वार्षिक प्रतिवेदन
Annual Report
2023

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

वार्षिक प्रतिवेदन
ANNUAL REPORT
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ICAR - INDIAN INSTITUTE OF MAIZE RESEARCH
Punjab Agricultural University Campus,
Ludhiana - 141004 (INDIA)

परिशुद्ध उद्धरण :
Citation:

भाकृअनुपभा.म.अनु.सं. (2018) वार्षिक प्रतिवेदन 2017.18, भाकृअनुप–भारतीय मक्का अनुसंधान संस्थान, पीएयू परिसर, लुधियाना 141004
ICAR-IIMR Annual Report 2020, ICAR-Indian Institute of Maize Research Punjab Agricultural University campus, Ludhiana – 141004.

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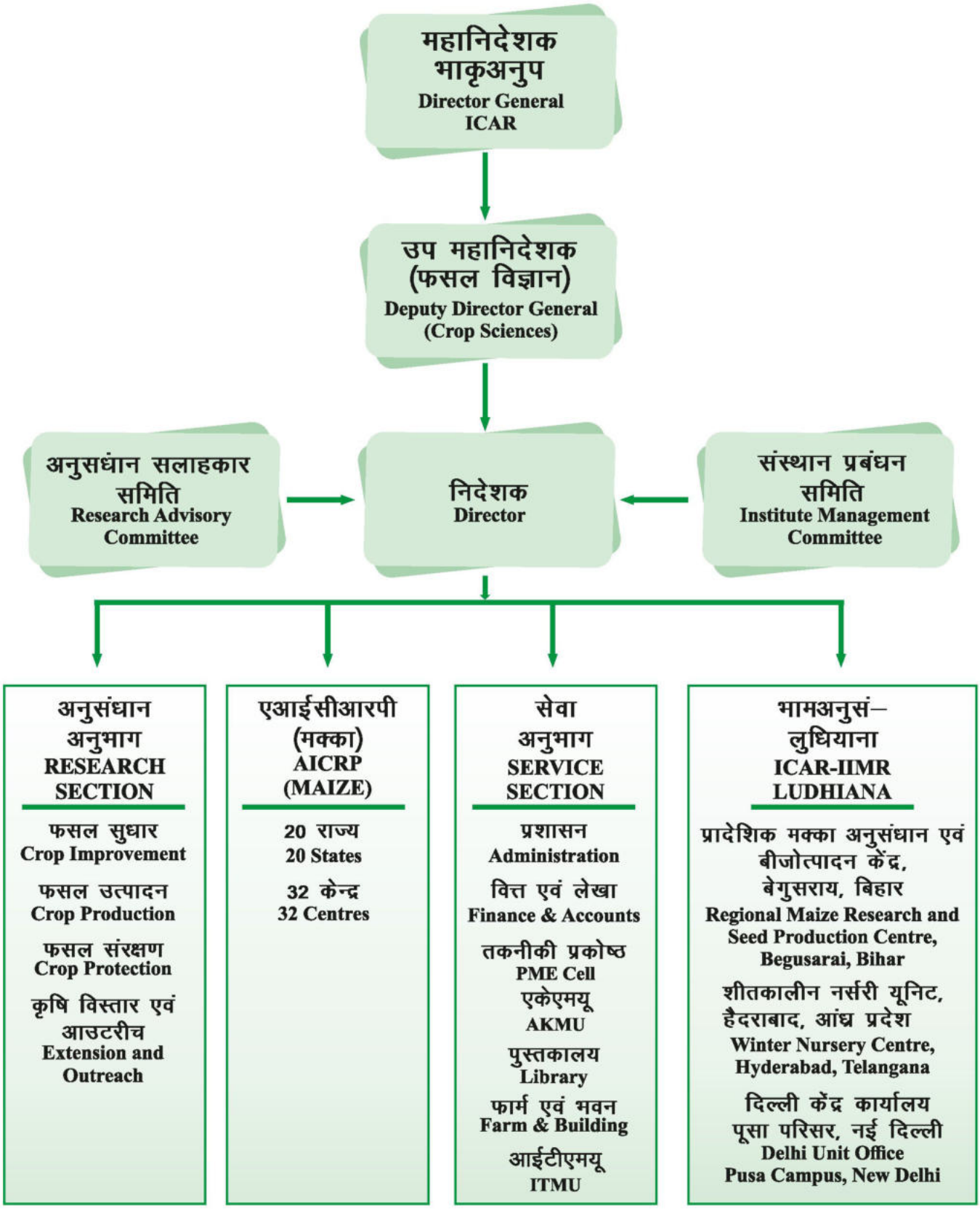


प्रस्तावना

मुझे आपके समक्ष वर्ष 2023 के लिए भाकृअनुप–भारतीय मक्का अनुसंधान संस्थान की वार्षिक रिपोर्ट रखने का सौभाग्य मिला है।

भाकृअनुप–भारतीय मक्का अनुसंधान संस्थान (आईसीएआर–आईआईएमआर) भारतीय कृषि अनुसंधान परिषद के तहत मक्का अनुसंधान का एक प्रमुख राष्ट्रीय संस्थान है। संस्थान ने देश में मक्का सुधार, मूल्य श्रृंखला, क्षमता निर्माण और उद्यमिता विकास पर अनुसंधान में अग्रणी रहा है। इस संस्थान की यात्रा सन् 1957 में मक्का पर समन्वित फसल सुधार परियोजना (CCPIM) के रूप में शुरू हुई। वर्ष 1963 में, मक्का पर समन्वित फसल सुधार परियोजना को और अधिक सुदृढ़ किया गया और इसका नाम बदलकर अखिल भारतीय समन्वित मक्का सुधार परियोजना (AICMIP) कर दिया गया। जिसे वर्ष 1994 में मक्का अनुसंधान निदेशालय (डीएमआर) में उन्नत किया गया। मक्का अनुसंधान निदेशालय को वर्ष 2015 में उन्नत करके भाकृअनुप–भारतीय मक्का अनुसंधान संस्थान बनाया गया। भाकृअनुप–भारतीय मक्का अनुसंधान संस्थान एकमात्र संस्थान है जो देश भर में फैले अपने अखिल भारतीय समन्वित अनुसंधान परियोजना (एआईसीआरपी) केंद्रों के माध्यम से पूरे देश के लिए मक्का में शोध योग्य विषयों को संबोधित करता है और बीज उत्पादन और विकासात्मक एजेंसियों के साथ प्रभावी संपर्क स्थापित करता है।

मक्का अनुसंधान कार्यक्रम उच्च उपज वाली मक्का की संकर किस्मों के विकास, पैतृक वंशावली में सुधार, जैविक और अजैविक तनावों के प्रतिरोध के लिए जर्मप्लाज्म वृद्धि और बदलती जलवायु तथा बाजार की मांग को पूरा करने के लिए गुणवत्ता लक्षणों में सुधार के क्षेत्र में अपनी यात्रा जारी रख रहा है। आनुवंशिक वृद्धि और परिनियोजन के अलावा, साइलेज, बेहतर गुणवत्ता वाले प्रोटीन, सुसंगत स्टार्च सामग्री, जिंक और उच्च उपज वाली किस्मों में उनके इंट्रोग्रेसन जैसे विभिन्न मांग वाले मापदंडों के लिए लक्षण परिवर्तनशीलता का पता लगाने के लिए अनुसंधान में विविधता लाई गई है ।

इथेनॉल उत्पादन में उपयोग के कारण मक्का भारत में रणनीतिक रूप से महत्वपूर्ण व्यावसायिक फसल के रूप में उभरी है। ऐतिहासिक रूप से, मक्का की विस्तार क्षमता को उत्पादन में उल्लेखनीय वृद्धि के माध्यम से प्रदर्शित किया गया है, जो 1950–51 के दौरान उत्पादन मात्र 1.73 मिलियन टन (mt) से बढ़कर वर्ष 2022–23 में 34.6 मिलियन टन तक पहुंच गया है। इस अवधि में अनुसंधान की प्रगति बहुत ही प्रेरणादायक रही है। यह गर्व की बात है कि वर्ष 2023 के दौरान, फील्ड मक्का की चार संकर किस्में, अर्थात् आईएमएच 225, आईएमएच 226, आईएमएच 227, आईएमएच 228, एक क्यूपीएम संकर (क्यूपीएमएच 6), एक बेबी कॉर्न संकर आईबीसीएच 401, एक पॉपकॉर्न संकर (आईपीसीएच– 501) और एक स्वीट कॉर्न संकर आईएससीएच–601 को देश भर में व्यावसायिक खेती के लिए जारी और अधिसूचित किया गया । पिछले छह वर्षों में, भाकृअनुप–भारतीय मक्का अनुसंधान संस्थान ने मक्का की 25 संकर किस्में विकसित और जारी की हैं। वर्तमान में, 16 विभिन्न बीज कंपनियों के साथ 29 समझौता ज्ञापनों पर हस्ताक्षर करके सात संकर किस्मों का व्यावसायीकरण किया गया है।

सूचित प्रजनन प्रयासों के लिए मक्का जीनोटाइप का हेटेरोटिक समूहीकरण किया जा रहा है। विशिष्ट मक्का प्रजनन एक अन्य क्षेत्र है जो बहु–स्थान परीक्षणों में कई किस्मों के साथ तेजी से प्रगति कर रहा है। संस्थान उपज वृद्धि और तनाव लचीलेपन के लिए पूर्व–प्रजनन में लगातार प्रयास कर रहा है। जैव प्रौद्योगिकी सक्षम अनुप्रयोगों के माध्यम से फसल सुधार कार्यक्रम को बढ़ाने के लिए, हाल ही में, एग्रोबैक्टीरियम–मध्यस्थता परिवर्तन प्रणाली को अनुकूलित किया गया है।

उच्च प्रणाली उत्पादकता प्राप्त करने के लिए, मक्का आधारित उत्पादन प्रणालियों में परिशुद्ध संरक्षण कृषि पद्धतियाँ विकसित की गई हैं। कीट और रोग प्रतिरोधक क्षमता के लिए जर्मप्लाज्म स्क्रीनिंग की जा रही है और फसल सुरक्षा में प्रभावी मूल्य श्रृंखला और बीज रोगविज्ञान के लिए खेत पर मक्का के भुट्टों को सुखाने की प्रणाली विकसित की गई है। आईसीएआर–आईआईएमआर ने भारत में आक्रामक कीट फॉल आर्मीवर्म के प्रबंधन में जागरूकता पैदा करने के लिए संयुक्त राष्ट्र के खाद्य और कृषि संगठन के सलाहकार के रूप में भी काम किया।

सिद्ध प्रौद्योगिकियों को हितधारकों तक विस्तारित करने के लिए, संस्थान अग्र–पंक्ति प्रदर्शनों और अनुसूचित जनजाति घटक, उत्तर पूर्वी पहाड़ी घटक, अनुसूचित जाति उप योजना और मेरा गांव मेरा गौरव जैसे विभिन्न प्रायोजित कार्यक्रमों के माध्यम से एक जीवंत विस्तार और आउटरीच कार्यक्रम संचालित करता है, जो प्रौद्योगिकी को जमीनी स्तर तक पहुचने में मदद मदद करता है। इस रिपोर्ट में वर्ष 2023 के लिए मक्का पर आईसीएआर–आईआईएमआर और एआईसीआरपी द्वारा की गई महत्वपूर्ण उपलब्धियों पर प्रकाश डाला गया है।

Hem Pahay

एच. एस. जाट
निदेशक

उद्देश्य और विज़न

Mission & Vision

भाकृअनुप–भा.म.अनु.सं.
ICAR-IIMR

भामअनुसं
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

I am privileged to place before you the annual report of the ICAR-Indian Institute of Maize Research for the year 2023.

ICAR-Indian Institute of Maize Research (ICAR-IIMR) is the premier national institute on maize under ICAR- Indian Council of Agricultural Research. The institute has pioneered research on maize improvement, value chain, capacity building and entrepreneurship development in the country. It started its humble journey as Coordinated Crop Improvement Project on Maize (CCPIM) in 1957. The CCIPM was further strengthened in 1963 through and was renamed s All India Coordinated Maize Improvement Project (AICMIP). It was further upgrated to Directorate of Maize Research (DMR) in 1994. DMR was upgraded to ICAR-Indian Institute of Maize Research in 2015. ICAR-IIMR is the sole institute which address researchable issues in maize for the entire nation through its AICRP centers distributed across India and provides effective linkage with seed production and developmental agencies.

The maize research programme is continuing its journey in thein the development of high yielding maize hybrids, improvement of parental lines, germplasm enhancement for resistance to biotic and abiotic stresses and improvement of quality traits to meet the changing climate and market demand. In addition to the genetic enhancement and deployment, the research has been diversified towards exploration of trait variability for different target parameters in demand, viz., silage, enhanced quality proteins, consistant starch, zinc etc and its introgression in high yielding cultivars.

Maize has emerged as strategically important commercial crop in India because of its use in producing ethanol. The expansion potential of maize has been demonstrated historically with the phenomenal rise in production from a meagre 1.73 million tonnes (mt) during 1950-51 to 34.6 mt in 2022-23. The progress of the research during the period is quite encouraging. It is a matter of pride that during 2023, four field corn hybrids, *viz*., IMH 225, IMH 226, IMH 227, IMH 228, one QPM (QPMH 6), one baby corn hybrid IBCH 401, one popcorn hybrid (IPCH-501) and one sweet corn hybrid ISCH-601 were released and notified for commercial cultivation across India. In the past six years, the ICAR-Indian Institute of Maize Research has developed and released 25 hybrids. Currently, seven of those have been commercialized by signing 29 MoUs with 16 different seed companies.

Heterotic grouping of maize genotypes is being carried out for informed breeding efforts. Specialty corn breeding is another area which is progressing fast with several varieties in multi-location trials. The institute is continuously making efforts in pre-breeding for yield enhancement and stress resilience. To enhance the crop improvement programme through biotechnology enabled applications, recently, *Agrobacterium*-mediated transformation system was optimised.

To attain higher system productivity, precision conservation agricultural practises have been developed in maize-based production systems. Germplasm screening is being done for pest and disease resistance and on-farm maize cob drying system was developed for effective value chain and seed pathology in crop protection. ICAR-IIMR also acted as consultant for the Food and Agriculture Organisation of the United Nations for its interventions to create awareness in managing invasive pest fall armyworm in India.

To extend the proven technologies to stakeholders, the institute operates a vibrant extension and outreach programme though Frontline Demonstrations and various sponsored programmes such as Scheduled Tribe Component, North Eastern Hill Component, Scheduled Caste Sub Plan and Mera Gaon Mera Gaurav, which helps to penetrate the technology to the grass root level.

In this report, the significant achievements made by ICAR-IIMR and AICRP on Maize for the year 2023 are highlighted.

H. S. Jat
Director

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 पस्थितियों 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

फसल सुधार

संकर विकास, बीज उत्पादन और व्यावसायीकरण

कृषि फसलों के लिए फसल मानकों, अधिसूचना और किस्मों का विमोचन पर केंद्रीय उप–समिति (सीएसएन एंड आर वीएसी पर सीएसएस) द्वारा 21 नवंबर, 2023 को आयोजित 91वीं बैठक के दौरान फील्ड कॉर्न की चार संकर किस्में, अर्थात, आईएमएच 225, आईएमएच 226, आईएमएच 227, आईएमएच 228, एक क्यूपीएम (क्यूपीएमएच 6) और एक बेबी कॉर्न संकर (आईबीसीएच 401) जारी और अधिसूचित की गई।

आनुवंशिक संसाधन प्रबंधन

प्रक्षेत्र में 457 इनब्रेड लाइनों के एक सेट का अनुरक्षण किया गया और बल्क परागण के माध्यम से इन्हें बनाए रखने के लिए 29 पूल उगाए गए । पीढ़ी उन्नति में, 171 लाइनें 3 से 4 पीढ़ी में उन्नत किया गया। परीक्षक के रूप में एलएम 15 का 264 इनब्रेड लाइनों के साथ क्रॉस करने का प्रयास किया गया और चयनित इनब्रेड लाइनों का उपयोग करके 90 क्रॉस विकसित करने का प्रयास किया गया।

विशेष मकई प्रजनन

चार स्वीट कॉर्न संकर अर्थात् एनडब्ल्यूपीजेड में आईएसएच 6–2104, एनडब्ल्यूपीजेड, एनईपीजेड, पीजेड और सीडब्ल्यूजेड में आईएसएच 6–2105, एनईपीजेड और पीजेड में आईएसएच 6–2113 और पीजेड में आईएसएच 6–2114 को एनआईवीटी से एवीटी– I में प्रोन्नत किया गया। उनमें से, एवीटी– I में एक हाइब्रिड ISH 6–2104 और परीक्षण के NIVT चरण में दो नए प्रायोगिक संकर अर्थात् ISH 6–2101 और ISH 6–2107 को मक्का पर AICRP के तहत परीक्षण के लिए योगदान दिया गया। सीएमएस आधारित बेबी कॉर्न संकर विकसित करने के लिए, कुल 16 बेबी कॉर्न इनब्रेड लाइनों को सीएमएस लाइनों में परिवर्तित किया गया और इन लाइनों का विभिन्न स्थानों पर मूल्यांकन किया गया। इसके अलावा, इन लाइनों का उपयोग 16 सीएमएस आधारित प्रायोगिक बेबी कॉर्न संकर विकसित करने के लिए विभिन्न संयोजनों में किया गया। कुल 16 प्रायोगिक संकरों में से 4 संकरों ने भूसी के बिना बेबी कॉर्न की उपज के मामले में दोनों जांचों से श्रेष्ठता दिखाई।

जंगली प्रजातियों द्वारा मक्का में तनाव सहनशीलता और चारे के लक्षणों के लिए आनुवंशिक आधार का विविधीकरण

आशाजनक सेग्रिगेंट्स का पता लगाने के लिए, दो दूसरी पीढ़ी के यादृच्छिक संभोग (2GenRM) जंगली आबादियों को इनब्रेड लाइन यूएमआई 1201, यूएमआई 1210 और जंगली प्रजाती जिया मेस एसपीपी.पार्वीग्लुमिस का उपयोग करके विकसित किया गया ।

अजैविक तनाव के लिए प्रजनन

ठंडे तनाव वाले वातावरण में कुछ विमोचित इनब्रेड लाइनों सहित 300 नव विकसित और स्थिर इनब्रेड लाइनों का आईसीएआर–आईआईएमआर, लुधियाना में परीक्षण किया गया। चार इनब्रेड लाइनों में 4.14 से 5.37 टन/हेक्टेयर उपज दर्ज की गई और तीन संकर आईएमएच 2–22 आर–530, आईएमएच 2–22आर–584 और आईएमएच 223 ने शीत तनाव वाले वातावरण में 10 टन/हेक्टेयर से अधिक उपज दर्ज की। खरीफ 2022 के दौरान सामान्य और जलभराव वाले वातावरण में 280 इनब्रेड लाइनों के एक सेट का आरएमआर एंड एसपीसी, बेगुसराय में मूल्यांकन किया गया। चार इनब्रेड लाइनों (एमआईएल 2–814–2, एमआईएल 2–114, एमआईएल 2–983–1 और एमआईएल 2–1587) ने अच्छा प्रदर्शन किया और आठ इनब्रेड लाइनों ने जलभराव की स्थिति में 2 टन/हेक्टेयर से अधिक अनाज की उपज प्राप्त हुई। तीन संकर संयोजन अर्थात् एमआईएल 2–1062–1–2 एलएम 13, एमआईएल 2–324–1 एलएम 14 और एमआईएल 2–376–2 एलएम 13 में सामान्य वातावरण के साथ–साथ जलभराव के तहत उच्च उपज दर्ज की। दो संकर एमआईएल 2–1062–1–2 एमआईएल 2–343–3 और एमआईएल 2–800–1 एमआईएल 2–406–1 ने जलभराव के तहत सर्वोत्तम चेक बायो 9544 की तुलना में 10% से अधिक उपज दी। रबी 2021–22 के दौरान एआईसीआरपी कोल्हापुर केंद्र में सुखा तनाव के तहत पांच जांचों सहित 500 लाइन टेस्टर और डायलेल प्रयोगात्मक संकरों के एक सेट का मूल्यांकन किया गया, जिनमें से 13 संकरों ने सर्वोत्तम चेक डीकेसी 9081 से >10% उपज श्रेष्ठता दर्ज की ।

जैविक तनाव के लिए प्रजनन

खरीफ 2022 के दौरान आईआईएमआर, लुधियाना में एमएलबी के विरुद्ध 100 इनब्रेड लाइनों के एक सेट का मूल्यांकन किया गया इनमें से 10 प्रतिरोधी पाए गई। खरीफ 2023 के दौरान बयालीस सफेद मक्का जीनोटाइप के एक और सेट की दो पुनरावृत्ति में लुधियाना में एमएलबी के विरुद्ध प्रतिरोध के लिए जांच की गई। दो जीनोटाइप, अर्थात, एमआईएल 10–19492, एमआईएल 10–19679 और एमआईएल 10–19682 एमएलबी के खिलाफ प्रतिरोधी पाए

गए। रबी 2022–23 के दौरान स्पॉटेड स्टेम बोरर (एसएसबी), पिंक स्टेम बोरर (पीएसबी) और खरीफ 2022 के दौरान फॉल आर्मीवर्म (एफएडब्ल्यू) के विरुद्ध 500 इनब्रेड लाइनों के एक सेट का मूल्यांकन किया गया । हालाँकि, इनमें से कोई भी लाइन प्रतिरोधी नहीं पाई गई।

गुणवत्ता लक्षणों के लिए प्रजनन

उच्च ट्रिप्टोफैन सामग्री वाली कुल 30 सबसे आशाजनक लाइनों की पहचान की गई है। अड़तालीस क्यूपीएम लाइनों के लिए उत्पन्न हेटेरोटिक समूहीकरण जानकारी के आधार पर, हेटेरोटिक समूह ए और हेटेरोटिक समूह बी के भीतर वंशावली क्रॉस बनाए गए। हेटेरोटिक पूल को चेन क्रॉस विधि द्वारा विकसित किया गया और फिर दो सीजन के लिए आबादी के यादृच्छिक संभोग के बाद नई लाइनों का संश्लेषण शुरू किया गया। मार्कर असिस्टेड चयन (एमएएस) के माध्यम से दो संकर सीएमएच–08–282 और सीएमएच 08–292 को मोमी संकर मक्का में परिवर्तित करने का लक्ष्य रखा गया है। सीएमएच–08–282 (यूएमआई 1200 × यूएमआई 1230) और सीएमएच 08–292 (यूएमआई 1201 × यूएमआई 1230) के जनकों को आवर्तक जनक के रूप में चुना गया है, जबकि मोमी जीनोटाइप यानी पूसा वैक्सी 55411 का उपयोग दाता जनक के रूप में किया गया। उत्परिवर्ती मोमी एलील को दाता जनक से तीन आवर्तक जनकों में अंतर्गमन किया गया। उन्नत यूएमआई 1200, यूएमआई 1201 और यूएमआई 1230 की औसत एमाइलोपेक्टिन मात्रा क्रमशः 97%, 95% और 96% है। भारतीय परिस्थितियों के अनुकूल उच्च एमाइलोज जीनोटाइप विकसित करने के लिए, मार्कर–असिस्टेड बैकक्रॉस ब्रीडिंग के माध्यम से उत्परिवर्ती एई1 (ae1) एलील को दो उच्च उपज देने वाले मक्का संकर (एचएम 5 और एचएम 12) के तीन जनकों में स्थानांतरित करने के लिए संयुक्त राज्य अमेरिका से उच्च एमाइलोज दाता का उपयोग किया गया। संपरिवर्तित लाइनों में एमाइलोज मात्रा, जनकों (22.25 से 26.39:) की तुलना में 40.40 से 58. 10% तक थी।

उष्णकटिबंधीय मक्का में उच्च जिंक संचय के लिए महत्वपूर्ण DEG की पहचान करने के लिए, उच्च जिंक और नियंत्रण (पर्याप्त जिंक) स्थितियों के अंतर्गत विषम इनब्रेड लाइनों से ट्रांसक्रिप्ट प्रोफाइलिंग की गई। सभी दस गुणसूत्रों के लिए सर्कोस प्रतिनिधित्व का उपयोग करके विभिन्न संयोजनों से डीईजी के गुणसूत्र–वार वितरण की कल्पना की गई (चित्र 1.16)। कुल मिलाकर 4628 डीईजी विभिन्न संयोजनों में पाए गए हैं। एक अधिक उपज देने वाली बायो–फोर्टिफाइड संकर मक्का (आईक्यूएच 7–219) को एनईपीजेड, पीजेड और सीडब्ल्यूजेड जैसे तीन क्षेत्रों में दूसरे वर्ष के परीक्षण के लिए बढ़ावा दिया गया है। इसके अलावा, तीन और संकर भी एआईसीआरपी खरीफ 2023 परीक्षणों में परीक्षण के अधीन हैं।

बुनियादी विज्ञान

मेथिओनिन बायोफोर्टिफिकेशन पर अध्ययन

जीन अभिव्यक्ति डेटा से पता चला है कि 10– और 18–केडीए जीन की उच्च अभिव्यक्ति मक्का में उच्च मेथियोनीन संचय से जुड़ी हुई है जो इंगित करती है कि 10– और 18–केडीए जीन मक्का में मेथियोनीन बायो–फोर्टिफिकेशन के लिए संभावित लक्ष्य हैं। अध्ययन में प्राप्त परिणामों का उपयोग उच्च मेथिओनिन दाताओं के साथ विभिन्न जर्मप्लाज्म पृष्ठभूमि की मक्का लाइनों को शामिल करके प्रजनन कार्यक्रम में विविधता लाने के लिए किया जा सकता है।

विभिन्न नाइट्रोजन उपचारों के तहत मक्का में नाइट्रोजन उपयोग दक्षता के लिए आनुवंशिक विविधता

नाइट्रोजन उपयोग दक्षता लक्षणों के लिए विषम मक्का जीनोटाइप की पहचान करने के लिए फेनोटाइपिक, सस्य विज्ञान और जड़ विन्यास अध्ययन किए गए। मक्का में उच्च नाइट्रोजन सक्षम और निम्न नाइट्रोजन सक्षम के लिए प्रत्येक में पांच लाइनों की पहचान की गईं। नाइट्रोजन उपयोग दक्षता से जुड़े लक्षणों को नियंत्रित करने वाले अनुमानित जीन की परिवर्तनीय अभिव्यक्ति के लिए चयनित लाइनों का आगे विश्लेषण किया जाएगा।

एग्रोबैक्टीरियम–मध्यस्थता परिवर्तन के लिए प्रोटोकॉल का अनुकूलन

इष्टतम मापदंडों का पता लगाने के लिए सकारात्मक परिणाम वाले संयोजनों में एग्रोबैक्टीरियम–मध्यस्थता परिवर्तन प्रयोग को तीन बार दोहराया गया। कैली को रूपांतरण के बाद अंधेरे में 50 मिलीग्राम/एल हाइग्रोमाइसिन (एग्रोबैक्टीरियम–मध्यस्थता विधि के माध्यम से रूपांतरर्तित कैली के लिए) वाले कॉलस मीडिया में रखा गया। कैली में जीयूएस (GUS) अभिव्यक्ति के लिए हिस्टोकेमिकल परख रूपांतरण के दस दिन बाद किया गया और कैली में नीले धब्बों की उपस्थिति ने जीयूएस प्रोटीन (बीटा–ग्लुकुरोनिडेज) की अभिव्यक्ति का संकेत दिया। उपयोग किए गए तीन उपभेदों में, उच्चतम रूपांतरण दक्षता (63.63%) एग्रोबैक्टीरियम ईएचए 105 तनाव के साथ हासिल की गई।

ZmPDS जीन को खत्म करने के लिए CRISPR/Cas9 निर्माण का विकास

बी73 समशीतोष्ण मक्का इनब्रेड लाइन से फाइटोइन डीसटुरेज, पीडीएस, जीन अनुक्रम को मक्का जीडीबी (https://www-maizegdb-org) का उपयोग करके पुनर्प्राप्त किया गया तथा भारतीय मक्का जीनोटाइप डीएमआरएच 1308 और बीएमएल6 से कोडिंग अनुक्रम (सीडीएस) के पृथक्करण के लिए विशिष्ट प्राइमर डिजाइन करने के लिए उपयोग किया गया। विशेष कल्टीवार (डीएमआरएच 1308 और बीएमएल 6) से उत्पन्न सीडीएस अनुक्रम जानकारी का उपयोग CRISPR डायरेक्ट (https://crispr-dbcls-jp/) और CHOP&CHOP (https://chopchop-cbu-uib-no/) सॉफ्टवेयर का उपयोग करके न्यूनतम ऑफ–टारगेट के साथ कोडिंग क्षेत्र के 5' छोर की ओर एक लक्ष्य–विशिष्ट गाइड आरएनए (जीआरएनए) डिजाइन करने के लिए किया गया। सफलतापूर्वक एकत्रित की गई रचना का उपयोग डीएमआरएच 1308 से प्राप्त नोडल एक्सप्लांट्स व्युत्पन्न कैलस में एग्रोबैक्टीरिया–मध्यस्थता विधि का उपयोग करके आनुवंशिक रूपांतरण के लिए किया जाएगा।

मक्का में वायरल रोग प्रतिरोधक क्षमता के लिए मेटा–क्यूटीएल विश्लेषण

मेटा–क्यूटीएल विश्लेषण से पता चला कि 27.04% (53) क्यूटीएल 11 वायरस जनित बीमारियों (एससीएमवी, बीवाईडीवी, एमएसवी, एमएमवी, एमसीएमवी, एमसीडीवी, एमएलएन, एमआरसीवी, फोमवी, एमएसडी और एमआरएफवी) के विरुद्ध प्रतिरोधकता से जुड़े हैं । इस विश्लेषण में, Ch1, Ch3 और Ch10 पर वायरल प्रतिरोध से जुड़े 14 मेटा–क्यूटीएल की पहचान की गई। इन मेटा–क्यूटीएल क्षेत्रों ने 13–93% के बीच औसत फेनोटाइपिक भिन्नता प्रदर्शित की। विशेष रूप से, Ch1, Ch3 और Ch10 में क्रमशः 6, 5 और 3 मेटा–क्यूटीएल क्षेत्र शामिल हैं। तिरेपन प्रारंभिक क्यूटीएल में, गुणसूत्रों में वितरण इस प्रकार थाः Ch10 पर 22, Ch3 पर 20, और Ch1 पर 11A 14 मेटा–क्यूटीएल क्षेत्रों में कुल 1715 उम्मीदवार जीन की पहचान की गई।

फसल उत्पादन

सिन्धु–गंगा के मैदानों में अनाज आधारित प्रणाली में परिशुद्ध संरक्षण कृषि पद्धतियों का विकास

चावल–गेहूं की तुलना में मक्का–गेहूं प्रणाली के अंतर्गत प्रणाली उत्पादकता अधिक पाई गई। चावल–गेहूं प्रणाली की तुलना में, छठे वर्ष में संरक्षण और पारंपरिक मक्का–गेहूं प्रणाली में प्रणाली उत्पादकता क्रमशः 30.2% और 7.8% अधिक थी। उर्वरक प्रबंधन प्रथाओं के बीच, ग्रीन सीकर सेंसर के उपयोग से किसान उर्वरक अभ्यास और आरडीएफ की तुलना में काफी अधिक शुद्ध लाभ प्राप्त हुआ। बी:सी (लाभ:लागत) अनुपात के संबंध में, अन्य सभी फसल प्रणालियों की तुलना में स्थान विशिष्ट पोषक तत्व प्रबंधन (एसएसएनएम) के साथ ग्रीन सीकर और साथ ही संरक्षण कृषि–एमडब्ल्यूएमबी में काफी उच्च अनुपात पाया गया।

विभेदक कृषि संबंधी प्रबंधन के तहत मिट्टी के गुण

पांच साल पूरे होने के बाद मिट्टी के गुण, यानी मिट्टी के जैविक कार्बन को भी मापा गया। संरक्षण कृषि मक्का–गेहूं प्रणाली में सबसे अधिक मृदा कार्बनिक कार्बन का निर्माण हुआ, इसके बाद संरक्षण जुताई मक्का–गेहूं का स्थान रहा और सबसे कम मृदा कार्बनिक कार्बन का निर्माण धान–गेहूं फसल प्रणाली में देखा गया।

मक्का और स्थानिक मक्का में विभिन्न जैविक पोषक तत्वों के स्रोतों का अध्ययन

जैविक उपचार में बेबी कॉर्न, स्वीट कॉर्न और सामान्य मक्का की उपज में छह साल पूरे होने के बाद, केवल बेबी कॉर्न की उपज 100% एफवाईएम उपचार के साथ आरडीएफ के बराबर पाई गई। जबकि स्वीट कॉर्न के साथ–साथ सामान्य मक्का में भी जैविक उपचार से काफी कम उपज प्राप्त हुई।

मक्का में खरपतवार प्रबंधन

पाइरोक्सासल्फोन (अंकुरण के पूर्व) के बाद टेम्बोट्रियोन (अंकुरण के बाद) और पाइरोक्सासल्फोन (अंकुरण पूर्व) के बाद टोप्रामेजोन (अंकुरण के बाद) के प्रयोग से मक्का में खरपतवार के घनत्व में उच्च कमी के साथ अनाज की उपज में वृद्धि होती है।

फसल सुरक्षा

मक्का के प्रमुख कीटों के लिए स्थायी प्रबंधन उपकरणों का विकास

कृत्रिम संक्रमण के तहत धब्बेदार तना छेदक के विरुद्ध प्रतिरोध के लिए कुल 339 लाइनों की जांच की गई, और छह जीनोटाइप मध्यम प्रतिरोधी पाए गए। गुलाबी तना छेदक के प्रतिरोध के लिए जांच की गई 144 लाइनों में से, एक जीनोटाइप MIL-1-11 (2.61) कृत्रिम संक्रमण के तहत प्रतिरोधी पाया गया। फॉल आर्मीवर्म के प्रतिरोध के लिए 169 जीनोटाइप के एक सेट की जांच की गई, केवल एक लाइन, यानी सीएमएल 60 (3. 57) को आशाजनक पाया गया जबकि 127 मध्यम प्रतिरोधी पाई गई। पेटेंट–'गतिशील अस्थिर संग्रह प्रणाली'– भारतीय पेटेंट संख्या 431210, दिनांक 8 मई 2023 को अमर चंद एंड कंपनी, 56, इंडस्ट्रियल एस्टेट, अंबाला कैंट–133 006 के साथ व्यावसायीकरण किया गया और इसका उपयोग आईसीएआर संस्थानों, जैसे एनआईबीएसएम और आईआईआरआर द्वारा किया जा रहा है।

प्रमुख रोगों के विरुद्ध प्रतिरोध

मेडीस लीफ ब्लाइट के प्रतिरोध के लिए जांच की गई 307 लाइनों में से कुल 78 को प्रतिरोधी पाया गया। एमएलबी के कृत्रिम रूप से निर्मित एपिफाइटोटिक्स के तहत जांच की गई 273 आरआईएल में से 14 आरआईएल ने एमएलबी के खिलाफ प्रतिरोधी प्रतिक्रियाएं प्रदर्शित कीं। मेडीस लीफ ब्लाइट के विरुद्ध जांचे गए सफेद मक्का के 42 विशिष्ट जीनोटाइप में से तीन जीनोटाइप (19492, 19679, और 19682) प्रतिरोधी थे। चारकोल रोट के प्रतिरोध के लिए जांच की गई 557 लाइनों में से बारह लाइनें प्रतिरोधी पाई गईं। दो सौ इकसठ जीनोटाइप की स्क्रीनिंग के बाद बैंडेड लीफ और शीथ ब्लाइट के विरुद्ध प्रतिरोध के लिए 75 आशाजनक लाइनें पाई गईं। प्रकाश माइक्रोस्कोप के तहत कोनिडिया की रूपात्मक विशेषताओं और आलू डेक्सट्रोज अगार पर मायसेलियम की विशिष्ट वृद्धि के आधार पर एमएलबी रोगजनक के विभिन्न आइसोलेट्स के कुल 25 शुद्ध कल्चर की पहचान की गई। प्रभावी मूल्य श्रृंखला और बीज रोगविज्ञान के लिए खेत पर मक्का भुट्टा सुखाने की प्रणाली विकसित की गई।. यह पाया गया है कि डिजाइन की गई संरचना 1000 किलोग्राम मक्का के भुट्टों को सहन करने में सक्षम है।

विस्तार और आउटरीच

संस्थान राष्ट्रीय खाद्य सुरक्षा मिशन (एनएफएसएम), अनुसूचित जनजाति घटक (एसटीसी), उत्तर पूर्वी पर्वतीय घटक (एनईएच) घटक, अनुसूचित जाति उपयोजना (एससीएसपी), कृषि व्यवसाय ऊष्मायन केंद्र (एबीआई), और मेरा गांव मेरा गौरव (एमजीएमजी) के तहत कृषि और सहकारिता विभाग, भारत सरकार द्वारा प्रायोजित विभिन्न कार्यक्रमों, अर्थात् अग्र पंक्ति प्रदशनों (एफएलडीएस) सहित विभिन्न कार्यक्रमों के माध्यम से किसानों और अन्यहितधारकों के तक पहुंचता है। रबी 2022–23 राष्ट्रीय खाद्य सुरक्षा मिशन के अग्र पंक्ति प्रदशनों के तहत, , 10 राज्यों के 13 केंद्रों द्वारा 130 हेक्टेयर पर एफएलडी आयोजित किए गए, जिससे 16.0: की औसत उपज लाभ के साथ 330 किसानों को लाभ हुआ। वसंत 2023 में, 10 हेक्टेयर पर एफएलडी आयोजित किए गए, जिससे 20 किसानों को लाभ हुआ और 1.91: की औसत उपज में वृद्धि हुई। खरीफ मौसम के दौरान, एफएलडी में 27.31: की उपज वृद्धि प्रदर्शित की। खरीफ 2023 में, एफएलडी के अंतर्गत 386.43 हेक्टेयर को कवर किया, जिससे 12 राज्यों के 1,005 किसानों को लाभ हुआ।

अनुसूचित जनजाति घटक, अनुसूचित जाति उपयोजना और पूर्वी पर्वतीय घटकों के तहत, बेहतर प्रौद्योगिकियों के साथ अग्र पंक्ति प्रदशनों का प्रदर्शन क्रमशः 606, 184 और 32 हेक्टेयर में किया गया, जिससे 2,139 किसानों को लाभ हुआ। कृषि व्यवसाय ऊष्मायन केंद्र (एबीआई) पहल के माध्यम से, कई मक्का–आधारित उत्पाद विकसित किए गए हैं और विभिन्न प्लेटफार्मों पर प्रदर्शित किए गए हैं। इस अवधि के दौरान विभिन्न परियोजनाओं और कार्यक्रमों के तहत कुल 139 प्रशिक्षण और क्षमता निर्माण गतिविधियाँ आयोजित की गईं, जिससे 6,170 से अधिक किसान लाभान्वित हुए। आईसीएआर–आईआईएमआर द्वारा सीमिट, राज्य कृषि विश्वविद्यालयों और राज्य कृषि विभाग के साथ शुरू की गई एक सहयोगी परियोजना, ष्पंजाब और हरियाणा में मक्का आधारित फसल प्रणालियों की संभावित उपज प्राप्ति पर भागीदारी नवाचार मंचष् ने शोधकर्ताओं, नीति निर्माताओं और अभ्यासकर्ताओं को मूल्यवान अंतर्दृष्टि प्रदान की है। ।

मक्का पर एआईसीआरपी

अपनी नियमित अनुसंधान गतिविधियों के अलावा, आईसीएआर–आईआईएमआर मक्का पर अखिल भारतीय समन्वित अनुसंधान परियोजना (मक्का पर एआईसीआरपी) के माध्यम से विभिन्न कृषि विश्वविद्यालयों के मक्का अनुसंधान कार्यक्रमों का समन्वय भी कर रहा है। खरीफ 2022 के दौरान, मक्का पर एआईसीआरपी के तहत बहु–स्थानों पर कुल 356 प्रविष्टियों का परीक्षण किया गया, जिसमें सभी प्रकार के मक्का जैसे फील्ड मक्का, क्यूपीएम, बेबी कॉर्न, स्वीट कॉर्न और पॉप कॉर्न शामिल हैं। रबी के दौरान भी जोन I (एनएचजेड) के अलावा सभी क्षेत्रों में सभी प्रकार की मक्का की मध्यम अवधि और देर से पकने वाले संकरों का परीक्षण किया गया । किस्म पहचान समिति को पहचान के लिए इकतीस प्रविष्टियाँ प्राप्त हुईं। जिसमें से 30 की पहचान की गई, जिसमें रबी के लिए 05 फील्ड कॉर्न , 10 फील्ड संकर मक्का और 02 ओपीवी खरीफ के लिए शामिल हैंय 08 विशेष संकर मक्का (3 पॉप कॉर्न, 3 स्वीट कॉर्न और 02 बेबी कॉर्न खरीफ के लिए) और खरीफ सीजन के दौरान खेती के लिए पांच क्यूपीएम संकर की पहचान की गई। 2022 के दौरान व्यावसायिक खेती के लिए पैंतीस संकरों को अधिसूचित किया गया । पैंतीस में से, 26 संकर फील्ड कॉर्न, छह बायोफोर्टिफाइड, एक बेबी कॉर्न और दो पॉप कॉर्न किस्में थी । खरीफ 2022 के दौरान एनएचजेड में टीएलबी और बीएलएसबी के विरुद्ध कुल 83 प्रविष्टियों का परीक्षण किया गया, जबकि एनडब्ल्यूपीजेड, एनईपीजेड, पीजेड और सीडब्ल्यूजेड में एमएलबी, टीएलबी, सीएचआर, बीएलएसबी, बीएसआर, एसडीएम, एफएसआर और सीएलएस के विरुद्ध 282 प्रविष्टियों का परीक्षण किया गया।. मक्का जर्मप्लाज्म की स्क्रीनिंग के अलावा, महत्वपूर्ण बीमारियों के प्रबंधन के तरीके भी विकसित किए गए और कुछ नए रसायनों की भी

पहचान की गई जो विभिन्न क्षेत्रों में विभिन्न बीमारियों के प्रबंधन में सहायक होंगे। इसी तरह, खरीफ 2022 के दौरान विभिन्न गर्म स्थानों पर चित्तीदार तना छेदक (एसएसबी) और फॉल आर्मी वर्म (एफएडब्ल्यू) के विरुद्ध मक्का जीनोटाइपस की जांच के लिए प्रयोग किए गए । चित्तीदार तना छेदक (एसएसबी) और फॉल आर्मी वर्म (एफएडब्ल्यू) के विरुद्ध मक्का की 103 प्रविष्टियों का मूल्यांकन किया गया जिसमें कोई भी प्रविष्टि प्रतिरोधी नहीं मिली। इसके अलावा, फॉल आर्मी वर्म के प्रबंधन के लिए नए रसायनों का भी परीक्षण किया गया। इसी प्रकार रबी 2022–23 के दौरान गुलाबी तना छेदक, चित्तीदार तना छेदक, एफएडब्ल्यू और शूट फ्लाई के विरुद्ध 47 मक्का प्रविष्टियों की जांच की गई। फील्ड कॉर्न श्रेणी के तहत एक प्रविष्टि मध्यम अवधि वाली प्रविष्टि, आईएमएचएसबी 20 आर–10 और दो देर से परिपक्व होने वाली प्रविष्टियाँ एडीवी 7559, बीएच 417193 प्रतिरोधी पाई गईं, जबकि, विशेष मक्का के तहत, एक पॉप कॉर्न एमबीसी 21–10, दो स्वीट कॉर्न प्रविष्टियाँ हाय ब्रिक्स 81, और हाई ब्रिक्स 59 को गुलाबी तना छेदक के प्रति प्रतिरोधी पाया गया। रबी 2022–23 के दौरान, फील्ड कॉर्न और पॉप कॉर्न प्रविष्टियों ने उच्च पादप घनत्व और बेहतर पोषक तत्व प्रबंधन के लिए अच्छी प्रतिक्रिया दिखाई, जबकि खरीफ सीजन के दौरान लंबी अवधि के फील्ड कॉर्न संकर ने पीजेड में 125% आरडीएफ और सीडब्ल्यूजेड में 150% आरडीएफ के लिए अच्छी प्रतिक्रिया दी। इसी तरह, मध्यम अवधि वाली मक्का संकर, बेबी कॉर्न और ओपीवी ने 150% आरडीएफ पर अच्छी प्रतिक्रिया दी।

Executive Summary

CROP IMPROVEMENT

Hybrid development, seed production and commercialization

Four field corn hybrids, viz., IMH 225, IMH 226, IMH 227, IMH 228, one QPM (QPMH 6), one baby corn hybrid (IBCH 401) one popcorn hybrid IPCH-501 and one sweet corn hybrid ISCH-601 were released by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops (CSS on CSN&R VAC) during the 91st meeting held on November 21, 2023.

Genetic Resource Management

A set of 457 inbred lines were maintained at field and 29 pools were maintained through bulk pollination. In generation advancement, 171 lines advanced from S3 to S4 generation. Crosses were attempted using 264 inbred lines with LM 15 as tester and 90 crosses were attempted using selected inbred lines.

Specialty corn breeding

Four sweet corn hybrids namely ISH 6-2104 in NWPZ, ISH 6-2105 in NWPZ, NEPZ, PZ and CWZ, ISH 6-2113 in NEPZ and PZ, and ISH 6-2114 in PZ were promoted from NIVT to AVT-I. Out of them, one hybrid ISH 6-2104 in AVT-I and two new experimental hybrids namely ISH 6-2101 and ISH 6-2107 in NIVT stage of testing were contributed for testing under AICRP on maize. To develop the CMS based baby corn hybrids, a total of 16 baby corn inbred lines were converted into CMS lines and these lines were evaluated at different locations. Further, these lines were used in different combinations to develop 16 CMS based experimental baby corn hybrids. Among the total 16 experimental hybrids 4 hybrids showed superiority over both the checks in terms of baby corn yield without husk.

Diversification of genetic base for stress tolerance and fodder traits in maize using wild species

To find out the promising segregants, two second generation random mating (2GenRM) wild populations were developed using inbreds UMI 1201, UMI 1210 and wild species Zea mays. Spp. Parviglumis.

Breeding for abiotic stress

A trial of 300 newly developed and fixed inbred lines including some released inbred lines was conducted under cold stress environment at ICAR-IIMR, Ludhiana. Four lines recorded 4.14 to 5.37 t/ha grain yield and three hybrids IMH 2-22R-530, IMH 2-22R-584 and IMH 223 yielded >10 t/ha under the cold stress environment. A set of 280 inbred lines was evaluated under normal as well as waterlogging environment during kharif 2022 at RMR&SPC, Begusarai. Four inbreds (MIL 2-814-2, MIL 2-114, MIL 2-983-1 and MIL 2-1587) performed well and eight inbred lines yielded more than 2 t/ha grain yield under waterlogging conditions. Three hybrid combinations namely MIL 2-1062-1-2 × LM 13, MIL 2-324-1 × LM 14 and MIL 2-376-2 × LM 13 had high yield under normal environment as well as under waterlogging. Two hybrids MIL 2-1062-1-2 × MIL 2-343-3 and MIL 2-800-1 × MIL 2-406-1 out yielded >10% yield superiority over best check Bio 9544 under waterlogging.

A set of 500 line × tester and diallel experimental hybrids including five checks was evaluated under drought environment during rabi 2021-22 at AICRP Kolhapur centre, 13 hybrids out yielded the best check DKC 9081 with >10% yield superiority.

Breeding for biotic stress

A set of 100 inbred lines was evaluated against MLB during kharif 2022 at IIMR, Ludhiana. Out of them, 10 were found resistant. Another set of 42 white maize genotypes were screened for resistance against MLB during kharif 2023 at Ludhiana in two replications. Two genotypes, viz., MIL 10-19492, MIL 10-19679 and MIL 10-19682 were found resistant against MLB.

A set of 500 inbred lines was evaluated against spotted stem borer (SSB), pink stem borer (PSB) during rabi 2022-23 and fall armyworm (FAW) during kharif 2022. However, none of the lines were found resistant.

Breeding for quality traits

A total of 30 most promising lines have been identified with higher tryptophan content. Based on the heterotic grouping information generated for 48 QPM

lines, pedigree crosses were made within heterotic group A and Heterotic group B. The heterotic pools were developed by following chain cross method and then synthesis of new lines was started after random mating of population for two seasons.

Two hybrids CMH 08-282 and CMH 08-292 have been targeted for conversion in waxy maize hybrids through MAS. Parents of CMH-08-282 (UMI 1200 × UMI 1230) and CMH 08-292 (UMI 1201 × UMI 1230) have been selected as recurrent parents, whereas the waxy genotype i.e. Pusa Waxy 55411 was used as donor parent. The mutant waxy allele was introgressed from the donor parent to the three recurrent parents. The mean amylopectin content of improved UMI1200, UMI1201 and UMI1230 are 97%, 95% and 96%, respectively.

To develop high amylose genotype adapted to Indian conditions, high amylose donor from the USA was used to transfer the mutant ae1 allele into the three parents of two high-yielding maize hybrids (HM 5 and HM 12) through marker-assisted backcross breeding. In converted lines, amylose content ranged from 40.40 to 58.10% in comparison to 22.25 to 26.39% in parents.

To identify significant DEGs for higher Zn accumulation in tropical maize, transcript profiling from contrasting inbred lines was performed under high Zn and control (sufficient Zn) conditions. The chromosome-wise distribution of DEGs from various combinations was visualized using Circos representation for all ten chromosomes (Figure 1.16). In total 4628 DEGs have been found in various combinations. One high yielding bio-fortified maize hybrid (IQH 7-219) has been promoted to second year testing in three zones such as NEPZ, PZ and CWZ. Further, three more hybrids are also under testing in AICRP kharif 2023 trials.

BASIC SCIENCES

Studies on methionine biofortification

Gene expression data revealed that higher expression of 10- and 18-kDa zeins are associated with higher methionine accumulation in maize which indicate that 10- and 18-kDa genes are the potential target for the methionine bio-fortification in maize. The results obtained in the study can be utilized to diversify the breeding program by introgressing maize lines of different germplasm backgrounds with high methionine donors.

Genetic diversity for nitrogen use efficiency in maize under different nitrogen treatments

Phenotypic, agronomic, and root architecture studies were conducted to identify contrasting maize genotypes for NUE traits. Five lines each of high nitrogen efficient and low nitrogen efficient were identified in maize. The selected lines will be further analyzed for variable expression of putative genes controlling traits associated with nitrogen use efficiency.

Optimization of protocol for Agrobacterium-mediated transformation

The Agrobacterium-mediated transformation experiment was repeated three times in the combinations having positive results to find out the optimal parameters. The calli were kept in callusing media having either 50 mg/L hygromycin (for calli transformed via Agarobacterium-mediated method) in the dark after transformation. Histochemical assay for GUS expression in calli was performed ten days after transformation and the presence of blue spots in calli indicated the expression of GUS protein (?-glucuronidase) . Among three strains used, the highest transformation efficiency (63.63%) was achieved with the Agrobacterium EHA 105 strain.

Development of CRISPR/Cas9 construct for knocking out ZmPDS gene

Phytoene desaturase, PDS, gene sequence from B73 temperate maize inbred line was retrieved using maize GDB (https://www.maizegdb.org/) and used for designing specific primers for the isolation of a coding sequence (CDS) from Indian maize genotype, DMRH 1308 and BML6. The CDS sequence information generated from the specific cultivar (DMRH 1308 and BML6) was used to design a target-specific guide RNA (gRNA) towards the 5' end of the coding region with minimal off-target using CRISPR Direct (https://crispr.dbcls.jp/) and CHOP-CHOP (https://chopchop.cbu.uib.no/) software. The successfully assembled construct will be used for genetic transformation using the Agrobacteria-mediated method into the nodal explants derived callus from DMRH 1308.

Meta-QTL analysis for viral disease resistance in maize

The MQTL analysis unveiled that 27.04% (53) of the QTLs were linked to resistance against 11 viral diseases (SCMV, BYDV, MSV, MMV, MCMV, MCDV, MLN, MRCV, FoMV, MSD, and MRFV). Within this analysis, 14 MQTLs associated with viral resistance were identified on Ch1, Ch3, and Ch10. These MQTL regions exhibited average phenotypic variance ranging between 13-93%. Specifically, Ch1, Ch3, and Ch10 contained 6, 5, and 3 MQTL regions, respectively. Among the 53 initial QTLs, distribution across chromosomes was as follows: 22 on Ch10, 20 on Ch3, and 11 on Ch1. A total of 1715 candidate genes were identified within the 14 MQTL regions.

CROP PRODUCTION

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

System productivity was higher under maize-wheat system compared to rice-wheat. In comparison to the rice-wheat system, the system productivity was 30.2% and 7.8% higher significantly in conservation and conventional maize-wheat system, respectively in the 6th year. Amongst fertilizer management practices, the use of Green Seeker sensors produced significantly higher net return over farmer fertilizer practice and RDF. With regards to B:C (Benefits:Cost) ratio, significantly higher ratio was found with conservation agriculture-MWMb with green seeker along with SSNM over all other cropping systems.

Soil properties under differential agronomic management

Soil properties, viz., soil organic carbon was also measured after completion of five years. Highest soil organic carbon was built up in conservation agriculture maize-wheat system followed by CT maize-wheat and least soil organic carbon built-up was observed in puddled rice-wheat cropping system.

Study of different organic nutrient sources in maize and spatiality corn

Comparing the yield of baby corn, sweet corn and normal maize in organic treatments, only the yield of baby corn was found at par with RDF with 100% FYM treatment. While in sweet corn as well as in normal maize, significantly lower yield was obtained in organic treatments.

Weed management in maize

Application of pyroxasulfone (Pre-emergence) followed by tembotrione (Post-emergence) and pyroxasulfone (Pre-emergence) followed by topramezone (Post-emergence) enhances grain yield with high reduction in weed density in maize.

CROP PROTECTION

Development of sustainable management tools for major insect pests of maize

A total of 339 lines screened for resistance against spotted stem borer under artificial infestation, six genotypes were found moderately resistant. Out of 144 lines screened for resistance to pink stem borer, one genotype MIL-1-11 (2.61) was found resistant under artificial infestation. A set of 169 genotypes screened for resistance to FAW, only one line, i.e. CML 60 (3.57) was found promising while 127 were moderately resistant. Patent-'Dynamic volatile collection system'- Indian Patent No. 431210, dt. 8 May 2023 has been commercialized with Amar Chand & Co., 56, Industrial Estate, Ambala Cantt-133 006 and is being used by ICAR institutes viz., ICAR-NIBSM and ICAR-IIRR.

Resistance against major diseases

A total of 78 out of 307 lines screened for resistance to Maydis Leaf Blight were found resistant. Out of 273 RILs screened under artificially created epiphytotics of MLB, 14 RILs exhibited resistant reactions against MLB. Out of 42 elite genotypes of white maize screened against MLB, three genotypes (19492, 19679, 19682) were resistant. Twelve lines out of 557 screened for resistance to Charcoal Rot, were found resistant. Seventy five promising lines resistant against Banded Leaf and Sheath Blight, were obtained after screening 261 genotypes. A total of 25 pure cultures of different isolates of MLB pathogen were identified on the basis of morphological characteristics of conidia under light microscope and typical growth of mycelium on PDA. On-farm maize cob drying system was developed for effective value chain and seed pathology. It is found that the designed structure is capable of sustaining 1000 kg maize cobs.

EXTENSION AND OUTREACH

The institute engages with farmers and other stakeholders through various programs, including Frontline Demonstrations (FLDs) sponsored by the Department of Agriculture and Cooperation, Government of India, under the National Food Security Mission (NFSM), Scheduled Tribe Component (STC), North Eastern Hill (NEH) component, Scheduled Caste Sub Plan (SCSP), Agribusiness Incubation Centre (ABI), and MeraGaonMera Gaurav (MGMG). Under the NFSM FLDs, in the Rabi season of 2022-23, FLDs were conducted on 130 hectares by 13 centers across 10 states, benefiting 330 farmers with an average yield gain of 16.0%. In spring 2023, FLDs were conducted on 10 hectares, benefiting 20 farmers, with a mean yield gain of 1.91%. During the *Kharif* season, FLDs demonstrated a yield gain of 27.31%. In *Kharif* 2023, FLDs covered 386.43 hectares, benefiting 1,005 farmers in 12 states. Under the STC, SCSP, and NEH components, FLDs with improved technologies were demonstrated on 606, 184, and 32 hectares respectively, benefiting 2,139 farmers. Through the Agri-Business Incubation (ABI) initiative, several maize-based products have been developed and showcased at various platforms. A total of 139 training and capacity-building activities were conducted, benefiting more than 6,170 farmers during this period under different projects and programs. The "Participatory Innovation Platform on Potential Yield Realization of Maize-Based Cropping Systems in Punjab and Haryana," a collaborative project initiated by ICAR-IIMR with CIMMYT, SAUs, and the state agricultural department, has provided valuable insights to researchers, policymakers, and practitioners.

AICRP ON MAIZE

In addition to its regular research activities, ICAR-IIMR is also coordinating maize research programmes of various agricultural universities through All India Co-ordinated Research Project on Maize(AICRP on Maize).During Kharif 2022, a total of 356 entries were tested at multi-locations under AICRP on maize which includes all types of maize viz., field corn, QPM, baby corn, Sweet corn and pop corn. During Rabi season also medium and late maturing hybrids of all types of corns were tested in all zones except zone I (NHZ). Thirty one entries were received for identification by Varietal Identification Committee. Out of 31, 30 were identified which includes 05 field corn for Rabi, 10 field corn hybrids and 02 OPV for Kharif ;08 specialty corns hybrids (03 pop corn, 03 Sweet corns , 02 baby corn for Kharif) and five QPM hybrids were identified for cultivation during Kharif season. Thirty five hybrids were notified for commercial cultivation during 2022. Out of 35, 26 hybrids were from field corn, six biofortified , one baby corn and two were pop corn. A total of 83 entries of maize were tested against TLB and BLSB in NHZ during Kharif 2022 whereas, 282 entries were tested in NWPZ,NEPZ, PZ and CWZ against MLB, TLB, Ch.R, BLSB, BSR, SDM,FSR and CLS. In addition to screening of maize germplasm, management practices of important diseases were also developed and a few new chemicals were also identified which will be helpful in management of different diseases in different areas. In similar fashion, experiments were conducted for screening of maize genotypes against spotted stem borer (SSB) and Fall Army Worm (FAW) at different hot spots during Kharif 2022. 103 entries of maize were evaluated against SSB & FAW and none of the entries found resistant. In addition to this, new chemicals were also tested for management of FAW. Similarily during Rabi 2022-23 . 47 maize entries were screened against Pink Stem Borer, Spotted Stem Borer, FAW and shoot fly. One entry medium maturing entry, IMHSB 20R-10 and two late maturing entries ADV 7559, BH 417193 under field corn category were found resistant, whereas, under specialty corns, one pop corn MBC 21-10, two sweet corn entries Hi Brix 81, and Hi Brix 59 were found resistant to Pink Stem Borer. During Rabi 2022-23, field corn and pop corn entries responded well to high plant density and better nutrient management whereas during Kharif season long duration field corn hybrids responded to 125 % RDF in PZ & 150 % RDF in CWZ. Similarly, medium maturing field corn hybrids, baby corn and OPV responded well to 150% RDF.

CROP IMPROVEMENT 1

The major activities under crop improvement includes, development of high yielding maize hybrids, improvement of parental lines, germplasm enhancement for resistance to biotic and abiotic stresses and improvement of quality traits to meet the changing climate and market demand.

Success stories of IIMR hybrids

The performance of LQMH-1 at farmers' field has been covered in ICAR Facebook page. LQMH 1, the bio-fortified hybrid released in 2020 was demonstrated in the farmers' field at Himachal Pradesh, Jammu & Kashmir and West Bengal in 35 acres land during *kharif* 2023 and *rabi* 2022-23. It has performed very well in all the states with yield ranging from 6.5-8.0 t/ha (*kharif*) to up to 10.0 t/ha in the rabi season. The suitable features marked by the farmers for this hybrid are, it is short duration which take around 25-30 days less compared to the commercial hybrids being grown by them. Has a better shelling percentage, biofortified, and comparable in yield with the existing hybrids in the farmers' field. The said hybrid has already been taken up by 5 different private seed companies and is already in DAC seed chain. For *kharif* 2024, 300 kg female line breeder seeds demand has been received for the hybrid through DAC, which can produce certified seeds for more than 1.5 lakhs hectare land. The said hybrid has been included in package and practices of West Bengal state for *rabi* as well as *kharif* cultivation.

Hybrid development, seed production and commercialization

Hybrids released by the institute

Four field corn hybrids, viz., IMH 225, IMH 226, IMH 227, IMH 228, one QPM (QPMH 6), one baby corn hybrid (IBCH 401), one popcorn (IPCH 501) and one sweet corn (ISCH 601) were released by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops (CSS on CSN&R VAC) during the 91st meeting held on November 21, 2023.

IMH 225: This is a medium maturity single cross field corn hybrid for cultivation during *rabi* and spring season in Punjab, Haryana, Plains of Uttarakhand, Western UP and Delhi. It has grain yield of 10.25 t/ha and has shown significant yield superiority (18.07%) over the relevant best check in North-Western Plains Zone. This hybrid has long cylindrical ears with semi-dent yellow kernels, moderately resistant to stem borer (*Chilo partellus*),

Figure 1.1: LQMH 1 hybrid in farmers' field

pink stem borer (*Sesamia inferens*) and fall armyworm (*Spodoptera frugiperda*) insects. The hybrid is also resistant to maydis leaf blight (MLB), fusarium stalk rot (FSR) and moderately resistant to Charcoal rot, turcicum leaf blight (TLB) diseases. The hybrid has erect leaves that can be accommodated in high density plantation. The female parent has high seed productivity. This hybrid is responsive to high inputs.

IMH 226: This is a medium maturity single cross field corn hybrid released for cultivation during *rabi* season in Punjab, Haryana, Plains of Uttarakhand, Western UP and Delhi. It has grain yield of 10.48 t/ha and has shown significant yield superiority (13.93%) over the relevant best check in North-Western Plains Zone. The hybrid has long cylindrical ears with semi-dent kernels, moderately resistant to stem borer (*Chilo partellus*), pink stem borer (*Sesamia inferens*) and fall armyworm (*Spodoptera frugiperda*) insects. The hybrid is also resistant to fusarium stalk rot (FSR) and moderately resistant to maydis leaf blight (MLB), Charcoal rot, turcicum leaf blight (TLB), diseases. The female parent is highly productive. The hybrid is responsive to high inputs.

IMH 227: This is a medium maturity single cross field corn hybrid released for cultivation during rabi season in Eastern UP, Bihar, Jharkhand, Orissa and west Bengal. It has grain yield of 10.91 t/ha and has shown significant yield superiority (17.65%) over the relevant best check in North-Eastern Plains Zone. This hybrid has Conico-cylindrical thick ears with semi-dent yellow kernels, moderately resistant to fall armyworm (*Spodoptera frugiperda*) insects. This hybrid is also moderately resistant to Maydis leaf blight, Charcoal rot and Turcicum leaf blight diseases. Has high seed productivity of female parent. The hybrid is responsive to high nutrient inputs.

IMH 228: This is a medium maturity single cross field corn hybrid released for cultivation during rabi season in Eastern UP, Bihar, Jharkhand, Orissa and west Bengal. It has grain yield of 10.57 t/ha and has shown significant yield superiority (173.96%) over the relevant best check in North-Eastern Plains Zone. This hybrid has long Conico-cylindrical ears with dent yellow kernels, moderately resistant to Fall armyworm (*Spodoptera frugiperda*) insects. This hybrid also moderately resistant to Maydis leaf blight, Charcoal rot and Turcicum leaf blight, diseases. The hybrid is highly responsive to high nutrient inputs.

IBCH 401: Hybrid IBCH 401 (IMHSB 19KB-2) is a medium maturity single cross baby corn hybrid released for cultivation during kharif season in Peninsular Zone (PZ), comprising the states of Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Telangana and in Central Western Zone (CWZ), comprising the states of Rajasthan, Gujarat,

Madhya Pradesh & Chhattisgarh. This hybrid has baby corn yield (without husk) of 1.58 t/ha in Peninsular Zone and 1.627 t/ha in Central Western Zone. The hybrid has good quality and creamy white colour with baby corn length of 7.5 to 12 cm long. The hybrid is resistant to Curvularia Leaf Spot (CLS), moderately resistance to turcicum leaf blight (TLB), charcoal rot (C. Rot) and fusarium stalk rot (FSR) diseases, also moderately resistance to stem borer (*Chilo partellus*) and fall armyworm (*Spodoptera frugiperda*) insects. The hybrid showed good response to high inputs and lodging tolerant.

QPMH 6: QPMH 6 is an essentially derived variety (EDV) of initial variety or origin hybrid PMH 6 was identified for release for commercial cultivation under irrigated conditions in northeastern plains zone (NEPZ) during *kharif* season. QPMH 6, an improved version of PMH 6 for enhanced levels of lysine and tryptophan, the essential amino acids which are limited in the field corn. The tryptophan and lysine in the QPMH 6 are 0.85 and 3.09% of protein, whereas in the original hybrid PMH 6 it was 0.39 and 1.91 per cent of protein, respectively. The tryptophan and lysine content in the QPMH 6 were increased by 119 and 62%, respectively. The grain yield of the improved version, QPMH 6 (6417 kg/ha) is numerically superior to its original hybrid, PMH 6 (6379 kg/ha). The CD at 5% was 571 kg/ha. The improved version, QPMH 6 showed a similar and comparable reaction as that of its original hybrid PMH 6 for maydis leaf blight (MLB), one of the major diseases in NEPZ. The improved version, QPMH 6, also showed a statistically similar reaction as that of the original hybrid, PMH 6 to major insect pests namely *Chilo partellus* (Swinhoe) and Fall armyworm, *Spodoptera frugiperda* (J.E. Smith) with leaf and/ear damage rating of 5.3 and 2.8 on all India basis.

Hybrids under advance stage of AICRP testing

- Two medium maturity field corn hybrids IMHSB 20K-10 and IMHSB 20K-11 have completed three years of evaluation in AICRP medium maturity trials for *kharif* season in NEPZ.
- One medium maturity field corn hybrid IMHSB 20R-6 has completed three years of evaluation in AICRP Medium maturity *rabi* trials in NEPZ.
- One medium maturity field corn hybrid IMHSB 20R-16 has completed three years of evaluation in State Varietal Trial (SVT) of Bihar in *rabi* trials.
- Three hybrids IMH 2-22K-4, IMHSB 21R -6, IMH 2-22K-8 were found promising for silage making under NDDB trial.

Seed production and commercialization of maize hybrids

In the past six years, the ICAR-Indian institute of maize research has developed and released 25 hybrids. Currently, seven of those have been commercialized by signing 29 MoUs with 16 different seed companies. For the last three years (2021-22 to 2023-24), ICAR-IIMR hybrids have remained on top in the country's DAC maize breeder seed demand with their share ranging from 33.5 to 62.4 percent. ICAR-IIMR hybrids which receive an adequate amount of breeder seed indents through the DAC include DMRH 1308, IQMH 203, DMRH 1301, LQMH 1 and IMH 224 (Table 1.1). Over the past three years, DMRH 1308 hybrid has stayed on top of the country's DAC breeder seed demand with 20.1 % (2022), 26.1 % (2023) and 34.9 % (2024) share. Since its release, 4628 Kg of breeder seed has gone into the seed chain through the DAC, and the remaining 17189 Kg through non-DAC channels, such as directly from institutes or through partners. Another hybrid, DMRH 1301, has also received significant demand through the DAC. Since its release, so far a total 1873 Kg of breeder seed demand has been obtained and supplied through the DAC for DMRH 1301. In addition, 4260 Kg of parental seed demand has been met through non-DAC channels, such as directly through institutes and other partners. Private seed companies have signed 18 MoUs with ICAR-IIMR to acquire these two hybrids. In total, 11 different private seed companies have taken up DMRH 1301 and 7 have taken up DMRH 1308. A QPM hybrid LQMH 1, released in 2020 is also gaining popularity among farmers and receiving substantial amounts of seed demand through DAC and directly at the institute. So far, five seed companies have taken up LQMH 1. Another

Table 1.1. Year-wise total breeder seeds* produced and supplied (kg) for ICAR-IIMR hybrids.

Particular / Parents of hybrids	Year wise breeder seeds produced and supplied (kg) 2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	Total
Female of DMRH 1301 & 1308	1110.0	188.0	2212.0	5542.0	4085.0	6157	19294
Male of DMRH 1301	295.0	60.0	725.0	200.0	385.0	183	1848
Male of DMRH 1308	-	-	429.0	1895.0	2069.0	2415	6808
Female of DMRH 1305	-	20.0	40.0	-	-	-	60
Male of DMRH 1305	-	10.0	20.0	-	-	-	30
Female of LQMH 1	-	-	-	30.0	45.0	-	75
Male of LQMH 1	-	-	-	15.0	15.0	-	30
Female of IMHB 1539	-	-	10.0	-	-	-	10
Male of IMHB 1539	-	-	5.0	-	-	-	5
Female of LPCH 3	-	-	-	5.0	-	-	5
Male of LPCH 3	-	-	-	2.5	-	-	2.5
Female of IMHB 1532	-	-	30.0	-	-	-	30
Male of IMHB 1532	-	-	10.0	-	-	-	10
Female of IQMH 203	-	-	-	20	-	32	52
Male of IQMH 203	-	-	-	10	-	30	40
Female of IMH 224	-	-	-	-	-	0.5	0.5
Male of IMH 224	-	-	-	-	-	0.5	0.5
Grand total	**1405**	**278**	**3481**	**7719.5**	**6599**	**8818**	**28330.5**

Note*:

1. During 2022-23, of total 6599 Kg, 2900 Kg parental seed of DMRH 1308 (2200 Kg female and 700 Kg male) was produced at Zonal Adaptive Research Station Krishnagar Farm, Nadia WB and supplied into the chain @ foundation seed rate.
2. During 2023-24, of total 8818 Kg, 6750 Kg parental seed of DMRH 1308 and DMRH 1301 (4800 Kg female and 1800 Kg male of DMRH 1308 and 150 kg male of DMRH 1301) was produced at Zonal Adaptive Research Station Krishnagar, Nadia WB and supplied into the chain @ foundation seed rate.
3. The quantity supplied includes the total demand received (through DAC+ direct demand to the institute) from various states and national seeds producing agencies.

biofortified hybrid IQMH 203, notified in 2021 has been taken up by two different privates seed companies and started receiving significant amount of breeder seed demand through the DAC.

Furthermore, ICAR-IIMR is also producing hybrid seeds for institute cultivars in a participatory manner with state seed corporations such as WBSSC, National seed corporations, cooperatives, and SMEs. Over the past five years, around 19375 quintals of hybrid seed (F_1) have been produced in participative mode, where IIMR provided breeders seed and technical advice to seed growers both on and off farms for quality seed production. From a total of 19375 quintal, 9394 quintals of hybrid seed were produced for DMRH 1308, 8781 quintals for DMRH 1301, 1000 quintals for IQMH 203, and 200 quintals for LQMH 1.

Hybrids promoted/contributed under AICRP testing

Field Corn Hybrids

Following field corn hybrid entries were promoted in the AICRP and state trials. As details given below in the table 1.2.

Table 1.2: Hybrid promoted in different AICRP trials

Name of hybrid	Type of hybrid	Trial	Promoted to	Maturity	Zone	Yield (q/ha)	Superiority (%)
AICRP on maize rabi 2022-23 to rabi-2023-24							
IMH 2-22R-10	Field Corn	NIVT	AVT-I	Medium	PZ	10.0	22.9
IMH 2-22R-4	Field Corn	NIVT	AVT-I	Medium	PZ	9.3	21.9
	Field Corn	NIVT	AVT-I	Medium	CWZ	11.1	19.7
IMHSB 20R-3	Field Corn	AVT-I	AVT-II	Medium	NEPZ	9.3	28.9
	Field Corn	AVT-I	AVT-II	Medium	PZ	10.4	22.0
	Field Corn	AVT-I	AVT-II	Medium	CWZ	9.9	11.6
IMHSB 20R-11	Field Corn	AVT-I	AVT-II	Medium	NEPZ	9.3	28.8
IMHSB 21R-7	Field Corn	AVT-I	AVT-II	Medium	CWZ	10.6	19.0
AICRP on maize spring 2023 to spring 2024							
IMH 10-22S5	Field Corn	NIVT	AVT-I	Medium	NWPZ	10.88	12.6
IMH 10-22S1	Field Corn	NIVT	AVT-I	Medium	NWPZ	10.84	12.2
IMH 2-23S-6	Field Corn	NIVT	AVT-I	Medium	NWPZ	10.7	10.7
IMH 2-23S-12	Field Corn	NIVT	AVT-I	Medium	NWPZ	10.6	10.4
IMH 2-22R-10	Field Corn	NIVT	AVT-I	Medium	NWPZ	10.6	9.9
IMH 2-23S-7	Field Corn	NIVT	AVT-I	Medium	NWPZ	10.5	9.1
IMH 2-22R-7	Field Corn	NIVT	AVT-I	Medium	NWPZ	10.3	7.1
IMH 2-23S-11	Field Corn	NIVT	AVT-I	Medium	NWPZ	10.3	7.0
IMH 2-22R-6	Field Corn	NIVT	AVT-I	Medium	NWPZ	10.1	5.3
IMH 2-23S-8	Field Corn	NIVT	AVT-I	Medium	NWPZ	10.1	4.9
IMH 2-22R-5	Field Corn	NIVT	AVT-I	Medium	NWPZ	10.0	4.3
IMH 2-22R-2	Field Corn	NIVT	AVT-I	Medium	NWPZ	10.0	4.0
AICRP on maize *kharif* 2022 to *kharif* 2023							
IMH2 22K-7	Field Corn	NIVT	AVT-I	Medium	NWPZ	9.1	5.0
	Field Corn	NIVT	AVT-I	Medium	NEPZ	7.9	11.5
IMH2 22K-4	Field Corn	NIVT	AVT-I	Medium	NEPZ	7.1	1.1
IMH2 22K-6	Field Corn	NIVT	AVT-I	Medium	PZ	9.4	3.6

Sl. No.	Name of hybrid	Type of hybrid	Trial	Promoted to	Maturity	Zone	Yield (q/ha)	Superiority (%)
IMHSB 20K-10		Field Corn	AVT-I	AVT-II	Medium	PZ	9.5	6.0
State Varietal Trial of Bihar (Rabi-2020-21 to 2021-22)								
IMH 2-20R-3		Field Corn	1st year	2nd year	Medium	Bihar	9.691	10.06
State Varietal Trial of Bihar (Kharif-2022 to 2023)								
IMHSB 19K-11		Field Corn	2nd year	3rd year	Medium	Bihar		
IMH 2-22K-22		Field Corn	1st year	2nd year	Medium	Bihar		
IMH 2-22K-23		Field Corn	1st year	2nd year	Medium	Bihar		

Biofortified hybrids

Four hybrids were promoted for testing under AICRP trials during kharif 2023. Out of these four hybrids two hybrids, namely IQPMH 2102 and IQPMH 2105 were promoted for testing in Zone I whereas IQPMH 2109 was promoted for testing in Zone II and II. IQPMH 2108 was promoted for testing in AVT II in Zone III only. In addition to these hybrids, IQPMH 2203, 2204 and 2205 were also promoted for testing in AVT I in different zones. The details is given in Table 1.3 below.

Baby corn hybrids

After conversion of normal fertile lines into CMS lines, two CMS based baby corn hybrids namely, IBH 11-223 and IBH 11-227 have been developed and contributed into AICRP on maize for testing in kharif 2022 (among these IBH 11-227 was EDV of IMHB 1539). As per the promotion list of kharif 2023 the entry IBH 11-233 has been promoted from NIVT to AVT-I in NHZ, NEPZ, PZ and CWZ. IBH 11-227 was promoted from NIVT to AVT-II in NHZ as EDV, further it was also promoted into NEPZ, NWPZ and PZ (Table 1.4, Figure 1.2).

Evaluation of experimental hybrid

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

Evaluation of early maturity maize hybrids generated through L × T design

A set of 140 early maturity testcrosses including four checks was evaluated during *kharif* 2022 at IIMR, Ludhiana. The hybrid MIL 5-11436 × LM 16 out yielded the best check DKC 7074 with marginal superiority of 2.42% (Table 1.5).

Table 1.3: QPM Hybrid promoted in different AICRP trials

Hybrid	Grain Yield (Q/ha)			Advanced to AVT I/AVTII
	Hybrid	Best Check		
IQPMH 2102	7560	7486 (HQPM 4)	Zone I	AVT II
IQPMH 2105	7418	7486 (HQPM 5)	Zone I	AVT II
IQPMH 2109	7930	7797 (P.QPM Hyb.1)	Zone II	AVT II
	5807	5690 (IQMH 203)	Zone III	AVT II
IQPMH 2108	5691	5690 (IQMH 203)	Zone III	
IQPMH 2204	8035	7797 (P.QPM 1)	Zone II	AVT I
	8304	8156 (IQMH 203)	Zone IV	
	7022	6876 (HQPM 5)	Zone V	
IQPMH 2205	8242	7797 (P.QPM 1)	Zone II	AVT I
	5838	5690 (IQMH 203)	Zone III	
	8188	8156 (IQMH 203)	Zone IV	
IQPMH 2203	7175	6876 (HQPM 5)	Zone V	AVT I

Table 1.4: Baby corn hybrids promoted in AICRP

Hybrid Name	Trial Name	Stage	Zone	Yield Kg/ha	(Superiority %)
IBH 11-223	BC-I-II-III	AVT I	NHZ	1939	21
			NEPZ	2136	2
			PZ	1534	5
			CWZ	1719	18
IBH 11-227*	BC-I-II-III	AVT II	NHZ	1914	21

*This entry was also promoted in other zones also: NWPZ, NEPZ & PZ

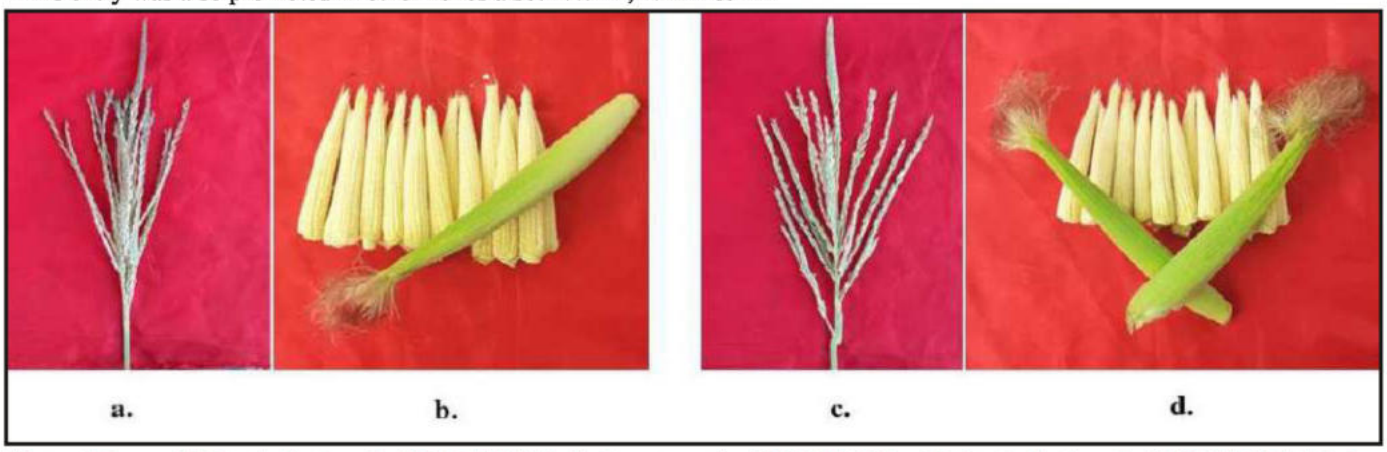


Figure 1.2: a. Male sterile tassel of IBH 11-223, b. baby corn cob of IBH 11-223, c. Male sterile tassel of IBH 11-227, d. baby corn cob of IBH 11-2227

Table 1.5: Performance of top ten early maturity L × T experimental maize hybrids in *kharif*-2022 at IIMR, Ludhiana

Hybrids	DTS	DTM	PH (cm)	EH (cm)	EL (cm)	ED (mm)	KR/E	K/R	SP% (%)	GY (t/ha)	Sup (%)
MIL 5-11436 × LM 16	45	83	178	94	17.7	38	13	37	84	7.83	2.42
MIL 5-11328 × LM 16	46	82	172	80	17.7	42	14	36	83	7.43	-
MIL 5-11687 × LM 16	47	85	196	98	17.5	40	14	32	82	7.33	-
MIL 5-11144 × LM 16	48	83	189	106	16.6	42	15	34	84	7.29	-
MIL 5-11390 × LM 16	48	82	192	101	17.4	41	13	35	81	7.19	-
MIL 5-11302 × LM 16	48	81	174	87	16.8	36	13	33	89	7.15	-
MIL 5-11481 × LM 16	44	82	171	84	15.1	39	12	30	82	7.02	-
MIL 5-11633 × LM 16	48	82	181	97	19.3	39	12	36	78	6.84	-
MIL 5-11380 × LM 16	44	80	177	92	18	40	13	38	85	6.81	-
MIL 5-11484 × LM 15	48	81	182	83	16.3	41	14	34	85	6.76	-
DKC 7074	50	82	169	91	17.5	39	13	34	82	7.64	-
Bio 605	49	84	204	106	20.1	45	14	38	83	7.52	-
VH 45	45	79	152	81	16.6	40	13	32	81	5.73	-
PMH 2	51	88	153	67	16.3	42	15	36	86	4.83	-
Mean	48	81	171	85	16.3	40	14	34	83	5.50	-
CV (%)	3.99	2.52	7.02	10.11	7.75	4.1	6.89	8.53	3.59	16.8	-
CD (5%)	3	3	19	14	2	3	2	5	5	1.50	-

DTS: Days to silking, DTM: Days to maturity, PH: Plant Height, EH: Ear height, EL: Ear length, ED: Ear diameter, KR/E: Kernel Row/Ear, K/R: Kernel/Row, SP: Shelling percentage, GY: Grain Yield, Sup: Superiority

Evaluation of medium maturity maize hybrids generated through L × T design

A set of 310 line × tester experimental hybrids including five checks was evaluated during kharif 2022 at IIMR, Ludhiana. Four hybrids out yielded the best check with >20% yield superiority over best check. A total of 61 hybrids out yielded the best check LG 34.05 (Table 1.6).

Evaluation of early maturing fresh hybrids for grain yield in kharif-2023

A field trial comprising of 431 fresh crosses with six checks, was conducted in kharif-2023. The crosses were significantly superior (P = 0.5) for grain yield as compared to the best check DKC 7074. Five crosses were numerically superior to the check DKC 7074 (Table 1.7).

Evaluation of white maize hybrids for grain yield in kharif-2023

During kharif 2023, a set of 152 white maize hybrids were evaluated at Ludhiana along with two checks,

Table 1.6: Performance of best LxT experimental hybrids (medium maturity) during *Kharif*-2022 at IIMR, Ludhiana

Entry no.	Pedigree	E/P	DTA	DTM	PH	HKW	SP (%)	GY (t/ha)	Sup %	Rank
IMH 2-22K-108	MIL 2-1626 × LM 13	1.03	52	93	253	37.5	85.7	13.821	28.95	1
IMH 2-22K-284	MIL 2-1568 × LM 14	1.03	50	93	255	35.5	84.9	13.128	22.49	2
IMH 2-22K-305	UMI 1210 × LM 14	1.00	51	93	252	34.5	84.2	13.103	22.25	3
IMH 2-22K-261	MIL 2-1628 × LM 14	1.00	52	93	245	33.5	84.4	12.949	20.81	4
IMH 2-22K-266	MIL 2-1624 × LM 14	1.15	52	95	258	32.0	87.6	12.769	19.14	5
IMH 2-22K-264	MIL 2-1623 × LM 14	1.00	51	93	249	30.0	86.9	12.744	18.90	6
IMH 2-22K-300	MIL 2-1620 × LM 14	1.03	50	93	238	33.5	84.8	12.538	16.99	7
IMH 2-22K-187	MIL 2-387-2 × LM 14	1.00	52	93	225	32.5	86.3	12.487	16.51	8
IMH 2-22K-136	MIL 2-83-1 × LM 14	1.00	50	93	231	30.5	86.3	12.282	14.59	9
IMH 2-22K-95	MIL 2-1053-2-2 × LM	131.00	51	93	241	34.5	84.2	12.256	14.35	10
IMH 2-22K-234	MIL 2-976-1 × LM 14	0.97	50	93	238	34.5	83.3	12.231	14.11	11
IMH 2-22K-98	MIL 2-1062-1-2 × LM	131.07	52	93	240	34.5	88.8	12.179	13.64	12
IMH 2-22K-295	MIL 2-3633 × LM 14	1.00	51	93	245	35.5	86.0	12.154	13.40	13
IMH 2-22K-165	MIL 2-245-2 × LM 14	1.00	52	93	248	31.5	85.0	12.077	12.68	14
IMH 2-22K-56	MIL 2-551-2 × LM 13	1.03	50	93	248	36.5	85.1	12.051	12.44	15
IMH 2-22K-161	MIL 2-219-1 × LM 14	1.00	50	93	238	28.5	86.9	11.872	10.77	16
IMH 2-22K-286	HKI-163 × LM 140.	97	52	94	244	30.5	81.5	11.821	10.29	17
IMH 2-22K-180	MIL 2-343-3 × LM 14	1.04	52	93	242	31.0	83.2	11.795	10.05	18
IMH 2-22K-15	MIL 2-173-2 × LM 13	1.00	51	93	232	37.5	85.2	11.667	8.85	19
IMH 2-22K-265	MIL 2-1621 × LM 14	1.00	50	93	238	31.5	88.5	11.667	8.85	20
Check-1	Bio 9544	1.00	54	95	228	33.5	84.1	10.179		
Check-2	LG 34.05	0.87	53	94	243	33.5	88.6	10.718		
Check-3	DHM 121	0.95	52	93	225	36.0	80.8	7.769		
Check-4	CMH 08-287	1.25	53	93	238	35.5	84.4	10.128		
Check-5	NK 6240	1.33	53	93	204	39.0	85.9	6.667		
Mean		1.00	51	93	232	32	84	9.304		
CV (%)		13.1	8.1	9.1	7.6	12.1	11.6	12.160		
CD (5%)		0.1	3.1	5.6	14.2	2.4	4.7	0.914		

DTA: Days to anthesis, DTM: Days to maturity, PH: Plant Height, HKW: Hundred kernel weight, SP: Shelling percentage, GY: Grain Yield, Sup: Superiority

Table 1.7: Promising fresh hybrids for grain yield during *kharif*-2023

Crosses	Days to Anthesis	Days to Silking	Days to Maturity	SOT (%)	GY/ha (kg)	Superiority (%)
MIL 5-11637 × LM 16	51	52	86	82	7538	32
MIL 5-11509 × LM 16	48	49	85	84	6885	20
MIL 5-11663 × LM 15	48	49	85	85	6415	12
MIL 5-11090 × LM 15	48	50	86	82	6316	10
MIL 5-11316 × LM 15	49	50	88	83	6295	10
DKC 7074	51	52	89	83	5726	
CV (%)	3.76	4.12	2.36	2.77	22.36	
CD (5%)	3	3	3	4	1593	

GY/ha: Grain Yield/ha, SOT: Shelling Outturn

viz., CMH 08-292 (medium) and Bio 605 (early). Total eight hybrids, viz., 18524 × MIL-10-16-W, 18608 × MIL-10-15-W, 18591 × MIL-10-16-W, 18533× MIL-10-15-W, 18606× MIL-10-15-W, 18609 × MIL 10-328C1, 18537 × MIL-10-16-W and 18608 × MIL-10-16-W recorded >10% yield over the best check CMH 08-292 (Table 1.8).

Evaluation of fresh crosses for yield and related traits - field corn for *rabi* season

Evaluation of medium maturity maize hybrids generated through L × T design

A set of 600-line x tester experimental hybrids including five checks was evaluated under normal environment during *rabi* 2022-23 at RMR&SPC, Begusarai. Fifteen hybrids out yielded the best check KMH-25K45 and four hybrids yielded with >10% yield superiority over best check (Table 1.9).

Evaluation of diallel experimental crosses

A set of 250 diallel experimental hybrids including four checks was evaluated during rabi 2022-23 at RMR&SPC, Begusarai. Only nine hybrids out yielded the best check P 3522 and only one hybrid

Table 1.8: Promising white hybrids yield during *kharif* 2023

Cross	DTA	Mean Yield (Kg/ha)	Superiority
18524 × MIL-10-16-W	52	6513.23	17.31
18608 × MIL-10-15-W	50	6362.35	14.59
18591 × MIL-10-16-W	52	6354.19	14.45
18533× MIL-10-15-W	50	6272.23	12.97
18606× MIL-10-15-W	53	6208.30	11.82
18609 × MIL 10-328C1	51	6207.06	11.80
18537 × MIL-10-16-W	52	6191.10	11.51
18608 × MIL-10-16-W	56	6160.95	10.96
18535 × MIL 10-696	52	6047.10	8.91
18596 × MIL 10-9C1	56	6034.07	8.68
18532 × MIL-10-16-W	50	6020.33	8.43
18610 × MIL-10-16-W	51	5948.90	7.15
18602 × MIL-10-16-W	51	5834.38	5.08
CMH 08-292	55	5552.18	-
CV (%)	-	15.75	-
CD (5%)	-	723.68	-

Table 1.9: Promising line × tester experimental hybrids under normal condition during *rabi* 2022-23 at RMR&SPC, Begusarai

Entry name	Pedigree	DTA	ASI	DTM	PH (cm)	SP (%)	GY (t/ha)	Sup %	Rank
IMH 2-22R-492	MIL 2-1292-4 × LM 14	102	3	162	185	83.0	12.58	16.89	1
IMH 2-22R-297	MIL 2-83-1 × LM 14	104	4	165	189	87.0	12.25	13.83	2
IMH 2-22R-441	MIL 2-941-3 × LM 14	97	3	162	195	83.3	12.05	11.99	3
IMH 2-22R-489	MIL 2-1292-1 × LM 14	103	3	168	207	84.9	11.99	11.43	4
IMH 2-22R-229	MIL 2-1623 × LM 13	104	4	167	203	84.0	11.49	6.73	5
IMH 2-22R-570	MIL 2-1568 × LM 14	99	3	165	203	82.7	11.37	5.63	6
IMH 2-22R-307	MIL 2-137-2 × LM 14	103	3	167	189	87.4	11.30	4.96	7
IMH 2-22R-235	MIL 2-3099 × LM 13	104	3	147	159	82.4	11.16	3.66	8
IMH 2-22R-442	MIL 2-955-1 × LM 14	103	3	166	184	86.1	11.15	3.55	9
IMH 2-22R-228	MIL 2-1625 × LM 13	107	3	167	574	83.4	11.11	3.22	10
IMH 2-22R-567	MIL 2-1569 × LM 14	99	3	164	198	85.6	11.09	3.07	11
IMH 2-22R-468	MIL 2-1058-2-2 × LM 14	98	3	167	168	86.6	10.95	1.74	12
IMH 2-22R-583	MIL 2-3776 × LM 14	103	3	164	196	81.4	10.91	1.40	13
IMH 2-22R-87	MIL 2-481-1 × LM 13	102	3	167	192	78.5	10.81	0.42	14
IMH 2-22R-227	MIL 2-1626 × LM 13	109	3	168	187	83.6	10.79	0.29	15
Check-1	KMH-25K45	106	2	169	196	81.4	10.76		
Check-2	P-3522	106	4	171	217	86.1	10.38		
Check-3	NMH-713	107	3	168	161	88.2	9.41		
Check-4	Bio-9544	109	4	165	182	83.9	8.83		
Check-5	DHM-117	107	3	165	178	83.4	5.94		
Mean		103.0	3.0	184.1	183.5	83.0	7.76		
CV (%)		6.72	12.47	7.15	6.59	12.64	14.7		
CD (5%)		5.94	0.42	12.48	14.65	5.79	0.96		

DTA: Days to anthesis, ASI: Anthesis to silking interval, DTM: Days to maturity, PH: Plant Height, SP: Shelling percentage, GY: Grain Yield, Sup: Superiority

IMH 2-22R-811 yielded with >10% superiority over best check (Table 1.10).

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

Screening of experimental maize hybrids for Spring season

A set of 600 line × tester experimental hybrids including five checks was evaluated under during spring 2023 at ICAR-IIMR, Ludhiana. Forty-one hybrids out yielded the best check P 3522 and six hybrids yielded with >10% yield superiority over best check (Table 1.11).

Evaluation of early maturing fresh hybrids for grain yield in spring-2023

A field trial comprising of 47 fresh crosses with four checks, was conducted in spring 2023. None of crosses was statistically superior with respect to critical difference (CD at P = 0.5) for grain yield as compared to the superior check P 1844. However, three crosses were numerically superior with reference to check P 1844 (Table 1.12).

The seeds of two fresh hybrids (MIL 5-11341 × LM 16 and MIL 5-11347 × LM 16) submitted in AICRP testing for spring-2024.

Evaluation of white maize hybrids for grain yield

A total of 135 test crosses (27 lines crossed with 5 testers) were evaluated in two replications at Ludhiana during spring 2023. Out of 135 hybrids, 21 hybrids showed >10% superiority over the check PMH 10. The superior hybrids have been listed in

Table1.10:Promising diallel experimental hybrids during *rabi* 2022-23 at RMR&SPC, Begusarai

Entry name	Pedigree	DTA	ASI	DTM	PH (cm)	SP (%)	GY (t/ha)	Sup %	Rank
IMH 2-22R-811	MIL 2-119-2 × MIL 2-1062-1-2	103	4	165	193	88.2	12.45	10.27	1
IMH 2-22R-839	MIL 2-1299-5 × MIL 2-406-1	109	3	165	151	85.9	12.10	7.16	2
IMH 2-22R-625	MIL 2-1286-3 × BML 6	108	3	164	168	84.9	12.03	6.55	3
IMH 2-22R-805	MIL 2-1289 × MIL 2-571-1	110	3	161	203	88.0	11.86	5.11	4
IMH 2-22R-603	MIL 2-83-1 × BML 6	106	3	164	180	86.4	11.84	4.92	5
IMH 2-22R-772	MIL 2-3482 × HKI 1128	106	3	163	197	81.0	11.65	3.21	6
IMH 2-22R-746	MIL 2-794-1 × HKI 1128	105	3	166	189	85.6	11.62	2.97	7
IMH 2-22R-808	MIL 2-406-1 × MIL 2-1510	108	3	160	185	84.8	11.56	2.43	8
IMH 2-22R-678	MIL 2-1292-2 × BML 7	110	3	161	202	80.7	11.48	1.70	9
Check 1	P 3522	110	3	160	172	86.3	11.29		
Check 2	KMH 25K45	112	3	165	194	83.7	11.21		
Check 3	NMH 713	108	4	160	183	88.5	8.69		
Check 4	DHM 117	109	3	163	175	83.8	5.89		
Mean		107.4	3.0	163.2	181.3	82.9	7.52		
CV (%)		7.84	12.91	8.64	7.68	14.15	16.42		
CD (5%)		6.12	0.52	13.54	13.68	6.49	0.81		

DTA: Days to anthesis, ASI: Anthesis to silking interval, DTM: Days to maturity, PH: Plant Height, SP: Shelling percentage, GY: Grain Yield, Sup: Superiority

Table 1.11: Promising line × tester experimental hybrids during spring 2023 at ICAR-IIMR, Ludhiana

Hybrid	NEP	DTA	DTM	PH (cm)	SP (%)	GY (t/ha)	Sup %	Rank
MIL 2-1286-3 × LM-14	1.00	75	112	224	86.0	15.77	29.02	1
MIL 2-1620 × LM-14	1.17	73	116	211	85.7	14.28	16.79	2
MIL 2-277-1 × LM-13	1.13	74	119	212	88.2	13.92	13.86	3
MIL 2-1568 × LM-14	0.95	73	112	230	86.7	13.74	12.37	4
MIL 2-173-3 × LM-14	0.75	75	119	190	87.5	13.69	11.99	5
MIL 2-1046-5-2 × LM-14	0.94	75	110	210	80.5	13.61	11.34	6
MIL2-1621 × LM-13	1.20	75	112	198	86.6	13.44	9.95	7
MIL 2-376-2 × LM-13	0.81	75	112	193	83.4	13.38	9.45	8
MIL 2-3502 × LM-14	0.94	75	113	209	86.8	13.37	9.36	9
MIL 2-938-1 × LM-14	1.19	73	115	210	85.7	13.36	9.33	10
MIL 2-1240 × LM-14	1.00	75	113	208	83.8	13.36	9.30	11
MIL 2-1623 × LM-14	1.14	76	117	202	85.0	13.32	9.00	12
MIL 2-1624 × LM-14	1.00	74	114	234	77.6	13.28	8.66	13
MIL 2-1620 × LM-13	1.12	73	117	208	83.2	13.25	8.37	14
MIL 2-1292-4 × LM-14	0.94	73	117	204	87.1	13.24	8.35	15
MIL 2-83-1 × LM-14	1.06	74	116	180	82.9	13.24	8.28	16
MIL 2-406-2 × LM-13	1.15	76	115	217	82.3	13.22	8.19	17
MIL 2-160-1 × LM-14	1.05	72	117	220	87.6	13.12	7.34	18
MIL 2-2083 × LM-13	1.22	75	116	193	81.9	13.11	7.23	19

Hybrid	NEP	DTA	DTM	PH (cm)	SP (%)	GY (t/ha)	Sup %	Rank
MIL 2-406-2 × LM-14	1.03	74	117	212	85.0	13.04	6.67	20
Bio 9544	1.03	78	118	194	81.6	10.52		
DHM 117	1.00	78	118	191	79.2	8.08		
NMH 713	1.00	80	119	174	80.9	9.76		
KMH 25K45	1.05	80	121	203	83.5	11.50		
P 3522	1.11	79	121	233	83.2	12.22		
Mean	1.02	77.24	114.65	196.52	83.01	8.94		
CV (%)	14.60	8.69	7.96	12.49	13.42	12.56		
CD (5%)	0.18	2.56	4.76	9.53	3.47	1.34		

NEP: Number of ear per plant, DTA: Days to anthesis, ASI: Anthesis to silking interval, DTM: Days to maturity, PH: Plant Height, SP: Shelling percentage, GY: Grain Yield, Sup: Superiority

Table 1.12: Promising fresh hybrids for grain yield during spring 2023

Hybrid	Days to Anthesis	Days to Maturity	GY/ha (Kg)	SOT (%)	Superiority (%)
MIL 5-11341 × LM 16	73	115	11972	80	16
MIL 5-11347 × LM 16	72	117	11365	79	10
MIL 5-11389 × LM 16	72	117	11356	84	10
P 1844	73	117	10330	81	
CV (%)	1.75	1.47	18.68	2.50	
CD (5%)	2	3	2450	3	

GY/ha: Grain Yield/ha, SOT: Shelling Outturn

Table 1.13: Evaluation of white maize hybrids for grain yield during spring 2023

Hybrid	DTA	Yield (Kg/ha)	Sup. %
15382 × MIL 10-9C1	74	14454.7	31.1
15376 × HKI1378	76	13395.1	25.7
15379 × MIL 10-9C1	80	13234.1	24.8
15403 × HKI1378	79	13023.3	23.5
15406 × MIL 10-9C1	76	12568.1	20.8
15378 × MIL 10-328C1	76	12155.3	18.1
15383 × MIL 10-328C1	77	12128.7	17.9
15387 × HKI 1378	75	11956.0	16.7
15378 × MIL 10-696	76	11624.6	14.3
15385 × HKI1378	78	11554.6	13.8
15398 × MIL 10-328C1	78	11527.7	13.6
15375 × MIL 10-328C1	77	11313.8	12.0
15398 × HKI 1378	78	11272.4	11.7
15385 × MIL 10-328C1	80	11269.8	11.7
15375 × HKI1378	73	11264.0	11.6
15392 × HKI1378	76	11212.7	11.2
15385 × MIL 10-9C1	78	11185.6	11.0

Hybrid	DTA	Yield (Kg/ha)	Sup. %
15384 × HKI 1378	75	11166.5	10.8
15381 × MIL 10-9C1	79	11145.0	10.7
15400 × HKI 1378	74	11086.0	10.2
15405 × MIL 10-328C1	76	11081.7	10.2
PMH 10	76	9956.6	-
CD (5%)	-	1612.7	-
CV (%)	-	15.2	-

Figure 1.3: Superior white maize hybrids from spring trials at Ludhiana

Table 1.13.

Evaluation of inbred lines - field corn

Evaluation of early maturing inbred lines for grain yield

In spring 2023, a set of 49 inbred lines was evaluated for grain yield. The observations were taken on days to anthesis, silking and maturity, plant and cob height, cob length and diameter, grain rows/cob and grains/row in cob, grain yield and shelling outturn. Top 10 inbreds for grain yield are given in table 1.14.

Maize Genetic Resource Management

Early maturing maize: Maintenance, generation advancement, hybridization and seed multiplication

A set of 457 inbred lines were maintained at Ludhiana dring spring 2023. Twenty-nine pools were grown for maintaining these pools through bulk pollination. In generation advancement, 171 lines advanced from S3 to S4 generation. Crosses were

Table 1.14: Promising inbreds for grain yield during spring-2023

Inbreds	DTA	DTS	DTM	PH (cm)	CPH (cm)	CL (cm)	CD (mm)	GR/C	G/R	GY/ha (Kg)	SOT (%)
MIL 5-11357	75	75	114	135	73	14.0	36	12	35	6074	81
MIL 5-11664	82	83	119	163	89	14.3	40	16	27	5447	78
MIL 5-11053	75	75	121	151	90	14.2	39	15	32	5225	80
MIL 5-11319	80	81	123	114	65	14.2	40	16	34	4028	80
MIL 5-11002	78	80	117	125	64	14.8	43	18	26	3892	71
MIL 5-11675	74	75	116	114	63	16.2	39	13	30	3835	73
MIL 5-11050	70	69	119	125	66	13.1	34	12	26	3761	82
MIL 5-11103	67	68	114	119	55	14.7	40	12	36	3442	84
MIL 5-11492	71	69	113	105	55	14.7	37	12	26	3242	78
MIL 5-11447	76	78	122	129	69	13.8	42	16	30	3197	86
CV (%)	1.87	1.88	1.62	7.64	10.83	9.21	5.68	7.70	12.16	30.87	5.55
CD (5%)	2	2	3	14	10	2.0	3	2	5	1253	7

DTA: Days to Anthesis, DTS: Days to Silking, DTM: Days to Maturity, PH: Plant Height, CPH: Cob Placement Height, CL: Cob Length, CD: Cob Diameter, GR/C: Grain Rows/Cob, G/R: Grains/Row in Cob, GY/ha: Grain Yield/ha and SOT: Shelling Outturn

attempted using 264 inbred lines with LM 15 as tester. In kharif-2023, fresh 90 crosses were attempted using selected inbred lines. The hybrid seeds of two promising crosses (MIL 5-11341 × LM 16 and MIL 5-11347 × LM 16) were multiplied for submitting seeds in AICRP for testing in NIVT spring-2024.

Specialty corn breeding

Breeding for sweet corn

Six experimental hybrids namely ISH 6-2102, ISH 6-2103, ISH 6-2104, ISH 6-2105, ISH 6-2113, and ISH 6-2114 were evaluated under all India coordinated research project (AICRP) on maize during kharif 2022. Out of which, four hybrids namely ISH 6-2104 in NWPZ, ISH 6-2105 in NWPZ, NEPZ, PZ and CWZ, ISH 6-2113 in NEPZ and PZ, and ISH 6-2114 in PZ were promoted from NIVT to AVT-I. The details of the performance of the hybrids are given below (Table 1.15).

Further, out of four sweet corn hybrids promoted from NIVT to AVT-I, one hybrid ISH 6-2104 in AVT-I and two new experimental hybrids namely ISH 6-2101 and ISH 6-2107 in NIVT stage of testing were contributed for testing under AICRP on maize during kharif 2023.

Breeding for baby corn

Evaluation of CMS based baby corn hybrids

To develop the CMS based baby corn hybrids, a total of 16 baby corn inbred lines were converted into CMS lines and these lines were evaluated at different locations, Results showed consistent sterility over the locations. Further, these lines were used in different combinations to develop 16 CMS based experimental baby corn hybrids which were evaluated in spring season 2023, in RBD design with two replications with the check CMVL baby corn 2 and G 5417. Among the total 16 experimental hybrids 4 hybrids showed superiority over both the checks in terms of baby corn yield without husk (Table 1.16).

Fodder maize breeding

Diversification of genetic base for stress tolerance and fodder traits in maize using wild species

Two second generation random mating (2GenRM) wild populations were developed using inbreds UMI 1201, UMI 1210 and wild species *Zea mays. Spp. parviglumis* (Figure 1.4, 1.5) to find out the promising segregants. On the other hand, a total of 66 wild crosses were attempted in *kharif* 2023 with cultivated inbred lines to diversify the material.

Silage trial: To find out the promising genotypes for silage in terms of morphological traits and biochemical, a trial was conducted using different types of maize, *viz.,* normal grain hybrids from public and private sector, composites, baby corn hybrids.

Table 1.15: Performance of sweet corn hybrids in AICRP

Entry Name	NWPZ EWWH (kg/ha)	NEPZ EWWH (kg/ha)	PZ EWWH (kg/ha)	CWZ EWWH (kg/ha)
ISH 6-2102	10430	8182	8261	6818
ISH 6-2103	11138	8514	10096	6880
ISH 6-2104	11193	8077	10192	7322
ISH 6-2105	11529	9197	10480	8931
ISH 6-2113	10519	8635	11013	7704
ISH 6-2114	11102	7937	11174	8030
CMVL Sweet Corn-1 (C)	10574	7855	10053	6970
Mishthi (C)	10927	8435	10069	7635
Pusa Super Sweet Corn-1 (C)	10375	7900	9362	7874
Pusa Super Sweet Corn-2 (C)	10435	8030	9034	6949

EWWH: Ear weight without husk

Table 1.16: Evaluation of baby corn hybrids

Ex. hybrids	Baby Yield without husk (q/ha)	% superiority		BCL (cm)	BCD (cm)
		CMVL BC 2	G 5417		
IBCH 11-2	14.11	31	10	9.25	1.2
IBCH 11-8	16.66	55*	30	8.83	1.3
IBCH 11-9	14.61	35	14	8.5	1.23
IBCH 11-14	15.12	40	18	9.6	1.1
CMVL BC 2 (Check)	10.77				
Check G 5417 (Check)	12.82				

CV- 22.52, CD- 5.20 at 5%, (BCL-baby corn length, BCD-Baby corn diameter)

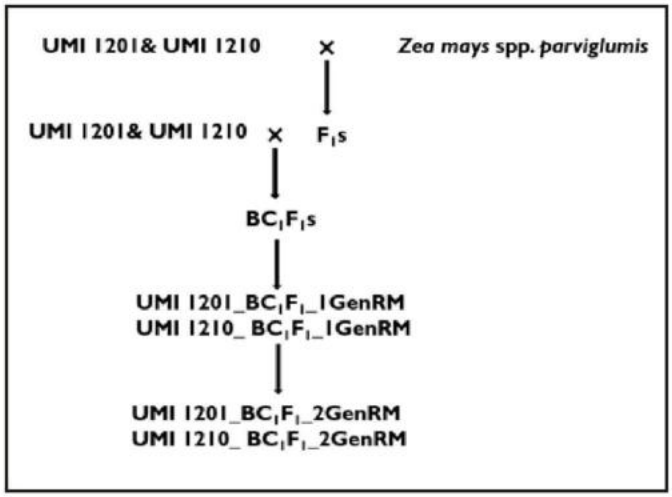


Figure 1.4: Development of wild population to diversify the germplasm

The trial was conducted in RBD design in 3 replications with 10 rows each (21 m2) in a spacing of 70 × 20 cm. The genotypes included were African tall, DKC-9164, LQMH-203, DMRH-1410, CP-858, DMRH-1419, J-1006, DESI MAIZE, IMH-1840, IMHB-1539, CMS-2 (IBH 11-227), LQMH-1, CMS-1 (IBH 11-223), P-1844 and SUGAR-75. Different parameters like plant height, leaf length, leaf width, stem girth, total number of leaves and fodder yield at silage stage were recorded, none of the genotypes were found promising for all the traits. Overall, the hybrids *viz.,* DMRH 1410, LQMH 203, DMRH 1419, DKC 9164 and CP 858 were found

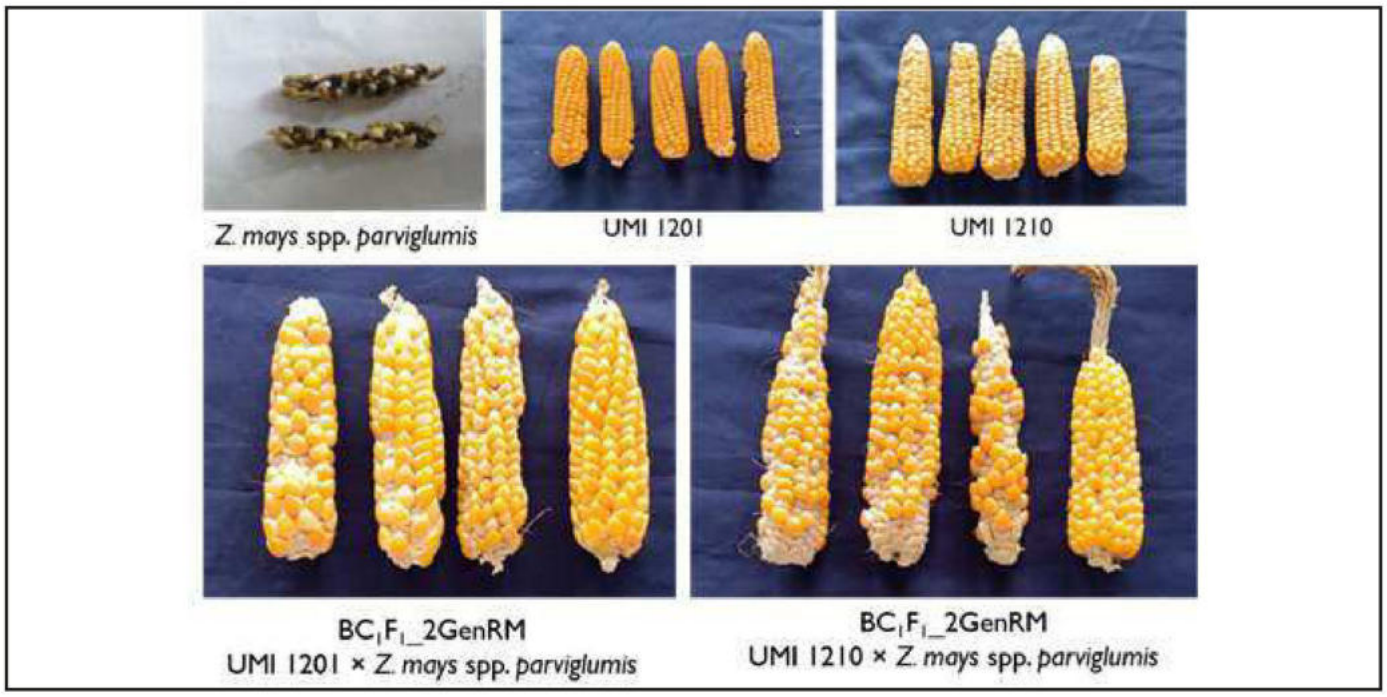


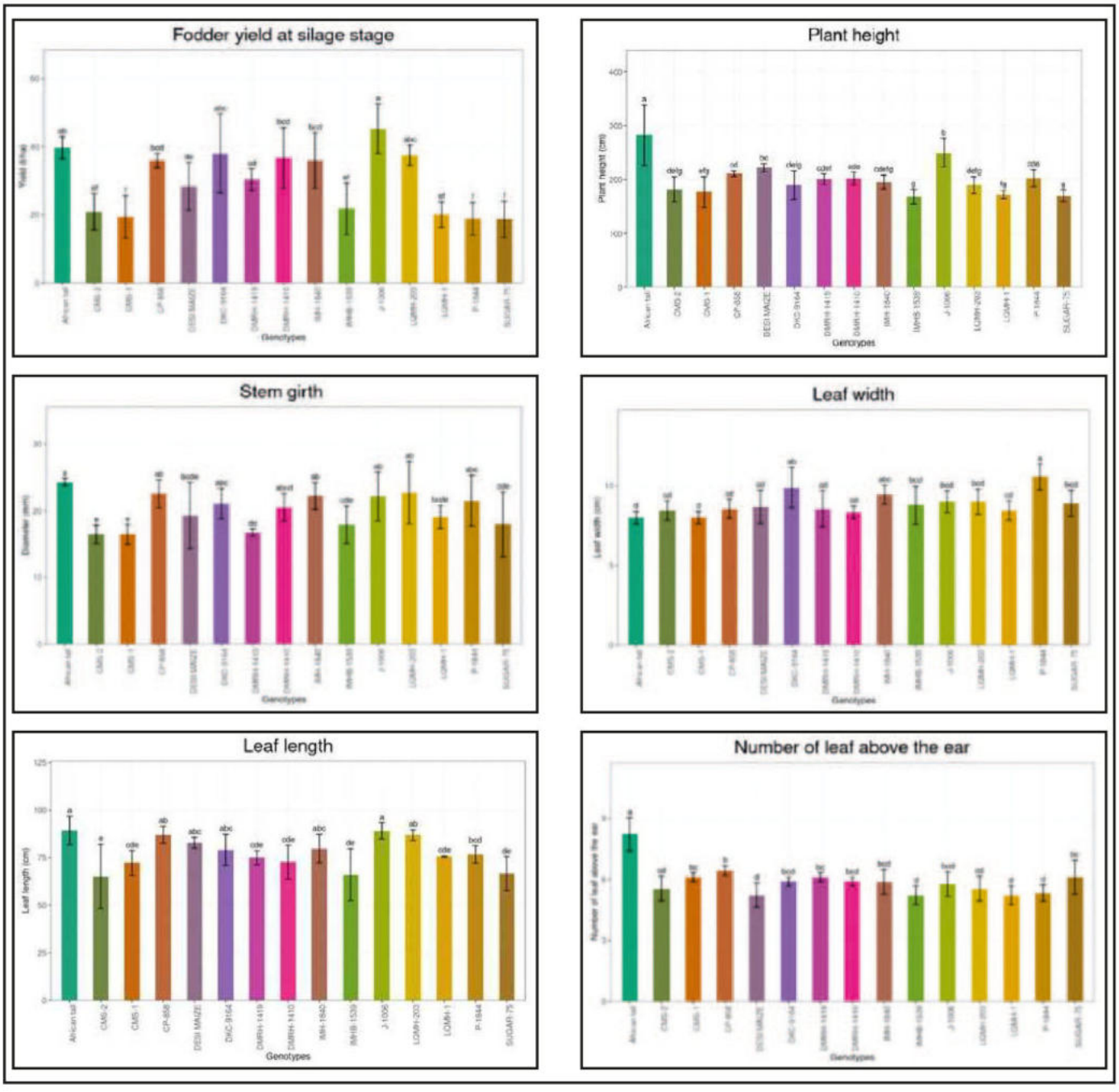
Figure 1.5: Pictorial view of wild, inbred and their population

better. Similarly, various digestibility parameters were also recorded like dry matter content, crude protein, neutral detergent fibre, acid detergent fibre, total digestible dry matter and lignin content. Highest dry matter content was recorded in DMRH 1419 and LQMH 1. Highest crude protein was recorded in CMS + grain a baby corn hybrid and highest digestible dry matter in DMRH 1419 (Fig 1.6).

Breeding for abiotic stress

Screening of maize inbred lines under cold stress

A trial of 300 newly developed and fixed inbred lines including some released inbreds was conducted at ICAR-IIMR, Ludhiana. The trial was laid during optimum sowing time of rabi i.e. first fortnight of November. Observations on survival percentage, maturity traits and yield traits were recorded. Out of the 300 inbred lines, seed setting was reported only in 237 inbreds, and there was no seed setting in 22 inbreds, whereas in 41 inbreds complete mortality was observed due to freezing/chilling injury.



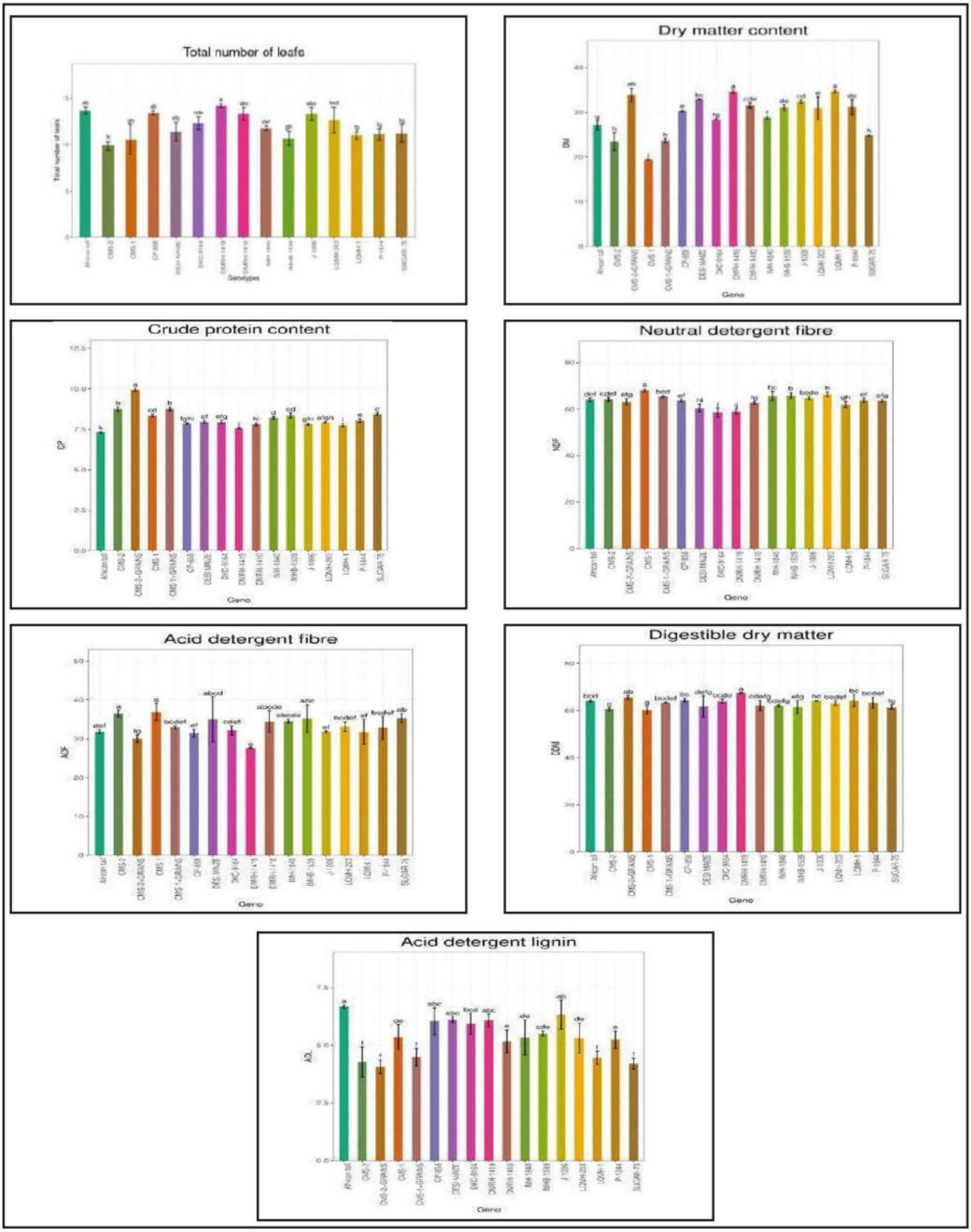


Figure 1.6: Morphological traits and biochemical properties of maize hybrids for better silage quality

Table 1.17: Yield performance of top 20 inbred lines under normal environment during *rabi*-2022-23 at Begusarai

Name of inbred	Survival rate (%)	DTA	ASI	DTM	PH (cm)	GY (t/ha)
MIL 2-1627	100.0	149	9	198	123	5.37
MIL 2-1626	93.8	145	8	201	185	4.63
UMI-1210100.0	143	7	199	135	4.34	
MIL 2-801-1	78.9	150	7	201	135	4.14
BML 15 95.0	151	8	200	132	3.97	
MIL 2-3482	94.1	156	3	194	108	3.44
MIL 2-1506	90.0	153	4	198	78	3.24
MIL 2-1074-1	100.0	145	8	199	82	3.07
MIL 2-1491	71.4	154	3	199	67	2.95
MIL 2-1292-2	66.1	149	4	198	72	2.37
MIL 2-814-2	52.6	150	7	198	100	2.33
MIL 2-83-1	66.7	145	6	198	72	2.21
MIL 2-1043-1-1	55.0	153	5	202	78	2.21
MIL 2-551-2	63.2	145	5	193	87	2.17
MIL 2-1084A-1	81.3	145	5	199	95	2.17
MIL 2-1628	78.6	149	6	199	128	2.13
MIL 2-245-2	73.3	148	6	198	83	2.09
MIL 2-1601	47.1	149	6	203	67	2.09
MIL 2-2039	56.3	153	6	201	77	2.05
MIL 2-91-2	35.0	146	5	201	91.7	2.01
Mean	34.0	150.6	4.4	198.0	79.6	0.70
CV (%)	24.3	10.5	18.7	9.6	14.2	19.42
CD (5%)	6.7	9.0	1.8	16.5	8.7	0.63

DTA: Days to anthesis, ASI: Anthesis to silking interval, DTM: Days to maturity, PH: Plant Height, GY: Grain Yield

However, four lines recorded 4.14 to 5.37 t/ha grain yield under the cold stress environment. (Table 1.17).

Screening of maize hybrids under cold stress

A set of 600 line × tester experimental hybrids including five checks was evaluated under cold stress environment during rabi 2022-23 at IIMR, Ludhiana. Out of 600 experimental hybrids and checks only 298 survived and 302 collapsed due to freezing injury. Among the survived hybrids only 12 hybrids out yielded the best check KMH 25K45. Two top ranking hybrids IMH 2-22R-530 and IMH 2-22R-584 yielded >10 t/ha (Table 1.18)

Screening of maize hybrids under cold stress in bigger plot

Three newly released hybrids IMH 222, IMH 223, IMH 224 and two hybrids, viz., IMHSB 17R-16 and IMHSB-17R-17 promoted under AICRP were evaluated in big plots size (19.5 sq. m) under cold stress (Table 1.19). The plant population of IMH 222 was damaged by rodents at germination. The crop growth was suffered heavily due to chilling and freezing injury during the month of January 2023, but many plants survived. Among these hybrid IMH 223 recorded the highest yield of 10.5 t/ha.

Screening of maize inbred lines under waterlogging stress

A set of 280 inbred lines was evaluated under normal as well as waterlogging environment during kharif 2022 at RMR&SPC, Begusarai (Table 1.20).

Table 1.18: Promising L × T experimental hybrids under cold stress at IIMR, Ludhiana during *rabi*-2022-23.

Entry no.	Pedigree	Ears per plot	SP (%)	GY (t/ha)	Sup %
IMH 2-22R-530	MIL 2-1623 × LM 14	16	86.2	10.05	50.83
IMH 2-22R-584	MIL 2-3633 × LM 14	17	79.0	10.00	49.99
IMH 2-22R-444	MIL 2-975-2 × LM 14	19	78.1	9.94	49.16
IMH 2-22R-342	MIL 2-291-1 × LM 14	22	73.4	9.83	47.49
IMH 2-22R-85	MIL 2-474-2 × LM 13	15	76.7	9.50	42.49
IMH 2-22R-395	MIL 2-583-2 × LM 14	19	73.3	8.55	28.33
IMH 2-22R-537	MIL 2-3240 × LM 14	17	70.6	7.88	18.33
IMH 2-22R-313	MIL 2-165-1 × LM 14	16	74.6	7.83	17.49
IMH 2-22R-462	MIL 2-1050-2-2 × LM 14	23	72.9	7.33	9.99
IMH 2-22R-483	MIL 2-1271 × LM 14	13	79.8	7.22	8.33
IMH 2-22R-508	MIL 2-2011 × LM 14	14	78.7	7.16	7.49
IMH 2-22R-502	MIL 2-1299-5 × LM 14	24	69.4	6.94	4.16
IMH 2-22R-178	MIL 2-1060-8-1 × LM 13	15	68.2	6.00	-
IMH 2-22R-445	MIL 2-976-1 × LM 14	12	74.5	5.83	-
IMH 2-22R-329	MIL 2-224-2 × LM 14	14	70.3	5.77	-
IMH 2-22R-478	MIL 2-1086-2 × LM 14	10	76.7	5.22	-
IMH 2-22R-506	MIL 2-1612 × LM 14	10	81.9	4.94	-
IMH 2-22R-231	MIL 2-1624 × LM 13	13	73.3	4.88	-
IMH 2-22R-16	MIL 2-119-1 × LM 13	12	73.9	4.72	-
IMH 2-22R-99	MIL 2-566-1 × LM 13	10	71.8	4.72	-
Check 1	KMH-25K45	6	73.3	6.66	-
Check 2	NMH-713	7	70.8	3.50	-
Check 3	DHM-117	5	53.3	0.44	-
Check 4	Bio-9544	0	0.0	0.00	-
Check 5	P-3522	0	0.0	0.00	-
Mean		5.59	54.6	1.32	-

EPR: Ears per plot, SP: Shelling percentage, GY: Grain Yield, Sup: Superiority

Table 1.19: Performance of newly released and advanced stage hybrids under cold stress in bigger plot

S. No.	Name of Hybrid	Plants/plot	Plot size (m^2)	Grain Yield (t/ha)
1	IMH 222*	14	19.5	1.46
2	IMH 223	128	19.5	10.50
3	IMH 224	34	19.5	2.01
4	IMHSB 17R-16	62	19.5	2.11
5	IMHSB 17R-17	52	19.5	5.24

*Plant population severely damaged by rats at germination

Waterlogging treatment was given at knee high stage to pre-flowering stage of crop growth by continuous flooding of water for seven days. Out of 280 inbreds, seed setting was observed only in 75 inbreds under waterlogging. Out of the top twenty inbred lines under normal environment, four inbreds (MIL 2-814-2, MIL 2-114, MIL 2-983-1 and MIL 2-1587) also performed well under waterlogging condition. These inbreds also have the low ASI under waterlogging condition. Eight inbred lines yielded more than 2 t/ha grain yield under waterlogging condition.

Screening of maize hybrids under waterlogging stress

Evaluation of L × T hybrids under normal and waterlogging stress at RMR&SPC, Begusarai during kharif 2022

Two set of 310 line × tester experimental hybrids including five checks were evaluated under normal and waterlogging environment during kharif 2022 at RMR&SPC, Begusarai. Among the top 20 hybrids, three hybrid combinations namely MIL 2-1062-1-2 × LM 13, MIL 2-324-1 × LM 14 and MIL 2-376-2 × LM 13 had high yield under normal environment as well as under waterlogging (Table 1.21).

Performance of diallel hybrids under normal and waterlogging stress at RMR&SPC, Begusarai during Kharif 2022.

Two set of 120-diallel experimental hybrids

Table 1.20: Yield performance of top 20 Inbred lines under normal and waterlogging condition during *kharif* 2022 at Begusarai

Inbred line	Normal				Inbred line	Waterlogging				SSI
	DTS	ASI	SP (%)	GY (q/ha)		DTS	ASI	SP (%)	GY (q/ha)	
MIL 2-269-1	57	3	83.7	11.3	MIL 2-1587	56	4	76.5	2.89	0.614
MIL 2-814-2	59	2	85.0	9.78	MIL 2-3368	53	4	75.0	2.44	0.625
MIL 2-1567	55	1	84.2	9.33	HKI-1348	54	3	70.0	2.44	0.689
MIL 2-219-3	59	2	74.5	8.89	MIL 2-58-2	55	3	78.6	2.22	0.264
MIL 2-114-1	58	1	80.2	8.67	MIL 2-703-3	55	4	72.9	2.22	0.768
MIL 2-164-2	55	2	77.7	8.44	MIL 2-814-2	56	1	71.4	2.22	0.885
MIL 2-224-2	56	1	79.5	7.78	MIL 2-511-1	52	2	81.8	2.06	0.409
MIL 2-1062-1-2	60	2	78.9	7.78	MIL 2-664-1	56	4	81.8	2.00	0.208
MIL 2-250-2	57	3	72.7	7.56	MIL 2-571-1	54	3	80.0	1.78	0.663
MIL 2-91-2	57	3	80.6	7.33	MIL 2-794-1	55	3	73.3	1.78	0.327
MIL 2-983-1	54	2	80.8	7.33	MIL 2-3633	58	3	80.0	1.78	0.682
MIL 2-1569	56	2	72.9	7.11	MIL 2-3470	61	4	73.2	1.78	0.636
MIL 2-173-3	61	1	83.6	6.67	MIL 2-114-1	55	2	77.8	1.56	0.939
MIL 2-200-2	56	3	78.4	6.67	MIL 2-250-2	58	4	77.8	1.56	0.909
MIL 2-207-1	62	2	68.5	6.44	MIL 2-566-1	53	5	70.0	1.56	0.700
MIL 2-343-3	59	2	82.5	6.44	MIL 2-583-2	56	2	87.5	1.56	0.569
MIL 2-1043-1-1	62	2	81.2	6.44	MIL 2-812-2	54	3	87.5	1.56	0.254
MIL 2-1587	58	3	80	6.23	MIL 2-883-1	56	4	60.7	1.56	0.700
MIL 2-93-2	58	2	69.2	6.22	MIL 2-941-3	54	5	70.0	1.56	0.416
MIL 2-173-4	63	3	81.3	6.22	MIL 2-983-1	55	3	70.0	1.56	0.902
Mean	54.50	1.70	81.20	2.39		54.87	3.07	74.15	1.13	
CV (%)	7.89	12.84	16.90	18.42		13.40	19.50	28.90	24.67	
CD (5%)	2.14	0.08	7.92	0.63		3.14	0.23	12.78	0.34	
Total inbreds=280					Out of 280 seed setting in only 75					

DTS: Days to 50% silking, ASI: Anthesis to silking interval, SP: Shelling percentage, GY: Grain Yield, SSI: Stress Susceptibility index.

Table 1.21: Performance of L × T experimental hybrids under normal and waterlogging stress at RMR&SPC, Begusarai during *kharif* 2022

Normal								Waterlogging									
Hybrid	E/P	ASI	DM	PH	SP (%)	GY (t/ha)	Sup %	Hybrid	E/P	R Lodg %	BR N/P	ASI	PH	SP (%)	GY (t/ha)	Sup %	SSI
MIL 2-1622 × LM 14	1.2	2	97	178	76.5	7.9	36.5	MIL 2-164-2 × LM 14	0.93	0.00	1.1	2	147	82.5	4.8	50.4	0.36
MIL 2-1062-1-2 × LM 13	1.0	2	101	171	56.6	7.8	35.1	MIL 2-15-2 × LM 13	1.04	0.00	2.0	3	164	82.0	4.6	46.1	0.30
MIL 2-324-1 × LM 14	1.0	2	100	169	82.2	7.8	34.6	MIL 2-376-2 × LM 13	0.96	0.00	1.7	3	170	84.6	4.6	44.3	0.63
MIL 2-1281-5 × LM 13	0.8	2	100	195	85.6	7.8	33.7	MIL 2-1298-1 × LM 13	0.85	6.6	1.4	3	149	76.0	4.5	43.5	0.37
MIL 2-141-2 × LM 14	1.0	2	100	177	77.2	7.8	33.7	MIL 2-3633 × LM 14	0.77	9.3	1.1	3	160	86.1	4.5	41.7	0.42
MIL 2-343-1 × LM 13	1.1	2	102	179	80.8	7.6	31.3	MIL 2-3681 × LM 14	0.93	13.4	1.2	3	143	83.8	4.4	39.1	0.56
MIL 2-83-4 × LM 13	1.1	2	100	162	80.2	7.5	29.9	MIL 2-1062-1-2 × LM 13	0.94	0.0	2.0	4	157	86.1	4.4	38.2	0.83
MIL 2-1624 × LM 13	0.9	2	99	175	85.3	7.4	27.9	MIL 2-1624 × LM 14	0.96	0.0	1.8	3	174	87.4	4.2	33.0	0.39
MIL 2-119-2 × LM 14	0.8	3	98	160	86.9	7.2	24.1	MIL 2-324-1 × LM 14	0.87	5.0	1.5	4	158	80.4	4.2	32.1	0.88
MIL 2-457-2 × LM 14	0.9	2	98	150	72.6	7.1	23.2	MIL 2-459-1 × LM 14	0.92	6.6	1.6	2	157	86.3	4.2	32.1	0.49
MIL 2-83-4 × LM 14	1.0	2	98	171	84.2	7.1	23.0	MIL 2-814-2 × LM 14	0.77	0.0	1.9	3	174	83.6	4.1	28.7	0.76
MIL 2-456-1 × LM 14	1.1	1	98	155	85.6	7.1	22.2	MIL 2-349-2 × LM 14	0.97	0.0	1.1	4	160	76.9	4.0	26.9	0.33
MIL 2-1521 × LM 13	0.9	2	100	173	82.3	7.1	21.8	MIL 2-3482 × LM 14	1.00	0.0	1.0	2	126	84.9	4.0	26.1	0.57
MIL 2-983-1 × LM 14	1.1	2	98	144	84.4	7.1	21.6	MIL 2-71-2 × LM 14	0.88	8.3	0.7	5	140	85.0	4.0	25.2	0.65

Normal								Waterlogging								
Hybrid	E/P	ASI	DM	PH	SP (%)	GY (t/ha)	Sup %	Hybrid	E/P	R Lodg %	BR N/P	ASI	PH	SP (%)	GY (t/ha)	Sup %	SSI
MIL 2-590-2 × LM 13	0.9	2	99	160	86.6	7.0	20.9	MIL 2-246-2 × LM 14	0.96	7.1	1.2	3	153	85.4	3.9	23.5	0.66
MIL 2-3742 × LM 14	0.9	2	99	156	81.7	7.0	19.9	BML 6 × LM 13	0.96	13.8	1.8	3	156	84.9	3.9	22.6	0.50
MIL 2-511-1 × LM 13	1.2	2	101	176	81.5	6.9	19.4	MIL 2-184-1 × LM 13	0.90	3.8	1.9	2	138	84.9	3.8	21.7	0.62
MIL 2-376-2 × LM 13	0.9	1	99	179	81.0	6.9	18.4	MIL 2-381-1 × LM 13	0.96	7.1	1.1	3	141	83.2	3.8	20.8	0.71
MIL 2-363-1 × LM 13	0.8	2	99	155	83.1	6.9	18.2	MIL 2-393-1 × LM 13	0.98	0.0	1.2	4	132	82.5	3.8	20.8	0.31
MIL 2-133-2 × LM 13	1.0	3	98	174	84.4	6.8	17.8	MIL 2-173-2 × LM 13	1.01	0.0	1.3	3	164	83.2	3.8	20.0	0.71
Bio 9544	0.7	2	99	164	66.4	3.7		Bio 9544	0.92	0.0	1.3	3	137	80.2	2.1		0.81
LG 34.05	1.1	2	100	181	86.1	5.6		LG 34.05	0.84	0.0	1.4	3	170	84.7	2.4		1.08
DHM 121	1.00	2	101	173	77.4	5.3		DHM 121	0.84	0.0	1.2	2	128	80.3	2.3		1.08
CMH 08-287	1.1	3	100	189	77.0	5.6		CMH 08-287	1.06	0.0	1.3	2	165	81.2	3.0		0.88
NK 6240	1.1	1	97	163	84.5	5.8		NK 6240	0.90	0.0	1.7	3	156	81.0	3.1		0.86
Mean	0.9	2	99	161	80.5	5.2		Mean	0.82	6.7	1.2	2.91	139	80.68	2.5		
CV (%)	16.3	18.4	12.8	14.2	17.2	14.3		CV (%)	16.20	18.3	14.2	18.3	10.4	14.8	16.3		
CD (5%)	0.03	0.04	6.12	12.14	7.34	0.76		CD at 5%	0.02	0.8	0.03	0.08	14.30	7.80	0.79		

E/P: No of ear per plant, BRN/P: Brace root nodes/plant, DTM: Days to maturity, ASI: Anthesis silking interval, PH: Plant Height, SP: Shelling percentage, GY: Grain Yield, Sup: Superiority

Table 1.22: Performance of diallel experimental hybrids under normal and waterlogging stress at RMR&SPC, Begusarai during *Kharif* 2022.

Hybrid	E/P	ASI	PH	SP	GY (%)	Sup (t/ha)	Hybrid %	E/P	R	BR Lodg %	ASI N/P	PH	SP	GY (%)	Sup (t/ha)	SSI %
MIL2-1062-1-2 × LM 13	1.01	2	163	88.2	6.94	43.69	MIL2-231-2 × MIL2-571-1	0.91	0.0	18.5	4	143	86.4	4.88	66.1	0.34
BML-6 × MIL 2-3470	1.08	3	178	81.8	6.83	41.39	MIL2-3482 × LM 14	0.84	0.0	20.0	3	168	84.5	4.72	60.4	0.09
MIL2-231-2 × MIL2-571-1	1.12	4	153	87.4	5.61	16.10	LM 13 × IML2-1062-1-2	1.00	30.0	19.0	3	165	88.1	4.52	53.8	0.03
MIL2-1041-4-2 × MIL2-1299-5	0.96	2	157	86.3	5.58	15.53	HKI-1128 × MIL 2-406-1	1.07	0.0	23.0	5	167	83.1	4.36	48.1	0.14
MIL2-343-3 × MIL 2-571-1	1.13	2	149	82.1	5.44	12.65	MIL2-387 × LM 13	0.96	16.7	24.0	3	152	81.8	4.25	44.4	0.29
MIL2-883-1 × MIL 2-1299-5	0.92	2	172	86.1	5.16	6.90	MIL2-30-1 × LM 13	0.89	0.0	26.0	4	155	85.3	3.80	29.3	0.05
MIL2-1510 × BML6	1.07	3	171	83.6	5.11	5.75	MIL2-1062-1-2 × MIL2-201-2	1.00	0.0	22.0	5	158	87.8	3.72	26.4	0.05
MIL2-1292-2 × MIL2-164-1	1.10	2	148	83.7	5.00	3.46	MIL2-343-3 × BML7	0.79	8.3	20.5	3	185	78.9	3.69	25.5	0.41
MIL2-1292-2 × BML7	1.00	2	143	75.0	5.00	3.46	MIL2-219-1 × LM 14	0.97	27.3	17.5	4	143	82.9	3.63	23.6	0.47
MIL2-1298-8 × LM 13	1.00	2	172	81.3	5.00	3.46	MIL2-3482 × LM 13	0.91	0.0	17.5	4	167	80.8	3.52	19.8	0.74
MIL2-3482 × LM 13	1.00	2	154	75.9	4.88	1.16	MIL2-58-2 × MIL2-207-1	0.98	0.0	23.0	4	153	78.7	3.47	17.9	0.10
MIL2-3482 × LM 14	0.90	3	168	85.8	4.86	0.74	MIL2-93-1 × MIL2-1062-1-2	0.84	11.1	17.5	5	153	81.0	3.44	17.0	1.35
MIL2-1292-2 × HKI 1128	0.90	2	145	85.2	4.86	0.58	MIL2-1062-1-2 × LM 13	0.97	35.3	17.5	2	170	85.5	3.44	17.0	0.64
MIL2-173-3 × BML7	0.95	1	176	80.5	4.83	0.01	MIL2-571-1 × MIL2-406-1	0.86	0.0	16.0	4	143	81.9	3.41	16.1	0.70
MIL2-406-1 × LM 13	1.10	3	179	76.8	4.80		MIL2-1041-4-2 × MIL2-1299-5	0.85	0.0	18.0	2	169	83.0	3.38	15.1	1.05

Hybrid	E/P	ASI	PH	SP	GY (%)	Sup (t/ha)	Hybrid %	E/P	R	BR Lodg %	ASI N/P	PH	SP	GY (%)	Sup (t/ha)	SSI %
MIL 2-387 × LM 13	0.98	2	164	87.3	4.77		MIL 2-428 × IML 2-3470	0.83	0.0	24.5	3	169	85.1	3.38	15.1	0.04
BML-7 × HKI 1128	1.01	2	166	61.9	4.72		MIL 2-343-2 × IML 2-3470	1.07	0.0	23.5	4	184	89.4	3.36	14.2	0.10
MIL 2-54-2 ×LM 14	1.37	3	156	87.6	4.72		MIL 2-1292-2 × MIL 2-164-1	1.03	0.0	21.0	4	143	84.3	3.30	12.3	0.91
MIL 2-571-1 × MIL 2-406-1	0.97	2	144	424.1	4.63		MIL 2-883-1 × MIL 2-1299-5	0.75	0.0	26.0	6	168	89.1	3.27	11.3	0.98
HKI-1128 × MIL 2 -406-1	0.90	2	173	80.22	4.61		MIL 2-1299-5 × BML 7	1.06	0.0	15.5	5	161	78.3	3.22	9.5	0.17
CMH 08-287 (Check 4)	1.14	2	166	78.7	4.83		DHM 121 (Check 3)	0.73	12.0	17.0	4	157	80.2	2.94	0.0	0.77
LG 34.05 (Check 2)	1.00	2	179	86.4	4.55		NK 6240 (Check 5)	1.25	0.0	12.0	4	169	77.8	2.55		0.5
DHM 121 (Check 3)	0.79	2	153	78.9	4.13		CMH 08-287 (Check 4)	0.42	16.0	13.0	3	175	81.2	1.91		1.62
NK 6240 (Check 5)	1.08	1	155	81.1	3.22		Bio 9544 (Check 1)	1.00	0.0	17.0	4	128	82.7	1.72		0.93
Bio 9544 (Check 1)	0.90	2	143	81.2	2.63		LG 34.05 (Check 2)	0.73	9.1	23.0	4	152	70.6	1.63		1.72
Mean	0.96	1.87	157.86	82.56	3.57		Mean	0.86	23.94	17.69	3.63	152.61	79.17	2.24		
CV (%)	15.32	14.32	12.47	16.48	14.68		CV (%)	16.21	45.24	31.24	22.14	9.75	18.63	18.94		
CD (5%)	0.07	0.32	11.27	5.64	0.63		CD at 5%	0.02	18.62	1.45	0.04	14.12	6.79	0.86		

E/P: No of ear per plant, BRN/P: Brace root nodes/plant, DTM: Days to maturity, ASI: Anthesis silking interval, PH: Plant Height, SP: Shelling percentage, GY: Grain Yield, Sup: Superiority

and waterlogging environment during kharif 2022 at RMR&SPC, Begusarai. Among the top 20 hybrids, nine hybrids 2-1062-1-2 × LM 13, MIL 2-231-2 × MIL 2-571-1, MIL 2-1041-4-2 × MIL 2-1299-5, MIL 2-883-1 × MIL 2-1299-5, MIL 2-3482 × LM 13, MIL 2-3482 × LM 14, MIL 2-387 × LM 13, MIL 2-571-1 × MIL 2-406-1 and HKI-1128 × MIL 2-406-1 were high yielding under normal as well as under waterlogging. (Table 1.22).

Performance of diallel crosses under waterlogging at IIMR, Ludhiana during kharif-2022

A set of 120-diallel experimental hybrids including five checks were evaluated under waterlogging environment during Kharif-2022 at IIMR, Ludhiana. Only nine hybrids out yielded the best check Bio 9544. Two hybrids MIL 2-1062-1-2 × MIL 2-343-3 and MIL 2-800-1 × MIL 2-406-1 outyielded >10% yield sueriority over best check Bio 9544 (Table 1.23).

Performance of advanced stage hybrids under water logging CIMMYT multilocation trial during kharif 2022

A set of 25 AVT trial hybrid entries including commercial checks was evaluated under

Table1.23:Performance of diallel experimental hybrids under and waterlogging stress at IIMR, Ludhiana during *kharif* 2022.

Entry no.	Pedigree	E/P	BRN/P	ASI	DTM	PH (%)	SP (t/ha)	GY %	Sup	Rank
IMH 2-22K -315	MIL 2-1062-1-2 × MIL 2-343-3	1.03	1.44	3	91	220	87.1	8.349	14.01	1
IMH 2-22K -384	MIL 2-800-1 × MIL 2 -406-1	0.99	1.82	3	91	233	82.2	8.267	12.89	2
IMH 2-22K -398	MIL 2-1289 × BML 7	0.98	1.21	3	91	218	85.6	8.021	9.52	3
IMH 2-22K -313	MIL 2-457-2 × MIL 2-418	1.00	1.47	5	93	197	84.6	7.836	7.00	4
IMH 2-22K-417	LM 13 × IML 2-1062 -1-2	1.21	1.52	4	91	218	86.3	7.754	5.88	5
IMH 2-22K -374	MIL 2-406-2 × BML 7	0.97	1.43	3	91	215	82.9	7.487	2.24	6
IMH 2-22K -385	MIL 2-801-1 × MIL 2 -1299-5	1.04	1.66	4	91	199	85.1	7.467	1.96	7
IMH 2-22K -350	MIL 2-83-1 × T4	0.90	1.04	3	91	213	84.9	7.446	1.68	8
IMH 2-22K -308	MIL 2-173-2 × MIL 2-418	1.00	1.46	8	93	204	84.7	7.364	0.56	9
Check-1	Bio 9544	1.04	1.39	5	93	173	82.7	6.851		
Check-2	LG 34.05	1.00	1.89	5	95	212	85.0	5.838		
Check-3	DHM 121	0.83	1.75	5	93	188	79.7	1.785		
Check-4	CMH 08-287	1.18	1.16	4	93	210	83.4	7.200		
Check-5	NK 6240	1.00	1.28	4	91	178	84.3	7.323		
	Mean	1.01	1.45	3.96	91.87	193.04	81.86	6.279		
	CV (%)	14.29	18.72	15-32	8.42	9.41	13.71	12.38		
	CD (5%)	0.07	0.08	0.06	5.34	14.61	4.38	0.674		

E/P: No of ear per plant, BRN/P: Brace root nodes/plant, DTM: Days to maturity, ASI: Anthesis silking interval, PH: Plant Height, SP: Shelling percentage, GY: Grain Yield, Sup: Superiority

including five checks were evaluated under normal waterlogging environment at four locations (Begusarai, Ludhiana, Varanasi and Hyderabad) during kharif 2022. Three hybrids (IMHSB 21K-6, IMHSB 20K-10 and IMHSB 21K-4) performed well with > 4 t/ha average productivity under waterlogging stress across the location and were also superior to the check (Table 1.24).

Screening experimental maize hybrids under managed drought environment

Performance of L × T and diallel experimental hybrids under drought during rabi-2021-22 at AICRP centre, Kolhapur.

A set of 500 line × tester and diallel experimental hybrids including five checks was evaluated under drought environment during *rabi* 2021-22 at AICRP Kolhapur centre, 13 hybrids out yielded the best check DKC 9081 with >10% yield superiority (Table 1.25).

Breeding for biotic stress

Screening of maize genotypes against MLB

A set of 100 inbred lines was evaluated against MLB during *kharif* 2022 at ICAR-IIMR, Ludhiana (Table 1.26). Out of 100 inbreds 10 resistant, 27 moderately resistant, 35 moderately susceptible and 10 susceptible inbred lines were observed. Twenty-eight inbreds did not germinate.

Another set of 42 white maize genotypes were screened for resistance against MLB during *kharif* 2023 at Ludhiana in two replications (Table 1.27). Three genotypes, *viz.*, MIL 10-19492, MIL 10-19679 and MIL 10-19682 were found resistant against MLB.

Table1.24:Performance of advanced stage hybrids under water logging CIMMYT multilocation trial Kh-2022 during *kharif* 2022.

CIMMYT Code	Name of entry	Grain Yield t/ha)						
		BGS	LDH	BHU	HYB	Pooled mean	Sup %	Rank
IIMR22K-20	BH 417206	3.62	5.50	4.17	5.93	4.81	61.8	1
IIMR22K-2	JH 32487	4.71	4.60	4.05	4.71	4.52	52.1	2
IIMR22K-15	IMHSB 21K-6	4.50	4.16	2.96	6.02	4.41	48.4	3
IIMR22K-21	IMHSB 20K-10	4.07	2.36	3.57	7.13	4.28	44.2	4
IIMR22K-9	EH 3721	3.44	3.19	3.18	6.83	4.16	40.0	5
IIMR22K-13	IMHSB 21K-4	4.11	4.15	2.87	5.17	4.08	37.2	6
IIMR22K-23	BH 418456	4.02	3.15	2.25	5.69	3.78	27.2	7
IIMR22K-16	IMHSB 21K-8	2.76	2.38	3.40	6.35	3.72	25.4	8
IIMR22K-1	JH 32662	3.81	3.40	2.35	5.13	3.67	23.6	9
IIMR22K-14	IMHSB 21K-5	2.28	4.08	2.84	5.31	3.63	22.1	10
IIMR22K-7	EH 3531	2.99	2.89	3.03	4.75	3.41	14.9	11
IIMR22K-3	AH 8323	1.64	3.47	3.02	5.25	3.34	12.6	12
IIMR22K-22	IMHSB 20K-11	3.09	3.21	2.07	4.97	3.34	12.3	13
IIMR22K-18	EH 2936	3.35	3.13	1.07	5.60	3.29	10.7	14
IIMR22K-5	EH 3572	2.20	2.88	2.32	5.52	3.23	8.8	15
IIMR22K-19	BH 41715	2.09	3.01	3.00	4.32	3.10	4.4	16
IIMR22K-11	EH 3562	2.09	3.02	2.41	4.43	2.99	0.5	17
Check		1.80	2.54	3.77	3.80	2.97		18
Mean		2.77	3.27	2.68	5.07	3.45		
CV (%)	38.54	22.92	29.02	19.41	27.47			
CD (5%)	1.33	1.68	1.69	1.37	1.52			

BGS: Begusarai, LDH: Ludhiana, BHU: Banaras Hindu University, HYB: Hyderabad

Table1.25:Performance of L × T and diallel experimental hybrids under drought during *rabi* 2021-22 at AICRP centre, Kolhapur.

Entry name	Pedigree	E/P	DTA	ASI	PH (cm)	SP (%)	GY (t/ha)	Sup %
IMH 2-21R-145	MIL 2-1721-4 × LM 13	1.00	74	2	180	77.3	9.26	28.53
IMH 2-21R-68	MIL 2-1248 × LM 13	1.00	74	2	200	79.1	9.05	25.64
IMH 2-21R-12	MIL 2-119-2 × LM 13	0.95	77	2	203	80.7	8.93	23.98
IMH 2-21R-228	MIL 2-1062-1-2 × LM 14	1.00	74	2	205	82.9	8.75	21.47
IMH 2-21R-20	MIL 2-205-1 × LM 13	1.00	75	2	205	78.8	8.74	21.42
IMH 2-21R-418	MIL 2-571-2 × MIL 2-1510	1.00	78	2	168	80.2	8.74	21.39
IMH 2-21R-209	MIL 2-569-3 × LM 14	1.00	75	3	190	82.8	8.59	19.26
IMH 2-21R-4	MIL 2-23-2 × LM 13	1.03	74	2	183	75.8	8.45	17.28
IMH 2-21R-190	MIL 2-343-1 × LM 14	1.00	76	2	213	74.8	8.265	14.72
IMH 2-21R-203	MIL 2-451-3 × LM 14	1.00	73	2	203	79.9	8.21	14.02
IMH 2-21R-460	MIL 2-1601 × BML 6	1.00	78	2	178	77.7	8.03	11.50
IMH 2-21R-117	BML 7 × LM 13	1.00	78	2	188	75.0	8.01	11.20
IMH 2-21R-185	MIL 2-302-1 × LM 14	1.08	73	2	170	77.9	7.92	10.00
IMH 2-21R-14	MIL 2-133 × LM 13	1.00	74	3	175	78.5	7.88	9.46
IMH 2-21R-305	MIL 2-3678 × LM 14	1.00	74	3	200	77.0	7.78	8.06
IMH 2-21R-226	MIL 2-1043-1-1 × LM 14	1.00	71	2	203	76.3	7.76	7.75
IMH 2-21R-19	MIL 2-201-1 × LM 13	1.00	75	2	190	74.7	7.73	7.32
IMH 2-21R-43	MIL 2-387-3 × LM 13	1.00	75	2	190	76.1	7.69	6.83
IMH 2-21R-333	MIL 2-58-2 × MIL 2-428	1.00	76	2	210	77.3	7.68	6.71
IMH 2-21R-50	MIL 2-452-2 × LM 13	1.00	75	2	203	78.8	7.68	6.60
Check-1	Bio-9544	1.00	83	2	185	80.3	3.81	
Check-4	DKC-9081	1.00	77	2	160	80.4	7.20	
Check-5	P-3522	1.00	83	3	195	71.7	3.68	
Check-2	NK-6240	1.03	84	2	168	76.8	5.70	
Check-3	CMH-08-292	1.00	78	2	188	74.6	5.65	
Mean		1.01	76.5	2.1	182.6	77.2	5.03	
CV (%)		14.29	14.6	12.7	10.3	12.9	16.4	
CD (5%)		0.08	3.2	0.1	9.1	4.4	0.84	

E/P: No of ear per plant, DTA: Days to anthesis, ASI: Anthesis silking interval, PH: Plant Height, SP: Shelling percentage, GY: Grain

Screening of maize inbreds against spotted stem borer, pink stem borer and fall armyworm

A set of 500 inbred lines was evaluated against spotted stem borer (SSB), pink stem borer (PSB) during *rabi* 2022-23 and fall armyworm (FAW) during *kharif* 2022 (Figure 1.7, 1.8 & 1.9). The

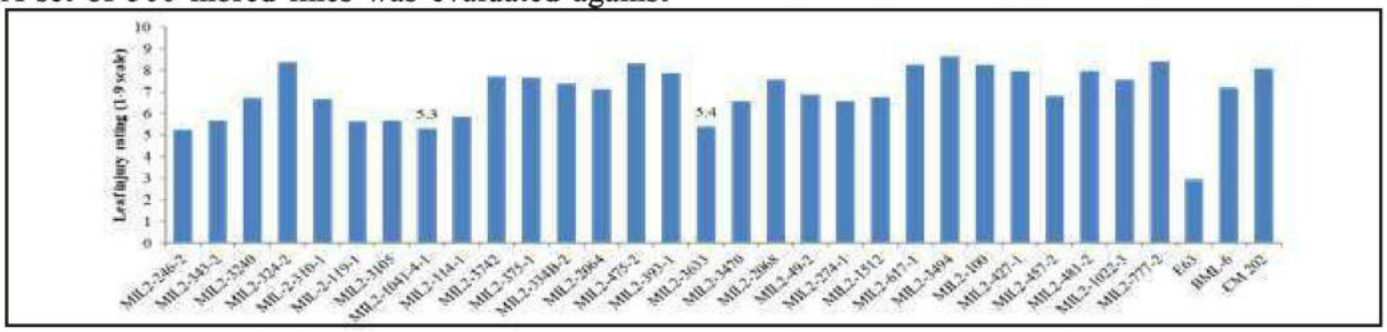


Figure 1.7: performance of inbreds against spotted stem borer

Table1.26:Disease reaction of promising maize inbred lines against MLB at IIMR, Ludhiana during *kharif*-2022

Inbred	Score	Re-action	Inbred	Score	Re-action	Inbred	Score	Re-action
MIL2-3-1	4.67	MR	MIL2-350-1	-	-	MIL2-1046-5-2	6.50	MS
MIL2-15-2	3.50	MR	MIL2-376-2	5.00	MR	MIL2-1052-1-1	7.70	S
MIL2-30-1	5.33	MS	MIL2-380-1	4.00	MR	MIL2-1053-2-2	8.00	S
MIL2-37-2	4.50	MR	MIL2-387-3	4.00	MR	MIL2-1059-2-2	-	-
MIL2-43-2	3.00	R	MIL2-388-1	-	-	MIL2-1062-1-2	-	-
MIL2-49-2	2.00	R	MIL2-406-1	-	-	MIL2-1074-1	4.50	MR
MIL2-54-2	3.30	MR	MIL2-428-2	6.00	MS	MIL2-1281-5	8.00	S
MIL2-55-1	-	-	MIL2-446-2	4.00	MR	MIL2-1289-2	-	-
MIL2-58-2	2.00	R	MIL2-475-2	4.35	MR	MIL2-1292-2	-	-
MIL2-83-2	3.70	MR	MIL2-511-1	3.00	R	MIL2-1296-1	5.70	MS
MIL2-91-2	-	-	MIL2-568-2	2.50	R	MIL2-1298-2	-	-
MIL2-93-2	-	-	MIL2-571-1	3.80	MR	MIL2-1298-6	-	-
MIL2-114-1	-	-	MIL2-591-1	6.00	MS	MIL2-1298-8	2.45	R
MIL2-119-1	-	-	MIL2-592-2	5.65	MS	MIL2-1299-5	4.38	MR
MIL2-133-2	6.00	MS	MIL2-607-1	4.50	MR	MIL2-1300	-	-
MIL2-164-1	3.10	MR	MIL2-681-2	5.87	MS	MIL2-1602	5.00	MR
MIL2-173-2	6.00	MS	MIL2-719-1	-	-	MIL2-2034	2.00	R
MIL2-173-3	5.50	MS	MIL2-800-1	2.00	R	MIL2-2037-1	-	-
MIL2-173-4	7.50	S	MIL2-801-1	6.00	MS	MIL2-2039	6.25	MS
MIL2-176-2	2.70	R	MIL2-814-2	6.00	MS	MIL2-2068	3.75	MR
MIL2-201-1	5.60	MS	MIL2-882-1	4.00	MR	MIL2-2077	3.50	MR
MIL2-207-1	-	-	MIL2-883-1	8.00	S	MIL2-2083	6.75	MS
MIL2-219-1	8.00	S	MIL2-921-2	-	-	MIL2-2119	8.00	S
MIL2-244-1	6.70	MS	MIL2-941-3	-	-	MIL2-1622	5.75	MS
MIL2-246-2	5.80	MS	MIL2-975-2	2.50	R	MIL2-1625	6.50	MS
MIL2-274-1	-	-	MIL2-976-1	3.75	MR	MIL2-1621	8.00	S
MIL2-280-1	4.75	MR	MIL2-1011-2	3.90	MR	MIL2-1624	7.00	MS
MIL2-301-1	7.50	S	MIL2-1036-1	5.17	MS	MIL4-2061	5.00	MR
MIL2-310-1	4.50	MR	MIL2-1038-4-2	-	-	MIL2-3240	7.50	S
MIL2-334B-2	-	-	MIL2-1040-3-1	6.00	MS	MIL2-3470	5.50	MS
MIL2-343-3	4.65	MR	MIL2-1041-4-1	-	-	MIL2-3482	7.00	MS
MIL2-310-1	4.50	MR	MIL2-1043-1-1	5.00	MR	MIL2-1587	7.00	MS

E/P: No of ear per plant, DTA: Days to anthesis, ASI: Anthesis silking interval, PH: Plant Height, SP: Shelling percentage, GY: Grain Yield, Sup: Superiority

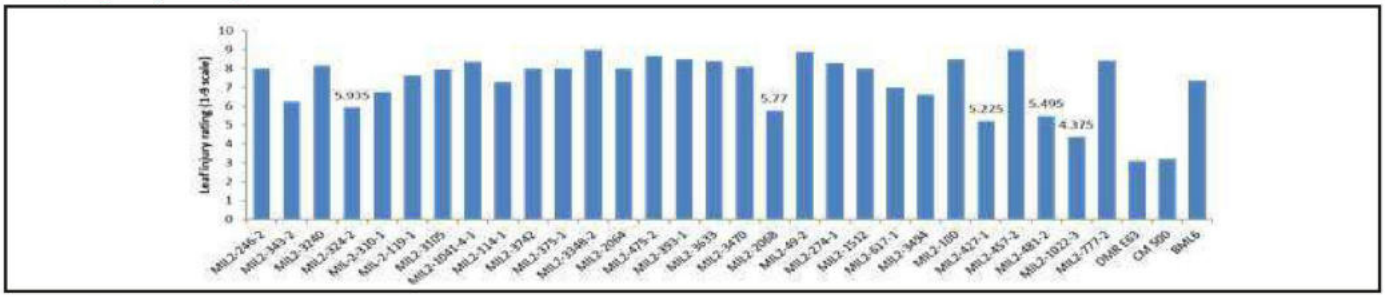


Figure 1.8: Performance of inbreds against pink stem borer

Table1.27:Screening of maize genotypes against MLB during *kharif* 2023

Sl. No.	Genotype	Disease score	Disease Reaction	Sl. No.	Genotype	Disease score	Disease Reaction
1	MIL 10-19401	7.30	S	22	MIL 10-19503	3.50	MR
2	MIL 10-19407	5.91	MS	23	MIL 10-19610	6.19	MS
3	MIL 10-19408	4.83	MR	24	MIL 10-19632	4.20	MR
4	MIL 10-19409	6.96	MS	25	MIL 10-19639	4.60	MR
5	MIL 10-19414	5.45	MS	26	MIL 10-19643	4.15	MR
6	MIL 10-19415	7.80	S	27	MIL 10-19655	4.00	MR
7	MIL 10-19422	4.40	MR	28	MIL 10-19664	8.50	S
8	MIL 10-19423	7.08	S	29	MIL 10-19665	7.00	MS
9	MIL 10-19424	6.25	MS	30	MIL 10-19667	8.00	S
10	MIL 10-19426	5.05	MS	31	MIL 10-19671	6.50	MS
11	MIL 10-19427	7.50	S	32	MIL 10-19676	4.75	MR
12	MIL 10-19432	7.11	S	33	MIL 10-19677	6.50	MS
13	MIL 10-19434	6.65	MS	34	MIL 10-19679	2.45	R
14	MIL 10-19435	5.43	MS	35	MIL 10-19682	2.30	R
15	MIL 10-19462	5.63	MS	36	MIL 10-19689	7.50	S
16	MIL 10-19472	4.55	MR	37	MIL 10-19691	5.16	MS
17	MIL 10-19475	4.00	MR	38	MIL 10-19692	6.50	MS
18	MIL 10-19476	4.80	MR	39	MIL 10-19695	4.65	MR
19	MIL 10-19492	2.45	R	40	MIL 10-19696	8.05	S
20	MIL 10-19495	5.25	MS	41	MIL 10-19699	5.75	MS
21	MIL 10-19500	4.42	MR	42	MIL 10-19700	6.50	MS

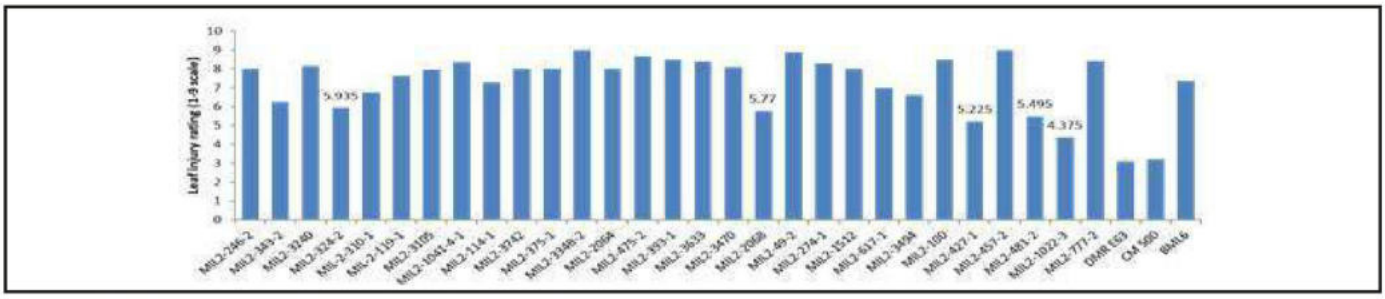


Figure 1.9: Performance of inbreds against FAW

reaction of the inbreds is shown in figure 1-3 below.

Breeding for quality traits

Promising QPM lines identified

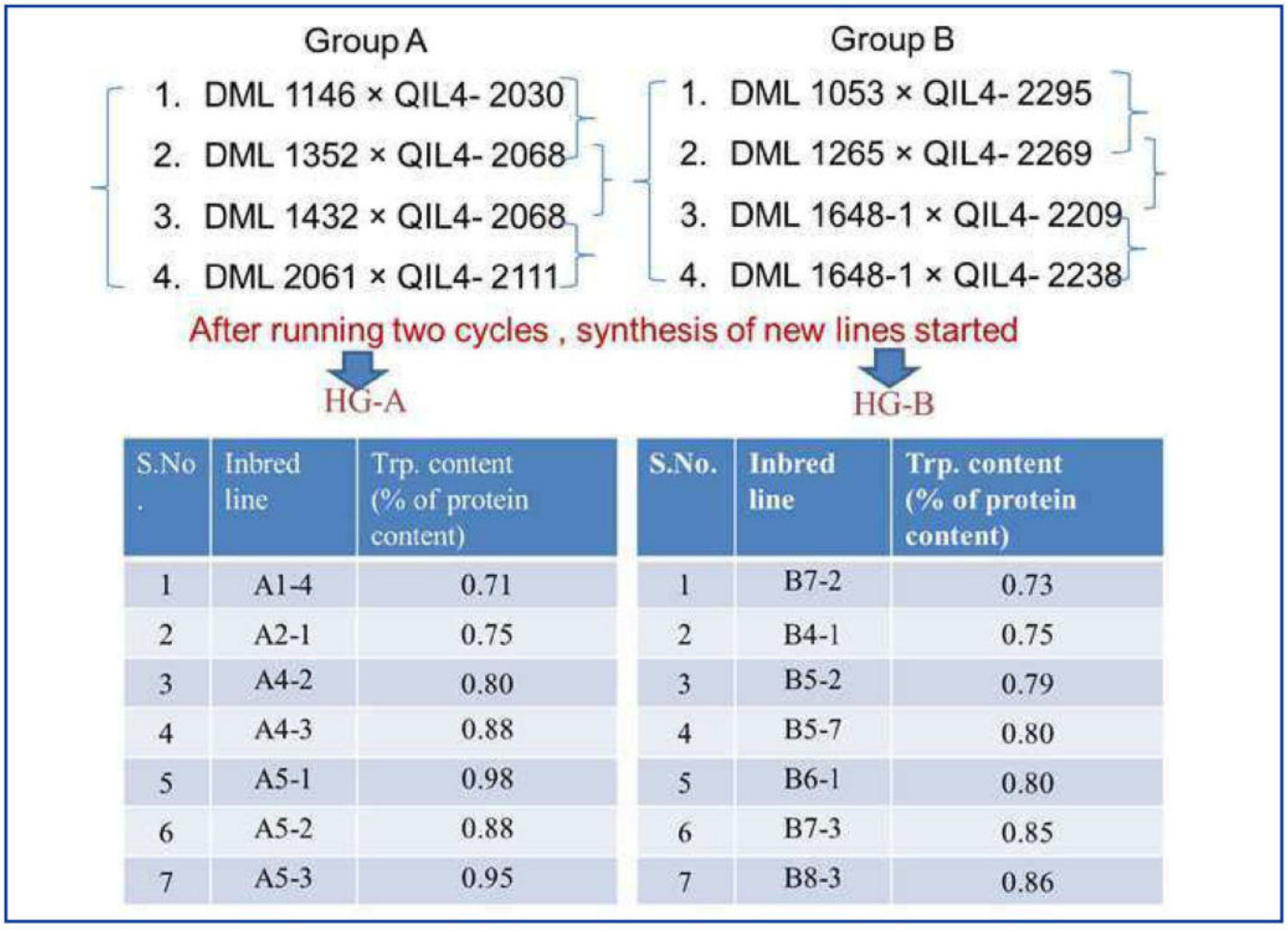
A set of 205 lines was planted at the experimental field of ICAR-IIMR, Ludhiana and the selfed samples were submitted to biochemistry laboratory for biochemical analysis (Table 1.28). Out of 205, a set of 30 most promising lines have been identified with higher tryptophan content as given below (Table 1.28).

Diversification of QPM germplasm

Based on the heterotic grouping information generated for 48 lines, pedigree crosses were made within heterotic group A and heterotic group B. The heterotic pools were developed by following chain cross method and then synthesis of new lines was started after random mating of population for two seasons (Figure 1.10). The promising S4 lines from each heterotic pools are given below with the estimated tryptophan level. After evaluation of these newly synthesized lines, the same will be used for hybrid combination.

Table1.28:Identification of tryptophan rich germplasm

Inbred Line	Tryptophan (% of Protein)	Inbred Line of Protein)	Tryptophan
QIL4-2381	0.89	QIL4-2526	0.76
QIL4-2018-6	0.89	QIL4-2370	0.75
QIL4-2379	0.86	QIL4-2457	0.75
QIL4-2662	0.86	QIL4-2480	0.75
QIL4-2536	0.85	QIL4-2513	0.75
QIL4-2579	0.85	QIL4-2530	0.75
QIL4-2562	0.84	QIL4-2649	0.75
QIL4-2651	0.84	QIL4-2482	0.74
QIL4-2225-1	0.83	QIL4-2434	0.73
QIL4-2443	0.81	QIL4-2502	0.73
QIL4-2546	0.81	QIL4-2533	0.73
QIL4-2569	0.79	QIL4-2551	0.73
QIL4-2580	0.79	QIL4-2456	0.72
QIL4-2451	0.78	QIL4-2500	0.72
QIL4-2472	0.76	QIL4-2515	0.72



S.No.	Inbred line	Trp. content (% of protein content)
1	A1-4	0.71
2	A2-1	0.75
3	A4-2	0.80
4	A4-3	0.88
5	A5-1	0.98
6	A5-2	0.88
7	A5-3	0.95

S.No.	Inbred line	Trp. content (% of protein content)
1	B7-2	0.73
2	B4-1	0.75
3	B5-2	0.79
4	B5-7	0.80
5	B6-1	0.80
6	B7-3	0.85
7	B8-3	0.86

Figure 1.10: Deriving new QPM lines from heterotic groups

Table1.29:Germplasm with high lysine, tryptophan and methionine

Back Cross Population	Stage	Families
For Lysine & Tryptophan		
CP 858 × QPM lines	BC1F4	122
Bio 9544 × QPM lines	BC1F5	10
UMI lines × QPM lines	BC1F5	17
High Methionine & high lysine , tryptophan content		
High Methionine lines	F5	52

Development of new material for quality traits (lysine, tryptophan and methionine)

New material for different quality traits needs to be developed, in this regard development of new lines have been initiated by using different source material (Fig. 1.11). For high lysine and tryptophan as well as for high methionine content, field corn material has been used as source material (Table 1.29).

Evaluation of new cross combinations:

A set 127 experimental hybrids was planted in alpha lattice design at VC Farm, Mandya during *kharif*

Figure 1.11: Deriving new sources of QPM lines from high yielding field corn

Table 1.30:New QPM crosses evaluated during *kharif* 2023

Experimental Hybrid	Grain Yield (Q/ha)	DA	DS
BC-57 × MB-122	126.40	52	51
BC-34 × MB-122	125.68	55	56
BC-24 × MB-109	125.31	52	54
BC-59 × MB-122	121.02	55	55
BC-13 × MB-109	120.49	51	52
BC-96 × MB-109	120.21	53	53
BC-32 × MB-122	114.77	53	53
BC-96 × MB-122	114.63	53	53
BC-58 × MB-122	113.17	51	51
BC-57 × MB-109	112.53	51	51
BC-2 × MB-122	112.16	56	55
BC-15 × MB-109	110.51	51	51
BC-47 × MB-109	109.19	52	53
IQMH-203 (Check)	107.95	54	53
BC-16 × MB-122	107.34	54	54

Experimental Hybrid	Grain Yield (Q/ha)	DA	DS
BC-129 × MB-109	106.59	52	53
BC-116 × MB-109	106.03	53	54
BC-126 × MB-122	104.38	54	54
BC-53 × MB-109	101.69	54	52
BC-123 × MB-122	101.20	54	53
BC-87 × MB-109	101.18	55	53
BC-105 × MB-122	100.84	54	54
BC-87 × MB-122	99.15	54	54
BC-153 × MB-122	98.94	52	52
BC-123 × MB-109	98.75	53	53
Check CP-858	98.16	56	56
CD (5%)	9.68	-	-
CV (%)	11.23	-	-

2023. One QPM and one field corn check were planted alongwith experimental hybrids. The best performing hybrids at Mandya are listed below (Table 1.30). Thirteen hybrids out yielded the best check IQMH 203 and all the hybrids have recorded more than 10.0 t/ha grain yield.

Molecular breeding for high amylopectin/waxy maize

Two hybrids CMH-08-282 and CMH 08-292 have been targeted for conversion in waxy maize hybrids through MAS. Parents of CMH-08-282 (UMI 1200 × UMI 1230) and CMH 08-292 (UMI 1201 × UMI 1230) have been selected as recurrent parents, whereas the waxy genotype i.e. Pusa Waxy 55411 was used as donor parent. Kernel amylopectin content of UMI 1200, UMI 1201 and UMI 1230 was 75%, 78% and 72%, respectively whereas the donor

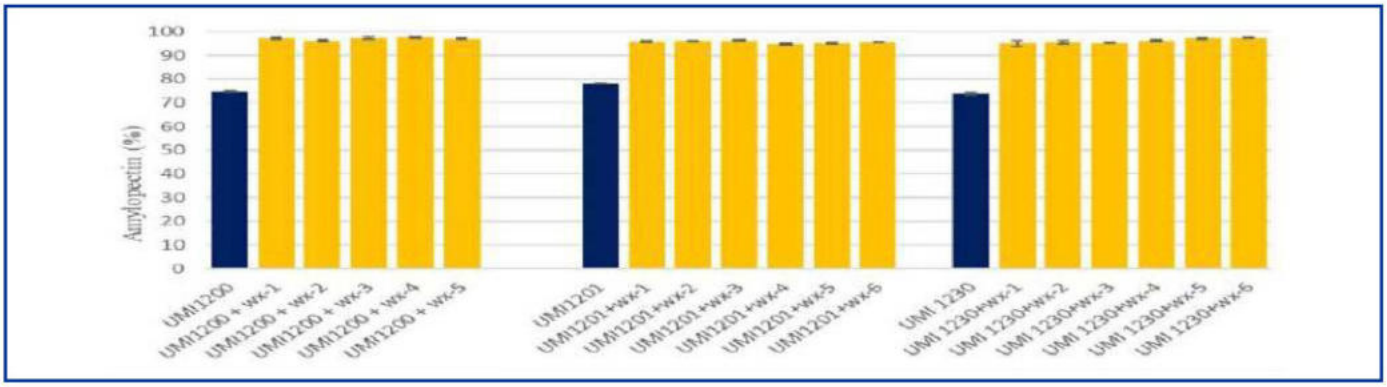


Figure 1.12: Improvement of amylopectin content in the mutant waxy allele introgressed lines

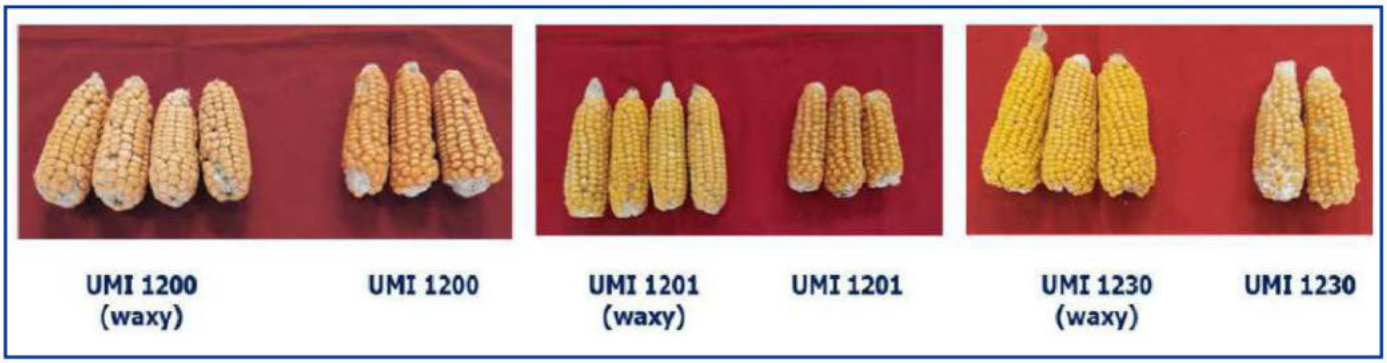


Figure 1.13: Appearance of normal and waxy converted lines

parent recorded 96% of kernel amylopectin. The mutant waxy allele was introgressed from the donor parent to the three recurrent parents. The mean amylopectin content of improved UMI1200, UMI1201 and UMI1230 are 97%, 95% and 96%, respectively (Figure 1.12, 1.13). Maximum amylopectin content in UMI1200, UMI1201 and UMI1230 was 97.51%, 96.19% and 97.17%, respectively.

Molecular breeding for high amylose maize

Amylose is a type of resistant starch possessing numerous health benefits and industrial applications. Normal maize starch contains an amylose content of ~25%. The aim was to develop high amylose genotype adapted to Indian condition. High amylose donor from the USA was used to transfer the mutant ae1 allele into the three parents of two high-yielding maize hybrids (HM 5 and HM 12) through marker-assisted backcross breeding (Figure 1.14). In the converted lines, amylose content ranged from 40.40 to 58.10% in comparison to 22.25 to 26.39% in parents. The percent increase of amylose ranged between 63.70 to 153.03%. There was a significant amount of background recovery in each backcross generation which ranged from 67.15 - 79% in BC1F1, 72.85 - 89.75% in BC2F1and 84.45 - 93.70% in BC2F2 (Figure 1.15). Overall, the starch content was reduced (~22%) in the ae1 introgressed families. The converted lines developed in the present are enriched with kernel amylose. The high amylose lines developed in the present study may be highly beneficial for diabetic patients and bioplastic industry.

Genetic enhancement for high zinc in maize kernels

Identification of differentially expressed genes for higher Zn accumulation: To identify significant DEGs for higher Zn accumulation in tropical maize, transcript profiling from contrasting inbred lines was performed under high Zn and control (sufficient Zn) conditions. The chromosome-wise distribution of DEGs from various combinations was visualized using Circos representation for all ten chromosomes (Figure 1.16). In total 4628 DEGs have been found in various combinations (Table 1.31).

Validation of the expression pattern of the DEG by qRT-PCR: Six different DEGs were selected based on their function in Zn transportation and translocation to validate the expression pattern via a quantitative real-time polymerase chain reaction

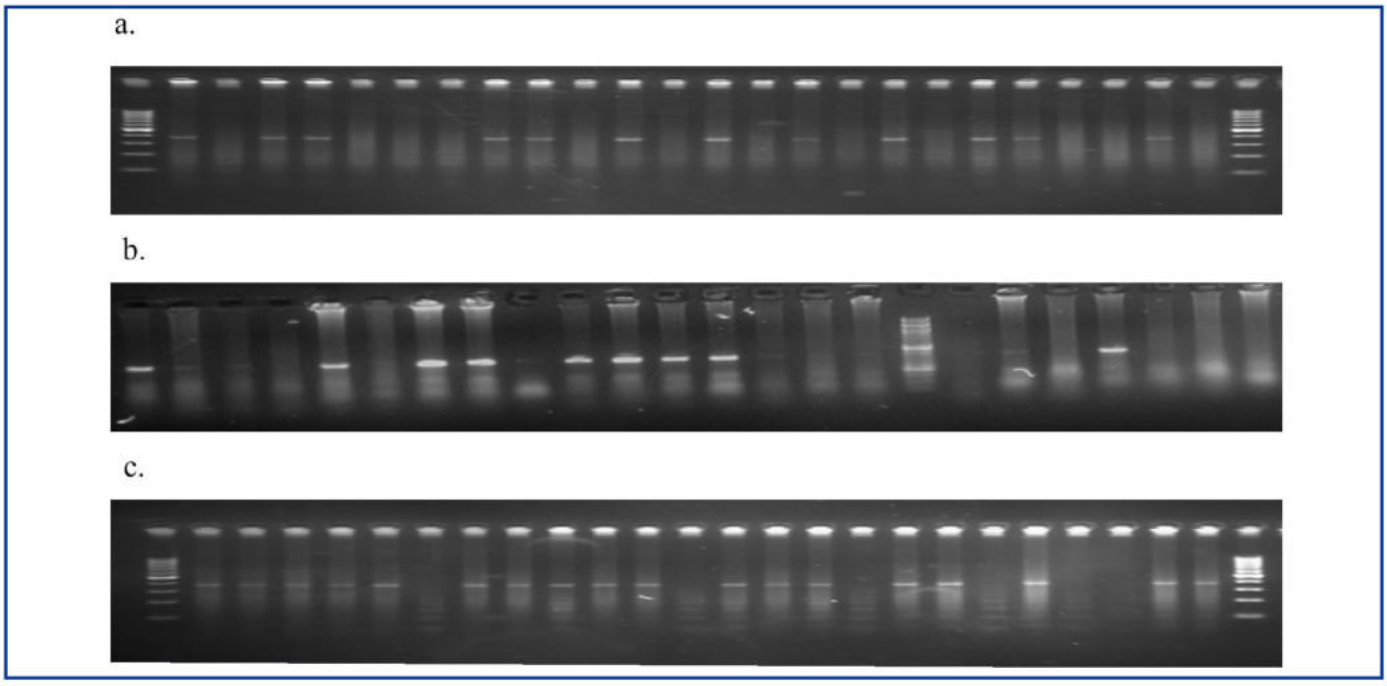


Figure 1.14: Foreground selection in (a) BC1F1 (AML2), (b) BC2F1 (SbeIIb) and (c) BC2F2 (AML2) generation, positive individuals amplified 332 bp donor band for AML2 and 700bp donor band for SbeIIb

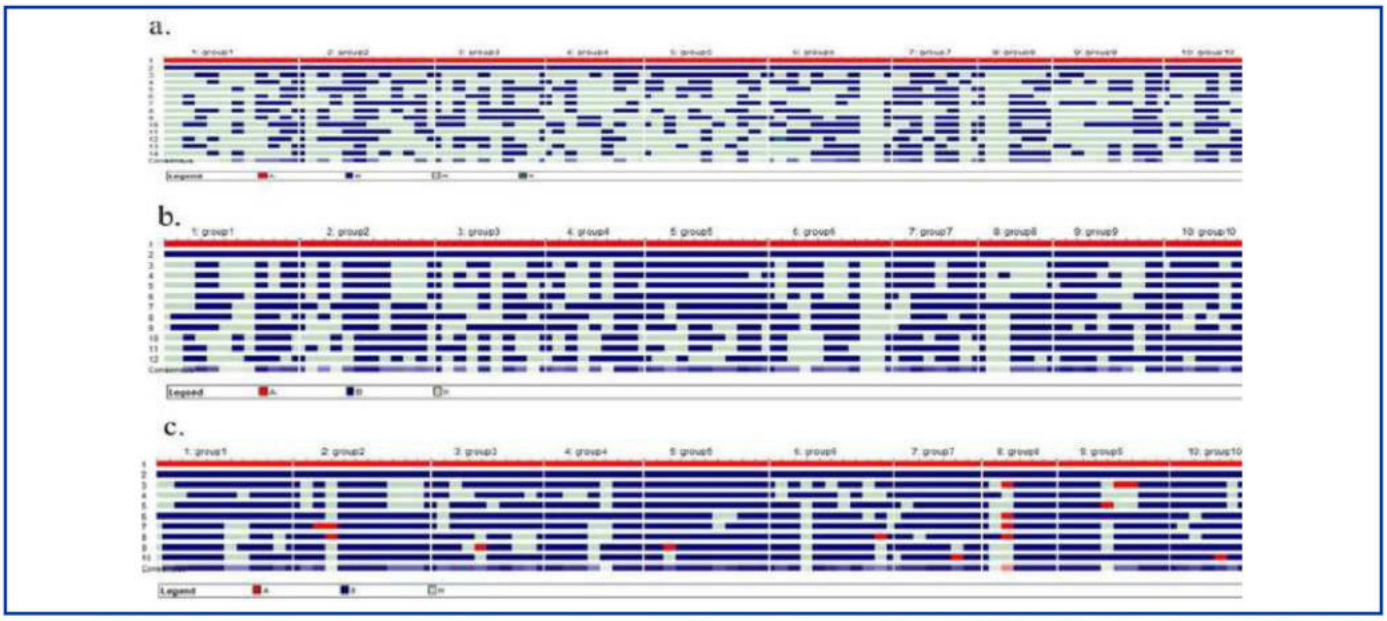


Figure 1.15: Background recovery in BC_2F_2generation. a. HKI 1344 × GEMS 0067, b. HKI 1348-6-2 × GEMS 0067, c. HKI 1378 × GEMS 0067

Table1.31:Details of DEGs identified in various combinations

No in circos track	Comparison Detail	Total Significant DEGs
1.	Distribution of HC vs HT Significant DEGs	1493
2.	Distribution of LC vs LT Significant DEGs	1021
3.	Distribution of LT vs HT Significant DEGs	2114
4.	Represents expression (log2 FC) of Significant DEGs of HC vs HT	845 upregulated + 648 downregulated
5.	Represents expression (log2 FC) of Significant DEGs of LC vs LT	932 upregulated + 89 downregulated
6.	Represents expression (log2 FC) of Significant DEGs of LT vs HT	761 upregulated + 1353 downregulated

(qRT-P[illegible]-based expressi[illegible]ression patterns[illegible] all the

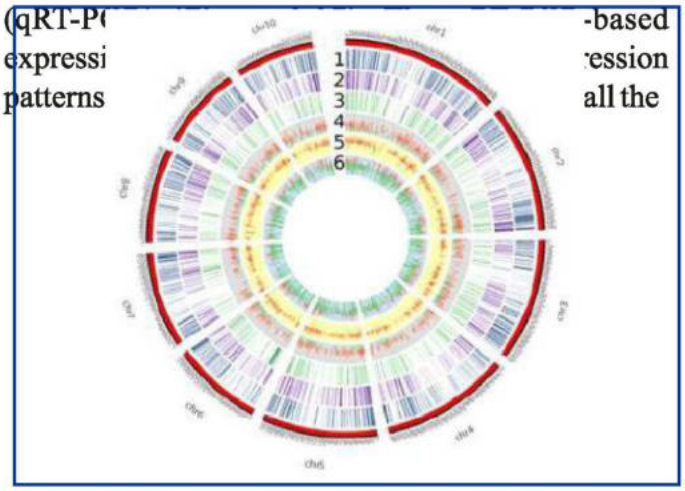


Figure 1.16: Circos plot depicting the distribution of DEGs on 10 chromosomes of maize. In this figure, all the maize chromosomes are displayed in the first outer ring. 1-6 numbers represent the expression (log2 FC) of DEGs in various comparisons.

selected DEGs. Selected DEGs were: ZmZIP1 (High-affinity zinc transporter), ZmZIP2 (Low-affinity zinc transporter), ZmZIP4 (Zn and Fe transporter), ZmZIP5 (Zn and Fe transporter), ZmZIP8 (Induced by zinc deficiency). These key DEGs selected for validation encode genes /transporters playing a pivotal role in Zn transport mechanisms. For example, a high-affinity transporter is involved in the constitutive high-affinity transport system under long-term Zn starvation conditions in plants.

Develo rtified
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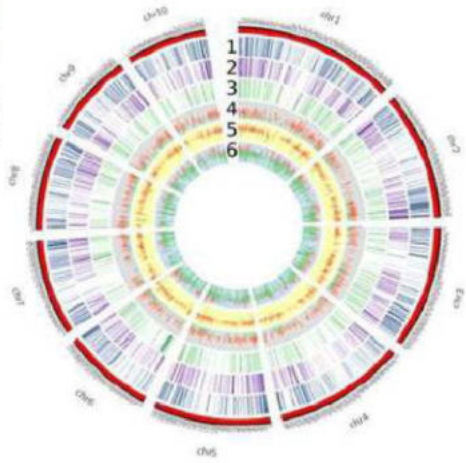


Figure 1.17: Comparison of expression analysis of selected Zn stress-responsive genes via qRT-PCR (represented by blue color) and NGS approach (represented by red color) in maize, in response to Zn stress treatment

Zn lines were advanced to F4 (418) and of those, the best 116 families were selected for early generation testing of Zn accumulation which ranged from 3.7 ppm to 39 ppm. There was a significant gain in new families over the base materials. During kharif 2023, the best 88 inbred lines were selected at F5 stage for crossing as well as further advancement to F6 through control pollination. Total of 300 crosses were attempted from elite inbred lines for developing hybrids with high lysine, tryptophan, zinc and Iron content. These crosses are under evaluation at three different locations such as Begusarai (rabi 2023-24), Karnal (spring 2024) and Ludhiana (spring 2024). The experimental hybrids will be evaluated for high yield as well as better iron, zinc and QPM traits. Further, seed of three hybrids with high zinc, lysine and tryptophan was multiplied and contributed for testing in first year of AICRP Rabi 2022-23 trials. Out of three, one hybrid (IQH 7-219) has been promoted to second year testing in three zones such as NEPZ, PZ and CWZ. Further, three more hybrids are alsoer testing in AICRP kharif 2023 trials.

Efforts on maize seed production and commercialization

In the past six years, the ICAR-Indian institute of maize research has developed and released 25 hybrids. Currently, seven of those have been commercialized by signing 29 MoUs with 16 different seed companies. For the last three years (2021-22 to 2023-24), ICAR-IIMR hybrids have remained on top in the country's DAC maize breeder seed demand with their share ranging from 33.5 to 62.4 percent. ICAR-IIMR hybrids which receive an adequate amount of breeder seed indents through the DAC include DMRH 1308, IQMH 203, DMRH 1301, LQMH 1 and IMH 224. Over the past three years, DMRH 1308 hybrid has stayed on top of the country's DAC breeder seed demand with 20.1 % (2022), 26.1 % (2023) and 34.9 % (2024) shares. Since its release, 4628 Kg of breeder seed has gone into the seed chain through the DAC, and the remaining 17189 Kg through non-DAC channels, such as directly from institutes or through partners. Another hybrid, DMRH 1301, has also received significant demand through the DAC. Since its release, so far total 1873 Kg of breeder seed demand has been obtained and supplied through the DAC for DMRH 1301. In addition, 4260 Kg of parental seed demand has been met through non-DAC channels, such as directly through institutes and other partners. Private seed companies have signed 18 MoUs with ICAR-IIMR to acquire these two hybrids. In total, 11 different private seed companies have taken up DMRH 1301 and 7taken up the DMRH 1308. A QPM hybrid LQMH 1, released in 2020 is also gaining popularity among farmers and receiving substantial amounts of seed demand through DAC and directly at the institute. So far, five seed companies have taken up LQMH 1. Another biofortified hybrid IQMH 203, notified in 2021 has been taken up by two different privates seed companies and started receiving significant amount of breeder seed demand through the DAC.

Furthermore, ICAR-IIMR is producing hybrid seeds for institute cultivars in a participatory manner with state seed corporations such as WBSSC, National seed corporations, cooperatives, and SMEs. Over the past five years, around 19375 quintals of hybrid seed (F1) have been produced in participative mode, where IIMR provided breeders seed and technical advice to seed growers both on and off farms for quality seed production. From a total of 19375, 9394 quintals of hybrid seed were produced for DMRH 1308, 8781 for DMRH 1301, 1000 for IQMH 203, and 200 quintals for LQMH 1 (Table 1.32).

Table 1.32: Breeder seed production (BSP-IV) Year-wise total breeder seeds* produced and supplied (kg) for different hybrids of the Institute. The quantity supplied includes the total demand received (through DAC+ direct demand to the institute) from various states and national seeds producing

Particular	Year wise breeder seeds produced and supplied (kg)						
Parents of hybrids	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	Total
Female of DMRH 1301 & 1308	1110.0	188.0	2212.0	5542.0	4085.0	6157	19294
Male of DMRH 1301	295.0	60.0	725.0	200.0	385.0	183	1848
Male of DMRH 1308	-	-	429.0	1895.0	2069.0	2415	6808
Female of DMRH 1305	-	20.0	40.0	-	-	-	60
Male of DMRH 1305	-	10.0	20.0	-	-	-	30
Female of LQMH 1	-	-	-	30.0	45.0	-	75
Male of LQMH 1	-	-	-	15.0	15.0	-	30
Female of IMHB 1539	-	-	10.0	-	-	-	10
Male of IMHB 1539	-	-	5.0	-	-	-	5
Female of LPCH 3	-	-	-	5.0	-	-	5
Male of LPCH 3	-	-	-	2.5	-	-	2.5
Female of IMHB 1532	-	-	30.0	-	-	-	30
Male of IMHB 1532	-	-	10.0	-	-	-	10
Female of IQMH 203	-	-	-	20	-	32	52
Male of IQMH 203	-	-	-	10	-	30	40
Female of IMH 224	-	-	-	-	-	0.5	0.5
Male of IMH 224	-	-	-	-	-	0.5	0.5
Grand total	1405	278	3481	7719.5	6599	8818	28330.5

Note*: 1. During 2022-23, of total 6599 Kg, 2900 Kg parental seed of DMRH 1308 (2200 Kg female and 700 Kg male) was produced at Zonal Adaptive Research Station Krishnagar Farm, Nadia WB and supplied into the chain @ foundation seed rate.

2. During 2023-24, of total 8818 Kg, 6750 Kg parental seed of DMRH 1308 and DMRH 1301 (4800 Kg female and 1800 Kg male of DMRH 1308 and 150 kg male of DMRH 1301) was produced at Zonal Adaptive Research Station Krishnagar, Nadia WB and supplied into the chain @ foundation seed rate.

BASIC SCIENCES 2

Studies towards understanding methionine biofortification

Nutritional quality of maize grain is poor due to the deficiency of methionine, which is required for the growth and development of livestock. Bio-fortification of maize for methionine is a good alternative in this regard. The accumulation pattern of methionine, protein fractions, and the activity of key enzymes, along with the expression of methionine-associated target genes were evaluated in high and low methionine lines to understand their regulation pattern. It was found that methionine accumulation starts before 15 DAP and increases towards kernel maturity (Figure 2.1). Total protein, albumin, and globulin accumulation showed a declining trend with kernel maturity whereas prolamin, prolamin-like, glutelin, and glutelin-like fractions increased towards kernel maturity. Methionine showed a significant positive correlation with prolamin and a negative correlation with glutelin, indicating their use as markers to select high methionine lines and is a novel finding of this study. A combined accumulation of lysine and tryptophan along with methionine was observed, indicating that the above three essential amino acids can be enhanced collectively to improve the overall nutritional value of maize. The line 194010, rich in all three amino acids, can be used as a potential donor for developing a high methionine maize.

Serine acetyl-transferase enzyme showed a positive correlation with methionine at all the stages of kernel suggesting that sulfur reduction profoundly affects methionine accumulation in maize. Moreover, homology analysis of SAT enzyme isoforms showed that higher expression and enzymatic activity of ZmSAT1 is specifically pivotal for the bio-fortification of methionine in maize. It is, therefore, concluded that serine acetyl-transferase is the most important target for genetic engineering to enhance methionine content to improve the quality of maize protein.

Moreover, the results of SDS PAGE revealed that the 10-kDa zein was accumulated during kernel development, and its accumulation was higher in high methionine lines. Gene expression data revealed that higher expression of 10- and 18-kDa zeins are associated with higher methionine accumulation in maize (Figure 2.3). These results

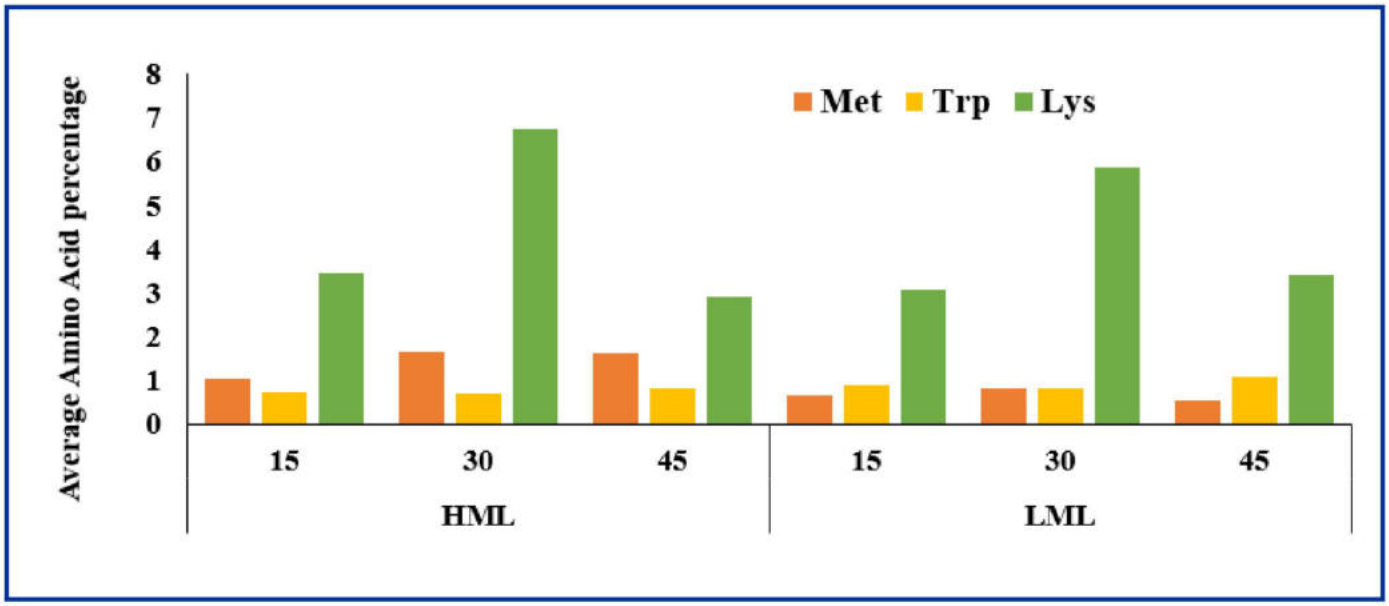


Figure2.1: Average amino acid percentage in high and low methionine lines during kernel development (Letters A, B, C depict that all the means are significantly different from each other)

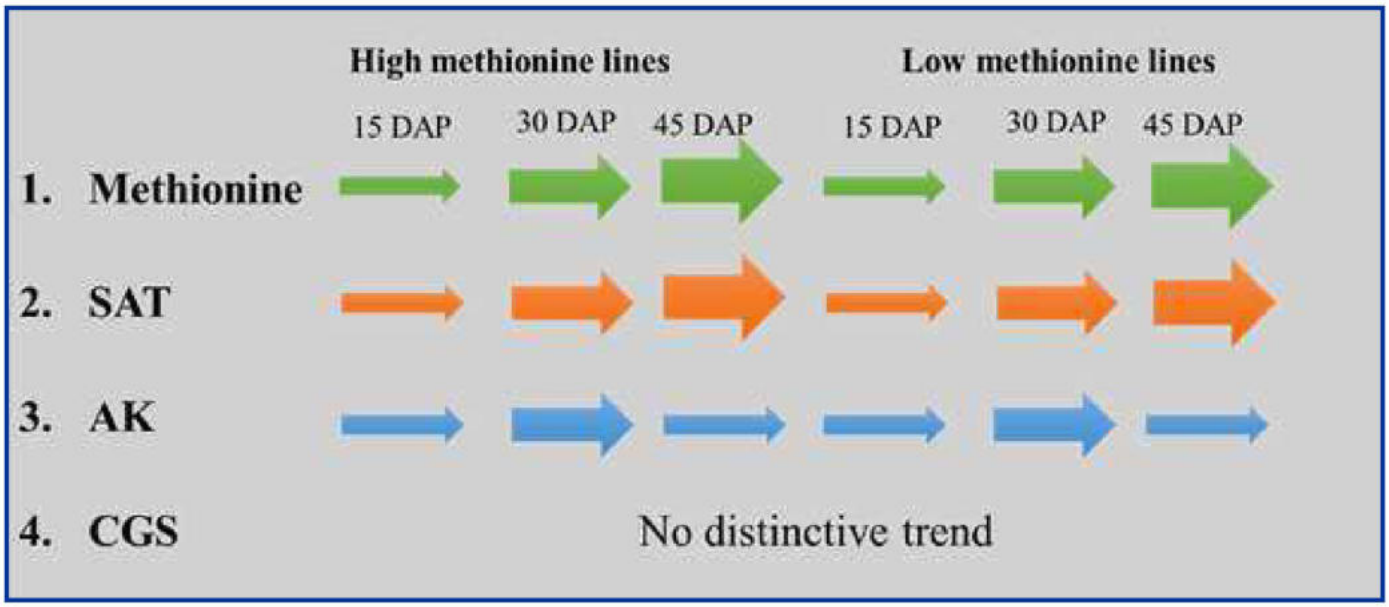


Figure 2.2: Accumulation pattern of methionine and activities of associated enzymes in developing maize

indicate that 10- and 18-kDa genes are the potential target for the methionine bio-fortification in maize. The outcome of the study can be utilized to diversify the breeding program by introgressing maize lines of different germplasm backgrounds with high methionine traits.

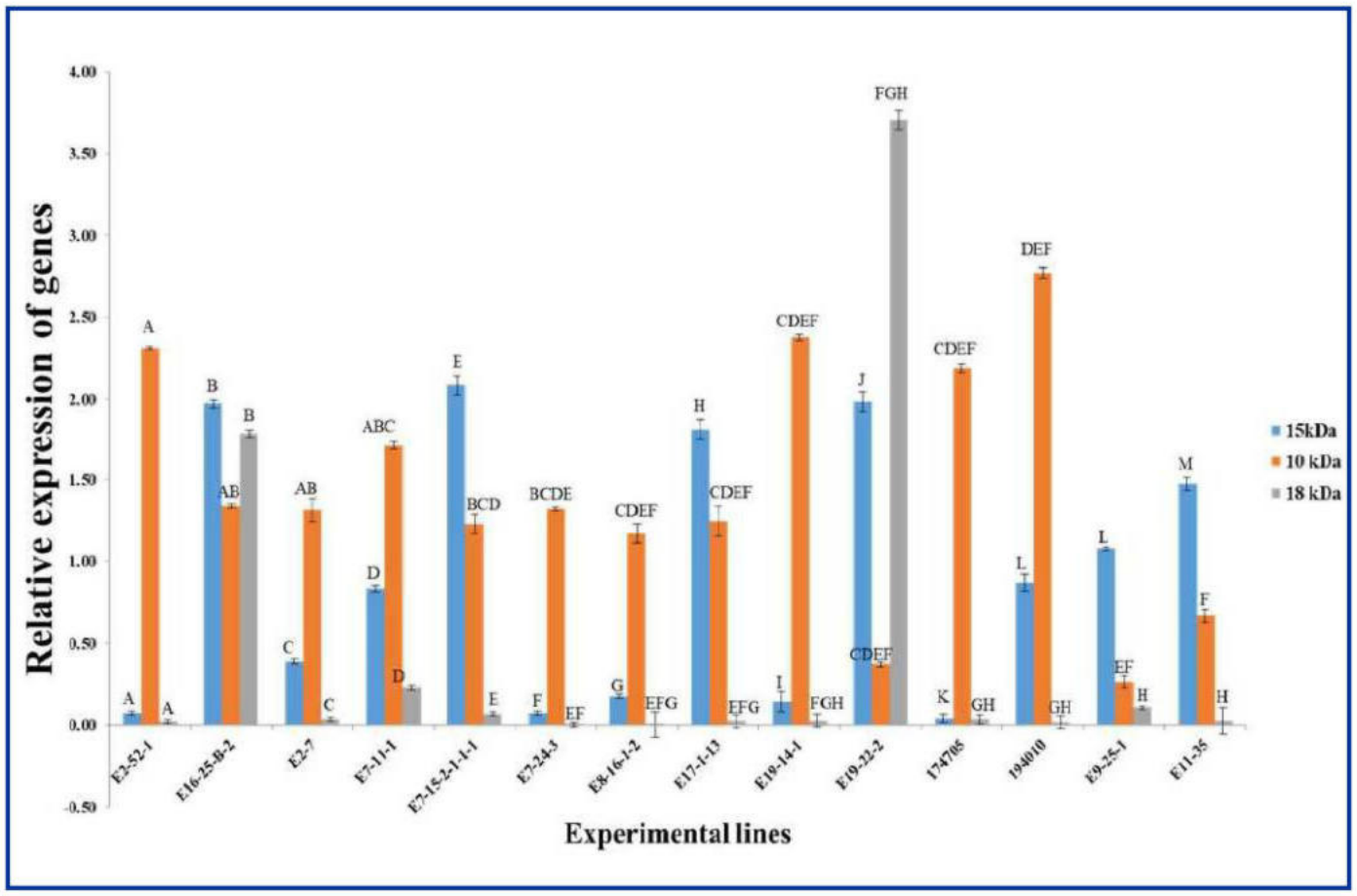


Figure 2.3: Expression profiling of methionine-related genes of maize kernel at the final stage of kernel maturity

Genetic diversity for nitrogen use efficiency in maize under different nitrogen treatments

Nitrogen is the most limiting macronutrient because it is an essential component of bio-molecules such as nucleic acids, proteins, secondary metabolites, and chlorophyll. Nitrogen availability can infuence maize plant growth and grain yield. Phenotypic, agronomic and root architecture studies were conducted to identify contrasting maize genotypes for Nitrogen Utilization Effiiciency traits. The randomized complete block design with three replicates was used in the present study. The genotypes were grown in N variable soil with zero, half, and recommended doses of urea, and different physiological parameters including germination, vigor, flowering, plant height, SPAD, and grain yield were estimated. Root samples were collected at different growth stages (30-35 DAS, 45-50 DAS and 75-85 DAS) for root architecture analysis. Results indicated that RSA (total root surface area), RD (total root diameter), RV (total root volume), NF (number of forks), and N tips (number of tips) were enhanced with increased nitrogen application, irrespective of the genotypes. Plant height, ear length, shoot and root fresh and dry weight at DAS, kernel weight, and grain yields all increased significantly as nitrogen levels increased in both seasons. High genetic variability was noted for NUE traits. Based on the above observations, five lines each of high nitrogen efficient and low nitrogen efficient were identified in maize. The selected lines will be further analyzed for variable expression of putative genes controlling traits associated with nitrogen use efficiency. The knowledge of key genes can be utilized in molecular breeding programs to develop high-yielding nitrogen-efficient maize hybrids.

AICRP Quality Breeding Program

From 2022 to 2023, a total of 20 entries including 12 newly developed genotypes, *viz.*, QPMH 6, LPAP 6, PVAPMH 1, PVAPMH 3, PVAPMH 6, QPMH 1, HQPM 29, APH 4, APTQH 5, ABSH 4-2, FQH 186, FPVH 1 and eight check namely PMH 6, PMH 1, PMH 3, APQH 9, Pusa HQPM 5 Improved, HM 4, HQPM 1 and VMH 53 received under AICRP quality trial were analyzed for protein quality, provitamin A and tocopherols as required. The detailed data was presented in the AICRP report.

Characterization of phi112, a molecular marker tightly linked to nutritional quality in maize

The presence/absence variation provided by the phi112 marker, which differentiates normal maize from QPM, makes it a good candidate for designing molecular tests to understand the underlying mechanism. Being close to the opaque2 gene, a transcription factor involved in the QPM phenotype, analysis of phi112 marked DNA was done to determine the mechanism of its influence over maize phenotype. Using phi112 Forward and Reverse sequence, the intervening DNA sequence was retrieved using Zea mays genome (taxid: 4577). This intervening DNA, along with phi112 primer sequences, was termed 'phi112 marked DNA', which is of 152 base-pair [Figure 2.4(A)]. The phi112-marked DNA was scanned for DNA motifs using the MEME Motif Discovery module. Three motifs were discovered, out of which Gene Ontology identification using the Arabidopsis thaliana (Plant) database revealed transcription factor activity in one motif TCTTCTTT [shown in green in Figure 2.4(A)]. This indicated that TCTTCTTT could be one of the regions associated with a transcription factor. However, as the discovered motif was identified based on A. thaliana database, it was necessary to confirm if it also functions in maize. Thus, interaction analysis of the motif-containing DNA with its putative transcription factor protein is desired.

To find the putative transcription factor of the tightly regulated opaque2 system, functional associations of the opaque2 transcription factor were elucidated using the STRING database. The database predicts functional associations based on experimental techniques like co-expression or text-mining. A transcription factor PBF1 was found to be functionally associated with opaque2 with a high probability (score = 0.780) PBF1 is also associated with proteins like ?-zein and ribosome-inactivating protein b-32.

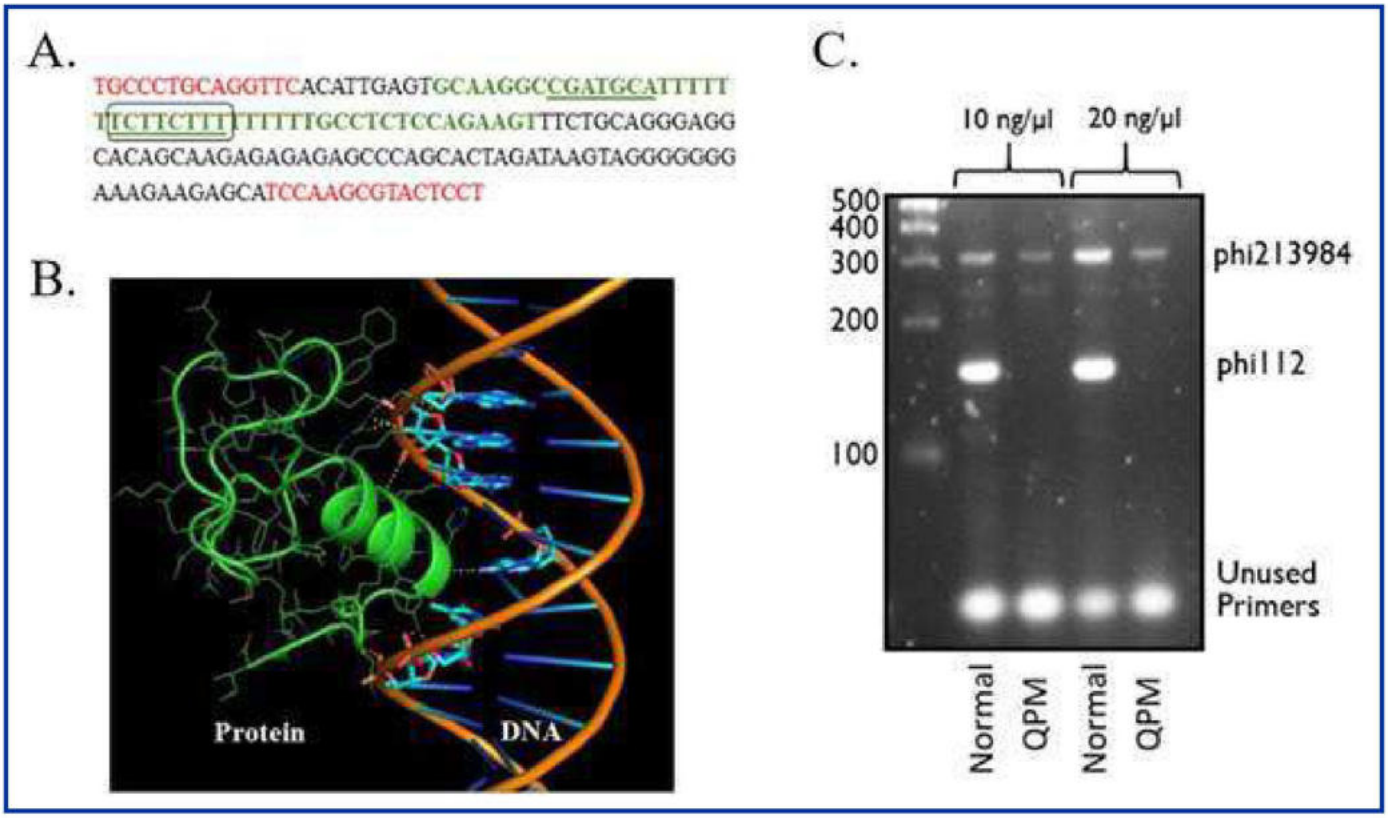


Figure 2.4: Characterization of phi112 region and multiplex PCR for protein quality differentiation. A. ph112 marked DNA. The primer sequences are shown in red. The discovered motifs are underlined. The motif discovery associated with transcription factor activity is boxed. The green region marks the DNA sequence used to perform protein-DNA interaction analysis. B. PBF1 partial structure (green) interacting with DNA (orange double helix with nucleotides in cyan). C. Multiplex PCR using primers phi213984 and phi112. One µl of two concentrations of genomic DNA, viz., 10 and 20 ng/µl, each of normal and QPM genomic DNA, were used in a 20 µl PCR for amplification.

To further characterize the PBF1 protein, it was modeled via an automated homology algorithm. It showed a 17.39% sequence identity with endothelial transcription factor GATA-2, deposited as 509B entry in Protein Data Bank. The structure has a Global Model Quality Estimation (GMQE) and QMEAN score of 0.34 and -3.98, respectively. Though the modeled structure is partial, its identity with transcription factor confirmed the possibility of DNA binding activity. To find the possibility of Zea mays PBF1 binding to the phi112 marked DNA and to elucidate the potential binding site in DNA, a longer sequence of 48 nucleotides, spanning 20 nucleotides on the sides of TCTTCTTT DNA sequence was taken further for analysis. The PBF1-DNA interaction was analyzed via a hybrid docking algorithm utilizing template-based modeling and ab initio free docking [Figure 2.4(B)]. It was found that PBF1 binds partially with the computationally discovered motif TCTTCTTT. The DNA motif that interacts with PBF1 is CTTCTTT. Both the sense and antisense strand nucleotides interact with amino acids in PBF1.

To design an alternative protocol for determining the genetic makeup of the sample, a multiplex PCR was designed. Two primers, viz., phi213984 and phi112 were used together in multiplex format [Figure 2.4(C)]. Other primers giving amplicon in molecular weight range other than 150 kDa (given by phi112 primers) can also be used. In normal maize, the phi213984 and phi112 resulted in respective products, whereas in QPM, only phi213984 resulted in the amplicon.

The multiplex PCR assay based on the use of phi112 as a dominant marker for protein quality differentiation can be used as a supplement or a standalone test to screen for high protein quality

material to enable differentiation of the bulk samples and aggregation of the QPM material. Also, in case of any ambiguity in ascertaining the nature of the material being tested, its genetic makeup can be confirmed using the described PCR assay, in addition to its purity.

Reproducibility testing of Agrobacterium-mediated transformation protocol

Previously, 108 combinations representing various factors /parameters affecting Agrobacterium-mediated transformation were evaluated using at least 30 calli per combination. During the reporting period, the transformation experiment was repeated three times in the combinations having positive results to find out the optimal parameters. The calli were kept in callusing media having either 50 mg/L hygromycin (for calli transformed via Agarobacterium-mediated method) in the dark after transformation. Histochemical assay for GUS expression in calli was performed ten days after transformation and the presence of blue spots in calli indicated the expression of GUS protein (?-glucuronidase) and hence stable genetic transformation (Figure 2.5). Among three strains

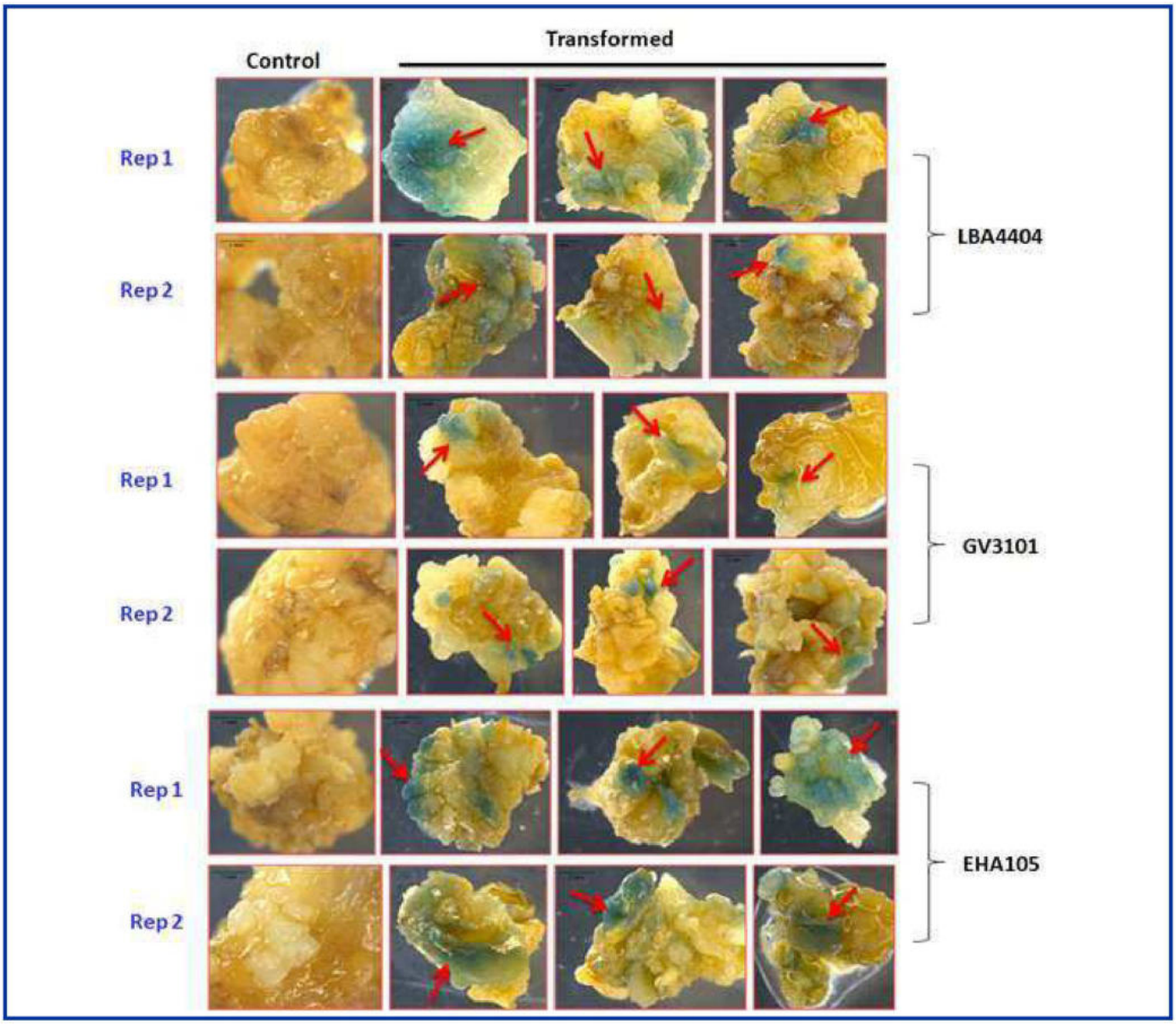


Figure 2.5: GUS staining in calli (X-Gluc stained calli) after Agrobacterium-mediated transformation using three different strains.

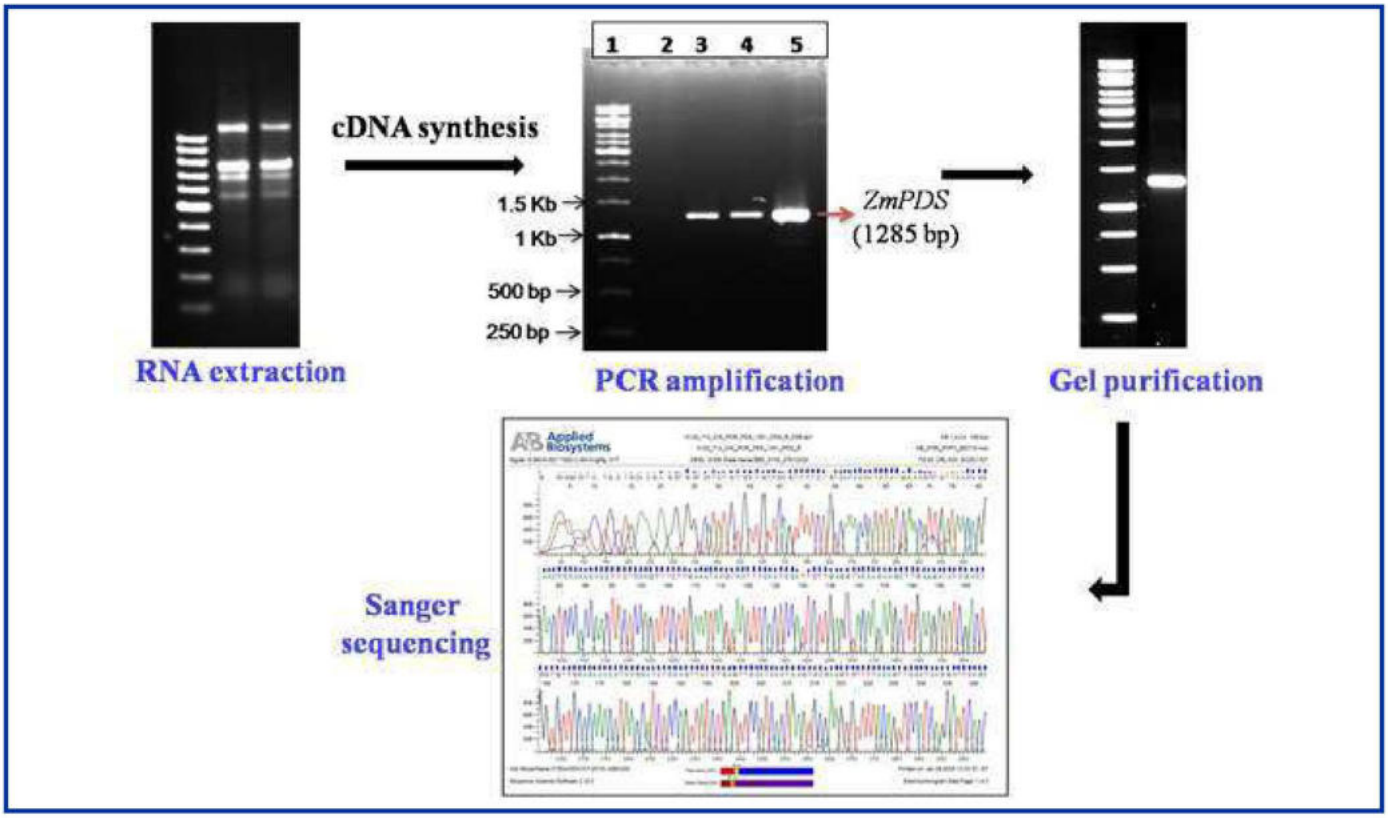


Figure 2.6: Amplification and sanger sequencing of PDS coding sequence from Indian maize genotypes i.e. DMRH1308, and BML6.

used, the highest transformation efficiency (63.63%) was achieved with the Agrobacterium EHA 105 strain. These results confirmed the reproducibility of standardized Agrobacterium-mediated transformation protocol. Further, efforts are underway to regenerate putative transformants and confirm the transgenic status of the same using the optimized protocol.

Developing CRISPR/Cas9 construct for knocking out ZmPDS gene

Phytoene desaturase, PDS, gene sequence from B73 temperate maize inbred line was retrieved using maize GDB (https://www.maizegdb.org/) and used for designing specific primers for the isolation of a coding sequence (CDS) from Indian maize genotype, DMRH 1308 and BML6. Briefly, total RNA was isolated from 10-day-old seedlings using the Trizol reagent (Thermo Fisher Scientific) and treated with DNase I (EN0521, Thermo Fisher Scientific) to eliminate DNA contamination. cDNA was synthesized with the PrimeScript 1st strand cDNA Synthesis Kit (TAKARA) using 1 ?g of DNA-free total RNA. The ZmPDS gene was amplified using gene-specific primers (Figure 2.6) and sanger sequencing of amplicons was performed. The CDS sequence information generated from the specific cultivar (DMRH 1308 and BML6) was used to design a target-specific guide RNA (gRNA) towards the 5' end of the coding region with minimal off-target using CRISPR Direct (https://crispr.dbcls.jp/) and CHOP-CHOP (https://chopchop.cbu.uib.no/) software. The designed gRNAs will be cloned in the pRGEB32-BAR (Hunter, 2021) vector which has already been acquired from Addgene, USA. The successfully assembled construct will be used for genetic transformation using the Agrobacteria-mediated method into the nodal explants derived callus from DMRH 1308.

Meta-QTL analysis for viral disease resistance in maize (Zea mays L.)

Literature survey was done to conduct MQTL analysis concerning resistance against 14 viral diseases affecting maize, namely Sugarcane mosaic virus (SCMV), Maize streak virus (MSV), Barley

yellow dwarf virus (BYDV), Maize stripe virus disease (MSD), Mal de río cuarto virus (MRCV), Maize chlorotic dwarf virus (MCDV), Foxtail mosaic virus (FoMV), Maize rough dwarf virus (MRDV), Maize chlorotic mottle virus (MCMV), Maize lethal necrosis (MLN), Maize fine streak virus (MFSV), Maize dwarf mosaic virus (MDMV), Maize rayado fino virus (MRFV), and Maize mosaic virus (MMV). The 51 research papers were meticulously assessed to gather necessary information. A total of 39 QTL mapping experiments from 30 studies, containing essential details such as traits, mapping populations, QTLs, positions, LOD values, confidence intervals (CI), groupings, phenotypic variance, and genetic maps, were utilized. Twenty-one mapping studies were excluded due to insufficient information. The genetic map data were retrieved from MaizeGDB, and a consensus map was constructed using a reference map. Summaries were made for information regarding 196 QTLs associated with resistance to the 14 viral diseases. Using the MetaQTL software, the input text files containing QTL and genetic map data were converted into XML format. Subsequently, these files were utilized as inputs in the BioMercator V4.2.3 software for MQTL analysis.

The MQTL analysis unveiled that 27.04% (53) of the QTLs were linked to resistance against 11 viral diseases (SCMV, BYDV, MSV, MMV, MCMV, MCDV, MLN, MRCV, FoMV, MSD, and MRFV). Within this analysis, 14 MQTLs associated with viral resistance were identified on Ch1, Ch3, and Ch10. These MQTL regions exhibited average phenotypic variance ranging between 13-93%. Specifically, Ch1, Ch3, and Ch10 contained 6, 5, and 3 MQTL regions, respectively. Among the 53 initial QTLs, distribution across chromosomes was as follows: 22 on Ch10, 20 on Ch3, and 11 on Ch1.

The average confidence interval (CI) of MQTLs (7.48) and initial QTLs (15.23) for Viral Disease Resistance (VDR) demonstrated a significant reduction in the CI of MQTLs, offering maize breeders an effective tool for VDR breeding programs. Noteworthy MQTLs such as MQTL3_2 and 3_4 were associated with a maximum of three viral diseases (Table 2.1). A total of 1715 candidate genes were identified within the 14 MQTL regions. Further analysis to verify these candidate genes through existing Genome-Wide Association Studies (GWAS) and identification of constitutive genes is currently underway.

Table 2.1: Meta-QTLs associated with resistance against viral diseases, related information, and number of retrieved putative candidate genes

Meta QTL	Position (cM)	Flanking marker	Range (bp)	CI (95%)	Average pheno-typic variance	Diseases	No. of QTL	No. of Popu lations	No. of candidate genes
MQTL3_2	77.6	PZE.103054855-PZE.10307 1320	66,947,062 -117,095,619	1.14	34.40	SCMV, MSV, MLN	6	4	336
MQTL3_4	106.67	PZE.103112740-SYN13862	172,489,869-173,419,826	1.37	27.09	SCMV, MSD, MCDV	7	4	22

CROP PRODUCTION 3

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

Rice-wheat (RW) cropping system in north-west India despite providing food security in the country, has also led to soil degradation and over-exploitation of underground water resources. To diversify the 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 various industrial sectors. This experiment was planned and started in 2017.

In the sixth year, significantly higher system productivity was obtained under maize-wheat system compared to rice-wheat. In comparison to the rice-wheat system, the system productivity was 30.2% and 7.80% higher in conservation and conventional maize-wheat system, respectively (Figure 3.1). Overall system productivity was significantly higher in conservation agriculture over conventional tillage maize-wheat and rice-wheat system. Among different fertilizer management treatments, significantly higher system yield was obtained under Green Seeker (GS), Recommended Dose of Fertilizer (RDF) and Site Speicific Nutrient Management (SSNM) over Farmers Fertilizer Practice (FFP). The maize-wheat system was also water-use efficient as it reduced water consumption by 84% 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, leads to increased system productivity (up to 30%), profitability (up to 71%) and also resulted in huge (80%) water saving.

Net return and Benefit to Cost (B:C) ratio was also calculated. In sixth year significantly high net return and B:C ratio was found with conservation maize-wheat-mungbean (Figure 3.2) as compared to

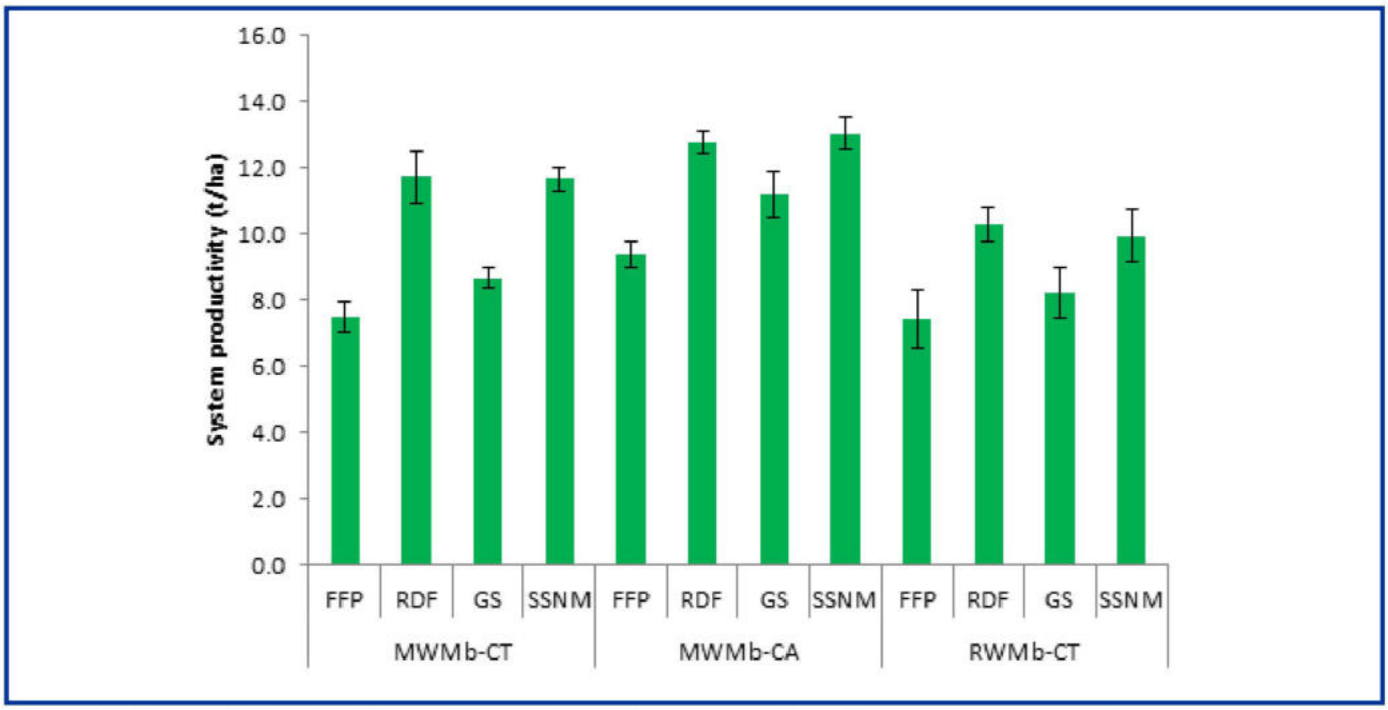


Figure 3.1: System yield under different tillage and cropping system and nutrient management practices

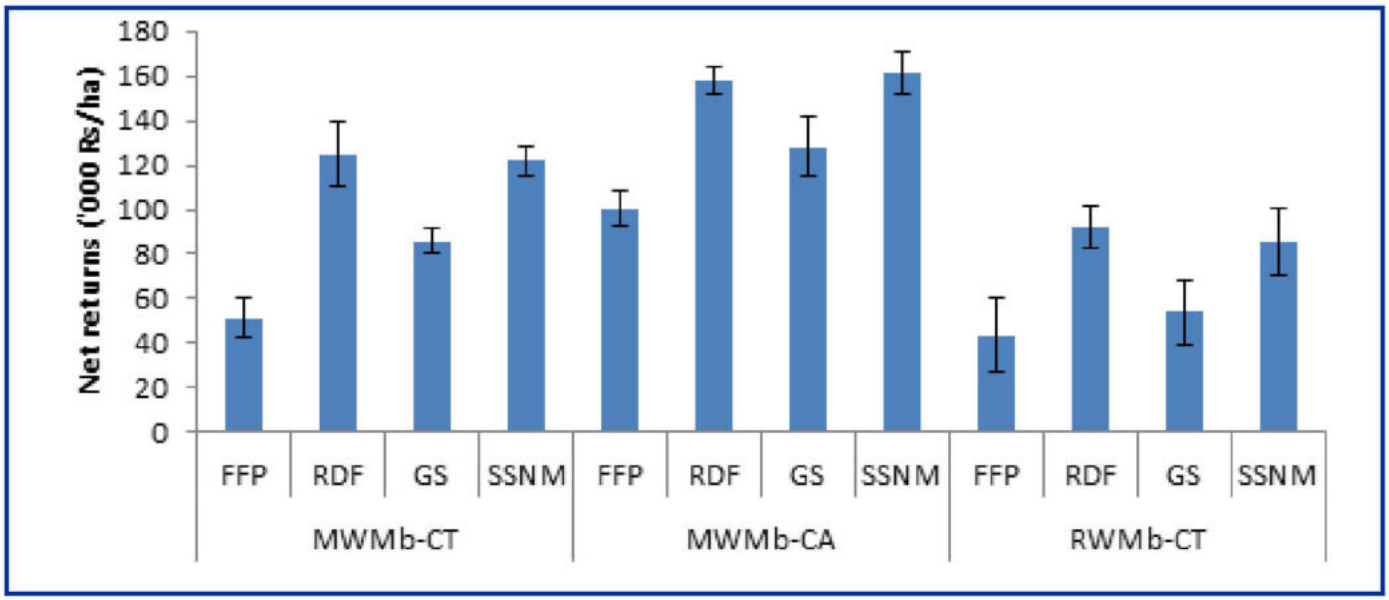


Figure 3.2: Net returns under different tillage and cropping system and nutrient management practices

conventional maize-wheat-mungbean and rice-wheat-mungbean systems. Amongst fertilizer management practices, use of green seeker sensors produced significantly higher net return over farmer fertilizer practice and RDF, however it remained at par with SSNM practice.

Soil properties:

Soil properties, viz., soil organic carbon was also measured after completion of five years. Highest soil organic carbon was built up in conservation agriculture maize-wheat system followed by CT maize-wheat and least soil organic carbon built-up was observed in puddled rice-wheat cropping system (Table 3.1).

Study of different organic nutrient sources in maize and spatiality corn

Presently, there is an increased demand for the organic product due to their better nutrition value and quality. However, no concrete information is available on organic maize production with special reference to speciality maize that has great potential. Hence, on a long term basis, one experiment has been conducted on fixed-site to measure the effect of fertilizer vis-à-vis

Table3.1: Total soil carbon (%) after completion of five years in Maize-wheat vis-à-vis Rice-wheat cropping

Main plot	Sub plot	Total Carbon (%)		Total organic carbon (%)	
		0-15 cm	15-30 cm	0-15 cm	15-30 cm
CT	F1	0.985	0.723	0.542	0.398
	F2	0.920	0.626	0.506	0.344
	F3	0.981	0.600	0.539	0.330
	F4	0.940	0.830	0.517	0.457
CA	F1	1.142	0.679	0.628	0.373
	F2	0.980	0.826	0.539	0.455
	F3	0.982	0.795	0.540	0.437
	F4	1.213	0.830	0.667	0.457
RW-CT	F1	0.893	0.801	0.491	0.441
	F2	0.827	0.658	0.455	0.362
	F3	0.905	0.716	0.498	0.394
	F4	0.922	0.677	0.507	0.372
CD		NS	NS	NS	NS

Table3.2: Effect of different organic nutrient sources in maize and spatiality corn

Maize type	Treatment	Maize (2017)	Maize (2018)	Maize (2019)	Maize (2020)	Maize (2021)	Maize (2022)
Baby corn	RDF	7570	8876	8750.0	4607.3	9848	9.67
	100% FYM	6585 (-13)	7721	6995.9	4674.0	7317	10.16
	50% FYM+ 50% VC	6268 (-17)	7349	6834.5	5173.8	6583	7.02
	25%FYM+25%VC+ 1/3Straw	6598 (-12)	7736	4095.5	2400.1	6496	6.37
	LSD (P=0.05)	NS	NS	2176.8	1432.2	1473.7	2.06
Sweat corn	RDF	9986	12642	10464.1	8597.5	12010	13.60
	100% FYM	9417 (-5)	8751	5970.6	6998.7	10415	9.89 (37.5%)
	50% FYM+ 50% VC	9121 (-8)	8510	5709.6	5966.2	9363	9.56
	25%FYM+25%VC+ 1/3Straw	8635 (-13)	7561	2590.9	2634.7	5350	4.52
	LSD (P=0.05)	NS	1272.8	1260.8	1691.6	1591.2	2.9
Normal maize	RDF	6435	9706	8391	5388.7	6597	6.99
	100% FYM	4453(-30)	6428	6693	5098.1	4732	3.76 (85.9%)
	50% FYM+ 50% VC	4487(-30)	5621	6136	5378.7	4478	3.95
	25%FYM+25%VC+ 1/3Straw	4518(-29)	5514	5286	5068.8	3925	3.28
	LSD (P=0.05)	290.1	230.6	240.5	979.4	668.1	1.72

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

different organic sources in maize and speciality corn i.e. baby corn and sweet corn (Table 3.2). After completion of six years, only the yield of baby corn was found at par with RDF with 100% FYM treatment. While in sweet corn as well as in normal maize, significantly lower yield was obtained in organic treatments. So, it clearly showed that complete organic treatments are not a suitable option particularly with single cross hybrid maize.

Weed management in maize

A field experiment was conducted to find out the best combinations of pre and post emergence herbicides in maize for effective weed control with higher productivity at ICAR-IIMR farm during 2021 and 2022. It was found that pre- (PE) and post- (POE) herbicide application reduced the NLW and BLW density by 91.46-62.41% and 82.11-55.53% as compared to weedy check. Among the PE, pyroxasulfone performed superior over atrazine owing to selectivity towards maize with better weed control during 2021 and 2022. In POE, the density of Cyperus spp. was significantly reduced with halosulfuron POE along with atrazine or pyroxasulfone PE over the years. Pyroxasulfone + topramezone recorded 46.97% increase in grain yield over weedy check. The conventional practice of weed control through atrazine + hand weeding recorded yield penalty of 18.84% as compared to pyroxasulfone + topramezone. Pyroxasulfone + topramezone and pyroxasulfone + tembotrione recorded higher net returns and B:C ratio owing to effective weed control. A higher WCE was found with pyroxasulfone + topramezone (90.4), while and pyroxasulfone + tembotrione (84.1) higher and atrazine + topramezone (84.8) recorded similar values of WCE. We found that weeds can cause yield losses in maize by 49.5% without suitable weed strategy. Additionally, the traditional practice of atrazine + hand weeding causes the yield penalty by 20.8 to 24% over to pyroxasulfone fb topramezone.

Overall, it can be concluded that application of pyroxasulfone PE followed by tembotrione POE and pyroxasulfone PE followed by topramezone POE enhances grain yield with high reduction in weed density in maize.

Application of image analysis for area, yield and stress estimation in maize

Maize have got renewed importance in view of the its multifaceted uses for industrial purposes. The high production growth rate is currently required in order to fulfill growing demand of the crop specially after addition of bioethanol segment recently. Hence, mapping of maize in new and traditional ecologies could unravel the pathways for sustainable production.

The kharif season is an important season for maize cultivation as it presently contributes around ~78% of maize area. The mapping of the state-wise acreage and production during the 1997-98 to 2019-20 was performed (Figure 3.3). The study showed that total 1.5 lakh ha area increased during this period in the eastern, central and southern parts of the country during kharif season. The major districts in 1997-98 were lying in the central-western and northern parts which expanded to the peninsular India in 2019-20. The kharif crop has now present almost pan India having large acreage districts concentrated in Western half of India. However, the productivity level was below 5 t/ha in most of the districts which is now reached over 10 t/ha. A perusal of map indicates that

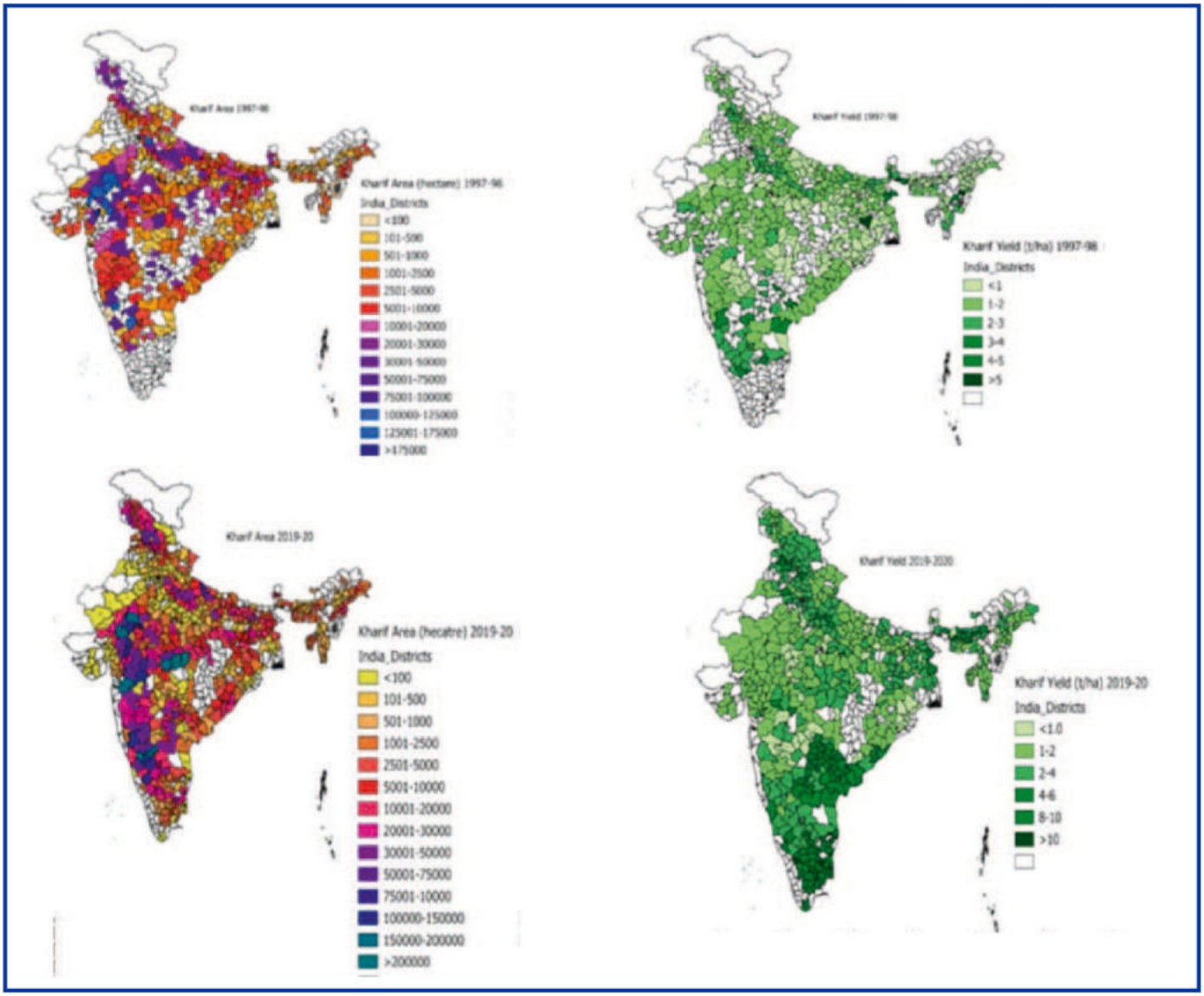


Figure 3.3: The district-wise maize acreage and yield in kharif season during 1997-98 to 2019-20.

eastern peninsula, north western IGP and central India has concentration of high productivity districts.

During rabi season from very less presence in the lower and middle Indo-Gangetic plains and Karnataka maize expanded to almost all states barring Himalayan states, Punjab and Haryana (Figure 3.4). The higher acreage with high productivity districts spiked in new ecology of West Bengal and Tamil Nadu and also in traditional Andhra Pradesh. The highest productivity tripled from 3 to over 10 t/ha during 1997-98 to 2019-20. The high productivity districts (>7 t/ha) in this season concentrated in Andhra Pradesh, Bihar, Tamil Nadu and West Bengal. Similarly, the summer season also contributed approximately 5 lakh ha in the total acreage with productivity of 1.4 to 7.1 tonnes/ha.

Overall, the maize acreage expanded by 53% during TE 1997-98 to 2019-20 The future requirements of the maize can be met from effective resource allocation in these prospective areas.

Best production practices fo enhanced productivity and profitability in maize-based cropping system

The crop diversification requirement is well known fact for sustaining productivity and profitability of the food basket of India in Western IGP. The agri-innovation platforms has been established at the farmers field for potential yield realization in kharif

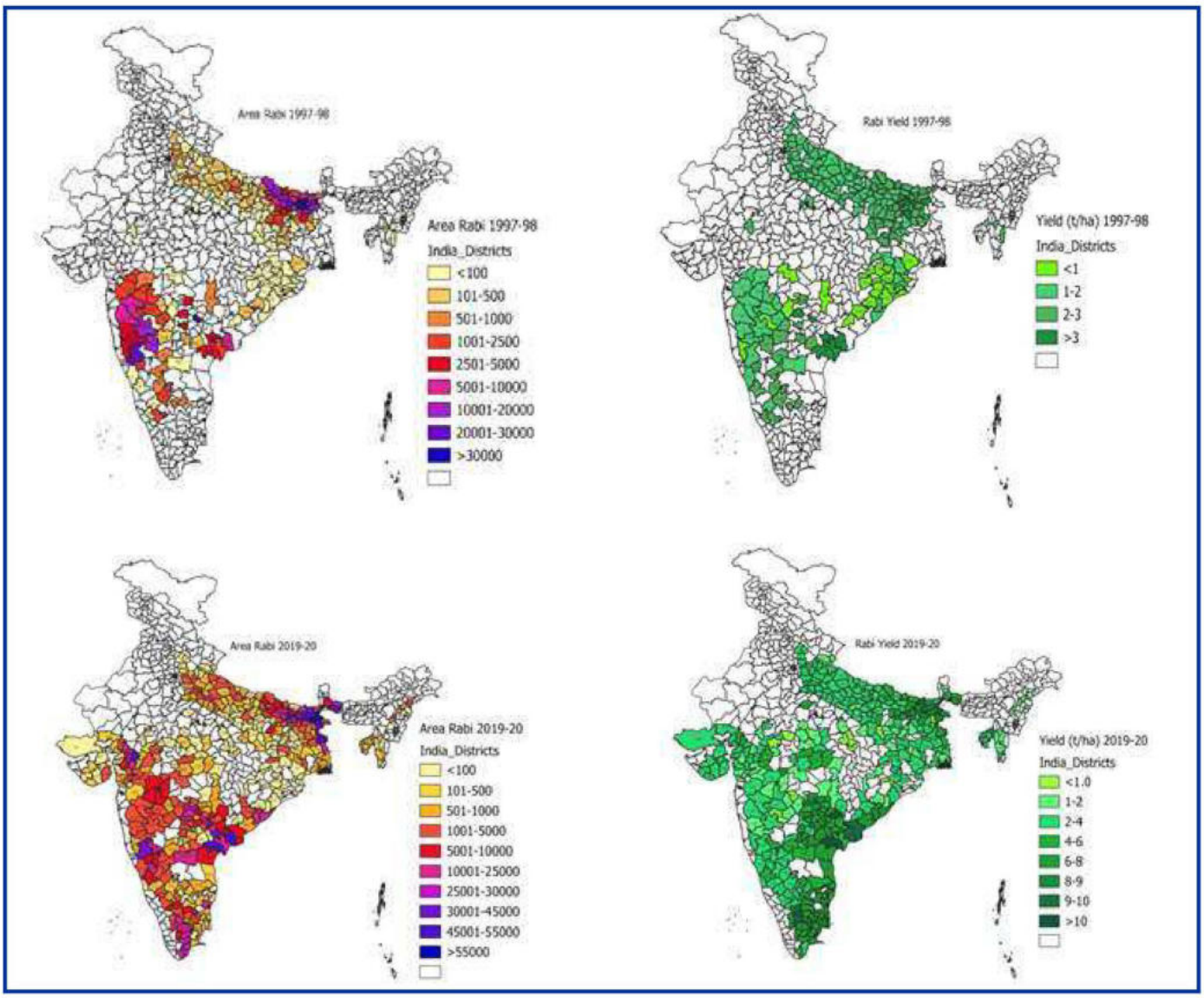


Figure 3.4: The district-wise maize acreage and yield in kharif season during 1997-98 to 2019-20.

maize in five districts of Punjab. The maize grain yields varied from 4.48 to 7.55 t/ha in on-farm platforms with average of 6.15 t/ha which was at par with average rice yield of 6.33 t/ha (Figure 3.5). The results showed that the maize has potential to expand in all these districts of the Punjab with proper market arrangements and appropriate policy support.

The placement of nitrogen plays important role in improving the nitrogen use efficiency and crop productivity. The improved nitrogen placement methods (NPMs) were tested in maize by sub-surface N placement of second split of N at knee high stage. The interaction effect showed that the improved recommended dose of N (RDN) with zero tillage (ZT) + residue (R) retention gave maximum grain yield which was at par with ZT-R. Thus, the sub-surface placement of the second split of nitrogen has potential to further improve productivity of maize.

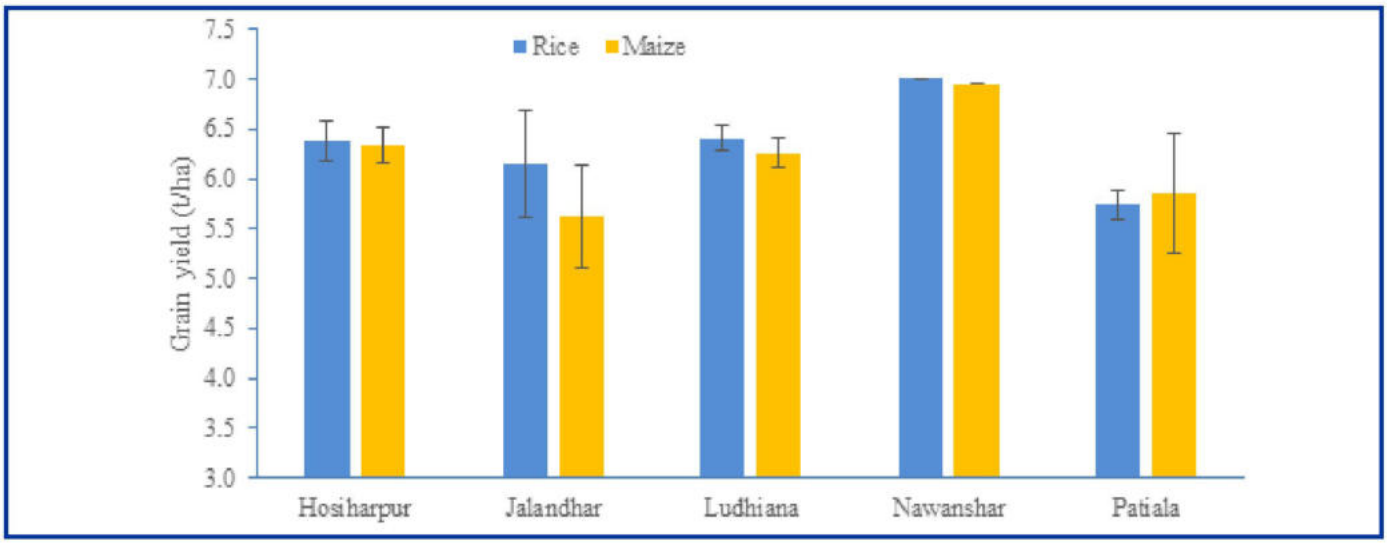


Figure 3.5: Grain yield (t/ha) of rice and maize at different locations of Haryana and Punjab

CROP PROTECTION 4

Plant Pathology

Resistance against major diseases:

Maydis leaf blight (MLB)

During Kharif 2023, a total of 307 inbred lines were evaluated against Maydis leaf blight under artificial inoculation using alpha lattice design. Out of these, 78 inbred lines were found resistant with disease score ≤3 (Table 4.1). Moreover, a total of 273 RILs including checks were screened under artificially created epiphytotics of MLB in augmented design. Out of these, 14 and 113 RILs exhibited resistant and moderately resistant reactions against MLB. Additionally, 42 elite genotypes of white maize were also evaluated against MLB in RBD design (Table 4.1). Out of those, three genotypes (19492, 19679, 19682) were resistant, whereas, thirteen genotypes (19408, 19422, 19472, 19475, 19476, 19500, 19503, 19632, 19639, 19643, 19655, 19676, 19695) were moderately resistant.

Banded leaf and sheath blight (BLSB)

During Kharif 2023, a total of 261 inbred lines were evaluated against Banded leaf and sheath blight under artificial inoculation using alpha lattice design. Out of these 75 inbred lines were found promising against BLSB (Table 4.1).

Charcoal rot (ChR)

During Kharif 2023, a total of 557 inbred lines were evaluated against charcoal rot under artificial inoculation using alpha lattice design. Out of these, 12 inbred lines were found resistant against ChR (Table 4.1).

Spring 2023

Charcoal rot (ChR)

During spring 2023, a total of 255 inbred lines were evaluated against charcoal rot under artificial inoculation using alpha lattice design. Out of these, 22 inbred lines were found resistant against ChR.

Development of On-farm maize cob drying system for effective value chain and seed pathology

Analyzing maize cultivation it is found that 85% of maize cultivation is done during the Kharif season. It become difficult to dry maize cobs in the field during this season since the ambient temperature drops and the quantity of moisture in the air rises. Usually, it is dried in the field; the cobs are spread out on the bare ground and left to dry. It takes a significant time and a massive effort to spread them out on the ground. At night, the temperature drops below the dew point resulting in condensation of moisture as dew onto the surface of the maize cob leading to increase in moisture content. The problem gets worse for cobs drying, in case of rain. Weather conditions and inadequately dried cobs are conducive to mould infestation, posing a significant threat to maize quality, including the development of mycotoxins such as aflatoxin, which is lethal to humans and dairy & poultry animals. As a result, this project was undertaken to build an on-farm maize cob drying system to solve these challenges. The designed capacity of the maize cob drying system is about one ton (1000 kg). The developed model of the drying system is depicted in Figure 4.1. The intended system was also stimulated by using the Ansyis software to analyse the behaviour of the structure under the applied force 9800 N. It is found that the designed structure is capable of sustaining 1000 kg maize cobs (Figure 4.1).

Isolation of fungus

Maize harvested grains (Cultivar CP 858) were taken from IIMR Ladhowal field, Ludhiana. Out of these few seeds were tested for seed borne pathogens (before drying under dryer) in the Plant pathology laboratory and the remaining were sent to ICAR-CIPHET Ludhiana for drying purpose. After completion of the drying, seed samples were tested in the same laboratory. For this purpose, samples were washed with tap water to remove soil debris, and then transferred to Laminar Air flow cabinet. Seeds were washed with sterilized distilled water in petri dishes and shifted into 70% ethanol for 30 seconds. Afterwards, the seeds were dipped sequentially in 4% sodium hypochlorite for 2 min, and then rinsed three times thoroughly with sterilized distilled water for 1 min. Finally, the seeds were dried over sterile blotting

Table 4.1 Promising inbred lines against MLB, BLSB and ChR

Season	Disease	Resistant lines
Kharif 2023	**MLB** (Total-307)	**(Design-Alpha lattice; Resistant-78)** MIL-2-592-2, MIL-2-3633, MIL-2-1298-6, MIL-2-43-2, MIL-2-350-1, MIL-2-1624, MIL-2-976-1, MIL-2-173-4, MIL-2-801-1, MIL-2-1623, MIL-2-883-1, MIL-2-591-1, MIL-2-380-1, MIL-2-1521, MIL-2-1601, EI-670, MIL-2-310-1, MIL-2-814-2, MIL-2-406-1, EI-586-2, MIL-2-246-2, MIL-2-58-2, MIL-2-173-2, MIL-2-1045-1-1, MIL-2-975-2, MIL-2-133-2, MIL-2-1053-2-2, MIL-2-475-2, MIL-2-1298-8, MIL-2-3681, MIL-2-800-1, MIL-2-719-1, MIL-2-2034, MIL-2-428-2, MIL-2-2077, MIL-2-1281-5, QIL-4-2612, QIL-4-2621, QIL-4-2625, QIL-4-2634, QIL-4-2644, QIL-4-2645, QIL-4-2654, QIL-4-658, QIL-4-2659, QIL-4-2666, BIL-23-63, BIL-23-69, BIL-23-70, BIL-23-75, BIL-23-76, BIL-23-77, BIL-23-78, BIL-23-80, BIL-23-90, BIL-23-91, P22K2150, P22K2163, P22K2095, P22K2108, P22K2126, P22K2161, P22K2188, P22KMT-1, P22KMT-2, P22KPant Teo Sel-1, P22KTeo15, P22KTeo19, P22KTeo23, P22KTeo20, P22KTeo3, P22KTeo12, P22KTeo13, P22KTeo9, P22KTeo5, P22KTeo26, P22KTeo27, P22KPantCoixx1
	MLB (Total-273)	**(Design-Augmented; Resistant-14)** M15-36, M15-101, IML-15-144, IML-15-153, IML-15-219, IML-15-253, IML-15-302, IML-15-303, IML-15-92, IML-15-102, IML-15-186, IML-15-214, IML-15-245, IML-15-301
	MLB (Total- 42)	**(Design-RBD; Resistant-3)** 19492, 19679, 19682
	BLSB (Total-261)	**(Total number of resistant- 75)** MIL-2-592-2, MIL-2-1074-1, MIL-2-1041-4-1, MIL-2-380-1, MIL-2-1521, MIL-2-2068, MIL-2-1601, EI-670,MIL-2-310-1, MIL-2-55-1, MIL-2-164-1, MIL-2-1043-1-1, MIL-2-406-1, MIL-2-119-1, MIL-2-681-2, MIL-2-1062-1-2, MIL-2-343-3, MIL-2-1298-2, EI-586-2, MIL-2-219-1, MIL-2-54-2, MIL-2-1036-1, MIL-2-1296-1, MIL-2-3240, MIL-2-58-2, MIL-2-941-3, MIL-2-173-2, MIL-2-1045-1-1, MIL-2-387-3, MIL-2-2037-1, MIL-2-975-2, MIL-2-133-2, MIL-2-568-2, MIL-2-1053-2-2, MIL-2-475-2, MIL-2-1621, MIL-2-1298-8, MIL-2-3-1, MIL-2-376-2, MIL-2-3707, MIL-2-1292-1, MIL-2-83-2, MIL-2-3742, MIL-2-207-1, MIL-2-15-2, MIL-2-921-2, MIL-2-176-2, MIL-2-719-1, MIL-2-1040-3-1, MIL-2-388-1, MIL-2-3470, MIL-2-49-2, MIL-2-1038-4-2, MIL-2-93-2, MIL-2-511-1, MIL-2-3773, MIL-2-274-1, QIL-4-2518, QIL-4-2537, QIL-4-2545, QIL-4-2557, QIL-4-2561, QIL-4-2571, QIL-4-2584, QIL-4-2602-1, QIL-4-2604, QIL-4-2612, QIL-4-2616, QIL-4-2621, QIL-4-2644, QIL-4-2647, QIL-4-2664, BIL-23-73, BIL-23-90, BIL-23-91
	ChR (Total-307	**(Total number of resistant- 12)** MIL-2-1587, MIL-2-201-1, MIL-2-37-2, MIL-2-883-1, MIL-2-814-2, MIL-2-164-1, MIL-2-1045-1-1, MIL-2-2037-1, BIL-23-76, BIL-23-77, P22K2141, P22KTeo13
Spring 2023	**ChR** (Total-255)	**(Total number of resistant- 22)** MIL-2-941-1, 11005, 11196, 11702, 11380, 11394, 11450, 11582, 11672, QIL-4-2640, QIL-4-2661, QIL-4-2664, BIL-23-74, BIL-23-98, BIL-23-79, BIL-23-84, BIL-23-89, 13659, 13720, 13609, 13657, 13630

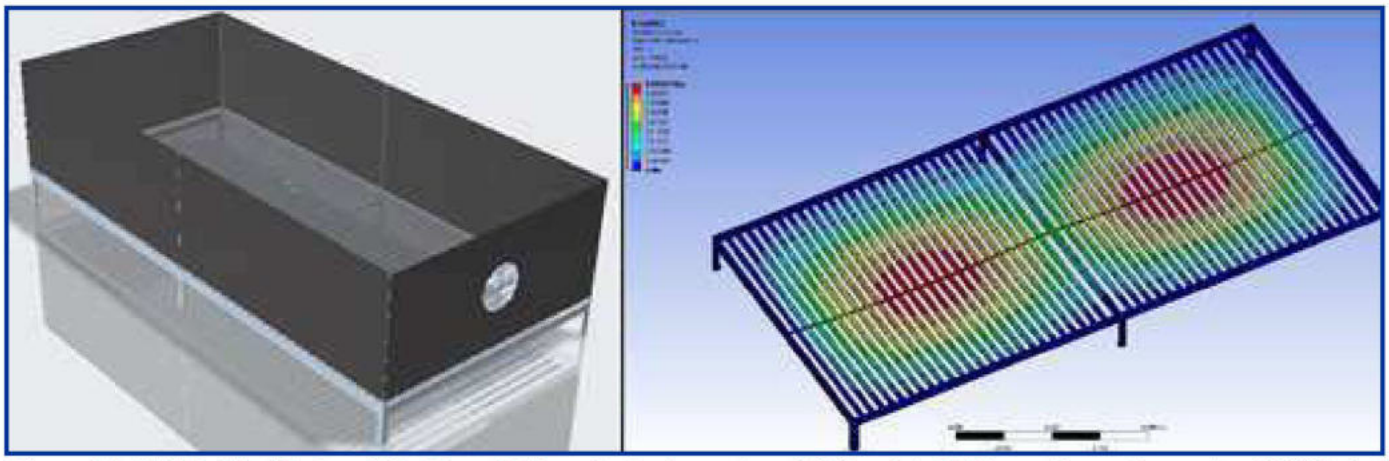


Figure 4.1: (A) Model of designed On-Farm Maize cobs drying system. (B) Simulated deformation under one ton (1000 kg) of maize cobs (9800 N applied force) on the design structure

paper inside the laminar airflow chamber. Surface sterilized seeds were taken out using a sterile forceps and placed on petri plates containing potato dextrose agar (PDA) medium supplemented with streptomycin sulphate (15 mg/L). The plates were kept in an incubator at 27-29°C for 7 to 10 days. Fungal growth on each plate was sub-cultured to a new plate, until pure fungus isolated plate was obtained. The growth of fungus was observed daily. Pure plates have been sent for identification (Figure 4.2).

However, in the second trial with cultivar ADV 764, there was no fungus or any pathogen growth in both the conditions.

Studies on turcicum leaf blight isolates diversity in Maize

Morphological studies of all 61 isolates have been completed. Out of 61 isolates, some of the isolates showed different species of Exserohilum and other fungus. Hence, validation by different markers is under progress. Further some of the isolates recollected from Jammu and Kahmir and their morphological studies and molecular work is under progress.

Moreover, a total of 34 diseased leaf samples of maize showing MLB symptoms were collected/procured from 18 different maize growing states of India. Isolations were made on PDA plates and a total of 25 pure cultures of different isolates of MLB pathogen were identified on the basis of morphological characteristics of conidia under light

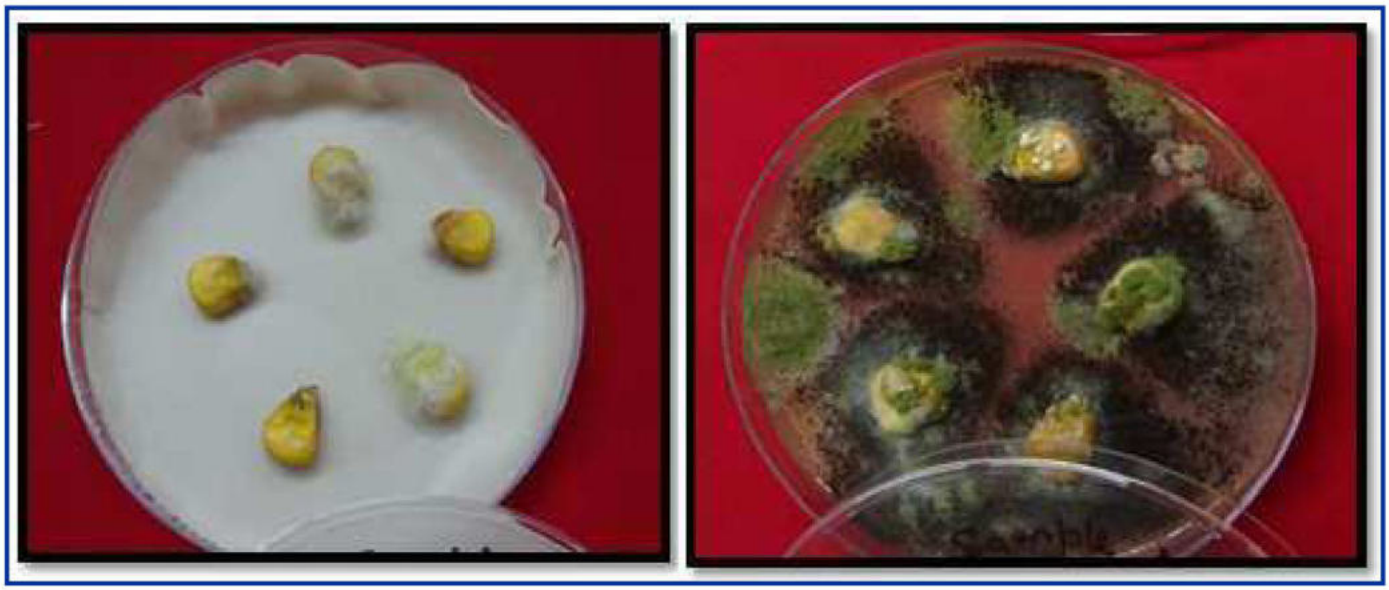


Figure 4.2: First trail: Sample 1 (Before drying) **Sample 2 After drying**

microscope and typical growth of mycelium on PDA.

Entomology

Development of sustainable management tools for major insect pests of maize

Identification of resistant sources against spotted stem borer, Chilo partellus (Swinhoe)

Spotted stem borer, *Chilo partellus* (Swinhoe) is a serious pest of maize during kharif season causing 26 to 80% yield losses in different agroecological regions of India. A total of three hundred thirty-nine inbred lines along with resistant and susceptible checks were screened under artificial infestation against spotted stem borer during kharif 2023 at WNC, ICAR-IIMR Hyderabad. The resistant, moderately resistant and susceptible lines were categorised by LIR 1.0-3.0, >3.1-6.0 and >6.1-9.0, respectively. Among the screened lines, none of the genotypes were found resistant against SSB, while six lines were moderately resistant (Figure 4.3).

Identification of resistant sources against pink stem borer, Sesamia inferens Walker

Pink stem borer (PSB), Sesamia inferens Walker is the most important insect pest of rabi sown maize in India, and is reported to cause 25.7-78.9% yield losses in maize. A total of one hundred forty four inbred lines along with resistant checks (DMRE 63, CM 500) and susceptible check (BML 6) were screened under artificial infestation against pink stem borer (SSB) during Rabi 2022-23 at WNC, Hyderabad. The resistant, moderately resistant and susceptible lines were grouped based on LIR of 1-3, >3.1-6 and >6.1-9, respectively. Only one genotype MIL-1-11 (2.61) was found resistant against pink stem borer under artificial infestation while 33 were moderately resistant (Figure 4.4).

Identification of resistant sources against fall armyworm, Spodoptera frugiperda (J.E.Smith)

Fall armyworm Spodoptera frugiperda (J.E.Smith) is the major invasive insect pest of maize reported to cause yield losses of 20-50% in maize. A total of 169 and 300 lines were evaluated for foliar resistance at the V5 leaf stage under artificial infestation against fall armyworm during Rabi 2022-23 and Kharif 2023, respectively. The resistant, moderately resistant and susceptible lines were categorized by LDR 1.0-4.0, >4.1-6.0 and >6.1-9.0, respectively. Among 169 genotypes screened, only one line, i.e. CML 60 (3.57) was found promising while 127 were moderately

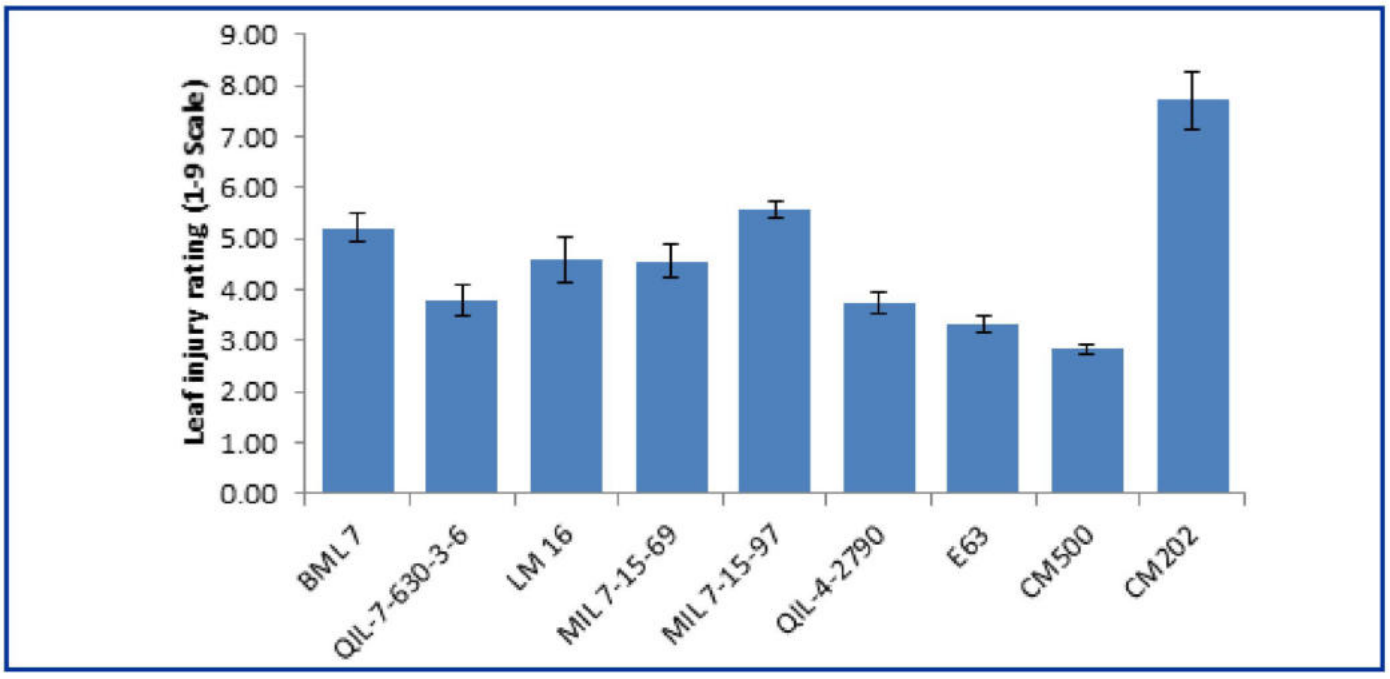


Figure 4.3: Moderately resistant maize germplasm along with checks against spotted stem borer

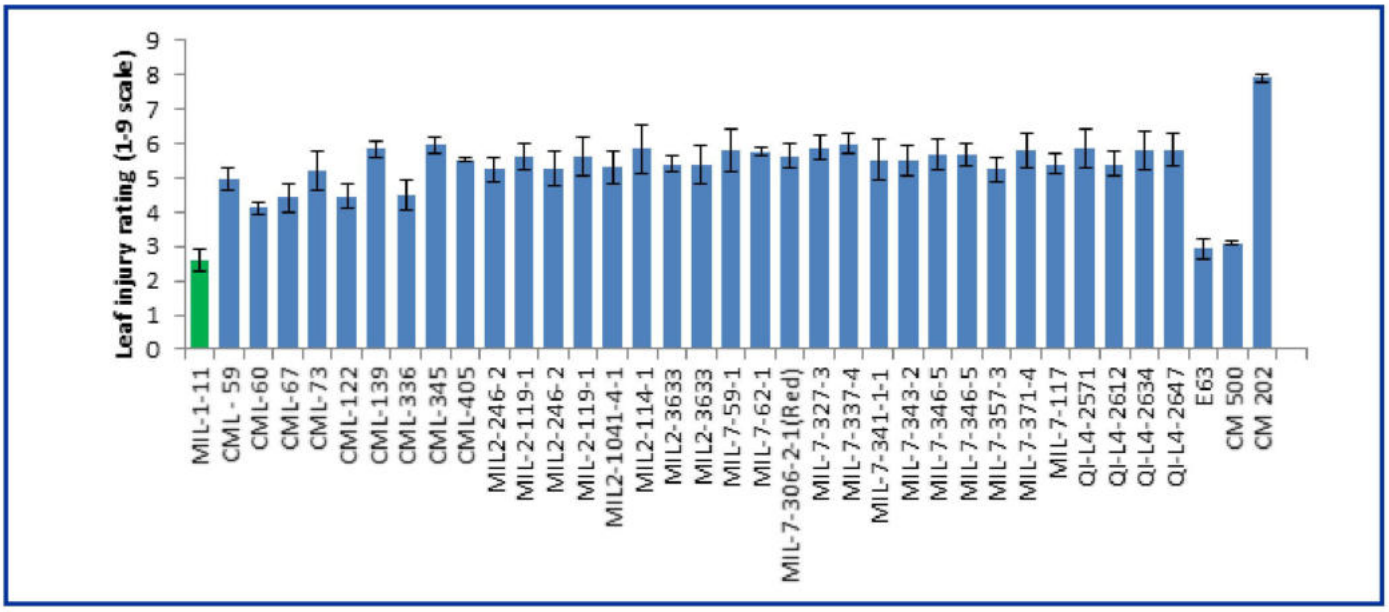
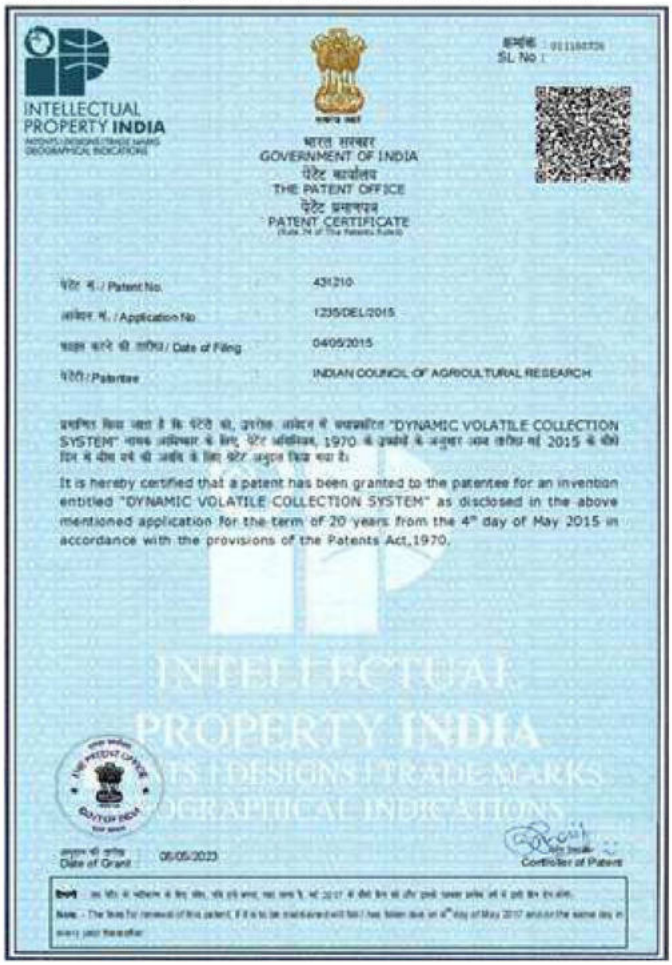


Figure 4.4: Moderately resistant maize germplasm along with checks against pink stem borer

resistant. Out of 300 lines screened, none of the lines were found resistant while 129 were moderately resistant against FAW.

Patent: 'Dynamic volatile collection system'- Indian Patent No. 431210, dt. 8 May 2023 Inventors: S.B. Suby, P. Kumar, J.C. Sekhar, L.P. Soujanya

The salient feature of the Technology: Conventional systems that are designed to collect volatiles from specimens like living things, organic matter, liquids, soil, and atmospheric air, are able to collect volatiles from at most two specimens at a single time point. Further, the conventional systems are complex comprising separate flow meters and suction pumps for each suction and vacuum unit and a unit to control all, which add to the overall cost of sample collection. The patented invention is a dynamic sampling system that overcomes such deficiencies by simultaneous sampling of volatiles from multiple specimens from many specimen chambers at a time using a single flow meter and single pump in 'pull' mode and two flow meters and two pumps or an external air-source with single flow meter and single pump in 'push- pull' mode. The simultaneous multiple sampling is enabled by a multi-port aeration and a unique multi-port vacuum unit which is in fluid dynamics with multiple specimen chambers (Figure 4.5). The technology is currently commercialized with Amar Chand & Co., 56, Industrial Estate, Ambala Cantt-133 006 and is being used by ICAR institutes viz., ICAR-NIBSM and ICAR-IIRR.


INTELLECTUAL PROPERTY INDIA

भारत सरकार
GOVERNMENT OF INDIA
पेटेंट कार्यालय
THE PATENT OFFICE
पेटेंट प्रमाणपत्र
PATENT CERTIFICATE

पेटेंट सं./ Patent No. 431210
आवेदन सं. / Application No 1235/DEL/2015
फाइल करने की तारीख/ Date of Filing 04/05/2015
पेटेंटी/ Patentee INDIAN COUNCIL OF AGRICULTURAL RESEARCH

It is hereby certified that a patent has been granted to the patentee for an invention entitled "DYNAMIC VOLATILE COLLECTION SYSTEM" as disclosed in the above mentioned application for the term of 20 years from the 4th day of May 2015 in accordance with the provisions of the Patents Act,1970.

Date of Grant 08/05/2023
Controller of Patents

Figure 4.5: Patent on 'Dynamic volatile collection system'

EXTENSION AND OUTREACH 5

ICAR-IIMR, Ludhiana has 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 by conducting various 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 Agri-Drone project.

Frontline demonstration under NSFM

During the *rabi* season of 2022-23, 13 centres across 10 states implemented Front line Demonstrations (FLDs) on 130 hectares at 330 farmer's field (Table 5.1 & Fig. 5.1 & 5.2). The mean yield increase compared to farmer practices during the season was 16.00 (9.2% in Kalyani to 36.54% in Kolhapur). In the spring 2023, FLDs were conducted on 10 ha at 20

Table 5.1: Centre-wise, season-wise NFSM FLD conducted in maize during 2023-24

Centre	Area (ha)	Yield (q/ha)		Gains in FLD		No. of FLD
		FLD	FP	Diff. +/- in q/ha	Yield Gain (%)	
Rabi 2022-23						
AAU, Gossaingaon	10.00	59.07	43.90	15.17	34.55	48
BCKV, Kalyani	20.00	80.27	73.51	6.76	9.20	55
DrRPCAU, Dholi	6.00	77.07	68.40	8.67	12.67	15
RMRSPC, Begusarai	10.00	82.92	73.59	9.33	12.68	25
MPKV, Kolhapur	10.00	47.92	35.10	12.83	36.54	25
PJTSAU, Karimnagar	10.00	80.80	69.60	11.20	16.09	25
ANGRAU, Peddapuram	10.00	76.21	68.16	8.05	11.81	17
TNAU, Coimbatore	10.00	80.21	70.67	9.54	11.90	25
UAS, Dharwad	10.00	56.22	48.94	7.28	14.87	10
WNC, IIMR, Hyderabad	10.00	61.20	55.20	6.00	10.87	25
TNAU, Vagarai	10.00	69.65	63.65	2.43	9.43	25
AAU, Godhara	4.00	41.17	33.52	7.65	22.82	10
ARS, Banswara	10.00	79.44	64.56	14.88	23.05	25
Total/mean (Rabi 2022-23)	**130.00**	**68.6**	**59.1**	**9.21**	**16.0**	**330**
Spring 2023						
GBPUAT, Pantnagar	10.00	82.70	81.15	1.55	1.91	20
Total/mean (Spring 2023)	**10.00**	**82.7**	**81.15**	**1.55**	**1.91**	**20**
Kharif 2023						
VPKAS, Almora	10.00	41.30	28.37	12.93	45.59	32
SKUAST, Srinagar	36.00	52.00	35.36	16.64	47.06	150
IIMR, Ludhiana	20.00	51.20	48.65	1.02	5.23	50
PAU, Ludhiana	10.00	44.43	42.41	2.02	4.76	25
BHU, Varanasi	20.00	52.71	37.43	15.28	40.82	40
RLBCAU, Jhansi	20.23	37.70	21.93	15.77	71.91	50
DrRPCAU, Dholi	4.00	57.50	46.80	10.70	22.86	10
MPKV, Kolhapur	20.00	56.31	35.45	20.86	58.83	50

Table 5.1: Centre-wise, season-wise NFSM FLD conducted in maize during 2023-24

Centre	Area (ha)	Yield (q/ha)		Gains in FLD		No. of Beneficiary
		FLD	FP	Diff. +/- in q/ha	Yield Gain	
ANGRAU, Peddapuram	20.00	62.33	57.85	4.50	7.74	40
TNAU, Coimbatore	50.00	80.58	71.30	9.28	13.02	125
UAS, Mandya	40.40	31.22	27.68	3.54	12.78	86
UAS, Dharwad	32.00	48.91	41.24	7.68	18.61	32
AAU, Godhara	17.60	33.05	28.13	4.91	17.46	44
JNKVV, Chhindwara	26.00	77.99	51.02	26.97	52.85	65
MPUAT, Banswara	10.00	35.16	28.77	6.4	22.23	25
MPUAT, Udaipur	50.20	33.44	22.70	10.74	47.27	181
Total/mean (Kharif 2023)	**386.43**	**49.74**	**39.07**	**10.67**	**27.31**	**1005**

#FLD-front line demonstration; FP-Farmer practice

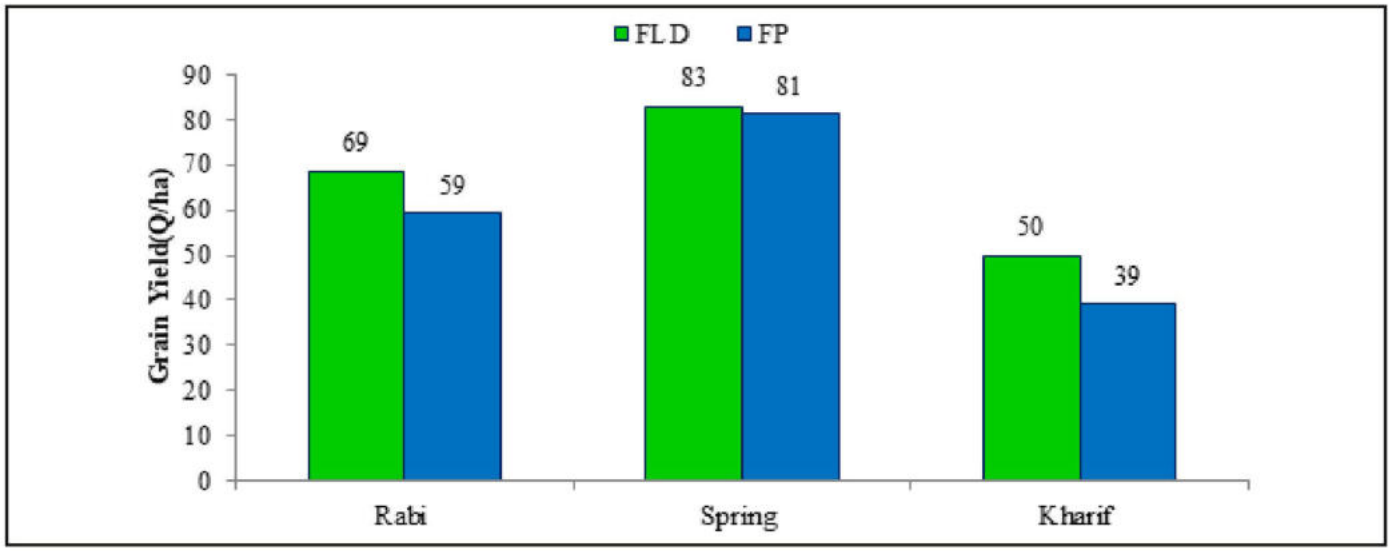


Fig5.1: Average maize yield during across season in FLDs and farmers' Practices.

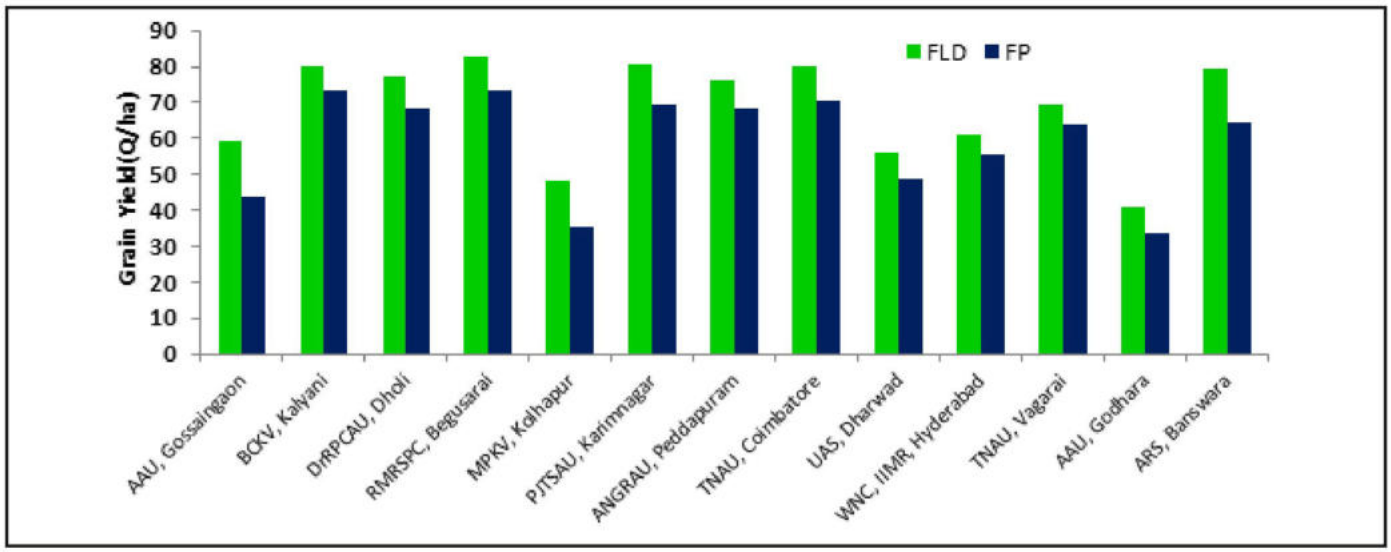


Fig 5.2: Maize Yield during rabi 2022-23In FLDs and farmers' Practices.

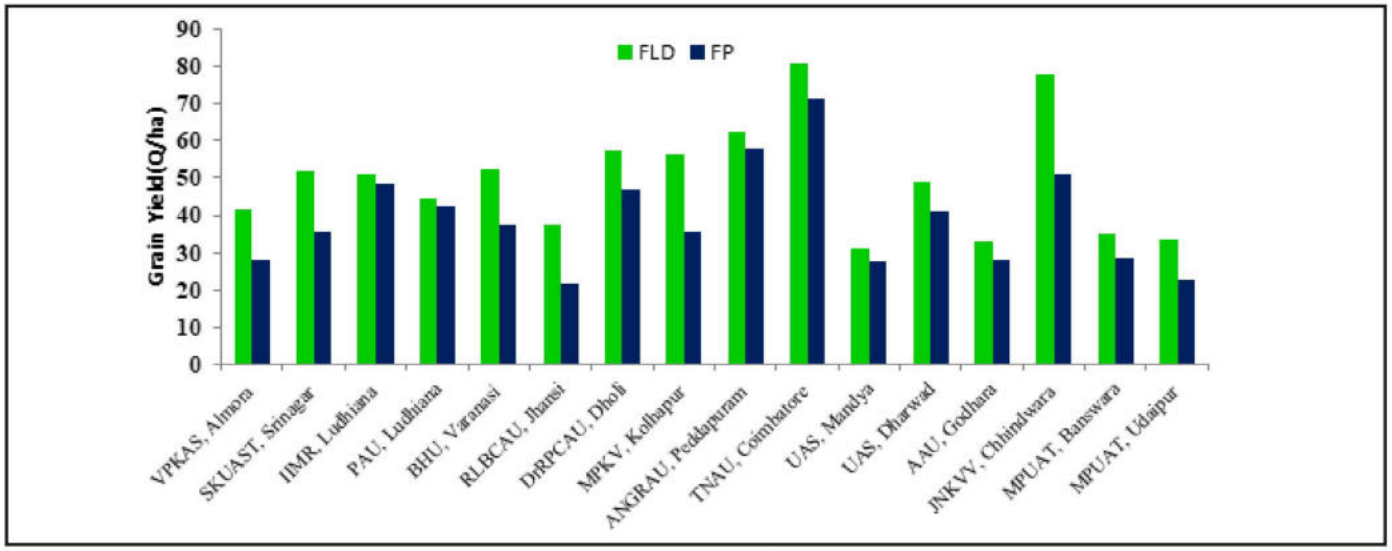


Fig 5.3: Maize Yield during kharif 2023-24 in FLDs and farmers' Practices.

Public hybrid demonstration by Vagarai centre

Input distribution by Kolhapur centre

Field day programme by Chhindwara centre

Field day programme by Mandya centre

farmer's field and recorded yield increase of 1.91% compared to spring rice in Pantnagar. In *kharif* 2023, FLDs were expanded to cover 386.43 ha at 1005 farmer's field across 12 states. These demonstrations exhibited a yield increase of 27.31% over farmer practices (4.76% in Ludhiana to an impressive 71.91% in Jhansi).

The FLDs showcased recently released public sector hybrids such as VLQPMH 45, VLQPMH 59,

Table 5.2: Centre-wise, season-wise STC FLD conducted in maize during 2023

Centre	Area(ha)	Yield (q/ha)		Yield Gain (%)	No. of beneficiary
		FLD	FP		
Rabi 2022-23					
KVK Tripura, Sipahijala	9	31.06	18.75	65.65	50
AAU, Gossaingaon	20	60.00	40.50	48.15	72
BCKV, Kalyani	30	82.10	75.02	9.44	90
MPUAT, Banswara	20	86.00	67.00	28.36	50
MPKV, Kolhapur	20	56.90	31.90	78.37	50
MPUAT, Udaipur	61	62.10	51.47	20.65	152
AAU, Godhra	17.2	41.00	33.03	24.13	43
MRS, TNAU, Vagarai	20	63.48	57.30	10.78	50
Total/mean (Rabi 2022-23)	**197.2**	**60.33**	**46.87**	**28.71**	**557**
Kharif 2023					
SKUAST, Srinagar	210	42.00	22.00	90.91	300
DrRPCAU, Dholi	4	55.10	46.70	17.99	20
BAU, Ranchi	50	52.40	22.60	131.86	191
IGKV, Ambikapur	22.4	54.80	27.20	101.47	56
OUAT, Bhubaneswar	30	51.20	32.60	57.06	75
ZARS, Chhindwara	30	47.48	31.71	49.73	75
AAU, Godhra	6.8	32.54	27.80	17.05	17
MPUAT, Udaipur	10	43.17	28.90	49.38	50
PJTSAU, ARS, Karimnagar	45.6	63.80	56.10	13.73	114
Total/mean (Kharif 2023)	**408.8**	**49.17**	**32.85**	**49.69**	**898**

DMRH-1301, COH (M) 6, COH(M) 8, Shaktiman 5, GAWMH-2, GAYMH-3, LQMH-1, etc along with improved weed management and IPM technologies.

Scheduled Tribe Component (STC)

Under STC, in rabi season 2022-23, FLDs were taken up on 197.2 ha benefitting 557 farmers (Table 5.2). An average yield gain of 28.71% (9.44% in Kalyani to 78.37% in Kolhapur) was observed. During kharif 2023, 408.8 ha FLDs were conducted benefitting 898 farmers. An average yield gain of 49.69% was recorded over

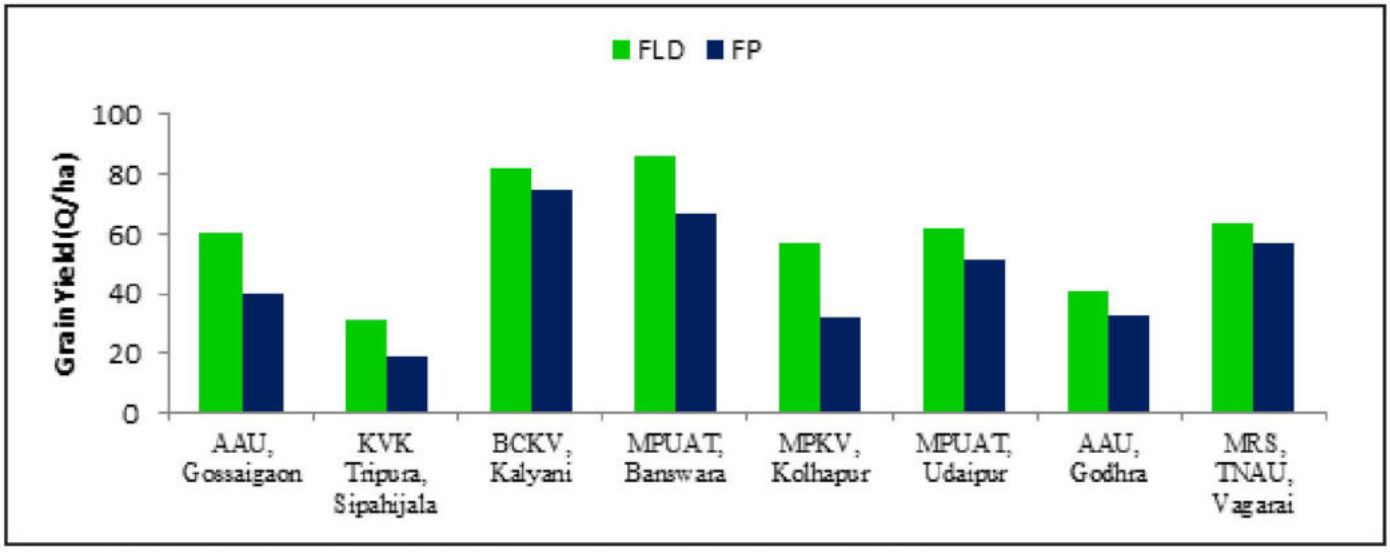


Fig5.4: Maize Yield during rabi 2022-23 in FLDs and farmers' Practices under STC.

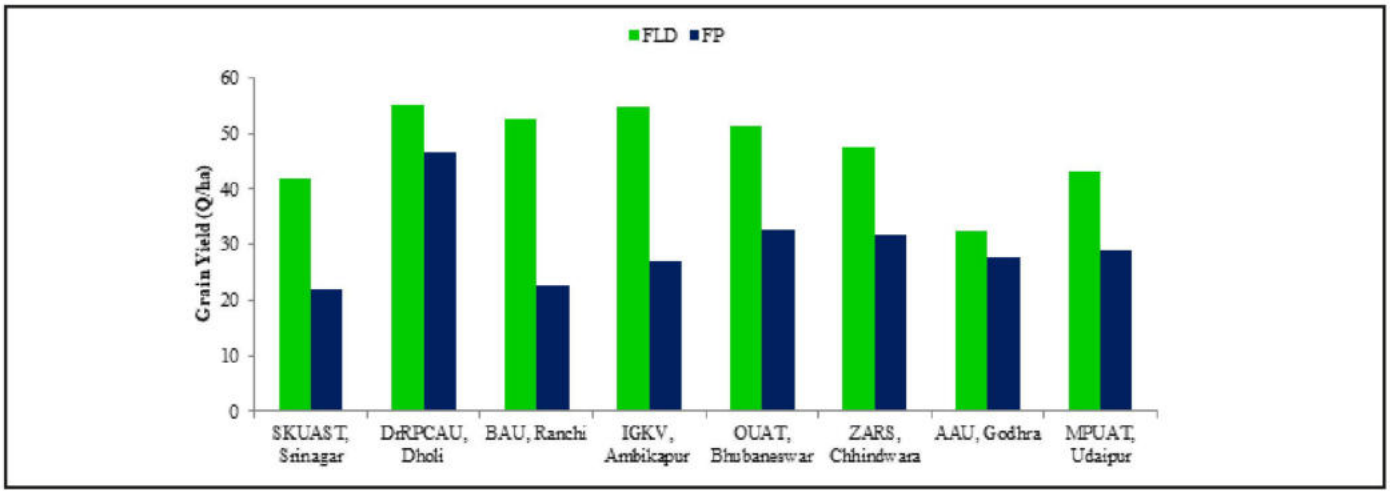


Fig. 5.5 Maize Yield during Kharif 2023 in FLDs and farmers' Practices under STC.

Input distribution by Karimnagar centre

Training programme organized by Ranchi centre

Training programme organized by Kalyani centre

FLD organized by Ambikapur centre

Field day organized by Vagarai centre

Harvest maize at Gossaigaon centre

Table 5.3: Details of training programme conducted under STC.

Sl. No.	Centre	Date of training	Place(village, Block, District)	Type of programme	Training/ programme name	No. of beneficiary	No.of female participant
1.	MRS, TNAU, Vagarai	06.03.2023	Mottur, Rasipuram, Namakkal	T, ID	Maize Production technologies	25	8
2.	MRS, TNAU, Vagarai	06.03.2023	Mottur, Rasipuram, Namakkal	FD	Hybrid Maize/ weed Management	25	13
3.	MRS, TNAU, Vagarai	22.03.2023	Kariyampatti Rasipuram, Namakkal	FD	Hybrid Maize/ weed Management	25	8
4.	MPKV, Kolhapur	28.08.2023	Katri, Dhadgaon, Nandurbar	T	Improved Maize cultivation practices	30	04
5.	MPKV, Kolhapur	29.08.2023	Surypur, Dhadgaon, Nandurbar	T	Improved Maize cultivation practices	20	01
6.	MPKV, Kolhapur	10.11.2023	Beti, Akkalkuwa, Nandurbar	T	Improved Maize cultivation practices	29	04
7.	MPKV, Kolhapur	01.12.2023	Waki, Akole, Ahmednagar	T	Improved Maize cultivation practices	33	
8.	PJTSAU,ARS, Karimnagar	23.06.2023	Guntapally cheruvu thanda, Yellareddy pet mandal, Rajanna siricilla	T, ID	Good agriculture practices for Kharif maize production	114	58
9.	OUAT, Bhubaneswar	16.09.2023	KVK, Umerkote, Nabarangapur	T, ID	Farmers' Training on & Farm Tool Distribution Programme	30	12
10.	OUAT, Bhubaneswar	24.03.2023	KVK, Jashipur, Mayurbhanja	T, ID	Farmers' Training on & Farm Tool Distribution Programme	30	4
11.	OUAT, Bhubaneswar	29.03.2023	Mohana, Gajapati	T, ID	Farmers' Training on & Farm Tool Distribution Programme	25	1
12.	BAU, Ranchi	28.03.2023	BAU, Ranchi	T	Improved production Technology of maize	32	10
13.	BAU, Ranchi	28.03.2023	BAU, Ranchi	T	Improved production Technology of maize	35	12
14.	BAU, Ranchi	29.03.2023	BAU, Ranchi	T	Improved production Technology of maize	34	11
15.	ARS, Banswara	13.03.2023	Borwat, Talwada, Banswara	T	Post-flowering stalk rot and production technologies	52	08
16.	ARS, Banswara	20.06.2023	Borwat, Talwada, Banswara	ID	Seed and fertilizer distribution to farmer and training on cropping system	50	06

Sl. No.	Centre	Date of training	Place(village, Block, District)	Type of prog-ramme	Training/ programme name	No. of bene-ficiary	No.of female parti-cipant
17.	ARS, Banswara	03.08.2023	Borwat, Talwada, Banswara	T	Nano Urea distribution to farmers and enhancing input use efficiency and economy	50	09
18.	ARS, Banswara	28.11.2023	Borwat,Talwada, Banswara	ID	Seed and fertilizer distribution to farmer and training on seed treatment for post flowering stalk rot	50	12
19.	ZARS, Chhindwara/ JNKVV, Jabalpur	28.08.2023	Jamunbarra, Junnardeo, Chhindwara	T, ID	Improved and scientific maize cultivation	34	04
20.	ZARS, Chhindwara/ JNKVV, Jabalpur	28.08.2023	Naulakhapa, Junnardeo, Chhindwara	T, ID	Improved and scientific maize cultivation	72	12
21.	ZARS, Chhindwara/ JNKVV, Jabalpur	28.08.2023	Jamai, Junnardeo, Chhindwara	T, ID	Improved and scientific maize cultivation	32	07
22.	ZARS, Chhindwara/ JNKVV, Jabalpur	28.08.2023	Upli, Junnardeo, Chhindwara	T, ID	Improved and scientific maize cultivation	28	04
23.	ZARS, Chhindwara/ JNKVV, Jabalpur	09.10.2023	Mehlari Bakol, Mohkheda, Chhindwara	FD	Improved and scientific maize cultivation	79	22
24.	TCA, Dholi	27-28.07. 2023	Santpur, West Champaran	T	Production technology of Kharif maize cultivation and it's management.	40	26
25.	AAU, Godhra	05.06.2023	MMRS. AAU, Godhra	T, ID	Scientific Maize Cultivation in Maize	17	-
26.	AAU, Godhra	21.10.2023	MMRS. AAU, Godhra	T	Scientific Maize Cultivation in Maize	25	-
27.	AAU, Godhra	11.01.2023	MMRS. AAU, Godhra	T	Scientific Maize Cultivation in Maize	28	-
28.	MPUAT, Udaipur	25.02.2023	Lohagarh	FD	Field day on rabi maize	225	105

Sl. No.	Centre	Date of training	Place(village, Block, District)	Type of prog-ramme	Training/ programme name	No. of bene-ficiary	No.of female parti-cipant
29.	MPUAT, Udaipur	13.07.2023	Gajpur, Kumbhalgadh	T	Management of Fall Army worm in Maize	48	20
30.	MPUAT, Udaipur	16.09.2023	Gajpur, Kumbhalgadh	FD	Field day on Maize	52	24
31.	MPUAT, Udaipur	19.10.2023	Banswara	T	Improved cultivation techniques in rabi maize	40	01
32.	MPUAT, Udaipur	04.04.2023	Shantivan	FD	Field day on maize	40	08
33.	ANGRAU, Peddapuram	19.02.2023	Gopalapuram, Gokavaram, Godavari	FD	Demonstration of weed management practices technology in maize	25	2
34.	Kalyani, West Bengal	17.11.2023	Shaldanga, Binpur I, Jhargram	T & ID	Cultivation of Hybrid Maize	50	50
35.	Kalyani, West Bengal	07.12.2023	Lokat, Binpur I, Jhargram	T & ID	Maize is profitable than upland rice	73	73
36.	SKUAST, Srinagar	23-24.08. 2023	KVK, Pulwama	T	Quality seed production in maize	50	10
37.	IGKV, RMD CARS Ambikapur, C.G.	27.06.2023	RMD CARS Ambikapur, C.G.	A & ID	Improved Maize Production Technology	56	06
38.	IGKV, RMD CARS Ambikapur, C.G.	04.12.2023	RMD CARS Ambikapur, C.G.	A & ID	Improved Maize Production Technology	21	02
39.	IGKV, RMD CARS Ambikapur, C.G.	11.01.2024	RMD CARS Ambikapur, C.G.	T	Maize Production Technology	37	-
40.	IGKV, RMD CARS Ambikapur, C.G.	29.01.2024	RMD CARS Ambikapur, C.G.	T	Maize Production Technology	35	-
41.	IGKV, RMD CARS Ambikapur, C.G.	30.01.2024	Mendrakhurd, Ambikapur, Surguja	FD	Maize Production Technology	45	-
42.	IGKV, RMD CARS Ambikapur, C.G.	12.02.2024	RMD CARS Ambikapur, C.G.	T	Maize Production Technology	43	-

T-Training; ID-Input Distribution; FD-Field Days; A-Awareness

Table 5.4: Input distribution under STC

Particulars	Unit	Quantity	No. of Beneficiary
Maize Seeds	Tonnes	18.16	1692
Nursery plants	No.	108	54
Sprayer, spade, Khurpi etc.	No.	755	625
Medium Equipment's/ machinery (upto Rs 25000)	No.	70	70
Fertilizers (NPK)/ Secondary fertilizers	Tonnes	153.47	676
FYM/ Vermicompost	Tonnes	30.43	60
Plant protection chemicals	Kg	117.61	409
Plant growth Promoter	Kg	20	50
Any other (Specify)	Packets	254	234
Distribution of Literature	No.	885	882

farmers' practices which varied from 13.73% in Karimnagar to 131.86% in Ranchi.

Under the STC, 42 farmers' training/field day/awareness programmes were conducted in different parts of the country on various aspects of scientific maize cultivation, benefiting 1884 tribal farmers which include 557 farmers (Table 5.3). More than 1692 households also benefitted from the input distributions (Table 5.4).

SCSP programme

Under the SCSP, improved technologies of maize were demonstrated in 184 ha and benefitted 549 farmers (Table 5.5). The result of the *rabi* FLDs showed that average yield was recorded 10.86% higher over farmers' practices, while *kharif* FLD had yield gains of 44.85% (23.86% in Ranchi to 70.10% in Kolhapur). In capacity building, 23 trainings/agricultural inputs distributions/ awareness/field day programmes were organized benefitting 1509 farmers (Table 5.6). The capacity building programmes also benefited 667 women farmers. Various inputs including seed, fertilizers, chemicals, small farm implements and farm literature were also distributed to 1420 households under the SCSP programme (Table 5.7).

Promotion of Maize in North Eastern Hill Region under NEH component

FLD was conducted in 45 ha, in which a yield gain of 50.23% was observed (Table 5.8). FLD under the NEH component benefited 135 farmers. 21 training/

Table 5.5: Centre-wise, season-wise SCSP FLD conducted in maize.

Centre	Area(ha)	Yield (q/ha)		Yield Gain (%)	No. of beneficiary
		FLD	FP		
Rabi, 2022-23					
BCKV, Kalyani	25	80.01	75.02	6.65	161
PJTSAU, ARS, Karimnagar	22	70.50	60.75	16.05	55
Total/mean (Rabi 2023)	**47**	**75.26**	**67.89**	**10.86**	**216**
Spring 2023					
ICAR-IIMR, Ludhiana	42	93.15	89.05	4.60	102
Kharif 2023					
ZARS, Chhindwara, JNKVV, Jabalpur	25	57.69	42.99	34.19	65
BAU, Ranchi	20	46.82	37.80	23.86	37
MPKV, Kolhapur	25	55.64	32.71	70.10	62
RLBCAU, Jhansi	25	40.08	24.73	62.07	67
Total/mean (Kharif 2023)	**95**	**50.06**	**34.56**	**44.85**	**231**

Table 5.6: Details of training programme conducted under SCSP.

Sl. No.	Centre	Date of training	Place(village, Block, District)	Type of programme	Training/ programme name	No. of beneficiary	No.of female participant
1.	ZARS, Chhindwara	19.08.2023	Petdeori , Amarwara, Chhindwara	T	Scientific maize cultivation and role of plant protection measures	96	20
2.	ZARS, Chhindwara	20.08.2023	Simariya, Amarwara: Chhindwara	T,ID	Scientific maize cultivation and role of plant protection measures	54	11
3.	ZARS, Chhindwara	29.08.2023	Satnoor, Parasiya, Chhindwara	T	Women's oriented baby corn production and its utilisation	25	25
4.	ZARS, Chhindwara	29.08.2023	Darbai, Parasiya Chhindwara	T,ID	Women's oriented baby corn production and its utilisation (Sickle and maize Sheller distributed)	20	20
5.	ZARS, Chhindwara	29.08.2023	Jamunbarra, Parasiya Chhindwara	T,ID	Women's oriented baby corn production and its utilisation (Sickle and maize Sheller distributed)	113	113
6.	ZARS, Chhindwara	12.10.2023	Petdeori , Amarwara, Chhindwara	FD	Improve maize technology	82	19
7.	MPKV, Kolhapur	13.07.2023	Ranjani, Kavathemahankal, Sangli	T, ID	Improved production Technology of Maize	62	13
8.	MPKV, Kolhapur	21.11.2023	Nej, Hatkanangale, Kolhapur	T, ID	Improved production Technology of Maize	50	08
9.	MPKV, Kolhapur	28.11.2023	Andur, Gaganbavda, Kolhapur	T, ID	Opportunities to Farm women in Maize Cultivation	35	35
10.	ICAR-IIMR, Ludhiana	23.02.2023	Naugajja, Jalandhar	T, ID	Improving The Livelihood Of Maize Farmers Through Improve Maize Technologies	66	27
11.	ICAR-IIMR, Ludhiana	03.03.2023	Garshankar, Hoshiarpur	T, ID	Improving The Livelihood Of Maize Farmers Through Improve Maize Technologies	40	16

Sl. No.	Centre	Date of training	Place(village, Block, District)	Type of prog-ramme	Training/ programme name	No. of bene-ficiary	No.of female parti-cipant
12.	ICAR-IIMR, Ludhiana	03.03. 2023	Saroya, SBS	T, ID	Improving The Livelihood Of Maize Farmers Through Improve Maize Technologies	21	7
13.	WNC, ICAR-IIMR, Hyderabad	03.03.2023	WNC, ICAR-IIMR, Ludhiana	T, ID	Improving The Livelihood Of Maize Farmers Through Improve Maize Technologies	65	34
14.	RMRSPC, Begusarai	08.03.2023	RMRSPC, Begusarai	T, ID	Improving The Livelihood Of Maize Farmers Through Improve Maize Technologies	100	100
15.	ICAR-IIMR, Ludhiana	03.03.2023	ICAR-IIMR, Ludhiana	T, ID	Improving The Livelihood Of Maize Farmers Through Improve Maize Technologies	35	12
16.	WNC, ICAR-IIMR, Hyderabad	20.03.2023	WNC, ICAR-IIMR, Ludhiana	T, ID	Improving The Livelihood Of Maize Farmers Through Improve Maize Technologies	30	30
17.	ICAR-IIMR, Ludhiana	28.03.2023	ICAR-IIMR, Ludhiana	T, ID	Improving The Livelihood Of Maize Farmers Through Improve Maize Technologies	68	68
18.	RLBCAU, Jhansi	01.10.2023	Khaikhera, Lalitpur	T,FD	Advanced technology of maize production in Bundelkhand	100	12
19.	RLBCAU, Jhansi	02.10.2023	Tikamgarh	T,FD	Advanced technology of maize production in Bundelkhand	98	21
20.	RLBCAU, Jhansi	03.10.2023	Oracha, Niwari	T,FD	Advanced technology of maize production in Bundelkhand	103	26
21.	RLBCAU, Jhansi	04.10.2023	Siron, Lalitpur	T,FD	Advanced technology of maize production in Bundelkhand	100	22

Sl. No.	Centre	Date of training	Place(village, Block, District)	Type of prog-ramme	Training/ programme name	No. of bene-ficiary	No.of female parti-cipant
22.	RLBCAU, Jhansi	05.10.2023	Siron, Lalitpur	T,FD	Advanced technology of maize production in Bundelkhand	95	18
23.	Kalyani, West Bengal	21.12.2023	Krishnagar, Sagar, South 24 PGS	T & ID	Profitable maize Cultivation in Coastal Belt of West Bengal	51	10

T-Training; ID-Input Distribution; FD-Field Days; A-Awareness

Table 5.7: Majors Inputs distributed under SCSP.

Particulars	Unit	Quantity	No. of Beneficiary
Maize Seeds	Tonnes	5.07	1175
Mushroom Spawns/ Bio-Fertilizers (in Packets)	packets	140	108
Small equipment's (upto Rs 2000)	No.	781	816
Medium Equipment's/ machinery (upto Rs 25000)	No.	75	75
Large Equipment's / machinery (> Rs. 25000)	No.	50	50
Fertilizers (NPK)/ Secondary fertilizers	tonnes	19	112
Micro nutrients	tonnes	0.11	153
FYM/ Vermicompost	tonnes	7.50	68
Plant protection chemicals	kg	123	292
Any other (Specify)	No	155	173
Testing samples of Soil, plant, water, feed, fodder and livestock	No.	90	90
Distribution of Literature	No.	930	920

Hybrid maize promotion among SC farmers by Chhindwara centre

Training programme for farmers by Mandya centre

Input distribution programme by Kolhapur centre

Training programme by RLBCAU, Jhansi

Input distribution by RMRSPC, Begusarai

Input distribution by IIMR, Ludhiana

Training cum input distribution programme by Barapani centre

Training cum input distribution programme by Imphal Centre

Training cum input distribution programme by NRC on Yak Centre

Training programme by CAU, Nofra, AP

Table 5.8: Centre-wise NEH FLD conducted in maize

Centre	Area(ha)	Yield (q/ha)		Yield Gain (%)	No. of beneficiary
		FLD	FP		
Kharif 2023					
CAU (I), Nafra	5	35.01	27.02	29.57	30
CAU, Barapani	10	32.60	20.20	61.39	50
CAU, Imphal	20	30.51	16.13	89.15	20
ICAR-NRC on Yak, Dirang	10	30.12	22.01	36.85	35
Total/Mean (Kharif 2023)	**45**	**32.06**	**21.34**	**50.23**	**135**

input distribution programmes/ field days/ awareness programmes were also organized benefitting 1007 beneficiaries including 569 women (Table 5.9). Besides these, 529 rural households also benefitted from input distribution programmes (Table 5.10).

Rice vs maize demonstrations

A study conducted in West Bengal, Odisha, and Jharkhand under the STC programme analyzed the comparison between upland/midland rice and maize

Table 5.9: Details of training programme conducted under NEH

Sl. No.	Centre	Date of training	Place(village, Block, District)	Type of programme	Training/ programme name	No. of beneficiary	No.of female participant
1.	CAU (I), Nafra	19-21.08. 2023	Kyit, East Siang, Arunachal Pradesh	T	Scientific cultivation and hybrid seed production techniques of Maize	30	25
2.	CAU (I), Nafra	19.08.2023	Kyit, East Siang, Arunachal Pradesh	ID	Seed Distribution of LQMH 1 hybrid	30	25
3.	CAU (I), Nafra	04.10.2023	Nafra, West Kameng		Farmers Scientist Interaction	40	30
4.	CAU (I), Nafra	4-6.10. 2023	1. Nakhu Nachibon, 2. Upper Dzang 4. Ditchik Nafra, West Kameng	T	Scientific cultivation and hybrid seed production techniques of Maize	70	50
5.	CAU (I), Nafra	12.10.2023	Kyit, East Siang, A.P.	FD	Farmers Field Day	60	55
6.	CAU, Barapani	29.04.2023	Umtham & 6 KM Village, Kyrdemkulai	T	Cultivation practices of millets	30	-
7.	CAU, Barapani	28.07.2023	COA, CAU (Imphal), Kyrdemkulai	FD	Field Day & Method Demonstration cultivation and harvesting techniques for babycorn	13	9
8.	CAU, Barapani	03.08.2023	Thad, Ri-Bhoi	T & ID	Cultivation practices of specialty corn & FAW management and Input distribution programme	27	20
9.	CAU, Barapani	04.08.2023	Nongbah Myrdon, Ri-Bhoi	T & ID	Cultivation practices of specialty corn & FAW management and Input distribution programme	40	30
10.	CAU, Barapani	29.09.2023	COA, CAU (Imphal), Kyrdemkulai	Farmer-Scientist Interaction	Farmer-Scientist Interaction and Input distribution programme for promotion of cultivation of maize in the region	30	21

Sl. No.	Centre	Date of training	Place(village, Block, District)	Type of programme	Training/ programme name	No. of beneficiary	No.of female participant
11.	CAU, Barapani	12-14.12. 2023	State Agri Expo, 4 mile, Chumoukedima, Dimapur	A, ID	Input distribution during CAU Regional Agri Fair 2023	100	43
12.	NRC on Pig, Rani Guwahati	23.08.2023	Rani, Guwahati	T,ID	Seed and Input Distribution	65	08
13.	NRC on Pig, Rani Guwahati	23.12.2023	Rani, Guwahati	T, ID	Seed and Input Distribution	37	05
14.	ICAR-NRC on Yak, Dirang	8.03.2023	Nyukmadun, West Kameng	A, T	Maize production potentiality in NEH region for improved livestock productivity	45	27
15.	ICAR-NRC on Yak, Dirang	09.03.2023	Showda, West Kameng,	T	Scientific production of maize in NER	80	46
16.	ICAR-NRC on Yak, Dirang	10.03.2023	Dirang, West Kameng,	T	Scientific production of Maize in Arunachal Pradesh	36	21
17.	ICAR-NRC on Yak, Dirang	18-21.03. 2023	NRCY, Dirang, West Kameng,	T	Scientific production maize in NER	97	54
18.	CAU, Imphal	28.02.2023	Mao Village, Senapati District, Manipur	T	Sustainable maize based intercropping system under Manipur condition	50	27
19.	CAU, Imphal	08.02.2023	Tongou Village, Ukhrul	T &ID	Scientific cultivation and IPM of maize crop	56	36
20.	CAU, Imphal	20.03.2023	Leimaram, Bishnupur	ID	Inputs distribution of sweetcorn at Bishnupur district	20	0
21.	CAU, Imphal	27.03.2023	Sirarakhong, Urkhul district	T &ID	One day training cum awareness programme on scientific cultivation of maize in Manipur	51	37

across an 83.8 ha (Table 5.11). In West Bengal, hybrid maize showed a monetary advantage of approximately Rs. 25,500 per ha over upland rice. However, price realization constraints limited the monetary benefits for maize farmers in West Bengal. In Jharkhand and Odisha, hybrid maize demonstrated an average monetary gain of Rs. 32,540 per ha and Rs. 16,564 per ha, respectively, over midland/upland paddy. These findings underscore the potential for developing maize ecosystems in upland/midland paddy regions of eastern India, offering substantial benefits to farmers and enhancing agro-ecosystem sustainability.

Learning platform for diversification with maize in western IGP

The "Participatory innovation platform on potential yield realization of maize-based cropping systems in Punjab and Haryana" an ICAR-IIMR

Table 5.10: Majors Inputs distributed under NEH.

Particulars	Unit	Quantity	No. of Beneficiary
Maize seed	tonnes	0.247	37
Sprayer, Spade, Khurpi etc.	No.	73	73
Manual Maize sheller	No.	50	50
Fertilizers (NPK)/ Secondary fertilizers	tonnes	0.30	62
Liquid Biofertilizer	L	50	50
Plant protection chemicals	Kg	1	1
Vermicompost unit	No.	6	6
Distribution of Literature	No.	250	250

initiated collaborative project with CIMMYT, SAUs and the State Agricultural Department have provided learning to researcher, policy makers and practitioner. In the third year, the learning platforms have been established in total of 65 acres of 4 districts of Punjab viz. Hoshiarpur, Jalandhar, Ludhiana, Patiala and 2 districts of Haryana (Karnal and Ambala). Information on new agronomic production techniques and agricultural inputs, including seeds of superior maize varieties and insecticides and herbicides to fight fall armyworm were provided to the participatory farmers. Consecutively, the productivity at the learning sites reached up to 76q/ha, providing hope that maize might pave the

Table 5.11: Upland maize vs paddy in eastern India

Maize (Variety)	Area (ha)		Topography (Upland/ midland)	Location (village, district, state)	Yield (q/ha) (Rs/q)		Average selling price		Net returns (Rs/ha) @ farmers' selling price	
	Maize	Paddy			Maize	Paddy	Maize	Paddy	Maize	Paddy
West Bengal (kharif)										
CP 838	5	5	Upland	Jhargram	98.1	45	1200	1900	68720	25500
Odisha (kharif)										
Kalinga Raj upland Nabarangpur,	28.8	1.2 Koraput	Medium/ 54.7	36.6	2053	2146	69696	32540		
Jharkhand (kharif)										
DHM 117	50	25	Upland	Chanho	52.4	22.6	1870	1940	58743	16564

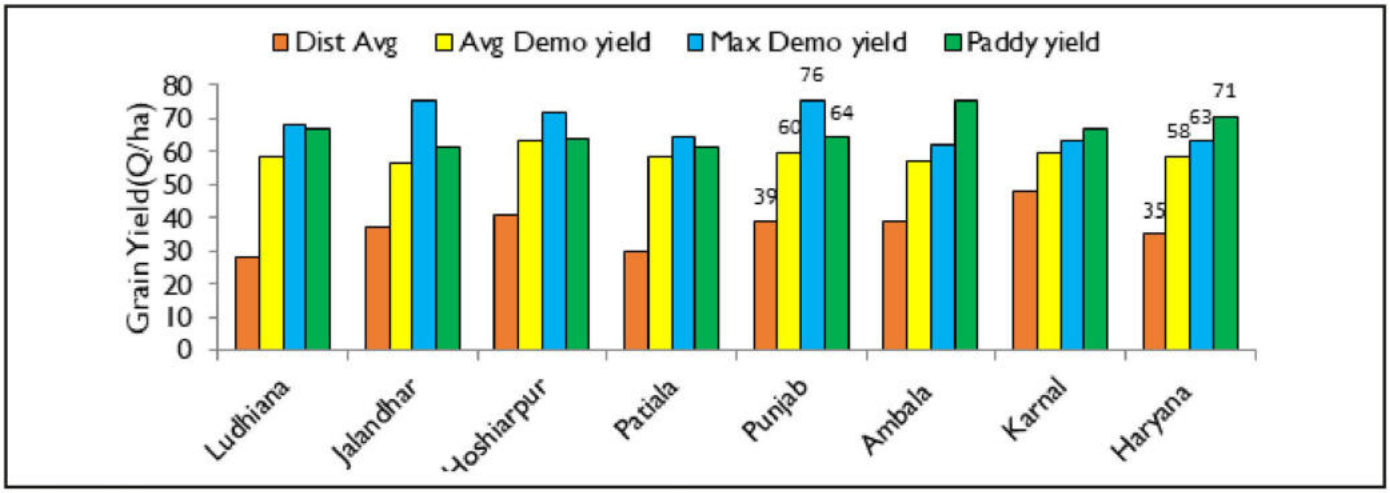


Fig 5.6: Maize vs Paddy yield under the platform demonstration

Dignitaries addressing the participants during the state level maize day


मक्का को धान का विकल्प बनाएं किसान : डॉ. डीके यादव

Media coverage of the state level maize day

way for diversification (Fig 5.6) State-level maize day was organized at Nadana, Karnal, Haryana on 24 September, 2023 to further promote crop diversification and persuade decision-makers and other stakeholders. The programme was attended by 380 farmers from various districts of Haryana and Punjab, it included 60 female farmers.

Entrepreneurship development under ABI

Under the Agri-Business Incubation (ABI), several maize-based products such as QPM based value added products such as Biscuit, Cookies, Burfi, Pop Corn, Laddu, Pop Corn Ghachak, Muffins, Cakes, & Normal Maize Pasta, Nachos, Halwa etc. have been developed and demonstrated in different exhibitions and melas during 2023. In 2023, two agri-start-up has joined the ABI of ICAR-IIMR. Two hands-on training programmes were also conducted on "Entrepreneurship development for women farmers through promotion of value addition of maize" for the popularization of technologies

Table 5.12: Training programme for farm women under ABI

Sl. No	Programme	Date	Location	Beneficiaries
1.	Entrepreneurship Development for Women Farmers through Promotion of Value Addition in Maize	22.03.2024	Birmi Village, Ludhiana, Punjab	34
2.	Entrepreneurship development for women farmers through promotion of value addition of maize	29.12.2023	Lapran village, Ludhiana, Punjab	50

Start-up incubation at ABI, IIMR

EDP programme for rural women

Glimpses of the activities under the APART project

developed by ICAR-IIMR in which 74 participants benefited from the training programme.

Augmenting Maize Production in Assam: APART project

Under the World Bank financed Assam Agribusiness and Rural Transformation Project (APART) on "Augmenting Maize Production in Assam for Sustainable Livelihood Security" ICAR-Indian Institute of Maize Research (IIMR) carried out different activities to strengthen the maize value chain in the state. The launching meeting cum workshop for the technical consultancy assignment to ICAR-IIMR, Ludhiana was organized on 5th July, 2023, in which 100 officials from different organization and departments participated the training programme. During 2023, 12 master training programmes were organized for the extension workers and line departments of Barpeta, Bongaigaon, Darrang, Dhemaji, Dhubri, Kokrajhar, Kamrup, Karbi, Anglong, Morigaon, Nagaon, Nalbari and Sonitpur districts. 360 participants participated in the master training programmes in which different aspect of scientific maize cultivation and value chain development were imparted. 14 training programmes for the progressives of the same districts were also organized benefitting 480 farmers. 19 technical training programmes for the farmers linked to demonstrations of Maize under ICAR-IIMR-APART of the mentioned districts were also organized benefitting 479 farmers during 2023. Demonstration is undertaken in 1400 sites in 12 districts of the state.

Agri-Drone initiative

Under the Agri-Drone initiative, two advanced agricultural drones were acquired, and four scientists received specialized training in its operation and application. The drones were demonstrated at various farm locations, highlighting their capabilities to local farmers and other stakeholders. The demonstrations included the application of nano urea, nano DAP, micronutrients, and a range of weedicides and pesticides on different crops, illustrating the efficiency and effectiveness of drone technology in modern farming practices.

Outreach for bio-ethanol program

ICAR-Indian Institute of Maize Research,

Demonstration of agri-drone technology in farmers' field

Demonstration of agri-drone to Bio-ethanol stakeholders

Ludhiana organised various programmes to discuss and work towards achieving target of 20% Ethanol Blended of Petrol (EBP) by 2025-26. National workshop, seminar, stakeholders meet and training programmes for bio-ethanol stakeholder were organized.

The Department of Food and Public Distribution, Govt. of India in association with ICAR- Indian Institute of Maize Research (IIMR), Ludhiana, National Sugar Institute (NSI), Kanpur and All India Distillers' Association (AIDA) organized a 'National Seminar on Maize to Ethanol' on 2nd May'2023 at Vanijya Bhawan, 6, Akbar Rd, New Delhi.

Dr. H.S. Jat, Director, ICAR-Indian Institute of Maize Research, delivered a presentation on "Maize -a potential feedstock for Ethanol " during the panel discussion at the Odisha State Level Conference for Rabi Campaign 2023-24. The event was held on October 20, 2023, at the Convention Center, Loka Seva Bhawan in Bhubaneswar.

ICAR-Indian Institute of Maize Research Ludhiana organized a one day strategic planning meeting on maize for ethanol on 12th July 2023 at Hyderabad. The meeting was chaired by Dr S.K. Pradhan,

Glimses of the actvities

Glimpses of the exposures visits

ADG(FFC) ICAR, New Delhi. Dr H.S. Jat, Director IIMR while making introductory remarks emphasized for greater partnership to achieve the target of 20% EBP by 2025-26. The stakeholders from seed industries, feed industries, ethanol industries, poultry industries and maize reaserch institute including CGIAR's CIMMYT and ICRISAT met to chalk out plan to enhance maize production by additional 15 million tonnes by 2025-26. The research and developmental priorities for enhancing maize production with acreage expansion and yield enhancement were finalized in this endeavour. The collaboration and linkages across the sector were emphasized to achieve this target. The meeting had presence of Dr AK Joshi, CIMMYT-BISA, Dr BM Prasanna, Global Maize Programme, Dr M.L. Jat, ICRISAT, Dr Mahesh Gathala, CIMMYT.

A master training programme on "Best management practices in maize for profitable bioethanol production" was organized from 29 November to 1st December 2023. The training programme aimed to enlighten stakeholders from the ethanol industry and their collaborators about the best practices in maize management to enhance productivity and facilitate bioethanol production. During the training sessions, participants engaged in detailed theoretical and practical discussions covering various aspects of maize production, suitable hybrids and their seed production techniques, mechanization in cultivation, disease and pest management (particularly aflatoxin and Fall Army Worm), storage practices, maize DDGS, processing, grading, and value addition of maize for bioethanol production. Sixteen stakeholders from the ethanol industries actively participated in the programme.

Exposure visits from different institute

On April 9, 2023, a group of 28 scientists and extension workers from Assam Agricultural University, Jorhat, visited the ICAR-Indian Institute of Maize Research to engage with the institute's

scientists. A team of 35 Scientists and extension workers from the Dept. of Agriculture, Assam visited ICAR- Indian Institute of Maize Research for exposure and interaction with the institute's scientists on April 27, 2023. The visit is sponsored by APART, Assam. Additionally, on August 9, 2023, participants of the International Training Course on "Conservation Agriculture for Sustainable Intensification of Drylands" organized by ICRISAT visited the ICAR-Indian Institute of Maize Research, Ludhiana, for interaction and knowledge exchange with its scientists.

AICRP on Maize

6

During *kharif* 2022, a total of 356 entries were received for multi-location evaluation in AICRP early, late, medium maturity of normal corn and quality protein maize (QPM), sweet corn, baby corn, popcorn and OPV trials. Out of 356 test entries, 196 entries were received in NIVT trials -NIVT late (70) and NIVT medium (88), NIVT early (38); total 47 entries were evaluated in AVT I trials- AVT-I late (12) AVT-I medium (18), and AVT -I early (17); there were twenty entries for testing in AVT II trials- AVT-II late (11), AVT-II medium (07) and AVT-II early (02); forty-three (43) entries were received for QPM trial; In baby corn trial there were 13 entries; sweet corn trial had 18 entries; popcorn trial had only one (01) entry, 10 entries were OPV and 8 in rainfed trials in for evaluation. Total of 28 different breeding trials were conducted. One set of trials exclusively for Zone I (Northern Hill Zone) and the other for the rest of the zones were conducted during *kharif* 2022.

Promotion of entries:

Field Corn

Early: In North Hilly Zone, out of 6 test entries, only one entry namely IX 7851 was promoted for testing in AVT I during *kharif* 2023. This entry outperformed the best check BIO 605 with the yield superiority of 0.6%. In advance trials, out of 7 test entries, only two entries namely JH 32662 and JH 32652 were promoted for testing in AVT II during next *kharif* season. These entries outperformed the best check BIO 605 with the yield superiority of 8.7 % and 7.1%, respectively. Out of 27 test entries, only four entries namely IX 7851, AH 4670, SRMH 99M66 and AHD 2008 showed yield superiority of 9.9%, 6.9%, 4.4% and 0.7% over best check DKC 7074, were considered for promotion to AVT-I in NWPZ. Out of the eight entries in NWPZ, three entries namely CP 999, SMH 4555 and CP 111 were considered for promotion to AVT-II with yield superiority of 12.3%, 11.4% and 5.2%, respectively over the best check DKC 7074. In CWZ, out of the five test entries in AVT-I, only three entries JH 32487, SMH 4555 and AH 8323 were considered for promotion to AVT-II, as these entries significantly out yielded the best check DKC 7074 with yield superiority of 10.0%, 8.9% and 6.8%.

Medium: In NHZ, out of 22 test entries, only three entries namely IW 8477, IQ 8624, JH 20088 were considered for promotion to the AVT-I. These entries outperformed the best check BIO 9544 with the yield superiority of 8.8%, 8.1% and 3.8%, respectively. In another NIVT trials which was conducted for rest of the zones, in set I, out of 44 test entries, eight entries namely IM 36511, JH 20088, PM 22102, IQ 8624, KMH 8111, IQ 8393, PM 22104 and SYN 225721M for CWZ with yield superiority of 15.5%, 10.5%, 10.2%, 7%, 6.1%, 5.8%, 5.5% and 4.5%; thirteen entries namely PM 22101, JH 20088, IW 8477, PM 22102, IMH2 22K-7, SYN 225721M, IQ 8624, PM 22104, Indo US Royal Maize, IQ 8393, AHD 2077, CP 509 and IMH2 22K-4 for NEPZ with yield superiority of 13.8%, 12.8%, 12.3%, 12.0%, 11.5%, 10.9%, 6.8%, 6.3%, 6.2%, 5.8%, 2.9%, 2.8%, 1.1%; ten entries namely IW 8477, JKMH 4823, PM 22104, PM 22101, IQ 8624, CP 509, SYN 225721M, IMH2 22K-7, PM 22102 and IQ 8393 for NWPZ with yield superiority of 12.5%, 7%, 6.3%, 6.3%, 6.2%, 5.9%, 5.9%, 5.0%, 4.7% and 2.2%; nine entries namely KMH 8111, JKMH 4059, PM 22103, JKMH 4823, PM 22102, IM 36511, IW 8477, IMH2 22K-6 and Indo US Royal Maize for PZ with yield superiority of 10.1%, 8%, 7.6%, 6.4%, 6.1%, 5.5%, 5.4%, 3.6% and 1.9% over best check, were considered for promotion to AVT-I. In Set II, out of 28 test entries, three entries namely BH 417189, RCRMH 20 and BH 417144 for CWZ with yield superiority of 15.4%, 11.3% and 11%; four entries namely RCRMH 20, BH 417144, IMH 10-21K2 and BH 417189 for NEPZ with yield superiority of 10.6%, 5.6%, 4.4%, 1.1%; two entries namely IMH9 222 and BH 417189 for NWPZ with yield superiority of 1.5% and 0.5%; one entry namely RCRMH 20 for PZ with yield superiority of 2.7% over best check BIO 9544, were considered for promotion to AVT-I.

In the case of advance trials in NWPZ, out of five test entries, only one entry namely DKC 9224 was considered for promotion to AVT-II with yield superiority of 9.7% over best check BIO 9544. In PZ, out of the 7 test entries, six entries namely DKC 9228, JKMH 4546, DKC 9224, JKMH 4505, HM 20105 and IMHSB 20K-10 were considered for promotion as they outperformed over the best check BIO 9544 with yield superiority of 11.1%, 10.6%, 10.4%, 8.9%, 6.5% and 6.0%, respectively. In CWZ, Out of the eight test entries, only four entries namely DKC 9224, PM 21103M, HM 21204 and JKMH 4546 were considered for promotion to AVT-II as these entries out yielded the best check BIO 9544 with yield superiority of 8.0%, 7.7%, 5.7% and 1.3%, respectively.

Late: In NIVT Set I, out of the 43 test entries, seven entries namely AM 05674, HARLAL 24, SUPER 2727, PM 22107, SYN 223671L, CP 988 and GK 3309 outperformed over the best check CP 858 with yield superiority of 11.7%, 10.7%, 3.0%, 2.8%, 2.3%, 1.7%, 1.6% respectively and were considered for promotion to AVT I. In Set II, out of 27 test entries, five entries for CWZ namely KMH 8206, MFH 22-65, INDO US ROVER maize, IQ 8701 and BH 417177 with yield superiority of 7.2%, 5.5%, 5.5%, 3.7%, 3.1%; one entry for NEPZ namely IX 8699 with yield superiority of 0.1%; two entries for NWPZ namely IQ 8701 and IX 8699 with yield superiority of 2.1% and 1.8%; eleven entries for PZ namely BIO 9766, KMH 8208, BH 417177, IX 8699, KMH 8206, MFH 22-65, KMH 8388, IQ 8701, HM 22201, BH 417018 and VNR 4324 with yield superiority of 9.7%, 9.6%, 9.4%, 8.9%, 7.8%, 7.1%, 5.8%, 5.6%, 5.4%, 5.0% and 2.5% over best check, were considered for promotion to AVT-I. In advance trials, in NWPZ, out of the three test entries in AVT-I, only two entries namely PM 21111L and PM21107L, were considered for promotion to AVT-II with yield superiority of 2.4% and 1.8% over the check NK 6240. In NEPZ, only one entry namely DKC 9226 outperformed over the best check CMH 08-287 with yield superiority of 11.2% and was considered for promotion to AVT-II. In PZ, all the five entries namely KMH 8333, PM 21107L, BIO 207, ADV 7212 and ADV 7211 were considered for promotion to AVT-II with yield superiority of 5.6%, 4.8%, 4.1%, 1.4% and 1.1% over the check NK 6240. In CWZ, out of the six test entries, three entries namely R 8050, PM 21111L and DKC 9226 were considered for promotion to AVT-II with yield superiority of 16.5%, 8.6% and 8.5% respectively over the best check BIO 9682.

Rainfed: In rainfed (early) trial, one entry namely EH 2936 was found superior (with mean yield of 7.25 t/ha) over the best check DKC 7074 with mean yield of 7.19 t/ha. In medium maturity category under rainfed conditions, all the six test entries were found superior over the best check DHM 121 with mean yield of 7.506 t/ha.

Quality Protein Maize (QPM)

Out of 13 test entries in trial no. 1034 which was conducted in Zone I (NHZ), three entries were EDV and remaining 10 were conventionally bred QPM entries. Similarly in trial no. 1066 which was conducted in rest of the zones, out of 32 test entries 12 were EDV's and 20 were conventionally bred QPM entries. In trial no. 1034, out of 10 conventionally bred QPM varieties, IQPMH 2102 and IQPMH 2105 were promoted over best performing check (HQPM 4) from AVT I to AVT II. Both EDV's namely, FQLPH 20 and FWQH 1 were promoted from QPM II to QPM III against their corresponding checks. In addition to these entries three IDV's FLPH 45 (Low Phytate), FPVH 1 (Pro. A) and FMH 24 (Fe & Zn) were also promoted from QPM I to QPM II. In trial no. 1066, out of 32 conventionally bred QPM entries, two entries namely IQPMH 2205 and IQPMH 2204 were promoted in NWPZ (Zone II) over the best check Pratap QPM Hyb.1; one entry (IQPMH 2205) was promoted in NEPZ (Zone III) over best check IQMH 203; two entries namely IQPMH 2204 & IQPMH 2205 were promoted in PZ (Zone IV) over IQMH 203 and four entries namely IQPMH 2203, IQPMH 2204, FQH 160 and JQPM 1 were promoted in CWZ (Zone V) over the best check HQPM 5 from NIVT to AVT I for testing during *kharif*, 2022.One entry IQPMH 2109 was promoted from AVT I to AVT II for testing in zone II against the best check Pratap QPM Hyb.1 and two entries namely IQPMH 2108 &