वार्षिक प्रतिवेदन
ANNUAL REPORT
2019

भाकृअनुप-भारतीय गेहूँ एवं जौ अनुसंधान संस्थान
करनाल - 132001, भारत

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 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.

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Correct Citation : Annual Report 2019, ICAR-Indian Institute of Wheat and Barley Research, Karnal-132001, Haryana, India

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Published by : Director
ICAR-Indian Institute of Wheat and Barley Research
Agraisain Road, Karnal-132001, Haryana, India
Tel. : 0184-2267490, Fax : 0184-2267390
Website : http://iiwbr.org

Photography : Rajinder Kumar Sharma

Copies : 300

Design & Printing : Aaron Media
UG-17, Super Mall, Sector-12, Karnal-132001
Mob. : +91-99965-47747, 98964-33225
E-mail : aaronmedia1@gmail.com

भाकृअनुप-भारतीय गेहूँ एवं जौ अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद)
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डॉ. ज्ञानेन्द्र प्रताप सिंह
निदेशक
Dr. G.P. Singh
DIRECTOR

PREFACE

ICAR-Indian Institute of Wheat and Barley Research strives to ensure food and nutrition security to all, improve the livelihood of farmers and promote sustainability in an equitable agri-food system. Unlike the past Annual Reports which used to be from April to March, the present one has been prepared for the calendar year 2019 highlighting the accomplishments and activities for the aforementioned period to advance the ICAR-IIWBR vision. In 2019 several significant accomplishments were made in wheat and barley arena. The year has witnessed a phenomenal output in foodgrains production in which wheat accounted for about 36 per cent share. The annual wheat production has been estimated at 103.60 million tonnes from 29.32 million hectare (13.43% of global area) registering an all-time highest crop productivity of 3533 kgha^{-1}. The production of barley on the other hand stood at 1.66 million tonnes from a declining crop area of 0.58 million hectares with a record national productivity of 2837 kgha^{-1}. The current year *Rabi* season has been on a full swing with sowing surpassing the past year acreage. Increased sowing area has been facilitated by the GoI's policy decision on raising the support price by 6.1 and 2.1 per cent, respectively for wheat and barley.

ICAR-IIWBR has been carrying out commendable work on research and outreach activities in achieving the set production targets of GoI comprising varietal development, regular monitoring of pests & diseases, issuing timely advisories addressing the demands of diverse stakeholders. For the reporting period (2019), several feats have been accomplished by ICAR-IIWBR focussing on sustainability dimensions *viz*., economic, social and ecological. Of them, 58^{th} All India wheat and barley research workers meet held at Indore, M.P. has been the pinnacle which led to identification of 15 wheat and 2 barley varieties for different zones and production conditions in the country. The identification committee spotted two prominent varieties namely HD 3086 and DBW 187 for outscaling in NEPZ and NWPZ, respectively. This year, the High Yield Potential Trial (HYPT) at multi-locations has been continued with modified package of practice targeting 10 t ha^{-1}. To strengthen the seed delivery system, ICAR-IIWBR has signed MoA with 172 seed companies in 2019 encouraging Public-Private Partnership. To promote malt barley and create awareness among barley growers, a consultancy project has been signed with AB InBev.

It's a privilege and honour for ICAR-IIWBR and our collaborators, for being recognised by the Council and bestowed with the Chaudhary Devi Lal Outstanding AICRP Award during July 2019. Our organisation is fully committed for wheat and barley improvement in the country and in safeguarding the interests of diverse clientele. I sincerely acknowledge the support from ICAR, research partners and farmers for achieving the significant feat of producing over 100 million tonnes of wheat and wish the track record keeps continuing.

Jai Kisan, Jai Vigyan !

(GP Singh)

CONTENTS

कार्यकारी सारांश

फसल सुधार

- वर्ष 2019 में गेहूँ का रिकॉर्ड उत्पादन (102.2 मिलियन टन) और अधिकतम उत्पादकता (35.7 कुंतल प्रति हैक्टर) प्राप्त करने के लिए महत्वपूर्ण रहा।
- भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल ने देश में व्यावसायिक खेती के लिए गेहूँ की 12 नई किस्में (8 चपाती गेहूँ + 4 कठिया गेहूँ) के विकास एवं उनकी अधिसूचना जारी कराने में महत्वपूर्ण भूमिका निभाई। पहले से जारी दो किस्मों एचडी 3086 (उत्तर पूर्वी मैदानी क्षेत्रों के लिए) और डीबीडब्ल्यू 187 (उत्तर पश्चिमी मैदानी क्षेत्रों के लिए) के क्षेत्र विस्तार की भी सिफारिश की गई।
- भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल ने एनबीपीजीआर, नई दिल्ली की पौध जननद्रव्य पंजीकरण समिति द्वारा अनुशंसित कुल 23 गेहूँ जननद्रव्यों में से 13 नये जेनेटिक स्टॉकों को विकसित और पंजीकृत कराया।
- संस्थान की जर्मप्लाज्म रिसोर्स यूनिट (जी आर यू) ने 2019 में राष्ट्रीय और अंतर्राष्ट्रीय संगठनों से गेहूँ के जननद्रव्य के 1882 एक्सेशन्स का संरक्षण के लिए अधिग्रहण किया। इसके अलावा 350 उन्नत लाईनों को गेहूँ की बिमारियों (व्हीट ब्लास्ट) के परीक्षण के लिए बंग्लादेश और बोलीविया भेजा गया। जी.आर.यू. द्वारा इस वर्ष के दौरान 250 नए जननद्रव्य एक्सेशन्स के 38 डीयूएस लक्षणों को वर्णित भी किया गया।
- संस्थान ने 29 मार्च, 2019 को गेहूँ और जौ दिवस आयोजित किया। जिसमें सीजीआईएआर संस्थानों, राज्य कृषि विश्वविद्यालयों, भारतीय कृषि अनुसंधान परिषद के संस्थानों और गैर सरकारी संगठनों के 40 प्रतिभागियों ने भाग लिया और जननद्रव्यों का चयन किया। जी.आर.यू. ने विभिन्न शोधकर्ताओं द्वारा चयनित 1155 जननद्रव्य की मांग के अनुसार आपूर्ति की।
- प्री–बीडिग परियोजना के अंतर्गत वर्ष 2019 में *थिनोपाइरम बेसारबीकम* और *एजीलोप्स पेरेग्रीन* जैसी जंगली प्रजातियों के साथ चपाती गेहूँ के संकरण द्वारा नई आनुवंशिक विविधता सृर्जित की गई। प्रोजेक्ट टीम ने सूखे की सहनशीलता के लिए पहचानी गई लाइनों के साथ–साथ उच्च आयरन, जिंक और प्रोटीन वाली कई संभावित उत्कृष्ट लाईनों की भी पहचान की।
- उत्तरी भारत के उच्च उत्पादकता वातावरण के लिए गेहूँ सुधार परियोजना के अंतर्गत, उत्तर पश्चिमी मैदानी क्षेत्रों के लिए सिंचित एवं समय पर बोई जाने वाली परिस्थितियों हेतु एक उच्च उपज वाली गेहूँ की किस्म डीबीडब्ल्यू 222 (करण नरेंद्र) विकसित की गई। इसके अलावा, शीघ्र परिपक्वता और उच्च 1000 दाने के वजन (50 ग्राम) के लिए जननद्रव्य (आरडब्ल्यूपी 2014–18) को भी जेनेटिक स्टॉक के रूप में पंजीकृत कराया गया।
- पूर्वी क्षेत्र के लिए गेहूँ प्रजनन परियोजना के अंतर्गत जल जमाव सहिष्णुता और स्पॉट ब्लॉच प्रतिरोधकता के लिए एक नये जननद्रव्य बीएच 1146 की पहचान की गई।
- उष्ण क्षेत्रों के लिए गेहूँ सुधार परियोजना के अंतर्गत उत्तर पूर्वी मैदानी क्षेत्रों में समय पर बुवाई और सीमित सिंचाई की स्थितियों के लिए एक नई उच्च उपज वाली गेहूँ की किस्म डीबीडब्ल्यू 252 (करण श्रीया) विकसित की गई।
- संकर गेहूँ परियोजना के अंतर्गत वर्ष 2019 में 16 सीएमएस स्रोतों और 60 विविध नई सीएमएस लाईनों को बनाए रखा और प्रयोगात्मक संकरों का मूल्यांकन किया गया।
- गेहूँ की गुणवत्ता प्रजनन परियोजना के अंतर्गत कठिया गेहूँ की एक बेहतर किस्म, डीबीडब्ल्यू 47, जिसमें उच्च उपज, रोगरोधिता के साथ–साथ अभी तक की सर्वाधिक पास्ता गुणवत्ता स्कोर (7.9) और उच्च पीले वर्णक की मात्रा (7.57 पीपीएम) दर्ज की गयी।
- जैव प्रौद्योगिकी समूह द्वारा तापक्रम नियंत्रित फिनोटाईपिंग सुविधा (टीसीपीएफ) का उपयोग करते हुए अंतस्थ ताप सहिष्णुता को नियंत्रित करने वाले क्षेत्रों को मानचित्रित करके 30 क्यूटीएल की पहचान की गई। वर्ष 2019 के दौरान सूखा सहिष्णुता क्यूटीएल रीजन्स के अंतर्गमन के लिए मार्कर एस्सिटेंड बैकक्रॉस ब्रीडिंग (एमएबीबी) का उपयोग किया गया।
- प्रकाश संश्लेषण के महत्वपूर्ण मापदंडों के लिए जननद्रव्यों की पहचान कार्यिकी (फिजिओलोजिकल) स्क्रीनिंग के माध्यम से की गयी।
- आरडब्ल्यूपी–2017–21 को स्क्रीनिंग के माध्यम से गर्मी के प्रति सहिष्णुता वाले जननद्रव्य के रूप में पहचाना गया।

- विकिरण उपयोग दक्षता (आरयूइ) को बढ़ाने के लिए गेहूँ के जननद्रव्यों की स्क्रीनिंग के उद्देश्य हेतू संस्थान में एक नई पहल की गयी।
- गेहूँ में पैदावार और अजैविक तनाव सहिष्णुता लक्षणों में सुधार के लिए जीन और जीनोम के संपादन की नवीनतम तकनीक (क्रिस्पर/कैस 9) का उपयोग किया जा रहा है।
- वर्ष 2019 के दौरान संस्थान बीज इकाई द्वारा गेहूँ की 8 किस्मों के 3170.5 कुंतल बीज का उत्पादन किया गया तथा विभिन्न हितधारकों को बेहतर गुणवत्ता वाले बीज के वितरण से लगभग 2.51 करोड़ की राजस्व राशि प्राप्त हुई।

फसल सुरक्षा

- गेहूँ की फसल के स्वास्थ्य की निगरानी, रोग और कीटों व रतुआ रोग के नए पैथोटाईपों के आगमन पर चौकसी रखते हुए, और रोग को कम करने के लिए उपचारात्मक उपायों का समय पर सुझाव देकर की गई। दिनांक 14.1.2019 को पंजाब के जिला रूपनगर के ब्लॉक चमकौर साहिब के गाँव फतेहगढ़ विरान से पीला रतुआ (स्ट्राइप रस्ट) की पहली रिपोर्ट देखी गई। समग्र रूप से फसल स्वस्थ बनी रही और जैविक प्रतिबलों के कारण नगण्य नुकसान हुआ और इस प्रकार रिकॉर्ड गेहूँ उत्पादन में योगदान किया।
- गेहूँ के झौंका/ब्लास्ट रोग के लिए बंग्लादेश बोर्डर के साथ पश्चिम बंगाल में सर्वेक्षण किये गए और पश्चिम बंगाल में गेहूँ के झौंका अथवा ब्लास्ट रोग की कोई रिपोर्ट नहीं मिली।
- चेक्स सहित प्रारम्भिक पादप सुरक्षा जाँच नर्सरी (आईपीपीएसएन.) में कुल 1250 प्रविष्टियाँ और पादप सुरक्षा जाँच नर्सरी (पीपीएसएन) में 418 प्रविष्टियाँ की प्रमुख बीमारी व कीटों के लिए जाँच की गई और इस आधार पर प्रविष्टियों को उपज परीक्षणों के साथ–साथ किस्मों के रूप में पहचान और जारी करने में बढ़ावा दिया गया था।
- कुल 16 प्रविष्टियों, जिनकी पहचान कई बिमारियों के लिए प्रतिरोधी पुष्ट स्रोतों के साथ की गयी थी, उनको देश के विभिन्न कृषि–जलवायु क्षेत्रों में 27 प्रजनन केंद्रों के साथ जैविक प्रतिबलों के प्रतिरोधिता के लिए प्रजनन में उनके उपयोग के लिए सांझा किया गया।
- विभिन्न क्षेत्रों में अनेकों मंडियों से कुल 7321 अनाज के नमूने एकत्र किए गए और उनका विश्लेषण करनाल बंट रोग के लिए किया गया। समग्र रूप से 32.02 प्रतिशत नमूने करनाल बंट रोग से संक्रमित पाए गए। विभिन्न राज्यों में जहाँ से नमूने लिए गये थे उनमें मध्य प्रदेश, गुजरात, महाराष्ट्र और कर्नाटक करनाल बंट संक्रमण से मुक्त पाये गए।
- गेहूँ के झौंका अथवा ब्लास्ट रोग के खतरे से निपटने के लिए एवं बंग्लादेश से झौंका अथवा ब्लास्ट रोग के प्रवेश को रोकने के लिए, कठोर संगरोध अपनाया गया है और मुर्शिदाबाद व नादिया जिले में "गेहूँ की छुट्टी" के साथ–साथ बंग्लादेश सीमा के 5 किलोमीटर में 'गेहूँ रहित क्षेत्र' लागू किया गया।
- गेहूँ के झौंका अथवा ब्लास्ट रोग प्रतिरोधी स्रोतों की पहचान के लिए, सीमिट के माध्यम से जेसोर, बंग्लादेश और बोलीविया में कुल 353 भारतीय गेहूँ किस्मों और अग्रिम प्रजनन सामग्री की जाँच की गई। पश्चिम बंगाल के रोग संभावित क्षेत्रों में उगाने के लिए पांच प्रतिरोधी किस्मों की पहचान की गई है, जिनमें डीबीडब्ल्यू 187, एचडी 3249 और एचडी 2967 (सिंचित और समय पर बुवाई हेतू) और डीबीडब्ल्यू 252 और एचडी 3171 (सीमित सिंचाई और समय पर बुवाई हेतू) को संस्तुत किया गया।
- भारत के चार अलग–अलग भौगोलिक क्षेत्रों से उत्पन्न गेहूँ के अनावृत कंडुवा रोग के रोगजनक (*अस्टीलैगो सेगेटम* प्रजाति *ट्रिटिसी*) (यूएसटी) की समष्टि संरचना का विश्लेषण किया गया। वंशीय भूगोल (फाइलोजियोग्राफी) और समष्टि संरचना विश्लेषण ने स्पष्ट रूप से प्रदर्शित किया कि *अस्टीलैगो सेगेटम* प्रजाति *ट्रिटिसी* में विविधता और विभिन्नता जीन प्रवाह और उत्परिवर्तन की क्रियाविधि के कारण होती है।
- जौ के आवृत कंड रोग के रोगजनक *अस्टीलैगो होर्डे* के अंदर आनुवंशिक विविधता के अध्ययन हेतू एसएसआर मार्कर विकसित किए गए जो रोगजनक की समष्टि की गतिशीलता में गहरी अंतर्दृष्टि प्रदान करने में उपयोगी होगे।
- करनाल के गाँवों जैसे लाडवा, यमुनानगर, कुंजपुरा, सुभरी, रसीना और हजवाना आदि में गेहूँ के माहू (एफिड) और गुलाबी तना बेधक की सामान्य से गंभीर घटनाओं को देखा गया। गेहूँ के माहू (एफिड) से प्रभावित खेतों में कोक्सीनेलिड बीटल के गिडार (ग्रब्स) और वयस्कों को अकसर देखा गया था।
- जैविक अध्ययन से पता चला है कि *सी. सेप्टेम्पंक्टाटा* का जीवन–चक्र माहू (एफिड), *रोपालोसिपुम मेडिस* पर 51.4–59.2 दिनों में पूरा हुआ।
- गेहूँ के माहू (एफिड) कॉम्प्लेक्स की जनसंख्या की गतिशीलता से पता चलता है कि प्रथम एसएमडब्ल्यू, 2019 से 13 वें एसएमडब्ल्यू, 2019 (जनवरी, 2019 के पहले सप्ताह से अप्रैल, 2019 के पहले सप्ताह) तक खेत में दर्ज की गई माहू आबादी

को 7 वीएसएमडब्ल्यू, 2019 (फरवरी, 2019 के तीसरे सप्ताह) के दौरान आर्थिक सीमा स्तर को पार करते हुए देखी गई थी।

- अलग–अलग परीक्षण किए गए निगरानी जालों (ट्रैप्स) जैसे चिपचिपे जाल (स्टिकी ट्रैप) और ट्रे–जाल में, पीले चिपचिपे जाल (येलो स्टिकी ट्रैप्स) की दक्षता तुलनात्मक रूप से ट्रे जाल से अधिक थी।
- नाइट्रोजन की उच्च खुराक के साथ उपचार जैसे 150 और 225 कि.ग्रा./हैक्टर में नाइट्रोजन की कम खुराक की तुलना में माहू (एफिड्स) की संख्या सबसे अधिक थी। अतिसंवेदनशील चेक ए–9–30–1 की तुलना में प्रजाति एच.डी. 2967 में माहू (एफिड्स) की संख्या सबसे कम थी।
- गेहूँ के प्रमुख कीटों जैसे पर्णीय माहू (फोलियर एफिड्स), प्ररोह मक्खी (शूट फ्लाई), दीमक और गुलाबी तना बेधक के विरुद्ध परीक्षण किये गए। एकीकृत कीट प्रबन्धन मॉड्यूल ने आईपीएम मॉड्यूल उपचार में कृषक अभ्यास से तुलनात्मक रूप से कम कीट आबादी दर्शाई। हालांकि, कृषक अभ्यास उपचार में प्राकृतिक शत्रुओं की आबादी आईपीएम उपचार से थोड़ी अधिक थी।
- चार अलग–अलग प्रकार के अनाज भंडारण थैलों जैसे जूट, कपड़ा, एचडीपीई और बीओपीपी थैलों का परीक्षण भंडारण कीट संक्रमण के साथ–साथ अनाज की गुणवत्ता पर उनके प्रभाव को निर्धारित करने के लिए किया गया। अवलोकनों से पता चला है कि बी.ओ.पी.पी. थैलों में अन्य थैलों की तुलना में भंडारण कीटों की संख्या सबसे कम थी।

संसाधन प्रबंधन

- धान–गेहूँ प्रणाली में दस वर्षीय लम्बी अवधि के जुताई प्रयोग के परिणाम दर्शाते हैं कि धान में की गई विभिन्न जुताई विकल्पों का गेहूँ की उत्पादकता पर कोई प्रभाव नहीं पड़ता जबकि गेहूँ में विभिन्न जुताई विकल्पों का गेहूँ की उत्पादकता पर कुछ प्रभाव पाया गया और उत्पादकता रोटरी टिलेज में कुछ अधिक पाई गई।
- मक्का–गेहूँ–मूँग फसल प्रणाली के लम्बी अवधि प्रयोगों में पाया गया कि गेहूँ की उत्पादकता सबसे ज्यादा (73.5 कुंतल/हैक्टर) तब मिली जब अनुशंसित उर्वरकों के साथ 10 टन प्रति हैक्टर गोबर की खाद डाली गयी।
- संरक्षित खेती (सीए) के दीर्घकालीन प्रयोगों में गेहूँ उगाने के दौरान भूमि का 5 सें.मी. गहराई तक का तापमान परम्परागत विधि की तुलना में सुबह थोड़ा अधिक तथा दोपहर बाद थोड़ा कम दर्ज किया गया।
- धान–गेहूँ फसल प्रणाली के अंतर्गत प्रक्षेत्र प्रदर्शनों (बदरपूर और तरावड़ी) में ट्र्बो हैप्पी सीडर एवं सामान्य जुताई द्वारा बोये गए गेहूँ (एचडी 2967 व एचडी 3086) में गेहूँ की समान उत्पादकता दर्ज की गई।
- उन्नत रोटरी डिस्क ड्रिल (आर.डी.डी.) मशीन को पूर्ण धान फसल अवशेष एवं पूर्ण गन्ना पत्ती अवशेष में गेहूँ की बिजाई हेतू परीक्षण किया गया और इसकी दक्षता में सार्थक सुधार दर्ज किया गया। किसानों के खेतों पर ट्र्बो हैप्पी सीडर के मुकाबले पूर्ण गन्ना पत्ती अवशेषों की उपस्थिति में गेहूँ बिजाई हेतू यह मशीन बेहतर पायी गयी।
- संरक्षित खेती (सीए) प्रणाली के लिए प्रजातियों की पहचान हेतू किये गये अध्ययन में सामान्य बुआई की तुलना में अगेती बुआई में सार्थक उत्पादकता वृद्धि पायी गई। सीए तथा परम्परागत जुताई में उत्पादकता समान पायी गई। जबकि भिन्न–भिन्न किस्मों में उत्पादकता में सार्थक अन्तर पाया गया और दस किस्मों में से पीबीडब्ल्यू 723, बीआईएसए 921 एवं बीआईएसए 927 ने अन्य किस्मों की तुलना में अधिक पैदावार दी।
- उच्च उत्पादकता हेतू गेहूँ की 15 किस्मों को अनुशंसित मात्रा से अधिक रासायनिक उर्वरकों एवं देशी खादों को वृद्धि तथा रोधक कारकों का स्प्रे करते हुए परखा गया। इसमें दो किस्मों डीबीडब्ल्यू 187 और डीबीडब्ल्यू 303 ने सबसे अधिक क्रमशः 78.8 एवं 78.2 कुंतल/हैक्टर उत्पादन दिया जहाँ 150 प्रतिशत अनुशंसित उर्वरक + 15 टन देशी खाद + क्लोरमिक्वाट (लिहोसिन) 0.2 प्रतिशत व टेबुकोनाजोल (फॉलीकर 430 एससी) 0.1 प्रतिशत उत्पाद मात्रा को प्रथम गाँठ बनने व ध्वज पर्ण अवस्था पर स्प्रे किया।
- समेकित पोषण प्रबन्धन में अनुशंसित उर्वरकों के साथ 15 टन देशी खाद/हैक्टर की दर से डालने पर गेहूँ की सबसे अधिक उत्पादकता दर्ज की गई।
- गेहूँ की उन्नत किस्मों एचडी 2967, एचडी 3086, डब्ल्यूबी 2 व डब्ल्यूएच 1105 के जैविक उत्पादन प्रयोग में पाया गया कि देशी खादों के 10 से 30 टन/हैक्टर की दर से उपयोग करने पर खाद रहित की तुलना में सार्थक उत्पादकता वृद्धि दर्ज की गई लेकिन अनुशंसित रसायनिक उर्वरकों की तुलना में 20–25 प्रतिशत कम उत्पादकता पायी गई।
- देशी खादों के बढ़ते क्रम में (10 से 30 टन/हैक्टर) उपयोग से मृदा की जैविक कार्बन, उपलब्ध नाइट्रोजन, फॉस्फोरस एवं पोटाशियम में अनुशंसित उर्वरकों व खाद रहित की तुलना में सार्थक वृद्धि दर्ज की गई।

- फसल अवशेष प्रबन्धन प्रयोग के नतीजे दर्शाते हैं कि धान की पराली को अनुशंसित मात्रा से 25 प्रतिशत ज्यादा नाइट्रोजन उपयोग के साथ मिट्टी में मिलाने पर गेहूँ की उत्पादकता में वृद्धि दर्ज की गई और इससे नाइट्रोजन का स्थिरीकरण भी कम हुआ।
- अवशेष प्रबन्धन के दूसरे प्रयोगों में यह पाया गया कि गेहूँ के बाद मूंग उगाने पर इसका 10–12 कुंतल/हैक्टर उत्पादन मिला और इसके अवशेषों को खेत की मिट्टी में मिलाने से धान की फसल में 50 प्रतिशत नाईट्रोजन की बचत हुई और धान की उत्पादकता भी अधिक पायी तथा मिट्टी की भौतिक–रासायनिक गुणवत्ता में भी सुधार हुआ।
- गेहूँ के बाद धान से पहले शून्य जुताई और बिना उर्वरकों के भी मूंग उगया जा सकता है। इसमें मूंग की 10–12 कुंतल/हैक्टर उत्पादकता प्राप्त हुई तथा धान में 25 प्रतिशत नाईट्रोजन की भी बचत हुई।
- मक्का के साथ दलहनी फसलों के अतः फसलीकरण से केवल मक्का–गेहूँ फसल–चक्र के मुकाबले अधिक भू तुल्यांक अनुपात प्राप्त हुआ और गेहूँ में 25 प्रतिशत नाईट्रोजन की भी बचत हुई।
- भिन्न–भिन्न फसल–चक्रों के अध्ययन में पाया गया कि मक्का–आलू–गेहूँ तथा ज्वार (चारा)–आलू–गेहूँ फसल–चक्रों में सबसे अधिक आय प्राप्त हुई।
- चौड़ी पत्ती वाले विभिन्न खतपतवारों का प्रभावी नियन्त्रण हैलोक्सीफैन + फ्लुरोक्सीपायर 200.6 (6.1 + 194.5) ग्राम/हैक्टर तैयार मिश्रण के उपयोग से पाया गया। इस तैयार मिश्रण संयोजन ने गेहूँ फसल में उच्च चयनात्मकता दर्ज की।
- खरपतवारनाशी संयोजन पायरोक्सासल्फोन + मेटसल्फ्यूरोन व पैन्डीमैथालिन + मेट्रीब्यूजिन जमाव पूर्व उपयोग के रूप में तथा क्लोडिनाफॉप/पिनोक्साडेन + मेट्रीब्यूजिन के टैंक मिश्रण को जमाव के बाद उपयोग करने के रूप में परखा गया और इससे गेहूँ के विभिन्न खरपतवारों का प्रभावी नियन्त्रण पाया गया।
- पायरोक्सासल्फोन + पेन्डीमैथालिन 125+1000 ग्राम/हैक्टर तथा फ्लुमिओक्साजिन 100–125 ग्राम/हैक्टर की दर से अंकुरण पूर्व उपयोग करने से गेहूँ फसल में संकरी पत्ती एवं चौड़ी पत्ती वाले खरपतवारों का प्रभावी नियन्त्रण पाया गया।
- धान–गेहूँ प्रणाली में दोहरी शून्य जुताई वाले खेतों में चौड़ी पत्ती वाले खरपतवारों जैसे; जंगली पालक (*रूमैक्स डेन्टेटस*) व *मेडिकागो डेन्टीकुलाटा* की समस्या में वृद्धि दर्ज की गई।
- मंडूसी और जंगली जई की बहुशाकनाशी प्रतिरोधकता (क्लोडिनाफॉप, पिनोक्साडेन व सल्फोसल्फ्यूरोन के विरुद्ध) प्रबंधन के लिए वैकल्पिक खरपतवारनाशी पायरोक्सासल्फोन तथा मेट्रीब्यूजिन प्रभावी पाये गये।
- सल्फोनाईल यूरिया खरपतवारनाशी प्रतिरोधी लोमड़ घास के नियंत्रण हेतू गेहूँ में पेन्डीमैथालिन तथा पायरोक्सासल्फोन प्रभावी पाये गये।
- सतह पर फसल अवशेष को रखने के साथ शून्य जुताई तथा बिजाई पूर्व डाले गये खरपतवारनाशी (पेन्डीमैथालिन + मेट्रीब्यूजीन या पायरोक्सासल्फोन + मेटसल्फ्यूरोन) का समेकित प्रयोग मन्डूसी नियंत्रण के लिए प्रभावी पाया गया।
- मेटसल्फ्यूरोन रोधी जगंली पालक (*रूमैक्स डेन्टेटस*) तथा बथुआ (*चिनोपोडियम एलबम*) के नियन्त्रण के लिए (2, 4–डी.) कारफेन्ट्राजोन तथा फ्लोक्सीपायर शाकनाशी उपयुक्त पाये गये।
- गेहूँ में पोटाशियम सल्फेट या पोटाशियम क्लोराइड की 2 प्रतिशत सान्द्रता का पणीर्य छिड़काव सीमित सिंचाई वाली परिस्थितियों में लाभकारी पाया गया।
- गेहूँ की नौ किस्मों (डीबीडब्ल्यू 222, डीबीडब्ल्यू 173, डीबीडब्ल्यू 110, डीबीडब्ल्यू 166, डीबीडब्ल्यू 187, आईबीडब्ल्यू, एसएन 106, आईबीडब्ल्यूएसएन 1278, पीवाईटी 69, पीवाईटी 80) में 80 व 60 प्रतिशत सीपीई नमी स्तर पर जल उपयोग दक्षता 2.51 किलोग्राम/घनमीटर जल से अधिक पायी गई।
- प्रायद्वीपीय क्षेत्र की एचआई 1605, एनआईएडब्ल्यू 3170, एनआईएडब्ल्यू 1415, एनआईएडब्ल्यू 3624 किस्में उचित उत्पादकता स्तर बनाये रखते हुये बेहतर जल उपयोग दक्षता वाली पायी गई।
- गाँठ बनने व बालियाँ निकलने की अवस्थाओं पर पोटाशियम के दो पर्णीय छिड़कावों का गेहूँ उत्पादकता पर सकारात्मक प्रभाव पाया गया।
- भू उपयोग भू आवरण विश्लेषण और गेहूँ की बुआई का हरियाणा में क्षेत्रफल जाँचने के लिए लैडसट 8 ऑपरेशनल लैंड़ इमेजर (ओ एल आई) का उपयोग किया गया। गेहूँ बीजाई क्षेत्र का अनुमान वर्गीकृत छवि के अन्दर पाये गये पिक्सेल की गणना को पोस्ट क्लासीफिकेशन तकनीक का उपयोग करते हुए लगाया गया। गेहूँ का कुल क्षेत्र 2.32 मिलियन हैक्टर पाया गया जो कि हरियाणा के कुल भौगोलिक क्षेत्रफल (4.41 मिलियन हैक्टर) का लगभग 52.6 प्रतिशत था।

गुणवत्ता एवं मूलभूत विज्ञान

- ब्रेड गेहूँ (*ट्री. ऐस्टिवम*) में कई प्रजातियाँ चपाती बनाने के लिए योग्य पाई गई जिनका गुणवत्ता स्कोर 10 में से 8 से अधिक था। इन प्रजातियों में शामिल हैं; पीबीडब्ल्यू 771, डीबीडब्ल्यू 301 एवं पीबीडब्ल्यू 824
- ब्रेड गेहूँ की प्रजातियों डीबीडब्ल्यू 221, डीबीडब्ल्यू 222, बीआरडब्ल्यू 3806, एनआईएडब्ल्यू 3170, एचआई 1621, डब्ल्यूएच 1254 एवं डीबीडब्ल्यू 303 में लोफ आयतन ≥ 600 सीसी के साथ अच्छी ब्रेड गुणवत्ता पाई गई।
- एनआईएडब्ल्यू 3170 एक नरम दाने वाली प्रजाति जिसका कठोरता सूचकांक 35 से कम पाया गया को बिस्कुट बनाने के लिए चयनित किया गया।
- चेक सहित सभी एवीटी प्रस्तुतियों में ग्लू–ए1, ग्लू–बी1 एवं ग्लू–डी1 द्वारा कोडिड उच्च आणविक भार ग्लूटन की सब यूनिट इकाईयों की पहचान की गई।
- कठिया (ड्यूरम) गेहूँ की किस्म डीडीडब्ल्यू 47 को उच्च पीला रंजक (7.6 पीपीएम) के लिए चयनित किया गया जोकि पास्ता उत्पादों के लिए उपयुक्त विशेषता है। तीन ड्यूरम प्रविष्टियों यूएएस 466, एचआई 8627 एवं डीडीडब्ल्यू 47 में प्रोटीन की मात्रा 13 प्रतिशत से अधिक पायी गई। ।
- एवीटी प्रथम वर्ष की प्रस्तुतियों में जीडब्ल्यू 509 (प्रायद्वीपीय क्षेत्र) प्रजाति में अधिक मात्रा में लोहा (44.6 पीपीएम) और जस्ता (46.3 पीपीएम) पायी गई।
- देश के 15 स्थानों पर उगाई गई क्यूसीएसएन की 52 प्रस्तुतियों का दानो के रंग–रूप, परीक्षण भार, प्रोटीन एवं अवसादन मान के लिए आंकलन किया गया।
- पीला रंजक तथा ग्लूटेन शक्ति के मूल्यांकन के लिए सूक्ष्म स्तरीय परीक्षणों का विकास किया गया जिससे लगभग 400 जननद्रव्य लाईनों, 500 पृथक्कृत पीढ़ियों, 300 विमोचित प्रजातियों, तथा 2000 समन्वयक कार्यक्रम के नमूनों का सफलतापूर्वक मूल्यांकन किया गया जिससे समय की बचत के साथ–साथ कम मात्रा में रसायनों का प्रयोग किया गया और वातावरण में प्रदूषण कम हुआ।
- दो वर्षो तक गेहूँ में लौह एवं जस्ता का छिड़काव किया गया जिसमें यह पाया गया कि दानो में जस्ते की मात्रा में महत्वपूर्ण बढ़ोत्तरी हुई। इससे यह पता चलता है कि सस्य क्रियाओं द्वारा बायोफोर्टीफिकेशन विधि से गेहूँ के दानो में जस्ता की मात्रा को बढ़ाने का एक प्रभावी तरीका है।
- गेहूँ की 100 प्रजातियों का सीडी विषाक्त एपीटोप की उपस्थिति के लिए मूल्यांकन किया गया। दो वर्षों के आंकड़े यह दिखाते हैं कि पिछले 60 वर्षों में विमोचित प्रजातियों में सीडी विषाक्त एपीटोप की उपस्थिति में अर्थपूर्ण बदलाव नहीं आया है।
- लौह/जस्ता के अवशोषण/स्थानांतरण एवं संचयन की प्रक्रिया को समझने के लिए गेहूँ के चार जीनोटाइपों का ट्रांसक्रिप्टोम विश्लेषण किया गया। ट्रांसक्रिप्टोम विश्लेषण दिखलाता है कि लौह/जस्ता की कमी में फॉयटोसिडेरोफोर संश्लेषण से संबंधित जीनों की अभिव्यक्ति है।
- पीबीडब्ल्यू 502 की पृष्ठभूमि में विकसित उच्च फाइटेज स्तर (>2000 एफ.टी.यू/कि.ग्रा.) वाली उत्परिवर्तक लाईनों को फसल वर्ष 2018–19 में उगाया गया तथा सूक्ष्म तत्वों की जैव उपलब्धता में सुधार के लिए इन्हें अधिक उपज वाली किस्मों के साथ संकरण के लिए इस्तेमाल किया गया।
- उच्च प्रोटीन तथा अधिक लौह एवं जस्ता से सम्बंधित आणविक मार्करों की पहचान के लिए जीपी सी–बी1 जीन वाली गेहूँ की लाईन तथा अधिक उपज वाली किस्म एचडी 2967 के संकरण से आरआईएल (एफ 7) विकसित की गई।
- नापहाल के ग्लू–डी1 डबल नल को उच्च उत्पादकता वाली प्रजातियों जैसे पीबीडब्ल्यू 373, यूपी 2425, राज 3765, डीपीडब्ल्यू 50 एवं एचडी 2967 में आणविक मार्करों तथा सूक्ष्म स्तरीय परीक्षणों की सहायता से स्थानांतरित किया गया। ये सभी लाईनें विकास के अलग–अलग चरण में हैं।
- नापहाल में ग्लू–डी 1 डबल नल के लिए विकसित सहप्रभावी मार्करों का विविध जननद्रव्यों में प्रमाणीकरण किया गया। यह मार्कर उच्च उत्पादकता वाली किस्मों की बिस्कुट की गुणवत्ता बढ़ाने के लिए प्रजनन कार्यक्रमों में उपयोगी होगा।
- 2.5 एलओडी मान के साथ इन्टरवल और कम्पोजिट इन्टरवल मानचित्रण के द्वारा लवण तनाव से सम्बधित गुणसूत्र खण्डों को पहचाना गया। 10 विभिन्न लक्षणों के लिए 7 गुणसूत्र खण्डों पर 25 क्यूटीएल का पता लगाया गया जोकि 2.6–15.1 प्रतिशत पीवीई को दर्शाता है। यह लवण सहिष्णुता के मजबूत आनुवंशिक गुण को दर्शाता है तथा इस जानकारी को गेहूँ में लवण सहिष्णुता में सुधार के लिए इस्तेमाल किया जा सकता है।
- एनआईवीटी के नमूनों के विश्लेषण के आधार पर यह पता चला कि अम्बर गेहूँ की तुलना में रंगीन गेहूँ में कुल एंटी ऑक्सीडेंट गतिविधि तथा प्रसंस्करण गुणवत्ता में कोई विशिष्ट

अंतर नहीं है इसीलिए इनकी अलग से प्रजाति के रूप में संस्तुति नहीं दी जानी चाहिए।

सामाजिक विज्ञान

- वर्ष 2018–19 में रबी फसल सत्र के दौरान देश भर में एक–एक एकड़ के 1500 अग्रिम पंक्ति प्रदर्शन 83 समन्वयक केन्द्रों को आवंटित किए गए। गेहूँ के अग्रिम पंक्ति प्रदर्शनों को देश भर के 19 राज्यों में 1562 किसानों के 1503.34 एकड़ क्षेत्रफल पर आयोजित किया गया।
- गेहूँ के अधिकतम अग्रिम पंक्ति प्रदर्शन उत्तर प्रदेश (192), इसके बाद बिहार (142) में आयोजित किए गए। अधिकतम उपज लाभ मणिपुर (36.75 प्रतिशत) में दर्ज किया गया। उन्नत किस्मों के कारण अधिकतम उपज लाभ उत्तर पूर्वी मैदानी क्षेत्र (20.21 प्रतिशत) में दर्ज किया गया।
- मध्य क्षेत्र के इन्दौर केन्द्र पर कठिया गेहूँ की उन्नत प्रजातियाँ एचडी 4728 एवं एचडी 8759 से औसत उपज 65.00 कुंतल/हैक्टर प्राप्त हुई। जबकि प्रायद्वीपीय क्षेत्र के पूना केन्द्र पर डाईकोकम गेहूँ की उन्नत प्रजाति एमएसीएस 3949 से औसत उपज 46.50 कुन्तल/हैक्टर प्राप्त हुई। मध्य क्षेत्र के वीजापुर केन्द्र पर गेहूँ की उन्नत किस्म जीडब्ल्यू 11 की औसत उपज 52.87 कुन्तल/हैक्टर थी जोकि जाँचक किस्म से महत्वपूर्ण रूप से अधिक थी।
- औसत रूप से, अग्रिम पंक्ति प्रदर्शन में गेहूँ की नवीन किस्मों एवं तकनीकों के कारण एक रूपये की लागत पर 3.07 रूपये की आमदनी प्राप्त हुई। विभिन्न राज्यों में यह आमदनी 1.54 रूपये से 6.90 रूपये तक रही। हैप्पी सीडर के प्रयोग से अर्जित आय 7.37 रूपये तक रही। अग्रिम पंक्ति प्रदर्शन से यह ज्ञात होता है कि सबसे अधिक प्रति हैक्टर लाभ हरियाणा (100224 रूपये) दर्ज किया गया। गेहूँ की नई किस्म या उत्पादन तकनीक के उपयोग से प्रति हैक्टर 64592 रूपये लाभ प्राप्त हुआ।
- सभी क्षेत्रों की समग्र बाधाओं के विश्लेषण से पता चलता है, कि आवकों की उच्च कीमत, छोटी जोत, नई संस्तुत किस्मों के बीज की अनुपलब्धता, श्रमिकों की अनुपलब्धता, भूमि के समतलीकरण के लिए अधिक मशीन किराया लागत, आदि को गेहूँ के उत्पादन एवं उत्पादकता को प्रभावित करने वाली प्रमुख बाधाएं हैं।
- रबी फसल सत्र 2018–19 के दौरान जौ के 250 अग्रिम पंक्ति प्रदर्शन देश भर के 6 राज्यों के 264 किसानों की 238.5 एकड़ क्षेत्रफल पर किया गया।
- देश में जौ का अधिकतम उपज लाभ उत्तर प्रदेश (27.28%) में उसके बाद मध्य प्रदेश (24.58%) में दर्ज किया गया।
- उत्तर पूर्वी मैदानी क्षेत्र के कानपुर केन्द्र पर जौ की प्रजाति डीडब्ल्यूआरबी 137 की औसत उपज 52.75 कुंतल/हैक्टर एवं उत्तर पश्चिमी मैदानी क्षेत्र के दुर्गपुरा केन्द्र पर जौ की प्रजाति आरडी 2907 की औसत उपज 63.72 कुंतल/हैक्टर पाई गई।
- जौ के अग्रिम पंक्ति प्रदर्शन में नई प्रजातियों से प्रचलित प्रजातियों की तुलना में 25 प्रतिशत अधिक आमदनी प्राप्त हुई। प्रदर्शनों के माध्यम से प्रति रूपये लागत पर सर्वाधिक आमदनी पंजाब (6.49 रूपये) में, उसके बाद उत्तर प्रदेश (4.16 रूपये) में दर्ज की गई। सबसे अधिक प्रति हैक्टर लाभ उत्तर प्रदेश (73870 रूपये) में प्राप्त किया गया। जौ में प्रति रूपये लागत से सर्वाधिक आमदनी उत्तर पूर्वी मैदानी क्षेत्र (4.16 रूपये) में हुई। मध्य प्रदेश में सबसे कम (271रूपये प्रति कुंतल) उत्पादन की लागत थी।
- भूमि जलस्तर में गिरावट, छोटी जोत, कम बाजार मूल्य, आवकों की उच्च कीमत, किसानों में नवीन तकनीकी ज्ञान का अभाव फसल पकने के समय उच्च तापमान, फसल विकास के दौरान तापमान में उतार–चढ़ाव, आदि प्रमुख बाधाएं थी जो जौ के उत्पादन को प्रभावित करती हैं।
- रबी फसल सत्र 2018–19 के दौरान भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल द्वारा अमीन, बीड अमीन, अमीन डेरा रामपुरा, डीग एवं यारा गाँवों के 20 किसानों के 20 एकड़ खेत में गेहूँ की उन्नत किस्मों एचडी 3086 एवं डीबीडब्ल्यू 173 के अग्रिम पंक्ति प्रदर्शन आयोजित किए गए।
- इस अवधि में भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल, कृषि एवं किसान कल्याण मन्त्रालय एवं सम्बन्धित केन्द्रों के विशेषज्ञों के दल द्वारा खुडवनी अनंतनाग, राजौरी, कठुआ, नोएडा, रेवाड़ी, उजवा, आईएआरआई, नई दिल्ली, इंदौर, उज्जैन, रतलाम, फैजाबाद, कानपुर, वाराणसी, धारवाड़, बेलागवी, वेलिंगटन जूनागढ़, वीजापुर, जयपुर, अजमेर, टोंक और करौली केंद्रों द्वारा आयोजित अग्रिम पंक्ति प्रदर्शनों का अवलोकन किया गया।
- वर्ष 2018–19 के दौरान हरियाणा राज्य के रोहतक जिले के बैंसी और सांघी गांवों के कुल 120 नमूना किसानों जिन्होंने गेहूँ की बीजाई के लिए शून्य जुताई (जीरो टिलेज) या टर्बो हैपी सीडर को अपनाया हुआ था का सर्वेक्षण किया गया। कुल 120 किसानों में से 60 लाभार्थियों एवं 60 गैर लाभार्थियों को सर्वेक्षण के लिए चुना गया था। इनमें 64.17 किसान बड़ी श्रेणी

के थे, तथा 27.5 मध्यम श्रेणी में थे। शून्य जुताई के तहत प्रति किसान औसत क्षेत्र 17.70 एकड़ था, जबकि शून्य जुताई तकनीक लाभार्थियों की प्रति किसान औसतन 18.82 एकड़ था।

- पूर्वी उत्तर प्रदेश के दो जिलों में (प्रयागराज/ इलाहाबाद व गाजीपुर) 200 गेहूँ के उत्पादकों सर्वेक्षण में जोत का आकार पर एकत्रित आकड़ों के विश्लेषण के निष्कर्षों से संकेत मिलता है कि प्रयागराज जिले में उपज अन्तराल–1 नकारात्मक था जबकि गाजीपुर जिले में उपज अन्तराल–2 न्यूनतम पाया गया। डाटा इन्वेलपमेंट विश्लेषण (डीईए) से पता चलता है कि संवेदनशील मौसम सप्ताह, फसल विशेष एवं क्षेत्र विशेष आकड़ों के विश्लेषण इशारा करते हैं कि समान उत्पादन स्तर पर आदानों का स्तर लगभग 15 प्रतिशत कम किया जा सकता है। उदाहरण के लिए गाजीपुर जिले में गेहूँ के उपज स्तर ग्यारहवें सप्ताह के दौरान वर्तमान तापमान के प्रति अधिक संवेदनशील हैं। परन्तु प्रयागराज जिले में ऐसा नहीं देखा गया। परिणामों से आशय यह है कि चयनित शोध क्षेत्रों में गेहूँ की फसल फूल आने, दानो में दूध बनने एवं दाना बनने की अवस्थाओं के दौरान मौसम की अनियमितताओं के प्रति संवेदनशील है। जौ के मामले में, कल्ले निकलने, फूल आने, दाने सख्त होने, पकने की अवस्था एवं संवेदनशील फसल विकास की अवस्थाओं के रूप में चिन्हित की गई हैं।
- वर्ष 2018–19 के दौरान आदिवासी उप–परियोजना (टीएसपी परियोजना) के तहत निम्नलिखित आठ केन्द्रों को शामिल किया गया था जो इस प्रकार हैं; खुडवनी, लेह (जम्मू एवं कश्मीर), लाहौल एवं स्पिति (हिमाचल प्रदेश), जबलपुर (मध्य प्रदेश), बिलासपुर (छत्तीसगढ़), उदयपुर (राजस्थान), धारवाड़ (कर्नाटक) एवं रांची (झारखंड)। वर्ष 2018–19 के दौरान इस परियोजना के अंतर्गत विभिन्न केन्द्रों द्वारा विभिन्न गतिविधियों जैसे प्रशिक्षण (1), फसल प्रदर्शन (193), किसान मेले/प्रक्षेत्र दिवस (16) का आयोजन किया गया।
- इसी अवधि में मेरा गाँव मेरा गौरव, किसानों की आय दोगुनी करने, मृदा स्वास्थ्य कार्ड के प्रति जागरूकता पैदा करने से सम्बंधित गतिविधियों का संपादन हुआ। साथ ही 4 प्रशिक्षण कार्यक्रम, 7 प्रदर्शनी 5 टीवी कार्यक्रम, 77 भ्रमण समन्वयन एवं 7 जागरूकता कार्यक्रम/किसान दिवस आयोजित किए गए। 1200 से अधिक किसानों/उद्यमियों/अन्य हितधारकों को विभिन्न प्लेटफार्म के माध्यम से उनके प्रश्नों के उत्तर दिए गए।

जौ सुधार

- वर्ष 2018–19 में भारत में 6.1 लाख हैक्टर क्षेत्रफल से 17.5 लाख टन जौ का उत्पादन हुआ तथा 28.8 कुंतल प्रति हैक्टर की अब तक की सर्वाधिक उत्पादकता दर्ज की गई।
- जौ की पाँच नई किस्में, डीडब्ल्यूआरबी 160, आरडी 2899, आरडी 2907, पीएल 891 और एचबीएल 713 व्यवसायिक खेती के उद्देश्य से जारी की गई।
- दो जेनेटिक स्टॉक डीडब्ल्यूआरबी 191 एवं डीडब्ल्यूआरबी 192 को क्रमशः उच्च जस्ता तथा लौह तत्व हेतु एनबीपीजीआर, नई दिल्ली में पंजीकृत किया गया।
- समन्वित अनुसंधान केंद्रों की सहायता से कृषि मंत्रालय के आग्रह पर 827.85 कुंतल के मांग पत्र के एवज में जौ 29 की किस्मों के 1421 कुंतल प्रजनक बीज का उत्पादन किया गया ।
- एवीटी में श्रेष्ठता के आधार पर, डीडब्ल्यूआरबी 182 को एवीटी अंतिम वर्ष परीक्षण में पदोन्नत किया गया था, जबकि–छिलका रहित खाद्य जौ परीक्षण में डीडब्ल्यूआरबी 204 को एवीटी में पदोन्नत किया गया है। साथ ही तीन अन्य प्रविष्टियों; डीडब्ल्यूआरबी 197 और पीएल 908 को एवीटी–माल्ट जौ में पदोन्नत किया गया।
- इकार्डा अंतर्राष्ट्रीय नर्सरी आईबीवाईटी–18–9, आईएनबीवाईटी– एचआई– 19–11, 5वीं जीएसबीवाईटी–18–19, आईबीओएल–18–47, आईबीओएल–18–60 वीकेएसजे आईबीओ–18–100 से छह विदेशी जननद्रव्य लाईनें पर्ण झुलसा रोग के लिए मध्यम प्रतिरोधी पायी गयीं।
- इकार्डा अंतर्राष्ट्रीय नर्सरी में अन्य छह विदेशी जननद्रव्य लाइनों (आईबीवाईटी– एचआई–19–15, आईबीवाईटी– एचआई–19–17, आईबीवाईटी– एचआई–19–22 आईबीवाईटी– एचआई– 19–12, आईबीवाई– एचआई– 19–7 एवं आईबीवाईटी– एचआई–19–22) को मूल्यांकन द्वारा उत्तम पाया गया।
- 118 चयनित जननद्रव्यों के बीजों को विभिन्न कृषि विश्वविद्यालयों एवं भाकृअनुप के संस्थानों में काम करने वाले जौ प्रजनकों को आपूर्ति की गई।
- भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल में मध्यम अवधि के भंडारण मॉड्यूल सुविधा में जौ के कुल 8193 परीक्षण का संरक्षण किया जा रहा है। रबी 2018–19 के

दौरान कुल 500 जननद्रव्य लाईनों का संग्रह हेतु फिर से उत्पादन किया गया।

- धान के अवशेष में जीरो टिलेज बुआई में अन्य विधियों की तुलना में अधिक अनाज की उपज प्राप्त हुई एवं जौ के बीज और अनाज की गुणवत्ता में भी सुधार हुआ। परिवर्तनीय लागत और बीःसी (मुनाफा÷लागत) अनुपात पर आमदनी लगभग बराबर थी। कैनोपी का तापमान इस स्थिति में कम पाया गया, और एनडीवीआई और क्लोरोफिल सूचकांक अधिक दर्ज हुआ। इससे खेती की लागत, समय, ऊर्जा में बचत तथा शुद्ध लाभ में वृद्धि होती है।
- जननद्रव्य बीसीयू 2030 की पहचान निम्न बीटा ग्लूकन और उच्च बीटा ग्लुकेनेस एंजाइम हेतु की गयी।
- हलैक्सीफेन मिथाइल (10.21 ग्राम सक्रिय तत्व / प्रति हैक्टर) और फ्लोरासुलाम (20 ग्राम / हैक्टर) के तैयार मिश्रण को जौ में चौड़ीपत्ती वाले खरपतवारों को नियंत्रित करने के लिए इस्तेमाल किया जा सकता है।
- पूसा हाइड्रोजेल और एक अन्य नई हाइड्रोजेल को 2.5 किलोग्राम प्रति हैक्टर की दर से प्रयोग करने पर जाचँक प्लॉट की तुलना में अधिक उपज हुआ। इस हाइड्रोजेल के उपयोग से एक सिंचाई की बचत जा सकती है।

क्षेत्रीय केन्द्र फ्लावरडेल, शिमला

- भारत के गेहूँ उगाये जाने वाले क्षेत्रों से इस वर्ष कोई भी रतुआ महामारी की रिपोर्ट नहीं थी। उत्तरी भारत के कुछ स्थानों पर पीला रतुआ को बहुत कम आवृत्ति में देखा गया। आश्चर्यजनक रूप से पीला रतुआ को मध्य प्रदेश के इंदौर जिले के ईगल बीज फार्म (ग्राम–पिपलिया) में लोक–1 एवं सुजाता किस्मों पर प्रतिबंधित फोसाई के रूप में देखा गया। भूरा रतुआ महाराष्ट्र, गुजरात और कर्नाटक के कुछ क्षेत्रों में छिटपुट रूप से दिखाई दिया। देश के किसी भी राज्य या क्षेत्र में गेहूँ एवं जौ का काला रतुआ किसानों के खेतों पर नहीं देखा गया।
- इस वर्ष गेहूँ की फसल पर रतुआ रोग लगभग नहीं पाये गये। भारत के 13 राज्यों एवं नेपाल से प्राप्त गेहूँ एवं जौ रतुआ के 627 नमूनों में क्रमशः पीले, भूरे और काले रतुओं के 201, 292 और 134 नमूने शामिल थे। पीला रतुआ प्रतिरोध जीन्स बाई आर 5, 10, 15 एस पी, काला रतुआ प्रतिरोध जीन्स एस आर 26, 27, 31, 32, 35, 39, 40, 43, टीटी 3 एवं टीएमपी और भूरा रतुआ प्रतिरोध जीन्स एलआर 25, 29, 32, 39, 42, 45 एवं 47 क्रमशः *पाक्सीनिया स्टॉईफॉर्मिस* एफएसपी *ट्रिलिसिन* की पापुलेशन के प्रति प्रभावी थे।
- रतुआ नमूनों के विश्लेषण में, पीएसटी पैथेटाइप 46 एस 119 की आवृत्ति अधिकतम (47.3 प्रतिशत) पायी गई। पीटी पैथेटाइप 77–9, 77–13, एवं 77–5 प्रबलता में पाये गये और इनकी आवृति क्रमशः 51.1, 20.2 एवं 15.1 प्रतिशत थी। *पक्सीनिया ग्रेमिनिस ट्रिटिसाई* का पैथोटाइप 11 सर्वाधिक नमूनों में 50 प्रतिशत पाया गया। तत्पश्चात, पैथेटाइप 15–1 और 40 ए क्रमशः 22.3 और 15.6 प्रतिशत नमूनों में पाये गये।
- गेहूँ एवं जौ की 3000 से अधिक लाईनों का मूल्यांकन पीएसटी, पीजीटी एवं पीटी के विभिन्न पैथोटाइपों के विरूद्ध किया गया। इनमें एवीटी की 158, एनबीडीएसएन एवं ईबीडीएसएन की 284 और ब्रीडर्स लाईने शामिल थीं। चार एवीटी लाईने (पीबीडब्ल्यू 821, 822, 823, 757) पीला, भूरा एवं काला रतूआ पैथोजन के सभी प्रभेदों के लिए प्रतिरोधी थीं। जबकि, एनआईडीडब्ल्यू 1158, पीबीडब्ल्यू 752 एवं पीबीडब्ल्यू 581 केवल पीला रतुआ प्रतिरोधी थी। वीएल 3021 में पीएसटी के पैथोटाइप (46एस 119, 110एस 119) और पीटी (77–9, 104–2) के प्रति प्रभेद विशिष्ट व्यस्क पौध प्रतिरोधकता पायी गयी।
- चार प्रकार के वाईआर जीन्स (वाईआर 2, 9, ए एवं 18) की 91 एवीटी लाईनों में पता लगाया गया। इसी प्रकार ग्यारह एलआर जीन्स (एलआर 1, 2, 3, 10, 13, 18, 19, 23, 24, 26, 34) और चौदह एस आर जीन (एसआर 2, 5, 7बी, 8ए, 8बी, 9ए, 11, 13, 24, 25, 28, 30, 31) को क्रमशः 75.3 और 79.1 प्रतिशत एवीटी लाइनों में अनुमानित किया गया।
- एनबीडीएसएन एवं ईवीडीएसएन की किसी भी लाईन में सभी पीएस, पीजीटी एवं पी प्रभेदों के प्रतिरोधिता नहीं पायी गयी। एनबीडीएसएन की तीन लाईन (बीएस 1024, केबी 1762, आरडी 3008) भूरा एवं काला रतुआ प्रतिरोधी थीं। इसी प्रकार, बीएचएस 474, एचबीएल 845, 863, आरडी 2786, आरडी 2991 और आरडी 3003 भूरा एवं पीला, डीडब्ल्यूआरबी 182, एचबीएल 812 काला एवं पीला रतुओं के प्रति प्रतिरोधी पायी गयी।
- सभी रतुआ पैथोजनों के 145 से अधिक प्रभेदों को जीवित होस्ट के साथ–साथ क्रायो–संरक्षित भी किया गया। भारत में रतुआ अनुसंधान को सुचारू ढंग से चलाने के लिए विभिन्न प्रभेदों के नाभकीय इनोकुलम को 45 शोधकर्ताओ / केन्द्रों को भेजा गया। गेहूँ रोग परीक्षण नर्सरी (डब्ल्यूडीएमएन) और सार्क (एसएएआरसी) नर्सरी को रतुआ निगरानी के उद्देश्य से भारत में 41 एवं सार्क देशों की अलग–अलग 28 स्थानों पर लगाया गया ।

क्षेत्रीय केंद्र, दालंग मैदान

- मई–अक्तूबर, 2018 के दौरान ग्रीष्मकालीन नर्सरी सुविधा के कुशल उपयोग के लिए विभिन्न संस्थानों के 36 सहयोगियों के गेहूँ और जौ की लगभग 31,000 लाईनों का भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, क्षेत्रीय केंद्र, दालंग मैदान में संतति वृद्धिकरण किया गया।
- वर्ष 2018 की ग्रीष्मकालीन की नर्सरी के दौरान, विभिन्न संस्थानों के शोधकर्ताओं द्वारा 550 से अधिक सुधारात्मक क्रॉस बनाये गए।
- पीला रतुआ और चूर्णिल आसिता की जाँच के लिए इस बार मौसम बहुत ही अनुकूल था। अतः विभिन्न केंद्रों द्वारा लगभग 15,000 लाईनों की जांच की गई।
- इस केंद्र पर वर्तमान में 9000 गेहूँ और 2000 जौ के जननद्रव्यों को प्राकृतिक परिस्थितियों में संरक्षित किया जा रहा है।

बीज एवं अनुसन्धान प्रक्षेत्र, हिसार

- इस अवधि के अंतर्गत 51 एकड़ क्षेत्रफल पर गेहूँ का प्रजनक बीज उगाया गया, जिससे कुल 761.5 कुंतल गेहूँ बीज का उत्पादन हुआ। गेहूँ बीज की औसत उपज लगभग 14.93 कुंतल प्रति एकड़ प्राप्त हुई।
- लगभग 7 एकड़ भूमि पर जौ का प्रजनक बीज उत्पादन किया गया, जिससे 92.7 कुंतल जौ का बीज प्राप्त हुआ जिसकी औसत उपज 13.24 कुंतल प्रति एकड़ दर्ज की गयी ।

संस्थान की अन्य गतिविधियाँ

- 9 फरवरी, 2019 को भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल ने अपना पाँचवा स्थापना दिवस बड़े ही हर्ष एवं उल्लास के साथ मनाया। इस कार्यक्रम के मुख्य अतिथि डा केवी प्रभु चेयरमैन पीपीवी एंड एफआर, नई दिल्ली थे।
- 29 मार्च, 2019 को संस्थान में गेहूँ एवं जौ प्रक्षेत्र दिवस का आयोजन किया गया। इस अवसर पर देश के विभिन्न केन्द्रों से आए हुए गेहूँ एवं जौ के वैज्ञानिकों ने संभार जननद्रव्यों का चयन अपने–अपने अनुसंधान कार्यों के लिए किया।
- 6 अप्रैल 2019 को अमीन गाँव, जिला कुरूक्षेत्र में अग्रिम पंक्ति प्रदर्शन स्थल पर एक प्रक्षेत्र दिवस का आयोजन किया गया। जिसमें आस–पास के गाँव के किसानों ने भाग लिया।
- संस्थान प्रबंधन समिति की 26 वीं एवं 27वीं बैठक क्रमशः 27 अप्रैल और 16 सितम्बर, 2019 को सम्पन्न हुई।
- अन्तर्राष्ट्रीय योग दिवस का आयोजन 21 जून, 2019 को संस्थान में किया गया जिसमें संस्थान के कर्मचारियों ने उत्साहपूर्वक भाग लिया।
- संस्थान अनुसंधान परिषद बैठक 1 का आयोजन 4 जुलाई, 2019 को हुआ ।
- 24–26, अगस्त, 2019 के दौरान 58 वीं अखिल भारतीय गेहूँ एवं जौ कार्यकर्ता सम्मेलन का आयोजन भाकृअनुप– भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल व भाकृअनुप– भारतीय कृषि अनुसंधान संस्थान क्षेत्रीय केन्द्र, इंदौर द्वारा संयुक्त रूप से किया गया जिसका उद्‌घाटन डा. त्रिलोचन माहापात्र, सचिव डेयर व महानिदेशक भारतीय कृषि अनुसंधान परिषद, नई दिल्ली द्वारा किया गया।
- कृषक–वैज्ञानिक कार्यशाला एवं बीज दिवस का आयोजन 05 अक्तूबर, 2019 को नाबर्ड के सहयोग से किया गया। इस अवसर पर लगभग 9000 किसानों ने शिरकत की और नई किस्मों के बीज लिए।
- अनुसंधान सलाहकार समिति की बैठक 10–11 अक्तूबर, 2019 को डा एचएस गुप्ता, भूतपूर्व महानिदेशक बिसा एवं निदेशक भाकृअनुप–भारतीय कृषि अनुसंधान संस्थान, नई दिल्ली की अध्यक्षता में संस्थान में सम्पन हुई।
- कृषि शिक्षा दिवस का आयोजन 3 दिसम्बर, 2019 को भाकृअनुप– भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल में किया गया जिसमें स्कूल के विद्यार्थियों को कृषि शिक्षा के प्रति जागरूक किया गया।
- विश्व मृदा दिवस का आयोजन 5 दिसम्बर, 2019 को करनाल जिला के महमूदपुर गाँव में किया गया।
- स्वच्छ भारत अभियान के तहत "स्वच्छता ही सेवा" का आयोजन किया गया। इस दौरान विभिन्न आयोजन गतिविधियों में संस्थान के सभी अधिकारियों एवं कर्मचारियों ने बढ़–चढ़कर हिस्सा लिया साथ ही पौधा रोपण कर वातावरण को शुद्ध रखने के प्रति भी अपनी जिम्मेवारी बखूबी निभाई।
- संस्थान में 27 सितम्बर से 2 अक्तूबर, 2019 के दौरान राष्ट्रपिता महात्मा गाँधी की 150वीं जन्मशती के उपलक्ष्य में "गाँधी जयंती उत्सव" का आयोजन किया गया।
- 70 वें गणतंत्र दिवस का आयोजन 26 जनवरी, 2019 को संस्थान के परिसर में हुआ। संस्थान के निदेशक डा जीपी सिंह ने ध्वजारोहन किया और सभी कर्मचारियों एवं अधिकारियों को संबोधित किया।

- राजभाषा उत्सव एंव हिन्दी पखवाड़ा का आयोजन 16–30 सितम्बर, 2019 के दौरान संस्थान में किया गया तथा हिन्दी दिवस का आयोजन 16 सितम्बर को हुआ।
- 73वें स्वतंत्रता दिवस का आयोजन 15 अगस्त, 2019 को किया गया। इस अवसर पर ध्वजारोहण एवं संबोधन निदेशक डा. जीपी सिंह ने किया।
- सर्तकता जागरूकता सप्ताह का आयोजन 23 अक्तूबर, 2019 के दौरान किया गया। इस दौरान 2 अक्तूबर, 2019 श्री कन्हैया चौधरी के व्याख्यान का भी आयोजन हुआ।
- 70वें संविधान दिवस का आयोजन 26 नवम्बर, 2019 को संस्थान में मनाया गया। इस अवसर पर संविधान की उद्देशिका पढ़ी गई तथा नागरिकों के मौलिक कर्तव्यों की जानकारी सभी अधिकारियों/कर्मचारियों को दी गई।
- डा. त्रिलोचन महापात्र, सचिव, डेयर एवं महानिदेशक, भारतीय कृषि अनुसंधान परिषद, नई दिल्ली ने 25 मार्च, 2019 को संस्थान का दौरा किया।
- माननीय सांसद, करनाल लोकसभा श्री संजय भटिया जी एवं महापौर, करनाल श्रीमती रेणु बाला गुप्ता जी ने 19 नवम्बर, 2019 को संस्थान का दौरा किया तथा एक प्रशिक्षण कार्यक्रम के उद्घाटन सत्र के मुख्य अतिथि थे।
- माननीय श्री कैलाश चौधरी राज्य मंत्री, कृषि एवं किसान कल्याण मंत्रालय, भारत सरकार ने 23 दिसम्बर, 2019 को संस्थान का दौरा किया तथा कर्मचारियों से बात की।

EXECUTIVE SUMMARY

CROP IMPROVEMENT

- The year 2019 has been a landmark in achieving the record production of 102.19 million tonnes of wheat and highest productivity of 35.07qha^{-1}.
- ICAR-IIWBR, Karnal was instrumental in release and notification of 12 new wheat varieties (8 bread + 4 durum wheat) for commercial cultivation by farmers in the country. The extension proposal for cultivation area of two previously released varieties viz., HD 3086 (for NEPZ) and DBW 187 (for NWPZ) have also been recommended.
- ICAR-IIWBR developed and registered 13 novel genetic stocks out of total 23 wheat germplasm recommended for registration by the Plant Germplasm Registration Committee of the NBPGR, New Delhi.
- The Germplasm Resources Unit (GRU) at ICAR-IIWBR acquired 1882 accessions of wheat germplasm from national and international organizations for conservation in 2019. Additionally, 350 advanced lines were exported to Bangladesh and Bolivia for screening them against wheat blast disease. The GRU also characterized 250 new germplasm accessions for 38 DUS traits.
- The institute organised a wheat and barley field day on 29 March, 2019, 40 participants from CGIAR institutes, SAUs, ICAR institutes and NGOs attended the field day and selected germplasm. The GR unit supplied 1155 germplasm lines selected by various researchers working in wheat
- The pre-breeding project during 2019 created novel genetic variability by hybridization of bread wheat with wild species like *Th. bessarabicum* and *Ae. Peregrine* etc. The project team identified promising lines having higher Fe, Zn and protein along with several lines identified for drought tolerance.
- The project on wheat improvement for high productive environments of northern India, developed a high yielding wheat cultivar DBW 222 (Karan Narendra) for irrigated timely sown conditions of NWPZ. Also, germplasm (RWP 2014-18) with early maturity and higher 1000-grains weight of 50.0 g was registered as genetic stock.
- The wheat breeding eastern region project identified a novel germplasm (BH 1146) for water logging tolerance and spot blotch resistance.
- Wheat Improvement for warmer areas project developed a new high yielding wheat variety, DBW 252 (Karan Shriya) for timely sown restricted irrigation conditions of the NEPZ.
- Hybrid wheat project maintained 16 CMS sources and 60 diversified new CMS lines during 2019 and evaluated experimental hybrids for their heterotic potential.
- Wheat quality breeding project developed an improved durum wheat variety (DDW 47) having high pasta quality score (7.9) and high yellow pigment content (7.57 ppm).
- The biotechnology group mapped and identified 30 novel QTL regions controlling terminal heat tolerance using Temperature Controlled Phenotyping Facility (TCPF). Marker assisted backcross breeding (MABB) was also carried to introgress drought tolerance QTL regions during 2019.
- The germplasm donors for important photosynthesis parameters were identified through physiological screening.

- RWP-2017-21 was identified as heat tolerance germplasm through screening under multi location heat tolerance trial.
- A new initiative in the form of screening wheat germplasm for radiation use efficiency (RUE) was undertaken at the institute.
- The novel CRISPR/Cas9 technique of gene and genome editing is being used to improve yield and abiotic stress tolerance traits in wheat.
- During 2019, 3170.5 q seed of 8 wheat varieties was produced at ICAR-IIWBR and an amount of approximately ₹2.51 crores of revenue was generated by distribution of improved quality seed to various stakeholders.

CROP PROTECTION

- Wheat crop health was monitored by keeping vigil on disease and insect pest occurance, new pathotypes of rusts and timely suggesting the remedial measure to mange the disease. The first report of stripe rust was observed from village Fatehgarh Viran of block Chamkour Sahib of district Roopnagar, Punjab on 14.1.2019. Over all, the crop remained healty and negligible losses were happened due to biotic stresses thus contributed to the record wheat production.
- The surveys were also conducted in West Bengal along Bangladesh boarder for wheat blast and found no report of wheat blast occurance in West Bengal.
- A total 1250 entries in IPPSN and 418 entries in PPSN including checks were screened for major disease and insect pests on the basis of this the entries were further promoted in yield trials as well as in identification and release as varieties.
- The total 16 entries identified with confirmed sources of multiple diseases were shared with 27 breeding centers across different agro-climatic zones of country for their utilization in breeding for resistance to biotic stresses.
- A total of 7321 grain samples collected from various mandies in different zones and were analyzed for Karnal bunt (KB). The overall 32.02% samples were found infected with KB. Among different states from where samples were taken Madhya Pradesh, Gujarat, Maharashtra and Karnataka were found free from Karnal bunt infection.
- To combat the threat of wheat blast and check entry of blast from Bangladesh, strict quarantine has been observed and wheat holiday in Murshidabad and Nadia district as well as No wheat zone in 5 Km along Bangladesh boarder was implemented.
- For identification of wheat blast resistant sources, a total of 353 Indian wheat varieties and advance breeding material were screened at Jessore, Bangladesh and Bolivia through CIMMYT. Five resistant varieties identified namely DBW 187, HD 3249 and HD 2967 (irrigated and timely sown) and DBW 252 and HD 3171 (restricted irrigation and timely sown) have been recommended to be grown in disease prone areas of West Bengal.
- The population structure of loose smut pathogen of wheat (*Ustilago segetum* var. *tritici*) (UST) originated from four geographical distinct zones of India was analysed. The phylogeography and population structure analysis clearly demonstrated the mechanism of diversity and variation in UST isolates is due to gene flow and mutation.
- Developed SSR markers to study genetic diversty within *U. hordei* causal agent of barley coverd smut which will be useful in providing deep insight into the population dynamics of the pathogen.
- Moderate to severe incidence of wheat aphid and pink stem borer was observed in villages Ladwa, Yamunanagar, Kunjpura, Subhari, Rasina and Hajwana. The grubs and adults of coccinellid beetles were seen frequently in fields infested with aphids.

- Biological study revealed that life cycle of *C. septempunctata* was completed in 51.4 -59.2 days on aphid, *Rhopalosiphum maidis*.
- Population dynamics of wheat aphid complex shows that the aphid population was observed in the field from 1st SMW, 2019 to 13th SMW, 2019 (1st week of January, 2019 to 1st week of April, 2019), crossing the economic threshold level during 7th SMW, 2019 (3rd week of February, 2019).
- Among the different tested monitoring traps viz., sticky-traps and tray-traps, the efficiency of yellow sticky traps was comparatively more than tray traps.
- Treatments with higher doses of nitrogen i.e. 150 & 225 kg/ha had highest number of aphids as compared to lower doses of nitrogen. Variety HD 2967 had lowest number of aphids as compared to susceptible check A-9-30-1.
- The integrated pest modules tested against major pests of wheat viz., foliar aphids, shoot fly, termites and pink stem borer revealed comparatively lower pest population in IPM module treatment as compared to the farmer practice (FP). However, in FP treatment the population of natural enemies was little higher than IPM treatment.
- Four different types of grain storage bags viz., jute, cloth, HDPE and BOPP bags were tested for determining their effect on storage pest infestation as well as on grain quality. Observations have shown that BOPP Bags have lowest infestation of storage insect-pests as compared to other bags.

RESOURCE MANAGEMENT

- Based on the ten years long term experiment on rice-wheat system, it was concluded that wheat productivity was not affected by tillage either in wheat or in rice. However, tillage in wheat had some differential effects and marginally higher wheat productivity was recorded in rotary tillage compared to zero and conventional tillage.
- A long term tillage experiment in maize-wheat-green gram system indicated that wheat grain yield was maximum (73.5 q/ha) when FYM @ 10 t/ha was applied along with recommended NPK.
- Soil temperature studies in wheat season at 5 cm depth in long term Conservation Agriculture (CA) trial revealed that the morning temperatures were slightly higher in CA system where as the reverse was true in the afternoon.
- CA wheat demonstrations conducted using Turbo Happy Seeder and wheat cultivars HD 2967 and HD 3086 at two villages (Badarpur and Taraori) in rice-wheat system revealed that the mean wheat yield was similar in conventional tillage (CT) and Conservation Agriculture (CA) systems.
- Improved Rotary Disc Drill (RDD) machine was tested for seeding in full rice residue and full sugarcane trash and observed significant improvement in its efficiency. This machine was found superior to Turbo Happy Seeder for wheat sowing in the presence of full loose residues of sugarcane at farmers' field.
- Studies for identification of suitable wheat varieties under CA system at two dates of sowing revealed that the mean wheat yield of early sown wheat was significantly better than the timely sowing. The wheat yield was similar under CA and CT systems. However, the genotypic differences were significant and among ten genotypes, PBW 723, BISA 921 and BISA 927 were better yielder than other genotypes.
- To maximise wheat productivity, 15 genotypes were evaluated using higher level of inorganic fertilizers along with organics and spray of growth retardant to control lodging. The genotypes DBW 187 and DBW 303 yielded 78.8 and 78.2 q/ha, respectively, which was higher than other genotypes, under 150% RDF + 15t

FYM/ha + two sprays, as tank mixture of Chlormequat chloride (Lihocin) 0.2% + Tebuconazole (Folicur 430 SC) 0.1% of commercial product dose, at first node and flag leaf stages.

- Integrated nutrient mangement consisting of application of recommended doses of chemical fertilizers (NPK 150:60:40) with 15 t/ha FYM was found to be the highest yielder.
- In organic production of HYVs (WB 2, HD 2967, HD 3086 and WH 1105) of wheat, the yield increased with increase in FYM dose from 10 to 30 t/ha in comparison to control but the productivity remained significantly lower than to recommended doses of chemical fertilizers (NPK 150:60:40) .
- Application of increasing doses of FYM from 10 to 30 t/ha increased the soil organic carbon, available nitrogen, available phosphorus and available potassium contents as compared to recommended NPK and control treatments.
- Result on residue management revealed that rice straw incorporation along with 25% additional N application increased the wheat yield and reduced the immobilization of available N in soil.
- In residue management trial, the results revealed that green gram cultivation after wheat produced 10-12 q/ha pulse and its residue incorporation saved 50% nitrogen to rice crop and produced maximum rice yield as well as improved the physico-chemical properties of the soil.
- Green gram under zero tillage after wheat without any fertiliser application produced 10-12 q/ha grains and also saved 25% N in subsequent rice crop.
- Intercropping of pulses with maize produced higher land equivalent ratio and saved 25% nitrogen in succeeding wheat crop as compared to maize-wheat crop sequence.
- Maize-potato-wheat and sorghum(fodder)-potato-wheat crop sequences recorded the maximum returns as compared to other crop sequences.
- Diverse broadleaf weeds were effectively controlled by ready-mix combinations of Halauxifen+ fluroxypyr 200.6 (6.1+194.5) g/ha as post-emergence application. This ready mix combination has shown high selectivity in wheat.
- Herbicide combinations pyroxasulfone + metsulfuron and Pendimethalin + metribuzin as pre-emergence and tank mixture of clodinafop/pinoxaden + metribuzin as post emergence were evaluated and found effective for control of diverse spectrum of weeds in wheat.
- Pyroxasulfone + pendimethalin 125 + 1000 g/ha and flumioxazine at 100-125 g/ha as pre-emergence were found effective for control of grassy and broad leaved weeds in wheat.
- In rice-wheat system, double no-till system led to more problem of *Rumex dentatus* and *Medicago denticulata*.
- For management of multiple herbicide resistant *P. minor* and *A. ludoviciana* (against clodinafop, pinoxaden and sulfosulfuron), alternative herbicides found effective were pyroxasulfone and metribuzin.
- Pendimethalin and pyroxasulfone were found effective for control of sulfonyl urea herbicide resistant *Polypogon monspeliensis* in wheat.
- Integration of no-till seeding along with residue retention and application of pre-seeding herbicides (Pendimethalin + metribuzin or metribuzin or pyroxasulfone + metsulfuron) were found effective for management of *P. minor.*
- For control of metsulfuron resistant *Rumex*

dentatus and *Chenopodium album* 2,4-D, carfentrazone and fluroxypyr were found effective.

- Foliar application of potassium in wheat at 2 per cent concentration as K_2SO_4 or KCl was found beneficial under restricted irrigation conditions.
- Nine genotypes (DBW 222, DBW 173, IBWSN106, IBWSN1278, DBW 110, DBW 166, DBW 187, PYT 69, PYT 80) had water use efficiency of >2.51 kg/m^3 with desirble level of yield under 80% and 60% of CPE moisture level.
- Genotypes HI 1605, NIAW 3170, NIAW 1415 and NIAW 3624 from central and peninsular zones were found to be have higher WUE with yield level of 50 q/ha or more.
- Two foliar sprays of potassium at jointing and flowering stage confirmed its positive effect on wheat productivity.
- Landsat 8 Operational Land Imager (OLI) was used for assessing land use land cover analysis and wheat acreage of Haryana. The wheat areas were estimated by computing pixels under the classified image using post classification technique. The total wheat area was observed to be 2.32 mha; which is almost 52.6% of the total geographical area of Haryana (4.41 mha).

QUALITY AND BASIC SCIENCES

- In bread wheat (*T.aestivum*), genotypes having good chapati making quality (score >8.0/10.0) such as PBW 771, DBW 301 and PBW 824 were identified.
- Bread wheat genotypes namely DBW 221, DBW 222, BRW 3806, NIAW 3170, HI 1621, WH 1254 and DBW 303 expressed good bread quality with loaf volume >600cc.
- For biscuit quality, a soft genotype namely NIAW 3170 was identified with hardness index less than 35 and having higher cookie spread factor.
- High molecular weight glutenin subunits encoded at Glu A1, Glu B1 and Glu D1 loci were identified in all the AVT entries including checks.
- Durum wheat variety DDW 47 was identified for high yellow pigment content (7.6 ppm) which is a highly desirable trait for pasta products. Three of the entries of durum UAS 466, HI 8627and DDW 47 showed more than 13% grain protein content.
- One AVT-I year entry, GW 509 (PZ) with very high iron (44.6ppm) and Zn (46.3ppm) content was also identified.
- Quality Component Screening Nursery of 52 entries from 15 locations was evaluated for grain appearance, protein content, sedimentation volume and hectolitre weight.
- Microlevel tests developed for gluten strength and yellow pigment content were utilized for evaluating large numbers of germplasm lines (400), segregating generations (500), released varieties (300), coordinated samples (2000) and found very useful in saving time and use of chemicals and reducing environmental pollution.
- Two years evaluation of foliar spray of Fe and Zn exhibited significant increase in the grain Zn content and thus validated that agronomic biofortification can be very effective way of increasing Fe and Zn content in wheat.
- In addition, 100 varieties of wheat were evaluated for CD (celiac disease) toxic epitopes which indicated no change CD toxic epitope content during last 60 years.
- Transcriptome analysis of four Indian wheat genotypes was done at seedling stage to understand mechanism of Fe and Zn absorption, translocation and accumulation. This revealed differential expression of genes involved in phytosiderophore synthesis under Fe/Zn deficiency conditions in wheat.
- High phytase (>2000 FTU/kg) mutant lines

developed in the background of PBW 502 were grown during 2018-19 and used for making crosses with high yielding varieties for improving bio availability of micro nutrients in wheat to human beings.

- RILs (F7) of a cross between a wheat line containing *Gpc-B1* gene and high yielding variety HD 2967 were developed for identification of molecular markers associated with high grain protein content and Fe & Zn concentrations.

- *Glu-D1* double null of NAP HAL is being transferred into high yielding backgrounds of wheat such as PBW 373, UP 2425, Raj 3765, DPW 50, HD 2967 using molecular markers and microlevel tests. Materials with desirable traits are at different stages of development.

- A co-dominant marker developed for *Glu-D1* double null in Nap Hal was validated in diverse set of germplasm lines and in breeding to transfer Glu-D1 double null into high yielding backgrounds for improving biscuit making quality of wheat.

- Genomic regions controlling traits related to salt tolerance were identified by using Interval and composite interval mapping (using ICI Mapping) with a threshold of LOD 2.5. 25 QTLs were detected for 10 different traits on 7 chromosomal regions (1A, 1B, 2D, 4D, 5D, 6A and 7D) explained PVEs (2.6-15.1 %), respectively indicating strong genetic basis for salt tolerance. The information is useful in improving salt tolerance of wheat by using marker-assisted selection.

- Analysis of NIVT samples showed that there is no distinct advantage in coloured wheat as compared to amber wheat in terms of total antioxidant activity and processing quality traits, it is recommended not to have separate varieties for coloured wheat.

SOCIAL SCIENCES

- During 2019, 1500 Wheat Frontline Demonstrations (WFLDs) of one acre each were conducted through 83 cooperating centres covering 1503.34 acres area of 1562 farmers in 19 states. Technologies such as improved wheat (*T. aestivum*, *T. durum* and *T. dicoccum*) varieties with complete package of practices, rotavator, zero tillage/happy seeder and bio-fertilizer were demonstrated at the selected farmers' fields.

- The maximum number of WFLDs were conducted in UP (192) followed by Bihar (142). The maximum percent yield gain was observed in Manipur (36.74) followed by Assam (34.28) and Jharkhand (26.80). The percent yield gain due to improved varieties over check was highest in NEPZ (20.21) followed by NHZ (19.00), PZ (15.28), CZ (12.01) and NWPZ (07.99).

- Improved durum varieties viz., HD 4728 and HD 8759 recorded a significantly higher average yield of 65.00 qha^{-1} at Indore centre in CZ while in PZ, the variety MACS 3949 recorded an average yield of 46.50 qha^{-1} at Pune. UnderNHZ, at Bajaura, the improved rainfed variety HS 562 yielded 53.80 qha^{-1} which was higher than check varieties. The same variety gave significantly higher yield at Malan (41.11 qha^{-1}) and Kangra (40.14 qha^{-1}) centres against check varieties HPW 155 and HPW 349, respectively. Under CZ, GW 11 recorded a significantly higher yield at Vijapur center (52.87 qha^{-1}) than the check variety UAS 347 yielded 18.12 qha^{-1} under rainfed condition at Dharwad centre in PZ.

- WFLDs resulted in earning of ₹ 3.07 per rupee of investment in comparison to the check varieties (₹ 2.70). The returns per rupee of investment from WFLDs ranged from ₹ 6.90 (Haryana) to ₹ 1.54 (West Bengal), while it was ₹ 4.06 in NWPZ to ₹2.48 in NEPZ. The returns earned under technologies ranged from ₹7.37 (Happy Seeder) to ₹2.21 (Variety: Late Sown & Restricted Irrigation). The gross returns per hectare in WFLDs was highest in Haryana (₹100224), followed by Punjab (₹100161) and Madhya Pradesh (₹83387). On an average, a new wheat variety or production technology would earn ₹64592ha^{-1}. Further WFLDs demonstrated that new and improved varieties required relatively less investment (₹ 789) to produce a quintal of wheat as compared to the check varieties (₹913).

- High cost of inputs, small land holding, non-availability of seed of newly released varieties, non-availability of labour; higher custom hiring rate for land levelling, field preparation, sowing, harvesting and threshing and *Phalaris minor* were perceived as major constraints in wheat production in the country.
- During 2019, 250 Barley Frontline Demonstrations (BFLDs) of one acre each were conducted by 21 cooperating centers across six states namely, HP, UP, Punjab, Haryana, Rajasthan and MP covering 238.5 acres area under264 farmers. Improved barley varieties with complete package of practices (irrigation management, nutrient management, weed control, seed treatment etc.) were demonstrated.
- The highest percentage gain in barley yield was recorded in UP (27.28) followed by MP (24.58), and Punjab (22.67) while the lowest was in Haryana (5.05).
- In NHZ, barley variety HBL 713 yielded highest (32.17 qha^{-1}) at Bajaura centre. In NEPZ, DWRB 137 at Kanpur (52.75 qha^{-1}), RD 2907 at Durgapura (63.72 q ha^{-1}) in NWPZ and RD 2899 at Udaipur (42.70 q ha^{-1}) in CZ were the highest yielding varieties.
- BFLDs gave around 25 per cent profit per hectare in comparison to the check. Under BFLDs Punjab registered the highest returns per rupee of investment (₹6.49) followed by Uttar Pradesh (₹4.16) and Haryana (₹3.23). The profit per hectare in BFLDs was highest in Uttar Pradesh (₹73870), followed by Rajasthan (₹70789) and Punjab (₹61431). The returns per rupee of investment were highest in the NEPZ (₹4.16), followed by NWPZ (₹3.56) and CZ (₹2.86). Cost of production indicated that it was least (₹271 quintal^{-1}) in Madhya Pradesh (CZ).
- Decline in water table, small land holding, low market price, high cost of inputs, lack of knowledge among farmers about recent technologies, high temperature at maturity, temperature fluctuation during crop growth and higher custom hiring rates (land levelling, field preparation, sowing, harvesting and threshing), *Chenopodium album* and erratic power supply were perceived as major production constraints in barley.
- ICAR-IIWBR conducted 20 wheat FLDs (HD 3086 and DBW 173) with complete package of practices over 20 acres area at twenty farmers' fields in the villages namely Amin, Bid Amin, Amin Dera Rampura, Deeg and Yara in Kurukshetra district of Haryana.
- The ICAR-IIWBR team accompanied by the experts from the Ministry of Agriculture & Farmers Welfare and the concerned centres, monitored the FLDs conducted by Khudwani, Anantnag, Rajouri, Kathua, Noida, Rewari, IARI, KVK Ujwa, New Delhi, Indore, Ujjain, Ratlam, Faizabad, Kanpur, Varanasi, Dharwad, Belagavi, Wellington, Junagarh, Vijapur, Jaipur, Ajmer, Tonk and Karauli centres.
- Survey was conducted in Bainsi and Sanghi villages of Rohtak district of Haryana by120 farmers adopting resource conservation technologies such as Zero Tillage or Turbo happy seeder for sowing of wheat. A total of 120 farmers comprising 60 beneficiaries and 60 non beneficiaries were selected for the survey. Majority of the farmers (32.5%) belonged to age group 41-50 years of age. Eighty percent of them

were having education upto Matric. Agriculture was their main occupation (92.5%) and majority of them were practicing dairying as subsidiary occupation (52 %). Buffalo was the main source of milk production among majority of the farmers. Farmers were also categorized based land holding pattern it was observed that 65% of them were falling under in large category with more than 10 acres of land holding while 42% were under medium category. On total land holding basis 64.17% were under large category and 27.5% were grouped into medium category. The average area per farmer under zero tillage was 17.70 acres while the average land holding per farmer was 18.82 acres among the beneficiaries of zero tillage technology.

- Analysis of survey data (2017-18) from 200 wheat farmers in two districts of Eastern Uttar Pradesh viz., Allahabad and Ghazipur indicated that the Yield Gap I was negative in Allahabad, and the Yield Gap II was lowest in Ghazipur. Seeds were used more than the recommended doses. Fertilizers were used either below or above the recommended doses. Among all inputs, expenditure incurred on manure/bio-fertilizer showed a significant difference. Data Envelopment Analysis indicated that the sensitive weather weeks are crop specific and region specific. For instance, wheat yield levels are highly sensitive to temperature prevailing during week 11 in Ghazipur but not in Allahabad. The implication of the result indicates that wheat crop is sensitive to weather anomalies during flowering, milking and dough stage in the selected study regions. In the case of barley, the identified sensitive crop growth stages are: tillering, flowering, grain hardening and ripening.
- Under the TSP project, the following eight/seven centers were included for the year 2019-20, namely, Lahaul&Spiti (HP), Leh (J&K), Khudwani (J&K), Jabalpur (MP), Udaipur (Rajasthan), Bilaspur (Chhattisgarh), Ranchi (Jharkhand) and Dharwad (Karnataka). Under TSP project, a Three Days Training on 'Increasing farm income of Lahaul-Spiti farmers through improved wheat & vegetable production technologies' was organised during 19-21 December, 2019 at ICAR-IIWBR, Karnal for 45 farmers (30 men and 15 women) of district Lahaul&Spiti (HP). Development activities like demonstrations (193), Trainings (10), farmers fair/field day (6) were conducted by different centres.
- Apart from the above activities, social sciences unit coordinates the Governments flagship development programmes like “Mera Gaon Mera Gaurav” scheme and activities pertaining to doubling farmer income, creating awareness on soil health cards etc. During the period different activities likes training programmes (4), awareness programmes (8) were organised at ICAR-IIWBR apart from participation in 10 exhibition/outreach programmes and 5 TV programmes and 77 coordination visits of various stakeholders. The farmers were advised on various aspects related to queries on wheat and barley cultivation. More than 1200 farmers/entrepreneurs/others stakeholders were provided replies to their queries via multiple platforms. Weekly advisories were also issued to the farmers on weather and cultural practices during the crop season.

BARLEY IMPROVEMENT

- A production of 1.75 MT of barley in an area of 6.1 lakh ha area was achieved with a productivity of 28.8 q/ha, the highest recorded so far in India.
- Five barley varieties DWRB160 malt purpose for NWPZ, RD 2899 for CZ, RD 2907 for salinity conditions, PL 891 hulless food barley for NWPZ and HBL 713 rainfed timely sown for HP conditions were released for commercial cultivation during the year.
- Two genetic stocks namely DWRB 191 and DWRB 192 were registered with ICAR-NBPGR for their

uniqueness for higher zinc and iron content, respectively.

- Breeder seed production of 1421 q of 29 barley varieties was organized against the indent of 827.85 q from MOA, GOI with the help of coordinated research centers.
- On the basis of superiority over the checks in AVT, the entry DWRB182 was promoted to AVT Final year while DWRB 204 of food barley was promoted in AVT-hulless trial and three other entries namely DWRB196 and DWRB197 of malt barley were promoted to AVT-MB-TS.
- Six exotic germplasm lines from ICARDA International Nurseries (IBYT-18-9, INBYT-HI-18-11, 5th GSBYT-18-19, IBON-18-47, IBON-18-60 and IBON-18-100) were found moderately resistant to leaf blight
- Six exotic germplasm lines namely, IBYT-HI-19-15, IBYT-HI-19-17, IBYT-HI-19-22, IBYT-HI-19-12, IBYT-HI-19-7 and IBYT-HI-19-16 were found promising in ICARDA nurseries under multi-locational evaluation.
- Seeds of the 118 selected genotypes were supplied to the barley breeders working in different SAUs and ICAR-institutes.
- A total of 8193 accessions of barley are being conserved and maintained in medium term storage facility in module at ICAR-IIWBR, Karnal. A total of 500 germplasm lines were rejuvenated during *Rabi* 2018-19
- The maximum grain yield was realized in zero till sowing with rice residue retention which was significantly higher than other methods of sowing
- BCU 2030 identified as low beta glucan & high beta glucanase activity genotype from germplasm accessions evaluated.
- Readymix of Halauxifen methyl (10.21g a.i. /ha) and Florasulam (20g/ha) with surfactant can be used to control broad leaved weeds in barley.
- Application of Pusa Hydrogel and a New Hydrogel @ 2.5 kg per ha resulted in significantly higher grain yield as compared to control conditions. One irrigation water can be saved by use of the hydrogel.

REGIONAL STATION FLOWERDALE, SHIMLA

- There was no report of any rust epidemic in wheat growing areas in India. Practically it was another rust free wheat year. Yellow (stripe) rust was observed in very low frequency in few areas of the Northern India. Surprisingly yellow rust was observed on Lok1and Sujata as restricted foci at Eagle Seed Farm, Brahman Pipliya in Indore district of Madhya Pradesh.
- Brown rust appearance was observed sporadically in some areas from Maharashtra, Gujarat and Karnataka. There was no report of black rust of wheat and barley in farmer's field in any of the states/area of the country. Practically rusts remained absent on wheat crop during the year.
- A total of 627 samples of three rusts of wheat and barley were analyzed during the year from thirteen Indian states, and Nepal. These samples comprise 201, 292 and 134 samples of yellow, brown and black rusts, respectively.
- Yellow rust resistance genes *Yr5, Yr10,Yr15* and *YrSp*; stem rust resistance genes *Sr26, Sr27, Sr31, Sr32, Sr35, Sr39, Sr40, Sr43, SrTt3* and *SrTmp;* and leaf rust resistance genes *Lr24, Lr25, Lr29, Lr32, Lr39, Lr42, Lr45* and *Lr47* were effective against the population of *Puccinia striiformis* f. sp. *tritici* (Pst), *Puccinia graminis tritici* (Pgt) and *Puccinia triticina* (Pt) populations, respectively.
- Pathotyping of wheat rust samples revealed the maximum frequency of Pst pathotype 46S119 (47.3%) followed by pathotype 110S119 (34.3%).

Pathotypes 77-9, 77-13 and 77-5 were the most predominant in Pt and were identified in 51.1, 20.2 and 15.1 % of the samples, respectively. Pathotype 11 of *P. graminis tritici* was the most occurring pathotype and was observed in 50% of the samples followed by 15-1 and 40A which were observed in 22.3 and 15.6% samples, respectively.

- Seedling resistance evaluation of more than 3000 wheat and barley lines was conducted against an array of pathotypes of Pgt, Pt and Pst, having predominance and different avirulence/ virulence structures. These lines include 158 of AVT, 284 of NBDSN & EBDSN, received from Breeder's and other sources. Four advance lines (PBW 821, PBW 822, PBW 823 and PBW 757) possessed resistance to all the pathotypes of black, brown and yellow rust pathogens.
- Entries NIDW 1158, PBW 752 and PBW 781 were resistant to yellow rust only. VL3021 possessed race specific adult plant resistance to both the pathotypes of Pst (46S119 and 110S119) and Pt (77-9 and 104-2). Four *Yr* genes (*Yr2, Yr9, YrA,* and *Yr18*) were inferred in 91 advance wheat lines. Similarly eleven *Lr* genes (*Lr1, Lr2a, Lr3, Lr10, Lr13, Lr18, Lr19, Lr23, Lr24, Lr26* and *Lr34*) and fourteen *Sr* genes (*Sr2, Sr5, Sr7b, Sr8a, Sr8b, Sr9b, Sr9e, Sr11, Sr13, Sr24, Sr25, Sr28,Sr30* and *Sr31*) were characterized in 75.3% and 79.1% of AVT lines, respectively.
- None of the NBDSN and EBDSN entries showed resistance to all the tested pathotypes of Pst, Pt and Pgt. Three lines of NBDSN (BH1024, KB1762, RD 3008) were resistant to brown and black rusts. Likewise BHS 474, HBL 845, HBL 863, RD 2786(C), RD 2991 and RD 3003 possessed resistance to brown & yellow rusts whereas DWRB182, HBL 812 to black & yellow rusts of barley. In EBDSN, 37 of the 59 lines were resistant to one or more rusts of barley. HBL 814 was resistant to black & yellow rusts whereas RD 2786, RD 2972, RD 2973, RD 2875, RD 2976 were resistant to brown & yellow rusts.
- National repository of more than 145 pathotypes of different rust pathogens was maintained in live culture as well as cryo-preserved. Nucleus/bulk inoculum of different pathotypes of rust pathogen was supplied to 45 scientists/centers for conducting wheat and barley rust research elsewhere in India.
- To monitor, the occurrence of disease, wheat disease monitoring nursery (WDMN/TPN) and SAARC wheat disease monitoring nursery were organized and conducted at more than 41 locations in India and 28 locations across the six SAARC countries, respectively.

REGIONAL STATION DALANG MAIDAN

- In the summer nursery 2019 more than 28000 breeding lines received from 42 researchers /teams have been planted at Dalang Maidan.
- More than 550 corrective crosses, back crosses/three way crosses were made by researchers of various centres.
- The season was favourable for the screening for yellow rust and powdery mildew. More than 15,000 lines were screened by various centres and selections were made.
- The off-season nursery acts as natural repository for wheat and barley germplasm and at present about 9000 wheat accessions and about 2000 barley accessions are being conserved and maintained under natural cool temperature conditions in the station building.

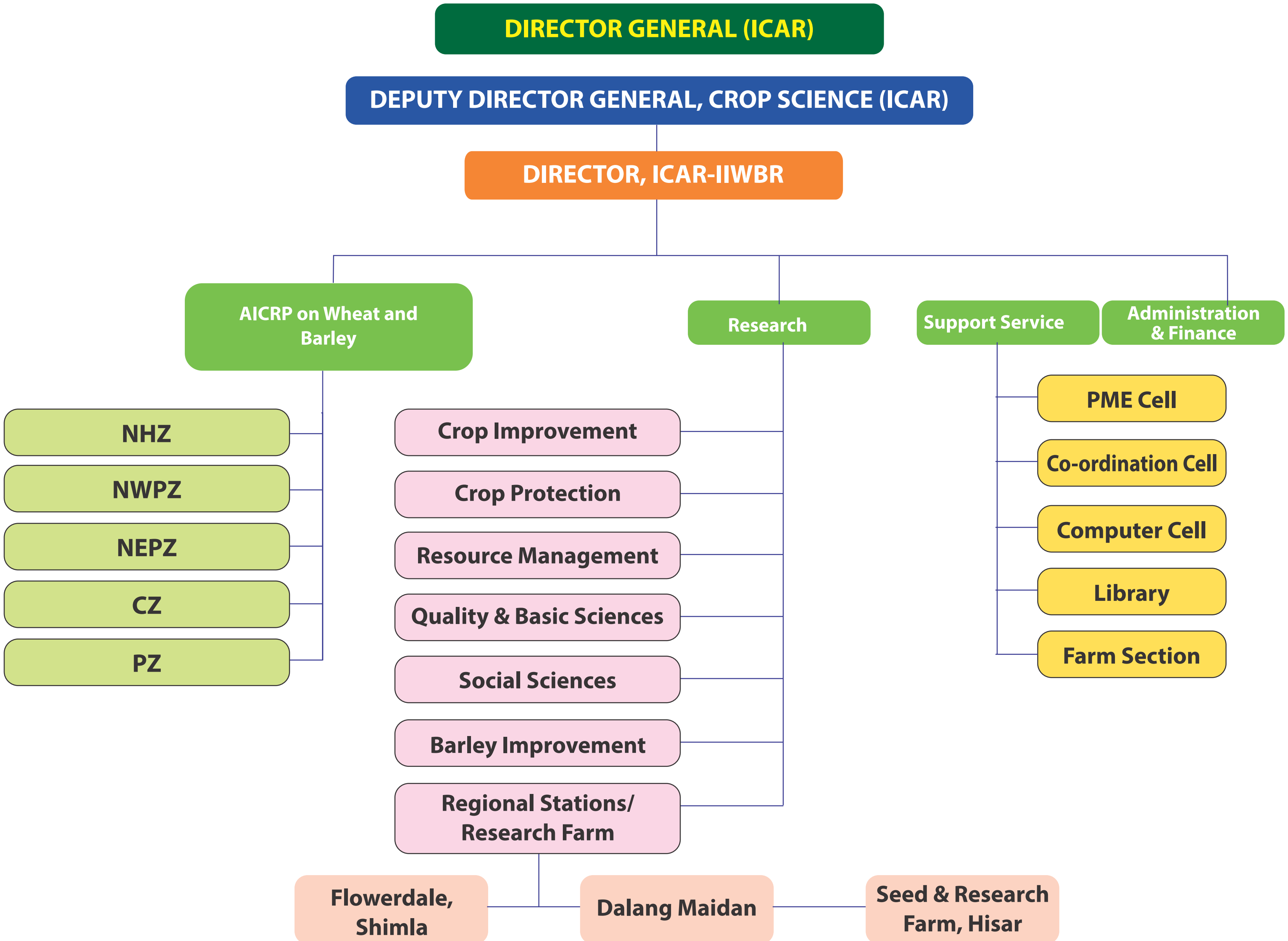
SEED AND RESEARCH FARM, HISAR

- During 2018-19, 761.5 quintals of wheat and 92.7 quintals breeder seeds of barley was produced.

OTHER INSTITUTIONAL ACTIVITIES

- ICAR-IIWBR Karnal celebrated its 5th Foundation Day on 9th Feb., 2019. Dr. KV Prabhu, Chairperson, PPV &FR, New Delhi was the chief guest on this occasion.
- Wheat and Barley Field Day organized on 29th March, 2019 at ICAR-IIWBR, Karnal.
- Field day under Wheat and Barley FLDs programme was organized by ICAR-IIWBR, Karnal in Village Amin district Kurukshetra on 6th April, 2019.
- The International Yoga Day was celebrated on 21st June, 2019 with full enthusiasm at ICAR-IIWBR, Karnal. A large number of staff and their family members participated in the programme.
- XXVI and XXVII IMC meeting was held on 27th April and 16 September 2019, respectively at IIWBR, Karnal.
- Institute Research Council-I meeting was organized during 4th July, 2019.
- The 58th All India Wheat and Barley Workers Meet was organized in collaboration with ICAR-IARI Regional Station, Indore during 24-26 August, 2019.
- Farmer-Scientist Workshop and Seed day was organized on 5th October, 2019 at IIWBR, Karnal in collaboration with NABARD. More than 9000 farmers participated in this mega event. Dr. AK Singh, DDG, Horticulture and Crop Science was the chief guest on this occasion.
- RAC meeting was organized during 10-11 October, 2019 at ICAR-IIWBR under the Chairmanship of Dr. HS Gupta former DG, BISA and Director ICAR-IARI, New Delhi.
- Agricultural Education Day was organized on 3rd December, 2019 at ICAR- IIWBR, Karnal.
- World Soil Health Day was organized on 5th December, 2019 at village Mehmoodpur, Karnal.
- Swachachhata Hi Sewa programme was organized under Swachchh Bharat Abhiyan during 11 September to 2nd October, 2019 at the Institute.
- Gandhi Jayanti Utsava was organized during 27th September to 2nd October 2019 at the institute to celebrate 150th birth anniversary of Rashtrapita Mahatma Gandhi.
- 70th Constitution day was organized at ICAR-IIWBR on 26th November, 2019.
- Vigilance Awareness Week was organized from 28th October to 2nd November 2019.
- Dr. T Mohapatra, Secretary DARE and DG, ICAR visited ICAR- IIWBR on 25th March, 2019.
- Honourable Shri Kailash Chaudhary, Minister of State, Ministry of Agriculture and Farmers Welfare visited ICAR-IIWBR on 23rd December, 2019 and interacted with the staff.
- Honourable Sri Sanjay Bhatia MP, Karnal Lok Sabha and Smt. Renu Bala Gupta, Mayor, Karnal visited ICAR-IIWBR, on 19th November, 2019. Sh. Bhatia was the chief guest of training programme organized for the farmers of Lahaul Spiti, HP.

Organogram



DIRECTOR GENERAL (ICAR)
DEPUTY DIRECTOR GENERAL, CROP SCIENCE (ICAR)
DIRECTOR, ICAR-IIWBR
AICRP on Wheat and Barley
Research
Support Service
Administration & Finance
NHZ
NWPZ
NEPZ
CZ
PZ
Crop Improvement
Crop Protection
Resource Management
Quality & Basic Sciences
Social Sciences
Barley Improvement
Regional Stations/ Research Farm
Flowerdale, Shimla
Dalang Maidan
Seed & Research Farm, Hisar
PME Cell
Co-ordination Cell
Computer Cell
Library
Farm Section

01 CROP IMPROVEMENT

The crop year 2019 has been once again a record breaking year as far as wheat production of India is concerned. This year the country has witnessed a record production of 102.19 million tonnes (4th AE, 2019) of wheat grains with highest ever productivity in the country. During the year under report, the constitution and dispatch of the advance varietal trials was performed by zonal coordinating units. The constitution and dispatch of advance varietal trials for North Eastern Plains Zone and Peninsular Zone were carried out at Karnal. All the work related to coding, constitution and dispatch of national initial varietal trials and special trials was done at Karnal. A summary of the work done and significant achievements made during the crop season 2018-19 are presented below.

Release of new wheat varieties for different zones

Central releases: During the year 2019, the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops (CVRC) in its 83rd meeting recommended the notification and release of eight bread and four durum wheat varieties for different production conditions in various zones (Table 1.1). The Sub-Committee also recommended the extension of areas of adoption of HD 3086 and DBW 187 to NEPZ and NWPZ, respectively

Table 1.1: Wheat varieties released by CVRC during 2019

Variety	Zone	Production condition	Grain yield (q ha^{-1})	
			Average	Potential
HI1621	NWPZ/NEPZ	Irrigated, very late sown	37.0 (NWPZ)	46.1
			28.3 (NEPZ)	40.7
HD3271	NWPZ/NEPZ	Irrigated, very late sown	36.6 (NWPZ)	45.5
			28.1 (NEPZ)	37.2
DBW222	NWPZ	Irrigated, timely sown	61.3	82.1
PBW771	NWPZ	Irrigated, late sown	50.3	62.3
HI1628	NWPZ	Restricted Irrigation, timely sown	50.4	65.1
DBW252	NEPZ	Restricted Irrigation, timely sown	37.0	55.6
HD3249	NEPZ	Irrigated, timely sown	48.7	65.7
UAS466 (d)	CZ	Restricted Irrigation, timely sown	38.8	62.5
DDW47 (d)	CZ	Restricted Irrigation, timely sown	37.3	74.1
HI8802 (d)	PZ	Restricted Irrigation, timely sown	29.1	36.0
HI8805 (d)	PZ	Restricted Irrigation, timely sown	30.4	35.4
GW1346	PZ	Restricted Irrigation, timely sown	28.5	40.4

State releases: Three wheat varieties were released by SVRC for different production conditions and notified by the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops (Table 1.2).

Table 1.2: Wheat varieties released by SVRC during 2019

Variety	State	Production condition	Grain yield (q ha^{-1})	
			Average	Potential
AAI-W13	UP	Irrigated, timely sown	34.8	52.1
WH1184	Haryana	Irrigated, timely sown	61.3	65.7
HPW368	HP	Rain fed, timely sown	26.0	38.7
		Irrigated, timely sown	50.9	58.6

Registration of new genetic stocks: During the year 2019, twenty genetic stocks of wheat were registered by the Plant Germplasm Registration Committee of the NBPGR, New Delhi for different traits. The genetic resources unit of the IIWBR, Karnal multiplies the seeds of these registered genetic stock and supplies to breeder across the country as per indents (Table 1.3).

Table 1.3: Genetic stocks of wheat registered during 2018-19

Name	Registration number	National ID	Traits	Developed by
IC536365	INGR 19007	IC0536365	Resistant to stem, leaf and stripe rust	IARI RS, Wellington
EC574482	INGR 19008	EC574482	Resistant to stem, leaf and stripe rust	IARI RS, Wellington
HI8774	INGR 19009	IC0628570	Resistant to stripe rust, Karnal bunt and powdery mildew	IARI RS, Indore
QLD 84	INGR 19010	IC0628572	Soft grain genotype	ICAR-IIWBR, Karnal
QLD 11	INGR 19011	IC0628573	High grain protein content	ICAR-IIWBR, Karnal
HTW 63	INGR 19032	IC36761A	Drought tolerance	ICAR-IIWBR, Karnal
BH 1146	INGR 19042	IC0415843	Tolerance to water logging and resistance to spot blotch	ICAR-IIWBR, Karnal
RWP 2014-18	INGR 19043	IC0630581	Early maturing and high grain weight	ICAR-IIWBR, Karnal
DCMS1A&1B	INGR 19047	IC 0630582-83	CMS (A) line in PBW 343 background	ICAR-IIWBR, Karnal
DCMS2A&2B	INGR 19048	IC 0630584-85	CMS (A) line in PBW 343 background	ICAR-IIWBR, Karnal
DCMS4A&4B	INGR 19049	IC 0630586-87	CMS (A) line in PBW 343 background	ICAR-IIWBR, Karnal
DCMS5A&5B	INGR 19050	IC 0630588-89	CMS (A) line in PBW 343 background	ICAR-IIWBR, Karnal
DCMS6A&6B	INGR 19051	IC 0630590-91	CMS (A) line in PBW 343 background	ICAR-IIWBR, Karnal
QLD 112	INGR 19052	IC 0632081	Soft grain genotype	ICAR-IIWBR, Karnal
QLD 102	INGR 19053	IC 0632082	High sedimentation value	ICAR-IIWBR, Karnal
IIWBR Phy-1	INGR 19054	IC 0632600	High phytase level and low phytic acid	ICAR-IIWBR, Karnal
IC 427824	INGR 04080	IC 427824	High zinc content	ICAR-IIWBR, Karnal
IC 529962	INGR 19044	IC 529962	Highly resistant to spot blotch	ICAR-NBPGR, New Delhi
IC 529684	INGR 19045	IC 529684	Highly resistant to spot blotch	ICAR-NBPGR, New Delhi
IC 290150	INGR 19046	IC 290150	Resistant to stem, leaf and stripe rusts pathotypes prevalent in India.	ICAR-NBPGR, New Delhi

Germplasm exchange, evaluation, characterization, conservation and documentation

Germplasm exchange: During 2019, global durum panel consisting 976 accessions from ICARDA; 117 accessions of wild species from IARI-Regional station, Wellington, 189 wheat germplasm accessions from ARI Pune and 600 accessions from JNKVV RS Powarkheda were acquired. Institute also supplied 2518 accessions to various indenters within the country. Apart from this, 1155 lines were supplied to the researchers/breeders. These lines were selected by them during the wheat and barley field day organized at ICAR-IIWBR, Karnal on 29 March, 2019. After taking the approval from DARE/ICAR, 350 advance lines of wheat were exported to Bangladesh and Bolivia through NBPGR/CIMMYT for screening against wheat blast.

Germplasm characterization: Two hundred six bread wheat accessions and two hundred thirty-seven durum accessions were evaluated and characterized as per DUS testing guideline for 38 characters during 2019. A wide range of variation was observed for days to heading (87-125 days); days to maturity (135-158 days); plant height (69-166 cm); 1000 grains weight (16-67g); spike length (4.4-14.9 cm); spikelets spike^{-1} (12-26); grains per spike (15-91); and grain weight spike^{-1} (0.26-4.01g). The promising accessions identified for individual and multiple traits are given below:

Plant height: Eight accessions showed dwarfness and recorded plant height <80cm. These were JU 80 (69.3 cm), JU 18 (77.3 cm), EIGN 4-5E10871 (74.7cm), E4757 (78 cm), CRESO (78.3cm) and NI88 (79cm).

Spike length: Five accessions (EIGN I (5-6) (13.62 cm), EIGN I (5-6) 107 (13.9 cm), EIGN I (5-6) 114 (13.1 cm), HS 375 (13.2 cm) and EIGN I (4-05) 77 (14.9 cm) had spike length more than 13 cm.

Spikelets spike: Four accessions namely EC 123547, I 15177, EIGN I (4-5) 85 and EIGN I (4-5) 86 had number of spikelet per spike equal to 26.

Grain number per spike: Four accessions of bread wheat namely EIGN I (5-6) 108 (91), EIGN I (5-6) 15 (85), EIGN I (5-6) 111 (84) and EIGN I (4-5) 85 (82) had more than 80 grains per spike.

Grain weight spike^{-1} : One bread wheat accession *viz.*, EIGN I (5-6) 32 (4.1g) and four durum wheat accessions namely NIDW 132 (3.96g), GW 1126 (3.72g), JU 170 (3.92g) and D639 (3.54g) had spike weight more than 3.5g.

Thousand grain weight: Five accessions namely RALNIS 1 (67.77g), Ratwadi Basmati (62.87g), JU168 (62.66g), JU20 (60.81g) and PDSN 689 (57.05g) had 1000 grain weight more than 57g.

Evaluation of *monococcum* lines: Out of 70 *monococcum* lines evaluated in NWPZ, only one line namely EC 542673 set seed under field conditions.

IC 427824: High Zinc Content genotype: The IC 427884 was evaluated for Zinc content in wheat biofortification nursery at 21 locations of four zones and IC 427824 ranked 1st in zinc content and accumulated a Zn content of 51 mg kg^{-1}, 48.5 mg kg^{-1}, 66.4 mg kg^{-1} and 52.2 mg kg^{-1} in NWPZ, NEPZ, CZ and PZ respectively. At national level also, IC 427824 (53.5 mg kg^{-1}) is the only entry that formed the first non-significant group for higher grain zinc content.

DUS testing in wheat: In crop season 2018-19, a total of 10 candidate varieties (NABIMG 10, NABIMG 11, NABIMG 12, SRW 303, SRW 404, SRW 252, SRW 231, SRW 111, MAHVEER KISHAN VARDAN, MALAV 221(durum), were tested under New/VCK category in three replications against 25 reference varieties in DUS trials for DUS testing. Data of all the test centres viz, Karnal, Indore and Dharwad was compiled, analyzed and submitted to PPV&FR Authority for making decision regarding registration. In addition, 13 farmer's varieties (BILASE, SHODA, SURAJMANI, ULOCHANA, SKF CN 5, LAMHRWAN GEHUN (DBR), NARENDRA 09, RITUR, WHEAT 'PUNJAB SHINGAR', SUPREME 1111, BANDHAN GEHUA, KAYADHU N 49, KATHIA DESI GEHUN (DUR)) were grown for recording of agro-morphological data in two replications against 21 reference varieties. In crop season 2019, 7 candidate varieties (SRW 111, SW 303, SRW 404, SRW 232, SRW 252, W 2019-1 and MALAV 221) of wheat and 64 farmer's varieties have been grown for DUS testing.

Registration of varieties with the PPV&FRA: Registration proposal of DBW187 was submitted to the PPV&FRA, New Delhi for seeking protection under PPV&FRA-2001 in extant category.

Wheat and barley field day

This year 'Wheat and Barley Field day' was organized on 29th March, 2019 at IIWBR, Karnal and 40 participants from CGIAR institutes, SAUs, ICAR institutes and NGOs attended the field day. The details of wheat trials/nurseries namely ESWYT (100 entries), SAWYT (100 entries), HTWYT (100 entries), HRWYT (100 entries), WYCYT (64 entries), IBWSN (300 entries), SAWSN (300entries), STEMRRSN (168 entries), HRWSN (139 entries), SATYN (66 entries), KBSN (38 entries), HLBSN (52 entries), MDSN (38 entries), EIGN (108 entries), NDSN (55 entries), NGSN (80 entries), Australian core (269 entries), AVT (58 entries) and barley trials namely IBYT (25 entries), GSBYT (25 entries), IBON (138 entries) and GSBON (161 entries) were made open to participants, so that they can carry out in-situ selection as per their requirement.

Pre-breeding for wheat improvement

Pre-breeding is an important tool for diversifying the gene pool and creating genetic variability in wheat as there has been a depletion of genetic resources. Wild relatives of wheat contain many useful and economic genes and thus provide a greater scope for introgressing the alien genes through wide hybridization. Keeping in view, the evaluation and hybridization program involving wild sources is underway at IIWBR.

Evaluation of material developed: Twenty cross combinations alongwith five checks were evaluated for yellow and brown rusts. Ten crosses namely PBW 703 / EC 787014 (CS/*Th. bessarabicum*), *Ae. peregrina* /IC 532653//DBW 14, NIDW15 / (Chinese spring/Ae speltoides), DBW621-50 / Paragon, *Ae. peregrina* /IC 532653// WH 1105, *Ae. ovata* 20/WH 1105, *Ae. peregrina* /IC 532653//HD 2967, MACS-2846/ (Langdon/*Th. bessarabicum*), PBW 702 / (Highbury/*Ae. mutica*), and check (HD 2932) had lesser incidence of yellow rust (10S to 20S) while Brown rust was recorded in nine crosses only (Table 1.4). These were tested against a mixture of races received from IIWBR Shimla.

Hybridization with non-conventional germplasm

About 250 cross-combinations involving non-conventional and wild sources were attempted to introgress the desirable genes particularly for biotic and abiotic stress tolerance, into Indian wheat varieties. The crosses were meant for biotic and abiotic stress tolerance. F_1s from twenty-one wild crosses were treated with colchicine for chromosome doubling. These 21 lines along with 4 checks were evaluated under timely irrigated and timely sown rainfed conditions for drought tolerance and disease incidence. Based on phenological data, these were divided into two groups; 10 crosses and one check with days to heading less than 90 days under rainfed conditions were put into one group and remaining into other group.

Table 1.4: Important crosses under pre-breeding program

SN	Cross details	BR	YR
1.	PBW 703/ EC-787014 (*CS/Th. bessarabicum*)	10S	20S
2.	*Ae. peregrina* /532653//DBW 14		20S
3.	DPW -621-50 /EC-787010 (Neodur/*Th. bessarabicum*)	10S	60S
4.	NIDW-15/ (Chinese spring/*Ae. speltoides*)	10S	20S
5.	Ae. kotshyii/IC532653//WH 1105		60S
6.	DBW 39/ EC 787009 (Karim/ Th. bessarabicum)		40S
7.	DBW 621-50/Paragon)	20S	20S
8.	*T. sphaerococcum* /HD 3118 (72)/ PBW-702	40S	40S
9.	*Ae. peregrina* /IC 532653//DPW 621-50		40S
10.	*Ae. peregrina* /IC 532653// WH 1105	40S	20S
11.	*Ae. peregrina* 226/Halberd / DBW-90	10S	20S
12.	PBW-702 / (Highbury/*Ae mutica*)		20S
13.	MACS 2846 / (Langdon/*Th. bessarabicum*)		10S
14.	*Ae. peregrina* /IC 532653//HD 2967		10S
15.	*Ae. ovata* 20/WH 1105		10S
16.	DBW 39/ (Highbury/*Ae mutica*)/DBW 39	20S	40S
17.	PBW343 X EC787008		40S
18.	*Ae. peregrina* 239 /HS 277 / DPW 621-50		40S
19.	PBW 698 / EC 787010 (Neodur/*Th. bessarabicum*)		40S
20.	DBW39 / EC 787012 (Azaziah/*Th. bessarabicum*)		40S
21.	HD 2932	10S	10S
22.	HD 3226	10S	40S
23.	HD 2967	10S	40S
24.	DBW 110	10S	60S
25.	DBW 93	10MR	40S

Drought stress tolerance: Based on the susceptibility index, in the first group two crosses namely, PBW 703/ EC-787014 (CS/*Th. bessarabicum*) and *Ae. peregrina* /IC 532653//DBW 14 were highly tolerant under rainfed conditions where as in the second group three crosses namely *Ae. peregrina* 226/Halberd /DBW-90, PBW 702 / (Highbury /*Ae. mutica*), and MACS-2846/ (Langdon/ *Th. bessarabicum*) were highly drought tolerant (Table 1.5).

Developing genotypes for high zinc, iron and protein content through pre-breeding in wheat: The selected amphidiploids received from University of Nottingham, United Kingdom under DBT-BBSRC project were used in crossing program to improve Indian varieties for micronutrients. The agronomic base promising varieties were involved in crossing program. Out of 150 cross combinations forty genotypes were selected and evaluated for two years along with four checks (promising varieties) for grain weight, zinc, iron and protein content. zinc and iron estimations were performed using an Oxford instruments X-Supreme 8000 fitted with 10 place auto sampler, holding 40 mm aluminum vials. The genotypes DWR-QW-6, DWR-QW-8 were found superior to checks for Zn while genotypes DWR-QW-1, DWR-QW-5, DWR-QW-12, DWR-QW-25, DWR-QW-29, DWR-QW-39, DWR-QW-40 for protein content and genotypes DWR-QW-1, DWR-QW-21, DWR-QW-31, for Iron content at IIWBR-Hisar farm and IIWBR-Karnal (Table 1.6).

Table 1.5: Days to heading, grain yield (g m^{-2}) and drought susceptibility index (DSI) in wild crosses

Cross details	Days to heading		Grain yield (g/m^2)		Drought Susceptibility
	TSIR	TSRF	TSIR	TSRF	Index (DSI)
Group I					
PBW 703/ EC-787014 (CS/*Th. bessarabicum*)	84.0	72.5	432.7	433.3	0.01
Ae. peregrina /532653//DBW 14	86.5	73.0	625.2	679.3	0.36
DPW -621-50 /EC-787010 (Neodur/*Th. bessarabicum*)	95.0	87.5	736.1	831.3	0.54
NIDW-15/ (Chinese spring/*Ae. speltoides*)	96.0	84.0	627.6	739.0	0.74
Ae. kotshyii/IC532653//WH 1105	92.0	82.5	519.7	632.3	0.91
DBW 39/ EC 787009 (Karim/ *Th. bessarabicum*)	96.0	88.0	642.5	791.1	0.97
DBW 621-50/Paragon)	92.5	85.0	543.8	678.8	1.04
T. sphaerococcum /HD-72 / PBW-702	78.0	65.5	576.0	721.5	1.06
Ae. peregrina /IC 532653//DPW 621-50	89.5	87.0	552.2	779.3	1.72
Ae. peregrina /IC 532653// WH 1105	94.5	88.0	538.3	867.7	2.57
HD 2932	94.0	81.5	672.7	855.8	1.14
Group II					
Ae. peregrina 226/Halberd / DBW-90	100.5	94.0	544.8	453.9	-0.50
PBW-702 / (Highbury/*Ae mutica*)	117.0	107.0	383.0	374.1	-0.07
MACS 2846 / (Langdon/*Th. bessarabicum*)	107.0	102.0	514.1	580.9	0.39
Ae. peregrina /IC 532653//HD 2967	98.5	94.5	649.8	831.5	0.85
Ae. ovata 20/WH 1105	101.5	95.5	561.1	724.6	0.88
DBW 39/ (Highbury/*Ae mutica*)/DBW 39	99.0	93.0	688.9	920.0	1.01
PBW343 X EC787008	103.0	101.5	411.1	553.6	1.05
Ae. peregrina 239 /HS 277 / DPW 621-50	109.0	102.5	504.7	708.5	1.22
PBW 698 / EC 787010 (Neodur/*Th. bessarabicum*)	100.0	96.0	633.0	908.1	1.31
DBW39 / EC 787012 (Azaziah/*Th. bessarabicum*)	97.0	92.5	574.4	860.9	1.51
HD 3226	102.0	94.5	749.6	966.8	0.88
HD 2967	105.5	99.0	621.3	840.5	1.07
DBW 110	106.5	95.0	434.2	744.3	2.16
DBW 93	100.0	95.5	464.2	824.1	2.34

TS-IR= Timely Sown irrigated; TS-RF= timely sown rainfed

Table 1.6: Promising genotypes for high zinc, iron, protein and agronomic traits

Pedigree of Genotype	Name	TKW(g)	Zn(PPM)	Fe(PPM)	Protein (%)
Chi. Spring / Ae. mutica (213004)// HD3086	DWR-QW-1	38.2	26.9	56.7	17.5
Chi. Spring / HD3086 / HD 3086	DWR-QW-2	41.2	21.2	36.2	12.3
Chi. Spring / Th. bessarabicum // WH1105	DWR-QW-3	37.0	32.2	39.9	12.4
Azazziah / *Th. bessarabicum* // HD 3086	DWR-QW-4	35.0	31.6	39.4	11.3
Chi. Spring / HD 3086	DWR-QW-5	37.8	27.2	35.9	14.6
Pavon 76 / *Ae. umbelullata* / WH1105	DWR-QW-6	37.0	76.8	38.4	13.1
Chi. Spring / *Th. bessarabicum* / HD 3086	DWR-QW-7	38.0	28.5	39.3	13.3
Pavon 76 / *Ae. mutica* (2130012 /*2 HD3086 / HD 3086	DWR-QW-8	42.8	54.5	39.7	13.2
Highbury/ WH1105	DWR-QW-9	36.2	28.5	35.2	13.9
Highbury/ DBW 88 / DBW 88	DWR-QW-10	38.8	25.8	34.4	11.5
Chi. Spring / WH1105	DWR-QW-11	37.0	25.4	30.9	13.7
Pavon 76 //*2 WH1105	DWR-QW-12	35.0	30.4	41.0	15.8
Karim / *Th. bessarabicum* / HD 2967	DWR-QW-13	36.0	32.1	39.0	13.0
Chi. Spring / PDW291/GDW1255	DWR-QW-14	39.8	33.8	40.3	13.6
Highbury / *Ae. mutica* / DBW88	DWR-QW-15	31.8	24.4	36.4	12.1
Karim / *Th. bessarabicum* / WH1105/HD2967	DWR-QW-16	38.0	25.0	42.4	12.4
Paragon //*2 HD2967	DWR-QW-17	34.5	24.5	33.9	13.5
Chi. Spring / *Th. bessarabicum* //*2 HD 2967/HD2967	DWR-QW-18	38.8	25.0	35.0	12.7
Chi. Spring / PDW 291	DWR-QW-19	37.8	28.2	36.3	12.6
Paragon / WH1105 / HD 2967	DWR-QW-20	36.4	27.2	36.3	15.3
Highbury/ DBW 88	DWR-QW-21	29.2	27.1	55.3	15.5
Pavon 76 / HD 3086	DWR-QW-22	39.8	30.9	42.5	13.9
WH1184 / Paragon	DWR-QW-23	30.6	31.2	38.8	14.3
Chi. Spring / *Th. bessarabicum* // HD 2967/HD2967	DWR-QW-24	35.0	31.3	37.0	14.6
Paragon / D. Dry	DWR-QW-25	34.0	33.5	36.1	18.0
Paragon / HD 2967	DWR-QW-26	38.8	26.9	36.4	15.7
Karim / *Th. bessarabicum* // HI8726 / WH1105	DWR-QW-27	37.8	24.4	39.1	13.0
Paragon / Israna	DWR-QW-28	35.4	28.1	39	12.6
Highbury/ DBW 110	DWR-QW-29	39.5	32.7	36.9	16.1
Pavon 76 / GW322	DWR-QW-30	35.8	26.2	36.1	12.9
Paragon / GW322	DWR-QW-31	36.6	27.9	60.1	11.8
Compactum / Pavon 76	DWR-QW-32	39.0	33.8	38.4	14.0
Highbury/ GW322	DWR-QW-33	30.6	30.2	34.3	12.6
Pavon 76 / *Ae. speltoides* / WH1184	DWR-QW-34	38.5	31.4	40.9	15.3
Paragon / GW 322	DWR-QW-35	38.0	32.0	37.6	12.8
Highbury / KRL 1-4	DWR-QW-36	36.2	28.0	32.1	13.3
Chi. Spring //*3 WH1105	DWR-QW-37	38.9	31.2	39.8	13.7
Paragon / HD 3086	DWR-QW-38	35.8	26.4	35.4	13.2
Karim / *Th. bessarabicum* / HI8726 / WH1105	DWR-QW-39	39.2	29.3	39.7	16.2
T. sphearococcum / Pavon 76	DWR-QW-40	34.4	39.0	38.5	16.7
MACS 6222	Check	44.0	40.9	45.0	12.1
HI 8498	Check	45.0	40.2	43.3	12.0
KRL 210	Check	40.0	36.2	42.8	11.8
HD 2967	Check	40.0	35.9	40.6	11.6

Agronomic traits like days to heading (DTH), days to maturity (DTM), plant height (PHT), thousand grain weight (TKW), CHL (Chlorophyll content) and grain yield plot^{-1} (GYPP) were also recorded.

Sharing the segregating material with cooperating centers: IIWBR pre-breeding program is engaged in developing specific crosses involving non-conventional parents. The purpose is to diversify the material. Ten populations were shared with cooperating centers across the country through segregating stock nursery (SSN). The parents involved were having tolerance to biotic stresses, lodging and high yielding wheats. In addition to it the fixed lines were also shared through National Genetic Stock Nursery and Biofortification Nursery (Table 1.7).

Table 1.7: Sharing of material through SSN

Entry	Pedigree
SSN-1	*T. compactum*/HD 2967//WB 2
SSN-2	*T. compactum*/HI8498//*T. polonicum*//HI8498
SSN-3	*T. compactum/HD* 2967//DBW 39
SSN-4	T. compactum/Pavon 76//HD 3086
SSN-5	*T. polonicum/HI* 8498//RAJ 1255/*3/ HI 8498
SSN-6	WB 2/ Ae. koschyii
SSN-7	*T. spelta/HD* 3086//HRWSN 2076
SSN-8	Triticale/2*WH 1105//C 306/3/ DBW 88
SSN-9	*T. dicoccum*/HD 2967//*T. spelta*/3/HD 3086
SSN-10	GW 322/Ventricosa//HD 2967

Genotypes contributed to national coordinated trials: Out of the material developed in the project, each year a number of fixed lines are evaluated in yield trials. This year one genotype DBW 322 has been promoted to restricted irrigated national trial NIVT-5A being a high yielder in station trial basis. This genotype performed better as compared to checks but due to not being significantly superior over check, it could not be promoted. The performance of genotype DBW 281 in NIVT-1A is shown in Table 1.8.

Table 1.8: Performance of DBW 281 in NIVT 1A

	Yield in q ha^{-1} and rank	
Centre	**DBW 281**	**Check**
NWPZ	65.5 (6)	HD 2967 : 53.5 (30)
NEPZ	52.4 (4)	HD 2967 : 47.6 (24)
National	58.7 (5)	HD 2967 : 50.6 (30)

Characterization of photosynthetic pathway in different species of wheat

In order to characterize photosynthetic pathway, gas exchange studies were conducted in three diverse species (i.e. *Triticum aestivum, T. tauschii* and *T. bioticum)* of wheat. Working protocol was developed for determination of CO_2 compensation point using gas exchange parameters. Mean values of photosynthesis were plotted against varying CO_2 concentrations. Intercept on X axis represent the CO_2 compensation point which explain about which photosynthetic pathway (either C_3 or C_4) is operating at physiological level. Value of CO_2 compensation point ranged from 50 to 100 ppm which strongly suggested that photosynthetic pathway operating in all the three species is only C_3 and in no case it was C_4.

Wheat improvement for high productive environments of northern India

DBW222 (Karan Narendra): a new wheat variety released for north western India: It was identified for cultivation under irrigated timely sown conditions of NWPZ. This variety DBW 222 yielding 61.3 q ha^{-1} has shown a significant yield superiority over HD 2967 (13.1%), WH 1105 (6.4%), HD 3086 (4.02%), DBW 88 (9.4%), DPW 621-50 (7.3%), PBW 550 (2.11%) and HD 3226 (0.6%) and has shown the potential yield of 82.1 q ha^{-1}. It was highest yielding in agronomical trials both under timely and late sown conditions. It is resistant to foliar diseases under natural and artificial epiphytotic conditions. SRT analysis revealed that DBW222 is resistant to most prevalent brown rust races (11,12-2,12-5,12-7,12-8,16-1,77,77-2,77-7 77-8, 77-9, 77-10,77A-1, 104-2, 104-3,104-4,107-1,162-1,162A). Presence of adult plant resistance and slow rusting genes in

Fig. 1.1 Field view of DBW 222 (Karan Narendra)

DBW 222 for brown rusts as indicated by race specific (77-5, 77-9, 104-2) APR response. DBW 222 has good nutritional quality as indicated by high Iron content (37.5 ppm). It is having a good chapati-making score (7.5), bread loaf volume (648 ml), bread quality (8.24) and a biscuit spread factor (8.45cm).

Notification and area extension of Karan Vandana (DBW 187): DBW 187 (Karan Vandana) was identified and released for cultivation in irrigated timely sown conditions of North Eastern Plain Zone (NEPZ) vide gazette notification S.O. 1498 (E) dated 01.4.2019. Based on high yield and input responsiveness, under Special-High Yield Potential Trial DBW 187 was identified for release under irrigated early sown & timely sown conditions in NWPZ by varietal Identification committee. This variety has been recommended for an area extension in North Western Plains Zone (NWPZ) by Central Varietal Release Committee in the meeting held on 4th October, 2019. This genotype has also shown resistance to wheat blast disease and was significantly superior in yield over popular check HD 2967 (19.2%), HD 3086 (3.9%) during 2018-19 under SPL-HYPT trial. It recorded average yield of 78.6 with potential yield of 96.6 q/ha. DBW 187 is tolerant to terminal heat under late sown conditions (HSI = 1.04). DBW 187 was higher yielding than all checks under late sown conditions in agronomical trials. It is resistant to foliar diseases under natural and artificial epiphytotic conditions. SRT analysis revealed that DBW 187 is resistant to most prevalent pathotypes of yellow and brown rust. Gene postulation indicated that DBW 187 carries *Lr26+10+, Sr5+11+, Yr2+* gene combinations for brown, black and yellow rusts. DBW 187 has good nutritional quality as indicated by high Iron (43.1 ppm). It is having a good chapati-making score (7.7) and good biscuit spread factor (8.6 cm). The quality of protein is also very good as indicated by a perfect Glu score of 10 with protein content of 11.6 %.

Performance of entries in Advance Varietal Trial: DBW 222 was tested in second year of AVT IR-TS-NWPZ and was identified for release as it showed significant superior performance over checks. Five entries were tested in AVT I year (SPL-HYPT): DBW301, DBW 302, DBW 303, DBW 304, DBW 187. while DBW 273 was tested in AVT-RI-TS-NWPZ. DBW 303 was promoted to AVT-II (SPL-HYPT) under irrigated early sown conditions of NWPZ (Table 1.9).

Performance of entries in National Initial Varietal Trials: Based on the performance of the entries in different NIVTs, genotype DBW 291 was promoted to AVT-I under irrigated late sown conditions of NWPZ . DBW 296 was promoted to AVT-I under restricted irrigation timely sown conditions of NWPZ (Table 1.10)

Contribution to coordinated trials/nurseries

IIWBR station trials: A total of 23 entries were contributed to different IIWBR station trials of 2019-20. From station trials of 2018-19, four promising genotypes namely, DBW 308, DBW 311, DBW 316 and DBW 318, were promoted to various National Initial Varietal Trials based on evaluation for yield and disease resistance. Performance of these lines

Table 1.9: Performance of entries in advance varietal trial

Entry	Promoted to	Zonal yield (q ha^{-1})	Rank	Best Check	CD
DBW 222	Identified and released (IR-TS-NWPZ)	64.4	1	HD3086 (62.8)	0.9
DBW 187	SPL-HYPT Released	78.6	2	HD3086 (75.6)	2.2
DBW 303	SPL-HYPT final year	80.4	1	HD3086 (75.6)	2.2

Table 1.10: Performance of entries in national initial varietal trial

Entry	Promoted to	Yield (q ha^{-1})	Rank	Best Check	CD
DBW 291	AVT-I (IR-LS-NWPZ)	52.0	8	DBW173 (49.2)	2.3
DBW 296	AVT-I (RI-TS-NWPZ)	61.9	1	WH1142 (57.3)	3.5

Table 1.11: Four promising entries promoted to NIVTs

Entry	Promoted to	Avg. Yield ($q\ ha^{-1}$)	IPPSN 2018-19							
			Stem Rust		Leaf rust (south)		Leaf rust (south)		Stripe rust	
			HS	ACI	HS	ACI	HS	ACI	HS	ACI
DBW 308	NIVT 1A	52.2	20S	8.8	10MS	3.5	20S	4.2	20S	12.2
DBW 311	NIVT 1B	54.2	60S	20.0	10S	6.8	20S	6.7	20S	6.8
DBW 316	NIVT 3A	45.3	5MS	1.6	0	0.0	TS	0.2	5S	1.5
DBW 318	NIVT 3A	48.6	10MS	3.2	40S*	10.2	TS	0.2	10S	3.9

in station trials and IPPSN are presented detailed in Table 1.11.

In addition, genotype DBW 187, DBW 301, DBW 302, DBW 303 and DBW 304 were promoted to special trial of High Yield Potential Trial (SPL-HYPT) under early/timely sown irrigated conditions of NWPZ. DBW 303 ranked first in the trial and was promoted to final year (Table 1.9). A total of 12 early maturing genotypes were contributed to SDSN. Genotypes RWP 2014-19, RWP 2013-20 and RWP 2016-29 performed consistently superior over the checks in three years of evaluation in SDSN. A total of 25 diverse segregating populations were contributed to Segregating Stock Nursery (SSN) during 2018-19. Genotypes RWP 2018-26 (0.92), RWP 2018-27 (0.89), RWP 2018-31 (0.88), RWP 2018-32 (0.87) and DBW 273 (0.89) were identified in NWPZ &NEPZ. In MLHT 2, RWP 2017-21 (0.93) was identified for CZ &PZ.

Creation of variability for different traits through hybridization: A total of 320 bread wheat cross combinations were successfully attempted with the aim of high yield, enhanced plasticity, resistance to diseases including rust diseases, drought and heat conditions. 40 backcrosses were also attempted in the off-season nursery at Dalang Maidan during 2019.

Evaluation of breeding material: A total of 370 F_1s, 574 F_2, 331 F_3, 550 F_4, 220 F_5, 132 F_6 populations were evaluated in field under high disease pressure of yellow and brown rust. Selections were made on the basis of disease resistance, agro-morphological traits and yield components.

Evaluation of advanced generation bulks in Preliminary yield trials: During the crop year 2018-19, a total of 40 advance generation bulks were evaluated in Preliminary Yield Trials (TS), 20 entries in PYT (RI) and 24 entries in PYT (LS) along with checks under artificial epiphytotic conditions for yellow and brown rusts. The yellow rust severity ranged from 0-60S whereas, brown rust severity ranged from 0-40S. A total 10 lines were found superior to checks with respect to yield and rust resistance in IR-TS entries whereas seven and six lines were found superior to checks in RI-TS and IR-LS entries respectively.

Breeding wheat genotypes for eastern region

Hybridization and generation advancement: During the year 2019, a total of 101 new cross combinations involving different targeted donors were attempted to diversify genetic base, improve tolerance against biotic/abiotic stresses and quality traits were advanced at IIWBR, RS Dalang Maidan during summer 2019. The F_1 & F_2 generation of these crosses have been sown at IIWBR, Karnal during 2019-20. Segregating generations viz., F_3 (55 crosses), F_4 (18 crosses) and F_5 (85 crosses) were sown during main season at Karnal. Apart from this, F_6 bulks (9 crosses), F_7 bulks (19 crosses) and F_8 bulks (22 crosses) were planted during main season, 2018-19. Apart from this about 1300 single spikes for different filial generations have been planted.

Contribution to national trials: Genotype DBW 277 and five other genotypes were tested in AVTs and NIVTs respectively, during 2018-19. Six genotypes were promoted to different NIVTs

Table 1.12: Wheat genotypes contributed under different NIVTs during 2019-20

DWR ST-Id	Entry	Pedigree	Trial
LBP 2018-07	DBW 312	HUW234/WH147	NIVT-1B
LBP 2018-13	DBW 335	RAJ3765/BH1146	NIVT-3A
LBP 2018-18	DBW 321	DBW39/DL788-2	NIVT-5A
LBP 2018-17	DBW 323	TILHI/SOKOLL/4/2*ATTILA*2/	
PBW65/PIHA/3/ATTILA/ 2*PASTOR	NIVT-5A		
LBP 2018-20	DBW 321	CHIPAK/83	NIVT-5B
LBP 2018-16	DBW 295	CROC_1AE.SQ(205)//BORL95	
/3/PRL/SARA//TSI	NIVT-5B		

during 2019-20 based on superior performance in station trials . (Table 1.12).

Contribution to national nurseries: Three genotypes (LBP 2018-23, NEP-RI-18-25, NEP-TS-18-51) were contributed to the Salinity/Alkalinity nursery; two genotypes (DT-RIL-1 and DT-RIL-110) were contributed for DTSN during 2019. Besides, 25 genotypes were contributed to the short duration screening nursery during 2019.

Contribution to IIWBR station trials and PYTs: Total 30 entries were contributed to different station trials conducted under different production conditions across zones during 2019. Also, 69 lines were contributed to three preliminary yield trials during 2019.

Sharing of material in eastern India: During 2019-20, North Eastern Special Trial (NEST) trial comprising 43 test entries along with five different checks (DBW 39, DBW 187, DBW 107, HD 2967 and Raj 3765) was planted at seven different locations (Sabour, Coochbehar, Kalyani, Shillongani, Ranchi, Pusa and Faizabad) in NEPZ for sowing in two dates (timely and late sown) to identify suitable genotypes which are early (in flowering and maturity) and superior in yield.

Assessment for grain yield and agro-morphological traits in bread wheat: Advanced breeding lines were evaluated to identify genotypes with superior agro-morphological traits along with stripe rust resistance. Appreciable amount of variation was observed for various agro-physiological traits and stripe rust incidence (Table 1.13). The traits viz., DTH (-0.42), PH (-0.20) and GNPS (-0.10) exhibited negative association with grain yield, whereas GWPS (0.08), NDVI (0.08) and BY (0.87) exhibited positive association with grain yield. Therefore, the traits which showed positive significant association with grain yield could be used as selection criterion for selecting high

Table 1.13: Selected genotypes for grain yield and agro-morphological traits

Code	Genotypes	DH	PH(cm)	GNPS(3 spikes)	NDVI	GWPS(gm)	BY(Kg)	GY (Kg plot^{-1})	Stripe rust
G1	LBP 18-1	106	120	149.7	0.69	9.1	16.1	4.6	tS
G2	LBP 18-13	88	110	125.0	0.65	8.5	13.4	5.2	tS
G3	LBP 18-16	104	120	155.3	0.72	11.8	15.2	5.6	0
G4	LBP 18-15	108	117	141.7	0.74	9.5	14.5	5.4	5S
G5	LBP 18-17	104	114	163.7	0.71	10.6	15.3	5.4	0
G6	LBP 18-18	104	120	124.7	0.68	9.0	15.4	6.0	0
G7	LBP 18-20	99	112	174.3	0.67	9.4	15.4	6.0	tS
G8	LBP 18-19	108	109	158.0	0.73	7.9	14.5	5.5	tS
G9	LBP 18-25	102	123	166.7	0.69	8.4	13.3	4.2	0
G10	BCW 2	107	118	143.0	0.69	7.8	12.2	5.3	0
G11	BCW 5	106	121	149.7	0.67	8.9	16.2	4.9	0
G12	BCW 6	103	110	161.7	0.68	8.0	14.7	5.6	0
G13	BCW 9	106	111	168.3	0.70	8.2	13.9	4.8	5S
G14	BH 1146 (C)	79	141	126.0	0.68	8.2	18.4	4.9	20S
G15	DBW 39 (C)	91	112	164.3	0.59	8.9	24.3	5.5	40S

yielding genotypes. Out of 38 genotypes, 13 genotypes *viz.*, G1, G2, G3, G4, G5, G6, G7, G8, G9, G10, G11, G12, and G13 were selected which exhibited less than 5S stripe rust incidence. Further, 05 genotypes *viz.*, G3, G6, G7, G8, and G12 were found better than check (DBW 39) for grain yield and stripe rust incidence. Further, these genotypes could be evaluated in multi-environments and/or multi-years' trials for the assessment of stability in respect of yield performance and stripe rust resistance.

Identification of water logging tolerant wheat genotypes using various selection: Waterlogging condition limits wheat yields in areas receiving heavy rainfall and poor drained soil around the world including India. Various agronomic practices have been proposed and are practiced to minimize the adverse effects of waterlogging on crop growth and development. A set of 65 genotypes including five checks (HD 2967, HD 2009, KRL 3-4, KRL 99, and Kharchia 65) were evaluated during Rabi 2018-19 under normal and waterlogging conditions in an augmented design to identify stress tolerant genotypes (Table 1.14). Each genotype was planted in a pot of 1 row of 2.0m length maintaining a spacing of 23cm between rows and 10cm between plants within a row. Promising genotypes (SSD C3-253, SSD C3-143, HPBW 2, HD 2888, SSD C3-24, SSD C3-113, and WH 1105) were selected based on high grain yield along with lower reduction percentage, and stress susceptibility index under waterlogging condition as compared to best check (KRL 3-4). However, some other genotypes viz., SSD C3-140, SSD C3-347, NW5054, DBW 71, SSD C3-264, PBW 550, PDW 314, SSD C3-253, HPBW 2, SSD C3-24, SSD C3-113, and WH 1105 were selected only based on stress susceptibility index, tolerance index and least reduction percentage in grain yield due to waterlogging, as compared to best check (KRL 3-4). Therefore, the selected promising lines could be used as donors to improve waterlogging tolerance in wheat.

Anticipatory breeding programme for mitigating threat of wheat blast: An Anticipatory Wheat Blast Screening Nursery (AWBSN) consisting of 86 entries was planted at eight locations in eastern states (Assam, West Bengal, Bihar, Jharkhand, Meghalaya & Manipur).

Table 1.14: Wheat germplasm evaluated for water logging tolerance

Genotypes	Grain yield (g plot^{-1})		% Yield reduction	Stress susceptibility
	Normal	Waterlogged		Index
SSD C3-253	370	320	13.51	0.26
SSD C3-143	396	294	25.66	0.51
HPBW 2 314	283	10.03	0.20	
HD 2888	365	265	27.40	0.54
SSD C3-24	300	260	13.19	0.26
SSD C3-113	280	249	11.25	0.22
WH 1105	308	223	27.64	0.55
SSD C3-140	245	213	13.06	0.26
SSD C3-347	245	210	14.29	0.28
NW 5054	241	182	24.32	0.48
DBW 71 221	163	26.47	0.52	
SSD C3-264	146	129	11.64	0.23
PBW 550	160	126	21.25	0.42
PDW 314	100	93	7.04	0.14
HD 2967 (C)	331	210	36.44	0.72
HD 2009 (C)	278	163	41.52	0.82
7 KRL 99 (C)	303	207	31.85	0.63
8 KRL 3-4 (C)	308	220	27.92	0.55
9 KH 65 (C)	275	167	39.35	0.78

Evaluation of wheat parental lines for physiological traits: Data on phenological and physiological traits was recorded on 66 advanced breeding lines and cultivars to identify physiological superior lines for use in crossing. The pooled results of two consecutive crop seasons revealed that grain yield had significant correlation with DM, NDVI, chlorophyll, assimilation rate and WUE (Table 1.15).

Sixteen lines including 6 cultivars had higher grain yield and physiological traits (Table 1.16). Of these, LBP 2017-10, LBP 2017-13, DBW 39, LBP 2017-14, LBP 2017-17, LBP 2017-4 and LBP 2017-8 were promising during both years of evaluation.

Wheat improvement for warmer areas

Release of new variety: New variety DBW 252 (Karan Shriya) has been released by the CVRC for timely sown restricted irrigation conditions of the NEPZ. This variety is highly resistant to wheat blast disease and tolerant to drought stress. DBW 252 has mean yield of 36.7 q ha^{-1} with potential of 55.6 q ha^{-1}. It also showed resistance to leaf rust, Karnal bunt, leaf blight and powdery mildew. It also has better quality attributes and end-product making qualities.

Fig. 1.2 Field view of DBW 252 (Karan Shriya)

Hybridization and evaluation of breeding material in different filial generations: A total of 286 new cross combinations were attempted during the crop season which included diverse

Table 1.15: Pearson correlation coefficients of various traits with grain yield

Trait	DH	DM	GFD	NDVI	CFL	CHL	gs	A	E	WUE
Correlation coefficient	0.157	0.253*	0.016	0.286*	0.087	0.327**	0.124	0.327**	0.116	0.241*
Probability	0.21	0.04	0.90	0.02	0.49	0.01	0.32	0.01	0.36	0.05

* significant at p<0.05; ** significant at p<0.01; DH=Days to heading, DM=Days to maturity, GFD= Grain filling duration, NDVI= Normalized difference vegetation index, CFL= Chlorophyll fluorescence (Fv/Fm), CHL= Chlorophyll, gs= Stomatal conductance, A= Assimmilation rate, WUE = Water use efficiency

Table 1.16: Grain yield and physiological traits in promising lines

Genotype	GY	DH	DM	NDVI	CFL	CHL	gs	A	WUE	RUE
KRL 2106	96.9	88.5	126.5	0.71	0.736	0.046	423.6	21.4	3.5	19.8
LBP 2017-10	690.0	93.8	133.3	0.73	0.770	0.041	298.5	22.7	3.5	19.8
LBP 2017-13	620.3	93.5	129.8	0.71	0.756	0.048	377.7	20.8	3.8	16.6
DBW 39	561.9	95.8	128.3	0.67	0.760	0.046	371.0	20.7	3.0	22.6
LBP 2017-14	557.5	91.0	129.3	0.71	0.761	0.047	523.9	26.5	3.2	23.7
RAJ 3765	552.4	93.0	130.8	0.71	0.769	0.040	455.3	19.1	3.0	20.3
LBP 2017-17	543.3	97.5	132.5	0.64	0.742	0.044	757.8	21.1	2.0	19.8
DBW 71	510.3	86.5	129.8	0.68	0.765	0.041	472.5	23.9	3.4	16.1
LBP 2017-3	504.9	97.3	133.3	0.63	0.733	0.048	372.3	18.8	3.3	18.3
WH 1105	492.1	94.8	126.8	0.70	0.748	0.042	454.5	23.2	2.8	18.9
LBP 2017-18	488.9	86.8	128.5	0.65	0.774	0.042	412.4	24.3	3.5	18.2
LBP 2017-4	486.6	97.8	132.0	0.60	0.750	0.045	394.8	21.0	2.4	19.6
LBP 2017-2	485.9	84.3	127.3	0.69	0.763	0.047	365.5	24.6	3.9	24.4
LBP 2017-8	485.0	85.5	128.0	0.68	0.767	0.045	590.2	26.6	3.4	28.9
DBW 50	483.3	95.0	130.8	0.67	0.764	0.035	505.5	21.7	3.2	18.7
LBP 2017-7	477.5	90.0	125.8	0.69	0.760	0.045	388.1	21.6	3.0	19.4

GY= Grain yield/plot, DH=Days to heading, DM=Days to maturity, NDVI= Normalized difference vegetation index, CFL= Chlorophyll fluorescence (Fv/Fm), CHL= Chlorophyll, gs= Stomatal conductance, A= Assimilation rate, WUE = Water use efficiency, RUE= Radiation use efficiency

Table 1.17: Performance of promising heterotic crosses

Cross	Heading (days)	Maturity (days)	Grain yield (g plot^{-1})	Heterosis over HD 3086 (%)
DWAP1510/DBW221	98	145	1372	49.0
DWAP1108/MP1349	102	147	1362	47.9
MP3382/DBW129	97	142	1336	45.1
DWAP1108/MACS2496	102	145	1336	45.1
DWAP1510/DBW71	95	144	1324	43.8
DWAP1510/DBW107	94	142	1274	38.3
PBW770/DBW129	97	145	1266	37.5
DWAP1509/DBW71	95	143	1252	35.9
HI1605/MP3493	98	146	1232	33.8
PBW770/MP3382	99	143	1228	33.3
DWAP1108/DBW235	103	145	1212	31.6
HI1605/DWAP1510	97	146	1202	30.5
DWAP1512/KRL1-4	95	144	1190	29.2
DWAP1509/CRS40	101	146	1186	28.8
MP3382/RAJ4083	95	142	1156	25.5
DWAP1511/KRL1-4	96	145	1156	25.5
DWAP1510/WB2	97	142	1146	24.4
DBW235/MP3382	101	144	1134	23.1
DWAP1511/RAJ4083	96	144	1128	22.5
DWAP1512/DBW221	96	143	1106	20.1
HD 3086 (C)	96	141	921	

genotypes as parents with the objective to incorporate the desirable traits for warmer areas. During the period under report, 213 F_1s were evaluated for yield and component traits along with 10 check varieties namely HD 3086, HD2967, MACS 6222 and GW 322. Heterosis over best check HD 3086 was estimated for yield and a wide range of -71.6 to 49.0% was observed. The promising combinations showing more than 20% standard heterosis for yield were identified for more precise evaluation in next generations.

Evaluation of breeding material in different generations: Breeding lines developed from diverse crosses were evaluated during 2018-19. These lines included advanced lines as well as segregating material in different filial generations. Artificial epiphytotic conditions were created to screen the material for resistance to diseases especially yellow rust. From these lines, 5647 selections representing 851 cross combinations were made based on plant type, maturity period, disease resistance, grain weight, tillering ability and grain number (Table 1.18). In addition, 78 bulks were taken for their evaluation in PYTs.

Evaluation of advanced bulks in PYT: Total 84 advanced bulks were contributed to common PYTs of the IIWBR (40 for timely sown, 20 for restricted irrigation and 24 for late sown trials) out of which 22 were promoted to IIWBR station trials (nine in ST-1, two in ST-2, five in ST-3 and six in ST-4) during 2019-20.

Table 1.18: Evaluation of segregating material in various generations

Generation	Line (crosses)	Selection (crosses)
F_2	256	225
F_3	345	2890 (289)
F_4	2173 (174)	1240 (124)
F_5	1492 (136)	912(122)
F_6	1079 (95)	257(48)
F_7	504 (68)	123 (43)
Total	5849 (1074)	5647(851)

Table1.19: Promising entries in PYT during 2018-19

Entry	Yield (q ha^{-1})	Yr	Br
ST-1(Irrigated timely sown for NWPZ/NEPZ)			
DWAP 39	83.7	tMR	20S
DWAP 27	82.6	10MS	0
DWAP 33	82.4	20MR	5MS
DWAP 23	80.8	10MS	0
DWAP 40	78.6	5MR	5MS
DWAP 36	78.5	10MS	5MS
DWAP 29	76.1	tR	10MS
DWAP 38	74.1	tR	0
DWAP 25	73.4	tMR	20S
ST-2 (Irrigated timely sown for CZ/PZ)			
DWAP 20	79.1	40S	10MS
DWAP 14	76.9	30S	0
ST-3 (Irrigated late sown)			
DWAP 21	55.1	tR	0
DWAP 22	54.7	tMR	0
DWAP 3	52.7	20MS	10MS
DWAP 13	49.2	20S	20MS
DWAP 17	48.2	tR	20MS
ST-4 (Timely sown restricted irrigation condition)			
DWAP 15	77.5	10MS	20S
DWAP 5	73.7	5MS	40S
DWAP 6	72.1	30MS	20MS
DWAP 3	71.4	tR	5MS
DWAP 20	69.0	40S	10MS
DWAP14	67.1	20MS	0

Table 1.20: Performance of dwarf bread wheat genotypes for yield and component traits during 2018-19

Genotypes	Grain yield (qha^{-1})	Plant height (cm)	Heading days	Maturity days	SL (cm)	Grains Spike^{-1}	TGW (g)	HI (%)
WAPD-1508	72.0	68	103	150	14	51.8	43.9	36.2
WAPD -1522	70.7	69	106	148	14	95.0	40.8	34.2
WAPD -1521	67.1	70	106	149	12	74.2	38.1	32.7
WAPD -1519	66.9	69	106	150	13	75.0	38.0	41.0
WAPD -1505	63.5	69	99	148	12	56.2	37.3	30.7
WAPD -1516	60.7	69	107	151	13	70.0	36.2	38.4
WAPD -1512	60.1	68	107	152	11	88.2	30.7	42.0
WAPD -1531	60.1	69	104	147	11	71.0	37.0	34.1
WAPD -1507	59.3	68	99	148	15	77.4	41.9	34.5
WAPD -1510	57.0	68	104	151	13	62.4	39.1	44.9
WAPD -1511	57.0	69	107	151	12	89.2	35.8	38.5
WAPD -1515	56.6	69	106	151	12	65.4	38.6	39.6
WAPD -1518	55.2	69	106	151	13	55.0	43.1	41.5
WAPD -1525	54.4	68	108	147	12	69.0	43.6	34.6
DM-6 (c)	33.8	61	99	147	12	89.6	25.8	20.6
DM-7 (c)	42.6	66	98	147	11	84.2	27.9	29.0
DBW 93 (c)	54.3	88	98	141	9	61.0	41.0	35.2

Table 1.21: Performance of DBW 290 in NIVT3A during 2018-19

Entry	Yield (q/ha^{-1})		Rust Reaction		Promotion (2019-20)
	NWPZ	NEPZ	Yellow (ACI)	Brown-N(ACI)	
DBW 290	54.0	47.4	20S (6.5)	10S (2.5)	AVT-IR-LS-NWPZ
DBW 107 (C)	51.1	46.1	10S (3.9)	20MS (3.5)	
CD (10%)	2.3	2.1	-	-	

Evaluation of dwarf genotypes for yield components: Thirty-eight dwarf genotypes were evaluated during 2018-19 for yield and component traits along with check variety DBW 93 and two registered genetic stocks namely, DM 6 and DM 7. The promising entries having higher yield than the check variety DBW 93 and registered genetic stocks with plant height of 70 cm or lesser were identified (Table 1.20) as potential genetic resources for further evaluation under agronomical manipulations for yield and associated traits.

Contribution to NIVTs/AVT: During 2018-19, twenty-one entries were contributed to IIWBR station trials out of which six entries were promoted to NIVTs namely DBW 306, DBW 309 in NIVT 1A, DBW 310 in NIVT 1B, DBW 314 in NIVT 2, DBW 320 in NIVT 3B and DBW 324 in NIVT 5A. Based on yield performance and disease reactions, DBW 290 has been promoted to AVT-I of NWPZ-LS during 2019-20 crop season.

New sources of heat and drought tolerance: Six genotypes were contributed in IIWBR station trials under late sown conditions during 2016-17 in replicated trials with plot size 6rows of 6.0m length. Further, these genotypes were evaluated under NICRA trials under timely sown irrigated, timely sown rainfed and late sown irrigated conditions at Akola, Karnal and Powarkheda during 2017-18 and 2018-19 crop seasons. Simultaneously same set was also evaluated under rain out shelter during both the crop seasons at Karnal. Data on yield components and phenological traits were recorded under all the three conditions. Stress susceptibility indices were calculated considering irrigated timely sown as control or non-stressed condition, timely rainfed as drought stress, irrigated late sown as heat stress and rainfed late as heat and drought stress together. Based on pooled data of two crop seasons across three locations under late sown irrigated conditions, two genotypes namely DWAP 1608 and DWAP 1607 were identified as heat tolerant genotype. Similarly, pooled data under late sown rainfed conditions categorized DWAP 1608 and DWAP 1612 as drought and heat tolerant genotype.

Table 1.22: Pooled susceptibility index of promising entries in multilocation trial during 2017-18 & 2018-19

Genotype	Akola (PZ)	Powarkheda (CZ)	Karnal (NWPZ)	Pooled
Heat susceptibility index (HSI) under late sown irrigated conditions				
DWAP 1608	2.74	-1.29	1.01	0.42
DWAP 1607	0.39	-0.09	1.08	0.70
AKW 2862-1(C)	1.72	0.61	0.87	0.74
HTW 11(C)	1.55	0.00	0.97	0.81
HINDI 62(C)	-0.71	2.19	0.53	0.86
DHTW 60(C)	0.77	2.17	0.52	0.90
Drought & heat susceptibility index (DHSI) under late sown rainfed conditions				
DWAP 1608	1.00	0.12	0.87	0.77
DWAP 1612	0.84	1.04	1.02	0.99
AKW 3717 (C)	0.70	1.05	0.84	0.85
HINDI 62 (C)	0.59	1.37	0.85	0.94
HTW 11 (C)	0.97	0.60	1.10	0.98
HTW 6 (C)	0.86	1.01	1.07	1.00

Table 1.23: Sixty diversified new CMS lines maintained at IIWBR

CMS ID	Pedigree	Male sterility (%)	A Line: Days to heading	A Line: Pl. ht (cm)	B line: Days to heading	B line: Pl. ht. (cm)
DCMS 8	CMS3A/DBW17	100	103	94	102	93
DCMS 9	CMS5A/DBW17	100	104	95	102	91
DCMS 10	CMS8A/DBW17	100	103	94	102	90
DCMS 11	CMS10A/DBW17	100	104	94	102	93
DCMS 12	CMS12A/DBW17	100	105	92	105	96
DCMS 13	CMS13A/DBW17	100	104	99	105	92
DCMS 14	CMS14A/DBW17	100	99	89	106	92
DCMS 15	CMS15A/DBW17	100	99	95	107	100
DCMS 16	CMS18A/DBW17	100	103	93	102	89
DCMS 17	CMS21A/DBW17	100	103	94	102	94
DCMS 18	CMS22A/DBW17	100	102	94	104	87
DCMS 19	CMS25A/DBW17	100	106	90	107	95
DCMS 20	CMS26A/DBW17	100	105	85	105	89
DCMS 21	CMS30A/DBW17	100	104	99	109	102
DCMS 22	CMS2A/DBW16	100	109	100	110	97
DCMS 23	CMS8A/DBW16	100	108	98	109	97
DCMS 24	CMS10A/DBW16	100	110	99	108	102
DCMS 25	CMS11A/DBW16	100	108	101	108	107
DCMS 26	CMS12A/DBW16	100	107	107	108	103
DCMS 27	CMS15A/DBW16	100	107	105	107	108
DCMS 28	CMS18A/DBW16	100	107	100	108	104
DCMS 31	CMS23A/DBW16	100	108	100	108	104
DCMS 35	CMS5A/DBW55	100	104	104	103	99
DCMS 36	CMS9A/DBW55	100	105	97	103	98
DCMS 37	CMS15A/DBW55	100	104	92	104	99
DCMS 38	CMS24A/DBW55	100	103	102	104	103
DCMS 39	CMS21A/DBW55	100	104	102	105	102
DCMS 32	CMS1A/PBW502	100	105	102	105	104
DCMS 33	CMS6A/PBW502	100	107	105	106	107
DCMS 34	CMS21A/PBW502	100	105	102	106	107
DCMS 40	CMS8A/DBW60	100	91	100	91	95
DCMS 41	CMS20A/DBW60	100	89	92	91	99
DCMS 58	CMS21A/DBW60	100	89	100	91	102
DCMS 42	CMS23A/DBW60	100	91	103	91	110
DCMS 44	CMS2A/CBW38	100	104	104	106	108
DCMS 45	CMS10A/CBW38	100	104	103	106	107
DCMS 46	CMS15A/CBW38	100	103	106	106	111
DCMS 47	CMS2A/RAJ3077	100	100	114	99	110
DCMS 48	CMS8A/RAJ3077	100	97	112	98	106
DCMS 50	CMS8A/DBW76	100	99	116	95	115
DCMS 51	CMS21A/DBW76	100	100	124	95	126
DCMS 52	CMS2A/UP2338	100	108	120	111	113
DCMS 53	CMS7A/GW411	100	102	108	107	107
DCMS 54	CMS14A/PBW550	100	108	91	101	95
DCMS 55	CMS14A/RAJ4037	100	103	103	102	109
DCMS 56	CMS28A/PBW175	100	101	120	101	113
DCMS 57	CMS28A/DBW39	100	109	115	109	108
DCMS 59	CMS22A/DBW87	100	107	104	107	98

DCMS 60	CMS24A/DBW87	100	106	106	107	111
DCMS 62	CMS20A/HD2967	100	105	110	108	106
DCMS 63	CMS15A/HD1925	100	102	104	101	102
DCMS 65	CMS9A/HI784	100	99	114	100	113
DCMS 66	CMS9A/HI977	100	105	111	103	115
DCMS 67	CMS29A/HI977	100	107	112	105	114
DCMS 68	CMS26A/K9006	100	105	124	100	120
DCMS 69	CMS11A/NW1012	100	106	116	106	112
DCMS 70	CMS28A/PBW550	100	102	106	100	104
DCMS 71	CMS29A/PBW550	100	105	89	100	92
DCMS 72	CMS2A/RAJ1482	100	108	112	106	111
DCMS 73	CMS10A/RAJ1482	100	107	111	106	108

Hybrid wheat

Maintenance of A, B & R lines: Total 16 CMS sources and 60 diversified new CMS lines were maintained through controlled pollination along with respective maintainer lines. These lines showed complete male sterility and are ready to use for hybrid development programme as parental lines.

Diversification of A & R Lines: Total 236 CMS lines are in different BC generations of diversification in the agronomic background of 40 Indian cultivars namely and > 8000 spikes have been pollinated in this activity during 2018-19. In order to diversify the restorer sources, the fertility restorer lines were crossed that resulted in development of 120 new restorer lines in 27 diverse genetic Indian backgrounds.

Development and evaluation of experimental hybrids: A total of 8 new experimental hybrids were attempted during 2018-19 crop season using 12 CMS lines and 4 restorer lines in 4:2 ratios. The CMS lines were planted between the restorer lines and the seeds of experimental hybrids were harvested from the CMS lines. During this season, 90 experimental hybrids were evaluated at half as well as full seed rate (50 & 100kg ha^{-1}) along with two checks (HD 3086 and HD 2967) having 4 rows of 2.5m length spaced at 20cm. A wide range of heterosis for grain yield was observed, but only one hybrid CMS3A/DBW17*Res 37 could out-yield the best check (HD 3086).

Breeding for quality traits

Wheat nutritional as well as end product quality is very important for many stakeholders in the wheat value chain: farmers (bold and plump grain), millers (high test weight and high flour yield), food manufacturers (processing quality) and consumers (end-use and nutritional quality). Wheat grain can be processed into flour, semolina and other products that form the basic ingredients of many foods globally like bread, cookies, pastries, pasta, noodles and couscous. Nutritional quality as determined by many factors (high grain protein content, iron, zinc) is very important for optimum growth and development of human beings. Presently, we are working on both end product quality as well as nutritional quality (Biofortification). Special emphasis was given for target breeding to develop product (biscuit, bread and chapatti), specific wheat varieties and nutritionally rich (iron, zinc and protein) varieties. Also, due emphasis has given for development of high yielding durum varieties with high yellow pigment content.

Hybridization programme: During the year 2018-19, a total of 223 new cross combinations were made for different quality traits in bread wheat. Targeted crosses have been attempted to improve grain protein content (donors: HD3226, QLD46, HUWL1733, HUWL1734), high sedimentation value (donors: QLD112, HD3241 and HD3304), high iron (donors: BWL7800, BNSR1, HD3310, UP2994) and zinc (donors: WB02, BWL7805, BWL7800, RAJ4541), low grain hardness index (suitable for better biscuit making) (donors: QLD112, QLD84, QLD49, HS490) high chapatti score (donor: C306), high bread loaf volume in bread wheat. Various segregating material evaluated in quality breeding program has been presented in Table1.24.

Table 1.24: Evaluation of segregating material of bread and durum wheat in different generations

Generation	Bread wheat progenies (crosses)	Durum wheat progenies (crosses)
F_2	240	Nil
F_3	1326 (210)	210 (48)
F_4	464 (186)	190 (42)
F_5	257 (76)	158 (33)
F_6	224 (59)	137 (27)
F_7	155 (48)	115 (25)

Contribution to coordinated trials/nurseries

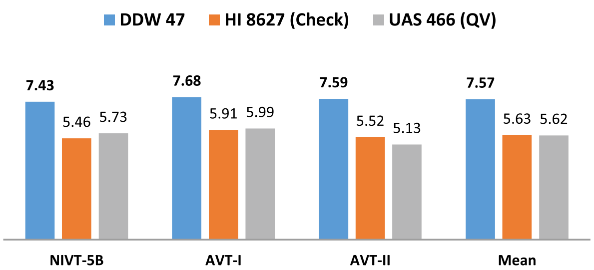
Bread wheat: A total of 10 entries were contributed to different ICAR-IIWBR station trial during 2018-19 (4 for timely sown, 3 for late sown and 3 for restricted irrigated conditions), which were evaluated at different wheat growing zones. On the basis of station trial data DBW334 promoted to NIVT1A, DBW313 to NIVT1B, and DBW17 and DBW19 to NIVT3A. Thirty-one advanced fixed lines were tested in common PYTs during 2018-19 (15 for timely sown, 10 for late sown and 6 for restricted irrigated conditions). Based on common PYT data 11 entries promoted to different station trials (3 for ST-1, 1 for ST-2, 5 for ST-3 and 2 for ST-4). Three entries were tested in QCWBN 2018-19 at different centres and one entry was promoted to further multilocation testing.

Durum wheat: Based on superior yield and quality performance of DDW48 and DDW49 in the first year of advanced varietal trial, both the genotypes have been promoted to test in the second year of advanced varietal trial in peninsular zone under timely sown irrigated conditions. DDW50 & DDW51 were tested in national durum trial NIVT4 and DDW52 was tested in NIVT5B. A total of 5 entries were contributed to different ICAR-IIWBR station trial 2018-19. On the basis of ICAR-IIWBR station trial data DDW53 and DDW54 were promoted to test in NIVT4 and DDW55 in NIVT5B. Based on common PYT 2018-19 data 6 entries were promoted to different station trials (4 for ST-2, 2 for ST-4).

Product development (varieties and genetic stocks)

Variety: DDW 47 has very high yellow pigment content of 7.57 ppm as compared to check variety HI8627 (5.63) thereby showing 34.45 percent superiority over best check. It is also the best variety for all the pasta quality traits as it out-performed the best check variety HI8627 for all the traits with very high overall pasta acceptability with 7.9 as compared to check variety HI8627 with 5.8.

The percent superiority of DDW47 over check variety HI8627 was 36.20% for pasta quality.



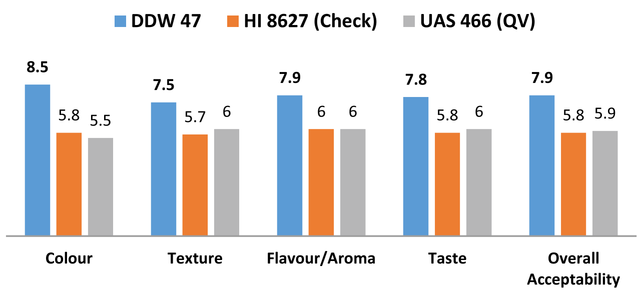


Fig. 1.3 Yellow pigment content and pasta quality of DDW 47 and checks

Fig. 1.4 Field view of DDW 47

DDW47 is the India's first high yielding durum wheat genotype having very high yellow pigment and also pasta quality score. It has a good balance of grain yield with grain and product quality. Besides high yield potential and productivity, it has registered resistance to black and brown rusts thereby providing desirable resistance in the central zone. The genotype is suitable for best pasta quality, since the yellow pigment plays a very important role in the final pasta products. The trait is very important both nutritionally and industrially. The genotype also had high grain iron and sedimentation value. Since pasta industry has high demand for high yellow pigment wheat, DDW47 can be an asset for providing remunerative price to the growers.

Genetic stocks: A total of 4 novel genetic stocks have been registered for various quality parameters. QLD 11 (INGR19011) for high grain protein content, QLD 84 (INGR19010) and QLD 112 (INGR19052) for low grain hardness index suitable for better biscuit making, QLD 102 (INGR19053) for high sedimentation value. All the 3 individual quality parameters (softness, protein and sedimentation value) are developed as 4 novel genetic stocks with high yielding genetic backgrounds. These high yielding genetic stocks with improved quality parameters could be potential donors for improvement of protein, softness and sedimentation value in bread wheat.

Biotechnology and physiological interventions

QTL analysis for terminal heat tolerance

Terminal heat stress is a major cause for reduction in wheat yield around the world especially in South-Asia. Global wheat production is estimated to fall 4.1% to 6.4% with 1°C rise in temperature. To address this issue, a state-of the –art Temperature Controlled Phenotyping Facility (TCPF) at the ICAR-IIWBR, Karnal has been in use for screening the mapping populations as well as trial materials concerning heat stress tolerance in this unique phenotyping facility. Based on the screening of a diverse set of germplasm under normal (field) and heat stress conditions (TCPF), using a set of more than 100 genotype, estimation of their performance on yield and its stability was done. The GGE biplot analysis of following genotypes showed stable and high yield across the environments (Table 1.24). Figure 1.6 depicts performance of genotypes under different environments (normal and stressed) in GGE biplot indicating those genotypes which have comparatively stable performance under both the environments.

Point worth noting is that out of 7 genotypes found stable, only three were high yielding and out of

Fig. 1.5 Temperature controlled phenotyping facility

Table 1.25: Yield of genotypes found comparatively stable under normal as well as heat stress conditions

SN	Genotype	Mean Yield (q ha^{-1})	SD
1	Synthetic 217	11.8	4.4
2	IC 59128B	19.6	12.2
3	IC 322014	20.5	9.2
4	MACS 2496	34.8	9.7
5	HD 2428	35.2	10.1
6	RW 39	42.1	20.7
7	RW 60	45.0	17.8

them two were the recombinant lines developed using Raj4014 / WH 730. Therefore, the Recombinant Inbred Lines (RILs) population developed from RAJ4014 (heat sensitive)/WH 730 (heat tolerant) was utilized to decipher quantitative trait loci (QTLs) for heat tolerance. Phenotyping was done under normal (timely sown), late planting as well as under the TCPF with 5° C above ambient temperature from flowering to physiological grain maturity. Genotyping of the mapping population was done with 35K Axiom® Wheat Breeder's Array. Filtering was done as more than 5% missing values, less than 5% minor allele frequency (MAF) and individuals with more than 15% missing SNP calls were removed from the dataset. In total 8656 (24.63%) markers were found polymorphic between WH 730 and RAJ 4014. In the absence of authentic chromosomal position assignment, 28 markers were further deleted. Another 33% markers out of these could not be included for the want of their marker position. After applying Chi-Square test and removing redundant SNP Markers, 523 well distributed markers were included in developing the framework linkage map for QTL mapping. Chromosome 3B had maximum number and chromosome 4D had lowest number of SNP markers.

QTL analysis was done by composite interval mapping using software WinQTL cartographer version 2.5. Total 30 QTLs were identified related to grain yield components out of which 15QTLs matched with already reported ones. Chromosomes 3B (8), 3D (5), 6B (7), 6D (3) showed maximum QTLs. The linkage map of SNP markers

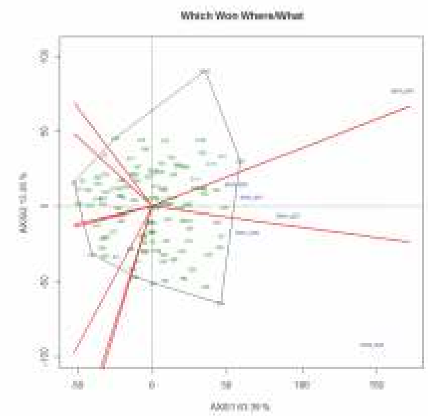


Fig. 1.6: GGE biplot to identify better adopted RILs under heat stress

was generated using software JoinMap version 4.1. QTL for difference in grain weight under Timely sown and Late sown/TCPF (TS-TCPF) conditions at LOD score 3.2 on Chromosome 6B has been depicted in Fig 1.8. One of the associated SNP markers, AX-94477019 was found annotating with the heat stress transcription factor A-9. These SNP markers are being utilized for developing KASP markers for marker assisted selection.

Genome wide identification and characterization of genes involved in fructan metabolism in wheat (*T. aestivum*)

Fructan is a short term storage carbohydrate which plays an important role in abiotic stress tolerance mechanisms in wheat. Fructan remobilization under stress conditions depend on the activities of fructosyltransferase and exohydrolase enzymes. These genes breakdown to fructans to simpler sugars forms viz. inulins and levan which saves the developing grain from starvation. Till now a few

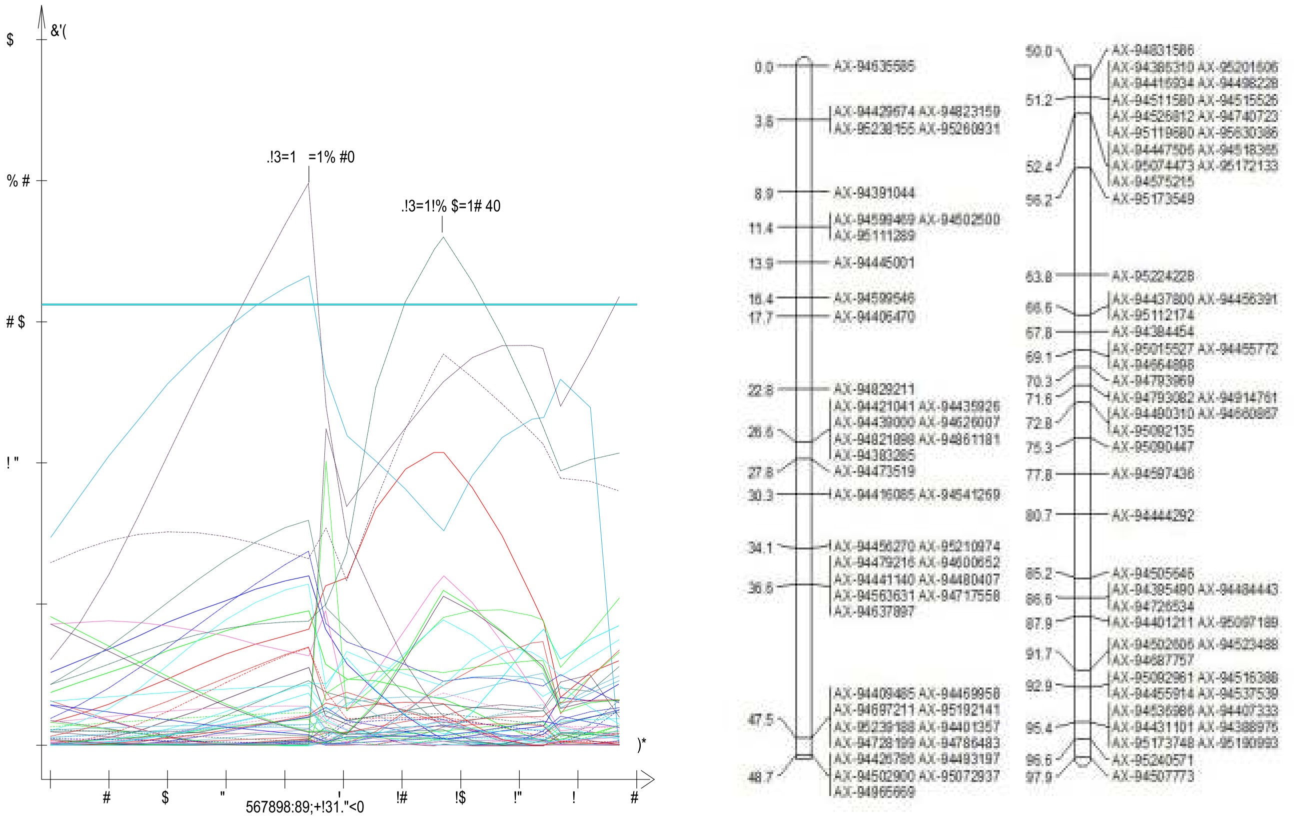


Fig. 1.7 QTL analysis using (a) linkage map of chromosomes 3B & 6D and (b) QTL map of grain numbers per plant on chromosome 3B

studies have been done to understand the genes regulating their activities. A genome wide identification study was conducted to gain insight into the structural and functional aspects of candidate genes viz., fructosyltransferase and exohydrolase enzymes using bioinformatics tools. In this study a total 81 candidate genes distributed all over 21 chromosomes of wheat were identified using recently drafted IWGSC whole genome sequence based on pre-identified and characterized genes in seven model organisms viz. *A. thaliana, A. lyrata, M. truncatula, B. oleracea, B. rapa, H. annus*, and *H. vulgare*. Significant role of tandem and segmental duplication was identified in the expansion of these genes. Ratio between synonymous and non-synonymous substitution suggested a time-line for duplication events from recent to as old as 32.5 MYA. Phylogentic analysis gave an insight into the evolutionary pattern of these genes from other model organisms. Numerous cis regulatory elements were identified in 1.5Kb 5' upstream promoter region of each of the 81 genes indicting response of these genes during development in biotic as well as in abiotic stress conditions. Furthermore, an in silico expression analysis indicated relatively higher expression of identified genes under water and heat stress conditions.

The sucrose non-fermentation-related protein kinase (*SnRK*) is a kind of Ser/Thr protein kinase, which plays an important role in regulating carbon metabolism and energy. In the present study, a total of 111 *TaSnRK* family genes were identified in wheat. Phylogenetic analysis divided these *TaSnRK* to three groups (Fig 1.9). The *TaSnRK* family members were distributed throughout all the 21 wheat chromosomes. Among 21 chromosomes studied, chromosomes 1A, 1D, 2A and 2B, each

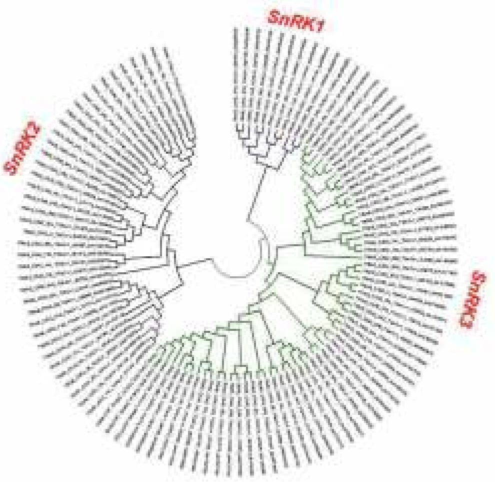


Figure 1.8 Phylogenetic relationship of TaSnRK family genes in bread wheat

encodes a maximum of 8 *TaSnRK* family members, while four chromosomes (2D, 3D, 4A and 5A) each encodes for 7 *TaSnRK* family members, chromosomes 1B, 4B and 4D each encodes for 6 *TaSnRK* family members, two chromosomes 3B and 5D each encodes for 5 *TaSnRK* family members, chromosomes 3A and 5B each encodes for 4 *TaSnRK* family members, three chromosomes 6B, 6D and 7D each encodes for 3 *TaSnRK* family members and three chromosomes each encodes for 2 *TaSnRK* family members. Work on expression pattern analysis of this family genes are in progress.

Introgression of major QTLs for drought tolerance: Breeding wheat varieties that may give high yield under drought environments play a key role in boosting wheat production in India. At present, only a few markers linked with genomic regions significantly affecting wheat yield performance under drought are available in public domain. Therefore, to develop drought tolerant wheat genotypes, a study is conducted for the introgression of important QTLs contributing to drought tolerance into drought sensitive high yielding wheat varieties through marker assisted backcross breeding (MABB). The two major QTLs, one on chromosome arm 7AL (Qyld.csdh.7AL) and other on chromosome 4AL (Qyld.4AL) mapped in the genotypes SQ1 and Dharwar Dry respectively were used for the introgression into two high yielding recipient genotypes (GW366 and DBW39). In this study, four crosses were attempted using these genotypes during crop season 2017-18. F_1 seeds planted in off-season at wheat summer

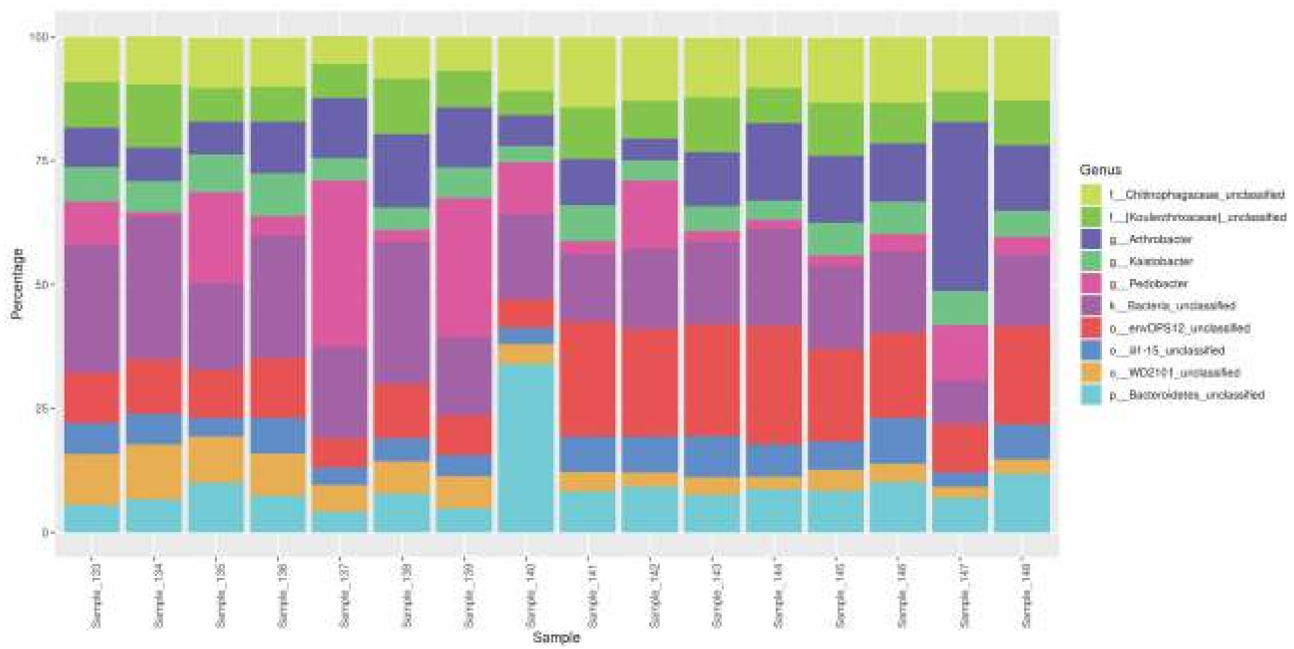


Fig 1.9. Top 10 Genus abundance distribution in drought sensitive and tolerant bread wheat genotypes

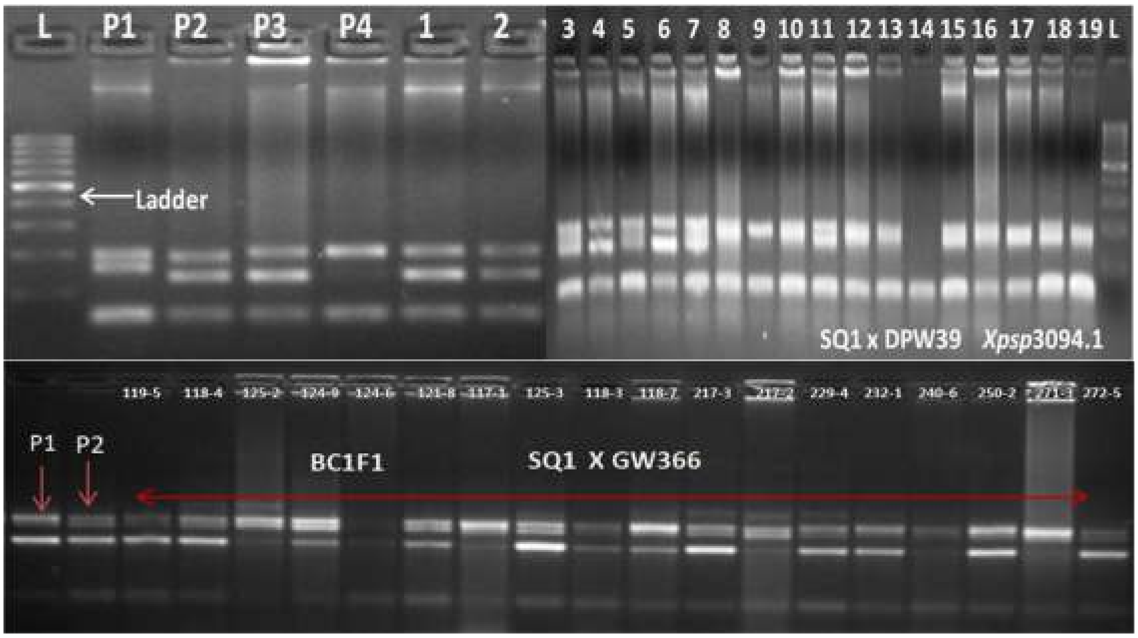


Figure 1.10 P1-SQ1, P2-Dharwad Dry, P3-DBW39, P4-GW366, Molecular profile of BC_1F_1 lines

nursery Dalang Maidan and screened with linked SSR marker Xwmc273.3 in SQ1 (Fig. 1.11) and Xwmc 89 in Dharwar Dry for foreground selection. The 2300 BC_1F_1 seeds were obtained from these 4 targeted crosses. Positive plants were identified and backcrosses were attempted again to obtain BC_2F_1 seeds. BC_2F_1 seeds were planted in off-season nursery at Dalang Maidan (2019-20) and screened for positive plants in homozygous condition using foreground selection. The BC_2F_2 and BC_3F_1 seeds of all the four crosses were sown in crop season (2019-20) at Karnal. The selected plants and their progenies will be advanced following conventional methods of breeding and the drought tolerant and high yielding superior progenies will be identified following phenotypic evaluation.

RWP-2017-21: A promising wheat genotype for heat tolerance; RWP-2017-21 was selected at ICAR-Indian Institute of Wheat and Barley Research (ICAR-IIWBR) in 15th Heat Tolerance wheat yield international trial (HTWYT) during 2016-17 crop season. RWP-2017-21 was one of the highest yielding entry in the 2016-17 HTWYT trial with 107cm plant height. The entry was found to be promising and has showed HSI lower than checks, DBW150 and WH730 which are registered genetic stocks for heat stress and HD2932 which is a promising heat tolerant variety for late sown conditions. Further, the entry was again validated for the second year also in the MLHT2 trial in the same four hot spot locations. The two years data was pooled and the pooled analysis showed that RWP-2017-21 was found be highly promising with lower heat sensitivity index (HSI) (0.93) and also recorded with lower yield reduction of 18% compared to checks (Table 1.25). The pooled analysis of other recorded traits over years in MLHT has showed that RWP-2017-21 is known to have higher grain weight/spike (GWS), days to maturity (DM), biomass (BM g plot^{-1}), thousand grain weight (TGW), Chlorophyll content Index (CCI) at 21DAA and lower canopy temperature (CT) both at 15 and 21 days after anthesis compared to checks under late sown condition. Thus, RWP-2017-21 will serve as a potential source to be utilized in future breeding programs to develop heat tolerant wheat varieties.

Table 1.26: The traits comparison of RWP-2017-21 over other checks in MLHT (data pooled over locations and years 2017-18 & 2018-19)

Genotypes	HSI	Yield reduction %	GWS (g)	DM	BM (g plot^{-1})	TGW (g)	CT (°C) 15DAA	CT (°C) 21DAA	CCI 21DAA
RWP-2017-21	0.93	18	2.0	96.6	2615.2	43.4	26.4	30.0	47.2
DBW 150 (C)	1.01	19.4	1.8	95.7	2157.6	38.3	26.8	30.8	46.9
HD 2932 (C)	0.98	18.8	1.8	95.5	2581.8	40.4	26.8	30.3	46.7
WH 730 (C)	1.25	24	1.9	95.4	2421.0	40.6	27.1	31.7	48.8

Characterization of new source of wheat genotypes for drought stress tolerance: A set of 10 wheat genotypes were selected as high yielding from field studies under drought condition compared to the checks (C306, NI5439). An attempt was made to characterize these identified genotypes under controlled condition at seedling stage, as our earlier reports has showed that seedling level tolerance has high correlation with adult level tolerance under field condition. The experiment was conducted in the climate controlled green house facility and genotypes were sown in pots containing 1:1:1 ratio of soil: coco peat: FYM. After 21 days of seedlings establishment, drought stress was imposed by withholding irrigation for 12days. Various physiological and biochemical parameters such as chlorophyll content, relative water content (RWC), membrane permeability, MDA, proline content, Osmotic potential and catalase enzyme activity were measured to assess their levels of tolerance to drought stress. Further to dissect the molecular mechanisms underlying in the selected genotypes, qRT-PCR analysis was carried out with few selected genes which are involved in drought stress tolerance. Most of these study traits were found to be higher in these genotypes compared to checks with lower electrolyte leakage (%). Hence, they will be further verified under field to serve as novel source for drought tolerance.

Deciphering photosynthetic, leaf anatomical and sink traits to improve yield in wheat: The recent genetic gain in wheat is <1% per annum which is insufficient to meet future food demand and advances in grain yield by improving harvest index has plateaued. Hence, there is a need to work on the other unexplored traits for wheat yield improvement. One such trait is increasing total plant biomass through efficient carbon capture by

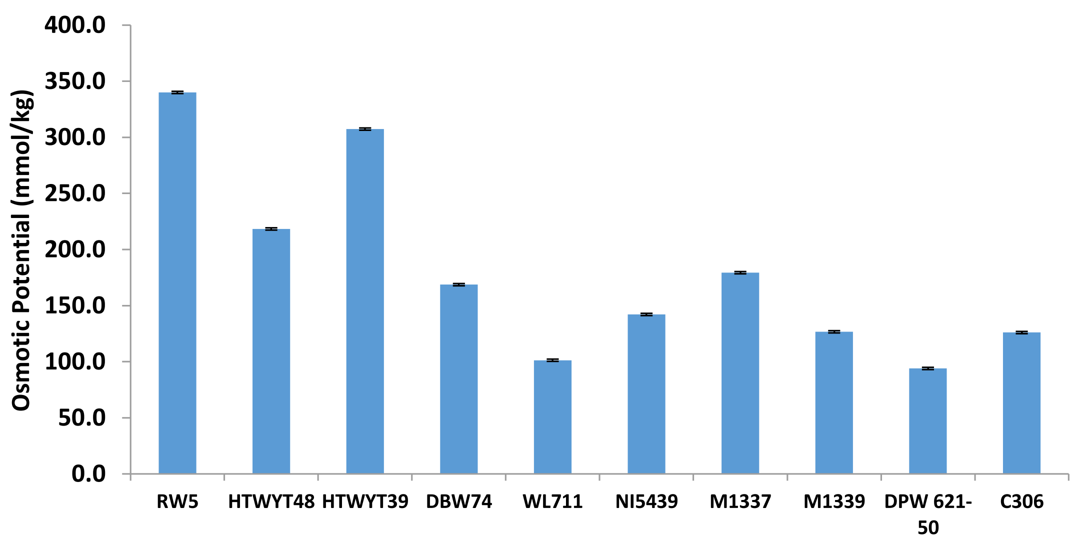


Figure 1.11 Osmotic potential of the genotypes tested using vapour pressure osmometer

Table 1.27: Promising genotypes identified for improving photosynthesis

Trait	Genotypes identified
High Rubisco carboxylation efficiency	DBW16, DBW14, HD3086, NIAW295, HD2932, HD2967, DBW107, WH1126
High mesophyll conductance	DBW110, LOK1, HW2004, HI1531, DBW187, HD2967
High internal $C0_2$ Concentration (CI)	DBW187, DBW189, PBW750, DBW88, Wb2
High Photosynthetic rate(A)	HI1531, NIAW295, HD3118, DBW16, HD3086, PBW343, M1043
High WUE	HD3118, HI1531, COW(W), PBW175, GW322, RAJ 3765, HUW468, NIAW34
High nitrate reductase	MACS6222, GW322, HD2967, NIAW1415
High water soluble carbohydrates at maturity	DBW17, DBW39, RAJ4037,GW322

photosynthesis. High photosynthetic rate, mesophyll conductance, rubisco caboxylation efficiency and leaf anatomical traits associated with C_4 pathway are known to improve the carbon fixation. Maximum yield expression also requires dynamic optimization of source: sink and in improving spike fertility. Currently, all these traits are very meagerly studied and less exploited in breeding programme. In the present study, around 75 high yielding wheat genotypes were characterized for traits associated with improved source and sink characters. Traits like stomatal conductance, mesophyll conductance, internal CO_2 concentration, photosynthetic rate and expression analysis of rate limiting enzymes in photosynthesis were studied. Leaf anatomical traits like bundle sheath cells size, dimorphic chloroplasts, intervenal distance and stomatal index for improved photosynthesis were explored. Sink associated traits like water soluble carbohydrates, percentage of spike fertility in different part of wheat spikelets were studied. Large variations were observed for all these measured traits among the genotypes tested and found different genotypes as best for different traits. Strategic crosses were attempted for complementing these studied traits. Thus, the study indicates that still there is a large scope for improving one or the other photosynthesis and sink traits in released varieties and also they can be used as a potential source for a specific trait in breeding programme. Hence, by complementing these traits we can increase the grain yield in wheat by improving current photosynthesis, biomass and assimilates mobilization into spikelets.

CRISPR/Cas9 mediated genome editing for wheat improvement: The discovery of Clustered Regularly Interspaced Short Palindromic repeats CRISPR Associated protein-9 nuclease (CRISPR/Cas9) gene editing system has revolutionized research in nearly 20 crop species and for various traits including yield improvement, biotic and abiotic stress management. The genome editing technologies can accelerate wheat breeding by allowing the introduction of precise and predictable modifications directly in an elite background. CRISPR technology is useful both in precise enhancing the activity of positive-regulator genes and in eliminating the negative-regulator genes that affect the trait of interest. However, there are only few reports available for validation of CRISPR technique in wheat. ICAR-IIWBR being the nodal institute for wheat research in India has taken initiative to establish a CRISPR-based genome editing facility. The main focus will be to produce novel wheat genotypes with target traits and use them in wheat breeding programs. Before initiating the work, we intensely reviewed the different components and conditions required for genome editing and also published the first exclusive review of genome editing in wheat. Presently, working on improving yield and abiotic stress tolerance traits for which, we have developed the wheat specific Cas9 vectors and designed the sgRNA for *TaGW2-A1, TaMS1 and TamiR398* genes for improving grain weight, male sterility for hybrid production and drought tolerance, respectively. The SgRNA's have been cloned to Cas9 binary vector, sequenced and transformed into *Agrobacterium* EHA105. Their further transformation into wheat system are under progress to develop CRISPR/Cas9 knock outs with improved trait of interest.

Evaluation of radiation use efficiency and gas exchange in wheat germplasm: Light interception and radiation use efficiency (RUE) are essential components of crop performance. Usually, radiation level is low or very low in the months of December and January due to foggy conditions especially in North-Western plains of India. If such conditions prevail for long time, growth of crops like wheat may be affected adversely due to insufficient light interception. Experiment was conducted using 42 selected entries of wheat under three diverse conditions (i.e. under drought, timely sown under irrigated condition, and late sown under irrigated condition). Physiological observations (photosynthesis, transpiration, stomatal conductance, water use efficiency and radiation use efficiency (RUE) were recorded in all the entries at heading stage. Huge variation was recorded in rate of photosynthesis, transpiration, water use efficiency within entries as well as under different growing conditions. RUE [Rate of photosynthesis (nmoles CO_2 fixed m^{-2} leaf area s^{-1}) per unit of PAR] varied from 12.85 to 19.71 under drought condition, 15.85 to 24.14 under timely sown irrigated condition, and 11.69 to 21.76 under late sown irrigated condition. Promising entries with high RUE were identified as DWAP 1613, HTW 67, HINDI 62 (under drought condition); SRIL1, DWAP 1612, HTW 14 (under timely sown irrigated condition); and QBP 605, HTW 64, DHTW 60 (under late sown irrigated condition). These entries can be further utilized in wheat improvement programmes with high RUE in high yielding varieties.

Seed production programme at ICAR-IIWBR

During 2018-19 a total of 3170.50q seed of eight promising wheat was produced on 146 acres of land at NDRI, Karnal. In order to popularize DBW 187, breeder seed was provided to 163 private seed production agencies, 17 ICAR institutes/NGOs, 10 SAUs and 18 KVKs for seed multiplication at large scale. The large quantity of TL seed was also distributed to the wheat farmers at IIWBR Kisan Mela on 5th October 2019 in which about 9,000 farmers from different part of the country participated. Besides a total 67.95q nucleus seed of 21 wheat varieties has been produced during 2018-19 at New farm of IIWBR. Nucleus seed of DBW 88, DBW 71, DBW 17, DBW 173, DBW 90, & WB 02 has been shared to SVPUA&T, Meerut, SKUAT-Jammu and BISA Ludhiana. For monitoring the genetic purity of breeder seed, Grow Out Test of 81 wheat varieties from seven BSP centres was conducted using two RBD design. The observation on off- type plants were recorded during the crop season which was found to be within permeable limits and no plot was rejected on the basis of GOT. The seed programme generated a revenue of approximately Rs. 2.51 crores under the revolving fund scheme of the institute.

Mobile app "Gehoon Doctor" on wheat crop diseases

Wheat Doctor is a mobile app developed in android version 3.0.1. Hindi language is used for information in this app, so that farmer community gets maximum benefit. It provides information mainly on wheat diseases, insects, main area specific diseases, location specific disease resistant varieties, IPM strategies and post-harvest storage management. Using this information farmer can look after their crop better and can identify the diseases /insects in it. Then they can adopt proper method to control that disease/insect. It will help farmers to increase their crop productivity. It provides information about main harmful insects (with their photos) so that farmer can easily identify them.

This app not only provides information on diseases and insects but also the integrated pest

Fig.1.12 Screen shots showing user interface of wheat doctor app

management practices of this crop along with post-harvest safe storage and insect management during storage of wheat crop.

This app is freely available on Google play store. It can be downloaded through following link:

https://play.google.com/store/apps/details?id=iiwbr.Gehoon.GehoonDoctor.

02 CROP PROTECTION

The biotic stresses (diseases, insect pests and nematodes) affect wheat health and quality which is critical to minimize the gap between attainable yield and actual yield. The crop protection programme is aimed at managing major biotic constraints and emerging challenges affecting wheat productivity in intensive production systems, with an ecofriendly manner to minimize pesticide use. Thereore, large number of germplasm and varieties are screened for major diseases and insect pests of wheat. Additionally, programme also work hand-in-hand with wheat breeders to evaluate breeding material for resistance to biotic stresses against rusts and blight in pre-coordinated yield trial entries (IPPSN) and against major diseases, insect pests and nematodes in coordinated yield trial along with check varieties aiming to help breeders for promotions of resistant entries in yield trials and finally for varietal identification as well as release.

Besides this, the progamme keeps vigil on any biotic threat to wheat crop as well as racial distribution and evolution of new races by intensive survey and surveillance. The crop health of wheat was monitored very well during 2018-19 by keeping vigil on new pathotypes of rusts and other diseases and timely suggesting the remedial measure to manage the disease. The first report of stripe rust was observed from village *Fatehgarh Viran* of block Chamkour Sahib of district Roopnagar, Punjab on 14.1.2019. The surveys were also conducted in West Bengal along Bangladesh border for wheat blast. Over all, the crop remained healthy and negligible losses were happened due to biotic stresses thus contributed to the record wheat production. There was no report of wheat blast disease from West Bengal. The resistant sources identified were shared with breeders to include in resistance breeding programme and resistant varieties were deployed strategically in disease prone areas in different agro ecological zones. Different agencies (DAC & FW, ICAR, State Agriculture Departments, KVKs, Farmer's etc.) were sensitized about the potent diseases and insect pests and their management through regular strategy planning meetings, trainings, field days, discussions and distributions of literature and use of mobile phones and IT tools. The Wheat Crop Health Newsletters were issued regularly and distributed as well as uploaded to ICAR-IIWBR (http://iiwbr.org.gov.in). Likewise, advices were given to farmers on crop health management on toll free No 18001801891. Integrated Pest Management (IPM) was worked out to manage biotic stresses in case of susceptible varieties and to use these under emergency conditions to avoid epidemics of rusts and other biotic stresses. Human Resource development was carried out. The achievements of programme, 2018-19 are as below:

PLANT PATHOLOGY

Host Resistance

The evaluation of large number of germplasm and breeding material was carried out under different plant pathological and entomological nurseries at various hot spot locations under artificially inoculated conditions. The major nurseries were: Initial Plant Pathological Nursery (IPPSN), Plant pathological Nursery (PPSN), Elite PPSN, Multiple Disease Screening Nursery (MDSN), Multiple Pest Screening Nursery (MPSN), and disease/pest specific nurseries. Advance Varietal Trial (AVT) entries were also evaluated at specific locations for Race Specific Adult Plant Resistance (APR) to three rusts (brown, black and yellow). Slow rusting lines for different rusts were identified by calculating the Area Under Disease Progress Curve (AUDPC) at different centres against stripe rust.

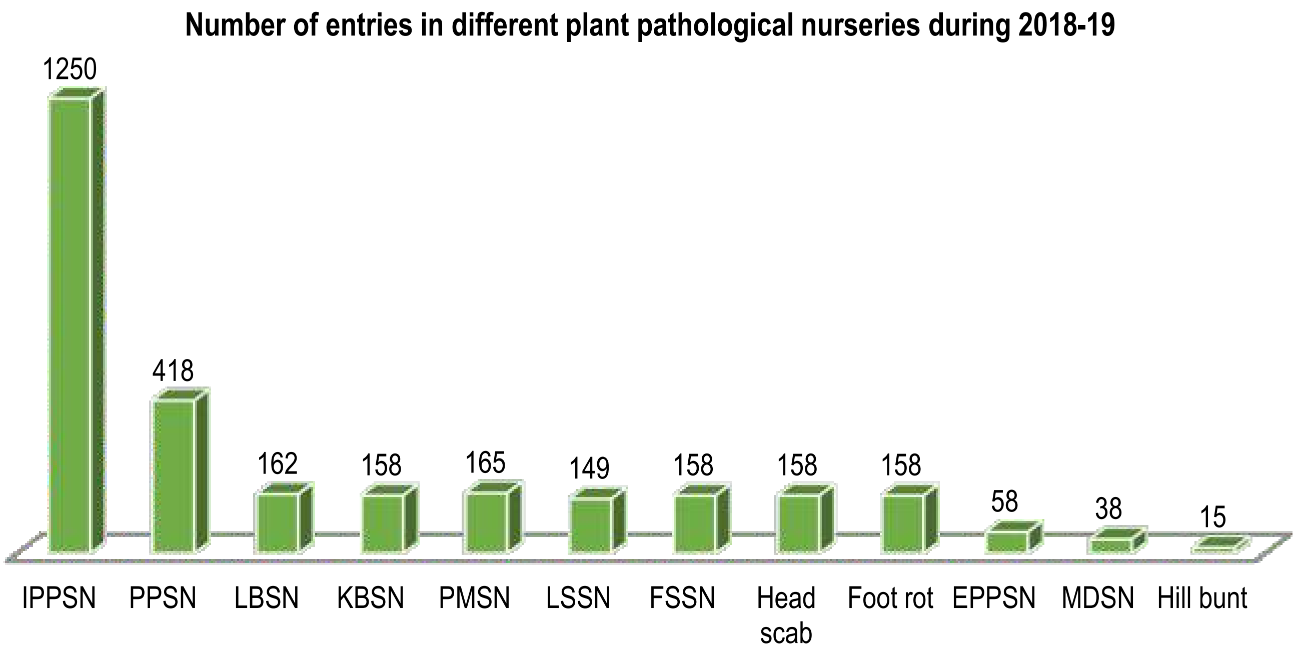


Fig 2.1:- Constitution of different plant pathological nurseries during 2018-19

A total 1250 entries in IPPSN and 418 entiris in PPSN including checks were screened for major disease and insect pests on the basis of this the entries were further promoted in yield trials as well as in identification and release as varieties. Besides this, advance varietal trial entries were also evaluated under disease/pest specific nurseries.These nurseries are evaluated under artificially inoculated and disease epiphytotic conditions at hot spot locations across six agro ecological zones along with susceptible checks. The numbers of entries tested under different nurseries are given in Fig. 2.1

Resistant entries identified

Rust resistance materials in AVT entries (2018-19) with ACI upto 10.0 are given below:

Stem, leaf and stripe rusts

HPW467, PBW820M, PBW821M, PBW 771*, HD3249*#Q, HD 3277, HI8713(d) (C), NIDW 1158 (d), HI 8811 (d), HI 8812 (d), GW 1348 (d), PBW 822B, DDW 48 (d), DDW 47(d)*Q, HI8808 (d), HI8807 (d), PBW 823B, UAS428 (d) (C), MACS3949 (d) (C), HI 8805(d)*, UAS446(d) (C), NIDW 1149(d), HI 8802(d)*, WH1270, DBW303 and DBW302

Leaf and stripe rusts

NW 7049, PBW752(I) (C), PBW 781, DBW187(I) (C), WH 1239, HI1612 (C), HI8737(d) (C), WHD 963 (d), AKDW2997-16(d) (C), DBW301, UP3043, UP3042 , WH1223, NW 7060, HD3271 and PBW 797

Leaf and stem rusts

VL907 (C), VL892 (C), PBW550 (C), HD2967 (C), DPW621-50 (C), DBW173 (C), HI1620(I) (C), HI 1628*, NIAW 3170*, DBW39 (C), HD2888 (C), K8027 (C), HI1544 (C), HI8627(d) (C), MP3288 (C), DBW 277, HD2864 (C), MP4010 (C), CG1029, HI1633, HI1634, MACS6222 (C), DDW 48 (d), GW509, HD3090 (C), NIAW 3170* , GW 1346(d)*, MACS 4058(d)*, DDK1029 (C), MACS5052, DDK1056, HW1098 (C), MACS5053, DDK1057, DBW304, PBW825, PBW757 (C) and DBW14 (C)

Stem and stripe rusts

HS507 (C), VL3020, VL3021, HD3226(I) (C), PBW 796, WH1142 (C), HD3317, WH1254 and HI1621

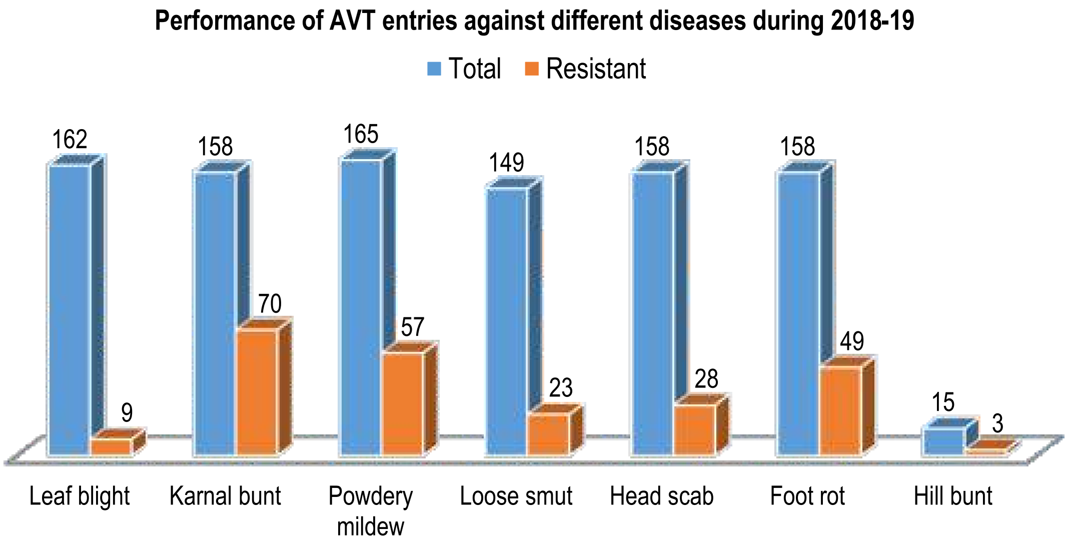


Fig. 2.2:- Performance of entries tested against different diseases during 2018-19

Performance of wheat entries tested against different diseases in plant pathological nurseries during 2018-19

The advance varietal trail entries were also screened against major diseases other than rust under disease specific plant pathological nurseries (Fig. 2.2).

Leaf blight resistance

The entries from AVTs which showed the moderate level of resistance within average score below 35 and the Highest Score of 57 are DDW 47(d), DDW 48 (d), HD 3345B, HD2967 (C), HD2967 (C), HPW 349 (C), HS 652 and VL 907 (C). The entries HD 3293, HD 2967 (C), HD 3171 (C), HI 1612 (C), HPW 467, HS 562 (C), PBW 550 (C) and VL 3021also showed moderate resistance to leaf blight with average score upto 35 but the highest score exceeded 57 due to high disease at one location.

Karnal bunt (KB) resistance

The lines in AVT entries (2018-19) which showed resistance (upto 5%) against Karnal bunt are AKDW2997-16(d) (C), DBW 252*#, DBW 273, DBW14 (C), DBW173 (C), DBW187, DBW187(I) (C), DBW301, DBW304, DBW93 (C), DDW 47(d)*Q, DDW 48 (d), DDW 48 (d), DDW 49 (d), DDW 49 (d), DPW621-50 (C), GW 1348 (d), HD 3277, HD 3293, HD 3345B, HD2932 (C), HD3059 (C), HD3086 (C), HD3226(I) (C), HD3298, HI 8802(d)*, HI 8811 (d), HI 8812 (d), HI1544 (C), HI1612 (C), HI1634, HI8627(d) (C), HI8713(d) (C), HI8737(d) (C), HI8807 (d), HI8807(d), HS507 (C), HS673, K1317 (C), KRL210 (C), MACS 6696*, MACS3949 (d) (C), MACS5052, MACS6222 (aest.) (C), MACS6222 (C), MP3336 (C), NIAW 3170*, NIDW 1149(d), NIDW 1158 (d), PBW 781, PBW 822B, PBW 823B, PBW752(I) (C), PBW757 (C), PBW820M, PBW821M, PBW824, UAS 3002, UAS3002, UAS428 (d) (C), UAS446(d) (C), UP3041, UP3043, VL3019, VL3021, WH 1239, WH1080 (C), WH1124 (C), WH1142 (C) and WHD 963 (d)

Powdery mildew (PM) resistance

The entries showed resistance (Average. score 0-3, highest score upto 5) to powdery mildew are DBW 257, DBW187, DBW187(I) (C), DBW301, DBW302, DBW303, DBW304, DBW39 (C), DBW71 (C), DDK1029 (C), DDK1056, DDK1057, DDW 47(d)*Q, DDW 49 (d), HD 3277, HD 3293, HD2932 (C), HD2932 (C), HD3086 (C), HD3086 (C), HD3226(I) (C), HD3271, HD3298, HD3347, HI1612 (C), HI1621, HI1634, HI8807 (d), HPW 451, HS 660, HS 662, HS507 (C),

HS674, HW1098 (C), K 1601, KRL19 (C), KRL210 (C), MACS6222 (C), MACS6478 (C), NW 7060, PBW 766, PBW 781, PBW 796, PBW 797, PBW757 (C), RAJ 4529, RAJ4083 (C), UAS3002, UP3042 , UP3043, VL 1014, VL3021, WH 1228, WH1105 (C), WH1223, WH1254 and WH1270

Resistance to multiple diseases

Based on rigorous screening of different genotypes under Multiple Diseases Screening Nursery (MDSN) at multilocations the following genotypes have been identified as conformed source of resistance for multiple diseases:

A. Resistant to stem, leaf and stripe rusts +

- Resistant to all three rusts + PM + FS + KB: PBW 777, TL 3011(T), TL 3012(T), TL 3013(T), TL 3014(T), TL 3015(T)
- Resistant to all three rusts + FS + KB: HS 611, PBW 778, B662, HG 110
- Resistant to all three rusts + FS: HI 8791(d)
- Resistant to all three rusts + PM + FS: VL 3014
- Resistant to all three rusts + LB + FS + FHS: HS 645
- Resistant to all three rusts + LB +PM + FS + KB: UAS 462(d)

B. Resistant to Stem and Leaf rust +

- Resistant to Stem and Leaf rust + FS + KB: HI 1620, DDK 1053(dicoccum.), HS 644, MACS 5047, MACS 5049, WH 1232, IWP 5019, Line 1172
- Resistant to Stem and Leaf rust + LB + PM + FS + KB: DDK 1052(dicoccum)
- Resistant to Stem and Leaf rust + PM + FS + KB: HS 646
- Resistant to Stem and Leaf rust + KB: VL 3013

C. Resistant to leaf and stripe rust +

- Resistant to leaf and stripe rust + PM + FS + KB: HPW 439, PBW 780, DBW 246
- Resistant to leaf and stripe rust + LB + FS + KB: HD 3271
- Resistant to leaf and stripe rust + FS + KB: HI 1619, KRL 370, DBW 251
- Resistant to leaf and stripe rust + KB: HI 1612
- Resistant to leaf and stripe rust + FS: HS 468, WH 1233

D. Resistant to LB +

Resistant to LB + PM + FS + KB + FHS: VL 1013

Utilization of multiple diseae resistant genotypes identified

The total 16 entries with confirmed sources of multiple disease and insect pest resistance were shared with 27 breeding centers across different agro-climatic zones of country for their utilization in breeding for resistance to biotic stresses. All 16 entries were utilized in the range of 7.4 – 48.1% by the breeding centres. The most utilized entries at many centres were HS 626, DBW 179, WH 1310 and HS 627. Out of these, Faizabad centre, utilized maximum 13 entries in their breeding programme followed by Niphad centre.

Strategy planning meetings

Management of yellow rust and Karnal bunt

To enhance the wheat production and productivity a strategy planning meeting was conducted. A meeting on "Evolving strategies for enhancing wheat production with special reference to management of wheat rusts and Karnal bunt disease" was conducted on 18th October, 2019 at Krishi Bhawan. The meeting was chaired by the Secretary, DAC&FW, Govt. of India. The status of yellow rust and Karnal bunt during the cropping season 2018-19 and the varietal advancement made during the season. Discussions were held on the varietal deployment strategy to combat the yellow rust threat in the disease prone areas. The survey and surveillance strategy for early detection of yellow rust disease onset was also discussed.

Preparedness to manage wheat blast

Strategy planning meeting was also conducted on “Alternate crop plan to combat the occurrence of wheat blast like disease in the state of West Bengal” on 21.10.2019 at Taj Bengal Hotel, Kolkata. The meeting was chaired by the Agriculture Commissioner, DAC&FW, Govt. of India. Secretary (Agriculture), West Bengal presented the efforts made to combat the wheat blast threat like wheat holiday, no wheat zone, strict quarantine on Bangladesh border and its effects. It was discussed that resistant varieties need to be promoted in the disease prone areas. Five resistant varieties identified namely DBW 187, HD 3249 and HD 2967 (irrigated and timely sown) and DBW 252 and HD 3171 (restricted irrigation and timely sown) have been recommended to be grown in disease prone areas of West Bengal. It was suggested that continuous monitoring of wheat crop is required and if any suspected symptoms are observed, it should be reported to the IIWBR immediately.

Advisory for stripe rust management

Advisory for stripe rust management was issued for northern states as well as for wheat blast in West Bengal. Awareness among farmers for stripe rust management was created through mobile, internet, toll free number, newspapers,discussions and delivering lectures in farmers training programmes. The details of survey andsurveillance done are presented in wheat crop health newsletter vol. 24 issues 1-5.

Preparedness for wheat blast disease

Survey were conducted in North and South West Bengal near Indo-Bangladesh boarder by team of scientists from ICAR-IIWBR, Karnal, UBKV, Cooch Behar, West Bengaland BCKV, Kalyani, Nadia, West Bengal and no wheat blast was observed. To check entry of blast from Bangladesh, strict quarantine has been observed and wheat holiday in Murshidabad and Nadia district as well as "No wheat zone" in 5 Km along the Bangladesh border was implemented. For identification of wheat blast resistant sources, a total of 353 Indian wheat varieties and advance breeding material were screened at Jessore, Bangladesh through CIMMYT. Five resistant varieties identified namely DBW 187, HD 3249 and HD 2967 (irrigated and timely sown) and DBW 252 and HD 3171 (restricted irrigation and timely sown) have been recommended to be grown in disease prone areas of West Bengal. Anticipatory breeding programme has been initiated for faster breeding of blast resistant cultivars. During the current year 30 fresh crosses were made involving resistant donors.

Post harvest surveys

The post-harvest surveys were made by different cooperating centres of All India Coordinated Research Project on Wheat and Barley during April-June 2019 from different grain mandies. A total of 7321 grain samples collected from various mandies in different zones and were analyzed for Karnal bunt (KB) at cooperating centers. The overall 32.02% samples were found infected with KB. The samples from Haryana showed maximum infection (56.69%) followed by Jammu (54.85%) and Punjab (45.18%). Among different states from where samples were taken Madhya Pradesh, Gujarat, Maharashtra and Karnataka were found free from Karnal bunt infection.

Management of diseases through chemical

Evaluation of chemical fungicides namely, Trifloxystrobin+ Tebuconazole at different concentrations along with standard recommended fungicide, Propiconazole at 0.1% were performed at Jammu, Karnal and Ludhiana locations for the management of yellow rust of wheat. Foliar application of Trifloxystrobin+ Tebuconazole @ 0.1% was found equally effective to two sprays of Propiconazole at 0.1% in minimizing rust infection on both PBW343 and HD 2967 cultivars.

Table 2.1: Karnal bunt situation in the country during 2018-19 crop season

State	Total samples	Infected samples	Infected samples (%)	Range of grain infection (%)
Punjab	2809	1269	45.18	0.1 – 12.14
Haryana	1318	747	56.69	0.05 – 14.0
Rajasthan	300	123	41.0	0.1 – 21.9
Uttarakhand	1189	58	4.88	0.1 – 5.0
Jammu	206	113	54.85	0.1 – 8.24
Uttar Pradesh	129	34	26.36	0.1 – 10.0
Madhya Pradesh	285	0	0	0
Maharashtra	341	0	0	0
Gujarat	692	0	0	0
Karnataka	52	0	0	0
Total	7321	2344	32.02	0.05 – 21.9

Population structure analysis and genetic differentiation of *Ustilago segetum* var. *tritici* causing loose smut of wheat

To study the population structure of loose smut pathogen of wheat, 112 samples were collected from major wheat growing zones of India. Thirty five microsatellite markers were used to evaluate allelic diversity among 112 *Ustilago segetum* var. *tritici* (UST) isolates. Twenty five SSR primer pairs produced clear single amplicons, among those only 16 showed polymorphism and therefore used in genetic diversity analysis of loose smut isolates originated from four geographically distinct zones of India. The 16 polymorphic primer pairs revealed a total of 68 alleles across the 34 loci in 112 isolates, ranging from 2 to 4 alleles per isolate. The markers were all selectively neutral according to the Ewens-Watterson test. Among these, 100 and 12 isolates were grouped in cluster 1 and cluster 2 (Fig. 3). The grouping by UPGMA using genetic distances do not showed any spatial clustering among the different geographic zones. Several subgroups within cluster 1 were observed irrespective to populations, indicating genetic variability within and among isolates in each population. Overall, phylogeography and population structure analysis clearly demonstrated the mechanism of diversity and variation in UST isolates is due to gene flow and mutation.

Development of novel microsatellite markers for genetic charecterization of *Ustilago hordei* causing covered smut of barley

Covered smut of barley caused by the fungus *Ustilago hordei* (Pers.) Lagerh is an externally seed bone diseaseprevalent in all the barley growing areas in India. At present, no comprehensive whole genome based inventory of microsatellite markers for the analysis of genetic variation and studying population biology of *Ustilago hordei* is available. However, the draft genome of *U. hordei* (Uh4857-4 and Uh364) is already available in public domain. Therefore, attempts have been made to dissect the molecular variation and genetic structure of *U. hordei* by analyzing 59 fungal isolates representing two distinct agro-ecological zones of India using simple sequence repeats (SSRs). Fifteen polymorphic microsatellites showing conservancies in both the genomes were selected for exploring population genetic structure of *U. hordei*. Fifty-nine isolates were distributed in two principal groups with about 65% genetic similarity according to UPGMA clustering and population structure analysis (K=2) (Fig 2.4). Gene flow analysis reflected restricted gene flow among the analyzed population. An AMOVA analysis displayed high level of genetic variation within population (87%) and low variation among populations (13%). The mean value of gene differentiation coefficient (Fst) was 0.248. Further analysis highlighted that *U.*

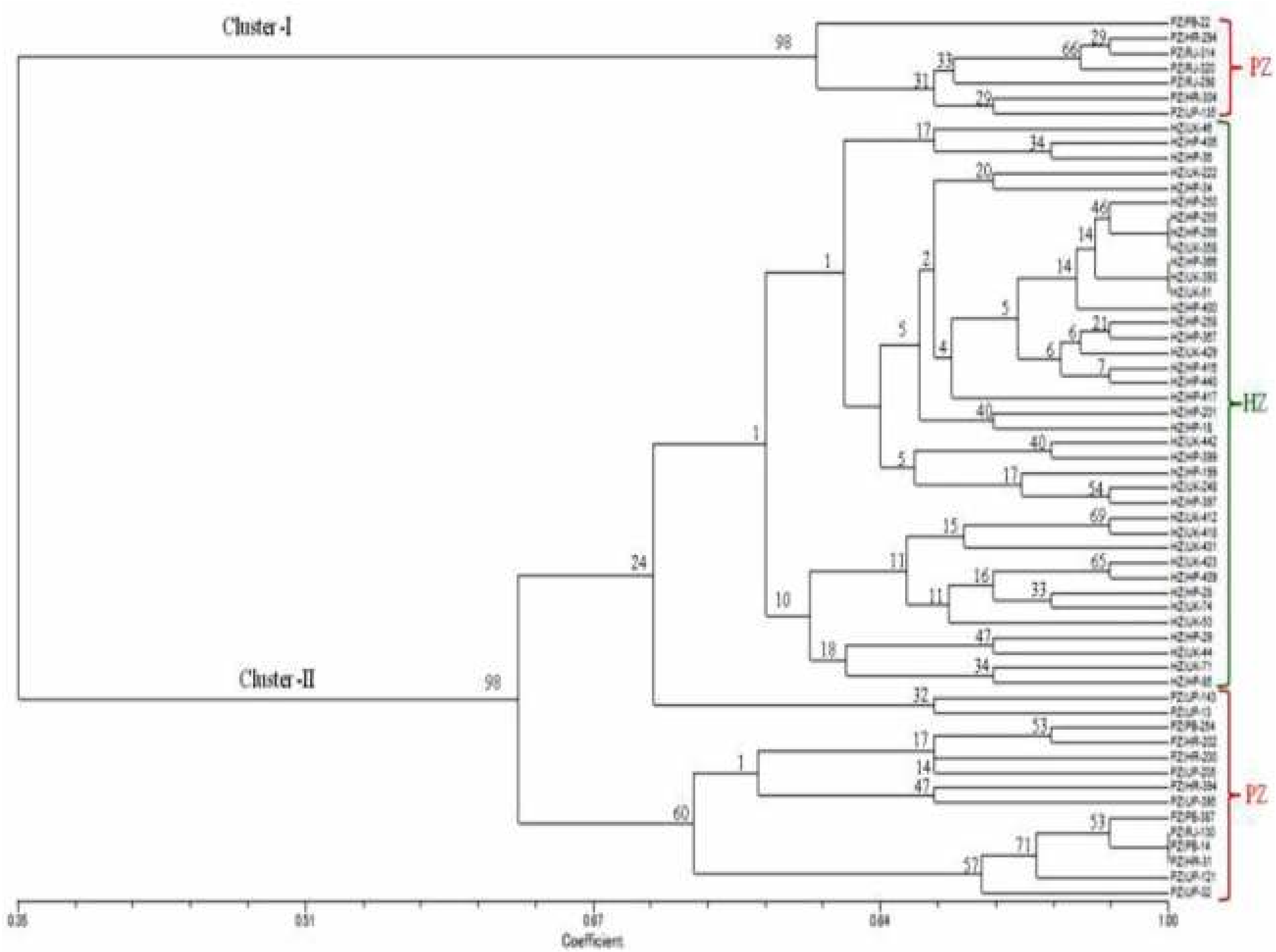


Fig.2.3:- Unweighted Neighbor-joining tree using the simple matching similarity coefficient based on 16 microsatellite markers for the 112 isolates of UST isolated.

Fig 2.4:- Population structure analysis of 59 isolates of Ustilago hordei

hordei population was under non-random mating and more likely took place through a population expansion in recent time rather than population bottleneck. In conclusion, the newly developed neutral SSR markers are highly polymorphic within *U. hordei* and will be useful in providing deep insight into the population dynamics of *U. hordei* and facilitate in developing management strategies for covered smut of barley.

ENTOMOLOGY

Survey and surveillance for insect pests

During the crop season 2018-19, in Punjab, the aphid incidence was above economic threshold level in some places *viz.* village Mullanpur&Jagraon (Ludhiana), Ajitwal & Dagru (Moga) and Salabatpura (Bhatinda) during the second and third week of March. Minor incidence of pink stem borer (3-5 %) was also observed in one patch of 0.5 acre in the fields of village Farwahi (Barnala). The incidence of armyworm was observed in patches and within patches the armyworm damage varied from 1-5 per cent except one field in village Kheri Malan where it was 15-20 per cent. In Vijapur, the incidence of aphids was low to moderate during ear head stage of the crop. The population of *H. armigera*, pink stem borer and surface grasshopper was very low. The appearance of minor pests like spodoptera, thrips, shoot fly, brown mite, jassids and cut worm was in occasional and in negligible form. In Rajasthan, survey of wheat and barley fields in Jaipur indicated moderate infestation of termite, mite *H. armigera* and pink stem borer. Moderate to severe incidence of wheat aphid and pink stem borer was observed in villages like Ladwa, Yamunanagar, Kunjpura, Subhari, Rasina and Hajwana in Karnal, Haryana. Heavy incidence of aphids was recorded in Nasik district. The coccinellid predatory grubs and beetles feeding on the aphid and spyrphid fly infested fields were also observed. The incidence of Jassids and stem borer were recorded in medium intensity.

Host plant resistance

The Advance Varietal Trial (AVT) entries were evaluated at multilocation hotspot locations during 2018-19 revealed that following genotypes possess resistance to insect pests:

Shoot fly (SF): The entries HI 1628, HPW467, DBW 252 & HI 8805(d) showed lower level of shootfly resistance (infestation < 10%) to shoot fly as compared to susceptible check entry.

Brown wheat mite (BWM): Three entries *viz.*,PBW821, MACS6478 (C) and HI8627 (d) were found promising and had recorded mite population below 10 in number in 10 cm^2 area.

Foliar aphid (FA) : Six entries *viz.*, DBW93 ©, UP3043, HD3086 (C),WH1223, KRL19 (C) and

Fig 2.5:- Experimental set-up to study biology of ladybird beetle, *C. septempunctata L.* on aphid

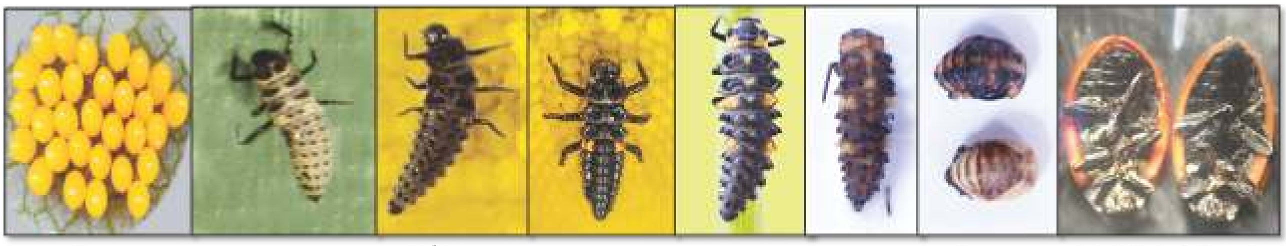


Fig 2.6:-Life stages of of ladybird beetle, *Coccinellaseptempunctata L.* reared on aphid

PBW757(C) showed moderately resistance response to foliar aphid.

Root aphid (RA): Eight entries *viz.*, PBW752 (I) (C), WH1124 (C), BRW 3806*, NIDW 1158 (d), GW322 (C), UAS 466(d)*, AKDW2997-16(d) (C) and HI1621 showed the moderate resistance reaction to root aphid.

Biology and predation potential of ladybird beetle, *Coccinella septempunctata* L. on aphid

Biological studies revealed that male of *C. septempunctata* completed its life cycle in 51 days whereas female completed its life cycle in 59 days. The larval period lasted for 12 days and consisted of four larval instars. The pre-pupal stage lasted for 1 day and the pupal period was for 5 days. Predation potential studies showed voracious behavior of *C. septempunctata* grubs and adult. Among the all larval instars, the 4th instar larvae were more efficient predators. Female have more predation potential than male. Inter-specific larval cannibalism of *C. septempunctata* was also observed in absence of aphids and were found that fourth instar has the highest degree of cannibalism.

Population dynamics of wheat aphid complex and *C. septempunctata* in relation to weather parameters

Population dynamics of wheat aphid complex shows that the aphid population was observed in the field from 1st SMW, 2019 to 13th SMW, 2019 (1st week of January, 2019 to 1st week of April, 2019), crossing the economic threshold level during 7th SMW, 2019 (3rd week of February, 2019) when the maximum temperature, minimum temperature and relative humidity were 19.9° C, 7.6° C and 80.30%, respectively. With a small increase in maximum temperature from February onward, the aphid population increased greatly and reached its peak during 10th SMW, 2019 (2nd week of March, 2019), when the maximum temperature, minimum temperature and relative humidity were 25.8° C, 8.9° C and 80.60%, respectively. A significant positive correlation of aphid population was found with maximum temperature (r=0.0386), sunshine hours (r=0.1526) and the relative humidity (r=0.2840).

Population of *C. septempunctata* adults was observed in the field from 10th SMW, 2019 (1st week of March, 2019) upto harvesting of crop. Due to availability of plenty of aphid population as host, *C. septempunctata* population increased steadily, reaching its peak during 13th SMW, 2019 (last week of March, 2019) when the maximum and minimum temperatures were 27.0°C and 12.0°C while relative humidity was 71.50%. *C. septempunctata* population had a significant positive correlation with maximum temperature (r=0.66) and minimum temperature (r=0.50). While it had a significant negative correlation with relative humidity (r=-0.68) and non-significant negative correlation with rainfall (r=-0.22).

Efficacy of insecticides and bio-pesticide for the management of wheat aphid complex

Amongst the tested insecticides against aphids, Thiamethoxam 25%WG @ 0.1g/l was found more effective as compared to Quinalphos 25% EC at 2ml^{-1}. However, amongst tested bio-pesticides,entomopathogenic fungi *Metarhizium anisopliae*@ 2 x 10^8c.f.u was more effective than *Verticillium leccani*@ 2 x 10^8c.f.u and *Beauveria bassiana*@ 2 x 10^8c.f.u. on wheat aphid complex, although their effect on aphid reduction was observed after 5-7 days after treatment. Neem formulation (Neemastra) @ 30 ml^{-1} was also at par with the bio-pesticides in reducing the aphid population.

Toxicity of insecticide and bio-pesticide to biocontrol agent, *C. septempunctata* adult and grubs

The toxicity of the insecticides and bio-pesticides was tested against *C. septempunctata* adults and grubs. Two concentrations were tested, one was the recommended dose and the other was twice the recommended dose which the farmer's uses in the illusion of getting higher pest reduction. Both chemical insecticides (thiamethoxam 25 WG and quinalphos 25 EC) were found to be highly toxic to the *C. septempunctata* adults and grubs. The toxic effect increased with increasing concentration of insecticide. Quinalphos 25 EC was more toxic than thiamethoxam 25 WG however at 10^{th} day after treatment both produced 100% mortality among *C. septempunctata* adults at both doses. The bio-pesticides on the other hand were highly safer to the *C. septempunctata*adults and grubs. Among the bio-pesticides, *Neemastra* was the safest treatments among all and produced no mortality

Fig. 2.7: Experimental set-up for toxicity studies of insecticide and bio-pesticide to biocontrol agent, C. septempunctata

to *C. septempunctata* adults and grubs at both doses. All the entomopathogenic fungi were also safer to the *C. septempunctata* adults. Among entomopathogenic fungi, *B. bassiana* was safest which produced 11% and 27% mortality in *C. septempunctata* adults at recommended dose and twice the recommended dose, respectively. *V. lecanii* and *M. anisopliae* followed *B. bassiana* in safety to *C. septempunctata* adults which produced 21% and 29% per cent mortality at recommended doses, 23% and 32 % mortality at recommended dose and twice the recommended dose, respectively.

Evaluation of trapping efficiency of different type of insect-traps for aphids

Different types of traps *viz.*, sticky-traps and tray-traps and their placement in the crop was tested to determine the efficiency of traps to capture aphids in the field. The population of alate (winged) and apterous forms of aphids captured in traps were recorded at weekly interval during the season. The observation recorded clearly revealed that the number of aphids trapped more in yellow coloured traps than blue colour traps on all dates of observations. The efficiency of sticky traps was relatively better than water tray traps. The 60 cm higher traps matched with the canopy of crop and recorded more aphids as compared with 120 cm high traps.

Effect of nitrogen fertilization on aphid abundance in popular wheat varieties

Impact of three different doses (low, medium & high) of nitrogen application on population abundance of foliar aphid and termites was investigated in wheat. The nitrogen doses were kept as 0, 75,150 and 225 kg/ha. Treatments with higher doses of nitrogen i.e. 150 &225 kg/ha had highest number of aphids as compared to lower doses of nitrogen. Variety HD 2967 had lowest infestation of aphids as compared to susceptible check A-9-30-1.

Storage entomology

Evaluation of different packaging materials for storage insect-pest infestation and its effect on wheat seed quality

Four different types of storage bags viz., jute, cloth, HDPE and BOPP were tested for their efficacy in protecting grain produce against storage pest infestation as well as on the quality. Observations have shown that BOPP bags have lowest infestation of storage insect-pests as compared to other bags.

03 RESOURCE MANAGEMENT

Tillage effects in rice-wheat system

In a long term experiment the effect of tillage options in rice-wheat system was evaluated with three tillage options in rice (1. Zero tillage transplanted; 2. Dry rotary followed by ponding of water and transplanting and 3. Wet rotary *i.e.* puddling using rotary tiller and transplanting) superimposed on which were three tillage options in wheat (1. Zero tillage; 2. Conventional tillage and 3. Rotary tillage). Depending upon the climatic conditions year to year variations were observed in wheat productivity. Six years out of ten years, marginally higher wheat productivity was recorded in rotary tillage although the differences were not statistically significant. The effect of tillage in rice as well as tillage in wheat were also not significant (Fig 3.1 and Fig 3.2).

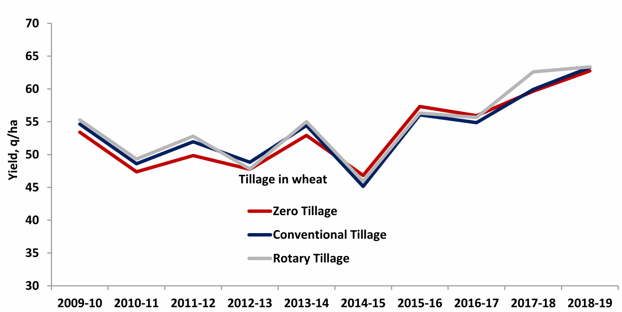


Fig. 3.1:- Effect of various tillage options in wheat on wheat productivity

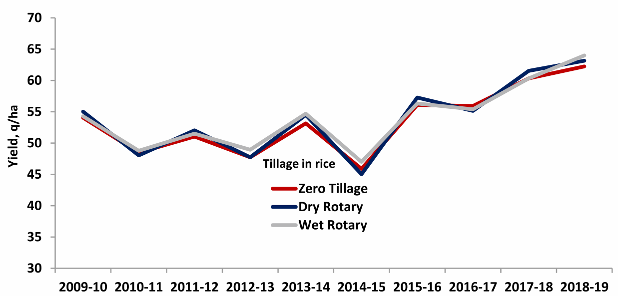


Fig. 3.2:- Effect of various tillage options in rice on wheat productivity

Based on the ten years average productivity under various tillage options in wheat across tillage options in rice, the yield recorded was marginally higher in rotary tillage (Fig 3.3) compared to zero and conventional tillage although the differences were not statistically significant. It shows that the tillage either in wheat or in rice does not adversely affect the wheat productivity.

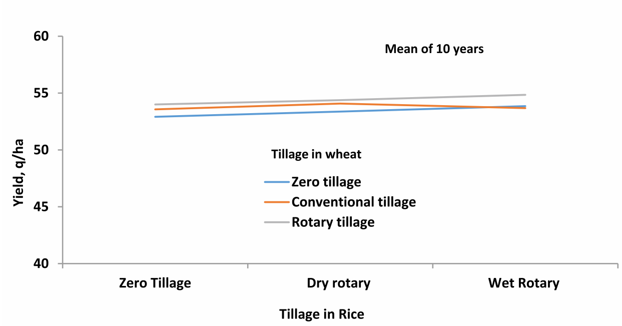


Fig 3.3. Effect of various tillage options in rice and wheat on wheat productivity

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 was initiated during *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 Rec. NPK + FYM 10 t ha^{-1}). The sowing was done using Turbo happy Seeder/ Rotary Disc Drill. The results 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 (15.42 q/ha^{-1}) was recorded in unfertilized

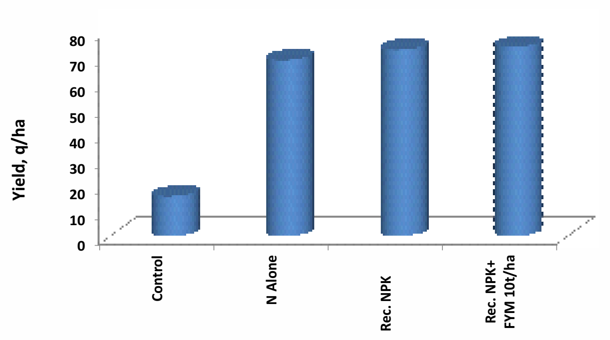


Fig 3.4:- Nutrient management in wheat across tillage option in Maize-Wheat system

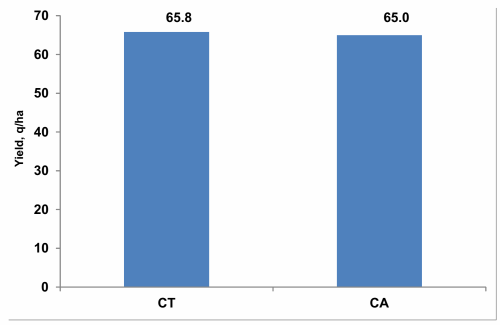


Fig. 3.5:- Comparative performance of CA and CT at farmers' field

control plots (Fig. 3.4). The wheat grain yield was maximum (73.5 q ha^{-1}) when FYM @ 10 t ha^{-1} was applied along with recommended NPK. However, statistically this treatment was at par with N alone and NPK application.

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.

Demonstrations at farmers' field

Three CA wheat demonstrations were conducted in two villages (Badarpur and Taraori) in rice-wheat system (Fig 3.5). Wheat cultivar HD 2967 and HD 3086 were sown using a seed rate of 125 kg ha^{-1} using the Turbo Happy Seeder. The mean wheat yield was almost similar in CA (*65.8 q* ha^{-1}) and CT (*65.0 q* ha^{-1}) system.

Improvement in Rotary Disc Drill (RDD) for seeding in residue

During January 2019, the RDD was modified by replacing the straight or about 10° curvature powered discs with new version of notched and serrated powered disc called "Soil Razor Disc" having much better residue cutting effect. These discs were imported by Beri Udyog Ltd Karnal from Bellota, USA. This was tested for seeding in full rice residue and full sugarcane trash and observed significant improvement in its efficiency. Further work is going on for its depth control and precision drilling mechanism.

RDD used for sowing of wheat in full residue load in sugarcane ratoon and wheat crop in sugarcane residue

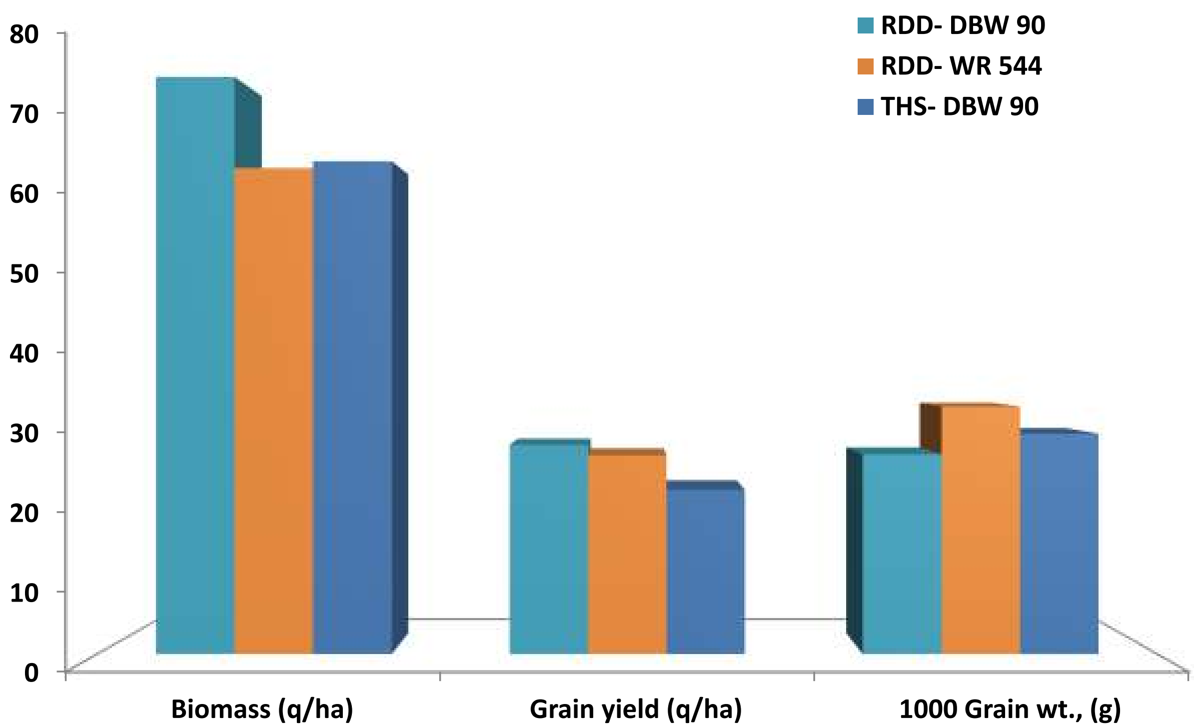


Fig. 3.6:- Wheat seeded in sugarcane ratoon using Rotary Disc Drill

Wheat seeded in sugarcane ratoon crop with full trash using RDD

Under "Mera Gaon Mera Gaurav" scheme in Village Badarpur village, two fields were selected for seeding of wheat in ratoon crop of sugarcane. The growing of wheat or other crops like green gram will be additional crops for the farmers and will enhance the profitability of the farmers as well as the wheat production. Moreover, this will promote the conservation agriculture with better environmental health by reducing the pollution with no straw/trash burning.

The two late sown varieties, WR 544 and DBW 90 were sown using a seed rate of 150 kg ha^{-1} on 28th January 2019. The new version of RDD was used for seeding in full trash of sugarcane, whereas for Turbo Happy Seeder, seeding was done in absence of residue.

The wheat yield obtained was 27.73 (DBW 90) and 26.33 (WR 544) qha^{-1} when sown using RDD, whereas with THS sown DBW 90 yielded 21.77 q ha^{-1} (Fig 3.6). Therefore an additional crop of wheat can be profitably taken in sugarcane ratoon using RDD.

Performance of wheat varieties under CT and CA

Studies were conducted to identify suitable varieties for CA system. In this experiment ten wheat varieties were evaluated at two dates of sowing under early sown conditions (Last week of October) and normal sowing (Mid November) with two tillage options *i.e.* CT (Conventional Tillage), CA (Conservation Agriculture). The residue load in CA treatments was about 8 t/ha^{-1}. The effect of tillage as well as their interaction was non-significant for yield (Fig. 3.7). The mean wheat yield of early sown wheat was significantly better than the normal sowing. However, the genotypic differences were significant and PBW 723, BISA 921 and BISA 927 were better yielder than other genotypes. Presently HD 2967 genotype is occupying maximum wheat

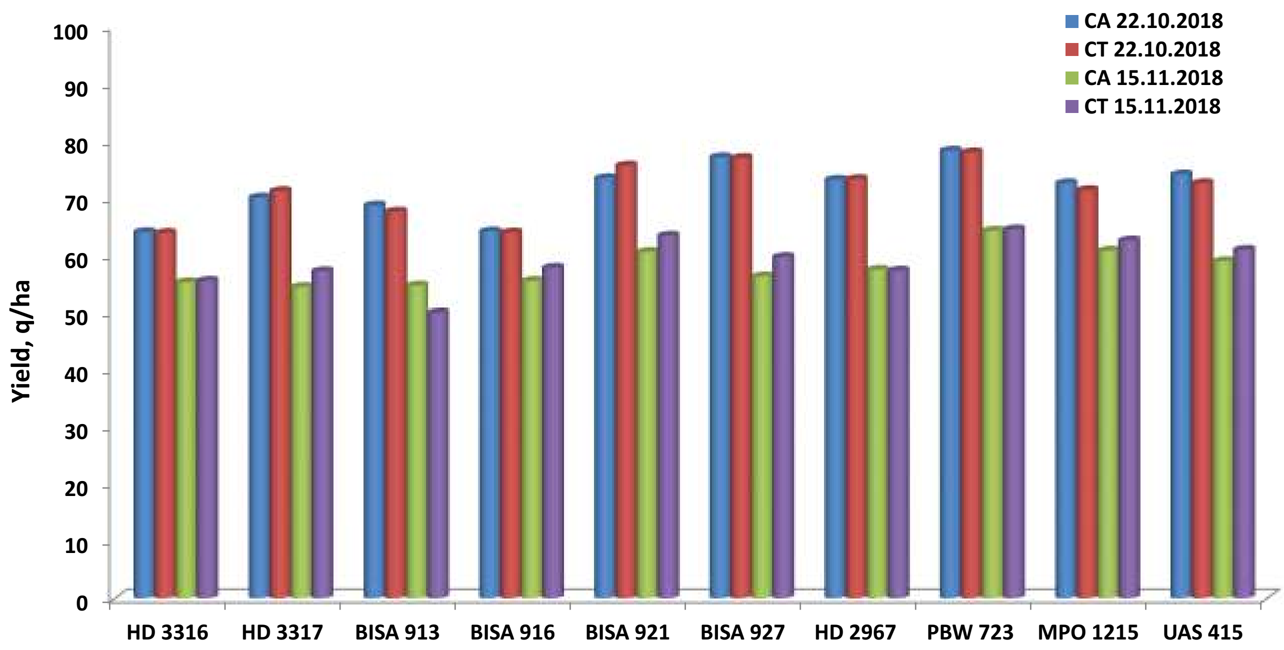


Fig. 3.7:- Performance of wheat varieties sown early and timely under CT and CA conditions during 2018-19

area in India and its performance was similar under CA and CT system. Therefore, wheat genotypes released for CT system can also be effectively grown under CA conditions.

Genotypes under early sown high fertility conditions

To maximise wheat productivity, an experiment was conducted using higher level of inorganic and organic fertiliser along with spray of growth retardant to control lodging. The experiment consisted of three fertility treatments *viz*. RDF, RDF +15 t FYM ha^{-1} and 150% RDF+15 t FYM ha^{-1}+two sprays as tank mix-Chlormequat chloride (Lihocin) @ 0.2%+ tebuconazole (Folicur 430 SC) @ 0.1% of commercial product dose at First Node and Flag leaf (Tank mix application) stages using 15 wheat genotypes. On mean basis, the genotypes DBW 187 (73.4 q ha^{-1}) and DBW 303 (73.8 q ha^{-1}) recorded marginally higher productivity compared to other genotypes (Fig 3.8). These genotypes yielded 78.8 and 78.2 q ha-1, respectively, under 150% RDF + 15t FYM ha^{-1} + two sprays as tank mix- Chlormequat chloride (Lihocin) @ 0.2%+tebuconazole (Folicur

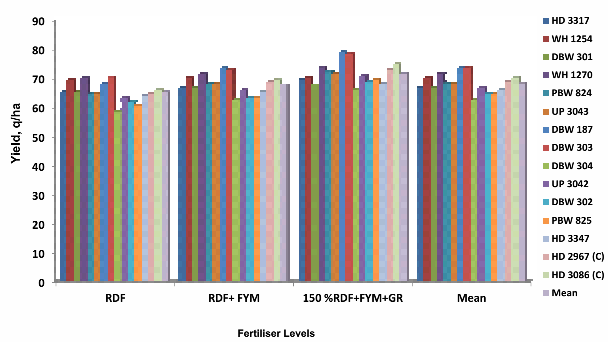


Fig. 3.8:- Genotypes under early sown high fertility conditions

430 SC) at 0.1% of commercial product dose at First Node and Flag leaf (Tank mix application) stage which was higher than other genotypes.

Nutrient management

Integrated nutrient management in rice- wheat system

An experiment with 10 treatments [Recommended NPK at the rate of 150:60:40 kg/ha N, P_2O_5 and K_2O, respectively (T1), T1+FYM15t ha^{-1}, Rec. N only, Rec. P only, Rec. K only, Rec. NP only, Rec. NK only, Rec. PK only, T1+ GM and absolute control] was conducted in Randomized Block Design with three replications using wheat variety HD 2967. The results revealed that biomass and grain yield were significantly lower where only P, K or PK were applied as compared to all other treatments (Fig. 3.9) indicating the significance of nitrogen. The highest grain yield (55.04 q ha^{-1}) was recorded in treatment where all the major nutrients and FYM 15 t ha^{-1} was applied followed by the treatment in which all the major nutrients as well as green manuring was done (52.68 q ha^{-1}). These treatments were significantly higher than all other treatments except recommended NPK treatment. Application of recommended nitrogen alone brought about significantly higher wheat productivity than alone recommended P, K or PK together, however, the lowest yield was recorded where only P, K or PK were applied indicating the importance of nitrogen alone.

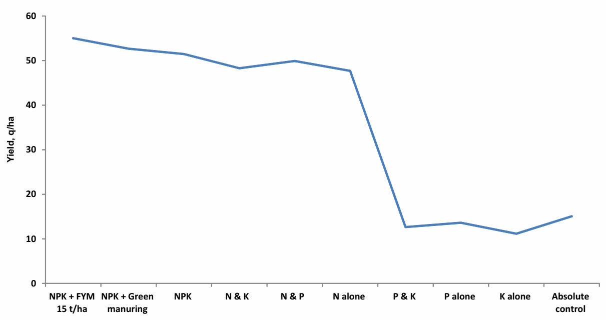


Fig 3.9:- Integrated nutrient management in wheat

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

Four newly released high yielding varieties (HYVs) of wheat (HD 2967, HD3086, WB 2 and WH 1105) and five combinations of organic nutrient supply (control, farm yard manure (FYM) 10 t ha^{-1},(FYM) 20 t ha^{-1}, (FYM) 30 t ha^{-1} and recommended doses of chemical fertilizers at the rate of 150:60:40 kg ha^{-1} N, P_2O_5 and K_2O, respectively) thus having total 20 treatment combinations, were evaluated in randomized block design with three replications. The results revealed that application of (FYM) from 10 t ha^{-1} to 30 t ha^{-1} 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^{-1} FYM treatment. Among the HYVs, HD 3086 recorded the highest grain yield (64.38 q ha^{-1}), followed by WH 1105 (60.12 q ha^{-1}) with recommended doses of NPK fertilizers (150:60:40). All the varieties performed similarly at all the organics levels except WB 2 which yielded significantly less than HD 3086 and WH 1105 varieties at recommended NPK level. Application of increasing doses of FYM from 10 to 30 t ha^{-1} increased the soil organic carbon, available nitrogen, available phosphorus and available potassium content as compared to recommended NPK treatment and control treatment.

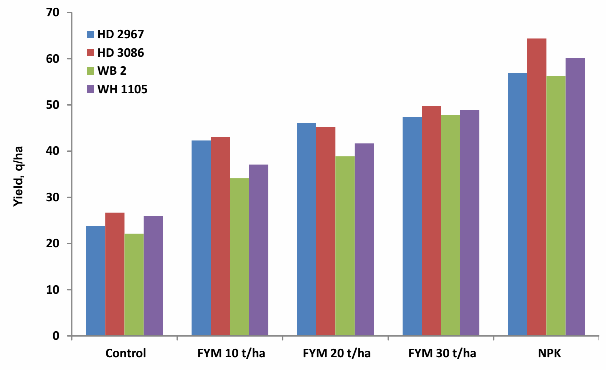


Fig 3.10:- Comparative performance of wheat varieties under inorganic and organic conditions

Residue management

An experiment was conducted with combinations of rice residue removal and incorporation along with and without green gram cultivation under rice-wheat system. The treatments receiving green gram incorporation was superimposed with 25 and 50%

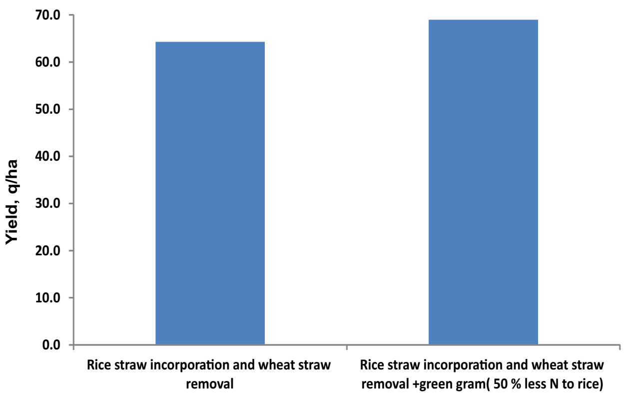


Fig 3.11:- Effect of green gram on rice yield

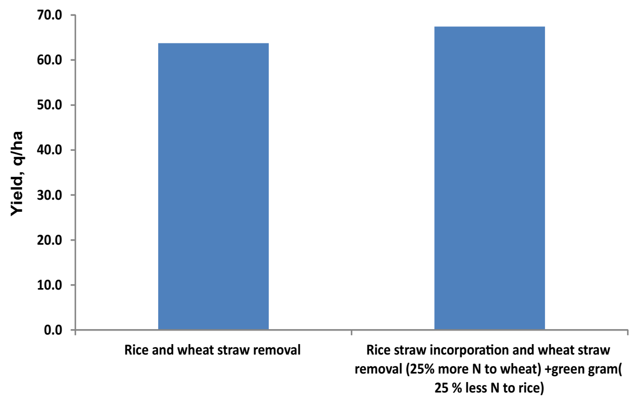


Fig 3.12:- Effect of rice straw incorporation, N management and green gram on wheat yield

less nitrogen to rice crop. Additionally, rice residue incorporation treatment was imposed with 25% higher basal nitrogen to wheat crop for comparison purposes. The data revealed that green gram cultivation after wheat produced 10-12 q ha^{-1} pulse yield and its residue incorporation saved 50% nitrogen to rice crop and produced maximum rice yield (68.97 q ha^{-1}) besides improving the soil physico chemical properties (Fig. 3.11). In case of rice residue incorporation, additional of 25% more N was needed to reduce the immobilization effect to wheat crop and produced maximum wheat grain yield of 67.43 q ha^{-1} (Fig. 3.12).

Intercropping of pulses with maize

Experiment on green gram, black gram, cowpea and guar intercropped with maize and followed by wheat crop was condcuted during 2018-19. Land equivalent ratio (LER) was calculated for each intercrop and it was found the maximum LER (1.6) with cowpea as intercrop followed by green gram as intercrop. This showed that sole crop require 60 more area to produce same output cowpea intercrop with maize. In wheat season, recommended fertiliser and 25 % less nitrogen was tried in pulse intercrop with maize treatments and it was found that 25 % less N application exhibited similar yield as compared with recommended N application.

Comparison of different cropping sequences

Sorghum and maize based crop sequnces namely sorghum–wheat, sorghum–wheat- green gram, sorghum-mustard-green gram, sorghum-potato-

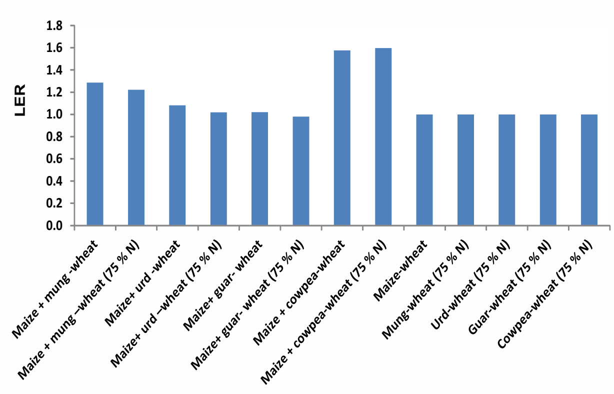


Fig 3.13. Land equivalent ratio (LER) of different intercrop sequences

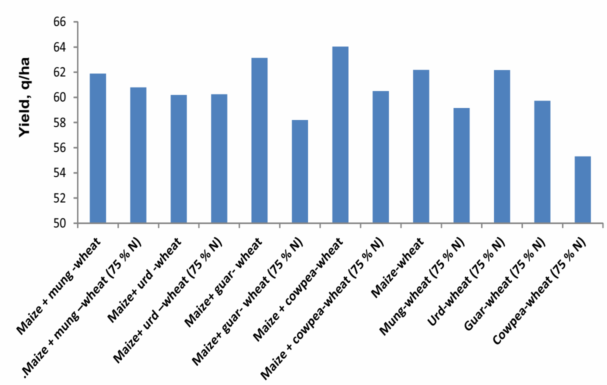


Fig 3.14. Effect of Kharif intercrops on wheat yield (q/ha)

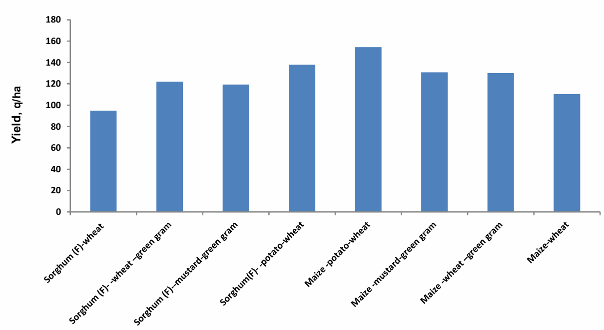


Fig 3.15. Comparison of wheat equivalent yield in different cropping sequences

wheat, maize–wheat, maize–wheat-green gram, maize-mustard-green gram, maize-potato-wheat were conducted in randomized block design with three replications. Wheat equivalent yield was calculated by taking minimum support price of each crop and market price of potato and sorghum (fodder) and comparison was made accordingly. Crop rotations having three crops showed higher wheat equivalent yield than two crops. Highest wheat equivalent yield was on crop rotations bearing potato either maize/sorghum as previous crop followed by mustard.

Weed management in wheat

Weed infestation is one of the major problems limiting crop production. For realizing potential crop yield, proper weed management is very important. For controlling weeds in wheat, herbicides are preferred due to cost and time effectiveness. The emergence of new weed flora and evolution of new cases of herbicide resistance demand evaluation of new herbicides from different chemical groups. Field experiments were conducted for evaluation of herbicides and herbicide mixtures against weeds in wheat and the results of which are as follows.

Evaluation of new herbicides

- Diverse broadleaf weeds were effectively controlled when ready-mix combinations of Halauxifen+ fluroxypyr 200.6 (6.1+194.5) g ha^{-1} were applied as post-emergence. This ready mix combination has shown high selectivity in wheat.
- Herbicide combinations were evaluated for the control of complex weed flora of wheat. Pyroxasulfone + metsulfuron and Pendimethalin + metribuzin as pre - emergence and tank mixture of Clodinafop/ pinoxaden+ metribuzin as post emergence were found effective for control of diverse spectrum of weeds in wheat
- Cloquintocet safener present in clodinafop was found effective in providing the safening effect to HPPD herbicides.
- Pyroxasulfone + pendimethalin 125 + 1000 g/ha^{-1} and flumioxazine at 100-125 g ha^{-1} as pre emergence were found effective for control of grassy and broadleaved weeds in wheat.
- In rice-wheat system double no till system led to more problem of *Rumex dentatus* and *Medicago denticulata*.
- In DSR, bispyribac+pendimethalin at sowing fb fenoxaprop + ethoxysulfuron were effective in controlling broad-spectrum weeds

Bioassay 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 Multiple Herbicide Resistant *P. minor and A. ludoviciana* management (against clodinafop, pinoxaden and sulfosulfuron) alternative herbicides found effective were pyroxasulfone and metribuzin. Whereas, pendimethalin and pyroxasulfone were found effective for control of sulfonylurea herbicide resistant *Polypogon monspeliensis* in wheat. For management of *P. minor*, experiments were also conducted with integration of no-till system in combination of various pre-seeding herbicides. Results revealed that the herbicide resistance problem can be tackled with integration of no-till seeding along with residue retention and application of pre-seeding herbicides (Pendimethalin + metribuzin or metribuzin or pyroxasulfone + metsulfuron). For control of metsulfuron resistant *Rumex dentatus* and *Chenopodium album* 2,4-D, carfentrazone and fluroxypyr were found effective.

Evaluation of pyroxasulfone + pendimethalin against weeds in wheat

The ready mix combination of pyroxasulfone + pendimethalin was evaluated at different doses consisted of 450 (50+400), 675 (75+600), 900(100+800) and 1125 (125+1000) g a.i. ha^{-1}. The major weeds infested the experimental plots were *P. minor*, *Avena ludoviciana*, *Rumex dentatus*, *Medicago denticulata* and *Coronopus didymus*. The dry weight of weeds reduced as the dose of ready mixture pyroxasulfone + pendimethalin increased up to 1125 g ha^{-1}. The total dry matter accumulated by weeds in untreated control was 583 g/m^2, (Fig 3.16). Compared to weedy check, all the herbicide treatments caused significant reduction in total dry weight of weeds. The ready mix combination, pyroxasulfone + pendimethalin at 1125 g a.i. ha^{-1} was superior to pyroxasulfone and pendimethalin in controlling weeds. The weed competition throughout the season resulted in the lowest grain yield (14.51 q ha^{-1}) compared to all other weed control treatments.

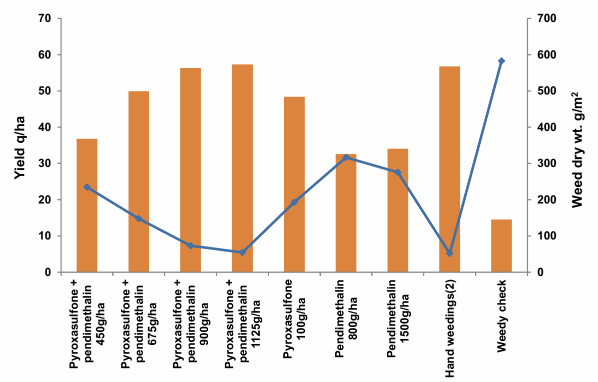


Fig. 3.16. Effect of pyroxasulfone + pendimethalin on weeds and wheat yield

Improving water use efficiency and mitigate abiotic stresses in wheat under conservation and conventional tillage practices

Experiments were conducted to study the water use efficiency of wheat genotypes under various moisture levels and explore the measures for improving water use efficiency and mitigate abiotic stresses in wheat crop under conservation and conventional tillage practices. Investigations were carried out to examine the role of foliar application of potassium with different source and levels in mitigating the abiotic stresses. Foliar application of potassium confirmed its positive impact on various kind of abiotic stresses. Data recorded for the experiment on effect of foliar application of potassium in wheat crop revealed that, 2 per cent concentration of either K_2SO_4 or KCl is beneficial under restricted irrigated conditions. The findings of the study are as mentioned below:

- Thirty genotypes of wheat were evaluated at various level of soil moisture *i.e.* 80, 60% of ET_0. The exact amount of irrigation water in mm was calculated with the help of CROPWAT software. A total of 9 genotypes (DBW 222, DBW 173, IBWSN106, IBWSN1278, DBW 110, DBW 166, DBW 187, PYT 69, PYT 80) were found having water use efficiency of >2.51 kg m^{-3} with desirable level of yield under 80% of ET_0 (5309 kg ha^{-1}) and 60% of ET_0 (4878 kg ha^{-1}) moisture level (Fig 3.17).
- Twelve genotypes of wheat from central and peninsular zone were evaluated at various level of soil moisture *i.e.* 80, 60% of ET_0. Genotype HI 1605, NIAW 3170, NIAW 1415, and NIAW 3624 are found to be having higher WUE with desirable level of yield (Fig 3.18).
- Significantly higher grain yield (6451 kg ha^{-1}) was recorded by foliar application of Potassium @ 2.0 % over control (6171 kg ha^{-1}). Total two sprays were done at jointing and flowering stage.

Production estimation of wheat using remote sensing and modelling in Haryana

- The present study was undertaken to investigate the use of multi date satellite imageries for assessment of wheat acreage in Haryana. Satellite scenes of Landsat 8 Operational Land Imager (OLI) having spatial resolution of 30 meters and temporal resolution of 16 days have been used for land use land cover analysis of Haryana.
- Seven satellite images of path 146, 147, 148 and row 39, 40, 41 for the wheat season 2018-19 covering Haryana were downloaded from the website https://earthexplorer.usgs.gov. Digitized shape file of Haryana was downloaded from the website https://www.diva-gis.org/. Atmospheric Correction was done using QuAC (Quick Atmospheric Correction Technique) using EnVI-4.8 software to remove the "noise" from the image which may be present due to atmospheric disturbances. All seven satellite scenes were mosaicked and a subset of Haryana was generated in one image as a whole. Images were classified into 7 major classes namely wheat, built-up land, barren/sandy land, water body, forest/tree, other crops and fallow land using Maximum Likelihood Classifier (MXL)

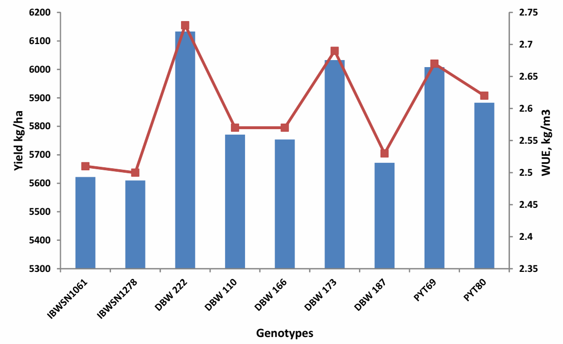


Fig. 3.17:- Productivity and water use efficiency of wheat genotypes

Table 3.1: Land use/ land cover area of Haryana

LULC	Area (mha)	Area (%)
Wheat	2.32	52.6
Built-up Land	0.21	4.8
Barren/Sandy Land	0.57	12.9
Water Body	0.01	0.22
Forest/tree	0.54	12.2
Other Crops	0.72	16.3
Fallow Land	0.04	0.9
Total	**4.41**	**100**

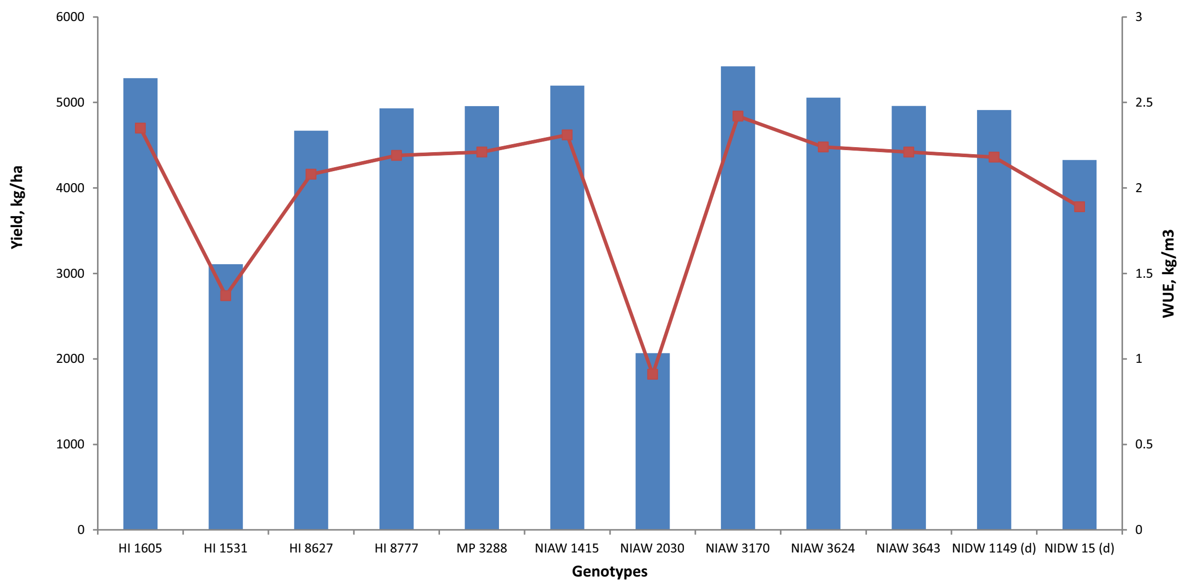


Fig. 3.18:- Productivity and water use efficiency of wheat genotypes

embedded under supervised classification in EnVI-4.8 software. To improve the classification accuracy, the non-agricultural areas were masked out.

- The areas were estimated by computing pixels under the classified image using post classification technique. The area under different entities has been summarized in table 1. The total wheat area was observed to be 2.32 mha; which is almost 52.6% of the total geographical area of Haryana (4.41 mha).

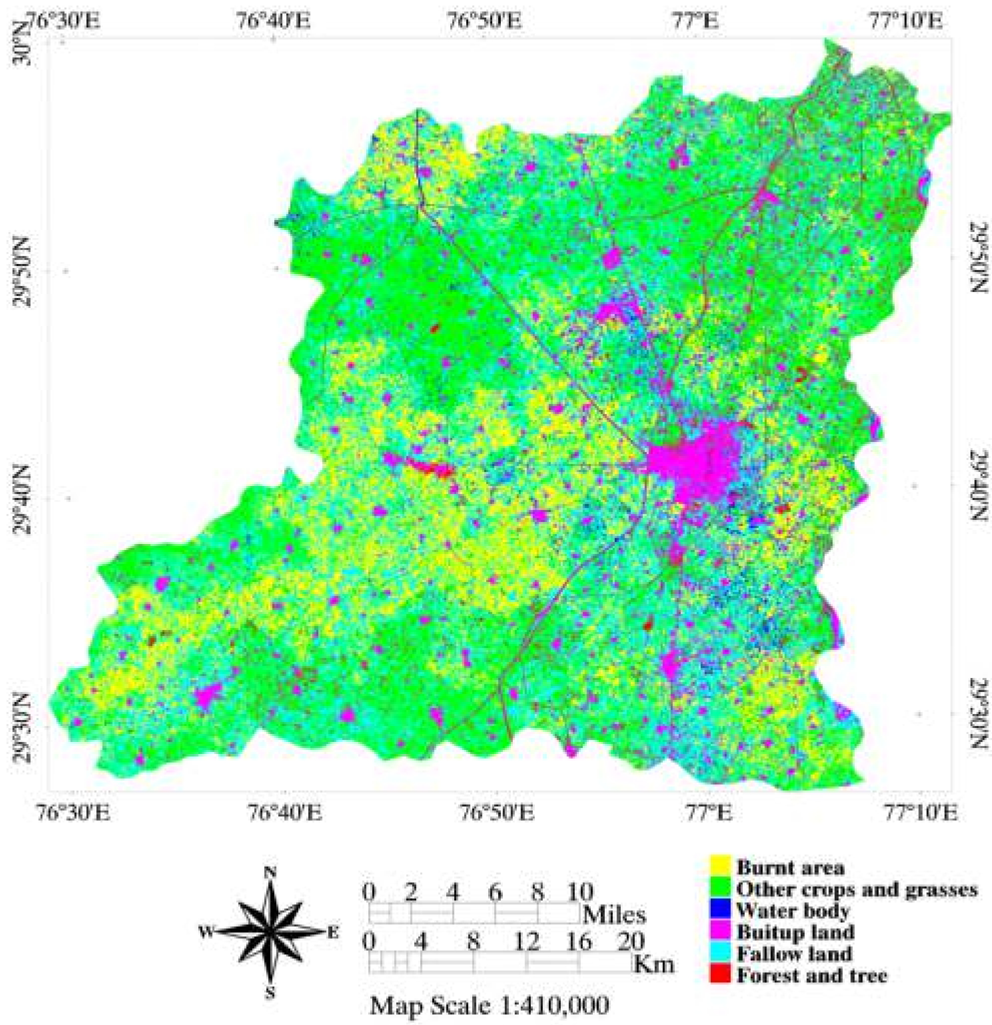
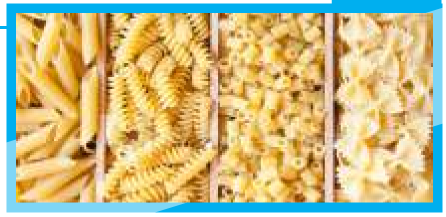


Fig 3.19:- Land Use/Land Cover Map of Haryana (2018-19)

04 QUALITY AND BASIC SCIENCES



Quality analysis of AICRP on wheat and barley trials and nursery

During the year 2019, a total of 126 AVTs, 244 NIVTs, 37 special, 52 QCWBN, and 68 preliminary QCWBN entries were analysed from different zones and growing conditions. All the AVT-II year entries including checks were also evaluated for chapati, bread and biscuit for identification of product specific promising genotypes (Table 4.1 to 4.3).

Table 4.1: Promising *T. aestivum* genotypes for chapati (score >8.0)

Category	Genotypes
Check varieties	HD 2967 (NWPZ-HYPT), HD 3086 (NWPZ-HYPT) HD 2967 (NEPZ-ITS), K 0307 (NEPZ-ITS), PBW 757 (NWPZ & NEPZ, SPL-VLS)
AVT entries	PBW 771 (NWPZ-ILS), DBW 301(NWPZ-HYPT), PBW 824 (NWPZ-HYPT)

Table 4.2: Promising *T. aestivum* genotypes for bread (loaf volume >600 ml)

Category	Genotypes
Check varieties	HD 3226 (NWPZ-ITS), WH 1105 (NWPZ-ITS), WH 1080 (NWPZ-RITS) DBW 93 (PZ-RITS)
AVT entries	DBW 221 (NWPZ-ITS), DBW 222 (NWPZ-ITS), BRW 3806*# (NWPZ-RITS), NIAW 3170* (NWPZ & PZ-RITS), HI 1621* (SPL-VLS), WH 1254 (HYPT), DBW 303 (HYPT)

**Final year AVT entry*

Table 4.3: Promising *T. aestivum* genotypes for biscuit (SF ~10.0)

Category	Genotypes
Check varieties	NIL
AVT entries	NIAW 3170* (NWPZ & PZ-RITS)

**Final year AVT entry*

Promising genotypes for both *T. aestivum* and *T. durum* for individual quality parameters like protein content, grain hardness index, sedimentation value, yellow pigment, iron, and zinc are given in Table 4.4.

Table 4.4: Promising genotypes for various quality parameters

Parameter	Value	Genotypes
(T. aestivum)		
Protein	^{3} 12.5%	NHZ : VL 3019
		NWPZ: HD3226
		CZ : HD 2932, MP 3336, MP 4010, UAS 3002, DBW 110, MP 3288 , DBW 277
		PZ : PBW 823, DBW93
Sedimentation value	> 65 ml	NHZ : HS 673
		NWPZ : HD 3226, PBW 752, DBW 173
		NEPZ : HD 3249, DBW 187, PBW 781, DBW 257, HI 1612
		CZ : DBW 110, MP 3288, DBW 277
Hardness index	<35	NHZ : HS 490
		NWPZ : NIAW 3170
Iron	^{3} 40ppm	NHZ : HS 507, VL 907, HS 562, HPW 468, HS 673, UP 3041, VL 3019
		NWPZ : HD 3086, DBW 173
		NEPZ : HD 3249, DBW 187, K 0307, DBW 257, HD 2888
		CZ : HI 1544, CG 1029, HI 1634, MP 4010, HD 3345, DBW 277
		PZ : PBW 823, Raj 4083, HD 3090, GW 509, HI 1633, MP 3170, DBW 93, HI 1605

Zinc	^{3} 40ppm	NHZ : HS 673, UP 3041, VL 3019
		NWPZ : WH 1105, PBW 550, PBW 771, PBW 752, DBW 173, WH 1021, HD 3043
		NEPZ : HD 2888
		CZ : PBW 822, HD 3345, MP 4010
		PZ : PBW 823, GW 509
(T. durum)		
Protein	>13.0%	CZ : UAS 466, DDW 47, HI 8627
Sedimentation value	^{3} 40ml	CZ : HD 8737, DDW 49, UAS 466
		PZ : MACS 3949, DDW 49, DDW 48, WHD 963
Yellow pigment	>7.0ppm	CZ : DDW 47
Iron	^{3} 40ppm	CZ : HI 8737, DDW 49, HI 8812, HI 8808, HI 8807, DDW 47, HI 8627
		PZ : UAS 428, MACS 3949, DDW 49,WHD 963, HI 8807, HI 8802, NIDW 1149
Zinc	^{3} 40ppm	CZ : HI 8737, HI 8812, DDW 49, HI 8627
		PZ : DDW 48, HI 8807, HI 8802

Table 4.5: Variability in the quality parameters of *T. aestivum* in AVT

Parameter	NWPZ	NEPZ	CZ	PZ	NHZ	Overall
GAS (Max. 10.0)	6.3(5.9-6.5)	6.45(5.8-7)	6.4(5.7-6.8)	6.4 (5.5-7.2)	5.44 (4.9-6.3)	6.19 (4.9-7.2)
Hectolitre Weight (kg/hl)	78.37 (76-81)	79.5(77.1-82)	80.97 (78.7-83)	81.3 (77.3-84.4)	79.36 (74.8-82.1)	79.9(74.8-84.4)
Protein content (%)	11.06 (9.5-12.6)	10.28 (9.09-12.0)	12.07 (10.3-12.9)	11.84 (10.7-13.0)	9.66(8.3-12.7)	10.98 (8.26-13.0)
Sedimentation value (ml)	55(42-67)	54(43-68)	54(40-69)	52(37-68)	53(39-67)	54(37-69)
Grain hardness index	79.89(26.8-90.1)	69.06(59.2-78.5)	77.88(63.5-84.7)	78.5(41-94.9)	73.64(29.2-83.5)	75.79(26.8-94.9)
Iron (ppm)	36.74(31.6-40.4)	39.1(34.3-45.4)	38.57(35.1-40.7)	39.4(34.6-44.6)	39.1(36.5-42.2)	38.58(31.6-45.4)
Zinc (ppm)	38.33(32.9-44.5)	31.8(26.5-41.6)	36.8(34.1-40.1)	36.2(31.2-46.3)	33.06(25.8-42.8)	35.23(25.8-46.3)
Wet gluten (%)	27.0(23.6-30.8)	23.5(19.7-28.2)	-	30.2(27.5-31.6)	-	26.9(19.7-31.6)
Dry gluten (%)	8.77(7.5-10)	7.7(6.3-8.9)	-	9.8(9-10.2)	-	8.75(6.3-10.2)
Gluten Index (%)	*80.34(37.5-95.5)*	*78.1(45.5-96.5)*	-	*78.7(59.3-86.3)*	-	*79.05(37.5-96.5)*

Table 4.6: Variability in the quality parameters of *T. durum* in AVT

Parameter	CZ	PZ	Overall
Grain Appearance score (Max. 10.0)	6.97(6.7-7.6)	7.3(6.7-7.6)	7.14(6.7-7.6)
Hectolitre Weight (kg/hl)	82.7(80.5-85.2)	82.6(77.8-84.6)	82.65(77.8-85.2)
Protein content (%)	12.27(10.72-13.66)	11.79(11.35-12.58)	12.03(10.72-13.66)
Sedimentation value (ml)	37(28 - 52)	41(26 - 57)	39(24 - 57)
Grain hardness index	81.5(73.9-87.6)	85.7(80.1-93.0)	83.6(73.9-93.0)
Iron (ppm)	39.8(36.4-41.6)	39.3(36.8-41.2)	39.55(36.4-41.6)
Zinc (ppm)	38.76(36.9-42.4)	37.2(34.1-39.9)	37.98(34.1-42.4)
Yellow pigment (ppm)	*5.47(3.93-7.59)*	*4.8(3.13-6.16)*	*5.14(3.13-7.59)*

One hundred and nine AVT, IVT and special trial entries including checks were evaluated for High Molecular Weight Glutenin subunits (HMWs) encoded by *Glu-A1*, *Glu-B1* and *Glu-D1 loci*. Subunits 5+10 and 2+12 were present in 70.6 % and 29.4 % of the total entries, whereas entries having 1, 2* and N subunits were 22.9 %, 62.4 % and 14.7 %, respectively. Entries with subunits 7, 7+8, 7+9, 17+18, 6+8, 20 and 13+16 were 45.0, 8.3, 5.5, 37.6, 0.9, 0.9 and 1.8% respectively.

Development and utilization of microlevel test for yellow pigment

The development of fast prediction methods for end use quality continues to be a major focus of wheat breeding programs. Yellow pigment content

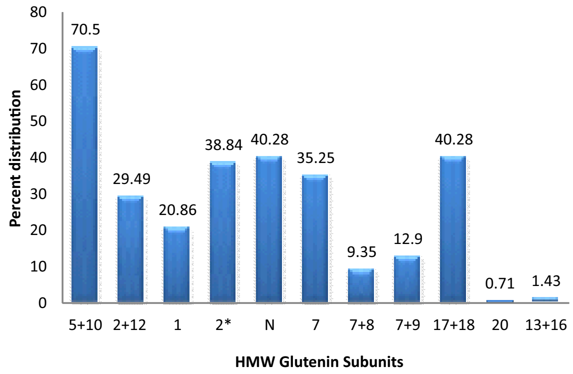


Fig. 4.1: Distribution of HMW glutenin subunit

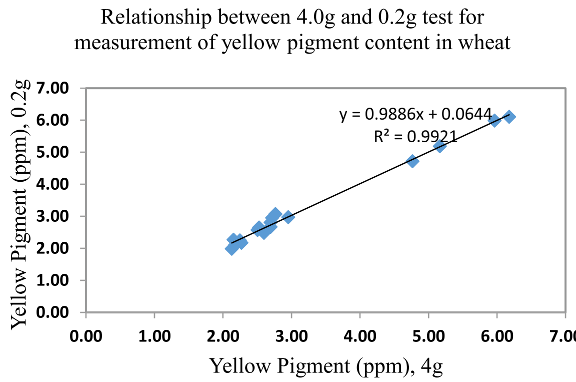


Fig. 4.2: Test for measurement of yellow pigment content

in durum wheat is an important quality trait for pasta products. Method of using 0.20g of whole meal flour was developed and used for estimating yellow pigments in AICRP samples and also the segregating generations in breeding programme. Since the method requires relatively small amounts of wheat flour (as compared to 4g method being used) and is rapid and repeatable, it is very useful in breeding programme. In early segregating generations when small quantity of materials is available and short time is left in between next sowing, chemical tests are very useful in predicting the quality. In addition it is environmentally very safe because of using very less amount of chemicals in extraction and measurement of yellow pigments.

Progress in transfer of *Glu-D1* double null from Nap Hal into high yielding wheat varieties

Significant progress has been made in transferring *Glu-D1* double null trait from Nap Hal, an Indian landrace of wheat, into high yielding backgrounds. *Glu-D1* double null is associated with reduced gluten strength and high cookie spread factor. The crossing was initiated during 2005-06 using PBW 373, PBW 502 and UP 2425 as recurrent parents and Nap Hal as donor and subsequently advanced into higher generations using microlevel tests for sedimentation volume. The advanced lines of the

Table 4.7: Advanced lines of crosses made using Nap Hal as the donor of Glu-D1 double null and high yielding wheat varieties grown during 2018-19

Cultivars and cross combinations	Generation	Sedimentation volume (1g test)	Average biscuit spread factor
UP2425/*3/NAP HAL	BC_3F_{11}	2.2	12.10
PBW373/*3/NAP HAL	BC_3F^{11}	1.9-3.7	11.20
PBW502/*2/NAP HAL	BC_1F_9, BC_2F_7	3.4	11.90
PBW373/*3/NAP HAL(BC3F4)//HD 2967	BC_1F^5; BC_2F_4	3.2	12.10
UP2425/*3/NAP HAL(BC3F4)//HD 2967	BC_1F_7, BC_2F_7	3.1	12.12
UP2425/*3/NAP HAL(BC3F4)//DPW621-50	BC^1F^7; BC^1F^3	2.7	12.7
PBW373/*3/NAP HAL(BC3F4)//DPW621-50	BC_1F_6; F_8	2.5	11.8
HS490/*2/NAP HAL	BC_2F_5	3.0	12.4
HD2967/*1/NapHal	BC_1F_6	3.2	11.8
NAP HAL		3.5	10.12
UP 2425		7.9	7.89
PBW 502		8.4	7.56
PBW 373		8.5	7.69
HD 2967		10.7	8.12
PBW 621-50		10.5	8.30
HS 490		*7.6*	*10.9*

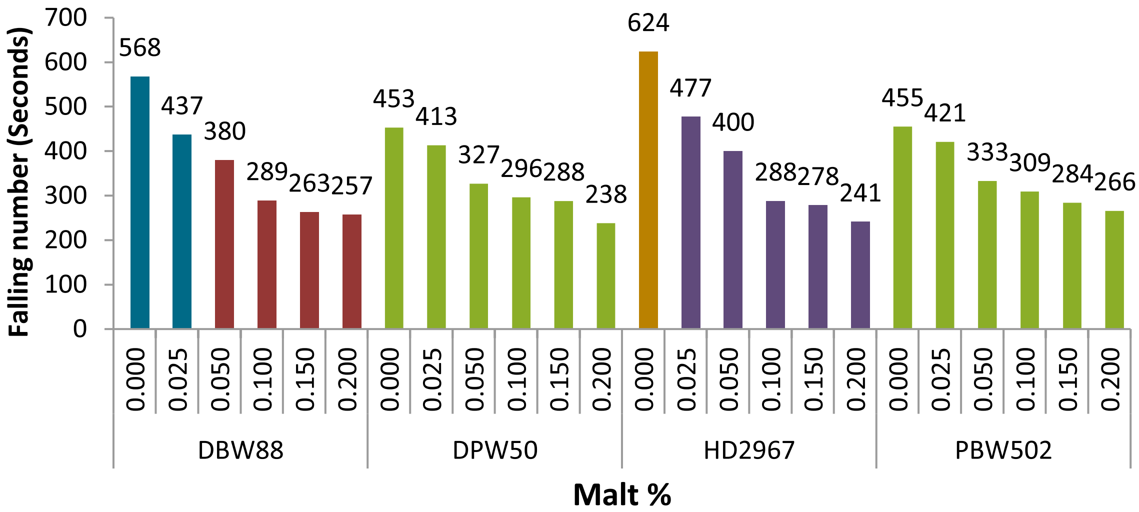


Fig. 4.3: Malt vis-à-vis falling number for different wheat varieties

above crosses were also used in making crosses with other high yielding genotypes including HD 2967, DPW 621-50, HS 490, HD 3086, and DBW 187. The sedimentation value of advanced lines of the above crosses exhibited transgressive *segrergants* towards low sedimentation under soft background, details are given in the table below.

Effect of malt addition on falling number and bread quality

Analysis of falling number of 4 wheat varieties indicated very high falling number (>450) and consequently lower bread loaf volume. There was significant reduction in falling number by adding 0.025 to 0.20% malt in the flour. The reduction in falling number is because of higher amylase activity in malt which is required for hydrolysis of starch used for fermentation of dough. There was significant increase in loaf volume of bread made of flour treated with malt. 0.1% malt in the flour showed maximum increase in loaf volume. The data demonstrated that there is need to increase alpha amylase activity in Indian wheat varieties so that falling number comes in the range of 300, the details are given in the figure.

Development of RILs using cross between HD 2967 and *Gpc-B1* line

Gpc-B1 line having gene associated with higher grain protein, Fe and Zn content ware used in making crosses with HD 2967 for developing RILs. This has been done to identify molecular markers associated with *Gpc-B1* locus for high grain protein, Fe and Zn content. Though some of the reports indicated significant contribution of *Gpc-B1* to Fe, Zn and grain protein content, in our investigation there was no significant association. Therefore, RILs (300) have been developed using cross between HD 2967 and *Gpc-B1* line to identify useful marker for utilization in breeding and were at F9 and BC1F8 stages during 2018-19 crop season. There was normal distribution of grain protein content in the RILs as shown in the Fig. 4.4.

Development of high yielding what genotypes for high phytase and low phytic acid levels using PBW 502 mutants

Enhancing wheat micronutrient density and their bioavailability for humans and monogastric animals could lead to both improved human health, reduced pollution and more sustainable

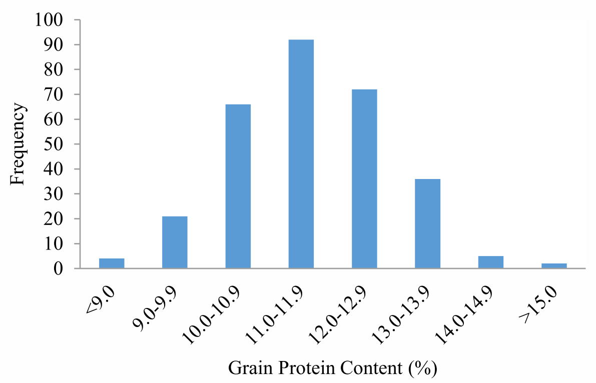


Fig. 4.4: Distribution of grain protein content in RILs (cross between HD 2967 & CRP 1660)

agriculture. High phytase and low phytic acid mutants were developed using EMS mutagenesis during 2008-09 crop season. Eight hundred mutant lines in the background of PBW 502 were advanced to higher generations and evaluated for phytase and phytic acid levels during 2014-15, 2015-16, 2016-2017 and 2017-18. More than 20 high phytase mutants were identified and used in making crosses with recently released high yielding varieties. The off-season nursery at Dailang Maidan was also used for generation advancement and making crosses during 2019. Materials are at various stages of development. The available material in F_1 generation of a cross between high phytase and low phytic acid mutant and HD 2967, HD 3086, HD 3226, DBW 88, DBW 137, DBW 187, WB 02, HD 3086; and BC_1F_1 generation with HD 2967, DBW 173 and DBW 187 has been grown for the crop season 2019-20 for further advancement and crossing. The available material in F_2 generation of the crosses between high phytase and low phytic acid mutant and HD 2967, HD 3086, PBW 502, DPW621-50, HD 3059, WB 02, HD 3059, HD 3226, WH 1105, DBW 88, DBW 187 and DBW 173 and BC_1F_2 generation with HD 2967 and HD 3059 has been grown for the crop season 2019-20 for further advancement and crossing.

Agronomic biofortification

Agronomic biofortification strategy is to enhance Fe and Zn content by foliar spray of Fe and Zn containing fertilizers during early grain filling stage. In this investigation, field trials were conducted at ICAR-IIWBR, Karnal using a set of 10 high yielding wheat varieties with Zn, Fe, Zn+Fe spray along with control during 2018-19 crop season as second year experiment. There was more than 40% increase in Zn content in Zn treated conditions while it was

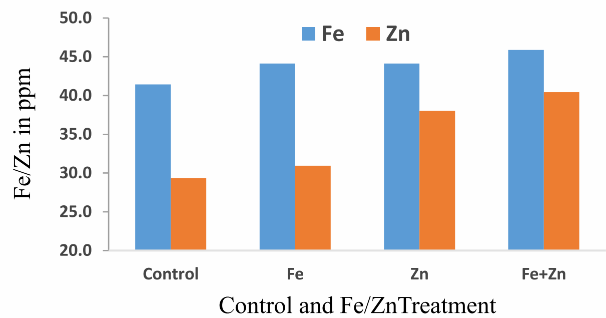


Fig. 4.5: Fe and Zn content under control and Fe/Zn foliar spray during 2018-19

10% enhancement in Fe content under Fe treatments. On an average Zn content enhanced from 29.3 ppm to 40.4 ppm from control to Zn treatment. Increased activity of Zn in the source (flag leaf and stem) during grain filling could be increased by additional Zn and Fe application through foliar application. Effect of foliar spray of Fe and Zn on their contents in wheat grain (average of 10 genotypes) are given in the Fig. 4.5.

Expression profiling of genes associated with Fe/Zn uptake, transport and utilization in wheat

qRT-PCR analysis was carried out to validate the differentially expressed genes of 12 key transcripts from 4 wheat genotypes differing in Fe/Zn content in grains. Compared to control, Fe/Zn withdrawal showed more significant differential expression

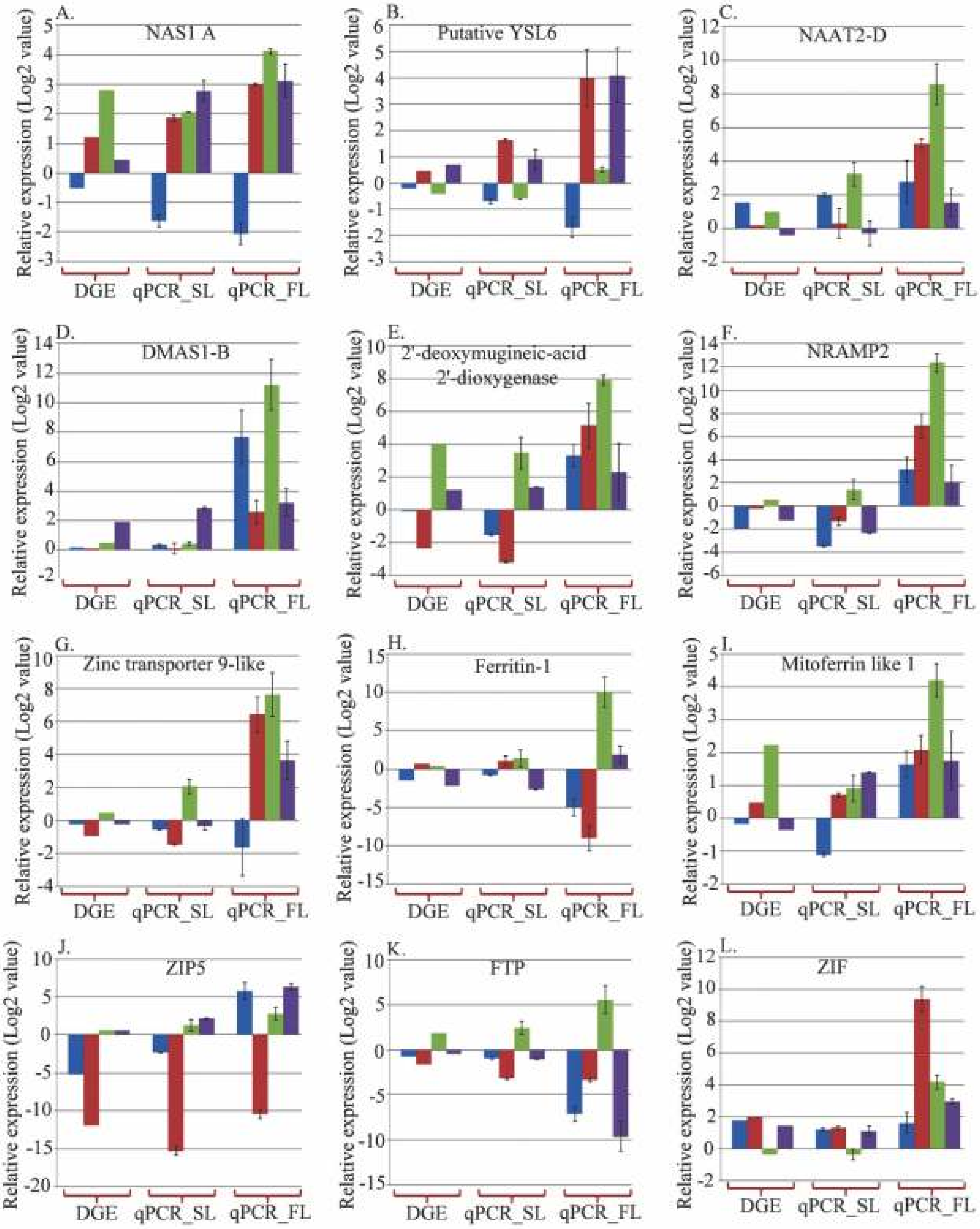


Fig. 4.6: qRT-PCR-based validation of the transcripts expression of twelve genes selected from the DEG analysis in seedling (SL) and flag leaf (FL).

landscape of Fe/Zn responsive transcripts involved in MA biosynthesis and transport in efficient genotypes as compared to inefficient genotypes (Fig. 4.6). Amongst up regulated transcripts at seedling stage, expression of DMAD (~3.4 fold), NAAT 2A (~3.24 fold), and FTP1-like (~2.39 fold) in CRP 1660 and ZIFL1(~1.9 fold), NAS1A (~1.85 fold) and YSL6 (~1.65 fold) in Vinata and NAAT 2A (~1.99 fold) in Sonora 64 and DMAS-1B (~2.8 fold), NAS1A (~2.7 fold), ZIP5 (~2.14 fold) in DBW17 were the top three most significant transcripts (Fig.4.6 A-L). Since flag leaf is actively involved in transporting nutrients to the developing grain, we also carried out expression analysis of these genes at flag leaf stage to see the difference between seedling and flag leaf stage. Surprisingly, compared to seedling stage, the expression of most of the transcripts was highly up regulated in flag leaf in CRP 1660 followed by Vinata and Sonora 64 with least expression in DBW 17 (Fig.4.6 A-L). Amongst up regulated transcripts in flag leaf, *NRAMP2* (~12.33 fold), DMAS-1B (~11.22 fold), ferritin (~10.07 fold) in CRP 1660, ZIFL1 (~9.39 fold), zinc transporter 9-like (~6.44 fold), DMAD (~5.14 fold) in Vinata, DMAS-1B (~7.67 fold), ZIP5 (~5.78 fold) and DMAD (~3.3 fold) in Sonora 64 and ZIP5 (~6.37 fold), YSL6 (~4.09 fold), zinc transporter 9-like (~3.63 fold) in DBW 17 were the top three up regulated transcripts (Fig. 4.6).

05 SOCIAL SCIENCES

In the realm of foodgrains, wheat and barley hold first and fourth position in terms of global cereals acreage. The nutri-rich cereals altogether have been under cultivation in around 271 million hectares (mha) with an estimated production of 933 million tonnes (mt) for the period 2018-19. In India, these *Rabi* cereals are grown in 29.74 million hectares (24% of total crop acreage) accounting for about 36 per cent of the total foodgrains produced during 2018-2019. Wheat has been under cultivation in 29.14 mha and barley covered 0.61 mha during 2018-2019 (Source: IV Advance Estimates, Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, India). The current year wheat production has touched a landmark output of 102.19 mt with a record national average productivity of 3507 kg ha^{-1}.

Frontline demonstrations (FLDs) conducted across regions also witnessed a similar kind of trend. The improved varieties and technologies demonstrated at farmers' field through the FLD programme showed that yield registered in FLDs is significantly higher than check plots. However, there existed yield gaps across regions which should be bridged through need based interventions by identifying the locations specific constraints. The ICAR-IIWBR strives to make continuous efforts to popularize the regions specific superior varieties as well as micro level strategies to enhance the wheat and barley productivity. Despite several outreach programmes, there exists the need for increasing the productivity of wheat and barley through different scientist-farmer interface activities with more emphasis on seed as well as variety replacement, integrated nutrient management (INM), efficient water management, integrated crop management (ICM) integrated pest management (IPM), weed management, incorporation/ retention of crop residues and soil health management. The farm advisory services through WhatsApp group, MANAGE portal and rigorous training of field level extension functionaries or subject matter specialists by the institute has also played a key role in taking contingent management measures, particularly against yellow rust. Several other programmes have been initiated as well at the institute level to transfer the efficient technologies to farmers' fields.

Creation of awareness through mass and print media on seed treatment, seed and variety replacement, and crop management helped to increase the farmers' livelihood and welfare. Procurement by different authorized agencies has also motivated the farmers to retain the same or allot more area under the respective crop. Developing storage facilities both at farm level and national level is the need of the hour and it warrants for some policy interventions. The report highlights the outcome of wheat and barley FLDs, yield gain due to FLDs, costs and returns as well as constraints in wheat and barley production.

Wheat frontline demonstrations (WFLDs) during 2018-19

During the wheat crop season 2018-19, 1500 Wheat Frontline Demonstrations (WFLDs) of one acre each were allotted to 83 cooperating centres across the country of which 1499 were conducted through 83 cooperating centers. The technologies such as improved wheat (*T.aestivum, T.durum and T. dicoccum*) varieties with complete package of practices, rotavator, zero tillage/happy seeder and bio-fertilizer were demonstrated at the selected farmers' fields. These WFLDs covered 1503.34 acres area of 1562 farmers in 19 states. The maximum number of WFLDs were conducted in UP (192), followed by Bihar (142), MP (137), Rajasthan (114), HP (104), Maharashtra (100), Assam (91), Haryana (89), Karnataka (75), Punjab (73), Jharkhand (65), Gujarat & West Bengal (50), J&K & Tamil Nadu (49), Chhattisgarh (43), Delhi & Uttarakhand (36) and Manipur (5).

All the improved varieties for different production conditions (timely sown, late sown, rainfed) have been included while calculating the yield gain over check/regional yield. The maximum yield gain was observed in Manipur (36.74%) followed by Assam (34.28%), Jharkhand (26.80%), West Bengal (25.45%), HP (20.07%), J&K (19.90%), Karnataka (17.45%) and Maharashtra (16.39%). Statewise yield gain over check in different states is given in Table 5.1.

The yield gain due to improved varieties over check was highest in NEPZ (20.21%) , followed by NHZ (19.00%), PZ (15.28%), CZ (12.01%) and NWPZ (07.99%) (Table 5.2). Concerted efforts are needed to be made by the developmental agencies in all zones to bridge yield gap and to increase wheat productivity to meet the ever increasing requirement. Across all zones demonstrated varieties have shown yield superiority over check varieties and it ranged from 07.99% in NWPZ to 20.21% in NEPZ.

Table 5.1 : State wise performance of improved wheat varieties under FLDs during 2018-19

State	Mean yield (q ha^{-1})		Per cent Gain
	Improved varieties	Check varieties	
Assam	26.15	19.48	34.28***
Bihar	40.72	35.77	13.85***
Chhattisgarh	31.75	28.58	11.09NS
Gujarat	52.57	47.09	11.63***
Haryana	52.21	50.18	04.06*
HP	31.85	26.53	20.07***
J&K	45.28	37.77	19.90***
Jharkhand	33.13	26.13	26.80***
Karnataka	30.12	25.64	17.45***
Maharashtra	37.41	32.14	16.39***
Manipur	22.33	16.33	36.74***
MP	52.40	46.05	13.79***
Delhi	49.56	46.28	07.10***
Punjab	52.87	51.23	03.18***
Rajasthan	51.65	47.13	09.59***
Tamil Nadu	29.44	-	-
UP	47.36	41.69	13.60***
Uttarakhand	42.03	37.10	13.31***
West Bengal	39.32	31.35	25.45***

**** Significant at 1 percent level, ** Significant at 5 percent level, * Significant at 10 percent level, NS–Non-significant*

Table 5.2 : Zone wise productivity under FLDs over check during rabi 2018-19

Zone	Mean yield (q ha^{-1}) WFLDs	Mean yield (q ha^{-1}) Check	Gain (%)
NHZ	33.26	27.95	19.00***
NEPZ	37.89	31.52	20.21***
NWPZ	52.27	48.40	07.99***
CZ	48.04	42.89	12.01***
PZ	33.76	29.28	15.28***

**** Significant at 1 percent level*

In case of improved durum varieties, the variety HD 4728 (d) and HD 8759 (d) gave a significant average yield of 65.00 q ha^{-1} at Indore centre in Central zone. In PZ, the variety MACS 3949 (d) gave an average yield of 46.50 qha_{-1} at Pune center, though it was non-significant.

In NHZ, at Bajaura, improved rainfed variety HS 562 yielded 53.80 qha^{-1} which was higher than the check varieties but non-significant. The same variety gave significantly higher yield of 41.11 qha_{-1} and 40.14 qha^{-1} at Malan Kangra centre against check varieties HPW 155 and HPW 349, respectively. In CZ, GW 11 gave 52.87 qha^{-1} yield at Vijapur center which was significantly higher than the check variety. In PZ, UAS 347 yielded 18.12 qha^{-1} under rainfed condition at Dharwad centre which was non-significant.

In case of late sown varieties, variety DBW 173 gave significantly higher yield (51.04 qha^{-1}) at Amity Noida center in NWPZ. In CZ, the significant average yield was recorded by GW 11 (52.87 qha^{-1}) at Vijapur center followed by Raj 4238 (51.56 qha^{-1}) at Kota center.

The location specific highest average varietal yield attained in a zone were by variety HI 8759 (d) (75.00 qha^{-1}) at Indore centre in CZ, HD 3086 (69.50 qha^{-1}) at Durgapura in NWPZ, K 1006 (58.00 qha^{-1}) at Kanpur in NEPZ, MACS 6478 (63.75 qha^{-1}) at Pune in PZ and HS 562 (53.80 qha^{-1}) at Bajaura in NHZ.

FLDs on bio-fertilizer (Azotobactor & PSB) along with 100% inorganic fertilizer as compared to check (100% recommended dose of inorganic fertilizer) showed that the significant yield gain was 21.70% at Faizabad and 11.73% at Shillongani in NEPZ. In NWPZ, significant yield gain of 8.29% was recorded at Agra centre. In CZ only 3.36% non-significant yield gain was recroded at Jagdalpur, Bastar center.

There was a significant yield gain of 09.51% at coochbehar centre in NEPZ under zero tillage of wheat sowing. In NWPZ, zero tillage gave the yield advantage of 8.82%, 5.37% and 3.05% at Agra, IIWBR Karnal and Kaithal centers, respectively. The yield gain due to zero tillage technology was non-significant at most of the centres.

Yield gain under rotavator technology was 18.45% at Siddharthnagar which was significantly higher than conventional tillage followed by 5.86% at Nagina Bijnor and 2.54% at Ludhiana.

The demonstration on micro nutrient application such as boron in wheat has shown encouraging result and it has given 13.64 per cent higher yield at Shillongani centre, though non-significant.

Analysis of constraints in different wheat producing zones of India

India witnessed a continuous increase in wheat production in the recent years. The current year production has reached an all-time record production and productivity. Variation in yield levels exists among different states, farmers and farms leading to yield gap in different states and different zones. Several reasons shall be attributed to this yield gap which needs to be addressed for sustainable wheat production. Through constraint analysis, an effort has been made to identify constraints impeding wheat production in different parts of the country (Table 5.3).

Northern Hills Zone (NHZ): In NHZ, small land holding, high cost of inputs, untimely rain, *Phalaris minor,* non availability of labour were the major constraints faced by the farmers of northern hills zone.

North Eastern Plains Zone (NEPZ): Realizing the potential of NEPZ, all constraints need to be addressed immediately for achieving the targets of second green revolution. Among major constraints of this zone, high cost of inputs, higher custom hiring charges, non-availability of farm labours, erratic power supply, poor information delivery by the state extension machinery and *Phalaris minor* were identified. Farmers of this zone need to be educated and trained on recent wheat production technologies to harvest potential yield in their

Table 5.3 : Overall constraints impeding wheat production (n=1562)

Constraints	Score	Rank
High cost of inputs	1662	I
Small land holding	1497	II
Non availability of seeds of newly released varieties	1413	III
Non availability of labour	1363	IV
High custom hiring rate of land levelling, field preparation sowing, harvesting & threshing	1276	V
Phalaris minor	1192	VI
Lack of facility of canal irrigation	1186	VII
Decline in water table	1162	VIII
Lack of knowledge among farmers about recent technologies	1128	IX
Problem in marketing of wheat	1121	X

fields. There is a need to address the problem of *Phalaris minor* through weed management strategies. Migration of farm labour from eastern zone to other parts of the country is creating scarcity of agricultural labourers in this zone. Marketing of wheat is still a concern for this region for better price realization and profitability.

North Western Plains Zone (NWPZ): In NWPZ, non-availability of seed of newly released varieties was identified as the most serious constraint. In addition to this, small land holdings, declining water table, low organic matter in the soil were also given high priority. Now Government of Punjab and Haryana has introduced kharif maize cultivation on a larger scale to save water. Green manuring has also been promoted by the State Department of Agriculture to improve soil organic carbon in the soil. Farmers need to be made aware about Government schemes launched for their benefit.

Central Zone (CZ): In central zone, high cost of inputs, decline in water table, low price of wheat, small land holdings and problem in marketing were the major constraints faced by the farmers. This zone has been identified as export zone for quality wheat. The processing quality of wheat in this zone is better than that of NEPZ and NWPZ. The above said constraints need to be addressed seriously for more income.

Peninsular Zone (PZ): In peninsular zone, higher rate of custom hiring, low price of wheat, water stress, high cost of inputs and high temperature at maturity were the major constraints of this zone. For making wheat cultivation remunerative, there is a need to develop proper market. For better price realization farmers need to be educated about selling of their agricultural produce through e-NAM portal.

Overall Constraints: The overall analysis of constraints across zones revealed that high cost of inputs, small land holding, non-availability of seed of newly released varieties, non-availability of labour; higher customer hiring rate of land levelling, field preparation, sowing, harvesting and threshing; and *Phalaris minor* were the major constraints of wheat production as identified under FLDs.

Farmers need to be educated and trained on recent wheat production technologies, complete package of practices and soil health management. There is a need of government intervention to ensure quality seeds as well as quality inputs. Farmers need to be updated on impact of climate change on wheat cultivation and what are the coping strategies they can adopt to mitigate it. The concept of conservation agriculture and adoption of resource conservation technologies at farmers' field can be propagated at a larger scale. To ensure better price, farmers have to go for quality wheat production. There is a need to register wheat growers on e-NAM platform for selling of wheat. All the constraints need appropriate attention in order to increase wheat production in all major wheat producing zones of the country.

Barley frontline demonstrations (BFLDs) during 2018-19

During the *rabi* crop season 2018-19, 250 Barley Frontline Demonstrations (BFLDs) of one acre each were allotted to 21 cooperating centers all over India in six states namely, HP, UP, Punjab, Haryana, Rajasthan and MP. Out of these, 225 were conducted by 21 centers, covering 238.5 acres area of 264 farmers. Improved barley varieties with complete package of practices (irrigation management, nutrient management, weed control, seed treatment etc.) were demonstrated.

The highest increase in barley yield (Table 5.4) was recorded in UP (27.28 %) followed by MP (24.58 %), Punjab (22.67 %), HP (20.22 %) and Rajasthan (12.27 %). The lowest gain in yield was reported in Haryana (5.05 %).

The yield gain due to improved varieties over check mean yield was highest in NEPZ (27.28 %),followed by CZ (20.39 %), NHZ (20.22 %) and NWPZ (9.90 %) (Table 5.5). Therefore, efforts should be made to increase barley yield in the NEPZ and CZ by promoting recent barley production technologies in collaboration with the state department of agriculture.

In NHZ, HBL 713 was the highest average yielding (32.17 qha^{-1}) variety at Bajaura centre. In NEPZ, DWRB 137 at Kanpur (52.75 qha^{-1}), RD 2907 at Durgapura (63.72 qha^{-1}) in NWPZ and RD 2899 at Udaipur (42.70 qha^{-1}) in CZ were the highest average yielding varieties.

At particular farmers' field as well as on average basis, varieties HBL 713 (34.50 qha^{-1}), K 1055 (62.00 qha^{-1}), RD 2907 (66.50 qha^{-1}) and RD 2907 (64.50 qha^{-1}) performed better than other varieties at Bajaura, Kanpur, Durgapura Jaipur and Hindon Karauli centres in the NHZ, NEPZ, NWPZ and CZ, respectively.

Analysis of constraints in different barley producing zones of India

Northern Hills Zone (NHZ): In northern hills zone, yellow rust, small land holding, lack of knowledge among farmers about recent technologies, water stress, lack of irrigation facilities, termite, poor quality seeds, jungali jai and lack of training facility were identified as major constraints faced by the farmers.

North Eastern Plains Zone (NEPZ): In this zone, erratic power supply, untimely rain, high cost of

Table 5.4 : State wise yield gain during rabi 2018-19

State	BFLDs yield (qha^{-1})	Check yield (qha^{-1})	Gain (%)
HP	26.12	21.72	20.22**
UP	43.71	34.34	27.28***
Punjab	43.43	35.40	22.67***
Haryana	45.78	43.58	05.05 NS
Rajasthan	52.51	46.77	12.27***
MP	34.43	27.64	24.58***

**** Significant at 1 percent level, ** Significant at 5 percent level, NS– Non-*

Table 5.5 : Zone wise productivity over check during rabi 2018-19

Zone	BFLDs yield (qha^{-1})	Check mean yield (qha^{-1})	Gain (%)
NHZ	26.12	21.72	20.22***
NEPZ	43.71	34.34	27.28***
NWPZ	49.27	44.83	09.90***
CZ	40.34	33.51	20.39***

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

inputs, non availability of electricity, lack of irrigation facilities, low price of barley, *Phalaris minor, Chenopodium album,* temperature fluctuation during crop growth, non availability of farm machinery and imbalanced use of fertilizers were major constraints. Most of the constraints were administrative in nature which need immediate intervention by the state governments of this zone. Regarding technical constraints, farmers need to be made aware through awareness programmes and trainings about the use of fertilizers. Marketing of barley is still a concern in NEPZ.

North Western Plains Zone (NWPZ): Being the highest barley producing zone of the country, there a need to address major constraints in NWPZ. Under FLD programme, small land holding was identified as the most serious constraint followed by low organic matter, *Chenopodium album*, higher custom hiring charges, decline in water table, poor soil fertility, erratic power supply, low level of micro nutrients in the soil and high temperature at maturity.

Central Zone (CZ): In central zone, decline in water table, temperature fluctuation during crop growth, high cost of inputs, high temperature at maturity, lack of knowledge among farmers about recent technologies, untimely rain, imbalanced use of fertilizers, higher customer hiring rate of land levelling, field preparation, sowing, harvesting and threshing, low price of barley and water stress were identified as major constraints.

Overall Constraints (All zones): Overall analysis of constraints in different zones clearly indicated that decline in water table, small land holding, low price of barley, high cost of inputs, lack of knowledge among farmers about recent technologies, high temperature at maturity, temperature fluctuation during crop growth higher customer hiring rate of land levelling, field preparation, sowing, harvesting and threshing, *Chenopodium album* and erratic power supply were identified as major constraints affecting barley production and productivity in the country (Table 39).

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

Wheat: On an average, wheat varieties or technologies demonstrated at farmers' field under the FLD program gave 3.07 per rupee of investment in comparison to the check varieties (2.70). A significant difference in returns per rupee of investment was noticed between the FLD and check plots across states, zones and technologies. The returns per rupee of investment from FLDs ranged from 6.90 (Haryana) to 1.54 (West Bengal) across states, 4.06 (NWPZ) to 2.48 (NEPZ) across zones, and 7.37 (Happy Seeder) to 2.21 (Variety: Late Sown & Restricted Irrigation) across technologies. Haryana registered the highest returns per rupee of investment owing to the low operational costs *i.e.,* ₹16978 per hectare. On the contrary, West Bengal registered lowest returns per rupee of investment due to higher operational costs per unit area (₹49232 qha^{-1}).

The profit per hectare in FLDs was highest in Haryana (₹100224), followed by Punjab (₹100161) and Madhya Pradesh (₹83387). The difference in profit levels between demonstration and check plots ranged from ₹20318 in West Bengal to ₹4077 in Chattisgarh. Interestingly, operational costs in Bihar, Gujarat, Haryana, Jharkhand, Madhya Pradesh, Punjab and West Bengal were lower in demonstrations in comparison to the check plots. The probable reason for Haryana might be demonstration of resource efficient CA techniques which reduced the operational costs, significantly. Estimates of cost of production indicated that the operational cost incurred in producing a unit quantity of output was least in Haryana (₹323 per quintal) owing to less operational costs and the likelihood of getting more yield being a progressive state located in the NWPZ. Among wheat growing zones, the cost of production in the NWPZ was ₹566 per quintal due to relatively less operational costs in raising the crop and realized yield levels was more than the other zones. NWPZ also realized a good return per rupee of investment at the demonstrated plots (4.06) which is mainly due to the higher productivity, followed by less operational costs.

Among the wheat production technologies demonstrated at farmers' field, dicoccum gave the highest profit per hectare (₹118400) and the least profit was observed for the boron application (₹32890), despite a single demonstrated plot. However, the results were not consistent across sites owing to testing of particular technology in different locations of diverse soil properties. Overall, on an average, an Indian farmer by adopting a new wheat variety or production technology will earn ₹64592/ha. Further, ₹789 have to be spent to produce a quintal of wheat through adoption of a new wheat variety or production technology against ₹913 (check varieties).

Barley: On an average, improved barley varieties demonstrated at farmers' field under the FLD program gave around 25 per cent profit per hectare in comparison to the check. A significant difference in returns per rupee of investment was noticed between the demonstration and check plots across states and zones. Punjab registered the highest returns per rupee of investment (6.49) through demonstrations, followed by Uttar Pradesh (4.16) and Haryana (3.23). The difference in returns per rupee of investment between demonstration and check plots was highest in Punjab, followed by Uttar Pradesh and Madhya Pradesh. The profit per hectare in FLDs was highest in Uttar Pradesh (₹73870), followed by Rajasthan (₹70789) and Punjab (₹61431). The difference in profit between FLD and check plots ranged from ₹22112 in Uttar Pradesh to ₹3189 in Haryana. Interestingly, operational costs in Uttar Pradesh were lower in FLDs than check plots. The valid reason might be reduction in the use of inputs based on the recommendation. The returns per rupee of investment across barley growing zones were highest in the NEPZ (4.16), followed by NWPZ (3.56) and CZ (2.86). Estimates of cost of production indicated that the cost incurred in producing a unit quantity of output was least (₹271 per quintal) in Madhya Pradesh (CZ) owing to higher yield and remunerative price factor.

Overall, the profit analysis on wheat and barley indicated that additional returns per hectare from FLDs was more than the check varieties by ₹11912 and ₹12250 respectively establishing the fact that FLDs 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 FLDs. However, the present estimates are only the indicators for comparison within the current year and may not have a complete inter-year relevance as the demonstrations were conducted in 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.

Wheat FLDs at ICAR-IIWBR, Karnal centre

The centre (ICAR-IIWBR) conducted 20 acres wheat FLDs at twenty farmers' fields in the villages namely Amin, Bid Amin, Amin Dera Rampura, Deeg and Yara in Kurukshetra district of Haryana state using varieties HD 3086 and DBW 173, during *Rabi* 2018-19. The demonstrations were conducted using happy seeder and conventional tillage technology with a complete package of practices and farmers were provided with the improved varieties seeds as per provision under the programme.

Monitoring of frontline demonstrations (FLDs)

The team of ICAR-IIWBR accompanied by the experts from the Ministry of Agriculture & Farmers Welfare and the concerned centres monitored the following FLDs centres during the crop season 2019.

Table 5.6 : FLDs Centers monitored during 2019

Team Leader	Centres Monitored	Dates of Monitoring
Dr. Satyavir Singh	Khudwani-Anantnag, Rajouri and Kathua	6-11 March, 2019
Dr. Anuj Kumar	Noida, Rewari, IARI and Ujwa, New Delhi,	9-10 April, 2019
Dr. Anil Khippal	Indore, Ujjain and Ratlam	19-24 February, 2019
Dr. Raj Pal Meena	Faizabad, Kanpur and Varanasi	6-7 March, 2019
Dr. Sendhil R.	Dharwad, Belagavi and Wellington	3-10 March, 2019
Dr. Mangal Singh	Junagarh and Vijapur	25 February-4 March, 2019
Dr. Ramesh Chand	Jaipur, Ajmer, Tonk and Karauli	6-10 March, 2019

Research project highlights

Project : Evaluation, Transfer and Impact Assessment of Wheat and Barley Production Technologies

Sub-Project I : Diagnosis of zero tillage based rice-wheat system in Haryana

The study was conducted during 2019 in Bainsi and Sanghi villages of Rohtak district of Haryana with 120 farmers who have adopted resource conservation technologies *viz*; zero tillage or turbo happy seeder for sowing of wheat crop. A total of 60 beneficiaries and 60 non beneficiaries of zero tillage technology were selected for the study. Majority of the farmers (32.5%) belonged to age group 41-50 years of age. Eighty percent of them were having education upto Matin. Agriculture was their main occupation (92.5%) for majority of the farmers and dairying was subsidiary occupation for 52 per cent of the farmers. A majority of the farmers were rearing buffalo for milk production.

When farmers were categorized based on owned land holding it was observed that 65% of the farmers were in large category having more than 10 acres of land and 42% were in medium category but when it was done on the basis of total land holding 64.17% were under large category where as 27.5% were grouped in medium category. There was not much difference regarding land holding among beneficiaries and non beneficiaries. Study on communication behaviour revealed that KVK/SAU/ICAR institutes were the main source of information for majority of the farmers in that area. Regarding mass media exposure television was the mostly used source for agriculture related information followed by radio. In the study area it was found that 73.33% of the farmers possessed zero tillage machines. Only 26.67% of the the adopter went for custom hiring of zero tillage machines. The adoption of wheat varieties under zero tillage was also explored and it was found that HD 2967 was adopted by a majority of the respondents followed by HD 3086, WH 1105 and HD 2851. The average area per farmer under zero tillage was 17.70 acres while the average land holding per farmer was 18.82 acres among the beneficiaries of zero tillage technology. The comparison between beneficiaries and non beneficiaries on seed rate, number of irrigations, wheat yield per acre, straw yield per acre, cost of cultivation and average gross income clearly depicted the advantage of zero tillage technology over conventional tillage. With the adoption of zero tillage technology a farmer can get an average yield advantage of 1.64 q $acre^{-1}$. He can save ₹1800 per acre on cost of cultivation and can get ₹4637.66 $acre^{-1}$ over non beneficiary farmer. The partial budgeting for zero tillage technology for adopters vis-à-vis non adopters clearly reflected that with an additional cost of ₹800 on hiring of zero tillage machine and ₹400 on labour, the adopters were able to harvest additional 1.64 q $acre^{-1}$ wheat grain and 1.2 q $acre^{-1}$ straw and a net gain of ₹5304 $acre^{-1}$. The major challenges related to adoption of zero tillage technology were; higher seed rate used by the farmers, weed management, cost of turbo happy seeder and higher dose of nitrogenous fertilizer. Hence there is a need to educate the farmer about recommended package of practices. They need to be trained on weed management aspects particularly in light of herbicide resistance. In recent year govt. initiatives have been taken to develop custom hire centres on farm machinery. There is a need to develop such centres in a cluster of 10-15 villages for faster adoption of zero tillage technology in this area.

Sub-Project II : Identifying yield gaps, resource use and adaptation strategies in vulnerable regions of wheat and barley production against climate change.

Primary data on relevant socio-economic variables from two districts of Western Uttar Pradesh *viz*., Allahabad and Ghazipur were collected from 200 wheat producers for the crop season 2018-19. Research findings indicated that the Yield Gap I was negative in Allahabad, and the Yield Gap II was lowest in Ghazipur. Seeds were used more than the recommended doses. Fertilizers were used either below or above the recommended doses. Among all inputs, expenditure incurred on manure/bio-fertilizer showed a significant difference. Secondary data on temperature, rainfall, relative humidity and wind-speed were collected for the two selected districts for the period 1988-89 to 2017-18 (30 years) spanning crop season. Timeseries data on wheat and barley yield levels were collected from the Directorate of Economics and Statistics, GoI. The present study has utilised the two-stage stepwise regression. At the first stage, crop yield was regressed (stepwise) against individual weekly weather variables (with intercept) by fitting four different regression functions respectively for temperature, rainfall, relative humidity and wind-speed. Subsequently, the significant weather weeks obtained in stage one were pooled and regressed again on crop yield using stepwise approach but without the intercept. The idea behind the stepwise regression methodology is, initially other factors that are excluded from the model might contribute to yield sensitivity apart from the selected variables. However, in stage two, we deciphered and reported only the significant weather weeks of selected variables that exclusively influence the crop yield. Findings from the analysis indicated that the sensitive weather weeks are crop specific and region specific. For instance, wheat yield levels are highly sensitive to temperature prevailing during week 11 in Ghazipur but not in Allahabad. The implication of the results indicate that wheat crop is sensitive to weather anomalies during flowering, milking and dough stage in the selected study regions. In the case of barley, the identified sensitive crop growth stages are: tillering, flowering, grain hardening and ripening. The study recommends for developing and/or popularising adaptation practices to the adverse effect of yield sensitivity owing to climate change. Further, the climate smart farming practices should be crop-farm-region specific to address the crop yield sensitivity.

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/seven centers were included for the year 2019-20, namely, Lahaul & Spiti (HP), Leh (J&K), Khudwani (J&K), Jabalpur (MP), Udaipur (Rajasthan), Bilaspur (Chhattisgarh), Ranchi (Jharkhand) and Dharwad (Karnataka). During 2018-19, different TSP activities were carried out. Under TSP project, a Three Days Training on 'Increasing farm income of Lahaul-Spiti farmers through improved wheat & vegetable production technologies' was organised during 19-21 December, 2019 at ICAR-IIWBR, Karnal for 45 farmers (30 men and 15 women) of district Lahaul & Spiti (HP).

The demonstrations on wheat crop were conducted with complete package of practices at 11, 82, 30, 15, 30 and 25 farmers' fields at Khudwani, Jabalpur, Udaipur, Bilaspur, Dharwad and Ranchi centers, respectively. Ten training programmes on wheat production technology were conducted at Khudwani, Jabalpur, Udaipur, Bilaspur and Ranchi centers. Six farmers fair/field days were conducted one each at Lahaul & Spiti and Bilaspur; and two each at Jabalpur and Ranchi centers. Three publications, two at Bilaspur and one at Udaipur were published. Under the 'Capital' head in budget, funds have been approved and released for the year 2019.

06 BARLEY IMPROVEMENT

The national barley research programme in the country is coordinated by ICAR-IIWBR, Karnal under AICRP on wheat and barley by means of multi-disciplinary and multi-locational experiments organized across the barley growing zones at funded and voluntary centres covering malt, feed and food barley. This results into the identification of new cultivars for commercial cultivation with wider adaptability, resistance to various biotic and abiotic stresses prevalent in the area, desired quality levels and suitability to specific production conditions. In addition, the production technologies evaluation experiments are also being conducted on aspects of input optimization and conservation agriculture. The crop protection experiments include the screening of new genotypes under artificial epiphytotic/ hotspot conditions and chemical control and IPM at various test centres. The zonal monitoring during crop season and annual review & work planning are also organized to facilitate the objectives of AICRP.

The AICRP research efforts are also supplemented by ICAR-IIWBR, Karnal through research on specific aspects of barley improvement especially on malt barley improvement, application of biotechnological tools in disease resistance and quality improvement and updating of cultivation package. Trait discovery for novel sources of resistance and their utilization especially from exotic genetic resources and creation of new variability are the important aspects of the barley improvement quality traits. Renewed focus is also placed on better yield and quality of hulless barley for food, better malt extract, high diastatic power, optimum protein and beta glucan content in malt barley.

In addition, ICAR-IIWBR has linkages with international organizations like ICARDA to facilitate the continuous access to new germplasm of diverse origin from various sources for evaluation and utilization in the national programme. New initiatives were undertaken to improve productivity and quality of malt and food purpose barley. Awareness programme were organized to popularize barley for the health benefits (high antioxidant, higher beta glucan content). Linkages with national and international industries were also strengthened. Scientists visited the malting, brewing and food industries to promote the use of malt and food barley in different products and farmers training for malt barley cultivation under consultancy project with M/s AB InBev, India were also organized.

The efforts of the barley improvement programme have led to the all-time high productivity of 28.8 qha^{-1} in India with a production of 1.75 million tonnes from an area of 6.1 lakh ha as per the 4^{th}advance estimates from the MoA&FW. The monitoring teams surveyed the major barley growing areas during the season and observed that the crop was by and large disease free with some localized incidence of aphids in the plains and yellow rust in foothills and mid hills.

Fig 6.1: DWRB 160: latest two-row malt barley cultivar developed at institute

Release of new barley varieties

During 2019, the Central Sub-Committee on Crop Standard, Notification and Release of Varieties for Agricultural Crops recommended the notification of following five barley varieties for commercial cultivation in different zones/state of the country (Table 6.1). Amongst them DWRB 160 is the new malt type barley cultivar developed under ICAR-IIWBR barley improvement program with very high grain yield coupled with disease resistance and better malting quality, which will fill the industrial demand in the north western plains region.

Genetic stocks registered

Two genetic stocks namely DWRB 191 and DWRB 192 were registered for their uniqueness with ICAR-NBPGR and their details are in Table 6.2:

Organization of the coordinated yield evaluation trials

Out of 92 yield evaluation trials proposed, 94 (91%) trials were conducted. After the analysis, only 83 trials (99% of proposed, 83% of conducted) were found good for reporting. These trials were conducted at 11 main centres and 28 testing centres (including ICAR, SAUs and State Department of Agriculture) during Rabi 2018-19. In all 98 test entries contributed by 11 centres, were evaluated against 31 checks in the coordinated yield trials under rainfed (plains and hills), irrigated (plains) and saline soils conditions. The new barley entries include malt, feed or dual purposes types and mostly were hulled type with a few hull-less types.

Promising entries in AVT/IVTs

Based upon the promotion criteria *i.e.* significantly superior, monitoring reports and disease and pest reactions, nine entries (Table 6.3) were found suitable for the promotion into advanced varietal evaluation in different trials. From ICAR-IIWBR barley program, entry DWRB182 was promoted to AVT-II year of malt barley for its final year evaluation. While on the basis of performance in station trials, the entry DWRB204 of food barley was promoted in IVT/AVT-Hulless trial and two other entries namely DWRB196, DWRB197 and PL 908 of malt barley were promoted in IVT-MB-TS.

Table 6.1: New barley varieties released in 2019

S.N	Variety	Zone/State	Developing institute	Production condition	Av.yield (q/ha)
1.	DWRB 160	NWPZ	ICAR-IIWBR, Karnal	IR-TS-Malt	53.72
2.	RD 2899	CZ	RARI, Durgapura	IR-TS-Feed	42.19
3.	RD 2907	NWPZ&NEPZ	RARI, Durgapura	Salinity soils	35.25
4.	PL 891	NWPZ	PAU, Ludhiana	IR-TS-Hulless	36.60
5	HBL 713	HP	CSKHPKV, Bajaura	RF-TS-Feed	33.60

Table 6.2: Genetic stocks registered in 2019

Genetic stock	INGR Number	Year	Trait
DWRB191	19012	2019	High grain zinc content
DWRB192	19013	2019	High grain iron content

Table 6.3: Promising entries in AVT/IVTs

S.N	Trial name	Zone	Entry
1	IVT-MB-TS	NWPZ	DWRB 196, DWRB 197, PL 908
2	AVT-MB-TS	NWPZ	DWRB 182
3	IVT/AVT- Hulless	CZ	DWRB 204
4	IVT-FB	NWPZ	KB 1707, PL 906, RD 2994, UPB 1080

Table 6.4: Zonal monitoring visits of the barley team

CZ	15-16 February, 2019	Udaipur, Vallabhnagar, Vijapur
NEPZ	21-24 February, 2019	Kanpur, Dalipnagar, Faizabad,Varanasi, Saini
NWPZ & CZ	05-08 March, 2019	Ludhiana, Bhatinda, Hisar, Bawal, Durgapura, Kumher, Mathura
NHZ I	24-26 April, 2019	RanichauriMajhera, Hawalbagh (Almora)
NHZ II	08-13 April, 2019	Shimla, Berthein, Kangra, Malan, Palampur, Bajaura, Katrain

Zonal monitoring

The monitoring team visited the different locations in NWPZ, NEPZ, Central Zone, NHZ-I and NHZ-II at the most appropriate stage of crop and recorded observations about the varietal performance, conduct of trials, disease/ pest incidence and genetic purity of test entries (Table 6.4). On the spot the decisions were taken about the acceptance/rejection of the trials and purity of test entries through consensus.

International and national nurseries and trials

Four trials and nurseries were supplied during *Rabi* 2018-19 season from ICARDA which included a total of 347 genotypes for different production conditions. These nurseries were evaluated at different locations and three test entries namely, IBYT-HI-19-15, IBYT-HI-19-17, and IBYT-HI-19-22 were found promising at Hisar centre, whereas three test entries, IBYT-HI-19-12, IBYT-HI-19-7 and IBYT-HI-19-16 were found promising at Ludhiana locations. In the 6thGlobal Spring Barley Yield Trial which grown under low input cultivation conditions, two test entries 6thGSBYT-8 and 6thGSBYT-9 were found promising. In addition, 15 lines were evaluated in NBGSN and 45 lines in EIBGN at 10 co-operating centres of barley.

Evaluation of ICARDA selected germplasm lines at ICAR-IIWBR, Karnal

A total of 308 lines were selected in Morocco; 37 at Amlaha and 21 during 'Field Day' organized at ICAR-IIWBR, Karnal. These 366 lines were evaluated in 2-replications in *Rabi*2018-19. Of them, 67 germplasm lines were selected and have been raised in *Rabi* 2019-20 for further evaluation and selection. In addition, 58 lines selected at Amlaha during the 'Field Day' were received and sown in the current season for site specific selection.

Germplasm selection and utilization

During *Rabi* 2018-19 season, a total of 118 germplasm lines were selected from six different international trials and nurseries of ICARDA during the 'Field Day' organized at ICAR-IIWBR, Karnal on 29thMarch 2019, by barley breeders of different cooperating centres for its utilization in their breeding programmes. Seeds of these selected lines have been supplied to concerned breeders for augmentation of their breeding programme.

Germplasm rejuvenation and characterization

A total of 8193 accessions of barley are being conserved and maintained in medium term storage facility in module at ICAR-IIWBR, Karnal. A total of 500 germplasm lines were rejuvenated during *Rabi*2018-19. Five hundred germplasm accessions were sown for rejuvenation and characterization during 2019-20. Two farmers' variety namely Maghe and Laxhmi were characterized as per the barley DUS guidelines with a set of 04 reference varieties during 2018-19. Four candidates' varieties namely B.2019-1, B.2019-2, B.2019-3 and B.2019-4 are under process of "Grow Out test" and DUS data recording during *Rabi*2019-20.

Crop Improvement

Malt barley

Crossing programme: During the season, 47 new crosses were attempted using promising parents of malting quality, agronomic adaptability, earliness and desirable plant types. A crossing block with 330 genotypes was maintained for potential donors under malt breeding programme. Out of these crosses, 45 were advanced during summer 2019 in off-season nursery at Dalang Maidan.

Generation advancement and selections: F_1 to F_7 generations were raised at the research farm, ICAR-IIWBR Karnal and evaluated under artificial epiphytic conditions for rusts and also natural incidence for aphids. Single plant selection was made from different segregating generations for plant vigour, tillering, early maturity, suitable plant types, morphological traits and resistance to rusts and blights. The details of breeding materials selected and shown are presented in Table 6.5.

Table 6.5: Generations advancement of malt barley during 2019

Generation	No of Crosses	No of Families
F_1	47	–
F_2	41	–
F_3	66	125
F_4	106	397
F_5	170	207
F_6	39	60
F_7	12	18
F_8	15	17

Feed and food barley

Hybridization, selections and generation advancement

Single spikes of 48-fresh crosses attempted using eight female lines and 15-donor parents for blight and rust resistance and grain quality characters were harvested cross-wise and these were sown in *Rabi* 2019-20 season to raise F_1 generation. In addition, 12 interspecific crosses with *H. vulgare ssp. spontaneum* were sown to raise F_1 generation in the net house. The selected 5-cross combination raised in F_1 generation in the last *Rabi* season were harvested and sown as F_2 bulks in the current *Rabi* season. Further, 101-single spikes selected in 33 F_2 crosses were raised in spike-to-row in F_3 generation. 9-crosses grown in F_3 and 87-spike-to-rows of 10 crosses in F_5 generations raised at Dalang Maidan in summer 2019 have been sown at Karnal during current *Rabi* season in single row-bulks to raise F_4 and F_6 generations respectively. 80-spikes selected in 8-crosses in F_4 generation in *Rabi*2018-19 were harvested spike-wise and cross-wise and have been sown in the current *Rabi* season in F_5 generation.

Screening for leaf blight and yellow rust

A total of 43-germplasm lines along with one susceptible check PL426 were screened at PAU, Ludhiana. The disease reaction was susceptible (PL426) to moderately resistant (IBYT-18-9, INBYT-HI-18-11, 5thGSBYT-18-19, IBON-18-47, IBON-18-60, IBON-18-100). A set of 45 wild accessions of *H. Vulgare ssp. spontaneum* was screened for black, yellow and brown rusts at RS, IIWBR, Shimla. All the accessions were found susceptible.

Seed enhancement of wild accessions

Seed of 45-wild accessions of *Hordeum vulgare ssp. spontaneum* obtained from ICARDA, Morocco were

Table 6.6: Barley crosses for advancement of generation at Lahaul & Spiti during *Rabi* 2019

S.No.	Combination	S.No.	Combination
1	INBON-HI-(2017)-77/ INBON-HI-(2017)-33	9	HUB113/INBYT-HI-(2015)-1
2	INBON-HI-(2017)-77/ INBON-HI-(2017)-32	10	HUB113/INBYT-HI-(2015)-4
3	INBON-HI-(2017)-81/ INBON-HI-(2017)-34	11	DWR83/ INBYT-HI-(2015)-6
4	INBON-HI-(2017)-87/ INBON-HI-(2017)-34	12	DWR83/ INBYT-HI-(2013)-11
5	INBON-HI-(2017)-88/ INBON-HI-(2017)-33	13	DWR83/ INBYT-HI-(2015)-1
6	INBON-HI-(2017)-88/ INBON-HI-(2017)-34	14	DL88/INBYT-HI-(2015)-1
7	PL426/INBYT-HI-(2013)-11	15	DL88/INBYT-HI-(2013)-11
8	DL 88 /INBYT-HI-(2015)-4	16	DL88/INBYT-HI-(2015)-6

Table 6.7: Feed and food barley breeding material grown during *Rabi* 2018-19

Generation	Grown		Field selection	
	Family	Cross	Family	Cross
F_9	2	2	-	-
F_8	11	10	6(B)	5
F_7	15	11	5(B)	4
F_6	63	32	4,12 (B)	13
F_5	162	46	92	35
F_4	71	24	31	15
F_3	215	43	106	39
F_2	55	55	143	45
Total	594	223	376	156

multiplied for their further characterization. Observations on morphological attributes were recorded. A set of these accessions was deposited with Germplasm Unit for further multiplication and medium-term storage.

The 63 cross combinations were attempted between Indian released varieties and exotic barley germplasm accessions out of which, 45 cross combinations were made to improve the feed and fodder for domestic animals while 18 cross combinations were made for improvement innutritional quality such as high beta-glucan, protein, zinc and iron content. Several sources of resistance (stripe rust) and yield attributes including indigenous and exotic two and six rowed lines have been utilised through hybridization programme.

Evaluation and selection in segregating breeding materials

F_2 to F_9 generations of hulled and hulless barley were grown at the ICAR-IIWBR Farm, Hisar and evaluated for agro-morphological traits under field conditions. Individual plant selection was made for early maturity, semi dwarf plant type, erect spike and resistance to yellow rust from segregating generations.

From breeding materials evaluated, 23 promising progenies were bulked from F_6, F_7 and F_8 generations for inclusion in station trial and grown during 2019-20.

Novel genotype with unique trait

A six-rowed black grain coloured barley genotype DWRB189 (IC0632077) was selected and evaluated for anti-oxidant properties during 2018-19 at ICAR-IIWBR, Karnal. The genotype DWRB189 showed unique black grain colour than all the existing released varieties and genetic stocks during *Rabi*, 2017-18 and 2018-19. DWRB 189 depicted total phenolic content of 1913 µgGAE/g, whereas, the registered genetic stock Kasota and six-rowed checks, namely BH46 and DWRB137 depicted total phenolic content of 1719, 1286 and 1341µgGAE g^{-1}, respectively during *Rabi*2019. Therefore, the

Fig 6.2: High anti-oxidant genotype DWRB189

Table 6.8: Antioxidant activity of DWRB189 and checks

S.N.	Name	Colour	Antioxidant activity DPPH Method (% Discoloration)	Antioxidant activity ABTS Method (µMTrolox Eq./g)	Total phenolic content (µgGAE*/g)
1	DWRB 189	Black	68.92	13.65	1913
2	Kasota (C)	Light yellow-Yellow	57.83	12.25	1719
3	BHS 946 (C)	Light yellow- Yellow	45.60	9.82	1286
4	DWRB 137(C)	Light yellow- Yellow	46.34	10.46	1341
5	BK1127 (C)	Light yellow- Yellow	31.76	7.40	943
6	DWRB 91 (C)	Light yellow- Yellow	35.24	9.30	1222
7	DWRB 92 (C)	Light yellow- Yellow	31.45	7.26	973
8	BH 902 (C)	Light yellow- Yellow	39.21	9.26	1117

**GAE – Gallic Acid Equivalents*

genotype DWRB189 is a unique barley germplasm for black grain colour and high anti-oxidant property.

Plant Protection

Barley fields were surveyed by different scientists of cooperative centers and no rust was recorded during the survey whereas loose smut, covered smut and bacterial streak were recorded in traces in some fields. Overall barley crop was healthy in all the barley growing areas in India. The incidence of insect-pests and their natural enemies also observed, the aphid and its population was found to be moderate to high in barley fields in some of the locations. Among natural enemies, coccinellid beetles, chrysoperla and syrphid fly were frequently noticed predating on barley aphids.

Screening of advanced and promising genotypes against rust, leaf blight, aphid and CCN

A total 538 entries were screened under various nurseries (IBDSN, NBDSN and EBDSN) for resistance against various diseases, aphid and CCN at different cooperating centers. Among these, 372 entries were evaluated under IBDSN, 19 were found free from yellow rust and 206 entries showed resistant reaction. In case of leaf blight screening, 35 entries were found moderately resistant against leaf blight. Out of 107 entries evaluated under NBDSN, 16 entries were found free from yellow rust and 65 entries showed resistant reaction. Among these, 32 entries were found moderately resistant against leaf blight.

None of the NBDSN entry was found resistance to all the tested pathotypes of black, brown or yellow rust pathogens. Three entries (BH1024, KB 1762, RD 3008) were resistant to brown and black rusts. BHS 474, HBL 845, HBL 863, RD 2786(c), RD 2991 and RD3003 possessed resistance to brown & yellow rusts whereas DWRB 182, HBL 812 to black & yellow rusts

Table 6.9: Screening of NBDSN entries

Yellow rust,ACI = 0,Entries – 16	DWRB 182, DWRB 184, DWRB 197, HBL 845, HBL 848, HBL 851, HBL 858, HBL 863, PL 908, PL 911, RD 3005, RD 3007, UPB 1078, BHS 380 (C), DWRB 123 (C) and RD 2899 (C)
Leaf blight, Avg. 14-35 with HS < 57, Entries - 32	BH 1024, BHS 472, BHS 475, BHS 476, DWRB 182, DWRB 184, DWRB 202, DWRB 203, DWRB 204, DWRB 205, DWRB 206, HBL 851, HBL 858, HUB 266, HUB 267, HUB 268, KB 1706, KB 1750, KB 1757, NDB 1712, PL 891, RD 3007, RD 3008, RD 3009, RD 3010, VLB 161, VLB 163, BHS 352 (C), BHS 380 (C), K 603 (C), RD 2899 (C) and VLB 118 (C)

Table 6.10: SRT evaluation of NBDSN entries

Resistant to	Number of entries	Detail of entries
Brown & Black	3	BH 1024, KB1762, RD3008
Brown & Yellow	6	BHS 474, HBL 845, HBL 863, RD 2786 (C), RD 2991, RD 3003
Black & Yellow	2	DWRB 182, HBL 812
Yellow	25	BH 1023, BHS 472, DWRB 200, DWRB 201, DWRB 207, HUB 266, KB 1707, KB 1713, PL 906, PL 908, PL 909, PL 911, RD 2969, RD 2992, RD 2999, RD 3000, RD 3002, RD3004, RD 3005, DWRB 137(C), HUB 113 (C), RD 2552(c), RD 2794, RD 2899, RD 2907
Brown	14	BHS 475, BHS 477, DWRB 184, DWRB 188, DWRB 197, DWRB 202, DWRB 204, DWRB 206, HBL 848, HBL 851, KB 1706, KB 1757, UPB 1082, HBL 113(c))
Total	50	

Table 6.11: Screening of EBDSN entries

Resistant to	Entries#	Detail of entries
Yellow rust, ACI = 0,	Entries – 10	BH 1011, BH 1018, BK 1719, DWRB 137, HBL 822, PL 900, RD 2973, RD 2976, UPB 1070 and VLB 130
Leaf blight, Avg. 13-35 with HS < 57	Entries - 11	BH 1011, BH 1018, BK 1719, BK 1723, DWRB 178, KB 1633, PL 890, PL 900, PL 902, UPB 1071 and VLB 130

Table 6.12: SRT evaluation of EBDSN entries

Resistant to	Entries#	Detail of entries
Black & Yellow	1	HBL 814
Brown & Yellow	5	RD 2786, RD 2972, RD 2973, RD 2975, RD 2976
Yellow	23	BK 1622, BK 1714, DWRB 186, DWRB 127, DWRB 137, DWRB 143, DWRB 152, HUB 113, KB 1634, PL 900, PL 902, RD 2552, RD 2794, RD 2899, RD 2907, RD 2967, RD 2971, RD 2977, RD 2978, RD 2980, RD 2981, RD 2982, RD 2983
Brown	8	BH 1013, BK 1719, BK 1723, VLB 153, BK 1725, DWRB 178, DWRB 180, HBL113
Total	37	

Among 59 entries screened in EBDSN, 10 entries were found free from yellow rust, whereas 46 shown resistant reaction. Eleven entries showed moderate level of resistance against leaf blight.

None of the EBDSN entries was resistant to all the tested pathotypes of black, brown and yellow rusts pathogens. HBL 814 was resistant to black & yellow rusts whereas RD 2786, RD 2972, RD 2973, RD 2875, RD 2976 were resistant to brown & yellow rusts.

Among different fungicidal treatments, seed treatment (ST) with Vitavax power + Propiconazole at 0.1% spray and ST with Vitavax power + Tebuconazole (Folicur) at 0.1% spray found equally effective against foliar blight and significantly superior over control.A total 166 entries that includes 107 of NBDSN and 59 of EBDSN, were screened against the Cereal Cyst Nematode (CCN) at three locations *viz.* Durgapura, Ludhiana and Hisar. Most of the entries fall in the category of susceptible or highly susceptible. A total of 125 barley NBDSN entries were screened against foliar aphid at three locations (Ludhiana, Kanpur and Karnal) during 2018-19. A majority of the entries at all the locations harboured aphids in different range depending upon their incidence level. The entries were found in the category grades *i.e.* 3 to 5. Five entries *viz.,* DWRB 182, DWRB 184, PL 911, RD 3005 and HBL 845 were found to be moderately resistant (grade 3) at Karnal. At Ludhiana, seven entries; BH 1025, PL 909, RD 2992, RD 2994, BH 902 (C), DWRB 123 (C) and K 508 (C) were found moderately resistant (grade 3). None of the entry was found to be in moderately resistant (grade 3) category at Kanpur.

Management of foliar aphid

Amongst eight treatments tested for their efficacy against foliar aphid at various locations; (Ludhiana, Vijapur, Kanpur, and Karnal), three insecticides *viz.*, Quinalphos 25 % EC at 400 ml ha^{-1}, Imidacloprid 200Sl at 100 ml ha^{-1} and Acetamiprid 20 SP at 100 g ha_{-1} were found to be equally effective in managing aphid population in barley and were significantly superior over control. Out of three bio-pesticides, Azadirachtin 1000 ppm was comparatively better than *Beauveria bassiana* and *Metarhizium anisopliae*.

Management of stored grain insect-pests through seed protectants

Studies on testing the plants having toxicity effects on insects were evaluated as seed protectant against major stored grain insect pests; *Sitophilus oryzae* or *Rhizopertha dominica*. Percent reduction in the insect population and weight of seed grains was taken at the end of each census. The seed treatment with Vekhand powder @ 10 g of seed recorded significantly lowest number of *Sitophilus oryzae* or *Rhizopertha dominica* over untreated control.

Varietal resistance of barley genotypes to stored grain insect-pest infestation

Barley genotypes were evaluated for infestation by three major storage insect-pests; rice weevil, lesser grain borer and red-rust flour beetle during 2018-19. It was recorded that maximum damage orientation /attraction of insect-pests was caused to varieties DWRB 92 and DWRB 101 and minimum damage and attraction was caused to DWRB 73.

Resource Management

Barley resource management group deals with evaluation of newly developed cultivars from AVT final year under different production conditions and take up the refinement of the package of practices for higher production of barley crop in different zones. The long-term objective of the program is to improve the productivity and quality of barley on sustainable basis. A total of 47 trials were proposed and conducted. In malt barley AVT trial, the grain yield of test entry DWRB 160 (51.20 q ha^{-1}) was statistically at par with the newly released malt barley varieties although BH 946 a six-row variety registered significantly highest grain yield (54.46 q ha^{-1}). In hulless barley trial, the test entry PL 891 recorded significantly highest grain yield (41.97 q ha^{-1}) as compared to the other varieties.

In case of new malt barley genotypes BK 306, BCU 2241, BK 1127, BK 303, BK 316, DWRB 316, DWRB 101 and BH 902 (feed barley) responded up to 90 kg N ha^{-1} whereas feed barley check variety BH 946 responded only up to 60 kg N ha^{-1}.

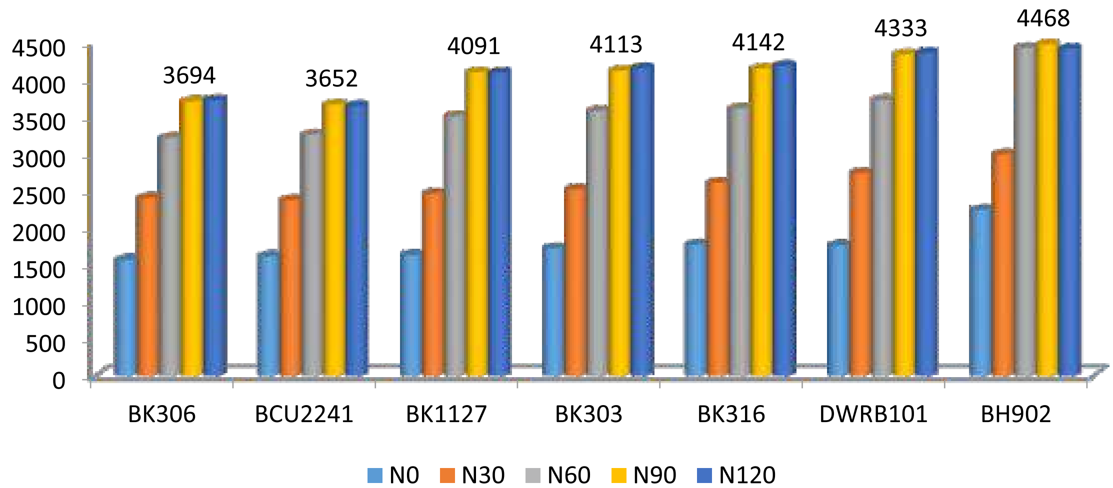


Fig 6.3: Effect of different nitrogen treatments on grain yield (kg/ha)

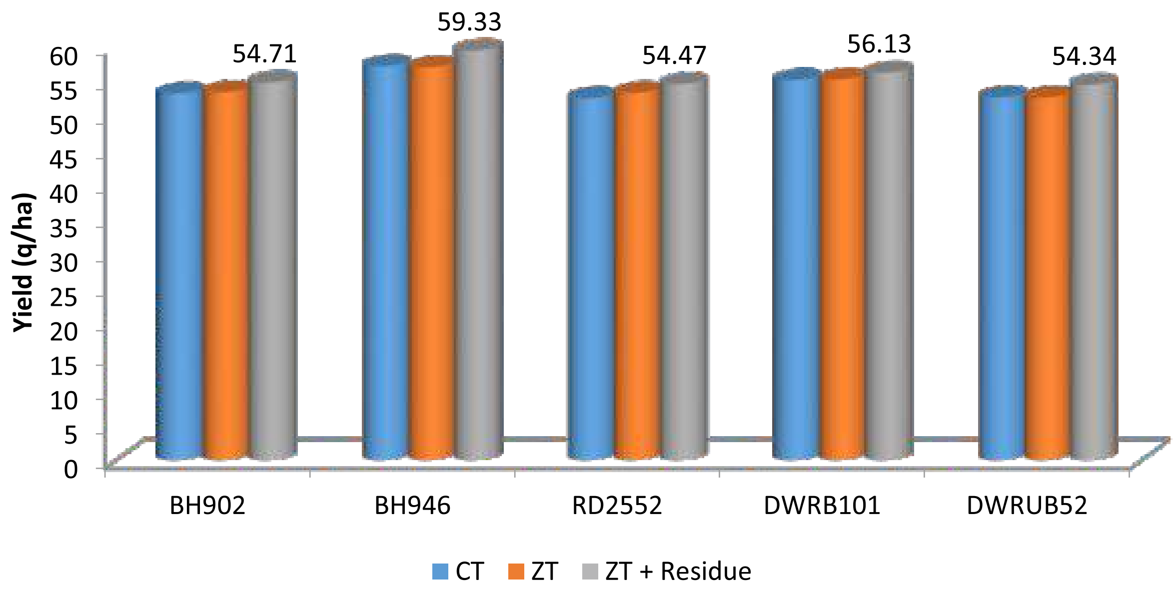


Fig 6.4: Effect of different tillage options on grain yield

In case of residue and tillage management experiments in NWPZ, maximum grain yield (BH 946, 55.80 q ha^{-1}) was realized in zero till sowing with rice residue retention which was significantly higher than other methods of sowing. In NHZ, maximum grain yield (32.24 q ha^{-1}) was recorded under zero till sowing with rice residue retention which was at par to conventional tillage.

The herbicide evaluation experiments for controlling broad leaved weeds in barley in two year indicated that a readymix of Halauxifen methyl (10.21g a.i. ha^{-1}) and Florasulam (20g ha^{-1}) with surfactant can be used to control broad leaved weeds in barley in NWPZ, NEPZ, NHZ and CZ and so incorporate in package of practices in all the zones.

The experiments on saving the irrigation water, application of Pusa Hydrogel @ 2.5 kg ha^{-1} and New Hydrogel @ 2.5 kg ha^{-1} resulted in significantly higher grain yield as compared to control conditions in Agra, Durgapura and Hisar locations in NWPZ. Highest grain yield (54.62 q ha^{-1}) was recorded with three irrigations which was significantly higher than other irrigation levels.

Under the integrated input management, application of recommended doses of fertilizer resulted in significantly highest grain yield (48.0 q ha^{-1}) as compared to application of FYM alone @ 15 t ha^{-1} or combination of FYM @ 10 t ha^{-1} and half of the recommended doses of fertilizer in NWPZ. Application of FYM @ 10 t ha^{-1} and half of the recommended doses of fertilizer resulted in significantly highest grain yield (42.66 q ha^{-1}) in CZ as compared to application of FYM alone @ 15 t ha^{-1} or recommended doses of fertilizer. In case of NHZ resulted at par grain yield with the application of 75 % and 100 % recommended dose of fertilizer. Use of Azotobacter + PSB resulted in significantly higher grain yield (35.05 q ha^{-1}) as compared to other treatments.

The experiment on use of plant growth regulators to manage the lodging in optimum input conditions to ensure higher production, Chlormequat-chlorid (CCC) at1.25 L ha^{-1} at GS30-31 followed by ethephon (Cerone) at 0.5 L ha^{-1} at GS39-40 recorded significantly higher grain yield and reduced the height by 7-10 cm which avoided the lodging.

Barley Quality

Quality evaluation of hulless genotypes

In the past two decades, a lot of research has been done on nutraceutical or health properties of barley and very positive benefits have been identified. Several health benefits of barley have been mentioned in ancient Indian scriptures. Hulless barley for development of food products are urgently required. For identification of sources having good biochemical parameters, the landraces along with controls were grown during *Rabi* season of 2019 in three replications and analyzed for various grain physical and biochemical parameters. The landrace BCU 8027 and BCU 8028 had good amount of grain beta glucan content (≥ 6.0 % db) with protein content of > 14 % on dry weight basis. Though there is non-significant difference in amylose content among genotypes, but numerically BCU 8028 had the highest amylose content. The genotype DWR 80 and BCU 7998 have the bold grain percentage of around 80% with good grain beta glucan and protein content.

Table 6.13: Grain traits of hulless genotypes

Genotype	Test wt (kg/hl)	Bold grain (%)	Thin grain (%)	TGW (g)	Protein (% db)	Beta glucan (% db)	Amylose (%)
BCU 8023	71.9	48.0	13.8	40.8	13.6	4.7	25.7
BCU 8024	72.6	28.0	29.9	34.3	15.2	5.4	25.2
BCU 8025	72.4	40.8	25.7	39.8	14.6	5.4	24.5
BCU 8026	72.5	48.3	18.7	36.6	13.8	5.6	25.1
BCU 8027	75.6	44.6	22.0	35.1	14.2	7.0	26.5
BCU 8028	75.6	49.3	16.9	35.0	14.4	6.5	27.3
BCU 8029	74.3	33.9	26.9	34.6	14.7	6.1	23.0
BCU 8030	73.2	35.3	24.1	36.3	14.2	5.6	23.0
BCU 8031	74.6	43.9	18.6	40.8	15.6	5.8	25.6
BCU 8032	73.1	36.2	26.5	35.7	15.0	5.9	26.8
BCU 8033	73.3	42.5	23.0	36.0	14.8	5.8	26.8
BCU 8034	72.0	44.2	21.8	35.8	15.3	5.4	25.8
BCU 8035	72.7	55.9	13.4	39.2	14.6	5.6	25.5
BCU 8036	72.7	35.3	23.4	37.7	14.4	6.4	24.0
BCU 8037	73.9	52.0	16.2	45.8	14.1	6.2	21.7
BCU 8038	75.7	53.9	14.8	42.4	14.1	5.6	22.8
BCU 8039	70.7	55.2	14.1	40.6	13.9	5.7	26.4
BCU 8040	71.7	38.0	21.6	37.2	15.2	6.2	25.7
BCU 8041	61.9	65.4	10.0	45.9	14.4	5.3	22.9
BCU 7998	72.7	79.2	3.3	48.4	12.6	5.8	23.0
DWR 62	72.4	66.0	5.2	37.3	13.7	6.1	24.1
DWR 80	66.3	80.1	3.1	40.9	13.1	5.3	26.0
DOLMA (C)	73.1	23.5	31.0	34.9	14.5	6.5	26.2
NDB 943 (C)	74.4	51.1	5.8	39.3	13.5	5.6	21.7
KARAN 16 (C)	70.2	53.8	11.1	44.1	12.1	4.9	26.3
BHS 352 (C)	74.9	26.4	36.1	36.8	12.8	6.5	23.4
GEETANJALI (C)	75.6	42.6	16.1	33.7	14.9	5.6	22.2
HBL 276 (C)	74.6	21.1	36.4	33.8	14.3	6.7	23.7
ATAHULAPA (C)	72.0	76.7	3.7	54.7	14.6	6.3	26.0
LSD (5%)	2.5	12.5	8.1	6.5	1.3	0.8	NS

Evaluation of genotypes for malting quality

Beta glucans have profound effect on malting quality of barley and in this regard the sources of is low beta glucan have been identified and are being used by breeders for introgression of this trait through conventional and molecular breeding. Further basic studies are being carried out to dissect the roles of beta glucans in the genotypes being grown under Indian conditions. The studies are underway and the work done till December is being reported. The genotype BCU 2030 has been found to contain low grain beta glucan (3.9%) along with higher glucanase activity.

Malting quality evaluation of AICRP material

The Barley Unit also took up the malting quality evaluation of grain samples from coordinated malt barley trials conducted in NWPZ during Rabi 2018-19 from various test sites at its central facility.

Table 6.14: Grain parameters of high & low β-glucan genotypes

S.N.	Genotype	B-glucan (% db)	Malt glucanase activity (U/kg malt)	Grain hardness Index (SKCS)	Protein (% db)	Starch (% db)	Bold grains (%)
1	20th IBON-3	6.1	133.6	15.9	11.6	62.0	89.3
2	BCU 554	6.4	146.2	15.2	11.2	62.3	79.9
3	DWR 30	7.1	194.9	13.9	11.7	61.8	67.8
4	DWRUB 76	6.6	246.6	15.3	11.4	61.9	81.8
5	ICARDA-54	6.3	356.0	15.3	11.5	60.9	86.4
6	BCU 2030	3.9	426.3	15.1	12.0	62.2	62.6
7	BCU 277	3.3	297.6	13.7	13.5	60.0	69.9
8	SLOOP SA WL 3167	3.4	290.4	13.9	11.5	61.3	75.8
9	SLOOP VIC VB 9953	3.4	307.3	14.2	10.3	64.5	80.3
10	DWR 39 (C)	3.7	153.9	15.0	11.0	62.8	85.8
11	DWRUB 52 (C)	4.2	292.6	13.8	10.5	63.4	89.5
12	DWRB 92 (C)	5.2	138.5	14.7	12.3	62.4	94.9
13	DWR 28 (C)	5.5	83.6	14.8	11.6	61.7	96.3
14	RD 2668 (C)	6.5	99.7	13.6	11.0	62.5	73.0
15	ALFA 93 (C)	4.2	365.5	14.8	11.1	64.7	86.9
16	BCU 73 (C)	4.2	87.0	14.6	10.9	61.4	83.3
17	K 551 (C)	3.9	82.2	14.2	12.2	61.6	73.7
18	Manjula (C)	3.2	291.1	14.6	11.7	61.2	72.5
19	DWRB 101 (C)	4.8	109.6	14.4	10.9	62.9	87.2
20	Clipper (C)	4.7	152.1	14.1	10.9	62.5	87.4
LSD (%)		0.7	196.7	NS	1.2	2.2	10.5

Table 6.15: Promising entries* for individual malting quality trait

Traits	Promising entries
Bold Grains (%)	DWRB 160, PL 907, DWRB 199, BH 1025, DWRB 196
Thousand grain weight	DWRB 160, DWRB 196, BH 1025, PL 907, DWRB 199, DWRB 198
Husk Content	RD 3008
Grain Beta glucan	DWRB 182, KB 1743, KB 1707
Malt Friability	DWRB 182, DWRB 184, RD 3008, BH 1025
Hot water extract	RD 3010, DWRB 184
Filtration Rate	PL 907, RD 3009, DWRB 199, RD 3008, RD 3007, DWRB 196
Diastatic Power	DWRB 198, KB 1743, RD 3008, DWRB 199
Kolbach Index	PL 908, DWRB 196, DWRB 197, RD 3008, BH 1025
FAN Content	RD 3009, DWRB 197, RD 3008, RD 3010, RD 3007
Wort beta glucan	DWRB 182, PL 908, KB1743, DWRB197, RD 3008, BH 1025, RD 3009
Over all MQ	DWRB 182, DWRB 160, BH 1025, RD 3008

Superior or at par to best check

Table 6.16: Marker assisted backcross program for quality traits and aphid tolerance

Trait		Recurrent parent	Donor parent	Generation harvested in 2018-19
Quality	β-Glucan Content	DWRB 101	SLOOP VICB 9953	BC_2F_4
		DWRB 101	SLOOP SAWL 3167	BC_2F_2
	Protein			
Content	DWRB 101	BK 306	BC_2F_3	
		DWRB 101	BK 1127	BC_2F_2
Biotic stress	Aphid tolerance	DWRB 101	EB 921	BC_2F_3

Marker assisted introgression of quality traits and aphid tolerance

New crosses were attempted, backcross made and generations advanced in crop season 2018-19 for marker assisted backcross program for quality traits (protein content and β-glucan) and biotic stress (corn leaf aphid resistance).

Identification of promising introgressed lines for β-Glucan content in backcross population of cross DWRB 101/SLOOP VICB 9953

Backcross population of cross DWRB 101/SLOOP VICB 9953 developed to introgress low β–glucan content in elite cultivar were analysed biochemically. A total of 257 BC_2F_2lineswereevaluated for grain β-glucan content using EBC enzymatic method. These lines were screened with STS marker BRZ located in close vicinity of QTL-HvCSFl6-7H controlling beta glucan content in contrasting parental lines DWRB101 and Sloop VICB 9953. Total three BC_2F_2 lines amplified diagnostic band for low β-glucan content as shown in figure total three lines as shown in table below gave desirable levels of β-glucan content and found carrying introgressed QTL.

Similarly, backcross population has been developed to introgress high protein content in elite cultivar DWRB101 for food purpose. Grain protein content of BC_2F_2lines of this population have been evaluated using NIR prediction. Total five lines has given desirable content of grain protein.

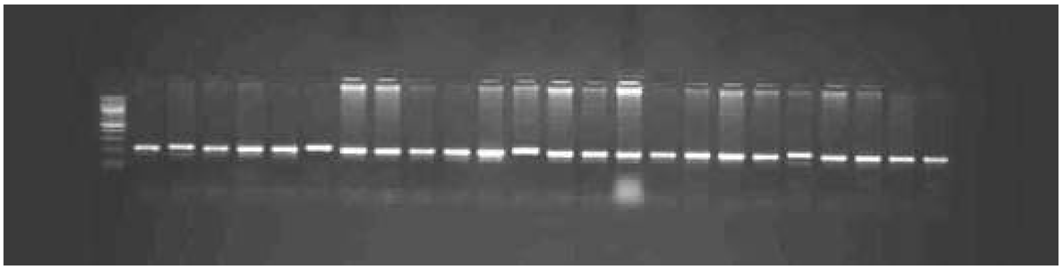


Fig 6.5: Molecular screening of BC_2F_2 lines with STS marker BRZ for β glucan content

Table 6.17: BC_2F_2 line with marker assisted backcross program for low glucan content

BC_2F_2line	β-glucan	1000 grain wt.
DWRB 101 /SLOOP VICB 9953-56	3.72	46.68
DWRB 101 /SLOOP VICB 9953-167	4.00	52.78
DWRB 101 /SLOOP VICB 9953-261	3.95	37.14

Table 6.18: BC_2F_2 line with marker assisted backcross program for higher protein content

BC_2F_2line	TGW	Protein %
DWRB 101/BK 306-26	43.96	13.8
DWRB 101/BK 306-79	43.9	13.8
DWRB 101/BK 306-134	53.66	12.8
DWRB 101/BK 306-207	49.76	13.1
DWRB 101/BK 306-212	50.42	13.3

Aphid resistance screening and selection of promising lines

Backcross population (BC_2F_2) developed from cross DWRB101/EB921 to introgress corn leaf aphid resistance in elite cultivar DWRB101 have been screened under epiphytotic conditions in Rabi season in net house at ICAR-IIWBR experimental field. Total eleven lines have shown moderate to resistant insect infestation tolerance as shown in Table 6.19.

The resistant genotypes identified in crop season 2018-19 were again screened and

Table 6.19: DWRB 101/EB 921 derived BC_2F_2 lines resistant to CLA

Line #	Resistance score (2018-19)	Line #	Resistance score (2018-19)
DWRB 101/EB921-49	R	DWRB101/EB 921-178	MR-R
DWRB 101/EB921-61	R	DWRB101/EB 921-201	R
DWRB 101/EB921-62	MR-R	DWRB101/EB 921-227	R
DWRB 101/EB921-63	R	DWRB101/EB 921-228	MR
DWRB 101/EB921-64	R	DWRB101/EB 921-230	MR
DWRB 101/EB921-72	MR-R		

confirmed for their tolerance against corn leaf aphid under epiphytotic conditions in net house and under natural condition in open experimental field in two replications. Total seven genotypes have been consistently found highly resistant in three consecutive seasons during 2016-19 as shown Fig. 6.6.

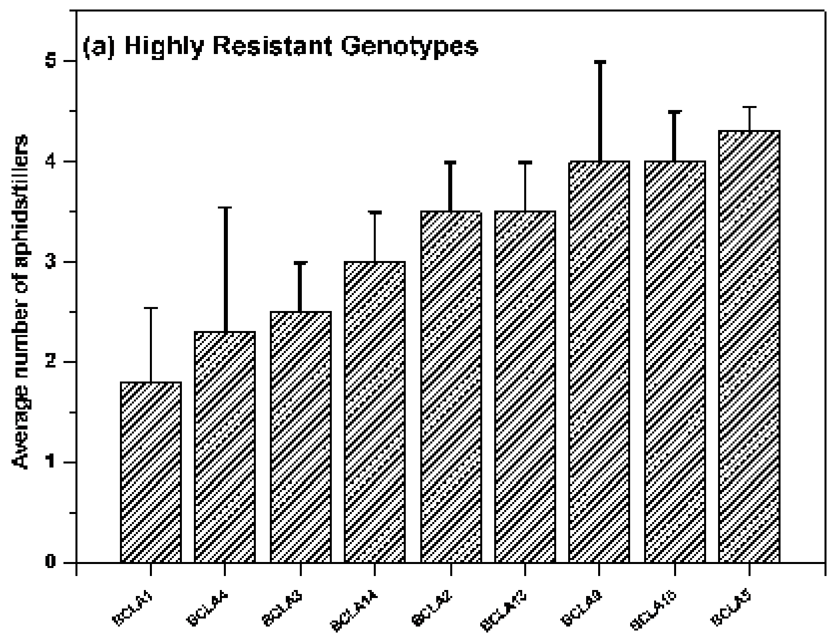


Fig 6.6: Resistant genotypes to aphids

07 REGIONAL STATION, FLOWERDALE, SHIMLA

Rust incidence and pathotype distribution of *Puccinia* species on wheat and barley

There was no report of any wheat rust epidemic in India. Practically it was another rust free wheat year. A diverse band of wheat varieties are grown in Northern India and yellow (stripe) rust was recorded in very low frequency in few pockets only. Surprisingly yellow rust was observed on Lok1 and Sujata at Eagle Seed Farm, Brahman Pipliya in Indore district of Madhya Pradesh. Brown rust appearance was observed sporadically in some areas in the states of Maharashtra, Gujarat and Karnataka. There was no report of black rust of wheat and barley in farmer's field in any of the states/area of the country. Practically rusts remained obscure on wheat crop during the year. A total of 627 samples of three rusts of wheat, yellow and black rusts of barley were analyzed from thirteen Indian states and Nepal during the year.

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

During this crop year, 201 samples of yellow rust of wheat and barley were pathotyped from eight Indian states and Nepal. Unusually yellow rust was observed on Lok1, Sujata and some wheat material of Eagle Seed Farm at Indore in Madhya Pradesh. There had been no occurrence of wheat yellow rust from Madhya Pradesh earlier. Cultivated wheat varieties and favourable environment indirectly influence the occurrence and distribution of pathotypes of rust pathogen in a geographical area. The spectrum of pathotypes has now narrowed down over the years. Six pathotypes (46S119, 110S119, 238S119, 110S84, P and T) of wheat stripe rust pathogen were identified during 2018-19. These were avirulent on *Yr5*, *Yr10*, *Yr15*, and *YrSp*. The frequency of pathotype 46S119 (virulent to *Yr2*, *Yr3*, *Yr4*, *Yr6*, *Yr7*, *Yr8*, *Yr9*, *Yr17*, *Yr18*, *Yr19*, *Yr21*, *Yr22*, *Yr23*, *Yr25*, *YrA*) was maximum (48.4%). Pathotype 110S119, identified in 2013-14, was detected in 35.3% samples. Most virulent pathotype 238S119 has also increased to 12.3% samples from 4% during last year. Remaining 3 pathotypes were observed in 4.1% samples only. Presence of barley yellow rust was negligible during this year. The barley yellow rust pathotypes 57 (0S0) and M (1S0) were observed in five and one samples, respectively.

Black rust of wheat (*Puccinia graminis* f. sp. *tritici*)

Eight pathotypes of black rust pathogen of wheat and barley were identified from 134 samples, received/collected from five Indian states and Nepal. Population analyzed during the year has avirulence to *Sr*26, *27, 31, 32, 35, 39, 40, 43, Tt3 and Tmp*. Maximum number of samples was from Karnataka followed by Tamil Nadu. Pathotype 11 (79G31), 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, SrMcN* was recorded in 50% of the samples, which was followed by 15-1 (22.3 %) and 40A (15.6 %). Other pathotypes were observed in few samples only. Diversity of black rust pathotypes was more in Karnataka. Pathotypes 40A and 11 were detected in nine barley samples, received from Tamil Nadu and Karnataka.

Table 7.1: Predominant pathotypes of *Puccinia* on wheat in India

Wheat rust pathogen	Predominant pathotypes
P. graminis tritici (black rust)	79G31(11), 123R15 (15-1) and 62G29(40A)
P. triticina (Brown rust)	121R60-1(77-9), 121R60-1,7 (77-13) and 121R63-1(77-5)
P. striiformis (Yellow rust)	46S119 and 110S119

Table 7.2: Rust resistance in advanced wheat material (AVT 2018-19)

Rusts	No. of lines	Wheat lines
Brown , Black and Yellow	4	PBW 821, PBW 822, PBW 823, PBW 757*
Brown & Black	4	CG 1029, HD 2864, K 8027*, MACS 6222
Brown	14	DDW 47, DDW 48, DDK1057, HD 3090, HI1633, HI1634, HS 562*, MACS 3949, PBW 550, PBW 797, PBW 820, PBW 824, UAS 446, UAS 466*
Black	12	DBW 110, DBW 303, HD 3226, HD 3237, HD 3277, HD 3298*, HI1628, NW 7049, RAJ 4529, PBW 825, WH 1105, WH 1223*
Yellow	3	NIDW 1158, PBW 752, PBW 781

**Lines showed variable reactions in different years.*

Brown rust of wheat (*Puccinia triticina*)

Twenty-three pathotypes of *P. triticina* causing brown rust of wheat were identified in 292 samples analyzed from 11 states of India, and Nepal. Indian population of *P. triticina* showed resistant infection types on *Lr24, Lr25, Lr29, Lr32, Lr39 Lr45* and *Lr47*. Among 12, 77, 104 and 162 groups of pathotype, 77 was the most predominant and was ascribed to 88.7% samples, whereas, remaining groups were attributed to 11.3% samples. Pathotype 77-9 (121R60-1) virulent on *Lr1, Lr3, Lr10, Lr11, Lr12, Lr13, Lr14a, Lr14b, Lr14ab, Lr15, Lr16, Lr17a, Lr17b, Lr18, Lr20, Lr21, Lr22a, Lr22b, Lr23, Lr26, Lr27+31, Lr30, Lr33, Lr34, Lr35, Lr36, Lr37, Lr38, Lr40, Lr44, Lr46, Lr48, Lr49, Lr67* was most frequent and identified in 149 rust samples (51.1%). It was followed by pathotypes 77-13 (121R60-1,7) in 20.2% and 77-5 (121R63-1) in 15.1% of the wheat brown rust samples. The diversity of *P. triticina* was comparatively higher in Haryana, Karnataka and Himachal Pradesh. Pathotype 77-9 was most frequent in all the states except for Himachal Pradesh and Punjab.

Rust resistance in wheat material

Rust resistance

A total of 3053 lines of wheat and barley were evaluated against the pathotypes of three rust pathogens. To identify rust resistant lines and characterize rust resistance genes in wheat, 158 advanced accessions (AVTI&II) were evaluated at seedling stage using an array of pathotypes of *Puccinia graminis* f. sp. *tritici* (black rust), *P. triticina* (brown rust) and *P. striiformis* f. sp. *tritici* (yellow rust) possessing different avirulence/virulence structures. Four lines, PBW 821, PBW 822, PBW 823, and PBW 757 were resistant to all the rusts. Rust resistance to all the pathotypes of black, brown and yellow rust pathogens was observed in four entries (PBW 821, PBW 822, PBW 823 and PBW 757) of advanced wheat material. Four lines namely CG 1029, HD 2864, K 8027 and MACS 6222 were found resistant to brown and black rusts. Entries NIDW 1158, PBW 752 and PBW 781 were resistant to yellow rust only. Twelve lines (DBW110, DBW303, HD 3226, HD 3237, HD 3277, HD 3298, HI 1628, NW 7049, RAJ 4529, PBW 825, WH 1105 and WH 1223) showed resistance to all the pathotypes of black rust pathogen only. Fourteen accessions (DDW 47, DDW 48, DDK 1057, HD 3090, HI 1633, HI 1634, HS562, MACS 3949, PBW 550, PBW 797, PBW 820, PBW 824, UAS 446 and UAS 466) were resistant to all pathotypes of brown rust pathogen only, whereas, five entries which possessed *Lr24*, were also resistant to brown rust. All the lines carrying *Sr31*, were resistant to black rust.

Rust resistance genes in AVT lines

Wheat rust resistance genes (*Lr, Sr, Yr*) were characterized in 158 AVT lines by using gene matching technique. Rust resistance genes were characterized only in the 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 clear host-pathogen differential reactions.

Table 7.3: Diversity for rust resistance in AVT lines

Rust	No. of lines	Number of genes inferred: Details of resistance genes
Yellow	91	Four: *Yr2, Yr9, YrA, Yr18*
Brown	119	Eleven: *Lr1, Lr2a, Lr3, Lr10, Lr13, Lr18, Lr19, Lr23, Lr24, Lr26* and *Lr34*
Black	1117	Fourteen : *Sr2, Sr5, Sr7b, Sr8a, Sr8b, Sr9b, Sr9e, Sr11, Sr13, Sr24, Sr25, Sr28, Sr30* and *Sr31*

Yr genes

In advanced wheat material, 4 *Yr*-genes (*Yr9*, *Yr2*, *Yr18* and *YrA*) were characterized in 91 entries. Among these, *Yr2* was characterized in 57 lines. *Yr9*, alone or in combination, was postulated in 25 lines. *YrA* was characterized in 09 lines. Gene combinations *Yr9+A+* and *Yr9+18+* were inferred in 03 and 01 lines, respectively.

Lr genes

Eleven *Lr*-genes (*Lr1*, *Lr2a*, *Lr3*, *Lr10*, *Lr13*, *Lr18*, *Lr19*, *Lr23*, *Lr24*, *Lr26* and *Lr34*) were characterized in 119 lines. These *Lr* genes were postulated alone or in combinations. *Lr13* and *Lr23* were the most commonly characterized resistance genes in advanced wheat material. Both were characterized either alone or in combination in 47 lines (39.5 %) each, followed by *Lr10* in 34 lines. Resistance gene *Lr26* (linked with *Sr31* and *Yr9*) was postulated in 25 entries. *Lr13* is known to confer high temperature resistance. Therefore, in most wheat growing areas in India, lines possessing *Lr13* will show less terminal disease severity as the temperature rises towards the maturity. Brown rust effective resistance gene *Lr24* (linked with *Sr24*), was inferred in GW 509, HD 2888, HI 1544, MP 3288 and MP 4010. Another effective resistance gene *Lr19* was characterized in WH 1254 only. Brown rust resistance genes *Lr3, Lr2a, Lr18* and *Lr34* were characterized only in four, two, two and one wheat entries, respectively.

Sr genes

Fourteen *Sr* genes (*Sr2*, *Sr5*, *Sr7b*, *Sr8a*, *Sr8b*, *Sr9b*, *Sr9e*, *Sr11*, *Sr13*, *Sr24*, *Sr25*, *Sr28, Sr30* and *Sr31*) were characterized in 125 lines. Genes were postulated alone or in combinations. *Sr2*, whose postulation is based on characteristic micro-flecking, was postulated in 81 lines (64.5 %) followed by *Sr11* in 34 lines. *Sr31* is linked with *Lr26* and *Yr9* was postulated in 25 lines. Entries DBW 252 and KRL 19 possessed a combination of four genes.

Race specific adult plant resistance (APR) in AVT material

To identify race specific adult plant rust resistance in wheat material, 158 lines of AVT were evaluated for identifying adult plant resistance. Four pathotypes, two each of yellow and brown rust pathogens, were used in the study. Optimum conditions for infection of rust and growth of wheat material were provided. Entry VL 3021 showed APR to both the pathotypes of yellow and brown rust pathogens.

Sixteen entries (AKDW 2997-16 (d) (C), DBW 257, DBW 273, DDW 47 (d), HD 3249 (C), HI 1621, HI 8627 (d)(C), HI 8805 (d), HPW 349 (C), HS 673, UAS 428 (d) (C), UAS 446 (d)(C), UP 3041, VL 3021, WH 1080 (C), WH 1270) of advanced wheat material were observed to carry APR to both the pathotypes of yellow rust pathogen. Fourteen entries possessed APR to pathotype 46S119 and fifteen to 110S119. Eight entries of AVT (DBW 39, DBW 110, HD 2733, HI 1612, GW 1346, HPW 467, K 1317, VL 3021) were resistant to both pathotypes (77-9 and 104-2) of brown rust pathogen at adult plant stage. Twenty entries of AVT showed APR to pathotype 77-9 and nine to pathotype 104-2.

Molecular basis of wheat-leaf rust interaction

The available transcriptome, genome sequence and EST data of *Puccinia triticina* was collected and computation prediction of non-coding RNAs, candidate effectors in the fungal genome of *P. triticina* was done using online databases PHI and NCBI Blast. qRT-PCR primers were designed and synthesized for all the predicted candidate

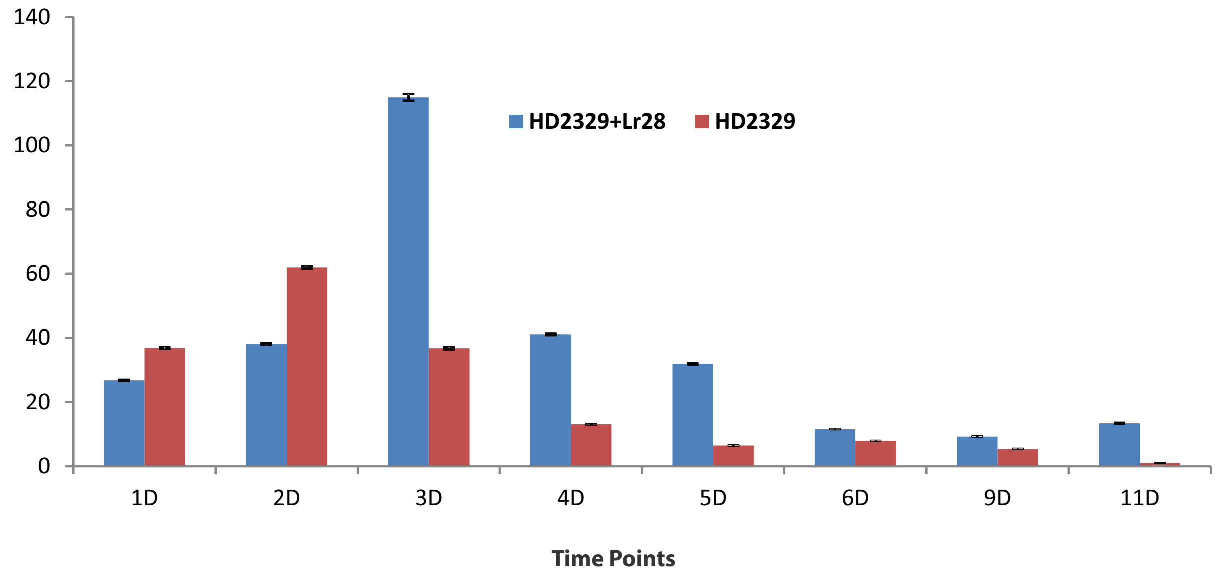


Fig. 7.1- The relative expression profile of candidate effector (Seq. Id. c1226_g1_i1) at different stages after Pt inoculation in compatible and incompatible interaction

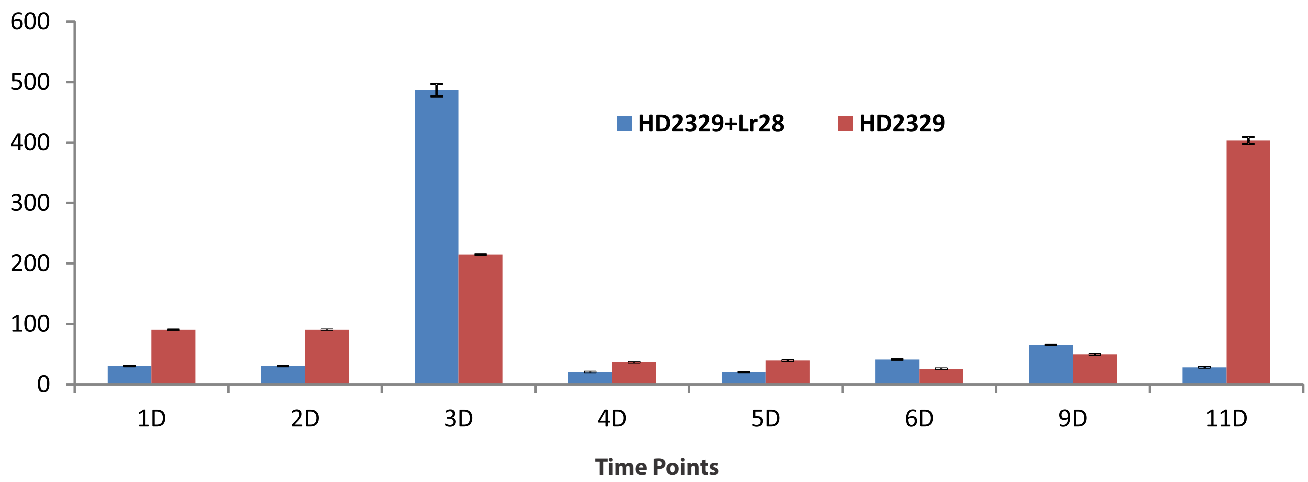


Fig. 7.2: The relative expression profile of candidate effector (Seq. Id. c45137_g1_i1) at different stages after Pt inoculation in compatible and incompatible interaction

effectors/sequences and some non-coding RNAs of pathogen. Inoculation of HD 2329 and HD 2329+*Lr28* with 77-5 and sample collection (at 9 time points post inoculation *i.e.* 0, 1, 2, 3, 5, 7, 9, 11 and 15 days post inoculation) was done for resistant (HD 232 +*Lr28*) and susceptible (HD 2329) wheat varieties. RNA extraction, cDNA synthesis from all the samples for each time points was done using the standard protocols. The qRT-PCR experiments for validation of Pt candidate effectors and non-coding RNAs in compatible and incompatible (*Lr28*) wheat leaf rust interaction was done. Some of the results are summarized below:

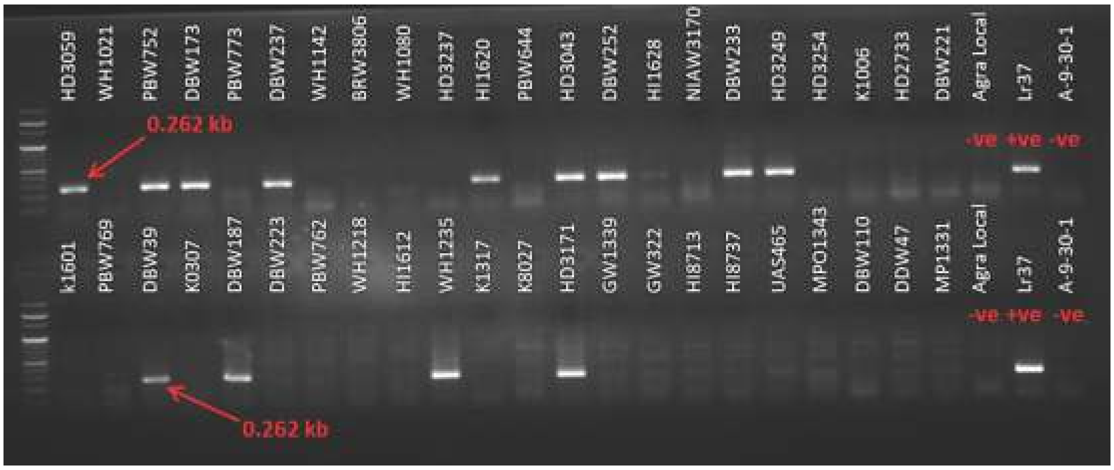


Fig. 7.3: Presence of leaf rust resistance gene Lr37 in AVT lines 2017-18

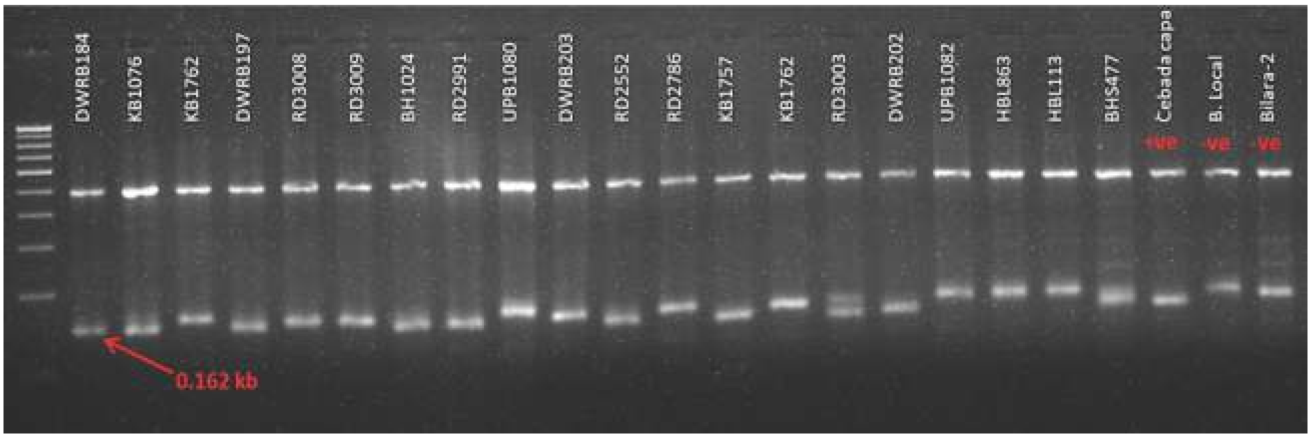


Fig. 7.4: Presence of barley leaf rust resistance gene Rph7 in NBDSN lines 2018-19

Expression of Seq. Ids. c1226_g1_i1 and c45137_g1_i1

The PHI blast results confirmed the close similarity of seq. Id. c1226_g1_i1 with candidate effector in *Magnaporthe grisea* that was contributing to loss of pathogenicity in rice blast. Our results also confirmed the role of this candidate effector in loss of pathogenicity as its expression was maximum in incompatible interaction at all the time points except at 24 and 48 hours after Pt inoculation (Fig. 7.1). Similarly the Seq. ID: c45137_g1_i1 had similarity to stress-induced-phosphoprotein 1 of *Phytophthora infestans* that contributes in increased virulence in potato late blight. In our experiment its expression was high in compatible interaction as compared to incompatible interaction at one, two, five and eleven days after Pt inoculation. Its highest relative expression was observed after three days of inoculation in incompatible interaction followed by eleven days after inoculation in compatible interaction (Fig. 7.2).

Screening of wheat and barley lines using resistance gene specific markers

Lr34/Sr57/Yr18 was confirmed in five AVT entries (UP 3016, HI 1625, PBW 770, PBW 757, HI 1624) out of twenty lines screened. Among the 44 lines, marker linked to *Lr37/Sr38/Yr17* was confirmed in thirteen AVT lines (HD 3059, PBW 752, BW 173, DBW 237, HI 1620, HD 3043, DBW 252, DBW 233, HD 3249, DBW 39, DBW 187, WH 1235 and HD 3171). *Lr67/Sr55/Yr46* was present only in K 8027 out of 42 AVT lines of 2017-18.

Rph7 confers resistance to the Indian population of barley leaf rust. To ascertain the presence of Rph_7 in barley lines, all the 20 leaf rust resistant lines were screened with gene specific marker. Presence of Rph_7 was confirmed in thirteen NBDSN 2018-19 lines (DWRB 184, KB 1762, DWRB 197, RD 3008, RD 3009, BH 1024, RD 2991, DWRB 203, RD 2552, KB 1757, RD 3003, DWRB 202, BHS 477).

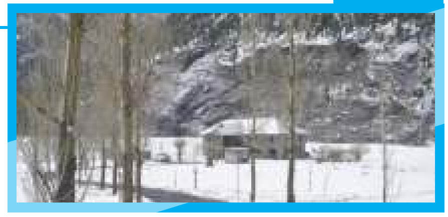
Maintenance and supply of nucleus inoculum of rust pathogens

National repository of more than 145 pathotypes of different rust pathogens of wheat, barley, oat and linseed was maintained in live culture as well as cryo-preserved. For the smooth conduct of wheat and barley rust research, nucleus/bulk inocula of different pathotypes of wheat and barley rust pathogens was supplied to more than 45 scientists/centers engaged on wheat rust research elsewhere in India.

Disease incidence in WDMN/SAARC wheat disease monitoring nursery

51st wheat disease monitoring nursery was conducted at more than 41 locations covering all the major wheat growing areas in the country, especially those situated near the bordering areas to the neighboring countries. The occurrence of wheat blast and *Sr31* virulences (Ug99 type of pathotypes) of black rust were not reported from any of the locations where WDMN was planted. Yellow rust was observed on few entries at some locations of Northern hills zone (NHZ) and North Western Plain Zone (NWPZ) except Shimla, Abohar and Ropar. It was also observed at Kanpur in North Eastern Plain Zone (NEPZ). Brown rust was reported from nine locations of NHZ and NWPZ. Black rust was observed at Powerkheda only in Central Zone (CZ), Dharwad in Peninsular Zone (PZ) and Wellington in Southern Hill Zone (SHZ). SAARC wheat disease monitoring nursery was conducted, by the station in collaboration with CIMMYT, Delhi, at 29 locations across the six SAARC countries, with the objectives similar to the wheat disease monitoring nursery (WDMN) in India. Information on wheat diseases in SAARC Wheat Disease Monitoring Nursery has been received from all the locations in India. Yellow rust was observed at all the SAARC nursery locations in India except at Abohar, Deenanagar, Faizabad and Wellington. Brown rust was observed at all the SAARC nursery locations except at Dhaulakuan, Ludhiana, Ropar, Abohar and Deenanagar. Black rust was observed only at Wellington.

08 REGIONAL STATION, DALANG MAIDAN



The ICAR - IIWBR Regional Station located at Dalang Maidan, Lahaul & Spiti, Himachal Pradesh act as a national off-season crop facility for wheat and barley researchers of the country. The station is located at Manali Leh Highway 14 KM towards East from District Headquarters Keylong. It is situated at 32030' N and 76059' E at an altitude of 3045 m (9990 feet) above mean sea level.

Generation advancement of wheat and barley

In the summer nursery (2019) more than 28000 breeding lines received from 42 researchers/teams have been planted at Dalang Maidan. These breeding lines of wheat and barley from different research institutes and state agricultural universities were advanced for speeding the breeding and genetics work. The facility was utilized by breeders, geneticists and plant pathologists from all five zones of the country. The maximum material was obtained from NWPZ followed by NHZ, CZ, NEPZ and PZ. Apart from ICAR-IIWBR Karnal, ICAR-IARI New Delhi, CCS HAU Hisar, NABI Mohali and VPKAS, Almora were major co-operators for utilizing the off season facility. The sowing of all the seed materials was done during 24-26 May, 2019, harvested in the month of October, 2019 and supplied to the respective researchers well in time. There was unexpected snowfall in the Lahaul valley in mid-August and at the time of harvesting in October which delayed the harvesting.

Corrective hybridization: The summer nursery (2019) was utilised by researchers from different research institutes for corrective crossing. More than 300 corrective crosses, back crosses/three way crosses were made by scientists and supporting staff members from different institutes such as ICAR- IIWBR Karnal, ICAR - IARI New Delhi, ICAR-VPKAS Almora, SKUAST-J Jammu, CSKHPKVV Palampur, NABI Mohali, CCS Meerut and NDUAT Faizabad and many others during second fortnight of July.

Disease screening and monitoring: The season was favourable for the screening for yellow rust and powdery mildew. More than 15,000 lines were screened by various centres and selections were made. The yellow rust incidence was first observed during first week of August and the disease severity was highest during mid-September, 2019. Powdery mildew disease also appeared during the last week of September. Wheat disease monitoring nursery (WDMN) was planted at this station and the samples of yellow rust were collected for pathotype analysis at Regional Station Flowerdale, Shimla.

Seed multiplication of important cultivars/ varieties: The seed multiplication of the wheat variety DDW47 was carried out and about three quintal seed was produced. For grow-out test 19 lines received from ICAR-VPKAS, Almora has also been planted in the summer nursery, 2019. Pure seed of C 306, Sonalika, WL 711, HD 2009, HD 2329 and PBW 343 was produced for use in Era trial of NWPZ 2019-20.

Natural repository for wheat and barley germplasm: The off-season nursery acts as natural repository for wheat and barley germplasm and at present about 9000 wheat accessions and about 2000 barley accessions are being conserved and maintained under natural cool temperature conditions in the station building. This low cost germplasm maintenance facility will be further strengthened by provision of separate germplasm storage room at the station.

New facility created: The EFC approved work for the Germplasm storage room at Regional Station was completed during the season. The irrigation pipeline work at the station is near completion.

Training to farmers of Lahaul-Spiti district: A batch of 45 farmers from thirteen villages of Lahaul Spiti were given training at IIWBR, Karnal on the theme "Increasing farm income of Lahaul-Spiti farmers through improved wheat & vegetable production technologies". The three days training was part of Tribal Sub-Plan (TSP) and was conducted from December 19-21, 2019.

09 SEED AND RESEARCH FARM, HISAR

The Seed and Research Farm, Hisar under the aegis of ICAR-Indian Institute of Wheat and Barley Research, covers total 200 acres of land, out of which approximately, 185 acres land have been utilized under crop cultivation and remaining 15 acres are under layout, official buildings, ponds, irrigation channel, roads etc. During 2018-19, wheat was sown in approximately 51.0 acres of land and produced the wheat breeder seed 761.5 quintals . However, barley breeder seed was sown on area of 7.0 acres land and produced 92.7 quintals. Average yield of wheat and barley breeder seeds was recorded 14.93 q ha$_{-1}$ and 13.24 q ha$_{-1}$, respectively. The wheat and barley mixtures produced from experimental materials were recorded as 10.7 and 36.2 q, respectively, which was sold to the staff of CIRB and IIWBR, Hisar. The wheat and barley straw produced from the crops 382.0q which was handed over to the CIRB as per the MOU.

The green manuring is very useful for improvement of saline soil. Hence, dhaincha crop was grown in whole cultivable area at the farm during Kharif season, 2018-19, so that salinity can be reclamed through green manure and soil fertility may be maintained for succeeding crop. The crop was ploughed into the soil after 50-55 days of sowing when crop was at green stage and initiated the flowering.

Table 9.1: *Rabi* crops area, production and revenue generated from IIWBR Hisar Farm (2018-19)

S N	Item	Production (quintals)	Revenue generated (Rs.)
1	Seed crops of wheat	761.5	Transferred to ICAR-IIWBR, Karnal for processing and packaging.
2.	Barley seed	92.7	Transferred to ICAR-IIWBR, Karnal for processing and packaging.
3	Wheat and barley mixture	46.9	Sold to ICAR-IIWBR and ICAR-CIRB staff for Rs 69,940.00
4.	Wheat and barley straw produced	382.0	Handed over to CIRB as per MOU

MGMG farmers visit at seed and research farm, Hisar

Ten farmers from MGMG village Nagthala, Hisar visited at Seed and Research Farm, Hisar during crop season. After observing the crops of wheat and barley at the farm, they were very happy to see the seed plots of wheat and barley crops.

Plantation at seed and research farm, Hisar

To make the farm green and beautiful, plantation of different tree species was done on periphery of the Hisar farm. This programme was supported by local NGOs working in Hisar area.

Inauguration of office building at Seed and Research Farm, Hisar

- On 12 september, 2019,office building and Farm store was inaugurated by Honourable Director in the presence of the Director, National Research Centre for Equine and Scientific, administrative and technical staff of the Indian Institute of Wheat and Barley Research, Karnal and Hisar Farm.

10 INSTITUTE ACTIVITIES/CELEBRATIONS

ICAR-IIWBR Karnal celebrated its Foundation Day on 9^{th} Feb, 2019 with full joy and happiness. Dr. KV Prabhu (Chairperson, PPV &FR, New Delhi) was chief of the function.

Wheat and Barley Field Day organized at ICAR-IIWBR, Karnal on 29^{th} March, 2019.

Institute Management committee Meeting was organized on 27^{th} April, 2019 at ICAR-IIWBR, Karnal

The International Yoga Day was celebrated on 21^{st} June, 2019 with full enthusiasm at ICAR-IIWBR, Karnal. A large number of staff members participated in the programme.

Field day under Wheat and Barley FLDs programme was organized by ICAR-IIWBR, Karnal in Village Amin district Kurukshetra on 6^{th} April, 2019.

XXVI and XXVII, IMC meeting was held on 27^{th} April, and 16^{th} September 2019, respectively at ICAR-IIWBR, Karnal.

IRC (Institute Research Council) meeting was organized during 4^{th} July, 2019.

58^{th} All India Wheat and Barley Workers Meet was organized during 24-26 August, 2019 in collabora-

tion with ICAR-IARI Regional Station, Indore. Secretary, DARE and DG, ICAR graced the occasion.

Farmer-Scientist Workshop and Seed day was organized on 5th October, 2019 at IIWBR, Karnal in collaboration with NABARD. More than 9000 farmers participated in this event

RAC meeting was organized on 10-11 October, 2019 at IIWBR under the Chairmanship of Dr. H.S. Gupta former DG, BISA and Ex. Director IARI, New Delhi.

Agriculture education day was organized on 3 December, 2019 at IIWBR, Karnal.

World Soil Health Day was organized on 5th December, 2019 at village Mehmoodpur, Karnal.

Social and Cultural Activities

Under Swachchh Bharat Abhiyan, Swachachhata Hi

Sewa was organized during 11th September to 2nd October, 2019 at the Institute.

During this periods, staff members of this institute activity participated in cleanness and plantation programme for the sake of better environment. A street play on "Plastic Jee Ka Janjal" was organised to create awareness among the urban mass about the ill effects of plastic on 28th Sept. 2020 at Atal Park, Karnal

Celebrations

Organised Gandhi Jayanti Utsava during 27th September to 2nd October 2019 at the institute to celebrate 150th birth anniversary of Mahatma Gandhi.

70th Republic day was celebrated was celebrated on 26th Jan 2019, with full enthusiasm and joy. On this occasion Dr. GP Singh, Director appealed the staff to deliver their best in the nation development.

73rd Independence Day was celebrated on 15th August, 2019

Rajbhasa Utsava and Hindi Pakhwada was celebrated during 16-30 September 2019. Hindi Diwas was celebrated on 16th September, 2019.

Seed Storage Unit was inaugurated by Honourable Director Dr GP Singh on 22nd August, 2019

Covered Threshing Unit of Hisar Farm was inaugurated by Honourable Director Dr GP Singh on 12th September, 2019.

Vigilance Awareness Week was organized from 28th October to 2nd November 2019. Sh. Kanhaiya Chaudhary delivered invited talk on vigilance awareness.

Celebrated 70th Constitution day on 26th November 2019 at the institute. Also started year long compaign on 'Citizens Duties" to be celebrated up to 26th November, 2020.

11 EXTENSION ACTIVITIES

Table 11.1: Training programmes organised/conducted at ICAR – IIWBR, Karnal

S.No.	Date	Duration (Days)	No. of Trainees	Subject	Organised by
1.	09 Jan., 2019	1	46 Farmers	Sri Ganganagar men Gehoon aur jau ki adhunik kheti	ICAR-IIWBR, Karnal
2.	14 Jan., 2019	1	60 Farmers	"Samsamayik sasya kriyaon dwara gehoon utpadan se labharjan	ICAR-IIWBR, Karnal in association with Omkar Sewa Sansthan, Amithi
3.	11-12 March, 2019	2	24 Farmers	Uttarakhand men Gehoon ki Adhunik Kheti	ICAR-IIWBR, Karnal with State Department of Agriculture, Tihari, Uttarakhand
4.	21-22 Nov., 2019	2	24 Farmers	Gehoon ki Unnat Kheti evam Phasal Vividhikaran Dwara Adhik Amadani	ICAR-IIWBR, Karnal with State Department of Agriculture, Uttarakhand

Table 11.2: Kisan mela/farmers day/field day

S.No.	Date	Subject	Organised by
1.	9th Feb. 2019	Foundation Day of ICAR-IIWBR, Karnal	ICAR-IIWBR, Karnal
2.	8th March, 2019	Live telecast programme on International Women Day by Honourable Prime Minister Sh. Narendra Modi Ji	ICAR-IIWBR, Karnal
3.	24th March, 2019	Live telecast of Pradhan Mantri Kisan Samman Nidhi Yojana by Honourable Prime Minister Sh. Narendra Modi Ji	ICAR-IIWBR, Karnal
4.	4th April, 2019	Field Day at FLD Site in Bid Amin village, Kurukshetra, Haryana	ICAR-IIWBR, Karnal
5.	5th October, 2019	Farmer-Scientist Workshop and Seed Day	ICAR-IIWBR, Karnal
6.	3rd December, 2019	Agricultural Education Day at ICAR-IIWBR, Karnal, Haryana	ICAR-IIWBR, Karnal
7.	5th December, 2019	World Soil Day at Nabipur Village, District Karnal, Haryana	ICAR-IIWBR, Karnal
8.	28th December, 2019	Sanitation Awareness Campaign at Nabipur Village, District Karnal, Haryana	ICAR-IIWBR, Karnal

Table 11.3: Organization/participation in exhibition

S.N.	Programme	Date	Duration (days)	Organized by
1.	106th Indian Science Congress	03-07 Jan., 2019	5	Lovely Professional University, Phagwara, Punjab
2.	'Golden Jubilee International Salinity Conference (GJISC-2019)	07-09 Feb., 2019	3	ICAR-CSSRI, Karnal
3.	Exhibition during XIV Agriculture Sciences Congress	20-23 February, 2019	4	National Academy of Agricultural Sciences, New Delhi
4.	Purvanchal Kisan Mela - 2019	02-03 March, 2019	2	Mahayogi Gorakhnath Krishi Vigyan Kendra, Chaukmafi (Peppeganj) Jangal Kaudia, Gorakhpur 373165 (UP)
5.	Pusa Krishi Vigyan Mela-2019	05-07 March, 2019	3	ICAR-Indian Agricultural Research Institute, New Delhi
6.	Kisan Mela-2019	14 March, 2019	1	Young Farmers Association, Rakhra, Patiala

7.	58th All India wheat & barley research workers' meet	24-26 August, 2019	3	RS, ICAR-IARI, Indore, Madhya Pradesh
8.	Rabi Kisan Mela 2019	13 September, 2019.	1	ICAR- CSSRI, Karnal at Netaji Subhash Stadium, Palwal, Haryana
9.	Kisan Mela - 2019	17 Sept., 2019	1	Young Farmers Association, Rakhra, Patiala, Punjab
10.	Ganna aur Makka Kisan Mela	14 Nov., 2019	1	CCS-HAU, RRS, Uchani, Karnal, Haryana

Table 11.4: Coordination of visits at ICAR-IIWBR, Karnal during 2019

S.No	Date	Number of Visitors	From
1	January 03, 2019	36 Women Farmers	Raypipla, Narmada, Gujarat
2	January 09, 2019	46 Farmers	Sriganganagar, Rajasthan
3	January 10, 2019	26 Farmers	Azamgarh, Uttar Pradesh
4	January 14, 2019	60 Farmers	Amethi, Sultanpur, Uttar Pradesh
5	January 15, 2019	26 Women Farmers	Gurugram Haryana
6	January 17, 2019	24 Farmers	Sriganganagar, Rajasthan
7	January 23, 2019	60 Students	Kutail, Karnal, Haryana
8	January 31, 2019	40 Farmers	Sriganganagar, Rajasthan
9	February 05, 2019	45 Farmers	Chhattisgarh
10	February 06, 2019	30 Farmers	Vidisha, Madhya Pradesh
11	February 11, 2019	32 Farmers	Ayodhya and Bareily, Uttar Pradesh
12	February 14, 2019	35 Farmers	Churu, Rajasthan
13	February 20, 2019	16 Students	Nashik, Maharashtra
14	February 23, 2019	28 Farmers	Jhunjhunu, Rajasthan
15	March 02, 2019	25 Farmers	Kullu, Himacha Pradesh
16	March 05, 2019	32 Farmers	Churu, Rajasthan
17	March 06, 2019	100 Farmers	Nilokheri, Karnal
18	March 11, 2019	50 Farmers	Hapur, Uttar Pradesh
19	March 16, 2019	20 Farmer s	Jhunjhunu, Rajasthan
20	March 26, 2019	50 Students	Meerut, Uttar Pradesh
21	April 3, 2019	59 students	Bharatpur, Rajasthan
22	April 11, 2019	56 Farmers	Bharatpur, Rajasthan
23	April 13, 2019	152 Student	Ahmedabad
24	April 18, 2019	70 Farmers	Bharatpur, Rajasthan
25	April 20, 2019	86 Students	Rajpura, Punjab
26	April 26,2019	55 Student	Baru Shahab, H.P.
27	April 29, 2019	15 Students	Dehradun, Uttarahand
28	May 03, 2019	19 Students	Raipur, Chhattisgarh
29	June 11, 2019	46 Students	Jhansi, Uttar Pradesh
30	June 12, 2019	09 Students	Kyrdemkulai, Meghalaya
31	June 22, 2019	50 Students	Jodhpur, Rajasthan
32	July 01, 2019	55 Students	Kanpur, Uttar Pradesh
33	September 16, 2019	100 Students	Krishnagiri, Tamil Nadu
34	September 16, 2019	118 Students	Madurai, Tamil Nadu

35	September 18, 2019	65 Students	Karaikudi, Tamilnadu
36	September 18, 2019	106 Student	Killikulam, Vallanadu, Tamilnadu
37	September 21, 2019	34 Farmers	Nowshera, Rajouri, J&K
38	September 23, 2019	34 Students	Madurai, Tamilnadu
39	September 24, 2019	38 Students	Sempuli, Tamilnadu
40	September 27, 2019	36 Farmers	Bignor, Uttar Pradesh
41	September 30, 2019	25 Farmers	Madhya Pradesh
42	October 01, 2019	98 Students	Namakkal, Tamilnadu
43	October 11, 2019	30 Students	Gwalior, Madhya Pradesh
44	October 13, 2019	42 Farmers	Basti, Uttar Pradesh
45	October 16, 2019	115 Student	Gujrat
46	October 18, 2019	63 Students	Gujrat
47	October 19, 2019	50 Students	Gujrat
48	October 19, 2019	32 Farmers	Gujrat
49	October 22, 2019	55 Students	Kalasaliya Tamil Nadu
50	October 24, 2019	52 Students	Karnal
51	October 31, 2019	70 Farmers	J&K
52	November 11, 2019	32 Students	Jaipur, Rajasthan
53	November 12, 2019	42 Students	Kamuthi, Tamil Nadu
54	November 13, 2019	111 Students	Pollachi, Tamil Nadu
55	November 15, 2019	54 Students	Perambalur, Tamil Nadu
56	November 16, 2019	53 Students	Kaithal, Haryana
57	November 18, 2019	25 Fertilizer Dealers	Jind, Haryana
58	November 18, 2019	71 Students	Periyakulam, Tamil Nadu
59	November 22, 2019	66 Students	Pudukkottai, Tamil Nadu
60	November 23, 2019	45 Farmers	Chhattisgarh
61	November 25, 2019	50 Farmers	Chhattisgarh
62	November 26, 2019	85 Students	Kalavai, Tamil Nadu
63	November 26, 2019	42 Students	Trichi, Tamil Nadu
64	November 29, 2019	49 Farmers	Chhattisgarh
65	November 29, 2019	81 Students	GB Nagar, Vellore, Tamil Nadu
66	December 02, 2019	28 Farmers	Dakshin, Dinapur, West Bengal
67	December 03, 2019	40 Students	Karnal, Haryana
68	December 09, 2019	50 Student	Kaithal, Haryana
69	December 09, 2019	81 Student	Kaithal, Haryana
70	December 10, 2019	30 Fertilizers Dealers	HAU, Hisar, Haryana
71	December 17, 2019	45 Farmers	Chhattisgarh
72	December 23, 2019	50 Farmers	Chhattisgarh
73	December 17, 2019	115 Farmers	Coimbatore, Tamil Nadu
74	December 18, 2019	40 Farmers	Delhi
75	December 21, 2019	50 Farmers	Raipur, Chhattisgarh
76	December 22, 2019	42 Farmer	Raipur Chhattisgarh
77	December 23, 2019	28 Students	Dindigul, Tamil Nadu

Table 11.5: Lectures delivered

Date	Topic
08.03.2019	Sendhil R delivered a lecture on the "Role of ICAR-IIWBR in Wheat Production Technologies" during the Field Day organised by the IARI-RS Wellington at the FLD site.
04.09.2019	Sendhil R delivered an invited presentation on "Wheat Production Technologies and Food Security: The Nexus and Prospects" at the National Conference on Ascertaining Food Security through Livelihood Enriching Interventions: Challenges and Opportunities held at PAJANCOA & RI, Karaikal from 04-06 September, 2019
20.09.2019	Sendhil R delivered a lecture on "Price Risk Management in Agriculture Exploring Futures" during the Training Program on Innovative Marketing Practices for Enhancing Farmers Income in Salt Affected Regions held at ICAR-CSSRI
17.10.2019	Sendhil R delivered a lecture on "Technology Development in Wheat and its Role in Farmers Income" during the CAFT program organized at Division of Agricultural Economics, ICAR-IARI. Sendhil R delivered a lecture on "Principal Component Analysis based Indexing" during the CAFT program organized at Division of Agricultural Economics, ICAR-IARI.
18.10.2019	Sendhil R delivered a lecture on "Farm Management: Records, Economics and Implications" during the workshop/training on Extension Strategy for Resource Management and Input Cost Reduction in Agriculture held at EEI, Nilokheri.
19.12.2019	Sendhil R delivered a presentation for "Young Agricultural Economist (2019)" awarded by the Agricultural Economics Research Association (AERA) at the 27th AERA Conference held at PAU, Ludhiana from December 17-19, 2019

Table 11.6: TV programmes

Date	Topic
18.02.2019	Vichar Vimarsh Programme on " Gehoon Ki Dekh bhal".
24.02.2019	Live telecast of Pradhan Mantri Kisan Samman Nidhi Yojana by Honourable Prime Minister Sh. Narendra Modi ji.
08. 03.2019	Live telecast of programme on International Women Day by Honourable Prime Minister Sh. Narendra Modi ji.
05.12.2019	DD Kisan, Kisan Prashan Manch pgramme organised at Nabipur village, Karnal, Haryana
05.12.2019	DD Kisan, Ghumate Phirte proramme organised at Mehmadpur village, Karnal, Haryana

12 AWARDS & RECOGNITIONS

- Dr. GP Singh is awarded with Best Scientist Award by Young farmer Association, Patiala Punjab in 2019.
- Dr. Ravish Chatrath is awarded with XXV Hooker award on Feb 9, 2019 by ICAR.
- Dr. PL Kashyap awarded NAAS Associate 2019 by the National Academy of Agricultural Sciences (NAAS), New Delhi.
- Dr. Amit Sharma received ICAR-IIWBR best worker award in scientific category during ICAR-IIWBR foundation day on 9th February 2019.
- Dr. PL Kashyap is awarded with MK Patel Memorial young scientist award by Indian Phyto Pathological society during 26-28th February 2019 at BHU, Varanasi.
- Dr. Sneh Narwal received Best poster presentation in the 4th IGM on wheat productivity enhancement through climate smart practices held at CSKHPKV, Palampur (HP) during 14-16 February 2019.
- Dr. Poonam Jasrotia received Best poster presentation in the 4th IGM on wheat productivity enhancement through climate smart practices held at CSKHPKV, Palampur (HP) during 14-16 February 2019.
- Dr. Bhumesh Kumar received Best poster presentation in the 4th IGM on wheat productivity enhancement through climate smart practices held at CSKHPKV, Palampur (HP) during 14-16 February 2019.
- Dr. Sendhil R bestowed with the 2019 Uma Lele Mentorship Award from the Agricultural and Applied Economics Association (AAEA) Trust, USA.
- Dr. Anuj Kumar, Sendhil R, Raj Pal Meena and JK Pandey received the 2019 Best Article Award (Hindi) on doubling farmers' income published in Swarnima.
- Dr. Sendhil R received the Best Presentation Award from the Society of Economics and Development in the 5th National seminar held at Punjab Agricultural University on April 05, 2019.
- Dr Ankita Jha received the "Young Achiever Alumnus Award" by Alumni Almamater Advancement Association (4A), GBPUA&T. Pantnagar during 16-17 November, 2019.
- Best Poster Award for researcher poster entitled "Characterisation of symbiont diversity in corn leaf aphid Rhodosiphummaidis (Fitch) infesting wheat crop through metagenomic approaches" authored by Poonam Jasroria, Prem Lal Kashyap, Sudheer Kumar and GP Singh in 4th International Group Meeting held at CSKHPKCV, Palampur during February 14-16, 2019.
- Dr. PL Kashyap awarded Prof. Mahatim Singh Memorial Award-2019 on the occasion of the 58th All India Wheat & Barley Research Workers' Meet at ICAR-IARI, Regional Station, Indore.
- Dr. Sewa Ram delivered Invited lecture on wheat processing and nutritional quality: status and challenges during International Wheat Seminar held at Bengaluru, Karnataka wef; 01-02 March, 2019 and also acted as a panelist on discussion on wheat trade today and tomorrow during the Seminar.
- Sewa Ram, presented Lead paper on "Improving nutritional quality of wheat: challenges and progress" at 4th International group meeting on "Wheat productivity enhancement through climate smart practices" held at CSK HPKV, Palampur from 14-16th Feb. 2019.

- Best Poster Presentation Award for topic "Exploring Indian wheat genotypes for less Celiac disease toxic epitopes" at 4th IGM held at CSK HPKV, Palampur from 14 -16th Feb. 2019 by Sneh Narwal, Bunty Sharma, Ritu Saini, RB Singh, OP Gupta, Vanita Pandey and Sewa Ram.
- Dr. O.P. Gupta received Jawahar Lal Nehru award for PG outstanding doctoral thesis research-Biotechnology, 2019.
- Shri Roop Ram was awarded Institute's best worker award in Administrative staff category for the year 2018.
- Shri Sant Ram received Institute's best worker award in skilled supporting staff category for the year 2018.
- Dr. Subodh Kumar was awarded the ICAR Cash award 2018 under technical category during 91st ICAR Foundation Day and award ceremony at New Delhi on 16th July, 2019.
- Dr. GP Singh received the Agriculture Leadership Award for outstanding vision, dedication, commitment to excellence and exemplary leadership during 2019.
- Dr. GP Singh received the Amrik Singh Cheema Award for outstanding contribution in the field of Wheat Research by Young Farmers Association, Patiala, Punjab (ICAR recognised) during 2019.
- ICAR-IIWBR has been honoured with the prestigious Chaudhary Devi Lal Outstanding All India Coordinated Research Project (AICRP) Award from the ICAR on July 16, 2019.
- Sendhil R honored with Lal Bahadur Shastri Outstanding Young Scientist Award in Social Sciences (2018) by the Indian Council of Agricultural Research (ICAR) during the ICAR Foundation Day held on July 16, 2019.
- Sendhil R honored with the Young Agricultural Economist (2019) awarded by the Agricultural Economics Research Association (AERA) at the 27th AERA Conference held at PAU, Ludhiana from December 17-19, 2019
- Dr. SK Singh received VS Mathur Memorial Award, 2019 of ISGPB.
- Dr. SK Singh was awarded for Reviewer Excellence Award, 2019 by ARCC as reviewer of Legume Research
- Dr. SK Singh was honored with ISGPB-Recognition Award, 2019 for development of landmark wheat variety DBW 17
- Dr. SK Singh acted as organizing secretary, 58th all India wheat & barley research workers' meet, 2019.
- Dr. SK Singh acted as organizing secretary, brainstorming on speed breeding, August 25, 2019, Indore.
- Dr. SK Singh was a member of Expert Working Group on "Wheat breeding methods and strategies" of the G-20 Wheat Initiative since April, 2019.
- ICAR-IIWBR was awarded with best exhibition Stall during Ganna Aur Makka Kisan Mela at CCSHAU, Uchani on 14th November, 2019

13 DISTINGUISHED VISITORS

Dr. Ravi P Singh, Distinguished Scientist and Head of Global Wheat Improvement, visited ICAR-IIWBR, Karnal on 2nd March, 2019 and interacted with the scientists of the institute.

Dr. K.V. Prabhu, Chairperson, PPV & FR, New Delhi grace the occasion as Cheif Guest, ICAR-IIWBR Foundation Day on 9th February, 2019.

Sri DV Prasad, IAS, MD, Food Corporation of India, visited ICAR-IIWBR, Karnal on 19th March, 2019.

Dr. T. Mohapatra, Secretary DARE and DG, ICAR Visited ICAR- IIWBR on 25th March, 2019.

Ten visitors from Uganda visited ICAR-IIWBR, Karnal on 23rd July, 2019 and exchanged the information about different research project on wheat and barley.

Dr. AK Singh ,DDG (Horticulture and Crop Science) visited ICAR-IIWBR Karnal as a chief guest on the occasion of Farm Scientist Workshop and Seed day on 5th October, 2019.

Dr. H.S. Gupta Chaired the RAC Meeting on 10th November, 2019 at ICAR-IIWBR, Karnal.

Honourable Shri Kailash Chaudhary Minister of State, Ministry of Agriculture and Farmers Welfare visited IIWBR on 23rd December, 2019 and interacted with the staff.

Honourable Sri Sanjay Bhatia MP Karnal Lok Sabha and Smt. Renu Bala Gupta, Mayor Karnal visited ICAR-IIWBR, on 19th November, 2019. Sh. Bhatia was the chief guest of training programme organized for the farmers of Lahaul Spiti.

Visit of European Union Members at IIWBR, Karnal on 10th December, 2019.

Dr. Punjab Singh Ex Secreatry DARE & DG ICAR, Ex VC BHU, Varanasi and President NAAS visited ICAR-IIWBR, Karnal on 20th December, 2019.

Dr. S.S. Khanna, , Ex-Advisor, Planning Commission, Govt. of India and VC NDUA&T, Faizabad visited ICAR-IIWBR, Karnal on 24th December, 2019.

14 TRAININGS & CAPACITY BUILDING

Name of employee	Designation	Name of training programme attended	Dates
Scientific staff			
Dr. GP Singh	Director	Executive Development Programme on Developing Effective Organizational Leadership for Senior Officers of ICAR (Domestic component)	2-4 Aug, 2019
Dr. GP Singh	Director	Executive Development Programme on Developing Effective Organizational Leadership for Senior Officers of ICAR (International component)	21-30 Sept., 2019
Dr. Satyavir Singh	Pr Scientist	Stress Management at NAARM, Hyderabad	26-29 June, 2019
Dr. Subhash Chander	Pr Scientist	Stress Management at NAARM, Hyderabad	
Dr. Arun Gupta	Pr Scientist	Managing rice genetic resources for climate resilience at NRRI, Cuttack	16-25 Oct., 2019
Dr. Pradeep Sharma	Pr Scientist	MDP on Leadership Development (a pre RMP programme) at NAARM, Hyderabad	2-13 Dec., 2019
Dr. Neeraj Kumar	Scientist	Attended 3 Months Professional Attachment Training at ICAR-CIAE, Bhopal on "Development and Performance Evaluation of Residue Management System under Soil Bin"	17 May - 26 Aug., 2019
Dr. OP Gupta	Scientist	Capacity building for ICAR Scientific staff at ICAR-IIWBR, Karnal	29-31 Jan., 2019
		Invitro mineral bioavailability assay at ICMR-NIN, Hyderabad	16-22 June, 2019
Dr. Chuni Lal	Pr Scientist	IP Valuation and Technology Management at NAARM, Hyderabad	15-19 Oct., 2019
Technical staff			
Sh. Surendra Singh	ACTO	Data analysis at NAARM, Hyderabad	22-27th Aug., 2019
Sh. Sunder Lal	TO	Automobile maintenance, road safety & behaviour skill at CIAE, Bhopal	26th July to 1st Aug., 2019
Administrative staff			
Sh. Krishan Pal	Assistant	Hospitality Management at NAARM, Hyderabad	26-27 July 2019
Sh. Sunil Kumar	LDC	Use of Hindi in office at NAARM, Hyderabad	25-26 June, 2019
Supporting staff			
Sh. Hawa Singh	SSS	Skill Development training at NDRI, Karnal	17-20th July 2019
Sh. Sant Ram	SSS	Skill Development training at NDRI, Karnal	
Sh. Raj Kumar	SSS	Skill Development training at NDRI, Karnal	
Sh. Khem Chand	SSS	Skill Development training at NDRI, Karnal	
Sh. Lakhvinder Singh	SSS	Skill Development training at NDRI, Karnal	

International deputations			
Name of employee	**Designation**	**Purpose**	**Period of deputation**
Dr. G P Singh	Director	Visited Netherlands, Belgium, Germany and Switzerland to take part in " Executive Development Programme on Developing Effective Organizational Leadership for Senior Officers of ICAR-International component"	21-30 Sept., 2019
Karnam Venkatesh	Scientist	To attend a meeting on "Brazil-China-India-UK Nitrogen Joint Virtual Centres" to be held at London as part of Indo-UK Centre for the Improvement of Nitrogen Use Efficiency in Wheat (INEW) project.	3-5, Dec., 2019
Dr SC Bhardwaj Dr Hanif Khan	Head, PS Sr Scientist	Ethiopian Institute of Agricultural Research, Kulumsa Ethiopia under ACIAR funded project	16-19, Oct., 2019
Dr Mamrutha HM	Scientist	To participate in 7th annual South Asia biosafety conference held at Dhaka, Bangladesh	14-16, Sept., 2019
Dr Sendhil R	Scientist	Visiting Scholar in the Department of Applied Economics at the University of Minnesota under the 2019 Uma Lele Mentorship Program followed by participation in the Agri-Executive Management Program (2019) held at Cornell University, USA.	8-27, July, 2019
Dr Vikas Gupta	Scientist	Wheat Breeding and Pathology" held at CIMMYT, Mexico, Bolvia	15th July 2018 to 30th May 2019
Dr Satish Kumar & Dr Pramod Prasad	Sr. Scientist Scientist	Mitigating effects of stripe rust on wheat production in South Asia and Eastern Africa at PBI Sidney Australia	1st Feb., 2019 to 30th June 2019
Dr SK Bishnoi	Scientist	Pathology and Breeding training targeted for wheat blast at CIMMYT, Mexico and INIAF Bolivia	1st Feb., 2019 to 30th June 2019
Dr PL Kashyap	Sr. Scientist	Disease screening and surveillance of wheat blast at Regional Agricultural Research Stations (RARS), BARI, Jashore, Bangladesh	19th-28th Feb., 2019
Dr Arun Gupta	Pr. Scientist	Visited ICARDA Rabat Morocco under ICAR-ICARDA collaboration on barley.	10th-13th April 2019
Dr SC Bhardwaj Dr Sewa Ram	Pr. Scientist Pr. Scientist	International wheat congress (IWC) held at Saskatoon, Saskatchewan, Canada.	21st-26th July 2019

Trainings programmes organised for Farmers

- ICAR-IIWBR organised one-day farmer's awareness cum training programme on "Identification and preventive measures of wheat blast and adoption strategies of resistant varieties" at BCKV Kalyani on 17th December, 2019 under wheat blast project.
- ICAR-IIWBR organised three days HRD training on "Entrepreneurship Development in Quality Seed Production Processing and marketing" under ICAR Seed Project during 27-29th June, 2019 at ICAR-IIWBR Karnal.
- Trainings on barley for malting uses and cultivation of improved varieties was given to the farmers (more than700) at eight villages in Haryana and Rajasthan under consultancy project of ICAR-IIWBR and ABInBev India during 5-8 December, 2019.

MOUs by IIWBR with different academic institutions

Institution	Date
Chaudhary Charan Singh Haryana Agricultural University (CCSHAU), Hisar (Haryana)	13.03.2019
Mahatma Jyoti Rao Phoole University, Jaipur (Rajasthan)	15.05.2019
DAV University, Jalandhar (Punjab)	28.11.2019
Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal (Puducherry)	07.12.2019
Lovely Professional University, Jalandhar (Punjab)	07.12.2019
Amity University, Jaipur (Rajasthan)	27.12.2019

15 RESEARCH PROJECTS

(A) Institute Projects

S.No.	Project Code	Title of the project/ sub-project	Name of the Project Leader (PL), Principal Investigator (PI) and Co-PI/s	Date of start	Date of completion
1	CRSCIIWBRCIL 201500100182	Multilocational and Multidisciplinary Research Programme on Wheat and Barley Improvement	PL: Dr GP Singh Co-PIs: All the Scientists of ICAR-IIWBR	Continuous nature	Continuous nature
2	CRSCIIWBRSIL 201500200183	Genetic resources and pre-breeding for wheat improvement	PL: Dr. BS Tyagi		
	CRSCIIWBRSIL 201500200183.1*	Wheat improvement utilizing novel germplasm resources through pre-breeding	PI: Dr BS Tyagi Co-PIs/Collaborators: Drs. Sindhu Sareen, Vikas Gupta, Arun Gupta, Gyanendra Singh, Bhumesh Kumar, Hanif Khan, CN Mishra	Nov, 2015	Oct, 2020
	CRSCIIWBRSIL 201500200183.2	Management of wheat and barley genetic resources for utilization in crop improvement	PI: Dr Arun Gupta Co-PIs/Collaborators: Charan Singh, Vishnu Kumar		
3	CRSCIIWBRSIL201 500300184	Developing high yielding and climate resilient wheat varieties	PI: Dr Gyanendra Singh		
	CRSCIIWBRSIL20 1500300184.1	Breeding wheat genotypes for North-Western Plains	PI: Dr Hanif Khan Co-PIs/Collaborators: Drs. GP Singh, Satish Kumar, CN Mishra, Raj Kumar, Sudheer Kumar, Poonam Jasrotia, Mamrutha HM, OP Gangwar, Rekha Malik, Ajay Verma, PL Kashyap Sh. Om Prakash , Madan Lal	Nov, 2015	Oct, 2020
	CRSCIIWBRSIL 201500300184.2	Breeding wheat genotypes for Eastern regions	PI: Dr Gyanendra Singh Co-PIs/Collaborators: Drs. AK Sharma, Charan Singh, Vikas Gupta, Sonia Sheoran, Sindhu Sareen, DP Singh, Sewa Ram		
	CRSCIIWBRSIL20 1500300184.3	Breeding wheat genotypes for warmer areas	PI: Dr SK Singh Co-PIs/Collaborators: Drs Lokendra Kumar, Rinki , Pradeep Sharma, OP Gupta, PL Kashyap, SK Bishnoi		
	CRSCIIWBRSIL 201500300184.5	Improvement of wheat for grain quality	PI: Dr K Venkatesh Co-PIs/Collaborators: Drs Gopalareddy K, BS Tyagi, Vanita Pandey		

4	CRSCIIWBRSIL 201500400185	Basic and genetic studies in wheat	PL: Dr Ratan Tiwari	Nov, 2015	Oct, 2020
	CRSCIIWBRSIL 201500400185.1	Genomics guided exploration for stress tolerance in wheat	PI: Dr Ratan Tiwari Co-PIs/Collaborators: Drs OP Ahlawat, Rajender Singh, Pradeep Sharma, Sonia Sheoran		
	CRSCIIWBRSIL 201500400185.2	Genetic studies and molecular mapping for rust resistance in wheat	PI: Dr Rekha Malik Co-PIs/Collaborators: Satish Kumar, CN Mishra, Pramod Kumar		Oct, 2019
	CRSCIIWBRSIL 201500400185.3	Exploring physiological, biochemical and anatomical variations in wheat	PI: Dr Mamrutha HM Co-PIs/Collaborators: Bhumesh Kumar, Rinki, Sneh Narwal, Rajender Singh		
5.	CRSCIIWBRSIL20 1501200193	Use of GIS and statistical techniques for wheat & barley improvement in climate change scenario	PL: Dr Ravish Chatrath		April, 2019
	CRSCIIWBRSIL 201501200193.1	Biplot analysis for GxE interaction in wheat and barley trials	PI: Dr Ajay Verma	Nov, 2015	Oct, 2019
	CRSCIIWBRSIL 201501200193.2	Impact of temperature variations on wheat yield and its Agro-climatic suitability assessment at different locations using GIS techniques	PI: Dr Suman Lata Co-PIs/Collaborators: Dr Ankita Jha	Nov, 2015	Oct, 2019
	CRSCIIWBRSIL 201501200193.3	Design, development and maintenance of mobile application on barley crop information for farmers in Hindi	PI: Dr Suman Lata Co-PIs/Collaborators: Dr AS Kharub	Oct, 2017	Oct, 2019
6.	CRSCIIWBRSIL 201500500186	Management of major diseases and insect pests of wheat in an agro-ecological approach under changing climate	PL: Dr Sudheer Kumar		
	CRSCIIWBRSIL 201500500186.1	Development of eco-friendly technologies for management of rusts, spot blotch, bunts and smuts in wheat	PI: Dr Sudheer Kumar Co-PIs/Collaborators: Dr PL Kashyap	Nov, 2015	Oct, 2020
	CRSCIIWBRSIL 201500500186.2	Management of major insect pests of wheat under field and storage conditions	PI: Dr Poonam Jasrotia Co-PIs/Collaborators: Dr Raj Kumar		
7.	CRSCIIWBRSIL 201500600187	Physiologic specialization, resistance and molecular studies on wheat and barley rusts	PL: Dr SC Bhardwaj	Nov, 2015	Oct, 2020
	CRSCIIWBRSIL 201500600187.1	Physiologic specialization in brown rust of wheat, barley and genetics of rust resistance	PI: Dr SC Bhardwaj Co-PIs/Collaborators: Drs Pramod Prasad, Subodh Kumar		

	CRSCIIWBRSIL 201500600187.2	Monitoring variability in yellow rust of wheat, barley and genetics of rust resistance	PI: Dr OP Gangwar Co-PIs/Collaborators: Dr Subodh Kumar		
	CRSCIIWBRSIL 201500600187.3	Physiologic specialization, genetics of resistance in black rust of wheat and barley	PI: Dr Pramod Prasad		
8.	CRSCIIWBRSIL 201500700188	Improving crop productivity through efficient input management	PL: Dr RK Sharma		
	CRSCIIWBRSIL 201500700188.1	Nutrient management strategies for wheat based cropping systems	PI: Dr SC Gill Co-PIs/Collaborators: Drs RK Sharma, RS Chhokar OP Ahlawat	Nov, 2015	Oct, 2019
	CRSCIIWBRSIL 201500700188.2	Developing effective weed management solutions in wheat	PI: Dr RS Chhokar Co-PIs/Collaborators: Drs RK Sharma, SC Gill, Rajender Singh	Nov, 2015	Oct, 2020
	CRSCIIWBRSIL 201500700188.3	Improving water use efficiency and mitigate abiotic stresses stresses in wheat under conservation and conventional tillage practices	PI: Dr RP Meena		
	CRSCIIWBRSIL 201500700188.4	Production estimation of wheat using remote sensing and modelling in Haryana	PI: Dr Ankita Jha	Nov, 2015	Oct, 2019
	CRSCIIWBRSIL 201500700188.5	Enhancing productivity and profitability of wheat based cropping system for marginal farmers	PI: Dr S C Tripathi Co-PIs/Collaborators: Drs SC Gill, Raj Pal Meena	Nov, 2015	Oct, 2019
9.	CRSCIIWBRSIL 201500900190	Improvement of industrial and nutritional quality of wheat	PL: Dr Sewa Ram	Nov, 2015	Oct, 2020
	CRSCIIWBRSIL 201500900190.1	Improvement of processing and nutritional quality of wheat using biochemical/ molecular approach	PI: Dr Sewa Ram Co-PIs/Collaborators: Drs BS Tyagi, Sneh Narwal, OP Gupta, Vanita Pandey	Nov, 2015	Oct, 2020
	CRSCIIWBRSIL 201500900190.2	Studies on the bioactive compounds in wheat and barley	PI: Dr Sneh Narwal Co-PIs/Collaborators: Drs Sonia Sheoran, Dinesh Kumar		
10	CRSCIIWBRSIL 201501000191	Development of barley varieties and technologies for yield, biotic & abiotic stresses and quality	PL: Dr AS Kharub	Nov, 2015	Oct, 2020
	CRSCIIWBRSIL 201501000191.1	Improvement of malt, feed, food and dual purpose barley for better yield, quality and biotic and abiotic stresses	PI: Dr Vishnu Kumar Co-PIs/Collaborators: Drs Chuni Lal, Jogendra Singh, Lokendra Kumar, Sudheer Kumar, Dinesh Kumar, Rekha Malik, Poonam Jasrotia, Rinki, SK Bishnoi, Suman Lata	Nov, 2015	Oct, 2020

	CRSCIIWBRSIL 201501000191.2	Agronomic interventions for better yield and quality of barley changing climatic conditions	PI: Dr Anil Khippal Co-PIs/Collaborators: Drs AS Kharub, OP Ahlawat, Dinesh Kumar, Mamrutha HM, Anuj Kumar, Ashwini Kumar (IARI-RS, Karnal)	Nov, 2015	Oct, 2020
11.	CRSCIIWBRSIL 201501100192	Evaluation, transfer and impact assessment of wheat and barley production technologies	PL: Dr Satyavir Singh	Nov, 2015	Oct, 2020
	CRSCIIWBRSIL 201501100192.1	Diagnosis of zero tillage based rice- wheat system in Haryana	PI: Dr Anuj Kumar Co-PIs/Collaborators: Drs Satyavir Singh, Sendhil R	Nov, 2015	Oct, 2020
	CRSCIIWBRSIL 201501100192.2	Identifying yield gaps, resource use and adaptation strategies in vulnerable regions of wheat and barley production against climate change	PI: Dr Sendhil R Co-PIs/Collaborators: Drs Satyavir Singh, Anuj Kumar, Ajit Kharub	Nov, 2015	Oct, 2020

(B) Externally Funded Projects

SN	Title of the project	Associated scientists (PI and Co-PI) Date of completion	Collaborating centres (if any)	Funding agency	Total budget (Rs in lakh)	Date of start	Date of completion
1.	Characterization of heat-linked QTLs and Enzymes associated with starch biosynthesis pathway in wheat	Dr Sindhu Sareen (PI) Dr Rajender Singh (Co-PI)	ICAR-IIWBR, Karnal ICAR-IARI, New Delhi ICAR-NBPGR, New Delhi	ICAR (Extramural Research Project)	458.79	Nov., 2018	March ,2021
2.	Exploiting alien genetic resources for developing climate resilient wheat and understanding mechanism of heat tolerance	PI : Dr Sindhu Sareen CO-PIs: Drs B.S. Tyagi Sonia Sheoran Vikas Gupta	ICAR-IIWBR, Karnal PAU, Ludhiana ICAR-NRCPB, New Delhi	NASF	133.31	1 Aug., 2018	July 31, 2021
3.	Marker assisted breeding for drought tolerance	PI-Dr Gyanendra Singh Co-PI: Drs BS Tyagi Sindhu Sareen Sonia Sheoran Vikas Gupta Charan Singh	IARI, New Delhi CCS, University, Meerut	DBT	120.89	March, 2018	March,2021
4.	High resolution QTL mapping for iron (Fe), zinc (Zn), grain protein, and phytate content and their introgression in high yielding wheat cultivars	PI:Dr Sewa Ram Co-PIs: Drs BS Tyagi Sneh Narwal, OP Gupta, Vanita Pandey Gopalareddy K	Overall Coordination by Director, NABI, Mohali	DBT	73.09	18 March, 2019	17 March, 2022
5.	Characterization Race Profiling and genetic analysis of wheat powdery mildew pathogen.	PI: Drs DP Singh Co-PI: Dr PL Kashyap	ICAR-IARI RS Wellington (Main centre) IARI RS Shimla ICAR-IIWBR Karnal	DBT	14.04	14 March , 2019	13 March,2021

6.	Survey and Surveillance for Wheat Blast caused by Maganaporthe Oryzae Pathotype Triticum and strategic Research to Manage it	Project Leader: Dr. GP Singh PIs: Drs D.P.Singh G. Singh CO-PIs: Drs Sudheer Kumar P.L. Kashyap Amit K Sharma Raj Kumar	ICAR-IIWBR, Karnal BCKV Kalyani UBKV Coochbehar IARI, New Delhi	NFSM	127.24	Jan.01, 2018	March 31, .2020
7.	Induction of high biomass and yellow rust resistance through gamma radiations in wheat varieties HD2967 and WH1105	PI: Dr Satish Kumar	-	BRNS	25.05	Aug., 2017	Aug., 2020
8.	Identification and characterization of terminal heat responsive microRNA in wheat	PI: Dr Pradeep Sharma	IIWBR	LBSYOA challenging scheme by ICAR	30.0 40.80	May, 2016 May 2015	May, 2019 March, 2020
9.	Molecular approaches for mapping of novel gene(s) / QTL(s) for resistance/ tolerance to different stresses in Rice, Wheat, Chickpea and Mustard including Sheath Blight Complex Genomics and Resistance Mechanism-Component Wheat.	PI: Dr Sonia Sheoran Co-PI: Dr Satish Kumar, PL Kashyap	IIWBR IARI CSSRI JNKVV Powarkheda	ICAR (Incentivizing Research in Agriculture)			
10.	Phenotyping and genetic enhancement for tolerance to prioritized abiotic and biotic stresses in wheat	PI: Dr Sindhu Sareen Co-PI: BS Tyagi	IIWBR JNKVV, Powarkheda MPKV, Akola UAS, Dharwad ICAR	(NICRA – Strategic Research Component)	44.50 for 2018-19	Jan. 2015	Jan.2020
11.	Indo-UK Centre for the improvement of Nitrogen use Efficiency in Wheat (INEW)	PI: Dr K Venkatesh	Lead Centre: ICAR-IIWBR, Karnal Collaborating Centres: ICAR-IARI,New Delhi ICAR-NRCPB, New Delhi ICAR-NBPGR, New Delhi BISA, Ludhiana PAU, Ludhiana	Department of Biotechnology	850.66	June 2016	June 2019
12.	Tribal-Sub-Plan (TSP) project on Improving the Socio-economic Condition and Livelihood of Tribes in India through Extension Education and Development Programmes	PI: Dr Satyavir Singh Co-PI: Drs Anuj Kumar Sendhil R	ICAR-IIWBR, Karnal. KVK, Leh MPUAT, Udaipur JNKVV, Jabalpur IGKVV, Bilaspur BAU, Ranchi UAS, Dharwad	Ministry of Agriculture and Farmers Welfare	11.50	2015	2020
13.	Frontline Demonstrations on Wheat	PI: Dr Satyavir Singh Co-PI: Drs Anuj Kumar Sendhil R	AICRP centres/ Voluntary FLD Centres	Ministry of Agriculture and Farmers Welfare	54.00	Ongoing	-
14.	Frontline Demonstrations on Barley	PI: Dr Satyavir Singh Co-PI: Drs Anuj Kumar Sendhil R	AICRP centres+ Voluntary FLD Centres	Ministry of Agriculture and Farmers Welfare	6.00	Ongoing	-

15.	DUS testing in wheat	Nodal Officer: Dr Arun Gupta Co-Nodal Officer: Dr Charan Singh		PPV&FRA, N. Delhi	11.50	Since 2013	Ongoing
16.	DUS testing in barley	Dr Vishnu Kumar	-	PPV&FRA, N. Delhi	11.50	Since 2013	Ongoing
17.	CRP on Conservation Agriculture	PI: Dr RS Chhokar Co PI: Drs RK Sharma Subhash Chander Gill	CRIDA,IIFSRIISS, IARI,CIAE DWR,RCER CSSRI,CRRI IIWBR,NIASM	ICAR	80.00	July, 2015	June, 2020
18.	Agri-CRP on water	PI: Dr RP Meena Co PI: Drs K Venkatesh Rinki, RK Sharma	-	ICAR	38.3	July, 2015	June, 2020
19.	Seed Project: Seed production in agricultural crops and fisheries	PI: Dr Raj Kumar Co-PI: Drs Amit Sharma CN Mishra	IISS. MAU	ICAR	15.39	March,2008	March, 2020
20.	ICAR-Network Project on Functional Genomics and Genetic Modification in Crops (Heat tolerance in wheat)	PI: Dr Mamrutha HM	-	ICAR	18.00	March, 2017	-
21.	ICAR-Network project on functional genomics in wheat	PI: Dr Ratan Tiwari		ICAR	18.00	March, 2017	-
22.	CRP on Biofortication	PI: Dr Sewa Ram Co-PI: Drs Sneh Narwal OP Gupta, Vikas Gupta Dr Vanita Pandey	ICAR-IIWBR, PAU, Ludhiana, CCSHAU, HisarUAS Dharwad, IARI-Indore Platform)	ICAR (Consortia Research	250.00	Dec, 2014	Mar, 2020

Externally Foreign Funded Projects

SN	Title of the project	Associated scientists (PI and Co-PI)	Collaborating centres (if any)	Funding Agency	Total budget (Lakhs)	Date of start	Date of completion
1	Biofortification of wheat	PI: Dr Gopala Reddy	ICAR-IIWBR Karnal & ICAR-IARI New Delhi	Harvest Plus / IFPRI	127.40	Aug., 2013	Dec., 2019
2	Combining field phenotyping and next generation to genetics to uncover markers, genes and biology underlying drought tolerance in wheat	PI: Drs Pradeep Sharma BS Tyagi Co-PI: Dr Mamrutha HM	ICAR-IIWBR, Karnal ICAR NIABM (Maharashtra) Rajasthan Agriculture Research station, Durgapura-Jaipur (Rajasthan) Sardarkrushinagar Dantiwada Agricultural University Wheat Research Station(SDAU-WRS), Vijapur, Gujrat	DBT (DBT-BBSRC joint call under CGAT (Crop Genomics and Technologies)	144.00	Feb., 2015	June, 2019
3	Mitigating the effects of stripe rust on wheat production in South Asia and eastern Africa	PI: Dr SC Bhardwaj Co-PI: Dr Hanif Khan	IIWBR, Karnal & & RS Shimla	ACIAR	104.91	July, 2016	June, 2020
4	Scaling breeding and agronomic management for increasing wheat productivity and adaptation to climate change causing risingtemperatures and water scarcity in South Asia	PI: Dr CN Mishra Co-PI: Drs RK Sharma RS Chhokar	IARI New Delhi, PAU Ludhiana, IARI-RS Indore, UAS Dharwad	ICAR-CIMMYT Work Plan	222.00	Jan., 2017	Dec., 2019
5	Application of Next Generation Breeding, Genotyping & Ditilization approaches for improving the genetic gain in Indian staple crops	PI: Dr Hanif Khan Co-PI: Drs Satish Kumar, C N Mishra, Gopalareddy K	IIWBR, Karnal	ICAR-BMGF	51.33	Nov., 2018	Oct. 2022

Contract Research Projects

S. No.	Project name	Project leader	Period	Funding agency	Project amount (Rs. Lakhs)
1.	Detecting herbicide resistance in Phalaris minor using RISQ test (IIWBR/CRP/RM-63)	Dr RK Sharma	2018-19	Syngenta India Ltd.	5.90
2.	Evaluation of herbicides against weeds in maize and wheat (IIWBR/CRP/RM-61)	Dr RS Chhokar	2018-19	Indofil India Ltd.	4.72
3.	Efficacy of carfentrazone and F9600-4 against weeds in wheat (IIWBR/CRP/RM-62)	Dr RK Sharma	2018-20	FMC India Ltd.	8.96
4.	Effect of Cytozyme and SDMCRO on growth, productivity and quality of wheat (IIWBR/CRP/RM-64)	Dr SC Gill	2018-19	Cytozyme India Ltd.	2.83
5.	Effect of Potassium Salt of Active Phosphorus (PSAP) on growth, productivity and quality of wheat (IIWBR/CRP/RM-65)	Dr SC Gill	2018-19	Isha Agro India, Pune	1.18
6.	Efficacy of Tebuconazole 50% + Triflorystrobin 2S% WG on wheat against wheat blast like disease in West Bengal (DWR/CRP/CP/26)	Dr DP Singh	2017-19	Bayer Crop Science Ltd.	16.82
7.	Evaluation of bioefficacy and phytotoxicity of Mefentrifluconazole 200 f Pyraclostrobin 200 g/l SC against Yellow rust and Powdery mildew diseases of wheat (DWR/CRP/CP/27)	Dr. Sudheer Kumar	2017-19	BASF India Ltd.	5.82
8.	Evaluation of bioefficacy and phytotoxicrty of Fluxapyroxad 167 gfl + Pyraclostrobin 333 g/l against yellow rust and spot blotch disease of wheat (DWR/CRP/CP/28)	Dr PL Kashyap	2017-19	BASF India Limited	5.74
9.	Evaluation of bio-efficacy of Thiamethoxam 75%SG against termites (Odontotermes obesus and Microtermes obesi) in wheat (DWR/CRP/CP/29)	Dr Poonam Jasrotia	2017-19	Syngenta, Crop Protection (North)	4.41
10.	Evaluation of bio-efficacy of Thiamethoxam 12.60/0 + Lambda cyhalothrin 9.5% ZC against foliar aphids (Rhaphalosiphum maidis and Sitobion avenae) in wheat (DWR/CRP/CP/30)	Dr Poonam Jasrotia	2017-19	Syngenta, Crop Protection (North)	4.40
11.	Evaluation of Azoxystrobin 7.5% Propiconazole + 12.5% SE against Stripe rust / Yellow rust (*Puccinia striiformisf. sp. tritici*) disease in Wheat (DWR/CRP/CP/31	Dr DP Singh	2017-19	ADAMA- India Private Limited (Formerly known as Makhteshim-Agan India Pvt. Ltd.)	6.22

16 PUBLICATIONS

Research papers

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17 हिन्दी कार्यक्रमों पर रिपोर्ट

वर्ष 2019 के दौरान भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल के हिन्दी अनुभाग द्वारा अनेकों कार्यक्रम आयोजित किये गए जिसका संक्षिप्त विवरण नीचे दिया जा रहा है।

राजभाषा कार्यान्वयन समिति की तिमाही बैठकें

इस संस्थान की राजभाषा कार्यान्वयन समिति की तिमाही बैठकें (15 जून, एवं 07 दिसम्बर, 2019) आयोजित की गई, जिनमें संस्थान द्वारा राजभाषा हिन्दी की प्रगति पर चर्चा की गई। संस्थान की कार्यान्वयन समिति द्वारा सुझाये गये अधिकतम मुद्दों पर प्रगति सराहनीय रही।

नगर राजभाषा कार्यान्वयन समिति की बैठकें

भाकृअनुप–राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल में नराकास की 69वीं छमाही समीक्षा बैठक का आयोजन दिनांक 26 जून, 2019 को हुआ जिसमें डा आर.के. शर्मा (कार्यकारी निदेशक) एवं डा अनुज कुमार प्रधान वैज्ञानिक एवं राजभाषा अधिकारी ने भाग लिया। दिनांक 15 नवम्बर, 2019 को 70वीं छमाही समीक्षा बैठक का आयोजन भाकृअनुप–राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल में हुआ जिसमें संस्थान के निदेशक डा ज्ञानेन्द्र प्रताप सिंह, राजभाषा अधिकारी डा अनुज कुमार एवं डा रविन्द्र कुमार ने भाग लिया।

नगर राजभाषा कार्यान्वयन समिति, पानीपत की 41वीं समीक्षा बैठक में नराकास, करनाल के कार्यकारी अध्यक्ष के रूप में दिनांक 24 दिसम्बर, 2019 को पानीपत रिफाइनरी के सभागार में भाग लिया।

राजभाषा उत्सव एवं हिन्दी पखवाड़ा

भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल में राजभाषा उत्सव एवं हिन्दी पखवाड़ा (16–30 सितम्बर, 2019) को आयोजन किया गया। इस दौरान विभिन्न प्रतियोगिताओं का आयोजन किया गया जिसमें संस्थान के सभी अधिकारियों/कर्मचारियों ने भाग लिया। 16 सितम्बर 2019 को हिन्दी दिवस का आयोजन किया गया।

तालिका 17.1 : राजभाषा उत्सव एवं हिन्दी पखवाड़ा 2019 के दौरान आयोजित प्रतियोगिताओं के परिणाम एवं विजेताओं की सूची

विजेताओं के नाम	वर्ग	प्रतियोगिता का नाम	प्राप्त स्थान
श्रीमती सुमन थापा	कुशल सहायक कर्मचारी वर्ग	हिन्दी सुलेख	प्रथम
श्री हरिन्द्र कुमार			द्वितीय
श्री अमन कुमार			तृतीय
श्री रामपाल			प्रोत्साहन
श्री लखविन्द्र सिंह			प्रोत्साहन
श्री सुनील कुमार	प्रशासनिक	टिप्पणी एवं मसौदा लेखन	प्रथम
श्रीमती प्रोमिला वर्मा			द्वितीय
श्री शिवा भारद्वाज			तृतीय
श्रीमती सोनम वर्मा			प्रोत्साहन
श्री रमेश चन्द्र			प्रोत्साहन
श्री नरेश कुमार			प्रोत्साहन
श्री रामकुमार	तकनीकी	भाषण : आज के समय में गाँधीवादी विचारधारा की प्रासंगिकता	प्रथम
श्री सुरेन्द्र सिंह			द्वितीय
श्री ओम प्रकाश			तृतीय
श्री चन्द्रबाबू			प्रोत्साहन
श्री बीके मीणा			प्रोत्साहन
सुश्री किरन, श्रीमती निशु एवं सुश्री रूचिका	(सभी के लिए)	गाँधी जी के जीवन पर पोस्टर प्रदर्शनी	प्रथम
सुश्री रीतु सैनी, श्री तुषार खंडाले, सुश्री शवानी, श्री अजीत सिंह, श्री विपिन कुमार मलिक, श्री विजय सिंह, श्रीमती सुनिता जसवाल, डा स्नेह नरवाल, श्रीमती जमुना देवी, डा सेवा राम, डा ओपी गुप्ता एवं डा वनिता पाण्डेय			द्वितीय
डा मंगल सिंह, डा रमेश चन्द, डा सत्यवीर सिंह, डा सेन्दिल आर एवं डा अनुज कुमार,			तृतीय
श्री विकास जून, सुश्री निधि कंबोज, श्री दिनेश चौधरी एवं श्री संदीप कुमार			प्रोत्साहन

श्री ओम प्रकाश, डा हनीफ खान, श्री सतीश कुमार, डा सी एन मिश्रा, डा मन्नुथा एच एम, डा पूनम जसरोटिया, श्री मदन लाल एवं श्री सुरेश कुमार			प्रोत्साहन
श्री योगेश कुमार, डा मन्नुथा एच. एम., डा रिंकी, श्री राकेश कुमार एवं सुश्री अंकिता पाण्डेय			प्रोत्साहन
डा प्रेमलाल कश्यप, सुश्री अंजू शर्मा, सुश्री पालिका शर्मा, श्री रविवेश्वर कुमार, श्री कृष्ण गोपाल, डा पूनम जसरोटिया, एवं डा सुधीर कुमार			प्रोत्साहन
डा लोकेन्द्र कुमार	वैज्ञानिक वर्ग	खुला मंच : आज की युवा पीढ़ी एवं गाँधी	प्रथम
डा पीएल कश्यप			द्वितीय
डा ओपी गुप्ता			तृतीय
डा नीरज कुमार			प्रोत्साहन
डा कर्णम वेंकटेश			प्रोत्साहन
श्रीमती पूनम सलूजा (एमएसएमई संस्थान)	नराकास स्तर	निबंध लेखनः गाँधी और आधुनिक भारत	प्रथम
श्रीमती सोनिका यादव (एनडीआरआई)			द्वितीय
श्री सुनील कुमार (आईआईडब्ल्यूबीआर)			तृतीय
सुश्री सोनम वर्मा (आईआईडब्ल्यूबीआर)			प्रोत्साहन

उत्कृष्ट कर्मचारी पुरस्कार 2019

प्रत्येक वर्ष की भांति वर्ष 2019 में भी राजभाषा हिन्दी में अधिकतर कार्य करने वाले कर्मचारियों को उत्कृष्ट कर्मचारी पुरस्कार से नवाजा गया। सभी वर्गों के लिए इस प्रतियोगिता के आयोजन का मुख्य उद्देश्य हिन्दी में कामकाज को बढ़ावा देना है।

कर्मचारी	पदनाम	अनुभाग	प्राप्त स्थान
श्री नरेश कुमार	प्रवर श्रेणी लिपिक	प्रशासनिक, अनुभाग	प्रथम
श्री कृष्ण पाल	सहायक	वित्त एवं लेखा अधिकारी	द्वितीय
श्री सुनील कमुार	सहायक	प्रशासनिक, अनुभाग	तृतीय
डा सुधीर कुमार	प्रमुख अन्वेषक	फसल सुरक्षा अनुभाग	प्रोत्साहन
डा मंगल सिंह	सहायक मुख्य तकनीकी अधिकारी	सामाजिक अनुभाग	प्रोत्साहन
श्रीमती प्रोमिला वर्मा	सहायक	प्रशासनिक, अनुभाग	प्रोत्साहन

नराकास करनाल का पुरस्कार

नराकास करनाल के अधीनस्थ सभी केन्द्रीय कार्यालयों/संस्थाओं को हिन्दी में उत्तम कार्य करने के लिए 2018–19 का पुरस्कार दिया गया जिसमें भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल को द्वितीय पुरस्कार से सम्मानित किया गया। संस्थान की ओर से डा आरके शर्मा, कार्यकारी निदेशक एवं डा अनुज कुमार प्रधान वैज्ञानिक व राजभाषा अधिकारी ने 20 जून, 2019 को राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल में नराकास की छमाही बैठक में आयोजित समारोह में पुरस्कार ग्रहण किया।

संस्थान राजभाषा गौरव प्रमाणपत्र

भाकृअनुप–राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल द्वारा संस्थान व नगर स्तर पर डा. अनुज कुमार, प्रधान वैज्ञानिक एवं राजभाषा अधिकारी को राजभाषा हिन्दी के प्रचार–प्रसार व प्रोत्साहन की दिशा में किए गए प्रयासों एवं उपलब्धियों के लिए ''संस्थान राजभाषा गौरव प्रमाणपत्र'' से 18 अक्तूबर, 2019 को राजभाषा हिन्दी उल्लास मास–2019 के पुरस्कार वितरण समारोह में दिया गया।

करनाल नगर राजभाषा गौरव प्रमाणपत्र

डा. अनुज कुमार, प्रधान वैज्ञानिक एवं राजभाषा अधिकारी को राजभाषा के उत्कृष्ट कार्यान्वयन की दिशा में सराहनीय एवं उल्लेखनीय योगदान के लिए ''करनाल नगर राजभाषा गौरव सम्मान'' से 15 नवम्बर, 2019 को नवाजा गया है।

गेहूँ एवं स्वर्णिमा उत्कृष्ट लेख पुरस्कार

संस्थान की वार्षिक हिन्दी पत्रिका गेहूँ एवं स्वर्णिमा के दसवें अंक में प्रकाशित ''भारत में सिंचाई जल एवं कृषि'' (राज पाल मीना, अनुज कुमार, कर्णम वेंकटेश एवं अंकिता झा) तथा ''दक्ष तकनीकियों द्वारा टिकाऊ खेती एवं सतत् उत्पादन'' (अनुज कुमार, राज पाल मीना, आरएस छोकर, सेन्दिल आर एवं रमेश चन्द) को उत्कृष्ट लेख पुरस्कार से सम्मानित किया गया है। इस प्रतियोगिता में चयनित दो लेखों के लिए 3000 रूपये प्रति लेख की नगद राशि दी जाती है।

कार्यशालाएँ

भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल में विभिन्न कार्यशालाओं का आयोजन किया गया।

1. **''योग ही जीवन''** विषय पर एक दिवसीय कार्यशाला का आयोजन 21 जून, 2019 को किया गया।

2 **''राजभाषा का उत्थान''** विषय पर एक दिवसीय कार्यशाला का आयोजन 16 सितम्बर, 2019 को किया गया।

3. **''सतर्कता जागरूकता कार्यशाला''** विषय पर एक दिवसीय कार्यशाला का आयोजन 2 नवम्बर, 2019 को किया गया।

4. **''भारतीय कृषि के विकास में बैंकों की भूमिका''** विषय पर 17 फरवरी, 2020 को एक दिवसीय कार्यशाला का आयोजन किया गया।

18 PERSONNEL

DIRECTOR CELL

Dr. G.P Singh, Director

Smt. Gian Aneja, PS to Director

Sh. Sunder Lal, STA

Sh. Aman Kumar, SSS

CROP IMPROVEMENT

Scientific Staff

Dr Gyanendra Singh, PI & Pr. Scientist

Dr OP Ahlawat, Pr. Scientist

Dr Ratan Tiwari, Pr. Scientist

Dr B.S Tyagi, Pr. Scientist

Dr Arun Gupta, Pr. Scientist

Dr Sindhu Sareen, Pr. Scientist

Dr Raj Kumar, Pr Scientist

Dr Rekha Malik, Pr Scientist

Dr Rajender Singh, Pr Scientist

Dr. Sanjay Kumar Singh, Pr. Scientist

Dr Lokendra Kumar, Pr. Scientist

Dr Pradeep Sharma, Pr. Scientist

Dr Bhumesh Kumar, Pr. Scientist

Dr Amit Kumar Sharma, Sr. Scientist

Dr Sonia Sheoran, Sr. Scientist

Dr Hanif Khan, Sr. Scientist

Dr Satish Kumar, Sr. Scientist

Dr Charan Singh, Scientist

Dr CN Mishra, Scientist

Dr Karnam Venkatesh, Scientist

Dr Mamrutha HM, Scientist

Dr Vikas Gupta, Scientist

Dr. Rinki, Scientist

Dr Gopalareddy K, Scientist

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Dr B.K Meena, ACTO

Sh Surendra Singh, ACTO

Sh Surendra Singh, ACTO

Sh Yogesh Kumar, ACTO

Sh Yogesh Sharma, ACTO

Sh Om Parkash, Tech. Officer

Sh Suresh Kumar, Tech. Officer

Sh Rahul Singh, Tech. Officer

Sr Ishwar Singh, STA

Sh Ronak Ram, STA

Sh Rajesh Kumar, STA

Skilled Support Staff

Sh Ramesh Pal, SSS

Smt Amresh , SSS

Smt Shanti Devi, SSS

CROP PROTECTION

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Dr Sudheer Kumar, PI & Pr. Scientist

Dr Poonam Jasrotia, Sr. Scientist

Dr Prem Lal Kashyap, Scientist

Dr Ravindra Kumar, Scientist

Technical Staff

Sh Ishwar Singh Barman, Tech. Officer

Sh Bhal Singh, STA

RESOURCE MANAGEMENT

Scientific Staff

Dr RK Sharma, PI & Pr. Scientist

Dr SC Tripathi, Pr. Scientist

Dr SC Gill, Pr. Scientist

Dr RS Chhokar, Pr. Scientist

Dr Raj Pal Meena, Sr. Scientist

Dr Ankita Jha, Scientist

Dr Neeraj Kumar, Scientist

Technical Staff

Sh Ram Kumar Singh, ACTO

Sh PHP Verma, ACTO

Sh Rajender Pal Sharma, Tech. Officer

QUALITY AND BASIC SCIENCES

Scientific Staff

Dr Sewa Ram, PI & Pr. Scientist

Dr OP Gupta, Scientist

Dr Vanita Pandey, Scientist

Technical Staff

Smt Sunita Jaswal, ACTO

Smt Jamuna Devi, Tech. Officer

Sh Vijay Singh, STA

Skilled Support Staff

Sh Desh Raj, SSS

SOCIAL SCIENCES

Scientific Staff

Dr Satyavir Singh, PI & Pr. Scientist

Dr Anuj Kumar, Pr. Scientist

Dr Sendhil R, Scientist

Technical Staff

Dr Mangal Singh, ACTO

Skilled Support Staff

Sh Harinder Kumar, SSS

BARLEY IMPROVEMENT

Scientific Staff

Dr RPS Verma, PI & Pr. Scientist

Dr AS Kharub, Pr.Scientist

Dr Chuni Lal, Pr. Scientist

Dr Dinesh Kumar, Pr. Scientist

Dr Anil Khippal, Pr. Scientist

Technical Staff

Sh Ravinder Singh, ACTO

Skilled Support Staff

Sh Rampal Saini, SSS

COMPUTER SCIENCE AND STATISTICS

Scientific Staff

Dr Ajay Verma, Pr. Scientist & In-charge

Dr Suman Lata, Pr. Scientist

Technical Staff

Sh P Chandrababu, ACTO

Skilled Support Staff

Sh Bhim Sen, SSS

PME CELL

Dr Poonam Jasrotia, Sr. Scientist & In-charge

Dr Ramesh Chand, ACTO

ADMINISTRATION

Sh Sachin Agnihotri, SAO

Sh Anil Kumar, AAO

Smt Hem Lata, PA

Sh Ramesh Kumar, AAO

Sh Rajendra Kumar Sharma, Tech. Officer

Smt Promila Verma, Assistant

Sh Sunil Kumar, Assistant

Sh Ramesh Chand, UDC

Sh Shiva Bhardwaj, Steno.Gr.III

Sh Sunil Kumar, LDC

Sh Naresh Kumar, LDC

Mrs Sonam Verma, LDC

Sh Paramjeet Singh, SSS

Sh Lakhwinder Singh, SSS

Sh Hawa Singh, SSS

Sh Biru Ram, SSS

ACCOUNTS & AUDIT SECTION

Sh Jagdish Chander, F&AO

Sh Ashok Kumar Kathuria, AF&AO

Sh Krishan Pal, Assistant

Smt Sushila, UDC

Smt Suman Thapa, SSS

Sh Ramu Shah, SSS

LIBRARY

Dr Ajay Verma, Pr. Scientist & Incharge

Sh Abhay Nagar, ACTO

FARM SECTION

Dr S.K Singh, Pr. Scientist & In-charge

Sh Madan LaL, Tech. Officer, Farm Manager (Old Farm)

Sh Raj Kumar, Tech. Officer, Farm Manager (New Farm)

Sh Raj Kumar, SSS

VEHICLE SECTION

Sh Abhay Nagar, ACTO & In-Charge

Sh Ram Jawari, Tech. Officer

Sh Kehar Singh, Tech. Officer

Sh Om Singh, STA

Sh Rajbir Singh, STA

Sh Sunder Lal, STA

Sh Vinod Kumar, Sr. Technician

Sh Rajbir singh, Sr. Technician

GUEST HOUSE

Shri Krishan Pal, In Charge Guest House

REGIONAL STATION, FLOWERDALE, SHIMLA

Scientific Staff

Dr SC Bhardwaj, Pr. Scientist & In-Charge

Dr OP Gangwar, Scientist

Dr Pramod Prasad, Scientist

Technical Staff

Dr OP Dhillon, CTO

Dr Subodh Kumar, ACTO

Sh Swaroop Chand, Sr. Technician

Administrative Staff

Sh Roop Ram, PA

Sh Anil Kumar Verma, LDC

Skilled Supporting Staff

Sh Sant Ram, SSS

Sh Bhoop Ram, SSS

Sh Khem Chand, SSS

REGIONAL STATION, DALANG MAIDAN

Dr Hanif Khan, Sr. Scientist & In-charge

Sh Nand Lal, STA

SEED & RESEARCH FARM, HISAR

Scientific Staff

Dr Jogendra Singh, Pr. Scientist & In-charge

Dr SK Bishnoi, Scientist

Technical Staff

Dr Rajendra Kumar, ACTO

Administrative Staff

Sh Mahabir Singh, UDC

19 STAFF POSITION & FINANCE

STAFF POSITION

Scientific Staff

Place	Destination	Sanctioned	Filled	Vacant
ICAR-IIWBR, Karnal	Director	1	1	0
including Seed & Research Farm,	Principal Scientist	07	03	4
Hisar	Senior Scientist	11	09	2
	Scientist	35	38	-3
	Sub-Total	54	51	3
IIWBR Regional Station, Shimla	Principal Scientist	1	0	1
	Scientist	4	3	1
	Sub-Total	5	3	2
IIWBR Regional Centre,	Scientist	2	0	2
Dalang Maidan, Lahaul Spiti	Sub-Total	2	0	2
	Grand Total	**61**	**54**	**7**

Administrative Staff

Place	Designation	Sanctioned	Filled	Vacant
ICAR-IIWBR, Karnal	SAO	1	1	0
including Regional Station, Shimla	AAO	3	2	1
Seed & Research Farm, Hisar	FAO	1	1	0
	AF&AO	1	1	0
	Assistant	7	3	4
	UDC	3	3	0
	LDC	5	4	1
	PS	1	1	0
	PA	2	2	0
	Steno.gr.III	1	1	0
	Grand Total	**25**	**19**	**6**

Technical Staff

Place	Designation	Sanctioned	Filled	Vacant
ICAR-IIWBR, Karnal including	T-3(Cat.II)	19	14	5
Seed & Research Farm, Hisar	T-1(Cat.I)	23	21	2
	Sub-Total	42	35	7
IIWBR Regional Station, Shimla	T-3(Cat.II)	2	2	0
	T-1(Cat.I)	3	1	2
	Sub-Total	**5**	**3**	**2**
IIWBR Regional Centre,	T-1(Cat.I)	1	1	0
Dalang Maidan, Lahaul Spiti	Sub-Total	1	1	0
	Grand total	**48**	**39**	**9**

Skilled Support Staff

Place	Designation	Sanctioned	Filled	Vacant
ICAR-IIWBR, including Regional Stations	SSS	18	18	0
Grand Total		**18**	**18**	**0**

Summary

Cadre	Sanctioned posts	Filled posts	Vacant posts
Director	1	1	0
Scientific	60	53	7
Administrative	25	19	6
Technical	48	39	9
Skilled Support Staff	18	18	0
Total Staff	**152**	**130**	**22**

Expenditure statement for the year 2019-20 (up to December, 2019)

Name of Scheme	HEAD	BE 2019-20	Proposed RE 2019-20	EXPENDITURE (Rs. in Lakhs)				TOTAL EXP.	% of EXP. Against BE
				Other than NEH & TSP	TSP	NEH	SCSP		
IIWBR, KARNAL	Grants in Aid - Capital	320.00	124.50	67.92	0.0	0.0	0.00	**67.92**	21.23
	Grants in Aid - Salaries	1823.79	1881.00	1554.87	0.0	0.0	0.0	**1554.87**	85.25
	Grants in Aid - General :-								
	(1) Pension	200.00	238.00	205.51	0.0	0.0	0.0	**205.51**	102.76
	(2) Others	808.15	693.50	523.30	6.05	0.0	0.00	**529.35**	65.50
TOTAL		**3151.9**	**2937.00**	**2351.60**	**6.05**	**0.00**	**0.00**	**2357.65**	74.80

Name of Scheme	HEAD	BE 2019-20	Proposed RE 2019-20	EXPENDITURE (Rs. in Lakhs)				TOTAL EXP.	% of EXP. Against BE
				Other than NEH & TSP	TSP	NEH	SCSP		
AICRP (Wheat & Barley)	Grants in Aid - Capital	0.0	0.0	0.0	0.0	0.0	0.0	**0.00**	
	Grants in Aid - Salaries	1864.46	1638.33	1256.29	0.0	35.75	0.0	**1292.04**	69.30
	Grants in Aid - General :-								
	(1) Pension	0.0	0.0	0.0	0.0	0.0	0.0	**0.00**	0.00
	(2) Others	355.50	253.55	109.52	4.95	1.95	0.0	**116.42**	32.75
TOTAL		**2219.96**	**1891.88**	**1365.81**	**4.95**	**37.70**	**0.00**	**1408.46**	63.45

20 JOINING, PROMOTION, TRANSFER & RETIREMENT

New Joining

1. Mr. Shiva Bhardwaj, Stenographer joined ICAR-IIWBR, Karnal on 19.03.2019.
2. Dr. Neeraj Kumar, Scientist joined ICAR-IIWBR, Karnal on 12.04.2019
3. Dr. RPS Verma, Principal Scientist, Joined ICAR-IIWBR Karnal on 1.11.2019 after completing his deputation as barley breeder at ICARDA, Morocco from 19 May 2013 to 31.10.2019.
4. Dr. Ravindra Kumar, Scientist joined ICAR-IIWBR, Karnal on 25.11.2019 on account of his transfer from ICAR-IARI Regional Station, Karnal.

Promotion

Scientist

1. Dr. Rinki, Scientist, promoted from RGP 6000 to RGP 7000.
2. Dr. Gopalareddy K., Scientist promoted from RGP 6000 to RGP 7000.

Technical

1. Sh. Om Singh, Tech. Assistant promoted to Sr. Tech. Assistant
2. Sh. Sunder Lal, Tech. Assistant promoted to Sr. Tech. Assistant
3. Sh. Rajbir Singh, Tech. Assistant promoted to Sr. Tech. Assistant
4. Sh. Kehar Singh, Sr. Tech. Assistant promoted to Tech. Officer.
5. Sh. Baldev Singh, STA promoted to TO.
6. Dr. O.P Dhillon, ACTO promoted to CTO

Administration

1. Smt. Hem Lata, PA was granted MACP from GP 4600 to GP 4800.

Skilled Support Staff

1. Sh. Ramu Shah, SSS was granted MACP.

Transfer

1. Dr. Vishnu Kumar, Scientist selected as Associate Professor at Rani Lakshmi Bai Central Agricultural University (RLBCAU) Jhansi (Tech. Resignation) relieved from his duties on 03.08.2019.

2. Dr. Sneh Narwal, Pr. Scientist transferred from ICAR-IIWBR, Karnal to ICAR-IARI, New Delhi and relieved from her duties on 30.11.2019.

Retirement

1. Sh. Guman Singh, SSS superannuated from service on 28.02.2019.
2. Sh. Sant Kumar, ACTO superannuated from service on 28.02.2019.
3. Dr. Ravish Chatrath, Pr. Scientist superannuated from service on 30.04.2019.
4. Sh. Baldev Singh, on superannuated from service on 31.05.2019.
5. Dr. D.P Singh, Pr. Scientist superannuated from service on 30.06.2019.

Obituary

1. Sh. Om Prakash, Technical Officer, Seed and Research Farm, Hisar expired on 06.02.2019. The ICAR-IIWBR family pays homage and prays to almighty for heavenly peace of the departed soul.

स्वच्छ भारत
एक कदम स्वच्छता की ओर

भाकृअनुप-भारतीय गेहूँ एवं जौ अनुसंधान संस्थान
करनाल - 132001, भारत

ICAR-Indian Institute of Wheat and Barley Research
Karnal-132001, India

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