वार्षिक प्रतिवेदन

ANNUAL REPORT

2024

Indian Council of Agricultral Research (ICAR)

Indian Institute of Wheat and Barley Research

Karnal-132001, India

MANDATE

- Basic and strategic research on wheat and barley to improve productivity and quality.
- Coordination and development of improved crop production and protection technologies for sustainable production.
- Providing genetic diversity and accelerate the breeding cycle through off season facilities.
- Surveillance and forewarning for management of rust diseases.
- Dissemination of improved technologies, capacity building and development of linkages.

THE MISSION

Ensuring food and nutritional security by enhancing the productivity and profitability of wheat and barley on an ecologically, socially and economically sustainable basis and making India the world leader in climate smart wheat system production.

भाकृअनुप
ICAR

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2024

भा.कृ.अनु.प.–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान

करनाल–132001, भारत

ICAR-Indian Institute of Wheat and Barley Research

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भा.कृ.अनु.प.–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान
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डॉ. रतन तिवारी
निदेशक
Dr. Ratan Tiwari
DIRECTOR

PREFACE

I am pleased to present the Annual Report of the ICAR-Indian Institute of Wheat and Barley Research (IIWBR) for the year 2024. This report encapsulates the significant achievements, ongoing research and developmental activities undertaken by the institute in pursuit of enhancing wheat and barley production in India.

As a premier institute under the Indian Council of Agricultural Research (ICAR), IIWBR remains committed to addressing the challenges faced by wheat and barley farmers through cutting-edge research, innovative technologies, and sustainable agricultural practices. Our scientists have made noticeable progress in breeding high-yielding, disease-resistant, biofortified and climate-resilient varieties, alongside advancements in crop management and post-harvest technologies which resulted in record wheat production of 113.29 million tons and barley production of 1.69 million tons in India during 2023-24.

ICAR-IIWBR successfully organized the 63rd All India Wheat and Barley Workers Meet held from September 11-13, 2024, at Acharya Narendra Deva University of Agriculture & Technology, Ayodhya (Uttar Pradesh). The Varietal Identification Committee has identified 13 wheat and 3 barley varieties for different production environments across India. During the year 2024, the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops recommended the release and notification of 10 bread wheat varieties and one durum wheat variety. Also, DBW327 was recommended for the extension of areas of adoption to irrigated, early sown condition of central zone. A total of 21 genetic stocks of wheat were registered for traits like resistance to rust, heat and drought, higher 1000 grain weight and higher grain protein content. IIWBR Seed Portal was upgraded with unified seed sale software for maintaining real time inventory of breeder and truthfully labelled seed sale of recently released wheat and barley varieties to thousands of farmers across the wheat growing states. Besides, efforts were put in to strengthen Public Private Partnership approach and more than 150 seed firms signed the memorandum of agreements with ICAR-IIWBR to strengthen the seed chain system of ICAR-IIWBR varieties in PPP mode.

I take this opportunity to express my sincere gratitude and heartfelt thanks to Dr. Himanshu Pathak, Secretary DARE and DG (ICAR), Dr. T.R. Sharma, DDG (Crop Science), Dr. S.K. Pradhan, ADG (F&FC), Dr. D.K. Yadava, ADG (Seeds), Dr. P.L. Gautam (Chairman RAC) and members of RAC for providing valuable guidance and suggestions towards implementation of various research programmes. Through collaborative initiatives with national and international institutions, IIWBR has strengthened its role in providing scientific solutions for the betterment of Indian agriculture.

I extend my sincere gratitude to cooperators from state agricultural universities, research partners, and stakeholders for their continuous support and guidance. I also commend the dedication and hard work of our scientists, technical staff, and administrative personnel, whose relentless efforts have contributed to the institute's success.

I hope this report will serve as a valuable resource for researchers, policymakers, and all stakeholders engaged in the wheat and barley sectors. Together, let us continue striving for excellence in agricultural research and ensuring food security for the nation.

Jai Jawan, Jai Kisan, Jai Vigyan, Jai Anusandhan

(Ratan Tiwari)

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कार्यकारी सारांश

फसल सुधार

- वर्ष 2024 के दौरान फसल मानकों पर केंद्रीय उप–समिति की सिफारिश के माध्यम से विभिन्न उत्पादन स्थितियों में खेती के लिए सात ब्रेड गेहूँ किस्मों यथा पूसा गेहूँ शरबती (एचआई 1665), पीबीडब्ल्यू जिंक 2 (पीबीडब्ल्यू 823), पीबीडब्ल्यू आरएस1, एमपी 3535, टीआरवीडब्ल्यू 155, टीजेडब्ल्यू 153, एचडी 3437; एक ड्यूरम गेहूँ किस्म (एचआई 8840) और एक डाइकोकम गेहूँ (खपली) किस्म (डीडीके 1063) को अधिसूचित किया गया।
- विभिन्न गेहूँ उत्पादक क्षेत्रों में खेती के लिए भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल द्वारा विकसित गेहूँ की दो किस्मों को अधिसूचित किया गयाः डीबीडब्ल्यू 359 (करण शिवांगी) मध्य और प्रायद्वीपीय क्षेत्रों की समय पर बुवाई, सीमित सिंचित स्थिति के लिए, और डीबीडब्ल्यू 377 (करण बोल्ड) मध्य क्षेत्र में शीघ्र बुवाई और उच्च उर्वरता स्थितियों के लिए।
- दो गेहूँ किस्मों (डीबीडब्ल्यू 386 और डीबीडब्ल्यू 443) को क्रमशः उत्तर पूर्वी मैदानी क्षेत्र की समय पर बुआई की स्थिति और प्रायद्वीपीय क्षेत्र की सिंचित समय पर बुआई की स्थिति के तहत जारी करने के लिए, किस्म पहचान समिति द्वारा अनुशंसित किया गया।
- गेहूँ के कुल 15 आनुवंशिक स्टॉक पंजीकृत किए गए, जिनमें गेहूँ के रतुआ रोग के प्रति प्रतिरोधकता, गर्मी और सूखे के प्रति सहनशीलता, गुणवत्ता गुण, उच्च प्रोटीन सामग्री और 1000 दानों का अधिक वजन जैसी विशेषताएं शामिल हैं। ये आनुवंशिक स्टॉक गेहूँ की चार फसल प्रजातियों से सम्बंधित हैं, जैसे *ट्रिटिकम एस्टिवम, टी. ड्यूरम, टी. डाइकोकम* और *टी. एस्टिवम* एसएसपी. स्फेरोकोकम।
- भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल की छह एवीटी–II गेहूँ प्रविष्टियों यथा डीबीडब्ल्यू 422, डीबीडब्ल्यू 425, डीबीडब्ल्यू 426, डीबीडब्ल्यू 432, डीबीडब्ल्यू 445 और डीबीडब्ल्यू 477 को विभिन्न क्षेत्रों के लिए एवीटी अंतिम वर्ष परीक्षण के लिए पदोन्नत किया गया। डीबीडब्ल्यू 426, डीबीडब्ल्यू 445 और डीबीडब्ल्यू 509 को उनकी बेहतर गुणवत्ता और उपज के आधार पर पदोन्नत किया गया।
- वर्ष 2024 के दौरान, विभिन्न स्रोतों से 688 गेहूँ जर्मप्लाज्म लाइनें प्राप्त की गईं और विभिन्न मांगकर्ताओं को गेहूँ की 943 किस्में उपलब्ध कराई गईं।
- डेयर/आईसीएआर से अनुमोदन प्राप्त करने के पश्चात, बांग्लादेश, बोलीविया, केन्या और मैक्सिको के हॉट स्पॉट स्थानों पर गेहूँ ब्लास्ट और अन्य बीमारियों के विरुद्ध जांच के लिए एनबीपीजीआर/सीमिट के माध्यम से गेहूँ की 418 अग्रिम सामग्री बांग्लादेश और मैक्सिको भेजी गई।
- डीयूएस परीक्षण दिशानिर्देश के अनुसार 465 गेहूँ किस्मों का मूल्यांकन किया गया, जबकि 96 गेहूँ जर्मप्लाज्म लाइनों को आणविक लक्षण वर्णन के साथ स्पाइक विविधता लक्षणों के लिए चिह्नित किया गया।
- पीपीवी–एफआरए नई दिल्ली ने चार ब्रेड गेहूँ किस्मों, करण वैदेही (डीबीडब्ल्यू 370), करण वृंदा (डीबीडब्ल्यू 371), करण वरुणा (डीबीडब्ल्यू 372), करण प्रेमा (डीबीडब्ल्यू 316) और एक ड्यूरम गेहूँ किस्म डीडीडब्ल्यू 55 (करण मंजरी), को वर्तमान किस्मों के श्रेणी में पंजीकृत किया।
- दो नई गेहूँ किस्मों अर्थात् डीबीडब्ल्यू 359 और डीबीडब्ल्यू 377 के पंजीकरण आवेदन मौजूदा श्रेणी के तहत पंजीकरण के लिए पीपीवी–एफआरए, नई दिल्ली को प्रस्तुत किए गए।
- गेहूँ की आठ मूल मैजिक जनक वाली आबादी की कुल 1780 पंक्तियों का मूल्यांकन किया गया तथा उपज विशेषताओं, जैविक और अजैविक तनाव सहिष्णुता के लिए चयन और पीढ़ी उन्नयन किया गया।
- उच्च उपज देने वाली गेहूँ की किस्मों में वृद्धि नियामक क्लोरमेक्वेट क्लोराइड (सीसीसी) के प्रभाव को मापने के उद्देश्य से किए गए एक अध्ययन से पता चला है कि पहली गांठ निर्माण अवस्था में 0.2% सीसीसी के एक ही छिड़काव से फसल गिरने को सफलतापूर्वक कम किया जा सकता है।
- तीन गेहूँ किस्मों (डीबीडब्ल्यू 187, डीबीडब्ल्यू 303 और डीबीडब्ल्यू 371) पर जैविक नाइट्रीकरण अवरोधक (बीएनआई) अध्ययन में यह देखा गया कि बाली की लंबाई, ध्वज पत्ती की लंबाई और चौड़ाई, बायोमास, हार्वेस्ट इंडेक्स, प्रोटीन संरचना और अनाज की उपज, और नाइट्रोजन संतुलन सूचकांक जैसे लक्षण कम नाइट्रोजन स्तरों पर काफी कम हो गए। इन लक्षणों के साथ संयोजन में नाइट्रोजन संतुलन सूचकांक का उपयोग कम नाइट्रोजन स्थितियों के तहत बाद की पीढ़ियों में वांछनीय पौधों के प्रकारों की पहचान करने के लिए किया जा सकता है।
- रिपोर्टिंग अवधि के दौरान गेहूँ सुधार के लिए प्री–ब्रीडिंग में बैकक्रॉस सहित 450 संकरण (क्रॉस) बनाने के प्रयास किये गए। हाईबरी, पैवॉन 76, पैरागॉन, फ्रंटाना, स्फीरोकोकम और एजिलॉप्स म्यूटिका जैसे जीनोटाइपस का उपयोग संकरण में विशिष्ट लक्षणों पर जोर देने के लिए किया गया।
- एजिलॉप्स टॉस्चाई (डीडी–जीनोम), एई. पेरेग्रीना (यूयूएसएस–जीनोम), ट्रिटिकम डाइकोकोइड्स (एएबीबी–जीनोम) और सिंथेटिक हेक्साप्लोइड्स (एएबीबीडीडी–जीनोम) सहित कुल 155 जीनोटाइपस का मूल्यांकन लगातार दूसरे वर्ष चार वातावरणों में गेहूँ शरीर–क्रियात्मक (पादक कार्यिकी) और अनाज लक्षणों का उपयोग करके गर्मी, सूखे और संयुक्त तनाव के प्रति सहनशीलता के सत्यापन के लिए किया गया।
- भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल ने भाकृअनुप–एनडीआरआई करनाल, भाकृअनुप–आईआईएफएसआर, मोदीपुरम (मेरठ) और भाकृअनुप–सीपीआरआई–क्षेत्रीय केंद्र, मोदीपुरम के साथ अंतर– संस्थागत सहयोग के तहत, 13 गेहूँ किस्मों के 6667 क्विंटल प्रजनक बीज और 2490 क्विंटल सत्य चिन्हित बीज का उत्पादन किया गया। इस अवधि के दौरान जौ की छः किस्मों के 300 क्विंटल बीज भी उत्पादन किया गया।
- संस्थान की रिवाल्विंग निधि (फंड) योजना के अंतर्गत गेहूँ के न्यूक्लियस/ब्रीडर और चिन्हित बीज की बिक्री से कुल 695.50 लाख रुपये की राशि अर्जित हुई।
- संस्थान ने गेहूँ और जौ की नवीनतम किस्मों के टीएल बीजों को पंजीकृत करने और वितरित करने के लिए आईआईडब्ल्यूबीआर बीज पोर्टल को अपग्रेड किया है। आईआईडब्ल्यूबीआर बीज पोर्टल के माध्यम से संस्थान ने 19–24 अक्तूबर, 2024 के दौरान कुल 22000 से अधिक पंजीकृत किसानों को गेहूँ और जौ की नवीनतम किस्मों के टीएल बीजों का 2400 क्विंटल से अधिक वितरण किया।
- एंडोफाइटिक बैक्टीरिया से उपचारित *ट्रिटिकम एस्टिवम* का उपयोग करते हुए ट्रांसक्रिप्टोम विश्लेषण में अभिव्यक्ति आकलन, विभेदक जीन अभिव्यक्ति और संपूर्ण जीन सेट की व्याख्या यूनिप्रोट डेटाबेस का उपयोग करके की गई।
- गेहूँ में करनाल बंट प्रतिरोध से जुड़े छह सुसंगत क्यूटीएल की पहचान गुणसूत्र 2बी, 3ए, 4बी और 5बी पर की गई, जो सामूहिक रूप से 13–18. 9% फेनोटाइपिक भिन्नता की व्याख्या करते हैं।
- गेहूँ के जैव–प्रबलीकरण के लिए आईटीपीके1 जीन के क्रिस्पर/केस9 (क्रिस्पर/कैस9) जीनोम संपादन का कार्य डीबीडब्ल्यू 187 और

डीबीडब्ल्यू 303 जैसी प्रमुख गेहूँ किस्मों में प्रगति पर है।

- विनराइज़ो का उपयोग करके जड़ प्रणाली संरचना (आरएसए) का अध्ययन किया गया तथा गेहूँ प्रजनन कार्यक्रमों में उपयोग के लिए विभिन्न आरएसए लक्षणों के लिए आशाजनक लाइनों की पहचान की गई।
- गेहूँ के जीनोटाइप में गिरने/झुकाव व्यवहार को बेहतर ढंग से समझने और झुकाव सहनशीलता के लिए सबसे महत्वपूर्ण पौधे के गुण की पहचान करने के लिए संस्थान में एक नया प्रोटोटाइप (जिसे पवन सुरंग कहा जाता है) विकसित किया जा रहा है।

फसल सुरक्षा

- गेहूँ की फसल के स्वास्थ्य डेटा की रिकॉर्डिंग विभिन्न एजेंसियों जैसे डी.ए.सी. एंड एफ.डब्ल्यू, आई.सी.ए.आर., एस.ए.यू. राज्य कृषि विभागों, के.वी.के., किसानों आदि द्वारा किसानों के खेतों के नियमित सर्वेक्षण द्वारा की जाती है और आई.सी.ए.आर.–आई.आई.डब्ल्यू.बी.आर. द्वारा समन्वित की जाती है। गेहूँ में पीले रतुआ की उपस्थिति की सूचना सबसे पहले 24.01.2024 को आर.स. पुरा (जम्मू) में एक अज्ञात किस्म पर और बदयाल काज़ियान में एचडी 2967 पर मिली थी।
- आईपीपीएसएन में कुल 1,212 प्रविष्टियों और पीपीएसएन में 469 प्रविष्टियों की गेहूँ रतुआ के खिलाफ जांच की गई, और उन्नत प्रजनन सामग्री की 146 प्रविष्टियों की प्रमुख बीमारियों और कीटों के लिए जांच की गई।
- देशी और विदेशी जर्मप्लाज्म वाले गेहूँ के 320 जीनोटाइपस का पत्ती रतुआ रोग के खिलाफ मूल्यांकन किया गया। इनमें से दस जीनोटाइपस (पीआई519975, पीआई271251, पीआई338443, पीआई383905, पीआई350306, पीआई322042 (डब्ल्यूसी 385), आईसी 138904 –बी, आईसी128360, आईसी128322, और आईसी78736) ने प्रतिरोधी प्रतिक्रियाएं प्रदर्शित की। 97 जीनोटाइपस को मध्यम रूप से अतिसंवेदनशील के रूप में दर्ज किया गया, और 163 जीनोटाइपस को अतिसंवेदनशील पाया गया जबकि पचास जीनोटाइपस को मध्यम रूप से प्रतिरोधी पाया गया ।
- जैविक तनावों के प्रतिरोध के लिए प्रजनन में उपयोग के लिए देश के विभिन्न कृषि–जलवायु क्षेत्रों में 19 प्रजनन केंद्रों के साथ उच्च स्तर की रोग प्रतिरोधक क्षमता के पुष्ट स्रोतों वाली 27 प्रविष्टियाँ साझां की गईं। तीन प्रविष्टियाँ, पीबीडब्ल्यू 902, पीबीडब्ल्यू 870, और एचडी 3440, मुख्य रूप से उपयोग की गईं। दुर्गापुरा केंद्र ने अपने प्रजनन कार्यक्रम में अधिकतम 9 प्रविष्टियों का उपयोग किया, इसके बाद लुधियाना और आई.सी.ए.आर.–सी.एस.एस.आर.आई., करनाल का स्थान रहा।
- विभिन्न क्षेत्रों की मंडियों से कुल 8,100 अनाज के नमूने एकत्र किए गए। इनमें से 93.44% नमूने करनाल बंट संक्रमण से मुक्त थे। करनाल बंट–संक्रमित अनाज की औसत घटना 0.0 से 7.3% तक थी, जिसमें करनाल के एक नमूने में 7.3% का अधिकतम अनाज संक्रमण देखा गया था। महाराष्ट्र, कर्नाटक, गुजरात और मध्य प्रदेश, करनाल बंट संक्रमण से मुक्त पाए गए।
- व्हीट ब्लास्ट रोग के खतरे से निपटने और पश्चिम बंगाल में इसके प्रवेश को रोकने के लिए, एक वैकल्पिक फसल योजना अपनाई गई। उत्तर और दक्षिण पश्चिम बंगाल में, भारत–बांग्लादेश सीमा के पास किए गए सर्वेक्षणों में, व्हीट ब्लास्ट की कोई उपस्थिति नहीं पाई गई। किसानों को निवारक उपायों के बारे में शिक्षित किया गया और प्रतिरोधी किस्में उगाने के लिए प्रोत्साहित किया गया। वर्ष 2023–24 में बांग्लादेश के जेसोर में व्हीट ब्लास्ट के खिलाफ कुल 378 प्रविष्टियों की जाँच की गई। पाँच प्रविष्टियाँ (डीबीडब्ल्यू 447, डीबीडब्ल्यू 448, डीबीडब्ल्यू 449, पीबीडब्ल्यू 942, पीबीडब्ल्यू 943) संक्रमण–मुक्त थीं, जबकि 12 प्रविष्टियाँ (यूपी 3141, डीबीडब्ल्यू 455, डीबीडब्ल्यू 454, एनआईएडब्ल्यू 4621, एचपी 1981, डीबीडब्ल्यू 446, के 2301,जेकेडब्ल्यू 317, एचयूडब्ल्यू 859, आरएयूडब्ल्यू 107, एचयूडब्ल्यू 861, क्यूवाईटी 2310) ने 10% तक संक्रमण स्तर के साथ प्रतिरोध दिखाया।
- पांच जीनोटाइप की जैव रासायनिक प्रोफाइलिंग से एंजाइम गतिविधियों और प्रतिरोध स्तरों में महत्वपूर्ण भिन्नताएं सामने आईं। चिर्या–3 ने लगातार 72 एच.पी.आई. पर एपीएक्स, सीएटी, जीआर, एच$_2$ओ$_2$, पीएएल, पेरोक्सीडेज, पीपीओ, सेल्यूलेज और फ्लेवोनोइड परीक्षणों में उच्चतम गतिविधियों का प्रदर्शन किया, जो *बाइपोलारिस सोरोकिनियाना* के मजबूत प्रतिरोध का संकेत देता है।
- नौ *बाइपोलारिस सोरोकिनियाना* आइसोलेट्स के तुलनात्मक संपूर्ण जीनोम विश्लेषण से माइक्रोसैटेलाइट की उपस्थिती में महत्वपूर्ण भिन्नताएं सामने आईं, जिसमें डब्ल्यूएआई 2406 में एस.एस.आर. की संख्या सबसे अधिक थी जबकि डब्ल्यूएआई 2411 में पूर्ण एस.एस.आर. का प्रतिशत सबसे अधिक था। अध्ययन ने पीसीआर और वास्तविक समय पीसीआर परीक्षणों के माध्यम से प्राइमरों की विशिष्टता और संवेदनशीलता की पुष्टि की, पर्याप्त आनुवंशिक भिन्नता की पहचान की और आइसोलेट्स को दो समूहों में विभाजित किया।
- एक अध्ययन ने पी.सी.आर. आधारित पहचान का उपयोग करके पांच प्रमुख भारतीय धारीदार रतुआ पैथोटाइप (46एस119, 110एस119, 238एस119, 110एस84, और 47एस103) में छह प्रभावकारी जीन (पीएसटी12806, पीएसईसी2, पीएसईसी17, पीएसईसी45, पीएसटीईएफ1, और पीएनपीआई) की उपस्थिति की सफलतापूर्वक पहचान की और पुष्टि की।
- अध्ययन में सीजी 1029 को सबसे कम और डीबीडब्ल्यू 222 को उच्चतम शूट फ्लाई संक्रमण सूचकांक के साथ पहचाना गया। कुछ प्रविष्टियों में पर्ण एफिड प्रतिरोध मध्यम था, जबकि अधिकांश अतिसंवेदनशील थे। सभी प्रविष्टियों में रूट एफिड प्रतिरोध आम तौर पर खराब था। ये निष्कर्ष लक्षित कीट प्रबंधन रणनीतियों और प्रतिरोधी किस्मों के विकास के महत्व पर जोर देते हैं।
- गेहूँ में भूरा रतुआ, काला रतुआ और फ्यूजेरियम हेड ब्लाइट के प्रबंधन के लिए टेबुकोनाजोल 50%+ट्राइफ्लॉक्सीस्ट्रोबिन 25% (डब्लूजी 0.06%) के आवश्यकता आधारित पर्ण स्प्रे की सिफारिश की जाती है। गेहूँ की पत्ती झुलसा रोग के प्रबंधन के लिए टेबुकोनाजोल 50% + ट्राइफ्लॉक्सीस्ट्रोबिन 25% (डब्ल्यूजी 0.1%) के पर्ण छिड़काव की सिफारिश की जाती है।
- तीन स्थानों में शूट फ्लाई के औसत संक्रमण के आधार पर, शूट फ्लाई प्रविष्टि का सबसे कम संक्रमण सूचकांक 7.35% प्रविष्टि सीजी 1029 में दर्ज किया गया था। हालाँकि, प्रविष्टि डीबीडब्ल्यू 222 में उच्चतम शूट फ्लाई संक्रमण सूचकांक 19.59% दर्ज किया गया था।
- प्रविष्टि एमपी 1386 में भूरे घुन (गेहूँ) की न्यूनतम आबादी 9.00/10 सेमी^{2} दर्ज की गई, जबकि प्रविष्टि एचडी 3468 में अधिकतम घुन की आबादी 15.67/10 सेमी^{2} दर्ज की गई।
- चार प्रविष्टियों (पीबीडब्ल्यू 891, पीबीडब्ल्यू 3118(सी), एनआईएडब्ल्यू 4364, और डीबीडब्ल्यू 443) ने औसतन 3.5 के बराबर या उससे नीचे स्कोर किया और पत्तेदार एफिड के खिलाफ मध्यम प्रतिरोधी श्रेणी (ग्रेड 3) में थे।

संसाधन प्रबंधन

- संरक्षण कृषि के अंतर्गत मक्का–सरसों–मूंग और मक्का–गेहूँ–मूंग जैसे फसल विविधीकरण विकल्प पारंपरिक कृषि की तुलना में अधिक उत्पादक और लाभदायक थे।
- कम नाईट्रोजन स्तर पर, धान फसल अवशेष अवधारण ने धान अवशेष समावेशन की तुलना में उच्च गेहूँ उत्पादकता दर्ज की।

- मक्का–गेहूँ–मूँग प्रणाली में दीर्घकालीन जुताई के प्रयोग से पता चला कि गेहूँ की फसल जुताई और अवशेषों के प्रबंधन से प्रभावित नहीं हुई।
- पोषक तत्व प्रबंधन तरीको में अनुशंसित एनपीके + 10 टन /हेक्टेयर देसी/गोबर खाद के प्रयोग से गेहूँ फसल की उपज अधिकतम प्राप्त हुई। पारंपरिक जुताई (सीटी) की तुलना में शून्य जुताई आधारित विकल्पों में मक्का की उत्पादकता अधिक प्राप्त हुई।
- सीधी बोई गई धान (डीएसआर) की तुलना में मचाई कर रोपित धान की उपज अधिक प्राप्त हुई, जबकि सीधी बोई गई धान (डीएसआर) के बाद बिना जुताई और अवशेष रखने की स्थिति में बोए गए गेहूँ की उपज में वृद्धि हुई।
- एकीकृत पोषक प्रबंधन, जिसमें रासायनिक उर्वरकों एनपीके 150:60:40 कि.ग्रा./हेक्टेयर की संस्तुत मात्रा के साथ 15 टन/ हेक्टेयर देसी/गोबर खाद का अनुप्रयोग उच्चतम उपज वाला पाया गया, इसके बाद अनुशंसित एनपीके+हरी खाद का स्थान रहा। पूर्ण नियंत्रण, उर्वरक रहित की तुलना में अकेले पी, के या पी के के एकमात्र उपयोग से गेहूँ की उत्पादकता में कोई वृद्धि नहीं देखी गयी।
- गेहूँ की उच्च उपज किस्मों जैसे एचडी 2967, डीबीडब्ल्यू 187, डीबीडब्ल्यू 222 और डीबीडब्ल्यू 303 की जैविक उत्पादन में गोबर की खाद (एफवाईएम) 10 से 30 टन प्रति हेक्टेयर की वृद्धि से उपज में बढ़ोत्तरी हुई लेकिन उत्पादकता अनुशंसित रासायनिक उर्वरकों एनपीके 150:60:40 कि.ग्रा. /हेक्टेयर की तुलना में काफी कम रही। पूर्ण नियंत्रण, उर्वरक रहित एवं अनुशंसित रासायनिक उर्वरकों की तुलना में देशी खाद (एफवाईएम) के उपयोग से मिट्टी के भौतिक–रासायनिक गुणों में सुधार हुआ।
- प्राकृतिक खेती प्रोटोकॉल के तहत गेहूँ और धान की उत्पादकता में काफी कमी पायी गई।
- हरियाणा के करनाल जिले में रोटरी डिस्क ड्रिल का उपयोग करते हुए गन्ना–गेहूँ फसल प्रणाली में फसल अवशेषों के यथास्थान प्रबंधन के लिए किसानों के खेतों में प्रक्षेत्र प्रदर्शन आयोजित किए गए। मशीन कम शक्ति और मिट्टी से न्यूनतम छेड़छाड़ के साथ फसल अवशेषों की उपस्थिति में फसल की सीधी बिजाई करने में प्रभावी पायी गई।
- गेहूँ के विविध खरपतवारों के नियंत्रण के लिए पाइरोक्सासल्फ़ोन+ मेट्रिब्यूज़िन का तैयार–मिश्रण 337.5 (127.5+210) ग्राम/हेक्टेयर की दर से अनुप्रयोग बहुत प्रभावी पाया गया
- पिनोक्साडेन+मेट्रिब्यूज़िन का तैयार–मिश्रण 225 (45+180) ग्राम/ हेक्टेयर की दर से गेहूँ में घास के साथ–साथ चौड़ी पत्ती वाले खरपतवारों के नियंत्रण के लिए बहुत प्रभावी पाया गया।
- प्रक्षेत्र अध्ययनों में पाइरोक्सासल्फोन + पेंडीमैथलिन 127.5+1500 ग्राम/हेक्टेयर, पाइरोक्सासल्फोन + फ्लुमिओक्साजिन 127.5+100 ग्राम/हेक्टेयर, पाइरोक्सासल्फोन + मेट्रिब्यूजिन 127.5+300 ग्राम/ हेक्टेयर और ऑक्सीफ्लोरफेन + मेट्रिबुजिन 300+300 ग्राम / हेक्टेयर के प्रयोग से विविध प्रकार के खरपतवारों का 90 प्रतिशत से अधिक नियंत्रण पाया गया।
- धान और गेहूँ के बीच मटर और आलू जैसी कम अवधि की फसलों को शामिल करने से देर से बोए गए गेहूँ में मंडूसी (*पी. माइनर*) का प्रकोप कम पाया गया।
- धान–गेहूँ फसल प्रणाली में दोहरी बिना जुताई प्रणाली के कारण जंगली पालक (*रूमेक्स डेंटेटस*) और *मेडिकैगो डेंटिकुलाटा* की अधिक समस्याएं देखी गयी। जंगली जई का प्रकोप धान–गेहूँ प्रणाली की तुलना में मक्का–गेहूँ प्रणाली में अधिक देखा गया।
- मेटसल्फ्यूरोन प्रतिरोधी जगंली पालक (*रूमक्स डटेंटस*) और बथुआ (*चिनोपोडियम एल्बम*) के नियत्रंण के लिए हैलोक्सिफेन् + फ्लूरोक्सीपायर, पेंडीमैथलिन, 2, 4–डी और कारफेंट्राजोन प्रभावी पाए गए।
- बहुशाकनाशी प्रतिरोधी *फ्लैरिस माइनर, एविना लुडोविसियाना* और *पॉलीपोगोन मोनस्पेलिएन्सिस* (क्लोडिनाफॉप, पिनोक्साडेन और सल्फोसल्फ्यूरॉन के खिलाफ) खरपतवारों के नियंत्रण के लिए खरपतवारनाशी पाइरोक्सासल्फोन और मेट्रिब्यूज़िन प्रभावी पाए गए।
- ग्लाइफोसेट के 1% या इससे अधिक वाले पानी के घोल 450 लीटर प्रति हेक्टेयर छिड़काव करने से दूब घास (*साइनोडोन डेक्टाइलॉन*) का प्रभावी नियंत्रण हुआ।
- जौ में चौड़ी पत्ती वाले खरपतवारों को नियंत्रित करने के लिए विभिन्न शाकनाशी और उनके संयोजन का मूल्यांकन किया गया। जौ में विविध प्रकार के चौड़ी पत्ती वाले खरपतवार वनस्पतियों के नियंत्रण के लिए हेलॉक्सिफेन + फ्लूरोक्सिपायर 200.6 (6 + 194.5) और मेटसल्फ्यूरॉन + कारफेंट्राजोन (4 + 20) ग्राम/हेक्टेयर को प्रभावी पाया गया।
- वृद्धि नियामक टीबा (2,3,5–ट्राईआयोडोबेंजोइक एसिड) का 100 पीपीएम की दर से कल्ले फुटाव के समय और सीसीसी (क्लोरमेक्वेट क्लोराइड) + टेबुकोनाजोल (0.2%+0.1%) के कल्ले फुटाव और ध्वजपत्ती अवस्था के समय पर्णीय छिड़काव से जौ की उत्पादकता में सुधार हुआ।
- सिंचाई स्तर को 80 प्रतिशत ईटीसी पर करने से गेहूँ के जीनोटाइपों की उपज और जल उत्पादकता में सार्थक रूप से वृद्धि पायी गई। उपज और जल उत्पादकता के दृष्टिकोण से बीज दर 80 किलोग्राम प्रति हैक्टेयर इष्टतम पाई गई जिससे बीज की 20 प्रतिशत बचत की जा सकती है।

गुणवत्ता एवं मूलभूत विज्ञान

- 2023–24 के दौरान विभिन्न क्षेत्रों और परिस्थितियों का प्रतिनिधित्व करने वाले 76 एवीटी, 280 एनआईवीटी, 22 एचवाईपीटी, 36 क्यूसीडब्ल्यूबीएन, 29 एसएटीएसएन और 30 आईवीटी प्रविष्टियों में प्रोटीन मान, अनाज कठोरता सूचकांक, अवसादन मान, पीला वर्णक, लोहा और जस्ता सहित विभिन्न गुणवत्ता लक्षणों के लिए विश्लेषण किया गया था। चपाती, ब्रेड, बिस्किट, पास्ता और ग्लूटेन मान के लिए चेक सहित सभी एवीटी द्वितीय वर्ष प्रविष्टियों का मूल्यांकन किया गया और आशाजनक जीनोटाइपस की पहचान की गई।
- विभिन्न क्षेत्रों में 8 से अधिक चपाती गुणवत्ता अंक वाली प्रविष्टियां निम्नलिखित हैः एचडी 3428 (एनडब्ल्यूपीजेड–आईएलएस), एनडब्ल्यूएस 2222 (पीजेड–आईटीएस), एनआईएडब्ल्यू 4114 (पीजेड–आईएलएस)।
- पीबीडब्ल्यू 891 (पीजेड–आईटीएस), एकेएडब्ल्यू 5100 (पीजेड–आईटीएस), और जीडब्ल्यू 543 (सीजेड–एचवाईपीटी) जैसी प्रविष्टियों को उच्च ब्रेड लोफ मान (>600 मिली) के लिए पहचाना गया।
- ग्लू–ए1, ग्लू–बी1 एवं ग्लू–डी1 जीन द्वारा जनित उच्च आण्विक भार वाली ग्लुटेनिन उप–इकाई (एच.एम.डब्ल्यू–जी.एस.) का 70 एवीटी–2 एवं एचवाईपीटी प्रविष्टियों तथा चेक्स में मूल्यांकन किया गया। ग्लू–ए1 द्वारा एन्कोडेड एचएमडब्ल्यू ग्लूटेनिन सबयूनिट्स 2*, ग्लू–बी1 लोकस द्वारा एन्कोडेड सबयूनिट्स 17+18 और ग्लू–डी1 लोकस द्वारा एन्कोडेड सबयूनिट 5+10 जो कि मजबूत ग्लूटेन और उच्च अवसादन मात्रा से सम्बंधित है, अधिकांश प्रविष्टियों में मौजूद थे।
- उच्च लौहा और जस्ता (>40 पीपीएम) के साथ उच्च खाद्य गुणवत्ता के लिए एवीटी की कई जीनोटाइपस की पहचान की गई।
- उच्च उपज पृष्ठभूमि वाली प्रजातियों व नेपहाल लैंडरेस के संकरण से जनित बीजों को 2023–24 फसल–सत्र के दौरान उगाया गया। अवसादन मान, लौहे और जस्ते के विश्लेषण के आधार पर, 6 आशाजनक प्रविष्टियों का चयन किया गया और बहुस्थान परीक्षण के लिए भेजा गया जिनमें से 2 प्रविष्टियां जैव–संवर्धित प्रविष्टियों के रूप में चिन्हित की गई हैं। जैव संवर्धन शोध में सभी पीढ़ीयों में लौह व जस्ता के

बीच सकारात्मक सहसंबंध पाया गया। उच्च लौहा व जस्ता और कम फाईटिक अम्ल के आधार पर, चार आशाजनक प्रविष्टियों का चयन किया गया।

- फेनोटाइपिक (समलक्षणीय) मूल्यांकन के आधार पर, पीबीडब्ल्यू 502 की पृष्ठभूमि में विकसित उच्च फाइटेज़ और कम फाइटिक एसिड म्यूटेंट और उच्च उपज देने वाली गेहूँ की किस्मों के बीच संकरण द्वारा उत्पन्न बीजों को शोध प्रक्षेत्र में अगली पीढ़ी में उन्नत किया गया। विकसित लाईनों का लौहा, जस्ता, प्रोटीन और फाइटेज़ स्तरों के लिए मूल्यांकन किया गया और उचित लाईनों का चयन किया गया।
- एस्टिवम (6) और ड्यूरम (9) (जारी) किस्मों के बीच ग्लियाडिन एंटीजेनेसिटी की तुलना अप्रत्यक्ष एलाइजा का उपयोग करके की गई थी जिसमें एस्टिवम और ड्यूरम के लिए सहसंबंध गुणांक क्रमशः 0.68 और 0.24 पाया गया।
- गेहूँ में ग्यारह माइटोफेरिन जीन पहचाने गए, जो गुणसूत्र 3, 4, और 6 पर वितरित हैं। ये जीन माइटोकॉन्ड्रियल लौह परिवहन प्रोटीन को एन्कोड करते हैं, जो लौह संतुलन के लिए आवश्यक हैं। प्रोटीन के गुण धर्म जल्स्नेही (हाइड्रोफिलिक) और स्थिरता में विविधता दर्शाते हैं।
- लौह और जस्ते के संतुलन से जुड़े 14 सूक्ष्म आरएनए को मान्य किया गया, जो पोषक तत्व स्थितियों में जीनोटाइप–निर्भर अभिव्यक्ति प्रदर्शित करते हैं। नर्मदा 195 जैसे प्रभावी जीनोटाइप में मजबूत सूक्ष्म आरएनए–आधारित नियम का नेटवर्क देखा गया, जो बेहतर लौह और जस्ते के अवशोषण और तनाव प्रबंधन में सहायक हैं।
- लुधियाना, जबलपुर और समस्तीपुर से 250 गेहूँ लाईनों के विश्लेषण में प्रोटीन सामग्री, हेक्टोलिटर भार और मिलिंग दक्षता में क्षेत्रीय भिन्नताएं पाई गईं। जबलपुर में प्रोटीन सामग्री सर्वाधिक थी, जबकि लुधियाना आटा रिकवरी (पुनः प्राप्ति) और मिलिंग दक्षता में उत्कृष्ट रहा।
- 15 गेहूँ जीनोटाइप्स ने स्टार्च संरचना, ग्लाइसेमिक सूचकांक और प्रतिरोधी स्टार्च में महत्वपूर्ण भिन्नता दिखाई। उच्च प्रतिरोधी स्टार्च और धीमे पाचनीय स्टार्च सहित निम्न–ग्लाइसेमिक सूचकांक वाले जीनोटाइपस, स्वास्थ्य–जागरूक उपयोगों के लिए आदर्श हैं, जबकि उच्च–ग्लाइसेमिक सूचकांक वाले जीनोटाइप ऊर्जा–आवश्यक उपयोगों के लिए उपयुक्त हैं।
- मध्य क्षेत्र के 4 अलग–अलग स्थानों पर उगाई गई गेहूँ की 17 प्रजातियों में कुल व घुलनशील पेंटोसन सामग्री का मूल्यांकन किया गया। प्रजाति एचआइ 1634 (7.19%) तथा एचडी 2932 (1.15%) में क्रमशः सबसे अधिक कुल व घुलनशील पेंटोसन पाया गया।
- गेहूँ की 20 किस्मों में लवणता तनाव के तहत मापदंडों के सहसंबंध विश्लेषण का प्रयोग किया गया जिस से यह ज्ञात हुआ की सुपरोक्साइड डिसम्युटेज, प्रोलीन और सोडियम आयन, लवणता तनाव सहिष्णुता के लिए सबसे उपयुक्त स्क्रीनिंग मानदंड है।
- स्थानीय गेहूँ चक्की मशीन के द्वारा दो गेहूँ की किस्मों में गेहूँ ग्रिट उपज 54 तथा 58% पाई गयी।
- चने के आटे और रागी के मिश्रण के प्रभाव को निर्धारित करने के लिए एक अध्ययन किया गया था। चने का आटा मिश्रित चपाती के लिए चपाती अंक 7.7 (नियंत्रण) से 6.6 (30% मिश्रित चना) तक पाया गया। रागी के आटे मिश्रित चपाती के लिए चपाती अंक 7.7 (नियंत्रण) से 6.1 (30% मिश्रित रागी) के बीच पाया गया।

सामाजिक विज्ञान

- रबी फसल सत्र 2023–24 के दौरान, 39 समन्वयक केंद्रों द्वारा एक–एक एकड़ के 338 जौ के अग्रिम पंक्ति प्रदर्शन आयोजित किए गए। इन प्रदर्शनों को 420 किसानों के खेतों पर 346 एकड़ क्षेत्रफल पर आयोजित किया गया। जौ की उन्नत किस्मों को फसल उत्पादन की समग्र सिफारिशों (सिंचाई प्रबंधन, पोषक तत्व प्रबंधन, खरपतवार नियंत्रण, बीज उपचार आदि) के साथ चयनित किसानों के खेतों में प्रदर्शित किया गया।
- जौ के सबसे अधिक अग्रिम पंक्ति प्रदर्शन उत्तर प्रदेश (101) में उसके बाद मध्य प्रदेश (60) में आयोजित किए गए। जौ की पैदावार में सबसे अधिक वृद्धि केन्द्र शासित प्रदेश जम्मू और कश्मीर (57.57%) में दर्ज की गई।
- क्षेत्रीय औसत उपज की तुलना में उन्नत किस्मों के कारण सबसे अधिक उपज लाभ उत्तरी पर्वतीय क्षेत्र (48.1%) में प्राप्त हुआ, इसके बाद उपज लाभ उत्तर पूर्वी मैदानी क्षेत्र (43.6%), मध्य क्षेत्र (38.3%) एवं उत्तर पश्चिमी मैदानी क्षेत्र (20.2%) में देखा गया।
- जाँचक (चेक) किस्मों की तुलना में उन्नत किस्मों के कारण सबसे अधिक उपज लाभ उत्तर पूर्वी मैदानी क्षेत्र (34.8%) में दर्ज किया गया, इसके बाद उत्तरी पर्वतीय क्षेत्र (34.5%), मध्य क्षेत्र (34.2%) एवं उत्तर पश्चिमी मैदानी क्षेत्र (16.6%) में देखा गया।
- उत्तरी पर्वतीय क्षेत्र के शिमला केंद्र पर बीएचएस 400 (29.25 कुंतल / हेक्टेयर), उत्तर पूर्वी मैदानी क्षेत्र के गोरखपुर केंद्र पर आरडी 2907 (44.50 कुंतल / हेक्टेयर), उत्तर पश्चिमी मैदानी क्षेत्र के दुर्गापुरा जयपुर केंद्र पर आरडी 2907 (70.40 कुंतल / हेक्टेयर) तथा मध्य क्षेत्र के राजगढ़ केंद्र पर डीडब्ल्यूआरबी 137 (47.38 कुंतल / हेक्टेयर) उच्चतम औसत उपज देने वाली किस्में थीं।
- भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल द्वारा युनाईटेड ब्रुअरीज लिमिटेड, पटियाला के सहयोग से हरियाणा राज्य के सिरसा जिले के फग्गु, कालांवाली, जलालआना एवं तरुआना गाँव के 5 किसानों के कुल 5 एकड़ क्षेत्र पर जौ की उन्नत किस्म डीडब्ल्यूआरबी 137 के अग्रिम पंक्ति प्रदर्शन आयोजित किए गए।
- किसानों के खेतों में अग्रिम पंक्ति प्रदर्शन कार्यक्रम के तहत जौ की उन्नत किस्मों के प्रदर्शनों में प्रति हेक्टेयर औसत लाभ लगभग 67404 रुपये प्राप्त हुआ। प्रदर्शनों के माध्यम से हिमाचल प्रदेश में प्रति रुपये निवेश पर उच्चतम आमदनी 6.58 रुपये प्राप्त हुई। अग्रिम पंक्ति प्रदर्शन और जाँचक प्लॉट के बीच लाभ का अंतर रुपये 28634 (केन्द्र शासित प्रदेश जम्मू और कश्मीर) से लेकर 5724 रुपये (हरियाणा) तक देखा गया।
- सभी क्षेत्रों की समग्र बाधाओं के विश्लेषण से पता चलता है कि जल स्तर में गिरावट, आवकों की उच्च कीमत, मंडूसी (*फैलेरिस माइनर*), भूमि की छोटी जोत, श्रमिकों की अनुपलब्धता, जौ अनाज की कम कीमत, नहर सिंचाई जल सुविधा का अभाव, असमय वर्षा, शाकनाशियों / कीटनाशकों की खराब गुणवत्ता एवं विभिन्न विभागों द्वारा आयोजित एक्सपोजर यात्राओं में कम भागीदारी को देश में जौ उत्पादन एवं उत्पादकता को प्रभावित करने वाली प्रमुख बाधाओं के रूप में पहचाना गया।
- रबी फसल मौसम 2023–24 के दौरान पंजाब में फसल अवशेष प्रबंधन परियोजना के तहत यह देखा गया कि अधिकांश किसानों (62%) ने गेहूँ की बीजाई के लिए सुपर सीडर को अपनाया। इसके बाद जीरो टिल ड्रिल (21%), हैपी सीडर (10%) एवं स्मार्ट सीडर (7%) को अपनाया। समग्र रुप से डी.बी.डब्ल्यू श्रृंखला की प्रजातियों का अंगीकरण 71.7 प्रतिशत था।
- फसल मौसम 2023–24 के दौरान, अनुसूचित जाति उप–परियोजना (एससीएसपी) कार्यक्रम के अंतर्गत पंजाब (18), हरियाणा (04), राजस्थान (02), केन्द्र शासित प्रदेश जम्मू और कश्मीर (01) एवं रानी लक्ष्मी बाई केन्द्रीय विश्व विद्यालय, झांसी के आकांक्षी जिलों में गेहूँ की उन्नत किस्में डीबीडब्ल्यू 187, डीबीडब्ल्यू 332 एवं डीबीडब्ल्यू 370 के 520 अग्रिम पंक्ति प्रदर्शन अनुसूचित जाति (एससी) वर्ग के 520 किसानों के कुल 520 एकड़ क्षेत्र में आयोजित किए गए।
- अनुसूचित जाति उप–परियोजना (एससीएसपी) कार्यक्रम के अंतर्गत गेहूँ प्रदर्शनों में उन्नत किस्मों के अंगीकरण के कारण जिलों में सबसे अधिक

उपज वृद्धि राजस्थान के श्रीगंगानगर (49.3%) जिले में देखी गई। इसके बाद उत्तर प्रदेश के झांसी (26.7%) जिले में, केन्द्र शासित प्रदेश जम्मू और कश्मीर के साँबा (21.6%) जिले में, पंजाब के अमृतसर (16.7%) जिले में और राजस्थान के हनुमानगढ (13.5%) जिले में प्राप्त हुई। सबसे कम उपज वृद्धि पंजाब के होशियारपुर (1.5%) जिले में देखी गई।

- एससीएसपी गेहूँ प्रदर्शन कार्यक्रम के अंतर्गत राज्यों में सबसे अधिक उपज वृद्धि राजस्थान (28.7%) में दर्ज की गई जबकि सबसे कम पंजाब (4.9%) में प्राप्त हुई। क्षेत्रीय (उत्तर पश्चिमी मैदानी क्षेत्र) उपज वृद्धि 7.0% रही। अग्रिम पंक्ति प्रदर्शन में शामिल किस्मों ने मौजूदा किस्मों की तुलना में बेहतर प्रदर्शन किया।
- औसतन, किसानों की पारम्परिक कृषि प्रथाओं (3.19 रुपये) की तुलना में गेहूँ के अग्रिम पंक्ति प्रदर्शन के तहत प्रति रुपये निवेश पर 3.44 रुपये लाभ प्राप्त हुआ। प्रदर्शन आयोजित क्षेत्रों पर सबसे अधिक लाभ (प्रति हैक्टेयर) राजस्थान (133866 रुपये) में दर्ज किया गया। जाँचक प्लॉटों की तुलना में गेहूँ के अग्रिम पंक्ति प्रदर्शन के प्लाटों में परिचालन लागत मामूली रूप से कम पाई गई।
- फसल सत्र 2023–24 के दौरान, भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल, कृषि एवं किसान कल्याण मन्त्रालय, नई दिल्ली एवं सम्बंधित केन्द्रों के विषेषज्ञों के दल द्वारा संगरूर, मानसा, बठिंडा, मुक्तसर, कठुआ, कपूरथला, अयोध्या, वाराणसी एवं मिर्जापुर केंद्रों द्वारा आयोजित जौ के अग्रिम पंक्ति प्रदर्शनों एवं एससीएसपी गेहूँ के प्रदर्शनों का अवलोकन किया गया।

जौ सुधार

- वर्ष 2023–24 के दौरान राष्ट्रीय जौ उत्पादकता 30.80 क्विंटल प्रति हेक्टेयर तक पहुंच गई, जिसमें 8.18 लाख हेक्टेयर में कुल 2.22 मिलियन टन उत्पादन हुआ। डीडब्ल्यूआरबी 219 नामक दो–पंक्ति माल्ट जौ की किस्म जारी की गई, जो 54.49 क्विंटल प्रति हेक्टेयर की औसत उपज और 93 क्विंटल प्रति हेक्टेयर की संभावित उपज देती है, जिसमें बेहतरीन माल्ट गुणवत्ता और रोग प्रतिरोधक क्षमता है।
- वर्ष 2024 में, चार नई जौ आनुवंशिक किस्में–डीडब्ल्यूआरबीजी 15, डीडब्ल्यूआरबीजी 16, डीडब्ल्यूआरबीजी 19 और डीडब्ल्यूआरबीजी 25 को आईसीएआर–एनबीपीजीआर में पंजीकृत किया गया, जिनमें उच्च प्रोटीन, बीटा–ग्लूकन सामग्री और बेहतर माल्ट गुणवत्ता जैसे विशिष्ट गुण हैं।
- जौ सुधार कार्यक्रम विशेष रूप से बिना छिलके वाली जौ की उपज और पोषण गुणवत्ता बढ़ाने पर ध्यान केंद्रित करता है, जबकि माल्ट निकालने के स्तर, प्रोटीन सामग्री और डायस्टेटिक शक्ति में सुधार इसे उच्च गुणवत्ता वाला बनाता है। वर्ष 2023–24 में, 787.50 क्विंटल प्रजनक बीज का उत्पादन किया गया, जो राष्ट्रीय आवश्यकता से अधिक था, जिससे उच्च गुणवत्ता वाले बीज की उपलब्धता सुनिश्चित हुई।
- पीला रतुआ और पत्ती धब्बा रोग के खिलाफ नई जांच और प्रबंधन रणनीतियों ने जौ फसल की सुरक्षा को बढ़ाया। विभिन्न कृषि–जलवायु परिस्थितियों में जौ किस्मों के मूल्यांकन के लिए समन्वित उपज परीक्षण किए गए, जिसमें 51 संभावित प्रविष्टियों ने श्रेष्ठ प्रदर्शन दिखाया।
- मार्कर–सहायता चयन (एमएएस) का उपयोग कर उच्च डायस्टेटिक शक्ति और अनाज प्रोटीन सामग्री वाली बेहतर किस्मों का विकास संभव हुआ। संस्थान 8,239 जौ अभिग्रहण को नियंत्रित परिस्थितियों में संरक्षित करता है, जिससे जौ आनुवंशिक विविधता का दीर्घकालिक संरक्षण सुनिश्चित होता है।

क्षेत्रीय केन्द्र, फ्लावरडेल, शिमला (हिमाचल प्रदेश)

- भारत में जौ के पत्तों में रतुआ रोग पैदा करने वाले *पक्सीनिया हॉर्डी* के पैथोटाइप को नामित करने के लिए पहली विभेदक प्रणाली विकसित की गई। भारतीय स्थानीय गेहूँ की किस्म हाँगो–2 के 1एएस गुणसूत्र पर एक नए ऑल–स्टेज तना रतुआ पर्तिरोधी जीन (एसआर65) की पहचान की गयी। फसल सीजन 2023–24 के दौरान, गेहूँ की सभी रतुआ बीमारियाँ भारत में स्थानिक रूप से दिखाई दीं।
- गेहूँ में धारीदार (पीला) रतुआ पहली बार 24 जनवरी, 2024 को आरएस पुरा (जम्मू) में एक अज्ञात किस्म पर और बदयाल काजियान में एचडी 2967 पर रिपोर्ट किया गया था।
- पत्ती (भूरा) रतुआ (गंभीरता 5एमएस से 10एस) पहली बार 19 दिसंबर, 2023 को धारवाड़ (कर्नाटक) के पास किसानों के खेतों में देखा गया था। महाराष्ट्र में पत्ती रतुआ (गंभीरता 5 एमएस से 20 एस) पहली बार जनवरी 2024 के दूसरे और चौथे सप्ताह के दौरान पुणे और सतारा जिलों में किसानों के खेतों में देखी गई थी। सीजन के दौरान अपेक्षाकृत गंभीर रूप से तने का रतुआ कर्नाटक, महाराष्ट्र, मध्य प्रदेश आदि में किसानों के खेतों में देखा गया था।
- 2023–24 के दौरान भारत और नेपाल से गेहूँ और जौ के तीनों रतुआ के कुल 858 नमूनों का विश्लेषण किया गया। छह राज्यों और नेपाल से गेहूँ और जौ के पीले रतुआ के 173 नमूनों का विश्लेषण किया गया। गेहूँ के रतुआ रोगजनक के नौ प्रभेदों {238एस119, 110एस119, 46एस119, टी (47एस103), पी (46एस103), 78एस84, 110एस84, 79एस68, और 6एस0} और *पक्सीनिया स्ट्रॉइफॉर्मिस* एफ. एसपी. नमूनों में केवल एक पैथोटाइप 57 (0एस0) की पहचान की गई।
- गुजरात, हिमाचल प्रदेश, मध्य प्रदेश, महाराष्ट्र, कर्नाटक, उत्तर प्रदेश, उत्तराखंड और तमिलनाडु तथा नेपाल से काले रतुए के कुल 208 नमूने प्राप्त हुए जिन्हें गेहूँ के डिफरेंशियल सेट द्वारा प्रभेद किया गया था। भारत के 10 राज्यों और पड़ोसी देश नेपाल से 2023–24 के दौरान विश्लेषण किए गए गेहूँ की पत्ती के रतुआ रोग के 477 नमूनों में *पक्सीनिया ट्रिटिसिना* के 26 प्रभेदों की पहचान की गई।
- रतुआ प्रतिरोध स्रोतों की पहचान करने के लिए, 2023–24 के दौरान, 5500 से अधिक गेहूँ और जौ की पंक्तियों का मूल्यांकन, अंकुर चरण में नियंत्रित परिस्थितियों में, तना रतुआ (*पी. ग्रेमिनिस एफ. एसपी. ट्रिटिसी*), पत्ती (*पी. ट्रिटिसिना*) और धारीदार रतुआ (*पक्सीनिया स्ट्रॉइफॉर्मिस एफ. एसपी. ट्रिटिसी*) के प्रभेदों की एक श्रृंखला का उपयोग करके किया गया था जिनमें अलग–अलग गैर विषाणु/विषाणु संरचनाएं पायी गई। एवीटी पंक्ति वीएल 2059 में तीनों रतुआ रोगजनकों के सभी प्रभेदों के लिए प्रतिरोध दर्ज किया गया जबकि 27 प्रविष्टियों में काले और भूरे रतुओं के प्रति प्रतिरोध देखा गया।
- पीबीडब्ल्यू 916, एच 1402 (आई)(सी) काले और पीले रतुआ के प्रति प्रतिरोधी थीं। आण्विक अध्ययन में, एवीटी की 146 लाइनों में से, 80 लाइनों में चार वाईआर जीन (वाईआर 2, वाईआर 9, वाईआर ए और वाईआर 18 पाये गये। 115 एवीटी प्रविष्टियों में आठ एलआर जीन (एलआर1, एलआर3, एलआर10, एलआर13, एलआर23, एलआर24, एलआर26, और एलआर34) पाए गये। इसी प्रकार, 121 एवीटी प्रविष्टियों में तेरह तना रतुआ प्रतिरोधी जीनों (एसआर 2, एसआर 5, एस आर7बी, एसआर8ए, एसआर8बी, एसआर9बी, एसआर9ई, एसआर11, एसआर13, एसआर24, एसआर28, एसआर30 और एसआर31) की उपस्थिति दर्ज की गई।
- एवीटी प्रविष्टियों को वयस्क पौध चरण में भूरे, पीले तथा काले रतुए के सबसे प्रमुख और विषैले प्रभेदों के खिलाफ भी जांचा गया था। पत्ती रतुआ रोगजनक के सभी प्रभेदों (77–5, 77–9 और 104–2) के लिए 04 पंक्तियों (एकेएडब्ल्यू 100, डीबीडब्ल्यू 296, एचडी 3171, एचडी 3369) में वयस्क पौध चरण प्रतिरोध देखा गया। एनबीडीएसएन और ईबीडीएसएन लाइनों की कुल 189 प्रविष्टियों को सटीक परिस्थितियों में जौ के तीनों रतुआ रोगजनकों के विभिन्न प्रभेदों/आइसोलेट्स

(*पक्सीनिया स्ट्रॉइफॉर्मिस हॉर्डी* के सात, पीजीटी के पांच और *पी. हॉर्डी* के ग्यारह) के खिलाफ जांच की गई थी। हालाँकि, 8 एनबीडीएसएन प्रविष्टियाँ पत्ती और धारीदार रतुआ के प्रति प्रतिरोधी थीं।

- एलआर10, एलआर67, एलआर23, एलआर46, एलआर13 और एलआर 26 जैसे विभिन्न पत्ती रतुआ प्रतिरोधी जीनों को धारण करने वाली कई जर्मप्लाज्म लाइनों और लैंडरेस को दो से अधिक पत्ती रतुआ प्रतिरोधी जीनों के साथ एफ1 (पीढ़ी 1) लाइनें विकसित करने के लिए संकरित किया गया। 2023–24 के फसल मौसम में कुल 15 एफ2 (पीढ़ी 2) और एफ3 (पीढ़ी 3) लाइनें, जिनमें 2 एलआर जीन थे, उनको 5–5 पंक्तियों में बोया गया था। एलआर80 जीन युक्त भूरा रतुआ प्रतिरोधी हांगो–2 को पीला रतुआ प्रतिराधी एफएलडब्लू रेखाओं के साथ क्रॉस किया गया।
- 2023–24 की एवीटी सामग्री में आण्विक मार्करों का उपयोग करके गेहूँ के रतुआ प्रतिरोधी जीनों (एलआर, एसआर, वाईआर) की पहचान की गई। वाईआर9 / एलआर26 / एसआर31 जीन कॉम्प्लेक्स को दस एवीटी लाइनों में दर्ज किया गया। प्रमुख मार्कर एसआर 24#50 का उपयोग करके 21 एवीटी लाइनो में एलआर24 / एसआर24 जीन कॉम्प्लेक्स को सत्यापित किया गया।
- **क्षेत्रीय केंद्र, दालंग मैदान (लाहौल स्पीति)**
- ऑफ–सीजन समर नर्सरी 2024 के दौरान गेहूँ और जौ की अनुसंधान सामग्री मई के चौथे सप्ताह में क्षेत्रीय केंद्र, दालंग मैदान में लगाई गई और सितम्बर–अक्तूबर में कटाई की गई थी।
- शोध सामग्री में देश भर के विभिन्न संस्थानों के 43 केन्द्रों से 37000 से अधिक गेहूँ और जौ की लाइनें शामिल थी।
- इस सीजन में विभिन्न केंद्रों द्वारा पीला रतुआ और पाउडरी फफूंदी के खिलाफ गेहूँ की लगभग 13500 लाईनों की जांच की गई।
- इस सुविधा का उपयोग क्रॉसिंग, पीले रतुआ के नमूनों के संग्रह, गेहूँ रोग निगरानी नर्सरी और जर्मप्लाज्म भंडारण के लिए भी किया गया था।

बीज व अनुसन्धान प्रक्षेत्र, हिसार

- वर्ष 2024 के दौरान गेहूँ (डीबीडब्ल्यू 303) एवं जौ (डीडब्ल्यूआरबी 123, डीडब्ल्यूआरबी137, डीडब्ल्यूआरबी 160 तथा डीडब्ल्यूआरबी 182, डीडब्ल्यूआरबी 101, डीडब्ल्यूआरबी 219) की किस्मों का कुल 1179.08 क्विंटल प्रजनक बीज उत्पादित किया गया।
- प्रतिवेदन की अवधि के दौरान अखिल भारतीय समन्वित गेहूँ एवं जौ सुधार परियोजना के अंतर्गत कुल दो समन्वय परीक्षण (जौ एवीटी–एसएएल / एएलके) अनुसंधान प्रक्षेत्र में लवणीय मृदा में लगाये गए।
- अखिल भारतीय समन्वित गेहूँ एवं जौ सुधार परियोजना के अंतर्गत गेहूँ की लवणता / क्षारीयता स्क्रीनिंग नर्सरी लगाई गई।
- गेहूँ का स्टेशन ट्रायल (25 प्रभेद, 2 रेप्लिकेशन) (एनडब्ल्यूपीजेड / एनईपीजे / सीजेड / पीजेड / आरआई / टीएस) अनुसंधान प्रक्षेत्र में लगाया गया।
- फसल वर्ष 2023–2024 के दौरान जौ का एक एग्रोनोमी (सस्य विज्ञान) परीक्षण नई चारा किस्मों के नाइट्रोजन स्तर के प्रति सवेंदशीलता परखने हेतु लगाया गया।
- जौ के पांच वन्य सबंधी (आईसी144117, आईसी144121, आईसी 144123, आईसी144128 और आईसी 145508) को मृदा लवणता की परस्थितियों में वैलीडेट किया गया।
- 25 विदेशी जौ जननद्रव्यों को मृदा लवणता की परस्थितियों में वैलीडेट किया गया।
- हिमालय क्षेत्र से संग्रहित मृदा लवणता सहिष्णु प्रभेदों जौ जननद्रव्यों (एसएलआर43, 48, 53, 57, 58, 92, 93, 109, 169, 171, 172, 175, 208, 211, 212, 213, 334, 335, 337, 339, 340 और 393) को वैलीडेट किया गया।
- जौ की दो किस्मों (डीडब्ल्यूआरबी 160 एवं जनाड्रू) का गुरु जम्भेशवर विश्वविद्यालय, हिसार के साथ बीटा ग्लुकेन ट्रांस्क्रिप्टोमिक्स / एक्सप्रेशन एनालिसिस पूर्ण किया गया।
- चारा जौ के 65 संकरण में एफ4 और 10 संकरण में एफ5 से आगे जनरेशन एडवांसमेंट किया गया।
- 105 जौ किस्मों को लवणता सहिष्णुता की पहचान के लिए लवणीय वातावरण में लगाया गया और पांच किस्में (के 508, ज्योति, पीएल 419 तथा आरडी 2552) चिन्हित की गयीं।

EXECUTIVE SUMMARY

CROP IMPROVEMENT

- During the year 2024, seven bread wheat varieties *viz.* Pusa Gehun Sharbati (HI1665), PBW Zinc 2 (PBW 823), PBW RS1, MP3535, TRVW 155, TJW153, HD3437; one durum wheat variety (HI 8840) and one dicoccum wheat (Khapli) variety DDK 1063 were notified for cultivation in different production conditions through recommendation of the Central Sub-Committee on Crops Standards.
- IIWBR wheat varieties were notified for cultivation in different wheat-growing zones: 1) DBW359 (Karan Shivangi) for timely sown, restricted irrigated conditions of Central and Peninsular zones, and 2) DBW377 (Karan Bold) for early sown, high-fertility conditions in Central Zone.
- Two bread-wheat varieties DBW386 and DBW443 were identified by varietal identification committee for release under timely sown condition of the North Eastern Plains Zone (NEPZ) and irrigated timely sown conditions of Peninsular Zone, respectively.
- A total of 15 genetic stocks of wheat were registered for traits like disease resistance to wheat rusts, heat and drought tolerance, quality attributes, higher protein content and higher 1000 grains weight. These genetic stocks belong to four crop species of wheat i.e. *Triticum aestivum, T. durum; T. dicoccum* and *T. aestivum* ssp. *sphaerococcum*.
- Six AVT-II bread-wheat entries of IIWBR, Karnal namely, DBW422, DBW425, DBW426, DBW432, DBW445 and DBW477 were promoted for the final year of testing in AVTs for various zones. DBW426, DBW445 and DBW509 were promoted based on their superior quality and yield.
- During the period a total of 688 wheat germplasm lines from various sources including a set of 203 accessions from NBPGR resistant to various fungal diseases were acquired.
- The institute supplied 943 accessions of wheat to various indenters for utilization in the research programme leading to good revenue generation.
- After taking the approval from DARE/ICAR, 418 lines wheat advance lines were sent to Bangladesh and Mexico through NBPGR/CIMMYT for screening against wheat blast and other diseases at hot spot locations in Bangladesh, Bolivia, Kenya and Mexico.
- At present, around 18500 accessions of wheat are being conserved in medium term storage module at IIWBR, Karnal (4°C and 30% RH). During 2024, 965 accessions of wheat were transported to Dalang Maidan for conservation under natural condition as safety duplicate.
- From conserved germplasm 465 wheat accessions were evaluated as per DUS testing guideline. 96 wheat germplasm lines were characterized for spike diversity traits including nine qualitative traits.
- During the period four bread wheat varieties of IIWBR, Karnal namely; DBW316, DBW 370, DBW371, and DBW372 and one durum wheat variety DDW 55 were registered by the PPV&FRA, New Delhi under extant category.
- Registration application of two new wheat varieties namely, DBW359 and DBW377 has been submitted to PPV&FRA, New Delhi for registration under extant category.
- During crop season 2023-24, six DUS trials were conducted in wheat, in which 93 coded entries along with national checks.
- An eight parent MAGIC population comprising of total 1780 lines of was evaluated and selections and generation advancement was done for yield traits, biotic and abiotic stress tolerance.
- A study aimed to quantify the effect of growth regulator Chlormequat chloride (CCC) on lodging incidence in high yielding wheat cultivars indicated that lodging can be successfully reduced by a single spray of 0.2 % CCC at the first node formation stage.
- In biological nitrification inhibitor (BNI) study on three wheat varieties (DBW187, DBW303 and DBW371) it was observed that traits such as spike length, length and width of flag leaf, biomass, harvest index, protein composition and grain yield, and nitrogen balance index (NBI) significantly

decreased at lower nitrogen levels. The BNI, in conjunction with these traits, could be utilized to identify desirable plant types in the subsequent generations under low nitrogen conditions.

- In pre-breeding for wheat improvement 450 crosses including backcrosses were attempted during the reporting period. The genotypes like Highbury, Pavon 76, Paragon, Frontana, Sphearococcum and *Aegilops mutica* were used in crossing emphasizing specific traits.
- A total of 155 genotypes comprising of *Aegilops tauschii* (DD), *Ae. peregrina* (UUSS), *Triticum dicoccoides* (AABB), and synthetic hexaploids (AABBDD) were evaluated under four environments for 2nd consecutive year for validation of tolerance to heat, drought and combined stress using physiological and grain traits.
- Under Inter-institutional collaborations with ICAR-NDRI Karnal, ICAR-IIFSR and ICAR-CPRI-RS, Modipuram ICAR-IIWBR has produced 6667 q of breeder seed and 2490 q of TL seed of 13 wheat varieties and 300 q seed of 6 barley varieties was produced during the period.
- Selling of Nucleus/ Breeder and TL Seeds of wheat generated a total amount of Rs. 695.50 lakhs under the revolving fund scheme of the institute.
- ICAR-IIWBR, Karnal has upgraded IIWBR Seed Portal to register and distribute TL seed of recent wheat and barley varieties. Through IIWBR seed portal the institute distributed >2400 quintals of TL seed of indented wheat and barley varieties to more than 22000 registered farmers during 19-24th October, 2024.
- In transcriptome analysis of plants treated with endophytic bacteria the expression estimation, differential gene expression and annotations of complete gene set were performed using uniprot database using *Triticum aestivum*.
- Six consistent QTLs associated with Karnal Bunt resistance in wheat were identified on chromosomes 2B, 3A, 4B, and 5B, collectively explaining 13%–18.9% of the phenotypic variation.
- The CRISPR/Cas9 genome editing of ITPK1 gene for biofortification of wheat is under progress in key wheat varieties like DBW187 and DBW303.
- The DBW-EMS23 is identified as promising heat and drought-tolerant genotype through testing under AICRP DHTSN nursery (2023-24).
- The root system architecture (RSA) is studied using WinRhizo and identified promising lines for different RSA traits for using in wheat breeding programs.
- To better understand the lodging behavior in wheat genotypes and to identify the most crucial plant trait for lodging tolerance a new prototype (termed as wind tunnel) is being developed at ICAR-IIWBR Karnal.

CROP PROTECTION

- Wheat crop health data recording is done by regular surveys of farmers' fields by different agencies such as DAC & FW, ICAR, SAUs, State Agriculture Departments, KVKs, Farmers, etc., and is coordinated by ICAR-IIWBR. The appearance of yellow rust of wheat was first reported on 24.01.2024, from RS Pura (Jammu) on an unknown variety, and at Badyal Qazian on HD2967.
- A total of 1,212 entries in IPPSN and 469 entries in PPSN were screened against rusts, and 146 entries of advanced breeding material were screened for major diseases and insect pests.
- Three hundred twenty genotypes of wheat comprising indigenous and exotic germplasm were evaluated against leaf rust disease. Out of these, ten genotypes [PI519975, PI271251, PI338443, PI383905, PI350306, PI322042 (WC 385), IC138904-B, IC128360, IC128322, and IC78736] exhibited resistant responses. Fifty were found to be moderately resistant, 97 genotypes were recorded as moderately susceptible, and 163 genotypes were found to be susceptible.
- Twenty-seven entries with confirmed sources of high levels of disease resistance were shared with 19 breeding centres across different agro-climatic zones of the country for use in breeding for resistance to biotic stresses. Three entries, PBW902, PBW870, and HD3440, were predominantly utilized. Durgapura centre utilized a maximum of nine entries in their breeding programme, followed

by Ludhiana and ICAR-CSSRI, Karnal.

- A total of 8,100 grain samples were collected from various mandies in different zones. Out of these, 93.4% of samples were found free from Karnal bunt infection. The average incidence of Karnal bunt-infected grains ranged from 0.0 to 7.3%, with the maximum grain infection of 7.3% observed in a sample from Karnal. Maharashtra, Karnataka, Gujarat, and Madhya Pradesh were found free from Karnal bunt infection.
- To combat the threat of wheat blast and prevent its entry into West Bengal, an alternate crop plan was adopted. Surveys conducted near the Indo-Bangladesh border in North and South West Bengal found no wheat blast presence. Farmers were educated on preventative measures and encouraged to grow resistant varieties. A total of 378 entries were screened against blast in Jessore, Bangladesh, at two sowing dates in 2023-24. Five entries (DBW447, DBW448, DBW449, PBW942, and PBW943) were infection-free, while 12 entries (UP3141, DBW455, DBW454, NIAW4621, HP1981, DBW446, K2301, JKW317, HUW859, RAUW107, HUW861, and QYT2310) showed resistance with infection levels up to 10%.
- Biochemical profiling of the five genotypes revealed significant variations in enzyme activities and resistance levels. Chirya-3 consistently exhibited the highest activities in APX, CAT, GR, H_2O_2, PAL, Peroxidase, PPO, Cellulase, and Flavonoid tests at 72 hpi, indicating strong resistance to *Bipolaris sorokiniana*.
- The comparative whole genome analysis of nine *B. sorokiniana* isolates revealed significant variations in microsatellite occurrence; with WAI2406 having the highest number of SSRs and WAI2411 the highest percentage of perfect SSRs. The study confirmed the specificity and sensitivity of the primers through PCR and real-time PCR assays, identifying substantial genetic variation and clustering the isolates into two groups.
- A study successfully identified and confirmed the presence of six effector genes (Pst 12806, PSEC2, PSEC17, PSEC45, PST EF1, and PNPi) in five predominant Indian stripe rust pathotypes (46S119, 110S119, 238S119, 110S84, and 47S103) using PCR-based detection.
- The study identified CG1029 with the lowest shoot fly infestation index and DBW222 with the highest. Foliar aphid resistance was moderate in a few entries, while most were susceptible. Root aphid resistance was generally poor across all entries. These findings emphasize the importance of targeted pest management strategies and the development of resistant varieties.
- Need-based foliar spray of Tebuconazole 50% + Trifloxystrobin 25% WG @0.06% is recommended for the management of leaf rust, stem rust, and head scab in wheat. A foliar spray of Tebuconazole 50% + Trifloxystrobin 25% WG @0.1% is recommended for the management of leaf blight of wheat.
- Based on the average infestation of shoot fly at three locations, the lowest infestation index of 7.35% of shoot fly was reported in entry CG1029. However, the highest shoot fly infestation index of 19.59% was recorded in entry DBW222.
- Entry MP1386 recorded the minimum brown wheat mite population of 9.00/10 cm^2, while the maximum mite population of 15.67/10 cm^2 was recorded in entry HD3468.
- Four entries [PBW891, HD3118(C), NIAW4364, and DBW443] scored an average of equal or below 3.5 and were in the moderately resistant category (grade 3) against foliar aphid.

RESOURCE MANAGEMENT

- Crop diversification options like maize-mustard-green gram and maize-wheat-green gram under conservation agriculture were more productive and profitable than conventional agriculture.
- Rice residue retention (RRR) produced higher wheat productivity under low N conditions as compared to rice residue incorporation (RRI).
- A long-term tillage experiment in a maize-wheat-green gram system indicated that the wheat crop was not affected by tillage and residue management.
- Among nutrient management, wheat grain yield was maximum with the application of recommended

NPK + 10 t/ha FYM. Maize productivity was higher in zero tillage-based options as compared to CT.

- Rice yield was higher under puddle-transplanted conditions over direct-seeded rice (DSR), whereas wheat yield improved when sown after DSR under no-till and residue retention conditions.
- Integrated nutrient management consisting of the application of recommended doses of chemical fertilizers (NPK 150:60:40) with 15 t/ha FYM was found to be the highest yielder, followed by recommended NPK + green manuring. Sole use of P, K, or PK did not improve the wheat productivity compared to absolute control.
- In the organic production of HYVs (HD 2967, DBW 187, DBW 222, and DBW 303) of wheat, the yield increased with an increase in the FYM dose from 10 to 30 t/ha in comparison to the control, but the productivity remained significantly lower than the recommended doses of chemical fertilizers (NPK 150:60:40). Use of FYM improved the physico-chemical properties of the soil as compared to the control and recommended NPK.
- Grain yield of wheat and rice was reduced significantly under natural farming protocol.
- Field demonstrations on *in-situ* crop residue management in sugarcane-wheat cropping systems were conducted at farmers' fields using Rotary Disc Drill (RDD) in Karnal district of Haryana. The machine was effective in direct seeding the crop in the presence of crop residue with lesser power requirement and lesser soil disturbance.
- Premix combination of pyroxasulfone + metribuzin at 337.5 (127.5 +210) g/ha was very effective for control of diverse weed flora in wheat
- Ready-mix combination of pinoxaden + metribuzin at 225 (45+180) g/ha was very effective for control of grass as well as broadleaved weeds in wheat.
- In field studies, more than 90% control of diverse weed flora was observed with application of pyroxasulfone + pendimethalin 127.5 + 1500 g/ha, pyroxasulfone + flumioxazine 127.5 + 100 g/ha, pyroxasulfone + metribuzin 127.5 + 300 g/ha and oxyflourfen + metribuzin 300 + 300 g/ha.
- Inclusion of short duration crops such as pea and potato in between rice and wheat reduced the infestation of *P. minor* in late sown wheat.
- In rice-wheat system, double no-till system led to more problems of *Rumex dentatus* and *Medicago denticulata*. Wild oat infestation was observed higher in maize-wheat than in rice-wheat system.
- For control of metsulfuron resistant *Rumex dentatus* and *Chenopodium album*, halauxifen + fluroxypyr, aclonifen + diflufenican, pendimethalin, 2,4-D and carfentrazone, were found effective.
- For management of multiple herbicide resistant *P. minor*, *Avena ludoviciana* and *Polypogon monspeliensis* (against clodinafop, pinoxaden and sulfosulfuron) pyroxasulfone, aclonifen + diflufenican and metribuzin were found effective in wheat.
- Spray of glyphosate at ≥1% spray solution using 450 lit/ha water provided the effective control of *Cynodon dactylon*.
- For controlling broadleaved weeds in barley various herbicides and their combinations were evaluated. Halauxifen + fluroxypyr 200.6 (6.1+194.5) and metsulfuron + carfentrazone 4+ 20 g/ha were found effective for control of diverse type of broadleaved weed flora in barley.
- The growth regulators TIBA (2,3,5-Triiodobenzoic Acid) @100 ppm at tillering and CCC (Chlormequat chloride) + tebuconazole (0.2% + 0.1%) at tillering and flag leaf as foliar spray improved the barley productivity.
- Significantly higher grain yield and water productivity of wheat genotypes were observed with 80% ETc irrigation level. The seed rate of 80 kg/ha was found to be optimum in terms of grain yield and water productivity, suggesting 20% savings of seed.

QUALITY & BASIC SCIENCES

- During 2023-24, 176 AVTs, 280 NIVTs, 22 HYPTs, 36 QCWBN, 29 SATSN and 30 IVTs, were analyzed for different quality traits including protein content, grain hardness index, sedimentation value, yellow pigment, iron & zinc from centers representing different zones and growing conditions. All the AVT IInd year entries including checks were evaluated for chapati, bread, biscuit, pasta and gluten content and promising genotypes were identified.

- HD3428 (NWPZ-ILS), NWS2222 (PZ-ITS), and NIAW4114 (PZ-ILS) were identified with high chapati quality score of >8.0.
- PBW891 (PZ-ITS), AKAW5100 (PZ-ITS), and GW543 (CZ-HYPT) were identified for high bread loaf volume (> 600ml).
- Seventy (70) 2nd year AVT and HYPT entries including checks were evaluated for HMWGS composition from various sowing conditions of different zones of the country. HMW glutenin subunit 2* encoded by Glu-A1, 17+18 encoded by Glu-B1 locus and subunit 5+10 encoded by Glu-D1 locus associated with stronger gluten and high sedimentation volume were present in majority of entries.
- Several entries in AVT were identified with high Fe and Zn (>40 ppm) for nutritional quality.
- During cropping season 2023-24, crosses of NapHal with high yielding background genotypes were propagated. Based on sedimentation volume, GFeC and GZnC analysis, 6 promising entries were selected and sent for multilocation testing. Out of 6, 2 entries have been clubbed with outstanding entries for GFeC and GZnC over baseline as these were also having high iron & zinc crossing (CRP) in their pedigree.
- Under CRP Biofortification experiments, there was positive correlation between Fe & Zn across generations. Four promising entries were selected based on high Fe & Zn and low phytic acid.
- Based on phenotypic evaluation, high phytase and low phytic acid mutants developed in the background of PBW 502 and high yielding wheat cultivars were advanced into next generation in the quality fields. The developed lines were evaluated for Fe, Zn, protein and phytase levels and selections were made.
- Gliadin antigenicity between aestivum (6) and durum (9) (released) varieties was compared using indirect ELISA with a correlation coefficient of 0.68 and 0.24 for aestivum and durum, respectively.
- Eleven mitoferrin genes were identified in wheat, distributed across chromosomes 3, 4, 6, and unanchored scaffolds. These genes encode mitochondrial iron transport proteins essential for Fe homeostasis, with protein properties indicating mostly hydrophilic and variable stability.
- Fourteen miRNAs linked to Fe/Zn homeostasis were validated, showing genotype-dependent expression under nutrient conditions. Efficient genotypes like Narmada 195 exhibited robust miRNA-mediated regulatory networks for superior Fe/Zn uptake and stress management.
- Analysis of 250 wheat lines across Ludhiana, Jabalpur, and Samastipur revealed regional differences in protein content, hectoliter weight, and milling efficiency. Jabalpur had the highest protein content, while Ludhiana excelled in flour recovery and milling efficiency.
- Fifteen wheat genotypes showed significant variability in starch composition, glycemic index (GI), and resistant starch (RS). Low-GI genotypes with high RS and slow digestible starch (SDS) are ideal for health-conscious applications, while high-GI genotypes suit energy-demanding uses.
- The total and soluble pentosan content was estimated in 17 wheat varieties across 4 locations in CZ and the highest total and soluble pentosan content was reported from HI 1634 (7.19 %, Junagarh) and HD2932 (1.37 %, Junagarh), respectively.
- Correlation analyses of parameters under salinity stress in 20 wheat cultivars showed that superoxide dismutase, proline, and Na^+ content emerged as the most efficient screening criteria for salinity stress tolerance.
- The yield of wheat grits prepared using local wheat machine from two wheat varieties was 54 and 58%.
- A study was conducted to determine the effect of blending chick pea flour and finger millet from 0-30%. The chapati score for the chick pea flour supplemented chapati varied from 7.7 (control) to 6.6 (30% addition). The chapati score for finger millet supplemented chapati ranged from 7.7 (control) to 6.1 (30 % addition).

SOCIAL SCIENCES

- During the *rabi* crop season 2023-24, 338 Barley Frontline Demonstrations (BFLDs) were conducted by 39 centers, covering 346 acres area of 420 farmers. Improved barley varieties with complete package of practices (irrigation management, nutrient management, weed control, seed treatment etc.) were demonstrated.
- The maximum number of BFLDs were conducted in UP (101) followed by Madhya Pradesh (60). The highest gain in barley yield was recorded in UT of J&K (57.6%).
- The yield gain due to improved varieties over regional mean yield was the highest in NHZ (48.1%) followed by NEPZ (43.6%), CZ (38.3%) and NWPZ (20.2%).
- The yield gain due to improved varieties over check was the highest in NEPZ (34.8%) followed by NHZ (34.5%), CZ (34.2%) and NWPZ (16.6 %).
- BHS400 (29.25 q/ha) at Shimla centre in NHZ; RD2907 (44.50 q/ha) at Gorakhpur in NEPZ; RD 2907 (70.40 q/ha) at Durgapura, Jaipur in NWPZ and DWRB 137 (47.38 q/ha) at Rajgarh in CZ were the highest average yielding varieties.
- Barley FLDs were conducted by ICAR-IIWBR, Karnal in collaboration with United Breweries Limited, Patiala using improved barley variety DWRB 137, involving five farmers in 5 acres area in villages Faggu, Kalanwali, Jalalana and Taruana in District Sirsa of Haryana State.
- On an average, improved barley varieties demonstrated at the farmers' field under the FLD programme gave profit around ₹67404 per hectare. Himachal Pradesh registered the highest returns per rupee of investment (₹6.58) through demonstrations. The difference in profit between FLD and check plots ranged from ₹28634 in UT of J&K to ₹5724 in Haryana.
- Major constraints in barley production were decline in water table, high cost of inputs, *Phalaris minor*, small land holding, non-availability of labour, low price of barley grains, poor participation in exposure visits arranged by various departments, lack of facility of canal irrigation water, untimely rain and poor quality of herbicides/pesticides.
- In Punjab, under crop residue management project it was found that a large majority (62%) adopted super seeder, followed by zero till drill (21%), happy seeder (10%) and smart seeder (7%) for wheat sowing. The overall adoption of DBW series varieties was 71.7% in the study area of Punjab.
- Under SCSP programme, 520 varietal demonstrations of wheat varieties DBW 187, DBW 332 and DBW 370 were organized during 2023-24 *rabi* crop season in aspirational districts of Punjab (18), Haryana (4), Rajasthan (2), UT of Jammu & Kashmir (1) andUP (1) covering a total of 520 acres area of 520 farmers of Scheduled Castes (SC) category.
- The yield gain due to improved variety under SCSP wheat demonstrations was highest in Sriganganagar (49.3%) district in Rajasthan state followed by Jhansi (26.7%) in UP state, Samba (21.6%) district in Jammu and Kashmir (UT), Amritsar (16.7%) district in Punjab state and Hunumangarh (13.5%) district in Rajasthan state. The lowest yield gain was in Hoshiarpur (1.5%) district in Punjab state.
- Under SCSP wheat demonstrations, the yield gain was highest *i.e.* 28.7% in Rajasthan. The lowest yield gain was 4.9% in Punjab state. The zonal (NWPZ) yield gain was 7.0%. The demonstrated varieties outperformed the existing varieties.
- On an average, demonstration of improved wheat varieties gave ₹3.44 per rupee of investment in comparison to the farmers' practice (₹3.19). The profit per hectare in the demonstrated plot was highest in Rajasthan (₹133866). Operational costs were found to be marginally lower in wheat demonstrations in comparison to the check plots.
- The ICAR-IIWBR team accompanied by the experts from the Ministry of Agriculture & Farmers Welfare and the concerned centres monitored the barley FLDs and SCSP wheat demonstrations conducted by Sangrur, Mansa, Bathinda, Muktsar, Kathua, Kapurthala, Ayodhya, Varanasi and Mirzapurcentres during the *rabi* crop season 2023-24.

BARLEY IMPROVEMENT

- The national barley productivity reached 30.80 q/ha, with a total production of 2.22 million tons across 8.18 lakh hectares during 2023-24. A significant milestone was the release of DWRB219, a two-row malt barley variety, which provides an average yield of 54.49 q/ha and a potential yield of 93.0 q/ha, exhibiting superior malting quality and disease resistance.

- In 2024, four novel barley genetic stocks-DWRBG15, DWRBG16, DWRBG19, and DWRBG25-were registered with ICAR-NBPGR for their superior traits, including high protein, beta-glucan content, and malt quality.
- The Barley Improvement Program emphasizes hulless barley improvement to enhance yield and nutritional properties for food applications, while advancements in malt extract levels, protein content, and diastatic power ensure high-quality brewing standards. In 2023-24, 787.50 quintals of breeder seed were produced, surpassing the national indent, and ensuring high-quality seed availability.
- New screening and management strategies strengthened resistance against yellow rust and leaf blight, safeguarding barley crops against climatic uncertainties.
- Coordinated yield trials were conducted across multiple locations to evaluate barley varieties under different agro-climatic conditions, with 51 promising entries demonstrating yield superiority.
- The application of marker-assisted selection (MAS) enabled the development of superior varieties with high diastatic power and grain protein content.
- The institute maintains 8,239 accessions under controlled conditions, ensuring the long-term preservation of barley genetic diversity.

REGIONAL STATION, FLOWERDALE, SHIMLA (HIMACHAL PRADESH)

- The first differential system for designating the pathotypes of *Puccinia hordei* causing barley leaf rust in India was developed. A new all-stage stem rust resistance gene (*Sr65*) was mapped on chromosome 1AS from Indian wheat landrace Hango-2. During the crop season 2023-24, all rust diseases of wheat appeared endemically in India.
- Stripe (yellow) rust of wheat was first reported on 24th January, 2024 from RS Pura (Jammu) on an unknown variety and at Badyal Qazian on HD2967. Leaf (brown) rust (severity 5MS to 10S) was first observed from the farmers' fields near Dharwad (Karnataka) on 19 December, 2023. In Maharashtra, leaf rust (severity 5MS to 20S) was first observed from the farmers' fields in Pune and Satara districts during 2nd and 4th week of January 2024. Stem rust was observed in the farmers' fields in Karnataka, Maharashtra, Madhya Pradesh etc. in relatively severe form during the season.
- A total of 858 samples of three rusts of wheat and barley were pathotyped during 2023-24 from India and Nepal. One hundred seventy-three samples of wheat and barley yellow rusts were analyzed from six states, and Nepal. Nine pathotypes {238S119, 110S119, 46S119, T (47S103), P (46S103), 78S84, 110S84, 79S68, and 6S0} of wheat rust pathogen (*Puccinia striiformis* f. sp. *tritici*) and only one pathotype 57 (0S0) of *Puccinia striiformis* f. sp. *hordei* (*Psh*) were identified in these samples. A total of 208 black rust samples received from Gujarat, Himachal Pradesh, Madhya, Pradesh, Maharashtra, Karnataka, Uttar Pradesh, Uttarakhand, and Tamil Nadu and Nepal were pathotyped on wheat differentials. Twenty-six pathotypes of *Puccinia triticina* were identified in 477 samples of wheat leaf rust analyzed during 2023-24 from 10 states of India and neighboring country Nepal.
- For identifying rust resistance sources, more than 5500 wheat and barley lines were evaluated during 2023-24 at seedling stage under controlled conditions using an array of pathotypes of stem (*P. graminis* f. sp. *tritici*), leaf (*P. triticina*) and stripe rust (*P. striiformis* f. sp. *tritici*) possessing different avirulence/virulence structures. AVT entry VL2059 possessed resistance to all pathotypes of three rust pathogens. Resistance to black and brown rusts was observed in 27 entries. Entries PBW916, WH1402(I)(C) were resistant to black and yellow rusts. Among the 146 lines of AVT, four *Yr* genes (*Yr2*, *Yr9*, *YrA* and *Yr18*) were characterized in 80 lines. Eight *Lr* genes (*Lr1*, *Lr3*, *Lr10*, *Lr13*, *Lr23*, *Lr24*, *Lr26*, and *Lr34*) were characterized in 115 AVT entries. Similarly, thirteen stem rust resistance genes (*Sr2*,

Sr5, Sr7b, Sr8a, Sr8b, Sr9b, Sr9e, Sr11, Sr13, Sr24, Sr28, Sr30 and *Sr31*) were characterized in 121 AVT entries.

- The AVT entries were screened against the most predominant and virulent pathotypes of *Pt*, *Pst* and *Pgt* at adult plant stage (APR). APR to all the pathotypes (77-5, 77-9 and 104-2) of leaf rust pathogen was observed in 04 lines (AKAW5100, DBW296, HD3171, HD3369).
- A total of 189 entries of NBDSN and EBDSN lines were screened against different pathotypes of three rust pathogens (seven pathotypes of *Psh,* five pathotypes of *Pgt,* and eleven pathotypes/isolates *P. hordei*) of barley under precise conditions of temperature and light. Resistance to all the pathotypes of *Pgt* was observed only in two lines DWRB2319 and UPB-1124. However, 8 NBDSN entries were resistant to leaf and stripe rusts.
- Several germplasm lines and landraces harboring different leaf rust resistance genes such as *Lr10, Lr67, Lr23, Lr46, Lr13* and *Lr26* were crossed to develop F_1 lines with more than two leaf rust resistance genes. A total of 15 F_2 and F_3 families with 2 *Lr* genes each and 5 rows per family were sown in 2023-24 cropping season. The brown rust resistance line *Hango*-2 harboring *Lr80* gene was crossed with FLW lines that carry yellow rust resistance.
- Wheat rust resistance genes (*Lr, Sr, Yr*) were identified using molecular markers in AVT material of 2023-24. The *Yr9/Lr26/Sr31* gene complex was validated in ten AVT lines. *Lr24/Sr24* gene complex was validated in twenty-one AVT lines using dominant marker *Sr24#50*.

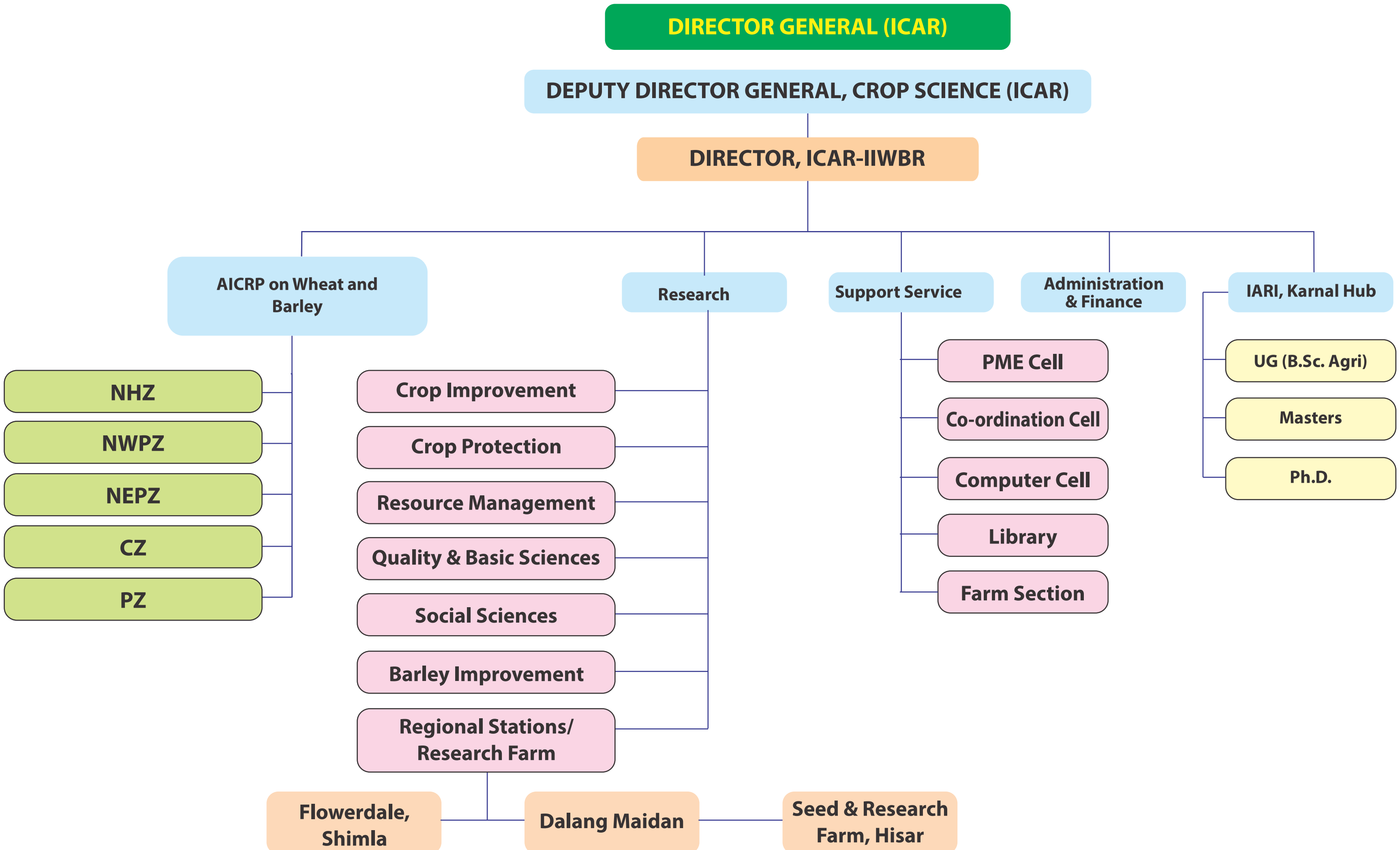
REGIONAL STATION DALANG MAIDAN (LAHAUL & SPIITI)

- During the off-season 2024 summer nursery, wheat and barley research material was planted at RS Dalang Maidan in the fourth week of May 2024 and harvested in September-October 2024.
- The research material was comprised of more than 37000 wheat and barley lines from 43 co-operators of different institutes across the country.
- This season around 13500 wheat lines were screened against yellow rust and powdery mildew by various centers.
- The facility was also utilized for crossing, the collection of yellow rust samples, wheat disease monitoring nursery, and germplasm storage.

SEED AND RESEARCH FARM, HISAR

- During the 2023-24 season, 1179.08 quintals of the breeder seed of different wheat (DBW303) and barley varieties (DWRB101, DWRB123, DWRB137, DWRB160, DWRB182 and DWRB219) was produced.
- Under the AICRP, Barley AVT-SAL/ALK was conducted during 2023-24 under two salinity environments. All India Coordinated Salinity/Alkalinity Tolerance Screening Nursery conducted. One station trial of wheat (NWPZ/NEPZ/CZ/PZ-RI-TS) with 25 entries in 2 replications was conducted. One barley agronomy trial was conducted to check the response of new feed barley genotypes to different Nitrogen levels under salinity condition in NWPZ.
- Five accessions of *Hordeum spontaneum* viz. IC144117, IC144121, IC144123, IC144128 and IC145508 were validated for soil salinity tolerance. 25 exotic barley accessions viz. AM-158, AM-159, AM-187, AM-188, AM-194, AM-196, AM-197, AM-199, AM-208, AM-213, AM-230, AM-235, AM-247, AM-261, AM-262, AM-270, AM-275, AM-285, AM-295, AM-296, AM-299,AM-302, AM-311, AM-315, AM-316 were also validated for tolerance to soil salinity.
- Moreover, 25 accessions of Himalayan landraces viz. HLR43, HLR48, HLR53, HLR57, HLR58, HLR92, HLR93, HLR109, HLR169, HLR171, HLR172, HLR175, HLR208, HLR211, HLR212, HLR213, HLR334, HLR335, HLR337, HLR339, HLR340 and HLR393 were also validated for soil salinity tolerance. The transcription/expression analysis of two varieties viz. DWRB160 and Xanadu was completed in collaboration with Guru Jambheshwar University of Science and Technology, Hisar was completed.
- A total of 105 released varieties were evaluated for soil salinity tolerance and five varieties (K-508, PL419 and RD2552) were identified as salt tolerant varieties. A total of 65 crosses of feed barley were advanced to F_5 and 10 crosses were advanced to F_6 generation. Selection and generation advancement was exercised in F_6 generation in 10 crosses and 65 crosses in F_5 generation.

ORGANOGRAM


DIRECTOR GENERAL (ICAR)
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Computer Cell
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Masters
Ph.D.

1 INSTITUTE'S BACKGROUND AND MANDATE

Wheat research across the country has been funded and promoted by the Indian Council of Agricultural Research-ICAR (erstwhile Imperial Council of Agricultural Research) established in 1929 at New Delhi. Despite several thrusts, the realised breakthrough in yield was narrow during the early phase. An important milestone in the wheat improvement programme was created with the establishment of the 'All India Coordinated Wheat Improvement Project (AICWIP) in 1965 with its headquarters at Indian Agricultural Research Institute (IARI), New Delhi. Globally, it became one of the largest networks for a crop improvement programme which laid the foundation for Green Revolution in India. High yielding wheat varieties were made to spread widely across traditional wheat growing regions during this phase. The AICRP, hitherto, has contributed in the release of 526 high yielding wheat varieties comprising bread, durum and dicoccum wheat and around 103 high yielding barley varieties comprising feed, food, malt and dual purpose barley recommended for different agro-climatic zones of the country. The wide adoption of wheat varieties has begun with the earliest semi-dwarf varieties like Lerma Rojo, Sonora 64, Chhoti Lerma, Kalyansona and Sonalika. Some of the varieties became extremely popular and occupied large acreage. The project later was elevated to the status of Directorate of Wheat Research in 1978. The Directorate was shifted to the present location at Karnal in 1990 and was also assigned the responsibility of coordinating Barley Improvement Project. This arrangement continued during the VIII Five Year Plan. During the IX Five Year Plan, both barley and wheat projects were merged as "All India Wheat and Barley Improvement Project" in 1997 and this arrangement is being continued since then and now popularly known as the All India Coordinated Research Project (AICRP) on Wheat and Barley. The Directorate has been upgraded to Indian Institute of Wheat and Barley Research in 2014 and popularly tagged as ICAR-IIWBR, Karnal. It is a premier organization under the aegis of ICAR coordinating the multidisciplinary and multi-location testing of varieties in different AICRP centres', crop management and crop protection technologies across the diverse ecosystems for increasing and stabilizing the wheat production. The 29 funded centres located in different locations across the country support multidisciplinary research on wheat and barley. Each Centre also has its regional mandate depending upon the agro-climatic conditions as well as the prevalent diseases/pest situation in addition to the national / zonal requirements. Increased industrial demand has put barley crop as cash crop. Contractual farming and giving premium on better malt producing varieties has given a boost to cultivation of the crop in its niche area. In addition to the headquarters, IIWBR has two Regional research stations, one at Flowerdale, Shimla (established in 1930), which serves as a national facility for monitoring wheat rust pathotypes, evaluating advanced generation material, postulating probable rust resistance genes in the test lines and act as a repository for maintenance of the wheat rust virulences. The another regional station at Dalang Maidan is located at an altitude of 10,000 feet with twelve hectares of land, of which six hectares is cultivable. The office cum laboratory and guest-house facilities has been created for the benefit of research workers. Facilities of this station are being utilized for advancing the generation, conservation of germplasm under natural conditions, making crosses during off-season and screening against yellow rust resistance by AICRP on Wheat & Barley Centres. Another important milestone in the institute's history was the allotment of 200 acre land by the council at Hisar in 2012 for experiment and seed multiplication purposes.

MANDATE

The institute mandate is

- Basic and strategic research on wheat and barley to improve productivity and quality.
- Coordination and development of improved crop production and protection technologies for sustainable production.
- Providing genetic diversity and accelerate the breeding cycle through off season facilities.
- Surveillance and forewarning for management of rust diseases.
- Dissemination of improved technologies, capacity building development of linkages.

THE MISSION

Ensuring food and nutritional security by enhancing the productivity and profitability of wheat and barley on an ecologically, socially and economically sustainable basis and making India the world leader in climate smart wheat system production.

2 CROP IMPROVEMENT

Release of new wheat varieties for different zones/states

During the year 2024, the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops released and notified seven bread wheat varieties (Pusa Gehun Sharbati (HI1665), PBW Zinc 2 (PBW- 823), PBW RS1 (WBL -1521), MP3535, TRVW 155 (Trombay Raj Vijay Wheat- 155), TJW153 (Trombay Jodhpur Wheat 153), HD3437); one durum wheat variety (Pusa Gehun Gaurav (HI- 8840)) and one dicoccum wheat variety (Krishidhara Krishna Super DWK 1063 (DDK 1063)) for different production conditions and states vide notification number 4388(E) dated 08-10-2024 (Table 2.1).

Table 2.1: Wheat varieties released during 2024

SN	Variety name	Developed by	Zone/ state	Production condition	Grain yield (q/ha)		Special features
					Average	Potential	
Central released varieties							
Bread wheat							
1.	Pusa Gehun Sharbati (HI1665)	IARI, Indore	PZ	RI, TS	33.2	43.5	Tolerance to heat (HSI 0.98) and drought (DSI 0.93); biofortified with protein (12%) and zinc (40.7 ppm); resistant to black rust
Durum wheat							
2.	Pusa Gehun Gaurav (HI8840)	IARI, Indore	PZ	RI, TS	30.2	39.9	Resistant / moderately resistant / tolerant to black and brown rust; tolerance to heat (HSI 0.94); higher amount of zinc (41.1 ppm)
State released Bread wheat							
3.	PBW Zinc 2 (PBW823)	PAU, Ludhiana	Punjab	IR, TS	57.2	68.3	Biofortified with zinc (48.5 ppm) and Fe (44.2ppm); resistant to yellow and brown rust
4.	PBW RS1 (WBL1521)	PAU, Ludhiana	Punjab	IR, TS	42.65	45.3	PBW RS1 is a premium wheat variety with high resistant starch. Owing to decreased digestibility of starch, it helped in lowering the glycemic index.
5.	MP3535	JNKVV, Jabalpur	Madhya Pradesh	IR, TS	59.1	80.6	Moderately resistant to black and brown rust; good amount of zinc content
6.	TRVW 155 (Trombay Raj Vijay Wheat 155)	RVSVV, Gwalior and BARC, Trombay, Mumbai	Madhya Pradesh	IR, TS	57.9	75.3	Resistant to black and brown rust
7.	TJW153 (Trombay Jodhpur Wheat 153)	AU, Jodhpur and BARC, Trombay, Mumbai	Rajasthan	IR, TS	43.4	59.7	Highly resistant to brown rust and moderately resistant to black rust; zinc (40.7 ppm)

SN	Variety name	Developed by	Zone/ state	Production condition	Grain yield (q/ha) Potential	Average	Special features
8.	HD3437	IARI, Delhi	NCT of Delhi	IR, TS	53.95	61.9	Developed through MABB to improve HD2967+Yr10+Lr34) ; Highly resistant to yellow rust (HS=5MS, ACI=1.7)
Dicoccum wheat							
9.	Krishidhara Krishna Super DWK 1063 (DDK- 1063)	UAS, Dharwad	Zone 3 and 8 in Karnataka	IR, TS	42.28	68.49	Resistant to black and brown rust; biofortified dicoccum wheat with protein (14.4%), iron (43.7ppm) and zinc (45.3 ppm)

New genetic stocks of wheat registered

During the year 2024, a total of 15 genetic stocks of wheat were registered for traits like disease resistance to rusts, heat and drought tolerance, phenol colour, higher protein content and higher 1000 grains weight. The genetic resources unit of the IIWBR, Karnal multiplies the seeds of these registered genetic stocks and supplies to breeder across the country for use in wheat improvement (Table 2.2).

Table 2.2: Wheat varieties released by SVRC during 2023

SN	Name of genotype	Registration number	Developing centre	Trait
1	DBW-EMS268	INGR24004	ICAR-IIWBR, Karnal	Drought and heat stress tolerant (DSI=0.81; HSI=0.77)
2	DBW-EMS339	INGR24005	ICAR-IIWBR, Karnal	Drought tolerance (DSI=0.66) with lower yield reduction (20.8%) under drought)
3	DTS 116	INGR24006	ICAR-IIWBR, Karnal	Drought stress tolerance (DSI=0.40)
4	DBW424	INGR24007	ICAR-IIWBR, Karnal	Drought and heat stress tolerance (HSI= 0.78; DSI = 0.89). Resistant to yellow rust of wheat (ACI=1.2)
5	PBS 2022-1	INGR24008	ICAR-IIWBR, Karnal	Heat stress tolerance (HSI: 0.76) with lower grain yield reduction (20.0%) under heat stress
6	IC029040 (Tested as CPIIWBR266) (d.)	INGR24009	ICAR-IIWBR, Karnal	Leaf rust resistance (HS= 0; ACI=0)
7	B2011\CIMCOG\21	INGR24010	ICAR-IIWBR, Karnal	Yellow (Stripe) rust resistance (ACI= 4.3; HS= 10MS)
8	WAP2206	INGR24011	ICAR-IIWBR, Karnal	Resistant to stem rust (HS=-10MR and ACI = 0.7). Resistant to leaf rust (HS= 10R and ACI = 0.3)
9	WAP2207	INGR24012	ICAR-IIWBR, Karnal	Resistant to yellow (stripe) rust (HS= 5S; ACI = 0.6). Resistant to leaf rust (HS= 5MR and ACI = 0.3)
10	DBW398	INGR24015	ICAR-IIWBR, Karnal	Low phenol colour score of 3.9 and 4.1 in NWPZ and NEPZ respectively.
11	IC535133; RRH-5072	INGR24013	ICAR-NBPGR, New Delhi	Resistant to leaf rust (Resistance score= ; to ;N for multiple pathotypes)
12	IC138898; VDV-5/88; NIC-1376 (dic.)	INGR24014	ICAR-NBPGR, New Delhi	Resistant to leaf rust (Resistance score= ; to ;N)
13	EC182958	INGR24016	ICAR-NBPGR, New Delhi	High grain protein content (17.16%).
14	IC634028; AD-19/101; Kathod Gehun (Sph.)	INGR24017	ICAR-NBPGR, New Delhi	High grain protein content (15.72%)
15	IC539313; TADIA GENEPOOL	INGR24018	ICAR-NBPGR, New Delhi	High thousand grain weight (55.03g). More grain length (7.15 mm)

Genetic Resources

Exchange: 688 wheat germplasm lines were acquired from various sources including a set of 203 accessions from NBPGR, which includes 31 accessions of Karnal bunt resistant, 20 accessions of leaf rust resistant, 16 accessions of stem rust resistant, 18 accessions of stripe rust resistant, 17 accessions of powdery mildew resistant, 21 accessions of spot blotch resistant, 25 accessions of fusarium head blight resistant, 20 accessions drought tolerance, 14 accessions of heat tolerance and 15 salinity tolerance. The institute supplied 943 accessions of wheat to various indenters for utilization in the research programme. This led to a revenue generation of Rs. 75000/-

Screening of wheat germplasm against wheat blast: After taking the approval from DARE/ICAR, 418 lines of wheat advance lines are being sent to Bangladesh and Mexico through NBPGR/CIMMYT for screening against wheat blast and other diseases at hot spot locations in Bangladesh, Bolivia, Kenya and Mexico.

Conservation: At present, around 18500 accessions of wheat are being conserved in medium term storage module at IIWBR, Karnal (4°C and 30% RH). During 2024, 965 accessions of wheat were transported to Dalang Maidan for conservation under natural condition as safety duplicate.

Characterization: 465 wheat accessions were evaluated as per DUS testing guideline. Promising accessions were identified for various traits (Table 2.3)

Table 2.3: Range of variability in wheat germplasm

Characters	Range	Mean	Promising Accessions/Best check
Days to heading	71-125	98.6	<76 cm: RUSSELL-DR, CHUGOKU 114/ WR 544 (81.4)
Plant height (cm)	61.7-147	95	<70cm: POTCH 93, SENGWA, SW89.2089, SW89.3243, SW89.5193, SW90.1057, SW91-12331, YUMAI 18/ WR544 (93.8 cm)
Ear length (cm)	6.5-14.7	10.1	>14cm: QING HAIBEI, SOTOME/ DBW187 (11 cm)
1000 grains weight (g)	15.7-59.7	36.4	>58 g: OCEPAR 17/ DBW187 (52.3g)
No. of spikelets per spike	16-30	21.2	>30: BUCK ARRAYAN, NAOFEN/ DBW187 (22)
No. of seeds per spike	31-95	54.1	>90: NAHUATL F2000, TRIGUERO 989/ Kalyansona (69.6)
Seed weight per spike (g)	0.25-3.58	1.96	>3.4 g: KENYA CHOZI, PFAU/SERI.1B//AMAD/3/WAXWING, ZHONGZOU 8131/ DBW187 (2.8g)

Spike diversity in wheat germplasm: 96 wheat germplasm lines were characterized for spike diversity traits. The data has been recorded for 9 qualitative traits, i.e., ear waxiness, ear shape, ear density, awn color, awn attitude, glume pubescence, grain shape, and grain colour, and 9 quantitative traits. For 1000 grain weight, 3 promising germplasm lines, namely SHOZE F3-6-10BO, IC 79007 A, and DRP 2001-108, have been identified.

Performance of entries in NIVTs

Three bread wheat entries nominated by the genetic resources unit and tested in different NIVTs during 2023-24. Based on better yield performance and disease resistance in NIVTs, two genotypes namely DBW446 and DBW465 were promoted to AVT-IR-TS and AVT-RI-TS of NWPZ, respectively (Table 2.4).

Table 2.4: Details of entries in NIVTs

Trial	Name of genotype /Check	Yield (q/ha)		Disease score (ACI) of tested genotype in PPSN	Remarks
		NWPZ	NEPZ		
NIVT1A	DBW446 DBW187(check)	69.4(6) 61.1(4)	69.2(7) 63.7(1)	YR:8.9; LR(N):14.9; LR(S):5.7;SR:12.9	Promoted to AVT-IR-TS-NWPZ
NIVT5A	DBW465 NIAW3170/HI1612 (Checks)	54.5(3) 46.1(4)	51.0(12) 48.0(2)	YR:8.9; LR(N):4.8; LR(S):2.7;SR:18.3	Promoted to AVT-RI-TS-NWPZ
		CZ	PZ		
NIVT3A	DBW463 HD2932 (check)	46.2(7) 40.2(21)	47.4(6) 45.7(11)	YR:10.2; LR(N):11.1; LR(S):6.0;SR:13.9	-

Rank with in parenthesis

Registration of varieties with PPV&FRA: Registration application of two wheat varieties namely DBW359 and DBW377 has been submitted to PPV&FRA, New Delhi for registration under extant category. Four bread wheat varieties namely Karan Vaidehi (DBW 370), Karan Vrinda (DBW371), Karan Varuna (DBW372), Karan Prema (DBW316) and one durum wheat variety DDW 55 (Karan Manjari) were registered by the PPV&FRA, New Delhi under extant category vide registration number REG/2023/0092, REG/2023/89, REG/2023/91, REG/2023/90, and REG/2023/93, respectively.

DUS testing in Wheat: During crop season 2023-24, six DUS trials were conducted in wheat, in which 93 coded entries (61 entries in bread wheat, 6 in durum and 26 in dicoccum) along with national checks (DBW 187, HD 2967 in bread wheat, HI 8737 and MACS 3949 in durum wheat and DDK1029 in dicoccum wheat) were tested as per the DUS test guidelines of wheat published by PPV&FRA. Each entry was sown in a 6-row plot of 6m with 3 replications. Observations on DUS characteristics on all the characters were recorded as per the prescribed guidelines. Data of all the centres *viz.* Karnal, Indore and Dharwad were compiled, analyzed and submitted to PPV&FR Authority for making decision regarding registration.

Varieties released by ICAR-IIWBR

DBW359 (Karan Shivangi): The Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops release the wheat variety DBW 359 (Karan Shivangi) for timely sown, restricted irrigated condition of Central and Peninsular zones. DBW359 gave an average yield of 41.70q/ha and 34.54q/ha in Central and Peninsular zone, respectively. It is highly resistant to leaf and stem rust.

DBW 377 (Karan Bold): DBW 377 (63.9 q/ha) has shown significant yield superiority over all the checks under three years of testing in the coordinated trials. DBW 377 has shown the potential yield of 86.4q/ha. DBW 377 is highly resistant for leaf rust under natural and artificial conditions (as evident from the lower ACI values (ACI-5.2) and resistant against stem rust (ACI-8.2). Under APR studies, it is highly resistant to the predominant races of leaf rust viz., 77-5, 77-9 and 104-2 races. The variety has shown moderate resistance against Karnal bunt (Avg. 13.4%) as compared to checks. DBW 377 has high hectoliter weight (79.5), high protein content (11.7%), good chapatti making quality (7.7/10.0) and high biscuit spread factor (8.5). The Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops released the wheat variety DBW377 for Central Zone comprising of Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh vide Gazette No. SO 1560 (E) dated 26.03.2024.

DBW327 (Karan Vaidehi) (Gazette No. SO 1560 (E) dated 26.03.2024) Area Extension: It is recommended for early sown (October 20 to November 5), high input (150% of recommended NPK) along with two sprays of growth retardants (Chlormequat chloride @ 0.2%+ tebuconazole @ 0.1% of commercial product dose at first node and flag leaf stage) under irrigated conditions in Central Zone comprising of Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh. The variety has average yield of 69.6 q/ha and potential yield of 100.4q/ha. The variety matures in 126

days and has 48 g thousand grains weight. It possess better chapatti quality score (7.9) and high Fe (39.7ppm) and ZN (40.2 ppm) Content.

Wheat varieteies identified

DBW386: DBW386 has been identified for release in the irrigated, timely sown condition of the North Eastern Plains Zone (NEPZ) by the varietal identification committee of wheat and barley in its meeting held on 7th October, 2024. DBW 386 (52.01q/ha) out yielded the check varieties DBW 222 (1.35%), DBW 187 (1.86%), HD 3086 (6.0%), PBW 826 (4.74%) and HD 3249 (1.4%). DBW 386 has yield potential of (70.6 q/ha). DBW 386 ranked 1st for two consecutive years i.e. 2021-22 and 2022-23 in breeding trials at NEPZ. DBW 386 is highly tolerant to heat stress with heat susceptible index (HSI) of 0.67 while the DBW 187 (C), PBW 826 (C) recorded HSI of 0.97 and 0.90, respectively. DBW 386 is a highest yielder in agronomical trials both under timely and late sown conditions under date of sowing experiments.

DBW443: Wheat variety DBW443 was identified for the irrigated timely sown conditions of Peninsular Zone. This variety is having an average and potential yield of 49.2q/ha and 77.6q/ha, respectively. It flowers in about 63days and matures in about 109 days. DBW443 is an indigenously developed biofortified wheat genotype having higher protein (13.4%), grain zinc (43.0 ppm) and iron (41.9ppm) This variety is having a thousand grains weight of 45g. It is resistant to wheat blast, leaf rust and brown rust diseases. DBW443 has shown low heat sensitivity index of (0.85) and drought sensitivity index (0.89) indicating better heat and drought stress tolerance. DBW443 has a hectoliter weight of 80.9kg, sedimentation value (52.9ml), high hardness index (82.7) and good chapati quality score (7.1/10).

Breeding for NWPZ

Performance of entries in AVT trials

DBW432 was tested in AVT-RI-TS in Central Zone and ranked number one in the trial. Based on its superiority in yield DBW432 was promoted to the final year testing in the AVTs 2024-25. Its performance in comparison to the checks are presented in Table 2.5.

Table 2.5: Performance of DBW432 as compared to checks in AVT-RI-TS-CZ 2023-24

Variety	Yield (q/ha)	Rank	Rust response (ACI)			
			Black	Brown (South)	Brown (North)	Yellow rust
DBW432	44.4	1	17.5	4.5	11.2	2.1
CG1040 (I) (C)	43.7	2	31.5	13	25.6	46.7
CG1036 (C)	41.8	5	9.5	4	3.9	77.8
DBW110 (C)	41.7	7	19.5	4.1	12.7	40.9
DBW 359 (I) (C)	41.8	6	15.8	13.7	16.4	6.7
HI1655 (C)	39.7	9	1.9	1.9	0.6	33.6

Performance of entries in NIVT trials

From the NWPZ breeding programme a total of eight bread wheat genotypes namely DBW449, DBW 457, DBW 4461, DBW464, DBW 467, DBW 469, DBW 470 and, DBW 474, were evaluated in the multilocation National Initial Varietal Trials (NIVT) during the season 2023-24 (Table 2.6). Out of eight NIVT entries four were promoted to the advanced varietal trials.

Table 2.6: Performance of wheat genotypes tested in various NIVTs during 2023-24

Genotype name	Tria	Promoted to	Yield (q/ha)		Rust score ACI			
			Zone 1*	Zone 2*	Bl	Br-S	Br-N	YR
DBW449	NIVT-1A	-	68.3 (13)	58.8 (11)	19.8	8.4	14.4	9.2
DBW457	NIVT-2	AVT-IR-TS CZ	59.8 (7)	53.7 (9)	14.0	8.1	19.3	12.2
DBW461	NIVT-3A	-	53.3 (21)	49.0 (11)	8.4	4.0	14.9	16.9
DBW464	NIVT-3B	-	43.6 (16)	36.6 (25)	7.5	3.3	15.0	11.8
DBW467	NIVT-5A	AVT-RI-TS NWPZ	55.5 (1)	44.6 (5)	29.8	3.0	6.1	6.0
DBW469	NIVT-5B	AVT-RI-TS-CZ	46.5 (9)	31.9 (19)	9.0	5.0	8.7	31.0
DBW470	NIVT-5B	AVT-RI-TS CZ	46.4 (10)	32.5 (16)	15.3	7.8	6.7	9.3
DBW474	NIVT-6	-	79.9 (7)	74.3 (3)	14.7	7.4	7.8	12.7

* Zone 1 and Zone 2 to are NWPZ and NEPZ respectively in case of NIVT-1A, NIVT-3A NIVT-5A and NIVT-6, and CZ and PZ in case of NIVT-2, NIVT-3B and NIVT-5B. Figures in the parentheses represent zonal rank.

Entries evaluated in station trials of IIWBR

A total of 22 entries of the breeding project were evaluated at two or more locations under various IIWBR station trials of the and one genotype RWP2079 promoted to NIVT-1B as DBW486.

Performance QCWBN, SATSN and DHTSN

Four entries in DHTSN and one each in QCWBN and SATSN were tested during 2023-24. Genotype RWP2196 from QCWBN was promoted to AVT-IR-TS-TAD-CZ as DBW509 based on quality superiority (Fe 43.5 ppm, Zn 42.7ppm, Protein 13.6%) and yield (69.6 q/ha). Performance of DHTSN entries were superior for drought and heat tolerance as indicated by the data in Table 2.7.

Table 2.7: Performance of wheat genotypes tested in DHTSN during 2023-24

Genotype	DH	DM	PH	TKW	Yield /plot	DSI	YR %	HSI	YR %
RWP1875	90	125	109	46	2249	1.01	46.6	1.15	38.9
RWP1896	91	131	105	49	2702	0.93	43.2	0.89	30.1
RWP2073	86	126	110	54	2852	1.12	52.6	0.84	28.5
RWP2077	89	126	106	52	2757	0.92	42.0	0.77	25.9

Performance of wheat genotypes in IPPSN 2023-24

Screening of station trial entries of NWPZ breeding program for various wheat rust diseases under Plant Pathological Screening Nursery (PPSN 2023-24) for three rusts of wheat which were conducted at more than 12 locations for each rust; yellow rust at sites Khudwani, Malan, Bajaura, Dhaulakuan, Almora, Jammu, Gurdaspur, Ludhiana, Karnal, Hisar, Delhi, Durgapura and Pantnagar; for brown rust (North): Jammu, Ludhiana, Karnal, Hisar, Delhi, Durgapura, Pantnagar, Kanpur, Ayodhya and Kalyani, brown rust (South) and stem rusts at Junagarh, Vijapur, Indore, Powarkheda, Niphad, Pune, Mahabaleshwar, Dharwad and Wellington. Table 2.8 presents wheat rust data average coefficients of infection (ACI) and highest score (HS) on 0-100 modified cobb scale from multilocation IPPSN 2023-24 for three rusts of wheat in 25 wheat entries.

Evaluation of advanced generation bulks

A set of 168 advanced bulks and selections from international nurseries were evaluated as preliminary yield trials (PYTs) at IIWBR Karnal Main farm(Fig. 2.1). The PYTs were conducted in three environments namely, timely sown irrigated condition, timely sown restricted irrigation and late sown irrigated conditions with augmented experimental designs. Six checks namely, DBW187, DBW296, DBW303, DBW316, PBW826, WH1270 were repeated six times in each PYT. Artificial

Table 2.8: Rust data (average coefficient of infection- ACI and highest rust score-HS) of 25 wheat genotypes under IPPSN 2023-24

SN	Name of genotype	Stem rust		Leaf (South)		Leaf (North)		Stripe rust	
		ACI	HS	ACI	HS	ACI	HS	ACI	HS
1	RWP2079	21.8	60S	1.1	5R	1.2	10MR	12.1	40S
2	RWP2080	2.7	20MS	4.7	10MR	4.0	15S	4.8	20S
3	RWP2081	15.0	60S	3.3	10MR	2.5	10S	16.8	40S
4	RWP2197	8.0	30S	5.7	50MR	8.3	30S	5.3	20S
5	RWP1062	14.2	30S	3.7	20S	10.7	40S	4	20S
6	RWP1199	9.3	40S	9.5	20S	18.3	40S	3.4	10S
7	RWP1057	22.3	60S	2.7	20MR	6.3	15S	15.4	40MS
8	RWP1131	19.3	60S	4.6	10MR	9.3	20MS	14.4	40MS
9	RWP2146	14.5	60S	2.8	10MS	3.4	20S	10.7	40MS
10	RWP2189	19.9	60S	1.7	10S	3.3	20S	18.4	40S
11	RWP1556	9.6	40MR	2.6	10S	14.8	40S	4.1	30S
12	RWP1831	14.1	40S	5.0	20S	13.7	40S	16.7	60S
13	RWP1880	13.5	40S	0.6	10MR	0.3	5MR	5.8	20S
14	BSP 2311	14.8	40S	8.3	20MR	10.4	30S	10	40S
15	RWP1549	17.8	40S	1.8	10R	6.7	30S	1.4	10MS
16	RWP1844	3.5	10S	3.1	20S	4.2	20S	1.4	10MR
17	RWP1899	2.2	10S	2.5	20MS	7.3	20MS	5.7	20S
18	RWP2060	47.5	80S	11.6	60S	0.8	5S	1.8	10MS
19	RWP2137	1.8	10MR	1.6	10S	0.3	5MR	15.2	40S
20	RWP2185	5.0	30S	1.5	10MR	1.0	10MR	8.8	20S
21	RWP2190	20.3	60S	7.5	20MS	7.4	30S	19.5	60S
22	RWP2191	11.9	30S	2.9	10R	3.8	20S	13.2	40S
23	RWP1526	1.2	10M R	1.5	10S	2.7	10S	8.6	40S
24	RWP1555	9.8	20S	4.0	20S	7.0	30S	3.4	20MS
25	RWP2068	4.0	20S	4.6	20S	4.7	20MR	13.3	40S

rust epiphytotic were created for rust screening. There was sufficient build-up of yellow and brown rust on infector rows. The PYT genotypes were also evaluated for seedling rust resistance against brown and black

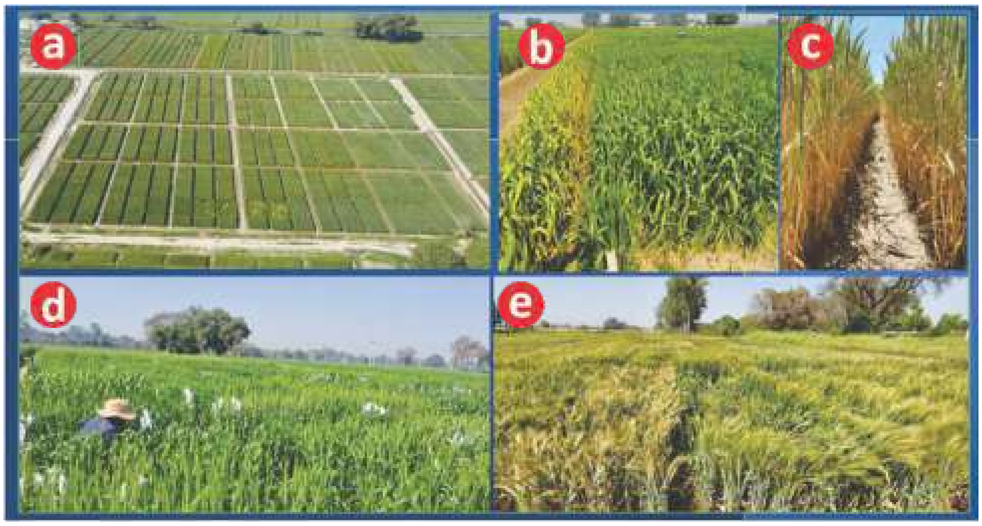


Figure 2.1: Wheat breeding activities in IIWBR field (a) evaluation of segregating materials and advanced bulks (PYTs), (b) Field screening of breeding lines against stripe rust, (c) Field screening for drought tolerance, (d) hybridization for generating new variability in wheat (e) screening for lodging and rust resistance

rusts at IARI Regional Station, Indore. Selection criteria were applied based on the following traits: grain yield (Kg/ha), the phenological characters like days to heading at 75% flowering, days to physiological maturity and plant height, yield attributing traits like tiller number per meter row length, number of spikelets/spike, grain numbers per spike, 1000-kernel weight (TKW), physiological traits like NDVI, Canopy Temperature, heat sensitivity index, drought sensitivity index, resistance to rust diseases and foliar blight. Quality parameters like grain protein content (GPC), Zn and Fe content, hectolitre weight etc. For promotions to station trials four principal criteria were grain yield, 1000-grain weight, adult plant rust resistance and maturity duration.

Evaluation and generation advancement of segregating material

Total 280 new Combinations were made using elite lines and trait specific lines at Karnal and off-season nursery Dalang Maidan. Utilization of diverse and novel rust resistance genes such as YrCK1, *Sr39, Sr65, Lr80,* TL2942 (Triticale) being undertaken in wheat pre-breeding programme. Crosses such as Lr80/HD3437, *Lr80*/CHIPAK, Lr80/HD3437//DBW296, *Lr80*/CHIPAK//*Lr80*/DBW187/3/DBW318, Lr80/CHIPAK//*Lr80*/PBW703/3/DBW318, *Lr80*/CHIPAK//DBW296, *Lr80*//2*DBW303 are in F_4 & F_5 stage. Among breeding materials, a total of 290 F1s, 440 F_2 populations, 153 F_3 populations, 86 F_4 populations were evaluated and selections were applied with SELBULK method. A total of 73 F_5 populations with more than 700 head rows were evaluated for rust resistance, agronomic and quality traits. The 300 selections from F_5s lines were evaluated (F_6) at summer nursery Dalang Maidan where screening for yellow rust resistance was done. In addition, 1780 lines of eight parent MAGIC populations were evaluated both at Karnal and offseason nursery, Dalang Maidan. Selections were made for agronomic and disease resistance traits. A total of 15 selections were included for yield evaluation in the PYT 2024-25.

Evaluation for lodging resistance

In total following seventy-one lodging resistant lines were selected from different international nurseries on the basis of morphological and disease resistance. Total 21 crosses were attempted including six recipient parents and four donor parents targeting generation of breeding material for lodging resistance. A replicated experiment was laid out for screening of 20 resistant wheat genotypes in second year. The material was subjected to both natural incidence and artificial lodging through a wind-blowing machine and data was recorded on height(cm), root depth (cm), stem width (mm), stem girth (mm), 1st, 2ndand 3rd internodes length (cm) and lodging score at vegetative and maturity stages. None of the genotype showed lodging both under natural and artificial lodging conditions.

Recommendation of foliar application of chlormequat chloride (CCC) for improving lodging resistance and grain yield in bread wheat

A study aimed to quantify the effect of growth regulator (GR) chlormequat chloride on lodging and yield attributes in the three recently released bread-wheat varieties was conducted during 2023 and 2024. The findings indicate that, lodging incidence in high yielding wheat cultivars can be successfully reduced by a single spray of GR chlormequat chloride (0.2 % Lihocin) at the first node formation stage. A single treatment of GR significantly increased the yield/plot in all three wheat varieties and the effect of the second spray on grain yield was less incremental on study genotypes. Further, there was a differential GR×genotype interaction observed in yield and yield component traits. The lodging percentage in treatments showed a significant positive correlation with plant height and negative correlation with grain yield/plot and biomass. The higher yield of genotypes with GR treatment was attributed to increased tiller number, grain numbers per spike, thousand kernel weight and less lodging.

Breeding for NEPZ

Performance of entries in AVT trials

Two wheat genotypes DBW443 and DBW426 were tested in the AVT-IR-TS-PZ and AVT-IR-LS-CZ trials in CZ and PZ, respectively (Table 2.9). Based on the superiority in yield performance and other desirable traits in respective zones, genotype DBW443 was identified by the VIC for release and DBW426 was promoted to final year evaluation in PZ.

Table 2.9: Performance of wheat genotypes tested in various AVTs during 2023-24

Trial	Entry	Yield (q/ha) PZ	Rank PZ	Rust Bl	Rust Br	Any specific trait like blast, quality
AVR-IR-TS-PZ	DBW443	46.0	10	ACI=5.6; HS=20MS	ACI=10.7; HS=20S	Biofortified genotype, heat and drought tolerant, resistant to wheat blast
AVT-IR-LS-PZ	DBW426	41.5	8	ACI=11.8; HS=30S	ACI=1.4; HS=10MR	Grain Iron: 44.2ppm, Grain Zinc: 44.5ppm, Grain protein: 13.1%

Performance of entries in NIVT trials

During 2023-24, five genotypes were evaluated in different NIVTs, out of which DBW448, DBW460 and DBW466 were promoted to next year of evaluation under different trials. Specific traits of the different genotypes are given in Table 2.10.

Performance of entries in common station trials (promotion to NIVTs)

During 2023-24 crop season, 20 wheat genotypes were contributed towards different IIWBR station trials which were conducted across different locations in different zones. Based on superior performance in yield coupled with disease resistance in station trials, eight wheat genotypes were contributed to different NIVTs *viz*., NIVT-1A: DBW482, NIVT1B: DBW484, NIVT-2: DBW489, NIVT-3A: DBW491, DBW492; NIVT3B: DBW497; NIVT-5A: DBW498; NIVT-6: DBW504.

Table 2.10: Performance of wheat genotypes tested in various NIVTs during 2023-24

Trial	Entry	Yield (q/ha)		Rust	Any specific trait like blast, quality
		NWPZ	NEPZ		
NIVT-1A	DBW448	72.4	51.9	Br (ACI=16.0; HS= 70S), Yl (ACI=9.9; HS=40S),	Resistant to wheat blast
NIVT-3A	DBW460	57.9	47.9	Br (ACI=3.3; HS= 15S), Yl (ACI=12.2; HS=40S)	Grain protein: 12.3%
NIVT-5A	DBW466	54.4	39.5	Br (ACI=7.0; HS= 40S), Yl (ACI=8.7; HS=40MS)	
		CZ	**PZ**		
NIVT-2	DBW456	57.6	47.8	Bl (ACI=20.5; HS= 40S), Br (ACI=8.7; HS=20S)	Grain protein: 12.1%
		NWPZ	**CZ**		
NIVT-6	DBW473	77.6	66.8	Yl: (ACI=11.8; HS= 40S), Br (ACI=7.8; HS=40S), Bl (ACI=4.3; HS=20S)	Grain protein: 12.0%

Evaluation of breeding materials in different generations

During the crop season 2023-24, one hundred five crosses were attempted including three/ four-way crosses. A total of 120 F_2, 186 F_3, 158 F_4, 120F_5 and 190 F_6 populations with more than 1000 progeny rows and 185 diverse selections were evaluated for yellow rust reaction. Based on visual selection for plant type and disease resistance selections were made in different filial generations. Generation advancement was undertaken at wheat summer nursery facility Dalang Maidan during summer 2023 and 49 new crosses were also attempted.

Development of Spot Blotch-Resistant Wheat Lines for the North-Eastern Zone

Spot blotch, a major disease affecting wheat production, is particularly prevalent in the north-eastern zone of India. To address this issue, lines resistant to spot blotch were developed using material derived from the cross BH1146 × HD2967. The resulting population is in the BC_2F_6 generation, and efforts are focused on phenotyping these lines to identify promising candidates. These lines were evaluated across multiple hotspot locations, including Kanpur, Kalyani, and Karnal, to assess resistance and agronomic performance. A specific QTL, *Qsb.iiwbr-7B*, known to confer resistance to spot blotch, was introgressed into the lines, and phenotypic data were collected.

Phenotypic Evaluation

The phenotypic evaluation focused on several key traits, including heading and maturity days, plant height, 1000-grain weight, and grain yield per plot. The data were collected from three hotspot locations, and the results are summarized in the Table 2.11.

- **Kanpur**: Lines showed significant variability in grain yield, ranging from 123 g to 459 g per plot, with an average 1000-grain weight of 33.96 g. Spot blotch scores ranged from 0 to 47, indicating varying levels of resistance.

- **Kalyani**: Grain yield was slightly lower, ranging from 190 g to 272 g per plot, with an average 1000-grain weight of 34.85 g. Resistance to Spot blotch was moderate to high.

Table 2.11: Performance of spot-blotch resistant lines at three hot-spot locations

	LB	Br	Heading (days)	Maturity (days)	Plant height	1000-grain Weight (g)	Grain Yield/plot (g)
Kanpur							
Average		00-20 S	80.86	124.91	101.9	33.961	266.63
Range	0 0-4 7		74-87	118-130	72-129	24-43	123-459
Kalyani							
Average			60.7	100.08	85.038	34.846	232.11
Range	23-4 8		58-63	98-102	82-89	32-37	190-272
Karnal							
Average			92.6	136.47	107.65	41.1-44	391.33
Range	12-48		84-101	135-140	67-134	36-51	255-514

- **Karnal**: Lines exhibited higher grain yield, ranging from 255 g to 514 g per plot, with an average 1000-grain weight of 41.1-44 g. This location highlighted the superior agronomic performance of certain lines under high disease pressure.
- The phenotyping of introgressed lines for spot blotch resistance across diverse agro-climatic conditions has led to the identification of promising genotypes. Lines with resistance alleles at ***Qsb.iiwbr-7B*** and favorable agronomic traits have been identified for further breeding programs. These resistant lines will contribute significantly to improving wheat productivity in the spot blotch-prone north-eastern region, ensuring sustainable wheat cultivation.

Evaluation of material for wheat quality

Quality data of samples under the project entitled breeding wheat genotypes for high productive areas of eastern region. 80 advance wheat genotypes were evaluated for few quality traits like protein (%) at 12% moisture level, hectolitre weight (Kg/hl), sedimentation value (ml).

Anticipatory breeding programme for mitigating threat of wheat blast disease

Different crosses have been attempted with the identified sources of wheat blast resistance for incorporating wheat blast resistance in the breeding material. However, the final evaluation will be done at the station trial level with the help of CIMMYT, Mexico in Bangladesh and Bolivia.

Contributions for Segregating Stock Nursery (SSN)

During crop season 2023-24, 15 F_3 's were contributed towards segregating stocks nursery and selections were exercised by the co-operators. Similarly, 15 F_2s were contributed during 2024-25 crop season.

Breeding for warmer areas

Performance of entries in AVT trials

During *rabi*, 2023-24, entry DBW422, was evaluated under AVT-LS-NWPZ first year trial, whereas DBW425 was evaluated under AVT-LS-CZ & PZ and DBW428 under AVT-RI-CZ. The entry DBW422 ranked first in NWPZ with mean grain yield of 54.3 q/ha. and the entry DBW425 ranked 2nd in CZ with mean grain yield of 48.1 q/ha. The yield and rank of the entries with the best checks are presented in Table 2.12.

Performance of entries in NIVT trials

During *rabi*, 2023-24, five entries, namely DBW450, DBW451, DBW453, DBW459 and DBW471 were evaluated under different NIVTs (Table 2.13). Entry DBW459 was found promising and was promoted for AVT first year evaluation.

Performance of entries in common station trials

Twenty-two entries were evaluated in IIWBR Station

Table 2.12: Details of the entries tested in AVT trials during 2023-24

Trial	Entry	Yield (q/ha)	Rank
AVT-IR-LS-NWPZ	DBW422	54.3	1
	JKW261 (c)	53.5	3
AVT-IR-LS-CZ	DBW425	48.1	2
	HD2931 (c)	46.6	4
AVT-IR- LS- PZ	DBW425	44.8	3
	HD3090 (c)	38.2	7
AVT-RI-CZ	DBW428	39.5	10
	CG1040	43.7	2

Table 2.13: Details of the entries tested in NIVT trials during 2023-24

Trial	Entry	Yield (q/ha)	
		NWPZ	**NEPZ**
NIVT-1A	DBW450	69.2 (8)	65.9 (5)
NIVT-1B	DBW451	68.7 (13)	47.3 (29)
	DBW453	67.4 (17)	49.5 (17)
NIVT-3A	DBW459	58.9 (2)*	47.3 (15)
Trial	**Entry**	**NWPZ**	**CZ**
NIVT-6	DBW471	47.3 (22)	59.2 (18)

Table 2.14: Entries tested in the Station Trials and promoted to NIVTs

S.No	Entry	Trial Series	Promotion	NIVT code (2024-25)
1	WAP2303	ST1	NIVT 1A	DBW478
2	WAP2301	ST1	NIVT 1A	DBW480
3	WAP2306	ST1	NIVT 1A	DBW481
4	WAP2304	ST1	NIVT 1B	DBW487
5	WAP2312	ST3	NIVT 3A	DBW493
6	WAP2315	ST4	NIVT 5A	DBW499
7	WAP2301	ST5	NIVT 6	DBW506
8	WAP2318	ST5	NIVT 6	DBW507

Trials (2023-24) and eight promising entries were promoted to the different NIVTs (Table 2.14).

Performance of entries in DHTSN

Entries WAP2319 and WAP2314 were evaluated in DHTSN during 2023-24 at four locations (Table 2.15). Entry WAP2319 was tolerant to both stresses whereas WAP2314 is tolerant to heat stress.

Performance of entries in IPPSN:

Six entries namely, WAP2211, WAP2322, WAP2323, WAP2324, WAP2325, and WAP2326 were contributed to IPPSN for evaluation for resistance against stem rust, leaf rust and stripe rust. The IPPSN was conducted at 13 locations for yellow rust, 10 locations for brown rust (N) and 9 locations for leaf rust (S) and stem rust. The data from these centres revealed that genotypes WAP2211, WAP2323, and WAP2325 are resistant to leaf rust whereas entry WAP2324 is resistant to stripe rust. The ACI and HS for these entries is given in Table 2.16.

Table 2.15: Performance of entries in DHTSN 2024

Entry	DSI	HSI	Entry	DSI	HSI
WAP 2319	0.91	0.74	GW322	0.88	1.13
WAP 2314	1	0.91	NIAW3170	0.75	0.72
Checks			RW5	0.92	1.01
DBW187	0.86	1.02	WH730	1.07	0.7
DBW296	0.94	0.89			

Table 2.16: Performance of entries for rust resistance in IPPSN 2023-24

S. No.	Name	Stem rust	Leaf rust (S)	Leaf rust (N)	Stripe rust				
		ACI	HS	ACI	HS	ACI	HS	ACI	HS
1	WAP2211	9.1	30S	3.2	10MR	1.33	10MS	12.6	40S
2	WAP2322	9.3	30S	2.1	10MS	9.33	40S	7.9	40S
3	WAP2323	9.8	20S	0.9	S10	1.17	5MR	5.4	20MS
4	WAP2324	3.3	20S	5.3	20MS	10	20S	1.2	5S
5	WAP2325	4.5	30S	0.7	10MR	2	10MS	3.9	10S
6	WAP2326	10.3	40S	12	20S	25	40S	1.8	20MS

Performance of entries in PYT trials

During *rabi*, 2023-24, 195 entries (F6 and exotic) were evaluated with 05 checks, namely DBW222, DBW327, DBW371, DBW372, and PBW872. Twenty-one promising entries were contributed for IIWBR station trials (2024-25). In addition, 05 genotypes (HTW2401, HTW2402, HTW2403, HTW2404 and HTW2405) were selected for contribution to DHTSN (2024-25).

Promotion of entries in WAP PYT trials (2023-24)

Out of the breeding materials (indigenous and exotic) grown during *rabi*, 2023-24, 129 promising advance bulks were promoted for PYTs (2024-25) along with five checks, namely DBW222, DBW327, DBW371, DBW372 and PBW872 and have been planted under irrigated and restricted irrigation conditions for promotions to IIWBR Station Trials (2025-26).

Evaluation of breeding material in different generations

During *rabi*, 2023-24, a total of 1017 breeding lines/progenies of different filial generations were grown. Out of which the selections were made on the basis of yield, rust resistance and grain traits. A total of 116 crosses were attempted (Table 2.17).

Table 2.17: Details of the breeding materials grown and selected during rabi, 2023-24

Generations	Evaluated lines	Selected lines
F_1	105	53
F_2	216	125
F_3	343	202
F_4	128	96
F_5	143	47
F_6	82	34
Total	**1017**	**557**

Contributions for Segregating Stock Nursery (SSN):

Harvested seed of 23 F2 crosses grown during *rabi*, 2023-24 were supplied to coordinating centres through SSN for enriching diversity and strengthening breeding programs.

Experiments on heat and drought stresses

During *rabi*, 2023-24, 88 genotypes were evaluated under rainfed and irrigated conditions with four checks, namely C306, DBW110, DBW296 and NIAW3170, while a set of 72 genotypes, including checks was evaluated under timely and late sown conditions. The data recorded for grain yield components and physiological traits are given in Table 2.18.

Rust SRT analysis

During the year 2023-2024, 87 wheat genotypes were screened against 5 pathotypes of leaf rust (12-5, 77-1, 77-5, 77-9, and 104-2) and stem rust (11, 21A-2, 40A, 117-6 and 122). Among these seventeen genotypes were resistant to all the pathotypes of stem rust and six genotypes were resistant to all the pathotypes of leaf rust pathogen. One genotype conferred resistance to all the pathotypes of stem and leaf rust pathogens.

Breeding for Quality Improvement

Evaluation of breeding materials in different generations:

During the year 2024, a total of 75 new cross combinations were made for different quality traits in bread wheat (Table 2.19-2.22). Targeted crosses have been attempted to improve grain protein content, high sedimentation value, high iron and zinc and high bread loaf volume in bread wheat.

20 promising lines from PYTs have been contributed to IIWBR Station trials 2024-25. Six lines to station trial 1; 04 lines to ST-4 and ST5 and 03 lines to ST2 and ST3 have been contributed for muli-location evaluation and IPPSN 2024-25

Experimental details:

The biological nitrification inhibitor trait (BNI) inhibits nitrification activity, which enhances uptake of nitrogen and improves assimilation of ammonium in wheat. Three wheat genotypes with the BNI trait, as well as commercial cultivars DBW187, DBW303, and DBW371,

Table 2.18: Mean statistics for grain yield components and physiological traits in heat and drought stress experiments

Trait	Heat Experiment		Drought Experiment	
	TS	LS	TSIR	TSRF
TKW(g)	36.38±0.75	31.26±0.60	34.48±0.58	42.44±0.49
YIELD (g)	529.08±16.59	316.06±10.67	385.47±13.38	362.98±10.95
NDVI 1	0.74±0.00	0.65±0.01	0.68±0.004	0.58±0.01
NDVI 2	0.60±0.01	0.47±0.01	0.61±0.01	0.45±0.01
CT 1	22.60±0.29	22.09±0.29	22.93±0.24	24.15±0.12
CT 2	29.22±0.19	34.79±0.18	27.31±0.25	28.41±0.18
CMS	67.95±1.82	56.49±2.26	66.66±1.84	72.38±1.78
RWC	85.84±1.24	65.59±1.92	83.11±0.98	82.29±1.06
Fv/m	0.705±0.006	0.646±0.01	0.687±0.006	0.699±0.007
Promising genotypes	DBW150, PPYT21-22-75, PPYT21-22-84, CG1029, 20HTWYT-2(78)		WCF 12-16, WCF 12-7, EC 531185, 20HTWYT-48 (89), 20HTWYT-25 (84), 29SAWYT-334 (376), 29SAWYT-341 (394), PPYT21-22-83, PPYT21-2284, PPYT21-22-114, PPYT21-22-91	

Table 2.19: Performance of entries in AVT trials:

Trial	Entry	Yield (q/ha)	Any specific trait like blast, quality	Remarks
AVT-IR-TS-NWPZ	DBW477	61.9	Highly Resistant against Yellow Rust	Promoted to AVT Final Year
	DBW476	60.0	Highly Resistant against Yellow Rust	-
	DBW88 (C)	60.9		

Table 2.20: Performance of entries in NIVT trials

Trial	Entry	Yield (q/ha)		Rust	Any specific trait like blast, quality
		NWPZ	NEPZ		
NIVT1A	DBW447	66.4(17)	61.7(3)	Yl 40S(15.0); Br 20S(7.5)	Resistance against blast
	DBW187(C)	69.2(7)	63.7(1)		
NIVT1B	DBW454	69.6(7)	51.4(13)	Yl10(3.8) 20S(5.0)	Resistance Against blast
	DBW455	70.6(4)	48.7(19)	Yl 10S(3.3), Br40S(10.0)	Resistance against blast Promoted to AVT-I NWPZ
	HD3086 (C)	70.2(5)	52.9(7)		
NIVT3A	DBW458	56.4(9)	49.6(8)	Yl 5S (0.8) Br10S5.0	Promoted to AVT-I NEPZ
	PBW771 (C)	57.6(8)	50.1(6)		
	HI1563 (C)	43.5(35)	49.3(9)		
NIVT5A	DBW468	49.7(16)	47.5(3)	Yl tS(0.2)Br 10S(2.5	-
	NIAW3170 (C)	51.0(12)	39.5(18)		
	HI1612 (C)	48.4(17)	48.0(2)		
NIVT6	DBW472	73.9(16)	49.9(25)	Yl 20MS	-
	DBW327 (C)	83.9(2)	75.0(2)		

*Rank with in parenthesis

Table 2.21: Performance of entries in common station trials (promotion to NIVTs)

SN	Entry	Trial	Pedigree
1	DBW494	NIVT3A	SOKOLL/3/PASTOR//HXL7573/2*BAU/4/2*PASTOR//HXL7573/2*BAU/3/ SOKOLL/WBLL1/5/BORL14
2	DBW503	NIVT5B	KOKILA/BOKOTA/8/ATTILA/3*BCN//BAV92/3/TILHI/4/SUP152/5/SUP152/6/KFA/2*KACHU/7/ ATTILA /3*BCN//BAV92/3/PASTOR/4/TACUPETOF2001*2/BRAMBLING/5/PAURAQ/9/ATTILA/ 3*BCN// BAV92 /3/TILHI/4/SUP152/5/SUP152/6/KFA/2*KACHU/7/ATTILA/3*BCN//BAV92/3/PASTOR/4/TACUPETO F

SN	Entry	Trial	Pedigree
3	DBW502	NIVT5B	SUP152/FRNCLN//KUTZ
4	DBW501	NIVT5A	TC870344/GUI//TEMPORALERA M87/AGR/3/2*WBLL1 /4/SOKOLL/WBLL1/8/ATTILA*2/PBW65/5/CNO79//PF70354 /MUS/3/PASTOR/4/BAV92/6/KINGBIRD #1/7/COPIO

Table 2.22: The details of different filial generation

Filial Generation	Number of crosses/families	Remarks	Number of plants/lines selected
F2	84	Selected Bulk	350
F3	763	SPS	665
F4	129	SPS	103
F5	91	SPS Carried out	82
F6	102	Bulk	48 lines selected for PYT

were assessed for various agro-morphological traits at 0%, 50%, 75%, and 100% of the recommended nitrogenous fertilizer. It was observed that traits such as spike length, length and width of flag leaf, biomass, harvest index, protein composition and grain yield, and nitrogen balance index (NBI) significantly decreased at lower nitrogen levels. The NBI, in conjunction with these traits, could be utilized to identify desirable plant types in the subsequent generations under low nitrogen conditions. The initial five principal components were found to account for 90.6% of the variability in the principal component analysis. The genotype by trait biplot's polygonal view revealed that NBI has a higher impact on BNI-derived lines. Following the assessment, BNI-Munal was recognized as a promising parent for integrating the BNI trait into the released varieties (DBW187, DBW222, DBW252, DBW110, and DBW303) used in the crossing programme. Several promising lines were identified in the F_4 generation grown with 50% of the recommended nitrogen dose using the genome-specific molecular marker 24_s81287. Additionally, a breeding strategy is proposed to incorporate the BNI trait, aiming to reduce the nitrogen requirement of wheat crops.

Strategic research for improving biotic stress

- 52 new crosses were made during 2023-24 season. 27 crosses during 2024 off season.
- Traits targeted were yellow rust and KB resistance.
- A set of wheat germplasm lines was constituted and is being screened against major fungal pathogens (rusts, KB, PM).
- Two entries (DBW445* & DBW452) were promoted to SPL-HYPT (CZ) and AVT-IR-(NEPZ).
- Six entries; DBW479 (1A), DBW483 (1B), DBW485 (1B), DBW490 (2), DBW495 (3A) and DBW496 (3B) were promoted to NIVTs.
- 16 entries (BSP2401 – BSP2416) are being evaluated in station trials 2024-25.
- Four genotypes (BSP2416 – BSP2420) were contributed to national nurseries 2024-25.
- A set of 752 germplasm was evaluated against KB for resistance under artificial inoculations in field conditions.
- Of the 752 genotypes 5% were classified as highly resistant (HR), 2% resistant, 3% moderately resistant (MR), 8% moderately susceptible (MS), 12%susceptible (S) and 70% highly susceptible (HS) during the crop season 2023-24.
- Out of 268 genotypes selected, 1% highly resistant (HR), 5% resistant, 4% moderately resistant (MR), 17% moderately susceptible (MS), 19% susceptible (S) and 54% highly susceptible (HS) genotypes were identified.
- 50 specific SSR markers known to be associated with KB resistance are being used for genotyping the set.

Breeding for early maturing and short duration wheat genotypes

The project has been started from January 2023 and we screening of around 500 genotypes selected from the trials viz., ST-5, ST-4, NIVT-6A, NIVT-5A, Spl HYPT, AVT-RI, ST-1, DHTSN, DHTST, NIVT-1A, NIVT-1B, AVT-TS, PYT-NEPZ, AGG, Zinc Mainstream, IPPSN, EPC trials. The data recorded for the traits i.e., days to heading, days to anthesis, diseases, chlorophyll content, days to maturity, grain filling duration, TKW, biomass, tillers/p, spikelets/spike, grain/spike and NDVI during the season. Based on the preliminary evaluation, the promising lines were observed for early maturing: HI 1690, QYT 2203, HI 1672, HI 1674, BBP-MABB-41, HI 1675, GW 512, PBS-2022-1, HI 1670, WH 730, HI 1673, WH 730, RAJ 3765. These genotypes were further tested for root traits. Besides molecular markers analysis of *Vrn* and *Ppd* genes. The lines further sown in the field for evaluation in replicated trials during the season 2024-25. During the crop season, 2024-25, the sixty-one (61) new cross combinations were made using parents, WR 544, DBW 14, Sonalika, Halna, Raj 3765, Lok 1, HI 1675, PBW 757, Raj 4014, Raj 3765, HD 2932, HD 3090, GW 366, GW 513, WH 147, HI 1668, DBW 408, PBW 925, HI 1690, GW 553 & DBW 370 for target traits. Besides, generation advancement & eleven corrective crosses in Off-season at ICAR-IIWBR-RS, Karnal. The new cross combinations were sent to Off-season, Dalang Maidan, HP for generation advancement. The F_2 received from Off-season, Dalang Maidan, HP were sown in the main season during 2024-25.

During the season, again 298 wheat germplasm was screened for the target traits. The data recorded for the traits i.e., days to heading, days to anthesis, diseases, chlorophyll content, days to maturity, grain filling duration, TKW, biomass, tillers/p, spikelets/spike, grain/spike and NDVI during the season. The promising lines for the early maturity are 14th HZWYT 435, ST 417, ST- 409, ST- 413, ST- 424, ST- 404, ST- 425, ST- 407, ST- 410, NW 303, ST- 420, ST- 403, NW 310, GSF 429, PYT-1 F 610, NW 309, HI 1669, Lok 79 and PYT-1 F 626. These promising lines were further sown during the season for seed multiplication.

Besides, further analysis of selected genotypes selected base on first year observations, the molecular markers (*Vrn, Ppd* genes) is underway for further confirmation of earliness in these selected genotypes. Also, the range of root architecture traits recorded in twenty- four genotypes which are early in maturity and variable were root length (cm), surface area cm^2, root volume (cm^3), root average diameter (mm). The contrast wheat genotypes (DHTSN 13 and ST 506) for root traits has been identified. The result shows that root length is showing highly significant correlation (<.0001) with root surface area (r+ 0.875) and root volume (r+ 0.717); however, with days to maturity the correlation was positive (r= 0.445).

Pre-Breeding

Pre-breeding for wheat improvement

The variability now a day has become of utmost importance as the efficiency and effectiveness of selection is directly correlated to it. Under era of climate change, pre-breeding becomes a tool for diversifying the gene pool and creating genetic variability in wheat. The reports are showing that wild gene pool can provide this diversity through wide hybridization. The non- conventional sources such as primary and secondary gene pool of wheat are being used to introgress the desirable genes into the agronomically promising varieties.

Around 450 crosses including backcrosses were attempted during the reporting period. The genotypes like Highbury, Pavon 76, Paragon, Frontana, *Sphaerococcum* and *Aegilops mutica* were used emphasizing specific traits. These have high canopy, early growth, head scab tolerance, high photosynthetic rates and hence were crossed with agronomically superior varieties to introgress these traits. Some promising cross combinations in advance stage are Highbury/*Ae.mutica*//DBW88 (High Canopy, early growth); Pavon 76/HD3086, Paragon/GW322 (heat tolerance); Frontana/ WH1105/HD2967 (Head scab and Wheat blast resistance); *T. urartu* /HI8498 (*aestivum* type with high photosynthetic rate) and one line Paragon / WB 2//WH 1105 has been included into station trial.

Use of *Thinopyrum bessarabicum* for abiotic stress and biofortification:

Thinopyrum sp is known for abiotic tolerance, particularly heat and salinity. Keeping this in view, the eight accessions were evaluated and used to introgress the desirable traits into well adapted varieties of bread and durum wheats. Similarly, S. *anatolicum* was also used for transferring biofortified traits. Important cross combinations were identified for for abiotic stress and biofortification are presented in Table 2.23.

Sixty new crosses were attempted for introgression of drought and heat tolerance involving *Aegilops peregrina, Ae. ovata, Ae. geniculata, Ae. tauschii* and

Thinopyrum (Fig. 2.2). Eighty-seven F_1s were raised and back crossed. More than 2500 lines at different filial stage (F_3 –F_5) were raised and selections made. Hundred and forty-four introgressed lines were evaluated under restricted irrigation.

Table 2.23: Important cross combinations were identified for abiotic stress and biofortification

Cross Name	Protein content %	Fe (ppm)	Zn (ppm)
Chinese Spring /*Thinopyrum bessarabicum*	16.0	50.2	65.0
Thinopyrum bessarabicum/HD2967	17.2	48.8	80.5
T. turgidum L. cv. Chinese Spring/*Thinopyrum bessarabicum*// *2 DBW 110	17.3	50.0	65.4
Thinopyrum bessarabicum /ICARSHA (durum)	15.0	52.0	63.6
Chinese Spring/ *S. anatolicum*	18.00	62.9	75.9
Pavon 76/*Ae. mutica*	17.9	45.1	60.1
DBW 187	13.7	37.6	35.6
HD 3086	12.3	40.6	35.9

Evaluation of wild introgressed lines under temperature-controlled conditions

Sixteen lines were evaluated for heat tolerance under temperature-controlled phenotyping facility (TCPF). Six lines were identified promising under high temperature (Table 2.24). The pedigree of these lines involved *Ae. compactum, Thynopyrum bessarabicum, T. dicoccoides* and *Ae. tauschii*.

Table 2.24: Performance of Introgressed lines temperature-controlled conditions

Entry	Pedigree	Heat susceptibility index (HSI)	
		GY	TGW
SS12005	*Ae. compactum* (72) / K1213/ WH1105	0.92	0.96
SS12007	PBW698 / *Th. bessarabicum* (EC787010)	0.96	0.86
SS12136	DBW-39 / EC 787012 Azaziah/ *Th. bessarabicum*/ PBW 703	0.98	0.72
SS12255	PBW712 / EC 787007 Langdon/*Th. bessarabicum* /PBW 725	0.93	0.76
SS12493	*T. dicoccoides* / WH1105/WH 1105/WH 1105	0.90	0.99
SS12526	AKDW289 / *Ae. tauschii* / HD 3086	0.86	0.91

Evaluation of wild accessions for heat, drought and combined stress:

One hundred and fifty genotypes comprising of *Aegilops tauschii* (DD), *Ae. Peregrina* (UUSS), *Triticum dicoccoides* (AABB), and synthetic hexaploids (AABBDD) were evaluated under timely sown irrigated (normal – non stress), timely sown drought (drought stress), late sown irrigated (heat stress) and late sown rainfed (heat and drought stress) for 2nd consecutive year for validation of tolerance to heat, drought and combined stress using physiological and grain traits. Of total accessions evaluated, 14 were tolerant to heat, 28 to drought and 26 to both drought and heat stress (Table 2.25).

Table 2.25: The accessions tolerant to heat, drought or both stresses

Species	Drought (under ROS)	Heat (LSIR)	Combined (LSRF)
Aegilops tauschii	**3806,3753, 3769**, 9803	14578	**3753**, 9822, 13764, **9803**, 3744, 3784, 3761, 13780 9785, 14338, 9798
Ae. peregrina	PI 604172	PI 604186	EC-573331, PI 604176, PI 604169, PI 604192, PI 604186, PI 604147
T. dicoccoides	**102, 103**	**102, 103,** 13993	**103**
Synthetic hexaploids	2, **15**, 16, 45, 54,**63**, 72	1, 2, 7, 13, **15**, 16, 20, **21**, 22, 23, 26, 28, 38, 39, **41**, 48, 51, 54, 61, **63**, 64, **76**, 82	13, **15**, 17, **21, 41, 63, 76,** 88

**Accessions number in bold represent tolerance to more than one stress.*

Accessions with tolerance against multiple stress conditions were identified. Accession 3753 and 9803 of *Aegilops tauschii* was tolerant to drought and combined heat and drought stress, Accession 103 of *Triticum* *dicoccoides* was tolerant to all the stresses. Five synthetic hexaploid lines were tolerant to multiple stresses.

Biofortification: Fe and Zn content were determined in these accessions grown under normal and stressed conditions. The iron and zinc content were higher in accessions of *Ae. peregrina* and *Ae. tauschii* under all the sowing conditions.

Developing RILs for quality traits:

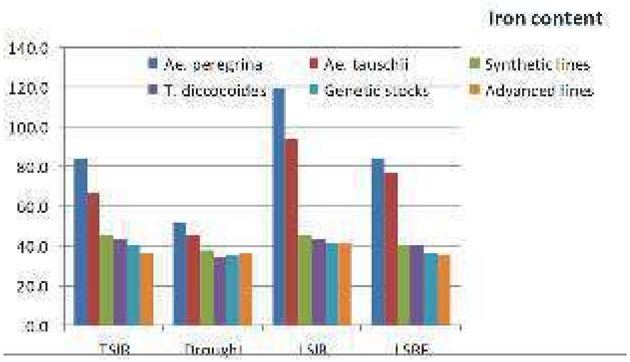
Under pre-breeding four RIL populations are being developed and advanced (Table 2.26). This year's harvest will be submitted to the GRU unit.

Contribution to SSN

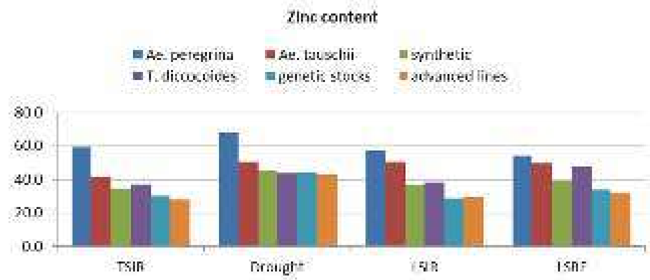
Keeping in view the importance of cooperating centres, the 15 F_2 were shared with cooperators to strengthen their breeding program (Table 2.27). These were having non-conventional parents where normal crossing is not possible.

Drought and heat tolerance in introgressed lines:

Eight introgressed lines were contributed to DHTSN



a



b

Fig.2.2 Grain iron content (mg/kg) (a) and grain zinc content (mg/kg) (b) in wild accessions, synthetic hexaploids, genetic stocks and advanced breeding lines.

Table 2.26: Details of four advanced RIL populations for quality traits

S.N.	Name of crosses/populations	Generation	No of lines	Purpose
1	Chinese Spring/ *S. anatolicum* (p201/142) // DBW187	F_6	241	Iron + Zinc+ Protein
2	Pavon 76/*Ae. mutica*//HD 3086	F_6	270	Zinc + Protein
3	Triticale/*T. dicoccum*//DDW 47 (F4 :23-24)	F_5	303	Protein + Quality Trait
4	Israna/HD2967//WH1105	F_5	307	Grain Quality & Size

Table 2.27: Details of segregating populations contributed to SSN 2023-24

S.N.	Code	Pedgree
1	PBS-SSN-23-1	*T.spelta* / HD3086
2	PBS-SSN-23-2	*T. spheearococcum* / WH1105
3	PBS-SSN-23-3	*T. sphearococcum* / DBW187
4	PBS-SSN-23-4	*Ae. compactum* / DBW303
5	PBS-SSN-23-5	Chinese spring /*S. anatolicum*// HD3086//PAVON 76/Ae.mutica// DBW187
6	PBS-SSN-23-6	Kundermiki /GDW929//HI8737
7	PBS-SSN-23-7	*T. dicoccum*/ WH1105
8	PBS-SSN-23-8	Karim/*Th. bessarabicum*//WH1105
9	PBS-SSN-23-9	FRONTANA /WB-2
10	PBS-SSN-23-10	HIGHBURY/ *S. anatolicum* // WH1105
11	PBS-SSN-23-11	Sphearococcum/ DBW222
12	PBS-SSN-23-12	Vovilovy /DBW 303
13	PBS-SSN-23-13	DBW 252 / D.DRY
14	PBS-SSN-23-14	DBW 222/ ISRANA
15	PBS-SSN-23-15	SUMAI-3/ WH1105

during 2023-24 which was conducted at Dharwad, Hisar, Karnal, Junagadh, and Pusa (2.28). Five of these lines were found tolerant. Two of these were tolerant to heat and drought stresses, two to heat and one to drought stress.

Table 2.28: Performance of introgressed lines in DHTSN 2024

Entry	Pedigree	DSI	HSI
HTW 2312	DBW39 /*Ae. speltoides*	0.94	0.79
HTW 2304	*Ae. tauschii*/4* HD2967	0.99	0.8
HTW 2309	PBW698 / *Th. bessarabicum*	1.0	0.99
HTW 2305	SYN224/3*WH1105	1.07	0.9
HTW 2307	*Ae. compactum*/K1213/2*WH 1105	0.96	1.13
Checks			
DBW187		0.86	1.02
DBW296		0.94	0.89
GW322		0.88	1.13
NIAW3170		0.75	0.72
RW5		0.92	1.01
WH730		1.07	0.7

DSI= Drought Susceptibility Index, HSI= Heat Susceptibility Index, Values < 1.0 = tolerant

Leaf and stripe rust resistance in wild introgressed lines:

Eight entries namely, 15003, 15005, 15007, 15009, 15010, 15004, 15006, and 15008 were contributed to IPPSN for evaluation for resistance against stem rust, leaf rust and stripe rust. The IPPSN was conducted at 13 locations for yellow rust, 10 locations for brown rust (N) and 9 locations for leaf rust (S) and stem rust. The data from these centres revealed that genotypes 15004 and 15006 are resistant to both leaf rust as well as stripe rust (Table 2.29) whereas entries 15005, 15007 and 15009 are resistant to stripe rust only. The ACI and HS for these entries is given in Table 2.30.

Table 2.29: Introgressed lines resistant to leaf and stripe rust

Entry	Pedigree	Leaf rust (S)		Leaf rust (N)		Stripe rust	
		ACI	HS	ACI	HS	ACI	HS
15004	DBW-39 / EC 787012 Azaziah/Th.bessarabicum/PBW 703	2.2	10S	3.13	20MR	10.2	20S
15006	PBW-712 / EC- 707814 CS/Th.bessarabicum/WH 1105	3.4	10MS	0.73	5MS	1.2	10MS

Table 2.30: Introgressed lines resistant to stripe rust

Entry	Pedigree	Stripe rust(N)	
		ACI	HS
15005	PBW698 /Ae speltoides/WH 1105	3.9	10S
15007	Ae. tauschii / HD-2967/HD 2967	2.9	10MR
15009	DBW-39 / EC787009 /PBW 725	2.8	10MS

Identification and development of wheat genotypes with higher Radiation use efficiency

A diverse set of 37 wheat genotypes (Amphidiploids and Double Haploid crosses) along with six checks (DBW187, DBW222, DBW303, HD3086, HD3226 and WH1105) was screened for identification of lines with higher radiation use efficiency during *Rabi* 2023-24. Data with canopy analyzer, InfraRed Gas Analyzer (IRGA), NDVI, SPAD and Infrared thermometer were recorded in all the lines for the identification of genotypes with higher RUE. A significant level of variation has been identified among the screened material for various traits (Table 2.31). Four wheat lines were identified for higher RUE based on one year data and need to be revalidated during 2024-25.

Table 2.31: Level of variation identified among the screened material for traits related to radiation use efficiency

Trait	Mean	Minimum	Maximum
A (Net CO_2 assimilation) µmol m^{-2} s^{-1}	34.99	12.9	61.6
gs (Stomatal Conductance) mmol m^{-2} s^{-1}	108.9	24.0	297.0
E (Evapotranspiration) mmol H_2O m^{-2} s^{-1}	2.51	0.60	5.0
VPD (Vapour Pressure Deficit)	2.40	1.9	2.8
WUE (Water Use Efficiency)	15.71	8.0	43.8
LA (Leaf Area) cm^2	5.31	2.97	8.0
CT (Canopy Temperature)	24.32	21.5	26.9
NDVI (Normalized Difference Vegetation Index)	0.65	0.41	0.82
SPAD (Chlorophyll Content)	43.0	31.1	57.2

Screening and identification of pre-breeding material with superior physiological traits

A set of 50 wheat genotypes including six checks (DBW187, DBW222, DBW303, HD3086, HD3226 and WH1105) was screened for superior physiological traits during *Rabi* 2023-24 to identify physiologically superior genotypes/lines. Plant traits such as plant growth and vigour (recorded with NDVI), chlorophyll content (SPAD), canopy temperature (CT) was recorded at different phenological stages. A significant level of variation has been identified among the screened material (Table 2.32).

Table 2.32: Variations observed for physiological traits

Trait	Maximum	Minimum
NDVI (Normalized Difference Vegetation Index)	0.82	0.41
SPAD (Chlorophyll Content)	57.2	31.1
CT (Canopy Temperature)	26.9	21.5

Genotypes promoted to national trials:

- Three Genotypes DDW 69, DDW 70 and DDW 71 have been promoted to NIVTs.
- Three genotypes DDW 65, DDW 66, DDW 67 have been promoted to durum trial NWPZ-AVT-IR-TDM.
- Two durum genotypes DDW 65, DDW 67 have been promoted to PZ-AVT-IR-TAD.
- One genotype DBW 462 has been promoted to NEPZ-IR-LS-TAS.

Seed Production Programme at ICAR-IIWBR, Karnal

Under Inter-institutional collaborations with ICAR-NDRI Karnal, ICAR-IIFSR and ICAR-CPRI-RS, Modipuram. ICAR-IIWBR has produced 6667.69q of breeder seed and 2490.12q of TL seed of 13 wheat viz., DBW 327, DBW 377, DBW303, DBW187, DBW222, DBW 359, DBW 370, DBW 371 and DBW 372 whereas total 300.39q seed of 6 barley varieties was produced at Seed and Research Farm, (ICAR-IIWBR), Hisar during 2024. Selling of Nucleus/ Breeder and TL Seeds of wheat generated a total amount of **Rs. 695.50 lakhs** under the revolving fund scheme of the institute. The details of seed production of wheat varieties are given in Table 2.33.

Strengthening the Seed Chain through Public and Private Partnership

In order to improve the seed access for ICAR-IIWBR Karnal recent varieties to the farmers, the institute has upscaled its seed production programme by involvement of the different public and private sector agencies. The institute is providing its breeder seed to different private seed growers (>900 MOAs), 14 ICAR institutes, State Agricultural Universities, KVKs and state government agencies for further seed multiplication and distribution of recent varieties to the farmers to meet their demands. A total of 6940.05q breeder seed was sold to the public and private seed for further multiplication of Foundation/Certified seed and distribution (Table 2.34).

Technological interventions for efficient seed distribution

ICAR-IIWBR, Karnal has upgraded IIWBR Seed Portal to register and distribute TL seed of recent wheat varieties *viz.*, DBW 327, DBW 377, DBW 303, DBW 187, DBW222

Table 2.33: Breeder seed (quintal) and TL Seed (quintal) produced during 2023-2024

S. No.	Variety	Govt. Sector Agencies	Private Seed Companies	Farmers (Tl Seed)	Total Sale
Wheat					
1	DBW187	1381.70	662.60	371.94	2416.24
2	DBW 327	431.60	603.35	266.94	1301.89
3	DBW 371	327.40	328.40	552.74	1208.54
4	DBW 372	323.00	312.60	537.81	1173.41
5	DBW 303	609.04	343.40	61.90	1014.34
6	DBW222	550.50	296.80	70.61	917.91
7	DBW370	80.20	14.20	153.80	248.20
8	DBW 377	14.00	98.40	125.02	237.42
9	DBW 359	47.90	45.00	140.11	233.01
10	DBW 332	72.60	10.00	120.70	203.30
11	DBW 316	99.80	6.40	15.20	121.40
12	DBW 173	2.00	0.80	39.70	42.50
13	JKW 261	0.80	5.20	33.65	39.65
	Total	**3940.54**	**2727.15**	**2490.12**	**9157.81**
Barley					
1	DWRB 137	143.55	66.8	25.37	235.72
2	DWRB 219	19.25	0	4.6	23.85
3	DWRB 182	11.3	0	0.4	11.7
4	DWRB 123	10	0	0.9	10.9
5	DWRB 101	0	10	0.12	10.12
6	DWRB 160	6.6	0	1.5	8.1
	TOTAL	**190.7**	**76.8**	**32.89**	**300.39**

Table2.34: Breeder seed distribution to the public and private agencies of different states during 2023-2024

S.N.	State	Govt.@Rs. 7050	Private@ Rs. 8820
1	Haryana	1298.60	959.00
2	Uttar Pradesh	1570.20	190.20
3	Punjab	10.80	1119.2
4	Rajasthan	349.40	301.95
5	Bihar	505.50	34.00
6	Chandigarh	140.00	0.00
7	Delhi	92.00	23.60
8	Madhya Pradesh	20.50	86.20
9	Uttarakhand	12.00	90.40
10	Himachal Pradesh	75.00	0.00
11	Jammu and Kashmir	62.00	0.00
		4136.00	**2804.00**

etc. for the farmers in all the wheat growing states. The seed portal was designed and executed through IIWBR website during the September month. All the interested farmer were allowed to provide needful information including his/her name, village, mobile number, district and state, upload soft copy of Aadhar card, select the variety and quantity of seed to be purchased (Fig. 2.3 & 2.4) After that he/she received an OTP on his mobile and then a message was sent to all such farmers their demand of seed has been registered with the IIWBR. This facility was utilized by about 5000 farmers from different states like Haryana, Punjab, U.P., Bihar, MP and Rajasthan, who successfully registered on the portal during 17.9.2024 to 21.9.2024. The portal was closed after the successful registration of the farmers as per the seed availability. The major task before the institute was to distribute the seeds to the registered farmers. The farmers were then grouped into clusters as per their districts and states; accordingly, farmers were informed through bulk SMS sent during 8th October to 15th October 2024 to come and collect the indented/ allotted seed on specific date and time. This way, IIWBR has distributed >2400q TL seed of indented wheat and barley varieties to the farmers during 19-24th October, 2024.

Fig. 2.3: IIWBR Seed Portal for registration of farmers

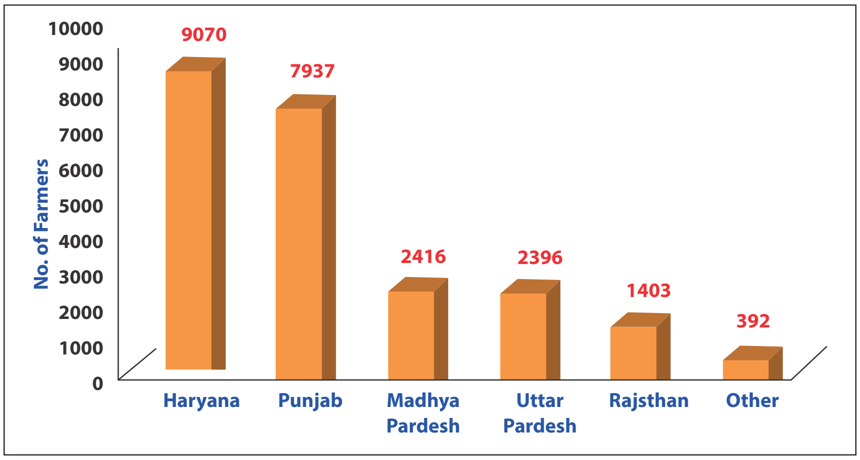


Fig. 2.4: State-wise number of farmers registered on IIWBR Seed Portal

IIWBR- Unified Seed Sale, Inventory and Finance Management Software

During 2024, ICAR-IIWBR developed Unified Seed Software in order to address the challenges of distribution, inventory tracking, financial reconciliation, for breeder seed and TL Seed Sale, integration of transaction ids with bill, generating reports of variety wise sale, state wise number of farmers registered and actual number of farmers lifting the seed (Fig. 2.5). This software has been designed to ensure timeline information on seed supply reduce errors and maintain transparency which is vital for stakeholders including farmers, agencies, government bodies and policy makers. This has helped in quick decision-making during seed distribution programme. The software is based on the Aadhar ID, which helps to avoid any duplicity during the generation of bills.

Fig.2.5: Unified Seed Sale, Inventory and Finance Management System

The software is developed on the programming language of ASP.net with C+ which ensures robust and secure platform having added security features. The database is sql Server-Microsoft and can be utilized for ten number of computers simultaneously. This software facilitated real time capabilities allow real time generation of bills during seed distribution and helped to monitored the seed sale.

Software is equipped with generation of various reports i.e.

i Agency billing report,
ii. farmers billing report,
iii. sales report
iv. breeder seed certificate
v. gate pass with date and quantity and variety name,
vi. farmers wise variety report and
vii. agency wise variety report.
viii. State/ district wise report.

These reports helped to understand the demand of the variety among farmers and indenting agencies, reconciliation of bills with finance department, state-wise number of farmers actually lifted the seeds and of which varieties and helps to plan the next year seed production programme.

Biotechnological and Physiological interventions

Transcriptome analysis of plants treated with endophytic bacteria

Bread wheat variety DBW303 seeds were treated with four bacterial endophytes *viz.*, *Priesta aryabhattai*, *Pseudomonas* sp., *Bacillus subtilis* (St. 30L 1-2) and *B. subtilis* (St. CICR-NG) separately and sown in small plastic trays with potting mixture of soil, sand and farm yard manure in 3:2:1 ratio. Seeds were exposed to drought conditions and the seedlings were harvested at 10th day of growth. One control without endophytic bacteria treatment was kept as control treatment (NIDS), while the endophytic bacteria treatments were coded as EIDS-2, EIDS-9, EIDS-10 and EIDS-20 based upon four bacteria used in the study. The leaf tissues were sent for whole transcriptome analysis using AdapterRemoval, HISAT2, FeatureCounts, edger, DIAMOND pipeline tools. The AdapterRemoval was used to filter out the adapters sequences and to perform quality trimming at Q30. The clean data were aligned to the *Triticum aestivum* reference genome using Hisat2. The expression estimation was performed using featureCounts, while the differential gene expression was performed using edgeR. The annotations of complete gene set were performed using uniprot database using *Triticum aestivum* (Table 2.35). The up-regulated and down regulated differentially expressed genes (DEGs) from non-inoculated sample were compared with rest four endophytic bacteria treatment samples and highest upregulation of DEGs was with *Pseudomonas* sp. treated sample (320), followed by *Priestia aryabhattai* (83), *Bacillus subtilis* (St. CICR-NG) and *B. subtilis* (St. 30L 1-2**)** (Table 2.35). Comparison between different endophytic bacteria treatments exhibited highest up-regulated DEGs in plants treated with *Pseudomonas* sp. compared to *P. Aryabhattai* (37), while in comparison between two strains of *B. subtilis*, it was with *B. subtilis* (St. CICR-NG)

In gene ontology, the up-regulation and down regulation of genes varied in presence of different endophytic bacteria. In presence of *P. aryabhattai*, the highest up regulation for biological processes was for photosynthesis (light harvesting photosystem), followed by response to light stimulus, hydrogen peroxide catabolic process and cell wall macromolecule catabolic process. In cellular components, it was mainly for chloroplast thylakoid membrane, photosystem II and photosystem I. For molecular function it was for chlorophyll binding, metal ion binding and heme binding (Fig. 2.6). In presence of *Pseudomonas* sp., the up regulation for biological processes was for phosphorylation, defense response, and response to other organisms. For cellular components, it was for membrane, plasma membrane and nucleus, while for molecular function, it was for ATP binding, metal ion binding and heme-binding (Fig. 2.7). Heme-binding was common in both cases. Similarly, the gene ontology varied in presence of other two bacteria, which shows that different bacteria affected plant system differently.

Table 2.35: Differential Gene Expression summary for Upregulated DEGs at Log2FC 1 AdjPvalue 0.05

Control	Vs	Treated	AdjPvalue	Log2FC	Regulation	DEG count
NIDS-1	vs	EIDS-2	0.05	1	Up	83
NIDS-1	vs	EIDS-9	0.05	1	Up	320
NIDS-1	vs	EIDS-10	0.05	1	Up	25
NIDS-1	vs	EIDS-20	0.05	1	Up	40
EIDS-2	vs	EIDS-9	0.05	1	Up	37
EIDS-2	vs	EIDS-10	0.05	1	Up	7
EIDS-2	vs	EIDS-20	0.05	1	Up	3
EIDS-9	vs	EIDS-10	0.05	1	Up	29
EIDS-9	vs	EIDS-20	0.05	1	Up	2
EIDS-10	vs	EIDS-20	0.05	1	Up	48

**NIDS, non-inoculated drought susceptible; EIDS, endophyte inoculated drought susceptible; EIDS-2, EIDS-9, EIDS-10 and EIDS-20 are different endophytic bacteria treated samples*

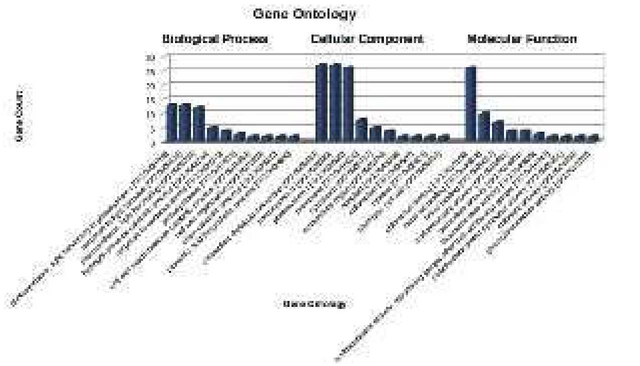


Fig.2.6: Gene ontology on interaction between wheat plant and *Pseudomonas sp.*

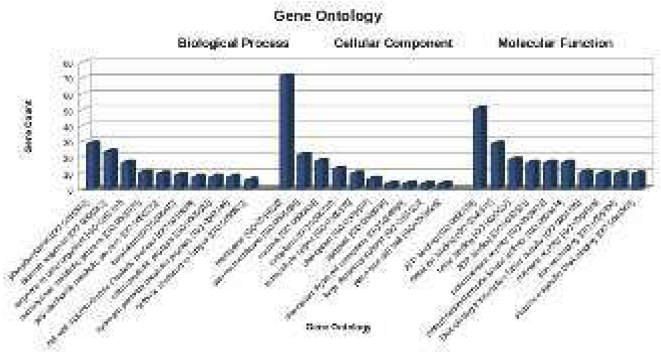


Fig. 2.7: Gene ontology on interaction between wheat plant and *Pristia aryabhattai.*

Identification of quantitative trait loci for Karnal bunt resistance

Karnal bunt (KB), caused by the pathogen *Neovossia indica*, is a major concern for the wheat industry due to its impact on international trade, restricted by strict quarantine regulations. This disease, which spreads through air, soil, and seed, is challenging to control effectively using chemical treatments. Developing wheat genotypes resistant to KB offers a sustainable solution for its management. However, the absence of rapid, simple, and environment-independent screening methods for identifying resistant germplasm remains a significant obstacle in breeding efforts. Quantitative trait loci (QTL) mapping provides a powerful approach for understanding the genetic basis of complex traits and identifying marker-trait associations. In this study, a mapping population of 214 recombinant inbred lines (RILs), derived from a cross between a highly resistant genotype (KBRL22) and a susceptible cultivar (PBW343), was evaluated to identify genomic regions conferring resistance to KB. The RIL population underwent phenotypic screening against a virulent isolate of *Tilletia indica* over two growing seasons. Pearson correlation and principal component analysis were performed to explore trait relationships, and QTL mapping was conducted to identify genetic loci associated with resistance.

The results revealed significant differences in disease severity among RILs, across years (E), and for genotype-by-environment (G×E) interactions. A positive correlation was observed between flag leaf length and KB infection. Six consistent QTLs associated with KB resistance were identified on chromosomes 2B, 3A, 4B, and 5B, collectively explaining 13%–18.9% of the phenotypic variation. Two major QTLs, located on chromosomes 4B and 5B, accounted for 18% and 18.9% of the phenotypic variation, respectively, highlighting their critical role in KB resistance. Additionally, two novel QTLs, *QKb.iiwbr-3A.1* and *QKb.iiwbr-3A.2* were detected on chromosome 3A using SSR markers, marking a significant advancement in understanding the genetic control of KB resistance. These findings have practical implications for wheat breeding programs. The resistant lines carrying favourable alleles at all identified QTLs represent valuable genetic resources for inter-crossing and selection to develop improved germplasm with enhanced KB resistance. Addressing the current challenges in screening methods will further accelerate the development of resistant wheat varieties and contribute to sustainable KB management.

Identification of Sugar Transport Protein gene family in wheat genome

Sugar transporters play a pivotal role in facilitating the movement and allocation of sugars within the wheat-rust infection zone. Their indispensable contribution lies in the establishment of a secondary sink at the point of invasion by the fungal pathogen within plant cells. These transporter proteins, present on the membranes of both plants and pathogens, are the main players in defense signaling as they control how sugars are distributed between them and determine whether an encounter will result in resistance or susceptibility. Sugar transporter protein gene family are identified in wheat genome and studied for their chromosomal location, conserved motif domains and phylogenetic relationship with *Arabidopsis thaliana*. International

Wheat Genome Sequencing Consortium (IWGSC) database was searched for identification of Sugar Transport Protein (STP) gene family in wheat by using Sugar_tr Hidden Markov Model (HMM) profile (Pfam: PF00083) as the query in a BlastP. A total of 476 TaSTP proteins with E-value of <1e−5, these sequences checked for presence of the Sugar_tr domain using Pfam database. Eighty-six candidate STP proteins were discarded due to either a partial or complete absence of the STP domain and remaining 390 putative TaSTP sequences used for phylogenetic analysis along with 14 *AtSTPs* (Sugar transporter proteins from *Arabidopsis thaliana*, named as AtSTP1 to AtSTP14, retrieved from NCBI database.

Identification of *Puccinia* proteins associated in different metabolic activities

Whole genome of three species of *Puccinia* was used for the protein targeting and localisation analysis. InterPro Domain search was performed on whole genome of different species of *Puccinia* given below at FungiDB (https://fungidb.org/fungidb/app). A total number of 7550 genes, encoding proteins with TM domain, were identified in the three genomes. 1941 genes in *Puccinia graminis* f. sp. *tritici*, 3821 in *Puccinia striiformis* and 1942 in *P. triticina* have been identified (Fig. 2.8).

gRNA designing in Calmodulin-Binding Domain from Glutamate Decarboxylase 3 to increases Gamma-aminobutyric acid (GABA) content in grains

Gamma-aminobutyric acid (GABA), a non-protein amino acid is synthesized from glutamate by glutamate decarboxylase (GAD). In plants, the enzymatic activity of GAD is activated by Ca2+/calmodulin binding (CaMBD) at the C-terminus in response to various stresses, allowing rapid GABA accumulation in cells. GABA is known to be a health-promoting functional substance that exerts improvements in life-style related diseases such as hypertension and diabetes. CaMBD in GADs possess an auto-inhibitory function because truncation of GAD resulted in extreme GABA accumulation in plant cells. Therefore, we attempted a genetic modification of GAD via genome editing technology to increase GABA levels in wheat.

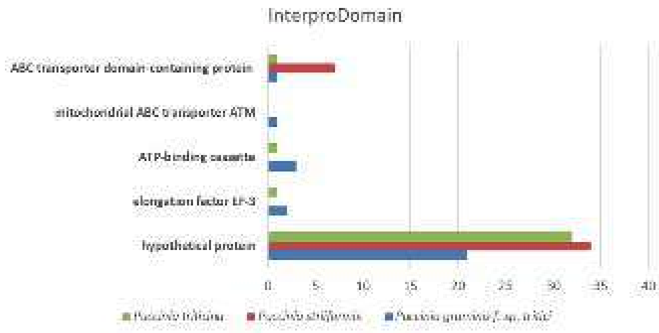


Fig. 2.8: Fungal proteins associated in different activities

The rice *OsGAD3* (AK071556) gene sequence was used to search the wheat sequences in EnsemblPlants database. The C-terminal region of *OsGAD3* was aligned of wheat sequences found on chromosome 4A, 4B and 4D plants. Trp (W) and Lys (K) essential for in vitro binding to CaM are indicated by asterisks and a thick line, respectively (Fig. 2.9). This C-terminal region of *GAD3* genes was used to design gRNA from conserved regions of homologous chromosomes.

Genome editing of ITPK 1 gene for improving micro nutrients in wheat

Addressing malnutrition in developing countries providing more nutritious cereal crops without compromising yield is one of the major thrust areas of research including wheat. Therefore, manipulation of the *TaITPK1* gene through CRISPR/Cas 9 provides a promising strategy to modulate gene expression to increase the availability of essential micronutrients like iron (Fe), and zinc (Zn). The *TaITPK1* gene plays a crucial role in the regulation of inorganic phosphate (Pi) and potassium (K+) homeostasis and is involved in phytic

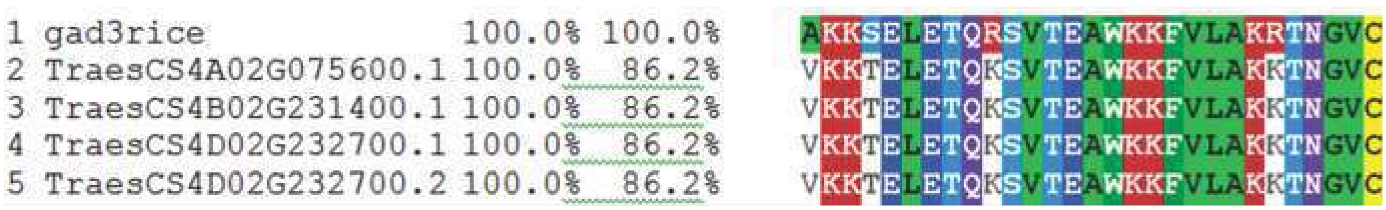


Fig. 2.9: Alignment of C-terminal regions of rice GAD3 gene with wheat sequences on chromosome 4A, 4B and 4D

acid synthesis. The CRISPR/Cas9 gene editing of *TaITPK1* gene is carried out at ICAR-IIWBR, specifically utilizing the SDN-1 (site-directed nuclease) approach. The gene sequence of *ITPK1* from the International Wheat Genome Sequencing Consortium (IWGSC) database, confirmed its presence at A & B genomic regions of wheat's chromosome two. The guide RNA (gRNA) tailored specifically to target the *ITPK1* gene across both genomes while ensuring minimal off-target effects was designed using WheatCRISPR software. The gRNA was successfully cloned into a Cas9 binary vector and introduced into DH5α *E.coli* cells. The transformation was confirmed through colony PCR, using U6 promoter forward and gRNA-specific reverse primers, and the results were further validated by sequencing of the amplified region. After confirming the successful transformation, the final plasmids from positive colonies were transferred into *Agrobacterium* EHA 105. Subsequently, the *Agrobacterium* culture was utilized for the transformation into wheat genotypes DBW187, DBW303, DBW327, and DBW371, via Agrobacterium-mediated transformation as per the established protocol using mature embryos as explants. Putative ITPK1 gene-edited plants were developed, and further phenotypic and molecular characterization of these plants is under progress.

DBW-EMS23: Promising wheat genotype for heat and drought tolerance

The wheat genotype DBW-EMS23 was developed from EMS induced mutant population of hexaploid wheat cultivar DPW 621-50 –(Singh et al., 2015) at ICAR-IIWBR, Karnal. This entry was assessed in the Drought and Heat Tolerance Screening Nursery (DHTSN) during 2023-24 crop season at Dharwad, Hisar, Karnal, Junagadh, and Pusa, which are hot spot locations for heat and drought stress. DBW-EMS23 showed a lower Heat Susceptibility Index (HSI:0.65) compared to checks DBW187 (1.02), DBW296 (0.89), GW322 (1.13), NIAW 3170 (0.72), RW5 (1.01) and WH730 (0.7). DBW-EMS23 recorded a lower yield reduction (22%) compared to all the checks under heat stress conditions (Table 2.36). Also, DBW-EMS23 has showed drought susceptibility index (DSI: 0.99) lower than the check WH730 (1.07). DBW-EMS23 recorded a lower yield reduction (22%) compared to all the checks under heat stress conditions (Table 2.36). Lower yield reduction (YR) under heat stress is the important characteristics of a heat tolerant genotype.

Table 2.36: The HSI, DSI and yield reduction (%) of wheat genotype

Genotype	Heat Susceptibility Index	Yield reduction under Heat stress (%)	Drought Susceptibility Index	Yield reduction under Drought stress (%)
DBW-EMS23	0.65	22.0	0.99	45.8
DBW187 (C)	1.02	34.4	0.86	39.8
DBW296 (C)	0.89	30.2	0.94	43.6
GW322 (C)	1.13	38.1	0.88	40.5
NIAW3170 (C)	0.72	24.5	0.75	34.6
RW5 (C)	1.01	34.2	0.92	42.5
WH730 (C)	0.7	23.8	1.07	49.6

Phenotyping for root system architecture

Root phenotyping aims to characterize root system architecture (RSA) because of its functional role in resource acquisition for selecting high yielding climate resilient varieties to enhance agricultural yield. Given the significance of root studies, an experiment has been conducted on the root system architecture of forty released wheat varieties of the peninsular zone, under controlled conditions. The plants were grown in plastic pots for one month and then uprooted carefully. The root samples were cleaned and examined using WinRhizo software to measure various root characteristics like root length, root surface area, average root diameter, root volume, and root to shoot ratio. Wheat genotypes for contrasting root traits were identified (Fig. 2.10). Root length is found significantly correlated with root surface area and root volume. Wheat variety HD2987 has been identified with maximum root length (139.3cm) and root surface area (14.9mm^3) followed by DBW93 for both the traits. Maximum root diameter (1.91mm^2) was recorded in

RAJ4083, however the genotype is showing minimum root surface area and root volume. Minimum, root shoot ratio (0.30) was observed in DWR39, however maximum (i.e. 1) was recorded in many genotypes like UAS347, HD2781, K9644, NIAW1415, HD2987, NI5439, NI747-19 and PBW596.

Fig. 2.10: Root system architecture analysis with WinRHIZO

Evaluation of wheat genotypes for lodging tolerance under open field conditions with Wind tunnel

Current climatic vagaries and high input cultural practices in the key wheat-producing regions are drawing attention to the problem of lodging in the near future, as significant crop lodging has been reported in the past few years. Considering the uncertainty of natural lodging events, simulated wind induction approaches can generate important information about lodging resistance in agricultural crops. In order to comprehend and distinguish the effects of lodging on wheat cultivars under natural conditions a new prototype (termed as wind tunnel) has been developed at ICAR-IIWBR Karnal. The aim behind this research is to better understand the lodging behavior in wheat genotypes and to identify the most crucial plant trait for lodging tolerance. Wind tunnel is a customized machine designed for lodging induction in open field conditions. The Wind tunnel comprised of an industrial fan with three phase VFD drive for high-speed air delivery, water tank and a portable engine generator set for continuous power supply. The machine is equipped with a waterproof and high-resolution video camera, digital rain gauge system, 3D Sonic anemometers which are connected to a data logger system for easy access of data. A group of forty newly released wheat varieties, synthetic wheat genotypes, mutant lines, selected breeding material from international nurseries and dwarf lines were sown in four-line plot of two-meter length with two replications was utilized to study the occurrence of lodging at the experimental farm of ICAR-IIWBR during 2023-24 crop season. All the standard agronomical practices such as, dose of fertilizer, irrigation at all critical stages and roughing were followed to raise a normal crop. The screening for lodging tolerance was done during the grain filling period with the help of 'Wind Tunnel' (Fig. 2.11). Data for lodging was recorded on the scale of 0-5, where 0: No lodging; 5: Completely lodged. In addition, data on plant height (cm), spike length (cm), length (cm) of lower three internodes, diameter of lower three internodes (mm), peduncle length (cm), thousand grain weight (g), biomass (g), lodging percentage, weight of three lower internodes (g) and tensile strength (kPa) were recorded in both the lodged and non-lodged conditions. Considerable variability in culm characteristics have been noted among the tested wheat genotypes, suggesting potential for utilizing these variations in wheat breeding initiatives aimed at enhancing wheat's ability to withstand lodging. The maximum positive correlation of lodging was identified with peduncle length (r=0.72) followed by plant height (r=0.57), however weight of all three internodes showed a negative correlation with lodging percentage. The identified wheat genotypes will be further evaluated for their performance under lodging stress. The standardization of the developed prototype is under process. The designed prototype can be used by researchers to enhance their understanding on traits associated with crop lodging to enhance lodging tolerance in wheat.

Fig. 2.11: Screening of wheat genotypes with wind tunnel for lodging tolerance in open field condition

Wheat germplasm and Marker's Database

The web based Indian wheat germplasm & Markers' database software is developed at ICAR-IIWBR (Fig. 2.12). This software includes following three modules: -

i. Wheat Germplasm

ii. SSR/SNP Markers

iii. Varieties and Genetic stocks

The first module of the software includes data of 493 wheat varieties with 54 DUS traits. Second module has information of 242 markers for 10 different traits. It has markers for drought, heat, salt, *Fusarium* head blight, Karnal bunt, pre harvest sprouting, powdery mildew, spot blotch, STB and rust. Third module contains details of wheat varieties released since 1965 under SVRC and CVRC. Genetic stocks part gives detailed information of registered genetic stocks for six different traits.

MS-SQL (Microsoft SQL Server Management Studio Ver. 19) is used to create the RDBMS. The primary key of databases is used in searching and sorting algorithms developed in query building & execution programs. Front end of web-based wheat database system has been designed using Java Script and CSS using (Microsoft Visual Studio Ultimate 2012).

This web-based database system is user friendly, easy to use and allows access to query based varietal information from RDBMS database through web browser, which is needed for fast data retrieval by web interfaces. HTML and Java scripting languages have been used for client side (Front End) operations such as entering data, uploading data from text and image file. C# in Asp.net as server-side language has been used for database connectivity and retrieval of data.

Fig. 2.12: Picture showing the wheat germplasm and markers' database main window

3 CROP PROTECTION

Under the changing climate scenario, wheat crops face an ongoing threat from both existing and emerging biotic stresses. Diseases such as rusts, mildew, blight, Karnal bunt, and smuts, along with insect pests like aphids, termites, and borers, significantly reduce the yield potential of wheat cultivars. To mitigate these risks, a comprehensive crop protection program is in place to monitor and manage these stresses. The program involves continuous surveillance through roving surveys to track disease and pest infestations, while providing timely, need-based advisories. In addition, it focuses on identifying new sources of resistance, strategically deploying resistant varieties, and developing effective management strategies. The program also monitors emerging rust pathotypes, the occurrence of exotic diseases, and the status of Karnal bunt. Crop health data are regularly shared among various agencies, including DAC & FW, ICAR, SAUs, State Agriculture Departments, KVKs, and farmers through regular strategy planning meetings, trainings, field days, discussions, distribution of literature, and the use of IT tools. Regular surveys also focus on monitoring wheat and barley health, particularly tracking yellow rust in the NWPZ and conducting surveillance for wheat blast near the Bangladesh border.

Wheat crop protection scientists from various centers, including ICAR-IIWBR, Karnal, conducted surveys, and findings were shared through the "Wheat Crop Health Newsletter" (Vol. 29, Issues 1-5), available on the ICAR-IIWBR website (www.iiwbr.icar.gov.in). Stripe (yellow) rust was first reported on January 24, 2024, from RS Pura (Jammu) on an unknown variety, and at Badyal Qazian on HD2967. During February, stripe rust was observed in fields in Niku Nangal, Dhokli, Chandpur Bela, Dher Raipur, and Mehakpur (Ropar, Punjab). While in March 2024, stripe rust was reported in Rawaikhal and surrounding areas in Bageshwar (Uttarakhand). A low incidence of stripe and leaf rust was recorded in Hansi, Shekhupur, Narnaund, and nearby villages of Hisar (Haryana).

Leaf rust infection was recorded at very low incidence in few farmers' fields in the (in Pune and Satara districts (Maharashtra) and Dewas, Indore, Sehore, and Dhar districts (Madhya Pradesh) and in Banaskantha (Gujarat) during the surveys conducted on January and February. Low incidence of leaf rust was observed in Sabour, Barari, Jagdishpur, Goradih, and Nathnagar of Bihar. Stem (black) rust was first reported from Dharwad district (Karnataka) in mid-January, spreading to Belagavi, Bagalkote, and other districts. In Maharashtra, stem rust was observed in Umbarkhed (Niphad) on January, 2024. Overall, crop health across wheat-growing areas remained excellent.

Plant Pathology

Host Resistance

During the 2023-24 season, wheat germplasm and advanced breeding materials were evaluated for resistance to diseases and insect pests at various hotspot locations under controlled, artificially inoculated conditions. The major plant pathological nurseries included: Initial Plant Pathological Nursery (IPPSN), Plant Pathological Nursery (PPSN), Elite Multiple Disease Screening Nursery (EMDSN), as well as disease-specific nurseries such as the Leaf Blight Screening Nursery (LBSN), Karnal Bunt Screening Nursery (KBSN), Powdery Mildew Screening Nursery (PMSN), Loose Smut Screening Nursery (LSSN), Flag Smut Screening Nursery (FSSN), Head Scab Screening Nursery, Foot Rot Screening Nursery, and Hill Bunt Screening Nursery. The number of entries tested in each nursery is shown in Figure 3.1.

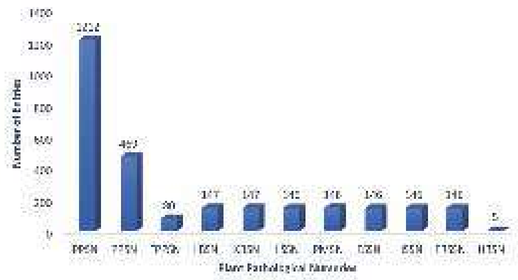


Fig 3.1: Number of entries in different plant pathological screening nurseries during 2023-24

Entries and check varieties identified resistant against rusts in advance breeding lines

Rust resistance materials in AVT (2023-24) with ACI upto 10.0 are given below:

Stem, Leaf and Stripe rusts

DBW476, DBW173(C), PBW927, WH1402(I)(C), HP1978, VL2059, MACS4125(d), MACS4135(d), HI8849(d), HI8850(d), DBW428, HI8851(d), HI8852(d), HI8627(d), DDW62(d), NIDW1149(d)

Stem and Stripe rust

HD3494, DBW476, PBW725, NW8071, DBW173(C), PBW927, HD3468, WH1402(I)(C), HP1978, VL2059, MACS4125(d), MACS4135(d), HI8849(d), HI8850(d), DBW428, HI8851(d), HI8852(d), HI8627(d), DDW62(d), DBW443*, NIDW1149(d)

Leaf rust and Stripe rust

DBW476, DBW477, HD3471, HD3455, DBW173(C), RAJ4581, HD3428, PBW771(C), PBW927, HD3369, DBW296(C), WH1402 (I)(C), HP1978, HD3447, PBW915, HD3388(C) (I)(C), PBW833(C), VL2059, MACS4125 (d), MACS4135 (d), HI8849 (d), HI8850 (d), MPO1395, HI8737 (d), DBW428, UAS484 (d), HI8851 (d), HI8852 (d), MACS4131 (d), MPO1398 (d), HI8627 (d), DDW62 (d), MPO1395(d), MACS3949(d), DBW426, UAS446(d), NIDW1149 (d), UAS478(d)(I)

Leaf and stem rust

DBW476, HD3059(C), DBW173(C), PBW927, WH1402(I)(C), HP1978, KRL2106, HI1563(C), VL2059, MACS4125(d), MACS4135(d), HI1669, HI1683, HI1684, HI8848(d), HI8849(d), HI8850(d), GW554, GW555, MACS6768, HI1650(C), GW547(I), HI8713(d), HI1674, HI1687, WSM138, MAC6830, GW556, DBW428, HI8851(d), HI8852(d), CG1036, HI1655*, HI8823(d), HI8627(d), DDW62(d), AKAW5100**, MACS6222, MP1378(I), MACS6829, NIAW4120, NIAW4432, LOK79, HD3090(C), HI1633(C), NIDW1149(d), HI1665(I)

Resistance to multiple diseases

Resistant to all three rusts+ HS +FS

DBW 386

Resistant to all three rusts

NIAW 4120

Resistant to stripe rust + leaf rust

DBW394

Resistant to stripe rust + leaf rust + KB + FS

PBW 893 and DDW 61(d)

Resistant to stripe rust + leaf rust + PM + FS

HI 1665 and PBW 889

Resistant to stripe rust + leaf rust + FS

HI1669 and NIAW 4028 and HI 8840(d)

Resistant to leaf rust + stem rust

DBW443, HI1672

Resistant to leaf rust + stem rust + KB +FS

PWU15

Resistant to leaf rust + stem rust + PM+FS

LOK 79

Resistant to leaf rust + stem rust + FS

DBW 444, NIAW 4183, HI 1673, HI 1675 and PBW 897

Resistant to stem rust + stripe rust + HS

NIAW4153

Resistant to stem rust + stripe rust + FS

VL 2041 and GW547

Besides advance breeding material, 320 genotypes comprising of indigenous and exotic germplasm were sown at ICAR-IIWBR. These genotypes were evaluated against leaf rust disease of wheat caused by *Puccinia triticina*. Out of 320 germplasm, 10 genotypes *viz.,* PI 519975, PI 271251, PI 338443, PI 383905, PI 350306, PI 322042 (WC 385), IC 138904-B, IC 128360, IC 128322 and IC 78736 exhibited resistance against the disease with AUDPC score 0 to 50 (Fig. 3.2).

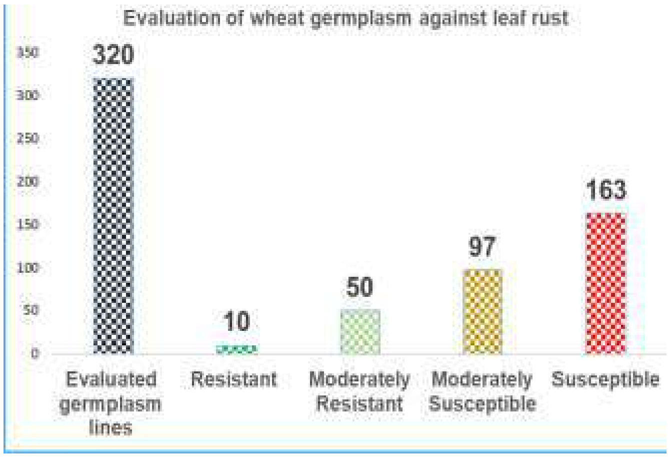


Fig 3.2: Evaluation of wheat germplasm against leaf rust disease

Utilization of resistant sources

During the cropping season under the NGSN, consisting of 27 entries with confirmed sources of high disease resistance, was distributed to 19 breeding centers across various agro-climatic zones of the country for use in breeding programs aimed at combating biotic stresses. A total of 24 entries were utilized by different centers, with utilization ranging from 4.17% to 37.50%. The most frequently used entries were PBW902, PBW870, and HD3440. Durgapura center made the highest use of 9 entries in their breeding program, followed by Ludhiana and ICAR-CSSRI, Karnal.

Preparedness to wheat blast

A survey conducted during the 2023-24 cropping season near the Indo-Bangladesh border in West Bengal, by teams from ICAR-IIWBR, Karnal, UBKV, Cooch Behar, and BCKV, Kalyani and Nadia, found no wheat blast. Farmers were also informed about preventive measures against wheat blast and encouraged to grow resistant varieties. To identify resistant sources, advanced breeding lines and germplasm were screened at Jessore, Bangladesh, through CIMMYT. A total of 348 entries were tested for blast resistance at two different sowing dates in 2023-24. Five entries (DBW447, DBW448, DBW449, PBW942, PBW943) were found free from infection, and 12 entries (UP3141, DBW455, DBW454, NIAW4621, HP1981, DBW446, K2301, JKW317, HUW859, RAUW107, HUW861, QYT2310) were classified as resistant, with infection levels up to 10%.

Advisory for stripe rust management

In the 2023-24 season, the weather in January was favorable for yellow rust in the NWPZ. However, the disease severity remained low due to the adoption of resistant wheat varieties. Need-based advisories for managing stripe rust and Karnal bunt were issued. Awareness about stripe rust management was raised among farmers through mobile messages, internet, toll-free numbers, newspapers, discussions, and lectures during farmer training programs.

Post-harvest surveys

A total of 8100 wheat grain samples collected from various mandies in different zones and were analyzed at different cooperating centers. The overall 6.56% samples were found infected. The samples from Hisar showed maximum infection (47.05%). The average incidence of Karnal bunt (KB) infected grains was ranging from 0 to 7.3%. The maximum grain KB infection of 7.3% was observed in a sample from Karnal. Samples from Madhya Pradesh, Karnataka, Gujarat and Maharastra were found free from Karnal bunt infection. In general, the Karnal bunt infection was less in comparison to previous year.

Field screening of germplasms against *Bipolaris sorokiniana* in wheat

A panel of 403 genotypes comprising released cultivars, indigenous and exotic germplasm was screened for two years (2022-23 & 2023-24) against *Bipolaris sorokiniana* usingfour parameters *viz*., disease severity, area under disease progress curve (AUDPC), Incubation Period (IP), lesion length and lesion breadth (Fig. 3.3). Among all genotypes, minimum DS (12) and minimum AUDPC (90.1) was found in HW2004, where maximum AUDPC was recorded in IC322001 (1313.38) with maximum DS (99), however, this maximum DS 99 was found in many other genotypes. Incubation period values ranged from 3-7 days. Maximum lesion length (mm) was noticed 37.6 cm in HINDI 62 genotype and minimum in case of Chirya-3 (0.23 cm), whereas maximum lesion breadth was recorded in BACANORA88 (5.7 mm) and minimum in case of IC212153AMB (1.0 mm).

Fig 3.3: Field screening of germplasms against *Bipolaris sorokiniana* in wheat

Biochemical profiling of genotypes against Spot blotch pathogens, *Bipolaris sorokiniana*

After screening of 403 genotypes under field conditions, five representative genotypes Chirya-3 (R), HD2967 (MR), HS420 (MR), DBW90 (MS), Sonalika (S) showing resistance or susceptibility levels were selected for biochemical profiling. Flag-leaves were collected after inoculation of *Bipolaris sorokiniana* and biochemical profiling was done at 0, 24, 48 and 72 hours post inoculation for nine biochemical tests *viz.,* Ascorbate Peroxidase (APX), Catalase, Cellulase, flavonoid, Glutathione Reductase (GR), Hydrogen Peroxide (H_20_2), Phenyl Ammonia Lyase (PAL), Peroxidase and Polyphenol oxidase (PPO)(Fig. 3.4).

Ascorbate Peroxidase: The Ascorbate Peroxidase activity increased with the increase in hours post inoculation (hpi) being maximum at 72 hpi irrespective of cultivars. APX activity was more in resistant variety as compared to the susceptible cultivar. The maximum APX activity (19.26 nmoles/min/g FW) was observed at 72 hpi in resistant variety Chirya-3. The minimum APX activity (2.26 nmoles/min/g FW) was recorded at 24hpi in susceptible variety Sonalika.

Catalase: Among all five varieties maximum CAT activity was exhibited by Chirya-3 at 72 hpi that was 2.04 µmoles/min/g FW. Minimum CAT activity was observed for susceptible variety Sonalika (0.11 µmoles/min/g FW) at 0hpi.

Glutathione reductase: Glutathione reductase activity was observed to be varied significantly with respect to the varieties as well as due to the different time intervals post inoculation. Spot blotch resistant variety Chirya-3 exhibited maximum GR activity (11.24 nmoles/min/g FW) at 72 hpi, whereas minimum GR activity (2.20 nmoles/min/g FW) was observed in susceptible wheat cv.

Sonalika at 0 hpi.

Hydrogen Peroxide (H_2O_2): Maximum H_2O_2activity was observed at 24 hpi among all the varieties. Chirya-3 exhibited maximum H_2O_2 activity (21.01 µmoles/g FW) at 24 hpi, whereas minimum H_2O_2 activity (1.09 µmoles/g FW) was observed in susceptible cv. Sonalika at 72 hpi.

Phenyl Ammonia Lyase: Maximum PAL activity (0.057 µg/hour/g FW) was observed in cultivar Chirya-3 at 24 hpi, whereas minimum PAL activity (0.0105 µg/hour/g FW) was observed at 0hpi in Sonalika.

Peroxidase:Maximum Peroxidase activity (2.876 µmoles/min/g FW) was observed in variety Chirya-3 at 72 hpi, whereas minimum Peroxidase activity (0.627 µmoles/min/g FW) was observed in susceptible variety Sonalika at 0 hpi.

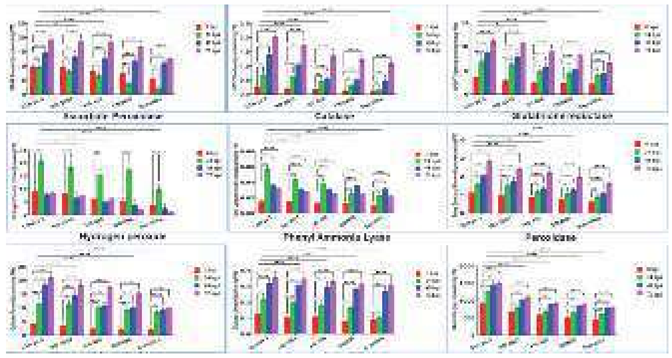


Fig. 3.4: Activities of Ascorbate Peroxidase, Catalase, Glutathione reductase, Hydrogen peroxide, Phenyl Ammonia Lyase, Peroxidase, Poly-phenol Oxidase, Cellulase and Flavonoid in wheat genotypes against spot blotch at different time intervals viz., 0 hpi, 24 hpi, 48 hpi and 72 hpi

Poly-phenol Oxidase: Maximum PPO activity (21.01 nmoles/min/g FW) was recorded in resistant variety Chirya-3at 72 hpi, whereas minimum PPO activity (1.839 nmoles/min/g FW) was found in susceptible variety Sonalika at 0 hpi.

Cellulase: Maximum cellulase activity (0.3595 µM/min/g FW) was recorded in resistant variety Chirya-3 at 72 hpi, whereas minimum cellulase activity (0.0815 µM/min/g FW) was recorded in DBW 90 at 0 hpi.

Flavonoid: Maximum flavonoid activity (1512.11 µg equivalent/g FW) was noticed in resistant variety Chirya-3 at 72 hpi, whereas minimum flavonoid activity (464.00 µg equivalent/g FW) was found in susceptible variety Sonalika at 0 hpi.

Genome-wide distribution of microsatellites for the development rapid diagnostic assay for the detection of *Bipolaris sorokiniana*

Bipolaris sorokiniana (BS) is an economically important fungal pathogen causing spot blotch of wheat and found in all wheat-growing zones of India. The Eastern Gangetic Plains (EGP) of northern India is the prime hot spot for spot blotch disease, but only limited efforts have been made to decipher *B. sorokiniana* diversity at the genomic level. Microsatellites provide an ideal molecular markers system to screen, characterize and evaluate genetic diversity of several fungal species. Currently, there is very limited information available on the genetic diversity of *Bipolaris sorokiniana* as determined using a range of molecular markers. In this study, the whole genomes of nine isolates of *B. sorokiniana* (BS112, BRIP10943a, BRIP27492a, WAI2411, WAI2406, ND90Pr, ND93-1, Sacc. Shoemaker and Yt-6) that exists in the public domain were explored to investigate the occurrence, relative abundance and relative density of microsatellites. The WAI2406 genome had the highest number of SSRs (5617), followed by WAI2411 (5290), and BRIP27492a (3878). The highest percentage of perfect SSRs was found in WAI2411 (97.39%). WAI2406 exhibited the highest relative abundance (152.28%) and relative density (2739.6). Tri-nucleotide motifs were the most prevalent across all genomes, with AAG being the most common motif in several isolates. Fifty SSR markers universally prevalent in all the genomes were tested, with 13 markers showing polymorphism across 30 geographical distinct isolates of *B. sorokiniana*, amplifying alleles ranging from 118 to 207 bp. A total of 39 alleles were identified, with BSPK3 amplifying the most (6 alleles). AMOVA revealed 94% genetic variation within populations of *B. sorokiniana*. A dendrogram divided the isolates into two clusters, with 27 isolates in Cluster I and 3 in Cluster II (Fig 3.5), which was confirmed by STRUCTURE analysis (Fig. 3.6). PCR analysis confirmed the specificity of primers

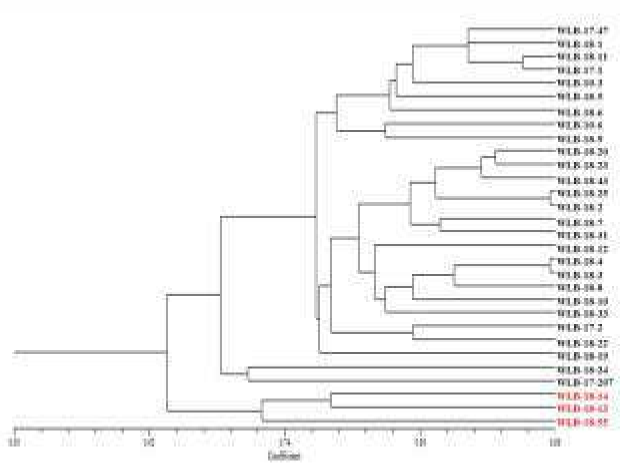


Fig. 3.5: Dendrogram generated by adopting UPGMA clustering method among 30 isolates of Bipolarissorokiniana using polymorphic microsatellite markers.

(BSPK1011 F/ BSPK1011R) to *B. sorokiniana*, with no amplification in other fungal species. Real time PCR assay with BSPK1011 F/ BSPK1011R detected DNA concentrations as low as 0.008 ng, with Ct values ranging from 18.34 to 27.77 with precision of 96.37% (Fig. 3.7).

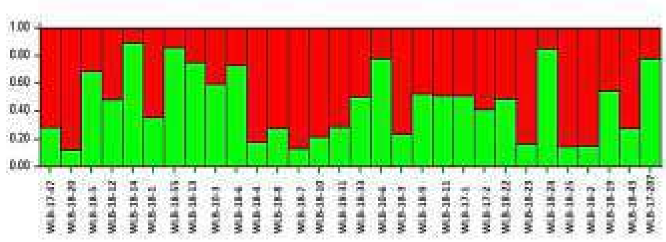


Fig.3.6: Bar plot showing genetic structure of 30 Bipolaris sorokiniana as revealed by STRUCTURE v2.3.3.

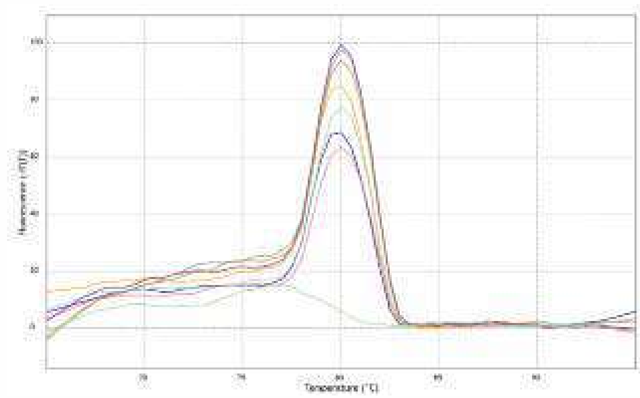


Fig. 3.7: Standard curve displaying the regression between DNA log quantities (ng, X-axis) and cycle thresholds (Ct, Y-axis) for qPCR assay using BSPK1011 F/ BSPK1011R primers. The standard curve was developed with serial dilutions of B. sorokiniana; melting curve showing melting temperatures 80°C required for 150bp qPCR product amplification with BSPK1011 F/ BSPK1011R primers.

Diversity and structures of physllosphere associated bacterial communities in different wheat genotypes

The phyllosphere provides a unique environment for microbial colonization, where the microbiota plays a crucial role in host performance and resilience to environmental perturbations. Consequently, efforts have been made to explore the phyllosphere microbiomes of six wheat varieties: HD2967, Unnat 343, Agra Local, HD 3086, PBW725, and PBW343. Metagenomic analysis was conducted on all six cultivars to assess microbial diversity. The results of alpha diversity analysis provided insights into the richness and evenness of microbial communities among the genotypes (Fig 3.8). PBW343 exhibited the highest richness with more than 465 observed OTUs and an estimated total richness of Chao1=465 and ACE=460. This was followed by Agra Local, which had over 457 observed OTUs, with an estimated total richness of Chao1=457.5 and ACE=465. Moderate species richness was observed in PBW725 and HD 3086, while the lowest richness was found in Unnat 343 and HD2967. Shannon and Simpson indices indicated the highest diversity and relatively even species distribution in Agra Local, followed by PBW343. Moderate diversity was observed in PBW725 and HD 3086, while the least diversity was noted in Unnat 343 and HD2967. The bacterial community was primarily composed of the phyla Firmicutes (94.84–98.67%), Proteobacteria (1.04-3.85%), Actinobacteria (0.2-1.4%), and Bacteroidota (0.06–0.51%). Additional phyla included Verrucomicrobiota (0.0006-1.895%), Fusobacteriota (0-0.03%), and Porifera (0-0.03%). Among these, the highest abundance of Firmicutes was found in Unnat 343, whereas Agra Local exhibited the lowest. Proteobacteria were most abundant in PBW343 and least in Unnat 343. Actinobacteria were highest in Agra Local and lowest in Unnat 343. The bacterial community at the class level was predominantly composed of Bacilli (93.08-98.18%), Gammaproteobacteria (1.17-2.66%), Alphaproteobacteria (0.24-1.11%), and Actinobacteria (0.25-1.83%). The mean relative abundance of Bacilli was highest in Unnat 343 and lowest in Agra Local. In contrast, other bacterial classes exhibited maximum relative abundance in Agra Local compared to Unnat 343. Gammaproteobacteria were most abundant in PBW343 and least in HD 3086, while Alphaproteobacteria showed the highest relative abundance in PBW343 and the lowest in Unnat 343. At the family level, the phyllosphere bacterial community consisted of 20 major families, including Enterobacteriaceae (7-31.02%), Bacillaceae (3.5-11.6%), Spirosomaceae (3.6-10.6%), Rhizobiaceae (0.7-13.9%), Enterococcaceae (0.2-25.5%), Pseudomonadaceae (1.9-16.9%), Lactobacillaceae (1.8-6.2%), Intrasporangiaceae (2.1-8.2%), Moraxellaceae (0.08-12.2%), Xanthobacteraceae (2.6-7.6%), Lachnospiraceae (1.7-7.1%), Paenibacillaceae (0.08-15.8%), Planococcaceae (0.5-5.7%), Rubritaleaceae (0.4-7.28%), Methylophilaceae (2.4-3.6%), Dermabacteraceae (0.1-7.6%), Ruminococcaceae (0.4-3.7%), Microbacteriaceae (0.5-1.4%), Veillonellaceae (0-1.4%), and Leptotrichiaceae (0-1.2%).

Bacterial communities belonging to different orders with relative abundance greater than 1% were

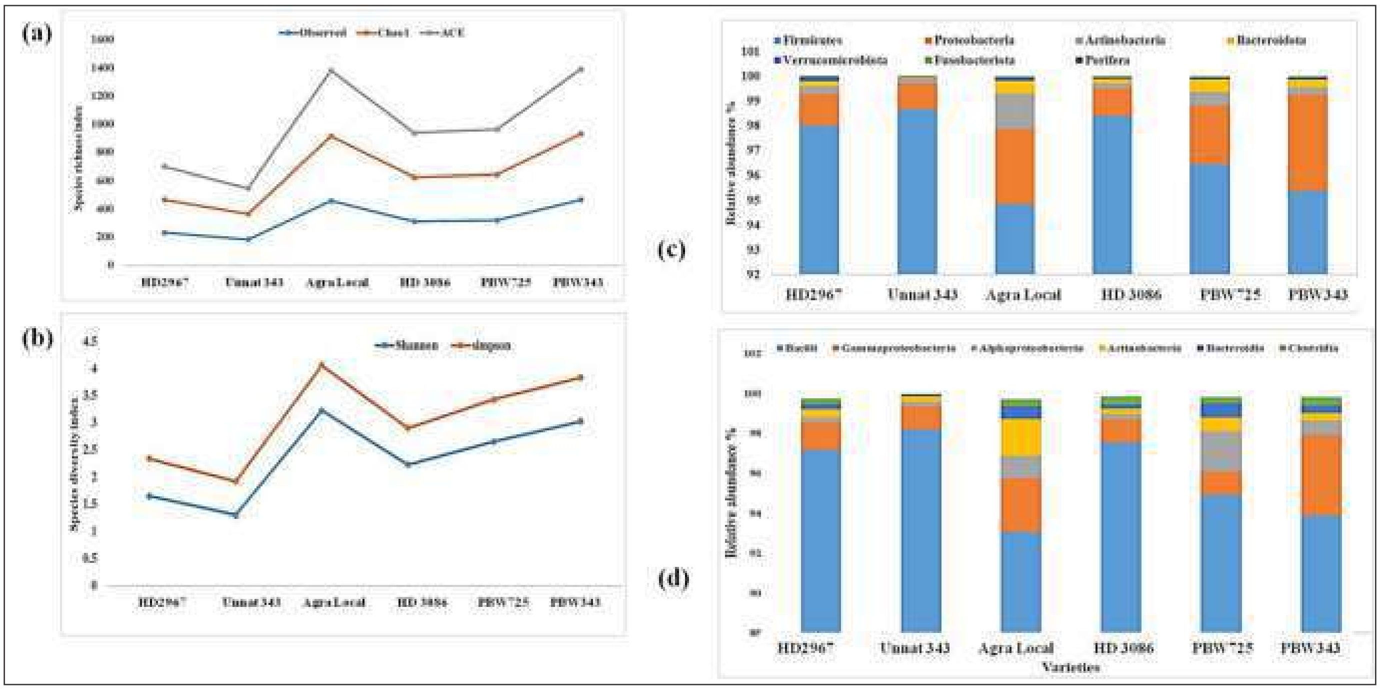


Fig 3.8: Alpha diversity indices, (a) Richness index (b) Evenness index, Relative abundance of (c) phylum and (d) class of phyllosphere microbial bacterial community among different wheat varieties

compared among the wheat genotypes. The dominant orders included Enterobacterales (6.4-27.59%), Bacillales (6.12-20.87%), Rhizobiales (5.52-20.70%), Pseudomonadales (3.14-22.64%), Lactobacillales (6.06-24.61%), Micrococcales (5.32-13.98%), Cytophagales (3.2-9.8%), Burkholderiales (3.6-9.2%), Lachnospirales (1.5-6.5%), Paenibacillales, Verrucomicrobiales (0.37-6.41%), and Oscillospirales (0.4-5.35%). Among these, the highest relative abundance of Verrucomicrobiales was found in HD2967, Pseudomonadales and Lactobacillales were most abundant in Unnat 343, Bacillales and Micrococcales were predominant in Agra Local, Lachnospirales and Oscillospirales were highest in HD 3086, Rhizobiales, Cytophagales, and Paenibacillales were more abundant in PBW725, while Enterobacterales and Burkholderiales were most prevalent in PBW343.

Identification of effectors in predominant Indian pathotypes of *P. striiformis* f. sp. *tritici*

Stripe rust, caused by *Puccinia striiformis* f. sp. *tritici* (Pst), is one of the most devastating diseases of wheat (*Triticum* spp.) worldwide. During infection, the wheat stripe rust fungus secretes clusters of effector proteins through the haustorium into host cells, where they modulate plant immunity and metabolism, ultimately increasing host susceptibility. Identifying the key effectors of *Pst* is vital for understanding the pathogenic mechanisms of rust fungi. Therefore, attempts have been made to identify and confirm the presence of six effector genes (*Pst* 12806, PSEC2, PSEC17, PSEC45, PST EF1, and PNPi) using PCR-based detection in five predominant Indian stripe rust pathotypes (46S119, 110S119, 238S119, 110S84, and 47S103). The results (Fig. 3.9) confirmed the presence of the *Pst* 12806 effector gene, which produced a 190 bp amplicon in all pathotypes. Similarly, the PSEC2 effector, a haustorial protein that inhibits wheat responses to pathogen-triggered immunity (PTI), was detected in all pathotypes with a 300 bp amplicon.

The PSEC17 and PSEC45 effector proteins, amplified at 200 bp and 120 bp respectively, were also present across all pathotypes, suppressing wheat PTI responses (Fig. 3.9). Additionally, the PST EF1 effector, amplified at 250 bp, was identified as a key factor in preventing host cell death and supporting the survival of *Pst*. The PNPi effector, amplified at 220 bp, was found to suppress acquired resistance in wheat leaves against the pathogen (Fig. 3.9). These findings confirmed that all six effector genes (*Pst* 12806, PSEC2, PSEC17, PSEC45, PST EF1, and PNPi) are conserved across the five

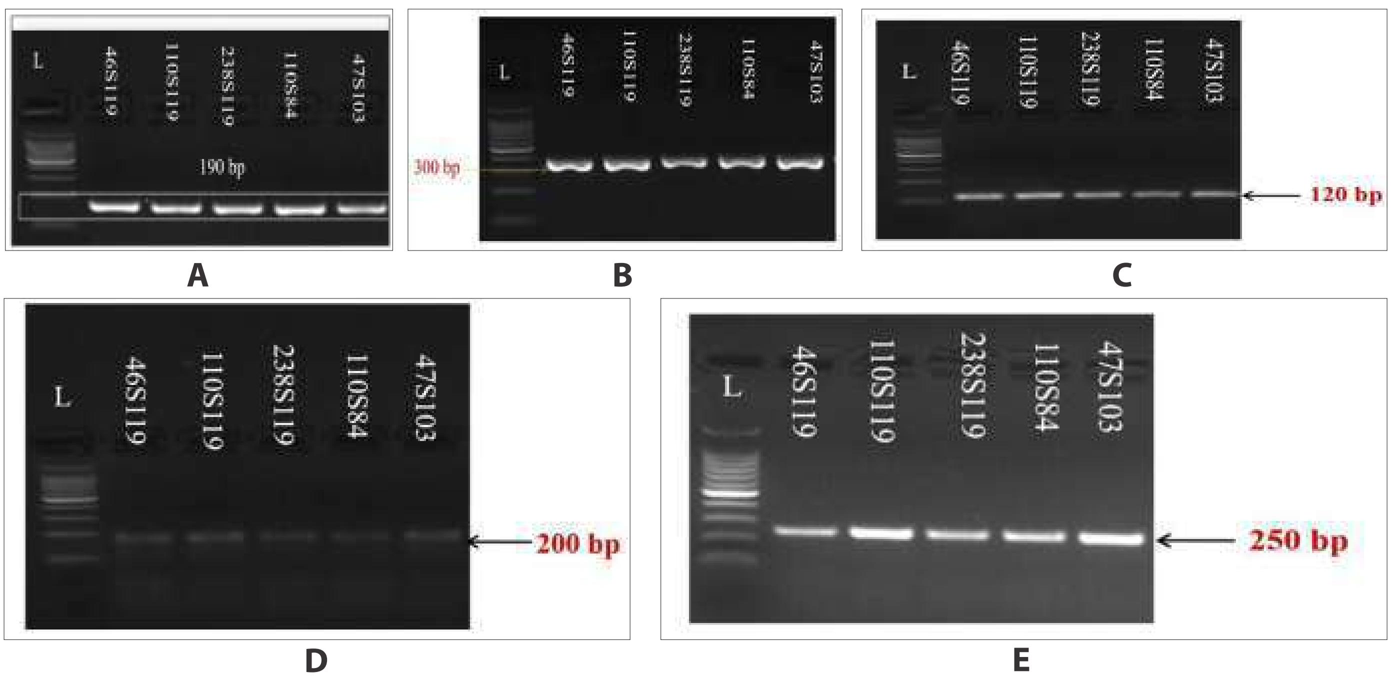


Fig 3.9: PCR-based amplification of effectors in five major pathotypes of *P. striiformis* f. *sp. tritici.* A) Pst 12806 effector B) PSEC2 effector C) PSEC17effector D) the PSEC45 effector gene, E) PST EF1 effector gene and F) PNPi effectorgene. L: 100 bp DNA ladder.

predominant Indian stripe rust pathotypes. This study provides valuable insights into the molecular basis of *Pst* pathogenicity and may facilitate the development of resistant wheat cultivars through targeted breeding and biotechnological interventions.

Genome sequence analysis of the fungal pathogen *Fusarium graminearum*

Fusarium graminearum is a globally significant plant pathogen that not only causes substantial yield losses but also contaminates crops with mycotoxins, making grains unsafe for human and livestock consumption. While the genomes of several *F. graminearum* isolates from different regions worldwide have been sequenced, no such studies have been conducted on isolates from India. This study addresses this gap by sequencing the genome of the *F. graminearum* isolate NFG1, obtained from wheat head spikes exhibiting typical blight symptoms on the PBW343 cultivar grown in Punjab, India. Sequencing was performed using the Illumina NextSeq500 platform with 2 x 150 bp chemistry. The FG-12 isolate revealed a 38.04 Mb genome with 93% coverage and approximately 14,145 predicted genes. Bioinformatic analyses further identified 11,982 genes likely encoding secreted effectors. The genome sequence and annotation data generated in this study offer a valuable resource for intra- and inter-species comparative genomics and gene functional studies, potentially enhancing our understanding of this critical pathogen.

Entomology

Host plant resistance

Shoot fly: Based on the average infestation of shoot fly at three locations viz., Ludhiana, Dharwad and Kanpur, the lowest infestation index of 7.35 % of shoot fly was reported in entry CG1029. However, the highest shoot fly infestation index of 19.59 % was recorded in entry DBW222. At Ludhiana centre, the lowest infestation index of 4.42 % was reported on GW547 and the highest infestation index of 8.44% on Sonalika. At Dharwad location, the lowest shootfly index (8.75 %) was recorded on entry MPO1395 while highest infestation (40.83%) was observed on Raj4581. At Kanpur location, the lowest infestation 2.85 % was observed on DBW 386 and the highest infestation of 20.00% was recorded on entry PBW957.

Brown wheat mite: At Ludhiana, entry MP1386 recorded the minimum mite population of 9.00/10 cm^2 area while the maximum mite population of 15.67 /10 cm^2 was recorded in entry HD3468. This seasonal incidence of mite was very low at Durgapura and Kanpur locations; therefore data of mite incidence were not included.

Foliar aphid: Based on the average score of aphids at four locations; Ludhiana, Karnal, Kharibari and Pusa, four entries viz., PBW891, HD3118(C), NIAW4364 and DBW443 scored an average score of equal or below 3.5 and were in moderately resistance category (grade 3). Location-wise, at Ludhiana centre one entry entry, HD3293 (C) were found to be moderately resistance category (grade 3). Two entries at Karnal viz., DBW443 & DBW426 and two entries at Pusa viz., HI1674 and HI1655 gave resistance response (grade 2). At Kharibari, entries were found to be either in susceptible (grade 4) or highly susceptible (grade 5) category. None of the entry showed the moderately resistance (grade 3) or resistance (grade 2) reaction at Kharibari.

Root aphid: Among the tested entries, all entries were found to be either in susceptible (grade 4) or highly susceptible (grade 5) category against root aphid. None of the entry showed the moderately resistance (grade 3) or resistance (grade 2) reaction at Ludhiana.

Resistance against multiple pests

The average infestation index of shootfly was recorded at three locations (Ludhiana, Dharwad & Kanpur) and it was lowest (12.82 %) in entry HD3428 and the highest (19.24 %) for VL2041(I)(C). The lowest population of 8.00 brown wheat mites/10 cm^2 was recorded in entry NIAW4114 while HI1669 had the highest population of 16.00 mites/10 cm^2 at Ludhiana. Based on an average score of four locations (Ludhiana, Karnal, Pusa and Kharibari), only one entry entry viz., DBW395 showed moderate resistance response (grade 3) to foliar aphid. The rest of entries were found to be either susceptible (grade 4) or highly susceptible (grade 5) to foliar aphid. At Ludhiana, only one entry, DBW386 showed moderatly resistance response (grade 3) to root aphid. All other entries were found to be either susceptible (grade 4) or highly susceptible (grade 5) to root aphid.

Survey and surveillance for insect pest incidence

- In order to monitor the insect pest of wheat and barley, a survey of Punjab state was undertaken during 2023-24 crop season. The aphid incidence was below economic threshold level in most parts of Punjab during the months of February-March. The natural enemies viz. grubs and adults of coccinellid beetles, syrphid fly and chrysoperla were observed in most of the fields infested with aphids. Surveys were also carried out in the months of November-December to monitor the pest prevalence in residue-managed wheat fields. Out of the total surveyed area, approx. 95% cropped area was free pink stem borer incidence; 1-5% pink stem borer incidence was recorded in about 3-4% area and 8-10% incidence in less than 1% area. About 1% area was found to be affected with general yellowing of the crop due to water stagnation in the fields. No serious infestation of armyworm was recorded during 2023-24 crop year.
- In Maharashtra state, survey was carried out in the villages of of Nashik and adjoining district Ahemednagar, Beed, Parbhani, Hingoli and Buldhana of different crop stages on farmer's field during the January and February 2024. There were 36 samples were observed, medium incidence of aphids was recorded during the survey. The Coccinellids larvae, beetles and *Crysoparla carnea* predator adults were also observed. The incidence of shoot fly, stem borer and jassids was recorded in low intensity also termite attack was also observed in some samples but was very low.
- In Kanpur, surveys were conducted in villages viz., Sani, Daleep Nagar and Kalimitti during 2023-24. Incidence of shootfly was recorded between 1 to 1.66 at these locations. The incidence of termite was observed 12-12.66 per cent on wheat varieties viz., PBW343 and HUW 234 of wheat. High infestation (30-55 aphid/tiller) of foliar aphid was on barley variety namely, 'Barley Local' at surveyed locations. The higher incidence of pink stem borer of 1.66% was observed in irrigated crop 1% in variety HD-2967 at Daleep Nagar.
- Moderate to severe infestations of foliar wheat aphids were reported in nearby location of Karnal viz., Indri, Kunjpua, Kathial, Racina, Jind. Early in the crop growth period, minor damage from termites and root aphids was also observed in Karnal and nearby locations. In some fields, pink stem borer and cutworm infestation was reported both at the beginning of the season in December and later in March. The overall incidence of aphids, termites, pink stem borers, and army worms was moderate, ranging between 2-5%. Termite and root aphid infestations were recorded at about 2-3% during November and December. Aphid infestations began appearing in January, starting with 5-6 aphids per tiller, but by February, the numbers had risen significantly, averaging 30-35 aphids per tiller in the fields. Natural enemies, coccinellid beetle grubs and adults and spiders were also observed in aphid-infested fields.

4 RESOURCE MANAGEMENT

Conservation agriculture and cropping system

The rice-wheat system in South Asia is crucial for sustenance, food security, and livelihoods. However, challenges like malnutrition, declining productivity, and resource degradation persist. Exploring alternative cropping systems is essential to address these issues and promote sustainability. Consequently, a field experiment was conducted at the research farm of ICAR-IIWBR, Karnal, to evaluate the potential of maize-based conservation agriculture (CA) compared to conventional tillage (CT) in enhancing diversification, energetics, productivity, profitability, and sustainability in North-West India. Over four-year average, the grain yield of maize, wheat, pea, mustard, and green gram under CA-based management practices surpassed that of CT-based management practices by 6.5, 3.3, 24.7, 12.3, and 33.6%, respectively. Additionally, system productivity of CA-based maize-wheat-green gram, maize-mustard-green gram, maize-pea-wheat, and maize-wheat systems exhibited improvements of 15.2, 15.5, 6.9, and 9.9%, respectively, over their corresponding CT-based cropping systems. Notably, CA-based cropping systems led to a substantial increase of 23.3-30.9% profitability and 10.9-21.8% organic carbon content as compared to their counterpart in conventional system. Maize-mustard-green gram (10.7) under CA showed 127.6% higher energy output: input ratio than rice-wheat system (4.7). Among the systems studied, the CA-based maize-wheat-green gram emerged as the most efficient production system, resulting in a notable 60.0% increase in system productivity and a substantial 129.1% surge in economic profitability compared to the traditional farmers' practice, thus, offering scalable alternative.

Rice residue retention (RRR) v/s rice residue incorporation (RRI)

Rice residue burning poses a significant challenge in the rice-wheat cropping system of India, leading to environmental pollution, health issues, and substantial nutrient loss. To combat this menace, a three-year study was conducted, investigating the effects of rice residue retention (RRR) and incorporation (RRI) at graded N levels (0, 50, 100, 150, and 200 kg/ha) alongside farmers' practices. The primary objective was to enhance wheat productivity, profitability, and soil fertility within this system. Pooled analysis revealed that RRR outperformed RRI at lower nitrogen doses, while RRI excelled with 7.5, 7.4, and 10.0% higher biological yields at higher nitrogen doses (100, 150, and 200 kg/ha). The success of RRR and RRI was attributed to 10.5 and 5.0% higher effective tiller/m^2, respectively, compared to farmers' practices at 150 kg N/ha. Notably, RRR exhibited superior NDVI values at the flag leaf stage (DC37) (0.76) followed by RRI and farmers' practices (0.73) at 150 kg N/ha, highlighting the advantages of RRR practices. At the recommended N dose (150 kg N/ha), RRR displayed a 9.6% lower cost of cultivation compared to RRI and farmers' practices, with 19.6% higher net returns at lower N levels (50 kg/ha), suggesting its greater benefits under low-input conditions.

Precision agriculture

The report from ICAR's Network Program on Precision Agriculture (NePPA) at ICAR-IIWBR showed the advancements in precision agriculture techniques to optimize wheat production in India's north-western states: Punjab, Haryana, and western Uttar Pradesh. Known as the "grain bowl" of the country, this region is essential for India's food security, with a dominant rice-wheat cropping system. However, intensive cultivation has led to challenges like nitrogen overuse, water scarcity, and vulnerability to diseases such as yellow rust. The NePPA program focuses on three core objectives to address these issues: enhancing nitrogen use efficiency (NUE), improving water productivity through precision water management (PWM), and developing a decision support system (DSS) for yellow rust monitoring. Field trials, both at the research stations and at farmers' fields, underscore the potential of these strategies in making wheat production more sustainable.

Nitrogen is essential for wheat growth, but the region's long-standing nitrogen overuse has caused inefficiencies, high costs, and environmental pollution. To improve NUE, the experiments were conducted under NePPA program with graded nitrogen doses (0–210 kg N/ha) on three wheat varieties at ICAR's IIWBR research station. A variety of tools-such as GreenSeeker (for NDVI), SPAD meters (for Chlorophyll Content Index or CCI), and drone-based multispectral imaging-were used to measure crop response to nitrogen.

The trials revealed that nitrogen applications guided by GreenSeeker could save nitrogen compared to the standard dose without affecting yield. GreenSeeker was especially effective in correlating NDVI readings with grain yield, allowing precise nitrogen adjustments based on real-time crop conditions. This precision reduces nitrogen waste and minimizes environmental impact. In addition, the use of drones for multispectral imaging showed that SCCCI (Simplified Canopy Chlorophyll Content Index) had a strong positive correlation with nitrogen doses, indicating its utility for future large-scale nitrogen application management.

Nano urea for enhancing NUE

The demonstrations on farmers' fields showed that 25% N can be saved to get the similar yield as farmers' practice by using two sprays of nano urea through drone application under 75% recommended dose of nitrogen applied plots (Fig. 4.1 and 4.2).

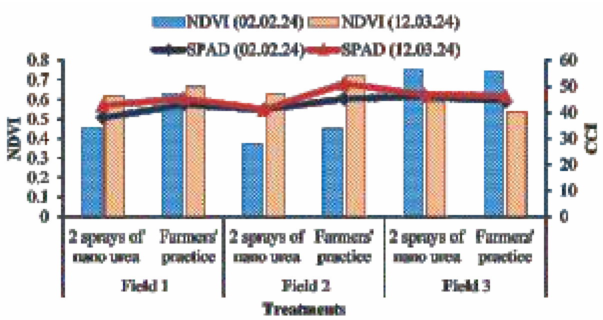


Fig. 4.1 Physiological indices as influenced by farmers' practice and 75% recommended nitrogen dose along with 2 sprays of nano urea

Wheat and rice grain yield in rice- wheat cropping system due to different residue management practices

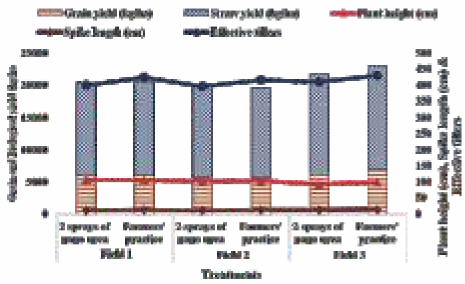


Fig. 4.2 Yield and yield attributes as influenced by farmers' practice and 75% recommended nitrogen dose along with 2 sprays of nano urea

Wheat crop was sown after puddled and direct seeded rice under conventional tillage (no rice residue, burning of rice residue and rice residue incorporation) and zero till condition (no residue, anchored rice residue and full rice residue).

- Significantly higher wheat grain yield was obtained by sowing wheat in anchored, full or no residue under zero till condition as compared to conventional method of sowing after puddlled transplanted rice (Fig. 4.3).
- Maximum wheat yield (65.61 q/ha) was obtained when wheat sowing was done with Happy Seeder in full rice residues after direct seeded rice.
- Maximum rice yield (48.67 q/ha) was obtained under puddled transplanted rice condition after sowing of wheat with happy seeder in full rice residues.
- The highest returns over variable cost (₹ 248469 per ha) and B:C ratio (3.50) under rice- wheat cropping system was realized in direct seeded rice condition and zero till sown wheat with happy seeder in full rice residue (Fig. 4.4).

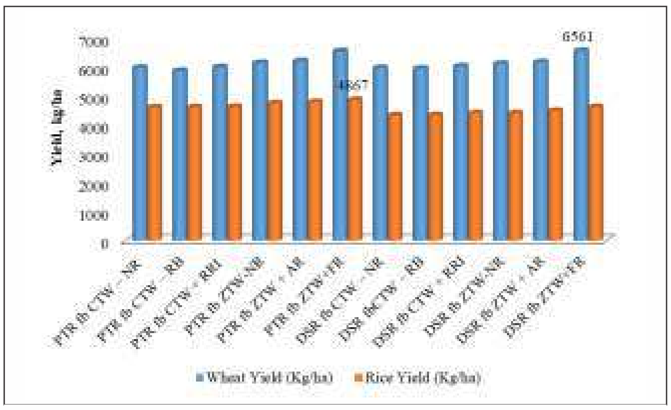


Fig. 4.3 Wheat and rice grain yield in rice- wheat cropping system under different tillage and residue management practices

Fig: 4.4 Economics of different treatments in rice- wheat cropping system under different tillage and residue management practices

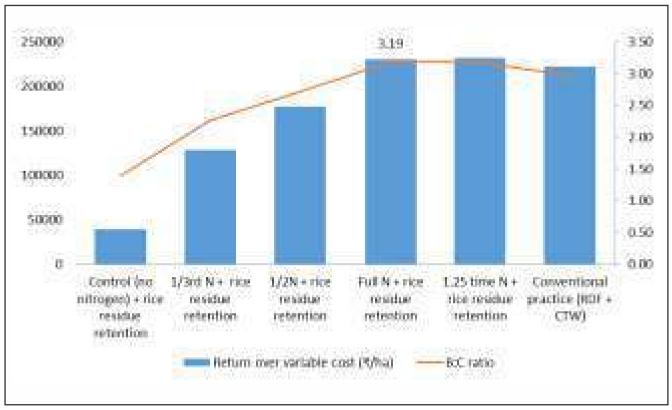


Fig. 4.6 Economics of different treatments in rice- wheat cropping system under different tillage and nitrogen management strategies

Wheat and rice grain yield in rice- wheat cropping system due to different residue and nitrogen management strategies

- Significantly higher grain yield (6112, 6135 and 6086 kg/ha) was recorded when sowing of wheat was done under zero till condition in full residue and N was applied @ 150 kg/ha, 200 kg/ha and recommended dose of fertilizer under conventional till method, respectively, as compared to lower doses of N or no N (Fig. 4.5).
- Similar trend was observed in rice crop also.
- Returns over variable cost (₹ 230703 per ha) and B:C (3.19) was realized under full N application in both the crops and rice residue retention in wheat crop (Fig. 4.6).

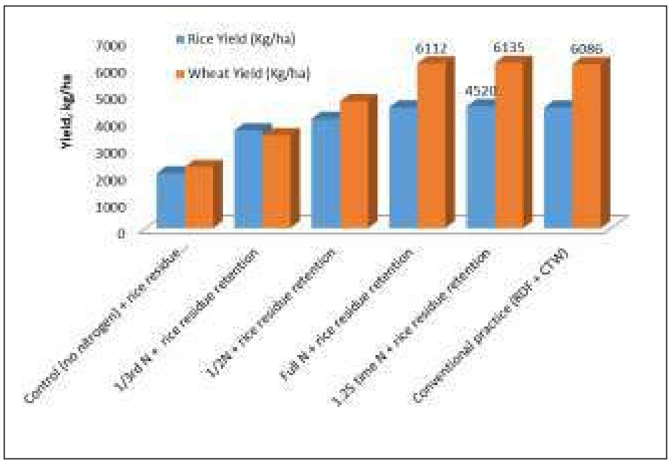


Fig. 4.5 Wheat and rice grain yield in rice- wheat cropping system under different tillage and nitrogen management strategies

Natural farming

In fixed plot experimentation, the initial years finding revealed that grain yield of wheat was reduced significantly under natural farming protocol. Grain yield of rice was also reduced significantly under natural farming protocol.

Popularization of Natural Farming

- Training was imparted regarding preparation of Beejamrit, Jeevamrit and Ghanjeevamrit to different progressive farmers' groups from Haryana, Punjab, Gujarat, Rajasthan, UP and Maharashtra.
- Fifteen trainings/awareness programmes were also organized in Haryana, Himachal Pradesh and Punjab regarding natural farming and conservation agriculture. These awareness programmes were published in national daily newspapers.
- More than 9000 farmers from various parts of country visited the conservation agriculture and natural farming experiments.
- Ten demonstrations were also conducted at farmers' field to popularize the technology.
- Kisan mela on Natural Farming was organized from 19.10.2024 to 22.10.2024 (Fig. 4.7).

Fig. 4.7 Kisan mela on natural farming organized during October 19-22, 2024

- Farmer-cum-scientist workshop was organized from 23.10.2024 to 24.10.2024 to popularize natural farming.

Nutrient Management

Integrated nutrient management in rice-wheat system

This experiment consisting of seven nutrients management combinations [Recommended NPK at the rate of 150:60:40 kg/ha N, P_2O_5 and K_2O, respectively (T_1), T_1+ FYM 15t/ha, T_1+ green manuring, Rec. N only, Rec. P only, Rec. K only and absolute control] of major and organic nutrients viz. FYM and green manuring was initiated with the objective of testing long term effects of nutrient management combinations on rice-wheat cropping system. This field trial was conducted by using wheat variety DBW222. The eighth-year results revealed that biomass and grain yield were significantly lower where only P or K were applied as compared to all other treatments, indicating the significance of nitrogen. The highest grain yield was recorded in treatment where all the major nutrients and FYM 15 t/ha were applied followed by the treatment in which all the major nutrients as well as green manuring were applied. These treatments were significantly better than all other treatments except recommended NPK treatment. The application of recommended nitrogen alone brought significantly higher wheat productivity than alone recommended P, K or PK together; however, the lowest yield was recorded where only P, K or no fertilizers (control) were applied, indicating the importance of nitrogen alone. The application of FYM or green manuring improved the organic carbon content significantly as compared to all other treatments.

Organics in high yielding varieties of wheat in rice-wheat cropping system

Organic production of high input responsive dwarf varieties of wheat is a matter of great concern and hence, four newly released High Yielding Varieties (HYVs) of wheat (HD 2967, DBW187, DBW222 and DBW 303) and five combinations of organic nutrient supply (control, farm yard manure (FYM) 10 t/ha, FYM 20 t/ha, FYM 30 t/ha and recommended doses of chemical fertilizers at the rate of 150:60:40 kg/ha N, P_2O_5 and K_2O, respectively) with two sprays of nano urea and prilled urea at maximum tillering and heading stage thus, having total 40 treatment combinations, were evaluated. The results revealed that application of FYM from 10 t/ha to 30 t/ha increased the biomass and grain yield of all the high yielding varieties of wheat significantly as compared to control (no organic or chemical fertilizer) treatment. However, the highest biomass and grain yield of all the high yielding varieties of wheat were recorded in the recommended NPK fertilizers treatment which was significantly higher than all the organic treatments including 30 t/ha FYM treatment. Among the high yielding varieties, DBW187 recorded the highest grain yield followed by DBW222 and DBW303 with recommended doses of NPK fertilizers (150:60:40 kg/ha). All the varieties performed similarly at all the organics levels and nano as well as prilled urea spray treatments. Prilled urea spay (3%) twice at maximum tillering and heading numerically improved the productivity than nano urea (1250 ml/ha) spray twice at maximum tillering and heading.

Conservation Agriculture (CA) in maize-wheat-green gram system

To evaluate the long-term effect of tillage, residue and nutrient management in maize-wheat-green gram system, an experiment is in progress since *Kharif* 2015 involving combination of tillage and residue management {Zero tillage (ZT); ZT with residue retention (CA); Conventional tillage (CT) and CT + residue incorporation} in main plots and sub plots were having the four nutrient management options (Control; recommended N alone; recommended NPK; and recommended NPK + FYM 10 t/ha). The sowing was done using Turbo Happy Seeder. The results of the season 2023-24 showed that the effect of nutrient management was significant, whereas, that of tillage and residue management and their interactions were non-significant. Among four nutrient management options, the minimum yield (15.51 q/ha) was recorded in unfertilized control plots (Fig. 4.8). The wheat grain yield recorded with application of recommended NPK + 10 t/ha FYM (62.29 q/ha) was significantly better than the recommended N alone (34.95 q/ha) and recommended NPK (57.09 q/ha).

These results indicate the superiority of integrated nutrient management in producing wheat yield.

Observations were also recorded on soil temperature at 5 cm depth in the morning and in the afternoon on different dates. The morning temperatures were slightly higher in CA system where as the reverse was true in the afternoon. Among the treatments, the afternoon temperature in the control plots was higher than different nutrient management treatments.

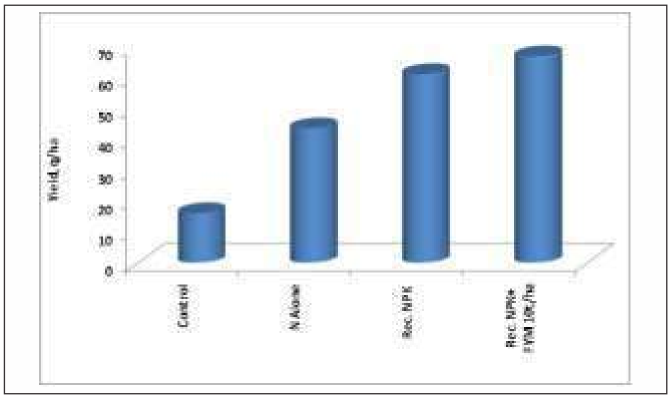


Fig 4.8. Nutrient management in wheat across tillage option in maize-wheat system

Field demonstration on direct seeding of wheat under rice residue and sugarcane trash using Rotary Disc Drill

Field demonstrations on *in-situ* crop residue management in sugarcane-wheat cropping systems were conducted at farmers' fields. In sugarcane-wheat cropping system, wheat was directly sown under no-till conditions using Rotary Disc Drill (RDD) in the presence of sugarcane trash at farmers' fields of Johar Majra and Kartarpur villages in Karnal district (Fig. 4.9). The machine was effective in direct seeding the crop in the presence of crop residue with lesser power requirement and lesser soil disturbance. It allows the farmers to take the additional crop of wheat or other pulse crop like moong bean and to earn the more profit from the same land resources through increased cropping intensity in sugarcane-based systems. The direct seeding of wheat into sugarcane trash through this technology would be helpful to expand the wheat area in the sugarcane belt. Moreover, it can also be used for direct seeding of other crops such as rice, soybean, barley, green gram, and pigeonpea.

Fig. 4.9. Field demonstrations of RDD for direct sowing of wheat under rice residue and sugarcane trash

Zero-till disc drill of ICAR-CIAE, Bhopal, was also tested in the presence of anchored and loose rice residue. The machine was able to perform the seeding operation under zero-till condition with or without anchored residue but clogging problem was observed under loose crop residue condition.

Weed management in wheat

Weed infestation is one of the major biotic constraints limiting the production and productivity of wheat. For realizing potential crop yield, efficient weed management is very important. The average losses caused by weeds if not controlled are about 25 to 30% but in some cases depending on weed flora, weed intensity, time of emergence, soil and environmental factors, the losses can be up to complete crop failure. Among various methods of weed control, chemical weed control method is preferred in wheat due to its cost and time effectiveness. However, the sole dependence on herbicides has resulted in the evolution of new cases of herbicide resistance in weeds, as a result there is a need of evaluating the new herbicides and herbicide mixtures from different chemical groups. The major findings of field and pot experiments conducted on evaluation of herbicides and herbicide mixtures against weeds in wheat are as follow:

- In field studies, more than 90% control of diverse weed flora was observed with pre-emergence application of pyroxasulfone + pendimethalin 127.5 + 1500 g/ha, pyroxasulfone + flumioxazine 127.5 + 100 g/ha, pyroxasulfone + metribuzin 127.5 + 300 g/ha and oxyflourfen + metribuzin 300 + 300 g/ha. The wheat grain yields recorded in these treatments were statistically similar to weed free check treatment.
- In another study, pyroxasulfone alone and in combination with metribuzin was evaluated for

weed control in wheat. Pyroxasulfone alone at 127.5 g/ha applied as pre-emergence effectively controlled the grass weeds namely, *Phalaris minor* and *Avena ludoviciana*, but was poor for control of broad-leaved weeds (*Rumex dentatus* and *Medicago denticulata*). However, pre-mix combination of pyroxasulfone + metribuzin was very effective for control of diverse weed flora in wheat and the optimum dose was observed as 337.5 (127.5 +210) g a.i./ha. As this pre-mix combination is having two mechanisms of action, the combination will be helpful in managing the herbicide resistance problem in weeds. Moreover, the pre-mix combination had no carry over effect on succeeding green gram and rice crop.

- Pinoxaden alone and in combination with metribuzin was also evaluated for weed control in wheat. Pinoxaden alone at 45 g/ha as post emergence was effective for control of grass weeds namely, *Phalaris minor* and *Avena ludoviciana*, but was not effective against broadleaved weeds. Ready-mix combination of pinoxaden+ metribuzin was very effective for control of grass as well as broad-leaved weeds in wheat. The optimum dose was observed as 225 (45+180) g a.i./ha. Also, the pre-mix combination had no residual effect on the succeeding crop of green gram and rice.
- In rice-wheat system, double no-till system led to more problems of *Rumex dentatus* and *Medicago denticulata*. The infestation of *Cyperus rotundus* in maize was significantly reduced with adoption of no-till and application of pre-plant non-selective herbicide glyphosate in maize-wheat-greengram system. Wild oat infestation was observed higher in maize-wheat than in rice-wheat system.
- Inclusion of short duration crops such as pea and potato in between rice and wheat reduced the infestation of *P. minor* in late sown wheat.
- Pot studies were conducted to identify and quantify the herbicide resistance in different weeds (*P. minor, Rumex dentatus, Avena ludoviciana, Chenopodium album* and *Polypogon monspeliensis*). For monitoring of herbicide resistance evolution in *P. minor,* 70 biotypes were collected across Haryana and evaluated in bioassay for resistance detection and found widespread multiple resistance (against clodinafop, pinoxaden and sulfosulfuron). For management of multiple herbicide resistant *P. minor, A. ludoviciana* and *Polypogon monspeliensis* (against clodinafop, pinoxaden and sulfosulfuron) pyroxasulfone, aclonifen + diflufenican, and metribuzin were found effective.
- Pre-emergence application of pyroxasulfone, pendimethalin, oxyflourfen, flumioxazine and metribuzin was found effective for control of ACCase and ALS inhibitor herbicide resistant population of *Phalaris minor*. In pot studies, 100% control of multiple herbicide resistant and susceptible populations of *P. minor* was observed with application of pyroxasulfone 127.5 g/ha, pendimethalin 1000 g/ha, oxyflourfen 300 g/ha, flumioxazine 125 g/ha and metribuzin 150 g/ha.
- For control of metsulfuron resistant *Rumex dentatus* and *Chenopodium album*, halauxifen + fluroxypyr, aclonifen + diflufenican, 2,4-D, carfentrazone, pendimethalin, and metribuzin were found effective.
- *Cynodon dactylon* is a problematic weed particularly under no till situations. In long term no till experiments, it has been observed that its infestation increases if not effectively controlled. For controlling *Cynodon dactylon* glyphosate, paraquat and glufosinate alone and in combinations were evaluated (Fig. 4.10). It was observed that paraquat 500 g/ha and glufosinate 400 g/ha were poor for control of *Cynodon dactylon*.

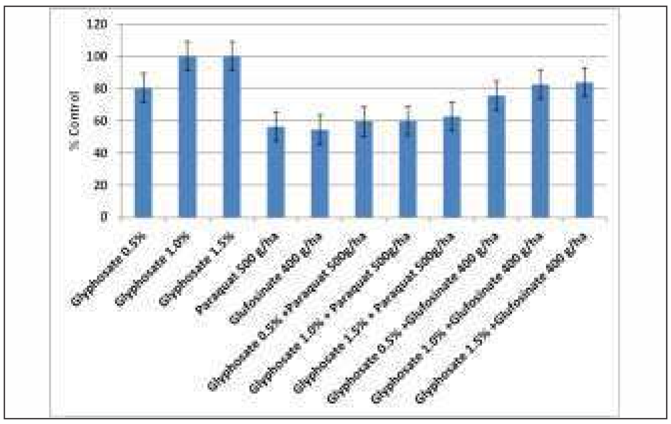


Fig. 4.10. Herbicides suitable against *Cynodon dactylon*

The biomass reduction with paraquat and glufosinate was 56.3 and 54.3%, respectively. Spray of glyphosate at ≥1% spray solution (500 lit/ha) provided the effective control of *Cynodon dactylon*.

Improving resource use efficiency in wheat

Experiments were conducted to study water productivity (WP) of 12 wheat genotypes under different moisture levels (60, 80 & 100% of ETc), and seed rate (60, 80 and 100 kg/ha). The findings of the study are as mentioned below:

- The mean grain yield (5332 kg/ha) with 80% ETc irrigation level was similar to 100% ETc (5453 kg/ha), suggesting 20% savings of irrigation water. The mean water productivity (WP) increased from 2.11 kg/m^3 to 2.41 kg/m^3 on changing the irrigation level from 100% ETc to 80% ETc.
- The seed rate of 80 kg/ha was found to be optimum in terms of grain yield and WP, suggesting 20% savings of seed.
- Among genotypes, the maximum mean WP was recorded to be 2.70 kg/m^3 for G8 (BWL 6321/QBP 1622) followed by 2.54 (BWL 6321/DBW 88), 2.52 (PBW 765/NW 5054) and 2.51 kg/m^3 (DBW 303).

Barley agronomy

The different experiments were conducted on evaluation of barley genotypes in AVTs under different production conditions such as date of sowing, seed rate, nitrogen scheduling, plant growth regulators application and weed control. The major findings are as follows:

- The mean productivity of hulless barley reduced from 46.78 to 29.12 q/ha on shifting the sowing time from normal to late condition primarily due to significant reduction in earhead/m^2, grains/earhead and thousand grain weight.
- Under salinity condition, the productivity of barley was higher with 90 kg/ha nitrogen as compared to 60 and 75 kg/ha nitrogen levels due to improvement in earhead/m^2 under high dose of nitrogen application.
- For controlling broadleaved weeds in barley, various herbicides and their combinations were evaluated. Halauxifen + fluroxypyr 200.6 (6.1+194.5) and metsulfuron + carfentrazone (4+ 20) g/ha were found effective for control of diverse type of broadleaved weed flora in barley.
- The barley grain yield increased with seed rate and the maximum mean grain yield (49.77 q/ha) was produced at 100 kg/ha seed rate which was significantly superior to both the lower seed rates (60 and 80 kg/ha).
- The application of plant growth regulators showed significant effect on the grain yield of barley. Among growth regulators treatments, maximum grain yield (47.68 q/ha) was recorded with TIBA (2,3,5-Triiodobenzoic Acid) @100 ppm application at tillering; however, it was statistically at par to two foliar tank-mix sprays of CCC (Chlormequat chloride) + tebuconazole (0.2% + 0.1% product dose) at tillering and jointing.

5 QUALITY AND BASIC SCIENCES

Analysis of AICRP on Wheat & Barley Trials

During 2023-24, 176 AVTs, 280 NIVTs, 22 HYPTs, 36 QCWBN, 29 SATSN and 30 IVTs, were analyzed from centres representing different zones and growing conditions. Promising genotypes showing superiority in various quality traits including iron and zinc content were identified. All the AVT IInd year entries including checks were also evaluated for chapati, bread and biscuit for identification of product specific promising genotypes (Table 5.1).

Table 5.1 : Promising *T. aestivum* genotypes for chapati and bread

Category	Genotypes
	Chapati (Score >8.0)
Check	HI1650 (C) (CZ-ITS)
AVT	HD3428* (NWPZ-ILS), NWS2222* (PZ-ITS), NIAW4114* (PZ-ILS)
	Bread (Loaf volume ~600 ml)
Check	DBW222 (C) (NWPZ-ITS), JKW261 (C) (NWPZ-ILS), DBW173 (C) (NWPZ-ILS), GW547(I) (C) (CZ-ITS), CG1040(I) (C) (CZ-RITS), MP1378(I) (C) (PZ-ITS), HD3090 (C) (PZ-ILS), DBW187 (C) (CZ-HYPT), DBW377 (I) (C) (CZ-HYPT)
AVT	PBW891* (PZ-ITS), AKAW5100* (PZ-ITS), GW543* (CZ-HYPT)

In addition, promising genotypes were identified both for *T. aestivum* and *T. durum* for individual quality parameters like protein content, grain hardness index, sedimentation value, yellow pigment, iron, and zinc (Table 5.2).

Table 5.2: Promising genotypes for various quality parameters

Parameter	Value	Genotypes
		(*T. aestivum*)
Protein	≥12.5%	**NEPZ:** PBW915, KRL2106, DBW107 (C), UP3124, PBW833 (C), WH1323, WH1324 **CZ:** GW547(I) (C), MACS6768 (C), HI1634 (C), MP4010 (C), MACS6830, DBW428 **PZ:** AKAW5100*, DBW443*, CG1045, LOK79*, NIAW4114*, HI1674*, HD3090(C), Raj4083 (C), HI1633 (C), NIAW4432, MACS6830, HI1687, DBW426, MACS6829, HI1605 (C), NIAW3170 (C), DBW359 (I) (C), CG1047, NIAW4267 **HYPT (CZ):** DBW434 **HYPT (NWPZ):** DBW187 (C), DBW372(I) ©, DBW380
Sedimentation value	> 60 ml	**NEPZ:** WH1323 **PZ:** MACS6842, DBW359 (I)© **HYPT (CZ):** DBW187 (C), WH1320
Hardness Index	< 35	**NHZ:** VL2041 © **NWPZ:** NIAW3170 © **HYPT (CZ):** DBW445
Iron	≥40ppm	**NHZ:** HS562 ©, VL907 ©, VL2041 ©, HPW349 ©, VL2059M **NWPZ:** HI1668*, HD3086 (C), PBW957M, HD3428*, DBW173 (C), NW8071, DBW422, HI1653 (C), HD3369 (C), PBW644 (C), NIAW3170 (C), DBW296 (C), PBW927 **NEPZ:** HI1563 ©, HD3171 ©, JKW 304 **CZ:** HI1650 ©, MACS6768 ©, HI1683, MACS6830, DBW110 ©, CG1036 ©, NIAW4267, UAS3029, DBW432

Parameter	Value	Genotypes (*T. aestivum*)
		PZ: PBW891*, WH1306*, NWS2222*, DBW443*, MACS6222 (C), MP1378(I) (C), UAS3026, MACS6844, CG1045, LOK79*, NIAW4120*, RAJ4083 (C), DBW425, MACS6830, HI1687, DBW426, MACS6829, HI1605 (C), HI1665(I) (C), DBW359(I) (C), CG1047, NIAW4267 **HYPT (NWPZ):** DBW327 (C) **HYPT (CZ):** CG1044*, DBW377(I) (C), DBW327(I) (C), MP1399, PBW906, DBW436
Zinc	≥40ppm	**NHZ:** VL907 ©, VL2059M **NWPZ:** DBW417, HD3494M **CZ:** HI1669*, GW547(I) (C), MACS6768 (C), GW555, HI1634 (C), MP4010 (C), CG1029 (C), UAS3029 **PZ:** WH1306*, DBW443*, GW322 (C), MACS6222 (C), MP1378(I) (C), MP3570, CG1045, LOK79*, HI1674*, HD3090 (C), RAJ4083 (C), HI1633 (C), DBW425, MACS6830, HI1687, DBW426, MACS6829, DBW359(I) (C), CG1047, NIAW4267
		(T. durum)
Protein	>13.0%	**PZ:** UAS446(d) (C), UAS478(d)(I) (C), MACS4131(d), GW1368(d), HI8852(d), UAS484(d), HI8851(d)
Sedimentation value	≥40 ml	**CZ:** MPO1395(d), MACS4135(d), MPO1398(d) **PZ:** MACS3949(d) (C), DDW62(d), MPO1395(d), MACS4135(d), UAS446(d)(C), UAS484(d)
Yellow Pigment	>7.0ppm	**CZ:** UAS484(d) **PZ:** HI8848(d), MACS4135(d), UAS478(d)(I) (C), HI8852(d), UAS484(d)
Iron	≥40ppm	**CZ:** MACS4125(d), MPO1395(d), HI8851(d) **PZ:** DDW62(d), HI8852(d), HI8851(d)
Zinc	≥40ppm	**CZ:** HI8737(d) (C), HI8713(d) (C), MACS4125(d), MACS4135(d), HI8850(d), HI8848(d) **PZ:** HI8737(d) (C), MACS3949(d) (C), HI8849(d), HI8850(d), HI8848(d), MACS4135(d), UAS446(d) (C), UAS478(d)(I) (C), MACS4131(d), GW1368(d), HI8852(d), HI8851(d)

Crosses involving Nap Hal source of *Glu-D1* double null : During cropping season 2023-24, crosses were propagated using NapHal as one of the parents with high yielding background varieties. The material was also screened for high grain Fe content (GFeC), grain Zn content (GZnC), protein clubbed with high phytase and low phytic acid. Generation wise values of quality components (mean values and range) and correlation between Fe and Zn are given in Table 5.3. There was a positive correlation between GFeC and GZnC across the generations. Minima and maxima for sedimentation volume (SDV), GFeC and GZnC were found in the range of 16.8-45.1 ml, 30.1-46.2 ppm and 25.4-42.1 ppm, respectively (Table 5.4). Based on SDV, GFeC and GZnC, 6 entries having NapHal background, have been selected and sent for multilocation testing. Out of these, 3 entries with low SDV and soft grain character (hardness index 22-36), can be suitable candidate for biscuit making (Table 5.4). The rest two entries of NapHal background have been clubbed with outstanding entries for GFeC and/or GZnC over baseline as these were also having high iron & zinc crosses (CRP) in their pedigree.

Table 5.3: Correlation between GFeC and GZnC, mean and range of quality components across various generations

Generation	Iron vs Zinc (Correlation)	Sed. volume (ml)		Fe (ppm)		Zn (ppm)	
		Mean	Range	Mean	Range	Mean	Range
F4	0.14	27.2	17.7-45.1	39.1	35.1-46.2	30.1	25.4-39.1
F5	0.75	23.3	21.1-26.4	39.4	37.7-41.9	30.0	25.4-33.8
F6	0.90	21.9	18.5-25.1	36.3	33.4-38.7	29.0	27.0-31.8
F7 onwards	0.50	21.7	16.8-38.6	36.1	30.1-44.6	31.9	25.8-42.1

Table 5.4: Promising entries for sedimentation volume, GFeC and GZnC during 2023-24

Pedigree	Hardness	Sed. Volume (ml)	Fe (ppm)	Zn (ppm)
HD3086*2/HD 2967*2/NapHal	22	21	41.9	33.8
HD 2967*2/NapHal	28	23	44.6	33.6
HS 490*2/UP 2425*4/NapHal	36	21	40.6	42.1
DBW187/CRP1663/ HD2967*2/NapHal	48	45	37.3	39.1

Generation of crosses for enhanced Fe, Zn, protein and low phytate content using suitable donors with high yielding cultivars:

Increasing essential micronutrient content in wheat genotypes and their bioavailability and bioaccessibility for monogastric animals and human consumption can ultimately lead to improved animals and human health. To achieve this goal, based on previous evaluation of crosses, selection was done for disease free plants at research field of ICAR-IIWBR, Karnal. During 2023-24 cropping season, several crosses were made into high yielding wheat cultivars' background (HD 2967, HD 3086, HD 3226, DBW 173, DBW 187, WB 02) using reasonable phytase and low phytic acid mutants developed in the background of PBW 502 at ICAR-Indian institute of Wheat and Barley Research, Karnal (work done previously) and advanced into higher generations based on phenotypic evaluations. Table 5.5 is showing various lines and their generations, carrying beneficial components (Fe, Zn, protein, phytase) clubbed with less antinutritional factors (phytic acid), raised during cropping season 2023-24. Different crosses made for intended quality parameters are at various generation stages as depicted in Table 5.5.

Table 5.5: Crosses for enhanced Fe, Zn, protein, and low phytate content along with high phytase levels using suitable donors with high yielding cultivars; selections made and advanced into higher generations during 2023-24 cropping season

High yielding cultivars	High Fe, Zn and protein content	High phytase and Low phytate levels	Three way (High Fe, Zn, and Phytase)
HD 2967	F_4, BC_1F_3, BC_1F_4, BC_1F_6, BC_2F_8, RIL	F_4, F_5, F_6, F_8, BC_1F_3, BC_1F_4, BC_1F_5, BC_2F_3	F_3, F_5
HD 3086	F_4, F_5, F_6, F_7, F_8, BC_1F_3, BC_1F_5, BC_1F_8	F_4, F_5, F_6, F_7, F_8, BC_1F_3, RIL	F_5
DBW 187	F_4, F_5, F_6, BC_1F_5	F_4, F_5, F_7, BC_1F_3, BC_1F_4	F_5
HD 3226	F_4	F_4, F_6, BC_1F_4	F_4
WB 02	F_4, BC_1F_4	F_4, F_5, F_6, BC_1F_4, RIL	F_3, F_4
DBW 173	BC_1F_4, BC_1F_5	F_4, F_5s, BC_1F_4s, BC_2F_3	F_3, F_4
DBW 316	F_2		
DBW 303	F_3		F_3
DBW 222	F_3		F_3
DBW 327	F_2		
DBW 332	F_2		

Reflection of generation wise iron and zinc improvement

Further, generation wise Pearson's correlation between protein, iron and zinc and corresponding range of grain Fe and Zn has been given in Table 5.6. The data depicted positive correlation close to 0.65 throughout generations between Fe and Zn inheritance. The range of GFeC and GZnC across the generations has been found between 30.6-47.6 and 23.1-48.1, respectively. Six outstanding entries (including two involving NapHal crosses) have been selected based on GFeC and GZnC as given below in Table 5. 7.

Table 5.6: Generation wise Pearson's correlation between biofortification components

Generation	Iron vs Zinc	Protein vs iron	Protein vs zinc	Fe (ppm)		Zn (ppm)	
				Minima	Maxima	Minima	Maxima
F4	0.65	0.49	0.70	31.6	47.6	23.5	48.1
F5	0.68	0.31	0.32	32.0	43.3	24.8	38.7
F6	0.65	0.42	0.56	30.6	43.8	23.1	43.2
F7 onwards	0.66	0.42	0.59	30.7	40.8	23.4	36.1

Table 5.7: Outstanding entries for GFeC and GZnC over baseline (40 mg/kg) during 2023-24

Pedigree	Sedimentation volume (ml)	Fe (ppm)	Zn (ppm)	Phytase (FTU/kg)	Phytic acid (%)
HD2967/T1-134/CRP1660	53.0	45.5	48.1	1479	0.57
HD3086/CRP1661/T1-242	38.6	43.2	43.1	1913	0.56
HD3086/CRP1661/T1-242	40.7	44.9	41.5	1901	0.80
HD 3086/CRP1663	43.8	43.3	43.2	4413	0.61
DBW187/CRP1660/ HD2967*2/NapHal	22.0	46.2	32.1	2958	0.62
DBW187/CRP1660/ HD2967*2/NapHal	41.0	44.3	33.5	2477	0.62

Antigenicity comparison between aestivum and durum: An experiment was conducted using monoclonal antibody (Sigma-Aldrich; SAB4200864; Anti-Gliadin antibody, Mouse monoclonal) to compare the gliadin antigenicity between aestivum (6) and durum (9) (released) varieties using indirect ELISA. Correlation coefficient for aestivum and durum was found to be 0.68 and 0.24, respectively, though both found to be non-significant statistically, may be due to less sample size. The average gliadin antigenicity for aestivum and durum was found to be 0.83 and 0.55, respectively for aestivum and durum.

Mitoferrin gene identification and characterization

Iron (Fe) and zinc (Zn) are vital for plant growth and human nutrition, regulated by genes and miRNAs. We identified and characterized 11 mitoferrin genes in wheat, distributed across chromosomes 3, 4, 6, and unanchored scaffolds (ChrUn). These genes encode mitochondrial iron transport proteins, essential for cellular respiration and Fe homeostasis. *In silico* analysis revealed protein molecular weights of 38–68 kDa, instability indices of 38–63, and isoelectric points (pI) of 6.8–9.6, indicating diverse stability and acidic to basic properties. GRAVY values (-0.43 to 0.31) suggested mostly hydrophilic proteins. These findings provide insights into Fe/Zn homeostasis in wheat.

Validation of Fe/Zn-responsive miRNAs and their target genes

Transcriptomic analysis identified 14 miRNAs linked to Fe/Zn homeostasis, targeting genes involved in metal transport, storage, and regulation. Validation via qPCR in Fe/Zn-efficient genotype, Narmada 195 and inefficient genotype PBW502 revealed differential miRNA expression in root and shoot tissues under hydroponic conditions with varying nutrient levels. Efficient genotypes exhibited higher miR399 and miR398 expression, aiding nutrient signaling and oxidative stress management, while PBW502 upregulated miR827 under deficiency. Fe/Zn-deficient conditions showed upregulation of miRNAs targeting Fe transporters in both genotypes, but Narmada 195 maintained higher target gene expression, highlighting its robust regulatory network for efficient Fe/Zn uptake and distribution.

Protein, hectoliter weight, flour, and bran recovery profile of 250 wheat lines at three locations

A study of 250 wheat lines from Ludhiana, Jabalpur, and Samastipur revealed significant regional variations in protein content, hectoliter weight, and milling profiles. Jabalpur location showed the highest average protein content (12.4%), with a range of 10.2 to 15.1%, attributed to favorable environmental factors (Fig. 5.1). However, its wheat grains had the lowest hectoliter weight (75.2 kg/hl), indicating lighter grains. In contrast, Ludhiana and Samastipur recorded higher average hectoliter weights (79.3 kg/hl), reflecting denser grains.

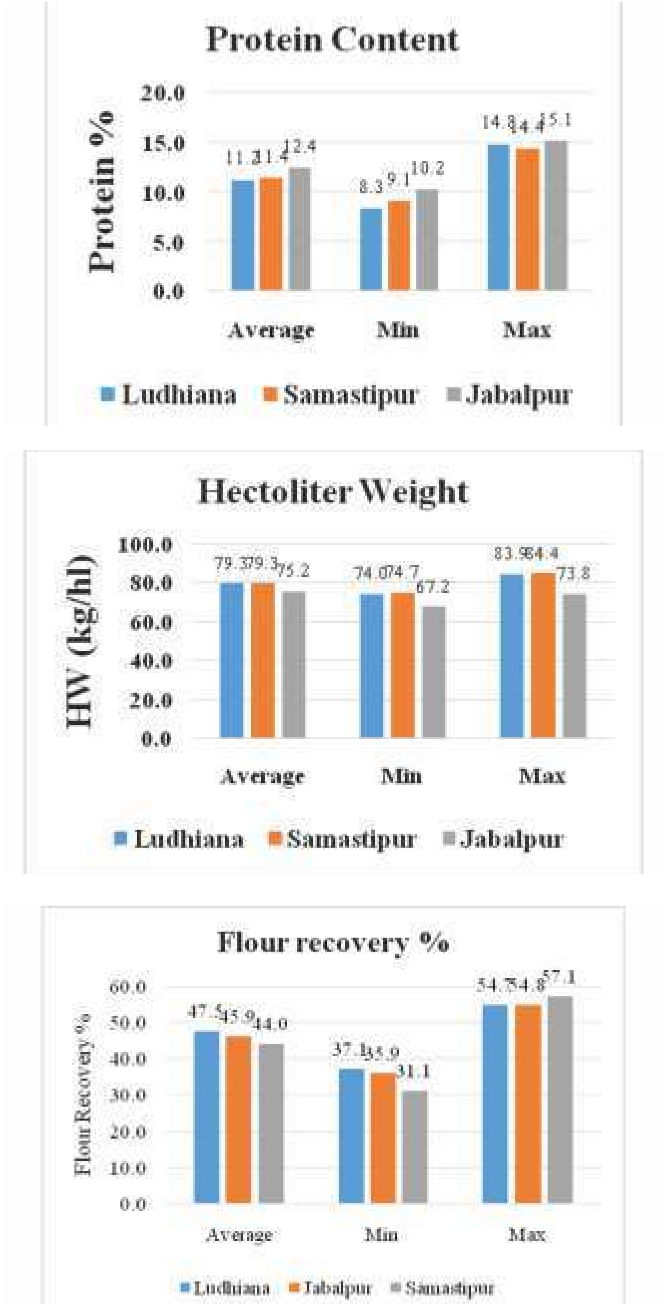


Fig. 5.1: Quality analysis of 250 wheat lines from three different locations

Ludhiana location excelled in flour recovery (47.5%), followed by Jabalpur (45.9%) and Samastipur (44.0%), which exhibited the widest variability. Samastipur location had the highest bran recovery (43.0%), while Ludhiana had minimal milling waste (11.2%), showcasing superior efficiency. These regional differences underline the influence of climate, soil, and crop practices on wheat quality, offering insights for tailored breeding and milling strategies to optimize grain characteristics for specific applications.

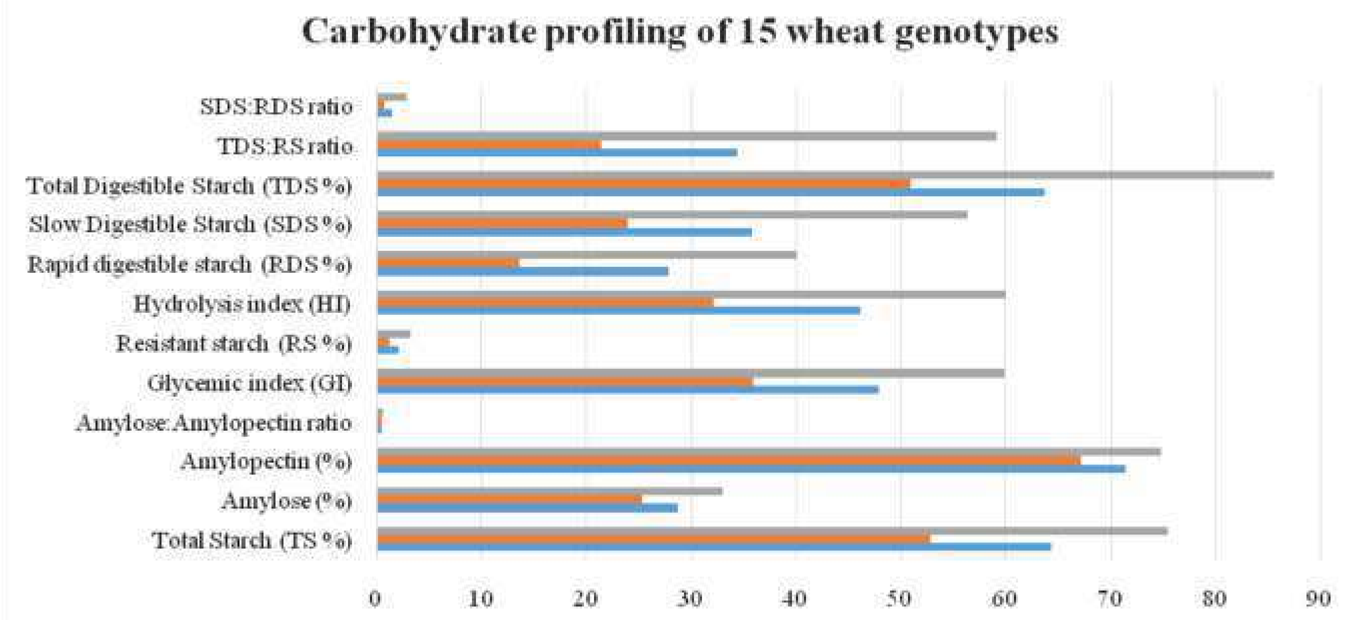
Profiling of starch composition, digestibility, glycemic index in fifteen recently released wheat genotypes

The analysis of starch composition, digestibility, and glycemic properties in 15 recently released wheat genotypes grown at Karnal location revealed significant variability, highlighting diverse nutritional and processing potential. Total starch content averaged 64.2% (range: 52.8–75.4%), with amylose at 28.7% (25.3–33.0%) and amylopectin at 71.3% (67.0–74.7%) (Fig. 5.2). The amylose-to-amylopectin ratio averaged 0.40, affecting digestibility. Glycemic index (GI) ranged from 35.8 to 59.8 (average: 47.9), identifying both low- and high-GI genotypes suitable for health-conscious populations. Resistant starch (RS) averaged 1.99% (1.1–3.19%), which is considered as a healthy contribution to dietary fiber. Digestible starch fractions showed reasonable variability: rapid digestible starch (RDS) averaged 27.8%, slow digestible starch (SDS) 35.7%, and total digestible starch (TDS) 63.6%. Ratios like TDS-to-RS (34.3) and SDS-to-RDS (1.45) further emphasized genotypic differences. Genotypes with high RS, SDS, and low GI are ideal for low-GI products, while those with high RDS and TDS suit energy-demanding applications, aiding tailored breeding efforts.

Iron and Zn content trends in *T. aestivum* varieties released during 1950 to 2023

Trend analysis of Fe and Zn content (measurad by EDXRF) in wheat across decades highlights significant genetic improvements. Fe content in varieties released from 1950-1970 averaged 34.2 ppm, increasing to 36.4 ppm in the Green Revolution era (1971-1980) due to dwarfing gene incorporation. From 1981-1990, Fe levels averaged 37.0 ppm, rising further between 1991-2000 (e.g., CPAN 3004, 41.5 ppm) (Fig. 5.3). Varieties from 2001-2010 showed an average of 37.8 ppm, peaking with WB 2 (46.3 ppm) from 2011-2023, reflecting biofortification success. The Zn content followed a progressive trend, starting with early varieties like NP 809 (38.4 ppm) and Sonalika (31.5 ppm). Green Revolution varieties showed modest improvement, while 1981-2000 saw Zn levels in the mid-30s range, advancing to 40.6-40.7 ppm in 2001-2010 (e.g., PBW

550). Modern varieties like WB 2 (42.5 ppm) and DBW 303 (40 ppm) underscored recent biofortification efforts, integrating nutrient-dense traits into wheat breeding.



	Total Starch (TS %)	Amylose (%)	Amylopectin (%)	Amylose :Amylopectin ratio	Glycemic index (GI)	Resistant starch (RS %)	Hydrolysis index (HI)	Rapid digestible starch (RDS %)	Slow Digestible Starch (SDS %)	Total Digestible Starch (TDS %)	TDS:RS ratio	SDS:RDS ratio
Maximum	75.4	33	74.7	0.49	59.8	3.19	59.9	40	56.3	85.4	59.1	2.84
Minimum	52.8	25.3	67	0.34	35.8	1.1	32	13.5	23.9	50.9	21.3	0.69
Average	64.2	28.7	71.3	0.4	47.9	1.99	46.1	27.8	35.7	63.6	34.3	1.45

Maximum Minimum Average

Fig. 5.2: Profiling of starch composition, and glycemic index in fifteen recently released wheat genotypes

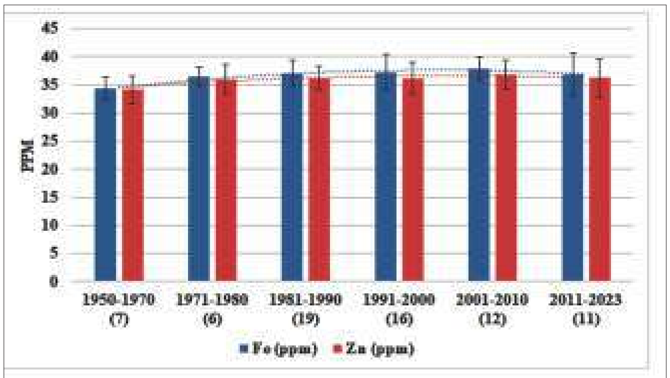


Fig. 5.3: Decadal trends in Fe and Zn content (ppm) in *T. aestivum* wheat varieties released during 1950 to 2023 grown at Karnal location during crop season 2022-23. All the genotypes were hand threshed to avoid mineral contamination especially Fe. Decadal trends are mean of genotypes mentioned in parenthesis

Quantification of total and soluble pentosan content in CZ varieties: Wheat, serves as a significant source of dietary fiber, comprising soluble dietary fibers (SDFs) and insoluble dietary fibers (IDFs). Among SDFs, soluble pentosans (SP), also known as water-soluble pentosans (WSPs), have garnered attention for their health benefits, including improved intestinal motility, blood sugar regulation, blood pressure reduction, and colon cancer prevention. Whole wheat typically contains 0.8–1.2% soluble pentosans. The total and soluble pentosan content of 17 wheat varieties grown across four locations in the Central Zone (Indore, Vijapur, Powar Khera, and Junagarh) was estimated using the Orcinol-HCl colorimetric method (Hashimoto et al., 1987). The highest total pentosan (TP) content was recorded in the HI 1634 variety (7.19 %, Junagarh), while the highest soluble pentosan content was observed in HD2932 (1.37%, Junagarh). Soluble pentosan percentages (SP/TP*100) ranged from 8.03 to 28.54%, with the maximum percentage reported for CG1036 (28.54%, Vijapur).

Investigation of salinity induced alterations in selected genotypes under field conditions: A field experiment was performed for two crop seasons (2021-22, 2022-23) with 20 varieties, under control and saline-sodic conditions. The varieties were tolerant, moderately tolerant, and sensitive to salinity and analyzed for their physiological, biochemical, and molecular response to salinity. Correlation analysis of parameters under salinity stress showed that superoxide dismutase and proline parameters were strongly positively correlated while Na^+ content was strongly negatively correlated with the grain weight per spike. Hence, these three factors could serve as effective criteria for the rapid screening of germplasm against salinity stress for the identification of new elite lines in breeding programs. Based on gene expression analysis of starch biosynthesis, genes like, SS1, SS2b, GBSS and ADPG, a gene GBSSI was selected for cloning. Cloning and sequencing of partial gene sequence of *GBSS1* was performed in DBW187, and three deletions were found that can be used as potential SNPs for the identification of salinity tolerance in wheat (Fig. 5.4).

Preparation of wheat grits/ daliya: Dalia is a traditional breakfast meal commonly consumed in North India. It is generally prepared by cooking wheat

Fig. 5.4: Alignment analysis of GBSS1 gene with cloned sequence of GBSS gene from DBW187. Mismatches and deletions are highlighted.

grits with water or milk and can be consumed as a salty /sweet preparation. The grits were made by grinding the wheat using a suitable milling technique. During the present study, the wheat grit yielding potential of the local wheat *chakki* machine was realized. The wheat grains from DBW 371 and DBW 372 were tempered to 12% moisture content, milled, and then sieved appropriately to obtain wheat grits. The yield of wheat grits was 54 and 58% for DBW 371 and DBW 372, respectively. The work related to the characterization of wheat grits is being carried out.

Quality evaluation of chapatti made with blended flour: A study was conducted to determine the effect of blending chick pea flour and finger millet flour ranging from 0-30%. The chapati score for the chick pea flour supplemented chapati varied from 7.7 (control) to 6.6 (up to 30% addition). The score for finger millet supplemented chapati ranged from 7.7 (control) to 6.1 (up to 30% addition).

6 SOCIAL SCIENCES

India has achieved a record wheat production of 113.29 million tons during 2023-24 despite of heavy rainfall and water logging during grain filling and harvesting stages in central India, higher temperature during early stages of crop establishment, too low temperature at flowering stage and rise in temperature during second fortnight of February in northern parts of the country. Despite of such weather vagaries, the climate resilient varieties being developed by the ICAR-Indian Institute of Wheat and Barley Research, Karnal and All India Coordinated Wheat and Barley Improvement Program helped in surpassing all-time record production in 2023-24. These varieties being developed are not only climate resilient but most of them are bio-fortified which provide nutrients such as protein (>12%), Iron and Zinc (above 40 ppm) to the consumers, thereby tackling malnutrition.

During *rabi* 2023-24, dissemination of wheat and barley production technologies was carried out among farmers through 24 KVKs and 15 All India Coordinated Wheat and Barley Improvement centres and other centers. The demonstrations were conducted in different agro-climatic conditions across the country on the basis of need-based interventions by identifying the location-specific constraints to bridge yield gap and to popularize these technologies. Under barley frontline demonstrations andwheat demonstrations under SCSP, TSP programs, and cluster demonstrations, critical inputs were provided to the farmers in addition to seeds of newly released varieties of wheat and barley. The neighboring farmers, extension workers and other stakeholders were invited at different stages of crop growth at the demonstration sites to demonstrate the superiority of technologies being demonstrated. The scientists and extension personnel interacted with the farmers to educate them about the latest technologies. The scientists issued need-based advisories to the farmers during the crop season. The DA&FW and ICAR-IIWBR Karnal organized regular meetings to issue advisories to the farmers to tackle heat stress, erratic rainfall and water logging problems. The beneficiary farmers were also advised to provide seed of improved varieties to the fellow farmers so that the whole village is saturated with the latest improved variety. Integrated communication approach was used to transfer the efficient technologies to farmers' fields

Barley Frontline Demonstrations (FLDs) during 2023-24

During the *rabi* crop season 2023-24, 350 Barley Frontline Demonstrations (BFLDs) of one acre each were allotted to 40 cooperating centers all over India in seven states/UT namely, Himachal Pradesh, Uttar Pradesh, Bihar, Jammu & Kashmir, Punjab, Haryana, Rajasthan and Madhya Pradesh. Out of these, 338 BFLDs were conducted by 39 centers, covering 346 acres area of 420 farmers. Improved barley varieties with complete package of practices (irrigation management, nutrient management, weed control, seed treatment etc.) were demonstrated.

All the improved varieties for different production conditions have been included while calculating the yield gain over check/regional yield. The highest gain in barley yield was recorded in UT of J&K (57.57%) followed by Central UP (42.52%), Eastern UP (38.56%), All UP (36.87%), MP (35.23%), HP (34.48%) and Rajasthan (25.65%). The lowest gain in yield was reported in Haryana (8.53%) (Table 6.1).

The yield gain due to improved varieties over check was highest in NEPZ (34.76 %) followed by NHZ (34.48 %), CZ (34.19%) and NWPZ (16.64 %).The yield gain under barley FLD was highest at Basti (81.47%) center followed by Kanpur (40.59%) in NEPZ; Rewa (64.92%) followed by RLBCAU Jhansi (62.65%) and Lalitpur (45.55%) in CZ; Shimla (34.48%) in NHZ; and Kathua (57.57%) followed by Mansa (34.53%) in NWPZ. The yield gain was lowest at Muktsar (04.58%) in NWPZ (Table 6.2).

The varieties BHS400 (29.25 q/ha) at Shimla centre in NHZ; RD 2907 (44.50 q/ha) at Gorakhpur in NEPZ; RD 2907 (70.40 q/ha) at Durgapura, Jaipur in NWPZ and

Table 6.1: State wise performance of improved varieties under barley FLDs during rabi 2023-24

State	Mean Yield (q/ha)		Gain (%)
	Improved varieties	Check varieties	
HP	29.25	21.75	34.48**
Eastern UP	35.58	25.68	38.56***
Central UP	34.78	24.40	42.52***
Western UP	61.25	49.53	23.67***
All UP	37.78	27.60	36.87***
Bihar	38.28	31.03	23.37***
UT of J&K	33.05	20.98	57.57***
Punjab	47.50	41.50	14.46***
Haryana	43.60	40.18	08.53*
Rajasthan (NWPZ)	57.90	51.78	11.83***
Rajasthan (CZ)	40.78	32.45	25.65***
All Rajasthan	51.38	44.43	15.64***
MP	40.40	29.88	35.23***
All India	42.05	33.83	24.32***

**** Significant at 1 per cent level, ** Significant at 5 per cent level, * Significant at 10 per cent level*

DWRB 137 (47.38 q/ha) at Rajgarh in CZ were the highest average yielding. The varieties BHS400 (33.75 q/ha), RD 2907 (47.25 q/ha), RD 2907 (70.85 q/ha) and DWRB 137 (49.40 q/ha) performed better than other varieties at Shimla, Gorakhpur, Durgapura, Jaipur and Vidisha centres in the NHZ, NEPZ, NWPZ and CZ, respectively.

Table 6.2: Zone wise barley productivity under FLDs over check during rabi 2023-24

Zone	Mean yield (q/ha)		Gain (%)
	FLDs	Check	
NHZ	29.25	21.75	34.48**
NEPZ	36.15	26.83	34.76***
NWPZ	47.15	40.43	16.64***
CZ	39.25	29.25	34.19***

**** Significant at 1 per cent level, ** Significant at 5 per cent level*

Major constraints impeding barley production in the country

Overall analysis of constraints in different zones clearly indicated that decline in water table, high cost of inputs, *Phalaris minor*, small land holding, non-availability of labour, low price of barley grains, poor participation in exposure visits arranged by various departments, lack of facility of canal irrigation water, untimely rain and poor quality of herbicides/pesticides were the major constraints affecting barley production and productivity in the country (Table 6.3). The Farmers need to be educated and up skilled on recent barley production technologies, complete package of practices and soil health management. There is a need of government

Table 6.3: Major constraints impeding barley production in the country (n=369)

Constraints	Score	Rank
Decline in water table	478	I
High cost of inputs	435	II
Phalaris minor infestation	393	III
Small land holdings	343	IV
Non availability of labour	337	V
Low price of barley grains	292	VI
Poor participation in exposure visits arranged by various departments	278	VII
Lack of facility of canal irrigation water	267	VIII
Untimely rain	263	IX
Poor quality herbicides/pesticides	254	X

intervention to ensure supply of quality seed and inputs to the farmers. Farmers need to be updated on impact of climate change on barley cultivation and adaptation strategies for mitigation. To ensure better price, farmers have to go for quality barley production. There is a need to register barley growers on e-NAM platform for selling of barley.

The ICAR-IIWBR team accompanied by the experts from the Ministry of Agriculture & Farmers Welfare and the concerned centres monitored the barley FLDs and SCSP wheat demonstrations during the *rabi* crop season 2023-24 at the following centres.

Team Leader	Centres Monitored	Dates of Monitoring
Dr. Satyavir Singh	Sangrur, Mansa, Bathinda, Muktsar	02-04 April, 2024
Dr. Anil Khippal	Kathua, Kapurthala	12-13 March, 2024
Dr. Raj Kumar	Ayodhya, Varanasi, Mirzapur	10-14 March, 2024

Wheat demonstrations conducted under SCSP programme during 2023-24

Under SCSP programme, 520 varietal demonstrations of wheat varieties DBW 187, DBW 332 and DBW 370 were organized during 2023-24 *rabi* crop season to assess their performance at farmers' field. The demonstrations were carried out through KVKs of Punjab (18), Haryana (4), Rajasthan (2), Jammu & Kashmir (1); and RLBCAU Jhansi (1) benefitting 520 farmers (Table 6.4). The demonstrations were conducted in 18 aspirational districts of Punjab (Amritsar, Barnala, Bathinda, Faridkot, Fatehgarh Sahib, Firozpur, Gurdaspur, Hoshiarpur, Jalandhar, Kapurthala, Ludhiana, Mansa, Moga, Muktsar Sahib, Rupnagar, Sangrur, Nawanshahar and Tarn Taran), in 360 acres area benefitting 360 SC farmers; in 4 aspirational districts of Haryana (Ambala, Fatehabad, Sirsa and Yamunanagar), in 80 acres area benefitting 80 SC farmers; in 2 aspirational districts of Rajasthan (Sriganganagar and Hanumangarh), in 40 acres area benefitting 40 SC farmers; in 1 aspirational district of UT of Jammu & Kashmir (Samba), in 20 acres area benefitting 20 SC farmers; and 1 aspirational district of UP (Jhansi), in 20 acres area benefitting 20 SC farmers. In each aspirational district, 20 demonstrations were conducted, covering a total of 520 acres area and 520 farmers of Scheduled Castes (SC) category. Improved wheat varieties DBW 187, DBW 332 and DBW 370 with complete package of practices (irrigation management, nutrient management, weed control, seed treatment etc.) were demonstrated. At all the locations, the yields of demonstrated varieties were more than the check varieties.

The yield gain due to improved variety under SCSP wheat demonstrations was highest in Sriganganagar (49.29%) district in Rajasthan state followed by Jhansi (26.66%) in UP state, Samba (21.60%)district in Jammu and Kashmir (UT), Amritsar(16.73%) district in Punjab state and Hanumangarh (13.47%) district in Rajasthan state. The lowest yield gain was in Hoshiarpur (1.53%) district in Punjab state.

Table 6.4: State wise wheat yield gain in demonstrations under SCSP programme during 2023-24

State and Zone	Mean yield (q/ha)		Gain (%)
	Improved varieties	Check	
Punjab	53.63	51.10	04.94***
Haryana	56.75	54.00	05.09***
Rajasthan	60.93	47.33	28.74***
Jammu & Kashmir	23.23	19.10	21.60***
Overall (North Western Plains Zone-NWPZ)	52.85	49.38	07.04***
Uttar Pradesh (CZ)	50.60	39.95	26.66***

***** *Significant at 1 per cent level*

Under SCSP wheat demonstrations, the yield gain was highest (28.74%) in Rajasthan. The lowest yield gain was 4.94 % in Punjab state (Table 6.4). The zonal (NWPZ) yield gain was 7.04% . The demonstrated varieties outperformed the existing varieties

In Punjab state, the significant yield gain due to improved wheat variety DBW 332 over check mean yield was highest at Fatehgarh Sahib (28.57%). In

Haryana state, the highest significant yield gain due to improved wheat variety DBW 187 was at Yamunanagar (6.76%). In Rajasthan state, the highest significant yield gain due to improved wheat variety DBW 370 was at Sriganganagar (80.86%). In J&K (UT), the highest significant yield gain due to improved wheat variety DBW 332 was at Samba (24.26%). In UP, the highest significant yield gain due to improved wheat variety DBW 187 was at Jhansi (27.81%).

In Punjab, the highest yield of variety DBW 370 was 70.00 q/ha in Sangrur district. In Haryana, the highest yield of variety DBW 332 was 68.00 q/ha in Sirsa district. In Rajasthan, the highest yield of variety DBW 370 was 68.80 q/ha in Hanumangarh district. In UT of Jammu & Kashmir, the highest yield of variety DBW 187 was 28.75 q/ha in Samba district. In UP, the highest yield of variety DBW 187 was 53.75 q/ha in Jhansi district.

Costs and returns for SCSP wheat demonstrations and barley FLDs vis-à-vis check plots

Profitability is one of the major factors influencing the adoption of any crop production technology. In this section, costs and returns analysis for wheat demonstrations under the SCSP programme and barley frontline demonstrations (FLDs) have been attempted across regions for the improved production technologies that were tested in the farmers' field during 2023-2024 *Rabi* season. Generally, in any economic study, total costs are discussed under two categories *viz.,* variable costs and fixed costs, the widely adopted norm. Nevertheless, variable costs alone are reckoned to be the cost incurred by the farmers ignoring the fixed costs. In any economic analysis of farm business, the fixed costs should also be taken into consideration to arrive at total costs for computing the net income. However, in the present analysis only operational or variable costs were considered to know the profitability of technology adoption with the assumption of fixed costs remain the same for the particular farm wherein the technology (or variety) has been demonstrated. Operational costs include expenditure incurred on labour, seeds, manure, fertilizers, plant protection chemicals, *etc*. The returns over variable costs give an idea of profitability accrued to the farmer after meeting all the day-to-day expenses. Cost of production was estimated to know the cost incurred in producing a unit quantity of crop output *i.e.,* ₹ per quintal. Returns per rupee of investment were also worked out to know the comparative profitability between wheat and barley.

Primary data were collected by the cooperating centres from the selected farmers who were allotted the FLDs. For wheat demonstrations conducted under the SCSP programme, the data were collected by the KVKs of the respective states. The personal interview and discussion method were adopted with the aid of pre-tested schedules designed exclusively for the purpose of evaluating the technologies disseminated through wheat demonstrations and barley FLDs. The data collected pertained to the *rabi* season 2023-2024. The communicated data were compiled and processed at the ICAR-Indian Institute of Wheat and Barley Research, Karnal for further analysis and reporting. Every genuine effort was made by the coordinators to collect realistic data from the wheat demonstrations and barley FLD beneficiaries.

Costs and returns for wheat demonstrations vis-à-vis check plot

On an average, demonstration of improved wheat varieties at the farmers' field under the SCSP programme gave ₹3.44 per rupee of investment in comparison to the farmers' practice (₹3.19). A significant difference in returns per rupee of investment was noticed between the demonstrated and check plots at the farmer's field. The profit per hectare in the demonstrated plot was highest in Rajasthan (₹133866), followed by Punjab (₹98259). The difference in profit levels between demonstration and check plots was highest in the case of Rajasthan. Operational costs were found to be lower in several wheat demonstrations in comparison to the check plots. Overall, by adopting a new wheat variety, a farmer earns a profit of ₹95301/ha comprising all regions. Further, ₹799 has to be spent to produce a quintal of wheat through a new variety against ₹871 (farmers' choice of variety in the check plots).

Costs and returns for barley (FLDs vis-à-vis check plot)

On an average, improved barley varieties demonstrated at the farmers' field under the FLD programme gave profit around ₹67404 per hectare. A significant difference in returns per rupee of investment was noticed between the demonstration and check plots across states and zones. Himachal Pradesh registered the highest returns per rupee of investment (₹6.58) through demonstrations, followed by Punjab (₹4.25) and Rajasthan (₹3.13). The difference in returns per rupee of investment between demonstration and check plots was highest in Himachal Pradesh, followed by U.T of J&K, and Uttar Pradesh. The profit per hectare in FLDs was highest in Rajasthan (₹86033), followed by Himachal Pradesh (₹75174) and Punjab (₹74516). The difference in profit between FLD and check plots ranged from ₹28634 in U.T of J&K to ₹5724 in Haryana. Interestingly, operational costs were lower in FLDs than in check plots for a majority of the barley growing states. The probable reason might be a reduction in the use of inputs based on the recommendation. The returns per rupee of investment across barley growing zones were highest in the NHZ (₹6.58), followed by NWPZ (₹3.39) and CZ (₹2.79). Estimates of the cost of production indicated that the cost incurred in producing a unit quantity of barley output was the least (₹476 per quintal) in Himachal Pradesh owing to relatively less operational costs coupled with relatively higher yield levels.

Overall, the profit analysis on wheat and barley indicated that the additional returns per hectare from the demonstrated varieties and/or technologies were more than the check varieties and/or technologies establishing the fact that demonstrations carry the successful technologies from lab to land. For some beneficiaries, it was found that the operational costs under check varieties were more than the demonstrations/FLDs. However, the present estimates are only the indicators for comparison within the current year's *rabi* season (2023-2024) and may not have a complete inter-year relevance as the demonstrations (improved varieties were different across regions) were conducted at different sites as well as by different farm households. Further, the difference in profit earned from wheat/barley cultivation is subject to farm-farmer-region specific conditions as it varies from case to case.

Cluster demonstrations of climate resilient and bio-fortified wheat varieties during 2023-24

The reduction in yield due to climate change and also to overcome malnutrition, Ministry of Agriculture and Farmers Welfare allocated a project entitled- "Cluster Demonstration of Climate Resilient and Bio-fortified Wheat Varieties" under NFSM- National Food Security Mission dated October 13th, 2023. This project is approved for three years i.e. 2023-24 to 2025-26 by NFSM Cell – Crops and PHMF division of MOA&FW. In this project, 33 districts of 7 states are to be covered during 2023-26. These states and districts are selected on the basis of need-based interventions by identifying the location specific constraints to bridge yield gap and popularize the varieties. Out of these 33 districts, 11 districts were covered during 2023-24 crop season.

During the *rabi* crop season 2023-24, 440 hectares of wheat cluster demonstrations were allotted to 11 selected districts of 7 states, namely Punjab (71): Moga, Haryana (77): Mewat, Uttarakhand (75): Haridwar, Rajasthan (100): Dholpur, UP (200): Shrawasti and Balrampur, MP (195): Chhatarpur and Damoh, and Bihar (322): Sitamarhi, Muzaffarpur and Begusarai. In these states, 1100 cluster demonstrations were conducted by 11 KVKs covering 440 hectares area benefitting 1040 farmers.

During the crop season, farmers were guided by providing timely advice on different cultural practices. Among all the demonstrations, maximum yield gain (27.03%) was recorded in Muzaffarpur (Bihar) and minimum yield gain (08.12%) was recorded in Shrawasti (UP). It could be inferred from these findings that in state like Bihar, yield potential of climate resilient and bio-fortified wheat varieties could be realized by organizing cluster demonstrations with complete package of practices.

The highest performing variety was DBW 332 with yield of 70 qtl/ha in Mewat, Haryana while at many centres it was noticed that performance of DBW 187 was the highest against other demonstrated varieties.

Assessment of farmers' perspective on crop residue management (CRM) in Indo-Gangetic Plains of India

The study was conducted during 2024 in Punjab involving 120 farmers adopting crop residue management technologies at their fields. It was found that experts from research institutes such as KVKs, State Department of Agriculture, ICAR institutes and agriculture development officers were the main source of information for a large majority (84%) of the farmers of Punjab. Among the sampled farmers, majority (35%) of them belonged to semi-medium category followed by medium (28.33%) and small (17.5%). Year-wise adoption of CRM technologies indicate that maximum adoption was during 2023-24 (32.5%) and 2022-23 (29.17%) crop seasons, respectively. A large majority (62%) of them adopted super seeder, followed by zero till drill (21%), Happy seeder (10%) and Smart seeder (7%) for wheat sowing. Farmers adopted large number of varieties at their field and maximum adoption (12.5%) was for DBW 371, DBW 222 (11.67%), DBW 303 and PBW 826 (10.83%), DBW 327 and DBW 372 (10%), HD 3086 (9.17%), DBW 187 and DBW 370 (8.33). The overall adoption of DBW series varieties was 71.67% in the study area of Punjab. Rate of custom hiring per acre ranged from Rs 2000 to 4000 depending upon number of machines used to manage stubbles of rice. The cost of cultivation of wheat ranged from Rs. 10000 to 14000 per acre. Paddy-wheat (52%) was the most predominant crop rotation in the study area. After Paddy-wheat rotation, paddy-mustard (13%), paddy-wheat-moong bean (11%), maize-wheat (10%) and cotton-wheat (5%), were also adopted by the farmers. The most of the farmers adopted complete package of practices of Punjab. In terms of no. of irrigations in wheat, 40% of the farmers applied 5 irrigations, while 33% of them applied 4 and rest 27% applied 6 irrigations. It could be inferred from the above finding that there is no much water saving in wheat even with the adoption of conservation tillage for wheat sowing.

Promotion and impact evaluation of IIWBR technologies at farmers' field

Under this project, during 2023-24 crop season, 520 wheat demonstrations (1 acre size each) were conducted at 26 locations in Punjab, Haryana, Rajasthan, Uttar Pradesh and Jammu & Kashmir states using IIWBR varieties DBW 187, DBW 332 and DBW 371. Similarly, 262 barley demonstrations (1 acre size each) were conducted at 38 locations in Punjab, Haryana, Rajasthan, Bihar, Uttar Pradesh and Madhya Pradesh states using IIWBR barley variety DWRB 137. The Progress of wheat and barley demonstrations were also monitored at Sangrur, Mansa, Bathinda, Muktsar, Kathua, Kapurthala, Ayodhya, Varanasi and Mirzapur centers. To promote entrepreneurship among farmers, a seed village programme was initiated in village Sangoha with 5 progressive farmers using IIWBR variety DBW 371. The main purpose of this programme is to increase the adoption of institute varieties in the nearby villages by adopting horizontal diffusion method. As an initiative to promote IIWBR technologies, 90q quality seed of wheat variety DBW 371 was multiplied under seed value chain model at 5 acres of land in adopted seed village Sangoha (Karnal, Haryana), during 2023-24. Out of this seed, 50q seed was spread over more than 100 acres of land with about 17 farmers for the faster popularity and horizontal spread of IIWBR wheat variety DBW 371 in villages Sangoha, Gheer, Jairampur, and Badagaon of Karnal district. The feedback about the wheat variety DBW 371 will be taken from the farmers of above villages during 2024-25.

Tribal-Sub-Plan (TSP) Project: Improving the 'socio-economic condition and livelihood of tribes in India through extension education and development programmes

Under the TSP project, the following eight centers were included for the year 2023-24, namely, Lahaul & Spiti (Himachal Pradesh), Leh (Jammu & Kashmir), Khudwani (Jammu & Kashmir), Jabalpur (Madhya Pradesh), Udaipur (Rajasthan), Bilaspur (Chhattisgarh), Ranchi (Jharkhand) and Dharwad (Karnataka). During 2023-24, different TSP activities were carried out. The demonstrations on wheat crop were conducted with complete package of practices at 46, 40, 25, 10 and 25 farmers' fields at Khudwani, Udaipur, Bilaspur, Dharwad, and Jabalpur centers, respectively. Under TSP wheat demonstrations, the seeds of improved wheat varieties were supplied and the demonstrations were conducted with the complete package of practices. One Awareness-cum-Training Programme on Barley was organised for 200 farmers at Dalang Maidan, Lahaul & Spiti (Himachal Pradesh), the agricultural inputs were distributed to the tribal farmers. One Awareness-cum-Training Programme in Agriculture was organised for 314 farmers at Dalang Maidan, Lahaul & Spiti (HP), the vegetable seed kits were distributed to the tribal farmers.

7 BARLEY IMPROVEMENT

The ICAR-IIWBR, Karnal, spearheads the National Barley Research Programme under the aegis of the AICRP on Wheat and Barley by orchestrating multi-disciplinary and multi-locational experiments across all barley-growing zones in India. These experiments are supported by both funded and voluntary centres, focussed on comprehensive aspects of genetic improvement of barley, protection, and production of malt, feed, and food barley. Such initiatives culminate in the identification of new cultivars that exhibit wider adaptability, resilience to biotic and abiotic stresses, superior grain and malt quality, and suitability for specific production conditions.

The program encompasses experimentation on input optimization, conservation agriculture, and evaluation of new varieties under diverse production technologies to identify widely adaptable genotypes. Additionally, advanced screening of new genotypes under artificial epiphytotic conditions, hot spots, chemical control, and Integrated Pest Management (IPM) is carried out at designated test centres under the crop protection section. Furthermore, zonal monitoring during the crop season and the organization of annual review and work-planning meetings serve to streamline the objectives of the AICRP on wheat and barley.

As a result of these coordinated efforts, the barley improvement program has achieved commendable productivity, with the national average reaching 30.80 q/ha and a production of 2.22 MT from 8.18 lakh hectares during 2023-24. The institute enhances these coordinated research efforts through specialized initiatives, particularly in malt barley improvement, disease resistance integration, and quality enhancement using biotechnological tools. Emphasis is placed on trait discovery, exploitation of exotic genetic resources, and creating novel variability.

AICRP coordination activities

Release of new malt barley variety

Hon'ble Prime Minister of India Shri Narendra Modi Ji dedicated to the nation DWRB219, a two-row hulled malt barley variety developed by the ICAR-Indian Institute of Wheat & Barley Research, Karnal, originated from the cross BETZS/DWRB88 (Fig. 7.1 & 7.2). Officially notified by the Varietal Identification Committee (VIC) for commercial cultivation for timely sown, irrigated conditions in the North-Western Plains Zone of India. Known for its exceptional productivity, DWRB219 boasts an average yield of 54.49 q/ha and a remarkable yield potential of up to 93 q/ha, making it a superior choice for farmers in the region.

Fig 7.1: DWRB 219, a two-rowed malt barley variety for cultivation in NWPZ.

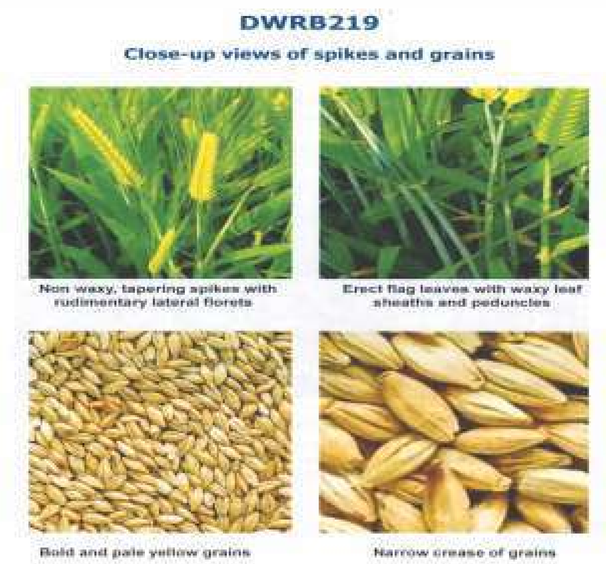


Fig. 7.2 : Close up view of spikes and grains of DWRB 219.

DWRB219 demonstrated superior performance by significantly outyielding standard two-row malt barley checks, surpassing DWRUB52 by 13.87%, DWRB160 by 12.14%, DWRB182 by 16.13%, and RD2849 by 12.18%. Additionally, it outperformed six-row feed barley checks, exceeding BH946 by 18.25% and DWRB137 by 4.74%, based on three years of rigorous trials. Agronomic trials revealed its superior grain yield, grains per ear, and 1000-grain weight across varying nitrogen levels. It exhibited minimal yield reduction (-7.20%) at lower nitrogen input (N60 kg/ha) and the highest yield gain (+6.80%) at higher nitrogen input (N120 kg/ha) compared to checks, showcasing its adaptability to nitrogen management. This variety possesses moderate lodging tolerance, critical for optimizing yield potential, and demonstrates robust resistance to yellow rust along with moderate resistance to leaf rust. In Seedling Resistance Tests, it proved resistant to the 6S0 yellow rust pathotype and the 40A and 122 black rust pathotypes.

DWRB219 achieved malting quality score of 17/36, complemented by a significant yield advantage over both current and long-term checks. It outperformed DWRB182 in critical malting quality parameters, including hectolitre weight, grain size distribution, husk content, and 1000-grain weight, establishing itself as a superior choice for both yield and quality in the malt barley category.

Registration of novel barley genetic stocks

During the year 2024, four distinct barley genetic stocks namely, DWRBG15, DWRBG16, DWRBG19, and DWRBG25 have been successfully registered with ICAR-NBPGR by ICAR-IIWBR, Karnal. These genetic stocks are recognized for their unique and valuable traits, contributing significantly to the advancement of barley genetic resources (Table 7.1).

Table 7.1 : Genetic stocks registered with ICAR-NBPGR, New Delhi during 2024.

SN	Name	INGRN	Trait (s)
1.	DWRBG15	INGR23084	High protein (14.6%) and β glucan contents in grains (6.0%) in six row hulless barley
2.	DWRBG16	INGR23085	High β-glucan (6.1%) in six row hulless barley
3.	DWRBG19	INGR23086	Low beta glucan (3.7%) in two-row malt barley
4.	DWRBG25 (Tested as INBON-HI-(2016)-73)	INGR24019	Highter grain beta glucan content (8.0% dwb) Bold grain percentage (90.7%) High protein content (16.1% dwb)

Organization of coordinated yield evaluation trials

A total of 102 test entries from 12 centres were evaluated against 23 checks in coordinated yield trials under various conditions, including rainfed (plains and hills), irrigated (plains), and saline soils. The entries comprised malt, feed, dual-purpose, and hulless barley, with hulled types predominating and a few hulless entries observed in the northern hills and plains. The trials were conducted across 10 primary centres and 31 additional sites, including ICAR and SAUs, during Rabi 2023-24. Of the 123 proposed trials, 122 were conducted against 23 checks, with one salinity and alkalinity tolerance trial at Bhilwara omitted. At Hisar, two salinity and alkalinity trials were rejected due to poor crop stand, as verified by the monitoring team. Timely data were received for 120 trials, of which 93 (75.61% of proposed and 77.50% of received) were found suitable for reporting.

Promising entries in AVT/IVTs

Following a comprehensive multilocation evaluation of various trial series across country, the 51 entries demonstrated significant yield superiority over the best check (Table 7.2). Additionally, 15 entries exhibited numerical superiority across different trials/zones; however, they were statistically at par with the best check. Notably, seven entries, while also statistically at par with best check, possessed additional desirable traits. The decision regarding their promotion or retention in the AICRP trials for the subsequent year will hinge on strict promotion criteria, including significant superiority over the check or the presence of additional trait(s), as well as monitoring reports for purity, disease/pest resistance, and relevant quality traits.

Table 7.2 : Leading entries in various trials for 2023-24

SN	Trial name	Zone	Significantly superior in grain yield over check	Numerically superior in grain yield over check + desirable trait(s)	AT par with check in grain yield but having traits of quality or economic importance
a.	**Malt Barley Trials (Plains)**				
1.	AVT-I-MB	NWPZ	DWRB235, DWRB238, RD3064	---	---
2.	IVT-IR-MB	NWPZ	DWRB2307, DWRB2309, DWRB2311, DWRB2312, RD3084, RD3086, RD3105, PL958, PL959	RD3087	---
b.	**Rainfed Barley Trial (Plains)**				
3.	AVT/IVT-Rainfed	NEPZ	None	HUB288, RD3098	---
c.	**Salinity/Alkalinity Barley tolerance Trials (Plains)**				
4.	IV/AVT-Sal/Alk	Plains	RD 3102	RD 3109	KB2031, HUB294
d.	**Hulless Barley Trials (Plains)**				
5.	AVT-(I&II) -NB	NWPZ	DWRB223, DWRB 244	---	---
6.	AVT-(I&II) -NB	CZ	NONE	---	---
7.	IVT-NB	NWPZ	NONE	PL960, RD3091	RD3092,R D3089, RD3090
8.	IVT-NB	NEPZ	DWRB2304, DWRB2306, PL960, RD3088, RD3089, RD3091,RD3092, UPB1121	---	---
9.	IVT-NB	CZ	PL960, RD3088, RD3089, UPB1121	DWRB2304, DWRB2306	RD3092
e.	**Rainfed Trials (Hills)**				
10.	IVT/AVT-FB	NHZ	HBL884, VLB187	BHS498, HBL886, VLB185	---
11.	IVT/AVT-DP	NHZ	BHS552, BHS498, HBL884, VLB184, UPB1118	---	---
12.	AVT-1-HB	NHZ	NONE	BHS497	---
13.	IVT-HB	NHZ	BHS499	BHS500	---
f.	**Feed Barley Trials (Plains)**				
14.	AVT-II-FB	NEPZ	UPB1106	---	---
15.	IVT-FB	NWPZ	RD3095, BH1059, PL955	---	---
16.	IVT-FB	NEPZ	BH1059, HUB290, PL955	---	---
17.	IVT-FB	CZ	---	---	---
g.	**Dual Purpose Barley Trials (Plains)**				
18.	IVT-DP	NWPZ	JHSBB19, JHSBB16, JHSBB22, JHSBB28, DWRB2318, DWRB2313	----	---
19.	IVT-DP	NEPZ	NONE	---	---

International Trials and Nurseries

During the Rabi 2023-24, two international trials and one international germplasm nursery were received from the International Center for Agricultural Research in the Dry Areas (ICARDA) and planted at different locations as indicated in Table 7.3. The trials, IBYT-FFM and IBYT-ASA, each comprised 24 test entries along with 3 control checks, one of which was a designated national check. The nursery, IBON-2024, consisted of 139 test entries, 2 control checks replicated three times each, and one locally replicated Indian check (also repeated three times). In total, 148 genotypes were obtained from ICARDA for testing. The IBYT-ASA trial was conducted across multiple locations: Durgapura, Hisar, Ludhiana, Pantnagar and Karnal. The IBYT-FFM trial was evaluated at Durgapura, Ludhiana, Hisar and Karnal. Meanwhile, the IBON nursery was tested at Durgapura, Pantnagar, Kanpur, and Karnal. A Field Day was organized at Karnal on March 19, 2024, to provide barley breeders from the National Agricultural Research System (NARS) with the opportunity to review and select materials from these nurseries according to the specific needs of their respective regions.

In addition one national trial of Elite International Barley Germplasm Nursery (EIBGN) was also established and shared with different locations in the country. EIBGN consisted of 24 germplasm lines and six released varieties-BH946, HUB113, BHS400, PL891, DWRB123, and DWRB137-used as checks. These 24 promising germplasm lines were selected from various international trials and nurseries based on their performance during the Rabi 2022-23 season. A total of 48 entries, including six checks, were distributed to twelve locations across NWPZ (Hisar, Karnal, Ludhiana, Durgapura, Pantnagar, Chatha), NEPZ (Kanpur, Varanasi, Kumarganj), and NHZ (Khudwani, Shimla, Bajaura). The nursery trials were successfully conducted at all these locations.

Table. 7.3: International trials and nurseries evaluated during crop season 2023-24.

SN.	Trials/Nurseries	Genotypes received	National Check	# SetsLocations
1	2024 International Barley Yield Trial for Feed, Forage and Malt in Favourable Environments (IBYT-FFM-24)	24	DWRB1374	Durgapura, Hisar, Ludhiana, Karnal
2	2024 International Barley Yield Trial for Arid and Semi-Arid regions (IBYT-ASA)	24	Lakhan6	Durgapura, Hisar, Ludhiana, Karnal, Pantnagar, Kanpur
3	2024 International Barley Observation Nursery (IBON-24)	147 + 6 checks	DWRB1375	Hisar, Kanpur, Karnal, Durgapura, Pantnagar

International Barley Yield Trial for Food, Feed, and Malt in Favourable Environments-24 (IBYT-FFM-24)

The International Barley Yield Trial for Food, Feed, and Malt in Favourable Environments (IBYT-FFM) consisted of 24 entries, including one Indian local check variety, DWRB 137 (C1, Entry IBYT-FFM-1), and two ICARDA checks: Entry IBYT-10 (V Morales = C2) and Entry IBYT-FFM-20 (Rihane-03 = C3). The trial was conducted at four locations-Durgapura, Hisar, Ludhiana, and Karnal-within the Northwestern Plain Zone (NWPZ), under high-input conditions. Entry IBYT-FFM-17 achieved the highest yield, recording 63.6 quintals per hectare, followed by IBYT-FFM-22 with 63.10 q/ha, and IBYT-FFM-19 with 61.30 q./ha.

International Barley Yield Trial-ASA-2024-(IBYT-ASA-2024)

The IBYT-ASA-2024 trial, consisting of 24 entries, including one Indian local check variety 'Lakhan' (C1, Entry IBYT-FFM-1), and two ICARDA check varieties, Entry IBYT-10 (Rihane-03 = C2) and Entry IBYT-FFM-20 (Furat-03 = C3), was evaluated using an Alpha-Lattice Design with two replications across six locations: Durgapura, Karnal, Kanpur, Hisar, Pantnagar, and Ludhiana. Data from all locations were integrated into a national pooled analysis. Entry IBYT-ASA-7 achieved the highest yield with 46.41 q/ha, followed by IBYT-ASA-4 with 45.94 q./ha, and IBYT-ASA-12 with 45.69 q/ha.

International Barley Observation Nursery-High Input-2024 (IBON-HI-2024)

The IBON-24 trial comprised 139 test entries alongside three check varieties-two ICARDA checks (Rihane-03 and V Morales) and one local check (DWRB137), with each check replicated three times. This nursery was conducted across five locations: Durgapura, Kanpur, Pantnagar, Karnal, and Hisar during 2023-2024. Data were collected from all locations. The entry No. 30 recorded the highest grain yield nationally (43.36q/ha), followed by entries 26 (41.48q/ha), 25 (40.73q/ha), 32(40.57q/ha), 22 (39.57q/ha), and 40 (39.11q/ha). Among the check varieties, the local check DWRB137 achieved the highest grain yield, with an average of 42.7 q/ha and a range from 15.03 to 43.36 q/ha across the locations.

Elite International Barley Germplasm Nursery (EIBGN-2023-24)

The EIBGN trial was established with 24 germplasm lines and six released varieties-BH946, HUB113, BHS400, PL891, DWRB123, and DWRB137-used as checks. These 24 promising germplasm lines were selected from various international trials and nurseries based on their performance during 2022-23. A total of 48 entries, including the six checks, were distributed to twelve locations across the NWPZ (Hisar, Karnal, Ludhiana, Durgapura, Pantnagar, Chatha), NEPZ (Kanpur, Varanasi, Kumarganj), and NHZ (Khudwani, Shimla, Bajaura). The nursery was successfully conducted at all these locations. Each entry was sown in 1.5 m^2 plot consisting of two rows, each 2.5 m in length with a spacing of 30 cm. Grain yield data, recorded in grams per plot, were converted to q/ha for analysis. The results were analysed on both a centre-wise and zone-wise basis for each trait across the 12 testing locations.

In the NWPZ, the highest location mean for grain yield was observed at Durgapura (89.4 q/ha), followed by Karnal (31.1 q/ha) and Pantnagar (30.7 q/ha), with an overall zonal mean of 38.8 q/ha. Notably, the grain yields at Durgapura were exceptionally high across different entries. The highest zonal mean for grain yield was recorded by the entry IBYT-FFM-2023-15 (53.4 q/ha), followed by IBON-HI-2023-57 (52.7 q/ha) and IBON-HI-2023-3 (52.4 q/ha). Among the checks, BH946, a variety recommended for NWPZ, recorded the highest grain yield of 47.5 q/ha.

In the NEPZ, grain yields were low at Varanasi (18.5 q/ha) and Kumarganj (12.8 q/ha), whereas the Kanpur location showed appreciable yields with a location mean of 40.8 q/ha. The highest grain yield in this zone was recorded by IBON-HI-2023-55 (37.1 q/ha), followed by IBYT-FFM-2023-6 (32.1 q/ha) and IBON-HI-2023-3 (30.6 q/ha). Among the checks, the two-rowed variety DWRB123 performed the best with a grain yield of 28.4 q/ha.

In the North Hill Zone, the highest location mean for grain yield was observed at Khudwani (32.2 q/ha), followed by Bajaura (28.8 q/ha) and Shimla (24.0 q/ha), resulting in a zonal mean of 28.3 q/ha. The highest yields among the check varieties were recorded by BH946 at Khudwani (41.3 q/ha), BHS400 at Shimla (22.1 q/ha), and PL891 at Bajaura (31.3 q/ha). The entry IBYT-FFM-2023-17 recorded the highest zonal mean grain yield (35.3 q/ha), followed by IBYT-ASA-2023-4 (33.9 q/ha) and IBYT-FFM-2023-22 (32.8 q/ha). BHS400 emerged as the best-performing check variety in this zone, with a grain yield of 29.8 q/ha.

National Barley Genetic Stock Nursery (NBGSN-2023-24)

The NBGSN nursery consisting of 12 promising genetic stocks with valuable breeding traits was distributed to 12 centres for utilization, including Hisar, Karnal, Ludhiana, Durgapura, Pantnagar, Chatha, Kanpur, Varanasi, Kumarganj, Khudwani, Shimla, and Bajaura.

Coordination of Breeder's Seeds Production of Barley during 2023-24

Breeder seed indent, allocation, and production

A total of 571.55 quintals of breeder seed, spanning 29 varieties, was indented by the Seed Division, DA&FW, New Delhi, for production in 2023-24 and distribution in 2024-25. This request was made by seven states-Rajasthan, Uttar Pradesh, Punjab, Haryana, Himachal Pradesh, Madhya Pradesh, and Uttarakhand-and five public sector agencies, including the National Seeds Corporation, IFFDC, NDDB, KVSS, and NSAI. Rajasthan submitted the largest indent of 200 quintals (35%), followed by Uttar Pradesh with 100 quintals (17%), KVSSL with 12%, and National Fertilizer Limited. The top five indenting agencies collectively represented nearly 85% of the total breeder seed demand. Of the total indent, 554.35 quintals, encompassing 20 varieties, was allocated to nine BSP centres across six states. Among the allocated varieties, DWRB 137 received the highest indent (129.55 quintals), followed by RD 2907 (68.50 quintals) and RD 2899 (60.0 quintals). Breeder seed production during 2023-24 totalled 787.50 quintals, surpassing both the indent of 571.55 quintals and the allocation of 554.35 quintals. This resulted in a surplus of 215.95 quintals compared to the allocation and 233.15 quintals against the indent. Among the nine production centres, RARI, Durgapura recorded the highest output with 405.80 quintals, followed by IIWBR, Karnal (148.00 quintals) and CCSHAU, Hisar (96.00 quintals). The top five indented varieties constituted 61.28% of the total indent. Additionally, 19.04 quintals of nucleus seed for 24 varieties were produced under BNS-1 during 2023-24, exceeding the allocation of 17.60 quintals.

Molecular profiling of barley AVT 2023-24

Molecular profiles were generated to distinguish entries with their respective checks for barley AVT-MB-NWPZ and AVT-NB-NWPZ trials 2023-24. A set of 46 SSR/STS markers covering all the seven linkage groups of barley was screened with twelve genotypes including entries and checks. During UPGMA clustering of AVT-MB-NWPZ, three entries under evaluation were grouped in single cluster at similarity coefficient (Sm) value 0.77 and showed sufficient genetic variability at molecular level (Fig. 7.3).

Average polymorphic information content (PIC) of AVT entries and checks of this trial entries varied from 0.31 to 0.44 across seven linkage groups of barley and chromosome 6H was found most variable (Fig. 7.4). Likewise, for AVT-NB-NWPZ trial, five genotypes including one entry and four checks clustered within Sm range of 0.63 to 1.0. (Fig. 7.5).

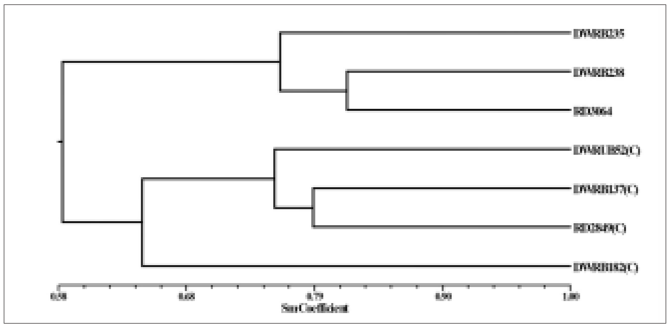


Fig. 7.3. UPGMA based clustering of AVT-MB-NWPZ 2023-24 entries and checks for genetic variability

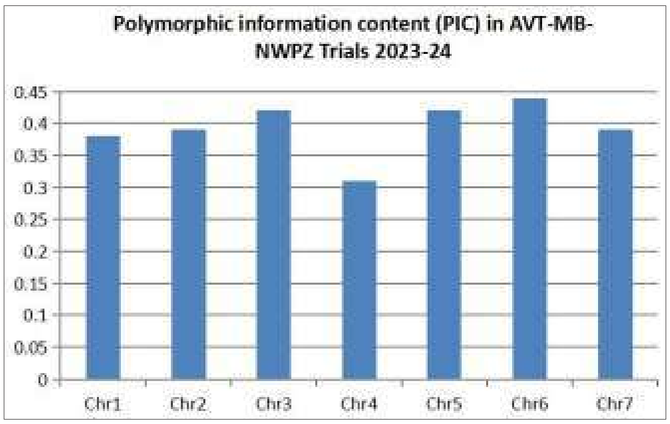


Fig. 7.4. Polymorphic information content (PIC) in AVT-MB-NWPZ Trials 2023-24

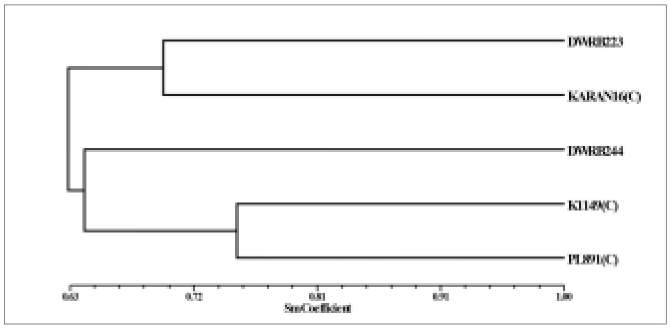


Fig 7.5. UPGMA based clustering of AVT-NB-NWPZ 2023-24 entries and checks for genetic variability

Average polymorphic information content (PIC) of AVT entries and checks of this trial varied from 0.23 to 0.46 across seven linkage groups of barley and chromosome 7H was found most variable (Fig. 7.6).

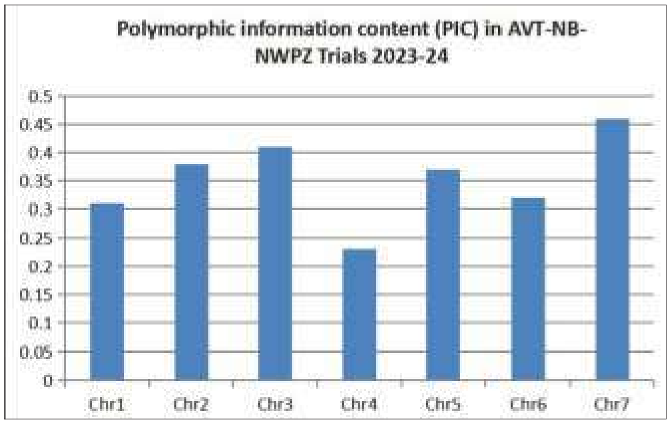


Fig. 7.6. Polymorphic information content (PIC) in AVT-NB-NWPZ Trials 2023-24

In both dendrograms, each entry is uniquely placed at separate node and is distinct from rest of entries and check lines, respectively. The eventual intend of this effort is to develop molecular markers-based amplification profiles for varietal characterization and to assess the level of genetic diversity in Indian barley.

Barley germplasm exchange, conservation and rejuvenation

A total of 358 barley accessions were supplied to various institutions across the nation, while 168 new barley germplasm accessions were integrated into the existing collection. The germplasm repository efficiently safeguards and manages 8,239 barley accessions in the Medium-term Storage Module at ICAR-IIWBR, Karnal, under stringent conditions of 4°C and 30% relative humidity. Additionally, 56 barley accessions, including 45 wild accessions of *Hordeum spontaneum*, are meticulously preserved. The barley database, encompassing 106 notified varieties, 67 genetic stocks, and the complete germplasm inventory, undergoes regular and precise updates to maintain its accuracy and comprehensiveness. Twenty-five barley genotypes, including 23 high-malting types and 2 hulless entries from the AVT final year, were rigorously characterized based on 32 DUS (Distinctness, Uniformity, and Stability) traits, strictly adhering to established DUS guidelines. This year, 1044 barley germplasm accessions were successfully rejuvenated, with detailed data collection emphasizing numerous promising traits. Specific accessions exhibiting favourable characteristics have been identified and documented (Table.7.4).

Table.7.4 : Accessions that exhibited promising characteristics

Trait	Criteria	Promising Accessions
Days to heading	<70 days	BCU 407, BCU 446, BCU 443, BCU 447, BCU 4865, BCU 411, BCU 485, BCU 594, BCU 457, BCU 591
Days to maturity	<120 days	BCU 449, BCU 4656, BCU 4865, BCU 5327, BCU 4827, BCU 4829, BCU 4830, BCU 4889, BCU 599, BCU 600, BCU 4826, BCU 4858, BCU 4883
Plant height	<80 cm	BCU 4956, BCU 411, BCU 4865, BCU 4907, BCU 594, BCU 633, BCU 420, BCU 370, BCU 616, BCU 558, BCU 924
Grain yield (g/plot)	High	BCU 4372 (1476 g), BCU 4364 (1404 g), BCU 4342 (1228 g), BCU 4259 (1136 g), BCU 4094 (1124 g), BCU 4282 (1120 g), BCU 4118 (1116 g)

DUS project on barley (Funded by PPV&FRA) Four candidate varieties-2880/3840, 2883/2394, 23BABC7301, and 23BARANA02 were planted for their first-year evaluation. Concurrently, the barley reference collections, comprising 49 and 106 released varieties, were systematically maintained. DUS data compilation is in progress for submission to the PPV&FRA, New Delhi.

Malt Barley Improvement

Breeding materials and hybridization program for malt barley

During 2023-24, a total of 139 crosses were strategically executed using diverse parental lines characterized by superior malting quality, agronomic adaptability, and earliness. A comprehensive crossing block comprising 350 entries with potential donor lines was established under the malt barley breeding program. Of the crosses attempted, 50 were advanced at the off-season nursery in Dalang Maidan for generation advancement. Within the malt barley breeding program, rigorous individual plant selections and family selections were conducted, prioritizing traits such as yield, yield-contributing factors, and disease resistance. Detailed information on the breeding materials selected and cultivated during 2023-24 is provided in Table 7.5. The 25 Bulks has been selected from F7 and F8 to be evaluated in station trials. A total of 166 new crosses were attempted as part of the malt program, focusing on quality traits. This effort included the raising of 134 F1 populations and 720 segregating progenies derived from 468 crosses, all aimed at improving quality traits essential for malt production.

Table.7.5 : Malt barley breeding materials selected and grown during rabi 2023-24

Generations	Families	Crosses
F_8	10	8
F_7	9	4
F_6	42	20
F_5	120	59
F_4	90	48
F_3	154	76
F_2	105	105
F_1	139	139
Total	**669**	**459**

The coordinated malt barley initial varietal trials for 2024-25 feature key entries showcasing advanced genetic combinations. DWRB2401 (*DWRB123/RD2849*), DWRB2402 (*PL426/DWRB101*), DWRB2403 (*DWRB123/SK*), and DWRB2404 (*DWRUB52/IRINA*) highlight efforts to integrate diverse traits for improved yield, resilience, and adaptability. These entries reflect innovation in breeding programs aimed at enhancing agricultural performance.

Feed and food barley improvement

Feed barley

To develop superior varieties for feed and dual-purpose barley, a total of 96 fresh crosses were attempted to incorporate tolerance to abiotic stress (combined heat and drought stress tolerance; tolerance to salinity stress and tolerance to drought stress) and biotic stresses (yellow rust and leaf blight). Four donors for resistance to yellow rust resistance in naked barley (BHS479, BHS483, BHS485, BHS486) were used from the National Barley Genetic Stock Nursery (NBGSN 2023-24) Sixteen F_1 cross combinations were raised at Dalang Maidan during summer 2024 for generation advancement and the harvested F_2s from these materials were planted at ICAR-IIWBR, Karnal Farm. The materials in different generation are given in Table. 7.5.

Food Barley

To maintain the genetic variability and exploitation of existing variability, a crossing block was constituted with 125 diversified germplasm lines of hulless barley and 93 lines of hulled barley during 2023-24. By selecting the desirable donor parents from the crossing block, 66 new crosses were attempted to broaden the genetic base, high yield, quality traits, and for attaining the tolerance against biotic and abiotic stresses. Out of these, 23 F_1 cross seeds were advanced at Dalang Maidan, and subsequently, F_2 generations of their crosses are grown at ICAR-IIWBR, Karnal, during 2024-25.

Evaluation of advanced breeding lines under different station trials

Feed barley station trials

Twenty-two lines, three of which were two-rowed were evaluated for grain yield in the Barley Station Trial (Feed Barley) along with three yield checks (DWRB137, BH946 and RD2715). Four lines (BST-FB-2024-08, BST-FB-2024-16, BST-FB-2024-11 and BST-FB-2024-07) were found superior for grain yields (50.2 to 69.75 q/ha) over the best check and possessed high levels of disease resistance, particularly to yellow rust.

Dual purpose barley (Feed and fodder) station trial

Out of 22-lines evaluated in the station trial, six lines namely BST-DPB-2024-9, BST-DPB-2024-19, BST-DPB-2024-12, BST-DPB-2024-13, BST-DPB-2024-6, and BST-DPB-2024-14 have registered superior green fodder yields (26.1 to 32.4 t /ha) at 55 days of sowing and grain yields over the dual-purpose barley variety RD2715 (Fig. 7.7). Grain yields (26.0 to 38.2 q/ha) obtained in these lines after the cut were also superior over the check variety. These lines have also possessed high levels of disease resistance.

Fig 7.7. Dual purpose barley.

Preliminary yield evaluation

The 29-homogenous bulks of hulled and naked barley in F_7 generation were evaluated in two-rowed plots of 4M each in two replications along with the check varieties PL891(hulless) and DWRB137 (hulled). Seven of the high yielding bulks among the hulled barley type were selected for their further evaluation in station trial for feed and dual-purpose barley in larger plot size. Similarly, among the naked barley genotypes, six high yielding bulks were identified for their further evaluation in the station trial for naked barley.

Selection of high yielding lines in the Elite International Barley Germplasm Nursery (EIBGN 2023-24)

Twenty-four high yielding germplasm lines selected from different international barley trials and nurseries received from ICARDA were evaluated in an augmented field design along with six-check varieties. Two of these germplasm lines (EIBGN 2023-24-2 and EIBGN 2023-24-2) which gave superior grain yields were selected for their further evaluation in station trials for feed and dual-purpose barley.

Contribution of promising entries to the All India Coordinated Research Project on Wheat & Barley Improvement (AICRPW&B)

During the crop season 2023-24 a set of 4-entries was promoted to IVT-Feed Barley trials and another set of 6-entries was contributed to IVT-Dual Purpose Barley for all the zones of plains. Based on the performance the test entry DWRB2313 has been promoted to AVT-I-(2024-25) of dual-purpose barley in NWPZ and CZ zones. DWRB2314 and DWRB2316 have also been promoted to AVT-I-(2024-25) trials of dual-purpose barley in CZ zone. Among the feed barley test entries, one test entry DWRB2302 was promoted to the AVT-I-(2024-25) trials of feed barley in NEPZ.

For Initial Varietal Trials (2024-25) four test entries DWRB2411, DWRB2412, DWRB2413 and DWRB2414 have been contributed to feed barley trials, and six test entries DWRB2415, DWRB2416, DWRB2417, DWRB2418, DWRB2419 and DWRB2420 have been entered in dual purpose barley trials.

Food barley station trial and entries contributed in coordinated trials

Based on the yield performance and yellow rust resistance, five hulless genotypes viz ;DWRB2407, DWRB2408, DWRB2409, DWRB 2410, DWRB 2424 and DWRB2425 were contributed to the initial varietal trial (IVT-IR-TS-Naked barley) during 2024. In addition two genotypes namely, DWRB 2304 and DWRB2306 were promoted from IVT to AVT-I in NEPZ and central zone while , DWRB244 was promoted from AVT-I to AVT-II in the NWPZ. DWRB223, a six row hulless entry was identified by varietal identification committee for irrigated timely sown conditions in north western plain zone. It had grain yield of 42.98 q/ha and resistance to yellow rust

New entry identified for release DWRB 223

The Varietal Identification Committee identified DWRB 223 as a breakthrough six-row hulless barley entry for irrigated, timely sown conditions in the NWPZ (Table 7.6). This superior variety demonstrated remarkable performance, delivering an 18.18% higher grain yield compared to the six-row hulless variety *Karan16* and a 14.13% improvement over the two-row hulless variety *PL891*. In addition to its exceptional yield, DWRB 223 stands out for its robust resistance to yellow rust, solidifying its potential as a game-changer in barley production for the region (Fig. 7.8).

Table 7.6 : Salient features of hulless barley variety DWRB 223.

Variety	Production condition	Days to heading	Days to maturity	1000 grain weight (g)	Test weight (Kg/hL)	beta-glucan (%)	Protein (%)	Iron (ppm)	zinc (ppm)
DWRB 223	irrigated, timely sown of NWPZ	92	138	36.7	71.1	6.0	11.7	43.7	47.8

The hulless barley genotype DWRB 244 has been contributed to AVT-II trials. This six-row hulless barley is specifically suited for production under NWPZ conditions, achieving an average yield of 40.6 q/ha. It exhibits resistance to yellow rust and moderate resistance to leaf blight, ensuring better disease management (Fig. 7.9). Additionally, it is notable for its high nutritional quality, with a zinc content of 38.2 ppm, an iron content of 43.3 ppm, and a beta-glucan level of 7.8%, making it a valuable strain for both productivity and health benefits.

Fig. 7.8. Field view of DWRB 223.

Fig. 7.9. Field view of DWRB 244.

Identification of novel genetic resources for food and feed barley

Identification of germplasm resources for high Zn, Fe and anti-oxidants: Fifteen-germplasm lines namely, HLR-10, HLR-24, HLR-34, HLR-64, HLR-125, HLR-136, HLR-153, HLR-196, HLR-310, HLR-322, HLR-355, EC0578267, IC0532979, IC0438103 and IC532985 were screened for contents of Zn and Fe, and antioxidant activity along with the four check varieties (registered genetic stocks) DWRB-191 for Zn, DWRB-192 for Fe and KASOTA and DWRB-189 for anti-oxidant activity. Five lines namely, HLR-136, EC0578267, IC0532979, IC0438103 and IC532985 had pigmented grains (Fig. 7.10). All the nineteen lines were raised at five locations namely Durgapura, Karnal, Ludhiana, Pantnagar and Kanpur for Zn and Fe and additionally at Hisar for antioxidant activity. The harvested seed-samples of these lines and checks obtained from these six locations were examined for the nutritional components.

Zn-content in grains ranged from 25.1ppm (HLR153) to 39.5 ppm (IC0532979). Seven test entries (IC0532979, EC0578267, HLR-136, IC0438103, IC532985, HLR-24 and HLR-64) outperformed the check DWRB192 for grain-Zn content. In case of Fe content in grains, it ranged from 31 ppm (HLR10) to 43.2 ppm (DWRB-192); and anti-oxidant activity from 40.8% to 64.9 % (DWRB-189). No test entry surpassed the checks used for these two nutritional quality traits. However, Fe-contents recorded in three test entries namely, IC532985(42.2ppm), HLR24 (41.4 ppm) and HLR-64 (41.2 ppm) were close to the check DWRB192 (43.2 ppm). The results also showed that the genetic stock DWRB189 (64.9 %) registered for antioxidant activity is the best source for genetic improvement of antioxidant activity in barley as the second-best test entry HLR-196 had 54.4 % of antioxidant activity.

Fig. 7.10. Pigmented naked barley.

Diversified germplasm resources for yellow rust in barley:

A set of 398 land races of barley was screened at Bajaura during the crop season 2021-22 against yellow rust under field conditions for adult plant reaction (APR), the infection was facilitated by artificial inoculation of a mixture of different pathotypes received from RS, Flowerdale and planting of a susceptible variety after a regular interval of 10-lines. During the same period this set of land races was also screened at RS, Flowerdale for Seedling Resistance Test (SRT) against 14-pathotypes of yellow rust. The promising 18-land races were further screened for APR and SRT at these locations during 2023-24 . Eight land races (HLR 75, HLR 103, HLR 115, HLR 134, HLR 137, HLR 271, HLR 272 and HLR 273) giving consistent results both for APR and SRT were screened for their reaction to yellow rust during 2023-24 at multi-locations (Bajaura, Hisar, Ludhiana, Durgapura, Karnal and Jammu), the hot spots for the disease along with all the 15-genetic stocks registered for resistance to yellow rust from time to time. An immune reaction was observed in three land races HLR115, HLR137 and HLR271 and 100S was observed in the susceptible check (infector). The three land races have also given nearly immune reaction against all the 14-pathotypes of yellow rust tried in SRT. Though six of the 15 genetic stocks registered for resistance to yellow rust also exhibited immune reaction to the disease, but the 3-land races exhibiting zero score for the disease can serve as diversified sources for yellow rust disease.

Diversified germplasm resources for resistance to Barley Leaf Blight: Twelve accessions(HVS-14, HVS-7, HVS-9, HVS-27, HVS-28, HVS-32, HVS-33, HVS-40, HVS-42, HVS-43, HVS-44, HVS-45 of *Hordeum vulgare* ssp. *Spontaneum*) out of 45 races which had shown promise against leaf blight in preliminary screening, were screened at multi-locations (Ayodhya, Pantnagar, Kanpur and Varanasi) along with the genetic stock registered for resistance of this disease and the infector (susceptible) line. Disease pressure was sufficient for screening. Performance of HVS-7, HVS-14 and HVS44 was better as compared to the registered genetic stocks used as resistance checks. Since these are wild accessions of *spontaneum*

Based on yield performance and yellow rust resistance, five entries of hulless barley viz; DWRB2407, DWRB2408, DWRB2409, DWRB2410, DWRB 2424 and DWRB2425 contributed to the initial varietal trial (IVT-IRTS-Hulless barley) during 2024-25. In addition, two entries namely, DWRB 2304 and DWRB 2306 were promoted from IVT to AVT-I in the north eastern plain and central zone while DWRB 244 was promoted from AVT-I to AVT-II in north western plain zone. DWRB 223 was identified by varietal identification committee for cultivation in irrigated timely sown conditions in NWPZ. It gives average grain yield (42.96 q/ha) and resistance to yellow rust.

Marker assisted selection and breedig (MAS/MAB) program for quality traits in barley

DWRBG19 (RMB2103) developed for low beta glucan (3.7% dwb) using integrated approach of marker assisted selection and multi-location based biochemical estimation of beta-glucan content and registered as genetic stock was contributed for malt barley station trial during 2023-24 for yield performance (Table 7.7 & 7.8). This entry is found competent in yield performance and promoted to NIVT-MB for 2024-25 for multi-location testing.

Table. 7.7 : Characteristic features of DWRBG19.

Genotype	TGW (g)	Test Wt (Kg/hL)	Starch (%)	Protein (%)	Grain β-glucan (%)	QTL	Chr	Significant marker
DWRBG19	51.1	62.7	62.9	10.9	3.7	QBgnm.StMo-7H.1	7H	HvCs1f-6Brz

Table. 7.8 : Characteristic features of MBST25.

Entry name	Grain yield/plot	1000-grain weight	Hectoliter weight	Bold grain %	Thin grain %
MBST-25 (DWRB101/ SLOOP SAWL3167)	2553 g (42.55q/ha)	46.0 g	69.54	81.46	2.79

Marker aided selection for grain protein and malt quality traits regulating QTLs in barley

Five marker assisted selected and fixed lines, 02 (RMB2301 & RMB2302) of backcross 2*DWRB101/SLOOP VICB 9953 and 02 (RMB2303, RMB2304 & RMB2305) lines of backcross 2*DWRB101/ SLOOP SAWL 3167 were contributed in BQSN for multi-location testing for *rabi* 2023-24. Significant markers identified for High DP, FAN & Malt Yield QTLs (QBgnm.StMo-7H.1-BRZ & QDp.StMo-4H-HVM67; 7H-EBmac471) were used for foreground selection during BC1 and BC2 populations. Off these lines, RMB2301 (DWRBG30) is identified for high diastatic power (113.4^{0}L), FAN content (174.6 ppm) and higher malt yield (89.3 %). This line will be submitted for genetic stock for superior malt quality in elite background (DWRB101) in hulled barley.

Three marker assisted selected lines, 02 (RMB2306 & RMB2307) of backcross 2*DWRB101/BK1127 and 01 (RMB2308) of backcross 2*DWRB101/BK306 were contributed in BQSN for multi-location testing for *rabi* 2023-24. Significant markers for grain protein content (GPC) QTLs QGpc.HaMo-4H (HVM40) and QS/T. HaMo-6H (ABG387) were used for foreground selection in during BC1 and BC2 populations. Of these, RMB2307 (DWRB101/BK1127) is identified for high protein (14.5%) as compared to existing best check line BK306 (11.1%) and BK1127 (14.0%). Other quality traits identified for line are 59.3 gm TGW, 63.3 hectolitre weight (Test weight in kg/hl) and 94.8% bold grain percentage. This line can be considered as the potential source of high protein in hulled barley malt background and can be included for improving protein content in barley breeding.

Assessment of grain and malt quality in barley (*Hordeum vulgare*) across diverse genotypes and locations

Malt quality is governed by a range of grain and malt-related parameters, which are influenced by genotype, environmental conditions, and their interactions (G×E). A study was conducted under the ICAR-AICRP Barley program to assess these effects, involving 20 genotypes cultivated across six locations (Karnal, Hisar, Durgapura, Pantnagar, Kanpur, Ludhiana) in India using a randomized complete block design with three biological replicates. The analysis revealed wide variation in grain quality parameters (Table 7.9). Similarly, malt quality parameters showed significant variability (Table 7.10), with malt yield ranging from 82.76% to 90.36%, friability from 23.44% to 95.57%, homogeneity from 59.16% to 99.72%, wort filtration rate from 136.67 ml/hr to 323.33 ml/hr, diastatic power from 56.21°L to 116.32°L, hot water extract from 68.76% to 85.57% (fwdg) and other traits listed in Table 7.10. Statistical analysis indicated that grain quality traits were significantly influenced by genotype, environment, and G×E interactions. For malt quality, most parameters were significantly affected by these factors, except saccharification rate, which was not influenced by location, and malt yield and hot water extract, which were not significantly affected by G×E interactions. These findings highlight the complex interplay of genetic and environmental factors in determining barley quality, providing a foundation for optimizing barley cultivation and malting processes to meet specific industrial requirements.

Table 7.9 : Descriptive statistics of grain quality parameters across all the locations. (HW: Hectoliter Weight; TGW: Thousand Grain Weight).

Parameter	Minimum	Maximum	Mean ± SEM	Range	SD	CV%
Protein (%)	7.93 (BCU5924)	16.03 (BK1127)	11.07 ± 0.62	8.1	1.5	6.9
Moisture (%)	8.63 (BCU6040)	13.93 (BCU6304)	10.22 ± 0.36	5.3	0.6	4.3
Starch (%)	59.03 (BCU5732)	63.40 (BCU6315)	60.94 ± 0.43	4.3	0.9	0.9
HW (kg/hl)	50.80 (BCU6369)	68.70 (DWRUB52)	30.27 ± 1.12	17.9	3.1	2.3
TGW (g)	30.95 (BCU6369)	73.28 (DWRB160)	48.23 ± 2.07	42.7	9.2	5.3
Bold grain (%)	48.96 (BCU6369)	99.61 (DWRB92)	88.07 ± 2.91	50.6	10.3	4.1
Thin grain (%)	0.22 (DWRB160)	14.38 (BCU6369)	2.51 ± 1.12	14.1	2.7	66.2

Table 7.10: Descriptive statistics of malt quality parameters across all the locations (WFR: Wort Filtration Rate; DP: Diastatic Power; HWE: Hot Water Extract; FAN: Free Amino Nitrogen)

Parameters	Minimum	Maximum	Mean ±SEM	Range	SD	CV%
Malt yield (%)	82.76 (BCU6315)	90.36 (DWRUB64)	87.48 ± 1.05	7.6	1.5	1.47
Friability (%)	23.44 (BCU5732)	95.57 (BCU6315)	62.95 ± 4.58	72.1	14.4	9.04
Homogeneity (%)	59.16 (DWRUB64)	99.72 (BCU6316)	89.14 ± 3.58	40.5	9.8	4.99
WFR (ml/h)	136.67 (BK1127)	323.33 (BCU6306)	242 ± 22.67	186.6	48.6	11.54
DP (oL)	56.21 (DWRUB52)	116.32 (BCU5957)	98.85 ± 5.62	60.1	13.6	6.61
HWE (%)	68.76 (BCU5924)	85.57 (BCU6306)	78.21 ± 2.24	16.8	3.5	3.51
FAN (ppm)	56.71 (BCU5957)	212.78 (BCU6040)	164.42 ± 14.6	156.0	29.3	10.98

DWRBG25 (INBON-HI-(2016)-73): A promising source of hulless barley genotype with high grain beta glucan, high protein and high bold grain percentage

Epidemiological studies confirm that whole grain barley is a nutritional powerhouse, offering protection against life style related diseases like diabetes, obesity, and cardiovascular issues. This is attributed to its rich content of beneficial phytochemicals, including β-glucan, phenolic acids, flavonoids, lignans, tocols, phytosterols, and folate. Among these compounds, β-glucan stands out for its numerous health benefits.

DWRBG25 (INBON-HI-(2016)-73), a 6-row hulless barley genotype was assessed across six locations during the 2022-23 rabi season. Quality analysis conducted at ICAR-IIWBR Karnal's Barley Quality laboratory revealed significantly superior characteristics, including higher bold grain percentage, elevated grain beta-glucan and protein content, very low thin grain percentage and high thousand-grain weight (TGW), compared to the hulless barley checks (Barley Network AICRP Report, 2022-23) (Table 7.11-7.13). These notable qualities make DWRBG25 (INBON-HI-(2016)-73) well-suited for direct consumption and as a donor for transferring these desirable traits into high-yielding hulless barley varieties.

Table 7.11: Grain beta glucan content (%db) in DWRBG25 (INBON-HI-(2016)-73) at different locations during 2022-23

Genotype	Hisar	Durgapura	Karnal	Ludhiana	Pant Nagar	Kanpur	Mean
INBON-HI-(2016)-73	8.0	8.4	7.8	7.9	8.1	NA	8.0
INBON-HI-(2016)-69	6.9	7.2	7.5	7.5	NA	6.7	7.2
DWRFB-40 ©	7.4	6.9	5.6	8.5	6.9	7.2	7.0
DWRFB-58 ©	6.2	6.5	5.8	6.8	NA	6.1	6.3

Table 7.12: Bold grain percentage in DWRBG25 (INBON-HI-(2016)-73) at different locations during 2022-23.

Genotype	Hisar	Durgapura	Karnal	Ludhiana	Pant Nagar	Kanpur	Mean
INBON-HI-(2016)-73	92.8	93.5	89.4	87.0	NA	NA	90.7
INBON-HI-(2016)-69	91.0	91.7	85.0	84.8	NA	88.5	88.2
DWRFB-40 ©	90.1	83.4	79.0	83.9	93.1	93.2	87.1
DWRFB-58 ©	77.6	86.6	57.1	77.2	NA	NA	74.6

Table 7.13: Grain protein content (%db) DWRBG25 (INBON-HI-(2016)-73) at different locations during 2022-23.

Genotype	Hisar	Durgapura	Karnal	Ludhiana	Pant Nagar	Kanpur	Mean
INBON-HI-(2016)-73	16.7	15.4	16.5	15.6	NA	NA	16.1
INBON-HI-(2016)-69	NA	16.1	15.4	14.9	NA	13.6	15.0
DWRFB-40 ©	11.0	11.2	14.5	12.0	11.4	11.4	11.9
DWRFB-58 ©	11.9	12.6	16.2	14.0	NA	12.9	13.5

Revenue generation through barley quality testing and analysis

A comprehensive quality analysis of various barley samples was conducted to assess grain and malt parameters, including beta-glucan and enzyme activities, received from multiple organizations. This testing not only contributed to advancing knowledge in barley quality but also generated significant revenue through service charges.

Barley Plant Pathology

Status of barley disease and pests:

Surveys and surveillance for diseases and pests were conducted by different scientists of cooperative centres, no case of severe rust occurrence was reported in the surveyed areas during the crop season. In the month of December, spot blotch in barley crop with severity ranges from 01 to 12 was noticed at farmer's field in Bhagalpur and adjoining areas *viz*., Barari, Jagdishpur, Nathnagar, Sabour and Kahalgaon in Bihar. During mid-January the incidence of leaf stripe, loose smut, covered smut and bacterial streak was noted in barley crop in traces at few locations in the areas of districts Jaipur and Dausa of Rajasthan. During mid-February to last week of February, spot blotch incidence was recorded up to 89 in barley crop at farmers' field in Pundibari, and Coochbehar.

Observation of any new barley diseases/ insect pests

To keep the strict vigil on the appearance of any quarantine pests on barley crop, the nurseries were observed for any new symptoms during the crop season till the harvest. There was no report from any centre for presence of any of quarantined pests (disease / insect pest) *viz.,* glume rot, barley stripe mosaic and barley ergot; in their respective areas during the crop season 2023-24.

Evaluation of breeding lines against stripe rust disease

Total 696 barley entries were evaluated against stripe rust disease of barley caused by *Puccinia striiformis* f. sp. *hordei* at Karnal under different barley plant pathological nurseries *viz.,* IBDSN (492), NBDSN (154) and EBDSN (50). Stripe rust inoculum was multiplied on susceptible barley cultivars *viz*., Jyoti, Lakhan, RD 103, Raj Kiran etc. through syringe inoculation under polyhouse conditions. This multiplied inoculum was sprayed and inoculated under field conditions and disease epiphytotic was created. The disease data was recorded for stripe rust and rust resistant entries were identified based on AUDPC (Fig. 7.11 & 7.12).

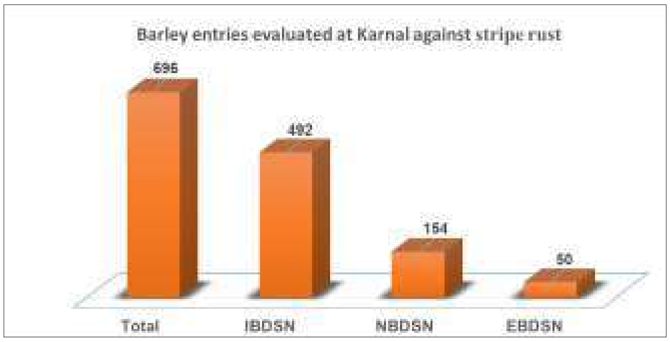


Fig. 7.11. Barley entries evaluated against stripe rust disease at Karnal during 2023-24

Fig. 7.12. Creation of epiphytotic conditions in Barley screening nursery at Karnal

Stripe rust inoculum multiplication, creation of disease epiphytotics and data recording: Stripe rust inoculum *Puccinia striiformis* f. sp. *hordei* was multiplied on susceptible barley cultivars viz., Jyoti, Lakhan, RD 103, Raj Kiran etc. through syringe inoculation under polyhouse conditions. The inoculum was supplied to the breeder and disease epiphytotic was created for recording of data in segregating material and advanced bulks.

Multiplication of spot blotch pathogen *Bipolaris sorokiniana* inoculum, creation of disease epiphytotic and data recording: The Spot blotch pathogen *Bipolaris sorokiniana* was isolated from diseased leaves on the PDA medium containing Petri plates. Seven days old *B. sorokiniana* culture was inoculated on pre autoclaved sorghum grains in 250 ml flasks. The inoculum was multiplied and was provided to the breeder and disease epiphytotic was created for recording of data in segregating material.

Evaluation of barley genotypes against stripe rust disease: Total 109 barley genotypes were evaluated against stripe rust caused by *Puccinia striiformis* f. sp. *hordei* at Karnal. Out of these genotypes, total fifteen genotypes *viz*., IC137789, EC328942, EC328957, IC138302, IC138007, IC138009, IC138029, IC138034, IC138048, IC138055, IC138058, IC138059, IC138083, IC138103 and IC138108 were found resistant against stripe rust of barley based on AUDPC.

Evaluation of barley genotypes against spot blotch disease:

Around 109 barley genotypes were evaluated against spot blotch caused by *Bipolaris sorokiniana* at Karnal and Kalyani locations. No entry was found resistant against spot blotch disease. However, three lines *viz*., EC328973, IC138009, and IC138041 were recorded as moderately resistant.

8 REGIONAL STATION, FLOWERDALE, SHIMLA

Development of barley leaf rust differential sets

A differential system for designating the pathotypes of *Puccinia hordei* causing barley leaf rust in India was developed. Using a binomial system of nomenclature, 11 distinct pathotypes of *P. hordei* occurring in India were identified and named. The establishment of an Indian differential system (Table 8.1) for the designation of *P. hordei* isolates will help in monitoring the shift in virulence patterns, predominance, and emergence of new pathotypes in the future and will help scientists of other countries to make comparisons with their virulences.

Table 8.1: List of three sets of differentials for the identification of pathotypes of *Puccinia hordei*

S. No.	Set 0	Set A	Set B
1	Astrix	Sudan (Rph1)	Egypt-4 (Rph8)
2	Topper	Rph10	Emir (Rph20)
3	Q21861(RphQ)	Rph11	Prior (Rph19)
4	HBL113	Rph13	Yeron (Rph23)
5	BHS46	Rph14	Abyssinian (Rph9)
6	RD3016	Ribari (Rph3)	Gold (Rph4)
7	BH1035	Peruvian (Rph2)	Quinn (Rph2+5)
8	PL908	Magnif 104 (Rph5)	Bolivia (Rph2+6)
9	RD3013	CebadaCapa (Rph7)	Ricardo (Rph2+21)
10	Barley Local	Triumph (Rph12)	

Sr65: a widely effective gene for stem rust resistance in wheat

Sr65 is an all-stage resistance gene that has been mapped on chromosome 1AS from Indian wheat landrace *Hango-2*. It is a globally effective all-stage resistance gene that has a potential to protect wheat from stem rust in Australia, India, Africa and Europe.

Indian landrace *Hango-2* showed resistance to *Pgt* races in India and Australia. Screening of a Hango-2/Avocet 'S' (AvS) recombinant inbred line population identified two stem rust resistance genes, a novel gene (temporarily named as *SrH2*) from Hango-2 and *Sr26* from AvS. A mapping population segregating for *SrH2* alone was developed from two recombinant lines. *SrH2* was mapped on the short arm of chromosome 1A, where it was flanked by KASP markers *KASP_7944* (proximal) and *KASP_12147* (distal). *SrH2* was delimited to an interval of 1.8–2.3 Mb on chromosome arm 1AS.

The failure to detect candidate genes through MutRenSeq and comparative genomic analysis with the pan-genome dataset indicated the necessity to generate a Hango-2 specific assembly for detecting the gene sequence linked with *SrH2* resistance. MutRenSeq however, enabled identification of *SrH2*-linked KASP marker *sunCS_265*. Markers *KASP_12147* and *sunCS_265* showed 92 and 85% polymorphism, respectively, among an Australian cereal cultivar diversity panel and can be used for marker-assisted selection of *SrH2* in breeding programs. The effectiveness of *SrH2* against *Pgt* races from Europe, Africa, India, and Australia makes it a valuable resource for breeding stem rust-resistant wheat cultivars. *Since no wheat-derived gene was previously located in chromosome arm 1AS, SrH2 represents a new locus and named as Sr65* (Fig. 8.1). Detailed information has been published in the journal *Theoretical and Applied Genetics* 137:1 (2024, https://doi.org/10.1007/s00122-023-04507-7).

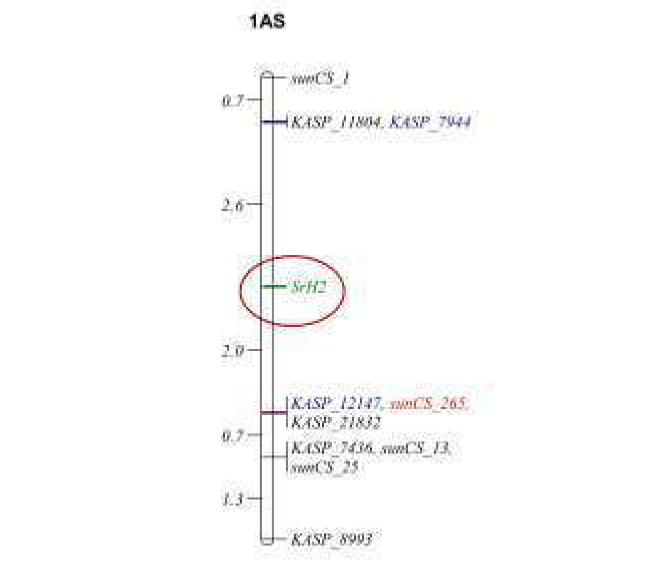


Fig. 8.1 Genetic linkage map showing position of the SRH2 locus on the short arm chromosome 1A along with markers developed from 90 K SNP Chip array, RNASeq and MutRENSeq datasets. Distances shown in centiMorgans.

Incidence of wheat and barley rusts in India and Nepal during 2023-24

During the crop season 2023-24, all rust diseases of wheat appeared endemically in India. Stripe (yellow) rust of wheat was first reported on 24th January, 2024 from RS Pura (Jammu) on an unknown variety and at Badyal Qazian on HD2967. Subsequently, the stripe rust was observed in 4 fields of villages NikuNangal and Dhokli in district Ropar (Punjab) on February 8, 2024. Low incidence of stripe and leaf rust was reported during March 28-29, 2024 from farmers' fields of Hansi, Shekhupur, Narnaund and other villages in Hisar (Haryana). Leaf (brown) rust (severity 5MS to 10S) was first observed from the farmers' fields near Dharwad (Karnataka) on 19 December, 2023. The occurrence of leaf rust in farmer's fields of Dewas, Indore, Sehore and Dhar districts of Madhya Pradesh was observed in February, 2024. In Bihar, leaf rust (up to 20S) was noticed in farmer's field of Sabour, Barari, Jagdishpur, Goradih, and Nathnagar. Stem (black) rust (severity up to 5MS) was first observed from the farmers' fields near Dharwad (Karnataka) on 19 December, 2023, and subsequently from other villages during the second fortnight of January, 2024. First incidence of stem rust from Maharashtra during the season was reported from Umbarkhed village (Niphad) on 31st January 2024. Leaf rust (severity 20S to 40S) and stem rust (20S to 60S) was also observed on off types and varieties from private companies during 2nd and 3rd week of February 2024 from the farmers' fields in Pune, Satara and Sangli districts. The incidence of stem rust was notably higher this season, particularly in the peninsular zone, compared to previous seasons. The wheat and barley rusts were kept under check with the help of cooperators, through exhaustive rust surveillance in different wheat growing areas of India and neighboring countries.

Pathotype distribution of *Puccinia* species on wheat and barley

During 2023-24, 858 samples including three rusts of wheat, stripe rust of barley collected/received from eleven states and Nepal were analyzed. Detail of the pathotype distribution is discussed below.

Stripe rust of wheat and barley (*Puccinia striiformis*)

During this crop year, 173 stripe rust samples of wheat were analyzed from six Indian states (Himachal Pradesh, Punjab, Haryana, Uttarakhand, Uttar Pradesh and Rajasthan) and Nepal. A total of nine pathotypes {238S119, 110S119, 46S119, T (47S103), P (46S103), 78S84, 110S84, 79S68, and 6S0} of wheat stripe rust pathogen were identified. Stripe rust pathogen populations were avirulent to *Yr5*, *Yr10*, *Yr15*, *Yr16*, *Yr32*, and *YrSP*. Most of the stripe rust samples of wheat were analyzed from Punjab (67) followed by Uttar Pradesh (21) and Uttarakhand (20). During the cropping season, frequency of pathotype 238S119 was maximum (36.4%) followed by 110S119 and 46S119. The frequency of 46S119 (virulent on *Yr2*, *Yr3*, *Yr4*, *Yr6*, *Yr7*, *Yr8*, *Yr9*, *Yr17*, *Yr18*, *Yr19*, *Yr21*, *Yr22*, *Yr23*, *Yr25*, and *YrA*) increased to 26.0%. However, other pathotypes were identified in low frequency (<4%).

Stem rust of wheat (*P. graminis* f. sp. *tritici*)

A total of 208 black rust samples received from Gujarat, Himachal Pradesh, Madhya, Pradesh, Maharashtra, Karnataka, Uttar Pradesh, Uttarakhand and Tamil Nadu; and Nepal were pathotyped on wheat differentials. Eight pathotypes, 11, 15-1, 21, 21-1, 21A-2, 40A, 40-2 and 40-3, of *Puccinia graminis* f. sp. *tritici* (*Pgt*) were identified. The *Pgt* population was avirulent to *Sr26*, *Sr27, Sr31, Sr32, Sr35, Sr39, Sr40, Sr43, SrTt3* and *SrTmp*.

Maximum number of samples was pathotyped from Karnataka (61) followed by Tamil Nadu (51) and Gujarat (28). Pathotype 11 (79G31=RRTSF), virulent on *Sr2, Sr5, Sr6, Sr7b Sr9a, Sr9b, Sr9c, Sr9d, Sr9f, Sr9g, Sr10, Sr13, Sr14, Sr15, Sr16, Sr17, Sr18, Sr19, Sr20, Sr21, Sr28, Sr29, Sr30, Sr34, Sr36, Sr38* and *Sr*McN, was recorded in 47.5 % of the samples. Pathotypes 40A and 40-2 were identified in 21 and 14% of the samples, respectively. Pathotypes 15-1 and 21 were identified in two samples while pathotype 21-1 was found only in one sample collected from Uttarakhand.

Leaf rust of wheat (*P. triticina*)

A total of 477 samples of wheat leaf rust were pathotyped from 10 states of India and neighboring country, Nepal. Among the 26 pathotypes of *Puccinia triticina* that were identified in these samples, pathotype 77-9 (121R60-1) was the most widely distributed and occurred in 44.8% of the samples followed by 52-4 (121R60-1,7) in 22.3% samples. Pathotype 77-5 (121R63-1), that remained the most predominant for more than 20 years was observed in 9.5% samples only. The remaining 23 pathotypes were identified in 75 samples only. In Nepal, fourteen pathotypes were identified in 76 samples. Pathotype 77-9 was the most predominant and recorded in 47.4 % samples received from Nepal.

The detail of predominant pathotypes of *Puccinia* spp. observed on wheat in India during 2023-24 is listed in Table 8.2.

Table 8.2: Predominant pathotypes of Puccinia spp. on wheat in India

Wheat Rusts	Predominant pathotypes
Stem	79G31(11), 62G29(40A) and 127G29 (40-3)
Leaf	121R60-1(77-9), 121R63-1,7 (52-4) and 121R63-1(77-5)
Stripe	238S119, 110S119 and 46S119

Seedling resistance test (SRT) and characterization of *Lr*, *Sr* and *Yr* genes in AVT lines

Screening of wheat and barley lines for rusts resistance at seedling stage

For identifying rust resistance sources, more than 5500 wheat and barley lines were evaluated during 2023-24 at seedling stage under controlled conditions using an array of pathotypes of stem (*P. graminis* f. sp. *tritici*), leaf (*P. triticina*) and stripe rust (*P. striiformis* f.sp. *tritici*) possessing different avirulence/virulence structures. Of these, 350 lines including 146 of AVT and 204 of NBDSN/EBDSN were subjected to multiple pathotypes screening under controlled light and temperature conditions. Seedling (all-stage) rust resistance remains effective throughout the life of wheat plants. Advanced wheat lines (146) were evaluated at seedling stage against 60 pathotypes of three *Puccinia spp.* on wheat. The gene matching technique was used to postulate rust resistance genes wherever required.

Rust Resistant Lines in AVT

Only entry VL2059 possessed resistance to all pathotypes of three rust pathogens (Table 3). Resistance to black and brown rusts was observed in 27 entries. Entries PBW916, WH1402(I)(C) were resistant to black and yellow rusts. Ten lines were found resistant to leaf rust, whereas thirteen to stem rust pathotypes. Fourteen entries conferred resistance to only yellow rust pathotypes (Table 8.3).

Table 8.3: Rust resistance in advanced wheat material during 2023-24

Rusts	No. of lines	Variety/line
Brown, Black and Yellow	01	VL2059
Brown and Black	27	CG1029, DBW426, GW547(I), GW554, GW555, GW556, HD3090(C), HI1563(C), HI1633(C), HI1634, HI1650, HI1669, HI1674, HI1683, HI1684, HI1687, HP1978, LOK79, MACS6222, MACS6768, MACS6829, MACS6830, NIAW4114, NIAW4120, NIAW4267, NIAW4432, WSM138
Brown and Yellow	01	PBW908
Black and Yellow	02	PBW916, WH1402(I)(C)
Brown only	10	CG1036, HI1665, MACS3949, MACS4125, MACS4131, MACS4135, MPO1398(d), PBW833, UAS446, UAS484

Rusts	No. of lines	Variety/line
Black only	13	AKAW5100, CG1040(I), DBW110, DBW173(C), DBW443, HD3447, HI1655, K1317(C), MACS6844, MP1378(I), PBW771(C), PBW891, VL907(C)
Yellow only	14	BCW29, DBW476, DBW477, HD3455, HD3494, JKW304, NW8071, PBW725, PBW913, PBW915, PBW921, PBW927, PBW957, PBW958

Characterization of rust resistance genes

Wheat rust resistance genes (*Lr, Sr, Yr*) were characterized using gene matching technique. Rust resistance genes were characterized in those lines where differential host-pathogen interaction was present. In addition, linked characters, morphological markers, characteristic infection types and pedigree also formed the basis for postulating rust resistance genes in absence of host-pathogen differential reactions.

a. *Yr* genes

Among the 146 lines of AVT, *Yr* genes were characterized in 80 lines. *Yr* genes were postulated in lines where differential interactions were observed and some cases of tight linkage of *Yr* genes to other *Lr* and *Sr* genes also implicated the presence of a resistance gene. Three *Yr* genes *viz. Yr2*, *Yr9*, and *YrA* contributed to yellow rust resistance in Indian wheat material. Among the postulated *Yr* genes, the frequency of *Yr2* was maximum and it was characterized in 73 lines while *Yr9* was postulated in 10 entries.

b. *Sr* genes

Thirteen stem rust resistance genes (*Sr2, Sr5, Sr7b, Sr8a, Sr8b, Sr9b, Sr9e, Sr11, Sr13, Sr24, Sr28, Sr30* and *Sr31*) were characterized in 121 AVT lines. The frequency of *Sr2,* postulated based on morphological marker micro flecking, was maximum as it was postulated in 48 AVT entries followed by *Sr11, Sr7b*, and *Sr13* which were characterized in 37, 35 and 34 entries, respectively. *Sr31* linked with *Lr26* and *Yr9* and conferring resistance to all the known *Pgt* pathotypes in Indian subcontinent was postulated in ten AVT entries, while *Sr24* linked to *Lr24* was characterized in twenty-one entries. Other *Sr* genes i.e. *9b, 9e*, and *8a* were characterized in 14, 6, and 3 lines respectively, while *Sr30* and *Sr5* in ten lines and *Sr8b* and *Sr28* were postulated in one line each. The *Sr* genes were characterized singly or in combination of up to three genes.

c. *Lr* genes

Eight *Lr* genes *Lr1*, *Lr3*, *Lr10*, *Lr13*, *Lr23*, *Lr24*, *Lr26,* and *Lr28* were characterized in 115 entries. *Lr13* was the most commonly postulated leaf rust resistance gene that was characterized, alone or in combination, in maximum number of lines (63) followed by *Lr10* (31 lines), and *Lr1* and *Lr23* (21 lines). *Lr24* that is linked with *Sr24*, was postulated in 21 entries. *Lr26,* tightly linked with *Yr9* and *Sr31*, was characterized in 10 lines. *Lr28* was postulated only in PBW915. Resistance to leaf rust in seven entries was based on a combination of three different genes.

Rust resistance in barley NBDSN and EBDSN lines during 2023-24

One hundred thirty-nine NBDSN and fifty EBDSN entries were screened against different pathotypes of three rust pathogens of barley under precise conditions of temperature and light. Confirmatory and selected testing was also undertaken wherever required. These lines were evaluated against seven pathotypes of *Puccinia striiformis* f. sp. *hordei* (M, 57, 24, G, Q, 6S0 and 7S0), five pathotypes of *P. graminis* f. sp. *tritici* (11, 21A-2, 40A, 117-6 and 122), and 11 isolates/pathotypes of *P. hordei* (*H1, H2, H3, H4, H5, H6, H7, H8, H9, H10* and *H11*). None of the NBDSN and EBDSN entries was resistant to all the tested pathotypes of *Pst*, *Pt* and *Pgt*. The detailed report is presented below.

NBDSN

A total 139 entries of NBDSN were evaluated against the different pathotypes of *Puccinia* spp. on barley. None of the lines was resistant to all three rusts of barley. Eight lines BHS498, GB1, RD2715(C), RD3096, RD3097, RD3100, RD3104, and RD3108 were resistant to all tested pathotypes/isolates of both leaf and stripe rust pathogens. DWRB-182 (C) was resistant against all the pathotypes of black and yellow rust pathogens Moreover, 33 lines were resistant to stripe rust and 15 lines to leaf rust. Resistance to all the pathotypes of *P. graminis* f. sp. *tritici* was observed only in two lines DWRB2319 and UPB-1124 (Table 8.4).

Table 8.4 : Seedling rust resistance in NBDSN during 2023-24

Resistant to rusts	No. of lines	Lines
Stripe and stem	01	DWRB182 (C)
Stripe and leaf	08	BHS498, GB1, RD 2715 (C), RD3096, RD-3097, RD-3100, RD-3104, RD3108
Stripe	33	BH1058, BH1059, DWRB 2301, DWRB 2314, DWRB-137 (C), DWRB2303, GB2, HBL888, HUB 290, HUB 291, HUB113, JHSBB19, JHSBD11, JHSBD22, JHSBF21, JHSBF28, PL955, PL956, RD2552 (C), RD3095, RD-2794 (C), RD2899 (C), RD2907(C), RD3088, RD3089, RD3090, RD3102, RD3103, RD3111, UPB1122, UPB1123, UPB1119, UPB1120
Stem	02	DWRB2319, UPB1124
Leaf	15	BHS380(C), BHS400(C), BHS501, DWRB2315, DWRB2312, DWRB238, HBL113(C), HBL885, NDB1821, NDB1829, RD3080, RD3093, RD3107, UPB1121, VLB186

EBDSN

Fifty EBDSN lines were evaluated for resistance to three rusts of barley. Resistance to all three rusts was not recorded in any EBDSN line. However, DWRB182 was resistant to stem and stripe rusts. Resistance to all the pathotypes of *Puccinia striiformis* f. sp. *hordei* and *P. hordei* was observed in 4 lines (BHS474, BHS478, BHS479, BHS481). Twelve lines were resistant to stripe rust and 4 lines to leaf rust. Resistance to all the pathotypes of *P. graminis* f. sp. *tritici* was observed only in HVS-9 (Table 8.5).

Table 8.5 : Seedling rust resistance in EBDSN during 2023-24.

Resistant to rusts	No. of lines	Lines
Stripe and stem	01	DWRB182
Stripe and leaf	04	BHS474, BHS478, BHS479, BHS481
Stripe	12	DWRB127, DWRB137, DWRB143, HLR 134, HLR271, HLR272, HLR273, HVS27, RD2794, RD2907, RD3077, RD3078
Stem	01	HVS9
Leaf	04	BHS486, DWRB190, VLB175, DWRB240

Genetics of rust resistance and developing rust resistant genetic stocks

Pyramiding multiple rust resistance and generation advancement

Germplasm lines harboring different leaf rust resistance genes such as *Lr10, Lr67, Lr23, Lr46, Lr13* and *Lr26* were crossed to develop F_1 lines with more than two leaf rust resistance genes. A total of 15 F_2 and F_3 families with 2 *Lr* genes each and 5 rows per family were sown in 2023-24 cropping season. These entries were evaluated and superior lines were selected as male and female parents for further crossing. The selected lines were screened using molecular markers for confirmation of *Lr* genes. The parental lines were then emasculated and crossed in all combinations to produce all possible 4 gene combinations among the 7 *Lr* genes. Nearly 90 crosses involving both direct and reciprocal crosses were made. The crossed seeds (F_1) along with parental lines were harvested. From each of F_2/F_3 families 10 ear-heads were also harvested for generation advancement.

Development of durable rust resistance

The brown rust resistance line Hango-2 harboring *Lr80* gene was crossed with FLW lines that carry yellow rust resistance. A total of 8 direct and reciprocal crosses were made. Crosses were also made among FLW lines and *Yr10* and *Yr15* to develop lines with high durable resistance to yellow rust. The F_5 generation from cross between Hango-2 and FLW17 carrying resistance to all the three rusts (*Lr80*, *Lr26/Yr9/Sr31*, *Sr65* and *YrSp*) was advanced to next generation.

In barley, for the purpose of developing leaf rust resistant genetic stocks, seeds of F_2 populations of several crosses that possessing leaf rust resistance genes *Rph5*, *Rph7* and *Rph12* in the background of major varieties RD3016, BH 1035, RD 3089, VLB173, RD3013, RD 3028 and KB 1926, were harvested.

Molecular Studies

Molecular profiling of AVT lines using molecular markers

Wheat rust resistance genes (*Lr, Sr, Yr*) were identified using molecular markers in AVT material of 2023-24. DNA from all 146 AVT entries was isolated by following the method of Murray and Thompson (1980) after some basic modifications. DNA quality was checked on 1% agarose gel electrophoresis and quantified on nanodrop. Robust molecular markers were applied on isolated DNA lines to ascertain additional rust resistance in these wheat lines. Eight previously validated molecular markers (*Sr24#50*, *SCSS30.2*, *CFd71*, *CsGsSTS*, *VENTRIUP*, *csLV34*, *WMC44* and *GWM533*) were used for identification of race specific and race nonspecific rust resistance genes in these lines. Details of molecular markers, linked genes, and the AVT lines consisting resistant gene are given in Table 8.6.

Table 8.6 : Detail of molecular markers, associated genes, and AVT lines containing resistant genes.

S. No.	Molecular Marker	Linked Genes	No. of lines
1.	SCSS30.2	Yr9/Lr26/Sr31	10
2.	Sr24#50	Sr24/Lr24	21
3.	CFd71	Lr67/Yr46/Sr55/Pm46/Ltn3	3
4.	CsGsSTS	Lr68	38
5.	VENTRIUP	Yr17/Lr37/Sr38	62
6.	csLV34	Yr18/Lr34/Sr55	11
7.	WMC44	Yr29/Lr46	26
8.	GWM533	Sr2	62

Amplification of *Yr9/Lr26/Sr31*

In AVT material, *Yr9/Lr26/Sr31* gene complex was validated by SCSS30.2 marker which amplified a sharp band of 550bp in ten AVT lines i.e. AKAW5100*, DBW173(C), HD3090, HI1633(C), HI1650, HI1634, MACS6768, MP1378(I), PBW771(C) and VL907(C) (Fig. 8.2A, B, C, and D).

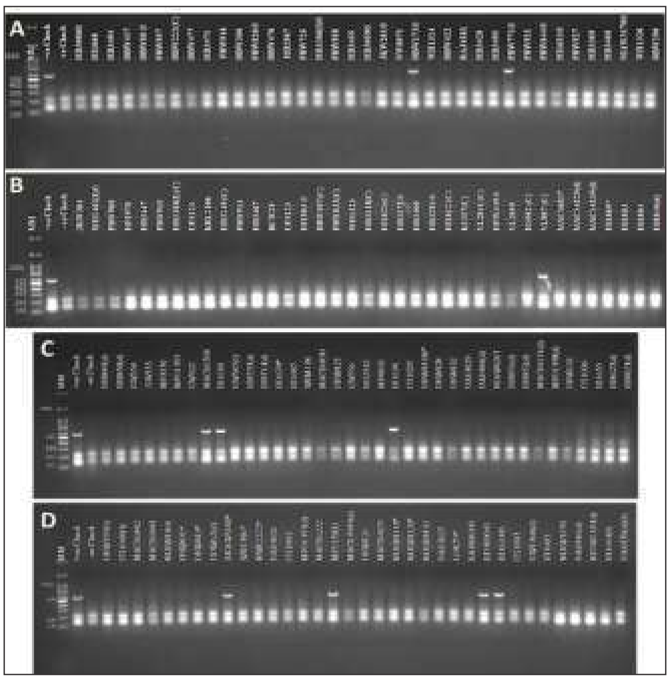


Fig. 8.2. Electrophoresis on 2.5% agarose gel showing amplification profile of marker SCSS30.2 indicated the presence of Yr9/Lr26/Sr31 gene complex. Upper row, Lane 1(MM)- Gene Ruler 100 bp DNA ladder; Lane 2(+ve)-Lr26 NIL as positive check for gene Lr26; Lane 3 (-ve)-LWH as negative check; Other lanes: AVT entries.

Amplification of *Lr24/Sr24*

In AVT material, 200bp amplicon produced by dominant marker *Sr24#50* indicated the presence of *Lr24/Sr24* gene complex in twenty-one wheat lines i.e. CG1029(C), GW547(I), GW554, GW555, GW556, HI1563(C), HI1669*, HI1674, HI1683, HI1684, HI1687, LOK79*, MACS6222, MACS6829, MACS6830, NIAW4114*, NIAW4120*, NIAW4267, NIAW4432, VL2059, and WSM138.

Amplification of *Yr18/Lr34/Sr55*

Amplification of 150 bp band by molecular marker *csLV34* indicated the presence of race nonspecific *Yr18/Lr34/Sr55* gene complex in 11 AVT lines (AKAW5100*, BCW29, DBW107(C), HI1563(C), HI1633(C), HI1634, KRL2106, PBW644, RAJ4083(C), VL907(C) and WSM138) while 229 bp band showed the absence of *Lr*34 gene in rest of the AVT lines.

Amplification of *Yr17/Lr37/Sr38*

Amplification of 259bp band by molecular marker *VENTRIUP* showed the presence of race nonspecific

Yr17/Lr37/Sr38 gene complex in maximum of 62 AVT entries.

Wheat- rust interaction studies

Narrowing down genomic region responsible for rust resistance

Sugar transporters play a pivotal role in facilitating the movement and allocation of sugars within the wheat-rust infection zone. Their indispensable contribution lies in the establishment of a secondary sink at the point of invasion by the fungal pathogen within plant cells. These transporter proteins, present on the membranes of both plants and pathogens, are the main players in defense signaling as they control how sugars are distributed between them and determine whether an encounter will result in resistance or susceptibility. Sugar transporter protein gene families are identified in wheat genome and studied for their chromosomal location, conserved motif domains and phylogenetic relationship with *Arabidopsis thaliana*.

Identification of Sugar Transport Protein gene family in wheat genome

International Wheat Genome Sequencing Consortium (IWGSC) database was searched for identification of Sugar Transport Protein (STP) gene family in wheat by using Sugar tr Hidden Markov Model (HMM) profile (Pfam: PF00083) as the query in a BlastP. A total of 476 TaSTP proteins with E-value of <1e–5, these sequences checked for presence of the Sugar_tr domain using Pfam database. 86 candidate STP proteins were discarded due to either a partial or complete absence of the STP domain and remaining 390 putative TaSTP sequences used for phylogenetic analysis along with 14 *AtSTPs* (Sugar transporter proteins from *Arabidopsis thaliana,* named as AtSTP1 to AtSTP14, retrieved from NCBI database.

Distribution of sequences in phylogenetic analysis

A phylogenetic tree, constructed based on the protein sequences of these 390 putative *TaSTPs* and 14 *AtSTPs*, revealed three subgroups (Fig. 8.3). Second subgroup exclusively housed all *Arabidopsis* sugar transporter proteins. This group represents monosaccharide transporters, and further we investigated only monosaccharides of this group in wheat. Within this subgroup, 81 wheat genes shared structural similarities with *Arabidopsis thaliana*.

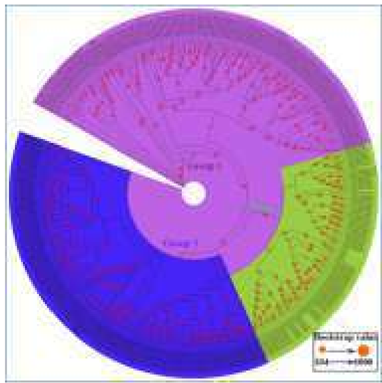


Fig. 8.3. Unveiling the phylogenetic relationship and delineating subfamily classifications among Sugar Transport Protein (STP) derived from both wheat and *Arabidopsis thaliana*

Chromosomal mapping of genes on all three genomes of *Triticum aestivum*

Chromosomal mapping of 81 STPs revealed an uneven distribution of these *TaSTP* genes on the long or short arms of the A, B, and D chromosomes (Table 8.7). The *TaSTPs* analyzed showed a coding sequence (CDS) length ranging from 1080 to 1848 base pairs. This variation indicates moderate to large gene sizes, potentially encoding structurally diverse proteins. The corresponding amino acid lengths ranged from 359 to 615 residues. The wide range suggests the presence of both shorter and longer protein isoforms, which may exhibit variations in structural complexity and functional roles. The molecular weight of TaSTPs was calculated to be between 39.55 and 67.04 kDa. This size range is typical of transport proteins and aligns with their potential role in complex membrane transport functions. The predicted isoelectric points (pI) ranged from 8.42 to 10.05, indicating that the majority of these proteins are basic in nature. This suggests a possible role in interacting with negatively charged molecules, such as phospholipids or nucleic acids, within cellular environments. The number of predicted transmembrane domains ranged from 6 to 13. The presence of multiple TMDs strongly supports the classification of TaSTPs as integral membrane proteins, potentially involved in the transport of ions, small molecules, or other substrates across cellular membranes.

Table 8.7: Distribution of Putative STPs on Chromosomes

Chromosome No.	No. of genes	Chromosome No.	No. of genes	Chromosome No.	No. of genes
1A	4	1B	4	1D	3
2A	7	2B	8	2 D	6
3A	2	3B	3	3 D	3
4A	3	4B	4	4 D	3
5A	8	5B	5	5 D	7
6A	3	6B	2	6 D	1
7A	2	7B	1	7 D	2

MapDraw software was used to determine approximate locations of the *TaSTP* genes on the chromosomes of wheat showed presence of 81 genes were located separately on chromosomes A, B, and D. Moreover, *TaSTP14-TaSTP18*, *TaSTP21-TaSTP26*, *TaSTP28-TaSTP32*, *TaSTP53- TaSTP55*, *TaSTP61-TaSTP63*, and *TaSTP66 -TaSTP68* formed a gene cluster with more than three genes on chromosomes 2A, 2B, 2D, 5A, 5B, and 5D, respectively. Based on the linkage map, the wheat sugar transporter (*TaSTP*) genes are mapped to specific chromosomes. The detail of linkage map revealed the chromosomal position of the wheat sugar transporter (*TaSTP*) genes on all three genomes of *Triticum aestivum* (Fig. 8.4).

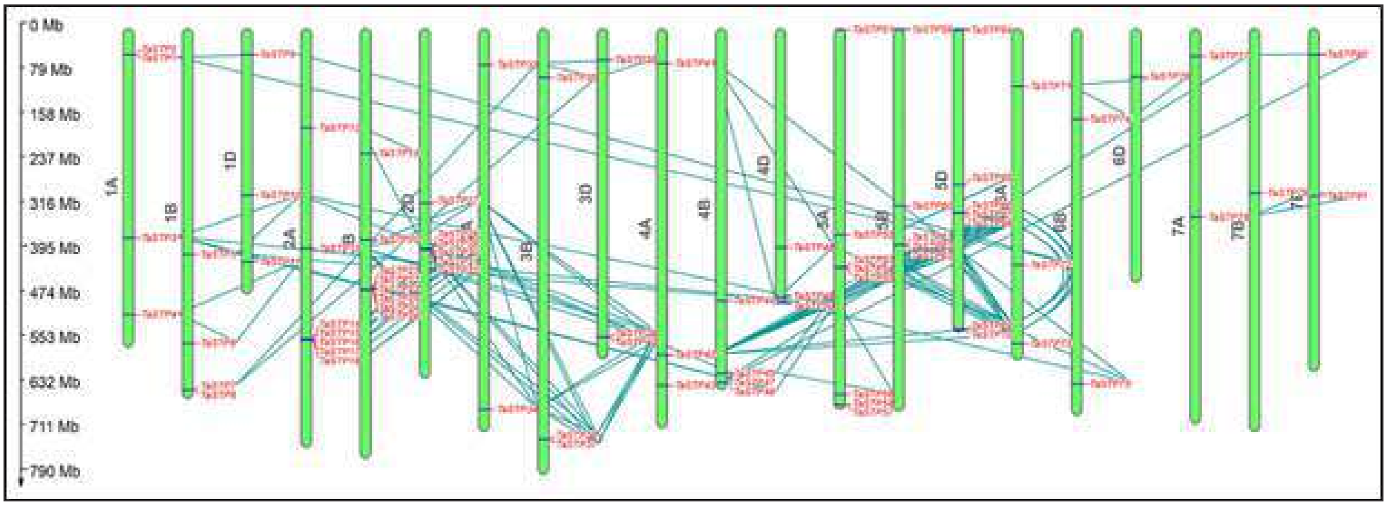


Fig. 8.4. Chromosomal locations of the wheat sugar transporter (TaSTP) genes according to the linkage map

Conserved Motifs of STPs- Pfam analysis gave conserved motifs present in STPs and this comprehensive exploration provides valuable insights into the distribution of conserved motifs among *TaSTP*

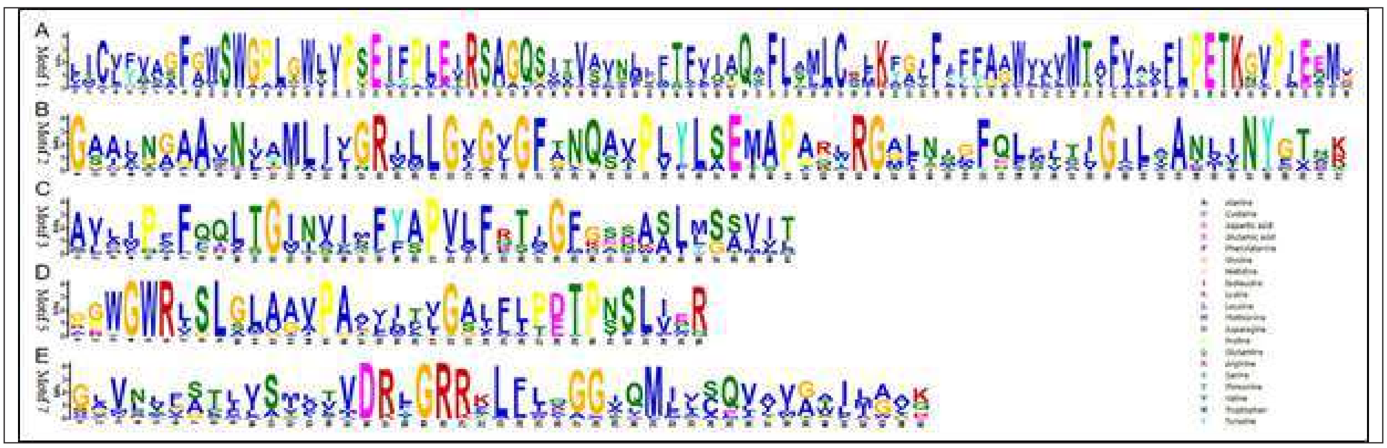


Fig. 8.5. Conserved motifs of STP proteins.

proteins, shedding light on their potential functional significance. The STP proteins exhibited conserved motifs, namely Motif A, B, C, D, and E. The representation of these motifs involved motif logos and amino acid compositions within the Sugar_tr motifs. On the x-axis, the amino acid types and positions are depicted, while the y-axis conveys the overall height of amino acid stacks, reflecting the sequence conservation at specific positions. The height of individual symbols within a stack signifies the relative frequency of a nucleotide base at that particular position. The graphical representation provides a comprehensive view of the conserved patterns and amino acid compositions within the STP proteins' Sugar_tr motifs (Fig. 8.5).

Identification of *Puccinia* proteins associated in different metabolic activities

Whole genome of three species of *Puccinia* was used for the protein targeting and localisation analysis. InterPro Domain search was performed on whole genome of different species of *Puccinia* given below at FungiDB (https://fungidb.org/fungidb/app). A total number of 7550 genes, encoding proteins with TM domain, were identified in the three genomes. 1941 genes in *Puccinia graminis* f. sp. *tritici*, 3821 in *Puccinia striiformis* and 1942 in *P. triticina* have been identified. Genome of all three wheat rusts was searched for protein associated in different activities. The detail of *Puccinia* proteins identified is listed in Table 8.8

Table 8.8 : Fungal proteins associated in different activities

Interpro Domain	Hypothetical protein	Elongation factor EF-3	ATP-binding cassette	Mitochondrial ABC transporter ATM	ABC transporter domain-containing protein	Total no. of proteins
P. graminis tritici	21	2	3	1	1	28
P. striiformis	34				7	41
P. triticina	32	1	1		1	35

Wheat disease monitoring/ SAARC nursery

The 56th wheat disease monitoring nursery was planted at 38 strategic locations evenly distributed throughout India. Data were received from all the locations except for 5. Yellow rust was noticed at all the locations of NHZ and NWPZ except IIWBR, RS, Shimla and ICAR-IARI, RS, Shimla. More than 40S severity of yellow rust was reported from NHZ and NWPZ except Durgapura where maximum yellow rust severity was 5S on Agra Local. At least six entries of WDMN had ≥ 40S severity at Almora, Bajaura, Khudwani, Dalang, Kathua, Jammu, Dhaulakuan, Gurdaspur, Ludhiana and Langroya.

Brown rust was reported from 12 locations of NHZ and NWPZ It was reported from all the locations of NEPZ except Kalyani and Ranchi. In central zone, brown rust appeared at Vijapur, Indore and Powarkheda and in PZ and SHZ, only at Pune and Wellington. At Durgapura, brown rust appeared only on HD2329 (TS), Lal Bahadur (TS), WH147 (TMS) and RNB1001 while at Shimla it was reported only on three entries *i.e.* PBW752 (10S), Agra Local (20S) and Lal Bahadur (15S) while other entries were brown rust free. Of the 33 locations of WDMNs, black rust was observed at Vijapur, Indore and Powarkheda in CZ, Dharwad in PZ and Wellington in SHZ. All the entries of WDMN were black rust free in NHZ, NWPZ, PZ and NEPZ. Leaf blight was reported from WDMNs planted at Rajouri, Kathua, Jammu (Udhaywalla), Sabaur, Pusa, Kalyani, Ranchi, Ayodhya, Kanpur, and Niphad. Powdery mildew was observed only at Almora, Rajouri, Kathua, Jammu, Dhaulakuan and Wellington.

SAARC wheat disease monitoring nursery was planted at 27 locations in India, Bangladesh, Bhutan, Nepal and Pakistan. Data were received from all the locations in India and Nepal whereas; it is still awaited from other SAARC countries.

National repository of pathotypes of *Puccinia* species on winter cereals

A collection of more than 150 pathotypes of different rust pathogens of wheat, barley, oat and linseed were maintained in live culture as well as cryo-preserved. For the smooth conduct of wheat and barley rust research, nucleus/bulk inoculum of different pathotypes of wheat and barley rust pathogens was supplied to more than 41 scientists/centers under public and private sector across India.

9 REGIONAL STATION DALANG MAIDAN, LAHAUL & SPITI (HP)

The ICAR-IIWBR, Regional Station located at Dalang Maidan, Lahaul & Spiti in Himanchal Pradesh act as a national service centre for providing various kind of support to wheat and barley researchers across the country. The efficient utilization of Off-season summer nursery facility is for development of varieties in shorter period of time, to improve the genetic gain and make the wheat breeding programme more efficient and effective. The ICAR-IIWBR Regional Station Dalang Maidan, Lahaul & Spiti, Himachal Pradesh is one of the strategic locations which helps in attaining this goal of many plant breeding programs. The natural environment of the valley provides excellent opportunity to the wheat and barley scientists of the country to use the facility for generation advancement and screening against yellow rust and powdery mildew diseases. The shuttle breeding approach helps in removing the photoperiodic alleles and providing better stability to the genotypes.

Generation advancement of wheat and barley crops during off season, 2024

During the period of May-October, 2024, more than 37000 lines of wheat and barley breeding material from 43 co-operators of different Institute across the country were advanced at ICAR-IIWBR Regional station, Dalang Maidan, by utilization summer nursery facility. The materials from all the major wheat zones were advanced at the station. The maximum materials were from NWPZ followed by NHZ, CZ, NEPZ and PZ. Apart from ICAR-IIWBR Karnal, ICAR-IARI New Delhi, CCS HAU Hisar, PAU RS Gurdaspur, NABI Mohali, VPKAS Almora, BISA Ludhiana and CSHPKV Palampur were major co-operators for utilizing the off-season facility. The sowing of all the materials was done during 24 - 26th May, 2024. All the research material was harvested at maturity in the month of Sep-Oct, 2024 and supplied to the respective researchers well in time. The disease pressure for both stripe rust and powdery mildew was adequate for screening of the lines and properly utilized by wheat workers across the country.

Corrective hybridization:

The summer nursery (2024) was also utilized for corrective crossing and backcrossing for gene introgression, mapping of the traits for genetic study and various breeding programmes of wheat and barley. More than 1050 corrective crosses, back crosses/three-way crosses were attempted during the Off-season. Scientific, Technical/RA/SRF and staff members from different institutes such as ICAR-IIWBR Karnal, ICAR-IARI New Delhi, ICAR-IARI-RS, Shimla, ICAR-VPKAS Almora, SKUAST-J Jammu, CSKHPKVV, Palampur, NABI Mohali, PAU-RS, Gurdaspur and many others visited the nursery during months of July and August, 2024, for attempting crosses.

Disease screening

The season was very favorable for the screening of yellow rust and powdery mildew. Around 13,500 lines were screened by various centers. The yellow rust incidence was first observed during mid of July and disease pressure was highest during beginning of August, 2024. Powdery mildew also appeared at the end of August 2024. The yellow rust incidence was first observed during last week of July and the disease pressure was highest during August.

Natural Repository of Wheat and Barley Germplasm:

The off-season facility also acts as a natural repository for wheat and barley germplasm and at present, about 12000 wheat germplasm accessions and about 8000 barley accessions are being conserved and maintained under natural cool temperature conditions at the station.

Seed multiplication of important Barley cultivars/ varieties

The seed multiplication of few barley genotypes from ICAR-IIWBR, Karnal was carried out at the station.

10 SEED AND RESEARCH UNIT, HISAR

The ICAR-Indian Institute of Wheat and Barley Research, Seed and Research Unit, Hisar is located at the Southern bypass in the North-West of Hisar city. With an area of 200 acres, it is mandated with breeder seed production of popular/newly released wheat and barley varieties and evaluation of wheat and barley lines and trials under the All India Coordinated Wheat and Barley Improvement Programme. The main research focus is on evaluation of wheat and barley genotypes under natural soil salinity conditions.

Breeder seed production and revenue generation

Breeder seed production of popular/newly released wheat and barley varieties is an important activity of the Seed and Research Farm Hisar (Fig. 10.1) and during the season pertaining to 2023-24, 1179.08q of breeder seed of one wheat (DBW303) and six barley varieties (DWRB101, DWRB123, DWRB137, DWRB160 and DWRB182) was produced. The variety wise seed production is given in the Table 10.1.

Table 10.1: Breeder seed production of different varieties during 2023-24

S. No.	Variety/Crop	Class of seed/mixture	Quantity (q)
1	DWRB101 (Barley)	Breeder seed	14.40
2	DWRB123 (Barley)	Breeder seed	30.35
3	DWRB137 (Barley)	Breeder seed	293.85
4	DWRB160 (Barley)	Breeder seed	15.75
5	DWRB182 (Barley)	Breeder seed	19.23
6	DWRB219 (Barley)	Breeder seed	52.50
7	DBW 303 (Wheat)	Breeder seed	753.00
			Total 1179.08

Fig.10.1 Monitoring of breeder seed crop at ICAR-IIWBR, Hisar

Trials under multi-locational and multi-disciplinary research programme on wheat and barley improvement

- Barley AVT/IVT-SST with 18 entries in 4 replications under two salinity environments was conducted during *rabi* 2023-24 and the data was supplied to the Principal Investigator barley.
- All India Coordinated Salinity/Alkalinity Tolerance Screening Nursery SATSN-Wheat) with 29 entries including 5 checks in ABD was conducted.
- Response of new feed barley genotypes to different Nitrogen levels under salinity condition in NWPZ was tested with 4 varieties (KB2031, RD2907, NDB1173 and RD2794) in four replications and 3 nitrogen levels in split plot design.

Station trials conducted

- Wheat Station Trial (NWPZ/NEPZ/CZ/PZ-RI-TS) with 25 entries in 2 replications in simple lattice was conducted.

Selection

- Selection was exercised in F6 generation in 10 crosses.
- Selection was exercised in F5 generation in 65 crosses.

Mutation breeding in barley

- A trial for mutation breeding in barley was laid out in

2023-24 crop season. The M1 generation of three popular and new barley varieties viz. DWRB137, DWRB219 were raised. The varieties were given gamma dosage of 250 & 300 Gy. The objective of the trial is selection of a hull less mutant (*Nud1* mutant) from agronomically superior hulled varieties. A total of 5000 individual spikes were selected from the M1 generation to raise the M2 generation.

Barley accessions validated for salinity tolerance:

- A total of five wild barley (*Hordeum spontaneum*) accessions (IC144117, IC144121, IC144123, IC144128 and IC145508) were screened for tolerance to salinity and these were found to be promising accessions for salinity tolerance as donor parents.
- 25 barley genotypes from ICARDA with different geographical origin were validated to harbor salinity tolerance and these, as well, can be used as donor parents.
- A total of 22 Himalayan landraces of barley were validated under salinity environment at ICAR-IIWBR, Hisar.
- A set of 105 released varieties was evaluated under field soil salinity conditions at Hisar Farm during 2023-24 in augmented block design. Promising varieties with high levels of salinity tolerance included K-508 (6R), Jyoti (6R), K-507 (6R), PL419 (6R) and RD2552 (6R).

Material screened for aphid resistance:

- 398 accessions collected from the Himalayas were screened for tolerance to aphid infestation under natural conditions. Out of these 23 accessions were found to be resistant to aphid infestation with an aphid resistance score of 2.

Diversity analysis in 366 Himalayan landraces

- A total of 366 Himalayan landraces were planted in augmented block design with seven checks (Bilara-2, DWRB-137, RD-2552, BH-946, RD-2907, DWRB-182 and RD-2794) and diversity analysis was performed on the data recorded on 10 agro-morphological traits. The GxE plot and dendrogram analysis revealed a significant proportion of genetic diversity in the analysed panel (Fig. 10.2).

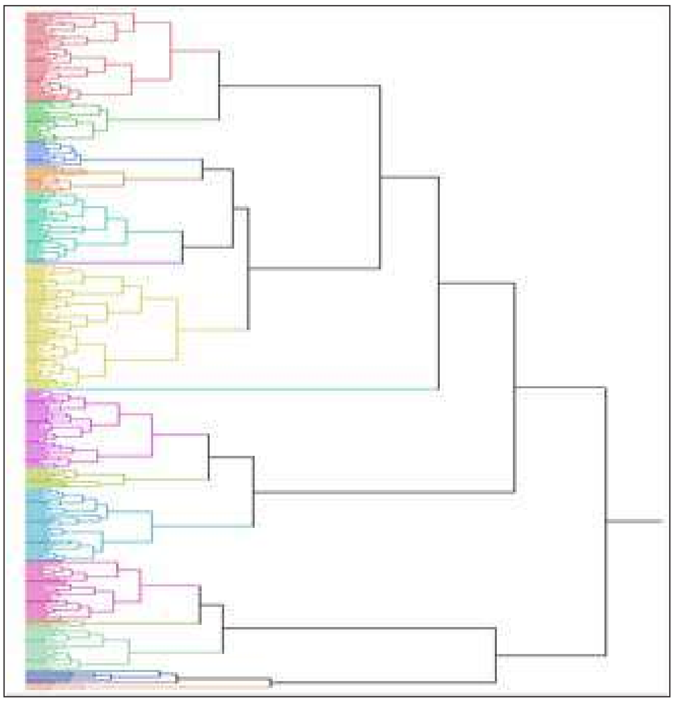


Fig. 10.2 Dendrogram depicting diversity in 366 Himalayan landraces

11 EXTENSION ACTIVITIES

Training programmes organized/conducted by ICAR–IIWBR, Karnal

S. no.	Date	Duration (Days)	No. of Trainees	Subject	Organized by
1.	09.01.2024	1	50 Farmers	Awareness-cum-Training Programme on Agricultural Technologies'	ICAR-IIWBR, Karnal in collaboration with KVK, Tepla, Ambala, Haryana
2.	10.01.2024	1	50 Farmers	Awareness-cum-Training Programme on Agricultural Technologies'	ICAR-IIWBR, Karnal in collaboration with KVK, Kaithal, Haryana
3.	11.01.2024	1	50 Farmers	Awareness-cum-Training Programme on Agricultural Technologies'	ICAR-IIWBR, Karnal in collaboration with KVK, Jhajjar, Haryana
4.	15.03.2024	1	100 Farmers	'Training Programme on Conservation Agriculture and Spray Techniques' at Ganju Majra, Ambala, Haryana	ICAR-IIWBR, Karnal, in collaboration with KVK, Ambala, Haryana
5.	06-10-2024	1	94 Dealers	Wheat and Barley Marketing	HAMETI, Jind Haryana
6.	21-23 Dec.,2024	3	40 Farmers	Uttarakhand me Gehoon evam Jau ki Adhunik Kheti	ICAR-IIWBR, Karnal

Coordination of visits at ICAR-IIWBR, Karnal

S. No.	Date	Numbers of visitors	Institute/States of the visitors
1.	09-01-2024	40 Farmers	Firozabad, Uttar Pradesh
2.	19-01-2024	45 Farmers	Sri Ganganagar, Rajasthan
3.	30-01-2024	50 Farmers	Nagore, Rajasthan
4.	31-01-2024	07 Officers	Ujjain, Madhya Pradesh
5.	01-02-2024	48 Farmers	Fatehpur, UP
6.	01-02-2024	50 Farmers	Alwar, Rajasthan
7.	05-02-2024	20 Students	PM Shri Govt. Sr. Sec. School, Kunjpura, Karnal, Haryana
8.	06-02-2024	245 Students	PM Shri Kendriya Vidyalaya ITBP, Bhanu Ramgarh, Panchkula (Haryana)
9.	06-02-2024	35 Students	GDGU, Gurugram, Haryana
10.	07-02-2024	37 Farmers	ICAR-CSWRI, Avikanagar, Tonk, Rajasthan
11.	07-02-2024	50 Farmers	Hanumangarh, Rajasthan
12.	08-02-2024	23 Farmers	Sugarcane Breeding Institute, Karnal, Haryana
13.	13-02-2024	48 Students	Govt. Sr. Sec. School, Nara, Panipat, Haryana
14.	13-02-2024	59 Farmers	ICAR-CSWRI, Avikanagar, Tonk, Rajasthan
15.	13-02-2024	50 Students	Govt. Sr. Sec. School, Kutail, Panipat, Haryana
16.	13-02-2024	50 Students	PM Shri Govt. Sr. Sec. School, Nilokheri, Karnal, Haryana
17.	16-02-2024	14 Farmers	Raisen, Madhya Pradesh
18.	19-02-2024	26 Students	ICAR-NDRI, Karnal, Haryana
19.	21-02-2024	160 Students	PM Shri Govt. Sr. Sec. School, Urlana Kalan, Panipat
20.	23-02-2024	100 Students	Uncha Samana, Haryana

S. No.	Date	Numbers of visitors	Institute/States of the visitors
21.	23-02-2024	150 Students	PM Shri Kendriya Vidyalaya No. 2 Ambala Cantt., Haryana
22.	26-02-2024	30 Farmers	Department of Agriculture, Meerut, Uttar Pradesh
23.	26-02-2024	43 Students	Shri Vaishnav Vidhyapeeth University, Indore (MP)
24.	28-02-2024	58 Students	Bharath University, Chennai
25.	02-03-2024	43 Students	Ahmednagar, Maharashtra
26.	05-03-2024	40 Students	College of Agriculture, Baramati, Pune, Maharashtra
27.	06-03-2024	19 Farmers	Amritsar, Punjab
28.	06-03-2024	08 Officers	Datiya, Madhya Pradesh
29.	07-03-2024	04 Offices	JIRCAS, Japan
30.	07-02-2024	112 Students	JSA college of Agriculture & Technology, Tamil Nadu
31.	07-03-2024	119 Students	Don. Bosco College of Agriculture, Arakkonam, Tamil Nadu
32.	12-03-2024	25 Farmers	Batala, Gurdaspur, Punjab
33.	12-03-2024	85 Students	DAESC KDM TNAU, Tamil Nadu
34.	12-03-2024	119 Students	MIT College of Agri. & Technology, Musiri Tamil Nadu
35.	12-03-2024	85 Students	SBA College & Res. Foundation, Karaikudi, Tamil Nadu
36.	12-03-2024	96 Students	Krishna College of Agri. and Tech. Usilampatty, Tamil Nadu
37.	13-03-2024	35 Students	CSAUA&T, Kanpur, Uttar Pradesh.
38.	13-03-2024	44 Farmers	CAFAD Ghaziabad, Uttar Pradesh
39.	13-03-2024	34 Students	CSAUA & Tech., Kanpur
40.	13-03-2024	110 Students	TNAU, Tamil Nadu
41.	14-03-2024	179 Students	AC&RI, Madurai, TNAU, Tamil Nadu
42.	14-03-2024	115 Students	AC&RI, Killikulum, TNAU, Tamil Nadu
43.	15-03-2024	110 Students	Adhiyaman College of Agri.& Res., Krishnagiri, Tamil Nadu
44.	16-03-2024	24 Students	CoA, Jodhpur Agricultural University, Jodhpur, Rajasthan
45.	18-03-2024	42 Students	CCSU, Meerut, Uttar Pradesh
46.	22-03-2024	122 Students	Adhiparasakthi Agricultural College, Tamil Nadu
47.	22-03-2024	95 Students	SRM College of Agricultural Sciences, Baburayanpettai, Tamil Nadu
48.	26-03-2024	20 Students	ICAR-NBPGR, New Delhi
49.	27-03-2024	95 Students	SRM College of Agricultural Sci., Changalpattu, Tamil Nadu
50.	29-03-2024	118 Students	Pushkaram College of Agri. Sci., Thiruxarangulam, Pudu & Katai
51.	01-04-2024	77 Students	RVS Padmavathy College of Horticulture, TNAU, Dindigul
52.	02-04-2024	105 Students	College of Agriculture, Jodhpur, Rajasthan
53.	03-04-2024	05 Students	Sam Higginbottom University of Agriculture and Technology, Prayagraj, Uttar Pradesh
54.	04-04-2024	107 Students	Aravindhar Agricultural Institute of Technology, Tiruvannamalai, Tamil Nadu
55.	05-04-2024	45 Students	Mayurakshi College of Agriculture, Jodhpur, Rajasthan
56.	08-04-2024	85 Farmers	Gautam Nayak Surya Foundation Project, New Delhi
57.	09-04-2024	21 Students	Meerut Institute of Technology, Meerut, Uttar Pradesh
58.	09-04-2024	49 Students	Palar Agricultural College, Vellore, Tamil Nadu
59.	12-04-2024	80 Students	Nammazhvar College of Agriculture and Technology, Kamudi, Tamil Nadu
60.	16-04-2024	73 Students	IFTH University, Moradabad, UP
61.	16-04-2024	122 Students	PGPCAS, Namakkal, Tamil Nadu
62.	06-05-2024	23 Students	CCSHAU, College of Agriculture, Kaul, Haryana
63.	07-05-2024	123 Students	TRIARD-TNAU, Tamil Nadu
64.	27-05-2024	22 Students	SVPUA&T, Meerut, Uttar Pradesh
65.	04-06-2024	22 Students	SVPUA&T, Meerut, Uttar Pradesh
66.	26-06-2024	01 Officer	Ms. Endo Noriko, Project Coordinator JICA Project Japan

S. No.	Date	Numbers of visitors	Institute/States of the visitors
67.	28-06-2024	61 Students	IGKV, BTS-CARS, Bilaspur, Chhattisgarh
68.	08-07-2024	04 Students	Kings College, Rohtak, Haryana
69.	10-07-2024	01 Officer	Dr. Jagdish Rane, ICAR-CIAH, Bikaner, Rajasthan
70.	22-07-2024	40 Students	Mahender Singh Sangor, Firozabad, UP
71.	26-07-2024	76 Students	DPS, Karnal, Haryana
72.	09-08-2024	79 Students	GMSSSS, Biana, Karnal, Haryana
73.	21-08-2024	51 Farmers	Basti, Uttar Pradesh
74.	13-09-2024	67 Students	GSSS Nara, Panipat, Haryana
75.	17-09-2024	30 Farmers	ATMA, Muzzafarpur, Bihar
76.	24-09-2024	60 Farmers	Bhavna Seva Sansthan, Lucknow, Uttar Pradesh
77.	25-09-2024	12 Students	SST University, Gurugram, Haryana
78.	26-09-2024	60 Farmers	Bhavna Sewa Sansthan, Lucknow, Uttar Pradesh
79.	29-09-2024	70 Farmers	Gramin Bal Vikas Evam Prashishaksan Sansthan, Basti, UP
80.	08-10-2024	12 Farmers	ATMA, Datia, Madhya Pradesh
81.	16-10-2024	29 Farmers	CCSHAU, Hisar, Haryana
82.	16-10-2024	35 Farmers	Deoria, Uttar Pradesh
83.	16-10-2024	22 Students	Phonics Group of Institution, Roorkee, Uttarakhand
84.	16-10-2024	32 Farmers	Department of Agriculture, Baliya, Uttar Pradesh
85.	18-10-2024	50 Farmers	Agriculture Department, Baghpat, Uttar Pradesh
86.	22-10-2024	20 Trainee	Agriculture University, Kota, Rajasthan
87.	23-10-2024	41 Farmers	Amethi, Uttar Pradesh
88.	24-10-2024	12 Farmers	Agriculture Division, Lahaul &Spiti, Himachal Pradesh
89.	25-10-2024	50 Farmers	Department of Agriculture, Baghpat, Uttar Pradesh
90.	28-10-2024	84 Students	GSSS, Kutail, Haryana
91.	12-11-2024	20 Farmers	IPS Foundation, Ambala, Haryana
92.	12-11-2024	42 Students	JUIT Solan, Himachal Pradesh
93.	13-11-2024	35 Farmers	Garib Uthan Seva Sansthan, Azamgarh, Uttar Pradesh
94.	15-11-2024	40 Farmers	ATMA, Jodhpur, Rajasthan
95.	20-11-2024	37 Students	Kalasalingam Academy of Research and Education, Tamil Nadu
96.	21-11-2024	17 Students	Geeta University, Panipat, Haryana
97.	22-11-2024	36 Students	Radha Krishna Public School, Thol, Haryana
98.	22-11-2024	71 Students	LNCT College, Bhopal, Madhya Pradesh
99.	02-12-2024	30 Students	ATMA, Tulsi Sarovar Ashoknagar, Madhya Pradesh
100.	03-12-2024	25 Farmers	ATMA, Kullu, Himachal Pradesh
101.	03-12-2024	52 Students	Dayal Singh Public School, Karnal, Haryana
102.	18-12-2024	200 Students	PM Shri KendriyaVidhyalaya, Beholi, Samalkha, Panipat
103.	18-12-2024	50 Farmers	ATMA, Bharatpur, Rajasthan
104.	19-12-2024	60 Students	CDTRI Partapur, Meerut, Uttar Pradesh
105.	19-12-2024	76 Students	GSSS, Ghimana, Jind, Haryana
106.	20-12-2024	84 Students	GSSS, Patti Afgan, Kaithal, Haryana
107.	24-12-2024	74 Students	TMU Moradabad, Uttar Pradesh
108.	26-12-2024	52 Farmers	Pragya Gramotthan Seva Samiti, Fatehpur, UP
109.	27-12-2024	30 Farmers	Department of Agriculture, Mandi, Himachal Pradesh
110.	31-12-2024	61 Farmers	Garsa, Kullu, Himachal Pradesh

Organization of Farmers Day/Field Day/Foundation Day etc.

Sr. no.	Date	Subject	Organized by
1.	29 January, 2024	Kisan Pathshala ka Ayojan at Village Furlak, Karnal	ICAR-IIWBR, Karnal
2.	08 February, 2024	International Women Day	ICAR-IIWBR Karnal
3.	09 February, 2024	10th Foundation Day of ICAR-IIWBR, Karnal	ICAR-IIWBR Karnal
4.	09 April, 2024	Field Day	ICAR-IIWBR Karnal at Village Bachki and Garhi Roran, Kurukshetra, Haryana
5.	21 June, 2024	International Yoga Day	ICAR-IIWBR, Karnal
	03 December, 2024	Agricultural Education Day	ICAR-IIWBR, Karnal
6.	05 December, 2024	World Soil Day at Village Sangoha, Karnal	ICAR-IIWBR, Karnal
7.	23 December, 2024	Rashtriya Kisan Diwas	ICAR-IIWBR, Karnal

Participation in Exhibitions

S. No.	Programme	Date	Organized by
1.	Kshetriya Krishi Mela	03-04 Feb., 2024	ICAR-Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh
2.	Virat Kisan Mela	01-03 March, 2024	Department of Agriculture, Uttar Pradesh at Samrat Prathviraj Chauhan Degree College, Baghpat, Uttar Pradesh
3.	Kisan Mela	03 March 2024	Gurbachan Singh Foundation for Research Education and Development, Kachhwa Road, Karnal, Haryana
4.	National Potato Festival-2024	09-10 March 2024	ICAR-Central Potato Research Institute, Regional Station, Modipuram, Meerut, UP
5.	Krishi Kisan Mela (Kharif) -2024	18-19 March, 2024	Chaudhary Charan Singh, Haryana Agriculture University, Hisar, Haryana
6.	National Conference on SmartFarming Solutions for Ornamental Horticulture	08-09 Nov., 2024	Maharana Pratap Horticulture University, Karnal, Haryana
7.	Global Soils Conference 2024	19-22 Nov., 2024	Indian Society of Soil Sciences and International Union of Soil Sciences at NASC Complex, New Delhi

TV Programme

Date	Name of the programme
09.01.2024	DD Kisan Prashan Manch
23.12.2024	DD Kisan Prashan Munch

12 LINKAGES

ICAR - IIWBR has a strong and wide network of linkages and collaborations with research organizations both in India and abroad.

Funded coordinated centers and other institutes

28 Funded centers
Department of Agriculture of 17 states
Around 96 voluntary centers

Research Linkages

International institutes such as International Maize and wheat improvement center (CIMMYT); Mexico; Australian centre for international Agricultural Research (ACIAR); Cornell University , USA; University of Sydney, Australia and International crop research institute for semi Arid Tropics (ICRISAT) , Hyderabad ; JIRCAS Japan ; National institutes like IARI, NBPGR, New Delhi (ICAR); and PPV & FRA, New Delhi; National Agri-food Biotechnology Institute (NABI), Mohali (Punjab), Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh); Kumaun University, Nainital (Uttarakhand); Jaypee University of Information Technology, Waknaghat (Himachal Pradesh); Guru Jambheshwar University of Science and Technology, Hisar (Haryana); Punjab Agricultural University, Ludhiana (Punjab); Indo Jordan Joint Agricultural Technical Committee (IJJATC); ICAR-IISS, Mau.

Academic Linkages

Deenbandhu Chhoturam University of Science and Technology, Murthal (Haryana); Amity University, Jaipur (Rajasthan); Mahatma Jyoti Rao Phoole University, Jaipur (Rajasthan); CSKHPKV, Palampur, (Himachal Pradesh); Indian Institute of Food Processing Technology, Thanjavur (Tamilnadu); DAV University, Jalandhar (Punjab); Lovely Professional University, Jalandhar (Punjab); Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal (Puducherry); CCSHAU, Hisar (Haryana); Ch. Charan Singh University, Meerut , (Uttar Pradesh); Banasthali University, Banasthali Vidyapith, (Rajasthan); Indian Institute of Science Education and Research, Kolkata, Mohanpur, (West Bengal); ICAR-CSSRI, Karnal, (Haryana); Kurukshetra University, Kurukshetra; CCS University , Meerut , RVSKWV Gwalior; Guru Jambeshwar university, Hisar; Jay Pee University of information technology , Solan Ch. Devi lal University, Sirsa; Maharishi Markendeshwer University; Mullana, Ambala ; Kumaun University, Nainital and ICAR-NDRI for pursuing their M.SC/ Ph.d under the guidance of ICAR – IIWBR scientists.

IIWBR-SAUs Partnership

In order to promote ICAR-IIWBR wheat and barley varieties in different zones, 10 agreements were signed between ICAR-IIWBR and following SAU'S and ICAR institutes for large scale multiplication of breeder seed and further distribution in the respective zones SKAUST, Jammu ; GBPUA &T, Pantnagar; BHU –Varansasi; JKNVV , Jabalpur; RVSKVV, Gwalior; SKNAU, Jobner; SKRAU Bikaner; BAUT Bandha ; RLBCAU, Jhansi.

Linkages with industry

Barley network programme has strong linkages with malt industry.

Linkages with TERI

Evaluation of Nano Fertilizers developed by the Energy Resource Institute (TERI), Gurugram (HR) in wheat and barley at ICAR- IIWBR, Karnal. Further, nano seed treatments in mitigation of biotic and abiotic stresses in wheat is being explored with TERI , Gurugram.

Linkages with Startup

Developed collaboration with start-up named RAAV Tech labs Private Limited, Delhi to develop NIR based protein analyser under public private partnership of "Make in India" programme.

INTERNATIONAL LINKAGES

13 INSTITUTE ACTIVITIES AND MAJOR EVENTS

75th Republic Day Celebration

ICAR-IIWBR, Karnal Celebrated 75th Republic Day (26th January 2024) with full enthusiasm in the presence of all institute staff, supporting workers, and students admitted under IARI Mega Univeristy, Karnal Hub. Dr. Gyanendra Singh, Director ICAR-IIWBR, Karnal hoisted the National Flag and acknowledged the efforts of institute staff as well as predecessors for their significant contribution to the institute. The Director also congratulated all the winning players and participants who took part in the ICAR –Zonal Sports Meet 2023 for North Zone.

Kisan Pathshala

Kisan Pathasala was organized by ICAR-IIWBR, Karnal on 29th January, 2024 at village Phurlak, District Karnal, Haryana under the Haryana Vigyan Manch. On this occasion farmers also gave heartily farewell and honour to Dr Randhir Singh. This meeting was coordinated by Dr Rajinder Singh, member, Haryana Vigyan Manch.

Women's day

International Day of Women and Girls in Science was celebrated at ICAR-Indian Institute of Wheat & Barley Research, Karnal on 8th February, 2024. Director, ICAR-IIWBR, Dr. Gyanendra Singh graced the occasion and shared his views about the role of women and girls in science. He appreciated the multifaceted duties played by women at the office and at home and congratulated them for making proactive contributions to the

institution. Women staff of the institute including scientists, technical, young professionals, SRFs, students and administrative personnel participated in this event and shared their respective views about increasing the contribution of women in science and at the same time maintaining a happy work-home balance.

Foundation day

ICAR-IIWBR, Karnal celebrated 10th Foundation Day on 9th February, 2024. Dr. Gurbachan Singh, and Dr. Arun Kumar Sharma were the chief guests on this occasion. Progressive farmers were also participated and they were honoured by the chief guest and Director .

India and CIMMYT Wheat Improvement Partnership Program

A Review and Planning Meeting under India and CIMMYT Wheat Improvement Partnership Program was held on 23rd February, 2024 at ICAR-IIWBR, Karnal. From CIMMYT Dr. Kevin Pixley (Wheat Program Director), Dr. Arun Kumar Joshi (BISA Managing Director), Dr.Velu Govindan (Senior Wheat Breeder), Dr. Sridhar Bhavani (Senior Scientist, Head of Rust Pathology and Molecular Genetics) and Dr. Pradeep Bhati (Wheat Breeder, BISA) participated in meeting and presented the achievements made under wheat improvement program. Dr. Gyanendra Singh gave the overview and achievements of CIMMYT activities under the CIMMYT India partnership.

National Women Day

National Women Day was organized by ICAR-IIWBR, Karnal on 8th March, 2024 at farmers field. Scientist of ICAR-IIWBR, Karnal interacted with the women engaged in agriculture at village Subri, District,Karnal.

Public Private Partnership meeting

ICAR-Indian Institute of Wheat and Barley Research, Karnal successfully organised one day "Technology Showcasing and Interface Meeting for Technology Commercialization through Public Private Partnership" on 19th March, 2024. More than 50 private seed company representatives, 40 progressive farmers, representatives from farmer producer organizations of Punjab, Haryana, Uttar Pradesh and Rajasthan attended the meeting.

5th IGM Meeting

ICAR-IIWBR organized the 5th IGM meeting on "Climate-Proofing Cereal Agriculture: Strategies for Resilience and Sustainability" from 24-27 March, 2024 at ICAR-IIWBR, Karnal. Dr. Trilochan Mohapatra (Chairperson, PPVFRA, Former Secretary, DARE & DG, ICAR, New Delhi) was the chief guest of the program. Dr. Suresh Kumar Chaudhari (DDG, Natural Resource Management, ICAR, New Delhi) joined the program through online mode.

Field Day

Field Day was organized at Sherpur Khelmau Haridwar in association with KVK Dhanauri Uttarakhand under cluster demonstration on climate resilient and biofortified variety on 5th April, 2024.

Brainstorming session

A special brainstorming session on "Augmenting pre-breeding for wheat improvement" was organized on 12th April, 2024 at ICAR-IIWBR, Karnal, in hybrid mode. In this session, Dr. Gyanendra Singh, Director ICAR-IIWBR, Karnal was the chairman and Dr. NS Bains, former Director Research, PAU Ludhiana, was co-chairman.

Meeting on wheat diseases and containment strategy

One-day meeting on important wheat diseases and containment strategy was organized at ICAR-IIWBR, Karnal in hybrid mode on 23rd April 2024. Dr Gyanendra Singh, Director ICAR-IIWBR Karnal welcomed the participants and presented salient achievements. Former Director, ICAR-IIWBR, Karnal, Dr. Indu Sharma was the chief guest of the program. The discussion was held on status of wheat diseases and emerging new threats.

Visit of ICAR-CSSRI, QRT team

An interactive meeting with QRT ICAR-CSSRI was organized on 25th April, 2024 at ICAR-IIWBR, Karnal. Dr. NK Tyagi, Chairman and Dr. Ashok Kumar, Dr. SK Gupta members, QRT-ICAR CSSRI along with Dr. RK Yadav, Director CSSRI and Dr. AK Rai, Head, Division of Soil & Crop Management and Dr. SK Sanwal, Head, Division of Crop Improvement attended the meeting.

Second brainstorming session

One day brainstorming session at IIWBR RS,Flowerdale, Shimla was organised on 26th April, 2024 entitle " Rust Research in India: Retrospect and Prospect. Secretary DARE and Director General, ICAR Dr Himanshu Pathak was the Chief Guest, who first unveiled a bust of Dr KC Mehta (Founder of this station) and made special remarks about importance of wheat rusts during brainstorming meeting and also visited facilities at this national facility on rusts.

Inauguration of S. Nagrajan Hall

It was a historic moment for ICAR-IIWBR to receive Dr Himanshu Pathak, Secretary DARE and DG ICAR on 28th April 2024. He unveiled Dr S Nagarajan bust and inauguratedz

newly created facilities such as Board Room and S Nagarajan Hall. He interacted with all the staff members and congratulated wheat family for their success.

IP Day 2024

Institute Technology Management Unit of ICAR-IIWBR, Karnal organized a lecture in respect of World IP Day 2024 under the chairmanship of Director, ICAR-IIWBR, Karnal on 30th April , 2024. An IP Guest lecture on "IPRs as a Tool for Innovation in R&D" was delivered by Dr. SK Soam Principal Scientist ICAR-NAARM, Hyderabad.

World Environment Day

ICAR-IIWBR, Karnal organized World Environment Day

on 5th June 2024. On this occasion, Director IIWBR and all staff planted more than four hundred trees to cope up with the pollution in the environment.

International Yoga Day

10th International Yoga Day was organized at ICAR-IIWBR, Karnal on 21st June 2024.

IRC Meeting

The Institute Research Council (IRC) meeting was held on 9th July, 2024 under the chairmanship of Dr. Ratan Tiwari, Director ICAR-IIWBR Karnal. All the Principal

Investigators, and Scientists of the institute attended the meeting. Scientists from Flowerdale Shimla and Hisar centre joined the meeting online.

IMC Meeting

The 32nd IMC meeting was held on 19th July 2024 in Dr. V.S. Mathur Hall, ICAR-Indian Institute of Wheat & Barley Research, Karnal under the chairmanship of Dr. Ratan Tiwari, Director, ICAR-IIWBR, Karnal.

Independence Day Celebration

ICAR-IIWBR celebrated the Independence Day on 15th August 2024 and Director-IIWBR, Dr. Ratan Tiwari hoisted the flag.

Plant 4 Mother

Tree plantation drive was organized at ICAR-IIWBR on

29th August 2024 and planted many plants in the name of mothers.

Swachhta Pakhwada

Various Swachhta Pakhwada activities were taken up by ICAR-IIWBR from 14th September – 2nd October 2024)

Research Advisory Committee Meeting

29th Research Advisory Committee (RAC) meeting was held at ICAR-IIWBR, Karnal on 18th November 2024. in the presence of Dr. P. L. Gautam, Chairman RAC and Former Vice Chancellor (GBPUAT, Pantnagar) & Former Chairman, PPVFRA, New Delhi and other distinguished members of RAC.

National Agriculture Education Day

National Agriculture Education Day was organized on 03rd December 2024 at ICAR-IIWBR, Karnal with school students.

World Soil Day

World Soil Day was organized on 5th December 2024 at Village Sangoha by ICAR-IIWBR Karnal with the theme "Caring for soils: measure, monitor and manage"

Awareness Programme

A workshop on "Prevention of Sexual Harassment at Workplace" was successfully organized at ICAR-IIWBR, Karnal on 9th December 2024. The event aimed to raise awareness about the POSH Act, 2013 and foster a safe and supportive work environment for women. Esteemed speakers, including madam Iram Hasan (Chief Judicial Magistrate), Dr. Anuradha Punia (Retired

Principal, Government College for Women), and Madam Babli (Sub-Inspector, Sonipat), shared their expertise on legal, practical, and social aspects of addressing workplace harassment. More than sixty members participated in the workshop.

IJSC Meeting

The first meeting of 10th IJSC was conducted on 11 December 2024 at ICAR-IIWBR, Karnal. The meeting was chaired by Honble Director, Dr. Ratan Tiwari. Various important agenda items related to employees of ICAR-IIWBR, Karnal were discussed and approved by the committee.

Swachhta Pakhwada

The cultural program was organized on 16 dec-2 jan during Swachhta Pakhwada. The students spread the message of cleanliness for a healthy and happy life through their acts. On this occassion, Sh. Dheeraj Kumar, Deputy Municipal Commissioner of Karnal participated as the chief guest in the presence of Dr. Ratan Tiwari, Director ICAR-IIWBR, Karnal. The chief guest showed his happiness on the clean and green campus of the institute and appreciated the initiatives taken by the Director. The participants were encouraged to give up the single use plastic to make this mission more effective. The decomposable plastic carry bags were also distributed on this occasion.

14 DISTINGUISHED VISITORS

Dr. Balraj Singh (VC-SKNRAU, Jobner) & Dr. Wazir Singh (DDA, Karnal) visited on 15 January, 2024 and discussed about the newly released wheat and barley varieties

Dr. Seth Meyer, Chief Economist, United State Department of Agriculture, USA along with Mr. Clay Hamilton, Minister Council, USDA, USA; Dr. Santosh Singh, Senior Agricultural Specialist, and Ms. Joanna Brown, Agri. Attache, Embassy of the United States of America, New Delhi visited on 1st February, 2024 and discussed issues about the current scenario and prospects of wheat production in India. Deliberations on the varietal release system, climate-resilient varieties in the seed chain and possible future collaborations with USDA were made during the interaction.

Dr. Gurbachan Singh and Dr. Arun Kumar Sharma were the chief guests on the occasion of 10th Foundation Day (9th February, 2024) of ICAR-IIWBR.

Dr. R.K. Yadav, Director, ICAR-CSSRI, was Chief guest on 13th February, 2024 for inaugural of 21 Days Vocational Training for Empowering Youth to Strengthen Seed Sector from 13 February-04 March 2024.

Dr. Daniel Muleta Fana (Coordinator-National Irrigated Wheat Project), Mr. Hailu Mengistu Biru (Wheat Breeder), Mr. Shimelis Alemayehu Seta (Wheat Breeder) and Mr. Lemma Mamo Haile (Soil Scientist, Soil Salinity Center) from Ethiopian Institute of Agricultural Research, visited the wheat and barley breeding experimental field trials and interacted with ICAR-IIWBR scientists on 16th February, 2024.

Dr. Kevin Pixley (Wheat Program Director, CIMMYT), Dr. Arun Kumar Joshi (BISA Managing Director), Dr. Velu Govindan (Senior Wheat Breeder), Dr. Sridhar Bhavani (Senior Scientist, Head of Rust Pathology and Molecular Genetics and Dr. Pradeep Bhati, Wheat Breeder, BISA participated in review and planning meeting under

India and CIMMYT wheat improvement partnership program on 23rd February, 2024.

Dr. Sanjay Kumar, Director, ICAR-Indian Institute of Seed Science, Mau visited on 28th February, 2024 and reviewed the nucleus seed production program, grow out test facility at new farm of the institute and breeder seed production program and STR experiments.

Dr. M.S. Saharan, Head, Department of Plant Pathology, ICAR-IARI, New Delhi interacted and delivered a lecture on "Disease free seed production of field crops" in 21 days Vocational Training for Empowering Youth to Strengthen the Seed Sector organised by ICAR-IIWBR, Karnal.

Dr. B. Mishra, Former Vice Chancellor, SKUAST, Jammu and Former Director, DRR and DWR, Karnal visited on 4th March, 2024 at the closing ceremony of "21 Days Vocational Training for Empowering Youth to Strengthen Seed Sector."

Sh. Sanjay Singh, IAS, Former Secretary, Steel, Additional Secretary DARE & Secretary ICAR, visited the institute on 4th March, 2024 and interacted with the scientists about wheat and barley scenario in India.

Dr. Yoshihasi, Dr. Kumashiro, Ms. Ozonoe from JIRCAS, Japan and Ms Endo Noriko visited the institute on 7th March, 2024 and interacted with the scientists about wheat and barley research.

Dr. R.S. Paroda, President TAAS & Former Secretary DARE & DG- ICAR visited the ICAR-IIWBR on 15th March, 2024.

Dr. R.P. Singh, international wheat scientist & Padma Shri Awardee and Dr. P.K. Singh, Agriculture Commissioner, visited the Institute on 16th March, 2024.

Dr. S.K. Malhotra, Vice Chancellor, Maharana Pratap Horticultural University Karnal was the Chief Guest in one day Technology Showcasing and Interface meeting for Technology Commercialisation through Public Private Partnership on 19th March, 2024.

Dr. A.K. Singh, Vice Chancellor, ICAR-IARI Mega University & Director IARI visited the ICAR-IIWBR on 21st March, 2024 and interacted with the mega university students about their facilities and constraints.

Dr.Trilochan Mahapatra, Chairman-PPVFRA & Former Secretary of DARE & DG-ICAR, New Delhi & Dr. Suresh Kumar Chaudhari, DDG (Natural Resource Management) ICAR- New Delhi inaugurated the 5th International Group Meeting on "Climate Proofing Cereal Agriculture Strategies for Resilience and Sustainability.

Dr. S.K. Malhotra (VC-MHU, Karnal) visited the ICAR-IIWBR on 29th March, 2024.

Dr. N.S. Bains, Former Director Research, PAU Ludhiana, was co-chairman in special brain storming session on "Augmenting Pre-breeding for Wheat Improvement".

Prof. B.S. Gill, Kansas State University, USA and Prof. Julie King, University of Nottingham, UK joined online for delivering lectures in special brain storming session on " Augmenting Pre-breeding for Wheat Improvement".

Dr. Indu Sharma (Former Director, ICAR-IIWBR, Karnal), Dr. S.C. Bhardwaj (Scientist Emeritus, RS IIWBR, Flowerdale, Shimla) & Dr. M.S. Saharan (ICAR-IARI, New Delhi) visited the Institute on 23rd April, 2024.

Dr. Himanshu Pathak, Secretary DARE & DG- ICAR visited ICAR-IIWBR on 28th April, 2024.

Dr. Sunil Tiwari (Director ICAR- IIFSR) & Dr. Ravi Shankar (Coordinator & Scientist) visited the Institute on 10th May, 2024.

Dr. S.S. Singh (Ex Project Director, DWR, Karnal) with his national coordinator team visited the institute on 27th May, 2024.

Dr. A.K. Singh, Director ICAR-IARI & VC IARI Mega University Hub visited ICAR-IIWBR, Karnal on 18th June, 2024.

Ms. Endo Noriko, Project Coordinator JICA Project Japan visited the Institute on 26th June, 2024.

Dr. Jagdish Rane, Director, ICAR-CIAH Bikaner, Rajasthan visited the Institute on 10th July, 2024.

Dr. Tilak Raj Sharma, DDG ,Crop Science visited ICAR-IIWBR, Karnal on 24th July, 2024.

Dr. R.K. Yadav, Director ICAR- CSSRI, Karnal visited the Institute on 26th July, 2024.

Dr. Anupama Singh (Dean, ICAR- IARI Mega University Hub) & Dr. Monika A. Joshi (Hub Associate Dean) interacted with the students and faculty of IARI Mega University, Karnal Hub on 5th August, 2024.

Dr. Kaveri Chauhan, Psychologist, Dayal Singh Public School, Karnal delivered a lecture on "Gender Sensitization" for the graduate/postgraduate students of IARI Mega University, Karnal Hub on 16th August, 2024.

Dr. Satoshi Tobita (Principal Investigator, JIRCAS), Ms. Ai Leon (Senior Researcher, JIRCAS) and Endo Noriko (Project Coordinator JICA Project Japan) visited the institute on 6th September 2024.

Sh. Anurag Yadav (IAS), Secretary Agriculture, UP interacted with scientists of the institute on different issues on wheat and barley on 1st October, 2024.

Dr. P. Govindaraj, Director ICAR- Sugarcane Breeding Institute, Coimbatore and Dr. M.L. Chhabra, Head, Regional Centre SBI, Karnal visited the ICAR-IIWBR on 19th October, 2024.

Madam Iram Hasan (Chief Judicial Magistrate), Dr. Anuradha Punia (Retired Principal, Govt. College for Women) and Madam Babli (Sub-inspector, Sonipat, Haryana) were invited on 9th December, 2024 at ICAR-

IIWBR, Karnal to share their expertise in prevention of sexual harassment at workplace.

Dr. B.E. Mishra, Director, ICAR-NBAGR was chief guest in training programme on “Accelerated Breeding for Mainstreaming Zinc Enrichment in Wheat” on 10th December, 2024.

Hon'ble Union Minister of Agriculture & Farmers' Welfare, Sh. Shivraj Singh Chouhan ji, visited in the institute on 11th December, 2024 and appreciated the work done on wheat by the staff of ICAR-IIWBR, Karnal.

15 AWARDS AND RECOGNITIONS

Awards

- Dr. Mamrutha HM received ICAR-IIWBR best scientist award for the year 2023 on 9th February 2024 during foundation day of ICAR-IIWBR, Karnal.
- Dr. Mamrutha HM is bestowed with SA Dadlani memorial award for the year 2024 from Society for Advancement of Wheat and Barley Research, Karnal, Haryana.
- Dr. Vikas Gupta received the SA Dadlani Memorial Award- 2023 from Society for Advancement of Wheat and Barley Research, Karnal, Haryana for his contributions in wheat research during the 5th International Group Meeting organized at ICAR-IIWBR, Karnal on March 27, 2024.
- Dr. Umesh Kamble was awarded Young Scientist Award 2024 by Prerna Foundation, Meerut during the 6th Global Meet on Science and Technology: Climate Smart Agriculture including Horticulture for Sustainable Development held during 21-22 September, 2024 at MHU, Karnal
- Dr Prem Lal Kashyap was conferred with Prof. J.P. Chathrath Endowment Award -2023 for significant contribution in the field of crop protection.
- Dr. Prem Lal Kashyap ranked among world's top 2% scientists published by Stanford University (USA) released for the year 2024.
- Dr Charu Lata conferred Early Career Travel Award from Wheat Initiative Germany to attend 3rd International Wheat Congress held at Perth, Australia.
- Dr. OP Gangwar was conferred the most cited paper award (2023) to article 'Barley diseases and their management: an Indian perspective' published in Journal of Cereal Research {2018, 10(3): 138-150} by SAWBAR.
- Research paper entitled "Weed control in wheat with pyroxasulfone and its combinations with other herbicides" by Chhokar RS and Sharma RK in Weed Biology and Management (WBM) Vol.23 No.2 pp.58-70 got the Weed Science Society of Japan Best Paper Award.

Fellow

- Dr. Mamrutha HM has been selected as Fellow of Indian Society for Plant Physiology for the year 2024

ICAR Certified Technologies

Seven resource management technologies of ICAR-IIWBR, Karnal were certified by ICAR in 2024:

Sr. No.	Name of Technology	Developer	Code	Year
1	Intensification of rice-wheat cropping system Rice-wheat -green gram Rice-wheat –cowpea Rice-vegetable pea-wheat	Lead: S. C. Tripathi Associates: Subhash Chander, Raj Pal Meena, Karnam Venkatesh, Ajay Verma	ICAR-NRM-IIWBR-Technology-2024-197	2024
2	Intercropping for 25% N saving in wheat Maize+pulses-wheat	Lead: S. C. Tripathi Associates: Karnam Venkatesh, Raj Pal Meena, Subhash Chander, G. P. Singh	ICAR-NRM-IIWBR-Technology-2024-198	2024
3	Skipping of P either in rice or in wheat with similar rice-wheat productivity	Lead: S. C. Tripathi Associates: Subhash Chander, Raj Pal Meena	ICAR-NRM-IIWBR-Technology-2024-199	2024
4	Management of complex weed flora in barley through Pinoxaden + carfentrazone application	Lead: Anil Kumar Khippal Associate: A.S. Kharub, Lokendra Kumar, R. S. Chhokar, S. C. Tripathi, Raj Pal Meena, Gyanendra Singh	ICAR-NRM-IIWBR-Technology-2024-200	2024

Sr. No.	Name of Technology	Developer	Code	Year
5	Improving wheat yield through use of growth retardants (CCC +tebuconazole) under high fertility conditions	Lead: R.S. Chhokar Associate: Neeraj Kumar, Subhash Chander Gill, S.C. Tripathi, Anil Kumar Khippal, Raj Pal Meena Gyanendra Singh	ICAR-NRM-IIWBR-Technology-2024-201	2024
6	Regulated deficit irrigation strategies in wheat for efficient water use	Lead: Raj Pal Meena Associate: Karnam Venkatesh, S. C. Tripathi, RK Sharma, R. S. Chhokar GP Singh	ICAR-NRM-IIWBR-Technology-2024-202	2024
7	Rice residue retention and 2 per cent K spray to enhance water use efficiency	Lead: Raj Pal Meena Associate: Karnam Venkatesh, Rinki Khobra, S. C. Tripathi, Kailash Prajapat, R. K. Sharma, Anil Khippal, G. P. Singh	ICAR-NRM-IIWBR-Technology-2024-203	2024

Best Oral Presentation

- Dr. Sunil Kumar received best oral presentation award for the topic "Celiac antigenicity analysis of Indian aestivum and durum wheat varieties" at 5th International Meeting on Climate-proofing cereal agriculture: Strategies for resilience and sustainability held at ICAR-IIWBR, Karnal during March 27-29, 2024.
- Dr. Mamrutha HM received best oral presentation award during International salinity conference on Rejuvenating salt-affected ecologies for land degradation neutrality under changing climate held at CSSRI, Karnal, Haryana, during 14-16 February, 2024.

Award for promotion of Hindi language

Best Exhibition Stall Award

- 3rd Best Exhibition Stall Award at Virat Kisan Mela-2024 organized by Department of Agriculture, Uttar Pradesh at Samrat Prithviraj Chauhan Degree College, Baghpat, Uttar Pradesh during 01-03 March, 2024.
- 3rd Best Exhibition Stall Award at *National Conference on Smart Farming Solutions for Ornamental Horticulture* organized by Maharana Pratap Horticultural University, Karnal, Haryana during 08-09 November, 2024.

Recognitions

- Dr. Sunil Kumar, imparted invited training lecture 'Wheat Quality, Processing & Current Understanding' on October 09, 2024 to participants in hands on training on 'Effective extension methods for upscaling and outscaling of wheat and barley production technologies' during October 7-11, 2024 (organized jointly by Extension Education Institute, Nilokheri and ICAR-IIWBR, Karnal).

16 TRAINING AND CAPACITY BUILDING

Training and capacity building

As per the ICAR guidelines, annual training calendar was prepared for the scientists, technical, administrative, and supporting staff. The details of training attended by the staff under ATP are given below:

Table 16.1: National trainings attended

S. No.	Employee name	Category	Training	Place of training (ICAR)	Duration (Days)
1.	Dr Prem Lal Kashyap	Scientific	Pedagogical Competencies for Agricultural Education	NASC, New Delhi	Jan 29- Feb 02, 2024
2.	Dr Sunil Kumar	Scientific	Pedagogical Competencies for Agricultural Education	NASC, New Delhi	04-08 March, 2024
3.	Dr Rajender S Chhokar	Scientific	Pedagogical Competencies for Agricultural Education	NASC, New Delhi	04-08 March, 2024
4.	Dr Charan Singh	Scientific	Pedagogical Competencies for Agricultural Education	NASC, New Delhi	04-08 March, 2024
5.	Dr Anuj Kumar	Scientific	ITU/FAO workshop on Cultivating tomorrow: Advancing digital agriculture through IoT and AI" and Workshop on Digital Agriculture by ICAR	NASC, New Delhi	18-20 March, 2024
6.	Dr Neeraj Kumar	Scientific	ITU/FAO workshop on Cultivating tomorrow: Advancing digital agriculture through IoT and AI" and Workshop on Digital Agriculture by ICAR	NASC, New Delhi	18-20 March, 2024
7.	Dr Anuj Kumar	Scientific	Short-term course on Food Quality and Safety Management systems	IITT and BCAS, Delhi	26 June – 26 July 2024
8.	Dr Anuj Kumar	Scientific	Pedagogical Competencies for Agricultural Education	NASC, New Delhi	April 29 to May 3, 2024
9.	Dr Jogendra Singh	Scientific	Pedagogical Competencies for Agricultural Education	NASC, New Delhi	April 1-5, 2024
10.	Dr Jogendra Singh	Scientific	Developing Winning Proposals	ICAR-NAARM, Hyderabad	15- 19 July, 2024
11.	Dr Chuni Lal	Scientific	Fostering Collaborative Ecosystem for Promoting Agri-Startups	ICAR-NAARM, Hyderabad	18-20 Sept., 2024
12.	Mr. Jayanth Kallugudi	Scientific	Streamlining Data Recording and Reporting under AICRP on Wheat and Barley	ICAR-IIWBR Karnal	11 - 15 March, 2024

Table 16.2: Trainings organized

S.N.	Name	Date	Venue
1.	Streamlining data recording and reporting under AICRP on Wheat and Barley	March 11-15, 2024	ICAR-IIWBR, Karnal
2.	Awareness-cum- Training Programme on Agriculture	19 March, 2024	ICAR-IIWBR, Karnal
3.	Brainstorming on Rust Research in India: Retrospect and Prospects	26 April, 2024	ICAR-IIWBR, Regional Station, Flowerdale, Shimla
4.	Training Program in Agriculture	25 to 27 June, 2024	Sirmour, HP in association with KVK (CSKHPKV), Dhaulakuan, Sirmour, HP

S.N.	Name	Date	Venue
5.	Hand on training on CRISPR/Cas9 genome editing in Wheat	15 –24 October, 2024	ICAR-IIWBR, Karnal
6.	"Accelerated Breeding for Mainstreaming Zinc Enrichment in Wheat" organized under the Zinc Mainstreaming Project	10-13 December, 2024	ICAR-IIWBR, Karnal

Table 16.3: Capacity building programmes organized under ICAR Seed Project during 2024

S. No.	Training	Title	Date	Kind of Stakeholders
1	Farmers' Awareness cum Training programme	Promotion of climate resilient varieties and quality seed production of wheat, barley and paddy at ICAR-IIWBR, Karnal	Feb 06-09, 2024	Progressive farmers sponsored by ATMA, Department of Agriculture, Govt. of Haryana. (25 participants)
2	Awareness -cum- Training Programme	Promotion of the latest wheat and barley varieties for accelerated genetic gain in eastern UP at CSAUT, Kanpur	March 13, 2024	Progressive farmers, post graduate students, seed growers, FPO and seed companies representatives (250 participants)
3	Technology Showcasing and Interface Meeting	Technology commercialization through Public Private Partnership at ICAR-IIWBR, Karnal	March 19, 2024	Private seed company representatives, progressive farmers and representatives from farmer producer organizations from Punjab, Haryana, Uttar Pradesh and Rajasthan (120 participants)
4.	Technology Commercialization and Interface Meeting	Promotion of wheat and barley varieties at ICAR-IIWBR, Karnal	May 29, 2024	Progressive farmers and seed companies representatives (50 participants)
5.	Seed Distribution Week for farmers	Seed distribution week at ICAR-IIWBR, Karnal	Oct. 19-25, 2024	Farmers from different wheat growing states (More than 18000 farmers)
6.	Awareness -cum- Training Programme	Promotion of latest wheat varieties and technologies in eastern Uttar Pradesh at ICAR-NISST, Mau	Nov. 25, 2024	Progressive farmers and FPO's from eastern Uttar Pradesh (300 participants)

Academic capacity building

The IIWBR was entrusted upon as nodal institute for Karnal Hub under IARI Mega University programme in 2023. All three tiers of agricultural education viz., B.Sc. Ag, M.Sc. Ag and Ph.D. programmes were initiated at Karnal hub. The session wise detail of academic capacity building is given in Table 16.4. Besides, IARI MU Karnal Hub activities, IIWBR usually offers one month training for on-roll UG & PG students.

Table 16.4: Academic capacity building activities at ICAR-IIWBR Karnal hub under IARI Mega University

Sr. No.	Name of the Program	Session 2023-2024	Session 2024-2025	Total Students
	UG			
1	B.Sc. (Agriculture)	22	22	44
	PG	16	15	31
2	M.Sc. (Agronomy)	05	03	08
3	M.Sc. (Plant Pathology)	06	03	09
4	M.Sc. (Genetics & Plant Breeding)	05	05	10
5	M.Sc. (Plant Physiology)	00	02	02
6	M.Sc. (Soil Science)	00	02	02

Sr. No.	Name of the Program	Session 2023-2024	Session 2024-2025	Total Students
	Ph. D.	07	11	18
7	Ph.D. (Agronomy)	03	02	05
8	Ph.D. (Plant Pathology)	01	02	03
9	Ph.D. (Genetics & Plant Breeding)	03	03	06
10	Ph.D. (Plant Physiology)	00	02	02
11	Ph.D. (Soil Science)	00	02	02

International Training / Deputation Abroad

- Dr. Ratan Tiwari, Director, participated in the 3rd International Wheat Congress 2024 and Workshop on Trait Mapping during 22-27 September, 2024 at Perth, Australia
- Dr CN Mishra participated in training on GISH (Genomic In Situ Hybridization) technology to confirm the incorporation of the Leymus racemosus chromosome N short arm into BNI-enabled wheat from18-21 Feb 2024 at Tsukuba Japan.
- Dr CN Mishra and Dr Ratan Tiwari participated in AGG annual meeting from 22-25 October 2024 at Nairobi Kenya.
- Dr CN Mishra participated in 5th BNI international Consortium held from 03-06 Dec 2024 at Tsukuba Japan.

Onboard of ICAR-IIWBR on GOT KARMAYOGI

Karmayogi Bharat is a national program for civil services capacity building, aimed at establishing a robust digital ecosystem to enable continuous, anytime-anywhere learning and making officials future-ready through the common platform iGOT. This special purpose vehicle (SPV) is responsible for managing, maintaining, and improving digital assets, including the intellectual property rights (IPR) of all software, content, and processes, on behalf of the Government.

To fulfill this vision, HRM Nodal Officers of ICAR institutes, acting as Mission Directors (MDOs), have been directed to onboard institute staff onto iGOT and assign courses as per cadre, in accordance with ICAR-HRM-HQ guidelines. At ICAR-IIWBR, a total of 96 staff members have been successfully registered on iGOT with the support of the institute's HRM cell. These members have been assigned training programs designed cluster-wise to address the specific needs of different staff categories by MDO (HRD Nodal Officer). Twenty-three personnel have already completed prescribed courses such as Critical Thinking, Leave Rules, Introduction to E-Office, Annual Performance Appraisal Report (APAR), and Yoga at the Workplace in 2024. The purpose of this initiative is to encourage staff members to explore additional courses aligned with institutional goals and individual growth areas. This systematic and tailored approach ensures the development of competencies across all cadres, fostering a culture of continuous learning and professional growth at ICAR-IIWBR.

Table 16.5: An overview of the iGOT Karmayogi on-boarding process of ICAR-IIWBR Karnal

IIWBR Staff Metric on iGOT	Value	IIWBR Staff Metric	Value
Total On-boarded users	96	Completed 1 or more courses	46
Enrolled in at least 1 course	59	Completed 5 or more courses	20
Completed at least 1 course	46	Completed 3 or more courses	30
Total Enrolments in courses	428	Completed 10 or more courses	13

17 RESEARCH PROJECTS

A. Institute's funded projects: Institute's funded projects are being carried out under 7 programmes

RESEARCH PROGRAMS (2020-25)	
Prog. 1	Multilocational and Multidisciplinary Research Programme on Wheat and Barley Improvement
Prog. 2	Wheat improvement for enhancing genetic gain and productivity under changing climate
Prog. 3	Biotic stress management in wheat
Prog. 4	Enhancing the productivity, sustainability and resilience of wheat-based cropping systems
Prog. 5	Wheat Improvement for Industrial and Nutritional quality
Prog. 6	Barley for feed, food and Industrial purposes
Prog. 7	Technology outreach and Impact Evaluation

Program 1. Multilocational and Multidisciplinary Research Programme on Wheat and Barley Improvement (CRSCIIWBRCL20200010194)

Programme Leader: Dr. Ratan Tiwari, Director, ICAR-IIWBR	
Crop Improvement	**PI: Dr. BS Tyagi**
Co-PIs	Drs. OP Ahlawat, Arun Gupta, Sindhu Sareen Hanif Khan, Sonia Sheoran, AK Sharma, Satish Kumar, Charan Singh, CN Mishra, Mamrutha HM, Vikas Gupta, UR Kamble, Rakesh Kumar Bairwa, Rinki, Ajay Verma
Crop Protection	PI: Dr. Pradeep Sharma w.e.f 12.06.2024
Co-PIs	Drs. Prem Lal Kashyap, Ravindra Kumar, OP Gangwar, P Prasad, Charu Lata Sharma, Jayanth Kallugudi
Resource Management	PI: SC Gill
Co-PIs	Drs. SC Tripathi, RS Chhokar, Anil Khippal, Neeraj Kumar, Ajay Verma
Quality & Basic Sciences	PI: Dr. Sunil Kumar w.e.f 01.08.2024/ Dr. Sewa Ram (till 31.07.2024)
Co-PIs	Drs. Sunil Kumar, OP Gupta, Vanita Pandey, Anuj
Barley Improvement	PI: Dr. Omvir Singh
Co-PIs	Drs. Chuni Lal, Jogendra Singh, Lokendra Kumar, Rekha Malik, OP Gupta, Santosh Kumar Bishnoi, Rinki, Ajay Verma
Social Sciences	PI: Dr. Satyavir Singh
Co-PIs	Drs. Anuj Kumar, Anil Khippal

Crop Improvement

Program 2. Wheat improvement for enhancing genetic gain and productivity under changing climate (CRSCIIWBRCL20200020195)		
Programme Leader: Dr. BS Tyagi		
Project 1: Developing high yielding and climate resilient wheat varieties		**(PI: Dr. BS Tyagi)**
1.1: Breeding wheat genotypes for high yield and wider adaptability in North Western Plains		PI: Dr. Hanif Khan
Co-PIs	Drs. CN Mishra, OP Gangwar, Raj Kumar, Mamrutha HM, Sunil Kumar, Rakesh Kumar Bairwa	
1.2: Breeding wheat genotypes for high yield in North Eastern Plains		PI: Dr. Vikas Gupta
Co-PIs	Drs. Gyanendra Singh*, Charan Singh, AK Sharma, Sonia Sheoran, Sewa Ram**, Ravindra Kumar	
1.3: Breeding high yielding wheat genotypes for stress conditions of warmer regions of India		PI: Dr. Sindhu Sareen
Co-PIs	Drs. Amit Kumar Sharma#, Pradeep Sharma, UR Kamble, Pramod Prasad	
1.4: Improving wheat genotypes for grain quality and end products		PI: Dr. CN Mishra
Co-PIs	Drs. BS Tyagi, Vanita Pandey, Parmod Prasad, Satish Kumar#	
1.5 Project: Breeding for early maturing and short duration wheat genotypes		PI: Dr. Charan Singh
Co-PI	Drs. Vikas Gupta, Sonia Sheoran, Rinki, Gyanendra Singh*	

***upto 31.05.2024** ****upto 31.07.2024** **#w.e.f. 09.07.2024**

Project 2: Pre-breeding and germplasm enhancement		**(PI: Dr. BS Tyagi)**
2.1: Wheat improvement utilizing novel germplasm resources through pre-breeding		PI: Dr. BS Tyagi
Co-PIs	Drs. Sindhu Sareen, Vikas Gupta, Arun Gupta, Hanif Khan, OP Gangwar, Rinki, Charan Singh, CN Mishra, Rakesh Kumar Bairwa	
2.2: Strengthening of Wheat and Barley genetic resources for utilization		PI: Dr. Arun Gupta
Co-PIs	Drs.: Charan Singh, Pradeep Sharma, Rakesh Kumar Bairwa, Rekha Malik	
2.3 Strategic research for improving biotic stress		PI: Dr. Satish Kumar
Co-PIs	Drs. CN Mishra, AK Sharma, PL Kashyap, Jayanth Kallugudi#	
#w.e.f. 09.07.2024		
Project 3: New insights & basic studies for integrating molecular, physiological and bioinformatic tools for augmenting wheat improvement		**(PI: Dr. OP Ahlawat)**
3.1 Biotechnological, bioinformatics and microbiological interventions for wheat improvement		PI: Dr. OP Ahlawat
Co-PIs/CC-PIs	Co-PI: Drs.Ratan Tiwari, Rajender Singh, Pradeep Sharma, Sonia Sheoran, Suman Lata, Charu Lata	
	CC-PIs: Dr. Dinesh Kumar (IASRI-New Delhi), Dr. Harsh Vardhan Singh (NBAIM-Mau)	
3.2: CRISPR/Cas9 genome editing and physiological interventions for wheat improvement		PI: Dr. Mamrutha HM
Co-PIs	Drs. Rajender Singh, Rinki, Sewa Ram*, Vanita Pandey, Charu Lata, Jayanth Kallugudi	
***upto 31.07.2024**		

Crop Protection

Program 3. Biotic stress management in wheat (CRSCIIWBRCL20200030196)		
Programme Leader: Dr. Pradeep Sharma		**(PI-CP) w.e.f 12.06.2024**
Project 1: Management of biotic stresses of wheat by integrating innovative approaches (PI: Dr. Pradeep Sharma w.e.f 12.06.2024)		
1.1: Management of wheat diseases by integrating molecular and agro-ecological approaches		PI: Dr. Ravindra Kumar
Co-PIs	Drs. Prem Lal Kashyap, Arun Gupta	
1.2: Management of wheat insect-pests through climate-smart pest management strategies***		PI: Dr. Poonam Jasrotia
Co-PIs	Drs. Sindhu Sareen, Rajender Singh, Prem Lal Kashyap	
1.3 Etiology and management of spike disease complex in wheat		PI: Dr. Prem Lal Kashyap
Co-PIs	Drs.Vikas Gupta, Rajender Singh, Pradeep Sharma#	
*****Project concluded on 09.07.2024**	**#w.e.f. 09.07.2024**	
Project 2: Physiologic specialization, resistance and molecular studies on wheat and barley rusts (RS- Flowerdale, Shimla)		**(PI: Dr. O.P. Gangwar)**
2.1 Mapping phenotypic diversity in wheat and barley rust pathogens, identifying resistance sources, and upkeep of culture collection		PI: Dr. O.P. Gangwar
Co-PIs	Drs. Pramod Prasad, Charu Lata, Jayanth Kallugudi Associate: Dr. Subodh Kumar	
2.2 Molecular studies on wheat and barley rust pathogens, gene pyramiding, and genetics of rust resistance		PI: Pramod Prasad
Co-PIs	Drs. O.P. Gangwar, Charu Lata, Hanif Khan, Jayanth Kallugudi Associate: Dr. Subodh Kumar	

Resource Management

Program 4. Enhancing the productivity, sustainability and resilience of wheat-based cropping systems (CRSCIIWBRCL20200040197)		
Programme Leader: Dr. SC Gill (PI-RM)		
1.1 Efficient nutrient management strategies for wheat-based cropping systems		PI: Dr. SC Gill
Co-PIs:	Drs. SC Tripathi, RS Chhokar, OP Ahlawat and Sunil Kumar	
1.2: Conservation agriculture for sustainable intensification of wheat-based systems		PI: Dr. Anil Khippal
Co-PIs:	Drs. SC Tripathi, RS Chhokar, SC Gill, Neeraj Kumar, OP Ahlawat, Mamrutha HM, and Charu Lata Sharma Raghuveer Singh (IIFSR, Modipuram), Santosh Bishnoi, Er. Swapnil Chaudhary (HAU) Associate: Ravindra Kumar	
1.3: Improving resource use efficiency in wheat under conservation and conventional tillage practices		PI: Dr. Neeraj
Co-PIs:	Dr. SC Tripathi	
1.4: Development of effective weed management practices for wheat-based cropping systems		PI: Dr. RS Chhokar
	Drs. SC Tripathi, SC Gill, Anil Khippal, and VK Choudhary (DWR, Jabalpur)	

Quality & Basic Sciences

Program 5. Wheat Improvement for Industrial and Nutritional Quality (CRSCIIWBRSL20200050198)
Programme Leader: Dr. Sewa Ram/ Dr. Sunil Kumar (w.ef. 01.08.2024) (PI-QBS)

Project 1: Improvement of processing and nutritional quality of wheat using biochemical and molecular approach

	PI: Dr. Sewa Ram/ Dr. Sunil Kumar (w.e.f. 01.08.2024)
Co-PIs	Drs. Sunil Kumar, OP Gupta, Vanita Pandey, Anuj Kumar, BS Tyagi

Barley Improvement

Program 6. Barley for Feed, Food and Industrial Purposes (CRSCIIWBRCL20200060199)
Programme Leader: Dr. Omvir Singh (PI-BI)

Project 1: Barley improvement and technological interventions for yield, quality, biotic and abiotic stress tolerance for better farmers' livelihood **(PI: Dr. Omvir Singh)**

1.1: Pre-breeding for novel genetic variability in barley using innovative techniques		PI: Dr. SK Bishnoi
Co-PIs	Drs. Omvir Singh, Chuni Lal, Rekha Malik, Jogendra Singh, Associate : OP Gupta	
1.2: Genetic enhancement of malt barley with changing industrial requirements using conventional	and molecular approaches	PI: Dr. Omvir Singh
Co-PIs	Drs. Lokendra Kumar, Rekha Malik, SK Bishnoi, Ravindra Kumar, Rinki, OP Gupta, Ajay Verma#	
1.3: Genetic amelioration of grain quality and yield in feed and food barley		PI: Dr. Chuni Lal
Co-PIs	Drs. Omvir Singh, Jogendra Singh, Rekha Malik, Ravindra Kumar, Rinki, OP Gupta, Lokendra Kumar, Anuj (Jr)#	

#w.e.f. 09.07.2024

Social Sciences

Program 7. Technology Outreach and Impact Evaluation (CRSCIIWBRSL20200070200)
Programme Leader: Dr. Satyavir Singh (w.e.f. 01.02.2024)

Project 1: Evaluation, dissemination and impact assessment of production technologies	**(PI: Dr. Satyavir Singh)**
1.1: Assessment of farmers' perspective on crop residue management in Indo-gangetic plains of India	PI: Dr. Anuj Kumar
Co-PIs: Dr. Satyavir Singh	
1.2: Promotion and impact evaluation of ICAR-IIWBR technologies at farmers' field	PI: Dr. Satyavir Singh
Co-PIs: Drs. Satyavir Singh, Anuj Kumar, Anil Khippal, Raj Kumar, Ajay Verma#, Dr. R Sendhil (Puducherry University, Puducherry)	

B. Externally Funded Projects

Externally funded project (National Agencies)

S. No.	Name of the project	Funding Agency	PI/CCPI	Co-PIs	Duration
1.	DUS testing in wheat	PPV&FRA, New Delhi	Nodal officer: Dr Arun Gupta	Co-nodal Off.: Dr Charan Singh	Since 2003
2.	DUS testing in barley	PPV&FRA, New Delhi	Nodal officer: Dr Charan Singh	Co-nodal Off.: Dr Arun Gupta	Since 2013
3.	ICAR-Network project on precision agriculture (NePPA 1013333)	ICAR	Dr SC Tripathi	Drs. Anil Khippal, Neeraj Kumar, RP Meena, Mamrutha HM, Ravindra Kumar, SC Gill, RS Chhokar	2021-2026
4.	Characterisation of genetic resources: Germplasm characterization and trait discovery in wheat using genomics approaches and its integration for improving climate resilience, productivity and nutritional quality Sub-proeject-1 Biotic stress component	DBT	Dr. OP Gangwar	Drs. Hanif Khan, Pramod Prasad	March 2020 – Feb. 2025

S. No.	Name of the project	Funding Agency	PI/CCPI	Co-PIs	Duration
5.	Development of herbicide tolerant wheat lines through physical mutagenesis	BRNS - DAE	Dr Satish Kumar	Dr Rajender Singh	2023-2026
6.	Genetic and genomic characterization of resistance to Karnal bunt of wheat	SERB-DST (ANRF)	Dr Satish Kumar	-	2024-2027
7.	Deciphering the genetic variability and factors responsible for rhizosheath formation in wheat for drought stress tolerance	DBT	Dr. Om Parkash Ahlawat	Dr Pradeep Sharma	Sep. 2023- Sep. 2026
8.	Artificial intelligence enabled biotic & abiotic stress detection and advisory mobile application for crops	NASF, ICAR	Dr. Prem Lal Kashyap	Dr. Anuj Kumar	2024-2027
9.	Development of synthetic microbiome for biotic stress and nutrient management in wheat	ICAR-NBAIM, Mau	Dr. Prem Lal Kashyap	Dr. Poonam Jasrotia	2024-2027
10.	CRP on conservation agriculture (Enhancing the productivity and profitability of wheat-based conservation agriculture systems)	ICAR	Dr RS Chhokar	Drs. SC Gill, Neeraj Kumar	Jul, 2015-2026 (ongoing)
11.	Enhancing climate resilience and ensuring food security with genome editing tools	ICAR-EFC project	Dr. Mamrutha HM	Drs. Vanita Pandey Rajender Singh, Rinki, Jayanth Kallugudi, Charu Lata Sharma	2023-26
12.	Improvement of stress adaptive traits in crops using endophytes under different agroecology	ICAR-NICRA	Dr. Mamrutha HM	-	2022- Mar. 2025
13.	CRP-Molecular breeding to biotic and abiotic stresses, yield and quality traits in crop	ICAR	Dr CN Mishra	Dr Satish Kumar	2020-25
14.	Incentivizing research - Molecular genetic analysis of resistance/tolerance to different stresses in rice, wheat, chickpea and mustard including sheath blight complex genomics-Wheat Component	ICAR	Dr. Sonia Sheoran	Drs. Rinki, Raj Kumar	2021-26
15.	Development and promotion of natural farming practices in wheat based cropping systems for sustainability and climate resilience in Haryana	RKVY, Haryana	Dr. Anil Kumar Khippal	Drs. OP Ahlawat, PL Kahsyap, SC Tripathi, Neeraj Kumar, Mamrutha HM, SC Gill, RS Chhokar, Charu Lata, Rinki	2023-2025
16.	CRP Biofortification in selected crops for nutritional security (ICAR) (Component: Wheat)	ICAR	Dr Sunil Kumar (wef 01/08/2024) Dr Sewa Ram (Till 31/07/2024)	Drs. OP Gupta, Anuj Kumar, Vanita Pandey, CN Mishra, BS Tyagi	2014-ongoing

S. No.	Name of the project	Funding Agency	PI/CCPI	Co-PIs	Duration
17.	Cluster demonstration of climate resilient and biofortified wheat varieties	DoA&FW (NFSM Cell)	Dr Anuj Kumar	Drs. CN Mishra, RS Chhokar, Satyavir Singh, Umesh Kamble	2023- 2026
18.	CRP on Hybrid Technology – Wheat	ICAR	Dr. Sindhu Sareen	Drs. BS Tyagi, Satish Kumar, Pradeep Sharma	2017-ongoing
19.	Germplasm characterization and Trait discovery in wheat using genomics approaches and its integration for improving climate resilience, productivity and nutritional quality" Sub project-3: Evaluation of wheat germplasm for abiotic stresses	DBT	Dr. Sindhu Sareen	Drs. Vikas Gupta, Charan Singh, Arun Gupta, S. Sheoran	March 2020 – Feb. 2025
20.	Germplasm characterization and trait discovery in wheat using genomics approaches and its integration for improving climate resilience, productivity and nutritional quality" under mission programme of "Characterisation of genetic resources" Sub project-3: Quality	DBT	Dr. OP Gupta (w.e.f. 01/08/2024) Dr. Sewa Ram (Till 31/07/2024)	Dr. BS Tyagi	March 2020 – Feb. 2025
21.	CRP on Agrobiodiversity (Wheat)	ICAR (NBPGR)	Dr. Arun Gupta	Drs. Sewa Ram(till 31/07/2024) Ravindra Kumar, Vanita Pandey (wef 01/08/2024), Rakesh Kumar Bairwa, OP Gangwar	Since 2021
22.	ICAR Seed Project- Seed production in agri. crops	ICAR	Dr. Amit Sharma	Drs Umesh Kamble, Rakesh K. Bairwa	Mar 2008 (ongoing)
23.	Tribal-Sub-Plan (TSP) project on Improving the socio-economic condition and livelihood of tribes in India through extension education and development programmes	Ministry of Agriculture & Farmers' Welfare	Dr. Satyavir Singh	Drs. Anuj Kumar, AK Khippal, Raj Kumar	Since 2015
24.	Frontline demonstrations on barley	Ministry of Agriculture & Farmers' Welfare	Dr. Satyavir Singh	Drs. Anuj Kumar, AK Khippal, Raj Kumar	Ongoing
25.	Monitoring of pesticide residues in rice -wheat cropping systems and mitigation strategies for reducing pesticide usage	RKVY, Haryana	Dr. Poonam Jasrotia	Drs. Prem Lal Kashyap, Anil Khippal	2022-24
26.	Intellectual property and technology management (IP&TM) IPR (NAIF), component-I	ICAR-NAIF	Dr Vikas Gupta	Drs. Umesh Kamble, Anuj Kumar (FT)	Ongoing
27.	Creating state of the art diagnostic facility for Karnal bunt in wheat to facilitate wheat trade for disease free regions benefitting farmers of Haryana	RKVY, Haryana	Dr Ravindra Kumar	Drs. Amit Sharma, BS Tyagi	2024-25

S. No.	Name of the project	Funding Agency	PI/CCPI	Co-PIs	Duration
28.	Establishing of an agri-reneurship cum food processing centre for wheat-based products to enhance the income of small and marginal farmers of Haryana	RKVY, Haryana	Dr Sunil Kumar	Drs. Anuj Kumar, Vanita Pandey, Vikas Gupta, Anuj Kumar (Sr.), OP Gupta	2024-25

Externally funded projects (International Agencies)

S. No.	Name of the Project	Funding Agency	PI	CO-PIs	Duration	Budget (Rs Lakhs)
1.	Accelerating genetic gains in maize and wheat for improved livelihood (AGG)	BMGF -CIMMYT	Dr Satish Kumar	Drs. BS Tyagi, Hanif Khan, Vishnu Kumar, SK Bishnoi	2021-2024	446.23
2.	Establishment of nitrogen-efficient wheat production systems in Indo-Gangetic plains by the deployment of BNI- technology.	JICA and JIRCAS, Japan	Dr CN Mishra	Drs. BS Tyagi, HM Mamrutha	2022-27	400.00
3.	Accelerating the mainstreaming of elevated zinc in global wheat breeding: A "Fluoride in the water" approach to nutrition	CIMMYT, Mexico	Dr CN Mishra	Drs. BS Tyagi, OP Gupta	2021-25	104.00

C. Contract Research Projects

S. No.	Name of the project	Funding Agency	PI	Duration
1.	Mapping of major soil borne pathogens in wheat based cropping systems in India	Syngenta India Pvt Ltd.	Dr Prem Lal Kashyap	2024-2026
2.	Evaluation of Amistar Gold 250 SC (Azoxystrobin 12.5% + Difenoconazole 12.5% w/v) against major wheat diseases	Syngenta India Pvt Ltd.	Dr Prem Lal Kashyap	2022-2024
3.	Evaluation of Pinoxaden 5% + Metribuzin 17.5% EC (225 g/L w/v) for weed control in wheat	Syngenta India Ltd.	Dr RS Chhokar	2022-2024
4.	Efficacy of GPH 1120 against complex weed flora of wheat	UPL India Ltd., Mumbai	Dr RS Chhokar	2022-2024
5.	Agronomic interventions for management of *P. minor* in wheat	Syngenta India Ltd.	Dr RS Chhokar	2021-2024
6.	Response of wheat to the application of bio-stimulants through foliar spray in terms of growth, yield, and quality of grains	Smartchem Technologies Ltd.	Dr Mamrutha HM	2023-2025
7.	Evaluation of bio-efficacy and phytotoxicity of monocrotophos 15% SG against foliar aphids and pink stem borer in wheat	UPL India Ltd., Mumbai	Dr Poonam Jasrotia	2022-24

18 PUBLICATIONS

Research Papers in referred journals

Adhikari S, Bhardwaj SC, Gangwar OP, Prasad P, Lata C, Kumar S and Chand G (2024). Morphological characterization and molecular diversity assessment of rust resistant genetic stocks of wheat. *Tropical Plant Pathology,* 1-14. https://doi.org/10.1007/s40858-024-00650-8. (**NAAS rating: 8.50**)

Ahlawat OP, Khippal A, Venkatesh K, Chhokar RS, Gill SC, Kashyap PL, Kharub AS, Kumar L, Kumar N, Sharma A and Kumari K (2024). Impact of different tillage and residue retention practices on soil nutrients, microbial community composition and grain yield of malt barley. *Journal of Soil Science and Plant Nutrition,* 24(4), 7651-7668. https://doi.org/10.1007/s42729-024-02065-5 (**NAAS rating: 9.90**)

Ahlawat OP, Khippal A, Walia N, Vankatesh K, Kumari K, Sheoran S, Bijarnia KK, Kumar L, Tripathi SC and Singh G (2024). Residue retention and tillage impact on microbial dynamics for enhanced rice-wheat production. *Sustainability,* 16(21), 9406-9423. https://doi.org/10.3390/ su16219406. (**NAAS rating: 9.90**)

Ahlawat OP, Yadav D, Walia N, Kashyap PL, Sharma P and Tiwari R (2024). Root exudates and their significance in abiotic stress amelioration in plants: A review. *Journal of Plant Growth Regulation* 43(1736-61). https://doi.org/10.1007/s00344-024-11237-7. (**NAAS rating: 9.90**)

Ayyappan MV, Kishore P, Panda SK, Kumar A, Uchoi D, Nadella RK and Ravishankar CN (2024). Emergence of multidrug resistant, ctx negative seventh pandemic Vibrio cholerae O1 El Tor sequence type (ST) 69 in coastal water of Kerala, India. *Scientific Reports*, 14(1), 2031. https://doi.org/10.1038/s41598-023-50536-z **(NAAS rating:9.80).**

Bhardwaj SC, Gangwar OP, Prasad P and Kumar S (2024). Deciphering the enigma of annual recurrence of wheat rusts in India. *Journal of Phytopathology,* 172(6), e13434. https://doi: 10.1111/jph.13434. (**NAAS rating: 7.10**)

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Chandra P, Khobra R, Sundha P, Chandra A, Sharma RK and Singh GP (2024). *Bacillus subtilis* strain BS87 as a biocontrol agent against spot blotch disease: effect on growth, nutrient status, and antioxidant enzymes in wheat. *Acta Physiologiae Plantarum* 46, 35. https://doi.org/10.1007/s11738-024-03657-5. (**NAAS rating: 8.40**)

Chhokar RS, Kumar N, Gill SC, Tripathi SC and Singh G (2024). Enhancing wheat productivity through genotypes and growth regulators application under higher fertility conditions in sub-humid climate. *International Journal of Plant Production*, 18(1), 85–95. https://doi.org/10.1007/s42106-023-00277-w (**NAAS rating: 8.10**)

Devi B, Singh G, Gupta SK, Prasad P, Bhardwaj SC and Rachappanavar V (2024). Racial diversity *in Uromyces appendiculatus* causing French bean rust. *Indian Phytopathology,* 77, 407-417. https://doi.org/10.1007/s42360-024-00736-y. (**NAAS rating: 5.97**)

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Jaswal R, Dubey H, Kiran K, Rawal H, Kumar G, Rajarammohan S, Deshmukh R, Sonah H, Prasad P, Bhardwaj SC, Gupta N and Sharma TR (2024). Identification and functional characterization of the npc-2-like domain containing rust effector protein that suppresses cell death in plants. *Molecular Biology Reports,* 51, 962. https://doi.org/10.1007/s11033-024-09894-8. (**NAAS rating: 8.60**)

Kakraliya M, Jat HS, Chhokar RS, Kumar S, Choudhary M, Sharma PC and Jat ML (2024). Conservation agriculture layered with subsurface drip fertigation influences weed dynamics, weed indices and productivity of rice-wheat system. Crop Protection, 183, 106761. **(NAAS rating: 8.50)**

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Khan H, Parkash O, Mamrutha HM, Bairwa RK, Mishra CN, Kumar R, Jasrotia P, Kumar S, Krishnappa G, Ahlawat OP and Singh G (2024). Foliar application of chlormequat chloride improves lodging resistance and grain yield in bread wheat. *Plant Physiology Reports*, 1-7. https://doi.org/10.1007/s40502-024-00824-1. **(NAAS rating: 7.50)**

Khare V, Shukla RS, Pandey S, Kumar S and Singh C (2024). Exploring the genotype-environment interaction of bread wheat in ambient and high-temperature planting conditions: a rigorous investigation. *Scientific Reports*, 14(1), 2402. https://doi.org/10.1038/s41598-024-53052-w. **(NAAS rating: 9.80)**

Khobra R, Sheoran S, Sareen S, Meena KB, Kumar A and Singh G (2024). Augmenting the basis of lodging tolerance in wheat (*Triticum aestivum*) under natural and simulated conditions. *Functional Plant Biology,* 51(9), FP24107. https://doi.org/10.1071/FP24107. **(NAAS rating: 8.60)**

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Kumar R, Azad CS, Chattopadhyay T, Bhati PK, Gangwar OP, Kumar S, Prasad P and Baranwal D (2024). Identification of terminal heat-tolerant and foliar disease-resistant fortified genotypes in wheat (*Triticum aestivum* L.). *Cereal Research Communications,* 52, 1799-1818. https://doi.org/10.1007/s42976-024-00505-7. (**NAAS rating: 7.60**)

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Kumar S, Bhardwaj SC, Gangwar OP, Prasad P, Lata C and Manjul AS (2024). Developing a differential system for designating the pathotypes of *Puccinia hordei* causing barley leaf rust in India. *Journal of Plant Pathology,* 1-12. https://doi.org/10.1007/s42161-024-01734-9. (**NAAS rating: 8.20**)

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Kumar S, Rahman M, Bouket AC, Ahadi R, Meena M, Bhupenchandra I, Singh UB, Arutselvan R, Kumar R, Singh SP and Kashyap AS (2024). Unravelling the multifarious role of wood vinegar made from waste biomass in plant growth promotion, biotic stress tolerance, and sustainable agriculture. *Journal of Analytical and Applied Pyrolysis,* 185, 106851. https://doi.org/10.1016/j.jaap.2024.106851

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Kumari J, Gupta RK, Gupta A, Honrao BK, Vaish SS, Sharma A, Ram S, Krishnappa G, Sharma S, Bhardwaj R, Jacob SR, Kumar S, Vikas VK, Pandey S, Rana JC, Kumar A, Singh GP and Singh K (2024). Multi-environment analysis to unravel bread wheat core collection to identify donors for grain quality, phenology, and yield traits. *Crop and Pasture Science,* 75 (8), https://doi.org/10.1071/CP22340.

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Mishra CN, Sharma S, Pawar S.K, Sabhyata, Kumar A, Kumar MS, Mamrutha HM, Tyagi BS, Singh GP and Singh G (2024). Phenotyping and breeding strategies for incorporating BNI trait in wheat varieties. *Plant Physiology Reports*, 29, 808-822. https://doi.org/10.1007/s40502-024-00843-y, **(NAAS rating: 7.50).**

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Tripathi SC, Kumar N and Singh G (2024). Climate change mitigation strategies for cereal based cropping

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Dr Ravindra Kumar delivered an Oral Presentation entitled "Virulence analysis of *Bipolaris sorokiniana*, fungal incitant of spot blotch disease in wheat" under theme Biotic Stress dynamics under changing environments in 5th International Group Meeting (IGM) on "Climate Proofing Cereal Agriculture: Strategies for Resilience and Sustainability" organized at Karnal (Haryana) by Society for Advancement of Wheat & Barley Research (SAWBAR) and ICAR-IIWBR, Karnal during March 27–29, 2024.

Dr. Prem Lal Kashyap delivered oral Presentation on "Genetic Diversity, Phylogeographic Relationships, And Population Structure of Wheat Loose Smut Fungus *Ustilago tritici* From the Hill and Plain Terrains of India" in 5th International Group Meeting (IGM) on Climate-Proofing Cereal Agriculture: Strategies for Resilience and Sustainability from Mar 27, 2024 to Mar 29, 2024 at ICAR-IIWBR, Karnal.

Dr. Prem Lal Kashyap delivered invited lecture on "Plant Disease Diagnostics: Research Trends, Knowledge Gaps and Opportunities" in National Conference titled "Expanding the Horizons of Microbial Research in Agriculture" from June 10-11, 2024, at the ICAR-National Bureau of Agriculturally Important Microorganisms (NBAIM), Mau, Uttar Pradesh

Dr. Prem Lal Kashyap delivered invited lecture on "Phenotyping of genome edited plants for biotic stresses" as a resource person in a training programme organised October 22, 2024 at ICAR-IIWBR, Karnal

Dr Anuj Kumar delivered oral Presentation at 5th IGM on title Blending millets with whole wheat flour for enhancing nutritive value of biscuits organized during 27-29 March 2024 at ICAR-IIWBR, Karnal.

Dr Anuj Kumar delivered oral presentation at AMU Millet-legume-wheat amalgamation for food products with enhanced nutritional potential to attend the Joint International Conference on Millets for Food Security on 21-22 February 2024 organized by the Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh, India

Dr. Vanita Pandey delivered oral presentation in 5th International Group Meeting (IGM) on "Climate-Proofing Cereal Agriculture: Strategies for Resilience and Sustainability at IIWBR, Karnal, Haryana from March 27-29, 2024 on Evaluation of Genetic Diversity of Hexaploid Wheat Cultivars for Total and Soluble Pentosan Content across Diverse Growing Conditions'.

Dr. Vanita Pandey delivered oral presentation in International Salinity Conference (ISC-2024) at ICAR-CSSRI, Karnal during 14-16 Feb 2024 on 'Salinity stress in wheat: effect on physiological, biochemical, molecular parameters and grain quality of wheat genotypes'.

Gupta OP delivered oral presentation on "Unveiling the complexities of NaFeEDTA and ascorbic acid fortification on Fe and Zn bioavailability in wheat cultivars" at 5th International Group Meeting (IGM) on "Climate-Proofing Cereal Agriculture: Strategies for Resilience and Sustainability" during 27-29 March, 2024.

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19 हिन्दी कार्यक्रमों पर रिपोर्ट

भारत की संस्कृति, सभ्यता, कला, साहित्य, जीवन मूल्य, जीवनचर्या, आध्यात्मिक आस्थाएं, धार्मिक मान्यताएं, बाजार, व्यापार, रोज़गार एवं समाज की बहुमुखी परम्पराएं आदि सदियों से पूरी दुनिया को अपनी ओर आकर्षित करते रहे हैं। इन सभी प्रयोजनों की पृष्ठभूमि में बहुरंगी–बहुभाषी–बहुधर्मी भारत जैसे देश को समझने का महत्वपूर्ण माध्यम हिन्दी ही है। हमारे बहुभाषी देश में सम्पर्क भाषा के रूप में हिन्दी भाषा का स्थान सर्वोपरि है। हिन्दी भाषा ने आजादी से पहले भी पूरे राष्ट्र को एक सूत्र में पिरोने का कार्य किया है। पूरब से पश्चिम, उत्तर से दक्षिण तक देश के सभी हिस्सों में राष्ट्रनायकों ने हिन्दी भाषा के प्रति सम्मान प्रदर्शित किया, यही कारण है कि संविधान में हिन्दी को राजभाषा का दर्जा प्राप्त है।

हिन्दी राजभाषा होने के कारण हम सभी का संवैधानिक दायित्व है कि अधिक से अधिक सरकारी काम–काज हिन्दी में ही करें तथा स्वयं के साथ दूसरों को भी हिन्दी में कार्य करने के लिए प्रोत्साहित करें। राजभाषा हिन्दी के कार्यान्वयन एवं प्रचार प्रसार तथा समय–समय पर इसके प्रगामी प्रयोग को गति देने एवं प्रगति के अवलोकन करने हेतु संस्थान में राजभाषा कार्यान्वयन समिति का गठन किया गया है। निदेशक, भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल के मार्गदर्शन में समिति के निरन्तर प्रयासों के परिणाम स्वरूप सभी विभागों में हिन्दी में किए गए उत्कृष्ट कार्य संस्थान के राजभाषा के प्रति समर्पण को परिलक्षित करता है।

राजभाषा हिन्दी से संबंधित प्रमुख उपलब्धियाँ

- संस्थान में राजभाषा अधिनियम 1963 की धारा 3(3) का अनुपालन किया गया।
- हिन्दी में प्राप्त पत्रों के उत्तर हिन्दी में दिए गए अर्थात् 1976 के तहत नियम 5 व 10(4) का अक्षरशः अनुपालन।
- संस्थान की राजभाषा कार्यान्वयन समिति के अध्यक्ष एवं समिति के सलाहकार तथा हिन्दी अधिकारी ने नगर राजभाषा कार्यान्वयन समिति की छमाही बैठकों में भाग लिया।
- डॉ. मंगल सिंह, हिन्दी अधिकारी एवं श्री सुरेन्द्र सिंह, मुख्य तकनीकी अधिकारी ने केन्द्रीय गृह एवं सहकारिता मंत्रालय, भारत सरकार, द्वारा भारत मंडपम, नई दिल्ली में दिनांक 14–15 सितम्बर, 2024 को आयोजित राजभाषा हीरक जयंती समारोह एवं चतुर्थ अखिल भारतीय राजभाषा सम्मेलन में भाग लिया।
- प्रत्येक तिमाही में हिन्दी कार्यशाला का आयोजन किया गया।
- संस्थान की राजभाषा कार्यान्वयन समिति की नियमित तिमाही बैठकें आयोजित की गईं।
- संस्थान की छमाही हिन्दी पत्रिका "गेहूँ एवं जौ संदेश" अंक–12 एवं "गेहूँ एवं जौ संदेश" के बीज विशेषांक अंक 13 का प्रकाशन किया गया।
- संस्थान की वार्षिक हिन्दी पत्रिका "गेहूँ एवं जौ स्वर्णिमा"के अंक 15 का प्रकाशन किया गया।
- द्वि–पंक्ति माल्ट जौ की उन्नत किस्म डीडब्ल्यूआरबी 219 के फोल्डर का प्रकाशन किया गया।
- "रोटरी डिस्क ड्रिलः फसल अवशेष प्रबंधन हेतु एक नवीनतम तकनीक" के फोल्डर का प्रकाशन किया गया।
- वार्षिक प्रतिवेदन 2023 का प्रकाशन किया गया।
- संस्थान की विभिन्न गतिविधियों से संबंधित समाचार, विभिन्न समाचार पत्रों में हिन्दी में प्रकाशित किए गए।
- संस्थान की विभिन्न गतिविधियों एवं तकनीकों के बारे में किसानों, छात्रों एवं अधिकारियों को संस्थान की हिन्दी चलचित्र के माध्यम से समझाया गया, साथ ही उनसे हिन्दी में ही संवाद किया गया।
- संस्थान में चल रहे राजभाषा हिन्दी के कार्यों का निरीक्षण श्री कुमार पाल शर्मा, उपनिदेशक (कार्यान्वयन), क्षेत्रीय कार्यान्वयन कार्यालय–1, नई दिल्ली द्वारा किया गया।
- हिन्दी पखवाड़ा के दौरान विभिन्न हिन्दी प्रतियोगिताएं आयोजित की गई, जिसमें विजेता प्रतिभागियों को नकद पुरस्कार राशि एवं प्रमाण पत्र से सम्मानित किया गया।

पुरस्कार व सम्मान

राजभाषा हिन्दी के प्रयोग एवं प्रचार–प्रसार के क्षेत्र में सर्वाधिक व सराहनीय कार्यों के लिए संस्थान को नगर राजभाषा कार्यान्वयन समिति, करनाल की 79वीं छमाही समीक्षा बैठक (जून, 2024) में वर्ष 2023–24 के दौरान सरकारी कामकाज (शोध संस्थान श्रेणी) में राजभाषा के उल्लेखनीय एवं सराहनीय कार्य हेतु दिनांक 12 जून, 2024 को तृतीय पुरस्कार से सम्मानित किया गया।

संस्थान के हिन्दी समाचार पत्र **"गेहूँ एवं जौ संदेश"** को नगर राजभाषा कार्यान्वयन समिति, करनाल की 79वीं छमाही समीक्षा बैठक (जून, 2024) में द्वितीय पुरस्कार से सम्मानित किया गया।

दिनांक 18 नवम्बर, 2024 को नराकास की 80वीं छमाही समीक्षा बैठक का आयोजन भाकृअनुप–राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल में किया गया। जिसमें भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल के राजभाषा अधिकारी डॉ. मंगल सिह एवं डॉ. अनुज कुमार, प्रधान वैज्ञानिक ने भाग लिया।

तिमाही बैठकों का आयोजन

राजभाषा विभाग, गृह मंत्रालय (भारत सरकार) तथा भारतीय कृषि अनुसंधान परिषद से समय–समय पर प्राप्त निर्देशों के अनुसार वर्ष 2024 के दौरान संस्थान की राजभाषा कार्यान्वयन समिति की तिमाही बैठकों का आयोजन नियमित रूप से किया गया। इन सभी बैठकों की अध्यक्षता संस्थान के निदेशक एवं समिति के अध्यक्ष द्वारा की गई। हिन्दी राजभाषा कार्यान्वयन समिति की जनवरी से मार्च 2024, तिमाही बैठक दिनांक 08.01.2024, अप्रैल से जून, 2024 तिमाही की बैठक दिनांक 22.04.2024, जुलाई से सितम्बर, 2024 तिमाही की बैठक दिनांक 01.07.2024, अक्तूबर से दिसम्बर, 2024 तिमाही की बैठक दिनांक 14.10.2024 को संस्थान के वीएस माथुर हॉल/बोर्ड कक्ष में आयोजित की गईं।

उपरोक्त बैठकों में संस्थान के सभी विभागों के प्रमुख अन्वेषकों, मुख्य प्रशासनिक अधिकारी, वित्त एवं लेखा अधिकारी तथा समिति के अन्य पदाधिकारियों ने भाग लिया। इन बैठकों में कार्यान्वयन से सम्बंधित सभी बिन्दुओं पर विचार विमर्श किया गया। संस्थान के नामित राजभाषा हिन्दी अधिकारी द्वारा पिछली तिमाही बैठकों का विस्तृत ब्यौरा प्रस्तुत किया गया, जिसमें राजभाषा अधिनियम 1963 की धारा 3(3) के अनुपालन की स्थिति के संदर्भ में बताया गया। तदुपरान्त पिछली तिमाहियों के अंतर्गत जारी पत्रिकाओं, फोल्डर्स, प्रतिवेदन, टिप्पणी मसौदा, द्विभाषीय फार्मों, आमंत्रण, कागजातों, निविदा प्रपत्र, निविदा सूचनाएं, मांगपत्रों एवं जाँच बिन्दुओं इत्यादि से सम्बंधित चर्चा की गई, साथ ही माननीय संसदीय राजभाषा समिति को दिए गए आश्वासनों के सम्बन्ध में उचित कार्रवाई करने के लिए सभी विभाग प्रमुखों, सभी अधिकारियों एवं कर्मचारियों को व्यक्तिशः आदेश जारी किए गए।

राजभाषा के वार्षिक कार्यक्रमों के तहत निर्धारित लक्ष्यों को प्राप्त करने तथा राजभाषा विभाग एवं भारतीय कृषि अनुसंधान परिषद से प्राप्त निर्देशों/आदेशों/समीक्षाओं के अनुपालन पर इन बैठकों में विधिवत चर्चा की गई। संस्थान की कार्यान्वयन समिति द्वारा सुझाए गए विकल्पों तथा लिए गए निर्णयों को लागू करने के लिए उचित कार्रवाई की गई।

राजभाषा कार्यान्वयन सम्बंधी तिमाही/छःमाही/वार्षिक प्रगति रिपोर्ट का संकलन

संस्थान के विभिन्न विभागों/अनुभागों द्वारा हिन्दी में किए जा रहे कार्यों की तिमाही प्रगति रिपोर्ट निर्धारित प्रपत्र के अनुसार प्रत्येक तिमाही में मांगी गई। सभी विभागों/अनुभागों से प्राप्त रिपोर्ट को संकलित कर समेकित रिपोर्ट तैयार की गई। समेकित रिपोर्ट को राजभाषा विभाग गृह मंत्रालय सूचना प्रबंधन प्रणाली के निर्धारित प्रपत्र के अनुसार प्रत्येक तिमाही को ऑनलाईन माध्यम से राजभाषा विभाग गृह मंत्रालय सूचना प्रबंधन प्रणाली पर प्रमाणपत्र सहित समयबद्ध अपलोड किया गया साथ ही तिमाही रिर्पार्ट को ई–मेल के माध्यम सें भारतीय कृषि अनुसंधान परिषद् को तथा छःमाही व वार्षिक रिपोर्ट को भाकृअनुप– राष्ट्रीय डेरी अनुसंधान संस्थान (मानद विश्वविद्यालय) करनाल, हरियाणा को समय पर भेजा गया।

कार्यशाला का आयोजन

- संस्थान में सभी विभागों/अनुभागों की महिलाओं हेतु दिनांक 08 फरवरी, 2024 को **''विज्ञान के क्षेत्र में महिलाओं की भूमिका''** पर एक दिवसीय कार्यशाला का आयोजन किया गया। इस अवसर पर संस्थान के निदेशक डॉ. ज्ञानेन्द्र सिंह ने विज्ञान के क्षेत्र में महिलाओं की भूमिका के बारे में अपने विचार व्यक्त किए तथा महिलाओं द्वारा कार्यालय एवं घर पर निभाई जाने वाली बहुमुखी जिम्मेदारियों की सराहना की।

- संस्थान के सभी अधिकारियों एवं कर्मचारियों के लिए दिनांक 05 जून, 2024 को अंतर्राष्ट्रीय योग दिवस के अवसर पर एक दिवसीय कार्यशाला का आयोजन किया गया जिसमें संस्थान के लगभग 100 अधिकारियों/कर्मचारियों ने भाग लिया। राजभाषा योग के माध्यम से सभी को जोड़ने का काम कर सकती है।

- संस्थान के सभी अधिकारियों/कर्मचारियों के लिए **''हिन्दी में काम करना कितना आसान''** विषय पर ''हीरक जयंती हिन्दी दिवस'' के शुभ अवसर पर 17 सितम्बर, 2024 को एक दिवसीय कार्यशाला का आयोजन किया गया।

- संस्थान में विभिन्न स्कूलों के छात्र, छात्राओं के लिए **''कृषि शिक्षा दिवस''** के अवसर पर 03 दिसम्बर, 2024 को एक दिवसीय कार्यशाला का आयोजन किया जिसमें कृषि शिक्षा के महत्व पर प्रकाश डाला गया। इस कार्यक्रम के आयोजन से 100 से अधिक विद्यार्थी लाभान्वित हुए।

निरीक्षण कार्य

भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल में राजभाषा हिन्दी में चल रहे कार्यों का निरीक्षण श्री कुमार पाल शर्मा, उपनिदेशक (कार्यान्वयन), क्षेत्रीय कार्यान्वयन कार्यालय–1, नई दिल्ली ने दिनांक 12 जून, 2024 को किया। निरीक्षण के दौरान सभी विभागों/अनुभागों को धारा 3(3) और राजभाषा नियम–11 एवं शत–प्रतिशत हिन्दी में कार्य करने के लिए प्रेरित किया तथा हिन्दी के कार्य में आ रही समस्याओं का निराकरण किया। उपनिदेशक महोदय ने संस्थान में हिन्दी के प्रयोग एवं राजभाषा कार्यान्वयन की स्थिति को संतोषजनक बताया।

राजभाषा उत्सव व हिन्दी पखवाड़े का आयोजन

भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल ने भारतीय कृषि अनुसंधान परिषद, नई दिल्ली के निर्देशानुसार राजभाषा कार्यान्वयन समिति द्वारा दिनांक 17 सितम्बर, 2024 को हिन्दी दिवस तथा 14–30 सितम्बर, 2024 के दौरान हिन्दी पखवाड़े का आयोजन किया। हिन्दी दिवस के अवसर पर संस्थान के निदेशक डॉ. रतन तिवारी की अध्यक्षता में हिन्दी पखवाड़े का उदघाटन किया गया। हिन्दी पखवाड़े के दौरान हिन्दी सुलेख, भाषण, टिप्पणी मसौदा लेखन, आशु भाषण, कविता पाठ, अंताक्षरी, वाद–विवाद प्रतियोगिता एवं निबन्ध लेखन जैसी नौ प्रतियोगिताएँ आयोजित की गई। इन प्रतियोगिताओं में संस्थान के समस्त वैज्ञानिकों, अधिकारियों एवं कर्मचारियों ने बढ़–चढ़कर भाग लिया।

विजयी प्रतिभागियों का विवरण

विभिन्न प्रतियोगिताओं में विजयी प्रतिभागियों का विवरण निम्नलिखित तालिकाओं में दिया गया है।

हिन्दी सुलेख प्रतियोगिता

यह प्रतियोगिता कुशल सहायक वर्ग के कर्मचारियों के लिए दिनांक 17 सितम्बर, 2024 को संस्थान के वीएस माथुर हॉल में आयोजित की गई।

क्र.सं.	विजेता प्रतिभागियों के नाम	पुरस्कार की श्रेणी
1.	श्री अमन कुमार	प्रथम
2.	श्री हरिन्द्र कुमार	द्वितीय
3.	श्री रामू शाह	तृतीय
4.	श्रीमती अमरेश	तृतीय
5.	श्री बीरू राम	प्रोत्साहन
6.	श्री लखविन्द्र सिंह	प्रोत्साहन

भाषण प्रतियोगिता

इस प्रतियोगिता का आयोजन तकनीकी वर्ग के सभी अधिकारियों एवं कर्मचारियों के लिए दिनांक 18 सितम्बर, 2024 को संस्थान के डॉ. एस नागराजन सभागार में किया गया।

क्र.सं.	विजेता प्रतिभागियों के नाम	पुरस्कार की श्रेणी
1.	श्री राहुल	प्रथम
2.	श्री अम्बरीष कुमार पटेल	प्रथम
3.	श्री ओम प्रकाश टुटेजा	द्वितीय
4.	श्री सुरेन्द्र सिंह – I	द्वितीय
5.	श्री सुरेन्द्र सिंह – II	तृतीय
6.	श्री रवि रंजन कुमार	तृतीय

टिप्पणी एवं मसौदा लेखन प्रतियोगिता

इस प्रतियोगिता का आयोजन प्रशासनिक/वित्त एवं लेखा अनुभाग के सभी अधिकारियों एवं कर्मचारियों के लिए दिनांक 19 सितम्बर, 2024 को संस्थान के वीएस माथुर हॉल में किया गया।

क्र.सं.	विजेता प्रतिभागियों के नाम	पुरस्कार की श्रेणी
1.	श्री सुनील कुमार (प्रवर श्रेणी लिपिक)	प्रथम
2.	श्री नरेश कुमार (प्रवर श्रेणी लिपिक)	द्वितीय
3.	श्री रमेश चन्द (सहायक)	तृतीय
4.	श्रीमती सुशीला (सहायक)	प्रोत्साहन
5.	श्री अंकुर (सहायक)	प्रोत्साहन
6.	श्री अमर सिंह (सहायक)	प्रमाण पत्र
7.	श्री साहिल कुन्डू (सहायक)	प्रमाण पत्र
8.	श्रुति बजाज (सहायक)	प्रमाण पत्र
9.	श्री सुभाष चन्द (प्रशासनिक अधिकारी)	प्रमाण पत्र

आशु भाषण प्रतियोगिता

इस प्रतियोगिता का आयोजन वैज्ञानिक वर्ग के लिए दिनांक 20 सितम्बर, 2024 को संस्थान के वीएस माथुर हॉल में किया गया।

क्र.सं.	विजेता प्रतिभागियों के नाम	पुरस्कार की श्रेणी
1.	डॉ. अनुज कुमार	प्रथम
2.	डॉ. सुनील कुमार	द्वितीय
3.	डॉ. चन्द्र नाथ मिश्र	तृतीय
4.	डॉ. उमेश काम्बले	तृतीय
5.	डॉ. हनीफ खान	प्रोत्साहन
6.	डॉ. रिंकी	प्रोत्साहन

कविता पाठ प्रतियोगिता

इस प्रतियोगिता का आयोजन सभी वर्ग के अधिकारियों एवं कर्मचारियों के लिए दिनांक 23 सितम्बर, 2024 को संस्थान के डॉ. एस नागराजन सभागार में किया गया।

क्र.सं.	विजेता प्रतिभागियों के नाम	पुरस्कार की श्रेणी
1.	डॉ. प्रतिभा	प्रथम
2.	डॉ. किरन देवी	द्वितीय
3.	श्री अरूण शर्मा	तृतीय
4.	कुमारी जहावी	प्रोत्साहन
5.	श्री सुरेन्द्र सिंह, मुख्य तकनीकी अधिकारी	प्रोत्साहन

अंताक्षरी प्रतियोगिता

यह प्रतियोगिता सभी वर्ग की महिला अधिकारियों एवं कर्मचारियों के लिए दिनांक 24 सितम्बर, 2024 को संस्थान के वीएस माथुर हॉल में आयोजित की गई, जिसमें 50 से अधिक प्रतिभागियों ने भाग लिया।

क्र.सं.	विजेता प्रतिभागियों के नाम	पुरस्कार की श्रेणी
1.	कुमारी अंजना सोलंकी, कुमारी प्रीति सिरसवाल, कुमारी इन्दू, कुमारी ऐश्वर्या सिंह राठौर	प्रथम
2.	डॉ. जीनत वधता, डॉ. प्रीति, कुमारी सपना, श्रीमती शोभा	द्वितीय
3.	डॉ. प्रतिभा, कुमारी निशा वालिया, कुमारी अंजलि झा, कुमारी शिवानी	तृतीय
4.	श्रीमती रेणु शर्मा, श्रीमती अमरेश, श्रीमती शकुन्तला रानी, श्रीमती सुनीता जसवाल	प्रोत्साहन
5.	डॉ. गरिमा सिंहरोहा, डॉ. विजेता, डॉ. शिफाली, डॉ. किरन देवी	प्रोत्साहन

वाद–विवाद प्रतियोगिता

यह प्रतियोगिता आरए, एसआरएफ, वाईपी–1, वाईपी–2 एवं परियोजनाओं से सम्बंधित सभी अधिकारियों एवं कर्मचारियों के लिए दिनांक 26 सितम्बर, 2024 को संस्थान के डॉ. एस नागराजन सभागार में आयोजित की गई।

क्र.सं.	विजेता प्रतिभागियों के नाम	पुरस्कार की श्रेणी
1.	डॉ. किरन देवी	प्रथम
2.	श्री नरेन्द्र मोहन	द्वितीय
3.	कुमारी अंजना सोलंकी	तृतीय
4.	श्री अरूण शर्मा	प्रोत्साहन
5.	श्री अश्वनी कुमार आर्य	प्रोत्साहन

निबन्ध लेखन प्रतियोगिता

यह प्रतियोगिता नगर राजभाषा कार्यान्वयन समिति के स्तर पर सभी अधिकारियों/कर्मचारियों के लिए संस्थान के वीएस माथुर हॉल में दिनांक 27 सितम्बर, 2024 को आयोजित की गई। इस प्रतियोगिता में भाकृअनुप–राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल, कर्मचारी राज्य बीमा निगम, भारतीय जीवन बीमा निगम, पंजाब नेशनल बैंक, केनरा बैंक, दी न्यू इंडिया एश्योरेंस कम्पनी लिमिटेड, भारतीय डाक एवं तार विभाग तथा अपने संस्थान सहित आठ संस्थानों/निगमों/उपक्रमों/बैंकों के लगभग 28 अधिकारियों ने भाग लिया।

क्र.सं.	विजेता प्रतिभागियों के नाम	पुरस्कार की श्रेणी
1.	श्री अम्बरीश कुमार पटेल भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल	प्रथम
2.	डॉ. रिंकी भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल	द्वितीय
3.	श्रीमती शालु बालियान कर्मचारी राज्य बीमा निगम, करनाल	तृतीय
4.	डॉ. उत्तम कुमार भाकृअनुप–राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल	प्रोत्साहन
5.	डॉ. शोभा सोनी भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान, संस्थान, करनाल	प्रमाण प्रत्र

क्र.सं.	विजेता प्रतिभागियों के नाम	पुरस्कार की श्रेणी
6.	कुमारी सोनिका जाखड़ भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान, संस्थान, करनाल	प्रमाण प्रत्र
7.	श्री रवि रंजन कुमार भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान, संस्थान, करनाल	प्रमाण प्रत्र
8.	श्री हितेश राणा कर्मचारी राज्य बीमा निगम, करनाल	प्रमाण प्रत्र
9.	डॉ. विजेता भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान, संस्थान, करनाल	प्रमाण प्रत्र
10	श्री अमर सिंह भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान, संस्थान, करनाल	प्रमाण प्रत्र
11.	श्री अमित दीनदयाल कर्मचारी राज्य बीमा निगम, करनाल	प्रमाण प्रत्र
12.	श्रीमती मीनाक्षी शर्मा भारतीय डाक विभाग प्रवर अधीक्षक डाकघर, करनाल	प्रमाण प्रत्र

साहित्य पुस्तक प्रदर्शनी

राजभाषा हिन्दी पखवाड़े (14–30 सितम्बर, 2024) के दौरान डॉ. सोनिया श्योरान, प्रधान वैज्ञानिक एवं श्री अभय नागर, मुख्य तकनीकी अधिकारी के सहयोग से संस्थान में साहित्य पुस्तक प्रदर्शनी का आयोजन किया गया। संस्थान के अनेकों अधिकारियों एवं कर्मचारियों द्वारा इस साहित्य पुस्तक प्रदर्शनी का लाभ उठाया गया।

पुरस्कार वितरण एवं समापन समारोह

हिन्दी पखवाड़ा समापन समारोह संस्थान के निदेशक डॉ. रतन तिवारी की अध्यक्षता में दिनांक 30 सितम्बर, 2024 को डॉ. एस नागराजन सभागार में आयोजित किया गया। इस समापन समारोह में संस्थान के सभी वैज्ञानिकों, अधिकारियों एवं कर्मचारियों ने भाग लिया। निदेशक महोदय ने सभी पुरस्कार विजेताओं को हार्दिक बधाई दी और अधिकारियों/कर्मचारियों को कार्यालय के सभी सम्भव कार्यों को राजभाषा हिन्दी में करने के लिए प्रेरित किया तथा सभी प्रतियोगिताओं के समस्त विजेताओं को प्रमाण पत्र वितरित किए। उन्होंने संस्थान में आयोजित 15 दिवसीय हिन्दी पखवाड़ा समारोह में हिन्दी प्रतियोगिताओं के सफल आयोजन के लिए राजभाषा कार्यान्वयन समिति के सभी सदस्यों की सराहना की। डॉ. अनुज कुमार, सलाहकार, राजभाषा कार्यान्वयन समिति ने हिन्दी पखवाड़ा कार्यक्रम के सफल संचालन में अहम भूमिका निभाई। डॉ. मंगल सिंह, हिन्दी अधिकारी ने वर्ष 2024 के दौरान राजभाषा हिन्दी से सम्बंधित प्रमुख उपलब्धियों की एक विस्तृत रिपोर्ट प्रस्तुत की। राजभाषा कार्यान्वयन समिति के वरिष्ठ सदस्य डॉ. रविन्द्र कुमार ने कार्यक्रम के अन्त में धन्यवाद प्रस्ताव प्रेषित किया। राष्ट्रगान से साथ कार्यक्रम सम्पन्न हुआ।

20 PERSONNEL

Headquarter, Karnal

Director

Dr. Ratan Tiwari

Director cell

Smt. Shakuntla, PS to Director
Sh. Sunder Lal, STA
Sh. Aman Kumar, SSS

Crop Improvement

Scientific staff

Dr. OP Ahlawat, Pr. Scientist & PI
Dr. BS Tyagi, Pr. Scientist
Dr. Arun Gupta, Pr. Scientist
Dr. Sindhu Sareen, Pr. Scientist
Dr. Raj Kumar, Pr. Scientist
Dr. Rajender Singh, Pr. Scientist
Dr. Amit Kumar Sharma, Pr. Scientist
Dr. Sonia Sheoran, Pr. Scientist
Dr. Hanif Khan, Pr. Scientist
Dr. Satish Kumar, Sr. Scientist
Dr. Charan Singh, Sr. Scientist
Dr. CN Mishra, Sr. Scientist
Dr. HM Mamrutha, Sr. Scientist
Dr. Vikas Gupta, Sr. Scientist
Dr. Umesh R Kamble, Sr. Scientist
Dr. Rinki, Sr. Scientist
Dr. Rakesh Bairwa, Scientist

Technical & Supporting staff

Sh. Surendra Singh, CTO
Sh. Yogesh Kumar, CTO
Sh. Yogesh Sharma, CTO
Sh. Surendra Singh, CTO
Sh. P Chandrababu, ACTO
Dr. Rajendra Kumar, ACTO
Sh. Om Prakash, TO
Sh. Suresh Kumar, TO
Sh. Rajesh Kumar, TO
Sh. Rahul, Technician
Ms. Kirti Gupta, Technician
Sh. Abhilash Kumar, Technician
Sh. Mohit Dhaka, Technician
Sh. Ravi Ranjan Kumar, Technician
Smt. Shanti Devi, SSS
Smt. Amresh, SSS

Crop Protection

Scientific staff

Dr. Poonam Jasrotia Pr. Scientist & PI (Till 09/06/2024)
Dr. Pradeep Sharma, Pr. Scientist & PI (Since 10/06/2024)
Dr. Prem Lal Kashyap, Sr. Scientist
Dr. Ravindra Kumar, Sr. Scientist

Technical & Supporting staff

Sh. Ishwar Singh, TO
Sh. Bhal Singh, TO

Resource Management

Scientific staff

Dr. SC Tripathi, Pr. Scientist & PI (Till 05/08/2024)
Dr. SC Gill, Pr. Scientist & PI (Since 06/08/2024)
Dr. RS Chhokar, Pr. Scientist
Dr. Anil Khippal, Pr. Scientist
Dr. Neeraj Kumar, Scientist

Technical & Supporting staff

Sh. PHP Verma, ACTO
Sh. Rajinder Pal Sharma, TO
Sh. Madan Lal, TO (upto 31/01/2024)
Sh. Ambarish Kumar Patel, Technician

Quality and Basic Sciences

Scientific staff

Dr. Sewa Ram, Pr. Scientist & PI (Till 31/07/2024)
Dr. Sunil Kumar, Pr. Scientist & PI (Since 01/08/2024)
Dr. Om Prakash Gupta, Sr. Scientist
Dr. Anuj Kumar, Sr. Scientist
Dr. Vanita Pandey, Scientist (SS)

Technical & Supporting staff
Smt. Sunita Jaswal, ACTO
Sh. Vijay Singh, TO

Social Sciences

Scientific staff
Dr. Randhir Singh, Pr. Scientist & PI (upto 31/01/2024)
Dr. Satyavir Singh, Pr. Scientist & PI
Dr. Ajay Verma, Pr. Scientist
Dr. Suman Lata, Pr. Scientist
Dr. Anuj Kumar, Pr. Scientist

Technical & Supporting staff
Dr. Mangal Singh, CTO
Sh. Harinder Kumar, SSS

Barley Improvement

Scientific staff
Dr. Om Vir Singh, Pr. Scientist & PI
Dr. Chuni Lal, Pr. Scientist
Dr. Jogendra Singh, Pr. Scientist
Dr. Lokendra Kumar, Pr. Scientist
Dr. Rekha Malik, Pr. Scientist

Technical & Supporting staff
Sh. Rampal Saini, Technician
Sh. Raghuraj Pratap, Technician

PME Cell

Dr. Satish Kumar, Sr. Scientist, Officer- In-charge
Dr. Ramesh Chand, ACTO

Administration

Sh. Ravi K Dobriyal, CAO
Sh. Subhash Chand, AO
Sh. Sunil Kumar, AAO
Sh. Ramesh Kumar, AAO
Smt. Promila Verma, AAO
Sh. Ramesh Chand, Asstt.
Sh. Amar Singh, Asstt.
Smt. Shruti Bajaj, Asstt.
Ms. Nisha, Asstt.
Sh. Sunil Kumar, UDC
Sh. Naresh Kumar, UDC
Smt. Hem Lata, PS
Sh. Biru Ram, SSS
Sh. Lakhwinder Singh, SSS
Sh. Desh Raj, SSS

Accounts and Audit

Sh. Anil Siddharth, CFAO
Sh. Krishan Pal, Asstt.
Sh. Sushila, Asstt.
Sh. Sahil Kundu, Asstt.
Sh. Ramu Shah, SSS

Library

Dr. Ajay Verma, Officer-In-charge
Sh. Abhay Nagar, CTO

Farm Section

Dr. Vikas Gupta, Officer- In-charge
Dr. Rajendra Kumar, ACTO
Sh. Hawa Singh, Landscaping

Vehicle Section

Dr. Ramesh Chand, ACTO & In-charge
Sh. Ram Jawari, TO
Sh. Kehar Singh, TO
Sh. Rajbir Singh, STA
Sh. Sunder Lal, STA
Sh. Vinod Kumar, STA

Regional Station, Flowerdale, Shimla

Scientific staff
Dr. OP Gangwar, Sr. Scientist
Dr. Pramod Prasad, Sr. Scientist
Dr. Charu Lata, Scientist
Dr. Jayant Kullugudi, Scientist

Technical & Supporting staff
Dr. Subhodh Kumar, ACTO
Sh. Swaroop Chand, Technician
Sh. Mukesh Kumar Mahato, Technician
Sh. Khem Chand, SSS

Administrative staff
Sh. Anil Kumar, UDC

Regional Station, Dalang Maidan, Lahaul & Spiti

Scientific staff

Dr. Charan Singh, In-charge

Technical staff

Sh. Nand Lal, Sr. Tech.

Seed and Research Farm, Hisar

Scientific staff

Dr. S.K. Bishnoi, Scientist

21 STAFF POSITION AND FINANCE

Staff position as on 31st December 2024

Scientific cadre strength

Designation	Sanctioned	Filled	Vacant
IIWBR, Karnal and Seed and Research Farm, Hisar			
Director	01	01	-
Principal Scientist	05	02	03
Senior Scientist	12	8	04
Scientist	42	30	12
IIWBR Regional Station, Shimla			
Principal Scientist	01	-	01
Scientist	05	04	01
IIWBR Regional Station, Dalang Maidan			
Scientist	01	-	01
Total	67 (66+1)	45 (44+1)	22

Administrative cadre strength

Designation	Sanctioned	Filled	Vacant
A. IIWBR, Karnal			
CAO	01	01	-
AD(OL)	01	-	01
CF&AO	01	00	01
AO	01	01	-
AAO	03	03	-
FAO	01	-	01
PPS	01	01	-
Assistant	12	07	05
UDC	04	02	02
LDC	06	00	06
PS	01	01	-
PA	02	-	02
Steno Gr III	--	01*	-
Total (A)	**34**	**16**	**18**
B. IIWBR Regional Station, Shimla			
PA 01	01	-	01
UDC 01	01	01	-
Total (B)	**02**	**01**	**01**
Grand Total (A+B)	**36**	**17**	**19**

*As per the revised cadre strength this position has been abolished from the Institute cadre and the surplus personnel is being adjusted against other unfilled position.

Technical cadre strength

Designation	Sanctioned	Filled	Vacant
A. IIWBR, Karnal			
T-3 (Cat.II)	19	10	09
T-1 (Cat.I)	23	21	02
B. IIWBR Regional Station, Shimla			
T-3 (Cat.II)	02	01	01
T-1 (Cat.I)	03	02	01
IIWBR Regional Station, Dalang Maidan			
T-1 (Cat.I)	01	01	-
Total (A+B+C)	**48**	**35**	**13**

Skilled supporting staff cadre strength

Station	Sanctioned	Filled	Vacant
IIWBR, Karnal	16	09	07
IIWBR Regional Station, Shimla	02	01	01
IIWBR Regional Station, DalangMaidan	-	-	-
Total (A+B+C)	**18**	**10**	**08**

Summary

Cadre	Sanctioned	Filled	Vacant
Director	01	01	00
Scientific	67	44	23
Technical	48	35	13
Administrative	36	17	19
Skilled supporting staff	18	10	08
Total staff	**170**	**107**	**63**

*one steno is surplus.

FINANCE

Resource Generation

Resource Generation Through Commercialization of Technologies

Commercialization of Wheat varieties was carried out through **granting of licenses** under MoA with different private seed companies and registered seed growers. A total of **150 MoAs** were signed with different stakeholders for production and distribution of seeds/Rotary disk drill(RDD) of the following wheat varieties.

1. DBW 377 17 Agreements
2. DBW 359 02 Agreements
3. DBW 187 48 Agreements
4. DBW 222 07 Agreements
5. DBW 296 01 Agreements
6. DBW 303 09 Agreements
7. DBW 327 36 Agreements
8. DBW 332 01 Agreements
9. DBW 370 01 Agreements
10. DBW 371 16 Agreements
11. DBW 372 08 Agreements
12. JKW 261 02 Agreements
13. RDD 02 Agreements

A total revenue of **Rs.9027000/-** (Ninety lakh twenty seven thousand only) was generated through commercialization of wheat varieties and Rotary disk drill(RDD).

Expenditure statement upto 31.03.2024 (in lakhs)
ICAR-IIWBR, Karnal

Name of Scheme	HEAD	BE 2023-24	NET RE 2023-24	EXPENDITURE: Other than NEH, TSP & SCSP	NEH	TSP	SCSP	TOTAL EXP.	% of Exp. Against Revised Estimate
IIWBR, KARNAL	Grants in Aid - Capital	335.00	359.00	324.00	15.00	0.0	20.00	359.00	100.00
	Grants in Aid - Salaries	2480.00	2446.48	2446.48	0.0	0.0	0.0	2446.48	100.00
	Grants in Aid - General :								
	(1) Pension-1270	160.00	264.16	264.16	0.0	0.0	0.0	264.16	100.00
	(2) Others-0085	820.00	1038.06	920.00	87.06	7.00	24.00	1038.06	100.00
Grand Total (GIA-Capital, Salary, General)		**3795.00**	**4107.70**	**3954.64**	**102.06**	**7.00**	**44.00**	**4107.70**	**100.00**

AICRP on Wheat and Barley

Name of Scheme	HEAD	BE 2023-24	NET RE 2023-24	EXPENDITURE Other than NEH, TSP & SCSP	NEH	TSP	SCSP	TOTAL EXP.	% of Exp. Against Revised Estimate
AICRP (Wheat & Barley)	Grants in Aid - Capital	13.00	13.00	10.00	3.00	0.0	0.0	13.00	100.00
	Grants in Aid - Salaries	1803.18	1803.18	1803.18	0.0	0.0	0.0	1803.18	100.00
	Grants in Aid - General :								
	(1) Pension	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(2) Others	248.00	286.74	231.00	21.74	10.00	24.00	286.74	100.00
Grand Total (GIA-Capital, Salary, General)		**2064.18**	**2102.92**	**2044.18**	**24.74**	**10.00**	**24.00**	**2102.92**	**100.00**

Expenditure Statement upto 31-12-2024 (In Lakhs)
ICAR-IIWBR KARNAL

Name of Scheme	HEAD	Pregressive Receipt of Grant against 2024-25	EXPENDITURE Other than NEH, TSP & SCSP	NEH	TSP	SCSP	TOTAL EXP.	% of Exp. Against Revised Estimate
IIWBR, KARNAL	Grants in Aid - Capital	199.50	55.85	0.0	0.0	0.0	55.85	27.99
	Grants in Aid - Salaries	2123.29	2009.29	0.0	0.0	0.0	2009.29	94.63
	Grants in Aid - General :-							
	(1) Pension	305.00	304.63	0.0	0.0	0.0	304.63	99.88
	(2) Others	710.51	514.62	0.0	3.11	2.70	520.43	73.25
TOTAL		**3338.30**	**2884.39**	**0.0**	**3.11**	**2.70**	**2890.20**	**86.58**

AICRP ON WHEAT & BARLEY

Name of Scheme	HEAD	Pregressive Receipt of Grant against 2024-25	EXPENDITURE Other than NEH, TSP & SCSP	NEH	TSP	SCSP	TOTAL EXP.	% of Against Revised Estimate
AICRP (Wheat &	Grants in Aid - Capital	10.50	8.00	0.0	0.0	0.0	8.00	76.19
Barley)	Grants in Aid - Salaries	1015.13	997.48	0.0	0.0	0.0	997.48	98.26
	Grants in Aid - General :-							
	(1) Pension	0	0	0	0	0	0	0.00
	(2) Others	233.21	151.69	8.01	8.98	18.67	187.35	80.34
	TOTAL	**1258.84**	**1157.17**	**8.01**	**8.98**	**18.67**	**1192.83**	**94.76**

22 JOINING, PROMOTIONS, TRANSFERS AND RETIREMENTS

Joining

- Shri Raghuraj Pratap & Miss Kirti Gupta, T-1 joined ICAR-IIWBR, Karnal w.e.f. 22.04.2024
- Shri Ablilash Kumar, T-1 joined ICAR-IIWBR, Karnal w.e.f. 23.04.2024
- Shri Ambarish Kumar, Patel T-1 joined ICAR-IIWBR, Karnal w.e.f. 24.04.2024
- Shri Mohit Dhaka, T-1 joined ICAR-IIWBR, Karnal w.e.f. 01.05.2024
- Sh. Subhash Chand, AO joined ICAR-IIWBR, Karnal on Transfer w.e.f. 02.05.2024
- Shri Mukesh Mahato, T-1 joined ICAR-IIWBR, Karnal w.e.f. 03.05.2024
- Shri Ravi Ranjan, T-1 joined ICAR-IIWBR, Karnal w.e.f. 07.05.2024
- Sh. Ankur, Assistant joined ICAR-IIWBR, Karnal w.e.f. 09.08.2024
- Sh. Sahil Kundu, Assistant joined ICAR-IIWBR, Karnal w.e.f. 09.08.2024
- Sh. Amar Singh, Assistant joined ICAR-IIWBR, Karnal w.e.f. 16.08.2024
- Smt. Shurti Bajaj, Assistant joined ICAR-IIWBR, Karnal w.e.f. 16.08.2024
- Miss Nisha, Assistant joined ICAR-IIWBR, Karnal w.e.f. w.e.f. 25.09.2024
- Dr Binay Kumar, Principal Scientist joined ICAR-IIWBR, Karnal w.e.f. 21.10.2024

Transfers

- Dr. Poonam Jasrotia, (PS), selected as Assistant Director General (Plant Protection and Biosafety)- 18.06.2024
- Sh. Shiva Bhardwaj, Stenographer Gr.III, selected as Personal Assistant Grade II in Cabinet Secretariat Govt. of India, New Delhi – 02.09.2024
- Sh. Ankur, Assistant, selected as Field Investigator in Town and Country Planning Department of Haryana, Govt. of Haryana- 04.11.2024
- Sh. Anil Kumar Siddharth, FAO transferred to ICAR-IASRI, New Delhi – 27.12.24

Promotions

- Dr. Santosh Kumar Bishnoi Scientist promoted to the next grade Level-12 w.e.f.- 15.12.2022
- Dr. Charan Singh Scientist promoted to the next grade Level-13A w.e.f.- 15.12.2022
- Dr. Neeraj Kumar Scientist promoted to the next grade Level-11 w.e.f.- 04.01.2023
- Dr. Sonia Sheoran Sr. Scientist promoted to Pr. Scientist grade Level-14 w.e.f- 07.01.2023
- Dr. Hanif Khan Sr. Scientist promoted to Pr. Scientist grade Level-14 w.e.f- 07.01.2023
- Dr. Om Prakesh Gangwar Scientist promoted to the next grade Level-13A w.e.f- 27.04.2023
- Dr. Mamrutha HM Scientist promoted to the next grade Level-13A w.e.f- 02.05.2023
- Dr. Rinki Scientist promoted to the Sr. Sci. next grade Level-12 w.e.f- 01.07.2023
- Dr. Anuj Kumar Scientist promoted to the next grade Level-12 w.e.f- 01.07.2023
- Sh. Sunder Lal promoted to (TO) Level-7 w.e.f 07.11.2023
- Sh. Rajbir Singh promoted to (TO) Level-7 w.e.f 07.11.2023
- Sh. Om Singh promoted to (TO) Level-7 w.e.f 07.11.2023
- Sh. Rajendra Kumar promoted to CTO Level-12 w.e.f 20.05.2024
- Sh. Rahul promoted to T-2, Level-4 w.e.f 19.12.2023
- Sh. Ramesh Chand promoted to CTO, Level-12 w.e.f 30.04.2024

Superannuation

- Dr. Randhir Singh, Principal Scientist, ICAR-IIWBR, Karnal superannuated on 31.01.2024
- Sh. Madan Lal, Technical Officer, ICAR-IIWBR, Karnal superannuated on 31.01.2024

- Sh Om Singh, Technical Officer, ICAR-IIWBR, Karnal superannuated on 31.03.2024
- Dr. A.S Kharub, Principal Scientist, ICAR-IIWBR, Karnal superannuated on 30.04.2024
- Sh. O.P Dhillon, CTO, ICAR-IIWBR, Karnal superannuated on 30.04.2024
- Dr. Gyanendra Singh, Director, ICAR-IIWBR, Karnal superannuated on 31.05.2024
- Dr. Sewa Ram, Principal Scientist, ICAR-IIWBR, Karnal superannuated on 31.07.2024
- Sh. Surendra Singh, Technical Officer, ICAR-IIWBR, Karnal superannuated on 31.12.2024

एक कदम स्वच्छता की ओर

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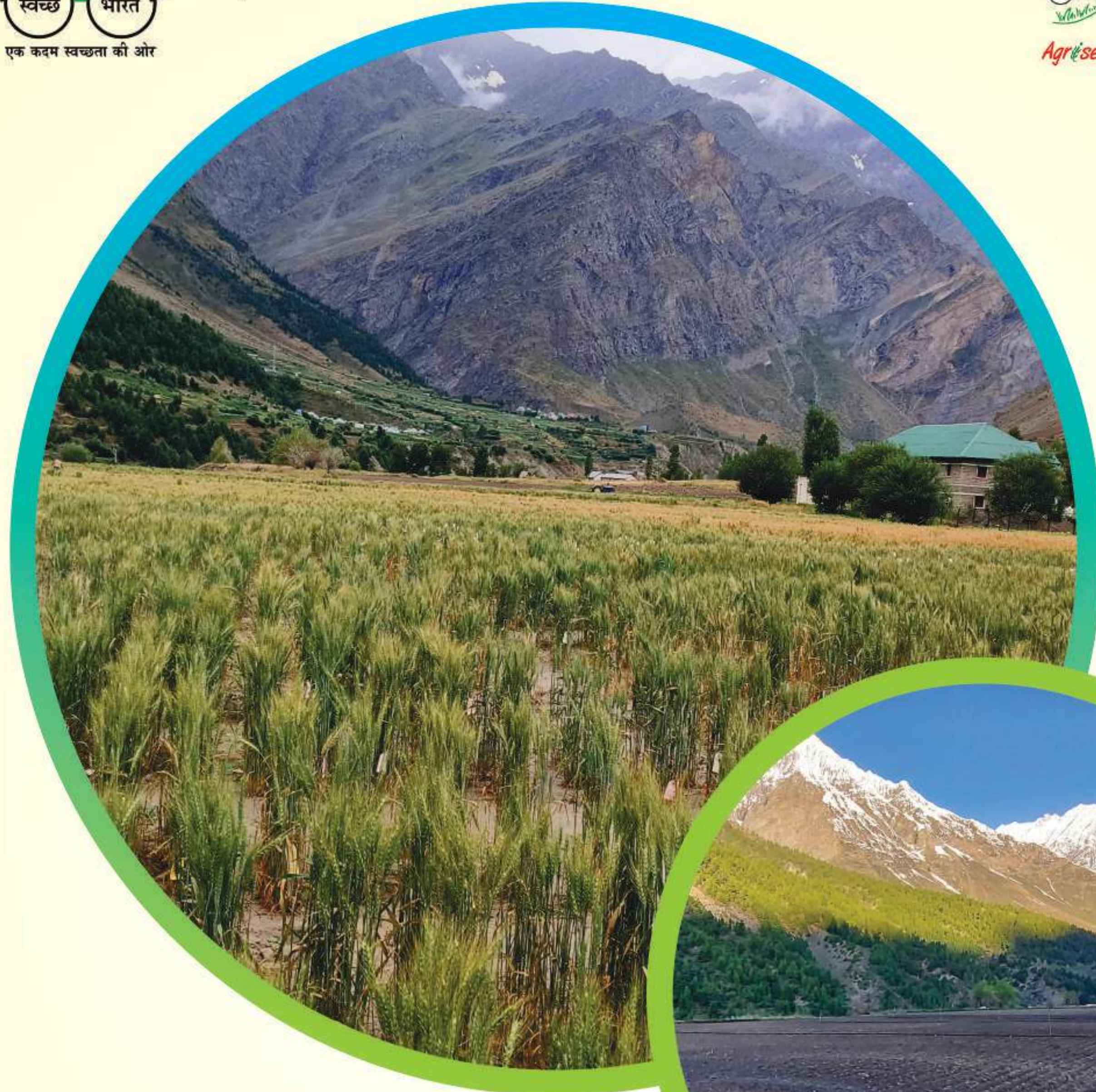

भाकृअनुप
ICAR

भा.कृ.अनु.प.–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान

करनाल – 132001, भारत

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Karnal-132001, India

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