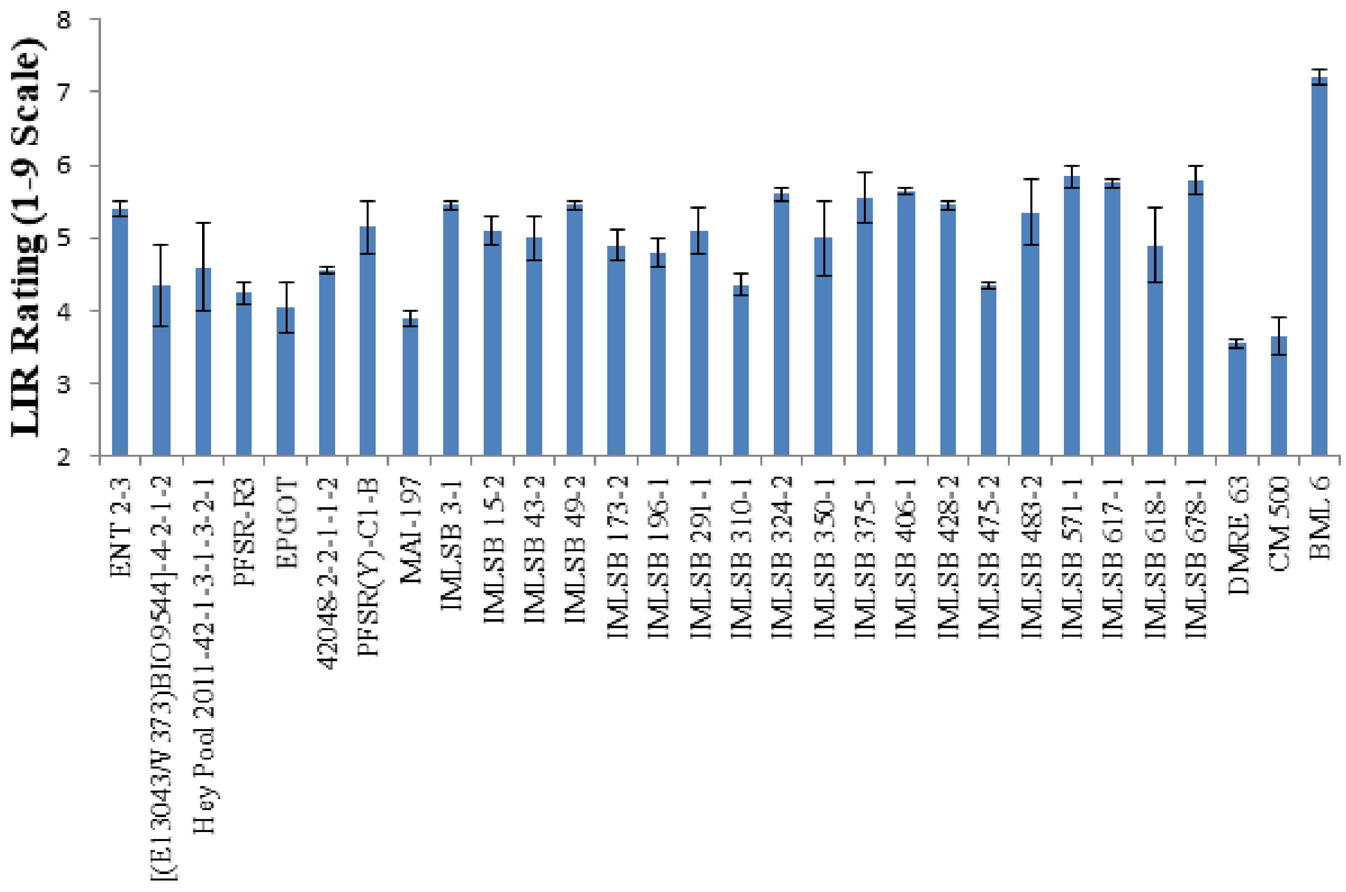


Figure 4.1: Moderately resistant maize germplasm with checks

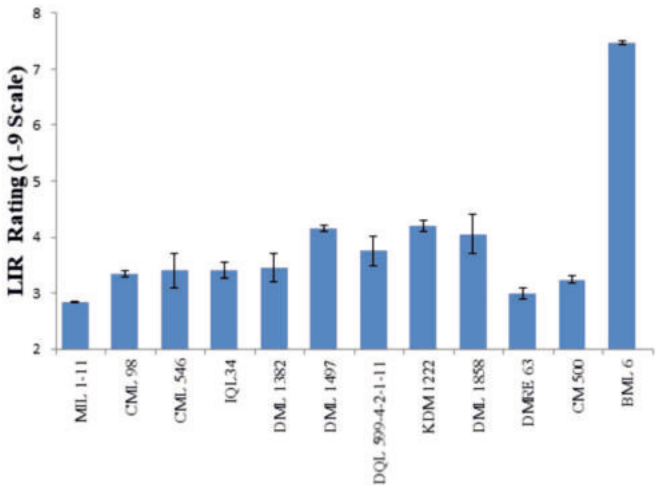


Figure 4.2: Resistant and moderately resistant maize germplasm with checks

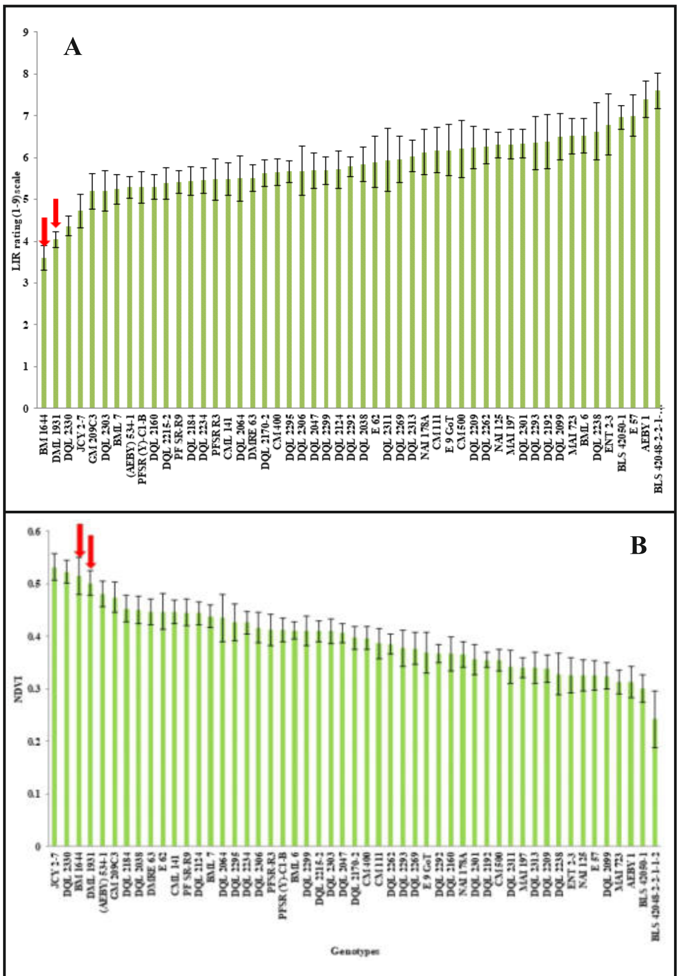


Figure 4.3: LIR values (A) and NDVI values (B) of maize lines under artificial infestation of SSB.

grouped based on LIR (Resistant: 1.0-3.0, Moderately Resistant: >3.1-6.0 and Susceptible: >6.1-9.0), respectively. Among the lines screened, MIL 1-11 (2.84) was found resistant against PSB, while eight lines were moderately resistant **(Figure 4.2)**.

Normalized Difference Vegetation Index (NDVI): a promising germplasm screening technique

Fifty one inbred lines were screened for spotted stem borer (SSB) resistance at Delhi during kharif 2021 by infesting 12 day old plants with 6 neonates of SSB. The LIR (Figure 4.3A) and NDVI (Figure 4.3B) readings five weeks after infestation revealed a negative correlation of 0.88 (P ?0.0001). Strong negative correlation ranging 0.7-0.9 between LIR and NDVI was observed in QPM and white maize genotypes during 2019 and 2020 kharif seasons too suggesting the utility of NDVI as a promising screening technique for resistance breeding. Further, the white maize genotypes BM 1644 and DML 1931 consistently performed the best during 2018 and 2021, with mean LIR of 3.13 and 3.01 respectively, are the promising sources for SSB resistance breeding.

Pathology

Resistance against major diseases

During kharif 2021, a total of 36 entries were evaluated against maydis leaf blight with resistant (BML 6) and susceptible (CM 600) checks (Table 4.1). Out of these, one genotype [(VQH9/VQH9)BIO9544]-5-1-1-1 was found to be resistant.

Studies on diversity of Setosphaeria turcica isolates of maize in India

Setosphaeria turcica causes turcicum leaf blight, which is a major disease of maize in India. To study the diversity in S. turcica, 61 isolates were collected and purified from 11 states, viz., Meghalaya, Uttarakhand, Himachal Pradesh, Andhra Pradesh, Odisha, Gujarat, Madhya Pradesh, Jammu & Kashmir, Gujarat, Tamil Nadu and Maharashtra. Morphological characterization (conidial length, conidial width, septa count, hyphal width, colony diameter, colony character, pigmentation, margin type, margin color and conidia color) has been completed for 61 isolates. The conidial length was ranged from 39.41 to 87.17 ?m. The conidial width was ranged from 11.57 to 17.26 ?m. The septa number ranged from 3 to 9 for different isolates. The hyphal width varied from 4.1 ?m to 7.26 ?m. The colony diameter varied from 4.2 cm to 8.5 cm after 12 to 14 days of growth in Petri plates. The

Table 4.1: Evaluation of inbreds against maydis leaf blight during kharif 2021

Sl. No.	Accessions/Inbred	Disease score	Disease reaction
1	PFSR (Y)-C0 ⊗ -2-1-1-2-1-2-1-1-1	5.67^{efg}	MS
2	PFSR (Y)-C0 ⊗ -2-1-1-2-1-2-1-2-2	4.67^{ghi}	MR
3	North East 3-1 (N)-1-2-⊗-1-1-1-1-1	6.00^{def}	MS
4	Pale Yellow Grains -2-⊗-1-1-1-2-1	4.67^{ghi}	MR
5	PFSR (White)-(B) -⊗-2-3	7.33^{abc}	S
6	705-C2+ -2	4.67^{ghi}	MR
7	732-Chain Crossing1-3	6.00^{def}	MS
8	736-Chain Crossing1-3	5.33^{fgh}	MS
9	801-10309 pool.1-2	7.00^{bcd}	MS
10	805-10309 pool.1-2	8.33^{a}	S
11	809-10309 pool.3-3	5.33^{fgh}	MS
12	821-10309 pool.2-2	6.00^{def}	MS
13	[(VQH9/VQH9)BIO9544]-5-1-1-1	3.67^{ijk}	MR
14	Hey Pool 2011-19-1-1-2-1-1-2	5.67^{efg}	MS
15	[(NS76B/ELCML1)BIO9544]-3-1-1-1-1	3.33^{jk}	MR
16	141139-1-PP-1-4-1	5.67^{efg}	MS
17	141140-1-PP-3-3-2	5.33^{fgh}	MS
18	141163-2-PP-16-1-1	4.67^{ghi}	MR
19	141165-1-PP-17-4-3	6.00^{def}	MS
20	141167-2-PP-25-4-3	6.67^{cde}	MS
21	802-10309 pool.1-1-1	5.67^{efg}	MS
22	847-chain crossing.6-1-1	7.00^{bcd}	MS
23	[(VQH9/VQH9)BIO9544]-2-1-2-2-1-1	4.33^{hij}	MR
24	765- C2 Pool 3@-⊗-11	5.67^{efg}	MS
25	773-C2 Pool-4@-⊗-05	7.67^{abc}	S
26	UMI 1201	3.00^{k}	R
27	UMI 1230	3.33^{jk}	MR
28	MLSP 117	5.33^{fgh}	MS
29	CMS 1	5.33^{fgh}	MS
30	HKI 323	7.33^{abc}	S
31	IBCH 3	4.00^{ijk}	MR
32	*Zea parviglumis*	3.33^{jk}	MR
33	CMS 2	5.67^{efg}	MS
34	CMSM 1	8.33^{a}	S
35	CMS 3	8.33^{a}	S
36	CMSM 2	8.00^{ab}	S
37	BML 6 (R check)	3.67^{ijk}	MR
38	CM 600 (S check)	8.00^{ab}	S
	$P < 2.2e^{-16}$ ***		
	CD = 0.94		
	CV = 10.47		

(R: Resistant, MR: Moderately resistant, MS: Moderately susceptible and S: Susceptible) colony characters varied from whitish gray slightly compressed colony to gray raised cottony type. The margin type varied from irregular to regular. The pigmentation of the colony varied from blackish/ dark gray to gray. The margin color varied from gray/dark gray to whitish-gray/ dark gray. The conidia color varied from light brown to dark brown. Typical colony characters, conidia and hyphal growth has been shown in Figure 4.4. The molecular characterization is under process.

Figure 4.4: Colony, conidia and hyphal structure of Setosphaeria turcica

Cluster Diagram of Setosphaeria turcica isolates based on morphological parameters

A cluster diagram of 58 isolates of the Setosphaeria turcica isolates was made on the basis of five parameters (conidial length, conidial width, hyphal width, colony diameter and septa count) by ward function using Euclidean based function in R software. The diagram was clustered in the eight groups mentioned in the Figure 4.5.

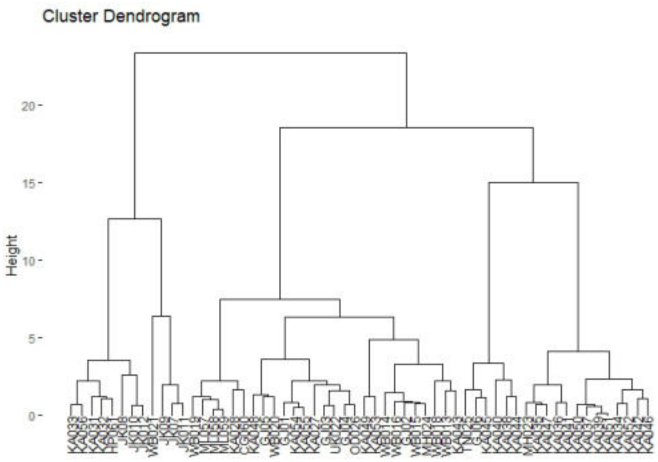


Figure 4.5: Cluster diagram of 58 isolates of the Setosphaeria turcica isolates

EXTENSION AND OUTREACH 5

The institute has an effective outreach programme for the transfer of technology and capacity building in the maize value chain from input supply to production of the crop and its utilization. The institute uses monetary grants received from ICAR under Scheduled Tribe Component (STC), North Eastern Hill (NEH) component and Scheduled Caste Sub Plan (SCSP) for enhancing adoption of technology amongst farmers and other stakeholders in the maize value chain. The institute also initiated a collaborative project with CIMMYT, SAUs and state agricultural department on "Participatory Innovation Platform on Potential Yield Realization of Maize-based Cropping Systems in Punjab and Haryana" to promote diversification of maize based cropping system to sustain the declining natural resources and ensure food security in long-run in Punjab and Haryana. The institute also has Mera Gaon Mera Gaurav (MGMG) programmes for capacity building, technology demonstration and regular interactions with maize growers for taking feedback towards the orientation of the farmer-friendly research programme. The Frontline Demonstrations programme sponsored by the Department of Agriculture and Cooperation, Government of India under National Food Security Mission (NFSM) for demonstration of the improved maize technologies is also being implemented by ICAR-IIMR as the nodal agency. The aspirational districts identified by the government of India and low maize productivity areas are focused on all these programmes.

Front Line Demonstrations

The Front Line Demonstrations (FLDs) under NFSM are being undertaken by ICAR-IIMR in collaboration with various centers throughout the country under AICRP on Maize in the three cropping seasons (kharif, rabi and spring) of maize. Improved technologies like ridge planting, zero-till, micronutrients application, weed management, FAW and integrated pest management, improved hybrids, viz., DMRH1308, Vivek hybrid maize 55, Shalimar QPM-1, KG-2, DKC9108, Pant Sankar Makka 5, PMH-13, LQMH-202, DMRH1301, Shaktiman-5, BPCH-6, DHM-121, CMH 12-686, DHM-121, GAWMH-2, PJHM-1, Partap QPM-1, CP808, CP838, CP999, etc. and intercropping of maize were demonstrated at farmers' field. In rabi 2020-21, FLDs were conducted on 97.7 ha by 8 centres in 6 states benefitting 215 farmers (Table 5.1). During the rabi season, average yield gains was 18.80% (7.35 % in Kalyani to 38.52% in Gossaingaon) (Fig. 5.1). In spring 2021, FLDs were conducted on 50 ha benefitting 56 farmers, where the technology of improved hybrid of the public sector (PMH13, Pant Sankar Makka 5) and private sector (DKC9108) were demonstrated and 28.60 % mean yield gains was recorded.

In kharif 2020, FLDs were conducted on over 143.4 ha, benefiting 422 farmers in 11 states. The recently released public sector hybrids like DMRH 1301, GAWMH-2, Shaktiman-5, Shalimar QPM-1, PJHM-1,

Table 5.1: Centre-wise, season-wise progress report of the FLDs conducted under NFSM in maize during 2021.

Sl. No	Name of the centre	Area (ha)	Yield (q/ha)		Yield gain (%)	No. of beneficiaries
			FLD	FP		
1	AAU, Gossaingaon	9.5	53.98	38.97	38.52	30
2	RMRSPC, Begusarai	9.8	67.35	60.94	10.52	29
3	Dr.RPCAU, Dholi	6	80.87	70.13	15.31	15
4	BCKV, Kalyani	19.2	90.31	84.13	7.35	50
5	WNC, Hyderabad	10	68.85	52.69	30.67	13
6	UAS, Dharwad	20	65.31	57.26	14.06	20
7	MPUAT, Banswada	13.2	73.40	56.82	29.18	33
8	PJTSAU, Hyderabad *	10	9.73	7.27	33.84	25
Total/mean (Rabi 2020-21)#		**97.7**	**71.44**	**60.13**	**18.80**	**215**

Sl. No	Name of the centre	Area (ha)	Yield (q/ha)		Yield gain (%)	No. of beneficiaries
			FLD	FP		
9	CCSHAU, Hisar	10	70.27	37.37	88.39	15
10	ICAR-IIMR, Ludhiana	30	46.81	37.16	25.96	56
11	GBPUAT, Pantnager	10	78.31	77.40	1.18	35
Total/mean (Spring 2021)		**50**	**65.13**	**50.64**	**28.60**	**106**
12	SKUAST, Srinagar	20	51.67	35.24	46.65	80
13	ICAR-VPKAS, Almora	6	39.09	24.99	56.45	36
14	CCSHAU, Hisar	13.6	63.51	26.86	142.88	25
15	PAU, Ludhiana	10	42.90	41.60	3.12	25
16	BHU, Varanasi	10.4	55.80	37.00	50.81	15
17	RLBCAU, Jhansi	10	32.33	12.69	154.77	10
18	Dr.RPCAU, Dholi	4	55.75	47.00	18.62	10
19	UAS, Mandya	9.2	65.70	53.55	22.69	16
20	TNAU, Coimbatore centre	10	67.79	58.55	15.78	54
21	MPUAT, Udaipur	20.2	31.17	23.46	32.83	101
22	MPUAT, Banswada	6.8	21.70	17.05	27.27	17
23	AAU, Godhra	3.2	36.14	29.29	23.39	8
24	ZARS, Chhindwara	10	52.87	36.43	45.13	25
25	BIOZONE, Gorakhpur**	10				
Total/mean (Kharif 2021)		**143.4**	**47.42**	**34.13**	**38.93**	**422**

*popcorn # mean value excluded popcorn **Failed due to waterlogging

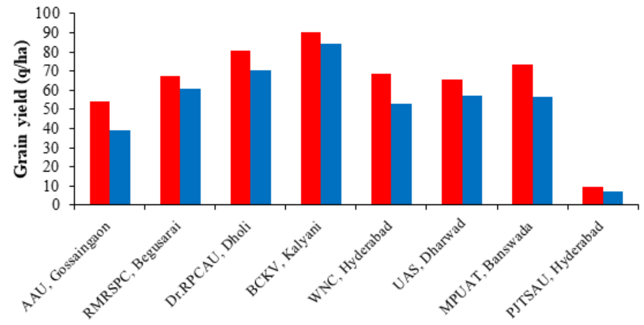


Figure 5.1: Maize yield during rabi 2019-20 in FLDs (in red) and farmers' practices (in blue)

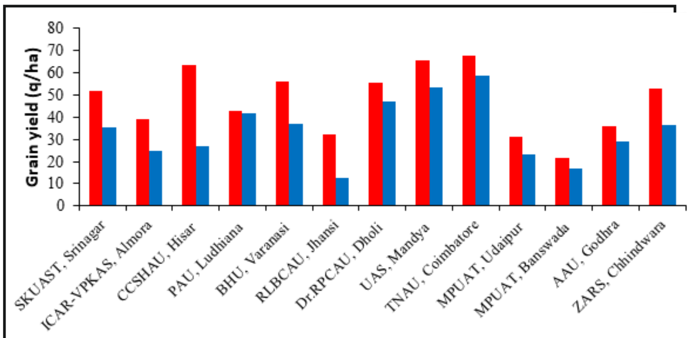


Figure 5.2: Maize yield during kharif 2021 in FLDs (in red) and farmers' practices (in blue)

Visit by expert in farmer field, Karnal

Farmer field, Ranchi

DMRH1308, VLQPMH 59, VL Maize Hybrid 57, etc. along with new hybrid varieties of private sector like CP999, CP838, etc. were demonstrated. This kharif season FLDs showed a yield gain of 38,93 % with improved technology demonstrated which varied from 3.12 % in Ludhiana to 154.77 % in Jhansi (Figure 5.2).

Scheduled Tribe Component (STC)

Scheduled Tribe Component (STC) funded by ICAR aims to enhance the income and profitability of tribal farmers. The programme was implemented in the tribal-dominated aspirational districts in 14 states, viz., Jharkhand, West Bengal, Uttar Pradesh, Chhattisgarh, Madhya Pradesh, Maharashtra, Rajasthan, Odisha, Telangana, Tamil Nadu, Uttarakhand, Bihar, Jammu and Kashmir and Manipur. In 2020-21, rabi season, FLDs were taken up on 50.6 ha of land benefitting 125 farmers (Table 5.2). The demonstration of improved technology have led to an average yield gains of 28.8% was recorded which ranged from 15.6% in Vagarai to 38.2% in Banswara. During kharif 2021, 486.8 ha FLDs were conducted under this STC component benefitting 1883 farmers and an average yield gain of 51.79 % was recorded which varied from 17.02% in Vagarai to 161.1% in Ranchi.

During 2021, 56 farmers' training/field day/awareness programmes were conducted in different parts of the country, benefiting 2579 tribal farmers on various aspects of scientific maize cultivation (Table 5.3). Different inputs including seed, biofertilizer/ biopesticide/botanical, chemical fertilizer, plant protection chemical, farm implements and farm literature were also distributed to the farmers during these programmes for awareness regarding improved maize production practices to enhance farm profitability (Table 5.4). Altogether, 1548 households were benefitted from the input distributions.

Scheduled Caste Sub Plan (SCSP) programme

The SCSP (Scheduled Caste Sub Plan) has been started by the Government of India to benefit the farmers of scheduled caste (SC) communities of the country. The institute implemented SCSP plan in maize to benefit the maize growing farmers of SC communities. Improved technologies of maize were demonstrated in 462.3 ha the farmer's field and benefitted 1393 farmers. The result of the FLDs showed that an average yield of 25.73 % was recorded with a minimum of 7.4% in Jagtial and highest in Rahuri with of 82.9% (Table 5.5).

Table 5.2: Centre-wise, season-wise progress report of the FLDs conducted under STC in maize

Centre	FLD (ha)	Beneficiary	Yield under FLD (q/ha)	Yield under FP (q/ha)	Yield gain (%)
***Rabi*, 2020-21**					
TNAU, Vagarai	10.6	25	52.0	45.0	15.6
MPUAT, Banswara	40.0	100	86.7	62.7	38.2
Total / mean	50.6	125	69.4	53.9	28.75
***Kharif*, 2021-22**					
IGKVV, Ambikapur	28.0	71	44.2	23.1	91.1
JNKVV, Chhindwara	16.0	40	49.4	31.3	57.8
MPUAT, Banswara	20.0	50	48.0	32.0	50.0
MPUAT, Udaipur	108.0	270	33.5	26.8	25.0
OUAT, Bhubneshwar	30.0	75	47.0	33.5	40.1
BAU, Ranchi	100.0	279	54.8	21.0	161.0
BHU, Varanasi	41.0	100	54.0	37.0	45.9
TNAU, Vagarai	8.8	22	55.0	47.0	17.0
Dr RPCAU, Dholi	30.0	150	75.0	55.0	36.4
SKUAST, Srinagar	40.0	160	60.0	40.0	50.0
BCKV, Kalyani	15.0	556	5.5	4.0	37.5
CAU, Imphal	10.0	10	31.5	19.8	59.1
MPKV, Kolhapur	40.0	100	44.0	26.0	69.2
Total / mean	486.8	1883	46.30	30.50	51.79

Table 5.3: Training and input distribution programme/ field days/ awareness programme organized under STC programme

Centre	Date of training	Place	Type of programme	Training name	No of person benefitted
AAU, Godhra	June 10, 2021	Kaliya, Fatepura, Dahod	T	Scientific Maize Cultivation Technology	60
	August 13, 2021	Limbodra, Shahera, Panchmahal	T	Scientific Maize Cultivation Technology	47
	August 24, 2021	Manli, Limkheda Dahod	T	Scientific Maize Cultivation Technology	38
IGKVV, Ambikapur	February 16, 2021	RMD CARS, Ambikapur	T	Maize production technology	46
	March 18, 2021	RMD CARS, Ambikapur	T	Maize production technology	33
	October 27, 2021	KVK Balrampur	T	Maize production technology	27
	November 23, 2021	Lohari Farm Koriya	T/FD	Maize production technology	28
	December 27, 2021	Mendrakhurd village, Ambikapur	T/FD	Maize production technology	54
	December 28, 2021	Khaliba village, Ambikapur	T/FD	Maize production technology	40
JNKVV, Chhindwara	September 4, 2021	Gailduba village of Tamia Tehsil	FD	Hybrid Maize Production over local cultivars	108
	September 5, 2021	ZARS, Chhindwara	T	Awareness for specialty corn and their benefits	
	September 15, 2021	Gailduba village of Tamia Tehsil	FD	Awareness about maize insect pest and diseases	
MPKV Kolhapur /Rahuri	June 10, 2021	Waki, Tal: Akole, Dist:Ahmednagar	T	Improved Maize Production Technology	50
	June 11, 2021	Ambapali, Tal: Navapur, Dist: Nandurbar	T	Improved Maize Production Technology	50
GBPUAT, Pantnagar	February 4, 2021	Banusha, U.S. Nagar	T	Cultivation practices of spring maize	73
	March, 8, 2021	Kumrah, U.S. Nagar	T	Weeds, Diseases and Insect Management in Spring maize	75
MPUAT, Banswara	January 21-22, 2021	ARS, Banswara	T	Farmer's Awareness on Fall army warm and post flowering rot stalk management in maize and production technologies	79

Centre	Date of training	Place	Type of programme	Training name	No of person benefitted
MPUAT, Banswara	March 17-18, 2021	ARS, Banswara	T	Farmer's Awareness training on Fall army worm and post 35 flowering rot stalk management in maize and production technologies	80
	March 19, 2021	Naropada village	FD	Maize production technology	35
	September 29, 2021	Habai patti, Talwara	FD	Maize production technology	50
	October 26-27, 2021	ARS, Banswara	T	Farmer's Awareness training on Fall army worm and post flowering rot stalk management in maize and production technologies	50
	November 29-30, 2021	ARS, Banswara	T	Farmer's Awareness training on Fall army worm and post flowering rot stalk management in maize and production technologies	50
OUAT, Bhubneshwar	March 20, 2021	High Altitude Research Station (HARS), OUAT, Pottangi, Koraput	T/ ID	Production Technology and Fall Army Worm Management in Maize	25
	March 22, 2021	Regional Research & Technology Transfer Sub-Station (RRTTSS) OUAT, Jeypore, Koraput	T/ ID	Production Technology and Fall Army Worm Management in Maize	25
	July 7, 2021	Mohana, Dist.- Gajapati	ID	Orientation for FLD on maize	50
	July 13, 2021	Village: Askipal, Block: Sukruli, Dist.: Mayurbhanj	ID	Orientation for FLD on maize	25
	September 24, 2021	KVK, Jashipur, Mayurbhanja	T/ID	Scientific Crop Production Technology & FAW management in maize	25

Centre	Date of training	Place	Type of programme	Training name	No of person benefitted
OUAT, Bhubneshwar	March 20, 2021	High Altitude Research Station (HARS), OUAT, Pottangi, Koraput	T/ID	Production Technology and Fall Army Worm Management in Maize	25
BCKV, Kalyani	July 2, 2021	Jhargram, Bankisole	T/ ID	Upland Maize Farming	40
	August 4, 2021	Jhargram, Baghghora	T/ ID	Upland Rainfed Maize and Faw Mangement	55
BHU, Varanasi	June 24, 2021	Dudhi, Sonbhadra, Uttar Pradesh	T	Hybrid Maize Production Technology	50
	October 2, 2021	Dudhi, Sonbhadra, Uttar Pradesh	T/FD	Hybrid Maize Production Technology/ Bed Planting	50
PJTSAU, Hyderabad	March 7, 2021	MRC, Hyderabad	T	Maize Production Technologies and fall army worm management	150
	March 8, 2021			Maize Production Technologies and fall army worm management	
	March 9, 2021			Maize Production Technologies and fall army worm management	
	March 16, 2021			Maize Production Technologies and fall army worm management	
	March 17, 2021			Maize Production Technologies and fall army worm management	
TNAU, Vagarai	February 10, 2021	Kappaluthu, Rasipuram taluk, Namakkal Dt	T	Hybrid Maize Production Technology	25
	February 16, 2021	Vadakaraiparai, Kodaikanal taluk Dindigul district	T	Hybrid Maize Production Technology	25
	February 18, 2021	Moolaiyaru, Kodaikanal taluk Dindigul district	T	Hybrid Maize Production Technology	25
	February 10, 2021	Kappaluthu, Rasipuram taluk, Namakkal Dt	FD	Visit was made to farmers field and field day was conducted at Kappaluthu village.	25
	February 16, 2021	Vadakaraiparai, Kodaikanal taluk Dindigul district	FD	Visit was made to farmers field and field day was conducted at vadakaraparai village	25

Centre	Date of training	Place	Type of programme	Training name	No of person benefitted
Dr RPCAU Dholi	March 25-27, 2021	TCA, Dholi	T/ ID/ FD/A	Scientific Cultivation of QPM Maize Crops	50
	July 23-25, 2021	Vill- Semra, West Champaran	T/ ID/ FD/A	Popularization and cultivation of single cross hybrid maize & processing techniques	50
	December 17-19, 2021	Vill- Santpur, Valmikinagar, West Champaran	T/ ID/ FD/A	*Rabi* maize cultivation through Scientific methods	85
SKUAST, AICRP-Maize, Srinagar	March 17, 2021	Srinagar	T	Production management of maize	40
	March 25, 2021	Srinagar	T	Production management of maize	
BAU, Ranchi	July 2, 2021	Ranchi	ID	Input distribution to compare Upland Maize Farming Vs Upland rice cultivation	279
Dhaanyaganga KVK, Sargachi	November 29, 2021	Sannyasidanga, Nowda	T	Farmers training on scientific cultivation and management of maize hybrid during *rabi* season.	45
	November 29, 2021	Sannyasidanga, Nowda	ID	Input distribution for demonstration of maize hybrid during *rabi* season under TSP scheme	30
	December, 16 2021	Asandighi, Nabagram	T	Farmers training on scientific cultivation and management of maize hybrid during *rabi* season.	48
	December 16, 2021	Asandighi, Nabagram	ID	Input distribution for demonstration of maize hybrid during *rabi* season under TSP scheme	40
CAU, Imphal	March, 2, 2021	Toribari village, Senapati District, Manipur	T/ ID	Scientific cultivation on Maize in Manipur	55
	March 12, 2021	Lambung village, Chandel dictrict, Manipur		Maize based inter-cropping system for sustainable livelihood of the tribal farmers	68

Centre	Date of training	Place	Type of programme	Training name	No of person benefitted
CAU, Imphal	March 19, 2021	Sanakeithel village, Ukhrul Dist., Manipur		Scientific cultivation and insect pest management of maize under TSP in Manipur conditions	36
	March 23, 2021	Kombirei vill., Tengnoupal District, Manipur		Scientific cultivation on Maize in Manipur	35

*T-Training, ID-Input distribution, FD-Field day, A-Awareness

Table 5.4: Distribution of key inputs under STC programme

Inputs distributed	Total quantity	Beneficiary
Maize seed (Kg)	8544	1548
DAP (Kg)	10000	279
SSP (Kg)	9350	636
MOP (Kg)	9110	915
Urea (Kg)	7470	661
Chlorantraniliprole(ml)	1750	51
Bio-fertilizer culture (Azotobactor +PSB) (Kg)	987.5	806
Literature (no)	1182	1130
Paddy seed (Kg)	412.5	95
Tarpaulin (no)	348	48
Knapsack (no)	262	112
Hand operated maize sheller (no)	250	175
Sickles (no)	175	175
Atrazine (Kg)	169	338
Khurpi (no)	150	150
Saplings (Papaya, Litchi, Coffee etc.)	150	94
Store bin (no)	125	100
Cycle hoe (no)	100	100
Metarhizium (Kg)	100	100
Spade (no)	98	98
Hand hoe (no)	75	75
Bio-pesticide (l)	75	75
Battery operated Knapsack sprayer (no)	58	58
Seed rhizomes of turmeric (Kg)	50	556
Neem oil (l)	50	60
Trichoderma (Kg)	50	100
Emamectin Benzoyate (Kg)	42.3	125
Cow pea (Kg)	20	556
Insecticide (l)	10.9	109
Novaluron (l)	10	60
Regent (Kg)	7.5	150
Plant protection chemical (l)	3.51	52
Mancozeb (Kg)	2.5	50

Women farmers participating at a training cum awareness programme at Kalyani, WB

Training cum input distribution by CAU, Imphal centre

Input distribution by IGKVV centre, Ambikapur

Monitoring team visit at farmer's field, Ambikapur

Farm Tool Distribution farmers, OUAT, Jeypore

FLD under TSP Programme, Ranchi

A total of 37 trainings/ agricultural inputs distributions/ awareness/ field day programmes were organized benefitting 2299 farmers under SCSP programme (Table 5.6). Various inputs including seed, fertilisers, chemicals, small farm implements and farm literatures were also distributed to 1385 farmers under the SCSP plan for improving the production and productivity of the maize cultivation (Table 5.7).

Demonstration of maize in compare to upland /midland paddy

Comparison of upland/midland rice vs maize was demonstrated in West Bengal, Uttarakhand, Odisha and Jharkhand in an area of 133.51 ha under SCSP/STC programme (Table 5.8). The profitability of hybrid maize cultivation over the upland/midland rice was also assessed at farmers filed. These

Table 5.5: Centre-wise, season-wise progress report of the FLDs conducted under SCSP.

Centre	FLD (ha)	Beneficiary	Yield under FLD (q/ha)	Yield under FP (q/ha)	Yield gain (%)
ARS PJTSAU, Karimnagar	80	200	75.2	68.1	10.43
RARS, PJTSAU, Polasa, Jagtial	80	200	72.5	67.5	7.41
BCKV, Kalyani*	6.3	160	5.5	4	37.50
CAU, Imphal	12	12	105.5	76.7	37.55
MPKV Kolhapur /Rahuri	40	100	52.3	28.6	82.87
DGKVKRMA, Sargarchi	40	136	51.5	47.1	9.34
RLBCAU, Jhansi	90	300	50.2	35.1	43.02
JNKVV, Chhindwara	14	35	49.7	32.5	52.92
ZARS, Mandya	100	250	74.1	67.1	10.43
Total / mean	462.30	1393.00	59.61	47.41	25.73

*Babycorn

demonstrations were conducted in kharif 2021 except in Uttrakhand where these were carried out in the spring season. In West Bengal, hybrid maize has a monetary gain of about Rs.42000/ha over the upland rice. In Uttarakhand, Jharkhand and Odisha the average monetary gain of hybrid maize over the midland paddy was about Rs. 47422/ha, Rs. 52585/ha and Rs.18647/ha, respectively.

Promotion of Maize in North Eastern Hill Region NEH component

ICAR-IIMR in collaboration with ICAR-Research Complex for North Eastern Hill Region (Umiam),

Table 5.6: Training/ input distribution programme/ field days/ awareness programme organized under SCSP.

Centre/State	Date (s)	Place	Type of programme*	Title	No. of benefi-ciaries
ARS PJTSAU, Karimnagar	July 5, 2021	ARS, Karimnagar, Telangana	T	Recent technologies of profitable normal maize production	260
	August 6, 2021	Perkapally village of Saidapur mandal of Karimnagar dist., Telangana	T	Recent technologies of profitable normal maize production	60
RARS, PJTSAU, Polasa, Jagtial	July 7, 2021	RARS, Polasa, Jagtial	T	Production technology, integrated management and mechanization in maize	140
	July 31, 2021	RARS, Polasa,, Jagtial	T	Production technology, integrated management and mechanization in maize	60
ARI, Rajendranagar, PJTSAU, Hyderabad	March 30, 2021	MRC, Hyderabad	T	Maize production technologies and Fall Army Worm Management	50

Centre/State	Date (s)	Place	Type of programme*	Title	No. of benefi-ciaries
ZARS, UAS, Mandya	July 15, 2021	UAS, Mandya	T	Production technologies of hybrid maize	250
ANGRAU, Peddapuram	June 14, 2021	UAS, Mandya	T	Maize production technologies	140
BCKV, Kalyani	July 2, 2021	Jhargram	T/ ID	Maize vs Rice under upland rainfed condition	50
	August 4, 2021	Jhargram	T/ID	Maize Farming	45
DGKVKRMA, Sargarchi	March 22, 2021	Andulberia, Beldanga-II	ID	Input distribution to SC farmers for cultivation of spring-summer maize under SCSP scheme	47
	March 25, 2021	Bali. Nowda	ID	Input distribution to SC farmers for cultivation of spring-summer maize under SCSP scheme	23
	April 7, 2021	Andulberia, Beldanga-II	T	Farmers training on scientific cultivation of maize hybrids during spring-summer season under SCSP scheme	72
	April 19, 2021	Bali. Nowda	T	Farmers training on scientific cultivation of maize hybrids during spring-summer season under SCSP scheme	38
	July 6, 2021	Jafrabad, Beldanga-I	T	Farmers training on cultivation of hybrid maize during kharif under SCSP scheme	48
	July 8, 2021	Jafrabad, Beldanga-I	ID	Input distribution to SC farmers for demonstration on performance of hybrid maize vs. upland paddy under SCSP scheme	24
	July 8, 2021	Binkar, Beldanga-I	ID	Input distribution to SC farmers for demonstration on performance of hybrid maize vs. upland paddy under SCSP scheme	07

Centre/State	Date (s)	Place	Type of programme*	Title	No. of benefi-ciaries
DGKVKRMA, Sargarchi	July 9, 2021	Colony para, Beldanga-II	T	Farmers training on cultivation of hybrid maize during kharif under SCSP scheme	63
	July 12, 2021	Colony para, Beldanga-II	ID	Input distribution to SC farmers for demonstration on performance of hybrid maize vs. upland paddy under SCSP scheme	27
	July 13, 2021	Saheb Nagar, Jalangi	T	Farmers training on cultivation of hybrid maize during kharif under SCSP scheme	31
	July 15, 2021	Saheb Nagar, Jalangi	ID	Input distribution to SC farmers for demonstration on performance of hybrid maize vs. upland paddy under SCSP scheme	08
CAU Imphal	March 27, 2021	Kakching Khunou village, Kakching District, Manipur	T/ID	Scientific cultivation on Maize in Manipur	35
	March 27, 2021	Andro machengpat village, Imphal west District, Manipur	T/ID	Scientific cultivation on Maize in Manipur	30
	March 28, 2021	Khurkhul village, Imphal west district, Manipur	T/ID	Maize based inter-cropping system for sustainable livelihood	35
RLBCAU, Jhansi	September 25, 2021	Lalitpur	T/FD/ID	FLDs on maize	300
	September 29, 2021	Lalitpur	T/FD/ID	FLDs on maize	
	October 2, 2021	Lalitpur	T/FD/ID	FLDs on maize	
MPKV, Kolhapur / Rahuri	March 27, 2021	Pohale & Khupire	T	Improved Maize Production Technology	100
	March 28, 2021	Pohale & Khupire	T	Improved Maize Production Technology	

Centre/State	Date (s)	Place	Type of programme*	Title	No. of benefi-ciaries
JNKV, Chhindwara	September 18, 2021	Simariya Multani, Amarwara	FD	Awareness about maize insect pest and diseases	56
ZARS, Mandya, Karnataka	August 12, 2021	Chakkodana halli, H.D.kote Tq, Mysuru district	T	Improved maize production technologies and Value addition	52
	August 14, 2021	Bachanahalli, Malavalli Tq, Mandya District	T	Improved maize production technologies and Value addition	42
	August 24, 2021	Garugadoddi, Koratagere Tq, Tumkur District	T	Improved maize production technologies and Value addition	30
	August 25, 2021	Mittemari Village Bagepallitaluk, Kolar dist	T	Improved maize production technologies and Value addition	25
	September 06, 2021	Hunasepalya, Hanur Tq, Chamarajanagara district.	T	Improved maize production technologies and Value addition	60
	September 08, 2021	Jagaravalli, Hassan District	T	Improved maize production technologies and Value addition	41
ANGRAU, Peddapuram	June 14, 2021	Peddapuram	T / ID	Maize production technologies	50

*T-Training, ID-Input distribution, FD-Field day, A-Awareness

Table 5.7: Distribution of quality seed and inputs for conduct of demonstrations under SCSP programme

Inputs distributed	Total quantity	Beneficiary (no)
Maize seed (Kg)	9622(mandya)	1335
Urea (Kg)	22955	626
SSP (Kg)	38947	326
MOP (Kg)	5190	326
Literature (no)	795	595
Pheromone trap (no)	967	160
Paddy seed (Kg)	528	38
Hand operated maize sheller (no)	508	210
Bio-fertilizer culture (Azotobactor +PSB) (Kg)	450	260
Tarpaulin (no)	780	780
Store bin (no)	209	209
Neem oil (l)	206	136
Sickles (no)	450	350
Khurpi (no)	400	400

Inputs distributed	Total quantity	Beneficiary (no)
Farm implements(no)	140	140
Insecticide (l)	114	138
Battery operated Knapsack sprayer (no)	168	168
Fork shovel (no)	100	100
Hand weeder (no)	80	80
Knapsack (no)	57	57
Novaluron (Lits)	56	110
Seed rhizomes of turmeric (Kg)	50	50
Spade (no)	50	50
Cow pea (Kg)	20	20
Atrazine (Kg)	5	10
Mancozeb (Kg)	1	160
Emamectin Benzoyate(kg)	20.7	80
Brass Chakkali varalu(no.)	250	250
Personal Safety kits	50	50

Women farmers participating at a training cum awareness programme at Kalyani, WB

Training cum input distribution by CAU, Imphal centre

FLD of summer maize under SCSP, Sargachi

Krishak Ghosthi under SCSP at Lalitpur, CAU, Jhansi

ICAR-National Research Centre on Pig (Guwahati), ICAR-National Research Centre on Yak (Dirang), ICAR-National Research Centre on Mithun (Dimapur) and AICRP on maize centre at CAU

Table 5.8: Profitability of hybrid maize cultivation over upland/ midland paddy

Maize	Paddy	Area (ha)		Topo-graphy (Upland/ midland)	Location (village, district, state)	Yield (q/ha)		Average selling price (Rs/q)		Gross return (Rs/ha) @ farmers' selling price		Net returns (Rs/ha)@farmers' selling price	
		Maize	Paddy			Maize	Paddy	Maize	Paddy	Maize	Paddy	Maize	Paddy
West Bengal													
COH (M)8	Gotra I	5	25	Upland	Bakisole, Binpur I Block, Ramgarh Panchayet, Jhargram, West Bengal	45.0	37.5	2000	1300	90000	48750	60000	18000
Uttrakhand													
DEKALB 9108	PR-1509, Noori	16.8	16.8	Midland/ summer	Khiarana, Vanusha, Kumrah, U.S. Nagar	86.7	78.8	1800	1400	156054	110388	116053	65387
PSM-5	PR-1509	1.6	1.6	Midland/ summer	Pratappur, U.S. Nagar, Uttarakhand	85.7	80.0	1800	1400	154350	112000	114350	67000
PSM-6	PR-1509	1.6	1.6	Midland/ summer	Vanusha, U. S. Nagar, Uttarakhand	85.0	81.3	1800	1400	153000	113750	113000	68750
Ranchi													
BAUMH-5	Gora Dhan	5	5	Upland	Ranchi, Jharkhand	55.9	21.0	1870	1940	104486	40740	72054	18192
DHM-121	Gora Dhan	0.38	0.38	Upland	Ranchi, Jharkhand	55.7	21.0	1870.00	1940	104173	40740	71741	18192
HQPM-5	Gora Dhan	79.38	79.38	Upland	Ranchi, Jharkhand	54.9	21.0	1870	1940	102617	40740	70185	18192
Suwan-2	Gora Dhan	15	15	Upland	Ranchi, Jharkhand	54.3	21.0	1870.00	1940	101562	40740	69130	18192
Odisha													
Kalinga Raj	Kalinga Dhan 1201	8.75	1.25	Medium	Village: Kradikupa, Kirting, Block: Mohana, District: Gajapati, State: Odisha	46.8	33.6	1500	1600	70200	53760	34200	15760
Kalinga Raj	Kalinga Dhan 1201	8.75	1.25	Medium	Village: Koiliguda, Christopur, K. Panigonda, Anjali, Narayanpur Block: Mohana, District: Gajapati, State: Odisha	44.2	35.4	1500	1600	66300	56640	30300	18640
Kalinga Raj	Kalinga Dhan 1204	8.75	1.25	Upland	Village: Askipal, Block: Sukruli, District: Mayurbhanj, State: Odisha	48.4	32.5	1850	1960	89540	63700	47540	21700

Upland rice vs Maize FLD in Mayurbhanj District, OUAT

(Imphal), CAU-CPGS (Barapani) implemented the NEH programme during 2021. Considering the importance of maize in livestock, a collaborative programme on "Maize production in NEH region for sustainable livestock production" was taken up with National Research Centers working on yak, pig and mithun. The programme has a research component besides demonstration and capacity development with an aimed to assess the effect of supplementation of QPM, maize fodder, grain and silage on production performances of pig, yak, and other livestock. Under the programme, promotion of location-specific maize in the farmers' field were taken up through technology demonstrations, capacity building programmes and input distribution across all the north eastern hill states of India.

FLDs conducted under NEH component in maize

FLDs of improve technologies were also demonstrated in different states under NEH programme. The FLD were taken up in 60.3 ha and benefitted 194 farmers of the NEH region. The average yield gain of 26.2% was recorded which ranged from 12.5% in Barapani to 53.1% in Imphal (Table 5.9).

Capacity building activities under NEH component

Under the NEH component, 17 Training/ input distribution programme/ field days/ awareness programme were organized under NEH in collaboration with different institutes for the maize growers in North-Eastern India (Table 5.10). The major theme of the training programmes was concentrated on the scientific maize cultivation technologies, integrated pest management, integrated nutrient, and water management, adaptation of high-yielding varieties (including sweet corn and baby corn cultivation) and post-harvest management under upland conditions. Altogether, 792 beneficiaries participated in the programmes. Apart from this, the input including maize seed, fertilizer, chemicals, vegetables seeds and small farm implements were distributed under the NEH programme, benefitting about 1462 rural households (Table 5.11).

Maize Production in NEH Region for sustainable livestock production

Utilization of maize fodder and banana stems mixed silage on nutrient utilization in Large White Yorkshire grower pigs.

The ration prepared from the maize fodder had higher organic matter (OM), crude protein (CP) and crude fibre (CF) compared to banana stem based ration (Table 5.12).

Preparation of mixed silage

Fresh banana stem with banana leaf was used for making silage. The stems and leaves were cut into small pieces and exposed to sunlight for 2-3 hours. Similarly, green maize fodder at the time of flowering was cut into small pieces and then materials were mixed @ 2:1 ratio of banana stem: maize fodder. Then juggery and salt were added @ 4% and 0.25%.

Table 5.9: FLDs conducted under NEH component in maize

Centre	FLD (ha)	No. of beneficiary	Yield under FLD (q/ha)	Yield under FP (q/ha)	Yield gain (%)
CPGS-AS, CAU (Imphal), Umiam	5.3	59	25.0	20.0	25.0
ICAR RC for NEH Region, Barapani	50.0	130	45.0	40.0	12.5
CAU, Imphal	5.0	5	32.6	21.3	53.1
Total / mean	**60.3**	**194**	**34.2**	**27.1**	**26.2**

Table 5.10: Training/ input distribution programme/ field days/ awareness programme organized under NEH

Centre	Date of training	Place	Type of prog-ramme	Training name	No of person benefitted
CPGS-AS, CAU (Imphal), Umiam	March 3, 2021	Wahiajer Village, West Jaintia Hills, Meghalaya	T/ID	Cultivation practices of specialty corn and FAW management	17
	March 4, 2021	Madanrtiang Village, Ri-Bhoi, Meghalaya	T/ID	Cultivation practices of specialty corn and FAW management	23
	April 22, 2021	Mawkyrdep Village, RI-Bhoi, Meghalaya	T/ID	Cultivation practices of specialty corn and FAW management	25
	August 16, 2021	Palawi village, Bhorymbong, RI-Bhoi, Meghalaya	T/ID	Cultivation practices of specialty corn and FAW management	15
	March 19, 2021	CPGS-AS, CAU, Umiam, Meghalaya	A/ID	Cultivation practices of sweet corn	13
	March 25, 2021	CPGS-AS, CAU, Umiam, Meghalaya	A/ID	Cultivation practices of sweet corn	34
	March 27, 2021	CPGS-AS, CAU, Umiam, Meghalaya	ID	Hybrid sweet corn seed distribution	13
	March 30, 2021	CPGS-AS, CAU, Umiam, Meghalaya	ID	Hybrid sweet corn seed distribution	16
	April 6-8, 2021	College of Agriculture, Kyrdemkulai, Meghalaya	A/ID	Cultivation practices of specialty corn and FAW management	79
ICAR RC for NEH Region, Barapani	May 4, 2021	Barapani	T	Hybrid Maize Cultivation Practices in NEH Region	140
ICAR-NRC on Yak, Dirang, Arunachal Pradesh	March 8, 2021	Dirang	A	Awareness on "Scientific production maize in NER"	68
	March 23-25, 2021	Chug	T	3 days capacity building programme on "Scientific production of Maize in Arunachal Pradesh"	76
	March 2 0-22, 2021	Thembang	T	3 days capacity building programme on "Scientific production of Maize in Arunachal Pradesh" held in during	68

Centre	Date of training	Place	Type of prog-ramme	Training name	No of person benefitted
ICAR-NRC on Pig, Rani, Guwahati	December 23, 2021	Guwahati	T/ID	Maize Seed Distribution	11
CAU Imphal	March 17, 2021	Salam, Imphal West district, Manipur	T/ID	One day farmers training programme cum input distribution programme for Pre-*kharif*/*kharif* crop in Manipur	100
	July 12, 2021	Maibam Kabui, Bishnupur, Manipur	T/ID	Scientific cultivation of maize and demonstration of poultry production in Manipur	34
	September 4, 2021	COA, CAU, Imphal	T/ID	Scientific cultivation of Maize	25
ICAR-NRC on Mithun, Medziphema	June 10, 2021	Yoruba and Upper Khomi, Nagaland	T/ID	Capacity building programme in maize	35

*T-training, ID-Input distribution, FD-Field day, A-Awareness

Table 5.11: Input distribution to farmers under NEH component

Inputs	Total	Beneficiary
Maize seed (Kg)	4891.35	1462
Urea (Kg)	2500	144
Vermi-compost (Kg)	1000	200
SSP (Kg)	600	144
MOP (Kg)	400	144
Soyabean (Kg)	350	70
Neem Cake (Kg)	200	40
Khurpi (no)	100	100
Gurdung (no)	100	100
Garden tools (Set of farm appliances) (no)/ farm implement	40+270	40+85
Sickles (no)	35	35
Spade (no)	35	35
Knapsack (no)	32	32
Atrazine (Kg)	24	24
Neem oil (l)	24	24
Vegetable seeds		
(Carrot, French Bean, ladies finger, cabbage & Tomato)	10	76
Emamectin Benzoyate (Kg)	1.75	45
Literature (no)	1562	452

Training cum input distribution programme at Dirang, Arunachal Pradesh

Training cum input distribution programme, ICAR-NRC on Pig

Training cum input distribution programme, CAU Imphal

Table 5.12: Nutritive value comparison of maize fodder and banana stem

Ration	OM%	CP%	CF%	EE%	Ash%	NFE%
Maize fodder	90.65±0.08	7.95±0.04	32.84±0.49	3.59±0.31	9.35±0.08	46.26±0.14
Banana Stem	85.44±0.26	2.48±0.08	21.11±0.61	2.36±0.06	14.56±0.26	59.50±1.00

Silage prepared using banana stem with maize fodder

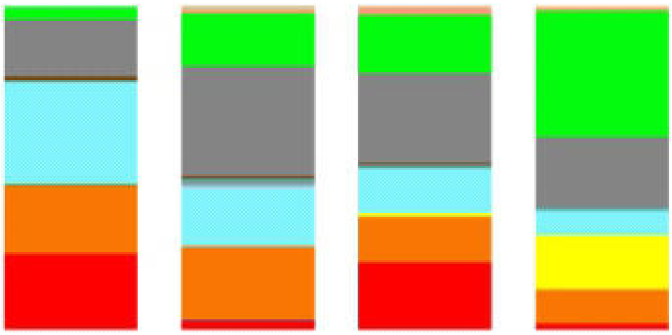
Pig feeding on the mixed silage

Feeding trial

Eighteen large white Yorkshire grower pigs (weight 11.7-11.9 kg) of either sex were divided into three groups of six each in a randomized block design. The experimental pigs were fed with diets namely standard grower ration (SGR) supplemented with 0% banana stem with maize fodder silage, 10% banana stem with maize fodder silage and 15% banana stem with maize fodder silage respectively in T1, T2 and T3 groups.

High throughput sequencing of grower pig meta-genomes

A high throughput sequencing of pig metagenomes was conducted to investigate the increase in gut beneficial bacteria found in the faecal contents of grower pigs fed with green maize supplemented diet. The study delineates the comparative analysis of the faecal samples of grower pigs at phylum, class, order, family, genus and species level as well as identify the beneficial faecal microbiota involved in fibre degradation and their abundance in the gastrointestinal tract. The putative microorganisms identified are found to be associated with nutrient digestion and growth traits. Study also gave an insight into improved understanding of digestion in the large intestine while providing novel insights into the regulation of microbial diversity and its role in the growth and production performance of pigs fed with green maize. The study has detected a lower bacterial diversity in fibre fed samples with approximately two hundred operational taxonomic units (OTUs) compared to the non-fibre fed samples with more than five hundred OTUs. The microbiome of groups fed with 10% maize was concentrated essentially of the phylum Firmicutes, Bacteroidetes, Proteobacteria, Spirocaetes and Fibrobacteres (Fig.1). Colonization of phylum Fibrobacteres was detected only in the fibre fed diets underscoring that feeding of green maize has stimulated the increase of fibrolytic bacterial genera- Fibrobacter and Treponema compared to the non-fibre diet. The synergistic effect of Fibrobacter and Treponema are found to have a greater capacity to degrade dietary cellulose, polysaccharide, and protein encouraging good intestinal health. The hypothesis concludes that feeding of fibre enriched diet has acclimatized the persistence of fibrolytic bacteria- Fibrobacter and Treponema, which has further increased the fibre digestibility in the monogastric animals. Thus, feeding with a fibre enriched diet have augmented healthy gut microbiota in grower pigs and led to the dominance of beneficial microbes that are



Legend	Taxonomy	1(%)	2(%)	3(%)	4(%)
	k_Bacteria;p_Firmicutes	31.7	18.1	14	7.5
	k_Bacteria;p_Euryarchaeota	23.4	2.7	20.8	1.8
	k_Bacteria;p_Bacteroidetes	21.1	22.9	14.1	10.6
	k_Bacteria;p_Proteobacteria	17.2	33.8	28	21.5
	k_Bacteria;p_Spirochaetes	4	16.4	17.8	39.1
	k_Bacteria;p_Planctomycetes	1.3	0.8	0.6	0.1
	k_Bacteria;p_Verrucomicrobia	0.5	0.4	0.4	0.1
	k_Bacteria;p_Lentisphaerae	0.4	2	0.9	1
	k_Bacteria;p_Fibrobacters	0	0	0.9	16.8
	k_Bacteria;p_Fusobacteria	0	0.6	0	0
	k_Bacteria;p_Synergistetes	0	1.3	2.4	0.7
	k_Bacteria;p_Tenericutes	0	0.6	0.2	0.7

Fig: Stacked Bar chart showing the relative abundance of each phylum within each sample (1=Random), 2=0% Maize, 3=5% Maize, 4=10% Maize). Colour legends indicate abundance different phylum in different samples.

important to enhance the gastrointestinal health of the porcine animals. Nevertheless, feeding of green maize has decreased the population of methanobacteria in the gut of pigs, which in turn has limited the production of methane. Therefore, a fibre rich diet being a good remedy to improve the intestine digestibility in pigs can also be implemented as a strategy to lower the global warming impact worldwide.

In vitro dry matter digestibility study using different level of fiber from maize fodder silage in pigs

Three types of diets were prepared using different levels of maize fodder silage in such a way that feeds contained about 8, 10 and 12% crude fibre (CF). The

Maize fodder silage

feeds so prepared were used for in-vitro digestibility trials using pig faecal inoculum. The in vitro DM digestibility was found as 66.49, 64.83 and 63.60% respectively for diet containing 8, 10 and 12% crude fibre.

Learning platforms for Yield Realization of Maize-based Cropping Systems at farmer's field

In *kharif* 2021, ICAR-IIMR initiated a collaborative project with CIMMYT, SAUs and state agricultural department on "Participatory Innovation Platform on Potential Yield Realization of Maize-based Cropping Systems in Punjab and Haryana". Over time the sustainability of the intensive rice-wheat systems of North-West India has become a major challenge owing to faster depletion of ground water table, stagnating or declining productivity growth, degrading soil health and environmental quality including air pollution and public health concerns, and diminishing farm profitability. Therefore, diversification of rice crop is the need of hour to sustain the declining natural resources to ensure food security in long-run in Punjab and Haryana. Replacement of rice with maize crop in this ecology could be one of the best options as its cultivation consumes 80% less water and energy with over 10% enhancement in wheat production. The project envisaged to embolden the most needed crop diversification with maize-based cropping systems for sustainable agriculture in these states Demonstrations have been conducted on maize-wheat-mungbean or maize-mustard-mungbean cropping system or other vegetable based maize systems were taken up to document benefits and plan strategy and future pathways for diversification in Punjab and Haryana. Learning platforms have been established in over 100 acres in Punjab in Hoshiarpur, SBS Nagar, Jalandhar, Ludiana, Pathankot and Rupnagar and 50 acre land in Karnal, Krurukshtra, and Ambala. In these sites, knowledge on improved agronomic production technologies and agro-inputs such as seeds of improved maize varieties, herbicides and pesticides to control fall armyworm have been distributed to the farmers.

In the first year, the yield realized at our learning sites was upto 75 q/ha which showed a hope that the maize can be inroads for diversification (Table 5.14).

Under this project, State Level Maize day on "Participatory Innovation Platform on Potential Yield Realization of Maize-based Cropping Systems in Punjab and Haryana" programme was organized by ICAR-IIMR and CIMMYT in collaboration with PAU and State Department of Agriculture at Garhshankar, Punjab on August 28, 2021 and at Karnal, Haryana on September 11, 2021. District level field day was also organized at Lallya Kala, Jalandhar on September 3, 2021, Sapeda, Ambala on August 16, 2021, Kamoda village, Thanesar Block, Kurukshetra on August 14, 2021.

Farmer led Innovations (FLI) and their Scaling up Mechanisms in Maize

Under the ICAR-IIMR, institute project "Farmer led Innovations (FLI) and their Scaling up Mechanisms in Maize". Several farmers' led innovation were collected and documented on different aspect of maize farming from different part of the country. Some of the prominent innovations collected are

Table 5.14: Realized Yield from the learning sites

District/state	Maize yield (q/ha)			Paddy yield (q/ha)
	District Av.	Demo Av.	Demo Max.	
Jalandhar	44	60	73	62
Hoshiarpur	37	59	67	63
SBS Nagar	37	54	60	59
Rupnagar	38	53	65	50
Ludhiana	39	54	63	58
Punjab	36	56	73	40
Karnal	-	60	73	60
Kurukshetra	-	62	71	74
Ambala	50	63	75	65
Haryana	28	62	73	66






Glimpses of activities under the potential demonstration programme

Wind operated bird scaring machine

Indigenous detasselling after pollination

wind operated bird scaring machine by using a cycle hub, cycle chain, and steel plate and table fan blades; Indigenous storage technique of maize; maize sheller; Indigenous practice; Indigenous detasselling after pollination by Assam farmers ; Techniques for early and better maturity of maize grain prevention of lodging and simultaneous use of green part of plant as fodder etc.

Training on value addition in maize

Indigenous storage technique of maize

Techniques for early and better maturity of maize grain prevention of lodging and simultaneous use of green part of plant as fodder

Development of a digital innovation repository portal in collaboration with ICAR-IASRI is under the process.

Entrepreneurship development under ABI

Under the Agri-Business Incubation (ABI) project, several maize based products such as QPM Biscuit, QPM Cookies, QPM Burfi, Pop Corn Laddu, Pop Corn Ghachak, QPM Muffins, QPM Cakes, QPM &

Joining of Start-up under ABIcentre, ICAR-IIMR

Table 5.15: Summary of activities organized under MGMG

S.No.	Name of activity	No. of activities conducted	No. of farmers participated/ benefitted
1.	Visit to village by teams	12	285
2.	Interface meeting/ Goshthies	3	47
3.	Trainings conducted	-	-
4.	Mobile based advisories	346	402
5.	Literature support provided	2	27
6.	Awareness created	2	20
7.	Linkages developed with other agencies	2	20

Distribution of seed under MGMG programme at Winter Nursery Centre, ICAR-IIMR, Hyderabad.

Normal Maize Pasta, QPM & Normal Maize Chapati etc. have been developed. These technologies were transferred through various value addition and entrepreneurship development training programmes and exhibitions. During 2021, Mr. Somil Soni, Coflux Sciences have joined as agri-startups under the ABI of ICAR-IIMR (Fig.). ICAR-IIMR, Ludhiana organized two hands-on trainings on "Value addition in maize" and "Value Addition in Maize and Specialty Corn Cultivation" for popularization of technologies developed by ICAR-IIMR through its Agri-business Incubator (ABI) at ICAR RC for ER, Patna on January 31, 2021 and ICAR-IIMR RMR&SPC, Begusarai on October 16, 2021 respectively. These trainings were organized in collaboration with "JEEVIKA" an NGO working in Bihar.

Mera Gaon Mera Gaurav (MGMG)

ICAR-IIMR and its regional stations implemented the MGMG programme in 23 villages adopted in the five blocks and 5 districts of Punjab, Haryana, Bihar and Telangana. The seven teams having scientists were in regular touch with the farmers of these villages through visits, ICT tools and organized several activities such as interface meeting/ gosthies, input distributions, awareness creation and linkage with others agencies (Table 5.15). 801 farmers were benefitted from the activities. Besides this 10 ha in the MGMG village were demonstrated with improve technologies such as DHM 121 and African Tall etc benefitting 13 farmers.

Due to prevailing COVID-19, experts responded also responded to the various queries raised by over the phone call and WhatsApp. 346 mobile advisories were also given the farmers on different aspect of maize cultivation including meteorological forecast. Extension literature on "ਪੰਜਾਬ ਅਤੇ ਹਰਿਆਣਾ ਵਿੱਚ ਮੱਕੀ ਅਧਾਰਤ ਫਸਲੀ ਪ੍ਰਣਾਲੀਆਂ ਦੀ ਸੰਭਾਵੀ ਉਪਜ ਪ੍ਰਾਪਤੀ ਬਾਰੇ ਭਾਗੀਦਾਰੀ ਨਵੀਨਤਾ ਪਲੇਟਫਾਰਮ" and "पंजाब और हरियाणा में मक्का आधारित फसल प्रणालियों की संभावित उपज प्राप्ति पर भागीदारी नवाचर प्लेटफार्म" were also distributed benefitting 450 farmers. Awareness on improved package of practices, fall armyworm and its management in maize through updated strategies, importance of soil health, were also done.

AICRP ON MAIZE

6

In the year 1957, All India Co-ordinated Research Project (AICRP) on Maize was established as the nodal agency to coordinate maize research in the country. The objective of AICRP on Maize is to develop and disseminate the high yielding maize cultivars along with protection and production technologies throughout the country. To execute the activities under AICRP the country is divided into five zones, viz., Northern Hilly Zone (NHZ), Northern Western Plain Zone (NWPZ), North Eastern Plain Zone (NEPZ), Peninsular Zone (PZ) and Central Western Zone (CWZ). At present, the AICRP on maize consists of 32 centres and 30 volunteer centres throughout country for testing newly developed technologies.

AICRP trials conducted during the year

AICRP-Breeding

Summary of rabi trials 2020-21

During Rabi 2020-21, a total of 127 entries were received for multi-location evaluation in AICRP late and medium maturity of normal corn, quality protein maize (QPM), sweet corn, baby corn and popcorn trials. Of 127 test entries, total 83 entries were received in NIVT trials (NIVT-Late: 34 and NIVT-Medium: 49), 12 entries were received in AVT-I trials (AVT-I-Late: 8 and AVT-I-Medium 4). There were ten (10) entries in AVT-II trials (AVT-II-Late: 4 and AVT-II-Medium: 6) and there entries were received in QPM trial, thirteen (13) in popcorn trial, baby corn trial had two (2) entries and in sweet corn trial there were four (4) entries (Table 6.1). Out of the total 127 entries, 66 entries were contributed by the private sector (20 different firms) and the rest 61 came from the public sector.

Table 6.1: Details of the breeding trials constituted during rabi 2020-21

Trial	Entries + Checks (No.)	No. of locations
NIVT-Late	34 + 5	24
NIVT-Medium	49 + 3	24
AVT-I-Medium	4 + 3	29
AVT-II-Medium	6 + 3	29
AVT-I-Late	8 + 3	29
AVT-II-Late	4 + 3	29
QPM	3 + 4	24
Popcorn	13 + 2	24
Baby corn	2 + 3	24
Sweet corn	4 + 3	23

During rabi 2020-21, the success rate of different trials for different zone was 85.0%, 90.2%, 100% and 100% for NWPZ, NEPZ, PZ and CWZ, respectively (Table 6.2).

Table 6.2: Details of success rate in reporting the data in rabi 2020-21

Zone(s)	No. of centers	Trials allotted	Trials reported	% success
NWPZ	6	48	41*	85.0
NEPZ	10	82	74	90.2
PZ	8	80	80	100.0
CWZ	5	50	50	100.0

*IARI_Delhi Majihan and Sriniketan

Summary of spring trials 2020-21

During spring 21, a total of 49 entries were received for evaluation in NWPZ in late and medium maturity of normal corn. Of 49 test entries, total 47 entries were received in NIVT trials (NIVT-Late: 7 and NIVT-Medium: 40, whereas two entries were received in AVT-I-Medium trial (Table 6.3). Success rate for the spring trial was 76.0% (Table 6.4).

Table 6.3: Details of the breeding trials constituted during spring 2021

Trial	Entries + Checks (No.)	No. of locations
NIVT-Medium	40 + 5	4
NIVT-Late	7 + 3	4
AVT-I-Medium	2 + 5	9

Table 6.4: Details of success rate in reporting the data in spring 2020-21

Zone(s)	No. of centers	Trials allotted	Trials reported	% success
NWPZ	9	17	13*	76.0

Summary of kharif 2021 trials

During kharif 2021, a total of 269 entries were received for multi-location evaluation in AICRP early, late and medium maturity of normal corn, QPM, sweet corn, baby corn, popcorn and OPV trials (Table 6.5). Of 269 test entries, total 126 entries were received in NIVT trials (NIVT-Late: 40, NIVT-Medium: 60, NIVT-Early: 26) and total 54 entries were evaluated in AVT-I trials (AVT-I-Late: 20, AVT-I-Medium: 27, AVT-1-Early: 7). There were 12 entries for testing in AVT-II trials (AVT-II-Late: 4, AVT-II-Medium: 6 and AVT-II-Early: 2). Forty (40) entries were received for QPM trial whereas 12 entries were there in baby corn trial. Sweet corn trial had 10 entries; popcorn trial had six entries and there were 10 entries in OPV trials for evaluation. Total 34 different breeding trials was constituted, of which one set of trial was exclusively for NHZ and the other for across the zones. Total of nine trial, viz., NIVT-Medium, NIVT-Early, AVT-I-II-Early, AVT-I-II-Medium, QPM I-II-II, Sweet Corn I-II-III, Baby Corm I-II-III, Popcorn I-II-III and OPV trials were exclusively conducted in NHZ and total seven trials, viz., NIVT-Late, NIVT-Medium, NIVT-Early, QPM I-II-II, QPM quality, Sweet Corn I-II-III, Baby Corn I-II-III, AVT-II-R/F-Early and AVT-II-R/F-Medium were constituted across the zones. Following are the zone specific trials:

- NWPZ (5): AVT-I-Early, AVT-I-Medium, AVT-II-Medium, AVT-I-Late, AVT-II-Late
- NEPZ (4): AVT-I-II-Early, AVT-I-Medium, AVT-II-Medium, AVT-I-II-Late
- PZ (4): AVT-I-Medium, AVT I-II-Medium, AVT-I-Late, AVT-II-Late
- CWZ (3): AVT-I-Early, AVT-I-II-Medium, AVT-I-II-Late

Ninety one (91) entries were promoted from the first and second year of testing. Out of the total 269 entries, 92 entries were contributed by the private sector (28 different firms) and the rest 177 came from 25 centres of AICRP on maize.

Table 6.5: Details of the breeding trials constituted in kharif 2021

Trial	Entries + Checks (No.)	No. of locations
NIVT-Early (NHZ)	21 + 3	7
NIVT-Medium (NHZ)	21 + 3	7
NIVT-Late	40 + 5	24
NIVT-Medium	50 + 4	25
NIVT-Early	16 + 4	14
AVT-I-Early (NWPZ)	5 + 4	12
AVT-I-Early (CWZ)	3 + 4	14
AVT-I-II-EARLY (NHZ)	2 + 5	10
AVT-I-II-EARLY (NEPZ)	2 + 5	9
AVT-I-Medium (NEPZ)	13 + 3	9
AVT-I-Medium (NWPZ)	14 + 2	12
AVT-I-Medium (PZ)	9 + 3	16
AVT-II-Medium (NWPZ)	1 + 4	12
AVT-II-Medium (PZ)	3 + 4	16
AVT-II-Medium (NEPZ)	2 + 3	9
AVT I-II-Medium (NHZ)	4 + 3	10
AVT I-II-Medium (CWZ)	3 + 4	15
AVT-I-Late (NWPZ)	13 + 2	13
AVT-I-Late (PZ)	7 + 3	16
AVT-II-Late (NWPZ)	1 + 4	13
AVT-II-Late (PZ)	3 + 2	16
AVT-I-II-Late (NEPZ)	8 + 3	9
AVT-I-II-Late (CWZ)	7 + 2	15
QPM I-II-III	29 + 10	26
QPM I-II-III (NHZ)	15 + 7	6
QPM Quality	9 + 7	2
Sweetcorn I-II-III (NHZ)	12 + 2	6
Sweetcorn I-II-III	11 + 2	24
Babycorn I-II-III (NHZ)	8 + 1	6
Babycorn I-II-III	6 + 2	26
Popcorn I-II-III (NHZ)	6 + 3	6
OPV (NHZ)	10 + 3	7
Rainfed AVT-II-Medium	6 + 3	4
Rainfed AVT-II-Early	2 + 5	4

AICRP Entomology
Rabi 2020-2021 and spring 2021

Maize AICRP entomology rabi 2020-21 and spring 2021 experimental trials were aimed mainly for screening resistance against pink stem borer (PSB: Sesamia inferens), spotted stem borer (SSB: Chilo partellus), fall armyworm (FAW: Spodoptera frugiperda) and shoot fly (Atherigona spp.). Post-screening, the genotypes were categorized as resistant, moderately resistant and susceptible based on Leaf Injury Rating (LIR) on 1-9 scale (resistant: 1.0-3.0, moderately resistant: 3.1-6.0 and susceptible 6.1-9.0) for stem borers. With respect to shoot fly, post-screening, the genotypes were categorized as resistant, moderately resistant and susceptible based on the mean percent dead hearts. The entries were classified based on mean percent dead hearts (Resistant: <10% plants with dead hearts, moderately resistant >10-20% plants with dead hearts, moderately susceptible >20-30% plants with dead hearts, susceptible >30-50% plants with dead hearts and highly susceptible >50 % plants with dead hearts) for shoot fly.

Out of 16 maize entries including checks in AVT-I and AV-II medium maturity group screened under artificial infestation against pink stem borer at Hyderabad, none of the entries were found resistant. Only three entries BIO 9544 (5.8), IMHSB 17R-16 (6.0) and IMHSB 19R-10 (6.0) were moderately resistant. Among the 18 late maturing entries including checks in AVT-I and AVT-II screened against pink stem borer at Hyderabad, none of the entries were found resistant and only one entry IT 8582 (5.2) was moderately resistant to pink stem borer. Among the nine popcorn I-II-III entries including checks screened against under artificial infestation against pink stem borer at Hyderabad, only one entry APCH 2 (5.4) was moderately resistant.

Out of 16 maize entries in AVT-I and AVT-II medium maturity group were screened under artificial infestation against spotted stem borer at Kolhapur, none of the entries were found resistant. Three entries IMHSB 17R-8 (4.9), IMHSB 17R-14 (6.0) and IMHSB 17R-14 (6.0) were found moderately resistant to spotted stem borer. Among the 18 late maturity entries including checks in AVT-I and AVT-II screened against spotted stem borer at Kolhapur, none of the entries were found resistant whereas the following entries, viz., RASI 7044 (5.5), HKI 9569 (5.6), NMH 712 (5.8), IT 8582 (5.9), JKMH 4510 (5.9) and KMH 018 (6.0) were found to be moderately resistant. Among the nine popcorn I-II-III entries including checks screened under artificial infestation against spotted stem borer at Kolhapur, three entries, viz., APCH 2 (5.4), BPCH 6 (5.5) and APCH 3 (6.0) were found to be moderately resistant.

A total of 16 maize entries including checks in the AVT-I and AVT-II medium maturity group were screened under natural infestation against fall armyworm at Coimbatore, Hyderabad and Kolhapur during rabi 2020-21. The Overall mean Davis score across the locations ranged from 4.7 to 6.1. A total of 18 maize entries including checks in the AVT-I and AVT-II late maturity group were screened under natural infestation against fall armyworm at Coimbatore, Hyderabad and Kolhapur during rabi 2020-21. The Overall mean Davis score across the locations ranged from 4.4 to 5.4. A total of eight maize popcorn I-II-III entries including checks were screened under natural infestation against fall armyworm at Coimbatore, Hyderabad and Kolhapur during rabi 2020-21. The Overall mean Davis score across the locations ranged from 4.9 to 6.2.

Sixteen maize entries including checks in AVT-I and AVT-II medium maturity group were screened under natural infestation against shoot fly at Karnal and Ludhiana centres during spring 2021. Based on the overall mean of these two locations, only one entry i.e. IMHSB 17R-17 (18.8) was moderately resistant. Eighteen late maturity entries including checks in AVT-I and AVT-II were screened under natural infestation against shoot fly at Karnal and Ludhiana during spring 2021. Based on the overall mean the lowest and the highest percent of dead hearts were recorded in PM 18202L (21.7) and RASI 5278 (47.5), respectively and none of the entries were found to be resistant or moderately resistant to shoot fly. Nine popcorn I-II-III entries including checks were screened under natural infestation against shoot fly at Karnal and Ludhiana hotspot locations. Based on the overall mean of these two locations, the lowest and highest mean percent dead hearts were observed in WN Synthetic (22.7) and CM 202 (59.2), and none of the entries were found to be resistant or moderately resistant to shoot fly.

A total of 95 maize accessions were evaluated under natural infestation against fall armyworm in augmented design at Coimbatore and Kolhapur during rabi 2020-21. The Davis score was recorded at 14, 28 and 45 days after germination (DAG). Based on the overall mean Davis score of the two locations, the lowest and highest Davis scores were recorded in IMLSB 208B (2.7) and IMLSB 800-1 (4.6). A total of 95 maize accessions were evaluated under natural infestation against shoot fly in augmented design at Karnal and Ludhiana during spring 2021. Based on the overall mean percent of dead hearts formed by the shoot fly, HUZM 79 (65.39) recorded highest percent dead heart. The following five entries, viz., IMLSB 807-1 (13.13), UMI 1205 (14.29), IMLSB 2160 (15.63), BML 2 (17.71) and E 9GoTC (18.83) recorded mean percent dead heart less than 20.0.

Management of fall armyworm

Field experiment was conducted at Kolhapur to evaluate the effect of different insecticides for the management of fall armyworm under natural infestation during rabi 2020-21. The lowest percent plant infestation was observed in Chlorantraniliprole 9.3% + Lambdacyhalothrin 4.6% ZC @ 0.5 ml/l (8.33%) followed by Novaluron 5.25% + Emamectin benzoate 0.9% w/w SC @ 2 ml/l (10.00%) compared to untreated control (73.33%) at seven days after first spray. At 14 days after the first spray, Chlorantraniliprole 9.3% + Lambdacyhalothrin 4.6% ZC @ 0.5 ml/l, Novaluron 5.25% + Emamectin benzoate 0.9% w/w SC @ 2 ml/l and Spinetoram 11.7% w/w SC @ 0.5 ml/l recorded lowest percent incidence of fall armyworm (5.00%) compared to untreated control (71.67%). The Davis score observed was less than 2 among all the treatments while in control it varied from 4.13 to 4.27. Maximum grain yield was obtained in Chlorantraniliprole 9.3% + Lambdacyhalothrin 4.6% ZC@ 0.5 ml/l (85.51 q/ha) and Novaluron 5.25% + Emamectin benzoate 0.9% w/w SC @ 2 ml/l (85.05 q/ha) followed by Spinetoram 11.7% w/w SC@ 0.5 ml/l (83.21 q/ha) and Chlorantraniliprole 18.5% SC@ 0.4 ml/l (81.29 q/ha) compared to untreated control (60.80 q/ha).

The field experiment was conducted at Hyderabad to evaluate the effect of the timing of insecticides for the management of fall armyworm under natural infestation during rabi 2020-21. At 10 days after the first spray, the lowest percent plant infestation (4.43%) was observed in the treatments when recommended insecticide sprayed at Davis score 2 (13.82%), 10% incidence (15.27%) and also at 7 and 14 DAG (16.89) compared to untreated control (75.53%). The remaining treatments recorded plant infestation of 18.88%, 20.36%, 23.66%, 26.88%, 27.76%, 46.19%, 46.94%,78.46% when sprayed during 7 DAG, as soon as moth found in the trap, 10 and 20 DAG, 14 DAG, 5% incidence, 10 DAG, 20 DAG, Davis score 4, respectively. At 10 days after the second spray, the percent plant infestation was significantly lower in the treatments when recommended insecticide sprayed at 7 DAG (13.85%) followed by single spray at 10% incidence (17.68%) and Davis scores 2 (20.81%) compared to untreated control (67.66%). However, all the treatments effectively reduced whorl leaf injury rating (<3.0) at 10 days after the first spray except Davis score of 4 (4.62) and untreated control (4.16). Maximum grain yield was obtained in recommended insecticide sprayed at 7 DAG (122.22 q/ha) followed by recommended insecticide sprayed, as soon as moth found in the trap (121.11 q/ha) compared to untreated control (88.15 q/ha). The fall armyworm was monitored in two locations, viz., Kolhapur and Hyderabad, using funnel traps and NBAIR slow-releasing dispenser by placing four pheromone traps at each location. At Kolhapur, trap data were recorded from 8-17 standard meteorological weeks (SMW) with peak moth catch during 11 SMW (3.0). At Hyderabad, trap data were recorded from 1-17 SMW with peak moth catch during 2 and 3 SMW (5.25).

Kharif 2021-Entomology

Details of the technical programme carried out during kharif 2021 are discussed below.

Evaluation of maize AICRP entries against Chilo partellus (Swinhoe) under artificial infestation (AVT-I and II)

Entries to be tested: Early, Medium, Late, Normal; QPM, Sweet corn, Popcorn and Baby corn.

Locations (hotspots): Dholi, Hyderabad, Karnal, Kolhapur, and Udaipur

Evaluation of maize AICRP entries against Spodoptera frugiperda (J.E.Smith) under artificial infestation (AVT-I and II)

Entriestobetested: Early, Medium, Late Normal; QPM, Sweetcorn, Popcorn and Babycorn.

Locations (hotspots): Coimbatore, Ludhiana, Hyderabad, Kolhapur and Udaipur

Evaluation of inbred lines against Spodoptera frugiperda (J.E.Smith) under artificial infestation

Locations: Coimbatore, Hyderabad, Kolhapur, Ludhiana and Udaipur

Monitoring of Spodoptera frugiperda (J.E.Smith) by pheromone traps with NBAIR slow releasing dispenser

The experiment to test the effectiveness of pheromone traps against FAW was conducted at the following locations, *viz.,* Coimbatore, Delhi, Dholi, Godhra, Hyderabad, Imphal, Kalyani, Karnal, Kolhapur, Ludhiana, Mandya, Pantnagar, Peddapuram, Rahuri, Udaipur and Vagarai. Two locations were selected at each centre and number of traps per location used was four per acre. The traps were installed during the time of sowing from June 1, 2021 and data were recorded at weekly interval throughout the season as per SMW. Data will be analysed for better understanding of the insect behaviour.

Monitoring of cob borer, Helicoverpa armigera by pheromone traps

To monitor cob borer experiment was conducted using pheromone traps at four locations, viz., Delhi, Karnal, Imphal and Udaipur. Two locations were used at each centre and four traps were used per acre per location. The traps were installed at six leaf stage. Observations were recorded once in two weeks and simultaneously lure was changed. Further to know which stage of crop growth attracts the moths, data were recorded for number of moths per trap at weekly interval as per SMW and also the stage of crop at the time of observation, i.e.V8, V9, VT, RI, R2 etc.

Evaluation of seed treatment against fall armyworm during kharif 2021

One experiment was conducted to test the effectiveness of insecticides as seed treatment against FAW at different locations, viz., Dholi, Imphal, Godhra, Karnal, Ludhiana and Rahuri. The detail of different treatment and dose used in the experiment is given in Table 6.6.

Table 6.6: Evaluation of seed treatment against fall armyworm during kharif 2021

Sl. No.	Insecticide	Dose ml /kg seed
T1	Cyantraniliprole 19.8% + Thiamethoxam 19.8%	6.0 ml
T2	Cyantraniliprole 600 FS	2.4 ml
T3	Chlorantraniliprole (Lumivia 50 FS)	5.6 ml
T4	Thiamethoxam 350 FS	8.0 ml
T5	Imidacloprid 600 FS	8.0 ml
T6	Chlorantraniliprole 18.5 SC* (spray std. check)	0.5ml/l
T7	Untreated control	-

Evaluation of insecticides as seed treatment and spray for the management of fall armyworm (1st year)

In another experiment, the insecticides were tested for their efficacy at different stages as seed treatment and foliar spray for the management of FAW at different locations, viz., Coimbatore, Hyderabad, Kolhapur, Ludhiana, Karnal and Udaipur during kharif 2021. The lists of different insecticides used against FAW have been mentioned in Table 6.7.

Evaluation of insecticides as spray based on incidence for the management of stem borers and FAW

In this experiment, the insecticides were tested for their efficacy at different stages as foliar spray for the management of stem borers and FAW at different locations of the country during *kharif* 2021. Stages of insecticide application and test locations for spotted stem borer, pink stem borer and FAW are given in Tables 6.8 and Table 6.9. The lists of different insecticides used against FAW have been mentioned inTable 6.10.

Evaluation of bio-pesticides/bioagents against fall armyworm during rabi 2021-22

The experiment for evaluation of bio-pesticides/bioagents against FAW was carried at Coimbatore, Hyderabad, Imphal, Kolhapur, Udaipur and Ludhiana. The name of insecticide and dose used are mentioned in the Table 6.11.

Table 6.7: Evaluation of insecticides as seed treatment and spray for the management of fall armyworm

Sl. No.	Treatment
1	Thiamethoxam 30FS @ 8ml/kg seed
2	Cyantraniliprole 19.8% + Thiomethoxam 19.8% @ 6ml/kg seed
3	Cyantraniliprole 600FS @ 2.4ml
4	Chlorantriniliprole (Lumivia) as seed treatment @ 5.6 ml/kg seed
5	Thiamethoxam 30FS @ 8ml/kg seed and Chlorantraniliprole 18.5% SC 0.4 ml/litre spray at 3 weeks after germination
6	Cyantraniliprole 19.8% + Thiomethoxam 19.8% @ 6 ml/kg seed and Chlorantraniliprole 18.5% SC 0.4 ml/litres pray at 3 weeks after germination
7.	Cyantraniliprole 600FS @ 2.4 ml and Chlorantraniliprole 18.5% SC 0.4 ml/litre spray at 3 weeks after germination
8	Chlorantriniliprole (Lumivia) as seed treatment @ 5.6 ml/kg seed and Chlorantraniliprole 18.5% SC 0.4 ml/litre spray at 3 weeks after germination
9	Thiamethoxam 30 FS @ 8 ml/kg seed and Chlorantraniliprole 18.5% SC 0.4 ml/litre spray at 4 weeks after germination
10	Cyantraniliprole 19.8 % + Thiomethoxam 19.8% @ 6 ml/kg seed and Chlorantraniliprole 18.5% SC 0.4 ml/litre spray at 4 weeks after germination
11	Cyantraniliprole 600FS @ 2.4 ml and Chlorantraniliprole 18.5% SC 0.4 ml/litre spray at 4 weeks after germination
12	Chlorantriniliprole (Lumivia) as seed treatment @ 5.6 ml/kg seed and Chlorantraniliprole 18.5% SC 0.4 ml/litre spray at 4 weeks after germination
13	Chlorantraniliprole 18.5% SC 0.4 ml/litre spray at 10% foliar damage or Davis score 3.0
14	Chlorantraniliprole 18.5% SC 0.4 ml/litre spray at 20% foliar damage or Davisscore 3.0
15	Untreatedcontrol

Table 6.8:Treatment and location details for stem borers

Sl. No.	Chlorantraniliprole18.5% SC 0.3 ml/litre
1	At 5% incidence (Visible leaf feeding damage)
2	At 10% incidence (Visible leaf feeding damage)
3	Appearance of Dead Heart (1)
4	At 7 DAG
5	At 14 DAG
6	At 7 and 14 DAG
7	At 10 DAG
8	At 20 DAG
9	At 10 and 20 DAG
10	Untreated Control

Table 6.9: Treatment and location details for FAW

Sl. No.	Chlorantraniliprole18.5% SC 0.4 ml/litre
1	At 5% incidence
2	At 10% incidence
3.	Davis score 2
4.	Davis score 4
5.	At 7 DAG
6.	At14DAG
7.	At 7 and 14 DAG
8.	At 10 DAG
9.	At 20 DAG
10.	At 10 and 20 DAG
11.	Untreated Control

Locations: Coimbatore, Kolhapur, Ludhiana, Hyderabad and Udaipur

Evaluation of indigenous technology knowledge (ITK) practice for the management of fallarmyworm in kharif and rabi maize

The experiment for evaluation of bio-pesticides/bioagents against FAW was carried at Imphal, Ludhiana during kharif 2021 and at Rahuri, Hyderabad during rabi 2021-2022. The name of insecticide and dose used are mentioned in the Table 6.12.

To develop pest incidence prediction model for

Table 6.10: The list of different insecticides used against FAW

Sl.No.	Treatment	Dose
1.	Chlorantraniliprole 9.3% + Lambdacyhalothrin 4.6% ZC	100 ml per acre (0.5 ml/litre)
2.	Novaluron 5.25% + Emamectin benzoate 0.9% w/w SC	350 ml per acre (2 ml/litre)
3.	Emamectin benzoate 5% SG	80 g/ha (0.4 g/litre)
4.	Spinetoram 11.7% w/w SC	100 ml per acre (0.5 ml/litre)
5.	Chlorantraniliprole 18.5% SC	80 ml per acre (0.4 ml/litre)
6.	Flubendamide 480 SC	60 ml per acre (0.3 ml/litre)
7.	Spinosad 45SC	100 ml per acre (0.5 ml/ litre)
8.	Cyantraniliprole19.8% + Thiomethoxam 19.8% as check	6 ml/kg seed treatment
9.	Untreated Control	-

Locations: *Kharif*: Coimbatore, Kolhapur, Ludhiana, Hyderabad and Udaipur; *Rabi* 2021-22: Dholi, Coimbatore, Kolhapur

Table 6.11: Biopesticide treatment details

Sl.No.	Treatment	Dose
1	EPN H. indica NBAIR H 38	10 g/litre
2	Pseudomonas fluorescens (PfDWD 2%)	20 g/litre
3	NBAIR Bt 252%	2 ml/litre
4	Metarhizi umanisopliae NBAIR-Ma 35, 0.5%	5 g/litre
5	Beauveria bassiana NBAIR-Bb45, 0.5%	5 g/litre
6	Spfr NPV (NBAIR1)	2 ml/litre
7	NSKE 5%	5 ml/litre
8	Neem formulation 1500 ppm	5 ml/litre
9	Chlorantaniliprole 18.5 SC	0.4 ml/litre
10	Emamectin benzoate 5% SG	0.4 g/litre
11	Commercial Bt formulation	6 ml/kg seed treatment
12	Untreated Control	-

Table 6.12: ITK treatment details

Sl.No.	Treatment	Dose
T1	Soil	15 kg/acre (~0.5 g/plant)
T2	Soil + insecticide (Chlorantaniliprole 18.5 SC)	5 ml/kg soil
T3	Soil + Lime	8: 2 (800g soil + 200 g lime)
T4	Soil + Bt	25 g Bt/kg soil
T5	Soil+ Metarhizi umanisopliae	65 g/kg soil
T6	Soil+ Beauveria bassiana	65 g/kg soil
T7	Sand	(~0.5 g/plant)
T8	Bait + Chlorantaniliprole 18.5 SC	5 ml/kg bait (bait: 600g soil + 130 g jiggery + 70 g sand + 200ml water)
T9	Chlorantaniliprole 18.5 SC0.4 ml/litre spray	
T10	Untreated control -	

maize growing ecologies, an experiment was conducted to study on incidence of spotted stem borer and fall armyworm in kharif sown maize in relation to plant age and meteorological factors at Coimbatore, Dholi, Hyderabad, Imphal, Karnal, Kolhapur, Ludhiana and Udaipur. Another experiment was conducted to study the pest succession of insect pests in kharif sown maize at different locations of country, viz., Dholi, Hyderabad, Imphal, Kolhapur, Karnal, Ludhiana, Udaipur and Coimbatore.

Plant Pathology

Rabi 2020-21

During rabi2020-21, 127 maize entries were evaluated against Maydis leaf blight (MLB), Turcicum leaf blight (TLB), Charcoal rot (ChR) and Sorghum downy mildew (SDM) in different zones across the country (Table 6.13).

Disease screening of NIVT (Medium maturity) maize hybrids

A total of 49 entries of medium maturity were evaluated for MLB, TLB, ChR and SDM across three zones (NEPZ, NWPZ and PZ). One entry (IV 8214) was found resistant against ChR in NWPZ.

Disease screening of NIVT (late maturity) maize hybrids

A total of 34 entries of late maturity were evaluated for MLB, TLB, ChR and SDM across three zones (NEPZ, NWPZ and PZ). One entry (GH 150125) was found resistant against ChR in NWPZ.

Table 6.13: Entries evaluated for different disease in rabi 2020-21

Trial	NWPZ		NEPZ		PZ	
	Late	Medium	Late	Medium	Late	Medium
NIVT	34	49	34	49	34	49
AVT I II	12	10	12	10	12	10
QPM and Speciality corn	22		22		22	
Total	127		127		127	

QPM: Quality protein maize; NEPZ: North Eastern Plain Zone, NWPZ: North Western Plain zone, PZ: Peninsular Zone

Details of the coordinated trials conducted at different centres under AICRP on maize during rabi 2020-21 are given below.

Sl.No.	Center	University	Total Trials allotted
1	Ludhiana	PAU, Ludhiana	5
2	Dholi	RAU, Samastipur	5
3	Kalyani	BCKV, Kalyani	5
4	Sabour	BAU, Bihar	5
5	Dharwad	UAS, Dharwad	5
6	Mandya	UAS, Bengaluru	5
7	Peddapuram	ANGRAU, Guntur	5
8	Coimbatore	TNAU, Coimbatore	5
9	Rahuri	MPKV, Rahuri	5

The success rate of trials in different zones is given below and overall 100% success rate has been achieved.

Zone	Centre	Trials allotted	Trials Reported	Success (%)
NWPZ	Ludhiana	5	5	100
NEPZ	Dholi, Kalyani, Sabour	5	5	100
PZ	Peddapuram, Mandya	5	5	100
	Dharwad	5	5	100
Overall		**20**	**20**	**100**

Disease screening of AVT-I-II (Medium maturity) maize hybrids

A total of 10 entries of medium maturity were evaluated for MLB, TLB, ChR and SDM across three zones (NEPZ, NWPZ and PZ). The following five entries, viz., IMHSB 17R-16, IMHSB 17R-17, IMHSB 17R-8, IMHSB 19R-10 and IMHSB 19R-2 were found resistant against MLB in NEPZ.

Disease screening of AVT-I-II (Late maturity) maize hybrids

A total of 12 entries of late maturity were screened against MLB, TLB, ChR and SDM across three zones (NEPZ, NWPZ and PZ). A total of six entries, viz., IT 8582, KMH 018, PM 18202L, PM 18204L, RASI 5278 and RASI 5640 were found resistant against MLB in NEPZ.

Disease Screening of QPM and Specialty corn maize hybrids

A total of 22 entries from QPM and specialty corn were screened against MLB, TLB, ChR and SDM across three zones (NEPZ, NWPZ and PZ). Only three QPM entries namely viz., BHQPM 418026, DZ-89, QPMMH 2155 were found resistant against MLB in NEPZ.

Efficacy of different components in the management of charcoal rot

Even though there is a significant difference in yield in the treatment of spraying of foliar application of Chitosan @ 5ml/litre at 35DAS and 45DAS with chemical components Mancozeb 75WP @ 2.5g/litre, the chitosan was found to be effective for the reduction of charcoal rot disease in maize and eco-friendly. The minimum disease incidence of 9.28% was recorded and an average yield of 6674 kg/ha was recorded.

Spring 2020-21

During spring 2020-21, the following maize entries were evaluated against Charcoal rot (C. Rot) in NWPZ zones of AICRP on Maize across the country:

Disease screening of Spring NIVT (Medium maturity) maize

A total of 40 entries of NIVT medium maturity were evaluated for ChR during spring season. None of the entries were found to be resistant against ChR.

Disease screening of Spring NIVT (Late maturity) maize

A total of seven entries of NIVT late maturity were evaluated for ChR. None of the entries were found to be resistant against ChR.

Disease screening of Spring AVT I (Medium maturity) maize

A total of two entries from Spring AVT I medium group were evaluated for ChR. No entry was found to be resistant against ChR.

Kharif 2021 Pathology

A total of nine coordinated trials for screening of different diseases has been sent for *kharif* 2021.

Agronomy

Rabi 2020-21

In rabi 2020-21, experiments were conducted on the agronomy of pre-release genotypes of different maturity, tillage and nutrient management, integrated nutrient management, ecological intensification, weed management, crop residue management in traditional and emerging maize systems, enhancing water use efficiency in spring maize and agro-ecological options for Fall Armyworm (FAW) management in maize systems.

Trial	NWPZ		NEPZ		PZ	
	Late	Medium	Late	Medium	Late	Medium
NIVT	7	40	-	-	-	-

Details of the coordinated trials conducted under AICRP on maize during spring 21 are given below

Sl.No.	Center	University	Total Trials allotted
1	Ludhiana	PAU, Ludhiana	3

The success rate of trial is given below:

Zone	Centre	Trials allotted	Trials Reported	Success (%)
NWPZ	Ludhiana	3	3	100

Response of pre release genotypes to density and nutrient levels:

The different hybrids of AVT-II in medium and late maturity were tested at fertility levels and density levels in four zones except NHZ. The five medium maturity genotypes with check was tested in NWPZ while one in NEPZ and CWZ, and two in PZ at 2-3 locations. The genotypes responded to higher nutrient level i.e. 150% recommended dose of fertilizer (RDF) and at normal (CWZ, 50 × 20 cm) and higher density (NEPZ, PZ and NWPZ, 60 × 20 cm). The NMH 4140 genotype showed significantly higher yield over best check at NWPZ, NEPZ and CWZ only, while other genotypes in NWPZ were at par with the best check. The one, four, two and one genotypes of late maturity were tested in NWPZ, NEPZ, PZ and CWZ, respectively. The late maturity genotype PM 18202L responded to high nutrient levels and density but was on par for grain yield with checks in PZ. In CWZ, long duration genotypes tested at two locations and genotype responded to high fertility levels (150% RDF), however none was found superior over best check. In NWPZ, four late duration genotype along with checks were tested, all the tested genotypes, viz., PM 18202L, PM 1824L, PM 18208L and IT 8582 gave significantly higher grain yield over check.

Nutrient management in maize-wheat-cowpea cropping system under different tillage practices:

It was observed that the application of different tillage practices had non-significant effect on wheat yield but the system yield (12.38 t/ha) and system net returns (143.46 thousands/ha) were significantly higher with zero tillage (ZT) in clay loam soil at Pantnagar which was at par with conventional tillage (CT). However, in nutrient management (100% RDF) showed significantly higher wheat and system yield as well as system net returns which was at par with site specific nutrient management (SSNM).

Nutrient management in rice-maize/soybean-maize cropping system under different tillage practices:

The experiments were conducted at Kalyani (NEPZ) for working out best nutrient and tillage management practices of emerging cropping system. Among tillage practices, ZT and in nutrient management, 33% + green seeker (GS) gave significantly higher yield and net return with 10.56 t/ha and 10.11 t/ha, and Rs 144.83 and 131.09 thousands/ha, respectively from maize. This was at par to permanent bed (PB) and SSNM, but CT practices were significantly inferior.

Nutrient management in maize based rainfed cropping system under different tillage practices:

The experiment was conducted at Banswara (CWZ) in maize-chickpea system. It was observed that ZT gave significantly higher maize and system yield followed by PB, and both were superior to CT. Among nutrient management, the SSNM based nutrient application gave significantly higher yield of both the crops over other options used in the study.

Long-term trial on integrated nutrient management:

The maize equivalent yield of system, net returns and benefit cost (BC) ratio were significantly highest with 100% RDF + 5 t/ha farm yard manure (FYM) which was at par with the 75% RDF + 5 t/ha at Pantnagar (NWPZ). FYM at Maize + legume intercropping (for economic produce) with FYM 10 t/ha + Azatobactor application produced highest yield which was statistically similar to the 100% RDF + 5 t/ha FYM treatment at Banswara.

Ecological intensification for climate resilient maize based cropping systems:

The experiment for yield and profit maximization through optimization of ecological processes was taken up at seven locations in various maize systems. The crop yield was statistically highest with ecological intensification (EI) at all seven locations (Pantnagar, Kalyani, Coimbatore, Peddapuram, Karimnagar, Hyderabad and Banswara). The EI minus weed management at Banswara and Hyderabad, Farmer practice at Kalyani, Peddapuram and Karimnagar, EI minus water management at Coimbatore and EI minus nutrient management at Pantnagar gave significantly lowest yield.

Weed management in maize systems:

The experiment was conducted at Gossaingaon, Pantnagar, Kalyani and Banswara on weed management in maize systems.Maize grain yield (kg/ha) of maize-wheat cropping system was significantly higher under weed free check at all locations which was at par to weed management treatments applied in maize with T7 (Atrazine 1000 g/ha (PE) followed byTembotrione 120 g/ha at 25

DAS), T4 (Atrazine 750 g/ha (PE) followed byTopramezone 25.2 g/ha at 25 DAS) and T3 (Atrazine 1000 g/ha (PE) followed by hand weeding at 25 DAS) at Gossainagaon, Kalyani and Banswara.

Crop residue management in traditional and emerging maize systems:
The experiment was conducted at seven differentlocations in NWPZ, NEPZ and PZ on residue management in different traditional and emerging cropping systems. The grain yield of crops were found maximum under M3 (residue incorporation + spray of microbial consortium on residue) and N1 (100% RDF of NPK), M4 (Zero-tillage + residue retention and spray of microbial consortia on residue) and N1, M3 and N2 (100% RDN and P and 50% RDK), M3 and N1, M3 and N1, and, M3 and N1 at Gossaingaon, Karnal, Kalyani, Karimnagar, Hyderabad and Peddapuram, respectively; whereas M3 and K1 (100% K2O) gave highest maize grain yield in Pantnagar.

Enhancing water use efficiency in spring maize:
Significantly higher yield and net returns were recorded with P2 (ZT flat planting) at par with P3 (ridge slope planting) while R2 (with paddy mulch) had significantly higher yield but lower net returns over without mulching in spring maize at Karnal. It was found that ridge slope planting with organic mulch @ 6 t/ha gave significantly higher spring maize yield, net returns and water use efficiency at Pantnagar.

Agro-ecological options for Fall Armyworm management: Chickpea or spinach intercropping with maize + marigold in push-pull experiment significantly reduced FAW infestation and maize + spinach gave significantly higher yield and net returns at Kalyani. Maize + marigold in push-pull experiment at Coimbatore also found effective in reducing FAW damage in cob and gave highest net returns, whereas intercropping treatment could not show promise for FAW control in Hyderabad and Pantnagar.

SIGNIFICANT EVENTS 7

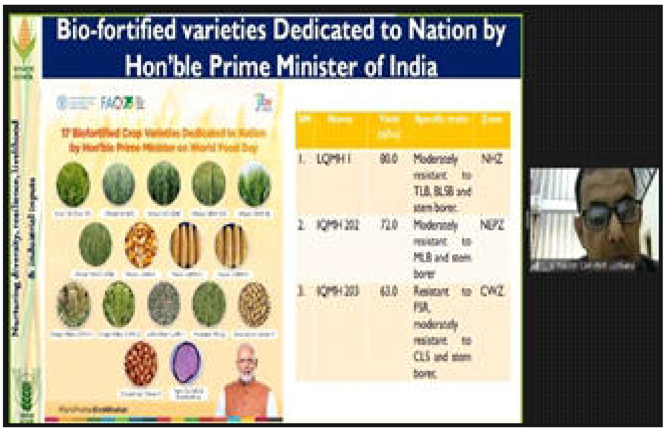
Institute Events

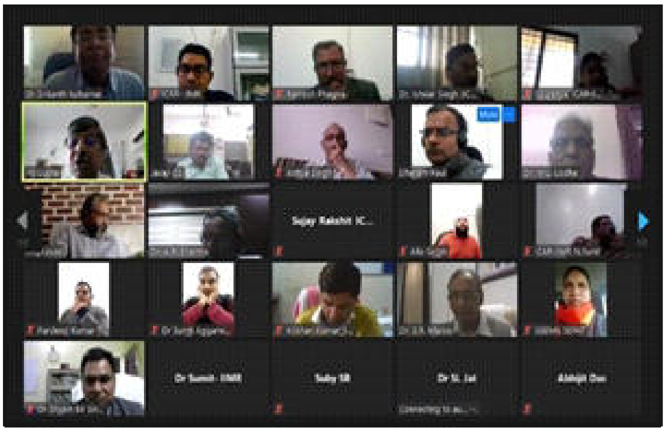
Research Advisory Committee Meeting

The Research Advisory Committee (RAC) meeting of the institute for 2020 was held online from February 24-25, 2021 under the chairmanship of Dr. H.S. Gupta, Former Director-General, BISA & Ex-Director, ICAR-Indian Agricultural Research Institute, New Delhi. During the meeting, Dr. Sujay Rakshit, Director, ICAR-IIMR presented an overview of the maize scenario and major accomplishments of the institute during 2020. Dr. H.S. Gupta, Chairman, RAC complimented the scientists for the inclusion of three biofortified maize hybrids developed by the institute in the list of 16 biofortified varieties released by the Hon'ble Prime Minister on the occasion of World Food Day. He further emphasized that maize has shown impressive growth despite the COVID-19 pandemic during 2020. The Chairman called upon the scientists to work passionately to solve issues being faced by the farming community. He also stressed that the results of field demonstrations must be disseminated and awareness regarding the latest technologies must be provided to the farmers.

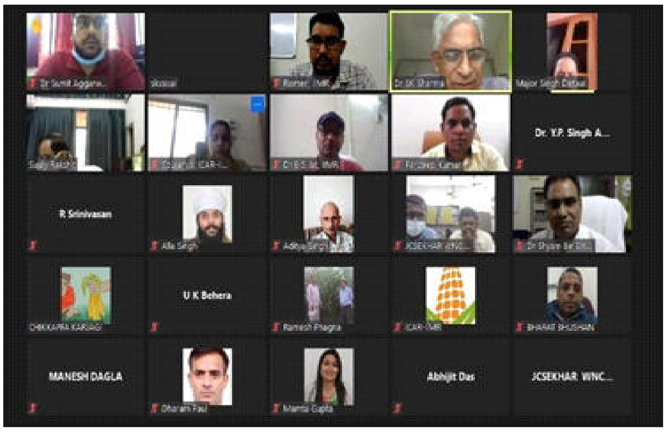
Research Advisory Committee (RAC) Meeting for 2021

Further, the Research Advisory Committee (RAC) of the institute for 2021was held in virtual mode from July 7-8, 2021 under the chairmanship of Prof. S.K. Sharma, Honorary Professor & Former Vice-Chancellor, HP Agricultural University, Palampur. Dr. Sharma emphasized that maize has become more of feed and industrial crop than a food crop and the Institute should gear up its research activities in this direction. He further suggested that the Institute should also find ways and means to enhance farmers'





Glimpses of the RAC Meeting to review institute progress during Feb 24-25, 2021



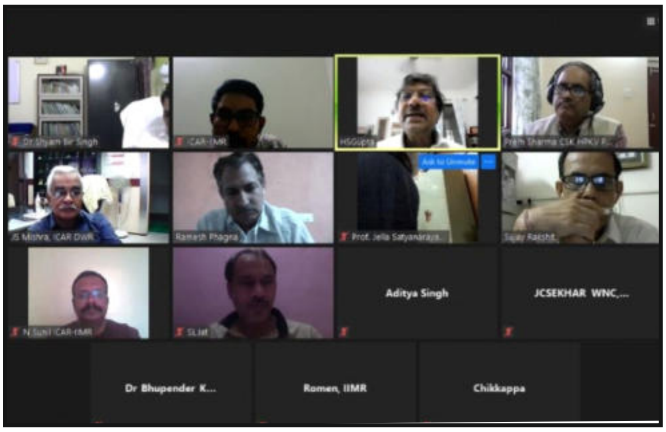
Glimpses of the RAC Meeting to review institute progress during 2021 profitability following the diversification of the rice-wheat cropping system, where maize can play an important role.This was followed by the presentation on the overview of accomplishments in research at the Institute as well asin AICRP by the Director, ICAR-IIMR. The RAC appreciated the scientists for their research achievements, particularly when the institute is still in the development stage. Members emphasized the need to focus research on the biology and management strategies of fall armyworm (FAW). The importance of germplasm enhancement and its heterotic groupings was highlighted. RAC mentioned the need to procure the germplasm tolerant to different biotic and abiotic stresses from various sources and efforts should be made to adapt these materials into local environments. RAC also highlighted the need for seed production of single-cross hybrids to meet the requirement of the farmers and development of alocation-wise package of practices.

Institute Management Committee Meeting

The 14th meeting of the Institute Management Committee (IMC) was held online on March 22, 2021, under the Chairmanship of Dr. Sujay Rakshit, Director, ICAR-IIMR, Ludhiana. In the meeting, utilization of Non-Plan, Plan, and AICRP budget for the year 2020-21, expenditure in EFC 2017-20, and status of advances were discussed. The other agenda of the meetings, buy back arrangement of seeds of public bred hybrids/parental lines through the individual farmer, SHGs/FPOs, filling up of two vacant posts of Assistant on a permanent transfer basis, shifting of HT line passing across the farm at Ladhowal of ICAR-IIMR HQ,bringing the orchard at ICAR-IIMR Ladhowal under farm experimentation were discussed.

Project Advisory and Monitoring Committee Meeting

PAMC meeting was held during the 64thAnnual Workshop of Maize on May 19, 2021,which was attended by Dr. H.S. Gupta,Chairman of PAMC, members viz; Dr.I.S. Singh (Breeding), Dr. P.N. Singh (Plant Pathology), Dr. Jella Satyanarayana (Entomology) attendedthe meeting.From ICAR-IIMR, Dr. Sujay Rakshit, Director ICAR-IIMR, Dr. J.C. Sekhar, Dr. Ramesh Kumar Phagna, Dr. Dharam Pal, Dr.S B Singh, Dr. Sunil Neelam, Dr. Bhupender

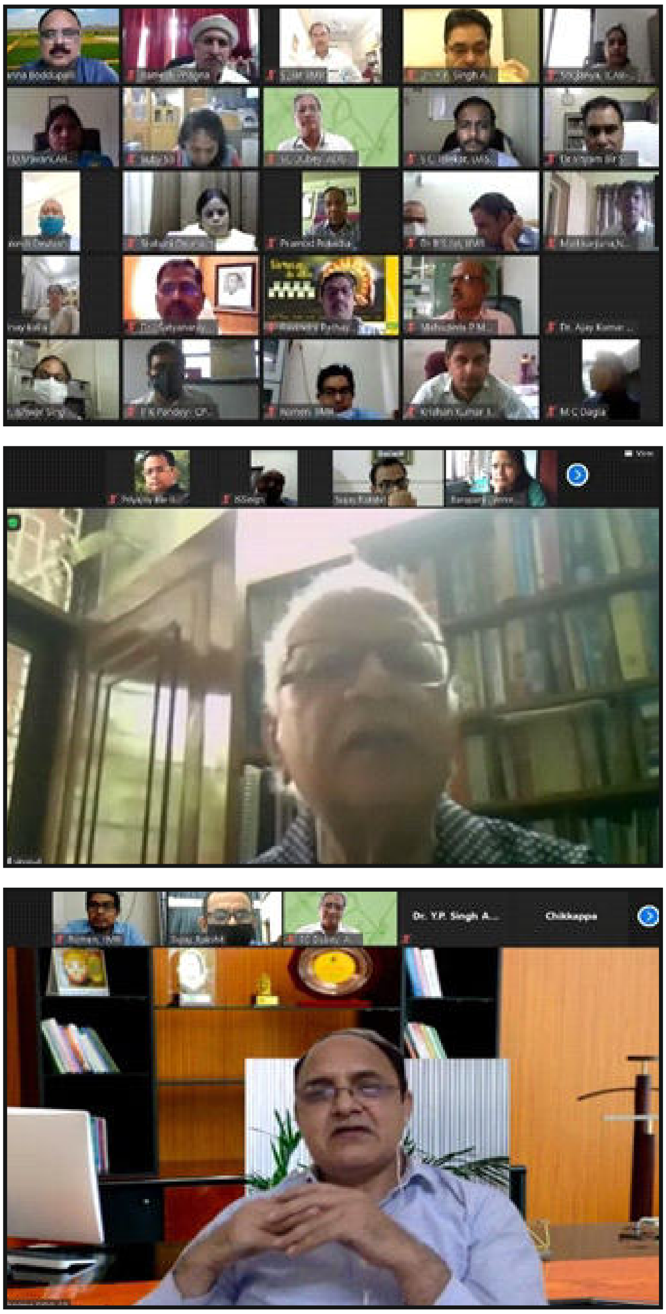


Discussions during PAMC Meeting

Kumar attended the meeting. Dr. J. Mishra, Director, ICAR-DWR fully attended the PAMC meeting as a special guest. Chairman appreciated the efforts of ICAR-IIMR and AICRP for streamlining the maize research in India. The committee suggested the strengthening of lead centers and recommended that all major discipline posts should be there at lead centres.

Annual Maize Workshop

The 64th Annual Maize Workshop was held online from May17-19 and on June17, 2021. Approximately 200 participants representing both public and private sectors across the country attended the meeting. The workshop was spread into 11 sessions over four days. The workshop was inaugurated by Dr. H.S. Gupta, former Director-General, Borlaug Institute for South Asia (BISA), and Director, IARI, and Chairman, Project Advisory and Monitoring Committee (PAMC) in the presence of Dr. S.K.Vasal, World Food Laureate, Dr. I.S. Singh, Dr. P.N. Sharma, and Dr. Jella Satyanarayana, members of PAMC. Dr. H.S. Gupta, Chairman,



Glimpses of the 64th Annual Maize Workshop

PAMC complimented the maize fraternity for developing technologies leading to over 30 million tonnes of maize production in the country in the current year. He highlighted the demand is much more and to reach the target, attention is to be given to increasing input use efficiency and improving the nutritional status through biofortification. He mentioned that other major challenges are seed production & larger inroads of under single cross hybrids in maize. Dr. S.K.Vasal highlighted the importance of the development of multi-parent source populations, heterotic pools, grouping ofinbred lines based on heterotic behavior, recycling ofinbred lines within the heterotic group, and identification of new testers and inbredlines with better productivity. Dr. T.R. Sharma, DDG (Crop Science) graced the occasion onJune 17, 2021, and reviewed the work done during Rabi 2019-20 and Kharif 2020. DDG congratulated the scientists and director for publishing in very high-rated journals when the institute is in the developing phase.

Variety Identification Committee Meeting

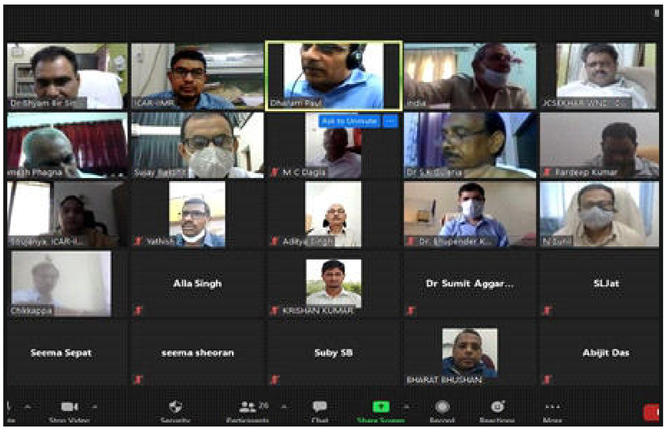
The Variety Identification Committee Meeting (VIC) of AICRP on Maize was held on June17, 2021 through Video Conferencing. The meeting was conducted under the chairmanship of Dr. T.R. Sharma, Deputy Director General (Crop Science), ICAR. Ten members of the VIC along with five resource persons from ICAR-IIMR attended the meeting. A total of 17 proposals were presented and after thorough discussion, 11 genotypes were identified for release.

Institute Technology Management Committee Meeting

The Institute Technology Management Committee (ITMC) meeting of the institute was held on May 15, 2021. The main agenda of the meeting was to discuss the draft MoU for seed production with West Bengal State Seed Corporation Ltd. and farmer Producing Organisation (FPO), Bishwa Bharati Krishi Swambar Gosthi, Kulgachi, Nadia. During this meeting, the terms and conditions of the MoU with both organizations were discussed in detail and finalized.

Institute Research Council Meeting

The Institute Research Council (IRC) meeting of the ICAR-Indian Institute of Maize Research, Ludhiana was held on June 22-24, and July 1, 2021, through video conferencing under the chairmanship of Dr. Sujay Rakshit, Director ICAR-IIMR to review the progress of on going research projects and to consider the new project proposals. Dr. R.S. Rathore, Professor and Sr. Maize Pathologist (Retd.) and Former In-charge, AICRP on Maize, MPUAT, Udaipur and Dr.S.K.Guleria, Sr. Maize Breeder (Retd.) and In-charge, AICRP on Maize, HAREC, CSKHPKV, Bajaura were the outside experts during



Participants of the IRC meeting

June 22-24, whereas Dr. N. K. Singh, Sr. Maize Breeder, GBPUAT, Pantnagar and Dr. R. Ravikeshavan, Professor, TNAU Coimbatore were the outside experts for the meeting held on July 1, 2021. A total of 18 in-house and 14 externally funded projects were reviewed and appropriate suggestions and recommendations were made for the improvement of research programs.

State Level Maize Day

The ICAR-Indian Institute of Maize Research, Ludhiana and CIMMYT, in collaboration with the State Agriculture Department, Government of Punjab, Punjab Agricultural University, Ludhiana organized this State Level Maize Day at Dana Mandi, Garhshankar Village, Hoshiarpur on August 28, 2021. Shri Suresh Kumar, Chief Principal Secretary, Government of Punjab was the Chief Guest. Welcoming the guest, Dr. Sujay Rakshit, Director, ICAR-IIMR briefed that these

Glimpses of State Level Maize Day with several dignitaries demonstrations are critical for the diversification in Punjab for sustainability. The IIMR has developed 12 maize hybrids,of which one is released for the Punjab and Haryana region. The institute also developed maize-based value-added products for dietary diversification and entrepreneurship development. He was impressed with the performance of the institute and commended its efforts for encouraging maize cultivation in Punjab towards crop diversification. He urged scientists and private partners to convince farmers with a credible solution to enhance credibility by giving proof of the technology in their field. Dr. M.L. Jat, CIMMYT briefed that Secretary DARE & Director General, ICAR, New Delhi has advised establishing such participatory innovation platforms of maize system with value chain for diversification of ricein Punjab and Haryana. Dr. S.S.Sidhu, Director of Agriculture, Government of Punjab, emphasized maize diversification of the cropping system for sustainability in Punjab. Guest of Honour, Sh. Anirudh Tewari, ACS(D) & Vice-Chancellor, Punjab Agricultural University emphasized that the whole maize-based cropping system should beencouraged for demonstration and emphasized to convince farmers for water-saving and enhancing profitability. Chairman of the function, Dr. T. R. Sharma, Deputy Director General (Crop Science), Indian Council of Agricultural Research, urged farmers to adopt maize-based cropping system technology demonstrated at farmer's field at a faster rate to save water and enhance profitability. A Policy Paper on "Diversification of Cropping System in Punjab and Haryana through Cultivation of Maize, Pulses and Oilseeds" was released by the honorable guests. The program was also graced with the presence of Ms. Apneet Riyait, DC, Hoshiarpur, Dr. N.S. Bains, Director (Research), Dr. J.S. Mahal, Director (Extension), PAU, Dr. J.P.S. Gill, Director (Research), GADVASU, Shri Vinay Kumar and Shri. Subhash Chander of Punjab Agriculture Department, Dr. Ramesh Kumar, Dr. D.P. Chaudhary, Dr.S.L.Jat, Dr. Romen Sharma, Ms. Seema Sheoran, and Mr. Priyajoy Kar of ICAR-IIMR. The stalls of the key stakeholders involved in the maize value chain were also displayed.

State-level Maize Day organized

The ICAR-CSSRI, ICAR-IIMR, and CIMMYT, in collaboration with the state AgricultureDepartment, Government of Punjab, CCS Haryana Agricultural University organized a StateLevel Maize Day at ICAR-CSSRI on September 11, 2021.Honorable Dr. B.R. Kamboj, Vice-Chancellor, CCS Haryana Agricultural University, Hisar was the Chief Guest of a state level maize field day held at ICAR- Central Soil Salinity Research Institute (CSSRI), Karnal. He was impressed with the performance of with ICAR-CIMMYT collaborative demonstration programme for diversification in Haryana. He talked that we need to think holistically for value chain development to realize the fruit of diversification. The involvement of KVK and the department agriculture will be needed for enhancing the adoption of diversified crops. Dr. Sujay Rakshit, Director, ICAR-Indian Institute of Maize Research (IIMR) briefed that Secretary DARE & Director General, ICAR, New

Dignitaries addressing the farmers on State level Maize Day

Delhi has advised to establish such participatory innovation platforms of maize system with value chain for diversification of rice in Punjab and Haryana. Dr. P.C. Sharma, Director, ICAR-CSSRI shared that the institute have established long-term research trial for the comparison of maize vs rice systems in 2009 in collaboration with CIMMYT. The yield, profitability, and water-saving recorded under the maize systems is higher over the rice system and hence farmers can go for adoption of such system for resource-saving and enhancing farm income. Dr. M.L.Jat, CIMMYT elaborated on the present issues of water table decline, residue burning and urged farmers to adopt maize for sustainable resources for future generations. The saving of the energy and enhancement in soil health can be key for future food security though adoption of maize systems. In the program, entrepreneurial based maize businesses were encouraged among the farmers for higher price realization. In the meeting, over 300 farmers and stakeholders participated. A field visit to the long-term research trial on maize systems at ICAR-CSSRI and a learning platform of farmers' field at Kulwehri, Karnal was also done, where a good crop of maize impressed the stakeholders. The farmers from different districts also shared their views and mentioned that now they are getting better maize productivity, the realization of prices as per MSP will help them for enhanced adoption of maize cultivation in place of rice. The programme was also graced with the presence of Dr. O.P. Choudhary, Regional Director, CCS HAU, Karnal with his team Dr. M.C. Kamboj, Dr. Narender Kumar; Dr. R.K. Yadav and Dr. H.S.Jat of ICAR-CSSRI, Dr. Ramesh Kumar, Dr S.L. Jat and Dr. Romen Sharma of ICAR-IIMR; Dr. D.K.Bijarniya, Dr. Yogesh Kumar, Dr. S.K.Kakraliya, Dr. K.M. Chaudhary and Shri Manish Kumar from CIMMYT.

Krishi Unnati Mela

ICAR-IIMR participated in three days of Krishi Mela held at IARI Pusafrom February 25- 27 under the theme of Atmanirbhar Bharat. The visitors interacted on spring maize, zero-till crop cultivation, silage from maize, value addition in maize, baby corn and sweet corn. These technologies in maize, having great potential to enhance farm profitability and livelihood security, were demonstrated.

Glimpses of Krishi Unnati Mela 2021

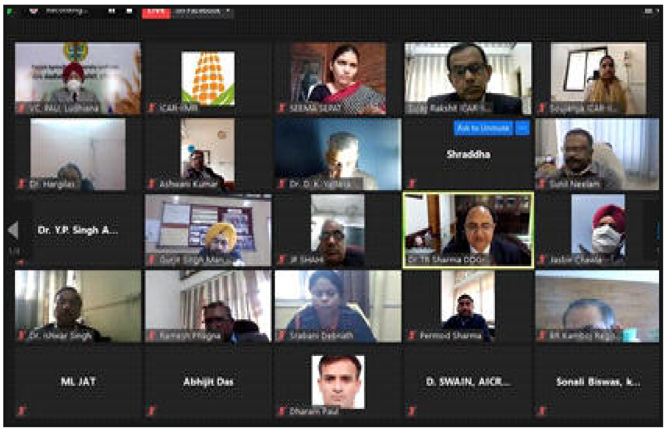
itutional Biosafety Committee

The Institutional Biosafety Committee (IBSC) meeting of ICAR-IIMR, was held online via video conferencing on November 30, 2021 under the chairmanship of Director ICAR-IIMR. Members, Dr. Sujay Rakshit (Director & Chairman), Dr. Parveen Chhuneja, (Principal Molecular Geneticist, PAU, Ludhiana & DBT nominee), Dr. Anita Srivastava (Medical Officer IARI dispensary & Biosafety Officer), Dr. Monika Dalal (Principal Scientist, NIPB & outside expert), Dr. Bhupender Kumar (Scientist, ICAR-IIMR & member), Dr. Alla Singh (Scientist, ICAR-IIMR & member) and Dr. Krishan Kumar (Scientist, ICAR-IIMR & Member Secretary) attended the online IBSC meeting. The committee reviewed the biosafety aspects of one newly sanctioned in-house project that involved the use of rDNA technology/ Genetically Modified Organisms (GMOs) and approved the project for execution. The committee also reviewed the biosafety aspects of the ongoing work and found them to besatisfactory.

Glimpses of the IBSC Meeting

Institute Foundation Day Celebration

The institute celebrated its "6th Foundation Day" through video conferencing on February 9,2021. Dr. T.R. Sharma DDG (CS), ICAR was the Chief Guest, Padma Shri Dr. B.S. Dhillon, Vice-Chancellor, Punjab Agricultural University (PAU) was the Guest of Honour on this occasion. Dr. Y.P. Singh, ADG (FFC), and Dr. D.K.Yadava, ADG (Seeds) graced the occasion as Special Guests. Dr. Sujay Rakshit, Director,ICAR-IIMR presented significant achievements of the institute during 2020. The Chief Guest delivered the Foundation Day Lecture on "Search for novel disease resistance genes in crop plants" and appreciated the efforts of ICAR-IIMR towards maize improvement. On this occasion, the Chief Guest released the annual report of the institute and the 4th edition of Hindi magazine "Krishi Chetna". Heals of elicitated the best-performing staff members of the institute. Dr.B.S. Dhillon stressed that the rice-wheat cropping system is unsustainable for the states of Punjab and Haryana. Maize can be the most profitable alternate crop for diversification of the rice-wheat cropping system in the region. Dr.D.K. Yadava highlighted the importance of maize in the changing climatic scenario and stressed upon the scientists to work towards resistance breeding and to develop high-yielding climate-resilient hybrids of maize. Dr. Y.P. Singh shared his thoughts on the management of pests, particularly, fall army worm to sustain maize production in the country.



Chief Guest Dr.T.R. Sharma, DDG(CS) delivering the Foundation Day Lecture

Republic Day Celebration

The 72nd republic day was celebrated with zeal, enthusiasm, and patriotic fervor by all the staff of the institute. On this occasion, the National Flag was hoisted by the Director in the upcoming campus of the institute at Ladhowal, Ludhiana while at other centres respective In-charges did the honor. The Director emphasized the need to honor our constitutional responsibilities. On this occasion, he praised the farming community for sustaining agricultural production despite all the adversities of nature, including the challenges of theCOVID-19 pandemic. The Director urged the staff of the institute to fully commit themselves to the welfare of the farming community.

Flag hoisting ceremony on the Republic Day

Independence Day

The 75th Independence Day was celebrated at ICAR-IIMR, Headquarters, and its regional stations with full zeal and patriotism. On this occasion, the flag was hoisted at ICAR-IIMR, Ladhowal farm, Ludhiana, and its regional centers. Director, ICAR-IIMR motivated the staff about the glorious past of India,s Independence journey. The function was attended by the staff and their family members.


Flag hoisting ceremony on the Independence Day

Glimpses of Swachtcha Mah Celebration at ICAR-IIMR

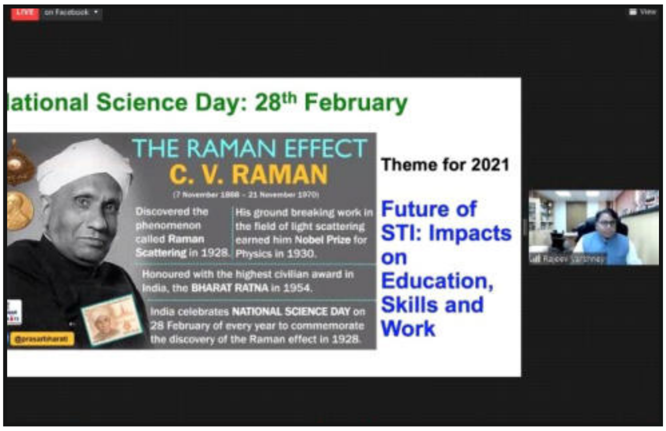
Swachh Bharat Campaign

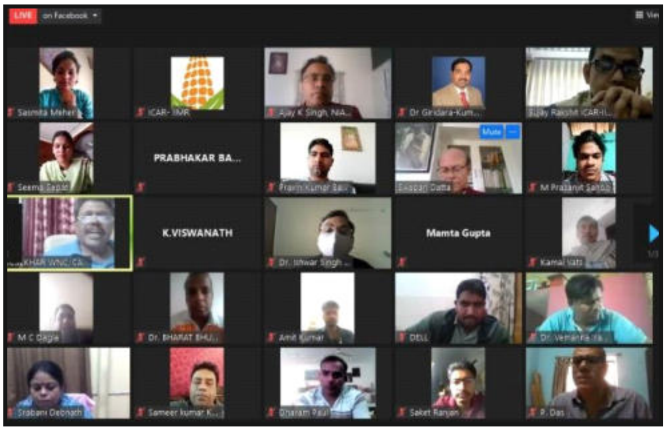
Special Swachhta Mah celebrations were held from 6- 20 October, 2021. The campaign was attended by all the staff and students at Ludhiana, and its regional centers. The old and obsolete files were weeded out during the Swachhta Mah campaign. The significance of Swachh Bharat Abhiyan was discussed and awareness was spread online on different social media platforms.

Swachhta Pakhwada Celebration

Swachhta Pakhwada celebrations was held from 16-31st December, 2021. The campaign was attended by all the staffs of Ludhiana and regional centers, A wide range of activities starting from taking the swacchta pledge, sanitation drive, organizing lectures, waste disposal campaign etc were carried out.


Glimpses of Swachtcha Pakwada celebration at ICAR-IIMR and its regional centers





Glimpses of the National Science Day celebration

National Science Day Celebration

The institute celebrated National Science Day on Feb 28, 2021, and organized a special lecture on "Science, Technology, and Innovations: a Perspective from Genomics-assisted Breeding". Dr. Rajeev K. Varshney, Research Program Director-Genetic gains, ICRISAT, Hyderabad was the speaker. Prof. Swapan K. Datta, Vice Chancellor., Biswa Bangla Biswavidyalay was chairman of the programme. Dr. Varshney highlighted the genomic-assisted breeding mechanism deployed in the development of high-oleic groundnut varieties and climate-resilient varieties in chickpea and other legumes. More than 100 participants from different ICAR institutes and AICRP on maize attended the program through video conferencing.

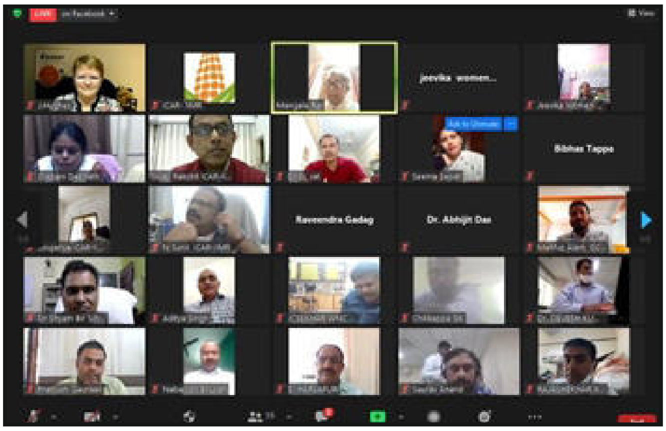
World Water Day Celebration

ICAR-IIMR celebrated world water day on Mar 22, 2021 with a special lecture by Dr. Mahi Pal, IES, Former Director, Ministry of Rural Development, GoI. In his address, the Director ICAR-IIMR stressed the judicious use of water. Dr. Pal addressed the gathering on "The role of Panchayats in Conservation, Management and Budgeting of Water in India". The staff of the institute and AICRP on Maize attended the virtual lecture. Dr. Mahi Pal discussed the potential role of scientist community in saving water.

International Women's Day Celebration

ICAR-IIMR observed International Women's Day on March 8, 2021, to celebrate womanhood, acknowledge women's roles and honor their dignity. Dr. Jacqueline d'Arros Hughes, Director General, ICRISAT, Hyderabad was the Chief Guest. Dr. Mangala Rai, Former Secretary DARE and Director General, ICAR was the chairman of the program. In her online address, the Chief Guest, Dr. Jacqueline, highlighted different issues of gender biases, gender inequality and inequity,and gender discrimination in agriculture, agricultural research, and also in society

Dr. Mahi Pal delivering a special lecture on the occasion of world water day



Glimpses of the International Women's Day celebration

Sample collection for COVID-19 RT-PCR testing

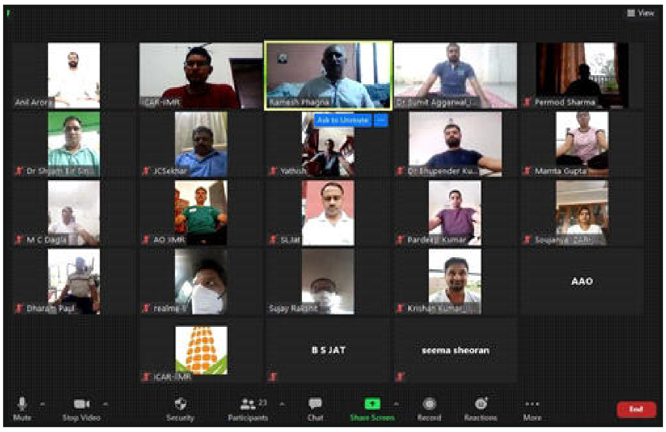
in general. On the occasion, three women entrepreneurs, viz., Smt. Amrita Devi of Somra, Khagaria, Bihar, Smt. Kiran Devi of Purnia, Bihar and Smt. Basanti Toppa of Modna, Nadia, West Bengal were felicitated for their outstanding contributions in the promotion of aggregation and marketing of maize through FPCs, value addition of maize, and hybrid maize seed production, respectively. Dr. Mangala Rai emphasized the significant role of women in our society, particularly in agriculture, and also highlighted the need for women's empowerment in today's world. The program was attended by more than 89 participants from across the country.

COVID-19 Mass Testing Drive

The institute conducted a free RT-PCR mass testing drive for COVID19 for all temporary and permanent employees including the labourers on April 26 and June 8, 2021. Testing done at ICAR-IIMR Ludhiana headquarter. A total of 87 and 77 people were tested on April 26 andJune8, 2021, respectively.

International Yoga Day

International Yoga Day was celebrated virtually by all the staff members on June 21, 2021 in their homes amid the COVID-19 pandemic. The theme of the same was "Yoga for Wellness". On this occasion, Director encouraged the staff to strengthen their body, mind, and soul with the goodness of yoga for abetter life. Mr. Anil Arora was the yoga master on the occasion.



The staff of ICAR-IIMR practicing Yoga online

ICAR-IIMR staff taking the pledge on Vigilance Awareness Week

Vigilance Awareness Week

ICAR-IIMR observed Vigilance Awareness Week on October 26- November 1, 2021. Dr.Pardeep Kumar, Vigilance Officer of the institute provided an integrity pledge in Hindi to all the staff of the institute on October 27, 2021. Quiz and debate competition in the line of Vigilance Awareness Week was also organized at the institute level.

Constitution Day Celebration

Constitution Day was celebrated at ICAR-IIMR, Ludhiana and its regional centres on November 26, 2021. The staff joined through Web Portal and viewed the program organized by the Government of India on the occasion of Constitution Day and took part in the reading of the preamble led by the President of India.

Rashtriya Ekta Diwas

Rashtriya Ekta Diwas pledge was taken online by the staff of ICAR-IIMR, Ludhiana and its regional centre on October 31, 2021. Dr. Sujay Rakshit, Director,

ICAR-IIMR staff taking the pledge on Constitution Day

Rashtriya Ekta Diwas celebration online by ICAR-IIMR


Glimpses of Farmer's Day Celebration

Celebration of World Soil Day at ICAR-IIMR Headquarters and its Regional stations

ICAR-IIMR administered the pledge to commemorate the birth anniversary of Sardar Vallabh Bhai Patel, the Architect of the national integration of independent India. A special lecture was organized on the occasion of National Unity Day by Prof Ashok K Sarial, former Vice-Chancellor, CSKHPKV, Palampur.

Kisan Diwas

CAR-IIMR Ludhiana and its regional centres celebrated Kisan Diwas on December 23, 2021. A special lecture on Swachhta by Director ICAR-CIPHET, Ludhiana was delivered, which was attended by all the scientific, administrative and technical staff. Farmers were also invited for sharing experiences on Swachhata initiatives. The farmers were also informed about the various developmental programs of the Government. A total 30 farmers were involved in the program in RMR&SPC, Begusarai Campus.

World Soil Day

World Soil Day was celebrated at ICAR-IIMR, Ludhiana and its regional stations on December 5, 2021. ICAR-IIMR celebrated World Soil Day among the farmers in Ladhowal. The farmers were educated about the genesis of World Soil Day and its significant role in the food security of the nation. The farmers were encouraged to save the soil from degradation happening due to excessive and unjustified use of fertilizers and insecticides, and emphasized the importance of the soil in maintaining healthy ecosystems and human well-being by addressing the growing challenges in soil management, fighting soil biodiversity loss and increasing soil awareness.

Inauguration of Seed Store and Implement Shed

Dr. T.R. Sharma, Deputy Director General (Crop Science), Indian Council of Agricultural Research, inaugurated the Seed store and Implement Shed of ICAR-IIMR at Ladhowal, Ludhiana in the presence of Dr. N. Kotwaliwale, Director, ICAR-CIPHET and Dr. Sujay Rakshit, Director, ICAR-IIMR. DDG(CS) also visited experimented plots, upcoming


Glimpses of Honourable DDG's visit at ICAR-IIMR, Ludhiana

infrastructure, laboratories, and the ABI centre. DDG(CS) appraised the scientists about their research work. He appreciated the stupendous efforts being made by the staff and the able leadership of the Director.

National Campaign on the theme "Agriculture and Environment: the Citizen Face" under Azadi Ka Amrit Mahotsav

ICAR-IIMR, Ludhiana and its regional centres organized a campaign on the theme"Agriculture and Environment: the Citizen Face" November 26, 2021, by interacting with School children and organizing various programs as part of the series of events under "Azadi Ka Amrit Mahotsav". Dr. Sumit Agarwal, Scientist, ICAR-IIMR gave an orientation lecture to school children about the opportunities in the agriculture sector for entrepreneurship and employment at the Government Senior Secondary Smart School, PAU Ludhiana. Besides this, a quiz competition and debate on the mentioned theme were also organized. In RMR&SPC, Begusarai, Dr. S.B. Singh, Principal Scientist, gave a lecture, highlighting various opportunities in agriculture education and research, and encouraging the student to pursue careers in agriculture and become an entrepreneur. The program was held at Higher Secondary School, Kushmahaut village, Begusarai, and was participated by nearly 225 school students of class 6th to 12th and ten teachers. A debate on "Agriculture and Environment" was also organized in which five students participated the debate. The students were motivated by providing them a folder kit containing agriculture and maize literature. Altogether, 276 students participated in the program. Scientists from ICAR-IIMR also interacted with students and answered questions and queries of students about agriculture education.

Parthenium Eradication Campaign

Parthenium eradication campaign was observed at Ladhowal Farm, ICAR-IIMR, Ludhiana and RMR &SPC, Begusarai on August 16-22, 2021. One of the major events was organized at village Tulsipur and


Glimpses of the National Campaign

Parthenium eradication campaign at ICAR-IIMR

RMR&SPC farm Kushmahaut on August19, 2021 to aware farmers about Parthenium weed. Parthenium is an alien weed that entered into India along with wheat imported from the USA in the early 1950s. The farmers were awarded by Dr. S.B. Singh (Principal Scientist) about the threat posed by this weed to living beings including humans and animals. This weed is notorious in causing many diseases likes kin allergy, hay fever, breathing problems in human beings and animals, besides reducing agricultural productivity loss of biodiversity. The main motive of this program was to educate the farmers and general public about the harmful effects of Parthenium and ways of its management. All the staff have taken up two hours voluntary service in the irrespective blocks for uprooting parthenium weed.

National Campaign on 'Food and Nutrition for Farmers'

In line with the "Azadi Ka Amrit Mahotsav" celebration series and under the aegis of ICAR's National level campaign for the month of August 2021-"Food and Nutrition for Farmers" a Gosthi, field visit, and an exhibition was organized jointly by Winter Nursery Centre of ICAR-IIMR and Maize Research Centre of Professor Telangana State Agricultural University (PJTSAU) on August 26, 2021. A total of 20 farmers from the Burjugadda Thanda village of Ranga Reddy district of Telangana participated in the program. The farmers thanked Dr. J.C.Sekhar, In-charge, WNC, and the team comprising of Dr. N. Sunil, Dr. P.L. Soujanya, Dr.Yathish KR fromICAR-IIMR and Dr.Bhadra and Dr.K. Vanisree from PJTSAU for organizing outreach this programs exhibition and Gosthis under the "Food and Nutrition for Farmers" campaign by ICAR.

Farmers field visit under 'Food for Nutrition' Campaign

An awareness programme on the topic 'Different nutritious food the products of maize for human diet' (मानव आहारहते मक्का के ववन्न पौ वक खाद्य उत्पाद) was organized at, Regional Maize Research and Seed Production Centre (ICAR-IIMR) Begusarai on August 26, 2021. A total of 67 farmers of village

Participants during the awareness program

Campaignon Nutri-garden and tree plantation

Kushmahaut and nearby villages participated in the program. Dr. S.B.Singh (Principal Scientist) delivered lecture and made the participants aware about the nutritious food products of maize for the human diet. He also talked about many local food products and processed food that are being made by maize like Ladoo, Halwa, Kheer, Namakpara, Bread, Biscuits, Cake, Muffin, etc. He emphasized the benefits of QPM maize for human consumption.

Campaign on Nutri-garden and TreePlantation

A Campaign on Nutri-garden and Tree plantation on September 17, 2021, was organized by ICAR-IIMR and its regional centers. ICAR-IIMR Ludhiana has undertaken the plantation drive on this occasion on its Ladhowal Farm. RMR & SPC, Begusarai have arranged the live telecast of the programme for 50 farmers and 70 school girls. A lecture was organized at RMR &SPC for enhancing nutrition. Lunch was arranged for school girls for enhancing nutrition and for encouraging millets in their daily diet.

Interaction Meeting with Secretary, DARE & DG, ICAR

Director and scientists of ICAR-IIMR took part in the Interaction Meeting of ICAR Scientists with Secretary, DARE & DG, ICAR on October 28, 2021. Various scientific, administrative, and technical issues were discussed at the meeting.

Live telecast of the Interaction meeting


Live telecast of the program of Hon'ble Prime Minister

Live telecast of the program of Hon'ble Prime Minister

ICAR-IIMR, Ludhiana, and its regional centres live telecasted the program of Hon'ble Prime Minister, where he dedicated 35 crop varieties to the nation on September 28, 2021 and the new campus of "National Institute of Biotic Stress Management, Raipur", and also conferred Clean Green Campus Award" to the institutes/universities, besides launching the 'Mass Awareness Campaign for Large-Scale Dissemination of Climate Resilient Technologies and Methods'. The program was attended by all the staff of the institute. Participants imbibed the spirit of cleanliness when they saw the "Clean Green Campus Award" to the institutes /universities. The participants enthusiastically listened to the issues raised by the Prime Minister regarding Climate Change under the 'Mass Awareness Campaign for Large-Scale Dissemination of Climate Resilient Technologies and Methods'.

Workshops/Meetings

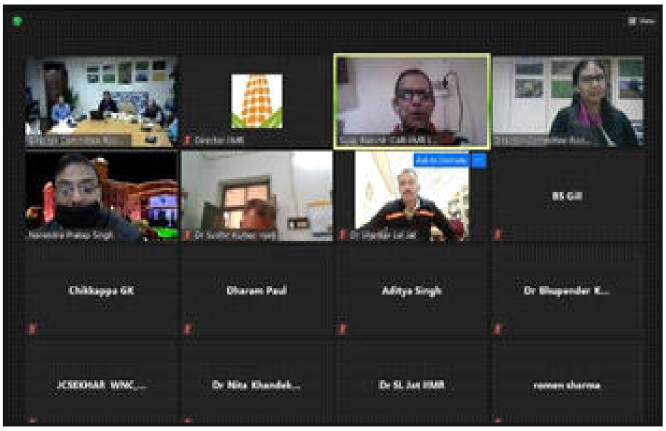
ICAR-Industry Meet on Aflatoxin

Director and staff of ICAR-IIMR attended the ICAR-Industry Meet on 'Aflatoxin management in food and feed: Challenges and opportunities' on January 4, 2021 organized by ICAR-IARI, which was chaired by the Secretary, DARE & DG, ICAR. The meeting was attended by 62 participants from the industry as well as public research organizations. Various challenges faced by the industry were discussed and researchable issues were noted.

Meeting on" Preliminary discussion on diversification of agriculture in Punjab and Haryana"

An online meeting on diversification of agriculture in Punjab andHaryana was hosted and chaired by Dr. Sujay Rakshit, Director, ICAR- IIMR on January 16,2020.ThemeetingwasattendedbyDr.N.P.Singh,Director,ICAR-IIPR,Dr.P.K.Rai,ICAR-DRMR, Dr. Nita Khadelkar, ICAR-IISR, and researchers of these institutes to discuss the policy framework for


ICAR-Industry Meet on Aflatoxin Management in food and feed



Online meeting on diversification of agriculture in Punjab and Haryana

diversification and intensification of the cropping system in Punjab and Haryana with maize, soybean, mustard, and pulses crop.

Meeting on Potential yield realization of maize-based cropping systems in Punjab and Haryana

Under Chairmanship of Director, ICAR-IIMR, a meeting on "Potential yield realization of maize-based cropping systems in Punjab and Haryana" with CIMMYT was held on March 3, 2021. They discussed the roadmap for introducing the maize-based cropping systems in the states of Haryana and Punjab.

Glimpses of the Meeting on Potential Yield Realization

ICAR-IIMR and ICAR NEH Meeting

A meeting was held on May 6, 2021, to discuss the roadmap of popularizing the biofortified varieties in the North-eastern region of India through the DBT-KISAN Project. Director ICAR-IIMR and ICAR-NEH chaired the meeting and suggests ever always to collaborate to implement the project in the remote corners of the NEH Region. Scientists from the two institutes attended the meeting with great zeal and enthusiasm. A roadmap for introducing maize in the North-Eastern Region was discussed and a tentative action plan was framed for the coming seasons.

IIMR-CIMMYT Meeting for Kharif Maize Demonstrations

An online meeting on May 11, 2021 was held to discuss the *Kharif* Maize Demonstrations between ICAR-IIMR and CIMMYT. A detailed presentation

Glimpses of the Meeting between ICAR-IIMR & ICAR-NEH

Glimpses of the meeting between ICAR-IIMR and CIMMYT

was made by Dr. S.L. Jat to discuss the demonstrations in several places of Punjab and Haryana. Officials from ICAR,CGIAR,KVKs, SAUs and State Governments attended the meeting.

National Thematic Workshop on "Diversification of Crops"

A National Thematic Workshop on "Diversification of Crops", was held at Indian School of Business, Mohali on December 9th, 2021. This was organized by the Department of Agriculture and Farmers Welfare, Punjab under the aegis of Ministry of Agriculture, Government of India. During the workshop, seven sessions on different topics related to crop diversification were organized, which were conducted in parallel in different halls. Dr. Sujay Rakshit (Director, ICAR-IIMR) informed the panel and audience about the importance of maize as an alternative to paddy in Punjab. He also highlighted the potential of Kharif maize in this regard. Dr. Alla Singh, Scientist, ICAR-IIMR attended two sessions, viz., 'Need for Diversification of Crops', and 'Farmer Producer Organization, Farmer Cooperatives and Other stake Holders in Crop Diversification'. In the session 'Need for Diversification of Crops', the role of cotton, maize and soil health parameters for supporting crop diversification was informed by the panelists.

Glimpses of the National Workshop at Mohali

Training

Training Programme on Host plant Resistance against FAW in Maize

An online training program on "Host plant resistance against FAW in maize" was organized on March 16, 2021 under NASF project. Special lectures were given on"Mass production techniques of FAW" and "Screening techniques and breeding for resistance against FAW" by Dr. Jagdish Jabba, Scientist, TICM (Research Programme), Asia, ICRISAT, and Dr. B.M.Prasanna, Director, CIMMYT, Global Maize Programme. More than 100 participants from different institutes participated in this online training program.

Awareness and Training Programme on FAW

A virtual training was organized on "Awareness training program on fall armyworm management on Maize in Nagaland"on May 24, 2021. The training coordinators were Dr. J.C. Sekhar, ICAR-IIMR, and Dr. Rajesh Dubey, National Operations and Program Officer, FAO India. The inaugural session was graced by Mr. Tomio Shichiri, FAO Representative in India, and Dr. N. Sathyanarayana, Joint Director, Directorate of Plant Protection Quarantine and Storage, Faridabad. Dr. SujayRakshit, Director, ICAR-IIMR, Ludhiana chaired the program. The training was attended by 52 participants from

A glimpse of an Awareness training program on FAW management on Maize in Nagaland

Agriculture Technology Members, Scientists of KVK, Agriculture officers from Nagaland, and AICRP Entomologists. The training lectures covered IPM for FAW on maize in the NEH region, Quick action strategy for FAW management in Nagaland, Agroecological options for FAW management in Nagaland, and CIB&RC recommendations and strengthening monitoring and surveillance for early detection using the FAWMES app. The training emphasized the need to create awareness on early monitoring of the fall armyworm incidence on maize and to advise the farmers to initiate timely management techniques in a sustainable manner using the FAWESapp.

Training on Hybrid Seed production

RMR&SPC, Begusarai conducted a training program on Maize Hybrid Seed under ICAR-Seed Projecton Enhancing farmers' Income through hybrid maize seed production. A total of 40 farmers attended the meeting.

Agribusiness Incubator program

Maize-based value-added products like ready-to-eat (RTE) food, ice cream, maize milk fordietary diversification provides a good opportunity for agri-business to infuse healthy food in India. It also has good business opportunities for export. ICAR-IIMR guided Mr. Dharambir Kamboj, Agri-Business Incubatee for making these products and indigenous machine for wet maize shelling, milk extractor, etc.

Glimpses of the Training Program on Hybrid Seed Production


यमुनानगर केसरी

'मक्के से बने विभिन्न व्यंजनों से किसानों की आय बढ़ेगी : काम्बोज'

'प्रदेश में हर तरफ हाहाकार मची'

Glimpses of the Agribusiness Incubator Program towards making value addition in maize a success. A maize food festival to celebrate success in maize value-added products and machines was held at Damla on 31 July 2021.

Visit

Exposure visit of students of LPU to Winter Nursery centre, ICAR-IIMR on November 27,2021

Three students from Lovely Professional University (LPU) Jalandhar, Punjab-144411 visited the Winter Nursery centre, ICAR-IIMR on November 27, 2021. Dr. Yathish K.R. and Dr. N.Sunil briefed the students about the various activities and facilities of Winter Nursery Centre,ICAR-IIMR, Hyderabad, including germplasm maintenance, breeding activities, AICRP coordination, FAW management. A field visit was also organized for the students.

Student Visit at WNC, Hyderabad

Visit of Honorable DDG(Crop Sciences) at ICAR-IIMR, Ladhowal Farm

Dr. T.R. Sharma, Deputy Director General (Crop Science), Indian Council of AgriculturalResearch, inaugurated the Seed store and Implement Shed of ICAR-IIMR at Ladhowal, Ludhiana in the presence of Dr. N. Kotwaliwale, Director, ICAR-CIPHET and Dr. Sujay Rakshit, Director, ICAR-IIMR. DDG (CS) also visited experimented plots, upcoming infrastructure, laboratories, and the ABI centre. He appreciated the stupendous efforts being made by the staff and the able leadership of the Director.

Visit of Director, NBPGR and ICAR Governing Body Members at RMR&SPC, Begusarai

Director ICAR -IIMR, Director ICAR-NBPGR, ICAR GB members, and scientists of ICAR-IIMR visited the maize field at ICAR- IIMR RMR&SPC, Begusarai on February 3, 2021. Nearly 12000 maize germplasm from National Gene Bank are under characterization, evaluation, and multiplication in the field. The experts applauded the efforts of IIMR for taking a step in the conservation of maize germplasm on such a large scale.

Lecture series organized by the ICAR-IIMR as part of the "Azadi Ka Amrit Mahotsav"lectureseries

Azadi Ka Amrit Mahotsav is an initiative of the Government of India to celebrate and commemorate 75 years of progressive India and the glorious history of its people, culture and achievements. This Mahotsav is dedicated to the people of India who have not only been instrumental in bringing India thus far in its evolutionary journey butal so hold within them the power and potential to enable Honourable Prime Minister Sh. Narendra Modi Ji's vision of activating India 2.0, fuelled by the spirit of Atmanirbhar Bharat. Azadi ka Amrit Mahotsav isan embodiment of all that is progressive about India's

Visit of DDG (Crop Sciences) at Ladhowal Farm


Visit of Director (NBPGR) and ICAR GB members at Begusarai Farm

socio-cultural, political and economic identity. The official journey of "Azadi ka Amrit Mahotsav" commenced on March 12, 2021which started a 75-week countdown to our 75th anniversary of Independence and will end post a year on August 15, 2023. To commemorate this occasion IAR-IIMR planned various activities lectures, webinars, field days, and literary competitions were planned and celebrated to commemorate this occasion.

Lectures organized as part of the "Azadi Ka Amrit Mahotsav" in 2021

S.No.	Topic	Delivered by (Name with designation)	Date and place	Facebook/YouTube watch (No.)
1.	National Science Day lecture "Science, Technology & Innovation: a perspective from Genomics-assisted breeding"	Dr. Rajeev K Varshney, Research Program Director -Genetic gains, ICRISAT, Hyderabad	February 28, 2021, (online)	2904
2.	International Women's Day, Special lecture	Dr. Jacqueline d' Arros Hughes, DG, ICRISAT, Hyderabad	March 8, 2021 (online)	2285
3.	The role of Panchayats in Conservation, Management and Budgeting of Water in India	Dr. Mahi Pal, IES, former Director, MoRD, GoI	Mar 22,2021 (online)	507
4.	Commercial Plant Breeding-Perspectives	Dr. Selvarangam Venkatesh, Corteva Agriscience	July 31, 2021 (online)	502
5.	Application of Simulation and Geospatial tools in Pest Management	Dr. Subhash Chander, Director, ICAR-NCIPM	August 7, 2021 (online)	360
6.	Global Exchange of Crop Germplasm: Phytosanitary Regulations and Procedures with reference to India	Dr. Anitha Kodaru, Officer in charge, ICAR-NBPGR, Regional Centre, Hyderabad	August 21, 2021 (online)	826

S.No.	Topic	Delivered by (Name with designation)	Date and place	Facebook/YouTube watch (No.)
7.	Aspergilli: Advances and Challenges	Dr. P Usha Sarma, CSIR Emeritus, Honorary scientist, I CAR-IARI, New Delhi	August 23, 2021 (online)	732
8.	Maize processing and value addition-key for maize growth as part of "ICAR National Level Campaign on"Food and Nutrition for Farmers"	Dr.D. Shobha, Assistant Prof. AICRP (PHET),UAS GKVK, Bangalore	August 26, 2021 (online)	1105
9.	Agri-food System:Current Challenges and Cross-Industry Technical Solutions	Dr. V. Praveen Rao, Hon'ble Vice-Chancellor, PJTSAU	October 5, 2021 (online)	792
10.	National Unity Day lecture on"Agriculture and national unity: where we are and way ahead"	Prof Ashok K Sarial, former Vice-Chancellor, CSKHPKV, Palampur	October 31, 2021 (online)	615

TRAINING AND CAPACITY BUILDING

8

A. Training and Capacity Building of ICAR Employees

A1. Under approved HRD Annual Training Plan (ATP) 2021

A1.1: Scientific

Name of the Scientist	Name of the training program attended	Venue	Date
Dr. S. K. Aggarwal	Diversity analysis and molecular marker development for identification and characterization of plant pathogens	ICAR-IIWBR, Karnal	March 15 to 22, 2021
Dr. A K Singh	Conservation agriculture	BISA, Ludhiana	March 22 to 27, 2021
Mr. Sameer Kumar Rai	Farm management	BISA, Ludhiana	March 25 to 27, 2021

A1.1: Technical

Name of the Stafff	Name of the training program attended	Venue	Date

A2.1: Others

A2.1: Scientific

Name of the Scientist	Name of the training program attended	Venue	Date
Dr. S. K. Aggarwal	Diversity analysis and molecular marker development for identification and characterization of plant pathogens	ICAR-IIWBR, Karnal	March 15 to 22, 2021
Yathish K. R	Plant Quarantine Procedures for Import and Export	NIPHM, Hyderabad	February 8-12, 2021
Dr. S. B. Singh	Attended Early Career Maize Breeding Course, organized by CIMMYT, Mexico	Online mode conducted by CIMMYT, Mexico	Attended six days (3^{rd}, 10^{th}, 13^{th}, 16^{th}, 21^{st}, and 24^{th} September 2021)
Dr. S. B. Singh	Attended a Training on Generic Online Training Course in Cyber Security	Centre for Development of Advanced Computing, Ministry of Electronics and Information Technology (MeitY), Government of India	January 5, 2021

Name of the Scientist	Name of the training program attended	Venue	Date
Chikkappa G. Karjagi	Analysis of Multi-Location Experiments	Online mode (conducted by ICAR-NAARM, Hyderabad)	October 28 to November 01, 2021
Pardeep Kumar	Attended Early Career Maize Breeding Course, organized by CIMMYT, Mexico	Online mode conducted by CIMMYT, Mexico	Attended six days (3rd, 10th, 13th, 16th, 21st, and 24th September 2021)
B S Jat	Attended Early Career Maize Breeding Course, organized by CIMMYT, Mexico	Online mode conducted by CIMMYT, Mexico	Attended six days (3rd, 10th, 13th, 16th, 21st, and 24th September 2021)

A2.1: Training conducted

Name of the Scientist	Name of the training program attended	Institute/Organizations Involved	Date
Drs J.C. Sekhar, P.L Soujanya, Suby, S.B and S.L Jat	Awareness training program on fall armyworm management on Maize in Nagaland	ICAR-IIMR, FAO India and DPPQ&S	May 24, 2021
Drs J.C. Sekhar, P.L Soujanya, Suby S.B, Yathish K.R, Priyajoy Kar and S.L Jat	TCP/3709/IND/FAW-National Training-cum-webinar on"On-farm and mass production protocols of bioagents and microbial agents for Fall armyworm management" for PZ	FAO India, ICAR-IIMR and DPPQ&S	September 28-30,2021
Drs J.C. Sekhar, P.L Soujanya, Suby S.B, Yathish K.R, Priyajoy Kar and S.L Jat	TCP/3709/IND/FAW - National Training-cum-webinar on"On-farm and mass production protocols of bioagents and microbial agents for Fall armyworm management" for CWZ	FAO India, ICAR-IIMR and DPPQ&S	October 6-8, 2021
Drs J.C. Sekhar, P.L Soujanya, Suby S.B, Romen Sharma, Yathish K.R. Priyajoy Kar and S.L Jat	TCP/3709/IND/FAW - National Training-cum-webinar on"On-farm and mass production protocols of bioagents and microbial agents for Fall armyworm management" for NWPZ	FAO India, ICAR-IIMR and DPPQ&S	October 25-27, 2021
Drs J.C. Sekhar, P.L Soujanya, Suby S.B, Romen Sharma, Yathish K.R. Priyajoy Kar, S.L Jat and S.B. Singh	TCP/3709/IND/FAW - National Training-cum-webinar on"On-farm and mass production protocols of bioagents and microbial agents for Fall armyworm management" for NEPZ	FAO India, ICAR-IIMR and DPPQ&S	November 15-17,2021
Drs J.C. Sekhar, P.L Soujanya, Suby S.B, Yathish K.R, Priyajoy Kar and S.L Jat	TCP/3709/IND/FAW - National Training-cum-webinar on"On-farm and mass production protocols of bioagents and microbial agents for Fall armyworm management" for NHZ	FAO India, ICAR-IIMR and DPPQ&S	November 23-25,2021

Name of the Scientist	Name of the training program attended	Institute/Organizations Involved	Date
Krishan Kumar	Summer training programme on "Hands-on training on maize tissue culture and molecular techniques"	ICAR-IIMR, Delhi Unit	31st May to 9th July 2021 (40 days)
Drs J.C. Sekhar, Yathish K.R, Sunil N. Basavraj Jesurajan and Vanishree	Farmer Field School on Sustainable Management of Fall Armyworm in Maize	FAO India, ICAR- IIMR and NIPHM	23rd Dec, 2021
Dr. S. B. Singh	A farmer training programme on Scientific cultivation of Maize and options for enhancing farmer's (मक्का की वैज्ञानिक खेती व कृषक आय वृद्धि हेतु नए विकल्प)	RPR&SPC, Begusarai	March 16-18, 2021
Dr. S. B. Singh	Farmer training programme under ICAR Seed project on Enhancing farmer income through hybrid maize seed production (संकर मक्का बीज उत्पादन द्वारा कृषक आय वृद्धि)	RPR&SPC, Begusarai	March 09, 2021
Dr. S. B. Singh	A field day cum training programme under ICAR Seed project on Scientific maize cultivation its seed production and awareness about FAW (मक्का की वैज्ञानिक खेती इसका बीज उत्पादन व फॉल आर्मीवर्म कीट के प्रति जागरुकता)	RPR&SPC, Begusarai	March 20, 2021
Dr. S. B. Singh	A training programme under DBT project on "Cultivation practices of Biofortified maize hybrids and its seed production" for collaborative partner scientists/project staff and farmers.	RMR&SPC, Begusarai	September 24, 2021

C. Seminar/Symposium/Conferences Organized and attended by employees

C1. Seminar/Symposium/Conferences/ Organized:

Name of the Scientist	Name of the training program attended	Venue	Date
Drs J.C. Sekhar, Yathish K.R, Sunil N. Basavraj, N. Lavanya and Jesurajan	An Interactive Workshop on 'Sustainable management of fall armyworm in maize' Organized under TCP/3709/IND(E) by FAO India, DPPQ&s, NIPHM and ICAR-IIMR	NIPHM, Hyderabad	December 21-22,2021

Name of the Scientist	Name of the training program attended	Venue	Date
Dr. B.S.Jat	'राजभाषा नियम व अधिनियम' विषय पर एक दिवसीय हिंदी कार्यशाला	ICAR-IIMR,Ludhiana	25 जून, 2021
Dr. B.S.Jat	'वर्तमान समय में हिंदी भाषा की प्रांसगिकता' विषय पर एक दिवसीय हिंदी कार्यशाला	ICAR-IIMR,Ludhiana	30 सितम्बर, 2021
Dr. B.S.Jat	'वर्तमान समय में हिंदी भाषा की प्रांसगिकता' विषय पर एक दिवसीय हिंदी कार्यशाला	ICAR-IIMR,Ludhiana	30 दिसम्बर, 2021

C2. Participation in Seminar/Symposium/Conferences/Workshop/Important meeting

Name of the Scientist	Name of the Conference/ Seminar/ Workshop/Meeting Attended	Venue	Date
P. Lakshmi Soujanya	Recent Advances in Crop Protection including IPM and Environmental Sciences from GLP Perspective	Vasanthraj David Foundation, Chennai, Tamil Nadu	17th October 2021
	International Conference on "Global Perspectives in Crop Protection for Food Security"	TNAU, Coimbatore, Tamil Nadu	8th -10th December, 2021
Krishan Kumar	International Symposium on "Advances in plant Biotechnology and genome editing (APBGE-2021)"	ICAR-Indian Institute of Agricultural Bio-technology, Ranchi-834010, India In association with Plant Tissue Culture Association-India (PTCA-I)	8-10 April 2021
	International Symposium on 'Plant Biotechnology towards improving agri-food industry and healthcare products (ISPB-2021)	BIT Mesra, Ranchi	27-30th October 2021
	7th International Conference on Agricultural and Biological Sciences (ABS 2021) held virtually	Bohai University, China	9-11th August 2021
	National Webinar on "GENOME EDITING IN AGRICULTURE: CURRENT STATUS AND PROSPECTS"	Department of Agricultural Biotechnology, Assam Agricultural University, Jorhat, Assam, India	25th March, 2021
	National Webinar on "Gene Editing Research in Agriculture: Key Initiatives in India"	Tata Institute for Genetics and Society in association with Biotech Consortium India Limited	17th Feb, 2021

Name of the Scientist	Name of the Conference/ Seminar/ Workshop/Meeting Attended	Venue	Date
Dr Shankar Lal Jat	5th International Agronomy Congress	Hyderabad, India	23rd to 27th November 2021
Yathish K.R	3rd International Conference (Hybrid Mode) on Food, Agriculture and Innovations (ICFAI)	Ranchi, Jharkhand	24 - 26th Dec, 2021
	Sustainable management of birds in agri-horticultural ecosystem	NIPHM, Hyderabad	30th Jun, 2021
J.C.Sekhar	Innovations for transformation by Dr Krishna Ella	ICAR-NAARM	1st Sept, 2021
	ICAR-Industry Meet	ICAR-IARI	January 04, 2021
	Biocontrol WS 2: Rearing of Parasitoids and Predators for FAW Control.	Grow Asia	January 14, 2021
	Preliminary Discussion on Diversification of Agriculture in Punjab	ICAR-IIMR	January 16, 2021
	Regional consultation meeting on Fall Armyworm - the status, challenges and experiences among the SAARC Member States	SAARC Bangladesh	January 27-28, 2021
	FAO "Update and Planning - FAW Global Action in India"	FAO Rome	February 22, 2021
	"Impact of Climate Change and Invasive Alien Species on Agriculture"	Department of Entomology, S.V. Agricultural College, Tirupati, ANGRAU	February 26, 2021
	Biocontrol WS 4: Biopesticide Efficacy Part 1: Why are biopesticide trials so difficult?	Grow Asia	March 4, 2021
	TCP/IND/3709: FAW trainings - Review meeting, FAO India, DPPQ&S	FAO India	March 15, 2021
J.C.Sekhar, Yathish.K.R	Online training on "Host plant resistance against FAW in maize" under NASF Project	PI NASF FAW Project	March 16, 2021
J.C.Sekhar	Fall Armyworm Global Action / India and -brief update on FAW in India and TCP activities, FAO Rome	FAO Rome	March 18, 2021

Name of the Scientist	Name of the Conference/ Seminar/ Workshop/Meeting Attended	Venue	Date
J.C.Sekhar	Biocontrol WS 5: Farmer acceptance of biocontrol approaches and scale-up issues	Grow Asia	March 18, 2021
	FAO FAW webinar on Host Plant Resistance	FAO Rome	March 23, 2021
	WEBINAR 4, A ONE HEALTH APPROACH, organized by	Event brite	March 31, 2021
	First Geo-Zone Coordination Meeting for Implementing the FAO Global Action on Fall Armyworm Control in Northeast Asia Region	FAO Rome	March 31, 2021
	First Geo-Zone Coordination Meeting for Implementing the FAO Global Action on Fall Armyworm Control in South Asia Region	FAO Rome	April 13,2021
	7th INDIA MAIZE SUMMIT 2021 Virtual Event	FICCI, New Delhi	April 15-16,2021
	Discussion on Frontline demon-strations of biofortified Maize varieties - IIMR and CIL	ICAR -IIMR	April 22,2021
	International Webinar on "Is gene editing a myth or reality? CRISPR CAS9 applications in Agriculture	Plant Protection Association of India and PJTSAU	April 22,2021
	ASEAN FAW Action Plan Session 7: Design tips for conservation biocontrol studies and programmes	Grow Asia	April 22, 2021
	Meeting to discuss the GA FAW India work plan for India by FAO	FAOR India	April 23, 2021
	ASEAN FAW Action Plan FAW Resistance Management Plan Workshop	Grow Asia	April 27, 2021
	Zoom meeting to discuss ICRISAT, Hyderabad-IIMR, Ludhiana collaboration on AI based project	ICAR-IIMR	May 5, 2021
	64th Annual Maize Workshop with PAMC	ICAR-IIMR	May 17-19,2021

Name of the Scientist	Name of the Conference/ Seminar/ Workshop/Meeting Attended	Venue	Date
J.C.Sekhar	Webinar on" Promise of biological control for sustainable pest management" by Dr ChandishBallal	Dept of Entomology, MPUAT Udaipur, Rajasthan	May 17, 2021
	FAO India Meetings the GA work plan for FAW management	FAO India	June 4, 2021
	AINP on emerging pests	DDG CS ICAR	June 10, 021
	64th Annual Maize Workshop	ICAR-IIMR	June 17, 2021
J.C.Sekhar, Yathish.K.R	Panel discussion on "Prospect of Bt transgenic at BRL 1 or 2 to be tested against their efficacy against FAW" Chaired by DDG CS	ICAR-IIMR	June 17, 2021
J.C.Sekhar	National webinar on "Sustainable management of birds in agri-horticultural ecosystem"	NIPHM	June 30, 2021
J.C.Sekhar, Yathish.K. R	International webinar on "Desert locust *Schistocrecagregaria* (Forskal)- International scenario and a potential threat to india"	NIPHM	July 2, 2021
J.C.Sekhar	Pre-workshop review meeting of AICRP Biocontrol	ICAR-NBAIR	July 10, 2021
	Virtual FAO-Asia-NENA: Invitation to Mid-Year meeting with the GA Demonstration countries on fall armyworm	FAO Rome	July 2, 2021
	AICRP-BC Annual Review Meet	ICAR-NBAIR	July 14-15,2021.
	Virtual meeting with FAO India on updating GA work plan on Fall armyworm	FAO India	July 15, 2021
J.C.Sekhar, Yathish. K. R	Webinar on "Remote sensing and drone applications in Agriculture-research opportunities"	PJTSAU, Hyderabad	July 17, 2021
J.C.Sekhar	CISCO Webex meeting on Post graduate student's synopsis presentation	PG Dean, PJTSAU, Hyderabad	July 19, 2021
	30th BP Pal Memorial lecture "Resilient Agriculture: The Pivot for Sustainable Development" Dr. G. R. Chintala Chairman, NABARD, Mumbai	Division of Genetics and Plant Breeding IARI, New Delhi	July 20, 2021

Name of the Scientist	Name of the Conference/ Seminar/ Workshop/Meeting Attended	Venue	Date
J.C.Sekhar	Webinar on" Artificial Intelligence for Smart Agriculture "	ICAR Research Complex for Eastern Region, Patna	July 22, 2021
	Expert talk on "Emerging AgriTech towards transforming Indian Agriculture" by Dr V Praveen Rao	ICAR-IIOPR, Pedavegi, Andhra Pradesh	July 23,2021
	AICRP-BC Technical Program	AICRP NBAII	July 24, 2021
	Webinar on "Migration of butterflies in the Western Ghats" by Ashokumar Raj and "Overview of spiders in Mysuru" Dr Abhjith APC	Dept of Zoology, University of Mysuru	July 24, 2021
	Webinar on "Empowering Farmer Decision-Making through Effective Communications" ASEAN FAW Action plan	ASEAN FAW Singapore	July 27, 2021
	Bharat Amrit Mahotsav lecture series ICAR-IIMR" Commercial Plant breeding-Perspectives" Dr S.Venkatesh	ICAR-IIMR	July 31, 2021
J.C.Sekhar, Yathish. K.R	Kosambi International Webinar Series on Plant Genomics	Dept. of Botany, Savitribai Phule Pune University, Pune and NABI, Mohali, India	July 31, 2021
J.C.Sekhar	Azadi ka Amrit Mahotsav lecture series ICAR-IIMR" Application of simulation and geospatial techniques in pest management" Dr. Subhash Chander Director NCIPM	ICAR-IIMR	August 07, 2021
	National Webinar- Integrated Farming System for Sustainable Livelihood and Nutritional Security on 12th August, 2021 at 11:00 AM onward	ICAR- Indian Institute of Farming Systems Research Modipuram, Meerut	Aug 12, 2021
	Azadi ka Amrit Mahotsav National national webinar on: Food and nutrition security: Challenges and opportunities in rainfed areas	Indian society of dryland agriculture and ICAR-CRIDA	August 16, 2021
	Azadi ka Amrut Mahotsav lecture series "Trichoderma: A super star of biopesticide Industry" by Dr H.B.Singh	ICAR-NCIPM	Aug 17, 2021

Name of the Scientist	Name of the Conference/ Seminar/ Workshop/Meeting Attended	Venue	Date
J.C.Sekhar	Azadi ka Amrut Mahotsav lecture series ICAR-IIMR" Global exchange of crop germplasm:Phytosanitary regulations and procedures with reference to India" by Dr K Anitha, Officer in charge, NBPGR Rs Hyderabad	ICAR-IIMR	August 21, 2021
	Azadi ka Amrut Mahotsav lecture series ICAR-IIMR"Aspergilli:advances and challenges" by Dr P. Usha Sharma	ICAR-IIMR	August 23, 2021
	Different programs - Azadi ka Amrut Mahotsav: Food and nutrition for farmers different programs	WNC ICAR-IIMR, MRC PJTSAU	August 26, 2021
	Azadi ka Amrut Mahotsav lecture series ICAR-IIMR" maize and value addition - key for maize growth" by Dr D.Shobha, UAS Bengaluru"	ICAR-IIMR	August 26, 2021
	"National workshop on bridging the yield gaps to enhance food grain production"	TAAS, New Delhi	August 26, 2021
	CHaBits Monthly seminar series "Dealing with pressure: Maize responses to abiotic and biorci stresses" By Dr Kevin Begey, University of Florida, USA	CHaBits	August 26, 2021
	Institute Industry Interface on "Maize Technologies"	Agriinnovate India Limited	August 31, 2021
	ICAR Lecture series #26 Innovations for transformation by Dr. Krishna Ella Chairman & MD of Bharat Biotech	ICAR-NAARM	September 1, 2021
	FAO INDIA TCP/3709/IND/FAW Meeting	FAO INDIA	September 1, 2021
	IQAC Enabled online International Workshop on "Changing Contours in Pest Management"	Dept, Entomology, Annamalai University	September 7-8, 2021
	Brainstorming Workshop on AI and Sensing for Monitoring and Management of Pests and Diseases in Rice	A joint program by Shah Lab, Purdue University, USA and ICAR-IARI, New Delhi, India	September 10-11, 2021

Name of the Scientist	Name of the Conference/ Seminar/ Workshop/Meeting Attended	Venue	Date
J.C.Sekhar	Stakeholder Workshop- Regional Consultation "Validation of Engagement Levels and Ecosystem Mapping for Fall Armyworm in India"	CABI	September 13, 2021
	Run-up for an International year of Millets 2023	ICAR-IIMR and DAC &FW, at Hyderabad	September 18, 2021
	Swasth Bharath:Nutritional challenges with Daal-Roti by Sridevi Annapurna Singh, CSIR-CFTRI	ICAR HQ	September 21, 2021
J.C.Sekhar, Yathish. K.R.	International webinar on biological control: A global sustainable approach for eco-friendly agriculture	NIPHM, Hyderabad	September 24, 2021
J.C.Sekhar	Online training program on" cultivation practices of biofortified maize hybrids and its seed production"	ICAR-IIMR	September 24, 2021
	Mass awareness campaign for large scale dissemination of climate-resilient technologies and methods By Prime Minster	ICAR HQ	September 28, 2021
	Monitoring of AICRP Kharif 2021 trials at ARS Karimnagar	ICAR-IIMR	October 1, 2021
	Meta QTL analysis for abioticand biotic stress in maize by Drs.Seema Sheoran and Mamata Gupta	ICAR-IIMR	October 4, 2021
	Amrit Mahotsav series-Agri Food system:Current challenges and cross-industry technological solutions by Dr. V. Praveen Rao, Vice-Chancellor, PJTSAU	ICAR-IIMR	October 5, 2021
	Dry run meeting for GA FAW control interaction with Women farmer by Dr Mirko	FAO Rome	October 5, 2021
	ICAR-NBAIR webinar series #008: Taxonomic diversity vis a vis functional diversity in insects-back to basics but looking forward by Dr (Smt) Dhriti Banerjee, Director,ZSI, Kolkata	ICAR-NBAIR	October 6, 2021
	Webinar on FAW monitor in Bangladesh used for surveillance and early warning by Dr. Timothy J.Krupnik CIMMYT	CABI	October 11, 2021

Name of the Scientist	Name of the Conference/ Seminar/ Workshop/Meeting Attended	Venue	Date
J.C.Sekhar	An evening with World Food laurates Discussion on Global food and nutrition security to meet SDGs during and after the Covid pandemic by Secretary DARE and DG ICAR	ICAR-IARI	October 16, 2021
	Sensitization workshop on ARMS and monthly reporting in ICAR institutions	ICAR-IISWC	October 18, 2021
	Joint Training and Geo-zone meeting on IPM of the FAW in Northeast Asia and South Asia	FAO Rome	October 18,2021
	Panel Session "Enabling Food and Nutrition Security in Drylands", organized as World Food Prize 2021 International Borlaug Dialogue's virtual side event.	ICRISAT	October 19, 2021
	Novel approaches for simplified detection of plant viruses and virus-like pathogens by Dr.V.K.Barnwal, IARI	PPAI, Hyderabad	October 22, 2021
	FAO IPPC FAW a global threat WEBINAR SERIES 1	FAO Rome	October 22, 2021
	XIII Dr S.Pradham Memorial Lecture by Dr. Z.R Khan ICIPE	Divison of Entomology, IARI	November 8, 2021
	A blight on maize leaves, but a model for fungal cell signaling: pathogenic development of *Cochliobolushetero-strophus* by Dr Benzamin A. Horwitz Israel Institute of Technology	IPS, New Delhi	November 9, 2021
	FAO NSP Fall Armyworm Webinar series	FAO Rome	November 19, 2021
	Technical Meeting: One CGIAR Initiative on Plant health and rapid response for protecting income and food supply. Technical Meeting: One CGIAR Initiative on Plant health and rapid response for protecting income and food supply.	CIMMYT	November 22, 2021
	Effective Farmer Communication for IPM: Part 4	Grow Asia	November 23, 2021

Name of the Scientist	Name of the Conference/ Seminar/ Workshop/Meeting Attended	Venue	Date
J.C.Sekhar	TCP/3709/IND/FAW Training 2- National Training-cum-webinar on "On-farm and mass production protocols of bioagents and microbial agents for Fall armyworm management	FAO India, ICAR-IIMR and DPPQ&S	November 23-25,2021
	Attended the CIMMYT DH facility at ARS Kunigal	CIMMYT & UAS -B	December 03, 2021
	FAO NSP Fall Armyworm all Armyworm, a global threat to prevent (webinar 3: Fall armyworm response and communication).	IPPC and FAO	December 10, 2021
	Participated in WEBINAR on "Entrepreneurship Development through Cultivation of Medicinal and Aromatic Plants"	CHF/CAU/IDP-NAHF.	December 17, 2021
	Participated in WEBINAR on "Plenary lecture by Dr. T. Mohapatra Secretary DARE & DG ICAR on "Gen Next technologies for enhancing, productivity, profitability and resilience of rice farming "	ARRW, Cuttack	December 17, 2021
S.K. Aggarwal	International Webinar on Capacity Building on OECD Certification	ICAR-IARI and IIMR (Online)	8-12, February, 2021
	Two days webinar on NGS for deciphering Host-pathogen Interactions	IPS and BIONIVID (Online)	4-5th February, 2021
	IPS National e-Conference 2021 on Plant Health and Food Security: Challenges and Opportunities	ICAR-IARI New Delhi by IPS (online)	25-27 March, 2021
Dr. Mamta Gupta	International Webinar on "Is gene editing a myth or reality? CRISPR CAS9 applications in Agriculture	Plant Protection Association of India and PJTSAU	April 22, 2021
	Lecture on "GM crop regulations, scope and opportunity using CRISPR-Cas 9 genome editing approach" by Dr. Viany Yadav	Central University of Punjab, Bhatinda	
	64th Annual Maize Workshop	ICAR-IIMR	May 17-19,2021
	Webinar on "Decoding the genomes with big data analytics on 3 June 2021	NIPGR	June 3, 2021

Name of the Scientist	Name of the Conference/ Seminar/ Workshop/Meeting Attended	Venue	Date
Dr. Mamta Gupta	64th Annual Maize Workshop Panel Discussion and Final Session	ICAR-IIMR	June 17, 2021
	Online Hindi Workshop on Official Language Rules and Acts	ICAR-IIMR, Ludhiana	25th Jun, 2021
	Webinar on "Genome editing tools and its applications for targeted plant breeding" was successfully organized on July 21, 2021	Asia-Pacific Association of Agricultural Research Institutions (APAARI) in association with Korea Biosafety Clearing House (KBCH) and Biotech Consortium India Limited (BCIL)	July 21,2021
	Bharat Amrit Mahotsav lecture series ICAR-IIMR" Commercial Plant breeding -Perspectives" Dr. S.Venkatesh	ICAR-IIMR	July 31,2021
	Webinar on "Advancing genome edited plants from lab to land"	APAARI in association with KBCH and BCIL	August 04, 2021
	Azadi ka Amrit Mahotsav lecture series ICAR-IIMR" Application of simulation and geospatial techniques in pest management" Dr. Subhash Chander Director NCIPM	ICAR-IIMR	August 07, 2021
	Webinar on "Enabling policies for genome editing in agriculture	APAARI in association with KBCH and BCIL	August 18, 2021
	Azadi ka Amrut Mahotsav lecture series ICAR-IIMR"Aspergilli: advances and challenges" by Dr P. Usha Sharma	ICAR-IIMR	August 23, 2021
	Azadi ka Amrut Mahotsav lecture series ICAR-IIMR" Global exchange of crop germplasm: Phytosanitory regulations and procdeures with reference to India" by Dr K Anitha, Officer incharge, NBPGR Rs Hyderabad	ICAR-IIMR	August 21, 2021
	Azadi ka Amrut Mahotsav lecture series ICAR-IIMR" maize and value addition - key for maize growth" by Dr D.Shobha, UAS Bengaluru"	ICAR-IIMR	August 26, 2021

Name of the Scientist	Name of the Conference/ Seminar/ Workshop/Meeting Attended	Venue	Date
	Webinar on "Institute Industry Interface on Maize Hybrids & Technologies"	Agriinovative, India	August 31, 2021
	ICAR Lecture series #26 Innovations for transformation by Dr Krishna Ella Chairman & MD of Bharat Biotech	ICAR-NAARM	September 1, 2021
	Nutri cereals Multi stakeholders mega convention 3.0	ICAR-IIMR (Millets), Hyderabad	17th, Sept, 2021
	Online Workshop on CRISPR-Mediated Plant Genome Editing	Under the aegis of DBT Star College Scheme. Department of Botany, Shivaji College University of Delhi, New Delhi and, The Global Plant Council in collaboration with ICAR-National Rice Research Institute, Cuttack and Shree Guru Gobind Singh Tricentenary University, Gurgaon	September 27-October 1, 2021
	. Amrit Mahotsav series-Agri Food system:Current challenges and cross-industry technological solutions by Dr V. Praveen Rao, Vice Chancellor, PJTSAU	ICAR-IIMR	October 5, 2021
	Webinar on "Gene Clusters and Speciation - Unraveling Complex Plant Genomes	Samplix, Denmark	7th September 2021
	Webinar on "Essential Tips for Publishing in High Impact Journals"	Elsevier	September 8, 2021
Dr. Pardeep Kumar	Participated online International Webinar on "Fighting the Hunger using Smart Technology"	ICAR-Indian Institute of Oil Palm Research, Pedavegi, Andhra Pradesh	October 26, 2021
Dr. B.S.Jat	नगर राजभाषा कार्यान्वयन समिति लुधियाना की 80वीं बैठक	नगर राजभाषा कार्यान्वयन समिति, लुधियाना	25 अगस्त, 2021
Dr. B.S.Jat	एक दिवसीय हिंदी कार्यशाला	नगर राजभाषा कार्यान्वयन समिति, लुधियाना	17 सितंबर, 2021
Dr. B.S.Jat	Participated online International Webinar on "Fighting the Hunger using Smart Technology"	ICAR-Indian Institute of Oil Palm Research, Pedavegi, Andhra Pradesh	October 26, 2021

D. Organization/participation of Kisan Mela/KisanGosthi/Exhibition/Field Day/Lectures

Name of the Scientist	Programme	Venue	Date
P. Lakshmi Soujanya	Delivered talk on Insect pests of maize with special reference to fall armyworm and their management to the tribal farmers of Rajavaram village, Chilpur Mandal, Jangam district, Telangana under Tribal sub plan during training programme on Maize Production Technologies organized by PJTSAU	MRC, PJTSAU, Telangana	9th March, 2021
	Delivered talk on Insect pests of maize and their management with special reference to fall armyworm and storage pests of maize and their management to the tribal farmers of Juvvichettu Thanda, Tirumala Girisagar Mandal, Nalgonda district, during Telangana under Tribal sub plan training programme on Maize Production Technologies organized by PJTSAU	MRC, PJTSAU, Telangana	10th March, 2021
Dr Sujay Rakshit, Ramesh Kumar, S.L. Jat and Romen Sharma	State Level Maize Day under "Participatory Innovation Platform on Potential Yield Realization of Maize-based Cropping Systems in Punjab and Haryana" programme by ICAR-CIMMYT in collaboration with CCSHAU, and state department of agriculture.	ICAR-CSSR, Karnal, Haryana	11 September, 2021
Dr Sujay Rakshit, Ramesh Kumar, D.P. Chaudhary, S.L. Jat, Priyajoy Kar and Romen Sharma	State Level Maize Day under "Participatory Innovation Platform on Potential Yield Realization of Maize-based Cropping Systems in Punjab and Haryana" programme by ICAR-IIMR in collaboration with PAU, state department of agriculture and CIMMYT.	Garhshankar, Punjab	28th August, 2021
Dr S.L. Jat, Romen Sharma and Priyajoy Kar	District level maize field day under "Participatory Innovation Platform on Potential Yield Realization of Maize-based Cropping Systems in Punjab and Haryana" programme by ICAR-CIMMYT.	Sapeda, Ambala	16th August, 2021

Name of the Scientist	Programme	Venue	Date
Dr S.L. Jat, Romen Sharma and Priyajoy Kar	District level field day under "Participatory Innovation Platform on Potential Yield Realization of Maize-based Cropping Systems in Punjab and Haryana" programme by ICAR-CIMMYT.	Kamoda village, Thanesar Block, Kurukshetra	14 August, 2021
YathishK.R	Monitoring of BML 7 inbred line seed production	PJTSAU, Hyderabad	23rd Feb, 2021
	Online Hindi Workshop on Official Language Rules and Acts	ICAR-IIMR, Ludhiana	25th Jun, 2021
	Nutri cereals Multi stakeholders' mega convention 3.0	ICAR-IIMR (Millets), Hyderabad	17th, Sept, 2021
	Monitoring of AICRP Kharif 2021 trials at ARS, Peddapuram, A.P	ICAR-IIMR, Ludhiana	29th Sep, 2021
	Monitoring of AICRP Kharif 2021 trials at ARS, PJTSAU, Karimnagar, Telangana	ICAR-IIMR, Ludhiana	1st Oct, 2021
	Monitoring of BML 7 inbred line seed production	PJTSAU, Hyderabad	5th Oct, 2021
Dr. Shankar Lal Jat	Understanding basics of Climate SmartAgriculture (CSA) in Online national certificate course through online modeduring 09 to 29 August, 2021 on Policies, Institutions and Marketing for Climate Smart Agriculture. Organized by CAAST, MPKV, Rahuri	Zoom platform virtual meeting	9 August, 2021
	Crop management practices adopted by the farmers in Online national certificate course through online mode during 09 to 29 August 2021 on Policies, Institutions and Marketing for Climate Smart Agriculture. Organized by CAAST, MPKV, Rahuri	Zoom platform virtual meeting	9 August, 2021
	Agroecological options for FAW management in Nagaland in Awareness training programme on fall armyworm management on Maize in Nagaland by FAO, DPPQ&S & ICAR- IIMR on 24th May, 2021	Zoom platform virtual meeting	24 May 2021

Name of the Scientist	Programme	Venue	Date
Dr. Shankar Lal Jat	Post-harvest processing and Value addition in maize in Virtual training programme to State Agricultural Department Officials of the Maharashtra by MPKV, Kolhapur	Zoom platform virtual meeting	12 May 2021
	Modern techniques of field crop production and recent trends in agronomy in Four days tutorial Classes for AICE-JRF(PhD). ICAR-NET and ARS Exams. Organized by Deptt. of Agril. Ext. and Comm, MPKV, Rahuri	Zoom platform virtual meeting	26 March 2021
	Organic farming and rainfed agriculture in Four days tutorial Classes for AICE-JRF(PhD). ICAR-NET and ARS Exams. Organized by Deptt. of Agril. Ext. and Comm, MPKV, Rahuri	Zoom platform virtual meeting	25 March 2021
	Agro- techniques of FAW Management with reference to Indian context in One Day Workshop onNew Invasive Pest: FAW (Spodoptera frugiperda) Infesting Maize by Department of Entomology RCA, MPUAT, Udaipr in collaboration with ATMA, Udaipur	Zoom platform virtual meeting	02 February 2021

E. Other Achievements

Name of the Scientist	Achievement

AWARDS AND RECOGNITION 9

- Director ICAR-IIMR, Dr. Sujay Rakshit received the Dr. A. B. Joshi Memorial Award conferred by the Indian Society of Genetics and Plant Breeding (ISGPB) on October 29, 2021.
- Director ICAR-IIMR, Dr. Sujay Rakshit received Dr. Kalayya Krishnamurthy National Award 2020-21 during the 56th Foundation Day of the University of Agricultural Sciences Bangalore.
- P. Lakshmi Soujanya received the Vasanthraj David Foundation Scientist Award during 3rd National conference on "Recent Advances in Crop Protection" on October 17, 2021.
- P. Lakshmi Soujanya received best oral presentation award during International Conference on "Global Perspectives in Crop Protection for Food Security" held from 8th-10th December, 2021 at TNAU, Coimbatore, Tamil Nadu.
- Dr. Krishan Kumar was awarded with the best poster award in International Symposium on "Advances in plant Biotechnology and genome editing (APBGE-2021) held virtually from 8-10 April 2021.
- One review article on "Genetically modified crops: current status and future prospects" published as first and corresponding author in Planta (NAAS rating 10.11) in 2020 was highlighted as one of the best papers of 2020 by Springer Nature group.
- Dr. Krishan Kumar delivered an oral presentation in the 7th International Conference on Agricultural and Biological Sciences (ABS 2021) held from 9-11th August 2021.
- Dr. Krishan Kumar delivered an oral presentation in International Symposium on 'Plant Biotechnology towards improving agri-food industry and healthcare products (ISPB-2021) held from 27-30th October, 2021.
- Dr. Yathish, K.R delivered an oral presentation in the 3rd International Conference (Hybrid Mode) on Food, Agriculture and Innovations (ICFAI) on Genetic diversity of maize inbred lines using morphological characters held from 24-26, Dec 2021.
- Dr Shankar Lal Jat conferred with NAAS Associate, by National Academy of Agricultural Sciences, New Delhi w.e.f 01 January 2021.
- Dr Shankar Lal Jat was conferred with the Best Senior Scientist Certificate by ICAR-Indian Institute of Maize Research, Ludhiana on its 6th Foundation Day on 9th February 2021.
- Dr Shankar Lal Jat conferred with ISA Associate by Indian Society of Agronomy (ISA) on 23rd November 2021 during the 5th International Agronomy Congress at PJTSAU, Hyderabad.
- Dr.S.K. Aggarwal was Selected as Gold Medalist for Ph D work from PAU, Ludhiana in March 2021
- Dr. S.K.Aggarwal participated in the IPS National e-Conference 2021 and received best oral presentation.
- Dr. S. B. Singh performed as Chairman of the Award Screening Committee in the International Conference on " Innovative and current Advances in Agriculture and Allied Sciences (ICAAAS-2021). held online on July 19-21,2021.
- Dr. S. B. Singh performed as Co-Chairman in Technical Session I: Innovative technology for crop improvement, biotechnology, and genetic engineering in the International Conference on " Innovative and current Advances in Agriculture and Allied Sciences (ICAAAS-2021). held online on July 19-21,2021.
- Dr. S. B. Singh performed as Co-Chairman in Technical Session I: Innovative technology for crop improvement, biotechnology and genetic engineering in the International Conference on " Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAAS-2021). held online on December 13-15, 2021.
- Dr. S. B. Singh was nominated as a panel member and external expert by Ch. Charan Singh

National Institute of Agricultural Marketing (CCS-NIAM) Pratap Nagar, Jaipur for the selection of candidates for admission in the Post Graduate Diploma in Management (Agribusiness Management).

- Dr. Bhupender Kumar has been awarded with "Prof. Mahatim Singh Memorial Award-2021" of Society for Advancement of Wheat and Barley Research (SAWBAR) ,ICAR-IIWBR, Karnal
- Dr. Bhupender Kumar has been awarded "Dr. Joginder Singh Memorial award-2021", of the Indian Society of Genetics and Plant Breeding (ISGPB)
- Dr. Bhupender Kumar has been awarded "Young Scientist Award - 2021", of the National Education Empowerment and Development Foundation (NEEDEF), U.P
- Dr Abhijit Kumar Das was conferred with the Best Scientist Certificate by ICAR-Indian Institute of Maize Research, Ludhiana on its 6th Foundation Day on 9th February 2021.
- Dr N. Sunil received Letter of Appreciation from Director, ICAR-Indian Institute of Maize Research, Ludhiana on its 6th Foundation Day on 9th February 2021.

Annexure I

List of cultivars identified during 64th Annual Maize Workshop

Cultivar	AICRP Centre/ Pvt. Company	Public/ Private	Average Yield (kg/ha)	Zones	Area of adaptation States	Maturity or Type of Corn	Season
ADV 7132 (ADV 732)	UPL Limited	Private	10577	NWPZ	Punjab, Haryana, Delhi, Uttarakhand (Plain regions), Uttar Pradesh (Western region)	Late	*Kharif*
KMH 005	Kaveri seed Company Ltd	Private	10410	NWPZ	Punjab, Haryana, Delhi, Uttarakhand (Plain regions), Uttar Pradesh (Western region)	Late	*Kharif*
DKC 9190	Monsanto	Private	8638	NHZ	Jammu and Kashmir, Himachal Pradesh, Uttarakhand (Hill region), Meghalaya, Sikkim, Assam, Tripura, Nagaland, Manipur, Arunachal Pradesh	Medium	*Kharif*
DKC 9194	Monsanto	Private	9880	PZ	Karnataka, Andhra Pradesh, Telangana, Maharashtra & Tamil Nadu	Medium	*Kharif*
APQH1	ICAR-IARI, New Delhi	Public	8190 6974 5911 7934 5093	NHZ NWPZ NEPZ PZ & CWZ	Jammu and Kashmir, Himachal Pradesh, Uttarakhand (Hill region), Meghalaya, Sikkim, Assam, Tripura, Nagaland, Manipur, Arunachal Pradesh. Punjab, Haryana, Delhi, Uttarakhand (Plain regions), Uttar Pradesh (Western region) Bihar, Jharkhand, Odisha, Eastern Uttar Pradesh (Eastern region), West Bengal. Karnataka, Andhra Pradesh, Telangana, Maharashtra & Tamil Nadu Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh.	EDV	*Kharif*
APH 1	ICAR-IARI, New Delhi	Public	7732 5438	NHZ & NEPZ	Jammu and Kashmir, Himachal Pradesh, Uttarakhand (Hill region), Meghalaya, Sikkim, Assam, Tripura, Nagaland, Manipur, Arunachal Pradesh Bihar, Jharkhand, Odisha, Eastern Uttar Pradesh (Eastern region), West Bengal.	EDV	*Kharif*
L315	CSK HPKV HAREC, Bajaura	Public	6362	NHZ	Jammu and Kashmir, Himachal Pradesh, Uttarakhand (Hill region), Meghalaya, Sikkim, Assam, Tripura, Nagaland, Manipur, Arunachal Pradesh	OPV	*Kharif*

Cultivar	AICRP Centre/ Pvt. Company	Public/ Private	Average Yield (kg/ha)	Zones	Area of adaptation States	Maturity or Type of Corn	Season
ABSH 4-1	ICAR-IARI, New Delhi	Public	2308	NWPZ	Punjab, Haryana, Delhi, Uttarakhand (Plain regions), Uttar Pradesh (Western region)	EDV, Baby corn	*Kharif*
PM17201 L(X35 M019)	Pioneer Hi-Bred Private Limited	Private	11827	NWPZ	Punjab, Haryana, Delhi, Uttarakhand (Plain regions), Uttar Pradesh (Western region)	Late	*Rabi*
PM 17205 L(P 3526)	Pioneer Hi-Bred Private Limited	Private	11819 11513	NWPZ & NEPZ	Punjab, Haryana, Delhi, Uttarakhand (Plain regions), Uttar Pradesh (Western region) Bihar, Jharkhand, Odisha, Eastern Uttar Pradesh (Eastern region), West Bengal	Late	*Rabi*
Rasi 4118	Rasi Seeds Pvt Ltd.	Private	11548	NEPZ	Bihar, Jharkhand, Odisha, Eastern Uttar Pradesh (Eastern region), West Bengal	Late	*Rabi*

Annexure II

List of cultivars notified during 2021-22

Sl. No.	Cultivar	AICRP Centre/ Private Company	Public/ Private	Notification Date	Notification No.	Maturity	Area of Adaptation	Average Yield (t/ha)	Cropping season	Type
1.	Pusa H Quality Protein Maize-1 Improved	ICAR-IARI, New Delhi	Public	24.12.21	S.O. 8(E)	Medium to Late	Across the country	6.7	Kharif	Bio-fortified EDV
2.	Pusa Biofortified Maize Hybrid -1	ICAR-IARI, New Delhi	Public	24.12.21	S.O. 8(E)	Medium	Jammu and Kashmir, Himachal Pradesh, Uttarakhand (Hill region), Meghalaya, Sikkim, Assam, Tripura, Nagaland, Manipur, Arunachal Pradesh, Bihar, Jharkhand, Odisha, Uttar Pradesh (Eastern Region), West Bengal	6.5	*Kharif*	Bio fortified EDV
3.	Pusa HM-4 male sterile baby corn (Shishu)	ICAR-IARI, New Delhi	Public	24.12.21	S.O. 8(E)	-	Punjab, Haryana, Delhi, Uttarakhand Plain, and Western Uttar Pradesh	6.4	*Kharif*	Bio fortified EDV
4.	Malaviya Swarn Makka- 1 (VEQH16-1)	BHU, Varanasi	Public	24.12.21	S.O. 8(E)	Medium	Punjab, Haryana, Delhi, Uttarakhand Plain, and Western Uttar Pradesh	7.2	*Kharif*	Quality Protein Maize
5.	L 315 (Him Palam Maize Composite 1)	CSK, HPKV, HAREC, Bajaura	Public	24.12.21	S.O. 8(E)	Medium	Jammu and Kashmir, Himachal Pradesh and Uttarakhand	6.3	*Kharif*	Field Corn
6.	Birsa Baby Corn- 1 (BVM-2)	BAU, Ranchi	Public	24.12.21	S.O. 8(E)	Extra Early	Jharkhand	1.6	*Kharif*	Baby Corn
7.	Sikkim Sankul Makka-1	ICAR-NOFRI, Gangtok	Public	24.12.21	S.O. 8(E)		Sikkim	-	-	-
8.	SKMC-2 (SKMC-03)	ICAR-NOFRI, Gangtok	Public	24.12.21	S.O. 8(E)		Sikkim	-	-	-
9.	Pratap Raj Hybrid Maize - 1010 (WH-1010)	MPUAT, Banswara	Public	24.12.21	S.O. 8(E)	Medium	Rajasthan	9.7	Rabi	Field Corn
10.	Pratap Raj Hybrid Maize -1095 (WH-1095)	MPUAT, Banswara	Public	24.12.21	S.O. 8(E)	Late	Rajasthan	7	Kharif	Field Corn
11.	Pratap Quality Protein Maize Hybrid -5 (EHQ- 64)	MPUAT, Udaipur	Public	24.12.21	S.O. 8(E)	Early	Rajasthan	5.4	Kharif	Field Corn

Sl. No.	Cultivar	AICRP Centre/ Private Company	Public/ Private	Notification Date	Notification No.	Maturity	Area of Adaptation	Average Yield (t/ha)	Cropping season	Type
12.	JC 4	PAU, Ludhiana	Public	24.12.21	S.O. 8(E)	Medium	Punjab	3.2	Kharif	Field Corn
13.	PMH 13	PAU, Ludhiana	Public	24.12.21	S.O. 8(E)	Late	Punjab	6.1	Kharif	Field Corn
14.	JC 12	PAU, Ludhiana	Public	24.12.21	S.O. 8(E)	Late	Punjab	4.5	Kharif	Field Corn
15.	RCRMH- 4	College of Agriculture, Bheemarayana-gudi, Yadgir (Karnataka)	Public	24.12.21	S.O. 8(E)		Karnataka	-	-	-
16.	ADV 7132 (ADV 765)	UPL Limited ,	Private	24.12.21	S.O. 8(E)	Medium	Punjab, Haryana, Hyderabad, Delhi, Uttarakhand Plain, and Western Uttar Pradesh	10.1	Kharif	Field Corn
17.	Pant Sankar Makka - 6 (PSM - 6) (DH - 296)	GBPUAT, Pantnagar	Public	20.07.21	2986 (E)	Medium	Uttarakhand	7.3	Kharif	Field Corn
18.	BRMH - 1	VRDC, Karnataka State seed Corporation Ltd., Dharwad	Public	20.07.21	2986 (E)	Late	Karnataka	6.7	Kharif	Field Corn
19.	RCRMH - 2	College of Agriculture, Bheemaray-anagudi, Yadgir (Karnataka)	Public	20.07.21	2986 (E)		Karnataka	-	-	-
20.	PAC 745 Gold	UPL, Ltd, Hyderabad	Private	20.07.21	2986 (E)	Medium	Uttar Pradesh	5.0 - 6.0	Kharif	Field Corn
21.	X35H270 (PM 16202L)	Pioneer Seeds, Warangal Medak, Telangana	Private	20.07.21	2986 (E)	Late	Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Telangana, Rajasthan, Madhya Pradesh, Chhattisgarh and Gujarat.	9.081	Rabi	Field Corn
22.	P 3392 (PM 16205L)	Pioneer Seeds, Warangal Medak, Telangana	Private	20.07.21	2986 (E)	Late	Rajasthan, Madhya Pradesh, Chhattisgarh and Gujarat.	9.21	Rabi	Field Corn
23.	P 3302 (PM 16 103L)	Pioneer Seeds, Warangal Medak, Telangana	Private	20.07.21	2986 (E)	Late	Punjab, Haryana, Delhi, Uttarakhand Plain, and Western Uttar Pradesh	8.81	Kharif	Field Corn
24.	Rasi 3499 (RMH 3499)	Rasi Seeds (P) Ltd., Coimbatore Tamil Nadu	Private	20.07.21	2986 (E)		Bihar, Jharkhand, Uttar Pradesh (Eastern region) , Odisha, West Bengal	7.72	Kharif	Field Corn

Sl. No.	Cultivar	AICRP Centre/ Private Company	Public/ Private	Notification Date	Notification No.	Maturity	Area of Adaptation	Average Yield (t/ha)	Cropping season	Type
25.	IQMH 202 Ludhiana	ICAR-IIMR,	Public	29.01.21	500 (E)	Medium	Punjab, Haryana, Delhi, Uttarakhand Plain, and Western Uttar Pradesh	6.3	Kharif	Quality Protein Maize
26.	IQMH 203	ICAR-IIMR, Ludhiana	Public	29.01.21	500 (E)	Medium	Rajasthan, Madhya Pradesh, Chhattisgarh and Gujarat	7.2	Kharif	Quality Protein Maize
27.	HT 17169	Hytech Seed India Pvt. Ltd.. Hyderabad	Private	29.01.21	500 (E)	Late	Punjab. Haryana, Western UP. Delhi and Plain of Uttarakhand	9.6	Kharif	Field Corn
28.	CP 858	Charoen Pokphand Seeds (India) Pvt. Ltd. Bangalore (Kamataka)	Private	29.01.1	500 (E)	Late	Punjab, Haryana, Delhi, Uttarakhand (Plains), Uttar Pradesh (Eastern and Western regions). Bihar, Uttarakhand. Odisha, West Bengal	8.8	Kharif	Field Corn
29.	NUZI 260	Nuziveedu Seeds Ltd. Hyderabad	Private	29.01.21	500 (E)	Medium	Punjab. Haryana, Delhi, Uttarakhand (Plains), Uttar Pradesh (Eastern and Westem Regions) Bihar. Jharkhand. Odisha. West Bengal Maharashtra. Karnataka. Andhra Pradesh. Tamil Nadu. Telangana	12.26	Kharif	Sweet Corn
30.	NMH-713	Nuziveedu seeds, Ranga Reddy, Telangana	Private	29.01.21	500 (E)	Late	Assam	9.2	Rabi	Field Corn
31.	NMH-731	Nuziveedu seeds, Ranga Reddy, Telangana	Private	29.01.21	500 (E)	late	Assam	9.7	Rabi	Field Corn
32.	NMH-920	Nuziveedu seeds, Ranga Reddy, Telangana	Private	29.01.21	500 (E)	late	Assam	7.7	Kharif	Field Corn
33.	VL Quality Protein Maize Hybrid 59 (FQH 106)	ICAR-VPKAS, Almora	Public	29.01.21	500 (E)	Early	Uttarakhand	3.3	Kharif	Quality Protein Maize
34.	Pant Sankar Makka-5 (PSM-5)	GBPUAT, Pantnagar	Public	29.01.21	500 (E)	Early	Uttarakhand (plain)	4.9	Kharif	Field Corn
35.	Jawahar Maize 215 (CHH 215)	ZARS, JNKVV, Chindwara, MP	Public	29.01.21	500 (E)	-	Madhya Pradesh	-	-	-

Annexure III

Application filed for registration at PPVFRA during 2021-22

Available with ITMU

S.No.	Hybrids	Name of centre	Date of filing	Acknowledgement no.
1	Ladhowal Popcorn Hybrid 3 (LPCH 3) IMHP 1540 (Hybrid)	ICAR-IIMR, Ludhiana	01.09.2021	REG/2021/0192
2	Ladhowal Quality Maize Hybrid 1 (LQMH 1) (IMH Quality Protein Maize 1530) (Hybrid)	ICAR-IIMR, Ludhiana	01.09.2021	REG/2021/0193
3	Ladhowal Popcorn Hybrid 2 (LPCH 2) (IMHP 1535) (Hybrid)	ICAR-IIMR, Ludhiana	01.09.2021	REG/2021/0191
4	IQMH 202 (LQMH-2) (IIMR Quality Protein MaizeH-1601)	ICAR-IIMR, Ludhiana	15-03-2021	REG/2021/0151
5	IQMH 203 (LQMH-1705) (IIMR Quality Protein MaizeH-1705)	ICAR-IIMR, Ludhiana	15-03-2021	REG/2021/0152

Dus Testing undertaken during 2021-22

List of Hybrid Entries

S. No.	Name of Entry	Testing Year	Category	SCH/MPH
1	NH-20-03 H	Second	Candidate Hybrid	SCH
2	NH-20-03 H	Second	F1 Hybrid SMG	SCH
3	NH-20-04 H	Second	Candidate Hybrid	SCH
4	NH-20-04 H	Second	F1 Hybrid SMG	SCH
5	NH-20-05 H	Second	Candidate Hybrid	SCH
6	NH-20-05 H	Second	F1 Hybrid SMG	SCH
7	NH-20-06 H	Second	Candidate Hybrid	SCH
8	NH-20-06 H	Second	F1 Hybrid SMG	SCH
9	NH-20-07 H	Second	Candidate Hybrid	SCH
10	NH-20-07 H	Second	F1 Hybrid SMG	SCH
11	NH-20-08 H	Second	Candidate Hybrid	SCH
12	NH-20-08 H	Second	F1 Hybrid SMG	SCH
13	NH-20-09 H	Second	Candidate Hybrid	SCH
14	NH-20-09 H	Second	F1 Hybrid SMG	SCH
15	NH-20-10 H	Second	Candidate Hybrid	SCH
16	NH-20-10 H	Second	F1 Hybrid SMG	SCH
17	NH-20-11 H	Second	Candidate Hybrid	SCH
18	NH-20-11 H	Second	F1 Hybrid SMG	SCH
19	NH-20-13 H	Second	Candidate Hybrid	SCH
20	NH-20-13 H	Second	F1 Hybrid SMG	SCH
21	NH-20-14 H	Second	Candidate Hybrid	SCH
22	NH-20-14 H	Second	F1 Hybrid SMG	SCH
23	NH-20-15 H	Second	Candidate Hybrid	SCH
24	NH-20-15 H	Second	F1 Hybrid SMG	SCH
25	NH-20-16 H	Second	Candidate Hybrid	SCH
26	NH-20-16 H	Second	F1 Hybrid SMG	SCH
27	NH-20-17 H	Second	Candidate Hybrid	SCH
28	NH-20-17 H	Second	F1 Hybrid SMG	SCH

S. No.	Name of Entry	Testing Year	Category	SCH/MPH
29	NH-20-18 H	Second	Candidate Hybrid	SCH
30	NH-20-18 H	Second	F1 Hybrid SMG	SCH
31	NH-20-19 H	Second	Candidate Hybrid	SCH
32	NH-20-19 H	Second	F1 Hybrid SMG	SCH
33	2122 H2	First	Hybrid	SCH
34	2122 H3	First	Hybrid	SCH
35	2122 H4	First	Hybrid	SCH
36	2122 H6	First	Hybrid	SCH
37	2122 H8	First	Hybrid	SCH
38	2122 H10	First	Hybrid	SCH
39	2122 H14	First	Hybrid	SCH
40	2122 H16	First	Hybrid	SCH
41	2122 H17	First	Hybrid	SCH
42	2122 H18	First	Hybrid	SCH
43	2886/2211	First	FV, Typical	SCH
44	2886/2212	First	FV, Typical	SCH
45	2877/2761	First	FV, Typical	SCH
46	3033	First	Reference	SCH
47	3499	First	Reference	SCH
48	Deklab 9144	Reference Hybrid	Reference	SCH
49	Bond NMH 007	Reference Hybrid	Reference	SCH
50	GK 3059	Reference Hybrid	Reference	SCH
51	GK 3090	Reference Hybrid	Reference	SCH
52	GK 3018 Super	Reference Hybrid	Reference	SCH
53	GK 3069	Reference Hybrid	Reference	SCH
54	GK 3064	Reference Hybrid	Reference	SCH
55	BIO- 9544	Reference Hybrid	Reference	SCH
56	P3401	Reference Hybrid	Reference	SCH
57	AMH-3436,	Reference Hybrid	Reference	SCH
58	Ajeet-Surya	Reference Hybrid	Reference	SCH
59	S-6668	Reference Hybrid	Reference	SCH

List of Inbred Entries

S. No.	Name of Entry	Testing Year	Category	SCH/MPH
1	NH-20-01 H	Second	Typical	Inbred
2	2886/2148	First	Typical (Other inbred parental line)	Inbred
3	2886/2149	First	Typical (Other inbred parental line)	Inbred
4	2886/2150	First	Typical (Other inbred parental line)	Inbred
5	2886/2151	First	Typical (Other inbred parental line)	Inbred
6	2886/2152	First	Typical (Other inbred parental line)	Inbred
7	2886/2153	First	Typical (Other inbred parental line)	Inbred
8	2886/2817	First	Typical (Other inbred parental line)	Inbred
9	HKI 193-1	Reference Inbred	Reference	Inbred
10	HKI 1105	Reference Inbred	Reference	Inbred
11	HKI 161	Reference Inbred	Reference	Inbred
12	HKI 163	Reference Inbred	Reference	Inbred
13	CM 212	Reference Inbred	Reference	Inbred
14	V 345	Reference Inbred	Reference	Inbred

Hybrid/variety registered with PPVFRA during 2021-22

Available with ITMU

S.No.	Name	Centre	Period of protection (Years)
1	KNMH 4010131 (Karimnagar Makka-1)	PJTSAU, Karimnagar	29 June 2016 to 28 June 2031
2	Pratap Maize Hybrid - 3	MPUA&T, Udaipur	29June 2016 to 28 June 2031
3	DPCH- 306	GBPAU&T, Pantnagar	06January 2020 to 05 January 2035
4	PJHM-1	ICAR-IARI New Delhi	01 April 2019 to 31 March 2034

Annexure IV

BSP IV: Breeder seed production in Maize during Kharif, 2020 & Rabi 2020-21

S. No.	Hybrid/Variety Name	Year of Notification	Quantity in Quintal		
			Allocation	Production	Surplus/ Deficit over DAC Indent
1	Vivek Sankul Makka 35 (VL 113)	2009	2	3.5	1.5
2	VL Hybrid 57 (FP)	2018	0.45	0.45	0
3	VL Hybrid 57 - Male Line	2018	0.15	0.15	0
4	Vivek Hybrid Maize (VMH- 53) (FP)	2015	0.2	0.8	0.6
5	Vivek Hybrid Maize (VMH- 53) (MP)	2015	0.11	0.2	0.09
6	Vivek Hybrid Maize (VMH - 45) (FP)	2013	0.3	0.3	0
7	Vivek Hybrid Maize (VMH - 45) (MP)	2013	0.15	0.2	0.05
8	Jawarhar Maize 218	2018	7.5	25	17.5
9	CO 6 (FP)	2016	0.2	0.8	0.6
10	CO 6 (MP)	2016	0.1	0.85	0.75
11	CO (M) - 8 (FP)	2014	0.2	1.04	0.84
12	CO (M) - 8 (MP)	2014	0.1	0	-0.1
13	Pusa Super Sweet Corn - 2		0.4	0	-0.4
14	Pusa Super Sweet Corn - 1		0.4	0.36	-0.04
15	PJMH - 1 (FP) 2018	0.32	0.5	0.18	
16	PJMH - 1 (MP)2018	0.18	0.25	0.07	
17	Pusa Vivek QPM (FP)	2017	0.2	0.04	-0.16
18	Pusa Vivek QPM (MP)	2017	0.1	0.6	0.5
19	Gujrat Anand White Maize HYB - 2 (FP)	2018	0.25	2	1.75
20	Gujrat Anand White Maize HYB - 2 (MP)	2018	0.15	2	1.85
21	Gujrat Anand Sweet Corn HYB - 1 Madhuram (FP)		0.25	2	1.75
22	Gujrat Anand Sweet Corn HYB - 1 Madhuram (MP)		0.15	2	1.85
23	Gujrat Anand Popcorn HYB - 21 Mahasweta (FP)		0.25	0	-0.25
24	Gujrat Anand Popcorn HYB - 21 Mahasweta (MP)		0.15	0	-0.15
25	BML - 6 (FP of DHM 117)	2014	0.25	25	24.75
26	BML - 7 (MP of DHM 117)		0.14	0.14	0
27	BML -45 DHM - 121 (FP)	2014	4.25	4.25	0
28	BML -6 DHM - 121 (MP)	2014	2	2	0
29	DHM - 117 (FP)		1	25	24
30	DHM - 117 (MP)		0.6	0.6	0
31	DHM - 117 (FP of BML 6)		6.95	25	18.05
32	DHM - 117 (MP of BML 7)		3.35	3.35	0
33	IML418-1 (MP of DMRH 1301)		0.8	2.89	2.09
34	IMBH-1532		0.4	0.46	0.06
35	V373 (FP of DMRH 1305)	2017	0.35	0.42	0.07
36	HKI1105 (MP of DMRH 1305)	2017	0.2	0.28	0.08
37	BML6 (FP of DMRH 1308)		0.5	8.43	7.93

S. No.	Hybrid/Variety Name	Year of Notification	Quantity in Quintal Allocation	Production	Surplus/ Deficit over DAC Indent
38	HKI163 (MP of DMRH 1308)		0.3	21.85	21.55
39	IML343-1 (FP of IMHQPM-1530)		0.1	0.2	0.1
40	BML6 (FP of DMRH 1301)		1	7.17	6.17
41	LM 13		1	1	0
42	LM 14		0.5	0.6	0.1
43	LM 23		2	2	0
44	LM 24		1	1	0
45	Birsa Vikas Makka - 2	2005	1.65	1.58	-0.07
46	Composite Suwan1985		1.1	0.8	-0.3
47	SHALIMAR POP CORN -1 (KDPF - 2)	2017	5	5	0
48	Pratap Hybrid - 3 (FP)	2015	6	7.2	1.2
49	Pratap Hybrid - 3 (MP)	2015	3	4.2	1.2
50	Pratap Hybrid Maize - 1 (FP)	2005	2	0	-2
51	Pratap Hybrid Maize - 1 (MP)	2005	1	0	-1

Note: FP: Female Parent MP: Male Parent

BSP IV: Breeder seed production in Maize during Kharif, 2021

S. No.	Hybrid/Variety Name	Year of Notification	Quantity in Quintal Allocation	Production	Surplus/ Deficit over DAC Indent	Producing Institute
1	PJMH-1 (FP of PML93)	2019	1.00	1.20	0.20	IARI, New Delhi
2	PJMH-1 (MP of PML105)	2019	0.50	0.60	0.10	
3	Pusa HQPM-5 Improved (FP of PMI-PV6)	2019	0.93	0.40	-0.53	
4	Pusa HQPM-5 Improved (MP of PMI-PV5)	2019	0.47	0.47	0.00	
5	Pusa HQPM-7 Improved (APQH7) (FP of PMI-PV7)	2020	0.03	1.00	0.97	
6	Pusa HQPM-7 Improved (APQH7) (MP of PMI-PV5)	2020	0.01	0.01	0.00	
7	Pusa HM-8 Improved (AQH-8) (FP of PMI-Q1)	2017	0.02	0.02	0.00	
8	Pusa HM-8 Improved (AQH-8) (MP of HKI161)	2017	0.01	0.01	0.00	
9	Pusa Vivek QPM 9 Improved (FP of PMI-PV2)	2018	0.20	0.50	0.30	
10	Pusa Vivek QPM 9 Improved (MP of PMI-PV1)	2018	0.10	0.50	0.40	
11	DMRH-1301 (FP of BML6)	2017	3.80	0.00	-3.80	IIMR, Ludhiana
12	DMRH-1301 (MP of IML418-1)	2017	2.20	0.00	-2.20	
13	DMRH-1308 (FP of BML6)	2018	6.42	0.00	-6.42	
14	DMRH-1308 (MP of HKI163)	2018	3.21	0.00	-3.21	

S. No.	Hybrid/Variety Name	Year of Notification	Quantity in Quintal			Producing Institute
			Allocation	Production	Surplus/ Deficit over DAC Indent	
15	IMHQPM 1510 or LQMH-1 (FP of IML-343-1)	2020	0.28	0.00	-0.28	
16	IMHQPM 1510 or LQMH-1 (MP of HKI163)	2020	0.14	0.00	-0.14	
17	PMH1 (FP of LM 13)	2007	1.00	1.50	0.50	P.A.U. Ludhiana
18	PMH1 (MP of LM 14)	2007	0.50	1.00	0.50	
19	PMH 10 (FP of LM 23)	2016	2.02	2.50	0.48	
20	PMH 10 (MP of LM 24)	2016	1.01	1.50	0.49	
21	Pratap Hybrid- 3 (FP of Line EI586-2)	2015	7.00	10.50	3.50	MPUAT, Udaipur
22	Pratap Makka Chari -6	2009	5.50	7.50	2.00	
23	Pratap Hybrid- 3 (MP of EI670-2)	2015	4.00	0.00	-4.00	
24	CO 6 (FP of UMI1200)	2012	0.20	0.00	-0.20	TNAU, Coimbatore
25	CO 6 (MP of UMI1230)	2012	0.10	0.00	-0.10	
26	CoH(M)8 (FP of of UMI1201)	2013	0.20	0.00	-0.20	
27	CoH(M)8 (MP of UMI1230)	2013	0.10	0.00	-0.10	
28	DMH-117 (FP of BML-6)	2010	1.89	0.00	-1.89	PJTSAU, MRC,
29	DMH-117 (MP of BML 7)	2010	0.93	0.00	-0.93	Hyderabad
30	DHM 121 (BH 41009)(FP of BML45)	2014	4.16	0.00	-4.16	
31	DHM 121 (BH 41009)(MP of BML6)	2014	2.08	0.00	-2.08	
32	HQPM-1 (FP of HKI193-1)	2007	0.89	0.00	-0.89	CCS HAU RRS
33	HQPM-1(MP of HKI163)	2007	0.44	0.00	-0.44	Uchani, Karnal
34	HQPM-5 (FP of HKI163)	2007	0.59	0.00	-0.59	
35	HQPM-5 (MP of HKI161)	2007	0.29	0.00	-0.29	
36	MAH-14-5 (FP of CAL1443)	2018	0.02	6.20	6.18	University of
37	MAH-14-5 (MP of CML451)	2018	0.01	4.20	4.19	Agricultural Sciences, Bangalore
38	BRMH-8 (CoH(M)-8) (FP)	2013	0.10	0.00	0.00	VRDC, Dharwad
39	BRMH-8 (CoH(M)-8) (MP)	2013	0.03	0.00	0.00	
40	Central Maize VL Sweet Corn-1 (FSCH 18) (FP)	2016	0.15	0.30	0.15	VPKAS Almora
41	Central Maize VL Sweet Corn-1 (FSCH 18) (MP)	2016	0.05	0.10	0.05	
42	Vivek Hybrid Maize 45 (VMH-45) (FP of V373)	2013	0.20	0.30	0.10	
43	Vivek Hybrid Maize 45 (VMH-45) (MP of V390)	2013	0.11	0.25	0.14	
44	Vivek Hybrid Maize 53 (VMH-53) (FP of V407)	2014	0.18	0.20	0.02	
45	Vivek Hybrid Maize 53 (VMH-53) (MP of V409)	2014	0.10	0.45	0.35	
46	Vivek Hybrid Maize 57 (MP of V412)	2019	0.10	0.60	0.50	

S. No.	Hybrid/Variety Name	Year of Notification	Quantity in Quintal			Producing Institute
			Allocation	Production	Surplus/ Deficit over DAC Indent	
47	Vivek Hybrid Maize 57 (FP of V433)	2019	0.20	0.10	-0.10	
48	Vivek Sankul Makka 35 (VL 113)	2009	2.00	1.50	-0.50	
49	Jawahar Maize 218	2018	8.60	100.00	91.40	JNKVV, Chhindwara
50	JM 215 (CHH-215)2019	5.00	0.00	-5.00		or RVSKVV Gwalior or JNKVV, Jabalpur
51	Shalimar Pop Corn -1 (KDPC-2)	2017	5.00	5.80	0.80	S.K.U.A.&T. Srinagar
52	Birsa Vikas Makka-2	2005	0.88	0.00	-0.88	BAU, Ranchi

Note: FP: Female Parent MP: Male Parent

Annexure V

Lecture/TV/Radio talks delivered

Scientist	Topic	Programme	Venue	Date
Dr. P. Lakshmi Soujanya	Insect pests of maize with special reference to fall armyworm and their management	Training programme on Maize Production Technologies under TSP	MRC, PJTSAU	9.3.2021
	Insect pests of maize and their management with special reference to fall armyworm and storage pests of maize and their management	Training programme on Maize Production Technologies under TSP	MRC, PJTSAU	10.3.2021
Dr. Krishan Kumar	Invited talk on ' Prospects of Genetic Engineering in Crop Improvement'	Winter school training programme	School of Agricultural Sciences, GD Goenka University, Haryana	27 Feb 2021
Dr. S.K. Aggarwal	Disease control in hybrid seed production of biofortified maize hybrids	Online training program on Cultivation practices of Biofortified maize hybrids and its see production under Himalayan States and Central India with special reference to North eastern region for sustainable Nutritional security		
	Makka ke Mukhya rig avum unka ekikrat prabhandhan	Farmers training under ATMA, Purnia	RMC&SPC, Vishnupur, Begusarai (Online)	March 17, 2021
	Makka ke Mukhya rig avum unka ekikrat prabhandhan	Farmer's training	RMC&SPC, Vishnupur, Begusarai (Online)	October 4, 2021
Dr. S. B. Singh	किसानों की आय वृद्धि हेतु संकर मक्का बीज उत्पादन तकनीकी	A farmer training programme on संकर मक्का बीज उत्पादन द्वारा कृषक आय वृद्धि	RMR&SPC, Begusarai.	March 09, 2021
	मक्का फसल में फॉल आर्मी वर्म की पहचान व रासायनिक रोकथाम	A farmer training programme on संकर मक्का बीज उत्पादन द्वारा कृषक आय वृद्धि	RMR&SPC, Begusarai.	March 09, 2021
	मक्का फसल में सूक्ष्म पोषक तत्वों की कमी के लक्षण एवं प्रबंधन	A farmer training programme on संकर मक्का बीज उत्पादन द्वारा कृषक आय वृद्धि	RMR&SPC, Begusarai.	March 09, 2021
	मक्का : एक परिचय, उत्पादन व उपयोग	A farmer training programme on मक्का की वैज्ञानिक खेती व कृषक आय वृद्धि हेतु नए विकल्प	RMR&SPC, Begusarai.	March 16, 2021

Scientist	Topic	Programme	Venue	Date
Dr. S. B. Singh	अधिक उत्पादन हेतु मक्का, की वैज्ञानिक पद्धति द्वारा खेती	A farmer training programme on मक्का की वैज्ञानिक खेती व कृषक आय वृद्धि हेतु नए विकल्प	RMR&SPC, Begusarai.	March 16, 2021
	मक्के की खेती में अन्तरवर्ती फसल प्रणाली द्वारा अधिक आय प्राप्ति	A farmer training programme on मक्का की वैज्ञानिक खेती व कृषक आय वृद्धि हेतु नए विकल्प	RMR&SPC, Begusarai.	March 16, 2021
	मक्का फसल में फॉल आर्मी वर्म की पहचान व रासायनिक रोकथाम	A farmer training programme on संकर मक्का बीज उत्पादन द्वारा कृषक आय वृद्धि	RMR&SPC, Begusarai.	March 09, 2021
	फॉल आर्मीवर्म : विनाशकारी कीट का प्रबंधन व रोकथाम	A farmer training programme on मक्का की वैज्ञानिक खेती व कृषक आय वृद्धि हेतु नए विकल्प	RMR&SPC, Begusarai.	March 16, 2021
	अधिक उपज हेतु बिहार प्रदेश के लिए मक्का की उन्नत किस्में	A farmer training programme on मक्का की वैज्ञानिक खेती व कृषक आय वृद्धि हेतु नए विकल्प	RMR&SPC, Begusarai.	March 17, 2021
	गुणवत्तायुक्त प्रोटीन मक्का की खेती द्वारा सामाजिक पोषण सुरक्षा	A farmer training programme on मक्का की वैज्ञानिक खेती व कृषक आय वृद्धि हेतु नए विकल्प	RMR&SPC, Begusarai.	March 17, 2021
	कृषक आय वृद्धि हेतु संकर मक्का बीज उत्पादन तकनीकी	A farmer training programme on मक्का की वैज्ञानिक खेती व कृषक आय वृद्धि हेतु नए विकल्प	RMR&SPC, Begusarai.	March 18, 2021
	संकर मक्का बीज प्रसंकरण, संवर्धन, संग्रहण, प्रमाणीकरण एवं विपणन तकनीकियां	A farmer training programme on मक्का की वैज्ञानिक खेती व कृषक आय वृद्धि हेतु नए विकल्प	RMR&SPC, Begusarai.	March 18, 2021
	मक्का की फसल में पोषण प्रबंधन	A farmer training programme on मक्का की वैज्ञानिक खेती व कृषक आय वृद्धि हेतु नए विकल्प	RMR&SPC, Begusarai.	March 18, 2021
	मक्के में अधिक आय हेतु विकल्प	A farmer training programme on मक्का की वैज्ञानिक खेती व कृषक आय वृद्धि हेतु नए विकल्प	RMR&SPC, Begusarai.	March 18, 2021
	Different types of maize their uses and production technology.	RAWE training programme of B.Sc.Ag. Students of BHU, Varanasi	RMR&SPC, Begusarai.	September 05,2021

Scientist	Topic	Programme	Venue	Date
Dr. S. B. Singh	Field experimentation for maize trials and experiments	RAWE training programme of B.Sc.Ag. Students of BHU, Varanasi	RMR&SPC, Begusarai.	September 05, 2021
	Methodology of single cross maize hybrid seed production	RAWE training programme of B.Sc.Ag. Students of BHU, Varanasi	RMR&SPC, Begusarai.	September 06, 2021
	Seed production technology of biofortified maize hybrids	A training programme organized for collaborative partner scientists/project staff/farmers under DBT project. "Cultivation practices of Biofortified maize hybrids and its seed production"	Online Training Programme on	September 24, 2021
	मक्का : एक परिचय, उत्पादन व उपयोग	A farmer training programme on मक्का की वैज्ञानिक खेती व कृषक आय वृद्धि हेतु नए विकल्प	RMR&SPC, Begusarai.	October 02, 2021
	अधिक उत्पादन हेतु मक्का, की वैज्ञानिक पद्धति द्वारा खेती	A farmer training programme on मक्का की वैज्ञानिक खेती व कृषक आय वृद्धि हेतु नए विकल्प	RMR&SPC, Begusarai.	October 04, 2021
	मक्के की खेती में अन्तरवर्ती फसल प्रणाली द्वारा अधिक आय प्राप्ति	A farmer training programme on मक्का की वैज्ञानिक खेती व कृषक आय वृद्धि हेतु नए विकल्प	RMR&SPC, Begusarai.	October 04, 2021
	किसानों की आय दुगुना करने हेतु संकर मक्का बीज उत्पादन	A farmer training programme on मक्का की वैज्ञानिक खेती व कृषक आय वृद्धि हेतु नए विकल्प	RMR&SPC, Begusarai.	October 05, 2021
	संकर मक्का बीज प्रसंकरण, संवर्धन, संग्रहण, प्रमाणीकरण एवं विपणन तकनीकियां	A farmer training programme on मक्का की वैज्ञानिक खेती व कृषक आय वृद्धि हेतु नए विकल्प	RMR&SPC, Begusarai.	October 05, 2021
	बीज उत्पादन हेतु मक्का की प्रजातियां	A farmer training programme on मक्का की वैज्ञानिक खेती व कृषक आय वृद्धि हेतु नए विकल्प	RMR&SPC, Begusarai.	October 05, 2021
	मक्का की फसल में अवशेष प्रबंधन	A farmer training programme on मक्का की वैज्ञानिक खेती व कृषक आय वृद्धि हेतु नए विकल्प	RMR&SPC, Begusarai.	October 06, 2021
	एकल संकर मक्का का गुणवत्तायुक्त बीज उत्पादन	A farmer training on Quality seed production of Single Cross Maize hybrid (एकल संकर मक्का का गुणवत्तायुक्त बीज उत्पादन)	RMR&SPC, Begusarai.	December 29, 2021

Scientist	Topic	Programme	Venue	Date
Dr. S. B. Singh	मक्के की खेती में आय वृद्धि हेतु अन्य विकल्प	A farmer training on एकल संकर मक्का का गुणवत्तायुक्त बीज उत्पादन	RMR&SPC, Begusarai.	December 29, 2021
	मक्का फसल में फॉल आर्मी वर्म की पहचान व रासायनिक रोकथाम	A farmer training on एकल संकर मक्का का गुणवत्तायुक्त बीज उत्पादन	RMR&SPC, Begusarai.	December 29, 2021
	मक्का फसल में फॉल आर्मी वर्म की पहचान व रासायनिक रोकथाम	A farmer training on एकल संकर मक्का का गुणवत्तायुक्त बीज उत्पादन	RMR&SPC, Begusarai.	December 29, 2021
	मक्का फसल में सूक्ष्म पोषक तत्वों की कमी के लक्षण एवं प्रबंधन	A farmer training on एकल संकर मक्का का गुणवत्तायुक्त बीज उत्पादन	RMR&SPC, Begusarai.	December 29, 2021
Dr. S. L. Jat	रबी मक्का की समसामयिक कार्य	किसान की बात कार्यक्रम	एफ एम गोल्ड	19 नवम्बर 2021
	रबी मक्का की बुवाई	हैलो किसान लाइव कार्यक्रम	डीडी किसान	15 नवम्बर 2021
	जलवायु परिवर्तन का फसलों के उत्पादन पर प्रभाव	किसान की बात कार्यक्रम	एफ एम गोल्ड	13 अक्टूबर 2021
	मक्का में समसामयिक कार्य	किसान की बात कार्यक्रम	एफ एम गोल्ड	25 अगस्त 2021
	खरीफ मक्का की बुवाई एवं देखभाल	हैलो किसान लाइव कार्यक्रम	डीडी किसान	16 जुलाई 2021
	जायदकालीन मक्का की खेती	किसान की बात कार्यक्रम	एफ एम गोल्ड	3 अप्रैल 2021
	बसंतकालीन मक्का की बुवाई	हैलो किसान लाइव कार्यक्रम	डीडी किसान	2 मार्च 2021
	रबी मक्का की देखभाल	किसान की बात कार्यक्रम	एफ एम गोल्ड	13 जनवरी 2021

Annexure VI

Publications

Research Papers

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- Jat, R.A., Jinger, D., Kumar, K., Singh, R., Jat, S.L., Dinesh, D., Kumar, A. and Sharma, N.K. 2021. Scaling-Up of Conservation Agriculture for Climate Change Resilient Agriculture in South Asia. S. P. Wani *et al*. (eds.), Scaling-up Solutions for Farmers, ISBN: 978-3-030-77935-1. https://doi.org/10.1007/978-3-030-77935-1_11, *Springer*

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- श्याम बीर सिंह, आकांक्षा पांडेय व विवेक कुमार सिंह (2021)। मक्के के आयुर्वेदिक व औषधीय उपयोग, कृषि चेतना 2021, अंक 4, पृष्ठ सं. 4–6। http://krishi-icar-gov-in/jspui/handle/123456789/68636
- भारत भूषण, मनेश चंद्र डागला, बहादुर सिंह जाट, सुमित कुमार, प्रदीप कुमार एवं मुकेश चौधरी (2021) खाद्य एवं पोषण सुरक्षा में कटाई उपरांत प्रौद्योगिकी की भूमिका कृषि चेतना (2021) चतुर्थ अंक, पृष्ठ संख्या 10–11.
- प्रियाजोय कर एवं सीमा श्योराण (2021) मक्का में मूल्यवर्धन. कृषि चेतना (2021) चतुर्थ अंक, पृष्ठ संख्या 12–14।
- प्रदीप कुमार, बी. एस. जाट, भारत भूषण, सुमित कुमार अग्रवाल, मनेश चन्द्र डागला एवं मुकेश चौधरी. साईलेजरू पशुओं के लिए चारा और फीड सुरक्षा हेतु बेहतर विकल्प . कृषि चेतना (2021) चतुर्थ अंक, पृष्ठ संख्या 30–34.
- दिव्यता जोशी, अंजली चुनेरा एवं प्रियाजोय कर (2021) राष्ट्रीय कृषि बाजार (ई–नाम) कृषि चेतना 2021, अंक –4 पृष्ठ सं 55–56.
- कृष्ण कुमार, पूजा शर्मा, अभिषेक झा, भूपेंद्र कुमार, प्रांजल यादव एवं सुजय रक्षित (2021) विश्व में ट्रांसजेनिक फसलों की स्थिति. कृषि चेतना 2021, अंक –4 पृष्ठ सं 64–66।
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Technical Bulletins:

- Aggarwal S. K., Gogoi R. and Rakshit S. (2021) Major Diseases of Maize and Their Management. IIMR Technical Bulletin 2021/04. ICAR-Indian Institute of Maize Research, Ludhiana, Punjab 141 004. pp.27.
- Singh S.B., Karjagi C.G., Kumar B., Kumar R., Jat S.L., Soujanya P.L., Aggarwal S.K., Sheoran S., Sekhar J.C., Yadava D.K. and Rakshit S. 2021. Manual of Hybrid Seed Production Technology in Maize. IIMR Technical Bulletin 2021/3. ICAR-Indian Institute of Maize Research, PAU Campus, Ludhiana-141004, pp 76. http://krishi.icar.gov.in/jspui/handle/123456789/68642

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Leaflets

- S.L. Jat, Seema Sepat, A.K. Singh, Romen Sharma, Suby S.B., Ramesh Kumar, D.P. Chaudhary, Deepak Bijarniya, KM Choudhary, Yogesh Kumar, P.H. Zaidi, M.L. Jat and Sujay Rakshit. 2021. Participatory Innovation Platform on Potential Yield Realization of Maize-based Cropping Systems in Punjab and Haryana. Pp. 1-8.
- ਐੱਸ. ਐੱਲ. ਜੱਟ, ਸੀਮਾ ਸਿਤੰਬਰ, ਏ.ਕੇ. ਸਿੰਘ, ਰੋਮਨ ਸ਼ਰਮਾ, ਸੂਬਾ ਐਸ.ਬੀ., ਰਮੇਸ਼ ਕੁਮਾਰ, ਡੀ.ਪੀ. ਚੌਧਰੀ, ਦੀਪਕ ਬਿਜਾਰਨੀਆਂ, ਕੇ.ਐਮ.ਚੌਧਰੀ, ਯੋਗੇਸ਼ ਕੁਮਾਰ, ਪੀ.ਐਚ. ਜ਼ੈਦੀ, ਐਮ.ਐਲ. ਜਾਟ ਅਤੇ ਸੁਜੇ ਰਕਸ਼ਿਤ। 2021. ਪੰਜਾਬ ਅਤੇ ਹਰਿਆਣਾ ਵਿੱਚ ਮੱਕੀ ਅਧਾਰਤ ਫਸਲੀ ਪ੍ਰਣਾਲੀਆਂ ਦੀ ਸੰਭਾਵੀ ਉਪਜ ਪ੍ਰਾਪਤੀ ਬਾਰੇ ਭਾਗੀਦਾਰੀ ਨਵੀਨਤਾ ਪਲੇਟਫਾਰਮ। ਪੰਨਾ 1-8।
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On-going projects

Annexure VII

List of ongoing institute projects

Project Code	Title of the project	Principal Investigator	CoPI / CCPI	Project Duration
Agronomy				
AR:IIMR: 17:09	Sensor guided nitrogen management in Maize base cropping system under conventional and conservation agriculture practices	Dr. SL Jat	Drs. AK Singh, Suby SB, Dilip Singh, D. Sreelatha, CS Singh, Mahesh Kumar, Amit Kumar Bhatnagar, PC Ghashal	July 2017 to June 2022
AR: IIMR: 17:10	Development of precision conservation agriculture practices in cereal-based system in Indo-Gagatic Plains	Dr. AK Singh	Drs. S.L. Jat, Seema Sepat, Mahesh Kumar	July 2017 to June 2022
Biochemistry				
AR:IIMR: 17:01	Analysis of starch diversity and digestibility in maize	Dr. Dharam Paul	Drs. Alla Singh, AK Das Yathish KR	April, 2017 to March, 2022
AR:IIMR:19:02	Extraction, identification and stability analysis of maize anthocyanins	Dr. Bharat Bhushan	Drs. Dharam Paul, MC Dagla	July, 2019 to June, 2022
Biotechnology				
AR:IIMR:19:05	Evaluation of potential of maize in the emerging Bio-based Industry	Dr. Alla Singh	Drs.GS Kocher, SS Dhaliwal, Dharam Paul, Ramesh Kumar, BS Jat, Shanti Bamboryia, Bharat Bhushan	July 2019 to June 2024
Entomology				
AR:DMR:17:03	Management of maize stem borers through host plant resistance	Dr. P Lakshami Soujanya	Drs. JC Shekhar, Chikkappa GK, Jawala Jindal, Maha Singh, CV Ratnavathi	July, 2017 to June, 2022
Plant Pathology				
AR:IIMR:19:01	Studies on diversity *Setosphaeria turcica* isolates of maize in India	Dr. Sumit Kumar Aggarwal	Drs. Harleen Kaur, S.I. Harlapur, Mohamma Ashraf Ahangar, N. Mallikarjuna, R Devlash Srabani Debnath, Shweta Singh, Alla Singh (Co-PI)	July, 2019 to June, 2024
Plant Breeding				
AR:IIMR:17:02	Genetic enhancement of QPM germplasm	Dr. Ramesh Kumar	Drs. AK Das, Dharam Paul, SB Singh, Sunil Neelam, SK Aggarwal, Suby SB	July, 2017 to June, 2022

Project Code	Title of the project	Principal Investigator	CoPI / CCPI	Project Duration
:IIMR: 19:03	Genetic enhancement of maize for the development of high yielding and climate resilient hybrids	Dr. S.B. Singh	Drs. Sunil Neelam, Ramesh Kumar, MC Dagla, Chikkapa GK, Bhupender Kumar, AK Das, Yathish KR, Pardeep Kumar, BS Jat, Santosh Kumar, Shanti Devi Bamboriya, PL Soujanya, Suby SB, Deep Mohan Mahala, SK Aggarwal Ms. Seema Sheoran	October, 2019 to September, 2024
AR:IIMR: 17:04	Genetic enhancement of white maize for food purpose	Dr. A.K. Das	Drs. SB Singh, Suby SB, Narendra Kumawat, SK Guleria, Savita Sharma, Baljit Singh	July, 2017 to June, 2022
AR:IIMR:17:05	Breeding for high yielding and better quality fodder cultivars in maize	Dr. Pradeep Kumar.	Drs. Yathish KR, MM Dass, JS Lamba, AK Singh (need based), Deep Mohan Mahala, JS Hundal, Yathish KR, Ms. Seema Sheoran	July, 2017 to June, 2022
AR:IIMR:17:06	Breeding for development of baby corn hybrids	Dr. Pradeep Kumar	Drs. Sujay Rakshit, Meenakshi Goyal, Bharat Bhusan, BS Jat, Yathish KR, Santosh Kumar, Shanti Devi Bamboriya	July, 2017 to June, 2022
AR:IIMR:17:07	Development of early maturing maize hybrid with enhanced yield and stress tolerance	Dr. M.C. Dagla	Drs. BS Jat, SK Aggarwal, PL Soujanya	July, 2017 to June, 2022
\AR:IIMR: 17:11	Diversification of sweet corn germplasm	Dr. Chikkappa G.K.	Drs. Sujay Rakshit, JC Sekhar, AK Das, Pardeep Kumar, Santosh Kumar, Yathish KR, Ms. Seema Sheoran	June, 2017 to May, 2022
Social Sciences				
AR: IIMR: 20:01	"Farmers Led innovation (FLI) in maize and mechanism for their scaling-up"	Mr. Priyajoy Kar	Drs. SL Jat, Shanti Devi Bamboriya, Sapna Nigam	July 2020 to July 2022
AR: IIMR: 21:01	Adoption and impact assessment of improved maize technology in different agro-ecologies	Dr. Ph. Romen Sharma	Dr. S.L. Jat & Mr. Priyajoy Kar	August 2021 to July 2024

Externally funded projects

Sl. No.	Scheme/project	P.I.	CoPI / CCPI	Project Duration	Funding agency
1.	Development of sustainable management tools for the invasive pest, Fall Armyworm *Spodoptera frugiperda* (J.E. Smith) in maize	Dr. JC Sekhar	Drs. Suby SB, P.L. Soujanya, SL Jat, Pranjal Yadav, Yathish, KR, N Baktavatsalam, Vinay K Kalia, Jyothilakshmi V.	2019-2022	NASF FAW project
2.	"Pre-breeding of wild crosses for yield enhancement and climate resilience maize using wild species"	Dr. Pradeep Kumar	-	2019-2022	DST-SERB
3.	Frontline demonstration in maize under NFSM	Dr. S.L. Jat	Dr. Romen Sharma and Priyajoy Kar	April, 2014 and continuing	Department of Agriculture and cooperation, Ministry of Agriculture and Farmers Welfare, Govt of India
4.	Long-term conservation agriculture impact on micro biome and soil health indicators for resource efficiency and resilience in maize systems.	Dr. S.L. Jat	Drs. Bhupender Kumar, Suby SB	2018-2021	Indian Council of Agricultural Research-NASF
5.	Seed Production in Agricultural Crops	Dr. S.B. Singh	-	2017-2026	ICAR-IISS, Mau
6.	Consortia Research Platform on Molecular Breeding (CRP on MB)	Dr. Chikkappa G.K.	Dr. Dharam Paul, Bhupender Kumar	2015-2026	Indian Council of Agricultural Research
7.	Consortia Research Platform on Agrobiodiversity (CRP AB)	Dr. Chikkappa G.K.	Dr. Sunil Neelam	2014-2026	Indian Council of Agricultural Research
8.	CRP on maize biofortification	Dr. Bhupender Kumar	Drs.SB Singh, Dharam Paul, Ramesh Kumar, Chikkappa GK, SL Jat, Abhijit Das, & Pradeep Kumar,	2017-2021	Indian Council of Agricultural Research
9.	Genome-wide association mapping and genetic characterization of turcicum leaf blight (*Setosphaeria turcica*) resistance in tropical maize germplasm	Dr. Bhupender Kumar	-	2018-2021	DST-SERB Early Career Research Award Grant Scheme
10.	Institute Technology Management Unit (ITMU)	Dr. Ramesh Kumar	Drs. Dharm Paul, Suby SB, Alla Singh	Ongoing from 2007	Indian Council of Agricultural Research

Sl. No.	Scheme/project	P.I.	CoPI / CCPI	Project Duration	Funding agency
11.	Artificial intelligence based mobile app for identification and advisory of maize diseases and insect pests	Dr Sudip Marwah (IASRI)	Drs. Soujanya Laxmi P (CCPI), SK Aggarwal (Co-CCPI)	2019 -2021	ICAR-National Agriculture Science Fund (NASF)
12.	Rapid Detection of Quality Protein Maize for Increased Farmer Remuneration	Dr. Alla Singh	Dr. AK Das	2018- 2021	DST
13.	Development of maize hybrids enriched with resistant starch through marker assisted intro-gression of ae1 allele and diversification of high amylose maize germplasm	Dr. Abhijit Kumar Das	Dr. Dharam Paul	2020 -2023	DST-SERB Core Research Grant. (Interdisciplinary Biological Sciences)
14.	Rapid Detection of Quality Protein Maize for increased farmer's remuneration	Dr. Alla Singh	Dr. Abhijit Kumar Das	2018- 2021	DST Scheme for young scientist award
15.	Heat Tolerant Maize for Asia	Dr. Ramesh Kumar	Dr. S.B. Singh and S.L. Jat	2019 -2024	CIMMYT
16.	Agri Business Incubator	Dr. Ramesh Kumar	Dr. S. L Jat	2020 onwards	ICAR scheme
17.	Popularization of Biofortified Maize Hybrids in Himalayan States and Central India with Special Reference to North Eastern Region for Sustainable Nutritional Security	Dr. S.B. Singh	Drs. Ramesh Kumar, Bhupender Kumar, SL Jat and Priyajoy Kar	2020-2023	DBT
18.	First generation Maize ethanol as a renewable energy model for climate change mitigation	Dr. Dharam Paul	Dr. Alla Singh, GS Kochhar (PAU), Dr. Seema Paroha and Vishnu Parbhakar (NSI Kanpur)	2021-2024	NICRA
19.	Development of amylopectin, lysine and tryptophan enriched maize hybrids and molecular tagging of genomic regions associated with high kernel starch in maize	Dr. Abhijit K. Dass		2020-2023	SERB
20.	Improving rainfed (Kharif) maize productivity	Dr. Yathish K.R.	Drs. Ramesh Kumar, Chikkappa GK and BS Jat	2021-2022	CIMMYT

Annual Financial Statement (2021-22)

Annexure VIII

Expenditure Statement (2021-22)

(Amount in Lakhs)

Head of Account	RE 2021-22 Institute Govt. Grant	RE 2021-22 Govt. Schemes	RE 2021-22 AICRP on `Maize	Actual Expenditure during 2021-22 Institute Govt. Grant	Actual Expenditure during 2021-22 Govt. Schemes	Actual Expenditure during 2021-22 AICRP on Maize
Grant in Capital	848.75	12.10	24.40	848.75	12.10	24.40
Grant in Salary	711.00	0.00	2166.59	711.00	0.00	2166.59
Grant in General	521.00	185.77	359.00	514.00	142.97	359.00
TSP (General)	40.00	0.00	39.75	40.00	0.00	39.75
NEH (General)	34.00	0.00	10.00	34.00	0.00	10.00
NEH (Capital)	3.06	0.00	0.00	3.06	0.00	0.00
SCSP (General)	44.00	0.00	0.00	44.00	0.00	0.00
Total	**2201.81**	**197.87**	**2599.74**	**2195.03**	**155.07**	**2599.74**

Revenue Generation during the year 2021-22

(Amount in Lakhs)

Particulars	Amount
Sale of Farm produce	20.80
Application fee from candidates	0.24
Analytical and testing fee	11.03
Interest earned on STDR	15.22
Total	**47.29**

Funds received for externally funded projects during the year 2021-22

Particulars	Amount (in Lakhs)
DUS	13.74
FLD	9.11
DST (RDQPMIFR)	4.04
SERB - Early Career Research Award Scheme	4.56
SERB - Pre Breeding of Wild Crosses	5.16
SERB - CRG	6.07
SERB - EEQ	0.15
IFFCO Nano Drop	9.00
ATMA Training 2021-22	1.00
DBT Project	0.62
HTMA (CIMMYT)	13.61
FAO Consultancy	4.33
ICRISAT	1.86
USDA Project	2.48
CIMMYT (Improving Rainfed Maize Productivity)	7.89
Total	**83.62**

Financial targets and achievements (All employees)

(Amount in Lakhs)

RE 2021-22 for HRD	Actual Expenditure up to 31st March 2022 for HRD	% Utilization of RE 2021-22
0.16	0.16	100.00

Personnel, Transfers, New Joining, Superannuation, Promotion

Annexure IX

Existing Staff in position

Name	Designation	Discipline
Indian Institute of Maize Research, PAU Campus, Ludhiana		
Dr. Sujay Rakshit	Director	Plant Breeding
Dr. Aditya Kumar Singh	Principal Scientist	Agronomy
Dr. Shyam Bir Singh	Principal Scientist	Plant Breeding
Dr. Dharam Paul	Principal Scientist	Biochemistry
Dr. Ramesh Kumar	Principal Scientist	Plant Breeding
Dr. Seema Sepat	Sr. Scientist	Agronomy
Dr. Manesh Chander Dagla	Sr.Scientist	Plant Breeding
Dr. Bharat Bhushan	Sr.Scientist	Biochemistry
Dr. Abhijit Kumar Das	Sr. Scientist	Plant Breeding
Dr. Pardeep Kumar	Scientist	Plant Breeding
Dr. Mamta Gupta	Scientist	Agricultural Biotechnology
Dr. Alla Singh	Scientist	Agricultural Biotechnology
Dr. Bahadur Singh Jat	Scientist	Plant Breeding
Ms. Avni	Scientist	Agricultural Biotechnology
Dr. P. Romen Sharma	Scientist	Agricultural Extension
Mr Praveen Kumar Bagaria	Scientist	Plant Pathology
Mr. Mukesh Choudhary	Scientist	Plant Breeding
Mr. Vishal Singh	Scientist	Plant Breeding
Mr. Deep Mohan Mahala	Scientist	Soil Science
Smt. Shanti Devi Bamboriya	Scientist	Agronomy
Dr. Sumit Kumar Aggarwal	Scientist	Plant Pathology
Mr Priyajoy Kar	Scientist	Agricultural Extension
Sh. Raj Kumar	Sr. Administrative Officer	
Mrs. Komal Sheokand	Sr. Finance & Account Officer	
Sh. Permod Sharma	Assistant Finance & Account Officer	
Mrs. Kamlesh Malik	Assistant Administrative Officer	
Sh. Prashant Garg	Assistant Administrative Officer	
Sh. Bhagesh Sharma	Assistant	
Mrs. Sandeep Kaur	Assistant	
Mr. Samir Kumar Ray	Sr. Technical Assistant (T4)	
Sh. Ram Kishan	Skilled Support Staff	
Indian Institute of Maize Research, Unit Office, Delhi		
Dr. Chikkappa G. Karjagi	Sr. Scientist & In-charge	Plant Breeding
Dr. Shanker Lal Jat	Sr. Scientist	Agronomy
Dr. Suby S.B.	Sr. Scientist	Entomology
Dr. Bhupender Kumar	Sr. Scientist	Plant Breeding
Dr. Krishan Kumar	Scientist	Agricultural Biotechnology
Sh. Anwar Ali	Skilled Support Staff	

Name	Designation	Discipline
Regional Maize Research and Seed production Centre, Begusarai, Bihar		
Dr. Shanker Lal Jat	Sr. Scientist & In-charge	Agronomy
Mr. Kamal Vats	Sr. Technical Assistant (T4)	
Mr. Rahul	Technical Assistant (T3)	
Winter Nursery Centre, Hyderabad		
Dr. J.C. Sekhar	Principal Scientist & In-charge	Entomology
Dr. N. Sunil	Principal Scientist	Plant Breeding
Dr. P. Laxmi Soujanya	Sr. Scientist	Entomology
Dr. K.R. Yathish	Sr. Scientist	Plant Genetics
S. Amar Nath	Skilled Support Staff	

Transfer

Name & Designation	Date of Transfer	Transferred to
Mrs. Seema Sheoran	06.10.2021	IARI, Regional Station Karnal
Sh. Ashwani Kumar	08.12.2021	IVRI, Izatnagar

Transfer from

Name & Designation	Date of Joining	Transferred from
Sh. Raj Kumar, Sr. Administrative Officer	18.10.2021	NRCE, Hisar
Mrs. Komal Sheokand, SF&AO	01.11.2021	ICAR Hqrs.
Mrs. Sandeep Kaur, Assistant	27.12.2021	RS, ICAR-IVRI, Palampur

Scientist on Study Leave

Name	Time period of Study Leave	Institute Name
Mr Praveen Kumar Bagaria	05.01.2019 to 04.01.2022	Punjab Agricultural University, Ludhiana
Mr. Mukesh Choudhary	28.10.2019 to 27.10.2022	University of Western, Australia
Mr. Vishal Singh	18.12.2019 to 17.12.2022	Utah State University, Logan, USA
Mr. Deep Mohan Mahala	26.10.2020 to 25.10.2022	IARI, New Delhi
Smt. Shanti Devi Bamboriya	26.10.2020 to 25.10.2022	IARI, New Delhi

Staff on Deputation

Name & Designation	Time of Deputation	Deputation Institute
Smt Seema Khatter	03.11.2020 to 02.11.2022	IARI, New Delhi

Staff Positions of ICAR-IIMR

Name & Designation	Date of Promotion	Promotion Post
Dr. P. Laxmi soujanya	21.04.2021	Sr. Scientist in next Higher grade
Dr. Suby S.B.	30.06.2019	Scientist to Sr. Scientist
Sh Pravin Kumar Bagaria	01.01.2021	Scientist in next Higher grade
Dr. Krishan Kumar	01.07.2019	Scientist in next Higher grade
Dr. Alla Singh	01.01.2020	Scientist in next Higher grade
Dr. Mamta Gupta	01.07.2019	Scientist in next Higher grade
Dr. Chikkappa G. Karjagi	21.04.2021	Sr. Scientist in next Higher grade
Dr. Manesh Chander Dagla	10.02.2022	Sr. Scientist in next Higher grade
Dr. Bahadur Singh Jat	05.01.2021	Scientist in next Higher grade
Dr. K.R. Yatish	30.04.2021	Scientist to Sr. Scientist
Dr. Bhupender Kumar	01.09.2019	Scientist to Sr. Scientist
Sh. Mukesh Choudhary	01.01.2021	Scientist in next Higher Grade
Dr. Abhijit Kumar Das	15.09.2021	Scientist to Sr. Scientist
Dr. Bharat Bhushan	10.02.2020	Scientist to Sr. Scientist
Sh Prashant Garg	06.10.2021	Assistant to AAO
Sh Samir Kumar Roy	30.03.2018	T-3 to STA (T-4)
Sh Kamal Vats	25.03.2018	T-3 to STA (T-4)

Promotion

Type of Post	Approved by D/O expenditure	In position	Vacant
Scientific	42	31	11
Administrative	21	8	13
Technical	5	3	2
Supporting	3	3	0