भाकृअनुप
ICAR

ANNUAL REPORT 2020

Indian Council of Agricultural Research –
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.

वार्षिक प्रतिवेदन

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भा.कृ.अनु.प.–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान
करनाल–132001, भारत

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भा.कृ.अनु.प.–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद)
पोस्ट बॉक्स 158, अग्रसेन मार्ग, करनाल–132001, हरियाणा

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निदेशक
Dr. G.P. Singh
DIRECTOR

PREFACE

Despite the incidence of pandemic (COVID-19) that disrupted and impacted all sectors of the economy, agriculture is the only savior to register apositive growth of 3.4% during the first quarter of 2020-21. Wheat, the most important *Rabi* season crop, served a pertinent role in progressing the nation towards economic growth as well as ensuring food and nutrition security. For the 2019-20 *Rabi* season, wheat production has registered an all-time highest output of 107.86 million tonnes and production of barley estimated at 1.72 million tonnes. Though the national lockdown was implemented since March 25, 2020, which coincided with the *Rabi* crops harvest, relaxation was given to agriculture and related activities that incapacitated the supply side disruptions leading to record production as well as procurement of 38.99 million tonnes in wheat being a major staple food crop. Unlike the past, Madhya Pradesh overtook Punjab in wheat procurement during 2020. With the mounting uncertain situation owing to the pandemic, ICAR-Indian Institute of Wheat and Barley Research, Karnal has taken proactive steps by strengthening the multi-disciplinary and multi-location research to enhance and sustain the production and productivity of wheat and barley crops.

Among the series of glorious achievements in 2020, the prominent one is the dedication of four wheat varieties to the nation as biofortified varieties by the Hon'ble Prime Minister of India commemorating the World Food Day. During the year 2020, the All-India Wheat and Barley Research Workers meet was held successfully at Karnal in virtual mode owing to the pandemic. In the online meeting, the Varietal Identification Committee has recommended10 wheat varieties and one barley variety for different production conditions. To cater the seed demand from the farmers, ICAR-IIWBR strives its best to offer yeoman service in strengthening the seed sector. During the pandemic, online seed delivery portal has been established and seeds of latest wheat and barley varieties booked by the farmers were disseminated across the country. To equip with the pandemic, the institute transformed its outreach activities, advisories and extension services to virtual mode by capitalizing the social media and other digital platforms. The institute brought several accolades during the reporting period including the Krishi Sansthan Samman Award by the Mahindra Group for outstanding contribution in transforming the Indian agriculture from shortage to surplus. Also, I congratulate and appreciate all the staff members who have been bestowed with awards and recognitions in various research and development platforms.

Despite many achievements against all production odds, 2020 has its own challenge in the form of pandemic. On a personal note, I take this opportunity to thank and express my sincere gratitude to Dr. T. Mohapatra, Secretary DARE and DG(ICAR); Dr. T.R. Sharma, DDG (Crop Science), Dr. D.K. Yadava, ADG (Seeds), Dr. Y.P. Singh, ADG (F&FC), Dr. H.S. Dhaliwal, Chairman RAC and members of RAC for providing valuable guidance and suggestions towards implementation of various research programmes. I appreciate the cooperators of AICRP on Wheat and Barley and staff of ICAR-IIWBR for their tremendous support during the pandemic to overcome all disruptions showcasing consistent progress in wheat and barley improvement. Finally, I applaud the entire fraternity of wheat and barley researchers for accomplishing their duties tirelessly which is being reflected as significant achievements in this annual report.

Stay Safe and Take Utmost Care.

GP Singh

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कार्यकारी सारांश

फसल सुधार

- फसल सीजन 2019–20 एक ऐतिहासिक वर्ष रहा, जिसमें कुल 107.59 मिलियन टन गेहूँ का रिकॉर्ड उत्पादन हुआ और देश ने गेहूँ की अब तक की रिकॉर्ड उत्पादकता 3508 किलोग्राम/हेक्टेयर प्राप्त की।
- केंद्रीय प्रजातीय विमोचन समिति द्वारा गेहूँ की 11 नई किस्मों (8 ब्रेड +3 कठिया गेहूँ) को देश के विभिन्न उत्पादन स्थितियों और कृषि परिस्थितियों के लिए अधिसूचित किया गया।
- गेहूँ के कुल 15 आनुवंशिक स्टॉक को पादप जननद्रव्य पंजीकरण समिति द्वारा पंजीकरण के लिए अनुशंसित किया गया, जिसमें से 7 आनुवंशिक स्टॉक संस्थान द्वारा विकसित किए गए।
- संस्थान के जर्मप्लाज्म रिसोर्स यूनिट (GRU) ने विभिन्न संस्थानों और विश्वविद्यालयों से 451 नये जननद्रव्य प्राप्त किए, जिसमें CIMMYT, मैक्सिको से भारतीय गेहूँ की 264 भू – प्रजातियाँ और 18 एफिड प्रतिरोधी जननद्रव्य भी शामिल हैं। संस्थान ने अनुसंधान उद्देश्यों की पूर्ति के लिए 2282 गेहूँ के जननद्रव्य को देश के विभिन्न मांगकर्ताओं को प्रदान किए तथा 350 गेहूँ की उन्नत लाइनों को ब्लास्ट रोग के परीक्षण के लिए बांग्लादेश और बोलीविया भेजा गया । संस्थान में 523 नए जननद्रव्यों को 38 DUS लक्षणों के लिए वर्णित किया गया ।
- पूर्व–प्रजनन परियोजना के अंतर्गत वर्ष 2020 के दौरान गेहूँ की जंगली प्रजातियों जैसे *थिनोपाईरम बेसरबिकम* और *एजिलोप्स पेरेग्रिना* के साथ ब्रेड गेहूँ के संकरण द्वारा गेहूँ की आनुवंशिक विविधता बढ़ाई गयी। गेहूँ में जस्ता की अधिक मात्रा के लिए करण पोषण 1 और लौह तत्व की अधिक मात्रा के लिए करण पोषण 2 आनुवंशिक स्टॉक विकसित एवं पंजीकृत किए गए।
- वर्ष 2020 के दौरान भारत के उत्तर–पश्चिमी मैदानी क्षेत्रों पर परियोजना के अंतर्गत, उत्तर– पश्चिमी मैदानी क्षेत्रों के उच्च उत्पादक वातावरण के लिए गेहूँ की सिंचित, अगेती बुवाई के लिए उच्च उपज देने वाली प्रजाति डी.बी.डब्ल्यू.303 (करण वैष्णव) का विकास किया गया था। केंद्रीय प्रजातीय विमोचन समिति द्वारा गेहूँ की प्रजाति डी.बी.डब्ल्यू.187 के क्षेत्र विस्तार की सिफारिश उत्तर–पश्चिमी मैदानी क्षेत्रों में सिंचित, अगेती बुवाई के लिए भी की गयी। परियोजना के तहत उच्च जल उपयोग दक्षता के लिए एक आनुवंशिक स्टॉक डी.बी.डब्ल्यू.166 का विकास किया गया था।
- भारत के उत्तर– पूर्वी मैदानी क्षेत्रों पर परियोजना के अंतर्गत वर्ष 2020 के दौरान, गेहूँ में ब्लास्ट रोग के लिए प्रतिरोधी एक आनुवंशिक स्टॉक बी.आर.डब्ल्यू.3806 की पहचान की।
- उष्ण क्षेत्रों के लिए गेहूँ सुधार परियोजना के अंतर्गत, वर्ष 2020 के दौरान, हरियाणा राज्य के सिंचित, समय पर बुवाई क्षेत्रों के लिए उच्च उपज देने वाली प्रजाति डी.बी.डब्ल्यू.एच.221 का विकास किया गया था। इसके अतिरिक्त देर से बोई गई परिस्थितियों में उच्च अवसादन मूल्य, भूरा रतुआ और करनाल बंट के लिए प्रतिरोधी एक आनुवंशिक स्टॉक डी.बी.डब्ल्यू.278 का भी विकास किया गया था।
- हाइब्रिड गेहूँ सुधार परियोजना के अंतर्गत 16 सी.एम्.एस. स्रोतों को बनाए रखा और 46 विविध नई सी.एम्.एस. लाइनों का विकास किया गया और प्रयोगात्मक संकर का हेट्रोटिक पोटेंशियल के लिए मूल्यांकन किया।
- गेहूँ की गुणवत्ता प्रजनन परियोजना के अंतर्गत भारत के प्रायद्वीपीय क्षत्रों में समय पर बुवाई के लिए एक उच्च उपज देने वाली कठिया गेहूँ की किस्म डी.डी.डब्ल्यू.48 का विकास किया गया। इसके अलावा सुखा सहन के लिए एक आनुवंशिक स्टॉक क्यू.एस.टी.1910 का भी विकास किया गया था।
- जैव प्रौद्योगिकी समूह ने विविध 483 जीनोम वाइड एसोसिएशन पैनल (जी.डब्ल्यू.ए.पी.) के माध्यम से भूरे, पीले और काले रतुआ के प्रतिरोध को नियंत्रित करने वाले क्यूटीएल क्षेत्रों की मैपिंग की। जीन क्षेत्रों से हीट रेस्पोंसिवे जीन आधारित SSRs (cg-SSR) मार्कर का विकास किया गया। वर्नालिजेशन जीन के कार्यात्मक मार्कर नामतः Vrn-B1, Vrn-D1, और Vrn-B3 के साथ कुल 400 भारतीय गेहूँ की जीनोटाइपिंग की गई थी। विविध गेहूँ की किस्मों में सूखे और गर्मी के तनाव सहिष्णुता के लिए बैक्टीरिया के जीन की डिफरेंशियल अभिव्यक्ति, विश्लेषण एवं अध्ययन किया गया था। सूखा और गर्मी तनाव सहिष्णुता के लिए एक आनुवंशिक स्टॉक आर.डब्ल्यू.5 का भी विकास किया गया था।
- प्रकाश संश्लेषण के महत्वपूर्ण मापदंडों के लिए जननद्रव्यों के पहचान की गयी, आर.डब्ल्यू.पी.–2018–31 व आर.डब्ल्यू.पी.–2018–32 की पहचान बढ़ते ताप के प्रति सहिष्णु वाले जननद्रव्य के रूप में की गयी ।
- जीन और जीनोम संपादन की CRISPR/CAS9 का प्रयोग गेहूँ में पैदावार और अजैविक तनाव सहिष्णुता लक्षणों में सुधार करने के लिए किया जा रहा है। संकर बीज उत्पादन के लिए गेहूँ में TaMS जीन 1 को कम कर के बाँझ नर लाइनों का विकास किया जा रहा है।
- संस्थान ने गेहूँ की 9 किस्मों का कुल 4284.6 कुंतल प्रजनक और टी. एल. बीजों का उत्पादन किया और इन के वितरण से लगभग 2.85 करोड़ का राजस्व प्राप्त हुआ। संस्थान ने कोविड–19 महामारी के दौरान किसानों को सुरक्षित बीज वितरण के लिए गेहूँ बीज पोर्टल बनाया।

फसल सुरक्षा

- किसानों के खेतों में रोग और कीटों की स्थिति की नियमित निगरानी भारतीय गेहूँ एवम जौ अनुसंधान संस्थान, करनाल के तत्वाधान में विभिन्न एजेंसियों जैसे कि कृषि सहयोग और किसान कल्याण विभाग, राज्य के कृषि विश्वविद्यालय, राज्य कृषि विभागों, केवीके, किसान आदि के संयुक्त प्रयासों के द्वारा की गई। फसल सीजन 2019–20 में पीले रतुआ की पहली घटना की रिपोर्ट पंजाब के रूपनगर जिले के आनंदपुर साहिब ब्लॉक में चंदेसर और दोरोली (हेठली) में दिनाक 26.12.2019 को गेहूँ की किस्म एच.डी. 3086, पी.बी.डब्ल्यू. 677 और डब्ल्यू.एच. 711 से प्राप्त हुई।
- गेहूँ के झोंका/ब्लास्ट रोग के लिए बांग्लादेश सीमा के साथ साथ पश्चिम बंगाल में सर्वेक्षण किये गए और पश्चिम बंगाल में गेहूँ के झोंका अथवा ब्लास्ट रोग की घटना की कोई रिपोर्ट नहीं मिली। जबकि कुछ स्थानों पर भूरा रतुआ और हेड स्कैब का निम्न स्तर का संक्रमण देखा गया।
- प्रारम्भिक पादप सुरक्षा जांच नर्सरी (आई.पी.पी.एस.एन.) में कुल 1324 प्रविष्टियाँ और पादप सुरक्षा जांच नर्सरी (पी.पी.एस.एन.) में 397 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 के लिय जाँचा गया।

- देश के विभिन्न गेहूँ उत्पादक क्षेत्रों में स्थित 20 प्रजनन केंद्रों के साथ विभिन्न रोगो के लिए प्रतिरोध स्रोतों की कुल 27 प्रविष्टियाँ साझा की गईं। विभिन्न प्रजनन केंद्रों द्वारा प्रतिरोध स्रोतों का 50.0% तक उपयोग प्रजनन में किया गया।
- फसल सत्र 2019–20 के दौरान, कोविड–19 के परिणामस्वरूप केवल हरियाणा, राजस्थान और उत्तराखंड से बहुत कम संख्या में नमूने एकत्र किए गए। कुल मिलाकर 50.5% नमूने संक्रमित पाए गए। हरियाणा के नमूनों में सर्वाधिक संक्रमण (57.8%) पाया गया।
- गेहूँ के झौंका अथवा ब्लास्ट रोग के खतरे से निपटने के लिए एवं बांग्लादेश से झौंका अथवा ब्लास्ट रोग के प्रवेश को रोकने के लिए, कठोर संगरोध अपनाया गया जबकि मुर्शिदाबाद और नादिया जिले में " गेहूँ की छुट्टी" के साथ–साथ बांग्लादेश सीमा के 5 किलोमीटर में 'गेहूँ रहित क्षेत्र' के प्रतिबंध को हटा कर राज्य सरकार ने उसके स्थान पर वैकल्पिक फसल योजना को लागू किया है।
- गेहूँ झौंका अथवा ब्लास्ट रोग प्रतिरोधी स्रोतों की पहचान के लिए, अंतर्राष्ट्रीय मक्का और गेहूँ सुधार केंद्र के माध्यम से जेसोर, बांग्लादेश और बोलीविया में कुल 350 भारतीय गेहूँ की किस्मों और अग्रिम प्रजनन सामग्री की जांच की गई। पश्चिम बंगाल के रोग संभावित क्षेत्रों में उगाने के लिए पांच प्रतिरोधी किस्मों की पहचान की गई है, जिनमें डी.बी.डब्ल्यू. 187, एच.डी.3249 और एच.डी.2967 (सिंचित और समय पर बुवाई हेतू) और डी.बी.डब्ल्यू.252 और एच.डी.3171 (सीमित सिंचाई और समय पर बुवाई हेतू) को संस्तुत किया गया। इसके अलावा एक नई झौंका अथवा ब्लास्ट रोग प्रतिरोधी किस्म एच.डी.3293 (सीमित सिंचाई और समय पर बुवाई हेतू) पहचान की गई है।
- नए कवकनाशी रसायनों का मूल्यांकन पीला रतुआ, चूर्णिल आसिता और गेहूँ के हेड स्कैब रोगों के खिलाफ किया गया है।
- फ्लैग स्मट कवक *(युरोसिसटिस एग्रोपाईरी)* के त्वरित पता लगाने के लिए पीसीआर आधारित डायग्नोस्टिक किट विकसित की गई है। *यु. एग्रोपाईरी* का पता लगाने के लिए, प्रजाति विशिष्ट प्राइमरों के दो सेट (UA&17F/ UA–519R और UA–15F/UA–562R) को क्रमशः आंतरिक उत्कीर्ण स्पेसर (ITS) डीएनए से विकसित किया गया, जो यु. एग्रोपाईरी के लिए विशिष्ट है।
- विभिन्न गेहूँ उगाने वाले क्षेत्रों से *बाइपोलरिस सोरोकिनियाना* के एकत्र आइसोलेट्स में आईटीएस अनुक्रमण के उपयोग से आनुवंशिक परिवर्तनशीलता का अध्ययन किया गया। आनुवंशिक विश्लेषण में दो अलग–अलग वंशावली के साथ 59 हैलोटाइप के अस्तित्व का पता चला, जिसमे तीन मुख्य हैलोटाइप कई एकल हैलोटाइप से घिरा हुआ स्टार–जैसी संरचना नेटवर्क बनाते है जो कुल आबादी में उच्च उत्परिवर्तन की आवृत्ति को दर्शाता है। H–3 हैप्लोटाइप सभी पांच क्षेत्रों में प्रमुख रूप में देखा गया।
- करनाल जिले के कुछ गाँव जैसे कुंजपुरा, सुभरी, रसीना और हजवाना आदि में गेहूँ के एफिड और गुलाबी तनाबेधक का मध्यम दर्जे का संक्रमण देखा गया। लाडवा, यमुनानगर, नूरपुर बेदी, आनंदपुर साहेब, बनूर, अभयान कलां रोपड़ और बजरूर में पर्ण माहू, दीमक और गुलाबी तनाबेधक का निम्न दर्जे का संक्रमण देखा गया, जबकि बनूर के कुछ हिस्सों में पर्ण एफिड क्षति दर्ज की गई। एफिड्स से प्रभावित खेतों में *कोक्सीनेलिड* बीट्लस के गिडार (ग्रब्स) और वयस्क अक्सर देखे जाते है।
- *एजिलॉप्स* की 198 प्रविष्टियों की मक्का पत्ती माहू के खिलाफ जांच की गई और उसमें से दस प्रविष्टियों ने प्रतिरोधी प्रतिक्रिया दर्शाई।
- थायमेथोक्सॉम के साथ मिश्रित जिंक सल्फेट के एक या दो छिडकाव गेहूँ में माहू की आबादी को प्रभावी ढंग से कम कर देते हैं। इसी तरह, जिंक सल्फेट को बिना किसी प्रतिकूल प्रभाव के प्रोपिकोनाज़ोल + थायमेथोक्साम के साथ मिलाया जा सकता है। गेहूँ में कीटनाशक और कवकनाशी के साथ मिश्रित जिंक सल्फेट के एक या दो छिडकाव से कोक्सीनेलिड परभक्षी पर भी कोई प्रतिकूल प्रभाव नहीं पड़ा।
- परीक्षण किए गए कार्बनिक यौगिकों जैसे किनीमास्त्र, ब्रम्हास्त्र, अग्न्यास्त्र, देशपर्णी, किण्वित मक्खन दूध और गोमूत्र में से ब्रम्हास्त्र @ 7.5% अन्य कार्बनिक उपचारों की तुलना में सबसे प्रभावी पाया गया। जैविक उपचार प्राकृतिक शत्रुओं के लिए सुरक्षित पाए गए और उनकी आबादी पर बहुत कम प्रतिकूल प्रभाव देखा गया।
- बीटा–साइफलथ्रिन 9% + इमिडाक्लोप्रिड 21% (सोलोमन), लैम्ब्डा साइहलोथ्रिन 5% ईसी @ 500 मिली / हेक्टेयर, इमिडाक्लोप्रिड 17.8 एसएल @ 400 मिली / हेक्टेयर और बीटा–साइफलफ्रीन 25 एससी @ 1450 मिली / हेक्टेयर को माहू के नियंत्रण के लिए समान रूप से प्रभावी पाया गया।
- पर्ण माहू और दीमक के द्वारा पारंपरिक जुताई में नुकसान अधिकतम था, जबकि जड़ माहू और गुलाबी तना बेधक का संक्रमण शून्य जुताई प्रणाली में सबसे अधिक था। एनडीवीआई और कैनोपी तापमान के साथ माहू की आबादी के बीच संबंध भी इन जुताई प्रणालियों के तहत अध्ययन किया गया था और यह पाया गया कि एनडीवीआई का माहू बहुतायत के साथ सकारात्मक संबंध था और कैनोपी तापमान के साथ नकारात्मक सहसंबंध था।
- विभिन्न जौ की किस्मों को भंडारण कीटों के खिलाफ जाँचा गया और पाया कि आजाद, बीएचएस –352, अंबर, केदार, बीएचएस –266, बीके –306, बीएच –959, बीएच –946, आर –56, बीजी –105 और बीसीयू –2241, भंडारण कीटों के लिए सहिष्णु पाई गई।

संसाधन प्रबन्धन

- मक्का–गेहूँ– मूंग की प्रणाली में एक दीर्घकालिक जुताई प्रयोग ने संकेत दिया कि गेहूँ की फसल जुताई और अवशेष प्रबंधन से प्रभावित नहीं थी। पोषक तत्व प्रबंधन के बीच गेहूं अनाज की उपज अनुसंशित मात्रा में रासायनिक उर्वरकों+. देशी खाद (NPK + 10 टन प्रति हेक्टेयर FYM (62.23 क्विंटल प्रति हेक्टेयर)) के आवेदन के साथ अधिकतम थी।
- बुवाई की दो तिथियों और दो जुताई के विकल्प (सीए और सीटी) के तहत दस गेहूँ किस्मों के प्रदर्शन का मूल्यांकन किया गया था। परिणामों से पता चला है कि समय पर बुवाई (15 नवंबर) की तुलना में अगेती बुवाई (25 अक्टूबर) की गेहूं में पैदावार काफी बेहतर थी। जीनोटाइप्स में, बीआईएसए 927, पीबीडब्ल्यू 723, एचडी 2967 और बीआईएसए 921 बेहतर उपज थे।
- करनाल के गांव कैमला में रोटरी डिस्क ड्रिल, टर्बो हैप्पी सीडर और सुपर सीडर का उपयोग करके चावल और गन्ने के अवशेषों के प्रबंधन के लिए किसानों के खेतों में फील्ड प्रदर्शन किए गए। सुपर सीडर का उपयोग करके गेहूँ की बुवाई के परिणाम उत्साहजनक पाए गए।
- गेहूँ की उत्पादकता बढ़ाने के लिए, 16 जीनोटाइप्स का मूल्यांकन 150% RDF + 15 टन FYM प्रति हेक्टेयर के साथ टैंक मिक्स के रूप में दो स्प्रे क्लोरमिकवैट / क्लोरेमिकवैट क्लोराइड (लिहोसिन) @ 0.2%. + टेबुकोनाजोल (फॉलिकुर 430 एससी)@ 0.1% वाणिज्यिक उत्पाद खुराक के साथ किया गया, इन किस्मों में से डी.बी.डब्ल्यू.187, एच.डी. 3086, डी.बी.

डब्ल्यू.303 और डी.बी.डब्ल्यू.329 ने, क्रमशः 75.86, 74.83, 74.49 और 74.31 क्विंटल प्रति हेक्टेयर उत्पादकता के साथ, उपज में अन्य किस्मों से बेहतर थी।

- समेकित पोषण प्रबंधन में, जब 15 टन प्रति हेक्टेयर की दर से देशी खाद को अनुसंशित मात्रा में रासायनिक उर्वरकों (150:60:40 किलोग्राम एनपीके प्रति हेक्टेयर) के साथ मिलाकर प्रयोग किया गया तो सबसे अधिक उत्पादकता दर्ज की गयी और इसके बाद अनुशंसित एनपीके+हरी खाद उपयोग द्वारा दूसरे स्थान पर अधिकतम उत्पादकता मिली। अकेले फॉस्फोरस, पोटाश या फॉस्फोरस+पोटाश के उपयोग ने पूर्ण नियंत्रण की तुलना में गेहूं की उत्पादकता में कोई सुधार नहीं किया।
- उच्च उपज देने वाली प्रजातियाँ (एच.डी.2967, एच.डी.3086, डब्ल्यू.बी.2, और डब्ल्यू.एच.1105) गेहूँ के जैविक उत्पादन में, देशी खाद 10 से 30 टन प्रति हेक्टेयर के उपयोग द्वारा पैदावार में नियंत्रण उपचार की तुलना में सार्थक वृद्धि हुई, लेकिन यह उत्पादकता रासायनिक उर्वरकों (एनपीके 150:60:40) की सिफारिश खुराक की तुलना में सार्थक रूप से कम पायी गयी। देशी खाद के उपयोग ने मिट्टी के भौतिक–रासायनिक गुणों को अनुसंशित मात्रा में रासायनिक उर्वरकों (150:60:40 किलोग्राम एनपीके प्रति हेक्टेयर) के उपचार की तुलना में काफी सुधार किया।
- गेहूँ के बाद मूंग की खेती ने 10–12 क्विंटल प्रति हेक्टेयर की पैदावार दी और इसके अवशेष मिटटी में मिलाने से धान की फसल में 50 प्रतिशत नाइट्रोजन की बचत हुई और मृदा भौतिक रासायनिक गुणों में सुधार के अलावा अधिकतम धान की पैदावार हुई। धान के अवशेषों को मृदा में मिलाने के मामले में, गेहूँ की फसल में नाइट्रोजन स्थिरीकरण प्रभाव को कम करने के लिए 25 प्रतिशत अतिरिक्त नाइट्रोजन की आवश्यकता थी और इसके उपयोग से अधिकतम गेहूँ की उपज मिली ।
- दालों के अन्तःफसलीकरण में गेहूँ की फसल के साथ मक्का के साथ मूंग, उड़द, चावल और ग्वार ने सिस्टम उत्पादकता और संसाधन उपयोग दक्षता में सुधार किया। अधिकतम भू–तुल्यांक अनुपात (1.71) मक्का चावल – गेहूँ उपचार के तहत प्राप्त किया गया।
- आठ फसल अनुकर्मों की तुलना में पता चला कि मक्का–आलू– गेहूँ (16.49 टन प्रति हेक्टेयर) और मक्का– गेहूँ – मूंग (16.17 टन प्रति हेक्टेयर) के तहत मापी गई उत्पादकता गेहूँ तुल्यांक पैदावार (WEY टन प्रति हेक्टेयर) के रूप में अन्य फसल अनुकर्मों की तुलना में सार्थक रूप से काफी अधिक थी।
- हैलक्सिफेन+फ्लुक्सिपायर 200.6 (6.1+194.5) ग्राम प्रति हेक्टेयर, मेट्सफ्लुरॉन+कारफेंट्राजोन 5+20 ग्राम प्रति हेक्टेयर और हेलाक्सिफेन+फ्लोरेसस 12.76 ग्राम प्रति हेक्टेयर के संयोजन के रूप में प्रयोग किया गया था, जो गेहूँ में पाये जाने वाले विविध व्यापक खरपतवार वनस्पतियों के नियंत्रण के लिए प्रभावी थे। इन खरपतवार नाशियों के संयोजन ने गेहूँ और जौ में अच्छा चयन दिखाया है। इसके अलावा, तीन शाकनाशी संयोजन, हैलक्सिफेन + फ्लोरासुलम + कारफेंट्राजोन ने खरपतवार वनस्पतियों के नियंत्रण में सुधार किया जिसमें सल्फोनाइल यूरिया शाकनाशी प्रतिरोधी रुमेक्स डेंटेटस का नियंत्रण भी शामिल है।
- मैटसल्फयूरान प्रतिरोधी *रुमेक्स डेंटेटस* और *चेनोपोडियम एल्बम* के नियंत्रण के लिए 2, 4–डी, कारफेंट्राजोन, आइसोप्रोटुरोन और फ्लुक्सिपायर प्रभावी पाए गए।
- गेहूँ में पाइरोक्सासल्फ़ोन+मैटसल्फयूरान 125+4 ग्राम प्रति हेक्टेयर, पाइरोक्सासल्फ़ोन+पेंडीमेथालिन 125+1000 ग्राम प्रति हेक्टेयर और पेंडीमेथालिन+मेट्रिब्यूजिन 1250+300 ग्राम प्रति हेक्टेयर जमावपूर्व तथा क्लॉडिनेफोप या पिनोक्साडेन के साथ मेट्रिब्यूजिन टैंक मिश्रण का जमाव उपरांत उपयोग विविध प्रकार के खरपतवारों के नियंत्रण में प्रभावी थे।
- सीधे बीजे गए धान में बुवाई पर बिस्पायरिबैक+पेंडीमेथालिन तदुपरान्त फेनोक्साप्रोप+ इथोक्सीसल्फ्युरोन का उपयोग विविध प्रकार के खरपतवारों को नियंत्रित करने में प्रभावी थे।
- बहुशाकनाशी प्रतिरोधक *फलेरिस माईनर* और *ए. लुडोविसिआना* (क्लोडिनाफॉप, पिनोक्साडेन और सल्फोसल्फ्युरोन के खिलाफ) के प्रबंधन के लिए पाइरॉक्सासल्फोन और मेट्रिब्यूजिन को प्रभावी पाया गया।
- नो–टिल सिस्टम को बुआई या बिजाई पूर्व उपयोग होने वाली विभिन्न खरपतवारनाशियों (पेंडीमेथालिन+ मेट्रिब्यूजिन या अकेले मेट्रिब्यूजिन या पाइरोक्सासल्फ़ोन+मैटसल्फयूरान) के साथ संयोजन के एकीकृत उपयोग से गेहूँ में फलेरिस माइनर का प्रभावी रूप से नियंत्रण हुआ ।
- उच्च जल उपयोग दक्षता परीक्षण में गेहूँ के 30 जीनोटाइप में से डी.बी.डब्ल्यू.110, डी.बी.डब्ल्यू.222, डी.बी.डब्ल्यू.173, डी.बी.डब्ल्यू.243 और डी.बी.डब्ल्यू.166 वांछनीय जल उपयोग दक्षता की 21.5 से 26.6 किलोग्राम प्रति मिमी सीमा में पाए गए।

गुणवत्ता और मूलभूत विज्ञान

- चपाती गेहूँ *(टी. एस्टीवम)* के कई जीनोटाईपस जैसे एच.डी.2967, डी.बी.डब्ल्यू.303 और एच.आई.1634 अच्छी गुणवत्ता चपाती बनाने के लिए उपयुक्त (चपाती स्कोर >7.9 / 10) पाई गई थी।
- ब्रेड गेहूँ के कई जीनोटाईपस जैसे एच.डी.3059, डी.बी.डब्ल्यू.173, डब्ल्यू.एच.1124, और एच.डी.3298 उच्च गुणवत्ता वाली पाव रोटी (लोफ आयतन >600 सी सी) के लिए उपयुक्त पाई गई।
- उच्च आणविक भार ग्लूटेनिन सब यूनिट्स लोसी में संलग्न *ग्लू ए 1, ग्लू बी1* और *ग्लू डी1* को चेक सहित अभी ए.वी.टी. प्रविष्टियों में पहचाना गया।
- गुणवत्तायुक्त पास्ता और उच्च प्रोटीन की मात्रा के लिए कठिया गेहूँ की किस्म यू.ए.एस.446, और डी.डी.डब्ल्यू.48 बेहतर पाई गई। पास्ता उत्पादों के लिए वांछनीय पदार्थ उच्च पीला वर्णक (>7.5 पी.पी.एम) के लिए किस्में डी.डी.डब्ल्यू.47 और डब्ल्यू.एच.डी.964 बेहतर पाई गई। *टी. एस्टीवम* और *टी. ड्युरम* की कई प्रविष्टियों में लौह और जस्ता की मात्रा 40.0 पी.पी.एम् से ज्यादा पायी गई, जोकि हाल ही में विकसित गेहूँ की किस्मों की बेहतर पोषण गुणवत्ता को दर्शाता है।
- देश के 10 स्थानों पर उगायी गई क्यू सी एस एन की 52 प्रविष्टियों को प्रोटीन की मात्रा, अवसादन मान, हैक्टोलीटर वजन, जस्ता और लौह की मात्रा के लिए आकलन किया गया।
- हाल ही में विकसित गेहूँ की किस्मों में अवसादन मान (>60 सी सी) में महत्वपूर्ण सुधार पाया गया । जोकि दर्शाता है कि ये किस्में पाव रोटी के लिए उपयुक्त हैं।
- विभिन्न संतति (800 लाइनें), विमोचित किस्में (300 लाइनें), म्यूटेंट लाइनें (1000), समन्वित कार्यक्रम की लाइनें (2000) का मूल्यांकन गुणवत्ता युक्त पदार्थ और पोषण गुणवत्ता के लिए किया गया ।
- Fe और Zn के स्प्रे का मूल्यांकन तीन वर्षो तक किया गया तथा यह पाया गया कि स्प्रे द्वारा गेहूँ के दानों में लौह और जस्ते की मात्रा को बढ़ाया जा सकता है।

- गेहूँ की दो प्रजातियों का अंकुरित अवस्था में ट्रांसक्रिपटाम विशलेषण कर लौह और जस्ता के अवशोषण से सम्बंधित जीनों की पहचान की गयी। पी.बी.डब्ल्यू. 502 की पृष्ठभूमि और उच्च फाईटेज़ स्तर (>2200 कि.ग्रा.) से विकसित एफ़$_2$, एफ$_3$, बी.सी$_1$ एवं बी.सी$_2$ संतति का चयन और अग्रगमन किया गया।
- जी.पी.सी.बी 1 जीन वाली गेहूँ की लाइन और एच.डी. 2967 के संकरण से विकसित आर.आई.एल की एफ़$_7$ संतति को उच्च प्रोटीन, लौह और जस्ते से सम्बंधित अनुसुचकों की पहचान के लिए उगाया गया ।
- गेहूँ की भू प्रजाति नपहल से ग्लू–डी 1 डबल नल को उच्च उत्पादक वाली प्रजातियों जैसे पी.बी.डब्ल्यू. 373, यू.पी. 2425, राज. 3765, डी.पी. डब्ल्यू 50 और एच.डी. 2967 में अणुसूचकों और माइक्रो लेवल परिक्षण के उपयोग से स्थानांतरित किया गया। वर्तमान में विकसित सामग्री विभिन्न चरणों के परिक्षण में है और एक लाईन का पंजीकरण के लिए आवेदन भी किया गया है।
- उत्तर पश्चिमी मैदानी क्षेत्र की 19 गेहूँ की किस्मों का फेनालिक की मात्रा तथा कुल एंटी आक्सीडेंट क्षमता के लिए आकलन दो स्थानों लुधियाना और पंतनगर पर किया गया। स्थान का प्रभाव एंटी आक्सीडेंट पर बहुत ज्यादा दिखा।

सामाजिक विज्ञान

- रबी फसल सत्र 2019–20 के दौरान देश भर में एक–एक एकड़ के 1468 अग्रिम पंक्ति प्रदर्शन 83 समन्वयक केन्द्रों द्वारा आयोजित किए गए। इन प्रदर्शनों में गेहूँ की उन्नत किस्में (चपाती, कठिया एवं खपली), रोटावेटर, शून्य जुताई/हैप्पी सीडर एवं जैव उर्वरकों के साथ–साथ फसल उत्पादन की समग्र सिफारिशों को चयनित किसानों के खेतों में प्रदर्शित किया गया। गेहूँ के अग्रिम पंक्ति प्रदर्शनों को देश भर के 19 राज्यों में 1607 किसानों के 1479.52 एकड़ क्षेत्रफल पर आयोजित किया गया।
- गेहूँ के अधिकतम अग्रिम पंक्ति प्रदर्शन उत्तर प्रदेश (190) में इसके बाद बिहार (142) में आयोजित किए गए। अधिकतम उपज लाभ मणिपुर (59.52%) में इसके बाद असम (35.12%) एवं झारखंड (32.23%) में दर्ज किया गया। उन्नत किस्मों के कारण अधिकतम उपज लाभ उत्तरी पर्वतीय क्षेत्र (23.94%) में इसके बाद उत्तर पूर्वी मैदानी क्षेत्र (21.55%), मध्य क्षेत्र (15.67%), प्रायद्वीपीय क्षेत्र (10.43%) एवं उत्तर पश्चिमी मैदानी क्षेत्र (08.07%) में दर्ज किया गया।
- मध्य क्षेत्र के इन्दौर केन्द्र पर कठिया गेहूँ की उन्नत प्रजाति एचडी 8759 से औसत उपज 67.60 कुंतल/हेक्टेयर प्राप्त हुई, जबकि प्रायद्वीपीय क्षेत्र के पूना केन्द्र पर डाईकोकम गेहूँ की उन्नत प्रजाति एमएसीएस 3949 से औसत उपज 40.00 कुन्तल/हेक्टेयर प्राप्त हुई।
- उत्तरी पर्वतीय क्षेत्र के अल्मोड़ा केन्द्र पर बारानी गेहूँ की उन्नत किस्म वीएल 967 की औसत उपज 37.17 कुन्तल/हेक्टेयर दर्ज की गई, जो कि जाँचक किस्मों से महत्वपूर्ण रूप से अधिक थी। बारानी गेहूँ की उन्नत किस्म एचएस 542 से खुडवनी एवं राजौरी केन्द्र पर क्रमशः 33.58 कुन्तल/हेक्टेयर एवं 30.28 कुन्तल/हेक्टेयर प्राप्त हुई, जो कि जाँचक किस्मों एसकेडब्ल्यू 355 और वीएल 829 की तुलना में महत्वपूर्ण रूप से अधिक थी। मध्य क्षेत्र के उज्जैन केन्द्र पर गेहूँ की उन्नत किस्म डीबीडब्ल्यू 110 की औसत उपज 71.40 कुन्तल/हेक्टेयर थी जो कि जाँचक किस्म एचआई 1544 से महत्वपूर्ण रूप से अधिक थी जबकि प्रायद्वीपीय क्षेत्र के निफाड केन्द्र पर वर्षा आधारित स्थिति में गेहूँ की उन्नत किस्म एनआईएडब्ल्यू 3170 की औसत उपज 41.90 कुन्तल/हेक्टेयर प्राप्त की गई।
- औसतन अग्रिम पंक्ति प्रदर्शन में गेहूँ की नवीन किस्मों एवं तकनीकों के कारण एक रुपये की लागत पर 2.78 रुपये की आमदनी प्राप्त हुई जबकि प्रचलित प्रजातियों के साथ यह आमदनी 2.47 रुपये थी। विभिन्न राज्यों जैसे गुजरात से लेकर तमिलनाडु तक यह आमदनी 3.74 रूपये से 1.88 रूपये तक रही। वहीं मध्य क्षेत्र से उत्तरी पहाड़ी क्षेत्र में यह आमदनी 3.32 रूपये से 2.38 रुपये तक रही। नई तकनीकों के तहत अर्जित आय हैप्पी सीडर के प्रयोग से 3.71 रुपये थी, जबकि खपली गेहूँ के उपयोग से 1.88 रुपये देखी गई। अग्रिम पंक्ति प्रदर्शन में प्रति हेक्टेयर लाभ की गणना से यह ज्ञात होता है कि सबसे अधिक प्रति हेक्टेयर लाभ गुजरात (93444 रुपये) में, इसके बाद मध्य प्रदेश (85402 रुपये) एवं नई दिल्ली (84547 रुपये) में दर्ज किया गया। किसानों के खेतों में प्रदर्शित की गई गेहूँ उत्पादन तकनीकों के अंतर्गत यह देखा गया कि औसतन एक नई गेहूँ की किस्म या उत्पादन तकनीक के उपयोग से 63690 रुपये प्रति हैक्टर लाभ प्राप्त हुआ। इसके अतिरिक्त गेहूँ के अग्रिम पंक्ति प्रदर्शन के अंगीकरण से नई अनुमोदित किस्मों (707 रुपये) के उपयोग से प्रति कुन्तल गेहूँ उत्पादन करने पर प्रचलित किस्मों (798 रुपये) की तुलना में अपेक्षाकृत कम निवेश की आवश्यकता होती है।
- सभी क्षेत्रों की समग्र बाधाओं के विश्लेषण से पता चलता है कि आवकों की उच्च कीमत, छोटी जोत, मंडूसी *(फेलेरिस माइनर)*, श्रमिकों की अनुपलब्धता, नई संस्तुत किस्मों के बीज की अनुपलब्धता, असामयिक वर्षा, गेहूँ की कम कीमत, नहरी सिंचाई सुविधाओं का अभाव, भूमि जल स्तर में गिरावट एवं कृषि यंत्रों की उच्च किराया दर को गेहूँ उत्पादन एवं उत्पादकता को प्रभावित करने वाली प्रमुख बाधाओं के रूप में माना गया।
- रबी फसल सत्र 2019–20 के दौरान जौ के 231 अग्रिम पंक्ति प्रदर्शन देश भर के 6 राज्यों; हिमाचल प्रदेश, उत्तर प्रदेश, पंजाब, हरियाणा, राजस्थान एवं मध्य प्रदेश के 20 समन्वयक केन्द्रों द्वारा आयोजित किए गए, जिनका आयोजन 251 किसानों की 237 एकड़ क्षेत्रफल पर किया गया। इन प्रदर्शनों में जौ की उन्नत किस्मों को फसल उत्पादन की समग्र सिफारिशों (सिंचाई प्रबंधन, पोषण प्रबंधन, खरपतवार नियन्त्रण एवं बीजोपचार इत्यादि) के साथ प्रदर्शित किया गया।
- देश में जौ का अधिकतम उपज लाभ उत्तर प्रदेश (31.05%) में, इसके बाद हिमाचल प्रदेश एवं मध्य प्रदेश (23.31%) में दर्ज किया गया, जबकि सबसे कम उपज लाभ हरियाणा (5.95%) में प्राप्त हुआ।
- उत्तरी पर्वतीय क्षेत्र के बजौरा केन्द्र पर जौ की प्रजाति बीएचएस 400 की अधिकतम औसत उपज 30.58 कुन्तल/हेक्टेयर थी, जबकि उत्तर पूर्वी मैदानी क्षेत्र के मिर्जापुर केन्द्र पर जौ की प्रजाति आरडी 2907 की औसत उपज 52.88 कुन्तल/हेक्टेयर एवं उत्तर पश्चिमी मैदानी क्षेत्र के दुर्गापुरा केन्द्र पर जौ की प्रजाति आरडी 2907 की औसत उपज 65.15 कुन्तल/हेक्टेयर पाई गई। मध्य क्षेत्र के विदिशा केन्द्र पर आरडी 2899 की अधिकतम औसत उपज 50.55 कुन्तल/हेक्टेयर दर्ज की गई।
- जौ के अग्रिम पंक्ति प्रदर्शन में नई प्रजातियों से प्रचलित प्रजातियों की तुलना में 12 प्रतिशत अधिक आमदनी प्राप्त हुई। देश के अनेक राज्यों के विभिन्न केन्द्रों पर अग्रिम पंक्ति प्रदर्शन एवं जाँचक प्लॉट के बीच प्रति रुपये लागत पर अर्जित आय में महत्वपूर्ण अन्तर देखने को मिला। प्रदर्शनों के माध्यम से प्रति रुपये लागत पर सर्वाधिक आमदनी उत्तर प्रदेश (4.50 रुपये) में, इसके बाद पंजाब (3.58 रुपये) एवं हरियाणा (2.58 रुपये) में अर्जित की गई। अग्रिम पंक्ति प्रदर्शन में प्रति हेक्टेयर लाभ की गणना से पता चलता है कि सबसे अधिक प्रति हेक्टेयर लाभ राजस्थान (62654 रुपये) में, इसके बाद उत्तर प्रदेश (62269 रुपये) में एवं पंजाब (60003 रुपये) में प्राप्त किया गया। जौ में प्रति रुपये लागत से प्राप्त

आमदनी विभिन्न उत्पादन क्षेत्रों में, सर्वाधिक उत्तर पूर्वी मैदानी क्षेत्र (4.50 रुपये) में, इसके बाद उत्तर पश्चिमी मैदानी क्षेत्र (2.89 रुपये) एवं मध्य क्षेत्र (2.29 रुपये) में प्राप्त हुई। उत्पादन लागत की गणना से संकेत मिलता है कि उत्तर प्रदेश (उत्तर पश्चिमी मैदानी क्षेत्र) में उत्पादन की लागत सबसे कम (442 रुपये प्रति कुंतल) थी, जो कि कम परिचालन लागत के साथ बढ़े हुए उपज स्तरों के कारण थी।

- सभी क्षेत्रों की समग्र बाधाओं के विश्लेषण से पता चलता है कि शाकनाशी प्रतिरोधिता, आवकों की उच्च कीमत, भूमि जल स्तर में गिरावट, जौ की कम कीमत, नहरी सिंचाई सुविधाओं का अभाव, छोटी जोत, श्रमिकों की अनुपलब्धता, फसल विकास के दौरान तापमान में उतार–चढ़ाव, कृषि यन्त्रो की उच्च किराया दर एवं मंडूसी *(फेलेरिस माइनर)* को देश की जौ उत्पादन एवं उत्पादकता को प्रभावित करने वाली प्रमुख बाधाओं के रुप में माना गया।
- रबी फसल सत्र 2019–20 के दौरान भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल द्वारा हरियाणा के करनाल जिले के रम्बा एवं बुटाना तथा कुरूक्षेत्र जिले के बीड़ अमीन, फतुहपुर, मिर्जापुर एवं दबखेड़ी गांवों के 20 किसानों के 20 एकड़ खेतों में गेहूँ की उन्नत किस्मों डीबीडब्ल्यू 187, एचडी 3226 एवं एचपीबीडब्ल्यू 01 के अग्रिम पंक्ति प्रदर्शन आयोजित किए गए।
- फसल सत्र 2019–20 के दौरान भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल, कृषि एवं किसान कल्याण मन्त्रालय एवं सम्बन्धित केन्द्रों के विशेषज्ञों के दल द्वारा निफाड नासिक, पूना, इम्फाल, कल्याणी, वेलिंगटन, धारवाड़, मेरठ, शामली, सहारनपुर, मुजफ्फरनगर, बिलासपुर, जगदलपुर, कॉंके रॉंची, मोराबादी रॉंची, पूसा समस्तीपुर, रीवा, पन्ना और जबलपुर केंद्रों द्वारा आयोजित अग्रिम पंक्ति प्रदर्शनों का अवलोकन किया गया।
- वर्ष 2015–16 से 2019–20 के दौरान 'हरियाणा में शून्य जुताई आधारित चावल–गेहूँ प्रणाली का निदान' नामक परियोजना के अंतर्गत अध्ययन के लिए हरियाणा के करनाल, यमुनानगर, कैथल और रोहतक जिलों के 420 किसानों का चयन किया गया था। इस अध्ययन में पूर्व और पोस्ट विधि, लाभार्थी और गैर–लाभार्थी विधियों का उपयोग करके इनके प्रभाव का आकलन किया गया। करनाल, यमुनानगर और कैथल जिलों में शून्य जुताई विधि की तुलना परम्परागत पद्धति से की गई, जबकि रोहतक जिले में शून्य जुताई के लाभार्थियों की तुलना गैर–लाभार्थियों द्वारा की गई। इस अध्ययन से पता चला है कि अधिकांश किसान (39.67) 31–40 वर्ष की आयु वर्ग के थे जबकि 41–50 वर्ष की आयु वर्ग के किसान 32. 33ः थे। कुल नमूना लिए गए 85.67 प्रतिशत किसान 50 वर्ष से कम आयु के थे। यह हरियाणा की कृषि में युवाओं की भागीदारी को दर्शाता है। इनमें से अधिकांश किसान (36.33%) मैट्रिक एवं उच्चतर माध्यमिक (22. 33%) शिक्षा प्राप्त थे, केवल पांच प्रतिशत किसान ही निरक्षर थे। अधिकतर किसानों (88.33%) का मुख्य व्यवसाय कृषि था, लगभग 9.67 प्रतिशत किसान कृषि के साथ–साथ डेरी से जुड़े थे। जबकि 32.33% किसानों ने डेरी को सहायक व्यवसाय के रूप में अपनाया हुआ था। किसानों को भूमि की जोत के आधार पर श्रेणीबद्ध करने पर यह देखा गया कि उनमें से एक बड़ा वर्ग (60%) 10 एकड़ से अधिक भूमि वाला था, जबकि 2.67 प्रतिशत किसान सीमांत श्रेणी के अंतर्गत थे। अधिकांश किसानों के लिए सिंचाई का मुख्य स्रोत नलकूप था। अध्ययन के लिए चयनित किए गए क्षेत्र में पानी की गुणवत्ता सामान्य थी। भूमि की उर्वरता उच्च से मध्यम श्रेणी के साथ मिट्टी मध्यम से भारी थी। गेहूँ की फसल की बुवाई के लिए अपने खेत की सफाई करने के लिए फसल के अवशेषों को जलाने वाले किसानों की संख्या काफी कम देखी गई। ऐसे किसानों की लगातार घटती संख्या का कारण राज्यों के कृषि विभाग द्वारा की गई पहल को माना जा रहा था। इस अध्ययन के तहत यह पाया गया कि 99. 33 प्रतिशत किसानों ने गेहूँ की बुवाई के लिए शून्य जुताई तकनीक को अपनाया। गेहूँ की बुवाई के लिए शून्य जुताई सीड ड्रिल या टर्बो हैपी सीडर या शून्य जुताई मशीन का उपयोग किया गया। धान की सीधी बीजाई वाली प्रौद्योगिकी (डीएसआर) को 32.67 प्रतिशत किसानों ने अपनाया जबकि 58.67 प्रतिशत किसानों द्वारा दोनों तकनीकों को अपनाया गया। अध्ययन में यह देखा गया कि कस्टम हायरिंग शुल्क शून्य जुताई सीड ड्रिल के लिए रुपये 600–700, टर्बो हैपी सीडर के लिए रुपये 1000–1200 तथा डीएसआर के लिए रुपये 900–1000 प्रति एकड़ था। यदि कोई भी किसान इन मशीनों को खरीदना चाहता है, तो वह 50 प्रतिशत सब्सिडी का लाभ उठा सकता है। अगर यह मशीनें कस्टम हायरिंग केंद्रों के लिए खरीदी जाती हैं, तो 80 प्रतिशत सब्सिडी का लाभ प्राप्त कर सकते हैं। इन प्रौद्योगिकियों को लोकप्रिय बनाने के लिए हरियाणा सरकार की यह एक मजबूत पहल है।
- शून्य जुताई की स्थिति में सबसे अधिक उपयोग में लाई जाने वाली गेहूँ की किस्म एचडी 2967 थी, और इसे 91.95 प्रतिशत किसानों द्वारा अपनाया गया था। गेहूँ की किस्म एचडी 3086, 28.19 प्रतिशत किसानों द्वारा सबसे अधिक अपनाई जाने वाली दूसरी किस्म थी। इसके अतिरिक्त डब्ल्यूएच 1105 (8.05%), डीबीडब्ल्यू 88 (5.37%) और अन्य किस्मों (एचडी 2851, एचडीसीएसडब्ल्यू 18 एवं पीबीडब्ल्यू 723) को केवल 3.02% किसानों द्वारा ही अपनाया गया था।
- शून्य जुताई तकनीक के प्रभाव का अध्ययन कई मापदंडों के आधार पर करने पर यह पाया गया कि 80.54% किसानों ने महसूस किया है कि गेहूँ की फसल की बुवाई के लिए पारम्परिक जुताई की तुलना में कम समय लगता है। अधिकांश किसानों (84.56%) द्वारा एक ही बीज दर एवं उर्वरक की समान मात्रा (57.38) का उपयोग करने पर बेहतर अंकुरण (55.37%) देखा गया। लेकिन कुछ किसानों ने अनुशंसित मात्रा की तुलना में कम (13.9%) या अधिक (22.82%) मात्रा का उपयोग किया।
- अधिकांश किसानों (71.47%) द्वारा शून्य जुताई के तहत संकरी पत्ती वाले खरपतवारों की संख्या में कमी को भी देखा गया, जबकि बहुत कम किसानों (2.01%) के खेतों में वृद्धि देखी गई। किसानों (28.51%) के एक वर्ग को खरपतवारों की आबादी में कोई अंतर नहीं मिला। 20 प्रतिशत किसानों के खेतों में शून्य जुताई अपनाने पर खेतों में चौड़ी पत्ती वाले खरपतवारों की संख्या में वृद्धि दर्ज की गई, लेकिन अधिकांश किसानों (32.21%) ने कोई बदलाव नहीं देखा। शून्य जुताई के तहत कुल खरपतवारों की आबादी में कमी देखी गई और अधिकांश किसानों (94. 97%) ने अपने खेतों में इसका अनुभव किया। परम्परागत विधि से बीजाई किए गए गेहूँ की तुलना में अधिकांश (82.55%) किसानों द्वारा शून्य जुताई तकनीक द्वारा गेहूँ की बीजाई के तहत पानी की कम आवश्यकता महसूस हुई। अधिकांश किसानों (94.97%) ने यह पाया कि यह तकनीक लागत प्रभावी है, जिससे बड़े पैमाने पर अधिक पैदावार प्राप्त की गई है। यद्धपि यह उपज लाभ 2–3 कुंतल प्रति हेक्टेयर था। इनमें से एक बड़े किसानों के समूह (91.95%) ने पाया कि दोनों परिस्थितियों में फसल अवधि में कोई बदलाव नहीं हुआ है।
- किसानों के एक बड़े समूह (93.62%) द्वारा मृदा मापदंडों पर शून्य जुताई का एक अन्य प्रभाव भी देखा गया कि जीरो टिलेज तकनीक को अपनाने से भूमि की उर्वरता के स्तर में वृद्धि होती है। इनमें से अधिकांश किसानों (83.22%) ने पाया कि बीजाई के दौरान धान के अवशेषों को शामिल करने के कारण जीरो टिलेज तकनीक को अपनाने से खेतों में जैविक और कार्बनिक तत्वों में वृद्धि हुई है। भूमि की जलधारण क्षमता में वृद्धि,

फसल के गिरने में कमी एवं टर्मिनल गर्मी से बचाव को क्रमशः 88.93, 92.285 एवं 93.96 प्रतिशत किसानों द्वारा देखा गया। शून्य जुताई को निरन्तर अपनाने के कारण मृदा के भौतिक–रासायनिक गुणों में भी वृद्धि देखी गई है। इन सभी निष्कर्षों के आधार पर यह कहा जा सकता है कि शून्य जुताई तकनीक गेहूँ उगाने वाले किसानों के लिए एक वरदान है। धान–गेहूँ प्रणाली से सम्बन्धित समस्या के निवारण हेतू शून्य जुताई तकनीक अपनाने के लिए किसानों को आसानी से प्रेरित किया जा सकता है।

- वर्ष 2019 के दौरान 'जलवायु परिवर्तन के प्रति गेहूँ एवं जौ के कमजोर (मध्यम संवेदनशील श्रेणी) क्षेत्रों से उपज अंतराल, संसाधन उपयोग एवं अनुकूलन रणनीतियों की पहचान' नामक परियोजना के अंतर्गत सामाजिक–आर्थिक विशेषताओं पर पूर्वी उत्तर प्रदेश के प्रयागराज (इलाहाबाद) और गाजीपुर जिलों के 200 गेहूँ एवं 100 जौ उत्पादक परिवारों से आंकड़े एकत्रित किए गए।

- गेहूँ के संदर्भ में, प्रयागराज में उपज अंतराल–1 नकारात्मक (–8%;–4 कुंतल / हेक्टेयर) पाया गया जबकि इलाहाबाद में उपज अंतराल–2 उच्चतम (148.63%; 28.89 कुंतल / हेक्टेयर) था। संसाधन उपयोग पैटर्न के विश्लेषण से संकेत मिलता है कि पूर्वी उत्तर प्रदेश के प्रयागराज और गाजीपुर जिलों के बीच संसाधनों के उपयोग में महत्वपूर्ण अंतर मौजूद है। पूर्वी उत्तर प्रदेश के इन चयनित क्षेत्रों में बीज का उपयोग अनुशंसित मात्रा से अधिक किया गया था, जबकि उर्वरकों का उपयोग अनुशंसित मात्रा से कम या अधिक किया गया था। सभी आदानों जैसे खाद / जैव–उर्वरकों पर किए गए व्यय में महत्वपूर्ण अंतर देखा गया।

- परिणामों के निहितार्थ से संकेत मिलता है कि गेहूँ की चयनित अवस्थाएं जैसे–पुष्पन, दुग्ध अवस्था एवं दाना सख्त होना एवं पकना मौसम विसंगतियों के प्रति संवेदनशील है। जौ के संदर्भ में, फुटाव, पुष्पन, दुग्ध अवस्था एवं दाना सख्त होना एवं दानों की पकने की अवस्था मौसम विसंगतियों के प्रति संवेदनशील हैं।

- आंकड़ों का स्कोरिंग विश्लेषण इशारा करता है कि नई प्रौद्योगिकियों, उन्नत किस्मों के बीजों का अंगीकरण, अधिक जैविक खादों का उपयोग, भूजल के माध्यम से पूरक सिंचाई, सिंचाई की गहराई या आवृत्ति एवं बीमा के प्रति किसानों में जागरूकता का स्तर बहुत कम था। आकड़ों के विश्लेषण ने पूर्वी उत्तर प्रदेश के किसानों के मध्य विशेष रूप से संरक्षण कृषि के लिए जलवायु स्मार्ट खेती की प्रथाओं और अनुकूलन रणनीतियों के बारे में जागरूकता बढ़ाने की आवश्यकता का संकेत दिया है।

- वर्ष 2019–20 के दौरान आदिवासी उप–परियोजना (टी.एस.पी. परियोजना) 'विस्तार शिक्षा एवं विकास कार्यक्रमों के माध्यम से जनजातियों की सामाजिक–आर्थिक स्थिति एवं आजीविका में सुधार' के अंतर्गत निम्नलिखित आठ केन्द्रों को शामिल किया गया था जो इस प्रकार हैं: लाहौल एवं स्पिति (हिमाचल प्रदेश), लेह, खुडवनी (जम्मू एवं कश्मीर), जबलपुर (मध्य प्रदेश), उदयपुर (राजस्थान), बिलासपुर (छत्तीसगढ़), राँची (झारखंड) एवं धारवाड़ (कर्नाटक)। वर्ष 2019–20 के दौरान इस परियोजना के अंतर्गत विभिन्न टी.एस.पी. गतिविधियों को पूरा किया गया। इस परियोजना के अंतर्गत खुडवनी, जबलपुर, उदयपुर, बिलासपुर, धारवाड़ और रांची केंद्रों पर क्रमशः 66, 50, 60, 43, 60 एवं 23 किसानों के खेतों पर गेहूँ फसल के प्रदर्शनों का आयोजन किया गया। आदिवासी उप–परियोजना (टी.एस.पी. परियोजना) के तहत प्रदर्शनों के लिए गेहूँ की बेहतर किस्मों के बीजों की आपूर्ति की गई। गेहूँ उत्पादन तकनीक पर 13 प्रशिक्षण कार्यक्रमों का आयोजन खुडवनी (2), बिलासपुर (2), धारवाड़ (1), लेह (4) और लाहौल और स्पीति (4) केंद्रों पर किया गया। इस परियोजना के अंतर्गत विभिन्न केन्द्रों द्वारा जागरूकता शिविर, प्रदर्शनी एवं एक्सपोजर यात्राओं का आयोजन किया गया। इस अवधि के दौरान तीन प्रकाशन खुडवनी (1) और धारवाड़ (2) केंद्रों पर प्रकाशित किए गए। वर्ष 2020 के लिए, बजट में सहायता अनुदान के तहत धनराशि को मंजूर किया गया है एवं जारी किया गया है।

- उपरोक्त गतिविधियों के अतिरिक्त, संस्थान की सामाजिक विज्ञान इकाई द्वारा, सरकार के प्रमुख विकास कार्यक्रमों जैसे–मेरा गाँव मेरा गौरव, किसानों की आय दोगुनी करने, सॉयल हेल्थ कार्ड के प्रति जागरूकता पैदा करने आदि से सम्बंधित गतिविधियों का समन्वय किया जाता है। इस अवधि के दौरान भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान में 3 प्रशिक्षण कार्यक्रम, 2 जागरूकता कार्यक्रम / किसान दिवस के अलावा 2 दूरदर्शन (टेलीविजन) कार्यक्रमों में भाग लेने एवं विभिन्न हितधारकों की 21 भ्रमण यात्राओं के समन्वय आयोजित किए गए। जिसके अर्न्तगत किसानों को गेहूँ एवं जौ की खेती के विभिन्न पहलुओं पर सलाह दी गई। 600 से अधिक किसानों / उद्यमियों / अन्य हितधारकों को विभिन्न प्लेटफार्म के माध्यम से उनके प्रश्नों के उत्तर प्रदान किए गए। इस फसल सत्र के दौरान किसानों को मौसम एवं सस्य क्रियाओं से सम्बन्धित साप्ताहिक परामर्श भी जारी किए गए।

जौ सुधार

- देश में जौ का 1.69 मिलियन टन उत्पादन 6.18 लाख है. क्षेत्रफल से 27.3 कु. / है. की औसत उपज से प्राप्त किया गया है।

- प्रस्तावित 86 उपज मूल्यांकन परीक्षणों में से 84 परीक्षणों का आयोजन किया गया था और विश्लेषण के बाद, केवल 78 परीक्षण (प्रस्तावित का 91%, आयोजित का 95%) रिपोर्ट के लिए अच्छे पाए गए। रबी 2019–20 के दौरान ये परीक्षण 11 मुख्य केंद्रों और 30 अन्य परीक्षण केंद्रों (आई.सी.ए.आर., एस.ए.यू और राज्य कृषि विभाग सहित) में किए गए थे।

- 12 केंद्रों द्वारा योगदान किए गए सभी 97 परीक्षण प्रविष्टियों में, वर्षा आधारित (मैदानी और पहाड़ी), सिंचित (मैदानी) और लवणीय मिट्टी की स्थितियों के तहत समन्वित उपज परीक्षणों में 24 वर्तमान प्रजातियों के साथ मूल्यांकन किया गया था।

- वर्ष के दौरान संस्थान द्वारा विकसित कम बीटा ग्लूकन्स (दाने और वोर्ट में) एवं अन्य गुणों वाली एक माल्ट जौ की किस्म "डी.डब्लू.आर.बी.182" उत्तर–पश्चिमी मैदानी क्षेत्रों में खेती के लिए जारी की गई है। यह प्रजाति वर्तमान माल्ट एवं बीयर उद्योग की आवश्यकताओं की पूर्ति करने में सक्षम है।

- अलग–अलग परीक्षणों में उपज के लिए छः जननद्रव्यों, आई.बी.वाई. टी–एच् आई 2019–20 (प्रविष्टि संख्या 6, 11 और 13) और जी.एस.वाई. टी.2019–20 (प्रविष्टि संख्या 10, 11 और 15) विभिन्न स्थानों पर बेहतर पाई गईं।

- एक आनुवंशिक स्टॉक "डी.डब्लू.आर.बी.207" पीला रतुआ के लिए प्रतिरोधक होने के साथ अच्छा 1000 दानों का वजन और कम प्रोटीन मात्रा के लिए एन.बी.पी.जी.आर द्वारा पंजीकृत किया गया।

- समन्वित अनुसंधान केंद्रों की मदद से 526.97 कु. के आवेदन पर 28 जौ किस्मों के 997.25 कु. प्रजनक बीज का उत्पादन आयोजन किया गया।

- ICAR–IIWBR करनाल में मध्यम अवधि के भंडारण मॉड्यूल की सुविधा में, जौ के कुल 8239 जननद्रव्यों का संरक्षण और रखरखाव किया जा रहा है। रबी 2019–20 के दौरान कुल 498 जननद्रव्य लाइनों का पुनः उत्पादन किया गया और 652 का आदान–प्रदान किया गया।

- दाने में बीटा एमाइलेज गतिविधि और माल्ट डायस्टेटिक पावर के बीच एक मजबूत संबंध पाया गया है।
- दो जीनोटाइप्स सलूप एस.ए.डब्लू.एल.3167 और सलूप.वि.क.वी.बी.9953 को माल्टिंग गुणवत्ता मूल्यांकन में बहुत कम वोर्ट बीटा ग्लूकन्स मात्रा के लिए पहचाना गया है, जबकि डी.डब्लू.आर.बी.182 दाने और माल्ट एक्स्ट्रेक्ट का एक अच्छा संयोजन था, जो कि विभिन्न प्रकार के वाणिज्यिक खेती के रूप में आवश्यक था।
- चार ए.वी.टी. प्रविष्टियाँ (डी.डब्लू.आर.बी.182, डी.डब्लू.आर.बी.196, डी.डब्लू.आर.बी.197 और पी.एल.908) और चेक (डी.डब्लू.आर.बी.101, डी.डब्लू.आर.बी.123, डी.डब्लू.आर.बी.160, आर.डी.2849 और बी.एच.902) का जौ विशिष्ट आणविक मार्करों (46 एस.एस.आर.) का उपयोग करके ए.वी.टी. परीक्षण 2019–20 में आनुवंशिक विभिन्नता विश्लेषण करने के लिए सात गुणसूत्रों को कवर करने वाले एस.टी.एस.मार्कर के उपयोग द्वारा आणविक स्तर की विभिन्नता पाई गई।
- विभिन्न सिंचाई स्तर के साथ हाइड्रोजेल का मूल्यांकन उत्तर पश्चिमी मैदानी भाग के शुष्क क्षेत्रों में किया गया और इसके परिणामस्वरूप पूसा हाइड्रोजेल@ 2.5 किलोग्राम प्रति है. और न्यू हाइड्रोजेल@2.5 किलोग्राम प्रति है. बिना हाइड्रोजेल स्थितियों की तुलना में बेहतर पाए गये। दो सिंचाई के साथ हाइड्रोजेल और तीन सिंचाई बिना हाइड्रोजेल के साथ उपज बराबर थी और इसलिए हाइड्रोजेल के उपयोग से हम एक सिंचाई पानी (6 लाख लीटर) को बचा सकते हैं। मूल्यांकन के दो वर्षों के बाद, पानी को बचाने और अधिक उत्पादन के लिए शुष्क क्षेत्रों में हाइड्रोजेल के उपयोग की सिफारिश की जाती है।
- उत्तर पर्वतीय क्षेत्रों में, पारंपरिक जुताई और शून्य जुताई + अवशेष से बराबर का उत्पादन प्राप्त हुआ और शून्य जुताई से श्रेष्ठ थे। मिट्टी की उर्वरता में अवशेषों के महत्व के कारण बुवाई के समय संसाधनों का निर्माण और बचत, उत्तर पर्वतीय क्षेत्र में जौ बुवाई के लिए शून्य जुताई + अवशेषों की सिफारिश की जाती है।
- उत्तर–पश्चिमी क्षेत्र में जिंक के मृदा प्रयोग और पर्ण छिडकाव परीक्षण में जिंक सल्फेट @ 25 किग्रा/ है. उपज के हिसाब से बेहतर पाया गया। इसमें बिना जिंक प्रयोग की तुलना से 14.6 प्रतिशत अधिक पैदावार हुई। उत्तर–पर्वतीय, उत्तर–पूर्वी तथा मध्य–क्षेत्र में जिंकसल्फेट@ 25 किग्रा / है. के साथ पर्ण छिडकाव (0.5% जिंक सल्फेट प्रारंभिक दुग्ध अवस्था पर) अन्य सभी उपचारों की तुलना में बेहतर पाई गयी। इन तीनों क्षेत्रों में बिना जिंक आवेदन की तुलना में जिंक डालने से 12.6–14.0% अधिक उपज का उत्पादन पाया गया।

क्षेत्रीय केन्द्र, फ्लावरडेल, शिमला (हि०प्र०)

- भूरा रतुआ के लिए प्रतिरोधि जीन *एलआर80* की गेहूँ की प्रजाति लोकल होगो के 2डीएस गुणसूत्र पर पहचान की गयी। यह जीन भारत में पाये जाने वाले *पक्सीनीया ट्रिटीसीना* के प्रमुख प्रभेदों के लिए प्रभावी है। इस जीन से जुडे हुए आण्विक मार्करों की सहायता से इस जीन को गेहूँ की अन्य प्रजातियों में डाल के भूरा रतुआ प्रतिरोध की विविधता को बढाया जा सकता है। यह जीन भारत में पहचाना गया छटवा रतुआ प्रतिरोधी जीन है।
- इस वर्ष भारत में गेहूँ उगाये जाने वाले क्षेत्रों में रतुआ रोगो को बहुत कम देखा गया। उत्तर भारत के कुछ राज्यों के कुछ स्थानों पर पीला रतुआ देखा गया। भूरा रतुआ को महाराष्ट्र, गुजरात, कर्नाटक, मध्य प्रदेश में कुछ स्थानों पर देखा गया। प्रायद्वीपीय भारत के कुछ क्षेत्रों में गेहूँ और जौ के तना रतुआ को देखा गया। व्यावाहारिक रूप में यह वर्ष रतुआ रहित वर्ष रहा। चौदह भारतीय राज्यों एवं नेपाल से इस वर्ष गेहूँ एवं जौ रतुआ के 897 नमूनों को विश्लेषित किया गया। इन नमूनों में पीले, भूरे और काले रतुऐ के क्रमशः 305, 465 और 127 नमूने शामिल हैं। पीला रतुआ प्रतिरोधी जीन्स *वाईआर* 5,10,13,15,16, और वाईआर *एसपी, तनारतुआ* के *एसआर26, एसआर27, एसआर31, एसआर32, एसआर35, एसआर39, एसआर40, एसआर43, टीसी3* और *एसआरटीएमपी* और भूरा रतुआ के *एलआर 24,एलआर25, एलआर29, एलआर32, एलआर39, एलआर42, एलआर45* और *एलआर47* क्रमशः पीले, काले और भूरे रतुए के प्रभेदों के लिए प्रभावीरहे। *पक्सीनीया स्टाईफारमिस* के सात प्रभेदों में 238एस119 सबसे प्रमुख प्रभेद था जिसको 44.06 प्रतिशत नमूनों में देखा गया। प्रभेद 46एस119 को 33.2 प्रतिशत जबकि 110एस119 को 18.98 प्रतिशत नमूनों में देखा गया। *पक्सीनीया गेमिनिस ट्रीटीसाई* के प्रभेद11 को सर्वाधिक 88.2 प्रतिशत नमूनों में देखा गया इसके पश्चात प्रभेद 40ए को 4.7 प्रतिशत नमूनों में देखा गया। *पक्सीनीया ट्रिटीसीना* के प्रभेदों 77–9(121आर60–1) और 77–5 (121आर63–1) को क्रमश 50.3 और 28. 2 प्रतिशत नमूनों में देखा गया।
- गेहूँ एवं जौ की 3500 से अधिक प्रविष्टियों में पौध अवस्था में रतुआ प्रतिरोधकता का आकलन पीला, काला और भूरे रतुआ के प्रभेदों के खिलाफ किया गया। इन प्रविष्टियों में एवीटी की 137, एनबीडीएसएन की 160 और प्रजनकों और अन्य स्रोतों से प्राप्त प्रविष्टियां शामिल है। गेहूँ की किसी भी लाईन में सभी रतुआ के प्रभेदों के लिए प्रतिरोधकता नहीं देखी गयी। पीबीडब्ल्यू813 काले और पीले रतुए के लिए प्रतिरोधी पायी गयी जबकि एचआई 1641, एचआई 1642 और एमएसीएस 6752 पत्ती और तना रतुआ के लिए प्रतिरोधी थी। अन्य 20 प्रविष्ठियां पत्ती रतुआ तथा 4 प्रविष्ठियां तना रतुआ के लिए प्रतिरोधी पायी गयी। इसके अलावा 25 प्रविष्ठियां जिनमें *एसआर31/एलआर26/वाईआर9* जीन थे, को तना रतुआ के लिए प्रभावी देखा गया। 4 वाई आर जीन्स *(वाईआर2, वाईआर 9, वाईआर ए* और *वाईआर 18)* को एवीटी की 25 लाईनों में आंका गया। इसी प्रकार दस एलआरजीन्स *(एलआर 1, एलआर 29, एलआर 3, एलआर 10, एलआर 13, एलआर 18, एलआर 23, एलआर 24, एलआर 26,* और *एलआर34)* को 112 लाइनों में और 13 एस आर जीन्स *(एसआर 2,एसआर5, एसआर 7बी, एसआर 8ए, एसआर 8बी, एसआर 9बी, एसआर 9इ, एसआर 9, एसआर 11, एसआर 13, एसआर 28, एसआर 30 औरएसआर* 31) को 122 एवीटी लाईनों में देखा गया।
- एवीटी की किसी भी लाईन में भूरे और पीले रतुऐ के लिए बरिष्ठ पौध अवस्था में प्रतिरोधकता नहीं देखी गयी। डीबीडब्ल्यू187 में बरिष्ठ पौध अवस्था में पीले रतुए के तीनों प्रभेदों तथा भूरे रतुए के 77–5 प्रभेद के लिए प्रतिरोधकता की पहचान की गयी। इसी तरह एचडी3086 में पीले रतुए के सभी प्रभेदों तथा भूरे रतुऐ के प्रभेद 104–2 के लिए तथा एचडी 3332 में पीले रतुए के सभी प्रभेदों तथा भूरे रतुए के प्रभेद 77–5 तथा 77–9 के लिए प्रतिरोधकता देखी गयी। एनबीडीएसएन की कोई भी लाईन जौ के सभी रतुआ प्रभेदों के लिए प्रतिरोधी नही थी। बारह लाईनों में भूरे तथा पीले रतुए के लिए एक लाईन में पीले और तना रतुआ के लिए जब कि चार लाईनों में भूरे और काले रतुए के लिए प्रतिरोधकता देखी गयी। इसके अलावा 16 पंक्तियों में पीले रतुआ के लिए 2 में तना रतुआ के लिए तथा 22 में भूरा रतुआ के लिए प्रतिरोधकता देखी गयाी। इबीडीएसएन की 44 में से किसी भी प्रविष्ठि में तीनों रतुआ रोगो के लिए प्रतिरोधकता नहीं देखी गयी। हालांकि 9 प्रविष्ठियां भूरे और पीले रतुए के लिए, 1 काले और पीले रतुआ के लिए और 2 भूरे और काले रतुए के लिए प्रतिरोधी पायी गयी। अलग–2 रतुआ के लिए 19 लाईनों में प्रतिरोधकता देखी गयी। इनमें से 10 पंक्तियों में पीले रतुए के लिए, एक में

काले रतुए के लिए और 8 में भूरे रतुए के लिए प्रतिरोधकता देखी गयी।

- भूरा रतुआ प्रतिरोधी जीन *एलआर68* जिसको गेहूँ और रोग जनक के व्यवहार के आधार पर नहीं पहचाना जा सकता है को इस जीन से जुडे हुए आण्विक मार्कर की सहायता से गेहूँ की 102 मे से 34 प्रविष्ठियों में पहचाना गया। डी.एन.ए. में बहुरूपता के आधार पर काले रतुए के 29 प्रभेदों, पीले रतुए के 11 प्रभेदों तथा भूरे रतुए के 5 नये प्रभेदों को वर्गीकृत किया गया और इनके बीच प्रर्याप्त बहुरूपता देखी गयी।
- विभिन्न रतुआ रोगों के 120 से अधिक प्रभेदों को जीवित तथा अतिन्यून्तम (–196 डिग्री सै) अवस्था में संरक्षित किया गया। भारत में गेंहूँ एवं जौ के रतुआ रोगों के अध्ययन के लिए 45 वैज्ञानिकों/केन्द्रों को रतुआ रोगों के बीजाणुओं की आपूर्ति की गयी। कम महत्वपूर्ण प्रभेदों को दीर्धकालिन भंडारण में रखा गया है। गेहूँ के रोगो की घटना एवं प्रसार के अध्ययन के लिए गेहूँ रोग निरीक्षण नर्सरी (गे.रो.नि.न.) और सार्क देशों में, रोग नियन्त्रण को क्रमश भारत के 37 से अधिक और सार्क देशों में 28 स्थानों पर आयोजित किया गया। इन क्षेत्रों में किसी भी बिमारी का ज्यादा प्रकोप नहीं था।

क्षेत्रीय केन्द्र दालंग मैदान (लाहौल और स्पीती)

- गेहूँ के 9000 और जौ के 2000 जननद्रव्य को प्राकृतिक परिस्तिथियों में संरक्षित किया जा रहा है। संरक्षण को दृढ़ता प्रदान करने के लिए एक अलग से भंडारण कक्ष की स्थापना की जा रही है।
- लाहौल– स्पीती के कृषकों की आय बढ़ाने के लिए जनजातीय उपयोजना के तहत एक त्रिदिवसीय प्रशिक्षण कार्यक्रम का आयोजन भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल में किया गया। इस प्रशिक्षण कार्यक्रम में घाटी के 45 किसानों ने भाग लिया ।
- दालांग मैदान प्रक्षेत्र में सिंचाई की समस्या से निपटने के लिए सिंचाई विभाग, हिमाचल प्रदेश द्वारा सिंचाई पाईप लाईन की मरम्मत का कार्य पूर्ण किया गया।

बीज एवं अनुसंधान प्रक्षेत्र, हिसार

- वर्ष 2020 के दौरान कुल 1011.65 कुंतल गेहूँ एवं जौ के प्रजनक बीज का उत्पादन किया गया, जिसमें से 765.5 कुंतल बीज गेहूँ की तीन प्रजातियों (डब्ल्यू.बी 2, डी.बी.डब्ल्यू. 173 और डी.बी.डब्ल्यू. 252) का था और शेष 246.1 कुंतल बीज जौ का था ।
- प्रक्षेत्र ने 47.24 कुंतल गेहूँ तथा जौ के मिश्रण का उत्पादन किया, जिससे कुल ₹ 67053 राजस्व प्राप्त हुआ ।
- प्रक्षेत्र की मृदा में कार्बनिक अंश को बढ़ाने के लिए खरीफ मौसम में ढेंचा उगाया गया ।

संस्थान की अन्य गतिविधियाँ

- वर्ष के दौरान संस्थान ने प्लांट डिसीस मैनेजमेंट पर एक राष्ट्रीय सेम्पोसियम, व्हीट प्रोडक्शन टेक्नीक पर ब्रेन स्टोर्मिंग सेशन, डी.यू.एस. पर अन्तर्राष्ट्रीय कार्यक्रम, डिजिटल फील्ड बुक पर राष्ट्रीय कार्यशाला आयोजित की।
- 59वीं अखिल भारतीय गेहूँ और जौ शोधकर्ताओं की बैठक का आयोजन वर्चुअल मोड में अगस्त 24–25, 2020 को किया गया।
- निदेशक, भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल की अध्यक्षता में संस्थान द्वारा संस्थान अनुसंधान परिषद की बैठक का आयोजन 11/02/2020 और 29/10/2020 को किया गया।
- संस्थान ने अपना स्थापना दिवस, गांधी जयंती उत्सव, स्वच्छता पखवाडा के साथ–साथ योग दिवस, अन्तर्राष्ट्रीय मृदा दिवस, सविंधान दिवस इत्यादि मनाया।
- वर्ष 2020 में संस्थान को कृषि संस्थान सम्मान पुरस्कार से सम्मानित किया गया। संस्थान के निदेशक, डा. जी.पी. सिंह को डा. ए.बी. जोशी मैमोरियल पुरस्कार, आउटलुक आउटस्टेंडिंग वैज्ञानिक पुरस्कार, कृषि में आउटस्टेंडिंग लीडरशिप पुरस्कार से सम्मानित किया गया।
- संस्थान के वैज्ञानिकों को डा. एम.वी. राव मैमोरियल पुरस्कार, एस. नागराजन मैमोरियल पुरस्कार, प्रोफेसर महातिम सिंह मैमोरियल पुरस्कार से सम्मानित किया गया।
- संस्थान ने वर्ष 2020 के दौरान लगभग 82 शोध पत्र राष्ट्रीय एवं अन्तर्राष्ट्रीय जनरल में प्रकाशित किये तथा 7 पुस्तकें भी प्रकाशित की।
- वर्ष के दौरान श्री संजय भाटिया, संसद सदस्य (करनाल), श्री संजय सिंह, सचिव (भा.कृ.अनु.प. नई दिल्ली), डा. ए.के. सिंह, उपमहानिदेशक (कृषि विस्तार), डा. आर.सी. अग्रवाल उपमहानिदेशक (शिक्षा), डा. के.वि. प्रभु, अध्यक्ष, पौ. कि. एवं कृ. अ. सं.प्रा., नई दिल्ली, डा. अनिल जोशी, संस्थापक हैस्को, डा. मनमोहन सिंह चौहान, निदेशक, रा.डे.अनु.सं. करनाल, डा. समर सिंह, उपकुलपति, महाराणा प्रताप बागवानी विश्वविद्यालय, करनाल इत्यादि गणमान्य व्यक्तियों ने संस्थान का दौरा किया।

EXECUTIVE SUMMARY

CROP IMPROVEMENT

- The crop season 2019-20 has been a landmark year in achieving the record production of 107.59 million tonnes of wheat and highest productivity of 3508 kg/ha.
- ICAR-IIWBR was instrumental in the release and notification of 11 new wheat varieties (8 bread + 3 durum wheat) by CVRC for commercial cultivation in different wheat growing regions of the country.
- ICAR-IIWBR developed and registered 7 novel genetic stocks out of total 15 wheat germplasm recommended for registration by the Plant Germplasm Registration Committee of the ICAR-NBPGR, New Delhi.
- The Germplasm Resources Unit (GRU) at ICAR-IIWBR acquired 451 accessions from various institutes including 264 land races of Indian wheat and 18 aphid resistance lines from CIMMYT, Mexico. Institute also supplied 2282 accessions of wheat to various indenters across the country for research purposes. Additionally, 350 advanced lines were exported to Bangladesh and Bolivia for screening against wheat blast disease. The GRU also characterized 523 new germplasm accessions for 36 DUS traits.
- The pre-breeding project during 2020 created novel genetic variability by hybridization of bread wheat with wild species like *Th. bessarabicum* and *Ae. peregrina* etc. Developed two novel genetic stocks for high grain zinc (Karan Poshan 1) and iron (Karan Poshan 2) concentration.
- The project on wheat improvement for high productive environments of north-western plains of India, developed a high yielding wheat cultivar DBW 303 (Karan Vaishnavi) for irrigated, early sown condition of NWPZ. The committee also recommended the area extension of wheat variety DBW187 (Karan Vandana) to irrigated, early sown conditions of NWPZ. A novel genetic stock DBW 166 for high water use efficiency was also developed under the project.
- The project on wheat breeding for eastern region identified a novel wheat blast resistance germplasm BRW3806.
- Wheat improvement for warmer areas project developed a new high yielding wheat variety, DBWH 221 for timely sown irrigated conditions of the Haryana state. Also developed a novel genetic stock DBW 278 for high sedimentation value under very late sown conditions of northern plains along with resistance to leaf rust, Karnal bunt and loose smut.
- Hybrid wheat project maintained 16 CMS sources and 46 diversified new CMS lines during 2020 and evaluated experimental hybrids for their heterotic potential.
- Wheat quality breeding project developed a high yielding durum wheat variety (DDW 48) for timely sown conditions of PZ. Also developed a novel germplasm QST1910 for drought tolerance.
- The biotechnology group mapped novel QTL regions controlling resistance to brown, yellow and black rusts through 483 diverse GWAS panel. Also identified novel QTLs for Karnal bunt resistance in wheat. Developed heat-responsive gene-based SSRs (cg-SSR) markers from genic regions. A total of 400 Indian wheat cultivars were genotyped with functional markers of vernalization genes viz. *Vrn-B1, Vrn-D1* and *Vrn-B3*. Differential expression analysis of bacterial genes in contrasting wheat genotypes for drought and heat stress tolerance was performed. Developed a novel drought and heat stress tolerance wheat genotype RW5.
- The germplasm donors for important photosynthesis parameters were identified through physiological screening. RWP-2018-31 and RW-2018-32 were identified as heat tolerance germplasm through screening under multi-location heat tolerance trial.
- The novel CRISPR/Cas9 technique of gene and genome editing is being used to improve yield and abiotic stress tolerance traits in wheat. Knock down of *TaMS1* gene in wheat to develop male sterile lines for hybrid seed production is also underway.
- A total of 4284.6q breeder and TL seed of 9 wheat varieties was produced at ICAR-IIWBR and an amount of approximately 2.85 crores of revenue was generated by distribution of improved quality seed to various stakeholders. The institute created the wheat seed portal for safe seed distribution to farmers during COVID-19 pandemic.

CROP PROTECTION

- The disease and pest situation in farmers fields was monitored by regular surveys and networking with different agencies DAC & FW, ICAR, SAUs, State Agriculture Departments, KVKs, Farmer's etc. The first occurrence of yellow rust in crop season 2019-20 is reported from the three fields in Anandpur Sahib block of

District Rupnagar in villages Chandesar and Darolli (Hethlii) on varieties HD3086, PBW677 and WH 711 on 26.12.2019.

- The surveys were also conducted in West Bengal along Bangladesh border for wheat blast and found no report of wheat blast occurrence in West Bengal whereas in some place leaf rust and head scab has been reported at low intensity.
- A total 1324 entries in IPPSN and 397 entries in PPSN were screened against rusts.
- A set of 27 entries with confirmed sources of multiple disease resistance were shared with 20 breeding centers located in different agro climatic zones of the country.
- During 2019-20, 2438 grain samples collected from Haryana, Rajasthan and Uttarakhand were analyzed for Karnal bunt infection. The 50.5% samples were found infected with maximum per cent infection from Haryana (57.8%).
- To combat the threat of wheat blast and check entry of blast from Bangladesh, strict quarantine has been observed in Murshidabad and Nadia district as well as 5 Km along the Bangladesh border.
- For identification of wheat blast resistant sources, a total of 350 Indian wheat varieties and advance breeding material were screened at Jessore, Bangladesh and Bolivia through CIMMYT. Six resistant varieties namely DBW187, HD3249, HD2967 (irrigated and timely sown), DBW252, HD 3171 (restricted irrigation and timely sown), and HD 3293 (restricted irrigation and timely sown) have been identified for NEPZ on the basis of resistant to wheat blast.
- New chemical has been evaluated against yellow rust, powdery mildew and head scab diseases of wheat.
- PCR based diagnostic assay for quick detection of flag smut fungus (*Urocystis agropyri*) has been developed. To detect *U. agropyri*, two sets of species specific primers namely UA-17F/UA-519R and UA-15F/UA-562R were developed from internal transcribed spacer (ITS) DNA region, which amplify the region of 503 and 548 bp, respectively, and specific to only *U. agropyri*.
- Genetic variability in *Bipolaris sorokiniana* was studied by using ITS sequencing of isolates collected from different wheat growing zones. Genetic analysis suggested the existence of two distinct lineages and 59 haplotypes with three major haplotypes which showed star-like structure network surrounded by several single haplotypes, revealing high frequency of the mutations in total analyzed population. H-3 haplotype was observed predominant and prevalent in all the five zones.
- Moderate to severe incidence of wheat aphid and pink stem borer was observed in some villages like Kunjpura, Subhari, Racina and Hajwana of Karnal district. Incidence of foliar aphid, termites and pink stem borer was also recorded in Ladwa, Yamunanagar, Noorpur Bedi, Anandpur Saheb, Banur, Abhiyana Kalan Ropar and Bajrur, whereas, foliar aphid damage was recorded in some parts of Banur. The grubs and adults of *coccinellid* beetles were seen frequently in fields infested with aphids.
- Amongst 198 *Aegilops* accessions screened against the corn leaf aphid (CLA) *Rhopalosiphum maidis* (Fitch), ten accessions viz., *Ae. ovata* 23, *Ae. tauschii* accession nos.15, 59, 3758, 14336, 14338, 3761, 9795, 3806 and 13757 gave resistant response to corn leaf aphid
- One or two sprays of $ZnSO_4$ mixed with thiamethoxam effectively reduced the aphid population. Similarly, $ZnSO_4$ can also be mixed with propiconazole + thiamethoxam without any adverse effect. The *coccinellid* predators were also not adversely affected by application of one or two sprays of $ZnSO_4$ mixed with insecticides and fungicides at reproductive stages of wheat crop.
- Amongst the tested organic formulations *viz.,* Neemastra, Bramhastra, Agniastra, Deshparni, Fermented butter milk and Cow urine, Bramhastra @7.5% was found to be the most effective treatment as compared to other tested organic treatments. The organic treatments were found safer to natural enemies and little effect was seen on their population as compared to check of insecticide spray with Thiamethoxam 25 WG.
- Beta-Cyfluthrin 9%+ Imidacloprid 21% (Solomon), Lambda cyhalothrin 5% EC @ 500 ml/ha, Imidacloprid 17.8 SL @ 400 ml/ha and Beta-cyfluthrin 25 SC @ 1450 ml/ha were also found equally effective for checking aphid population.
- Incidence of foliar aphids and termite damage was maximum in conventional tillage whereas root aphid and pink stem borer infestation were highest in zero tillage system. Relationship between aphid population with NDVI & canopy temperature was also studied under these tillage systems and it was found that NDVI had positive correlation with aphid abundance and with canopy temperature had negative correlation.

- Barley genotypes viz., Azad, BHS352, Amber, Kedar, BHS169, BK306, BH959, BH946,R-56,BG-105 and BCU2241 were found promising against storage insect-pests.

RESOURCE MANAGEMENT

- In a long term tillage experiment in maize-wheat-green gram systems indicated that the wheat crop was not affected by tillage and residue management. Among nutrient management wheat grain yield was maximum with application of Rec. NPK + 10 t/ha FYM (62.23 q/ha).
- The performance of ten wheat varieties under two dates of sowing and two tillage options (CA and CT) were evaluated. Results showed that mean wheat yield of early sowing (25^{th} Oct) was significantly better compared to timely sown (15^{th} Nov.). Among genotypes, BISA 927, PBW 723, HD 2967 and BISA 921 were better yielder.
- Field demonstrations were conducted at farmers' fields for *in-situ* management of rice and sugarcane residues using Rotary Disc Drill, Turbo Happy Seeder and Super Seeder at Kaimla village of Karnal. The results of the wheat sown using Super Seeder was found encouraging.
- For maximizing wheat productivity, out of 16 genotypes evaluated, DBW 187, HD 3086, DBW 303 and DBW 329 were better yielder with 75.86, 74.83, 74.49 and 74.31 q/ha, respectively, under 150% RDF + 15t FYM/ha along with two sprays as tank mix- Chlormequat chloride (Lihocin) @ 0.2% + tebuconazole (Folicur 430 SC) @ 0.1% of commercial product dose.
- Integrated nutrient mangement consisting of application of recommended doses of chemical fertilizers (NPK 150:60:40) with 15 t/ha FYM was found the highest yielder and it was followed by recommended NPK + green manuring. Sole use of P, K or PK did not improve the wheat productivity compared to absolute control.
- In organic production of HYVs (HD 2967, HD 3086, WB-2, 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). Use of FYM improved the soil physico-chemical properties of the soil as compared to control and recommended NPK.
- Green gram cultivation after wheat produced 10-12 q/ha pulse yield and its residue incorporation saved 50 % nitrogen to rice crop and produced maximum rice yield besides improving the soil *physico*-chemical properties. 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.
- Intercropping of pulses viz. green gram, black gram, cowpea and clusterbean with maize in sequence with wheat crop improved the system productivity and resource use efficiency. Maximum LER was obtained under treatments Maize + Cowpea-wheat (1.71).
- Comparing of eight cropping sequence revealed that system productivity measured as wheat equivalent yield (WEY t ha^{-1}) was significantly higher under Maize-Potato-Wheat (16.49 t ha^{-1}) and Maize-Wheat-Greengram (16.17t ha^{-1}) rotations than others.
- Herbicide combinations of Halauxifen+ fluroxypyr 200.6(6.1+194.5) g/ha, metsulfuron + carfentrazone 5+20 g/ha and Halauxifen + florasulam 12.76 g/ha applied as post emergence were effective for control of diverse broadleaved weed flora in wheat. These herbicide combinations have shown good selectivity in wheat and barley. Further, three herbicides combination, halauxifen + florasulam + carfentrazone improved the range of weed flora control including control of sulfonyl urea herbicide resistant *Rumex dentatus*.
- For control of metsulfuron resistant *Rumex dentatus* and *Chenopodium album* 2,4-D, carfentrazone, isoproturon and fluroxypyr were found effective.
- Pyroxasulfone + metsulfuron 125+4 g/ha, Pyroxasulfone + pendimethalin 125+1000 g/ha and pendimethalin + metribuzin 1250+300 g/ha as pre-emergence and tank mixture of Clodinafop/pinoxaden with metribuzin as post emergence were found effective for control of diverse spectrum of weeds in wheat.
- In Direct Seeded Rice, bispyribac+pendimethalin at sowing fb fenoxaprop+ ethoxysulfuron were effective in controlling broad spectrum weeds.
- For management of Multiple Herbicide Resistant *P. minor and A. ludoviciana* (against clodinafop, pinoxaden and sulfosulfuron) pyroxasulfone and metribuzin were found effective.
- Integration of no-till system in combination of various pre seeding herbicides (Pendimethalin+metribuzin or metribuzin alone or pyroxasulfone + metsulfuron) effectively controlled the *P. minor* in wheat.
- Out of 30 wheat genotypes tested for higher water use efficiency, DBW 110, DBW 222, DBW 173, DBW 243 and DBW 166 were found among genotypes with desirable water use efficiency ranging from 21.5 to 26.6 kg mm^{-1}.

QUALITY AND BASIC SCIENCES

- In bread wheat (*T.aestivum*), genotypes having good chapati making quality (score >7.9/10.0) such as HD2967, DBW303 and HI1634 were identified.
- Bread wheat genotypes namely HD3059, DDW173, WH1124 and HD3298 showed high bread quality with loaf volume >600cc.
- 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 UAS446, and DDW48 showed better pasta quality and grain protein content. DDW47 and WHD964 were identified for high yellow pigment content (>7.5 ppm), which is a highly desirable trait for pasta products.
- Several *aestivum* and *durum* entries of AVT exhibited high iron and zinc content (>40.0 ppm) indicating better nutritional quality in recently developed wheat entries.
- Quality Component Screening Nursery (QCSN) of 52 entries from 10 locations was evaluated for grain appearance, protein content, sedimentation volume and hectolitre weight and Fe and Zn content.
- Recently developed wheat varieties showed significant improvement in sedimentation value (>60 cc) across the zones indicating strong gluten in the newly developed varieties and thus suitable for bread quality.
- Large numbers of segregating generations (800), released varieties (300), mutant populations (1000), coordinated samples (2000) were evaluated for quality traits utilizing micro-level tests and desirable genotypes were selected for further advancement during 2020-2021 crop season.
- Three years evaluation of foliar spray of Fe and Zn exhibited significant increase in the grain Zn and Fe content indicating that agronomic bio-fortification can be very effective way of increasing Fe and Zn content in wheat.
- Transcriptome analysis of two Indian wheat genotypes conducted at seedling stage provided new insight of understanding mechanism of Fe and Zn absorption, translocation and accumulation. Several differentially expressed genes were identified with upregulation and involved in Phytosiderophore synthesis under Fe/Zn deficiency conditions in wheat.
- F_2, F_3 BC_1 and BC_2 generations of crosses involving high phytase (>2200 FTU/kg)mutant lines developed in the background of PBW502 and high Fe and Zn lines were grown during 2019-20 for further advancement and selection. This will lead to improved bioavailability of micronutrients in wheat to human beings.
- RILs (F_7) of a cross between a wheat line containing *Gpc-B1* gene and high yielding variety HD 2967 are at F_8 stage and grown during 2020-21. These will be used 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 PBW373, UP2425, Raj3765, DPW50, HD2967 using molecular markers and microlevel tests. Materials with desirable traits are at different stages of development. One of the improved lines has been submitted for germplasm identification.
- 19 wheat varieties of NWPZ were analysed for phenolic content and total antioxidant capacity in terms of DPPH radical scavenging activity from two locations namely Ludhiana and Pantnagar and it showed large variations and significant effect of the environment on antioxidant levels.

SOCIAL SCIENCES

- During 2019-20, 1468 Wheat Frontline Demonstrations (WFLDs) of one acre each were conducted through 83 cooperating centres covering 1479.52 acres area of 1607 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 (190) followed by Bihar (142). The maximum per cent yield gain was observed in Manipur (59.52%) followed by Assam (35.12%) and Jharkhand (32.23%). The per cent yield gain due to improved varieties over checks was highest in NHZ (23.94%) followed by NEPZ (21.55%), CZ (15.67%), PZ (10.43%) and NWPZ (08.07%).
- In case of improved durum varieties, the variety HD8759(d) gave an average yield of 67.60 q/ha at Indore centre in CZ. In PZ, the variety MACS3949 (d) gave an average yield of 40.00 q/ha at Pune center.
- In NHZ, at Almora centre, improved rainfed variety VL967 yielded 37.17 q/ha which was higher than the check varieties. Improved rainfed variety HS542 gave significantly higher yield of 33.58 q/ha and 30.28 q/ha at Khudwani and Rajouri centres against check varieties

SKW355 and VL829, respectively. In CZ, DBW110 gave 71.40 q/ha yield at Ujjain center, which was significantly higher than the check variety HI1544. In PZ, NIAW3170 yielded 41.90q/ha under rainfed condition at Niphad centre.

- Wheat FLDs gave ₹2.78 per rupee of investment in comparison to the check varieties (₹2.47). The returns per rupee of investment from wheat FLDs ranged from ₹3.74 (Gujarat) to ₹1.88 (Tamil Nadu) across states, ₹3.32 (CZ) to ₹2.38 (NHZ) across zones and ₹3.71 (Happy Seeder) to ₹1.88 (*Dicoccum* wheat) across technologies. The profit per hectare in FLDs was highest in Gujarat (₹93444), followed by Madhya Pradesh (₹85402) and New Delhi (₹84547). On an average, with the adoption of a new wheat variety or production technology, a farmer earns ₹63690/ha. Further, ₹707 have to be spent to produce a quintal of wheat through new technology against ₹798(farmer's practices: check plots).
- High cost of inputs, small land holding, *Phalaris minor*, non-availability of labour, non-availability of seed of newly released varieties, untimely rain, low price of wheat, lack of canal irrigation facility, decline of water table, higher customer hiring rate for field operations were perceived as major constraints in wheat production in the country.
- During 2019-20, 231 Barley Frontline Demonstrations (BFLDs) of one acre each were conducted by 20 cooperating centers across six states namely, HP, UP, Punjab, Haryana, Rajasthan and MP, covering 237 acres area of 251 farmers. Improved barley varieties with complete package of practices (irrigation management, nutrient management, weed control, seed treatment etc.) were demonstrated.
- The highest per cent gain in barley yield was recorded in UP (31.05 %) followed by HP and MP (23.31%). The lowest gain in yield was reported in Haryana (5.95 %).
- In NHZ, barley variety BHS400 was the average highest yielding (30.58 q/ha) variety at Bajaura centre. In NEPZ, RD2907 at Mirzapur (52.88 q/ha), RD2907 at Durgapura (65.15 q/ha) in NWPZ and RD2899 at Vidisha (50.55 q/ha) in CZ were the highest average yielding varieties.
- BFLDs gave around 12% profit per hectare in comparison to the check. Under BFLDs, Uttar Pradesh registered the highest returns per rupee of investment (₹4.50) through demonstrations, followed by Punjab (₹3.58) and Haryana (₹2.58). The profit per hectare in BFLDs was highest in Rajasthan (₹62654), followed by Uttar Pradesh (₹62269) and Punjab (₹60003). The returns per rupee of investment were highest in the NEPZ (₹4.50), followed by NWPZ (₹2.89) and CZ (₹2.29). Cost of production indicated that it was least (₹442 per quintal) in Uttar Pradesh (NWPZ) owing to less operational costs coupled with increased yields levels.
- Resistance against herbicides, high cost of inputs, decline in water table, low price of barley grain, lack of canal irrigation facility, small land holding, non-availability of labour, temperature fluctuation during crop growth, higher customer hiring rate for field operations and *Phalaris minor* were perceived as major production constraints in barley.
- ICAR-IIWBR conducted 20 wheat FLDs using varieties DBW187, HD3226 and HPBW01 with a complete package of practices over 20 acres area at twenty farmers' fields in the villages namely Ramba and Butana in Karnal District and villages Bid Amin, Fatuhpur, Mirzapur and Dabkheri in Kurukshetra District of Haryana state.
- The ICAR-IIWBR team accompanied by the experts from the Ministry of Agriculture & Farmers Welfare and the concerned centres, monitored the FLDs conducted by Niphad Nasik, Pune, Imphal, Kalyani, Wellington, Dharwad, Meerut, Shamli, Saharanpur, Muzaffarnagar, Bilaspur, Jagdalpur, Kanke Ranchi, Morabadi Ranchi, Pusa Samastipur, Rewa, Panna and Jabalpur centres.
- The study under the project *'Diagnosis of zero tillage based rice-wheat system in Haryana'* was conducted in Karnal, Yamunanagar, Kaithal and Rohtak districts of Haryana during 2015-16 to 2019-20. A total of 420 farmers were selected for this study. The impact was studied by using pre and post method and beneficiary and non-beneficiary methods. In Karnal, Yamunanagar and Kaithal districts zero tillage method was compared with conventional method whereas in Rohtak district the impact was studied by comparing beneficiaries of zero tillage with non-beneficiaries. The study revealed that majority (39.67%) of the respondent farmers belonged to 31-40 years age group followed by 41-50 years age group (32.33%). A total of 85.67% of the sampled farmers were below 50 years of age. It shows the involvement of youth in agriculture of Haryana. Only five percent of the farmers were illiterate. Majority (36.33%) of them were matriculate and 10+2 (22.33%). Agriculture was the primary occupation of 88.33% of the farmers and 9.67 were involved in dairying along with agriculture. Dairying was the subsidiary occupation of 32.33% of the farmers. Out of 300 farmers, majority (60%) were in large category (>10 acres of land holding). Only 2.67% were under marginal category. Tube well was the main source

of irrigation for majority of the farmers. Quality of water was normal in the study area and the soil was medium to heavy with high to medium fertility. Few farmers were found burning crop residue to get their field clear for sowing of wheat crop but their number was quite low. With the State Department of Agriculture initiatives the number was continuously decreasing. Under the study it was found that 99.33% of the farmers adopted zero tillage method for sowing of wheat. They used either zero till seed drill or turbo happy seeder for sowing of wheat. Direct seeded rice technology was adopted by 32.67% of the farmers and 58.67% of the farmers adopted both technologies at their farm. It was observed that for zero till seed drill, custom hiring charges were ₹ 600-700/acre, for turbo happy seeder ₹ 1000-1200 and for DSR ₹ 900-1000. If any farmer wants to purchase these machines, he can avail 50% subsidy, but if these machines are purchased for custom hiring centres then they can avail 80% subsidy. This is a strong initiative by Haryana Government to popularise these technologies in the state.

- The most frequently used wheat variety under zero tillage conditions was HD 2967 and was adopted by 91.95% of the farmers. HD 3086 was the second most commonly used wheat variety by 28.19% farmers. The other varieties were HD 1105 (8.05%), DBW 88 (5.37%) and others (HD 2851, HDCSW 18 and PBW 723) only 3.02%.
- The impact of zero tillage technology was studied on a number of parameters and it was found that 80.54% of the farmers felt that it takes less time in comparison to conventional tillage for sowing of wheat crop. Majority (84.56%) have used same seed rate, observed better germination (55.37%), applied similar quantity of fertilizer (57.38). But some of the farmers used less (13.9%) and more (22.82%) than the recommended dose.
- It was also observed by majority of farmers (71.47%) that there was decrease in number of narrow leaf weeds under zero tillage, increase by 2.01% farmers and 28.51% farmers did not find any difference in weed population. In case of broad leaf weeds there was increase in number in zero tillage fields and was recorded by 20% farmers but majority (32.21%) observed no change. There was decrease in overall weed population under zero tillage and 94.97% observed it in their fields. Majority (82.55%) felt less water requirement under zero tillage wheat than conventionally sown wheat. Most of the farmers (94.97%) found it cost effective and large majority harvested more yield i.e. 2-3q/ha under zero tillage. A large majority (91.95%) of them observed that there was not any change in crop duration under both the conditions.
- Impact of zero tillage on soil parameters was also recorded and was found that fertility status has increased due to adoption of ZT and was experienced by 93.62% farmers. Majority of them (83.22%) found increased organic carbon content in soil of ZT fields due to incorporation of rice residue during sowing. Increased moisture retention capacity was observed by 88.93%, less lodging by 92.285 and avoidance of terminal heat by 93.96% farmers. Soil physic-chemical properties also enhanced due to continuous adoption of zero tillage. It could be inferred from all findings that zero tillage technology is a boon for wheat farmers and with its adoption majority of the problem associated with rice- wheat system can easily be addressed.
- In this project *'Identifying yield gaps, resource use and adaptation strategies in vulnerable regions of wheat and barley production against climate change'*, primary data on wheat production particulars and socio-economic characteristics of farm households were collected during 2019 from 200 wheat and 100 barley producers across two randomly selected districts of Eastern Uttar Pradesh viz., Allahabad and Ghazipur (moderate vulnerable category).
- In the case of wheat, the Yield Gap I was found to be negative in Allahabad (-8 % : -4 Q/ha) and the Yield Gap II was highest in Allahabad (148.63 % : 28.89 Q/ha). Analysis of resource use pattern indicated that there exists significant difference in the use of resources between Allahabad and Ghazipur districts of Eastern Uttar Pradesh. Seeds were used more than the recommended doses. Fertilizers were used either below or above the recommended doses across the selected farms. Among all inputs, expenditure incurred on manure/bio-fertilizer showed a significant difference.
- The implications 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 scoring analysis indicated that the awareness level was too low with respect to adaptation strategies and poor access to the technologies and very poor adoption rate barring improved management with new crop varieties, application of more organic manures,

supplemental irrigation through groundwater, irrigation depth/frequency and insurance. The analysis indicated the need for increasing the awareness of climate smart farming practices and adaptation strategies among the farmers in Eastern Uttar Pradesh, especially with conservation agriculture.

- Under the TSP project, the following eight 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 2019-20, different TSP activities were carried out. The demonstrations on wheat crop were conducted with complete package of practices at 66, 50, 60, 43, 60 and 23 farmers' fields at Khudwani, Jabalpur, Udaipur, Bilaspur, Dharwad and Ranchi centers, respectively. Under TSP wheat demonstrations, the seeds of improved wheat varieties were supplied. Thirteen training programmes on wheat production technology were conducted at Khudwani (2), Bilaspur (2), Dharwad (1), Leh (4) and Lahaul & Spiti (4) centers. Three Awareness camps/Exhibitions/ Exposure visits were organised. Three publications, one at Khudwani and two at Dharwad center were published. Under the 'Grant in Aid-General' head in budget, funds have been approved and released for the year 2020.
- Apart from the above activities, Social Sciences unit coordinates the Government flagship development programmes like *'Mera Gaon Mera Gaurav'* scheme, activities pertaining to doubling farmer income, creating awareness on soil health cards etc. During the period, different activities likes training programmes (3), awareness programmes (2) were organised at ICAR-IIWBR apart from participation in 7 exhibition/outreach programmes and 2 TV programmes and 21 coordination visits of various stakeholders. The farmers were advised on various aspects of wheat and barley cultivation. More than 600 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 1.69 MT of barley from an area of 6.18 lakh ha was achieved in the country during 2019-20 with average productivity of 27.3 q/ha.
- Out of 86 yield evaluation trials proposed, 84 trials were conducted and after the analysis, only 78 trials (91% of proposed, 95% of conducted) were found good for reporting. These trials were conducted at 11 main centres and 30 testing centres (including ICAR, SAUs and State Department of Agriculture) during Rabi 2019-20.
- In all 97 test entries contributed by 12 centres, were evaluated against 24 checks in the coordinated yield trials under rainfed (plains and hills), irrigated (plains) and saline soils conditions.
- A malt barley variety DWRB182 with low levels of grain and wort beta glucans content was released for cultivation in North Western Plain Zone.
- A genetic stock DWRB207 with resistance to stripe rust coupled with good 1000 grain wt. and low protein content was got registered with NBPGR.
- Breeder seed production of 997.25q of 28 barley varieties was organized against the indent of 526.97q with help of coordinated research centers.
- Six germplasm lines namely, BYT-HI (2019-20) (entry nos. 6, 11 and 13) and 7th GSBYT (2019-20) (entry nos. 10, 11 and 15) were found superior in ICARDA nurseries under multi-locational evaluation.
- A total of 8239 accessions of barley are being conserved and maintained in medium term storage facility in module at ICAR-IIWBR, Karnal. A total of 498 germplasm lines were rejuvenated during rabi 2019-20 and 652 were exchanged.
- There is a strong correlation between grain beta amylase activity and malt diastatic power.
- Two genotypes SLOOP SA WL 3167 and SLOOP VIC VB 9953 have been identified for very low wort beta glucans content in malting quality evaluation, while DWRB182 was a good combination of grain and malt traits with other traits required as a variety for commercial cultivation.
- Application of Pusa Hydrogel and a New Hydrogel @ 2.5 kg ha^{-1} resulted in significantly higher grain yield as compared to control conditions. One irrigation water (6 lac litre/ha) can be saved by use of the hydrogel by producing same level of yield.
- In NHZ, conventional tillage and zero tillage+residue were at par and superior to zero tillage alone. Being the importance of residue in soil fertility build up and saving of resources at the time of sowing, zero tillage + residue is recommended for barley sowing in NHZ.
- Soil application with zinc sulphate @ 25 kg/ha was found superior as compared to all soil and foliar application in NWPZ. In NHZ, NEPZ and CZ, soil application with zinc sulphate @ 25 kg/ha followed by foliar application (0.5%

zinc sulphate) at heading and early milk stage was found superior compared to all other treatments.

- Different malt barley varieties produced maximum yield under 60 kg per ha after which crop lodged due to rain and high winds at the time of maturity and affected the yield adversely under higher nitrogen doses (> 60 kg/ha).
- Four AVT entries (DWRB182, DWRB196, DWRB197 and PL908) and checks (DWRB101, DWRB123, DWRB160, RD2849 & BH902) were characterized at molecular level to analyze genetic variability in advanced varietal trials 2019-20 using barley specific molecular markers (46 SSR/STS markers covering seven chromosomes).

REGIONAL STATION, SHIMLA

- *Lr80*, a widely effective leaf rust resistance gene was identified in 2DS chromosome of wheat land race, Local Hango. It confers resistance to all the predominant and virulent pathotypes of *Puccinia triticina* in India. Tightly linked markers will help in its precise transfer to wheat germplasm and increase the diversity for leaf rust resistance. This is the 6^{th} rust resistance gene designated from India.
- There was no report of any major rust epidemic in wheat growing areas in India. Stripe (yellow) rust was observed in localized fields of some areas in Northern India. Leaf (brown) rust was recorded sporadically in some areas from Maharashtra, Karnataka, Gujarat and Madhya Pradesh. There were few reports of stem (black) rust of wheat and barley in farmer's field from some areas of Peninsular India. Practically it was another rust free wheat year. A total of 897 samples of three rusts of wheat and barley were analyzed during the year from fourteen Indian states, and Nepal. These samples comprise 305, 127 and 465 samples of stripe, stem and leaf rusts, respectively. Stripe rust resistance genes *Yr5, Yr10,Yr13, Yr15, Yr16* 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), *P. graminis tritici* (Pgt) and *P. triticina* (Pt) populations, respectively. Pathotype 238S119 of *P. striiformis* was the most predominant among the seven pathotypes and was observed in 44.06% samples. The population of 46S119 has declined to 33.2% followed by 110S119 in 18.98% of the samples. Pathotype 11 of *P. graminis tritici* was the most occurring pathotype and was observed in 88.2% of the samples followed by 40A in 4.7% samples. Pathotype 77-9 (121R60-1) followed by 77-5 (121R63-1) were the most widely prevalent pathotypes of *P. triticina* and were found in 50.3% and 77-5(28.2%) samples, respectively.
- Seedling resistance evaluation of more than 3500 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 137 of AVT I and II, 160 of NBDSN and EBDSN, and lines received from Breeder's and other sources.
- Resistance to all the rusts was not observed in any wheat line. PBW813 was resistant to stem and stripe rusts. Whereas HI1641, HI1642 and MACS6752 were resistant to leaf and stem rusts. Twenty other lines were resistant to leaf and 4 to stem rust only. In addition, 25 lines having *Sr31/Lr26/Yr9* were resistant to stem rust. Four *Yr* genes (*Yr2, Yr9, YrA,* and *Yr18*) were inferred in 95 advance wheat lines. Similarly,Ten *Lr* genes *viz. Lr1*, *Lr2a*, *Lr3*, *Lr10*, *Lr13*, *Lr18*, *Lr23*, *Lr24*, *Lr26* and *Lr34* were characterized in 112 lines and thirteen stem rust resistance genes (*Sr2, Sr5, Sr7b, Sr8a, Sr8b, Sr9b, Sr9e, Sr11, Sr13, Sr24, Sr28, Sr30* and *Sr31*) were characterized in 122 AVT lines.
- APR to both leaf and stripe rusts was not observed on any wheat line. DBW187 possessed APR to all the three pts. of Pst and pt. 77-5 of Pt. Likewise HD3086 conferred APR to Pst and pt.104-2 of Pt whereas HD3332 to Pst and pts.77-5 and 77-9 of Pt.
- None of the NBDSN lines was resistant to all the rusts of barley. Twelve lines were resistant to both leaf and stripe rusts, one to stem and stripe rusts whereas 4 to leaf and stem rusts. In addition, 16 lines were resistant to stripe, 2 to stem and 22 to leaf rust only.In EBDSN, none of the 44 lines had resistance to three rusts. However, 9 lines were resistant to leaf and stripe rusts, 1 to stem and stripe rusts, 2 to leaf and stem rusts. Resistance to individual rust was observed in 19 lines. Of these 10 lines showed resistance to stripe, one to stem and 8 to leaf rust only.
- *Lr68* which cannot be identified through host pathogen interactions was identified through a tightly linked marker in 34 of the 102 wheat accessions evaluated. DNA polymorphism studies were conducted on selected pathotypes of three rusts.Sufficient polymorphism was observed in 29 pathotypes of *P. graminis tritici*, 11 pathotypes of *P. striiformis* and 5 new pathotypes of *P. triticina*.
- National repository of more than 120 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. Less important and avirulent pathotypes have been put under long term storage. To monitor, the occurrence/spread of diseases, wheat disease monitoring nursery (WDMN/TPN) and SAARC wheat disease monitoring nursery were organized and conducted at more than 37 locations in India and 28 locations across the six SAARC countries, respectively. There was not major outbreak of any disease in the region.

REGIONAL STATION DALANG MAIDAN (Lahaul & Spiti)

- About 9000 wheat accessions and 2000 barley accessions are being conserved and maintained under natural conditions in the station building.
- Department of Irrigation & Public Health, Govt. of Himachal Pradesh repaired the irrigation pipeline from Chokerling Nallah in Gondhla to RS Dalang Maidan.
- Under Tribal Sub Plan, a three days training programme was organized for farmers of Lahaul-Spiti at ICAR-IIWBR, Karnal.

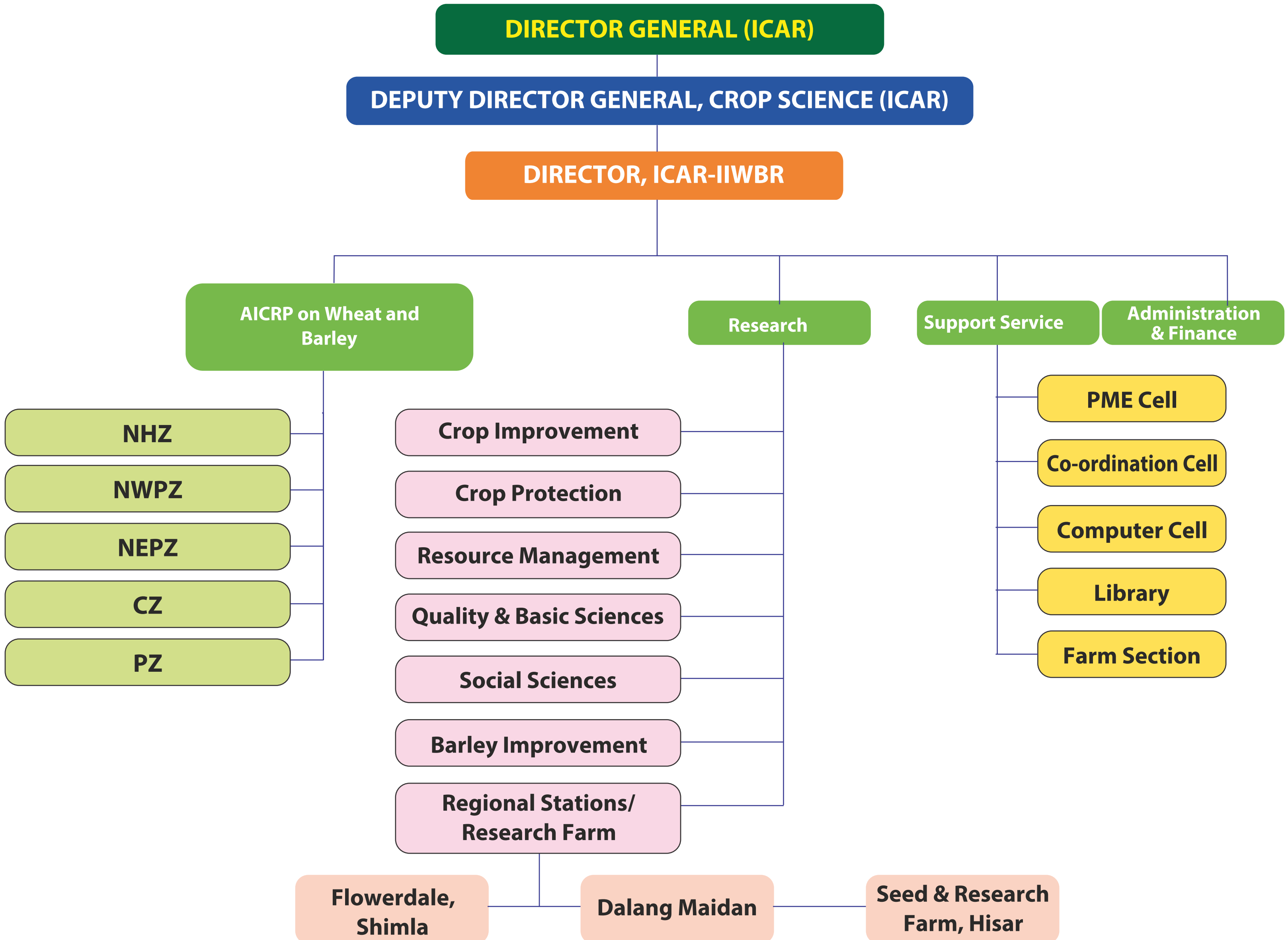
SEED AND RESEARCH FARM, HISAR

- A total of 1011.65 quintals of wheat and barley breeder seed was produced during the season. Of which 765.5 quintal breeder seed of three wheat varieties while 246.1 quintal breeder seed of barely varieties was produced.
- A total of 47.24 quintals of wheat and barley mixture was generated, which fetched a revenue of ₹67053.
- To improve the soil productivity, Sesbania (*dhaincha*) was grown as green manure crop in 185 acres of land during the *kharif* season.

OTHER INSTITUTIONAL ACTIVITIES

- During the year, institute organized National Symposium on Disease Management, Brainstorming session on Wheat Production Technology, International Workshop on DUS testing in Wheat and Barley and National Workshop on Use of Digital Field Book.
- The institute organized 59th All India Wheat and Barley Research Workers' Meet in virtual mode from August 24-25, 2020.
- Two Institute Research Council meetings were organized under the chairmanship of Dr. GP Singh, Director, ICAR-IIWBR, Karnal on 11/2/2020 and 29/10/2020.
- Institute celebrated Foundation day, Gandhi Jayanti Utsav, Swachhata Pakhwada, International Day of Yoga, World Soil Day, Constitutional Day etc.
- During the year, institute got Krishi Sansthan Samman Award-2020. Dr. GP Singh, Director, ICAR-IIWBR, Karnal received Dr. AB Joshi Memorial Award, Outlook Outstanding Scientist Award-2020 and National Award for Outstanding Leadership in Agriculture. Institute's scientists won various prestigious National Awards like Dr. MV Rao Memorial Award, S Nagarajan Memorial Award-2020, Professor Mahatim Singh Memorial Award-2020.
- Institute's scientists published around 82 research papers in various national and international journals of repute.
- Many dignitaries including Shri Sanjay Bhatia, MP(Karnal); Shri Sanjay Singh, Secretary, ICAR, N. Delhi, Dr. AK Singh, DDG (Agri. Extension), ICAR, N. Delhi; Dr. RC Agarwal, DDG (Agri. Education), ICAR, N. Delhi; Dr. KV Prabhu, Chairperson, PPV&FRA, N. Delhi; Dr. Anil Joshi, Founder HESCO; Dr. MS Chauhan, Director, NDRI, Karnal and Dr. Samar Singh, VC, Maharana Pratap Horticultural University, Karnal visited the institute.

Organogram


DIRECTOR GENERAL (ICAR)
DEPUTY DIRECTOR GENERAL, CROP SCIENCE (ICAR)
DIRECTOR, ICAR-IIWBR
AICRP on Wheat and Barley
NHZ
NWPZ
NEPZ
CZ
PZ
Research
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
Support Service
Administration & Finance
PME Cell
Co-ordination Cell
Computer Cell
Library
Farm Section

1. CROP IMPROVEMENT

Release of new varieties for different zones/states

Central released varieties

During the year 2020, the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops (CVRC) in its 84th and 85th meeting recommended the release and notification of eight bread wheat varieties, namely NIAW3170, CG1029, DBW303, HD3298, HD3293, HI1633, HI1634, WH1270; and three durum wheat varieties namely MACS4058, DDW48,

Table 1.1: Wheat varieties released by CVRC during 2020

SN	Variety	Areas of adoption	Developed by	Prod. condition	Grain yield (q/ha)		Special features
					Potential	Average	
Bread Wheat							
1	DBW 303 (Karan Vaishnavi)	NWPZ	ICAR-IIWBR, Karnal	IR, ES, High fertility	97.40	81.20	Resistance to yellow and brown rust. High grain protein content (12.1%), good Chapatti quality
2	WH 1270	NWPZ	CCSHAU, Hisar	IR, ES, High fertility	91.5	75.85	Resistance to yellow and brown rusts
3	HD3298	NWPZ	ICAR-IARI, N. Delhi	VLS, IR	47.40	39.00	Grain protein (12.12 %); Fe:43.1ppm, Chapatti quality (7.78) and Bread quality (7.27)
4	NIAW 3170 (Phule Satwik)	NWPZ&PZ	MPKV-ARS, Niphad	TS, RIR	71.70 (NWPZ), 44.30 (PZ)	51.1 (NWPZ), 36.80(PZ)	Soft grains, good biscuit spread factor (NWPZ:10.18; PZ:9.34)
5	HD 3293	NEPZ	ICAR-IARI, N. Delhi	TS, RIR	60.70	39.30	Resistant to Black and Brown rusts; good Chapatti quality; tolerance to heat stress
6	CG 1029 (Kanishka)	CZ	IGKV RS, Bilaspur	LS, IR	94.90	52.10	Resistant to Black and Brown rusts; good Chapatti quality; tolerance to heat stress
7	HI 1634 (Pusa Ahilya)	CZ	ICAR-IARI (RS), Indore	LS, IR	95.70	51.60	Good Chapatti quality, highly resistance to brown and black rusts
8	HI 1633 (Pusa Vani)	PZ	ICAR-IARI (RS), Indore	LS, IR	65.80	41.70	Nutritionally rich variety (Protein: 12.4%, Iron : 41.66 ppm and Zinc: 41.1ppm, Highly resistant to black rust
Durum wheat							
9	NIDW 1149	PZ	MPKV-ARS, Niphad	TS, RIR	36.80	29.70	Attractive grains and resistance to brown rust and yellow rust
10	DDW 48	PZ	ICAR-IIWBR, Karnal	TS, IR	72.00	47.40	Protein: 12.1 %, yellow pigment: 5.6 ppm, high pasta acceptability, resistance to brown rust
11	MACS 4058	PZ	ARI, Pune	TS, RIR	37.10	30.60	Highly resistance to leaf and stem rusts, protein content (12.8%)

NIDW1149 for different production conditions in various zones (Table 1.1). The Sub-Committee also recommended the extension of areas For adoption of DBW187 (Karan Vandana) and WB2 (under denomination WB02 (Rajendra Gehoon 3) in 85th meeting to irrigated, early sown high fertility condition of NWPZ and Bihar state, respectively.

Parentage of CVRC released varieties

1. **DBW303:***WBLL1*2/BRAMBLING/4/BABAX/LR42/ /BABAX* 2 /3/SHAMA*2/5/PBW343*2/ KUKUNA*2//FRTL/PIFED*
2. **WH1270:** *SHA7//PRL/VEE#6/3/FASAN/4/HAAS8446/2*TRCH/4/WHEAT//2*FASAN/5/CBRD/KAUZ/6/MILAN/AMSEL/7/FRET2*KUKUNA/8/2*WHEAT/SOKOLL*
3. **HD3298:** *CL1449/PBW343//CL882/HD2009*
4. **NIAW3170 (Phule Satwik):** *SKOLL/ROLF07*
5. **HD3293:** *HD2967/DBW46*
6. **CG1029 (Kanishka):** *HW 2004/ PHS 725*
7. **HI1634 (Pusa Ahilya):** *GW 322/PBW 498*
8. **HI1633 (Pusa Vani):** *GW 322/PBW 498*
9. **NIDW1149 (d):** *NIDW295/ NIDW15*
10. **DDW48 (d):** *HI8498/PDW233//PDW291*
11. **MACS4058 (d):** *MACS3125/AKDW2997-16//MACS3125*

State released varieties

Five wheat varieties namely GW 499, GW 1339(durum), VL Gehun 2015, Chattisgarh Hansa Wheat (CG 1023) and MP 3465 were recommended for notification by the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops for different production conditions prevailing in the named states (Table 1.2).

Parentage of SVRC released varieties

1. **GW 499 :** *CLN 3/PHR 1007 // GW 336*
2. **GW 1339 (Durum):** *DDW04/4/MEMO/YAV//AVK/3/RD 214*
3. **VL Gehun 2015:** *Sale 6*
4. **Chattisgarh Hansa Wheat (CG 1023):** *BOW/VEE/5/ND/VG9144//KAL/BB/3/YACO/4/CHIL/6/CASKOR/3/CROC_1/ AE SQUARROSA (224)/OPATA/PASTOR//MILAN/KAUZ/3/BAV92*
5. **MP 3465:** *NAC/TH.AC//3*PVN/3/MIRLO/BUC/4/2*PASTOR/5/KACHU/6/KACHU*

Registration of new genetic stocks

During the year 2020, fifteen genetic stocks of wheat were found suitable for registration by the Plant Germplasm Registration Committee for traits like disease resistance to rusts and spot blotch, higher protein content, water use efficiency, heat tolerant, drought tolerant, high grain iron and zinc content. The genetic resources unit of the IIWBR, Karnal multiplies the seeds of these registered genetic stocks and supplies to breeder across the country for use in wheat improvement (Table 1.3).

Genetic resources for wheat improvement

Germplasm exchange

During 2020, 451 accessions were obtained from various institutes including 264 land races of Indian wheat and 18

Table 1.2: Wheat varieties released by SVRC during 2020

SNo.	Variety	Developed by	State	Production	Yield (q/ha)		Special features
					condition	Potential	Average
1.	GW 499	Wheat Research Station (SDAU), Vijapur	Gujarat	LS,IR	59.90	46.02	Resistance to brown and black rusts
2.	GW 1339 (Durum)	Wheat Research Station (SDAU), Vijapur	Gujarat	TS,IR	67.60	49.60	Yellow pigment: 5.5 ppm
3.	VL Gehun 2015	ICAR-VPKAS, Almora	Uttarakhand hills	TS, RF for organic cultivation	36.67	19.88	Sedimentation value: 60ml, resistance to yellow and brown rusts
4.	Chattisgarh Hansa Wheat (CG 1023)	IGKV RS, Bilaspur	Chattisgarh	TS,IR	42.0	32.14	Chapati score: 8.06 & Zinc: 40.4ppm
5.	MP 3465	JNKV, Jabalpur	Madhya Pradesh	TS, RIR	73.2	59.41	Resistant to brown and yellow rust, high protein

Table 1.3: Genetic stocks registered during 2020

SN	Genotype	Registration number	National ID number	Developing Centre	Traits
1	HI8791	INGR20005	IC635014	ICAR-IARI (RS), Indore	Resistant to black, brown and yellow rusts; and flag smut.
2	HI1619	INGR20006	IC635015	ICAR-IARI (RS), Indore	Resistant to leaf and stripe rusts; Karnal bunt and flag smut.
3	DBW278	INGR20007	IC635016	ICAR-IIWBR, Karnal	High sedimentation value under very late (January) sown conditions of northern plains. Resistance to leaf rust, Karnal bunt and flag smut.
4	DBW166	INGR20008	IC635017	ICAR-IIWBR, Karnal	High water use efficient genotype with low drought susceptibility index. Heat tolerant genotype
5	RWP-2017-21	INGR20009	IC635018	ICAR-IIWBR, Karnal	Heat tolerant genotype with lower grain yield reduction under heat stress
6	RW5	INGR20010	IC635019	ICAR-IIWBR, Karnal	Drought as well as heat stress tolerance genotype
7	Karan Poshan 1 (33/2/1)	INGR20011	IC635020	ICAR-IIWBR, Karnal	High grain zinc content (78.4ppm).
8	Karan Poshan 2 (98/3)	INGR20012	IC635021	ICAR-IIWBR, Karnal	High grain iron content (62.9ppm).
9	HS628	INGR20013	IC635022	ICAR-IARI Regional Station, Shimla	Resistant to all the patho types of brown rust except 77-8 due to presence of genes Lr19/Sr25
10	GW2014-596	INGR20014	IC633422	Wheat Research Station (SDAU), Vijapur	High grain protein content (14.4%)
11	GW2010 288	INGR20015	IC623434	Wheat Research Station (SDAU), Vijapur	High number of grains per spike >60 along with high thousand grains weight and iron content (>42 ppm).
12	UP2994	INGR20016	IC635426	GBPUA&T, Pantnagar	High grain protein content (14.33%) along with high iron content (49 ppm) and zinc content (43.5ppm).
13	QST1910	INGR20017	IC635697	ICAR-IIWBR, Karnal	Drought tolerance genotype with low drought sensitivity
14	GW2012-475	INGR20081	IC633421	Wheat Research Station (SDAU) Vijapur	Early maturity with high yield
15	GW2010-321	INGR20082	IC633420	Wheat Research Station (SDAU), Vijapur	Early maturity with high yield

aphid resistance lines from CIMMYT, Mexico. Institute also supplied 2282 accessions of wheat to various indenters for research purposes.

Export

After taking the approval from DARE/ICAR, 350 advance lines of wheat were exported to Bangladesh and Mexico through NBPGR/CIMMYT for screening against wheat blast at hot spot locations in Bangladesh and Bolivia.

Characterisation

A total of 523 indigenous and exotic accessions comprising 460 accessions of *T. aestivum*, 49 accessions of *T. durum*, 12 of *T. dicoccum* and one each of triticale and *sphaerococcum* were evaluated and characterized as per DUS testing guideline for 36 characters during 2019-20. A wide range of variation was observed for days to heading (88-136 days); plant height (72-151cm); flag leaf length (18.8-48.2 cm); 1000 grains weight (8-49.10); spike length (5.5-17 cm);

spikelets/spike (14-28); grains per spike (8-91); and grain weight/spike (0.0.48-3.58g). The promising accessions identified for individual and multiple traits are given below:

Days to heading and maturity: During 2019-20, none of the accessions were earlier than check variety WR 544.

Plant height: Two accessions showed dwarfness and recorded plant height <80cm. These were EC 582321 and EC 582349, while seven accessions namely E 83, E 192, E 271, E344, E 395, E 630 and E 1971 recorded plant height more than 150cm.

Flag leaf length: Three accessions namely E 4035 (d), E 10156, EIGN (2006-07)10 recorded flag leaf length > 40.0cm.

Spike length: Ten accessions namely EIGN I (2006-07) 90, IC 212176A, EC 582316, EC 582330, E 581 (Triti), E 641, E 1053, E 3249, E 3477 and E 4508 had ear length > 13.5cm.

Spikelets/ spike: During 2019-20, four accessions EC 582316, EC 582322, E 4363(dicoccum), E 4687 (dicoccum) had spikelet per spike equal to 26 and days to heading <117 days. Some of the accessions (EC 582305, EC 582360, EC 582363, EC 582421, EC 582427, EC 493711, E 192, E 261, E 395, E 901, E 1001, E 1971 & E 2061) also have spikelet per spike equal to or >26 but they are late in maturity.

Grains number/ spike: Eight accessions IC 212176A, EIGN I (2006-07) 16, EIGN I (2006-07) 43, EC 582234, EC 582245, EC 582316, E 2075 and E 2345 had more than 70 grains per spike.

Grain weight/ spike: Four accessions (IC 212176A, EIGN I (2006-07) 16, EIGN I (2006-07) 43 & EC 582234) had grains weight/spike more than 3.5g.

Thousand grains weight: During 2019-20, none of the entries had thousand grains weight > 50g but nine entries (E 282, E 3414 (Dur), E 3477, EIGN I (2006-07) 9, EIGN I (2006-07) 12, EIGN I (2006-07) 13, EIGN I (2006-07) 23, EIGN I (2006-07) 25 and EIGN I (2006-07)) 40 had 1000 grains weight >45g.

Accessions with multiple yield contributing traits: The IC 212176 A and EIGN I (2006-07) 16 were found promising for multiple yield traits.

Registration of varieties with PPV&FRA

Three wheat varieties namely DBW 222, DBW 252, and DDW 47 were registered under extant category by the PPV&FRA, New Delhi vide registration number REG/2020/23, REG/2020/24, and REG/2020/25, respectively.

DUS testing in wheat

A total of 6 candidate varieties (W 2019-1- SRW 111, SRW 303, SRW 404 , SRW 252, SRW 231) of bread wheat were tested against 22 reference varieties. Similarly one durum wheat variety (Malav 221) was tested against 8 reference varieties. In grow-out test, 60 farmers' varieties of bread wheat and four farmers of durum were tested against 88 and 7 reference varieties, respectively. Data of all the centres viz. Karnal, Indore and Dharwad was compiled, analyzed and submitted to PPV&FR Authority for making decision regarding registration.

Contribution of entries in coordinated trials

A total of three entries were contributed to different station trials (timely sown, late sown, restricted irrigation) conducted in different zones of the country. One entry DBW 359 is promoted from station trial to NIVT5A and NIVT 5B.

Pre-breeding for wheat improvement

Selection efficiency and the effectiveness, both are directly correlated with the variability available in the genepool of any crop. In wheat partiticularly, the variability is narrowing down and therefore the yield levels are stagnating. Pre-breeding is an important tool for diversifying the gene pool and creating genetic variability in wheat and the wild relatives of wheat may provide a greater scope for introgressing the alien genes through wide hybridization. Keeping it in view, the evaluation and hybridization program involving wild sources is being carried at IIWBR.

Hybridization with non-conventional germplasm

Every year, non-conventional and wild sources are used in crossing program to diversify the gene pool and this year more than 300 cross-combinations were attempted, to introgress the desirable genes particularly for biotic and abiotic stress tolerance, into Indian wheat varieties.

Characterizing variation for various agronomical, physiological and quality traits in pre-breeding crossing block

We have designed our crossing block in such a way that it has maximum diversity in parents for various traits and sowing was done in a staggered way so that pollens are available at right time. In some cases the photoperiod was enhanced to 18 hours for early flowering. The table (Table 1.4) given represents the variability for various traits in the crossing block.

Use of Indian dwarf wheat *T. sphaerococcum*

As per the suggestions from RAC and QRT team, we have used ancient Indian dwarf wheat (*T. sphaerococcum*) in our program to improve the quality of our released varieties. Some of the selected crosses have been listed in the table 1.5.

Table 1.4: Variability for various traits in the crossing block

Character	Genotypes		Checks	
	Mean	Range	Mean	Range
Days to flowering (days)	80	64-93	80	76-83
Plant height (cm)	99	55-125	101	98-105
Spike length (cm)	11.58	9.50-15.80	10.64	9.80-11.20
Tillers per meter (no.)	103	69-145	113	105-126
1000 grain weight (gm)	37.93	31.00-50.40	37.63	35-55.10
Protein content (%)	12.63	10.50-15.56	12.16	11.83-15.37
Moisture content (%)	9.76	9.24-10.27	9.98	9.70-10.27
Canopy temperature at heading stage (^{0}C)	15.74	13.70-18.25	17.22	16.63-17.44
Chlorophyll content at heading stage (ind.)	47.48	40.95-56.05	45.11	43-47.56
NDVI at heading stage	0.81	0.72-0.87	0.84	0.83-0.85
Canopy temperature at anthesis stage (^{0}C)	21.43	18.60-24.65	23.12	22.74-23.40
Chlorophyll content at anthesis stage (ind.)	50.04	43.05-57.25	51.06	48.63-54.71
NDVI at anthesis stage	0.81	0.71-0.86	0.82	0.79-0.84
Grain yield (gm)	2134	1072-3525	2765	2300-3061

Table 1.5: Important *T. sphaerococcum* crosses with bread and durum wheat genotypes

S.No.	Cross Name	Traits
1	*T. sphaerococcum* / Pavon 76	High protein
2	*T. sphaerococcum* / HI8498	High protein
3	*T. sphaerococcum* / DBW 88	High protein
4	*T. sphaerococcum* / GW322 / HD2967	High protein
5	*T. sphaerococcum* / HD2967 // *Polonicum* / HI8498	High protein
6	*T. sphaerococcum* / WH1105 / WH1105	Yield
7	*T. sphaerococcum* / HD 2967	High yield
8	HD2967 / *T. sphaerococcum* (EC10511)	High yield
9	*T. sphaerococcum* / HI8498 / Dicoccum	High tillering
10	*T. sphaerococcum* / DBW90 / HD 3086	Drought tolerance
11	*T. sphaerococcum* (EC10511) / DBW 90	Drought tolerance
12	*T. sphaerococcum* / PBW 550*2	Early maturity
13	*T. sphaerococcum* (EC10511) / HD 3086	High zinc
14	*T. sphaerococcum* / Pavon 76 / HD3086	High zinc
15	*T. sphaerococcum* / HI8498 / HI8737 // HI 8737	Grain appearance
16	*T. sphaerococcum* / DBW88 / WH1105 / DM 7	Medium height

Developing novel germplasm resources through pre-breeding

A number of crosses were attempted involving wild accessions and the released varieties, and this year, twenty-one F_1s were treated with colchicine for chromosome doubling so that some fertile seed are harvested. Ten lines along with 6 checks were evaluated under timely irrigated, timely rainfed and late irrigated conditions for drought and heat tolerance and disease incidence. Based on the drought susceptibility index, three crosses namely, PBW-698 / EC-787010 (Neodur/*Th.bessarabicum*), NIDW-15 / (Chinese spring/*Ae. speltoides*), and DBW-39 / EC-78-7009 (Karim/ *Th.bessarabicum*) were highly tolerant under rainfed conditions (Table 1.6) where as for heat tolerance, five crosses namely PBW-698/EC- 787010 (Neodur/ *Th.bessarabicum*), DBW-39 / EC-78-7009 (Karim/ *Th.bessarabicum*), *Ae. peregrina* /532653// WH 1105, *Ae. kotschyii/532653//WH 1105*, DBW-39 / (Highbury/*Ae mutica*) were tolerant. DBW-39 / EC-78-7009 (Karim/ *Th.bessarabicum*), PBW-698 / EC- 787010 (Neodur/ *Th.bessarabicum*) were tolerant to both stresses (Table 1.6).

Chromosomal constitution of F_1s

F_1s developed from the wild crosses are generally sterile and set no seed due to various reasons like chromosome instability and aberrations. The seed of some of F_1s were subjected to GISH/FISH analysis and it was found that two crosses had chromosome anomalies. Whereas line no 623 (PBW703 / EC787014 (CS/*Th.bessarabicum*) had one additional chromosome i.e. 2n = 43 (Fig.1.1), another line no. 620 (PBW702 / EC787014 (CS/*Th.bessarabicum*) had 2n = 42 but one chromosome was substituted (Fig. 1.2).

Table 1.6: Grain yield (g/m^2), drought susceptibility index (DSI) and heat susceptibility index (HSI) in colchicine treated wild crosses

Cross details	Grain yield (g/m^2)			DSI	HSI
	TSIR	ROS	LSIR		
PBW 702/ (Highbury/*Ae. mutica*)	316.5	220.2	250.0	1.00	1.37
DBW 39 / EC787009 (Karim/ *Th.bessarabicum*)	469.7	340.0	464.0	0.91	0.08
*Ae.peregrina*226/Halberd WILD 371 / DBW 90	339.3	186.0	95.0	1.48	4.70
Ae. kotschyii/532653//WH 1105	422.2	276.7	389.5	1.13	0.51
NIDW 15 / (Chinese spring/*Ae. speltoides*)	490.7	364.8	304.8	0.84	2.47
DBW 39 / (Highbury/*Ae. mutica*)	501.3	330.5	449.0	1.12	0.68
Ae.peregrina /532653// WH 1105	407.0	272.8	397.0	1.08	0.16
Ae.peregrina /532653//DBW 14	367.2	249.5	310.2	1.05	1.01
PBW703 / EC787014 (CS/*Th.bessarabicum*)	396.7	251.5	340.2	1.20	0.93
PBW698 / EC 787010 (Neodur/*Th.bessarabicum*)	450.8	340.5	448.0	0.80	0.04
HD 2967	434.2	338.8	393.8	0.72	0.61
WB 02	510.5	304.5	477.7	1.33	0.42
HD 2932	441.5	351.3	384.7	0.67	0.84
PBW 723	546.7	363.3	494.8	1.10	0.62
DBW 173	504.7	348.2	524.2	1.02	-0.25
AKAW 4627	313.3	269.3	131.3	0.46	3.79

TSIR=Timely sown irrigated, ROS=Rainout shelter, LSIR= Late sown irrigated

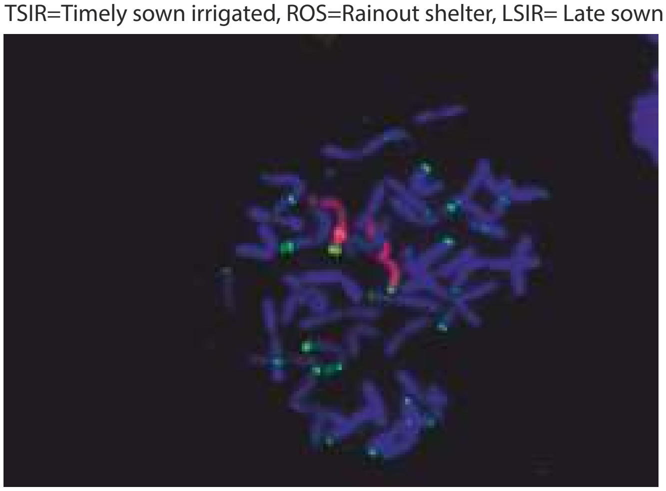


Fig. 1.1: Detection of 1R addition in line 623 by using probes: Bio-pSc119 (green) and Dig- rye genomic DNA (red)

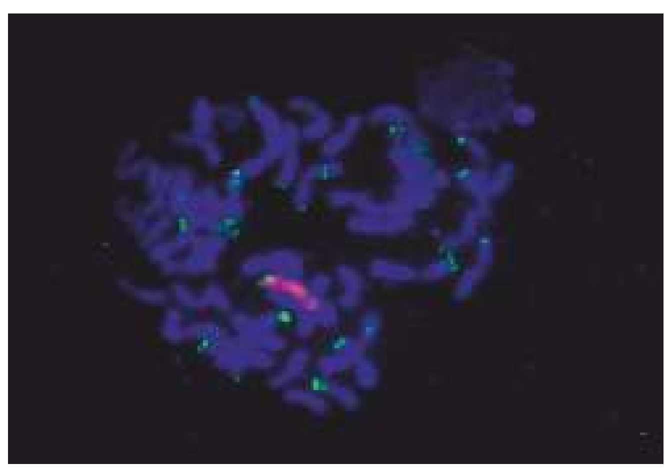


Fig. 1.2: Detection of 1R substitution in line 620 by using probes: Bio- pSc119 (green) and Dig- rye genomic DNA (red)

Status of resistance to diseases in accessions of wild relatives of wheat

Data on disease incidence in accessions of wild relatives of wheat was recorded three years (2017-18, 2018-19 and 2019-2020). Data on seedling resistance of these lines was also generated at Flowerdale centre (Table 1.7). Initially the accessions were subjected to mixture of races and the tolerance was noted. However the SRT data on specific lines were generated using prevalent races at Shimla during 2018-19 and 2019-20. The data given in table revealed that 10 accessions of *Ae tauschii* and three of *Ae. speltoides* are resistant to black rust, one accession of *Ae. geniculata* and nine accessions of *Ae. speltoides* are resistant to brown rust. Two accessions of *Ae. speltoides* namely 3581 and 3598 are resistant to both black and brown rusts whereas accession 35 is resistant to all three rusts.

Table 1.7: SRT data for accessions of wild relatives in wheat (Mixture of races during 2017-18 and specific races during 2018-19 and 2019-20)

Black rust

Species	Acc. No	2017-18			2018-19			2019-20							
		Tr mix (brown)	gr mix (Black)	St mix (Yellow)	11	40A	295	11	21-1	40A	40-2	40-3	34	117-6	295
Ae.	3571	;1	0;	_	;	;	;	;	1P0;	1P0;	1P0;	;1	0;	-	1P0;
speltoides	35	;	0;	1P0;	2-	1P;	2-	1P0;	0;	;	-	0;	;-	;-	1P;
-do-	3598	0;	0;	3	0;		1Po;	;	;	;1	1P0;	;N	-	-	1P0;
Ae.	5	2+	0;	3+	2-	;	2-	0;	0;	;-	2	22+	2--	;-	;1
tauschii	6	3+	3+	3+	2-	;1	;1	0;	;1	;	1p3+	2p0;	;-	;1	;-
-do-	9822	3+	3	3+	;	;	;	2--	0;	;	2--	2-	0;	;-	0;
-do-	3758	0;	1P0	3+	2=	1Po;	2-	2--	2-	0;	12	2-	1p0;	0;	;
-do-	13780	3+	0;	3	;	;	;	2-	1p0;	0;	;1	2+	1P0;	;-	0;
-do-	3757	3	2	3-	2-	;	2-	-	1p;	0;	0;	-	;-	;1	2-
-do-	9787	2+	;	_	1P;	;	;1	1p0;	;-	;	0;	;-	-	1p0;	1p0;
-do-	3784	_	2+	3+	2-	;	2-	1p0;	0;	;	0;	22+	0;	0;	-
-do-	3769	2+	3+	3+	2-	2=	2-	22+	;	0;	-	-	1p0;	1p;	-
-do-	14338	2+	2-	3+	2-	1P2-	1P2-	22+	;1	0;	12	22+	;1	-	;

Brown rust

Species	Acc. No	2017-18			2018-19			2019-20							
		Tr mix (brown)	gr mix (Black)	St mix (Yellow)	12-5	77-9	104-2	12-5	77A	77-1	77-5	77-9	104-2	104-3	162-2
Ae. geniculata	EC-596421	3	2	3+	0;	2	;	;1	;	;1	;	;1	;	;12+	;
Ae.	3571	;1	0;	_	0;		0;	0;	0;	0;	0;	-	0;	0;	0;
speltoides	3599	0	;	_	0;	;	;								
-do-	3596	;	;1	_			;	-	-	;1	-	-	0;	0;	-
-do-	3581	;	;1	3+	0;	;	;	;	;	0;	0;	0;	0;	-	0;
-do-	3582	;	0;	1P0;	0;	0;	0;	0;	;	0;	0;	0;	0;	0;	0;
-do-	3583	0;	;1	3+	0;	;1	;	-	-	0;	0;	0;	0;	0;	-
-do-	3590	;	;	3+			0;	-	-	-	0;	0;	0;	-	-
-do-	3595	0;	0;	3+	0;	0;		0;	1	0;	0;	0;	;	0;	0;
-do-	3598	0;	0;	3		0;	;	0;	0;	-	0;	0;	0;	-	0;
-do-	3595	0;	;	_		;1	;	0;	-	0;	0;	-	-	0;	-

Table 1.8: Promising genotypes for high zinc, Iron and Protein content

Cross no.	Cross	Karnal (Mean of two years)			Hisar (Mean of two years)			Mean		
		Zn	Fe	Protein	Zn	Fe	Protein	Zn	Fe	Protein
BFKW-1	Chinese. Spring / *Ae. mutica* (P 213004)	46.0	41.0	16.5	45.2	43.8	18.3	45.6	42.4	17.4
BFKW-2	Macoun x *Th. bessarabicum* (EC787708)	47.1	45.2	16.3	48.4	46.2	17.1	47.8	45.7	16.7
BFKW-3	Pavon 76 /*Ae. Mutica* (P 2130012)	55.0	51.3	16.5	53.6	53.0	17.1	54.3	52.1	16.8
BFKW-4	Highbury / *S. anatolicum* (P 208/142)	51.3	52.8	18.2	50.1	51.8	19.5	51.5	52.3	18.9
BFKW-5	*Th. Bessarabicum* (EC787708)/ cv Margarita	44.4	43.4	17.4	46.7	42.1	18.7	45.6	42.8	18.1
BFKW-6	SYN207//PBW502/16/621-50	48.6	44.3	15.2	47.4	45.8	16.0	48.0	45.1	15.6
BFKW-7	Chinese spring / *Th. bessarabicum* EC787708/HD3086	55.1	52.5	16.5	53.2	54.1	17.7	54.2	53.3	17.1
BFKW-8	PDW 314 /Cv Icarasha	43.3	42.1	15.2	43.4	40.8	15.3	43.4	41.5	15.2
BFKW-9	PARAGON/WH1105/GW322	53.6	52.2	18.5	52.6	52.0	17.5	53.1	52.1	18.0
BFKW-10	PARAGON/WH1105//DBW88	52.3	55.5	18.4	51.7	52.2	18.2	52.0	53.8	18.3
BFKW-11	Chinese spring/ cv Margarita	50.3	49.6	16.5	51.6	47.0	15.5	51.0	48.3	16.0
BFKW-12	Pavon 76 x *Ae.mutica* (2130012)/HD3086	51.7	50.3	18.1	50.7	51.2	17.5	51.2	50.8	17.8
BFKW-13	*T. sphaerococcum* (EC10511) / DBW 90	45.7	41.4	14.8	43.9	43.1	16.0	44.8	42.3	15.4
BFKW-14	*T. sphaerococcum* / Pavon 76	47.2	45.0	16.4	48.5	46.5	17.4	47.8	45.7	16.9
Check	DBW187 (A)	35.6	37.0	13.6	36.0	37.6	13.8	35.8	37.3	13.7
Check	HI8498 (D)	40.4	44.2	12.5	40.8	45.4	13.0	40.6	44.8	12.8

BFKW: Bio-Fortified Karnal Wheat; Zn and Fe contents are in ppm while Protein content in per cent

Bio-fortification for Zinc, Iron, and Protein contents through introgression in agronomic base in wheat

The wild germplasm and the already developed amphiploids were used in crossing program to improve Indian varieties for micronutrients. The high yielding promising lines were involved in crossing program. Out of 200 cross combinations fourteen genotypes were selected and evaluated for two years at two locations Hisar and Karnal. Two checks one durum (HI 8498) and the other bread wheat check (DBW 187) were used for the comparison of Zinc, Iron and protein contents. Zinc and Iron estimations were performed using an Oxford instruments X-Supreme 8000 fitted with 10 place auto sampler, holding 40 mm Aluminum vials. While the protein was estimated non destructive spectra machine and was calculated at 12 per cent moisture level. The mean of two years at each location Hisar and Karnal was calculated and is presented in the Table 1.8.

All the fourteen genotypes were found superior with regards to Zinc, Iron and Protein contents as compared to the bread wheat check DBW 187. While ten genotypes were found superior for all the three traits in comparison to the durum check HI 8498. Highest protein content ie 18.9% was found in BFKW-4 (Highbury /*S. anatolicum* (P 208/142) followed by BFKW-10 and BFKW-5. Similarly highest Zn content ie 54.3 ppm was found in BFKW-3 followed by BFKW-7 (54.2 ppm). The iron content was found in BFKW-10 (53.8 ppm followed by BFKW-7 (54.2 ppm). All these genotypes are now stable being utilized in our crossing programme.

Sharing the segregating material with cooperating centers

Pre-breeding program at ICAR–IIWBR is developing specific crosses involving non-conventional parents and sharing this diverse material to cooperating centers. During the period ten populations were shared with cooperating centers across the country through segregating nursery (SSN). The parents involved were having quality traits, tolerance to biotic and abiotic stresses. In addition to it the fixed lines were also shared through National Genetic Stock Nursery and Biofortification Nursery (Table 1.9).

Genotypes contributed to national coordinated trials

Out of the material developed in the project, each year a number of fixed lines are evaluated under yield trials. This year one genotype DBW 322 has been promoted to advance varietal trial of restricted irrigation in NEPZ and other genotype DBW 234 has been promoted to NIVT 1B trial. One genotype DBW 281 was shared for high yield station trial.

Table 1.9 : Sharing of material through SSN

Entry	Pedigree
SSN-1	Synthetic 67/ PBW 502 (heat tol.)
SSN-2	Synthetic 400 / PBW 502 (heat tol.)
SSN-3	Synthetic 107/*3DBW 17 (dis. resi.)
SSN-4	Synthetic 26/*3PBW 502 (dis. resi., soft)
SSN-5	New Synth 88 / PBW 343//UP 2425 (dis. resi.))
SSN-6	Synthetic 207 / *2PBW 502 (heat tol.)
SSN-7	Syn 14 / PBW 502 // Syn 59 / DBW 16// DBW 16
SSN-8	Syn 98 / PBW 343 // Syn 59 / DBW 16 (dis. resi. soft)
SSN-9	Syn 206 / DBW 17 / DBW 17 (dis. resi.)
SSN-10	Syn 99 / UP 2425 / FLW 21 (dis. Resi. & soft)

Table 1.10: Genotypes promoted to national trials

Entry name	Pedigree	Promoted to
DBW234	Synth 99/UP 2425/ FLW 22//PBW 502	NIVT-1B
DBW322	PBW175/Ae. Ovata/ /PBW175	AVT-RI-NEPZ

Wheat improvement for high productive environments of north-western plains of India

Release of new variety DBW303 (Karan Vaishnavi)

A new very high yielding early sown wheat variety released for north western India: It was released and notified by CVRC, MoA&FW, Govt. of India *vide* gazette notification number SO (E) 500 dated 29.01.2021 for commercial cultivation in North Western Plains Zone (NWPZ) of India under early sown conditions. DBW303 is a high input (150% RDF + FYM + growth regulators *i.e.* chlormequat chloride and tebuconazole) responsive wheat genotype, which has shown a significant yield superiority over the checks HD2967 (30.3%) and HD3086 (11.7%). This variety showed average yield of 81.2 q/ha which is the highest mean yield for any wheat variety so far in India. DBW303 showed wider yield stability across the zone by appearing 8 times out of 12 times in the 1st non-significant group and also recorded very high yield potential of 97.4 q/ha (Fig. 1.3). In agronomic trials under different input conditions, DBW303 was higher yielder compared to checks HD2967 and HD3086. Two sprays of growth regulators chlormequat chloride 50% SL @ 0.2% + tebuconazole 250 EC @ 0.1% at first node and flag leaf stage are recommended to realize potential of DBW303 under early sown conditions. The growth regulators can be applied by tank mix application of 200 ml CCC and 100 ml tebuconazole (commercial product dose) in 100 litre water. DBW303 is having desirable plant architecture with robust stem and a long compact spike with high grain numbers and medium maturity duration. This cultivar is resistant to most virulent and prevalent pathotypes of yellow, brown and black rusts under artificial and natural conditions. It is also resistant to wheat blast and most foliar diseases. Resistance gene *Yr2+* (yellow rust), *Lr13+* (brown rust) have been postulated in this variety through multipathotype testing. DBW303 has uncharacterized *Sr* gene which imparts resistance against all the stem rust pathotypes in India.

Area extension and release of DBW187 (Karan Vandana)

DBW187 is a high yielding wheat variety released through area extension by CVRC, MoA&FW, Govt. of India *vide* gazette notification number S.O. 500 (E) dated 29.01.2021 for cultivation in the NWPZ. The same variety was also released and notified for commercial cultivation in North Western Plains Zone (NWPZ) of India under early sown conditions by CVRC MoA&FW, Govt. of India *vide* gazette notification number SO (E) 500 dated 29.01.2021. DBW187 was tested for two years in Special High Yield Potential Trial (SPL-HYPT 2018-2019 and 2019-20) under early sown high fertility conditions in NWPZ. DBW187 is a high input

Spikelet and glumes

DBW 303 at heading stage | Spike characteristics | Grain characteristics

Fig.1.3: Field view and some characteristic features of DBW303 (Karan Vaishnavi)

responsive (150% RDF + FYM + growth regulators chlormequat chloride and tebuconazole) responsive wheat genotype, which has shown yield superiority over the checks HD 2967 (21.2%) and HD 3086 (3.9%), with an average yield of 75.5 q/ha and potential yield of 96.6 q/ha. Under early sown conditions, two sprays of growth regulators chlormequat chloride 50% SL (CCC) @ 0.2%+ tebuconazole 250 EC @ 0.1% of commercial product dose (tank mix application) at first node and flag leaf stage are recommended.

This variety also showed wider yield stability across the locations as it appeared 6 times out of 12 times in 1st non-significant group. It showed less yield reduction under late sown condition than all the check varieties. DBW187 showed lowest heat sensitivity index of 0.82, indicating high heat tolerance. It has desirable plant architecture with robust stem and a large compact spike, ear shape is tapering with intermediate density. The variety has field resistance against most virulent and prevalent pathotypes of yellow, brown and black rust disease of wheat. DBW187 has all the desirable HMW sub-units required for making of good bread like (5+10) *Glu-D1*, *Glu-A1*, and (17+18) *Glu-B1* with *Glu-1* score of perfect 10 in comparison to other checks and candidate varieties. It also has high (63.3) sedimentation value reflecting its strong gluten. The variety possess good chapati (7.6/10.0) and bread quality (7.3/10) characters along-with high sedimentation value (63.5). Licensing for seed production and marketing of this high yielding variety has been provided to 279 seed producers/firms. Due to high yield potential coupled with wider adaptability and multiple disease resistance cultivar Karan Vandana has been quickly adopted by large number of farmers in Northern India.

Performance of entries in national trials

DBW296 was tested in first year of AVT RI-TS-NWPZ 2019-20 and showed significant superior performance over all checks, therefore promoted to second year advanced varietal testing. DBW316 and DBW318 were evaluated in NIVT-3A and based on significant yield superiority and disease resistance, including resistance to wheat blast both the entries were promoted to AVT-RI-TS-TAS-NEPZ. DBW318 has also included in CI-HYT-IR-ES-NWPZ/CZ for evaluation. Based on station trials performance, DBW347 and DBW349 have been promoted to NIVT-1B and DBW357 have been promoted to NIVT-3A. A total of 71 entries from the programme were evaluated in preliminary yield trials (PYTs) at ICAR-IIWBR and 36 of them were promoted to various multilocation station trials. A total of 15 genotypes were contributed for blast nursery in Bangladesh.

Evaluation of advanced generation bulks

A set of 150 advanced bulks of bread wheat were evaluated for resistance to rust and yield component traits in

Table 1.11: Promising wheat lines identified for rust resistance and yield component traits

Genotype	Hd.	Mat.	Ht. (cm)	Yl. Rust	Br. Rust	GNPS	Spike Wt.(g)	TKW(g)	GY/plot(g)
RWP1008	107	150	113	5MS	5MS	77	3.50	45.5	2171
RWP1026	112	150	106	0	10MS	76	3.44	45.3	2803
RWP1027	112	151	105	0	20MR	70	3.12	44.6	2924
RWP1053	111	153	109	5MR	10MR	89	3.91	43.9	2517
RWP1054	104	150	114	0	tMS	74	3.52	47.6	2808
RWP1056	111	153	116	10MR	tMS	79	3.45	43.7	2709
RWP1061	101	149	111	tMS	5MS	73	3.21	44.0	2483
RWP1090	97	149	109	5MS	tMS	70	3.00	42.8	2566
RWP1097	102	148	111	tMS	tMS	78	3.34	42.8	2722
RWP1106	110	148	113	0	tMS	75	3.72	49.6	2600
RWP1107	101	146	112	10MR	5MS	84	3.75	44.6	3089
RWP1112	102	148	119	5MS	tMS	77	3.55	46.1	2795
RWP1128	101	149	108	5MR	tMS	87	3.88	44.6	2428
HD3086 (C)	95	144	100	10S	tMS	62	2.54	41.0	2278
DBW187 (C)	101	147	104	5MS	tMS	72	3.17	44.0	2695
DBW90 (C)	97	147	102	20S	10S	61	2.29	37.5	2191
WH1142 (C)	104	148	102	40S	10S	59	2.13	36.1	1950

augmented block design with four checks HD3086 (IR-TS), DBW187 (IR-TS), DBW90 (IR-LS) and WH1142 (RI-TS). The lines were planted in a plot of 4 rows of 3 m length and 20 cm apart. The experiment was conducted under three sowing conditions i.e. irrigated timely sown, irrigated late sown and restricted irrigation timely sown conditions during *rabi* 2019-20 with all the recommended management practices followed to raise a good crop. Rust spreader rows were planted after every ninth entry. Data was recorded on days to heading, plant height, days maturity, lodging, 1000 kernel-weight, grain number per spike, spike weight, yield per plot, yellow and brown rust (0-100 modified Cobb scale). Yellow and brown rust severity ranged from 0-60S and 0-30S respectively in the test genotypes and 80S-100S on infector rows. Thirteen genotypes were found to be superior based on superior performance under three conditions as compared to check varieties were found promising for yellow and brown rust resistance, high grain number per spike (≥70), other yield components traits and desirable Agronomic traits (Table 1.11). Out of 150 tested genotypes for yellow and brown rust resistance, high grain number per spike (≥70) (GNPS), other yield components traits and desirable agronomic performance, 63 lines been contributed to PYTs.

Creation and evaluation of segregating breeding material

A total of 445 crosses were attempted during 2019-20. Among them the majority were three-way/double/ backcrosses. A total of 357 F_1 s, 270 F_2s, 132 F_3, 146 F_4, 150 F_5 132 and 65 F_6 populations with more than 9000 progeny rows and 640 bulk populations were evaluated in yield and agronomic traits under high disease pressure of yellow and brown rust. Selections were made on the basis of disease resistance, agro-morphological traits and yield components.

Breeding wheat genotypes for high yield in north eastern plains

Identification of new germplasm

Genotype BRW 3806 (NI 5439/ MACS 2496) was developed at ICAR-IIWBR, Karnal, following pure line breeding method was selected and nominated by BAU-Sabour for testing in the Restricted irrigation trials under AICRP on wheat and barley. Genotype BRW 3806 was identified to be resistant to wheat blast disease at Jessore, Bangladesh and Bolivia under artificial screening. BRW 3806 was also found to be resistant to all the races of *Puccinia graminis tritici* tested at seedling stage having gene combination Sr28+5+ against stem rust. This genotype carries Yr2 against yellow rust and Lr13+1+ against leaf rust and submitted to ICAR-NBPGR, New Delhi for its registration.

Hybridization and generation advancement

During the crop season 2019-20, The F_{1s}& segregating generations and bulks were planted and selections were made among the promising crosses. During 2020-21, F_1s (171) were planted along with segregating generations *viz.*, F_2 (120 crosses including single and three way crosses), F_2 (18 crosses), F_3 (28 crosses), F_4 (15 crosses) and F_5 (27 crosses), F_6 (19 crosses) and Bulks (130) at Karnal. Apart from that 1500 single spikes for different filial generations have been planted.

Contribution to national trials

Based on the performance of entries in different NIVTs, three genotypes DBW321, DBW325 and DBW326 have been promoted to AVT-I. DBW321 has been promoted to first year testing in AVT-RI-TS in both NWPZ & NEPZ. DBW325 has been promoted to first year testing in AVT-RI-TS-PZ and DBW326 promoted to AVT-RI-TS-CZ. Based on superior performance in ICAR-IIWBR station trials, six genotypes were promoted to different NIVTs during 2020-21 *i.e.* DBW 345 & DBW 362 (NIVT-1A), DBW 348 & DBW 350 (NIVT-1B), DBW352 (NIVT-2), DBW 355 (NIVT-3A) with parentage of ATTILLA*2/PBW65, BECARD/KACHU/3/UP2338*2/ KKTS*2//YANAC, WH1105/KRL210, KH65/BH1146, DBW88/KRL1-4, RAJ3765/BL1804, respectively. Three entries were evaluated in special Sal/Alk nursery during 2019-20, out of which two entries (NEPZ18-25 and LBP-18-23) have been promoted for evaluation in Sal/Alk trial during 2020-21 as DBW368 and DBW369. Also, three promising entries DBW 373, DBW 377 and DBW378 were contributed for testing in CI-HYPT (IR-ES-NW/CZ) trial during 2020-21.

Contribution to national nurseries

Genotype LBP 2017-2 tested in short duration screening nursery (SDN) during 2018-19 & 2019-20 was found promising in different zones on the basis of early heading, maturity and grain yield, has been retained for third year of testing. For the current crop season 2020-21, three entries (LBP-2019-14, LBP-2019-21 and LBP-2019-31) were contributed for multilocation testing in special Sal/Alk nursery from the programme. Similarly, two more genotypes (LBP-2019-22 and LBP 2019-24) were contributed towards drought and heat tolerance screening nursery (DHTSN) during crop season 2020-21. Also, one of the registered genetic stock (DBW150) from this programme is being utilized as heat tolerant check in MLHT. In addition, 15 entries were also contributed to segregating stock nursery 2020-21.

Contribution to national nurseries

Total 17 entries were contributed to different station trials conducted under different production conditions across zones during 2020-21. Also, 72 advanced bulks were contributed to three preliminary yield trials during 2020-21 crop season at Karnal.

Sharing of material in eastern India

During 2020-21, seven sets of North Eastern Special Trial (NEST) trial comprising 45 test entries along with five standard checks (DBW 39, DBW 187, DBW 107, HD 2967 and Raj 3765) were shared and planted at different locations (Sabour, Coochbehar, Kalyani, Shillongani, Ranchi, Pusa and Faizabad) in NEPZ for sowing and evaluation in two dates (timely and late sown) to identify suitable genotypes which are early (in flowering and maturity) and superior in yield.

Anticipatory breeding programme for mitigating threat of wheat blast disease

As an activity of breeding programme, sets of special nursery "Anticipatory Wheat Blast Screening Nursery (AWBSN) consisting of 122 entries were supplied and planted at six locations covering three states namely, West Bengal (4), Bihar (1) and Jharkhand (1) for monitoring incidence of wheat blast like disease.

Evaluation of breeding lines for physiological traits

In order to identify physiological superior lines, data on various physiological traits (LAI, chlorophyll fluorescence and chlorophyll) was recorded in 24 advanced breeding lines. The range and mean values for the studied traits is given in Table 1.12. All the genotypes that were found better than the best check for chlorophyll fluorescence and chlorophyll content are listed in Table 1.13. Chlorophyll fluorescence had significant negative correlation with LAI and positive with Fm. Both Fo and Fm had significant correlation with SPAD, chlorophyll and stomatal conductance (Table 1.14).

Marker assisted backcross breeding for drought tolerance in Wheat

With the advancement in molecular marker technology, several drought tolerant QTLS have been mapped from diverse sources which are amenable to be used for marker assisted breeding. Among these, two QTLs (Qyld.csdh.7AL and Qyld.4AL) were already mapped in the genotypes SQ 1 and Dharwad dry, respectively. In order to develop drought tolerant genotypes, introgression of these already identified drought tolerance QTLs into DBW 39 and GW366 using marker assisted backcross breeding is underway at ICAR-IIWBR. During the crop season 2019-20, BC_2F_2 progenies were planted and identified positive plants for introgression of target QTL. We obtained 57 BC_2F_3 homozygous progenies/lines (35plants derived from the cross DBW39 / SQ1 and 19 plants derived from the cross GW366 / SQ1) for the targeted QTLs. Seeds of BC_2F_3 progenies of DBW39 x SQ1

Table 1.12: Mean and range for various physiological traits

Parameter	Mean ± SE	Range
Leaf area index	5.02 ± 0.102	3.00 – 6.60
Initial fluorescence (Fo)	22.30 ± 0.447	18.33 – 30.00
Maximum fluorescence (Fm)	92.79 ± 2.298	64.33 – 121.33
Chlorophyll fluorescence (CFL)	0.75 ± 0.004	0.68 – 0.83
SPAD (Chlorophyll)	39.61 ± 0.711	28.13 – 45.67
Chlorophyll content (CHL)	0.04 ± 0.001	0.0227 – 0.0465
Stomatal conductance (gs)	308.72 ± 9.565	206.93 – 406.60

Table 1.13: Promising genotypes for physiological traits

Trait	Value	Genotype	Check (DBW187)
LAI	>5.50	NEP-TS-18-25, NEP-TS-18-34, NEP-TS-18-19 NEP-LS-18-17, NEP-TS-18-35, NEP-TS-18-12, NEP-TS-18-19,	6.20
Chlorophyll fluorescence	>0.77	NEP-TS-18-24, NEP-LS-18-12, NEP-TS-18-4 NEP-TS-18-35, NEP-TS-18-12, NEP-TS-18-19, NEP-	0.731
Chlorophyll	>0.040	RI-18-2, NEP-TS-18-18, NEP-TS-18-24, NEP-RI-18-16, NEP-LS-18-8, NEP-TS-18-13, NEP-LS-18-7	0.036
Stomatal conductance	>350	NEP-LS-18-12, NEP-RI-18-16, NEP-LS-18-7	405.08

Table 1.14: Pearson Correlation Coefficients among various physiological traits

Trait(s)	LAI	Fo	Fm	CFL	SPAD	CHL	GS
LAI	1	0.024	-0.238	-0.321*	-0.068	-0.068	0.069
Fo		1	0.718**	-0.034	0.353*	0.373*	0.458**
Fm			1	0.656**	0.398**	0.411**	0.306*
Fv/m				1	0.21	0.206	-0.089
SPAD					1	0.999	0.274
CHL						1	0.27
g_s							1

** Significant at p=0.05; ** significant at p=0.01; CFL= Chlorophyll fluorescence (Fv/Fm), CHL= Chlorophyll, gs= Stomatal conductance, LAI=leaf area index*

and GW366 x SQ1 crosses were planted at ICAR-IWBR, Karnal. DNA will be isolated and foreground MAS will be conducted. Positive plants for target trait in homozygous condition will be selected. BC_2F_4 seeds of both the crosses will be harvested during 2020-21 crop season at IIWBR and will be raised at Dalang Maidan to get fixed BC_2F_5 material for PYT testing.

Wheat improvement for warmer areas

Release of new variety DBWH221

New variety DBWH 221 has been recommended by the SVRC for timely sown irrigated conditions of the Haryana state. DBWH 221 has 62.8q/ha mean yield and 76.1 q/ha potential yield in Haryana state. It showed yield level of 61.3q/ha in on-farm trials in Haryana (Fig.1.4). DBWH 221 being heat stress tolerant (HSI- 0.71) variety will be a suitable choice to mitigate climatic changes. It has shown quality attributes for chapatti (score 7.6), bread (score 8.3) and biscuit spread factor (score 8.4) thus suitable for all the three products (chapatti, bread and biscuit).

Fig.1.4: DBWH 221-New Wheat variety

Hybridization and evaluation of breeding material

A total of 286 new cross combinations were attempted involving diverse parents to incorporate the desirable traits for warmer areas. During the period under report, 279 F1s were evaluated for yield and component traits along with check varieties namely HD 3086, HD2967, MACS 6222 and GW 322. Heterosis over best check DBW 187 was estimated for yield and a wide range of -71.6 to 44.4% was observed. The combinations showing positive heterosis for yield are listed in Table 1.15.

A total of 5726 different breeding lines developed from 1010 diverse crosses were evaluated during 2019-20. 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, 6076 selections representing 829 cross combinations were made based on plant type, maturity period, disease resistance, grain weight, tillering ability and grain number (Table1.16). In addition, 57 bulks of advanced lines were selected for their evaluation in PYTs.

Evaluation of advanced bulks in common PYTs: A total of 84 advanced bulks were contributed to three common PYTs of the IIWBR, out of which following 21 were promoted to IIWBR station trials during 2019-20 (Table 1.17).

Evaluation of triple dwarf genotypes for yield components: Thirty-eight dwarf genotypes were evaluated during 2019-20 for yield and component traits along with check variety DBW 93 and two registered genetic stocks namely DM 6 and DM 7. A wide range of variability was observed for all the traits and recorded grain yield ranging 23.0 to 73.8q/ha with mean trial yield of 45.1q/ha. These genotypes have plant height range of 70-90 cm and higher 1000-grain weight range of 17.6 to 57.9% over checks. The promising entries having higher yield and reduced plant height of less than 80 cm were identified (Table 1.16) as potential genetic resources.

Table 1.15: Performance of promising heterotic crosses

SN.	Cross	Heading (days)	Maturity (days)	Pl. Ht (cm)	TGW (g)	Gr Yield (g plot^{-1})	%Heterosis over DBW187
1	HI1605/DBW71	95	148	118	48	1102	44.4
2	HI1605/KRL1-4	95	144	112	44	1044	36.8
3	GW492/HP1968	95	147	104	47	998	30.8
4	WB2/DBWH221	102	144	106	42	984	29.0
5	DBWH221 /HD2967	101	148	95	39	960	25.8
6	WH1105/RAJ4083	100	145	105	37	912	19.5
7	DBWH221 /DBW252	99	145	107	42	894	17.2
8	HI1605/WB2	100	145	100	45	894	17.2
9	WH1105/WB2	103	147	95	40	880	15.3
10	DBW129/ HD2967	101	147	106	38	846	10.9
11	PHSL1/DBW 163	97	148	115	42	798	4.6
12	HI1544/DBW252	97	143	105	45	796	4.3
13	GW322/HI1605	102	145	109	44	792	3.8
14	MP4010/ PHSL10	94	146	123	41	786	3.0
15	GW322/FLW5	104	147	98	50	782	2.5
16	DBW90/WB2	100	148	98	42	776	1.7
	DBW 187 (check)	97	145	104	42	763	0

These may be further evaluated under agronomical manipulations at variable inputs for yield and associated traits.

Contribution to station trials

During 2019-20, twenty-two entries were contributed to IIWBR station trials out of which seven entries were promoted to NIVTs namely DBW 342, DBW 343 (NIVT 1A); DBW 353 (NIVT 3A), DBW 354 (NIVT 3B) and DBW 358 in two trials (NIVT 5A and 5B).

Contribution to coordinated trials

During 2019-20, six entries were contributed in NIVT 1A (DBW 306, DBW 309), NIVT 1B (DBW 310), NIVT 2 (DBW 314), NIVT 3B (DBW 320) and NIVT 5A (DBW 324) and one entry DBW 320 has been promoted to AVT-I of PZ-LS during 2020-21 crop season.

Table 1.16: Performance of triple gene dwarf wheat genotypes for yield traits during 2019-20

Sr. No.	Genotype	DH	DM	PH	Yr	G/S	TKW	Yield (q/ha)
1	WAPD 1521	109	149	77	20S	92	36	71.3
2	WAPD 1514	103	149	75	40S	79	41	64.4
3	WAPD 1519	110	149	73	5S	79	33	61.8
4	WAPD 1513	115	147	79	20S	79	35	58.1
5	WAPD 1515	105	147	78	60S	56	33	57.8
6	WAPD 1508	89	146	70	40S	51	32	54.0
7	WAPD 1516	110	149	76	40S	67	37	53.5
8	WAPD 1510	97	145	72	5MS	64	37	50.7
C1	DBW 93 (check)	106	147	90	60S	63	42	41.7
C2	DM 6 (check)	95	145	72	80S	67	20	26.7
C3	DM 7 (check)	97	148	73	80S	54	25	36.0

Table 1.17: Evaluation of segregating material in various generations

Generations	Evaluated lines (crosses)	Selected lines (crosses)
F_2	207	196
F_3	220	2180 (218)
F_4	2890(289)	1560(156)
F_5	1240 (124)	1140(114)
F_6	912(122)	824(108)
F_7	257(48)	176 (37)
Total	5726 (1010)	6076 (829)

Number of crosses in parenthesis

Table 1.18: Promising entries in PYT during 2019-20

Entry	Yield (q plot^{-1})	*Yr*	*Br*
ST-1 (Irrigated timely sown for NWPZ/NEPZ)			
DWAP TS-14	54.3	10MS	5S
DWAP TS-13	52.0	20S	5S
DWAP TS-21	51.9	10S	5S
DWAP TS-22	48.9	20MS	10S
DBW 187 (check)	47.2	TMR	0
ST-2 (Irrigated timely sown for CZ/PZ)			
DWAP TS-04	47.8	40S	20S
DWAP TS-29	46.4	10MR	5S
DWAP TS-07	45.7	30MS	10S
DWAP TS-26	45.6	40S	10S
DWAP TS-28	45.5	TR	0
MACS 6222 (check)	40.3	10S	5MS
ST-3 (Irrigated late sown for NWPZ/NEPZ)			
DWAP LS-06	54.2	10MS	5S
DWAP LS-07	50.1	5MR	10S
DWAP LS-11	48.6	20S	10S
DWAP LS-08	47.5	10MS	5S
DBW 173 (check)	47.7	20MS	10MS
ST-3 (Irrigated late sown for CZ/PZ)			
DWAP LS-13	45.9	20MS	5S
DWAP LS-16	44.4	0	0
DWAP LS-19	40.2	20S	20S
DWAP LS-14	40.1	40MS	20S
HD 2932 (check)	36.7	10MS	10S
ST-4(Timely sown restricted irrigation condition)			
DWAP RI-10	56.3	TR	0
DWAP RI-04	51.8	5MR	5S
DWAP RI-19	49.1	20MR	10S
DWAP RI-06	48.7	20MS	10MS
DBW 110 (check)	48.6	30S	20S

Identification of promising genotypes for limited irrigation/water scarcity conditions

A set of 70 elite lines including seven checks were evaluated at ten locations during 2019-20 crop season in replicated trials under timely sown irrigated (IR-TS) and restricted irrigation conditions (TS-RI). The pooled analysis of stress susceptibility index (SSI) and per cent reduction of yield under stress (Red. %) indicated wide range of variability in the material. The SSI ranged from 0.14 to 1.74 with mean value of 0.99 whereas reduction percent ranged from 3.54% to 44.63% with mean value of 25.45%. The results indicated that seven genotypes that showed desirable SSI and Red. (%) lower than the best check DBW110 be used as source of water stress tolerance in the wheat improvement programme under limited irrigation conditions (Table 1.19).

Hybrid wheat

Maintenance of A, B & R lines: Total 16CMS sources and 46 new diversified CMS lines in Indian background were maintained through controlled pollination along with respective maintainer lines. The row ratio was 2B: 4A: 2B for maintenance of A lines. These lines showed complete male sterility and are ready to use for hybrid development programme as parental lines (Table 1.20).

Diversification of A&R lines: Total 140CMS lines are in different BC generations of diversification in the agronomic background of 36 Indian cultivars and >6000 spikes have been pollinated in this activity during 2019-20. In order to diversify the restorer sources, the fertility restorer lines were crossed with 27 diverse Indian varieties and 84 new restorer lines are in different generations.

***Development and evaluation of experimental hybrids*:** A total of 48 new experimental hybrids were attempted during 2019-20 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, 46 experimental hybrids were evaluated at half as well as full seed rate (50 & 100kg ha^{-1}) along with two checks (HD3086 and HD2967) having 4 rows of 2.5m length spaced at 20cm. A wide range of heterosis for grain yield was observed, but none of the hybrid could out-yield the best check(DBW 187).

Table 1.19: DSI and reduction (%) in promising drought tolerant genotypes

SN	Entry	Drought Stress susceptibility index (DSI)											Reduction in yield under stress (%)
		Karnal	Ayodhya	Jabalpur	Powarkheda	Junagadh	Vijapur	Bilaspur	Akola	Niphad	Dharwad	Pooled	
1.	DWAP 18-07	-4.89	0.91	0.12	2.59	1.21	0.85	-0.70	0.50	0.71	0.60	0.14	3.54
2.	DWAP 18-12	-0.86	0.91	-22.06	3.49	0.79	0.95	0.96	-0.75	1.07	-0.08	0.15	3.96
3.	DWAP 18-04	0.64	1.47	-11.56	2.24	1.30	0.28	1.34	-2.85	1.16	0.49	0.52	13.41
4.	DWAP 18-38	2.51	0.00	1.11	4.17	0.55	-0.09	1.38	1.33	0.76	-0.80	0.53	13.61
5.	DWAP 18-65	-1.39	-0.42	-4.12	1.35	0.91	0.56	1.11	1.90	0.79	0.15	0.63	16.15
6.	DWAP 18-52	0.92	1.40	1.48	1.55	0.94	0.30	1.01	0.34	0.69	0.30	0.64	16.30
7.	DWAP 18-15	-0.75	0.81	-2.54	5.03	0.61	1.28	0.84	0.47	1.05	1.45	0.66	17.01
DBW110 ©		-3.62	0.66	4.43	4.97	1.16	1.13	1.04	-0.13	1.16	0.80	0.66	17.04
DBW93 ©		0.53	0.59	-24.67	2.68	0.83	1.52	1.23	1.25	0.79	0.90	0.70	18.05
HD2967 ©		1.06	1.42	-6.52	-1.30	0.89	-0.13	1.10	-3.13	1.06	1.30	1.04	26.59
HD2932 ©		1.31	0.59	8.84	0.74	0.86	1.00	0.73	1.84	0.91	0.98	1.12	28.79
GW322 ©		2.65	2.15	3.58	3.46	1.11	1.77	1.11	0.84	1.01	1.07	1.25	31.99
MACS6222 ©		-0.44	0.68	1.72	-0.93	1.15	0.79	0.89	1.57	1.09	1.05	1.28	32.78
DBW222 ©		2.02	2.23	3.61	1.27	1.43	1.18	0.77	0.05	1.18	1.01	1.29	33.05

Table 1.20: New diversified CMS lines in Indian background

SN	CMS	Parentage	A - Lines			B - Lines	
			Male Sterility (%)	Days to heading	Plant height (cm)	Days to heading	Plant height (cm)
1	DCMS 8	CMS 3A/DBW 17	100	99	80	99	84
2	DCMS 9	CMS 5A/DBW 17	100	99	91	102	90
3	DCMS 10	CMS 8A/DBW 17	100	100	89	103	91
4	DCMS 11	CMS 10A/DBW 17	100	99	91	99	91
5	DCMS 12	CMS 12A/DBW 17	100	103	88	103	92
6	DCMS 13	CMS 13A/DBW 17	100	104	93	104	92
7	DCMS 14	CMS 14A/DBW 17	100	100	91	103	92
8	DCMS 15	CMS 15A/DBW 17	100	100	91	105	92
9	DCMS 16	CMS 18A/DBW 17	100	99	89	100	93
10	DCMS 19	CMS 25A/DBW 17	100	100	90	99	92
11	DCMS 20	CMS 26A/DBW 17	100	99	87	99	91
12	DCMS 22	CMS 2A/DBW 16	100	103	93	105	94
13	DCMS 23	CMS 8A/DBW 16	100	103	87	105	90
14	DCMS 25	CMS 11A/DBW 16	100	104	95	105	96
15	DCMS 26	CMS 12A/DBW 16	100	104	92	105	94
16	DCMS 28	CMS 18A/DBW 16	100	103	96	105	98
17	DCMS 31	CMS 23A/DBW 16	100	103	92	105	92
18	DCMS 32	CMS 1A/PBW 502	100	103	97	103	99
19	DCMS 33	CMS 6A/PBW 502	100	103	96	103	97
20	DCMS 35	CMS 5A/DBW 55	100	104	84	103	93
21	DCMS 38	CMS 24A/DBW 55	100	105	92	105	94
22	DCMS 39	CMS 21A/DBW 55	100	105	88	106	96
23	DCMS 40	CMS 8A/DBW 60	100	91	104	93	104
24	DCMS 42	CMS 23A/DBW 60	100	91	96	97	103
25	DCMS 44	CMS 2A/CBW 38	100	99	99	105	102
26	DCMS 45	CMS 10A/CBW 38	100	98	103	98	103
27	DCMS 52	CMS 2A/UP 2338	100	99	100	105	100
28	DCMS 55	CMS 14A/RAJ 4037	100	97	101	99	103
29	DCMS 58	CMS 21A/DBW 60	100	92	102	105	109
30	DCMS 59	CMS 22A/DBW 87	100	105	99	104	100
31	DCMS 62	CMS 20A/HD 2967	100	101	97	104	100
32	DCMS 66	CMS 9A/HI 977	100	104	107	104	109
33	DCMS 68	CMS 26A/K 9006	100	98	106	97	107
34	DCMS 69	CMS 11A/NW 1012	100	101	107	101	109
35	DCMS 70	CMS 28A/PBW 550	100	91	87	90	87
36	DCMS 72	CMS 2A/RAJ 1482	100	100	94	99	97
37	DCMS 74	CMS 6A/CBW 38	100	102	103	101	107
38	DCMS 76	CMS 18A/CBW 38	100	101	102	102	100
39	DCMS 77	CMS 24A/CBW 38	100	101	103	101	110
40	DCMS 78	CMS 2A/HD 2967	100	97	107	103	107
41	DCMS 79	CMS 3A/HD 2967	100	97	103	104	104
42	DCMS 80	CMS 29A/HD 2967	100	99	100	103	102
43	DCMS 81	CMS 7A/DBW 39	100	101	104	100	106
44	DCMS 82	CMS 10A/DBW 39	100	103	97	104	96
45	DCMS 83	CMS 24A/DBW 126	100	104	93	106	91
46	DCMS 84	CMS 6A/DWAP 1102	100	104	115	103	114

Improving wheat genotypes for grain quality and end products

Release of new durum wheat variety DDW48

DDW48 was an indigenously developed durum wheat variety with the parentage of HI8498/PDW233// PDW291. It was released and notified by the Central Sub-Committee on CVRC, Govt. of India vide gazette notification number SO (E) 500 dated 29.01.2021 for commercial cultivation in Peninsular Zone (PZ) of India (Fig. 1.5). DDW 48 has shown yield superiority over the checks MACS 3949 (3.3%) and UAS 428 (5.1%). It is higher yielding (47.4q/ha) durum wheat variety compared to the check varieties MACS 3949 (45.9q/ha) and UAS 428 (45.1q/ha) under timely sown irrigated conditions of PZ. It also registered high potential yield of 72.0q/ha and a stable genotype, as it appeared 17 times out of 27 in 1st non-significant group. DDW48 has a good balance of grain yield and product quality. Besides, high yield potential and productivity, it has registered resistance to black and brown rusts thereby providing desirable resistance in the Peninsular Zone. The genotype is suitable for better pasta quality as compared to check varieties.

A. B. C.

Fig.1.5: A. Field view B. Grain and C. Grain characteristic features of DDW 48

New genetic stock developed and registered QST1910 (low Drought Sensitivity Index (DSI))

QST1910 was developed at ICAR-IIWBR by crossing HD2967/WH1080 and registered with ICAR-NBPGR (INGR20017 dated 29th September, 2020). QST1910 recorded the lowest Drought Sensitivity Index (DSI) in all the tested centers compared to the drought tolerant check varieties. QST1910 found to be superior with DSI of 0.65 compared to drought tolerant check varieties viz., DBW 110 (0.81), C 306 (0.83), K1317 (1.36), MP 3288 (1.36), and NI 5439 (1.44). The percent DSI superiority of QST1910 over check varieties was 19.8% (DBW 110), 21.7% (C 306), 31.6% (K1317), 52.2% (MP 3288), 54.9% (NI 5439). QST1910 was also superior to all the 5 check varieties for percent yield reduction, plant height, grain filling duration, productive tillers, and days to heading. Thus, QST1910 would be a potential source to be utilized in breeding programs to develop drought tolerant bread wheat varieties.

Hybridization program

During the year 2020, a total of 320 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.

Contribution to coordinated trials/nurseries

***Bread wheat**:* A total of 60 entries were contributed to different ICAR-IIWBR common PYTs during 2019-20 (25 for timely sown, 18 for late sown and 17 for restricted irrigated conditions), which were evaluated at new seed research farm, ICAR-IIWBR. On the basis of PYT data 15 entries were promoted to different station trails (ST-1: 6; ST-2: 3; ST-3: 4; ST-4: 2) and evaluated at multilocations. Eleven entries were evaluated in different station trials and based on the superior performance four entries promoted to different NIVTs (DBW 346: NIVT1A; DBW 356: NIVT 3A; DBW 360 and DBW 361: NIVT-5A). Also, four entries were evaluated in different NIVTs and promoted two entries to AVT testing (DBW313: AVT-NWPZ-IR-TS and DBW317: AVT-NEPZ-IR-LS). One entry (DBW 374) was contributed to CI-HYPT-IR-ES. Seven entries were contributed to QCWBN for testing at different centres. A total of 15 genotypes were also contributed for blast nursery in Bangladesh and 10 crosses for segregating screening nursery (SSN).

Durum wheat: DDW 48 and DDW 49 were evaluated in second year advanced varietal trial for irrigated timely sown conditions of peninsular zone. Based on superior yield and quality performance of DDW48 in the second year of advanced varietal trial, the genotypes has been released and notified by CVRC for timely sown irrigated conditions of Peninsular Zone. DDW53 & DDW54 were tested in national durum trial NIVT-4 and DDW55 was tested in NIVT-5B. A total of 15 entries were tested in common PYTs (9 for timely sown and 6 for restricted irrigated conditions) and one entry promoted to ST-2. A total of six entries were tested in station trials at multilocations (ST-2: 4; ST-4: 2). On the basis of ICAR-IIWBR station trial data DDW56 and DDW57 were promoted to test in NIVT-4 and DDW58 in NIVT-5B.

Biotechnological and physiological interventions

GWAS of three rusts in a diverse spring wheat panel of 483 genotypes

Among several important wheat foliar diseases, stripe rust (YR), leaf rust (LR), and stem rust (SR) have always been an issue of concern to the farmers and wheat breeders. Evolution of virulent pathotypes of these rusts has posed frequent threats to an epidemic. Pyramiding rust-resistant genes are the most economical and environment-friendly approach in postponing this inevitable threat. To achieve durable long term resistance against the three rusts, a study was made searching for novel sources of resistant alleles in a panel of 483 spring wheat genotypes. This had been a unique and comprehensive study where evaluation of a diverse panel comprising wheat germplasm from various categories and adapted to different wheat agro-climatic zones was challenged with 18 pathotypes of the three rusts (Fig. 1.6) with simultaneous screening in field conditions. The panel was genotyped using 35K SNP array and evaluated for each rust at two locations for two consecutive crop seasons. High heritability estimates of disease response were observed between environments for each rust type. A significant effect of population structure in the panel was visible in the disease response. Using a compressed mixed linear model approach, 25 genomic regions were found associated with resistance for at least two rusts. Out of these, seven were associated with all the three rusts on chromosome groups 1 and 6 along with 2B. For resistance against YR, LR, and SR, there were 16, 18, and 27 QTL (quantitative trait loci) identified respectively, associated at least in two out of four environments. Several of these regions got annotated with resistance associated genes *viz*. NB-LRR, E3-ubiquitin protein ligase, ABC transporter protein, *etc*. Alien introgressed (on 1B and 3D) and pleiotropic (on 7D) resistance genes were captured in seedling and adult plant disease responses, respectively. The present study demonstrates the use of genome-wide association for identification of a large number of favorable alleles for leaf, stripe, and stem rust resistance for broadening the genetic base (Fig. 1.7).Quick conversion of these QTL into user-friendly markers will accelerate the deployment of these resistance loci in wheat breeding programs.

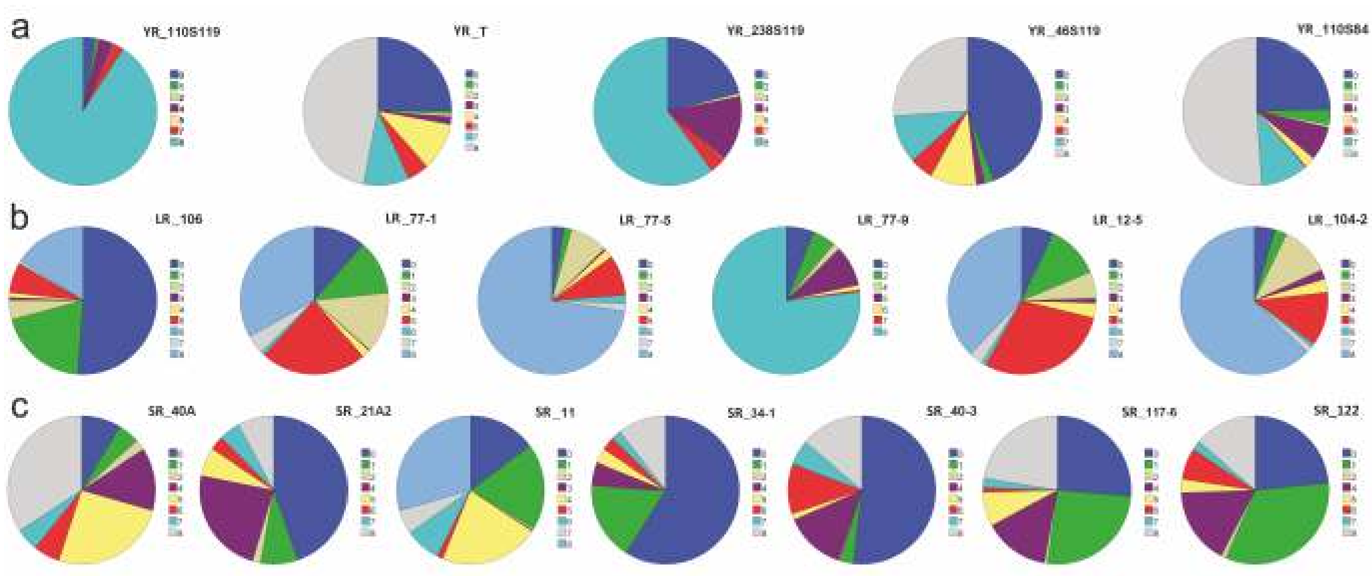


Fig.1.6: *Pie chart representing seedling response against (a) five pathotypes of stripe rust (YR), (b) six pathotypes of leaf rust (LR), and (c) seven pathotypes of stem rust (SR) of rust association mapping panel (RAMP). The color legend on the right side of each pie chart represents the infection type (IT) score. The magnitude of arc length is directly proportional to the frequency of genotypes showing corresponding IT scores*

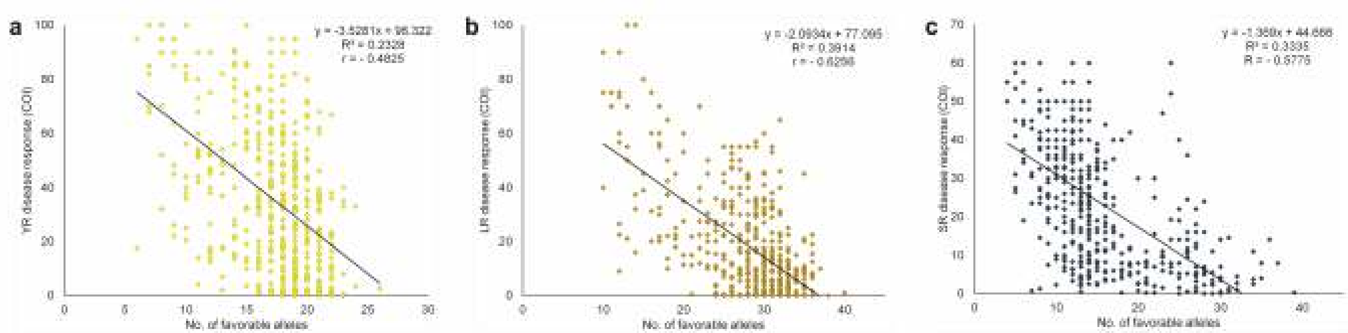


__Fig.1.7:__ Linear regression plots of field disease response towards (a) YR, (b) LR, and (c) SR, to favorable alleles of representative SNPs of identified QTL in each of the 483 genotypes in the panel and averaged COI score over different environments. All regressions were highly significant at P < 0.0001.

QTL mapping for Karnal bunt resistance in wheat

Karnal bunt (KB) disease of wheat, caused by the fungus *Neovossia indica*, is one of the most important challenges to the grain industry as it affects the grain quality and also restricts the international movement of infected grain. Genetics of Karnal bunt resistance indicates that the resistance is governed by one to several genes having partial dominance. Therefore, a study is being carried out to identify and characterize resistance loci (QTL) in mapping population (217) derived from cross KBRL22 (resistant and PBW343 (susceptible) parent. This population was phenotyped and screened for Karnal bunt for two consecutive years (2015-17) with the mixed strains of *Neovossia indica*. Earheads inoculated with KB were harvested and scored for disease incidence. More than 550 SSR markers were used for the parental screening spanning the wheat genome. In this study, we identified two consistent QTLs for KB resistance on chromosome 2B (*QKB.iiwbr*-2B) and on chromosome 5B (*QKB.iiwbr*-5B) accounting approximately 15% of phenotypic variation. The resistance at these loci was contributed by the parent KBRL22. The promising lines identified from the population (on the basis of agronomy, end use quality and KB resistance) carrying resistance alleles at identified loci, may be used for improving the wheat germplasm.

Validation of heat-responsive candidate gene based SSR markers

Based on literature review, we have selected functionally characterised heat-stress responsive candidate genes from model plant species. The sequence information of the identified genes were retrieved from the ensemble database. The sequences of genes/protein were used as query in database to identify the respective wheat orthologs. In this study, we have developed 177 heat-responsive gene-based SSRs (cg-SSR)markers derived from genic regions. The SSRs were mined using BlastPrimer3 from wheat genome for assessing genetic diversity analysis of 36 contrasting wheat genotypes for heat tolerance. Only, 144 SSRs yielded unambiguous and repeatable amplicons. Thirty seven out of 144 SSRs were found polymorphic and used for analysing the genetic diversity. The average mean of polymorphism information content was 0.35. Number of alleles produced per primer varied from 2 to 6. The UPGMA dendrogram analysis grouped all wheat genotypes into four clusters and one of the cluster having heat tolerance genotypes (Fig. 1.8). The markers developed in this study has potential application in the MAS based breeding programs for genetic diversity analysis and developing heat tolerant wheat cultivars.

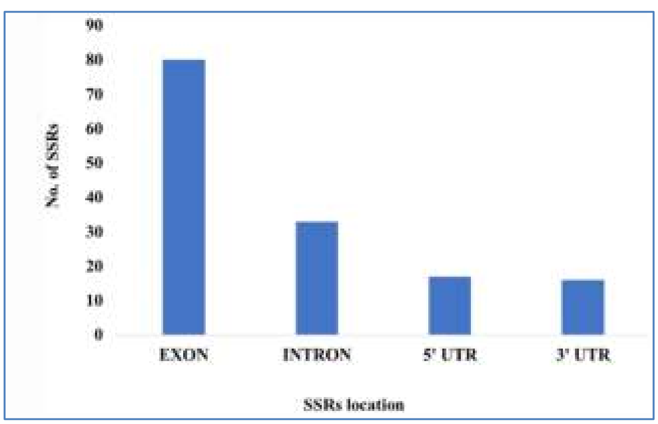


Fig. 1.8: SSRs distribution in the heat stress-responsive genes

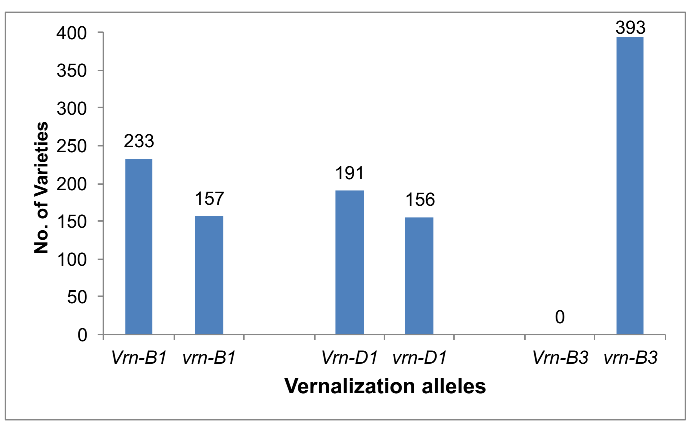


Fig. 1.9: Allelic variation at Vrn-B1, Vrn-D1 and Vrn-B3 loci in Indian wheat cultivars

Allelic variation at Vrn-B1, Vrn-D1 and Vrn-B3 loci in Indian wheat cultivars

Vernalization (*Vrn*) genes, photoperiod (*Ppd*) genes and genes controlling earliness per se (*Eps*) determine flowering and heading times and have a significant influence on the adaptability of wheat cultivars to diverse environmental conditions. The three major vernalization genes *Vrn-A1*, *Vrn-B1*, and *Vrn-D1* are located on the homeologous chromosomes 5A, 5B, and 5D and *Vrn-B3* is located on chromosome arm 7BS. Four-hundred Indian wheat cultivars were genotyped with functional markers of vernalization genes viz. *Vrn-B1*, *Vrn-D1* and *Vrn-B3*. At VRN-B1 locus, 59.74% cultivars were found to possess *Vrn-B1* allele and 40.25% cultivars have *vrn-B1*. At VRN-D1 locus, 55.05% cultivars have *Vrn-D1* allele and 44.95% have *vrn-D1* allele (Fig.1.9). All the cultivars screened with functional marker for VRN-B3 were found to possess *vrn-B3* allele.

Differential expression of bacterial genes in contrasting wheat genotypes for drought and heat stress tolerance

During the crop season 2019-20, five contrasting wheat genotypes each for drought stress tolerance and sensitivity were planted under rain out facility of ICAR-IIWBR, Karnal. The rhizospheric soil sampling along with plant roots was done at booting and anthesis stage of growth, and rhizoplane soil was precisely removed from each genotypes and processed for metagenomic analysis for finding the up- and down regulation of genes of bacterial microflora. Drought stress tolerant genotype DBW 110 showed highest up-regulation of *Staphylococcus saprophyticus, Methylotenera mobilis*, *Luteibacter rhizovicinus* and *S. succinus*, followed by *Dyella marensis* and *Comamonas*. Up-regulation of Comamonas and *Dyella marensis* along with *Streptomyces mirabilis* and *S. mashuensis* genes was also recorded in C 306 genotype. Another drought tolerant genotype NI 5439 also exhibited high numbers of up-regulated bacterial genes of *Brevibacillus laterosporus*, *S. mashuensis* and Cystobacterineae unclassified. Opposite to it, the drought sensitive mega variety HD 2967 exhibited low level of up-regulated genes of different bacteria and in majority cases it was of bacterial genera with lesser or no known plant growth promoting activities (Fig.1.10). Among sensitive genotypes, HUW 234 exhibited high up-regulation of *Agromyces mediolanus*, *Sinorhizobium*, *Adhaeribacter*, *Trachelomonas volvocinopsis*, *Paenibacillaceae* and *Paenibacillus*, while *Sphingomonas yebuuchiae* in both HUW 234 and HD 2733.

Similarly five contrasting wheat genotypes each for heat stress tolerance and sensitivity were planted under Temperature Controlled Phenotypic Facility of ICAR-IIWBR, Karnalduring the crop season 2019-20. The sampling and processing for metagenomic analysis was done as was done for the contrasting drought tolerant and sensitive genotypes. A distinct pattern of up-regulated and down-regulated bacterial genes was recorded in group of heat sensitive and tolerant genotypes. More numbers of bacterial genera were active in tolerant genotypes than sensitive genotypes. Bacterial genes from *Methylobacteriaceae*, *Nitrosomonadaceae*, *Rickettsiaceae*, *Massilia albidiflava* and *Sorangium cellulosum* were active in majority of the tolerant genotypes, while of genes of BSV 43, BPC015_unclassified, FBP_unclassified, C0119_unclassified, S-BQ2-57_unclassified, *Bacillus endophyticus* and *Candidatus Konbacter* were specifically up-regulated in sensitive genotypes (Fig.1.11).

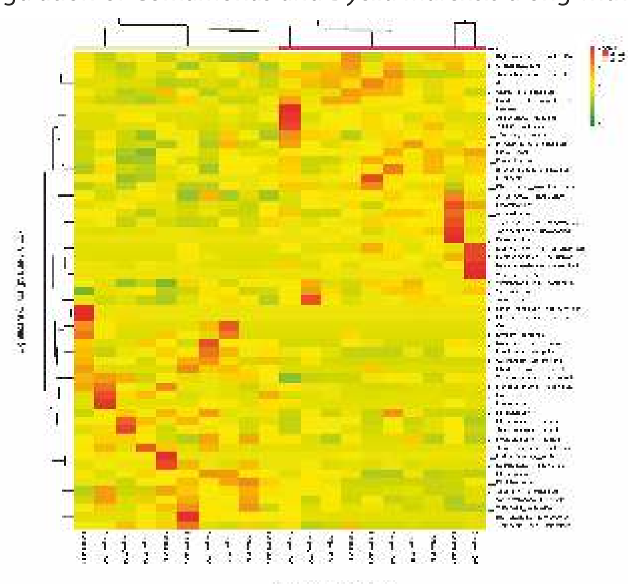


Fig. 1.10: Heatmap of rhizoplane region of contrasting genotypes for drought stress tolerance at anthesis stage of wheat growth

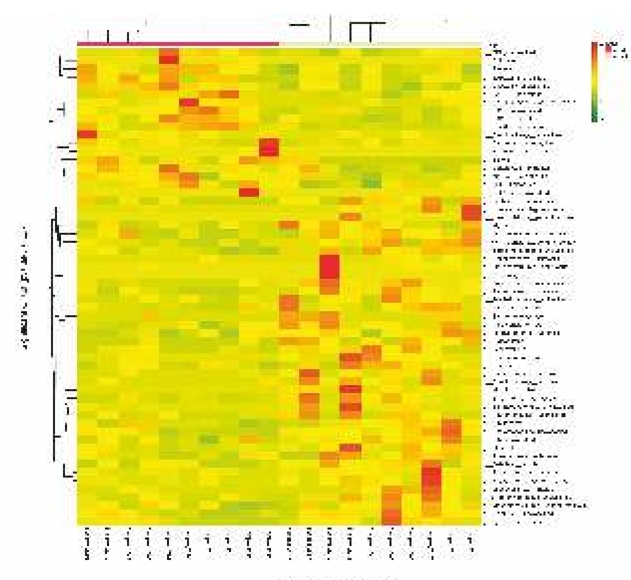


Fig. 1.11: Heat map of rhizoplane region of contrasting genotypes for heat stress tolerance at anthesis stage of wheat growth

Variation in the Carbon isotope discrimination Δ^{13}C/ stomatal resistance in wheat genotypes

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 other unexplored traits for wheat yield improvement. One such trait is increasing total plant biomass through efficient carbon capture by photosynthesis. High photosynthetic rate, stomatal/mesophyll conductance, rubisco caboxylation efficiency and leaf anatomical traits associated with C4 pathway are known to improve the carbon fixation. Currently, all these traits are very meagrely studied and less exploited in wheat breeding programmes. Improving stomatal/mesophyll conductance is attributing for nearly 10% improvement in photosynthesis, as stomata regulates exchange of gases between leaf and their surrounding and plays critical role in up taking carbon dioxide in plants. Hence, an attempt was made to study the stomatal resistance by indirectly measuring the carbon isotope (^{13}C). The leaf samples of around 75 wheat genotypes were collected at same phenological stage, ground to fine powder and later send to national facility for isotope measurements present at Dept. of Crop Physiology, UAS, GKVK, Bengaluru for IRMS analysis. The data indicated that there is significant variation exists for Δ^{13}C among the genotypes. The genotypes HD2864, HI1562, VL829, EMS 98, NIAW 295, HI8737 and Halna showed higher Δ^{13}C whereas the genotypes DBW 110, WH1105, DBW 71, HW 2004, LOK1, K0307 and HI 1563 showed lower Δ^{13}C with higher stomatal conductance and lower stomatal resistance (Fig. 1.12). Hence, Δ^{13}C can be efficiently used for faster screening of wheat genotypes with lower stomatal resistance for carbon dioxide uptake and further for improving photosynthesis.

Knocking down of TaMS1 gene in wheat using CRISPR/Cas9 mediated genome editing

CRISPR/Cas9 gene editing system is widely used for traits improvement in wheat. The genome editing technologies can accelerate wheat breeding by allowing the introduction of precise and predictable modifications directly in an elite background. ICAR-IIWBR has established a CRISPR-based genome editing facility and is working on few negative regulator genes with a focus to produce novel wheat genotypes with target traits and use them in wheat breeding programs. *TaMS1* is the gene which encodes a glycosylphosphatidylinositol (GPI)-anchored lipid transfer protein, which is necessary for pollen exine development and its knockdown helps in the generation of male sterile plants for hybrid seed production in wheat. CRISPR mediated knockout using SDN1 approach was used for *TaMS1* gene in Indian wheat genotypes. The SgRNA's targeting *MS1* gene at 4A and 4B chromosomes of the genome was designed using wheat crispr software, they were synthesised and ligated into sgRNA scaffold of pDIRECT_25F binary Vector. Transformed the ligation reaction into *E. coli* DH5α competent cells according to the manufacturer's protocol and plated the cells onto an LB plate containing Kanamycin. Incubated the plate at 37°C for overnight.Isolated the plasmid DNA from 5-ml cultures grown from individual colonies using a plasmid isolation kit (Qiagen) according to the manufacturer's instructions and confirmed the sgRNA insertion into vector

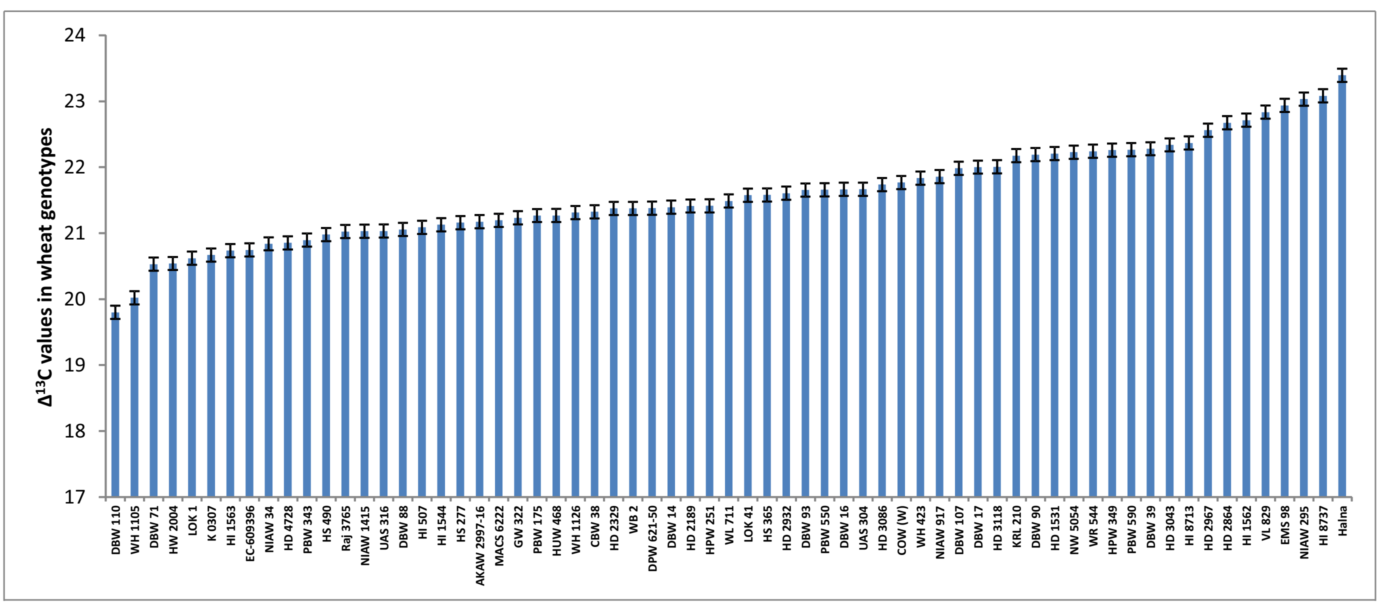


Fig. 1.12: Carbon isotope discrimination (Δ^{13}C) in wheat genotypes

by digestion and by PCR. The confirmed positive colonies with *MS1* SgRNA were transformed into agro strain EHA105 and then into DBW 187 wheat genotype according to protocol standardized as per Kumar et al., 2019 in our lab. Further characterization of T_0 plants for the required phenotype are under progress.

Promising wheat genotypes identified for heat tolerance

The wheat genotypes RWP-2018-31(HD3108/DPW621-50) and RWP-2018-32 (HD3131/DBW90) were developed at ICAR-IIWBR, Karnal. These entries were evaluated in national multi location heat tolerance trial (MLHT1) during the year 2018-19 and 2019-20 crop seasons and were evaluated at Durgapura, Hisar, Karnal, Ludhiana, Kanpur, Pusa, Ranchi, and Sabour centres which are hot spot locations for heat stress. RWP-2018-31 (0.90) and RWP-2018-32 (0.90) have showed Heat Susceptibility Index (HSI) values lower than checks, DBW150 (0.94), Raj3765 (0.93) and HD2932 (1.22). Both RWP-2018-31 and RWP-2018-32 recorded lower yield reduction (27%) compared to checks (table 1.21). Lower yield reduction (YR) under heat stress is the important character of a heat tolerant genotype. Both genotypes are also found to be promising for other traits like productive tillers (PT), biomass plot^{-1} (BM), plant height (PH), grain number spike^{-1} (GNS), grain weight spike^{-1} (GWS) and grain yield plot^{-1} (GY) under late sown condition. Thus, RWP-2018-31 and RWP-2018-32 can serve as a potential source to be utilized in future breeding programs to develop heat tolerant wheat varieties (Table 1.22).

Elucidating the anatomical variations in popular Indian wheat varieties

To improve the current understanding of the anatomical traits in wheat a study was conducted with the high yielding Indian wheat varieties. Anatomical characteristics like culm wall thickness, number of vascular bundles, arrangement of parenchymatous and sclerenchymatous cells has been studied by section cutting and microscopic investigations. A high level of anatomical variability was found among the genotypes studied. Raj 4037 and HI 1544 have solid pith along with more number of vascular bundles as compare to GW322. Solid pith provides better resistance to the culm and comparatively higher number of vascular bundles enhances the efficiency of transport system of the genotype. NW 5054 and NIAW 1415 both have a hollow culm and the number of vascular bundles in the outer ring is also less as compared to the other genotypes. Wheat varieties HD 2967, PBW 550 and DBW 17 have well developed chlorenchymatous cells which are contributing enhanced photosynthetic efficiency. K307 have multilayered scelerenchyma along with well developed conducting tissue (more number of vascular bundles) which enhance its culm strength despite having a tall stature. Zone wise characterization of anatomical variations in high yielding wheat genotypes has also been identified. The varieties were categorized on the basis of culm thickness (diameter), solidness/hollowness, presence/absence of chlorenchyma, thickness of sclerenchyma and number of vascular bundles. Wheat

Table 1.21: The HSI and yield reduction (%) of wheat genotypes over years (2018-19 & 2019-20)

Genotype	HSI			Yield Reduction (%)		
	2018-19	2019-20	Mean	2018-19	2019-20	Mean
RWP-2018-31	**0.88**	**0.93**	**0.90**	**31.8**	**23.1**	**27.4**
RWP-2018-32	**0.87**	**0.94**	**0.90**	**31.5**	**23.3**	**27.4**
DBW150(C)	1.06	0.82	0.94	38.4	20.3	29.4
HD2932(C)	1.22	1.19	1.22	44.1	29.6	36.9
Raj3765(C)	1.06	0.79	0.93	38.4	19.7	29.1

Table 1.22: Pooled data of agro-morphological traits of wheat genotypes under MLHT1 2018-19 & 2019-20 under late sown condition

Genotype	DH	DM	PT/3mt	BM(g)	PH(cm)	GNS	GWS(g)	GY(g)
RWP-2018-31	84	108	326.84	4681.88	96.72	52.14	1.89	1317
RWP-2018-32	81	109	293.59	4597.13	89.44	56.64	2.18	1325
DBW150(C)	78	106	275.88	4750.63	95.53	50.88	1.96	1248
HD2932(C)	80	108	285.06	4289.38	89.97	48.34	1.80	1270
RAJ3765(C)	76	106	293.53	4318.75	89.15	49.26	1.96	1270

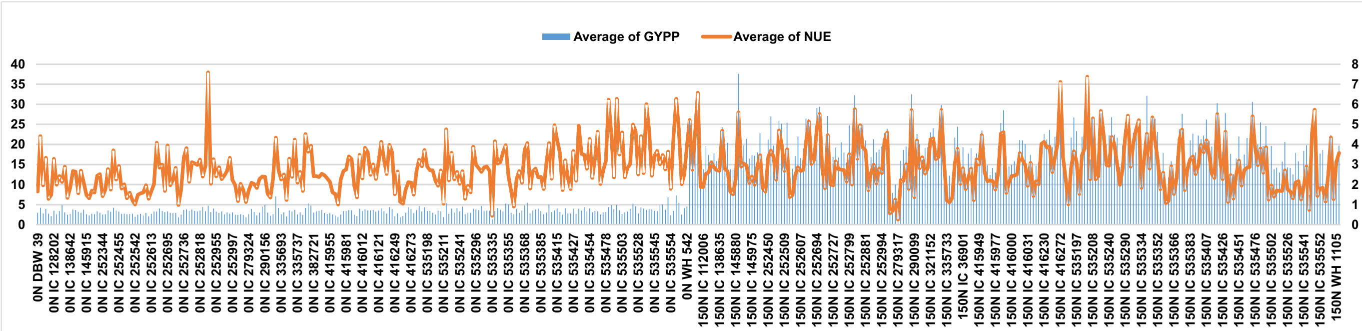


Fig. 1.13: Mean values of GYPP (g) and NUE (g GY g-1 N) of 241 wheat accessions under two N levels

genotypes of NWPZ and NWPZ/NEPZ (DBW17, HD2967) has been found mostly with solid/semi-solid culm and well developed sclerenchymatous cells. In the varieties of NEPZ presence of chlorenchymatous cells was not consistence but the vascular bundles was well developed. However the representative varieties (GW 366) of CZ have been reported to have mainly solid culm and well developed mesophyll tissue. More number of well developed vascular bundles represents efficient conducting system.However, the variability in shape, size, number and organization pattern of xylem and phloem cells of conducting tissue has also been studied but, further validation is needed to conclude the role of different types of cells within the tissue.

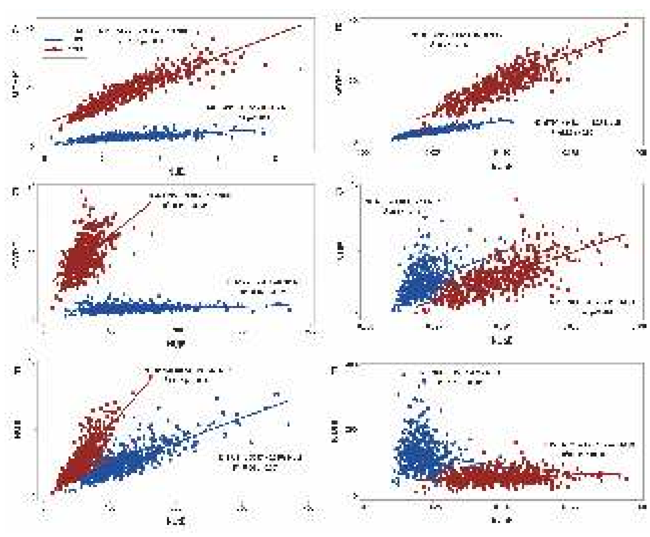


Fig. 1.14: Linear regression of A) GYPP vs NUE, B) GYPP vs NUpE, C GYPP vs NUtE, D) NUE vs NUpE, E) NUE vs NUtE and F) NUpE vs NUtE under high N (N0) and low N (N150) conditions for 241 indigenous wheat lines.

GYPP Grain Yield Per Plant (g), NUpE Nitrogen taken up by entire above ground biomass as a fraction of total nitrogen available to the crop, NUtE Grain yield as a function of the amount of nitrogen taken up (Moll et al., 1982), NUE Ratio of grain yield per plot to total available nitrogen (residual and fertilizer N); it is also the product of NUpE x NUtE (Moll et al., 1982).

Nitrogen use efficiency in wheat

Excessive nitrogen (N) use in agriculture adds additional cost to farmers and may also have adverse impact on environmental health. A study was carried out to identify wheat accessions with high nitrogen use efficiency (NUE) at ICAR-IIWBR, Karnal. Spring wheat lines comprising 235 indigenous gene bank accessions and 6 checks were screened for NUE, N Uptake Efficiency (NUpE) and N Utilization efficiency (NUtE) under two contrasting N levels.Grain yield per plant (GYPP), biomass, thousand grains weight (TGW), grain protein content (GPC), grain N (Gr N) were also measured. Significant N×genotype interaction was observed for GYPP, NUE and other studied parameters. GYPP in N0 was significantly (P = <0.001) reduced by 82.3 % (15.7 g plant^{-1}) compared to N150 (19.1 g plant^{-1}). Tukey's test of significance led ranking of genotypes identified IC535206 as the top ranked accession for NUE (7.37 g GY g^{-1} N) under N150. Under N0 treatment, IC252827 was the best genotype with NUE of 7.59 g GY g^{-1} N. GYPP was positively influenced by NUE amongst cultivars under both N0 (R^2 0.51, P< 0.001) and N150 (R^2 0.80, P< 0.001).

Association among NUE components: Linear regression between the NUE components and GYPP was performed to find out the relationship between them N levels and among the tested genotypes. GYPP was positively influenced by NUE amongst cultivars under both N0 (R^2 0.51, P< 0.001) and N150 (R^2 0.80, P< 0.001) treatments (Fig. 1.13 and 1.14). Also, NUpE was positively associated with GYPP under both N0 (R^2 0.78, P< 0.001) and N150 (R^2 0.77, P< 0.001) conditions. In the same manner, NUtE was also governed positively by GYPP in N0 (R^2 0.46, P< 0.001) and N150 (R^2 0.31, P< 0.001) treatments. When analysed across genotypes, the NUpE was having strong positive influence (R^2 0.48, P< 0.001) on NUE in N150 treatment, while on the other hand in N0 treatment the influence of NUpE on NUE was relatively weak (R^2 0.17, P< 0.001). NUtE had a strong positive effect on NUE both under N150 (R^2 0.67, P< 0.001) and N0 (R^2 0.64, P< 0.001) treatments. The regression analysis between NUpE and NUtE indicated

Table 1.23: Seed production of major bread and durum wheat varieties

S No	Variety	Production (q)
1	DBW187	1060.4
2	DBW222	1252.0
3	WB02	365.0
4	DBW173	262.14
5	DBW252	34.2
6	DBW303	134.6
7	DDW47 (d)	45.1

Table 1.24: Seed distribution of DBW187 and DBW222 to different agencies

Items	DBW187 (Karan Vandana)	DBW222 (Karan Narendra)
Private Seed Growers	239	185
ICAR-Institutes/NGOs	18	5
Krishi Vigyan Kendras	18	12
State Ag. Universities	10	8
State Government Agencies	7	5

presence of negative association between them under N0 (R^2 0.24, P< 0.001) and positive association under N150 (R^2 0.38, P< 0.001) treatment (Fig 2).Averaging across genotypes linear regression of NUE components and GYPP revealed that, GY attainment under N0 was mainly controlled by NUtE than NUpE at harvest. The availability of high NUE accessions in genebank and understanding the relationship between GY and NUE components under low to moderate N conditions would help in their best use towards breeding high NUE cultivars.

Wheat seed production programme

The institute produced 4284.6q breeder and TL seed of 9 wheat viz., DBW303, DBW187, DBW222, DBW252, DBW173, WB02, HD2967, HD3086, DDW47 (d) and four barley varieties viz., DWRB 137, DWRB 101, DWRB 160 & DWRB 182 during 2019-20 in collaboration with ICAR-NDRI Karnal and ICAR-CPRI-RS, Modipuram. After selling of Nucleus/ Breeder and TL Seeds of wheat. An amount of ₹2,85,42,438.00 has been generated in the revolving fund scheme of the institute (Table 1.23 &1.24).

ITMU: Technology commercialization through public-private partnership for strengthening

Intellectual Property and Technology Management Unit in ICAR facilitates matters related to intellectual properties and technology transfer/commercialization through '***National Agriculture Innovation Fund***' with three components viz. Component I: Innovation Fund (the XI Plan Scheme of Intellectual Property Management and Transfer/ Commercialization of Agricultural Technologies). The ITMU unit at IIWBR, Karnal during the last one year, has been successful in commercialization of three wheat (DBW187, DDW222 & DBW252) and one barley (DWRB160) varieties through licensing with private and public seed growers (Table 1.25). The details of the licenses issued during 2020 is given below along with the revenue generated from this activity.

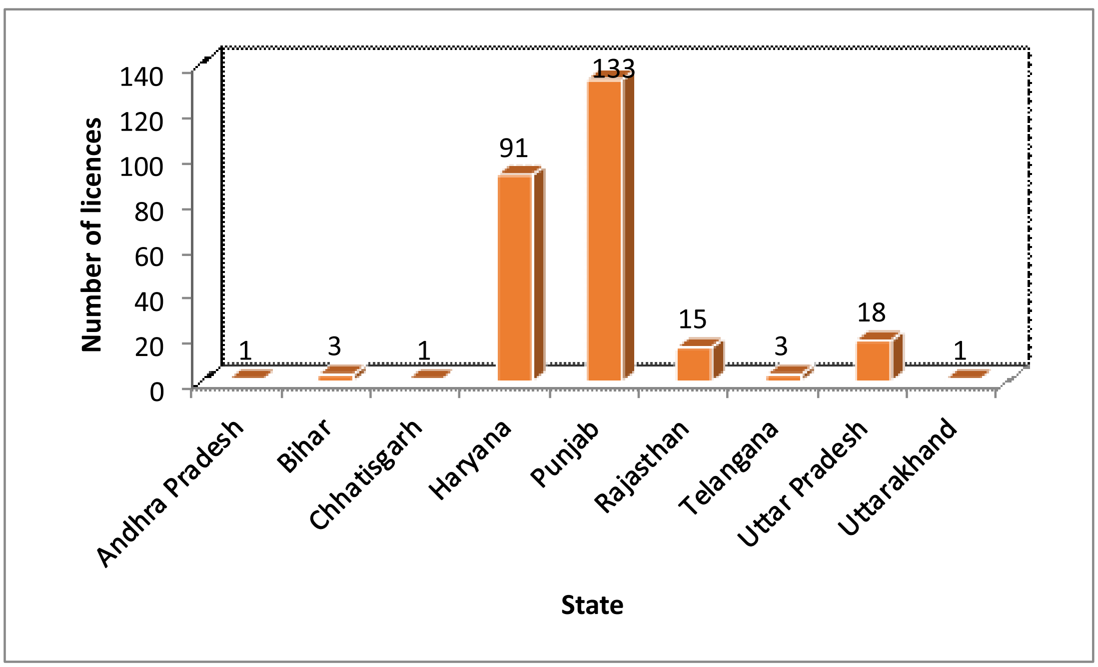


Fig. 1.15: Details of licences signed by the firms of different state

Table 1.25: Details of the licenses issued during 2020

SN	Wheat / Barley Variety	Year of Licensing	Revenue generated (₹)	Number of licenses issued
1	DBW 187	2020	4484000/-	76
2	DBW 222	2020	10915000/-	185
3	DBW 252	2020	29500/-	1
4	DWRB160	2020	118000/-	4
		Total	15546500/-	266

Technological Interventions for efficient seed distribution during Covid-19 pandemic

In order to supply the quality seed of recent wheat varieties viz., DBW187, DBW222 and DDW47, the institute created the wheat seed portal for the farmers. The seed portal was designed and executed through IIWBR website during the September month. All the interested farmer were allowed to provide needful information including his/her name, village, mobile number, district and state, upload soft copy of Aadhar card, select the variety and quantity of seed to be purchased. After that he/she received an OTP on his/her mobile and then a message was sent to all such farmers that their request has been registered with the IIWBR. This facility was utilized by about 5000 farmers from different states like Haryana, Punjab, U.P., Bihar and Rajasthan, who successfully registered on the portal during 15.09.2020 to 23.09.2020. The portal was closed after the successful registration of the farmers as per the seed availability. The major task before the institute was to distribute the seeds to the registered farmers. The farmers were then grouped into clusters and accordingly informed through bulk SMS sent during 17th October to 23rd October 2020 to come and collect the indented/ allotted seed on specific date and time. The institute then organized seed distribution through five counters by following COVID-19 guidelines of social distancing and options for digital modes of payment (QR code, net banking or card swipe) were given. This way, >6000 kg seed of indented varieties were provided to the farmers through this newly evolved, safe, IT technology driven and user friendly approach as most of the farmers were really happy and satisfied to receive the seed of recent varieties conveniently in the time of Covid19. The success story that gained attention of all stakeholders has also been published by the Indian Council of Agricultural Research on its website (https://icar.org.in/content/technological-interventions-efficient-seeds-distribution-during-covid-19-pandemic) for wider circulation and adoption.

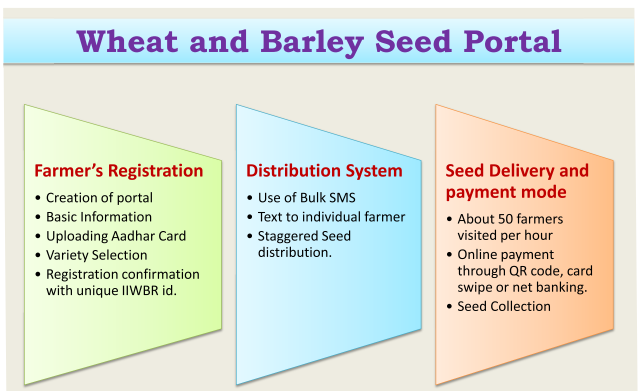


Fig. 1.16: Seed Portal of ICAR-IIWBR

2. CROP PROTECTION

Wheat is affected by several biotic and abiotic stresses that result in low production and productivity. Crop protection programme is aimed to reduce the avoidable losses caused by diseases, insect pests and nematodes which minimize the gap between attainable yield and actual yield. The biotic stresses are managed mainly through host resistance so there will be minimal use of pesticides. Therefore, large number of germplasm and varieties are screened for major diseases and insect pests of wheat to identify new sources of resistance. Crop protection programme supports wheat breeders to evaluate breeding material for resistance to biotic stresses against rusts and blight in pre-coordinated and coordinated yield trial entries against major diseases, insect pests and nematodes along with check varieties aiming to help breeders for promotion of resistant entries in yield trials and finally for varietal identification as well as release.

In adition to this, survey and surveillance is also a major activity under the crop protection programme to keep eye on any biotic threat to wheat crop as well as racial distribution and emergance of new races. Survey provides overall disease and insect pest situation at farmer's field which helps in timely action for remedial measure to check the further spread of diseases and pests. During the crop season 2019-20, first occurrence of yellow rust was reported from the three fields in Anandpur Sahib Block of district Rupnagar in villages Chandesar and Darolli (hethlii) on varieties HD 3086, PBW 677 and WH 711 on 26.12.2019. Later, in the month of January few reports of yellow rust were from only foot hills in Punjab namely Rupnagar, Anandpur Sahib, Kiratpur Sahib block, Chamkour Sahib block, Hoshiarpur and Gurdaspur. Minor incidence of leaf rust and stem rust was also reported from central and peninsular zone. The surveys were also conducted in West Bengal along Bangladesh border. No wheat blast disease is reported from West Bengal, whereas in some places leaf rust and head scab has been reported at low intensity. The detailed information was published in "Wheat Crop Health Newsletter", Vol. 25 (Issuses 1 to 4) and same were uploaded on ICAR-IIWBR website (iiwbr.icar.gov.in). Likewise, advices were given to farmers on crop health management on toll free No. 18001801891. Over all, the crop remained healthy and negligible losses were happened due to biotic stresses, thus contributed to the record wheat production. Different agencies (DAC & FW, ICAR, State Agriculture Departments, KVKs and 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 achievements of programme, 2020 are as below:

PLANT PATHOLOGY

Host resistance

Germplasm and breeding material were evaluated under different plant pathological and entomological nurseries at various hot spot locations under artificially inoculated conditions. The major nurseries were: Initial Plant Pathological Screening Nursery (IPPSN), Plant Pathological Screening 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 evaluated for different diseases at hot spot locations and 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.

A total 1324 entries in IPPSN and 397 entiries in PPSN including checks were screened for major diseases and insect pests and on the basis of this the entries were further promoted in yield trials as well as for 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.

Entries and check varieties identified resistant against rusts in PPSN

Rust resistance materials in AVT entries (2019-20) with ACI upto 10.0 are given below:

Stem, leaf and stripe rusts

DBW187 (C), DBW252(I) (C), DBW303*, DBW328, DDW47(d)(I), HD3249(I) (C), HD3334, HI 8823(d), HI8627(d), HI8805(d)(I) (C), HI8818(d), HS507 (C), HS679, HS681, MACS3949(d) (C), MP1358, MP1361, MPO1357(d), NIDW1149(d)*, PBW804, TAW155, UAS 472(d), UAS466(d)(I), VL 3024 and WH1252

Leaf and stripe rusts

DBW332, DBW333, DDW48(d)*, DDW49(d)*, HS680, JKW261, UAS428(d) (C), UAS446(d)(C), VL3022 and WHD964(d)

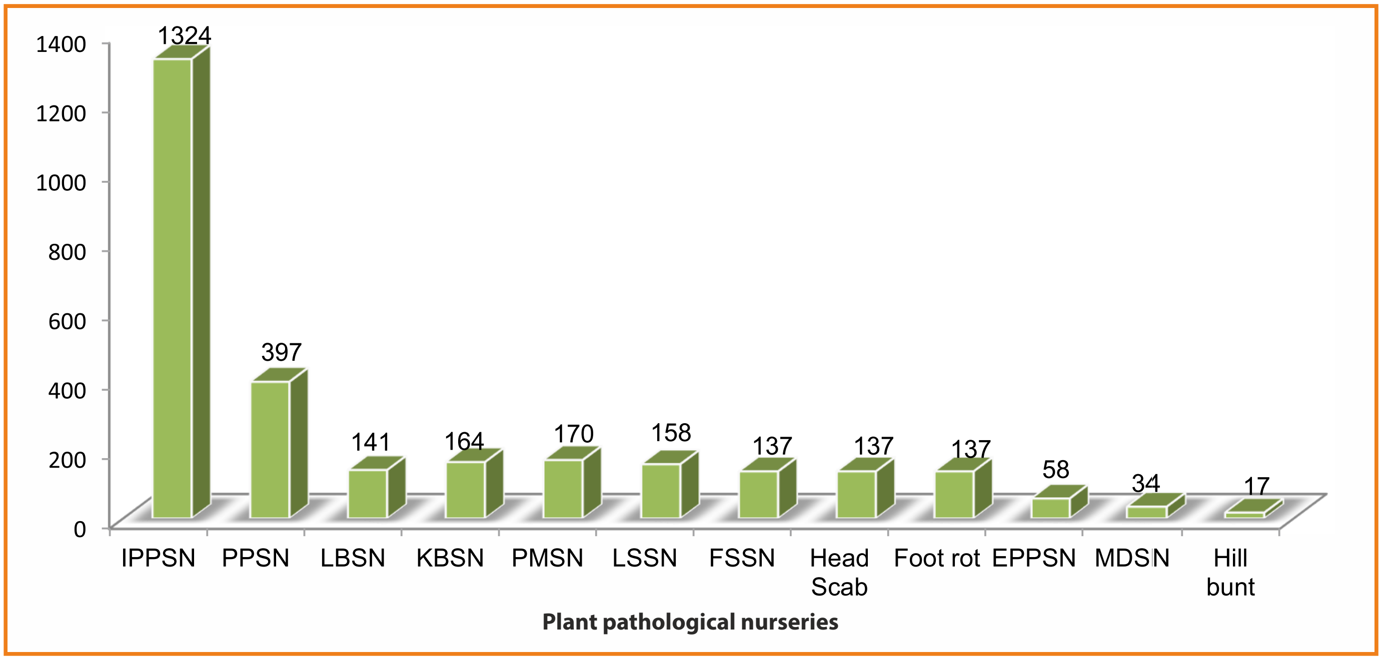


Fig. 2.1: Constitution of different Plant Pathological Nurseries during 2019-20

Leaf and stem rusts

CG1029*, DBW173 (C), DBW296, DBW329, DBW39 (C), DDK1029 (C), DDK1058, DDK1059, GW513, GW519, HD2864, HD3059 (C), HD3090 (C), HD3377, HI1544, HI1628(I) (C), HI1633*, HI1634*, HI1636, HUW838, HW1098 (C), MACS5054, MACS5055, MACS6222 (aest.) (C), MACS6747, MACS6749, MACS6752, MP3288, NIAW3170(I) (C), PBW550 (C), PBW771(I) (C), PBW840, RAJ4541, UP3033, VL 2036, VL 892 (C) and VL 907 (C).

Performance of wheat entries tested against different diseases in PPSN

The advance varietal trial entries were also screened against major diseases other then rust under disease specific plant pathological nurseries. The performances of the entries are given below:

Leaf blight resistance

The entries from AVTs which showed the moderate level of resistance with an average score below 35 are HS681, HD2967(C), HS680 and DBW331 but the highest score exceeded 57 due to high disease at one location.

Powdery mildew resistance

The entries showed resistant (average score 0-3, highest score upto 5) to powdery mildew are HS507(C), HS562(C), HS681, HS680, HPW474, UP3069, HPW473, HS490(C), HD3334, WH1264, HD3298*, WH 1124(C), UP3033, HUW838, HI1628(I)(C), WH1080(C), WH1142(C), NIAW3170(I)(C), PBW804, DBW187(C), K1006(C), HD2888(C), HI1612(C), DBW252(I)(C), MPO1357(d), HI8627(d), UAS466(d)(I), DBW110, WHD964(d), DDW48(d)*, MACS6749, UAS446(d) (C), MP1358, HW1098 (C), DBW330, DBW328, EIGN33, YRC1, ONS 27, ONS29, PMC1, MDSN15, VL3021, DBW257, HD3277, UP3042, DBW302, HD3347 and NW 7060.

Flag smut resistance

The entries HI8627(d), UAS466(d)(I), UAS472(d), HI8823(d), DDW47(d)(I), WHD964(d), DDW48(d)*, MACS3949(d) (C), HI8818(d), UAS428(d)(C), DDW49(d)*, NIDW1149(d)*, UAS446(d) (C), MACS4087(d), AKDW2997-16(d)(C), HI8805(d)(I)(C), UAS472(d), MPO1357(d), MACS5055, DDK1029 (C), MACS5054, DDK1058, HW1098 (C) and DDK 1059 were found free at all the locations.

Loose smut resistance

AVTs of year of 2018-19 expressed diseases symptoms during 2019-20 and found resistant (average infection upto 5.0 %) are HPW467, HD3086(C), HI8713(d)(C), HI8811(d), HI8812(d), GW1348(d), DDW49(d), DDW48(d), UAS466(d)*, DDW47(d)*Q, UAS428 (d)(C), WHD963(d), HI8805(d)*, AKDW2997, 16(d)(C), UAS446(d)(C), NIDW1149(d) and DDK1057.

Resistance to multiple diseases

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

A. Resistant to all three rust + KB+PM+FS+FHB: HS660, GW 1339, HI 8800 (d), PBW 757, DWB 187 and DBW 237

***Resistant to all three rusts +LB+ KB+FS+FHB**:* PBW 800 and PBW 763

***Resistant to all three rusts +PM+FS+FHB**:* HS661

***B. Resistant to stem and leaf rust + KB+PM+FS+FHB**:* GW1346 (d), GW492, HPW459, MACS4059 (d), MACS5051, GW491 and HPW451

Resistant to stem and leaf rust +LB+ KB+PM+FS+FHB: NIAW3171, UP3016 and HI1628

Resistant to Stem and Leaf rust+LB+ KB+FS+FHB: DDK1054

Resistant to Stem and Leaf rust + KB+FS+FHB: AKW4924 and HI1624

C. Resistant to leaf and stripe rust +KB+FS+HB: PBW797 and PBW801

Resistant to leaf and stripe rust +KB+PM+FS+FHB: MPO1336

Utilization of resistance sources

The NGSN comprising 27 entries with confirmed sources of multiple disease resistance were planted at 20 breeding centers across different agro climatic zones of country for their utilization in breeding for resistance to biotic stresses. All 27 entries were utilized in the range of 0.0 – 50.0% by the breeding centres. The most utilized entries at many centers were PBW777, HS611 and HS645. Malan and Ludhiana center, utilized maximum 12 entries in their breeding programme followed by Pune.

Strategy planning meetings

Preparedness to manage wheat blast

Strategy planning meeting was conducted on "Alternate crop plan to combat the wheat blast like disease" on 18.9.2020 through virtual platform. The meeting was chaired by the Agriculture Commissioner, DAC&FW, Govt. of India. From IIWBR the meeting was attended by Dr. Gyanendra Pratap Singh, Director, IIWBR, Dr. Gyanendra Singh, PI (Crop Improvement) and Dr. Sudheer Kumar, PI (Crop Protection). Dr. Sudheer Kumar made the presentation on work done in wheat blast project. It was discussed that resistant varieties need to be promoted in the disease prone areas. Five resistant varieties identified namely DBW187, HD3249 and HD2967 (irrigated and timely sown) and DBW252 and HD3171 (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

Need based advisory for stripe rust management was issued. Awareness among farmers for stripe rust management especially in Punjab, Haryana and Jammu was created through mobile, internet, toll free number, newspapers, discussions and delivering lectures in farmers training programmes.

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 Bengal and BCKV, Kalyani, Nadia, West Bengal and no wheat blast disease was observed. However, due to spread of COVID-19 and consequent lockdown surveys were not conducted in end of March and April, 2020. To check entry of blast from Bangladesh, strict quarantine has been observed. The restrictions on cultivation of wheat as wheat holiday in Murshidabad and Nadia district as well as No wheat zone in 5 Km along Bangladesh border have been enacted and in place of that state Govt. adopted alternate crop plan. A new variety HD3293 (restricted irrigation and timely sown) has been identified for NEPZ on the basis of resistance to wheat blast. Further, for identification of wheat blast resistant sources, a total of 350 Indian wheat varieties and advance breeding material were sent to screen at Jessore, Bangladesh and Bolivia through CIMMYT. Five resistant varieties identified namely DBW187, HD3249 and HD2967 (irrigated and timely sown) and DBW252 and HD3171 (restricted irrigation and timely sown) have been recommended for disease prone areas of West Bengal. Anticipatory breeding programme has been initiated for faster breeding of blast resistant cultivars.

Post harvest surveys

A total of 2438 grain samples collected from various mandies in different zones were analyzed at cooperating centers (Table 2.1). This year very limited samples have been collected due to lockdown in the country during the harvesting time because of COVID-19 outspread. The overall 50.5% samples were found infected. The samples from Haryana showed maximum infection (57.8%). In general, the Karnal bunt infection was higher in comparison to previous year because of intermittent rains during the booting and grain formation stages.

Table 2.1: Karnal bunt situation in the country during 2019-20

State	Total samples	Infected samples	Infected samples (%)	Range of grain infection (%)
Haryana	1183	684	57.8	0.05 – 4.4
Rajasthan	405	151	37.7	0.1 – 10.8
Uttarakhand	850	397	46.7	0.1 – 10.0
Total	2438	1232	50.5	0.1 – 10.8

Management of diseases through chemical

Evaluation of new chemicals against yellow rust and powdery mildew

Different fungicides were evaluated for the management of yellow rust and powdery mildew of wheat. The fungicide provided maximum disease protection against yellow rust in different locations include: Tebuconazole 50% + Trifloxystrobin 25% WG @ 0.06%, Propiconazole@0.1% and Picoxystrobin 7.05% + Propiconazole 11.7% SC @ 0.1%. Whereas, maximum disease protection against powdery mildew infection was provided by Tebuconazole 50% + Trifloxystrobin 25% WG @0.06% in Almora, Jammu and Karnal locations, while Azoxystrobin 18.2% w/w + Difenoconazole 11.4% w/w SC @0.1% were observed as highly effective at Dhaulakuan and Pantnagar location.

Sensitivity of *Fusarium graminearum*, fungal incitant of Fusarium Head Blight disease in wheat against newer fungicides

Fusarium head scab or Fusarium head blight is an emerging disease of wheat caused by a fungal pathogen, *Fusarium graminearum*. The sensitivity of the fungal incitant was evaluated against nine newer fungicides *viz.*, Tebuconazole 50% + Trifloxystrobin 25%, Tebuconazole 25.9%, Azoxystrobin 12.5% + Tebuconazole 12.5%, Picoxystrobin 7.05% + Propiconazole 11.7%, Propiconazole 25%, Pyraclostrobin 133g/L + Epoxiconazole 50g/L, Azoxystrobin 18.2% + Cyproconazole 7.3%, Azoxystrobin 18.2% + Difenoconazole 11.4% and Propiconazole 13.9% + Difenconazole 13.9%, at 25, 50, 75 and 100 ppm using *in vitro* poisoned food technique. After 8 days of incubation, Tebuconazole 50% + Trifloxystrobin

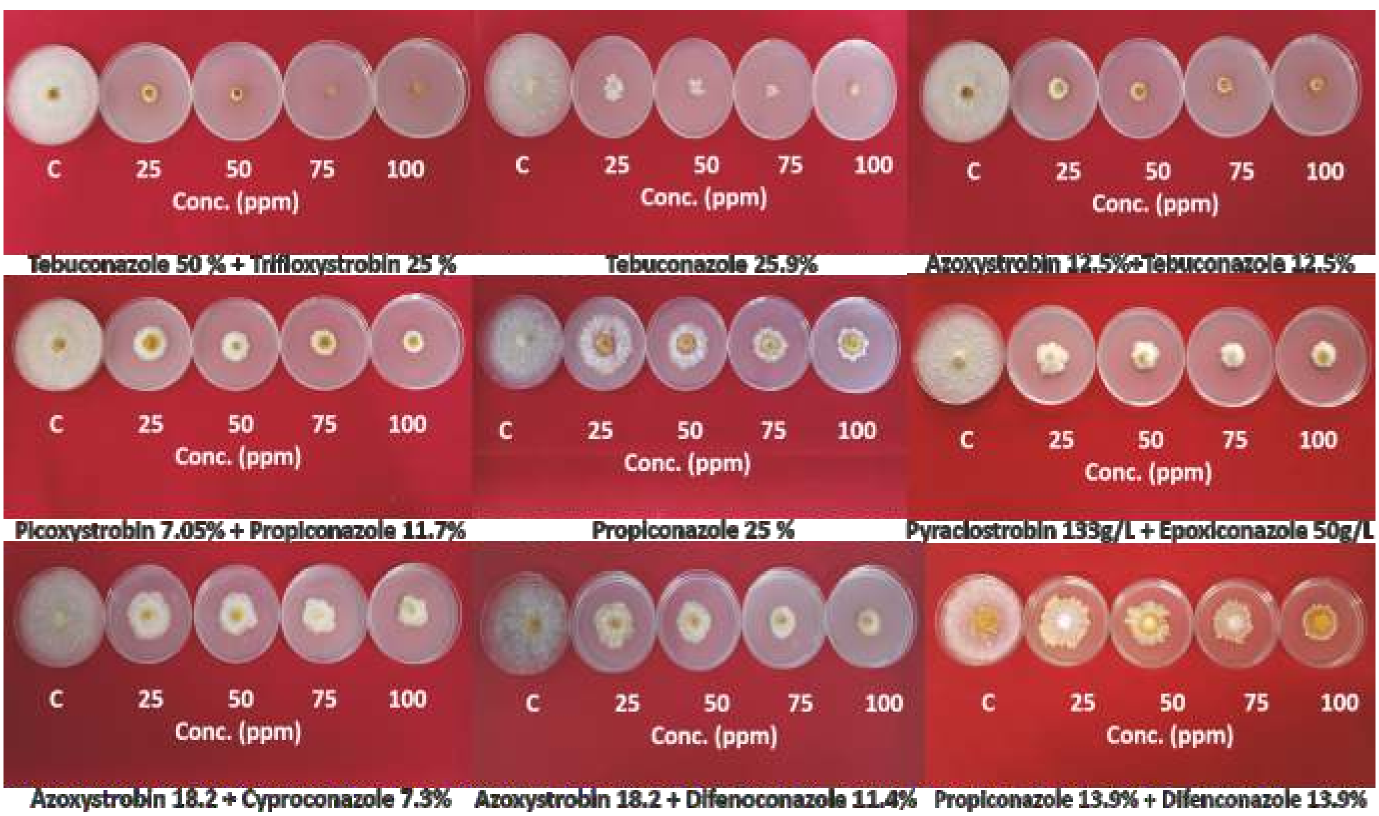


Fig. 2.2: Sensitivity of *Fusarium graminearum,* fungal incitant of Fusarium Head Blight disease in wheat against newer fungicides

25% (at 75 ppm & 100ppm), and Tebuconazole 25.9% (at 100 ppm) were most effective fungicides giving 100% control of this pathogen followed by Azoxystrobin 12.5% + Tebuconazole 12.5% (100 ppm) which caused 92.96% inhibition, whereas Propiconazole 25% (25ppm) showed minimum inhibition (41.11 %) in radial growth of the pathogen (Fig. 2.2).

Efficacy of newer fungicides against fungal biomass production by *Fusarium graminearum*, incitant of Fusarium head blight disease in wheat

The fungal biomass production potential of Fusarium head blight, fungal incitant was evaluated against nine newer fungicides *viz*., Tebuconazole 50% + Trifloxystrobin 25%, Tebuconazole 25.9%, Azoxystrobin 12.5% + Tebuconazole 12.5%, Picoxystrobin 7.05% + Propiconazole 11.7%, Propiconazole 25%, Pyraclostrobin 133g/L + Epoxiconazole 50g/L, Azoxystrobin 18.2% + Cyproconazole 7.3%, Azoxystrobin 18.2% + Difenoconazole 11.4% and Propiconazole 13.9% + Difenconazole 13.9%, at 5, 10, 15, and 20 ppm. The potato dextrose broth medium premixed with these fungicides separately was used as substrate for the experiment under laboratory conditions. After 15 days of incubation, Tebuconazole 50% + Trifloxystrobin 25% (at 20ppm), was most effective (95.40%) in limiting biomass production potential of the pathogen, whereas Propiconazole 25% (5ppm) was least effective in limiting the biomass production potential of the fungal incitant which caused only 27.86% inhibition in fungal biomass.

PCR based diagnostic assay for quick detection of flag smut fungus (*Urocystis agropyri*)

Flag smut caused by *Urocystis agropyri* has the potential to cause substantial reduction in yield and quality of wheat production. An early and precise diagnosis is a key component in the successful management of flag smut of wheat. Therefore, a simple molecular assay for the rapid detection of *U. agropyri* in wheat plants and field soil (Fig.2.3) was developed for the first time in the world. To detect *U. agropyri*, species specific primers were developed by comparing the partial sequences of internal transcribed spacer (ITS) DNA region of *U. agropyri* with related and unrelated phytopathogenic fungi. The clear amplicons of 503 and 548 bp were obtained with the two sets of designed primers (UA-17F/UA-519R and UA-15F/UA-562R) from the genomic DNA of 50 geographic distinct isolates of *U. agropyri*. However, no amplicon was obtained from the DNA of other 21 related and unrelated phytopathogenic fungi which showed the specificity of the primers for the *U. agropyri*. PCR reaction was also set up to confirm the presence of *U. agropyri* spores in six different wheat varieties along with eleven distinct regional soil samples as template DNA. The presence of *U. agropyri* in all the soil samples collected from an infected field and plant tissue of diseased plants collected at two different stages (20 and 40 days post sowing) and the absence in the soils and plants of healthy plots indicated 100% reliability for detection of *U. agropyri*. This simple and rapid test can be employed for the detection of *U. agropyri* from enormous wheat and soil samples in very short time with less man power. Thus, the reported molecular assay is very specific for *U. agropyri* and requires less time and man power over conventional diagnosis which is often confused by coinciding morphological features of closely related fungal pathogens, and therefore, it can be used for quarantine surveillance of flag smut.

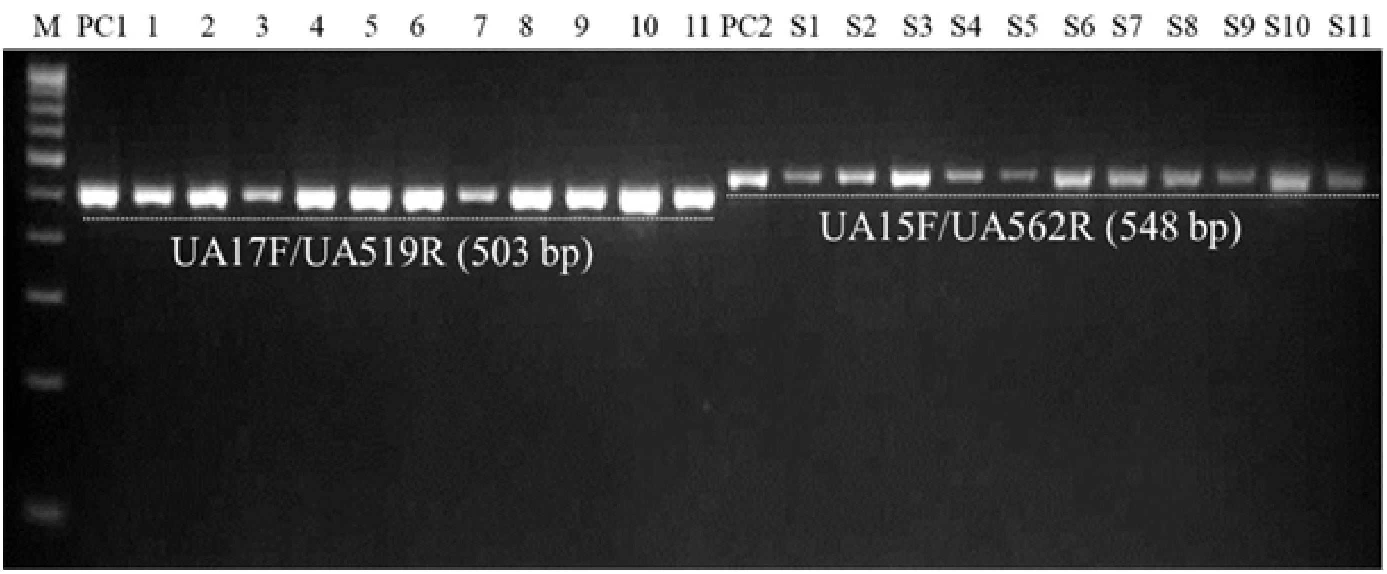


Fig. 2.3: PCR-mediated detection of *U. agropyri* in field soil samples collected from different locations

Genetic variation of *Bipolaris sorokiniana* causing spot blotch disease in wheat growing zones of India

Bipolaris sorokiniana (BS) is an economically important fungal pathogen causing spot blotch of wheat (*Trtiticum aestivum*) and found in all wheat growing zones of India. Very scanty and fragmentary information is available on its genetic diversity. The research was conducted to deciper geographic distribution, varaitaion and evolution of BS population in five geographically distinct wheat growing zones [North Western Plain Zone (NWPZ), North Eastern Plain zone (NEPZ); North Hill Zone (NHZ), Southern Hill Zone (SHZ) and Peninsular Zone (PZ)] of India, studied by performing nucleotide sequence comparison of internal transcribed spacer region of 183 isolates (Fig. 2.4). Phylogenetic analysis suggests that *B. sorokiniana* exist in two distinct lineages as all isolates under study were grouped in two different clades and found analogous to the findings of median joining network analysis (Fig. 2.4). The genetic parameters revealed the existence of 59 haplotypes with three major haplotypes (H_2, H_3, and H_25) which showed star-like structure network surrounded by several single haplotypes, revealing high frequency of the mutations (Eta = 2 – 437) in total analyzed population. H_3 was observed as a predominant haplotype and prevalent in all the five zones. Moderate level of genetic

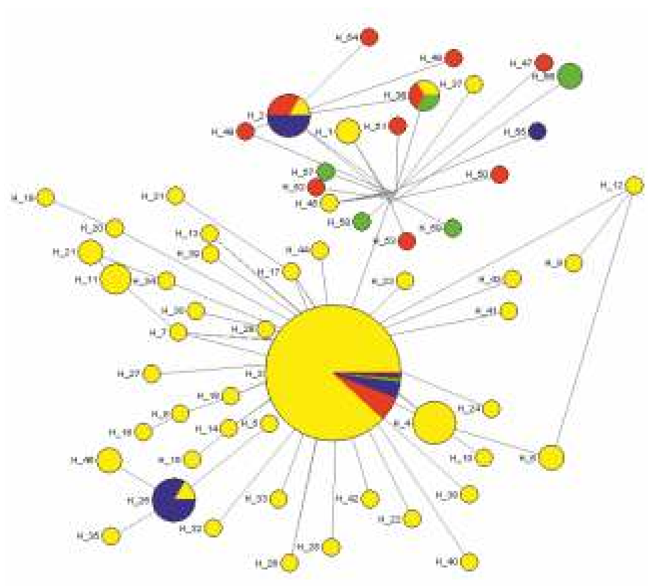


Fig.2.4: Haplotype network of ITS gene of *B. sorokiniana* isolates from different wheat growing zones of India. Major circles represent predominant haplotypes. The size of the each circle is proportional to the frequency of the haplotypes. NWPZ: North Western Plain Zone (Yellow circle); NEPZ: North Eastern Plain zone (red circle); NHZ: North Hill Zone (green circle); SHZ: Southern Hill Zone (purple circle); PZ: Pennisular Zone (blue circle).

differentiation was found between NEPZ and PZ (F_{st} = 0.563), whereas it was low between NEPZ and NHZ (F_{st}= -0.062). High level of gene flow was noticed between NWPZ and NEPZ (N_m = 14.32), while it was found minimum between SHZ and NHZ (N_m = 0.50). Moreover, negative score of neutrality statistics (Tajima's D and Fu's FS test) for NWPZ, PZ and SHZ populations, suggested recent population expansion in these zones. However, positive score for both the neutrality tests observed in NEPZ and NHZ indicated the dominance of balancing selection in structuring their population. Recombination events were observed in the NWPZ, NEPZ and NHZ population, while it was absent in SHZ and PZ population. Thus, the lack of any specific genetic population structure in all the zones indicates for the expansion history only from one common source population i.e. NWPZ, a mega zone of wheat production in India. Overall, it seems that the predominance of individual haplotypes with a moderate level of genetic variation and men mediated movement of contaminated seed and dispersal of inoculum, mutations and recombination as prime evolutionary processes play essential role in defining the genetic structure of BS population.

ENTOMOLOGY

Survey and Surveillance of Insect Pests

In Haryana, many reports of attack of pink stem borer and army worm came in the month of December from Yamunanagar, Ambala, Krushestra, Kunjpura, Ladwa etc. The incidence of these lepidopterous pests was reported around 5-7% in these areas. Termites and root aphid was also reported during November and December which was around 2-5%. Starting from January, incidence of aphids started and it was minimal in the beginning with 5-6 aphids/tiller but in February, higher infestation of aphids (60-85 aphids/tiller on an average) was observed in the fields. Natural enemies, wasps, spiders, grubs and adults of coccinellid beetles were seen during February and March frequently in the fields.

Host Plant Resistance

The evaluation of wheat genotypes carried at multilocation hot spot locations during 2019-20 revealed following genotypes possessing resistance to insect pests:

(i) Advanced Breeding material

(a) Shoot fly

Based on the average infestation levels, entries DBW303 (1.42%), HD3090 (C) (2.85%), DDK1059 (3.61%) and DDK1059 (3.57%) found promising against shoot fly.

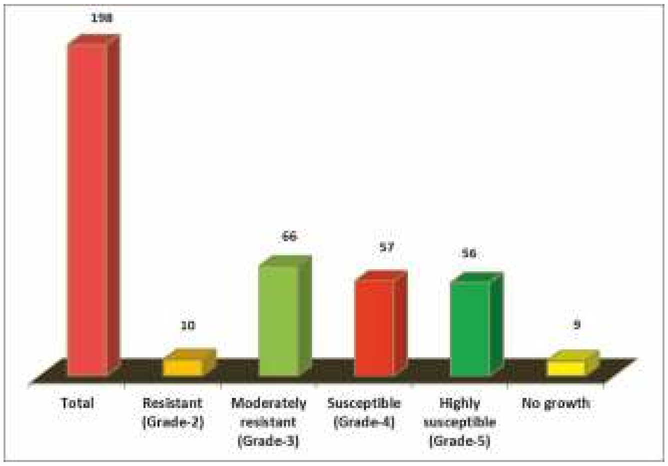


Fig. 2.5: Response of *Aegilops* germplasm to corn leaf aphid (CLA), *Rhopalosiphum maidis*

(b) Brown wheat mite

The promising entries against brown wheat mite are HPW 349 (C), MACS3949 (d)(C), DDK1058 and HS 681 which were recorded the minimum mite population of 4.67/10 cm^2.

(c) Foliar wheat aphid and root aphid

Foliar aphid: Eight entries *viz.,* HD3334, DDW47 (d)(I), DDW49(d), DBW327, HD3086 (C), DBW332, DBW303 and DBW329 showed moderately resistance to foliar aphid (grade 3).

Root aphid: Four entries *viz.,* GW513, GW322, HI1646 and HD3086(C) showed the moderate resistance (grade 3) response.

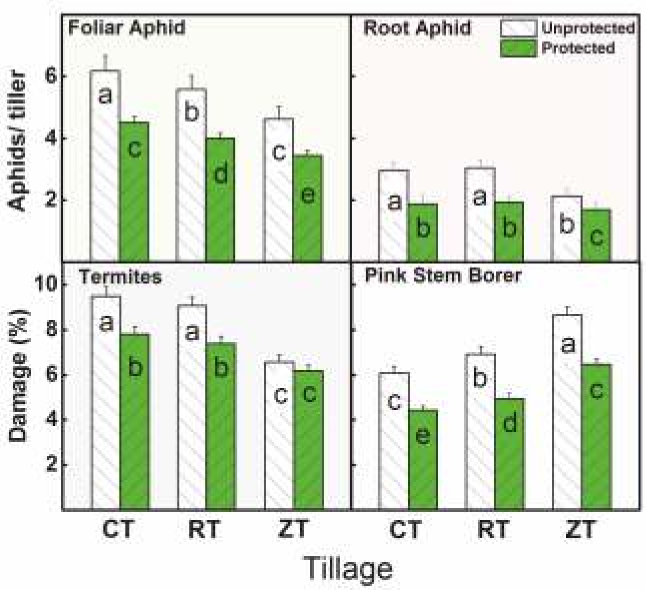


Fig.2.6: Insect-pest abundance of foliar aphid (*Rhopalosiphum maidis*) and root aphid (*Rhopalosiphum rufiabdominalis*), and per cent damage of termites (*Odontotermes obesus* and *Microtermes obesi*) and pink stem borer (*Sesamia inferens*) in wheat crop grown under three tillage practices (CT-conventional; RT- reduced and zero tillage-ZT)

(ii) Multiple pest resistance

a) **Shoot fly:** DDK1054

b) **Brown wheat mite:** UP301610 and PBW763

c) **Foliar aphid:** Five entries *viz.,* MACS4059(d), PBW800, UP3016, DBW237 and DDK1054 showed moderate resistance to foliar aphid.

d) **Root aphid:** HI8800 (d) showed moderate resistant (grade 3) to root aphid.

(iii) Screening of Aegilops germplasm for aphid resistance

Screening of 198 *Aegilops* accessions against the corn leaf aphid (CLA), *Rhopalosiphum maidis* (Fitch) was carried out for consecutive three seasons (2017-18, 2018-2019 and 2019-2020) to identify promising lines against corn leaf aphid. The aphid screenings was done by recording out aphid count/shoots from all these accessions, three times during the season and grades were designated according to 5 point scale system. On the basis of average grading of the aphid infestation, ten accessions gave resistant response to aphids (Fig. 2.5). These accessions include *Ae. ovata* 23, *Ae. tauschii* accession nos.15, 59, 3758, 14336, 14338, 3761, 9795, 3806 and 13757.

Integrated pest management

Effect of tillage and population build-up of major insect-pests of wheat and natural enemies

The effect of tillage on abundance of major insect-pests (foliar aphids, root aphids, termites and pink stem borer) and their natural enemies in wheat managed under three tillage practices, i.e., zero-till (ZT), reduced tillage (RT) and conventional tillage (CT) was investigated under protected and unprotected scenarios. For foliar aphid, higher tillage intensity (CT>RT>ZT) favoured its population build up. Conversely, reduction in tillage favoured better control of foliar aphid (Fig. 2.6). This tillage related effects were less pronounced in case of root aphid though the directions of trends are same. Reduced tillage provided better control for root aphids as well. Termite damage decreased with decrease in tillage intensity, with ZT recorded least damage. There was a significant effect of chemical protection under ZT yet significant control would be attained in CT and RT. The trends were opposite for pink stem borer with maximum damage in ZT followed by RT and CT. There were significant effects of tillage on the population of major natural enemies of insect-pests in wheat crop. The population of rove-beetles and spiders significantly increased with reduction in tillage intensity, however, the population of wasps and coccinelids decreased with decrease in tillage. Under insecticide protected conditions, the natural enemy population also decreased (Fig. 2.7).

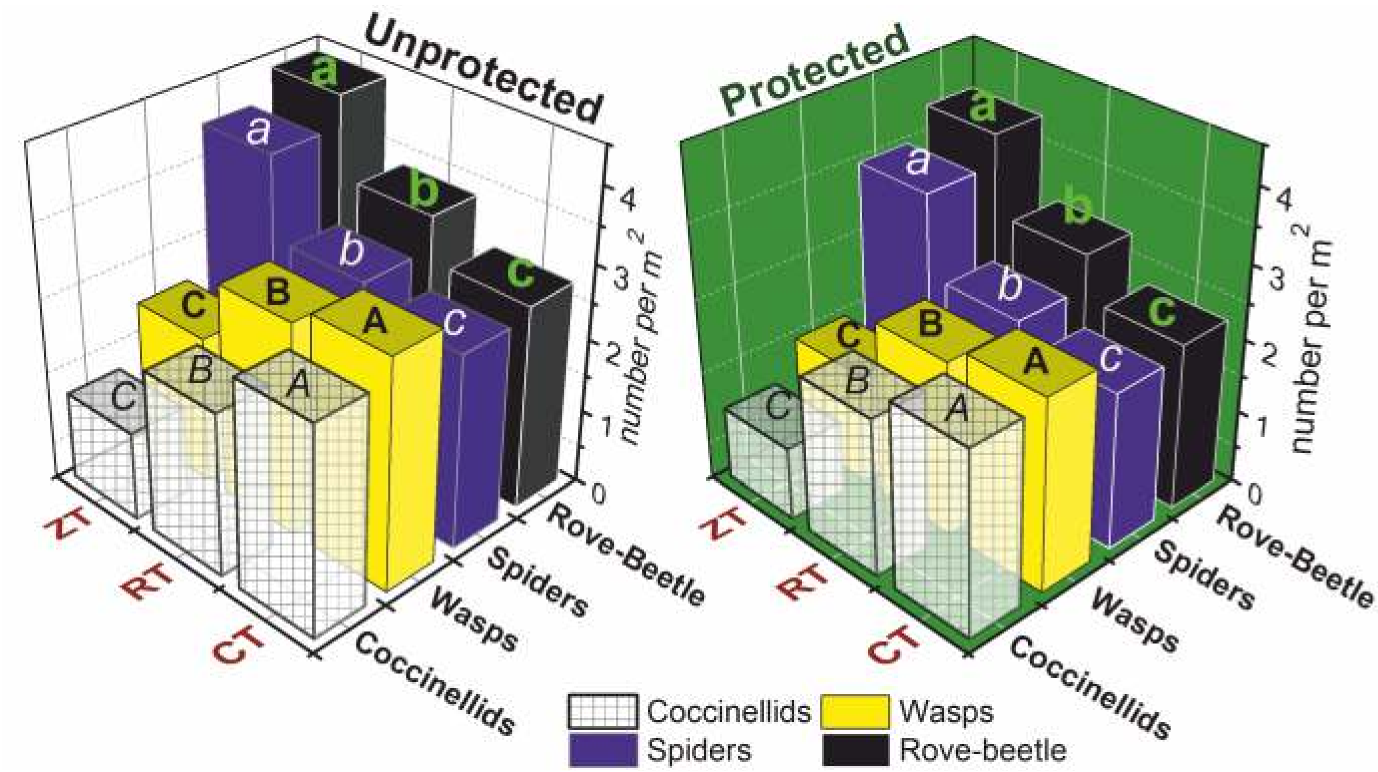


Fig. 2.7: Population of major natural enemies (number per m^2) in wheat grown under three tillage practices (CT-conventional; RT- reduced and zero tillage-ZT)

Influence of sowing time on the incidence and population build-up of major insect pest in wheat

Influence of sowing time on the incidence and population build-up of major insect pests of wheat was studied and it was found that the termite damage in early sown crop (first week of Nov. 2019) was more as compared to timely, late and very late sown crop. The pink stem borer damage was higher in early and timely sown crop as compared to late and very late sown crop. The aphid incidence was noticed in first week of January in early sown crop and in second week of January in 15 Nov. sown crop while it appeared in third week of January in other two sowing times. The recorded data indicated that the aphid incidence got delayed with the delay in sowing time (Fig. 2.8).

Zinc sulphate application effect alone or in combination with pesticides on aphid incidence in wheat

Effect of zinc sulphate ($ZnSo_4$) as foliar application was investigated to determine its effect on aphid abundance and their coccinellid predators in wheat. The data revealed that one or two sprays of $ZnSO_4$ mixed with Thiamethoxam effectively reduced the aphid population. Although some reduction in aphid control was observed when Thiamethoxam was mixed with $ZnSo_4$ but statistically it was not significant. Similarly, $ZnSO_4$ can also be mixed with Propiconazole + Thiamethoxam without any adverse effect. The coccinellid predators were also not adversely affected by application of one or two sprays of $ZnSO_4$ mixed with insecticides and fungicides at reproductive stage of wheat crop.

Effect of organic formulations on the incidence of major insect-pests and natural enemies

Keeping in view of the interest of farmers about zero budget farming, effect of organic treatments *viz.*, Neemastra, Bramhastra, Agniastra, Deshparni, Fermented butter milk and Cow urine were evaluated against major insect-pests of wheat and natural enemies. When observed one day after

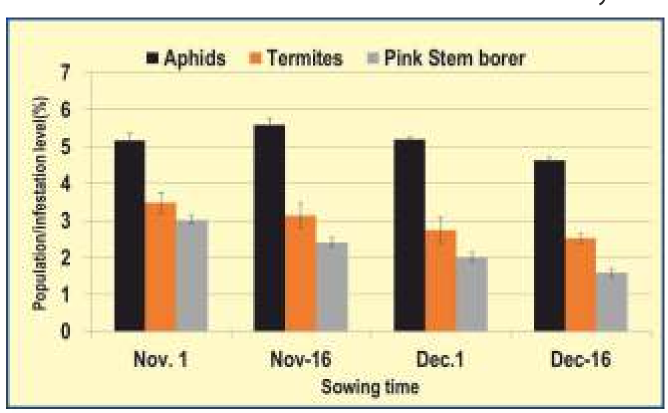


Fig.2.8: Influence of sowing time on the incidence and population build-up of major insect pest in wheat

spray, among the tested organic treatments, treatment of Bramastra @7.5% sprayed plots and Agniastra @ 7.5% recorded minimum 9.58 and 9.87 aphids/earhead, respectively. Almost similar trends were observed two, seven and fifteen days after spray. Overall, the data revealed that Bramastra @7.5% was the most effective treatment as compared to other organic treatments fewer aphids were recorded. The organic treatments where found safer to natural enemies and little effect was seen on their population as compared to check of insecticide spray with Thiamethoxam 25 WG. Maximum grain yield (q/ha) was recorded in plots treated with Bramastra @7.5% sprayed plots i.e. 57.45 q/ha. However, all the applied treatments recorded higher grain yield than untreated check (54.69 q/ha).

Efficacy of insecticides and bio-pesticide for the management of aphids and termites

Efficacy of various insecticides and their combinations against foliar aphid was determined and it was found that the treatment of Beta-Cyfluthrin 9% + Imidacloprid 21% (Solomon) was more effective in checking aphid population. Besides, Lambda cyhalothrin 5% EC @ 500 ml/ha, Imidacloprid 17.8 SL @ 400 ml/ha and Beta-cyfluthrin 25 SC @ 1450 ml/ha were also found equally effective against it.

In case of termite management through seed treatment, lowest termite damage was recorded in pre-mixed insecticide Imidacloprid 18.5% + Hexaconazole 1.5% FS followed by tank mixture of Imidacloprid 600FS + Tebuconazole. However, treatment of Fipronil 5 SC @ 0.3 g a.i./kg seed was also found equally effective followed by Thiamethoxam 25 WG @ 0.8 g a.i./kg and Thiamethoxam 30 FS @ 0.72 g a.i./kg.

Evaluation of barley genotypes for storage insect-pests resistance

The 104 released varieties of barley were evaluated against storage insect-pests against *Sitophilus oryzae, Rhyzopertha dominica* and *Tribolium castaneum*. The freshly harvested 25 g pest-free seed of each variety was taken in Petri dishes and 10 adults of each insect were introduced into each Petri dish. Observations such as orientation behavior, life span duration and per cent weight loss to grain were recorded. Promising genotypes were identified as Azad, BHS-352, Amber, Kedar, BHS-169, BK-306, BH-959, BH-946, R-56, BG-105 and BCU-2241.

3. RESOURCE MANAGEMENT

Conservation Agriculture

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

To evaluate the long term effect of tillage, residue and nutrient management in maize-wheat-green gram system an experiment is in progress since Kharif 2015 involving combination of tillage and residue management (Zero tillage (ZT); ZT with residue retention (CA); Conventional tillage (CT) and CT + residue incorporation) in main plots and sub plots were having the four nutrient management options (Control; Recommended N alone; Recommended NPK; and Rec. NPK + FYM 10 t/ha). The sowing was done using Turbo happy Seeder/ Rotary Disc Drill. The results of the season 2019-20 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 (20.24 q/ha) was recorded in unfertilized control plots (Fig. 3.1). The wheat grain yield recorded with application of Rec. NPK (62.9 q/ha) and Rec. NPK + 10 t/ha FYM (62.23 q/ha) was similar. However, these two treatments were marginally better than the N application alone (61.7 q/ha). However, statistically these treatments were at par among themselves but significantly superior to control treatment.

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

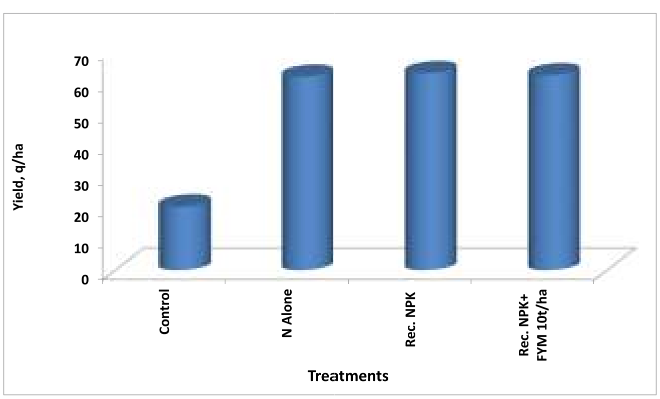


Fig. 3.1: Nutrient management in wheat across tillage option in Maize-Wheat system

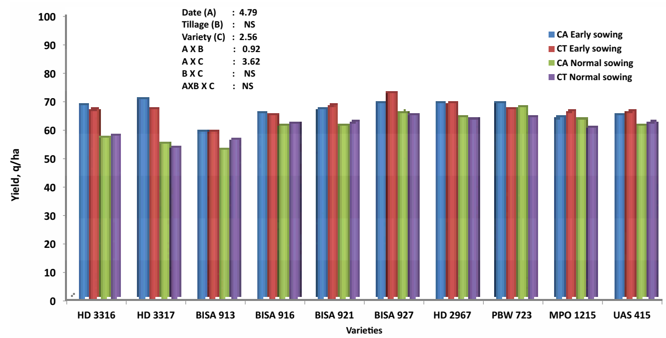


Fig. 3.2: Performance of wheat varieties sown early and timely under CT and CA conditions during 2019-20

Performance of wheat varieties under CT and CA systems

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 (22nd Oct 2019) and normal sowing (19th November, 2019) with two tillage options *i.e.* CT (Conventional Tillage) & CA (Conservation Agriculture). The residue load in CA treatments was about 8 t/ha. The effect of tillage as well as its interaction with varieties were non-significant for yield (Fig. 3.2). The mean wheat yield of early sown wheat was significantly better than the normal sowing. However, the genotypic differences were significant and BISA 927, PBW 723, HD 2967 and BISA 921 were better yielder than other genotypes. Presently HD 2967 genotype is occupying maximum wheat 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.

Field demonstration at farmers' field for in-situ management of rice residue

Field demonstrations were conducted at farmers' fields for in-situ management of rice and sugarcane residues. In sugarcane ratoon sowing was done using Rotary Disc Drill and after rice harvest the wheat seeding was done using Turbo Happy Seeder and Super Seeder. In Kaimla village of Karnal, large scale field testing and demonstration of Super Seeder was carried out (Fig. 3.3). Paddy crop was harvested using combine harvester fitted with straw management system (SMS). Simultaneously wheat seeding was performed using Super Seeder, which incorporated the chopped straw into soil and crop establishment was perfect. So, rice residue can also be managed with-in field by incorporating it into soil using suitable machines like Super Seeder.

Fig. 3.3: Wheat seeding after rice using super seeder

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 and 150% RDF+15 t FYM/ha+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 (69.07 q/ha), DBW 329 (68.07 q/ha), DBW 222(67.62 q/ha) and DBW 327 (67.09 q/ha) recorded marginally higher productivity compared to other genotypes (Fig 3.4). The genotypes DBW 187, HD 3086, DBW 303 and DBW 329 yielded 75.86, 74.83, 74.49 and 74.31 q/ha, respectively, under 150% RDF + 15t FYM/ha + 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) stage which were higher than other genotypes.

Nutrient and residual management

Integrated Nutrient Management in rice- wheat system

This experiment consisting of ten nutrients management combinations [Recommended NPK at the rate of 150:60:40 kg/ha N, P_2O_5 and K_2O, respectively (T1), T1+FYM15t/ha, Rec. N only, Rec. P only, Rec. K only, Rec. NP only, Rec. NK only, Rec. PK only, T1+ GM and absolute control] of major and organic nutrients viz. FYM and green manuring was initiated with the objective of testing long term effects of nutrient management combinations on rice-wheat cropping system. This field trial was conducted in Randomized Block Design with three replications by using wheat variety HD 2967. The fifth year results revealed that biomass and grain yield were significantly lower where only P, K or PK were applied as compared to all other treatments indicating the significance of nitrogen (Fig 3.5). The highest grain yield (65.36 q/ha) was recorded in treatment where all the major nutrients and FYM 15 t/ha was applied followed by the treatment in which all the major nutrients as well as green manuring was done (62.31) q/ha). 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.

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

Organic production of high input responsive dwarf varieties of wheat is a matter of great concern and hence four newly released High Yielding Varieties (HYV) 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, farm yard manure (FYM) 20 t/ha, farm yard manure (FYM) 30 t/ha and recommended

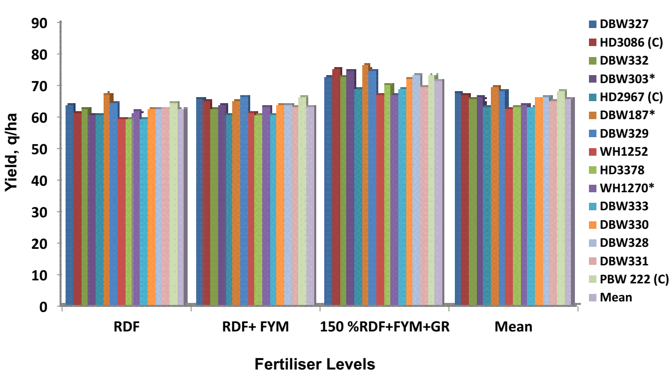


Fig. 3.4: Genotypes under early sown high fertility conditions

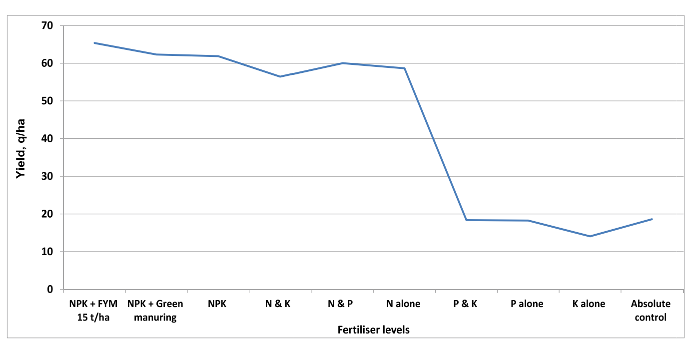


Fig. 3.5: Integrated nutrient management in wheat

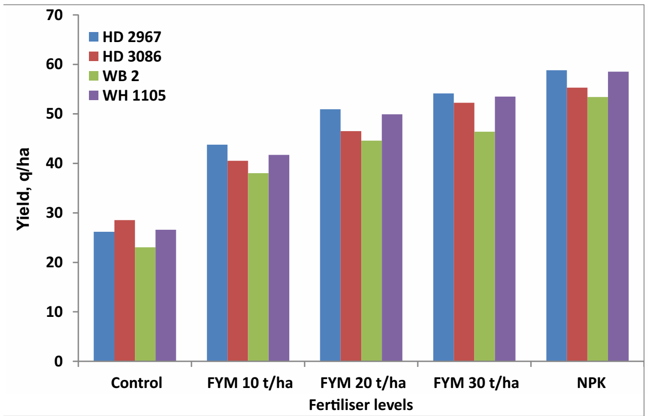


Fig. 3.6: Comparative performance of wheat varieties under inorganic and organic conditions

doses of chemical fertilizers at the rate of 150:60:40 kg/ha N, P_2O_5 and K_2O, respectively) thus having total 20 treatment combinations, were evaluated (Fig 3.6). The results revealed that application of farm yard manure (FYM) from 10 t/ha to 30 t/ha increased the biomass and grain yield of all the high yielding varieties of wheat significantly as compared to control (no organic or chemical fertilizer) treatment. However, the highest biomass and grain yield of all the high yielding varieties of wheat were recorded in the recommended NPK fertilizers treatment which was significantly higher than all the organic treatments including 30 t/ha FYM treatment. Among the high yielding varieties, HD 3086 recorded the highest grain yield followed by WH 1105 with recommended doses of NPK fertilizers (150:60:40). All the varieties performed similarly at all the Organic levels except WB 2 which yielded significantly less than HD 3086 and WH 1105 varieties. Application of increasing doses of FYM from 10 to 30 t/ha increased the soil organic carbon, available nitrogen, available phosphorus and available potassium content as compared to recommended NPK treatment and control treatment.

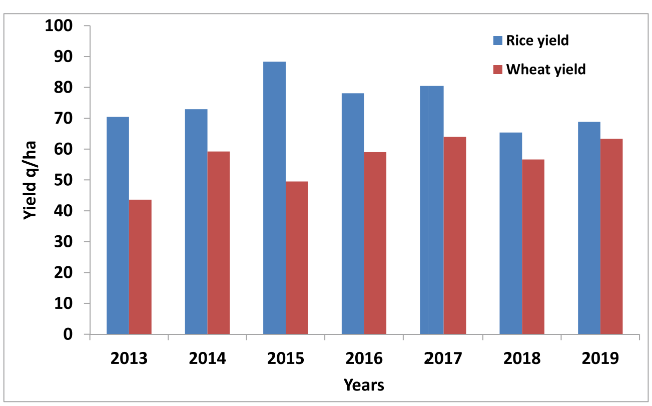


Fig. 3.7: Rice and wheat yield fluctuation during the years of study

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 during 2013-14 to 2019-20. The treatments receiving green gram incorporation was superimposed with 25 and 50 % less nitrogen to rice crop (Fig 3.7). 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 pulse yield and its residue incorporation saved 50 % nitrogen to rice crop and produced maximum rice yield besides improving the soil physico chemical properties. In case of rice residue incorporation, additional 25 % more N was needed to reduce the immobilization effect to wheat crop and produced maximum wheat grain yield. Rice yield was significantly higher in year 2015 whereas wheat yield was significantly higher in 2017 as compared to other years of study.

Intercropping of pulses with maize

Experiment on green gram, black gram, cowpea and cluster bean intercropped with maize and followed by wheat crop was conducted during 2017-2020. System productivity was determined in terms of wheat equivalent yield and it was recorded that maize+cowpea-wheat treatment produced the maximum WEY (15.9 t ha^{-1}). All the intercrops recorded more WEY than maize-wheat system. This showed that system productivity under intercrops was higher than sole maize-wheat or sole legume-wheat system. All the intercrops in this study showed more than 1.0 LER, revealing more system productivity under intercrop conditions. Maximum LER was obtained under treatments maize-+cowpea- wheat (1.71) and least LER of 1 was obtained under sole crops.

Comparison of different cropping sequences

System productivity measured as wheat equivalent yield (WEY t ha^{-1}) was significantly (P = <0.001) higher under maize –potato-wheat (16.49 t ha^{-1}) and maize-wheat-green gram (16.17t ha^{-1}) rotations than others (Table 1.1). This was followed by maize-mustard-green gram sequence (14.42t ha^{-1}) at second rank, sorghum-potato-wheat (13.53t ha^{-1}) and sorghum-wheat-green gram (13.39t ha^{-1}) which were at third and fourth position along with maize-wheat (13.73 t ha^{-1}) on the Tukey ranking. The crop sequences sorghum-mustard-green gram (11.59t ha^{-1}) and sorghum-wheat(10.85t ha^{-1}) were the lowest ranking crop sequences with respect to WEY. Maize-wheat-green gram showed maximum land use efficiency (87.67%) followed by maize-mustard-green gram (83.56%) whereas lowest was in sorghum-wheat (63.56%).

Table 3.1: Variation in wheat equivalent yield, land use efficiency, production efficiency and sustainable value index under different cropping systems

Crop sequences	Wheat Equivalent Yield (t ha^{-1})	LUE (%)	PE (kg ha^{-1}day^{-1})	SVI
Sorghum-wheat	10.85^{d}	63.56	46.78^{cd}	0.94
Sorghum-wheat- green gram	13.39^{c}	82.74	44.35^{d}	0.94
Sorghum-mustard- green gram	11.59^{d}	78.63	40.39^{e}	0.96
Sorghum-potato- wheat	13.53^{c}	74.52	49.75^{bc}	0.93
Maize-potato- wheat	16.49^{a}	79.45	56.87^{a}	0.91
Maize-mustard- green gram	14.42^{b}	83.56	47.29^{cd}	0.92
Maize-wheat- green gram	16.17^{a}	87.67	50.52^{b}	0.95
Maize-wheat	13.73^{bc}	68.49	54.90^{a}	0.89

LUE=Land use efficiency, PE= Production Efficiency, SVI= Sustainable value index

Maize-potato-wheat (56.87 kg ha^{-1} day^{-1}) and maize-wheat (54.90kg ha^{-1} day^{-1}) exhibited at par production efficiency but significantly (P = <0.001) higher than other crop sequences. Sorghum-mustard-green gram (0.96) and maize-wheat-green gram (0.95) showed maximum sustainable value index as compared to other crop rotations. In contrast, lowest sustainable value index was obtained with maize-wheat rotations (0.89). Other crop sequences also showed good sustainable value index which was in between 0.89 to 0.96.

Weed management

Weed management in wheat

Weed infestation is one of the major problems affecting production and productivity of wheat crop. For realizing potential crop yield, proper weed management is very important. For weed control 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 in weeds demand evaluation of new herbicides and herbicide mixtures from different chemical groups. Field experiments were conducted for evaluation of herbicides and herbicide mixtures against weeds in wheat and the major findings of which are as follows.

- For control of diverse broadleaved weeds different herbicides were evaluated. Effective control of diverse broad-leaved weed flora was observed when ready-mix combinations of Halauxifen+ fluroxypyr 200.6(6.1+194.5) g/ha, metsulfuron + carfentrazone 5+20 g/ha and Halauxifen + florasulam 12.76 g/ha were applied as post emergence. These ready mix combinations have shown good selectivity in wheat.
- The combinations of three herbicides, Halauxifen + florasulam + carfentrazone improved the range of weed flora control including control of ALS herbicide resistant *Rumex dentatus*. Also, diverse broadleaf weeds were effectively controlled when carfentrazone at 20 g/ha was tank mixed with either ready-mix combinations of Halauxifen + florasulam 10.21 g/ha or 2,4-D 400 g/ha or metsulfuron 4.0 g/ha. Also these mixtures were effective in controlling some problematic broad leaf weeds like *Fumaria parviflora, Malva parviflora and Solanum nigrum*. This ready mix combinations Halauxifen + florasulam have shown high selectivity in wheat spp. *aestivum, durum and dicoccum* as well as *triticale* and barley
- For the control of complex weed flora of wheat, herbicide combinations were evaluated. Pyroxasulfone + metsulfuron 125 + 4 g/ha, Pyroxasulfone + pendimethalin 125 + 1000 g/ha and pendimethalin + metribuzin 1250+300 g/ha as pre emergence and tank mixture of Clodinafop/pinoxaden with metribuzin as post emergence were found effective for control of diverse spectrum of weeds in wheat
- Flumioxazine at 100-125 g/ha as pre emergence was also found effective for control of grassy and broadleaved weeds in wheat.
- To reduce the phytotoxicity of HPPD herbicides, Cloquintocet safener present in clodinafop as well as its external application was found effective.
- In rice-wheat system double no-till system led to more problems of *Rumex dentatus* and *Medicago denticulata*. The triple no-till system in Maize-wheat-green gram was found effective in reducing the infestation of *Cyperus rotundus* in maize because of use of pre-plant non-selective herbicide glyphosate.
- Tank mixture of mesotrione/ topramezone/tembotrione with atrazine was found the best for control of complex weed flora compared to alone application.

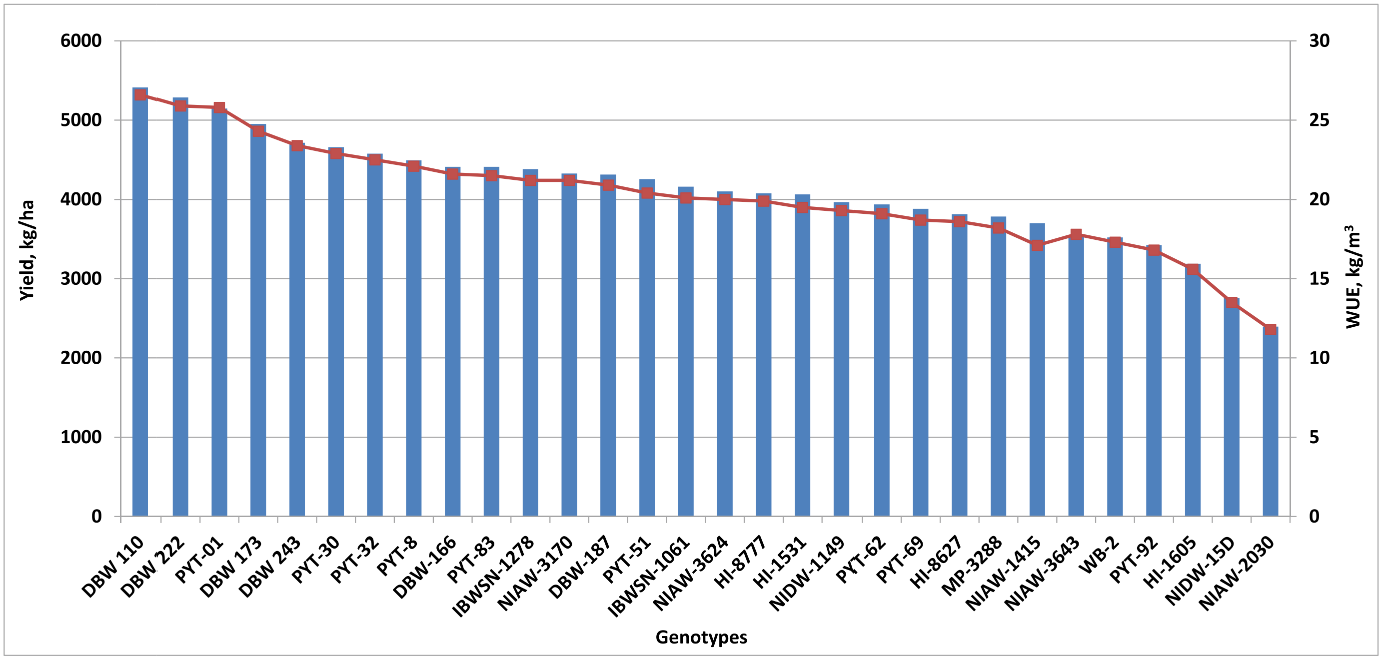


Fig. 3.8: Productivity and water use efficiency of wheat genotypes

- In DSR, bispyribac+pendimethalin at sowing fb fenoxaprop + ethoxysulfuron were effective in controlling broad-spectrum weeds
- Pot studies were conducted to identify and quantify the herbicide resistance in different weeds (*P. minor, Rumex dentatus, Avena ludoviciana, Chenopodium album and Polypogon monspeliensis*). For management of Multiple Herbicide Resistant *P. minor and A. ludoviciana* (against clodinafop, pinoxaden and sulfosulfuron) pyroxasulfone and metribuzin were found effective. Also, for control of multiple herbicide resistant *P. minor*, additional herbicides found effective were flumioxazin, aclonifen and oxyflourfen. Whereas, metribuzin, pendimethalin and pyroxasulfone were found effective for control of sulfonylurea herbicide resistant *Polypogon monspeliensis* in wheat.
- For control of metsulfuron resistant *Rumex dentatus* and *Chenopodium album* 2,4-D, carfentrazone, isoproturon and fluroxypyr were found effective.
- 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).

Irrigation management

Wheat genotypes evaluated for water use efficiency

With the objective to identify higher water use efficient genotypes an experiment was conducted with 30 genotypes under deficit soil moisture condition. The amount of irrigation water was calculated with the help of CROPWAT 8.0. The amount of applied water was measured by the inbuilt water meter in pipe line of the drip system. All agronomic and relevant physiological observations were recorded for all 30 genotypes studied (DBW 110, DBW 222, PYT 01, DBW 173, DBW 243, PYT 30, PYT 32, PYT 8, DBW 166, PYT 83, IBWSN 1278, NIAW 3170, DBW 187, PYT 51, IBWSN 1061, NIAW 3624, HI 8777, HI 1531, NIDW 1149, PYT 62, PYT 69, HI 8627, MP 3288, NIAW 1415, NIAW 3643, WB 2, PYT 92, HI 1605, NIDW 150 and NIAW 2030. Genotypes DBW 110 (5410 kg. ha^{-1}), DBW 222 (5285 kg. ha^{-1}), PYT 01 (5146 kg. ha^{-1}), DBW 173 (4951 kg. ha^{-1}), DBW 243 (4715 kg. ha^{-1}), PYT 30 (4660 kg. ha^{-1}), PYT 32 (4576 kg. ha^{-1}), PYT 8 (4493 kg. ha^{-1}), DBW 166 (4410 kg. ha^{-1}), PYT 83 (4410 kg. ha^{-1}) and IBWSN 1278 (4382 kg. ha^{-1}) produced desirable yield with water use efficiency (Fig. 3.8) ranging from 21.5 kg.mm to 26.6 kg.mm^{-1}.

Registration of higher water use efficient genotype DBW 166

DBW 166 of Wheat (INGR20008) has been registered for water use efficient genotype by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research on September 29, 2020.

4. QUALITY AND BASIC SCIENCES

Analysis of wheat & barley trials

During 2019-20, 124 AVTs, 244 NIVTs, 52 QCWBN, 25 CI-HYT, 16 IVT, 14 HYPT and 7 *dicoccum* and 52 QCSN entries were analysed from different centres representing all the zones and growing conditions. All the AVT-II entries including checks were also evaluated for chapati, bread and biscuit for identification of product specific promising genotypes (Table 4.1).

In addition, promising genotypes were identified both for *T.aestivum* and *T.durum* for individual quality parameters like protein content, grain hardness index, sedimentation value, yellow pigment, iron & zinc. Details are given in the table 4.2, 4.3, 4.4 below.

Distribution of HMW glutenin subunits in different trials

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 75.4 %

Table 4.1: Promising bread wheat genotypes for chapati score and bread loaf volume and durum genotypes for pasta acceptability

Category	Genotypes
Bread wheat genotypes Chapati (Score ~7.9)	
Check	HD2967 (NWPZ-HYPT)
AVT-IInd year	DBW303* (NWPZ-HYPT), HI1634* (CZ-IR-LS)
Bread wheat genotypes Bread (Loaf volume ≥600 ml)	
Check	HD3059 (NWPZ-IR-LS), DBW173 (NWPZ-IR-LS), WH1124 (NWPZ-IR-LS)
AVT-IInd year	HD3298* (NWPZ-IR-LS)
***T. durum* genotypes for Pasta (over acceptability >6.5/9)**	
Check	UAS446(d) (C) (PZ RITS)
AVT- IInd year	DDW48(d)Q* (PZ-ITS)

Table 4.2: Promising genotypes for various quality parameters in AVTs

Parameter	Value	Genotypes
		T. aestivum
Protein	≥12.5%	**NHZ :** NIL; **NWPZ:** DBW291, PBW813 **NEPZ:** PBW804, HD2888, DBW252 **CZ :** NIL ; **PZ :** MACS6222, HI1633*, HD3090, RAJ4083, GW519, HI1641, HI1642, MACS6752
Sedimentation value	> 65 ml	**NHZ :** UP3069 ; **NWPZ :** HD3059, WH1021 **NEPZ :** HD3249, PBW804, K1317, HI1612 **CZ :** NIL ; **PZ:** HI1605
Hardness Index	<35	**NHZ :** HS490 ; **NWPZ :** NIAW3170, DBW296 **NEPZ:** PBW804 ; **PZ:** NIAW3170
Iron	≥40ppm	**NHZ :** NIL **NWPZ :** DBW187, WH1105, PBW840M, PBW803, PBW813, **NEPZ :** K1006, HD3249, HD2888 ; **CZ:** HD3377 B, RAJ4541B **PZ :** MACS6222, HI1633*, HI1641, HI1642, MACS6752, HI1605, MP1358,
Zinc	≥40ppm	**NHZ :** NIL **NWPZ :** HD2967, PBW550, PBW840M, PBW771(I), PBW813 **NEPZ :** K1006, HD2888, DBW252 (I) **CZ :** GW322, HI1636, MACS6747, HI1637, RAJ4541B **PZ :** MACS6222, HI1633*, HD3090, HI1641, HI1642, MACS6752
		T. durum
Protein	>13.0%	**CZ :** NIL ; **PZ :** NIL
Sedimentation value	≥ 40ml	**CZ :** UAS466(d)(I), DDW47(d)(I) **PZ :** DDW48(d)Q*, DDW49(d)Q*, UAS428(d) , MACS3949(d) , UAS446(d) , AKDW 2997-16(d) , HI8805(d)(I) ,
Yellow Pigment	>7.0ppm	**CZ :** DDW47(d)(I) ; **PZ:** WHD964(d)
Iron	≥ 40ppm	**CZ :** NIL ; **PZ :** AKDW997-16(d), MACS4087(d), MPO1357(d)Q
Zinc	≥ 40ppm	**CZ :** NIL **PZ :** DDW49(d), UAS428(d), HI8805(d)(I), MACS 4087(d), MPO 1357(d)[Q]

Table 4.3: Variability in the quality parameters of *T. aestivum* in AVT's

Parameter	NWPZ	NEPZ	CZ	PZ	NHZ	Overall
GAS (Max. 10.0)	5.9 (5.1-6.3)	5.75 (5.5-6.1)	6.66 (6.2-7.0)	6.03 (5.7-6.3)	5.66 (5.3-6.1)	6.0 (5.1-7.0)
Hectolitre Weight (kg/hl)	77.9 (73.8-79.8)	75.2 (72.8-76.8)	81.41 (79.0-84.2)	79.26 (76.8-81.5)	78.3 (74.5-81.0)	78.4 (72.8-84.2)
Protein content (%)	11.6 (11.0-12.8)	11.95 (11.0-12.7)	11.4 (9.9-12.2)	12.16 (11.3-13.5)	9.1 (8.0-10.1)	11.2 (8.0-13.5)
Sedimentation value (ml)	59 (44-70)	62 (49-71)	57 (44-64)	56 (48-68)	51 (36-66)	57 (36-71)
Grain hardness index	75 (26-93)	69 (30-84)	74 (51-87)	72 (33-94)	71 (14-89)	72 (14-94)
Iron (ppm)	38.46 (35.0-41.9)	38.5 (34.9-41.2)	38.03 (34.9-40.0)	39.83 (36.3-42.8)	33.43 (30.6-38.5)	37.67 (30.6-42.8)
Zinc (ppm)	35.93 (31.1-42.4)	37.8 (30.6-43.9)	36.36 (31.8-45.4)	38.16 (34.6-42.8)	31.33 (25.4-39.3)	35.9 (25.4-45.4)
Wet gluten (%)	30.2 (29.3-32.1)	30.9 (27.2-33.4)	29.8 (27.6-33.0)	33.9 (32.7-34.4)	-	31.2 (27.2-34.4)
Dry gluten (%)	9.8 (9.3-10.4)	9.8 (8.7-10.5)	9.3 (8.6-10.1)	10.6 (10.4-10.9)	-	9.9 (8.6-10.9)
Gluten Index (%)	72 (49-91)	69 (59-91)	71 (56-83)	69 (58-81)	-	70 (49-91)

Range in parenthesis

Table 4.4: Variability in the quality parameters of *T. durum* in AVT's

Parameter	CZ	PZ	Overall
Grain appearance score (Max. 10.0)	6.7(6.5-7.0)	6.55 (5.9-7.11)	6.6 (5.9-7.11)
Hectolitre weight (kg/hl)	81.3(80.3-83.7)	81.55 (78.0-83.1)	81.4 (78.0-83.7)
Protein content (%)	11.9 (10.6-12.7)	11.8 (10.8-12.4)	11.8 (10.6-12.7)
Sedimentation value (ml)	40 (35-46)	46 (34-56)	43(34-56)
Grain hardness index	89 (80-94)	96 (88-105)	93(80-105)
Iron (ppm)	38.4 (35.7-39.6)	39.05 (37.1-40.8)	38.7 (35.7-40.8)
Zinc (ppm)	35.7 (33.6-38.2)	39.21 (37.6-41.6)	37.4 (33.6-41.6)
Yellow pigment (ppm)	6.17 (5.24-7.25)	5.02 (2.92-8.22)	5.5 (2.92-8.22)

and 24.6 % of the total entries, whereas entries having 1, 2* and N subunits were 14.9 %, 48.2 % and 36.8 %, respectively. Entries with subunits 7, 7+8, 7+9, 17+18, 20 and 13+16 were 22.8, 24.56, 8.77, 29.82, 1.75 and 4.38 % respectively.

Biofortification

Generations of crosses for enhanced Fe, Zn, protein and low phytate content using suitable donors with high yielding cultivars (Produce of crop season 2019-20)

Increasing essential micronutrient content in wheat genotypes and their bioavailability for monogastric animals and humans consumption could ultimately lead to improved animals and human health. Therefore, to achieve this goal, several crosses were developed into high yielding wheat cultivars background (HD 2967, HD 3086, HD 3226, DBW 173, DBW 187, WB 02) using previously high phytase and low phytic acid mutants in the background of PBW 502) during main crop season 2017-18 at ICAR-Indian institute of Wheat and Barley Research, Karnal. F1s were advanced and backcrossed using off-season nursery facility at Dailang Maidan, Lahaul spiti (Himachal Pradesh) during 2018. F_2s and BC_1F_1s of above crosses were planted and selection was

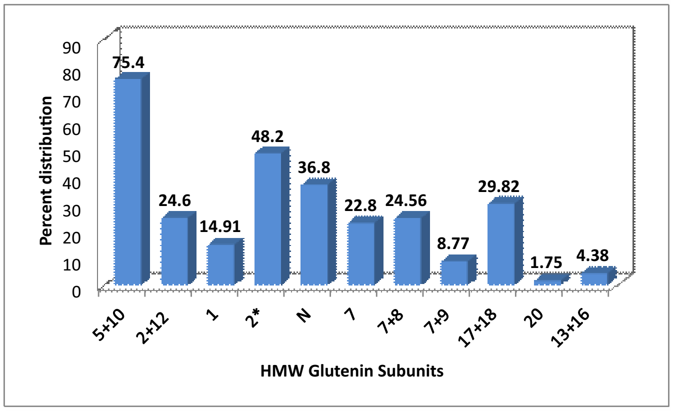


Fig. 4.1: Distribution of HMW glutenin subunits

done for disease free plants at research field of ICAR-IIWBR, during 2018-19 and promising progenies were advances at ICAR-IIWBR, Karnal during 2019-20 and 2020-21 (F_4 generation). Threeway crosses were attempted during 2019-20 for combining high Fe, Zn, Protein and high phytase and low phytic acid traits into high yielding backgrounds. The available material of F_2, F_3, F_4, BC_1F_1, BC_1F_2, BC_2F1, BC_2F_2 generations including three way crosses between were sown for the crop season 2020-21 and are given the table 4.5 below:

Transcriptomic analysis of wheat roots and shoots provides new insights into molecular regulatory network during Fe and Zn deficiency

In this investigation, two wheat genotypes namely Narmada 195 and PBW 502 differing in Fe and Zn concentrations were used for physiological and molecular analysis under controlled and Fe and Zn deficient conditions. 12 RNA-seq libraries generated from root and shoot tissues of each genotype from different treatments represented RNAs expressed during sufficient and deficient (partial and complete starvation) Fe and Zn concentrations. Besides analyzing the genome-wide expression profile of various transcripts associated with Fe-Zn metabolism, expression of 25 transcripts directly associated with Fe-Zn transport was investigated using reverse transcription (RT)-qPCR to decipher the fold change variation during starvation (Fig 4.2). Overall our results provide a unique and comprehensive insight into molecular, physiological and biochemical responses of two wheat genotypes under Fe and Zn starvation conditions.

Identification, functional classification and enrichment analysis of DEG in response toFe and Zn withdrawal in root and shoot

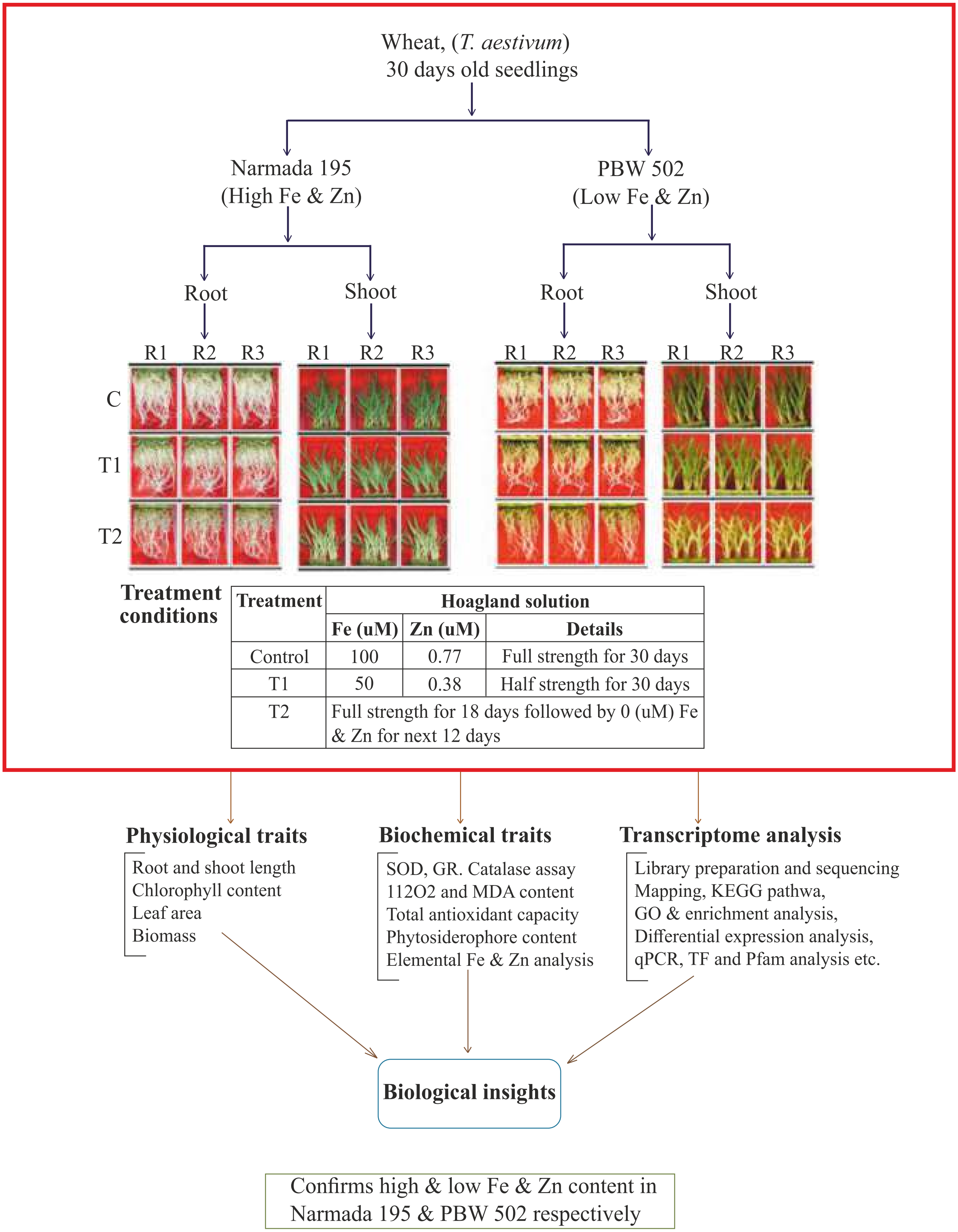
GO annotation, classification and enrichment analysis of DEGs were performed to gain more insight into their possible involvement during biological, molecular, and cellular functions. Significant GO categories were assigned to all the DEG under both the treatment conditions.Top ten over-represented significant terms of each of the three categories is given in the figure 4.3 below. ATP binding (11613 DEGs) and metal ion binding (3987 DEGs) were most enriched GO term in the molecular function category followed by integral components of membrane (19337 DEGs) and nucleus (5768 DEGs) in cellular component category and regulation of transcription (2192 DEGs) and translation (1942 DEGs) in biological process category

Physiological and biochemical responses under Fe/Zn deficient conditions

A hydroponics based experiment was set up with two wheat varieties inherently rich (Narmada 195) and poor (PBW 502) in iron and zinc content. Seedlings were subjected to two treatments with 50% Fe-Zn and 0% Fe-Zn. The seedlings were analysed for various morphological, physiological and biochemical parameters in order to attain inclusive information in wheat seedlings.Wheat plants subjected to Fe-Zn starvation show physiological defects such as decrease in root and shoot growth. The effect of Fe-Zn deficiency also significantly reduced the leaf area in PBW 502 in comparison to Narmada 195. Morpho-physiological data suggest that genotypic differences exist in Narmada 195 and PBW 502 depicted by minor decrease in shoot Zn content in Narmada 195, while PBW 502 showed a significant decrease in shoot Zn in response to Zn deficiency (Table 4.5). Similarly, for Fe the reduction in genotype PBW

Table 4.5: Details of filial generation

High yielding cultivars	High Fe, Zn and protein lines	Low phytate	Three way (High Fe, Zn, Low Phytate)
HD2967	F2s, BC1F1s, BC1F2s, BC1F4s	F2s, F3s, F4s, BC1F1s, BC1F2s, BC1F3s, BC2F1s	F1s (8)
HD3086	F2s, F3s, F4s, BC1F1s, BC1F3s, BC1F4s	F2s, F3s, F4s, BC1F1s, BC1F2s	F1s (6)
DBW187	F2s, F3s, BC1F1s	F2s, F3s, BC1F1s, BC1F2s	F1s (4)
HD 3226	F2s	F2s, BC1F1s,	F1s (2)
WB 02	F2s, BC1F1s	F2s, F3S, F4S	
DBW 173	BC1F2s	F2s, F3s, BC1F1S, BC2F1S, BC2F1S	F1s (3)



Treatment	Hoagland solution		
	Fe (uM)	Zn (uM)	Details
Control	100	0.77	Full strength for 30 days
T1	50	0.38	Half strength for 30 days
T2	Full strength for 18 days followed by 0 (uM) Fe & Zn for next 12 days		

Fig. 4.2: Molecular regulatory network during Fe and Zn deficiency

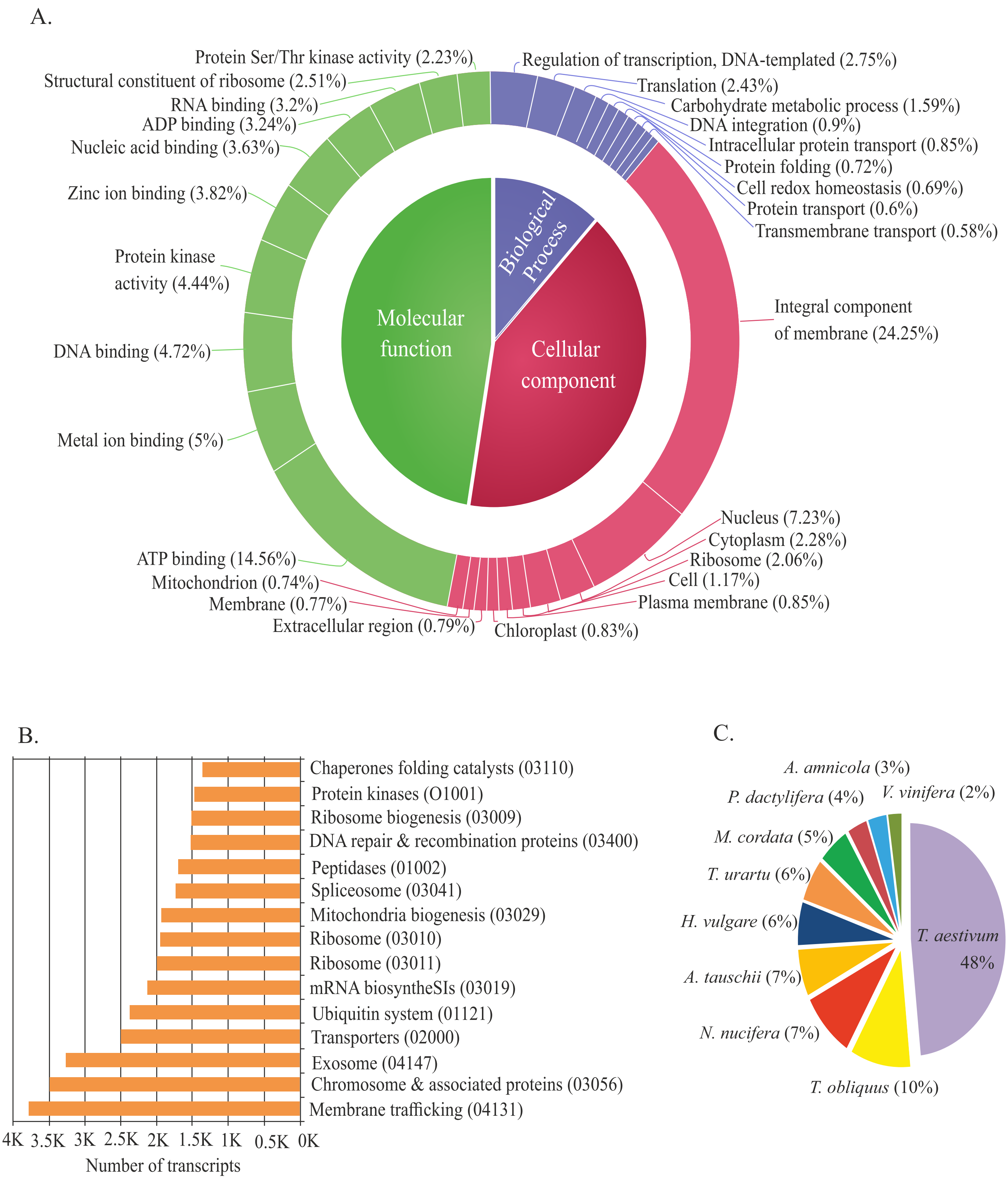


Fig. 4.3: A. Gene ontology (GO) enrichment analysis of DEGs B. Distribution of top ten most abundant KEGG pathways of DEGs among four wheat genotypes. C. Species distribution of annotated transcripts.

Table 4.6: Changes in Superoxide dismutase, Catalase, Glutathione reductase,Hydrogen peroxide, Malondialdehyde content, antioxidant capacity (DPPH Radical Scavenging activity) andphytosiderophore content in Narmada 195 and PBW 502 in response to deficiency treatments.

Treatments	SOD (units /g FW)	CAT (µmoles/ min/g FW)	GR (mM TNB min/g FW)	H_2O_2 (µmol/ g FW)	MDA (µM/ g FW)	DPPH Radical Scavenging activity	PS (nmol of Fe equivalent / g root biomass)
Narmada 195							
Control	23.1±1.92^{d}	8.6±0.91^{a}	1.8±0.28^{ab}	2.4±0.27^{a}	4.7±0.77^{a}	30.7±1.82^{a}	2.7±0.19^{a}
T1	19.4±0.97^{c} (-1.19)	14.2±1.17^{b} (1.65)	4.4±0.88^{c} (2.4)	4.7±0.39^{b} (1.95)	5.9±0.24^{b} (1.25)	51.1±1.42^{d} (1.66)	3.6±0.82^{b} (1.32)
T2	7.7±2.32^{b} (-3)	18.6±0.91^{c} (2.61)	4.8±1.06^{c} (2.6)	6.4±0.49^{c} (2.66)	5.3±0.47^{ab} (1.12)	53.6±1.53^{d} (1.74)	6±0.22^{c} (2.21)
PBW 502							
Control	21.3±0.94^{cd}	10.1±1.68^{a}	1.2±.036^{a}	2.3±0.49^{a}	5±0.25^{ab}	37.4±1.41^{b}	2.1±0.21^{a}
T1	9.8±1.05^{b} (-2.17)	10.5±2.14^{a} (1.03)	2.4±0.35^{ab} (2.0)	3.9±0.29^{b} (1.69)	7.4±0.56^{c} (1.48)	40.3±1.59^{b} (1.08)	2.7±0.18^{a} (1.32)
T2	2.8±0.36^{a} (-7.6)	10.9±0.34^{a} (1.07)	2.7±0.59^{b} (2.25)	4.1±0.67^{b} (1.78)	8.1±0.89^{c} (1.62)	44.4±4.34^{c} (1.19)	3.6±0.30^{b} (1.72)

Note: Different letters indicate significant differences between means ± SD of treatments (n = 3)at P<0.05. Figures in brackets depict fold change from respective control in each variety.

502 shoots was greater in comparison to Narmada 195.activity of CAT increased significantly in Narmada 195 under T1 (1.65-fold) and T2 (2.16-fold) while for PBW 502 the increase (1.03-fold in T1 and 1.07-fold in T2) was not significant as compared to control (P<0.05). In contrast the activities of GR, $H_2O_2$and total antioxidant activities increased in both Narmada 195 and PBW 502 under Fe and Zn deficiency in both treatments but the increase was more significant in Narmada 195 (P<0.05).

Biofortification: Development of RILs of a cross involving HD2967 and high Fe and Zn line CRP 1660

Gpc-B1 gene has been reported to be associated with high grain Fe, Zn and protein content However, our previous studies using molecular marker linked with Gpc-B1 showed no correlation of Gpc-B1 with Fe and Zn content. Therefore

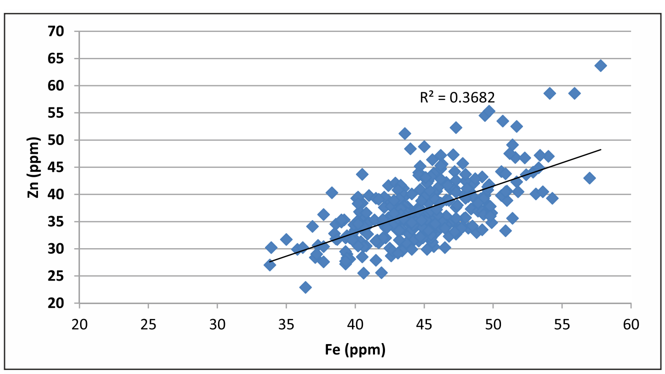


Fig. 4.4: Variation and relationship between Fe and Zn content in RILs of a cross between HD 2967 and CRP 1660

in this investigation we developed RILs involving HD2967 and high Fe and Zn line CRP 1660 for identification of marker/gene for high Fe and Zn content. The population was at F10 stage during 2019-20 crop season. There was significant positive correlation between Fe and Zn in this set of RILs (Fig. 4.4). The RILs were also analysed at three locations during 2019-20 for identification of QTLs associated with high Fe and Zn content.

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 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 IInd year experiment. There was more than 40% increase in Zn content in Zn treated conditions while it was 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 (Fig 4.5). 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.

Phenolic content and antioxidant activities of important wheat varieties of NWPZ

Nineteen wheat varieties of NWPZ were analysed for phenolic content and total antioxidant capacity in terms of DPPH radical scavenging activity. from two locations namely Ludhiana and Pantnagar. 0.1 g of each sample was mixed

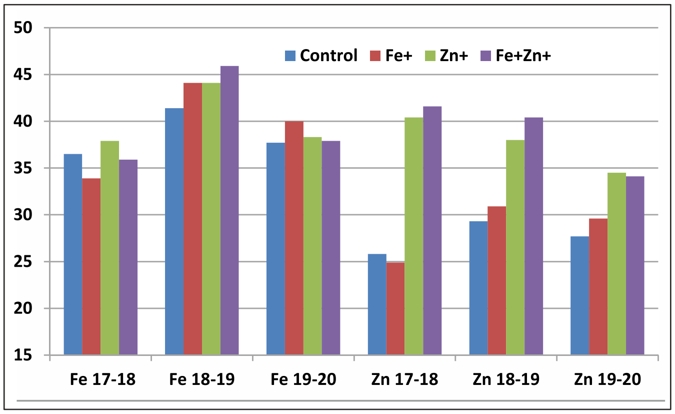


Fig. 4.5: Effect of foliar spray of Fe and Zn on their contents in wheat grain (Average of 10 genotypes)

with 1 ml of 80% methanol in eppendorf tubes by shaking constantly for 2h followed by centrifugation at 8000 rpm for 15 min. The supernatant was used for estimating phenolic content and DPPH activity. The phenolic content was expressed in terms of gallic acid equivalents as shown in table 4.7 below. The highest and lowest phenolic content reported was 1058±11 (PBW771; Pantnagar location) and 457±11 (DBW222; Pantnagar location) µg gallic acid equivalent/g d.wt. basis, respectively. The highest and lowest DPPH radical scavenging activity was 1466±43 (DBW173; Pantnagar location) and 545±11 (NIAW3170; Pantnagar location) n molstrolox equivalent/g d.wt. basis, respectively (Table 4.7). Mean average for DPPH radical scavenging of Pantnagar location (998) was found higher compared to mean average of Ludhiana location (822). Further screening of various wheat genotypes on the basis of phenol content and antioxidant profile is under progress.

Table 4.7: Phenolic content and DPPH radical scavenging activity of various genotypes from two different locations (n=4)

Genotype	Phenolic content (µg gallic acid equivalent/g d.wt. basis) (Mean±SEm)		DPPH radical scavenging activity (n molstrolox equivalent/g d.wt. basis) (Mean±SEm)	
	Ludhiana	Pantnagar	Ludhiana	Pantnagar
DBW88	629±13	555±16	982±13	942±9
DBW187	588±21	477±13	885±15	860±27
HD2967	588±5	579±19	978±8	884±21
WH1105	601±3	507±12	699±45	870±57
DBW222	628±5	457±6	724±7	846±23
HD3086	587±17	476±2	619±60	829±21
PBW550	697±5	534±6	812±11	1100±72
HD3059	770±18	594±39	873±28	1412±22
DBW173	593±4	859±19	751±28	1466±43
WH1021	656±8	788±5	975±37	1436±55
PBW771	612±10	1058±11	1030±42	1247±6
HD3298	580±10	957±102	768±10	1271±15
WH1124	670±6	802±4	663±21	1165±59
HD3043	774±6	609±18	746±17	1329±41
PBW644	736±20	564±12	692±27	705±51
HI1628	696±11	684±16	1069±29	829±24
WH1080	722±7	677±17	727±37	571±65
WH1142	785±11	744±27	881±69	653±28
NIAW3170	704±10	689±37	751±14	545±11

Patent Granted

Sachdev A., Jolly M., Kumar A., Krishnan V., Hada A., Basak N., Pandey V., Marathe A., Punjabi., M. 341699, application no. 2432/DEL/2015, Plant Transformation Vector For Suppressing MIPS Gene Expression And Method For Culturing Low Phytate Soybean as disclosed in the above mentioned application for the term of 20 years from the 7th day of August 2015 in accordance with the provisions of the Patents Act, 1970.

5. SOCIAL SCIENCES

Globally, wheat and barley has been under cultivation in 271.57 million hectares (Wheat: 220.83 million hectares and Barley: 50.74 million hectares) with the annual production reaching an all-time highest output estimated at 923.99 million tonnes (Wheat: 769.31 million tonnes and Barley: 154.69 million tonnes) (Source: United States Department of Agriculture). The nutri-rich cereals respectively hold first and fourth position in terms of global cereals acreage for the period 2019-2020. In India, these rabi cereals are grown in 31.17 million hectares (24.94% of total crop acreage) covering five agro-climatic zones viz., North Western Plains Zone (NWPZ), North Eastern Plains Zone (NEPZ), Central Zone (CZ), Northern Hills Zone (NHZ) and Peninsular Zone (PZ) contributing 36.79 per cent of the total foodgrains production during 2019-2020. Wheat has been under cultivation in 30.55 million hectares and barley covered 0.62 million hectares during 2019-2020 rabi season (Source: III 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 107.18 million tonnes with a record national average productivity of 3508 kg per ha. Similarly, barley registered 1.59 million tonnes during 2019-2020 from 0.62 million hectares with an average national productivity of 2617 kg/ha.

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 exhibited significant yield gain across regions. The gaps (yield and information) across regions should be bridged through need based interventions by identifying the location-specific constraints. ICAR-IIWBR strives to make continuous efforts in popularizing the region-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 crop productivity through different scientist-farmer interface activities with more emphasis on seed as well as varietal replacement, integrated crop

Table 5.1 : State wise performance of improved wheat varieties under Wheat FLDs during 2019-20

State	Mean yield (q/ha)		
	Improved varieties	Check varieties	Gain (%)
Assam	28.95	21.43	35.12***
Bihar	44.53	38.53	15.57***
Chhattisgarh	32.28	26.98	19.65***
Gujarat	56.65	49.95	13.41***
Haryana	52.70	49.95	05.51***
HP	27.48	22.80	20.50***
J&K	37.65	34.10	10.41***
Jharkhand	37.85	28.63	32.23***
Karnataka	26.48	24.75	06.97NS
Maharashtra	38.65	32.38	19.38***
Manipur	16.75	10.50	59.52***
MP	52.55	44.33	18.56***
Delhi	54.78	49.75	10.10***
Punjab	52.45	50.03	04.85***
Rajasthan	52.45	47.80	09.73***
Tamil Nadu	24.15	-	-
UP	46.40	40.45	14.71***
Uttarakhand	39.88	33.68	18.41***
West Bengal	41.80	36.28	15.23***

**** Significant at 1 percent level, NS is Non-significant*

Table 5.2 :Zone wise wheat productivity under FLDs over check during rabi 2019-20

Zone	Mean yield (q/ha)		Gain (in %)
	FLDs	Check	
NHZ	29.98	24.19	23.94***
NEPZ	38.47	31.65	21.55***
NWPZ	51.85	47.98	08.07***
CZ	49.61	42.89	15.67***
PZ	31.97	28.95	10.43***

*** *** *Significant at 1 percent level*

(nutrient, pest & diseases, water, weed etc.) management, incorporation/retention of crop residues and soil health management. The farm advisory services through social media 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. Several other programmes have been initiated as well at the institute level to transfer the efficient technologies to farmers' field. Creation of awareness through mass and print media on seed treatment, seed and varietal 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 2019-20

During the wheat crop season 2019-20, 1500 Wheat Frontline Demonstrations (WFLDs) of one acre each were allotted to 85 cooperating centres across the country of which 1468 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 in the selected farmers' fields. These WFLDs covered 1479.52 acres area of 1607 farmers in 19 states. The maximum number of WFLDs were conducted in UP (190) followed by Bihar (142), MP (137), Rajasthan (108), Maharashtra (100), Assam (91), Haryana (89), Karnataka (75), Punjab (73), HP (72), Jharkhand (65), J&K (51), Gujarat (50), Tamil Nadu (50), West Bengal (50), 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 (59.52%) followed by Assam (35.12%), Jharkhand (32.33%), HP (20.50%), Chhattisgarh (19.65%), Maharashtra (19.38%) and MP (18.56%). 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 NHZ (23.94%) followed by NEPZ (21.55%), CZ (15.67%), PZ (10.43%) and NWPZ (08.07%) (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 08.07% in NWPZ to 23.84% in NHZ.

In case of improved durum varieties, the variety HD 5759 (d) gave a significant average yield of 67.60 q/ha at Indore centre in Central zone. In PZ, the variety MACS 3949 (d) gave an average yield of 40.00 q/ha at Pune center, though it was non-significant.

In NHZ, at Almora centre, improved rainfed variety VL 967 yielded 37.17 q/ha which was significantly higher than the check varieties. The variety HS 542 gave significantly higher yield of 33.58 q/ha and 30.28 q/ha at Khudwani and Rajouri centres, respectively. In CZ, DBW 110 gave 71.40 q/ha yield at Ujjain center which was significantly higher than the check variety. In PZ, NIAW 3170 yielded 41.90 q/ha under rainfed condition at Niphad centre which was significant.

In case of late sown varieties, variety DBW 173 gave significantly higher yield (42.65 q/ha) at Meerut center in NWPZ. In CZ, the significant average yield was recorded by Raj 4238 (51.00 q/ha) at Udaipur center. In PZ, the significant average yield was recorded by AKAW 4210-6 (35.38 q/ha) at Akola center.

The location specific highest average varietal yield attained in a zone were by variety HI 8759 (d) (77.00 q/ha) at Indore centre in CZ, DBW 187 (74.00 q/ha) at Shamli in NWPZ, DBW

187 (62.50 q/ha) at Ayodhya in NEPZ, MACS 6478 (57.50 q/ha) at Pune in PZ and VL 967 (45.00 q/ha) at Almora 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 30.19% at Shillongani center in NEPZ, although it was non-significant. In NWPZ, significant yield gain of 7.60% and 4.08% was recorded at Bijnor and Hisar centers, respectively. In CZ, 13.98% and 8.03% significant yield gain was recorded at Jagdalpur, Bastar and Kota centers, respectively.

A significant yield gain of 10.19% at Coochbehar center was observed in NEPZ under zero tillage of wheat sowing. In NWPZ, zero tillage gave the significant yield advantage of 11.48% and 07.75% at ICAR-IIWBR, Karnal center. The yield gain due to zero tillage technology was non-significant at most of the centers.

Yield gain under rotavator technology was 05.65% at Bijnor center, which was significantly higher than conventional tillage. At other centers, it was non-significant.

The yield gain due to micro irrigations was non-significant at Vijapur center. Performance of salt tolerant variety KRL 210 was better at CSSRI, Karnal center in NWPZ, but in yield terms it was statistically 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.

Northern Hills Zone (NHZ): In NHZ, small land holding, high cost of inputs, lack of irrigation facilities, *Phalaris minor* infestation, non-availability of labour, non availability of seeds of newly released varieties, untimely rain, yellow rust, imbalanced use of fertilizers and lodging were the major constraints faced by the farmers.

North Eastern Plains Zone (NEPZ): In this zone, high cost of inputs, non-availability of seeds of newly released varieties, lack of canal irrigation facility, low price of wheat, untimely rain, small land holdings, non-availability of labour, poor information delivery by state extension machinery, poor participation in exposure visits arranged by state department of agriculture and *Chenopodium album* were identified as major constraints. Seed and variety replacement ratio is low in NEPZ as seeds are not easily available. Private seed growers are very few in number hence dependency on NSC and other government agency is very high. Due to non-availability of government procurement of wheat, the farmers are dependent on private traders and they are not offering good price. Hence, there is a need to ensure marketing of wheat on MSP in this zone for better price realization and profitability of wheat cultivation.

North Western Plains Zone (NWPZ): NWPZ is the most productive zone of the country. In this zone, maximum procurement of wheat is done by FCI and other government agencies for different welfare schemes. In recent years infestation of wheat fields with *Phalaris minor* has emerged as a major constraint of the zone and farmers are unable to manage it due to resistance developed against certain herbicides. High cost of inputs, decline in water table, small

Table 5.3 : Overall constraints impeding wheat production (n=1251)

Overall Constraints	Score	Rank
High cost of inputs	1767	I
Small land holding	1419	II
Phalaris minor	1287	III
Non-availability of labour	1202	IV
Non-availability of seeds of newly released varieties	1190	V
Untimely rain	1154	VI
Low price of wheat	1144	VII
Lack of canal irrigation facility	1137	VIII
Decline in water table	1097	IX
Higher customer hiring rate for field operations	1040	X

land holdings, non availability of labour, low price of wheat, higher custom hiring rate for field operations, untimely rain, poor information delivery by state extension machinery and lack of canal irrigation facility were also identified as major constraints of this zone.

Central Zone (CZ) : In central zone, high cost of inputs, *Phalaris minor,* small land holding, lack of canal irrigation facility, decline in water table, untimely rain, non-availability of labour, higher custom hiring rate for field operations, poor participation in exposure visits arranged by state department of agriculture and low price of wheat 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, high cost of inputs, non-availability of seeds of newly released variety, low price of wheat, poor plant population, small land holding, lack of training facility, higher custom hiring rate for field operations, erratic power supply, non-availability of labour and imbalanced use of fertilizers were the major constraints. 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 across zones revealed that high cost of inputs, small land holding, *Phalaris minor*, non-availability of labour, non-availability of seeds of newly released varieties, untimely rain, low price of wheat, lack of canal irrigation facility, decline in water table and higher custom hiring rate for field operations 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' fields 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 2019-20

During the *rabi* crop season 2019-20, 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, 231 were conducted by 20 centers, covering 237 acres area of 251 farmers. Improved barley varieties with complete package of practices (irrigation management, nutrient management, weed control, seed treatment etc.) were demonstrated.

Table 5.4 : State wise yield gain under barley FLDs during rabi 2019-20

State	BFLDs yield (q/ha)	Check yield (q/ha)	Gain (%)
HP	25.93	21.03	23.31*
UP	42.43	32.38	31.05***
Punjab	44.13	39.72	11.10***
Haryana	47.96	45.26	05.95**
Rajasthan	55.01	49.15	11.92***
MP	36.09	29.27	23.31***

*** Significant at 1 percent level, **Significant at 5 percent level, *Significant at 10 percent level

Table 5.5 : Zone wise productivity under barley FLDs over check during rabi 2019-20

Zone	BFLDs yield (q/ha)	Check mean yield (q/ha)	Gain (%)
NHZ	25.93	21.03	23.31*
NEPZ	42.43	32.38	31.05***
NWPZ	52.82	48.21	09.57***
CZ	37.87	31.68	19.55***

*** Significant at 1 percent level, *Significant at 10 percent level

The highest increase in barley yield was recorded in UP (31.05%) followed by HP and MP (23.31%). The lowest gain in yield was reported in Haryana (5.95 %).

The yield gain due to improved varieties over check mean yield was highest in NEPZ (31.05%) followed by NHZ (23.31%), CZ (19.55%) and NWPZ (09.57%). 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, BHS 400 was the highest average yielding (30.58 q/ha) variety at Bajaura centre. In NEPZ, RD 2907 at Mirzapur (52.88 q/ha), RD 2907 at Durgapura (65.15 q/ha) in NWPZ and RD 2899 at Vidisha (50.55 q/ha) in CZ were the highest average yielding varieties.

At particular farmers' field as well as on average basis, varieties BHS 400 (30.58 q/ha), RD 2907 (56.68 q/ha), RD 2907 (67.50 q/ha) and RD 2899 (52.00 q/ha) performed better than other varieties at Bajaura, Mirzapur, Durgapura Jaipur and Vidisha 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, non-availability of seed of newly released varieties, small land holding, water stress, yellow rust, lack of knowledge among farmers about recent production technologies, late sowing, high cost of inputs, untimely rain, lack of irrigation facilities and poor information delivery by state extension machinery were identified as major constraints faced by the farmers.

North Eastern Plains Zone (NEPZ) : In this zone, high cost of inputs, small land holding, untimely rain, imbalanced use of fertilizers, *Phalaris minor,* non availability of farm machinery, non-availability of labour, lack of land leveling facility, low price of barley and *Chenopodium album* were identified as major constraints. There is a need to address these constraints to exploit the potential of eastern states for wheat production. Regarding technical constraints, such as, imbalanced use of fertilizers, farmers need to be made aware through awareness programmes and trainings about the use of fertilizers. Marketing of barley and good price realization is a great concern in NEPZ.

North Western Plains Zone (NWPZ) : Being the highest barley producing zone of the country there a need to address major constraints faced by the farmers of NWPZ. Under FLD programme, resistance against herbicides was identified as the most serious constraint of this zone followed by high cost of inputs, decline in water table, low price of barley, low organic matter in the soil, small land holdings, lack of canal irrigation facility, neel gai, low micro nutrient level in soil and non availability of labour.

Central Zone (CZ): In central zone, resistance against herbicides, lack of canal irrigation facility, decline in water table, high cost of inputs, low price of barley, higher custom hiring rate for field operations, small land holding, lack of knowledge among farmers about recent technologies, poor quality of seeds and *Phalaris minor* were identified as major constraints.

Major constraints impeding barley production in the country: Overall analysis of constraints in different zones clearly indicated that resistance against herbicides, lack of canal irrigation facility, decline in water table, high cost of inputs, low price of barley, higher custom hiring rate for field operations, small land holdings, lack of knowledge among farmers about recent technologies, poor quality of seeds and *Phalaris minor* were the major constraints. It is evident that majority of the constraints are administrative in nature which require timely intervention by state department of agriculture. Some of the constraints are technical in nature and with awareness and skill upgradation of the farmers on weed management strategy, these can be easily addressed.

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 ₹2.78 per rupee of investment in comparison to the check varieties (₹2.47). 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 ₹3.74 (Gujarat) to ₹1.88 (Tamil Nadu) across states, ₹3.32 (CZ) to ₹2.38 (NHZ) across zones, and ₹3.71 (Happy Seeder) to ₹1.88 *(Dicoccum wheat)* across technologies. Surprisingly, Gujarat registered the highest returns per rupee of investment owing to the higher gross returns *i.e.,* ₹127562 per hectare during the 2019-2020 crop season. On the contrary, Tamil Nadu registered lowest returns per rupee of investment due to less gross returns owing to limited yield capacity in the region (₹29490 per hectare).

The profit per hectare in FLDs was highest in Gujarat (₹93444), followed by Madhya Pradesh (₹85402) and New Delhi (₹84547). The difference in profit levels between demonstration and check plots was highest in the case of Assam (₹18796 per hectare). Interestingly, operational costs in Bihar, Chhattisgarh, Gujarat, Haryana, Jharkhand and Karnataka were lower in demonstrations in comparison to the check plots. The probable reason for Haryana might be due to the 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 (₹588 per quintal) owing to less operational costs and the likelihood of getting more yield being a progressive state located in the NWPZ. Among the wheat growing zones, the cost of production in the CZ was lowest (₹752 per quintal), which is due to relatively less operational costs in raising the crop and realized yield levels was more as well. CZ also realized a good return per rupee of investment at the demonstrated plots (₹3.32) which is mainly due to the increasing productivity especially in Madhya Pradesh, followed by less operational costs. Among technologies demonstrated at farmers' field, happy seeder gave the highest profit (₹87454/ha) and the least was observed for the *dicoccum* variety (₹13932), despite growing demand in south India. However, the results were not consistent across years, sites owing to testing of particular technology in different locations of diverse soil properties and managed by different farmers. Overall, by adopting a new wheat variety or production technology a farmer earns ₹63690/ha. Further, ₹707 have to be spent to produce a quintal of wheat through new technology against ₹798 (farmers practice: check plots).

Barley : On an average, improved barley varieties demonstrated at farmers' field under the FLD program gave around 12 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. Uttar Pradesh registered the highest returns per rupee of investment (₹4.50) through demonstrations, followed by Punjab (₹3.58) and Haryana (₹2.58). The difference in returns per rupee of investment between demonstration and check plots for the crop season was highest in Uttar Pradesh, followed by Madhya Pradesh and Punjab.

The profit per hectare in FLDs was highest in Rajasthan (₹62654), followed by Uttar Pradesh (₹62269) and Punjab (₹60003). The difference in profit between FLD and check plots ranged from ₹22541 in Uttar Pradesh to ₹3155 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 (₹4.50), followed by NWPZ (₹2.89) and CZ (₹2.29). Estimates of cost of production indicated that the cost incurred in producing a unit quantity of barley output was least (₹442 per quintal) in Uttar Pradesh owing to less operational costs coupled with increased yield levels.

Wheat FLDs at ICAR-IIWBR, Karnal centre

The centre (ICAR-IIWBR) conducted 20 acres wheat FLDs at twenty farmers' fields in the villages namely Ramba and Butana in Karnal district and villages Bid Amin, Fatuhpur, Mirzapur and Dabkheri in Kurukshetra district of Haryana state using varieties DBW 187, HD 3226 and HPBW 01 during *rabi* season 2019-20. The demonstrations were conducted using happy seeder, zero tillage and conventional tillage technologies with 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 2019-20.

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

Diagnosis of zero tillage based rice-wheat system in Haryana

The study was conducted in Karnal, Yamunanagar, Kaithal and Rohtak districts of Haryana during 2015-16 to 2019-20. A total of 420 farmers were selected for this study. The impact was studied by using pre and post method and beneficiary and non-beneficiary methods. In Karnal, Yamunanagar and Kaithal districts zero tillage method was

Table 5.6 : FLDs Centers monitored during 2020

Team Leader	Centres Monitored	Dates of Monitoring
Dr. Satyavir Singh	Niphad Nasik and Pune	6-7 March, 2020
Dr. Anil Khippal	Imphal, Kalyani, Wellington and Dharwad	24-27 February and 12-15 March, 2020
Dr. Raj Pal Meena	Meerut, Shamli, Saharanpur and Muzaffarnagar	11-13 March, 2020
Dr. Sendhil R.	Bilaspur and Jagdalpur	4-7 March, 2020
Dr. Mangal Singh	Kanke Ranchi, Morabadi Ranchil and Pusa	17-20 March, 2020
Dr. Ramesh Chand	Rewa, Panna and Jabalpur	26-28 February, 2020

compared with conventional method whereas in Rohtak district the impact was studied by comparing beneficiaries of zero tillage with non-beneficiaries.

The study revealed that majority (39.67%) of the respondent farmers belonged to 31-40 years age group followed by 41-50 years age group (32.33%). A total of 85.67% of the sampled farmers were below 50 years of age. It shows the involvement of youth in agriculture of Haryana. Only five percent of the farmers were illiterate. Majority (36.33%) of them were matriculate and 10+2 (22.33%). Agriculture was the primary occupation of 88.33% of the farmers and 9.67 were involved in dairying along with agriculture. Dairying was the subsidiary occupation of 32.33% of the farmers. Out of 300 farmers, majority (60%) were in large category (>10 acres of land holding). Only 2.67% were under marginal category. Tube well was the main source of irrigation for majority of the farmers. Quality of water was normal in the study area and the soil was medium to heavy with high to medium fertility. Few farmers were found burning crop residue to get their field clear for sowing of wheat crop but their number was quite low. With the State Department of Agriculture initiatives the number was continuously decreasing. Under the study it was found that 99.33% of the farmers adopted zero tillage method for sowing of wheat. They used either zero till seed drill or turbo happy seeder for sowing of wheat. Direct seeded rice technology was adopted by 32.67% of the farmers, and 58.67% of the farmers adopted both technologies at their farm. It was observed that for zero till seed drill, custom hiring charges were ₹ 600-700/acre, for turbo happy seeder ₹ 1000-1200 and for DSR ₹ 900-1000. If any farmer wants to purchase these machines, he can avail 50% subsidy, but if these machines are purchased for custom hiring centres then they can avail 80% subsidy. This is a strong initiative by Haryana Government to popularise these technologies in the state. The most frequently used wheat variety under zero tillage conditions was HD 2967 and was adopted by 91.95% of the farmers. HD 3086 was the second most commonly used wheat variety by 28.19% farmers. The other varieties were HD 1105 (8.05%), DBW 88 (5.37%) and others (HD 2851, HDCSW 18 and PBW 723) only 3.02%.

The impact of zero tillage technology was studied on a number of parameters and it was found that 80.54% of the farmers felt that it takes less time in comparison to conventional tillage for sowing of wheat crop. Majority (84.56%) have used same seed rate, observed better germination (55.37%), applied similar quantity of fertilizer (57.38). But some of the farmers used less (13.9%) and more (22.82%) than the recommended dose. It was also observed by majority of farmers (71.47%) that there was decrease in number of narrow leaf weeds under zero tillage, increase by 2.01% farmers and 28.51% farmers did not find any difference in weed population. In case of broad leaf weeds there was increase in number in zero tillage fields and was recorded by 20% farmers but majority (32.21%) observed no change. There was decrease in overall weed population under zero tillage and 94.97% observed it in their fields. Majority (82.55%) felt less water requirement under zero tillage wheat than conventionally sown wheat. Most of the farmers (94.97%) found it cost effective and large majority harvested more yield i.e. 2-3q/ha under zero tillage. A large majority (91.95%) of them observed that there was not any change in crop duration under both the conditions. Impact of zero tillage on soil parameters was also recorded and was found that fertility status has increased due to adoption of ZT and was experienced by 93.62% farmers. Majority of them (83.22%) found increased organic carbon content in soil of ZT fields due to incorporation of rice residue during sowing. Increased moisture retention capacity was observed by 88.93%, less lodging by 92.285 and avoidance of terminal heat by 93.96% farmers. Soil physic-chemical properties also enhanced due to continuous adoption of zero tillage. It could be inferred from all findings that zero tillage technology is a boon for wheat farmers and with its adoption, majority of the problem associated with rice-wheat system can easily be addressed.

When comparison was made between beneficiaries and non-beneficiaries then it was found that beneficiaries were using slightly more seed rate than conventional sowing. Beneficiaries were able to save 1-2 irrigation with ZT. They harvested 1.64 q/acre grain yield and 1.2 q/acre straw yield with the adoption of zero tillage. The gross income of beneficiaries per acre was ₹ 51968 and for non-beneficiaries it was ₹. 47331 and this way beneficiaries were able to earn ₹ 4638/acre with the adoption of zero tillage technology.

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

In this project, primary data on wheat production particulars and socio-economic characteristics of farm households were collected during 2019 from 200 wheat and 100 barley producers across two randomly selected districts of Eastern Uttar Pradesh viz., Allahabad and Ghazipur (moderate vulnerable category). In the case of wheat, the Yield Gap I was found to be negative in Allahabad (-8 % : -4 Q/ha) and the Yield Gap II was highest in Allahabad (148.63 % : 28.89 Q/ha). Analysis of resource use pattern indicated that there exists significant difference in the use of resources between

Prayagraj and Ghazipur districts of Eastern Uttar Pradesh. Seeds were used more than the recommended doses. Fertilizers were used either below or above the recommended doses across the selected farms. Among all inputs, expenditure incurred on manure/bio-fertilizer showed a significant difference. The implications 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 scoring analysis indicated that the awareness level was too low with respect to adaptation strategies and poor access to the technologies and very poor adoption rate barring improved management with new crop varieties, application of more organic manures, supplemental irrigation through groundwater, irrigation depth/frequency and insurance. The analysis indicated the need for increasing the awareness of climate smart farming practices and adaptation strategies among the farmers in Eastern Uttar Pradesh, especially with conservation agriculture.

Improving the Socio-economic Condition and Livelihood of Tribes in India through Extension Education and Development Programmes

Under the TSP project, the following eight centers were included for the year 2019-20, namely, Lahaul & Spiti (HP), Leh (J&K), Khudwani (J&K), Jabalpur (MP), Udaipur (Rajasthan), Bilaspur (Chhattisgarh), Ranchi (Jharkhand) and Dharwad (Karnataka). During 2019-20, different TSP activities were carried out. The demonstrations on wheat crop were conducted with complete package of practices at 66, 50, 60, 43, 60 and 23 farmers' fields at Khudwani, Jabalpur, Udaipur, Bilaspur, Dharwad and Ranchi centers, respectively. Under TSP wheat demonstrations, the seeds of improved wheat varieties were supplied. Thirteen training programmes on wheat production technology were conducted at Khudwani (2), Bilaspur (2), Dharwad (1), Leh (4) and Lahaul & Spiti (4) centers. Three Awareness camps/exhibitions/exposure visits were organised. Three publications, one at Khudwani and two at Dharwad center were published. Under the 'Grant in Aid-General' head in budget, funds have been approved and released for the year 2020.

World Soil Day at Village Nabhipur, Karnal

6. BARLEY IMPROVEMENT

The ICAR-IIWBR Karnal is coordinating the national barley research programme in the country under AICRP on wheat and barley by organizing the multi-disciplinary and multi-locational experiments across the barley growing zones. The experimentation is supported by the funded and voluntary centres on aspects of crop improvement, protection and production of malt, feed and food barley. These efforts result into the identification of new cultivars for commercial cultivation with wider adaptability, resistance to various biotic and abiotic stresses prevalent in the area, desired grain and malt quality levels and suitability to specific production conditions.The experiments are also conducted on aspects of input optimization and conservation agriculture in addition, the new varieties evaluation under different production technologies to find widely adapted ones.The experiments on screening of new genotypes under artificial epiphytotic/ hot spot conditions and chemical control and IPM at various test centres are conducted under crop protection section. The institute is also conducting zonal monitoring during crop season and organized annual review&work planning meetings to facilitate the objectives of AICRP on Wheat and Barley. The efforts of the barley improvement programme have led to the high productivity of 27.3 q/ha in India with a production of 1.69 MT from an area of 6.18 lakh ha as per 4th advance estimates of 2019-20.

The institute also supplements research efforts of coordinated program through specific aspects of barley improvement especially on malt barley improvement, incorporation of disease resistance and quality improvement utilizing biotechnological tools 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 program at IIWBR Karnal. More emphasis on aspects like better yield and quality of hulless barley for food, better malt extract, high diastatic power, optimum protein and beta glucan content in malt barley are the current focus activities. In addition, ICAR-IIWBR also facilitates the continuous access to new germplasm of diverse origin from various sources for evaluation and utilization in the national programme thorough it's excellent linkages with international organizations like ICARDA.

Despite the travel limitations caused by COVID-19, monitoring teams surveyed the major barley growing areas during the season before the lockdown was enforced, except in northern hills zone where the virtual meetings were organized with help of the NHZ centers. The crop was bye and large disease free with some localized incidence of aphids in the plains and yellow rust in foothills and mid hills.

New initiatives were undertaken to improve productivity and quality of malt and food purpose barley in addition to the feed barley. Awareness programme were organized with linkages with national and international malting, brewing and food industries to promote the use of malt and food barley in different products. An institute consultancy project with M/s AB InBev India was undertaken on farmers training for malt barley cultivation which also generated the resources of ₹16.5 lakhs for the institute and at the same time benefitted the small holder barley farmers in states of Haryana and Rajasthan.

AICRP coordination activities

Release of new malt barley variety

During the year,a new malt barley cultivar, DWRB182, developed from the cross DWRUB52/DWRB78 at ICAR-IIWBR barley improvement program, was first identified for release by 59th Annual Meet of AICRP on Wheat and Barley in August, 2020 and subsequently released/ notified in December 2020 by the Central Sub-Committee on Crop Standard, Notification and Release of Varieties for Agricultural Crops for commercial cultivation in north western plains zone. DWRB182 is a combination of high grain yield and excellent malting quality, which will fill the industrial demand in region (Table 6.1). It is the only genotype reported with very low levels of grain (<5.0%) and wort (506 ppm) β-glucan based on three years average performance in AICW&BIP trials with high filtration rate (263 ml/hr). Another trait of current industrial preference is malt diastatic power, which is highest (860L) in the proposed genotype in the trials. These

Fig. 6.1: DWRB 182: latest two-row malt barley cultivar developed at ICAR-IIWBR, Karnal

Table 6.1: Important features of DWRB182 released in year 2020

Variety	Parentage	Zone/State	Production condition	Average and Potential* yield(q/ha)
DWRB182	DWRUB52/ DWRB78	NWPZ (Punjab, Haryana, Western UP, Rajasthan except Udaipur and Kota divisions)	IR-TS-Malt	49.7(74.5*)

Table 6.2: New barley genetic stock registered in 2020

Genetic stock	INGR Number	Parentage	Year	Trait
DWRB207	20019	CDC Manley /BCU2881	2020	Highly resistant to stripe rust with high 1000gw (47.5g) and low protein content (9.5%)

Table 6.3:. Promising entries in different trials during 2019-20

SN	Trial name	Zone	Entry
1	AVT-SST	NWPZ/NEPZ	RD3016
2	AVT/IVT- HLS	NWPZ/NEPZ/ CZ	UPB1086
3	IVT-FB	NWPZ	HUB272
4	IVT-FB	NEPZ	KB1822, RD3012, HUB272, BH1029, PL911 and PL917
5	IVT-FB	CZ	KB1822, RD3013 and UPB1088

two traits were lacking so far in the malt barley varieties released in country. The malting and brewing industry is really looking for such genotype, which they can use in place of the imported exotic barley cultivars.DWRB182 is highly resistant to yellow rust in field as well as in SRT testing to all known pathotypes in country and it also possesses better tolerance to the leaf blights over the checks in all the three years of screening in NBDSN.

Genetic stock registered

One genetic stock namely DWRB 207 developed at institute has been registered for its uniqueness (Highly resistant to stripe rust with high 1000gw and low protein content) with ICAR-NBPGR and their details are as under:

Organization of the coordinated yield evaluation trials

Out of 86 yield evaluation trials proposed 84 trials were conducted. After the analysis, only 78 trials (91% of proposed, 95% of conducted) were found good for reporting. These trials were conducted at 11 main centres and 30 testing centres (including ICAR, SAUs and State Department of Agriculture) during Rabi 2019-20.In all 97 test entries contributed by 12 centres, were evaluated against 24 checks in the coordinated yield trials under rainfed (plains and hills), irrigated (plains) and saline soils conditions. One entry was also contributed by private industry M/s AB InBev India Ltd. Bengaluru. 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 or better than check with additional trait(s), monitoring reports for purity, disease/pest reactions and the quality (as applicable), 11 entries (Table 6.3) namely; BH1029, HUB272, KB1822, PL911, PL917 KB1822, RD3012, RD3013, RD3016, UPB1086, and UPB1088 were found suitable for the promotion into advanced varietal evaluation in different trials.

Zonal monitoring

The teams constituted for monitoring of Barley Yield Trials & Nurseries in Central zone, NWP and NEP Zone, visited different locations (Table 6.4) at the most appropriate stage of the crop and recorded observations about the varietal performance, conduct of trials, disease/ pest incidence and genetic purity of the test entries. The team in NHZ conducted the virtual monitoring due to Coivid-19 pandemic related restrictions. On the spot decisions were taken about the rejection of trials and purity of test entries. The proceedings of these team meetings have been circulated for necessary action by concerned breeders and other scientists and copies of the same is appended in the report for record.

Table 6.4: Zonal monitoring visits of the barley teams

Zone	Date	Centres visited
CZ	13-14 Feb. & 03-05 Mar, 2020	Udaipur, Vijapur, Morena, Gwalior, Jhansi and Tikamgarh
NEPZ	23-24 Feb., 2020	Kanpur, Dalipnagar, Faizabad, Varanasi, Saini, Kalyani, Sabour, RAU Pusa, Ranchi and Chiyanki
NWPZ	03-07 March 2020	Bawal, Durgapura, Tabiji, Fatehpur, Hisar, Bhatinda, Ludhiana, Agra and Mathura

Table 6.5: International trials and nurseries evaluated during crop season 2019-20

SN	Trial/Nursery	Entries	Check	# Sets	Locations
1	IBYT-HI-2020	24	BH946	4	Durgapura, Hisar, Ludhiana, Karnal
2	7th GSBYT-2020	24	K603	4	Hisar, Pantnagar, Kanpur, Karnal
3	IBON-HI-2020	160	BH946	4	Durgapura, Pantnagar, Ludhiana, Karnal
4	7th GSBON-2020	180	Lakhan	4	Kanpur, Faizabad, Bajaura, Karnal

International and national nurseries and trials

In order to facilitate the availability of promising new diversity in the national barley program, the All India Coordinated Research Project (AICRP) on Wheat and Barley organizes the import and conduct of international trials and nurseries in country. During Rabi 2019-20, two international yield trials and two observation nurseries were supplied from ICARDA which included a total of 390 genotypes for different production conditions. One set each of these nurseries and trials was also evaluated at ICAR-IIWBR, Karnal. Rest of the sets were evaluated at different locations (Table 6.5) as per the requirements. Due to COVID-19 pandemic the *Field Day,* which is organized every year to give opportunity to barley breeders of NARS to select material from these nurseries as to cater their local needs, could not be organized.

In addition, one set each of EIBGN with 45 entries selected from ICARDA trials/ nurseries of 2018-19 crop season and six released varieties (BH946, BH959, BHS400, RD2715, DWRB101 and DWRB137) was each supplied to 10 barley breeding centres across NWPZ (Karnal, Hisar, Durgapura, Ludhiana, Pantnagar), NEPZ (Kanpur, Faizabad, Varanasi) and NHZ (Shimla, Bajaura) for further evaluation and utilization. Several EIBGN entries were found better than checks at different locations in three zones.

A National Barley Genetic Stock Nursery (NBGSN), was constituted during the year consisting of 15 entries as promising sources for important traits from AICRP trials/ nurseries during 2018-19 crop season. The NBGSN was supplied as suggested crossing block for evaluation and utilization at 10-centres (Durgapura, Ludhiana, Karnal, Hisar, Faizabad, Varanasi, Pantnagar, Kanpur, Shimla and Bajaura). Though the precise utilization reports for these genotypes by individual centers/ breeders during the crop season have not been received, while some centers indicated the utilization in hybridization.

A total of 410 lines selected from ICARDA advanced trials at Amlaha (India) and Morocco were raised in *Rabi* 2019-20 at Karnal for further evaluation and selection for selection by Indian breeders during field day, which however, could not be organized because of COVID-19 lock down.

Coordination of breeder seed production

An indent of 524.97q breeder seed of 26 varieties was received from DAC&FW, Ministry of Agriculture & Farmers Welfare, Govt. of India. The indent included the requirement of eight states (Punjab, Haryana, Himachal Pradesh, Jharkhand, Madhya Pradesh, Rajasthan, Uttar Pradesh and Uttarakhand) and three public sector agencies (National Seeds Corporation, IFFDC & HIL,) and one private agency (National Seed Association of India) for the season Rabi 2019-20. A total 526.97q breeder seed indent of 28 varieties was allocated among 12 BSP centres. Against this allocation, 997.25q breeder seed of 28 varieties was produced during 2019-20 which is significantly surplus (+470.28q) over the total allocated quantity (526.97) of breeder seed.

Molecular marker studies on AVT-II entries under AICRP

AVT entries were characterized at molecular level to analyze genetic variability in advanced varietal trials 2019-20. A set of nine genotypes including four test entries (DWRB182, DWRB196, DWRB197 and PL908) and checks (DWRB101, DWRB123, DWRB160, RD2849 & BH902) were screened using barley specific molecular markers. Total 46 SSR/STS markers covering seven chromosomes of barley were screened to develop molecular profiles. Total 78 alleles were scored for PCR based amplification profiles for nine genotypes. The number of alleles ranged from 1 to 3 with an average of 1.69 alleles per locus. The band fragment size varied from 90 bp to 1500 bp with PIC values ranging from 0.0 to 0.75. Polymorphic information content (PIC) score when compared across seven linkage groups of barley

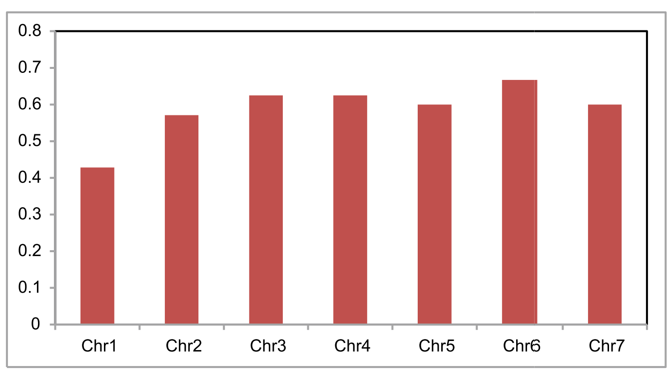


Fig.6. 2: Polymorphic information content scored for seven linkage groups of barley genome for final year AVT trials 2019-20

revealed variability ranging between 0.42 to 0.50 at molecular except for chromosome 3H that revealed 68% variability at molecular among AVT final year test entries and their checks as shown in figure 6.2. The dendrogram were developed for test entries and check lines indicating their molecular diversity based on similarity coefficient (GS) value around 0.57 to 0.77, which indicated sufficient genetic variability.

Barley germplasm rejuvenation and characterization

A total of 8239 barley accessions are being conserved and maintained in medium term storage facility in module at ICAR-IIWBR, Karnal. During the 2019-20 crop season a set of 498 barley genotypes (Table 6.6) were characterized as per barley DUS guidelines. Out of 498, fifteen genotypes were identified promising BCU 2878, BCU 2888, BCU 2899, BCU 2900, BCU 2966, BCU 2971, BCU 2977, BCU 3128, BCU 3133, BCU 3158, BCU 3267, BCU 3273, BCU 3339, BCU 3358 and BCU 3356 for days to heading, plant height, thousand grain weight and no. of grains per spike. For malting traits, the germplasm provided for quality parameters include hectoliter weight, bold weight and thin weight. The seven promising barley genotypes for quality parameters were identified namely, BCU 2911, BCU 2943, BCU 2967, BCU 2971, BCU 2975, BCU 2977 and BCU 2991 (Table 6.7). Six hundred fifty-two barley germplasm were supplied to various indenters for research purpose after proper formalities of MTA.

Table 6.6: Germplasm activities during 2019-20

Activity	Accessions 2019-20
Germplasm characterization	498
Germplasm rejuvenation	498
Germplasm exchange	652

DUS testing in Barley

During 2019-20, four farmer's varieties namely B.2019-1, B.2019-2, B.2019-3, B.2019-4 for first year and two farmer's varieties, Maghe and Laxhmi for second year, respectively, were characterized as per barley DUS guidelines with a set of eighteen examples varieties under the PPVFRA DUS Testing in barley project. The report for which was submitted in time to the PPV&FRA, New Delhi. During crop season 2020-21 seven new farmer's varieties namely BRDJ-287, BSLM-262, BBPC-286, BDPJ-238 and 20 Bar 1 for first year, and B 2019-1 and B 2019-3 for second year are being evaluated for DUS testing with nineteen example varieties as per DUS guidelines.

In addition to that, one set of 102 barley released varieties were grown for maintenance at IIWBR and also supplied to the RARI, Durgapura. Registration proposal of DWRB160 (Karan Maltsona) was submitted to the PPV&FRA, New Delhi for seeking protection under new extant category.

Malt barley improvement

Hybridization programme

A set of 333 diverse genotypes of barley were sown in crossing block and the genetic purity of these genotypes was assured through rigorous roughing at a regular interval. The choice of parental lines for crossing was made on the basis of their yielding ability, disease resistance, malting quality and other traits of economic importance and a set of 146 new crosses were made during the crop season. The breeding material comprising of F_1 to F_7 generations was evaluated under artificial epiphytic conditions for rusts and also natural incidence for aphids. Using the pedigree method, a number of selections were made from different segregating generations for vigor for desirable traits biotic parameters. The details of breeding materials handled are presented below in table 6.8.

Table 6.7: Promising barley accessions for barley quality parameters

SN	Accession	Row type	Hectolitre weight	%Bold grain	TKW (g)
1	BCU 2911 (black seed)	6	55.0	38.2	33
2	BCU 2943 (black seed)	2	63.6	67.5	38
3	BCU 2967	2	54.6	81.8	34
4	BCU 2971	2	60.8	77.1	40
5	BCU 2975 (Huskless)	6	70.3	42.9	26
6	BCU 2977	2	59.0	84.0	44
7	BCU 2991	6	59.2	74.9	38
8	DWRB 101 ©	2	57.5	76.2	48
9	DWRB 137 ©	6	55.6	82.8	43

Table 6.8: Malt barley breeding material handled during 2019-20

Generation	# Crosses	# Families	# selected lines/plants
F_7	18	22	13
F_6	53	99	24
F_5	89	226	223
F_4	50	92	73
F_3	27	90	55
F_2	45	45	212
F_1	47	47	47

Evaluation of advanced lines in station trial

The 18 advanced bulk lines of F_8 generation were evaluated for their yield potential and disease reactions in station trial of malt barley along with three checks (Table 6.9). Based on the yield, disease reactions and quality parameters, five lines were found superior over the checks and out of these four promising lines (BK-1902, BK-1907, BK-1910 and BK-1915) were promoted in the Initial Varietal Trial of Malt Barley (IVT-TS-MB-NWPZ).

During crop season 2019-20, a total of 13 genotypes were contributed in 8 trials of All India Coordinated Research Project of Barley (Table 6.10). The genotype DWRB182 has been released as variety after completing three years evaluation in AICRP trials.

Feed and food barley improvement

Evaluation of parental line

A crossing block was constituted with 110 diverse naked barley genotypes involving Indian prevalent cultivars and exotic germplasm lines in the crossing block. Eight exotic lines were selected from ICARDA nurseries which were

Table 6.9: Performance of various entries in station trial of malt barley (2019-20)

Name of the entry	Days to heading	Days to maturity	Plant height (cm)	Spike length (cm)	Yellow rust	Leaf blight	Hectolitre weight	Mean plot yield (q/ha)
BK-1901	98	138	117	8.8	7.8(20S)	46(68)	62.0	49.97
BK-1902	95	135	102	8.2	10.9(40S)	47(68)	65.0	60.00
BK-1903	95	135	102	7.8	2.3(5S)	57(89)	63.4	41.66
BK-1904	96	140	108	8.9	0.3(5MR)	58(89)	62.3	48.94
BK-1905	93	136	102	7.8	3.4(10S)	57(89)	65.4	46.80
BK-1906	96	138	112	10.6	9.0 (20S)	57(89)	61.1	38.16
BK-1907	99	137	102	8.6	2.6 (10S)	57 (89)	65.2	63.36
BK-1908	96	140	109	7.7	5.3(10S)	57(89)	64.6	57.00
BK-1909	98	138	108	8.7	16.7(40S)	57(78)	64.3	59.88
BK-1910	99	140	90	7.7	3.3(5S)	46(68)	62.9	60.83
BK-1911	99	141	122	9.6	1.8(10S)	46(68)	61.1	57.52
BK-1912	99	139	100	8.5	3.5(10S)	57(89)	63.4	51.44
BK-1913	96	138	116	8.6	1.8(10S)	46(68)	63.5	36.33
BK-1914	101	138	110	8.6	1.5(10MS)	56(89)	64.0	50.33
BK-1915	95	136	111	7.8	4.3(20S)	57(89)	63.5	62.08
BK-1916	96	134	102	8.7	2.5(10S)	57(89)	64.0	36.80
BK-1917	95	134	109	9.6	23.3(40S)	57(89)	57.0	40.22
BK-1918	97	138	102	7.8	21.8(60S)	57(78)	62.8	55.13
DWRB-123 ©	98	138	117	8.8	3.0(10MS)	56(89)	65.1	59.75
DWRB-160 ©	96	135	107	11.0	19.3(60S)	67(89)	59.0	49.38
DWRB-137 ©	98	135	102	10.5	6.3(30S)	68(99)	60.9	48.97

Table 6.10: Details of entries contributed in All India Coordinated testing programme of barley

SN	Entry name	Ear type	Contributed to
1	DWRB182	2R	AVT-II (Malt Barley) NWPZ
2	DWRB196, DWRB197	2R	AVT-I (Malt Barley) NWPZ
3	DWRB204	6R	AVT-I (Hulless) NWPZ/ NEPZ/ CZ
4	DWRB209, DWRB210, DWRB211, DWRB 212	2R	IVT (Malt Barley) NWPZ
5	DWRB-213	6R	IVT (Rainfed) NEPZ
6	DWRB-214	6R	IVT/AVT (Sal-Alk) NWPZ / NEPZ
7	DWRB-215	6R	IVT (Irrigated Feed Barley) NWPZ/ NEPZ / CZ
8	DWRB-216, DWRB-217	6R	IVT (Hulless) NWPZ/ NEPZ / CZ

included in the crossing block during 2019-20. In all, 18 cross combinations were attempted for improvement of nutrient enriched food barley such as high beta-glucan, protein content, zinc and iron. In feed barley program, 54-fresh crosses were attempted using 13-female lines and 14-donor parents for resistance to blight, yellow rust and aphids and bold grains. The 48 F_1-cross combinations were advanced to F_2 generation. Similarly, F_3 to F_6 generations were grown and selections were made, as per details in table 6.11.

Acquisition of landraces and wild accession

Seed of 407-landraces were procured from ICAR-NBPGR and multiplied during *rabi* 2019-20for their characterization. These land races belong to North-western Himalayas. Similarly, seed of 45-wild accessions of *Hordeum spontaneum* obtained from ICARDA, Morocco were multiplied for their further characterization. Observations on some morphological attributes were recorded.

Evaluation of exotic germplasm

Sixty-seven germplasm lines introduced from Morocco, Amlaha and also some of the lines selected during our field days at IIWBR, Karnal, were evaluated during 2019-20 season. Nineteen superior lines were selected for their further evaluation during *rabi* 2020-21 season. In addition, nine elite line of ICARDA were selected based on their performance during *rabi* 2019-20 season, for evaluation under Barley Station Trial (Feed Barley) and 15 promising lines have also been contributed for IBDSN for their yield evaluation in future.

Elite germplasm utilization

During *rabi* 2019-20 season a total of 45 germplasm lines were selected from four different international trials and nurseries of ICARDA based on their performance. A set of these selected lines was deposited in the Genetic Resource

Table 6.11: Feed and food barley breeding material handled during 2019-20

Generation	Grown		Selected	
	Family	Cross	Family	Cross
Feed Barley				
F_6	110	10	87	10
F_5	80	9	9	9
F_4	9	9	90	9
F_3	101	33	9	33
F_2	72	52	52	59
F_1	48	48	48	48
Food Barley				
F_7	04	01	01	01
F_6	90	33	27 (H) & 15 (N)	18
F_5	29	15	18	09
F_4	106	39	90	29
F_3	142	45	148	45
F_2	16	16	-	16

**H= hulled and N= huskless*

Unit (Barley) for maintenance and future utilization. This set along with ten checks was also supplied to the nine locations as EIBGN, besides its evaluation at Karnal. Ten genetic stocks for different agronomic and quality traits were collected from barley breeders of different SAUs and supplied to all the breeders at ten locations working on barley improvement for utilization of these genetic stocks in their local barley improvement programmes. 12-such genetic stocks collected from different coordinated centres were utilized in the barley improvement programme at Karnal for blight resistance, grain size and its quality.

Crop protection

Survey and surveillance for diseases and pests

There was negligible incidence of barley rusts in India during 2019-20. Few sporadic incidents of barley stripe rust were reported from Northern India only. The field surveys by different scientists of cooperative centers recorded loose smut, covered smut and bacterial leaf streak in traces in some fields. Loose and covered smuts were noted in traces to 3 percent in most of the area surveyed. *Drechslera* leaf stripe and bacterial streak were also noted 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 on barley crop indicated aphid as the main insect pest and its population was found to be moderate to high in barley fields at all the locations.

Pathotypes distribution and seedling resistance tests

The pathotypes distribution and seedling resistance tests (SRT) of barley rusts indicated that in stripe rust of barley (*P. striiformis hordei*), 10 samples were analyzed from Himachal Pradesh, Rajasthan and Nepal. Pathotypes 0S0(57) and 4S0(G) were most predominant whereas 1S0(M) was recorded in one sample only. The NBDSN (116 entries) and EBDSN (44 entries) were screened for SRT against the different pathotypes (Pts) of three rusts of barley under precise conditions of temperature and light at ICAR-IIWBR RS Shimla. The SRT against seven Pts of *P. striiformis hordei*, five Pts of *P. graminis tritici*, and 4 pts as well as mixture of pts. of *P. hordei* was completed. None of the NBDSN and EBDSN entries was resistant to all the tested pathotypes of yellow, brown and black rusts. In case of NBDSN, 12 lines were found as resistant to leaf and stripe rusts; one line was resistant to stem and stripe rusts and four as resistant to leaf and stem rusts (Table 6.12). Individually, 16 lines were resistant to stripe, 2 to stem and 22 to leaf rust pathotypes.

In case of EBDSN, nine lines were resistant to all pathotypes of leaf and stripe rusts, one to stem and stripe rusts and two to leaf and stem rusts (Table 6.13). Resistance to individual rust was observed in 19 lines, 10 lines showed resistance to stripe, one to stem and 8 to leaf rust only.

Field screening for diseases and pest

Under the field screening for diseases and pests 577 entries

Table 6.12: Seedling rust resistance in NBDSN lines during 2019-20

Resistant to	# entries	Entries
Leaf and stripe	12	BHS478, BHS481, BHS482, HBL865, HBL867, HBL868, PL908, RD3015, RD3016, RD3019, RD3021, HBL113(C)
Stem and stripe	1	DWRB182
Leaf and stem	4	DWRB197, KB1848, PL925, VLB169
Stripe	16	BH1030, DWRB213, HUB69, KB1817, KB1822, KB1830, PL906, PL911, RD2994, UPB1083, UPB1088, DWRB137(C), RD2552(C), RD2794(C), RD2899(C), RD2907(C)
Stem	2	DWRB212, PL915
Leaf	22	BHS479, BHS480, DWRB204, DWRB209, HUB273, KB1843, NDB1738, PL916, PL918, PL919, PL920, RD3011, RD3013, RD3022, UPB1080, UPB1085, UPB1086, VLB165, VLB166, VLB168, BHS400(C), VLB118(C)

Table 6.13: Seedling rust resistance in EBDSN lines

Resistant to	# entries	Entries
Leaf and stripe	9	HBL113, HBL845, HBL863, PL908, PL2999, PL3000, PL3002, PL3003, PL3004
Stem and stripe	1	DWRB182
Leaf and stem	2	DWRB197, UPB1078
Stripe	10	BK1714, DWRB137, HBL848, PL906, PL909, PL2899, PL2980, PL2981, PL2994, PL3005
Stem	1	PL3010
Leaf	8	BK1719(LB), DWRB184, HBL851, KB1633, KB1757, PL3009(LB), VLB130, VLB164

Table 6.14: Field screening for resistance in NBDSN and IBDSN lines during 2019-20

Disease	# entries	Entries
Yellow rust, ACI = <1.0 & HS up to 5MS	11 (NBDSN)	DWRB197, DWRB210, HUB69, KB1707, PL908, RD2552(C), RD2794(C), UPB1088, VLB166 and VLB168
	21 (IBDSN)	UPBM2, UPBM 9, UPBM 2, UPBM 9, BBM 839, PKB 1916, PKB 1947, HB-1903, BD-1850, LK-19/4, HB-1901, DWRFB 81, BBM 833, PKB 1912, BH-1908, BH-1943, NDB-1757, DWRFB 31, DWRFB 32, BBM 854 and BH-1949
Leaf blight, Avg. 13-35 with HS < 57*	1 (NBDSN)	RD3017
	4 (IBDSN)	DWRFB 58, BD-1831, HB-1917 and VB-1927

were screened under various nurseries (IBDSN, NBDSN and EBDSN) for resistance against various diseases, aphid and CCN at different cooperating centers during the crop season 2019-20.In NBDSN out of 116 entries evaluated, 11 entries showed higher resistant reaction (Table 6.14) having ACI less than 2.0 with less than 5MS highest reaction to . In case of leaf blight screening, only RD3017 found moderately resistant with an average score (double digit) 14-35 but HS was higher than 57. Amongst, 404 entries evaluated in IBDSN, 21 entries (Table 6.14) were found highly resistant to yellow rust (ACI = <1.0) and 163 entries showed moderate resistant reaction having ACI less than 10. In case of leaf blight screening, four (DWRFB 58, BD-1831, HB-1917 and VB-1927) entries were found moderately resistant against leaf blight with an average score (double digit) 14-35 and HS < 57.

A total of 116 barley NBDSN entries (including checks and infector) were screened against foliar aphid at three locations (Ludhiana, Kanpur, Karnal) during 2019-20. The entries were found to be in the category grades i.e., 2 to 5 and based on all three locations, five entries BH1028, HBL867, PL908, PL912 & RD3022 fell under moderately resistant category (grade 3).

Chemical control

In chemical control experiments, spraying of Tebuconazole 50% + Trifloxystrobin 25% W @ of 0.06% was found most effective in management of yellow rust. A total of eight treatments were tested for their efficacy against foliar aphid in barley, and treatment of Beta-Cyfluthrin 9 % + Imidacloprid 21 % (Solomon)@ 400 ml/ha was found the best treatment followed by Sulfoxaflor 12 % SC @250 ml/ha in managing aphid population in barley.

Evaluation of barley genotypes for storage insect-pests resistance

The 104 released varieties of barley were evaluated against storage insect-pests against *Sitophilus oryzae, Rhyzopertha dominica* and *Tribolium castaneum*. The freshly harvested 25 g pest-free seed of each variety was taken in petri dishes and 10 adults of each insect were introduced into each perti dish. Observations were recorded orientation behavior, life span duration and percent weight loss to grain. Promising genotypes were identified, these include;Azad, BHS-352, Amber, Kedar, BHS-169, B.K-306, BH-959,BH-946,R-56,BG-105 and BCU-2241.

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 31 trials were proposed and conducted at different locations under AICRP. In new genotypes (malt purpose) and soil fertility evaluation trial, the test entry DWRB182 (45.26 q/ha) was 4.25-5.51 % less yielding than best two row check. The genotypes responded up to 90 kg Nitrogen/ha in the experiment.

Use of Hydrogel with different irrigation level was evaluated in dry areas of NWPZ and it was found that application of Pusa Hydrogel @ 2.5 kg/ha and New Hydrogel @ 2.5 kg/ha were significantly better as compared to no hydrogel conditions and both the hydrogel were at par at all irrigation level. The hydrogel with two irrigations and no hydrogel with three irrigation were at par and hence at least one irrigation water (6 lakh litres) can be saved with the use of hydrogel to produce the same level of yield (Fig. 6.3). After two years of evaluation under AICRP Trials, the use of hydrogel is recommended in dry areas to save water and produce more.

The irrigation management trial was conducted in NWPZ, NEPZ and CZ. In NWPZ, two irrigations (one at 30DAS and other at 60-65 DAS) was found sufficient to produce optimum grain yield. Three and two irrigation levels were at par in NWPZ. Six row variety BH 946 and two row variety DWRB 160 were at par. In NEPZ, the genotypes responded up to three irrigation level. The variety DWRB137 was superior to HUB113 at all irrigation level. In CZ, the yield increase was up to two irrigation level in DWRB137 and up to three irrigation level in RD 2899 (Fig. 6.4).

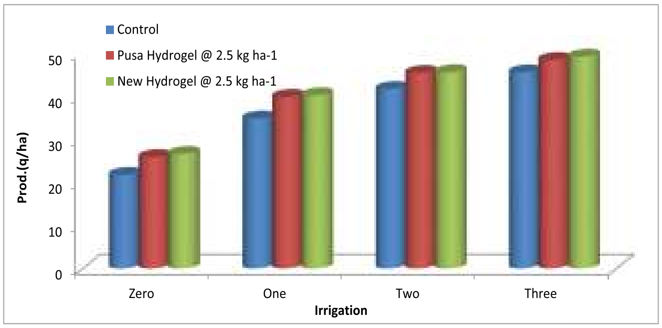


Fig. 6.3: Effect of hydrogel and irrigation levels on barley productivity in dry areas of NWPZ

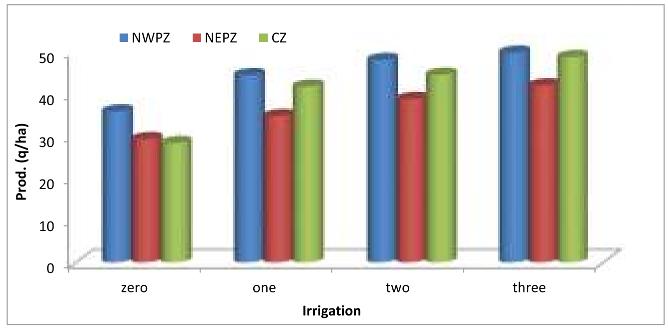


Fig.6.4: Barley productivity under different irrigation in different production conditions/ zones

Soil application with zinc sulphate @ 25 kg/ha was found superior compared to all soil and foliar application in NWPZ. It produced 14.6 percent more yield compared to no zinc application. In NHZ, NEPZ and CZ, soil application with zinc sulphate @ 25 kg/ha followed by foliar application (0.5% zinc sulphate) at heading and early milk stage was found superior compared to all other treatments. It produced 12.6-14.0 percent more yield compared to no zinc application in NHZ, NEPZ and CZ (Fig 6.5).

Barley quality

Relative performance of Indian barley varieties with respect to quality

Nineteen Indian barley varieties grown in timely sown condition were analysed for grain and malt quality traits for three years. The data over three years indicated that the desirable test weight (≥65 kg/hl) was obtained in Alfa 93, BCU 73, Clipper, DWRUB 52, DWRB 101, DWRB 91 and RD 2668. Bold grain percentage (>90%) was recorded in DWR 28, DWRB 91, DWRUB 64, DWRB 92 and BH 902. Beta glucan content of less than 4% was obtained in Amber, K 551 and BCU 73. Beta amylase activity was estimated in grain and kilned malt and higher grain enzyme activity (20.0 units/g flour or more) was obtained ALFA 93, Amber, Clipper, DWR 28, DWRB 92, RD 2668 and RS 6, while higher activity in malt was recorded in DWRB 92, DWR 28 and RS 6. Friability of>70% was obtained in ALFA 93, DWRB 91, DWRUB 52, DWRUB 64 and DWRB 101; while hot water extract (>80%)

Table 6.15: Quality of released genotypes of selected parameters

Variety	Test wt (kg/hl)	Bold grains (%)	β-glucan (% dwb)	Grain β-Amylase (Beta amyl units)	Malt β-Amylase (Beta amyl units)
ALFA 93	66.8	83.3	4.3	23.7	19.4
Amber	62.1	69.0	3.4	21.4	17.5
BCU 73	65.4	73.6	4.0	16.3	12.6
BH 902	62.2	90.3	5.4	13.9	12.9
Clipper	65.1	84.5	4.5	20.8	14.7
DL 88	59.9	81.2	4.5	14.8	12.8
DWR 28	64.5	91.0	5.6	22.7	21.3
DWRUB 52	69.4	83.7	4.7	13.8	8.4
DWRB 92	65.5	95.0	5.2	25.8	23.4
DWRB 101	69.0	84.7	4.6	14.6	12.6
DWRB 73	65.9	87.5	6.1	18.4	13.6
DWRB 91	67.5	91.2	6.0	17.1	14.9
DWRUB 64	63.3	91.4	4.8	15.6	13.6
K 551	63.5	81.8	3.3	17.5	16.7
NDB 1173	63.7	75.3	4.5	16.2	15.0
RD 2552	61.0	70.9	4.6	18.2	19.4
RD 2668	65.8	61.1	5.8	19.9	18.8
RD 2849	61.8	75.3	4.1	19.2	17.2
RS 6	63.5	61.5	4.5	23.4	25.4
MSD (5%)	**3.8**	**22.0**	**0.8**	**5.2**	**5.5**

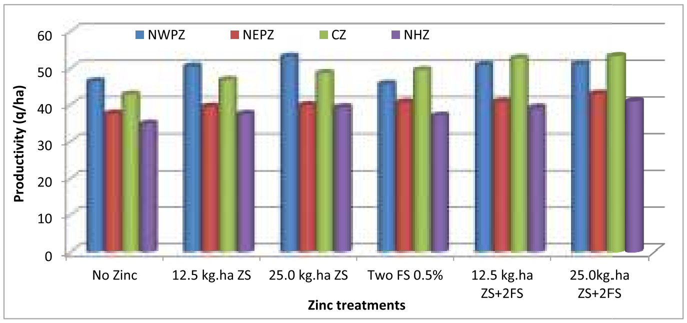


Fig. 6.5: Barley productivity under zinc treatments in different zones

was obtained in DWRB 101, DWRB 91, DWRUB 52 and DWRUB 64. Though the varieties DWRB91 (2 row) and DWRUB 64 (6 row) have been bred for late sown conditions, but have excellent malting quality attributes under timely sown conditions also and these varieties may be revisited from industrial perspective in view of the current quality requirements (Table 6.15).

At present the industry is pressing hard to get varieties with very low values of beta glucans and higher diastatic power. Based on the three years analysis at IIWBR, Karnal, significant correlation among different quality parameters was discovered. The positive correlation between grain beta glucans and thousand grain weight, has been observed (Fig. 6.6). Similarly, the malt beta amylase has been found positively correlated with the grain beta amylase activity. Despite the denaturation of amylases during kilning, grain amylase could be a good indicator of malt diastatic potential. Therefore, selection in early stages can be taken up on small quantity of samples for 1000 gw and beta amylase activity to get low grain beta glucans and higher diastatic power in genotypes.

Industrial evaluation of Indian barley varieties

Since last few years the barley industry has given the feedback that the Indian barley varieties are not meeting

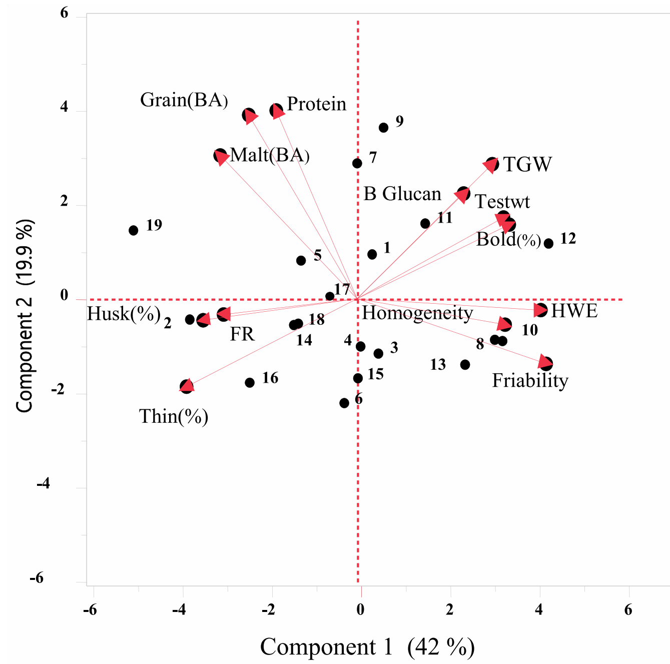


Fig. 6.6: Correlation between different quality parameters

their expectations. Through interaction with the industry, it came to the notice that industry has not tried some of the improved malt barley varieties developed during past few years. Therefore, three malt barley companies namely; Barmalt India, PMV Maltings Pvt Ltd and AB InBev India were given five-kilogram samples of five Indian malt barley varieties and one feed barley variety for their input on the quality so that more emphasis can be given to those traits in Indian malt barley programme. The feed barley DWRB 137 was included since this variety has been found promising in malting quality and also in some of the experiments conducted in NWPZ. Based upon the results, the varieties DWRB 91, DWRUB 64, DWRB 101, DWRB 123 and DWRB 137 were found suitable for the malt making (Table 6.16). The variety DWRB 137, released as feed barley

Table 6.16: Malting quality of recent Indian barley varieties

Genotype	Row Type	Hot water extract (%fgdwb)	Diastatic power (oL)	Free Amino Nitrogen (ppm)	Kolbach Index (%)
DWRB 91	2	80.7	84.7	160.7	46.3
DWRB 92	2	78.1	117.3	154.3	37.4
DWRUB 64	6	80.7	92.2	128.8	45.3
DWRB 101	2	80.2	55.6	167.5	45.2
DWRB 123	2	79.0	73.1	126.4	40.1
DWRB 160	2	77.6	82.5	125.1	43.0
DWRB 137*	6	79.6	111.3	159.4	45.4
LSD (5%)		1.4	23.1	22.4	5.1

*Feed barley

for NEPZ, has been found suitable for malting purposes also when grown in NWPZ in overall malting quality traits. The important lesson learnt through this exercise is to exclude high thousand grain weight (TGW) material in future breeding programmes, since the varieties DWRB 92 and DWRB 160 could not perform upto the mark because of poor malt modification due to higher TGW despite having good diastatic power. However as on date industry has good choice of material having good quality coupled with yield and biotic stress tolerance.

Identification of low wort beta glucan content genotypes

For malt purpose barley genotypes, endosperm cell wall needs to be degraded initially, for access of hydrolysing enzymes to starch and proteins. The major portion of endosperm cell walls is contributed by beta glucans. Information on beta glucan degradation during malting and mashing has been generated on 18 genotypes varying in beta glucan concentration for three years 2016-17, 2018-19 and 2019-20 (Fig. 6.7). Malting and mashing were done as per the standard protocol. A positive simple correlation (0.9) was obtained among grain, malt and wort beta glucan content, indicating that grain beta glucan content gives fairly good idea of final beta glucan in the wort. Minimum beta glucan in wort was obtained in SLOOP SA WL 3167 and SLOOP VIC VB 9953, which may be used for introgression of this trait in malt barley improvement programme.

Identification of genotypes with higher diastatic power

Off late the malt industry is demanding higher diastatic power in the malt. Therefore, it is important to identify the biochemical parameters correlated with higher diastatic power for selection of better genotypes for barley improvement and for screening smaller quantity

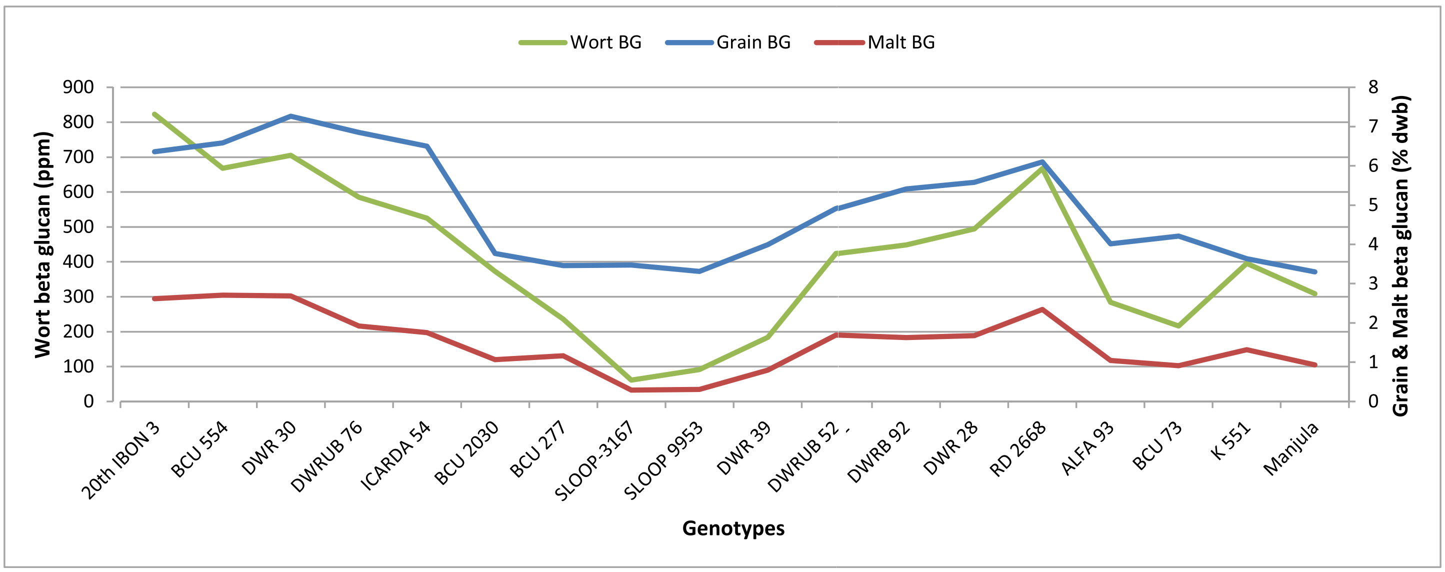


Fig 6.7: Content of beta glucan in grain, malt & wort of different barley genotypes

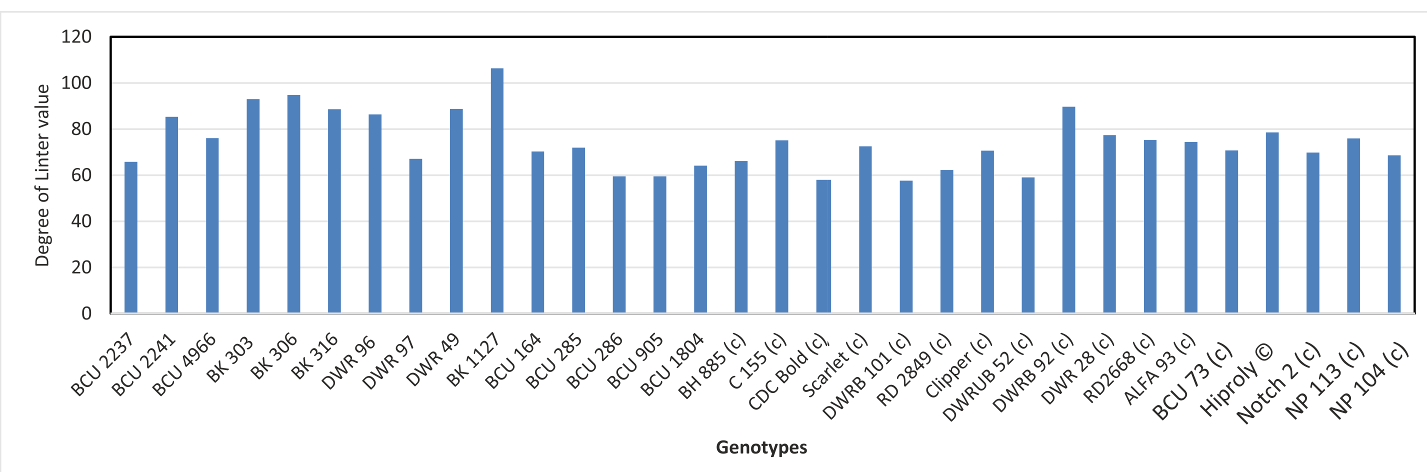


Fig 6.8: Diastatic Power in different barley genotypes

of grains in early generations of breeding. In this study 32 genotypes were evaluated for grain protein content, grain beta amylase, malt diastatic power, malt alpha and beta amylases. Therefore, selection for higher beta amylase activity can be one of the better criteria for higher diastatic power in malt. Thee genotypes BK 1127, BCU 2241 and BCU 2237 were identified for higher grain protein content. For diastatic power the genotypes BCU 2241, BK 1127, BK 303, BK 306, BK 316 and DWRB 92 are promising (Fig 6.8).

A strong positive correlation (Table 6.17) was obtained between malt diastatic power and grain and malt beta amylase activity in comparison to grain protein content.

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* 2019-20 from various test sites at its central facility. A total of 270 samples were analyzed with five checks in the malt barley improvement programme and the significant findings are given in table 6.18.

Marker assisted introgression of quality traits and aphid tolerance

Introgression of promising quality traits in elite barley cultivar DWRB101: In order to introgress the low / high beta glucan and high protein contents in commercial malt barley variety, DWRB101, the backcross populations were developed. After the advanced lines screening, eight entries identified promising (Table 6.19) for quality traits were screened under BQSN at multilocation sites to evaluate the effect of different environmental conditions on quality components of barley lines.

Another set of backcrosses derived lines were advanced in *Rabi* season 2019-20 for marker assisted backcross program for quality traits (protein content and low β-glucan) and insect pest resistance. Segregating backcross lines in population developed from crosses of DWRB101 with SLOOP VICB9953, SLOOP SAWL3167 (for low beta glucan); BK306 and BK1127 (high protein content) and EB921 (aphid resistance) were evaluated with closely linked molecular markers for selected traits at molecular level. These lines have reached to advanced generations as indicated in table 6.20.

Table 6.17: Pearson's correlations among different parameters

Variable	Protein	GBA#	MBA#	MAA#	DP#	Bold#
Protein	—					
GBA	0.158	—				
MBA	0.137	0.943***	—			
MAA	0.220 *	0.179	0.162	—		
DP	0.233*	0.720***	0.699***	0.455***	—	
Bold	-0.060	0.333	0.292**	0.386***	0.507***	—

* p < .05, ** p < .01, *** p < .001

#GBA=Grain Beta Amylase (Betamyl-3 Unit); MBA=Malt Beta Amylase (Betamyl-3 Unit); MAA=Malt ALFA Amylase (CerALFA Unit); DP=Diastatic Power (Degree Linters); Bold=Bold grains percentage (> 2.5mm)

Table 6.18: Promising entries for individual and over all malting quality traits

Traits	Promising entries
1000 grain weight	PL908 (6R), DWRB182
Bold Grains	DWRB 196
Protein content	DWRB182, DWRB 197, BH1026, DWRB212, BH1027, PL916, PL919, PL912, RD3026
Husk Content	DWRB209
Grain β- glucan	DWRB182, RD3025, DWRB211
Malt Friability	DWRB 197, DWRB211, BH1027, PL912, PL919, PL916
Hot water extract	DWRB211, DWRB209, BH1027, RD3024, UPB1090
Filtration Rate	DWRB182, DWRB209, RD3025
Diastatic Power	DWRB 197, PL916, BH1027, BH1026
FAN Content	RD 3025
Wort β- glucan	DWRB 211, BH 3025, DWRB 197, DWRB 182
Over all MQ	DWRB 182, DWRB 197, DWRB 211, DWRB 209, BH 1027

Table 6.19: Promising entries for individual and over all malting quality traits

Low Beta Glucan (3.7-4.0%)	High Protein content (12.5-13.5%)
LBG-56 (DWRB 101 /SLOOP VICB 9953)	HPC26 (DWRB101/BK306)
LBG-167 (DWRB 101 /SLOOP VICB 9953)	HPC79 (DWRB101/BK306)
LBG-241 (DWRB 101 /SLOOP VICB 9953)	HPC134 (DWRB101/BK306)
	HPC207 (DWRB101/BK306)
	HPC212 (DWRB101

Table. 6.20: Introgressed lines of DWRB101 with quality and aphid resistance

Trait		Recurrent Parent	Donor Parent	Generation
Quality	β-Glucan Content	DWRB 101 DWRB 101	SLOOP VICB 9953 SLOOP SAWL 3167	$BC2F_5$ $BC2F_3$
	Protein Content	DWRB 101 DWR101	BK306 BK1127	$BC2F_4$ $BC2F_3$
Biotic Stress	Aphid Resistance	DWRB101	EB921	$BC2F_4$

For basic genetic study on beat glucan, a cross of contrasting parents, Shebac (low) and DWR30 (high) was made and three advanced lines BGLU3 (Shebac/DWR30), BGLU4 (Shebac/DWR30) and BGLU6 (Shebac/DWR30) have been found to have higher beta glucan content in the range of 6.5-7.5%.

Similarly, four entries identified resistant for aphids from the RIL populations developed earlier, were contributed to the multilocation testing under AICRP Wheat and Barley in NBDSN in 2019-20 under natural hot spot conditions. Two entries, BCLA3 (two row barley)and BCLA11-6 (six row barley) have shown average resistance (1.7) in 2019-20 at two locations (table 6.21)validating their similar resistance score (1.60-1.67) recorded during 2014-19 at IIWBR, Karnal (table 6.22) on a 1 to 5 scale where 1 is immune and 5 is highly susceptible.

Table 6.21: Screening of promising genotypes against foliar aphids under natural hot spot conditions during 2019-20 in coordination trial at Karnal and Kanpur

Entry No.	Kanpur					Karnal					Overall Av. score	Overall HS
	Date of observation					Date of observation						
	05.02.20	12.02.20	19.02.20	Av. score	HS	03.02.20	17.02.20	02.03.20	Av. score	HS		
BCLA 3	1	2	1	1.3	2	2	2	2	2.0	2	1.7	2
BCLA 11-6	1	2	1	1.3	2	2	2	2	2.0	2	1.7	2
BCLA 17	2	2	2	2.0	2	2	2	2	2.0	2	2.0	2
BCLA 18	2	2	2	2.0	2	2	2	2	2.0	2	2.0	2
Alfa - 93	5	5	5	5.0	5	5	5	5	5.0	2	5.0	5

Table 6.22: Reaction of BCLA-3 and BCLA 11-6 against foliar aphids under natural hot spot conditions during 2014-15 to 2018-19 at Karnal

Year	Average number of aphids / tiller during the season		
	BCLA3	BCLA 11-6	Alfa – 93 (Susceptible Check)
2014-15	1.47	1.61	117.57
2015-16	1.68	1.63	119.03
2016-17	1.75	1.81	129.63
2017-18	1.56	1.69	114.13
2018-19	1.54	1.63	111.32
Average number	1.6	1.67	118.33
Reaction type	R	R	HS

7. REGIONAL STATION, FLOWERDALE, SHIMLA

Lr80: a new and effective source of leaf rust resistance in wheat identified

A new gene conferring resistance to predominant and virulent pathotypes of *Puccinia triticina* was designated as *Lr 80* in a local wheat land race Hango-2. This wheat was collected from Hango, District Kinnaur, Himachal Pradesh. Hango-2 exhibits a low infection type (IT;) to all Indian *P. triticina* pathotypes, except the pathotype 5R9-7 which produced IT 3+. Pathotype 5R9-7(16-1) does not infect bread wheat cultivars, however, is virulent to tetraploid wheat Khapli. Pathotype 5R9-7 is not prevalent in nature for the last 15 years. Genetic analysis based on Agra Local/Hango-2 derived F3 families indicated monogenic control of leaf rust resistance, and the underlying locus was temporarily named *LrH2*. Bulked segregant analysis using 303 simple sequence repeat (SSR) markers located *LrH2* in the short arm of chromosome 2D (Fig. 7.1).

An additional set of 10 2DS-specific markers showed polymorphism between the parents and these were mapped on the entire Agra Local/Hango-2 F3 population. *LrH2* was flanked by markers *cau96* (distally) and *barc124* (proximally). The 90 K Infinium SNP array was used to identify SNP markers linked with *LrH2*. Markers *KASP_17425* and

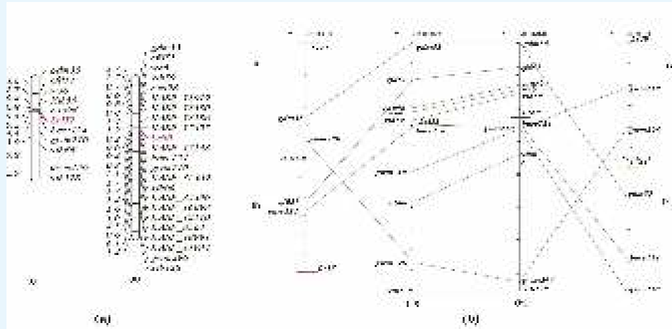


Fig. 7.1. a Genetic linkage maps of Agra Local/Hango-2 population (i) *LrH2* present study SSR map (ii) *Lr80* SSR and SNP map; b Comparison of common SSR markers across genetic linkage maps in Pretzel; a genetic map viewing software (http://plant informatics.io)

KASP_17148 showed association with *LrH2*. Comparison of seedling leaf rust response data and marker locations across different maps demonstrated the uniqueness of *LrH2* and it was formally named *Lr80*. This is the 6th rust resistance gene reported from India (others being *Lr10*, *Lr48*, *Lr49*, *Lr57* and *Lr58*). *Lr80* is being used to develop rust resistant genetic stocks and wheat varieties. It will help in creating diversity and management of leaf rust in India.

Incidence of wheat and barley rusts in India and Nepal

All the rusts of wheat and barley were observed in India and Nepal during crop season 2019-20. The first occurrence of stripe (yellow) rust was reported from Anandpur Sahib Block in district Rupnagar (Punjab) on 26th December, 2019, which was followed by few reports of stripe rust from foot hills in Punjab during January. During February-March stripe rust was observed as small foci from few areas of Punjab, Haryana, Himachal Pradesh, Rajasthan and Uttarakhand. Prevalence of rusts was low in off-season wheat; however, some of the dicoccum accessions supported substantial leaf and stem rust infection. Incidence of leaf rust was observed in some farmer's field of Belagavi, Bagalkot, Dharwad and other areas in Karnataka; Anandpur Sahib (Rupnagar) in Punjab; Satara, Pune, Niphad, Nashik and other areas of Maharashtra, Indore, Hoshangabad and other parts of Madhya Pradesh. Similarly, Stem rust was observed in Satara, Pune, Niphad, Nashik and other of Maharashtra and Belagavi, Bagalkot, Dharwad and Gadag districts of Karnataka.

Pathotype distribution of *Puccinia* species on wheat and barley

A total of 897 samples of three rusts of wheat and barley were pathotyped from India and Nepal during the year.

P. striiformis (stripe rust of wheat and barley)

During the year 305 samples of wheat stripe rust were pathotyped from seven states of India and Nepal. The Indian population of *P. striiformis* is avirulent on *Yr5*, *Yr10*, *Yr13*, *Yr15*, *Yr16*, and *YrSp*. Pathotype 238S119 was the most predominant among the seven pathotypes occurring on wheat and was observed in 44.06% samples. This pathotype is virulent on *Yr2*, *Yr3*, *Yr4*, *Yr6*, *Yr7*, *Yr8*, *Yr9*, *Yr17*, *Yr18*, *Yr19*, *Yr21*, *Yr22*, *Yr23*, *Yr25*, *YrA* and Riebesel 47/51. The population of 46S119 has declined to 33.2% followed by 110S119 in

Predominant pathotypes of *Puccinia* on wheat in India

Wheat rust pathogen	Predominant pathotypes
P. striiformis (Yellow rust)	238S119, 46S119, and 110S119
P. graminis tritici (Black rust)	79G31(11), and 62G29(40A), 58G15-3(40-2)
P. triticina (Brown rust)	121R60-1(77-9), 121R63-1(77-5), and 121R63(77-1)

18.98% of the samples. Among these pathotypes 238S119 is most virulent as it has additional virulence for Suwon x Omar92 and Riebesel when compared with pt. 46S119. Other pathotypes 14S64, 6S0, 7S0 and 47S103(T) have occurred in 0.3% to 1.2% samples each.

In stripe rust of barley (*P. striiformis hordei*), 10 samples were analyzed from Himachal Pradesh, Rajasthan and Nepal. Pathotypes 0S0 (57) and 4S0 (G) were most predominant whereas 1S0 (M) was recorded in one sample only.

***P. graminis tritici* (wheat stem rust)**

In general, wheat stem rust occurred in Peninsular and Central India. Seven pathotypes were identified in 127 samples of stem rust pathotyped from six states of India (Tamil Nadu, Karnataka, Maharashtra, Gujarat, Madhya Pradesh and Uttarakhand) and Nepal. 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 and SrMcN* was most predominant and was recorded in 88.2% of the samples analyzed. Other six pathotypes were identified in few samples only. While pathotype 62G29(40A) occurred in 4.7%, pt. 58G15-3(40-2) was observed in 3.9% of the samples. Remaining 4 pathotypes were detected in 0.78% samples each.

***P. triticina* (wheat leaf rust)**

A total of 465 samples of wheat leaf rust were pathotyped from 14 states of India and Nepal. Twenty three pathotypes of *P. triticina* were observed in varying frequencies. Indian population of *P. triticina* was avirulent on *Lr24, Lr25, Lr29, Lr32, Lr39 Lr45* and *Lr47*. 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* and followed by 77-5 (121R63-1) were the most widely distributed pathotypes and were found to occur in 14 and 11 states of India, respectively and Nepal. Pathotype 77-9 was identified in 50.3% of pathotyped samples followed by 77-5(28.2%), 77-1(109R63) in 7.1% and 104-2(21R55) in 3.2% samples. Remaining 19 pathotype were each detected in less than 1% of the analyzed samples.

In Nepal, 10 pathotype were identified in 20 samples. Pathotype 77-9 and 77-5 were most frequent followed by 77-1. The remaining pathotypes were observed in one sample each.

Seedling resistance to rusts on wheat, barley and characterization of *Lr*, *Sr* and *Yr* genes in AVT material

To know the rust resistance, more than 3500 lines of wheat and barley were evaluated at seedling stage. Among these, 287 lines including 137 of AVT and 160 of NBDSN/EBDSN were subjected to multi-pathotype screening under controlled light and temperature conditions. Seedling rust resistance remains effective throughout the life of wheat plants. To know the rust resistance of wheat lines comprising AVT I, II at seedling stage, 59 pathotypes of three species of *Puccinia* on wheat were used for screening. Sixteen most virulent, predominant pathotypes of Pst, 21 of Pgt and 22 of Pt were used for evaluation.

Rust resistant lines of wheat

None of the lines of AVT was resistant to all the rusts. The wheat lines showing resistance to one or other rusts are given below:-

PBW813 was resistant to stem and stripe rusts. Whereas HI1641, HI1642 and MACS6752 were resistant to leaf and stem rusts. Twenty other lines were resistant to leaf and 3 to stem rust only. In addition 25 lines having *Sr31/Lr26/Yr9* were resistant to stem rust whereas some to leaf rust also (Table 7.1).

Rust resistance genes in AVT material of wheat

Based on the gene matching technique rust resistance genes were characterized in wheat accessions of AVTI and II. The details of *Lr*, *Sr* and *Yr* genes are given in Table 7.2.

***Yr* genes**

Among the 137 lines of AVT, *Yr* genes were characterized in 95 lines. *Yr* genes were postulated in lines where differential interactions were observed and in other cases tight linkage of *Yr* genes to resistance genes to other rusts also facilitated to infer the presence of a resistance gene. Four *Yr* genes viz, *Yr2*, *Yr9*, *YrA* and *Yr18* contributed for yellow rust resistance in

Table 7.1: Rust resistant wheat lines in AVTI and II

Rust	No.	Resistant Lines
Stem and stripe rusts	1	PBW813
Leaf and stem rusts	3	HI1641, HI1642 and MACS6752
Leaf rust only	20	CG1020, GW513, GW519, HD3090 (C), HD2864, HI1544, HI1633, HI1634Q, HI1636, HI1637, MACS 4087 (D), MACS 6747, MACS 6749, MACS3940 (D) (C), MACS6222 (C), PBW550 (C), PBW771 (C), PBW840, RAJ 4541B and UAS446 (D) (C)
Stem rust only	3	DBW303, DBW110 and DBW332

Table 7.2: Diversity for rust resistance in AVT lines

Rust	No. of lines	Number of genes inferred: Details of resistance genes
Stripe	95	**Four:** *Yr2, Yr9, YrA and Yr18*
Stem	120	**Thirteen:** *Sr2, Sr5, Sr7b, Sr8a, Sr8b, Sr9b, Sr9e, Sr11, Sr13, Sr24, Sr28, Sr30* and *Sr31*
Leaf	112	**Ten:** *Lr1, Lr2a, Lr3, Lr10, Lr13, Lr18, Lr23, Lr24, Lr26* and *Lr34*

Table 7.3: Seedling rust resistance in NBDSN

Rust (s)	No. of lines	Lines
Leaf and stripe	12	BHS478, BHS481, BHS482, HBL865, HBL867, HBL868, PL908, RD3015, RD3016, RD3019, RD3021 and HBL113(C)
Stem and stripe	1	DWRB182
Leaf and stem	4	DWRB197, KB1848, PL925 and VLB169
Stripe	16	BH1030, DWRB213, HUB69, KB1817, KB1822, KB1830, PL906, PL911, RD2994, UPB1083, UPB1088, DWRB137(C), RD2552(C), RD2794(C), RD2899(C) and RD2907(C)
Stem	2	DWRB212 and PL915
Leaf	22	BHS479, BHS480, DWRB204, DWRB209, HUB273, KB1843, NDB1738, PL916, PL918, PL919, PL920, RD3011, RD3013, RD3022, UPB1080, UPB1085, UPB1086, VLB165, VLB166, VLB168, BHS400(C) and VLB118(C)

India. Among the postulated *Yr* genes, *Yr2* was most common and was characterized in more than half of the lines. *Yr9* on the other hand occurred in 25, *YrA* in 16 and *Yr18* in one line only.

Sr genes

Thirteen stem rust resistance genes (*Sr2, Sr5, Sr7b, Sr8a, Sr8b, Sr9b, Sr9e, Sr11, Sr13, Sr24, Sr28, Sr30* and *Sr31*) were characterized in 120 AVT lines. *Sr* genes *Sr2* and *Sr11* were postulated in 43 AVT entries. *Sr31*, linked with *Lr26* and *Yr9* and conferring resistance to all the known Pgt pathotypes in Indian subcontinent, was postulated in 25 AVT entries. *Sr*-genes *Sr24, Sr28, Sr5, Sr13* and *Sr7b* were characterized in 12, 4, 18, 12 and 31 entries, respectively. *Sr30, Sr9b,* and *Sr8a* were inferred in seven entries each. Most of the *Sr* genes occurred in the combination of other genes. Entry DBW252 possessed a combination of maximum four genes i.e. *Sr5+8a+11+2+*.

Lr genes

Ten *Lr* genes viz. *Lr1*, *Lr2a*, *Lr3*, *Lr10*, *Lr13*, *Lr18*, *Lr23*, *Lr24*, *Lr26* and *Lr34* were characterized in 112 lines. *Lr10* was the most commonly occurring leaf rust resistance and was characterized in highest number of lines (37) followed by *Lr13* (30 lines), *Lr1* (29 lines) and *Lr26* (25 lines). *Lr24* was also postulated in 12 lines. Among these *Lr13* becomes effective at higher temperature. While *Lr2a/Sr30* and *Lr3* were inferred in 6 lines each, *Lr18* was postulated in 2, *Lr34* in 1 line only. *Lr2a/Sr30* are closely linked and we have differentiating pathotypes for both the resistance genes. Most of the genes occurred in combination and many of the lines have leaf rust resistance derived from 3 or more *Lr* genes.

Rust resistance in NBDSN and EBDSN of barley

All the NBDSN and EBDSN lines were screened against the different pathotypes of three rusts of barley under precise conditions of temperature and light. Wherever needed confirmatory and selected testing was also undertaken. These lines were evaluated against five pathotypes each of *P. graminis tritici, P. striiformis hordei* and mixture of pathotypes. of *P. hordei*. None of the NBDSN and EBDSN entries was resistant to all the tested pathotypes of Pst, Pt and Pgt. The detailed report is presented below.

NBDSN

A total 116 lines of NBDSN were evaluated against the different pathotypes of *Puccinia* spp on barley .

None of the lines was resistant to all the rusts of barley. Twelve lines were resistant both to leaf and stripe rusts, one to stem and stripe rusts, whereas 4 to leaf and stem rusts. In addition, 16 lines were resistant to stripe, 2 to stem and 22 to leaf rust only (Table 7.3).

EBDSN

Forty four lines were evaluated for resistance to three rusts by using all the virulent and predominant pathotype of each. Resistance to all the rusts was not found in any line. However, 9 lines were resistant to leaf and stripe rusts, 1 to stem and stripe rusts, and 2 to leaf and stem rusts. Resistance to individual rust was observed in 19 lines. Of these 10 lines showed resistance to stripe, one to stem and 8 to leaf rust only (Table 7.4).

Table 7.4: Seedling rust resistance in EBDSN

Rust (s)	No. of lines	Lines
Leaf and stripe	9	HBL113, HBL845, HBL863, PL908, PL2999, PL3000, PL3002, PL3003 and PL3004
Stem and stripe	1	DWRB182
Leaf and stem	2	DWRB197 and UPB1078
Stripe	10	BK1714, DWRB137, HBL848, PL906, PL909, PL2899, PL2980, PL2981, PL2994 and PL3005
Stem	1	PL3010
Leaf	8	BK1719(LB), DWRB184, HBL851, KB1633, KB1757, PL3009(LB), VLB130 and VLB164

Table 7.5: Adult plant resistance to the predominant and virulent pathotypes of *Puccinia triticina* in wheat lines of AVT during 2019-20

Rust (s)	No. of lines	Lines
77-5, 77-9 and 104-2	9	HD3378, HI1605, JAUW672, K1006, K1317, PBW811, UP3069, WH1080 and WH1252
77-5 and 77-9	9	DBW88, DBW327, HD3059, HD3332, HD3349, HD3377, HPW349, NIAW3170, VL892 and WH1270
77-9 and104-2	3	HD2733, HS490, HS562 and MP3336
77-5 and 104-2	6	DBW296, HS668, HS679, HS681, PBW644 and PBW804
77-5	13	DBW110, DBW252, DBW291, GW322, HD2932, HD3334, HI1612, HI1628, RAJ4083, TAW155, WH1021, WH1105 and WH1124
77-9	5	DBW173, DBW187, DBW222, HS680, VL907
104-2	12	DBW290, HD3043, HD3086, HD3331, HD3298, HI8823, HPW474, MPO1357, UAS472, VL2036, WH1142 and WHD964

Adult plant resistance of AVT lines to different rusts in wheat

To identify race specific Adult Plant Resistant (APR), the AVT lines of wheat were screened against the most predominant and virulent pathotypes of *Puccinia triticina* and *P. striiformis*. These evaluations were conducted under polyhouses equipped with temperature and light adjustments. Proper checks including differentials, resistance genes and seedlings of AVT lines were evaluated under same set of conditions. The lines which showed susceptibility at seedling and resistance at adult plant stage were categorized as Adult plant resistant lines. Detailed information of APR for two wheat rusts is presented in Table 7.5 and 7.6.

None of the lines showed appreciable APR to both leaf and stripe rusts. DBW187 possessed APR to all the three pts. of stripe rust and pt. 77-5 of leaf rust. Likewise HD3086 conferred APR to stripe rust and pt.104-2 of leaf rust whereas HD3332 to stripe rust and pts.77-5 and 77-9 of leaf rust.

APR to Leaf rust

Fifty seven lines of AVT (2019-20) conferred APR to one or more pathotypes of leaf rust. Nine lines (HD3378, HI1605, JAUW672, K1006, K1317, PBW811, UP3069, WH1080 and WH1252) showed adult plant resistance to three pts.

Table 7.6: Adult plant resistance to the predominant and virulent pathotypes *Puccinia striiformis tritici* in wheat lines of AVT during 2019-20

Rust (s)	No. of lines	Lines
238S119, 110S119 and 46S119	12	AKDW 2997-16(d) (C), DBW187(I) (C), DBW333, DDW47(d)(I), HD3086 (C), HD3249(I) (C), HD3332, HI8805(d)(I) (C), HI8818(d), MACS3949(d) (C), UAS428(d) (C) and UAS446(d) (C)
238S119, and 110S119	11	DBW291, DBW296, DBW332, HI1612 (C), HPW 349 (C), HPW 474, HS 562 (C), JAUW672, PBW811, WH1124 (C) and WH1270
110S119, and 46S119	3	DBW328, HI 8823(d) and MPO1357(d)
110S119	32	DBW173 (C), DBW252(I) (C), DBW303 (C), DBW327, DBW331, DDW48(d)Q, HD3298, HI8627(d), HS 679, K1317,MACS5055, MACS6222 (C), MP1358, MP1361, MP3288, PBW644 (C), PBW803, PBW804, PBW812, PBW840 (M), TAW155, UAS466(d)(I), UAS472(d), UP 3069, UP3033, VL 2036, VL 3024, VL 907 (C), WH1080 (C), WH1142 (C), WH1252 and WHD964(d)

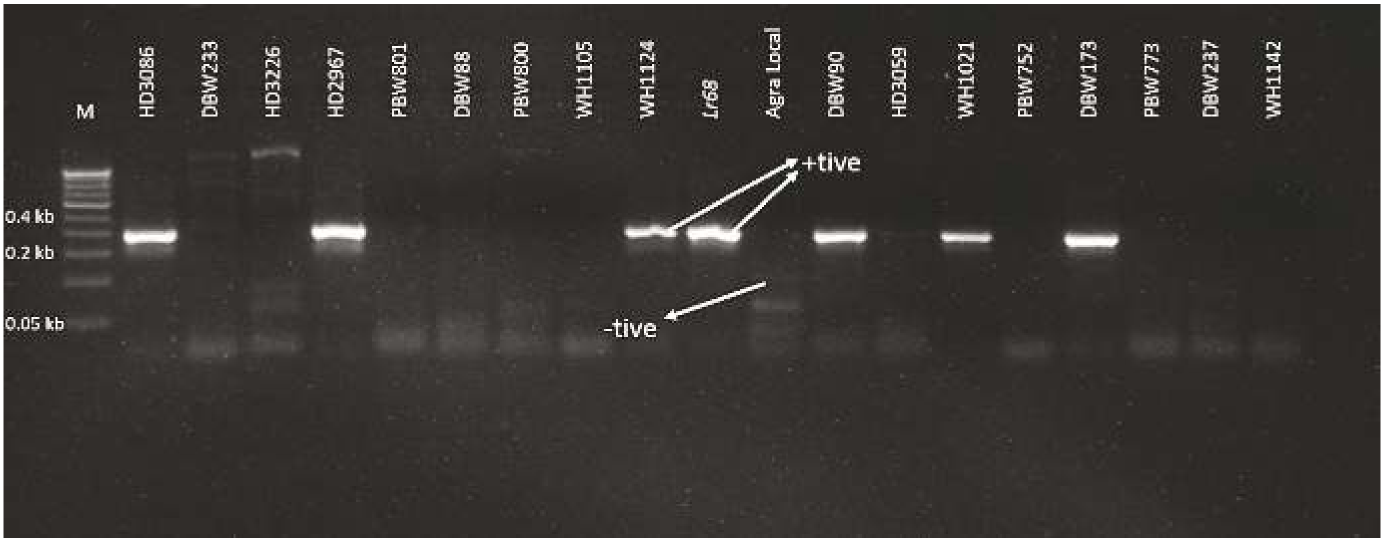


Fig. 7.2: Gel photograph showing the presence of *Lr68* in recently released wheat cultivars

Eighteen lines possessed APR to 2 pathotypes whereas 30 other lines supported APR to one or other pathotype.

APR to Stem rust

Fifty-eight lines exhibited APR to different pts. of stripe rust. Among these 12 lines *viz.* AKDW 2997-16(d) (C), DBW187(I) (C), DBW333, DDW47(d)(I), HD3086 (C), HD3249(I) (C), HD3332, HI8805(d)(I) (C), HI8818(d), MACS3949(d) (C), UAS428(d) (C) and UAS446(d) (C) could confer APR to all three major pathotypes of *P. striiformis* in India. Fourteen lines conferred APR to two of the three pts. Thirty-two other lines possessed APR to 110S119 (Table 7.6).

Molecular studies

Marker aided identification of *Lr68* in Indian wheat material

Recently released wheat varieties were screened for presence of different leaf, stem and stripe rust resistance genes using molecular markers linked to those genes. *Lr68/Ltn4*, a slow rusting gene, is known to interact with other *Lr* genes to contribute for durable rust resistance. *Lr68* linked simple sequence repeat marker (CsGS-STS-*Lr68*) was used to screen 102 wheat lines which included most of the wheat varieties identified during the last few years (Fig. 2).

Thirty four of these 102 lines showed the presence of *Lr68* (33.3% lines). This may be one of the interacting *Lr* genes in wheat which confers adult plant resistance to leaf rust in India.

Genetic variability in *Puccinia* spp.

P. striiformis

For a better understanding of the genetic diversity, we designed 89 pairs of novel SSR primers from the DNA sequence of pathotype 46S119 and screened on 11 pathotypes. Twenty-four of these primers were polymorphic. A total of 69 alleles were detected across the loci with an average of 2.87 alleles per locus. Principal component analysis (PCA) revealed 55.53% variability among the *Pst* pathotypes. Polymorphic information content (PIC) value from 0.28 to 0.68, with a mean of 0.47. Expected heterozygosity was in the range of 0.34 to 0.73 range, with a mean of 0.56. Generated information will potentially help in rust resistance breeding and deployment of resistant cultivars in yellow rust-prone areas. Moreover, new SSR markers with a considerable level of polymorphism will be beneficial in distinguishing the *Pst* isolates/pathotypes at both national and international levels.

P. triticina

Five new pathotypes of *P. triticina* detected from Northeast India, Nepal and Bangladesh were studied in detail and the sources of resistance to these were reported. Pathotypes 20-1, 49, 52-3 were identified from India, 162-5 from Nepal and 10-1 from Bangladesh. Based on 25 pairs of SSR primers, these pathotypes were found distinct and broadly categorized in two groups. Seventy-one lines, including 21 resistant to all the pathotypes, were identified that conferred resistance to these five new pathotypes. The detailed studies on these pathotypes, including distinguishing features, DNA marker based phylogenetic relationships, avirulence/virulence structure and sources of resistance were conducted.

P. graminis tritici

Molecular variability studies among the twenty-nine black rust pathotypes was carried out using selected *P. graminis tritici* specific SSR markers. Among the 30 black rust specific SSR markers, twenty were found to be polymorphic to selected pathotypes of *P. graminis tritici*. The polymorphic primers were further tested against all the black rust pathotypes. The PCR product was resolved in 3% Super MT4 Agarose (Life

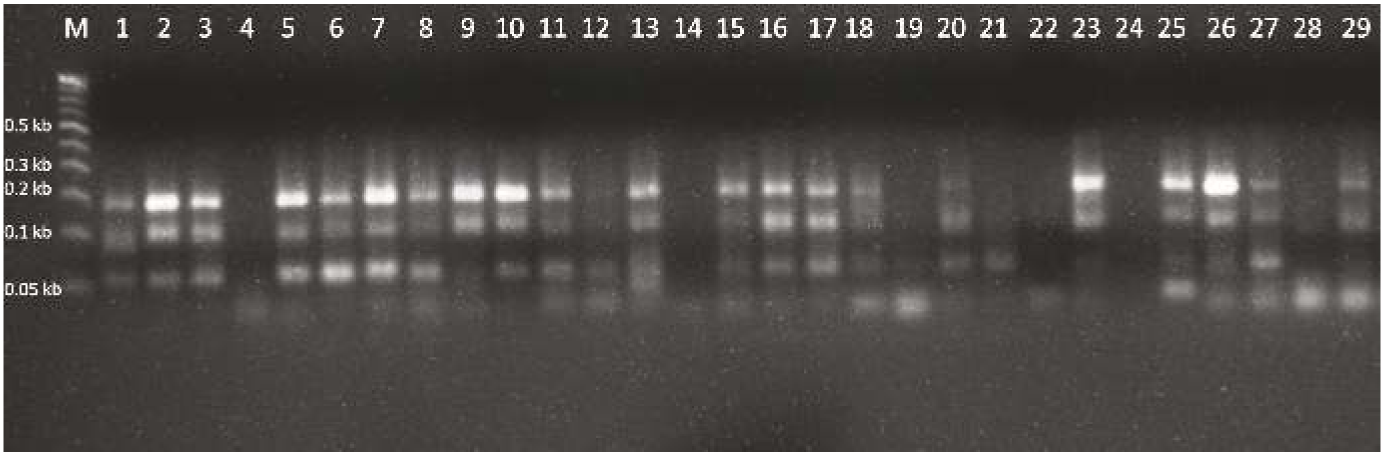


Fig 7.3: Allelic pattern among *Puccinia graminis tritici amplified* by SSR primer SSR-P TATC-40. PCR products were separated in 3 % Super MT4 Agarose gels. (M: 100 bp Ladder, 1 to 29 amplification pattern in pathotypes 11, 11A, 14, 15-1, 21, 21-1, 21A-2, 24A, 34-1, 40, 40A, 40-1, 40-2, 40-3, 42, 42B, 117, 117A, 117A-1, 117-1, 117-2, 117-3, 117-4, 117-5, 117-6, 122, 184, 184-1 and 295)

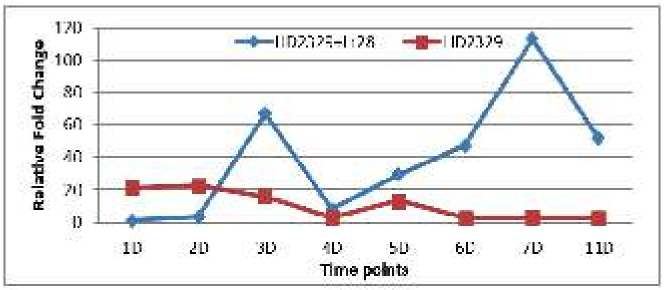


Fig. 7.4: The relative expression profile of Pt non-coding RNA (Id. URS000064D4E8_630390) at different stages after Pt inoculation in compatible and incompatible interaction

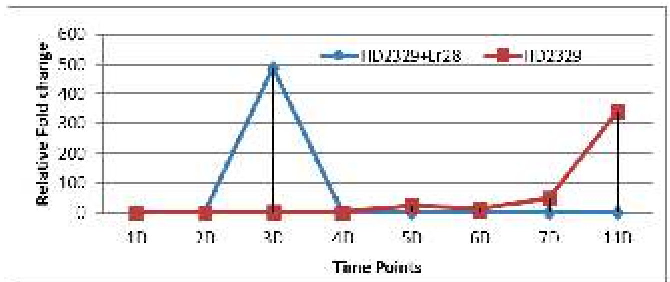


Fig. 7.5: The relative expression profile of Pt non-coding RNA (Id. URS00006E2FB0_630390) at different stages after Pt inoculation in compatible and incompatible interaction

Technologies) instead of normal agarose, which in earlier attempts was not able to resolve the DNA bands properly. Some of the primers clearly differentiated black rust pathotypes (Fig. 7.3). Further analysis of the SSR genotypes is being carried out, which is expected to deliver good molecular genotype grouping of the Indian repository of black rust pathotypes.

Molecular basis of wheat-leaf rust interaction

qRT-PCR for validation of eleven *Puccinia triticina* non-coding RNAs was done in compatible and incompatible (*Lr28*) wheat leaf rust interaction. The relative expressions of eight ncRNAs were relatively more in compatible interaction, whereas only one ncRNA expressed more in incompatible interaction. One ncRNA had almost equal expression in both compatible and incompatible interactions. The results of other target sequences were not comparable due to non-specific or false amplification during qRT-PCR. Following is the summary of qRT-PCR results for two ncRNAs:

The relative expression of ncRNA id. URS000064D4 E8_630390 was more pronounced in incompatible interaction. For initial two days its expression was more in compatible interaction (Fig. 7.4). From these results we could conclude that this ncRNA might be contributing to avirulence in the pathogen.

The relative expression of ncRNA id. URS00006E2 FB0_630390 was maximum in incompatible interaction after three days of inoculation (DAI), which remained 0 after 4 and peaked at 11 DAI (Fig. 7.5).

Maintenance and supply of nucleus inoculum of pathotypes of wheat and barley rust pathogens

A collection of more than 120 pathotypes of different rust pathogens of wheat, barley, oat and linseed were maintained in live culture as well as cryo-preserved. It has become difficult to maintain live cultures of more than 150 pathotypes of different rusts. Therefore, strategically less important pathotypes have been discontinued and sufficient inocula of those pathotypes have been cryo-preserved for use in future. Nucleus as well as bulk inocula of different rust pathotypes were supplied to 45 centers/ Scientists.

Wheat disease monitoring nurseries

Wheat disease monitoring nursery was planted at 37 strategic locations evenly distributed throughout India. Data were received from all the locations except for 5. Yellow rust was noticed at all the locations of NHZ and NWPZ except IIWBR, RS, Shimla. It was not reported from any other zones including NEPZ and SHZ. More than 60S severity of yellow rust was reported from all the locations of NHZ and NWPZ except Tutikandi and Abohar where maximum yellow rust severity was 40S on Agra local, Lal Bahadur and WH147 (Tutukandi) and Lal Bahadur (Abohar). At least nine entries of WDMN had more than 40S severity at Almora, Bajaura, Akrot, Dalang Maidan, Khudwani, Dhaulakuan, Ropar, Gurdaspur, Langroya, Ludhiana and Pantnagar. Agra Local, Kharchia Mutant and WH147 had 100S yellow rust severity at Hisar.

Brown rust was reported from ten locations of NHZ and NWPZ *viz*. Almora and Pantnagar in Uttarakhand, Akrot and Flowerdale in Himachal Pradesh, Kathua and Jammu (Jammu), Hisar (Haryana), Langroya, Ludhiana and Abohar in Punjab. It was reported from all the locations of NEPZ except Ranchi. In central zone, brown rust appeared at Raipur, Vijapur, Indore and Powerkheda and in PZ and SHZ at Dharwad, Niphad and Pune and Wellington. At Indore (CA) brown rust appeared only on Agra Local, Lal Bahadur and C-306 and other entries were brown rust free of the 32 locations of WDMNs, black rust was observed only at Gurdaspur in NWPZ, Powerkheda in CZ, Pune, Niphad and Dharwad in PZ and Wellington in SHZ. All the entries of WDMN were black rust free in NHZ and NEPZ. Leaf blight was reported from WDMNs planted at Almora, Kathua, Jammu (Udhaywalla), Sabaur, Ranchi, Kanpur, Varanasi, Raipur and Niphad. Powdery mildew was observed only at Almora, Akrot, Kathua, Jammu and Dhaulakuan. Wheat loose smut was reported only from Sabour.

Under the umbrella of Regional Station, ICAR-IIWBR, Shimla and CIMMYT, Delhi, SAARC wheat disease monitoring nursery was planted at 28 locations in India, Bangladesh, Bhutan, Nepal and Pakistan. Data were received from all the locations in India, Bangladesh and Nepal. Major outbreak of wheat diseases was not recorded in these South Asian countries.

8. REGIONAL STATION DALANG MAIDAN, LAHAUL & SPITI (H.P.)

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 $32^{0}30'$ N and $76^{0}59'$ E at an altitude of 3045 m (9990 feet) above mean sea level. The regional station serves as a national facility for providing environment for growing wheat, barley, mustard, lentil and chickpea and other crops during the off-season.

The summer nursery 2020 was not planted due to nationwide lockdown in April-June, 2020.

Natural repository for wheat and barley germplasm

The regional station 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 has been further strengthened by construction of separate germplasm storage room at the station.

Irrigation pipeline work

Special repair of irrigation pipeline of FIS Dalang from Chokerling Nallah in G.P Gondhla to RS Dalang Maidan was completed by Irrigation & Public Health Deptt. of Govt of Himachal Pradesh.

Farmers' training

A group of 45 farmers from Lahaul – Spiti was given 3 days training at IIWBR, Karnal under Tribal Sub Plan programme on the topic "Increasing farm income of Lahaul-Spiti farmers through improved wheat & vegetable production technologies".

Fig. 8.1: IIWBR Regional Station Dalang Maidan (Lahaul & Spiti, HP)

9. SEED AND RESEARCH UNIT, HISAR

The Seed and Research Unit, Hisar is located at the Southern bypass in the North-West of Hisar city. It has experimental farm an area of 200 acres and mandated with breeder seed production of popular/newly released wheat and barley varieties and evaluation of wheat and barley lines and trials under the All India Coordinated Wheat and Barley Improvement Programme.

Breeder Seed Production

During the *rabi* crop season 2019-20, wheat and barley crop was planted in a total of 62 acres. Out of this, wheat was planted in 43 acres while barley was planted in 19 acres. A total of 1011.65 quintals of wheat and barley breeder seed was produced during the season. The wheat varieties grown were WB2, DBW173, and DBW252 of which 765.5 quintal of breeder seed was produced. The average productivity was recorded to be 17.80 q/ acre. The breeder seed produced of three barley varieties viz. DWRB137, DWRUB101, DWRB160 amounted to be 246.15 quintals with a productivity of 12.97 q/ acre (Table 9.1).

Generation of Revenue

A total of 47.24 quintals of wheat and barley mixture was generated during the breeder seed production and it was put to retail and an amount of ₹ 67053/- was retailed to generate the revenue for the Institution. A total of 475 quintals of wheat and barley straw was given to the ICAR-Central Institute for Research on Buffaloes under MoU.

Soil improvement

The cultivated and fallow land at Seed and Research Farm, Hisar is low in organic matter and suffers from a very high salinity. To improve the soil for enhanced productivity, Sesbania (dhaincha) was grown for green manure in 185 acres during the kharif season.

Trials/Nurseries Conducted

During the period 32 wheat entries (SATSN) were evaluated under salinity conditions of Hisar. Selections were made from various segregating generations of barley crosses and station trial of various promising entries were also conducted.

Table 9.1: Production summary of seed and research unit, Hisar

S. No.	Commodity	Quantity (q)	Remarks
1	Wheat	765.5 (Breeder seed)	Handed over to ICAR-IIWBR, Karnal
2	Barley	246.15 (Breeder seed)	Handed over to ICAR-IIWBR, Karnal
3	Mixture	47.24	67053/-
4	Straw	475	Handed over to ICAR-CIRB

Fig. 9.1 : Evaluation of ICARDA barley gene pool (320 lines) under salinity conditions at Hisar

10. INSTITUTE ACTIVITIES AND MAJOR EVENTS

Brainstorming session

Brainstorming session on *"Adoption pattern of wheat production technologies in India – Key recommendations and landscape survey and future approaches"* under the project Cereal Systems Initiative for South Asia (CSISA) was organised on January 04, 2020. Dr. AK Singh, DDG (Extension), ICAR chaired the session.

Dr. AK Singh, DDG (Extension), ICAR chairing the Brainstorming session

National Symposium on Plant Disease Management for Food Security under Climate Change Scenario

National Symposium on *"Plant disease management for food security under climate change scenario and annual meeting of Indian Phytopathological Society (North Zone)"* organized on January 9-10, 2020 at ICAR-Indian Institute of Wheat and Barley Research, Karnal.

Inaugural session of National Symposium

VIth Foundation Day

Institute celebrated its 6th *Foundation day* on Feb 9, 2020. Padma Bhushan Dr. Anil P Joshi, Founder, Himalayan Environmental Studies and Conservation Organization (*HESCO*) delivered the foundation day lecture, while Dr. MS Chauhan, Director, NDRI, Karnal was the chief guest.

Padma Bhushan Dr. Anil P Joshi, Founder, HESCO delivering the foundation day lecture

National and International Workshop

International Workshop on DUS testing of Wheat and Barley

International Workshop on *"DUS testing of Wheat and Barley"* under the aegis of Indo German Bilateral Cooperation on Seed Sector was organized at ICAR-IIWBR, Karnal on February 19-20, 2020 under the chairmanship of Dr. K. V. Prabhu, Chairperson, PPV&FRA, New Delhi, while Dr. G.P. Singh, Director, ICAR-IIWBR, Karnal co-chaired the workshop. A total of 50 participants from various ICAR institutes, SAUs, Pvt. Seed companies and IPR attorneys attended the international workshop.

Participants visiting DUS wheat field

National Workshop on Use of Digital Field Book

A workshop on *"Use of digital field book in wheat"* was organized under the ICAR-BMGF project on February 25, 2020.

Discussion during the workshop on use of digital field book in wheat

59^{th} All India Wheat and Barley Research Workers' Meet

The *59^{th} All India Wheat and Barley Research Workers' Meet,* was virtually organized by the ICAR-Indian Institute of Wheat & Barley Research, Karnal from August 24-25, 2020. The meet was inaugurated by Dr T Mohapatra, Secretary, DARE & Director General, ICAR,New Delhi. The other dignitaries who graced the occasion were Dr TR Sharma, DDG (Crop Science), Dr. YP Singh, ADG (FFC), Dr. AK Singh, Director, IARI, New Delhi and Dr. AK Joshi, CIMMYT Co-ordinator, India. The meeting had five sessions for reviewing the research progress of 2019-2020, five year work performance of central zone centres and planning of 2020-21 season trials. Besides, one session on International collaborations with CIMMYT, ICARDA and HARVEST PLUS was also held wherein research program with these organizations was discussed.

Dr. T. Mohapatra, Secretary, DARE & Director General, ICAR, New Delhi delivering the inaugural address during the virtual 59^{th} All India Wheat and Barley Research Workers' Meet

VS Mathur Memorial Award Lecture

Dr Hans-Joachim Braun, Director, Global Wheat Program, CIMMYT, Mexico delivered the *VS Mathur Memorial Award* lecture on September 8, 2020.

Gandhi Jayanti Utsav Programme celebrated

Institute celebrated a week-long Gandhi Jayanti Utsav Program from September 25 to October 2, 2020. Number of events like importance of cleanliness. painting competition, swachhata abhiyan, yoga day, debate competition, poetry presentation on Gandhiji, tree plantation, slogan writing were organized. On 2^{nd} October 2020 a special programme was organized in which each and every employee of ICAR-IIWBR taken the Swachhta Oath followed by lecture by Dr. Anoop Kumar Mishra from BHU and he threw light on the philosophy of life of the Father of the Nation, Mahatma Gandhi.

Tree plantation during Gandhi Jayanti Utsav

Institute Research Council Meeting (2020)

Two Institute Research Council (IRC) meetings were organized during the year. The 1^{st} IRC meeting was held on 11-02-2020 while the 2^{nd} IRC Meeting was held on 29^{th} October, 2020 at ICAR, IIWBR under the Chairmanship of Dr. GP Singh, Director, IIWBR, Karnal in virtual mode in view of the Covid 19 guidelines. The Research Project Proposal – III (2015-20 projects) presentations were made by different programme leaders. A total of ten programmes for the period 2020-25 were approved by the IRC.

Institute Management Committee

The $XXVIII^{th}$ meeting of Institute Management Committee meeting was held under the chairmanship of Dr. GP Singh, Director, IIWBR, Karnal in virtual mode on November 28, 2020. The agenda note was discussed in detail during the meeting.

Swachhta Pakhwada

Swachhta Pakhwada was celebrated from 16^{th} to 31^{st} December, 2020. During this three different awareness programmes were organized in villages Sikander Kheri (district Kaithal) & Kaimla and Nali- Khurd (both from District Karnal). Two "Sanitation and SWM"' activities were carried out, one in the Gehoon Vihar campus and another at IARI Regional station residential area. A meeting was organized using video conferencing mode to share among the participants their experiences on household waste management. Participants from Karnal, Varanasi and Bangalore joined the meeting. Two short videos prepared on how to go for waste management were shared. Three separate competitions were organized viz., Essay writing, Elocution and painting competition for various categories involving students, staff and contractual employees.

Interaction meeting

An interaction meeting was held with the Glaxo smithkline Consumer Healthcare Gurgaon Ltd. on March 07, 2020 for enhancing the use of barley and malt in health products.

National and International Days

During the year Institute celebrated various days:

June 21, 2020: Celebrated as *International Day of Yoga*. On this occasion, the staff and their family members performed various asanas at home under theme "*Yoga at home and yoga with family".*

November 26, 2020: Celebrated as *Constitution Day (or Samvidhan Divas)*.

December 3, 2020: Celebrated as *Agricultural Education Day.*

December 5, 2020: Celebrated as *World Soil Day.*

December 23, 2020: Celebrated as *National Farmers Day.*

December 25, 2020: Interaction of *Hon'ble Prime Minister with Farmers and Kisaan Samman Nidhi.*

World Soil Day at Village Nabhipur, Karnal

11. EXTENSION ACTIVITIES

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

S. No.	Date	Duration (Days)	No. of Trainees	Subject	Organised by
1.	08 -10 January, 2020	3	37 Farmers	Gehoon Evam Jau Ki Unnat Kheti	DDA Dehradun, Uttarakhand sponsored at IIWBR
2.	12-13 January, 2020	2	3 Agriculture Professionals	Fasal Avshesh Prabandhan	Faculty of Agriculture, Bhopal at ICAR-IIWBR, Karnal
3.	20-22 January, 2020	3	37 Farmers	Gehoon evam jau fasal me jal prabandhan dwara kisano ki aaye me vriddhi	ICAR-IIWBR, Karnal

Table 11.2: Kisan Mela/Farmers Day/Field Day

S.No.	Date	Subject	Organized by
1.	09th February, 2020	6th Foundation Day of ICAR-IIWBR, Karnal	ICAR-IIWBR, Karnal
2.	15th October, 2020	Womens Day celebration at village Furlak Karnal, Haryana	ICAR-IIWBR, Karnal
3.	26th November, 2020	70th Constitution Day	ICAR-IIWBR, Karnal
4.	03rd December, 2020	Agricultural Education Day at ICAR-IIWBR, Karnal, Haryana	ICAR-IIWBR, Karnal
5.	05th December, 2020	World Soil Day at village Nabipur Karnal, Haryana	ICAR-IIWBR, Karnal
6.	23rd December, 2020	National Farmers Day at village Nabipur, Karnal, Haryana	ICAR-IIWBR, Karnal

Table 11.3: Organization/Participation in Exhibition

S.No.	Programme	Date	Duration (Days)	Organized by
1.	Sustainable Wheat Production and Nutritional Security in India	22 January, 2020	1	Directorate of Wheat Development, Govt. of India, Ministry of Agriculture & Farmers Welfare DAC&FW at National Centre for Organic Farming, Kamla Nehru Nagar, Ghaziabad, Uttar Pradesh.
2.	Global Potato Conclave 2020	28-31 January, 2020	4	Indian Potato Association in collaboration with Indian Council of Agricultural Research, New Delhi and ICAR-Central Potato Research Institute at Mahatma Mandir, Gandhinagar, Gujarat.
3.	Virat Kisan Mela 2020	06 February, 2020	1	Department of Agriculture, Baghpat at Samrat Prathviraj Degree College, Baghpat, Uttar Pradesh.
4.	National Dairy Mela 2020	15-17 February, 2020	3	ICAR-National Dairy Research Institute, Karnal, Haryana
5.	Ganna Vikas Mela 2020	28-29 February, 2020	2	ICAR-Sugarcane Breeding Institute, Regional Centre, Karnal, Haryana
6.	Rabi Kisan Mela 2020	03 March, 2020	1	On the occasion of 2nd Foundation Day of Dr. Gurbachan Singh Foundation, Kachhawa Road, Karnal
7.	Pusa Krishi Vigyan Mela 2020	05-07 March, 2020	3	ICAR-Indian Agricultural Research Institute, New Delhi at Mela Ground, IARI, New Delhi

Table 11.4: Coordination of visits at ICAR-IIWBR, Karnal during 2020

S.No	Date	Number of visitors	From
1.	January 16, 2020	40 Farmers	Gurugram, Haryana
2.	January 22, 2020	47 Students	Pehowa, Kurukshetra
3.	January 22, 2020	35 Farmers	Gujarat
4.	January 24, 2020	35 Women farmers	Gujarat
5.	January 27, 2020	50 Farmers	Uttar Pradesh
6.	January 27, 2020	55 Farmers	Amethi, Uttar Pradesh
7.	January 28, 2020	100 Farmers	Nillokheri, Karnal, Haryana
8.	January 30, 2020	100 Farmers	Asandh, Karnal, Haryana
9.	February 10, 2020	21 Students	Rahuri, Maharashtra
10.	February 13, 2020	20 Students	Uttar Pradesh
11.	February 14, 2020	44 students	Karnal, Haryana
12.	February 14, 2020	50 Farmers	Fatehpur, UP
13.	February 17, 2020	50 Students	Kaithal, Haryana
14.	February 17, 2020	50 Students	Maharashtra
15.	February 25, 2020	28 Farmers	Sonipat, Haryana
16.	March 04, 2020	41 Farmers	Raipur, Chhatisgarh
17.	March 05, 2020	25 Farmers	Chhattisgarh
18.	March 08, 2020	45 Farmers	Rajasthan
19.	March 14, 2020	6 Farmers	Bulandshahar, UP
20.	March 19, 2020	11 Farmers	Maharashtra
21.	November 20, 2020	50 Farmers	Basti, Uttar Pradesh

Extension lectures delivered

Dr. Anuj Kumar delivered a lecture (09.01.2020) on 'Krishi Me Udyamita Vikas' in Training on "Gehoon Evam Jau Ki Unnat Kheti" during 8-10 January, 2020 at IIWBR, Karnal sponsored by DDA Dehradun, Uttarakhand.

Dr. Anuj Kumar delivered a lecture (21.01.2020) on 'Krishi Me Udyamita Vikas' in Training ogranised during 20-22 January, 2020 on "Gehoon Evam Jau Me Jal Prabandhan Dwara Kisano Ki Aaye Me Vriddhi" at ICAR-IIWBR, Karnal.

Dr. Anuj Kumar delivered a lecture (05.02.2020) on 'Effective Writing and Editing' in Training programme on "Documenting Success Stories during 3-7 February, 2020 at NDRI, Karnal sponsored by MANAGE, Hyderabad.

Dr. Anuj Kumar delivered a lecture (06.02.2020) on 'Motivational Skills and Leadership' in MTC on "Livelihood Security of farmers through technological interventions in salt affected soils" during 31 January to 7 February, 2020 at CSSRI, Karnal, Haryana.

Dr. Anuj Kumar delivered a lecture (15.02.2020) on 'Formation of FPO for Entrepreneurship in Seed Sector' in ICAR- short course during 06-15, February 2020 on "Participatory Seed Production of Rabi Crops for Entrepreneurial Development" at ICAR- IIWBR, Karnal.

Dr. Anuj Kumar delivered a lecture (17.02.2020) on 'Bhartiya Krishi Ke Vikas Me Bankon Ki Bhumika' in UCO Bank Mandal Karyalaya Karnal during GD Birla Memorial Vyakhyanmala.

Dr. Sendhil R delivered a lecture (14.02.2020) on 'A Comparative Economics of Seed vis-à-vis Grain Production in Wheat' at the short course during 06-15 February, 2020 on 'Participatory Seed Production of Rabi Crops for Entrepreneurial Development' at ICAR-IIWBR, Karnal

Dr. Sendhil R delivered a lecture (13.02.2020) on 'Impact Assessment Scientific Method, Result Analysis and Report Writing' at the Workshop/Training on 'Impact Assessment and Program Evaluation' held at Extension Education Institute (EEI), Nilokheri during 11-14 February, 2020.

Advisories

COVID-19 advisories were disseminated to different stakeholders through ICAR-IIWBR website and social media.

12. DISTINGUISHED VISITORS

ICAR-IIWBR, Karnal

January 4, 2020: Dr. AK Singh, DDG (Extension) and Director, ICAR-IRI visited the institute to chair a brainstorming session on "Adoption Pattern of Wheat Production Technologies in India-Key Recommendations and Landscape Survey and Future Approaches".

Dr. AK Singh, DDG (Extension) and Director, ICAR-IARI chairing the brainstorming session

February 03, 2020: Dr. Samar Singh, Vice Chancellor, Maharana Pratap Horticultural University, Karnal visited the ICAR-IIWBR, Karnal and inaugurated the hands-on training programme on "Coordinated Trial Conduction and Data Recording and Reporting".

Dr. Samar Singh, Vice Chancellor, Maharana Pratap Horticultural University, Karnal delivering the inaugural address

February 06, 2020: Dr. RC Agrawal, DDG (Education), ICAR, New Delhi visited the ICAR-IIWBR, Karnal and inaugurated the Short Course on "Participatory Seed Production of Rabi Crops for Entrepreneurial Development".

Dr. RC Agrawal, DDG (Education), ICAR releasing the publication

February 09, 2020: Padma Bhushan Dr. Anil P Joshi, Founder, HESCO and Dr. MS Chauhan, Director, NDRI visited the institute as a chief guest of foundation day.

Padma Bhushan Dr. Anil P Joshi, Founder, HESCO and Dr. MS Chauhan, Director, NDRI planted a sapling in institute's premises

February 15, 2020: Dr. KV Prabhu, Chairperson, PPV&FRA visited the institute and chaired the valedictory session of the short course on "Participatory Seed Production of Rabi Crop for Entrepreneurial Development".

Dr. KV Prabhu, Chairperson, PPV&FRA distributing the certificates during valedictory function

February 19-20, 2020: Dr. KV Prabhu, Chairperson, PPV&FRA along with Mr.Ralf Roessler, Head of Section, DUS testing of cereals, Federal Plant Variety Office (BSA), Germany and Dr. Elmar Weissmann, Senior Seed Sector Expert, Indo-German Cooperation on Seed Sector visited the institute for international workshop on DUS testing of Wheat and Barley.

February 24, 2020: Sh. Sanjay Singh, Addl. Secretary DARE and Secretary, ICAR visited the institute.

Sh. Sanjay Singh, Addl. Secretary DARE and Secretary, ICAR interacting with IIWBR officials

February 26, 2020: Dr. Ravi P Singh, Dr. AK Joshi, Dr. RK Sharma from CIMMYT visited the institute and farmers' field.

Dr. Ravi P Singh, Dr. AK Joshi and Dr. RK Sharma visiting the farm and interacting with scientists

Sh. Sanjay Bhatia, MP, Karnal planted a sapling in the institute's premises on occasion of world environment day

April 05, 2020: Sh. Sanjay Bhatia, MP of Karnal Constituency visited ICAR-IIWBR, Karnal. The contribution to the COVID-19 fund was given to him.

June 3, 2020: Sh. Sanjay Bhatia, MP, Karnal along with Dr. (Mrs.) Amarinder Kaur, IFS from Haryana Forest Department visited the institute.

June 5, 2020: Sh. Sanjay Bhatia, MP, Karnal visited the institute on occasion of world environment day and planted a sapling in the institute's premises.

August 10, 2020: Sh. Sanjay Bhatia, MP of Karnal Constituencyvisited ICAR-IIWBR, Karnal.

ICAR-IIWBR Regional Station, Shimla

March 18, 2020: Dr. Rajinder Singh Chauhan, Dean, Research & Consultancy, Bennett University, Greater Noida, Uttar Pradesh, India visited the regional station, Shimla.

13. AWARDS AND RECOGNITIONS

Krishi Sansthan Samman Award 2020

ICAR-IIWBR received the Krishi Sansthan Samman Award-2020 under Mahindra Samridhi India Agri Award 2020 for its outstanding contribution in transforming the Indian Agriculture from shortage to surplus.

Director and staff of ICAR-IIWBR receiving the Krishi Sansthan Samman Award 2020 from officials of Mahindra Samridhi India

Dr. AB Joshi Memorial Award-2020

Dr. GP Singh, Director, ICAR-IIWBR, Karnal honoured with prestigious Dr. AB Joshi Memorial Award 2020 for his outstanding contribution in "Wheat Improvement for Food and Nutrition Security". Dr. GP Singh received this award from the Hon'ble Vice-President of India Sh. Venkiah Naidu during the convocation held at ICAR-IARI, New Delhi on February 12, 2020.

Hon'ble Vice-President of India Sh. Venkiah Naidu conferring the Dr. AB Joshi Memorial Award 2020 to Dr. GP Singh

Outlook Outstanding Scientist Award 2020

Dr. GP Singh honoured with the Outlook Agriculture Scientist Award for his outstanding contribution in wheat research. The award was given to him by Sh.Narendra Singh Tomar, Hon'ble Union Minister of Agriculture and Farmers Welfare, Government of India on February 24, 2020.

Sh.Narendra Singh Tomar, Hon'ble Union Minister of Agriculture and Farmers Welfare conferring Outlook Outstanding Scientist Award 2020 to Dr. GP Singh

National Award for Outstanding Leadership in Agriculture

Dr. GP Singh honoured with the All India Agricultural Students Association (AIASA) 2019 National Award for Outstanding Leadership in Agriculture for his contribution in Agricultural Research.

Dr. GP Singh receiving the National Award for Outstanding Leadership in Agriculture

Dr. MV Rao Memorial Award 2020

Dr. MV Rao Memorial Award 2020 by the Society for Advancement of Wheat and Barley Research (SAWBAR) awarded to Dr. Sewa Ram for his outstanding contribution in the field of wheat quality research.

Dr. Sewa Ram receiving the Dr. MV Rao Memorial Award 2020 from Dr. GP Singh, President, SAWBAR

Dr. S Nagarajan Memorial Award, 2020

Dr. SK Singh, Principal Scientist, ICAR-IIWBR, Karnal was awarded with Dr. S Nagarajan Memorial Award, 2020 for his immense contribution in wheat research.

Dr. SK Singh receiving the S Nagarajan Memorial Award, 2020 from Dr. GP Singh, President, SAWBAR

Professor Mahatim Singh Memorial Award 2020

Dr. Mamrutha HM was awarded with Professor Mahatim Singh Memorial Award 2020 by the Society for Advancement of Wheat and Barley Research, Karnal, Haryana.

Dr. Mamrutha HM receiving the Professor Mahatim Singh Memorial Award 2020 from Dr. GP Singh, President, SAWBAR

Dr YM Upadhyaya Memorial Lecture

Dr Ratan Tiwari, Principal Scientist delivered the Dr YM Upadhyaya Memorial Lecture titled *"Can wheat be more resilient in post genome sequence era?"* organized by ICAR-IARI Regional Station Indore on 11th September, 2020 through Video Conferencing mode.

Fellow of the Society for Advancement of Wheat and Barley Research

Dr. Anil Khippal, Dr. Sendhil R and Dr. OP Gupta were honored as elected fellow of the Society for Advancement of Wheat and Barley Research (2020).

Dr. GP Singh, President, SAWBAR awarding fellow certificate to Dr. Anil Khippal

Fellow of the Indian Society of Plant Genetics Resources

Dr. SK Singh was elected as fellow of the Indian Society of Plant Genetics Resources, New Delhi for his contribution in the evaluation and conservation of wheat genetic resources.

Distinguished Female Scientist Award

Dr. Poonam Jasrotia conferred with "Distinguished Female Scientist Award- Plant Protection Science 2020" by Society for Agriculture & Allied Research (SAAR), India.

Best Stall Award

The Institute stall got second prize during exhibition organized by NDRI, Karnal during 15-17 February, 2020.

Awards awarded by ICAR- IIWBR

For the year 2019-20, ICAR – IIWBR awarded the best worker to Dr. Poonam Jasrotia and Dr. Satish Kumar under scientific category, Sh Sunil Kumar under administrative category, Sh. Madan Lal under technical category and Sh Bhoop Ram under supporting category. The awards were given to them on the occasion of foundation day (09.02.2020).

Dr. Ravindra Kumar received "First Prize" in *Kavita Lekhan* competition organized by ICAR-IIWBR during *Rajbhasha Utsav evam Hindi Pakhwada* from September 14-30, 2020.

Dr. Ravindra Kumar received "First Prize" in Essay Writing

Competition (Hindi) organized by ICAR-IIWBR during *Rajbhasha Utsav evam Hindi Pakhwada* from September 14-30, 2020.

Dr. Anil Prakash Joshi and Dr. MS Chauhan giving best worker's award under scientific category to Dr. Satish Kumar

Dr. Anil Prakash Joshi and Dr. MS Chauhan giving best worker's award under administrative category to Mr. Sunil Kumar

Dr. Ravindra Kumar awarded "Appreciation Prize" in *Best worker* Competition (maximum use of Hindi in official work) organized by ICAR-IIWBR during *Rajbhasha Utsav evam Hindi Pakhwada* from September 14-30, 2020.

Best Poster Award

Dr. CN Mishra received best poster award for the poster entitled 'Identification of rust resistant lines for early sown conditions in wheat' in the National Symposium on Plant Disease Management for Food Security under Climate Change Scenario organized jointly by IPS and SAWBAR at ICAR-Indian Institute of Wheat and Barley Research, Karnal from January 9-10, 2020.

Vikram Singh, Prem Lal Kashyap, Pallika Sharma, Ragul Tripathi, Anju Sharma, Ravi Shekhar Kumar and Suhdeer Kumar received 2nd best poster award for the poster entitled "Antagonistic activity of volatile compounds producing bacterial endophytes from wheat (*Triticum aestivum*) against *Bipolaris sorokiniana*" in the National Symposium on Plant Disease Management for Food Security under Climate Change Scenario organized jointly by IPS and SAWBAR at ICAR-Indian Institute of Wheat and Barley Research, Karnal from January 9-10, 2020.

Awards for promotion of Hindi language

Satyavir Singh, Anuj Kumar, Sendhil R, Anil Kumar Khippal, Mangal Singh, Ramesh Chand and GP Singh awarded the first prize for editing "Gehun Evam Jau Sandesh, Jan-June 2019, Vol. 8(2)" in newsletter category from Town Official Language Implementation Committee (TOLIC), Department of Official Language, MHA (Govt. of India), Karnal.

Satyavir Singh, Anuj Kumar, Sendhil R, Anil Kumar Khippal, Mangal Singh, Ramesh Chand and GP Singh awarded the second prize for editing "Gehun Evam Jau Sandesh, Jan-June 2019, Vol. 8(1)" in newsletter category from Town Official Language Implementation Committee (TOLIC), Department of Official Language, MHA (Govt. of India), Karnal.

Dr. Ravindra Kumar received a Commendation Certificate from Town Official Language Implementation Committee (TOLIC), Department of Official Language, MHA (Govt. of India), Karnal on 4th August, 2020 for promoting the use of official language (Hindi) during the year 2019-20.

Drs. Ravindra Kumar, Nisha Kant Chopra and VK Pandita received the second prize for Technical Bulletin "*Gunvattayukt beej utpadan hetu uchit krishi kriyaayen* (TB-ICN: H 169/2019) in technical bulletin category from Town Official Language Implementation Committee (TOLIC), Department of Official Language, MHA (Govt. of India), Karnal on 4th August, 2020.

Dr. Raj Pal Meena, Karnam Venkatesh, Rinki, RK Sharma, Anuj Kumar and GP Singh awarded consolation prize for folder "Suxm sinchai: *Pani bachane ki nipun taknik*" in Hindi folder category by Town Official Language Implementation Committee (TOLIC), Department of Official Language, MHA (Govt. of India), Karnal on 4th August, 2020.

Certificate of recognition

Dr. CN Mishra received recognition award from Guru Gorakhnath Sewa Sansthan-Mahayogi Gorakhnath KVK for 2018-20.

Dr SK Singh received Reviewer Excellence Award, 2020 for Indian Journal of Agricultural Research by ARCC, Karnal.

Dr. Poonam Jasrotia appointed as Advisory board member of Group on International Plant Resistance to Insects on March 4, 2020 for 6 years at CIMMYT Mexico.

Invited talk/lead lecture

RPS Verma delivered a lecture on "Barley trials; constitution, conduction and data recording" during a training programme on "Coordinated Trial Conduction, Data Recording and Reporting" organized by ICAR-IIWBR, Karnal on February 05, 2020

Dr. Arun Gupta delivered a lecture on 'DUS testing of Wheat in India' during International Workshop on "DUS testing of Wheat and Barley" under the aegis of Indo German Bilateral Cooperation on Seed Sector organized at ICAR-IIWBR, Karnal on February 19-20, 2020.

Dr. Poonam Jasrotia delivered a plenary talk on "Deciphering mechanism of host-plant resistance in wheat to aphids in north-western plains of India" during 24th International Plant Resistance to Insects Symposium (IPRI2020) held at CIMMYT Mexico from March 2-6, 2020.

Dr. Sewa Ram delivered a lead lecture on nutritionally rich wheat and its products: production and consumption during a Webinar organized by Wheat product Promotion Society (WPPS) on 28-09-2020.

Dr. Sudheer Kumar delivered invited talk on "Karnal bunt status, issues and management strategies" in Brainstorming Session on 'Combating Rusts and Karnal Bunt of Wheat: Past and Future Strategies' organised jointly by Indian Phytopathological Society (North Zone Chapter), Indian Society of Plant Pathologists, Ludhiana and Department of Plant Pathology, PAU, Ludhiana from December 18-19, 2020.

Mahindra Samridhi Krishi Sansthan Award-2020

14. TRAINING AND CAPACITY BUILDING

Annual training plan (ATP)- 2019-20

As per the ICAR guideline, annual training calendar was prepared for the scientists, technical, administrative and supporting staff. The details are given below:

Table 14.1: Coordination of visits at ICAR-IIWBR, Karnal during 2020

Name	Designation	Topic	Place	Duration
Dr. Santosh Kumar Bishnoi	Sceintist	Data Analysis using R	ICAR-IASRI, N. Delhi	3 days
Mr. Nand Lal	Senior Technical Assistant	Farm management, Operation and Maintenance of Agricultural Implements	ICAR-IARI, N.Delhi	3 days
Mr. Roop Ram	Personal Assistant(PA)	Administrative matters	ISMT, New Delhi	3 days
Mr. Shiva Bhardwaj	Stenographer Grade-III	Administrative matters	ISMT, New Delhi	3 days
Mr. Anil Kumar Verma	LDC	Administrative matters	ISMT, New Delhi	3 days
Mr. Khem Chand	SSS	Exposure visit	Any ICAR institute	3 days
Mr. Bhoop Ram Thakur	SSS	Exposure visit	Any ICAR institute	3 days

Training organized

Several training programmes were conducted by the institute for strengthening the efficiency of scientific and technical workforce of agricultural institutes in the country. In addition, number of staff members attended or participated various training/symposia/conference /symposia/workshop or scientific meetings. The details thereof given below:

- A three-day farmers training on "Water Management in Wheat & Barley for Enhanced Farmer Income" was organised under the CRP Water Project during January 20-22, 2020. Around 36 farmers were trained on water conservation and irrigation management aspects.
- A three-day hands-on training was organized on "Coordinated Trial conduction and Data Recording and Reporting" from February 03-05, 2020 at ICAR-IIWBR Karnal.
- ICAR sponsored ten-day Short Course on "Participatory Seed Production of Rabi Crops for Entrepreneurial Development" was organized during February 06-15, 2020 at ICAR- IIWBR Karnal.
- Training programme on "Geo-Tagging of Frontline Demonstrations (FLDs) and Seed Hubs" was organized on February 28, 2020 for participants involved in AICRP on Wheat and Barley.
- Organized a three-day training programme on "Empowering Rural Youth for Self-reliance in Seed Sector" at ICAR-IIWBR, Karnal through virtual mode under the HRD component of ICAR Seed Project during November 24-26, 2020.
- Trainings (online) on barley for malting uses and cultivation of improved varieties was given to the farmers of Haryana and Rajasthan under the consultancy project of ICAR-IIWBR and ABInBev India during Oct-Dec. 2020 by the barley team led by Dr. RPS Verma.

Imparting water management training farmers

Resource person delivering lecture during training programme

Director, ICAR-IIWBR along with participants of training programme on Geo-Tagging of Frontline Demonstrations (FLDs) and Seed Hubs

Skill Development Programme

- ICAR-IIWBR organized a one-month summer training programme on "Skill Development and Enhancing Research Capacity of Young Scholars" during July 16 to August 17, 2020.
- ICAR-IIWBR organized a two-month training programme on "Rural Agricultural Work Experience for Skill Development" during September 14 to November 13, 2020.

Trainings/Meetings attended by scientists

- Dr. Charan Singh and Dr. Mamrutha HM attended the National Symposium on Plant diseases management for food security under climate change scenario at ICAR-IIWBR, Karnal during January 09-10, 2020.
- Dr. S. C. Bhardwaj and Dr. Pramod Prasad attended the 7th International Conference on Phytopathology in Achieving UN Sustainable Development Goals organized by Indian Phytopathological Society at ICAR-Indian Agricultural Research Institute, New Delhi, India during January 16-20, 2020.
- Dr. Ravindra Kumar attended the Hands-on-Training on "Coordinated Trial Conduction, Data Recording and Reporting" during February 03-05, 2020 organized by ICAR-IIWBR, Karnal.
- Dr. Charan Singh and Dr. Neeraj Kumar attended the Short Course on "Participatory seed production of rabi crops for entrepreneurial development" at ICAR-IIWBR, Karnal from February 6-15, 2020.
- Dr. Mamrutha HM and Dr. Vikas Gupta attended the International workshop on "DUS testing of Wheat and Barley" at ICAR-IIWBR, Karnal during February 19-20, 2020.
- Dr. Vikas Gupta participated in the training on "Germplasm screening and field surveillance of wheat blast" from March 01-10, 2020 at BARI, Jessore, Bangladesh.
- Dr. Poonam Jasrotia participated in the 24th Biannual International Plant Resistance to Insects (IPRI) Workshop CIMMYT, Mexico from March 02-07, 2020.
- Dr. Mamrutha HM and Dr. Rinki attended one day National webinar on "Patent and Intellectual Property Rights in Agricultural Research" organized by Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur on June 13, 2020.
- Dr. Rinki attended one-week international training on "Recent Physio-Molecular Digital Tools in Abiotic Stress Management for Crop Modeling" organized by the NAHEP-CAAST-DFSRDA VNMKV Parbhani from 29 June to 03 July, 2020.
- Dr. Poonam Jasrotia attended the MDP on Implementation of Access and Benefit Sharing Regulations in Agriculture Research: Awareness Cum Sensitization Workshop (Online) from July 07-10, 2020 organised by ICAR-NAARM (online).
- Dr AK Sharma attended the two-day (15 and 17 July, 2020) online training programme from NAARM Hyderabad on EDP for Master Trainers on Access and Benefit Sharing (ABS) Regulations in India and Nagoya Protocol.
- Dr. Arun Gupta attended the National Webinar on Implementation of Access to Plant Genetic Resources and Benefit Sharing on August 27, 2020.
- Dr. Umesh R Kamble attended workshop on "ABC of Scientific Writing" during 18th August-2nd September, 2020 through virtual mode organized by ICAR-National Rice Research Institute, Cuttack.
- Dr. Arun Gupta attended the CRP-Agro-biodiversity review meeting held under the Chairmanship of DDG (Crop Science) through webinar on September 7, 2020.
- Dr. Ravindra Kumar attended Training on "Advanced Bioinformatics Tools and its Applications in Agriculture (Online)" during September 14-19, 2020 organized by ICAR-NAARM, Hyderabad.
- Dr. Arun Gupta attended the international webinar and training on "DUS data management/Automation/Image analysis" in crops on October 06-07, 2020 organized by PPV&FR Authority, New Delhi under Indo-German Cooperation on Seed Sector Development.
- Dr. Hanif Khan attended the BGRI technical virtual workshop 2020 (October 06-08, 2020).
- Dr. Mamrutha HM and Dr. Rinki attended two-days international plant physiology virtual conference-2020, on "Prospects of Plant Physiology for Climate Proofing Agriculture" organized by the SUKAST, Jammu and ISPP, New Delhi from December 06-07, 2020.
- Dr. Mangal Singh participated in the Digital Training Programme on Science and Technology for Rural Societies for Scientists & Technologists during December 07-11, 2020 sponsored by the Department of Science and Technology, Government of India organized by Indian Institute of Public Administration, New Delhi.

15. RESEARCH PROJECTS

A. INSTITUTE'S FUNDED PROJECT : As approved by IRC for the period 2020-2025

ASSOCIATION IN VARIOUS INSTITUTE RESEARCH PROJECTS				
Program	**Project& Project No.**	**Sub-Project**	**PI**	**Co-PIs**
		CROP IMPROVEMENT		
AICRP on Wheat and Barley	1.0- Multilocational and Multidisciplinary Research Programme on Wheat and Barley Improvement CRSCIIWBRCL202000100194		Overall PI-GP Singh Crop Improvement PI- Gyanendra Singh	Gyanendra Singh, BS Tyagi, Arun Gupta, SK Singh, AK Sharma, Hanif Khan, Satish Kumar, Charan Singh, CN Mishra, K Venkatesh, Vikas Gupta, Gopalareddy K, Mamrutha HM, UR Kamble, Ratan Tiwari, Ajay Verma,
Crop Improvement Programme Program Leader/PI- Gyanendra Singh	2.0- Developing high yielding and climate resilient wheat varieties CRSCIIWBRCL202000200195	2.1: Breeding wheat genotypes for high yield in North Western Plains	Hanif Khan	GP Singh, CN Mishra, Gopalareddy K, Raj Kumar, UR Kamble, Ajay Verma, SC Bhardwaj, Mamrutha HM, Poonam Jasrotia, Sudheer Kumar, Sunil Kumar
		2.2: Breeding wheat genotypes for high yield in North Eastern Plains	Gyanendra Singh	Vikas Gupta, Charan Singh, AK Sharma, Sonia Sheoran, Sewa Ram, Ravinder Kumar, Anirban Majhi, Sunita Mahapatra (BCKV-Kalyani)
		2.3: Breeding high yielding wheat genotypes for stress conditions of warmer regions of India	SK Singh	Sindhu Sareen, Pradeep Sharma, Satish Kumar, AK Sharma, UR Kamble, Bhumesh Kumar, OP Gupta, Pramod Prasad
		2.4: Improving wheat genotypes for grain quality and end products	Gopalareddy K	BS Tyagi, Vanita Pandey, PL Kashyap
	3.0- Pre-breeding and germplasm enhancement CRSCIIWBRSL202000300196	3.1: Wheat improvement utilizing novel germplasm resources through prebreeding	BS Tyagi	Sindhu Sareen, Vikas Gupta, Arun Gupta, OP Gangwar
		3.2: Strengthening of Wheat and Barley genetic resources for utilization	Arun Gupta	Charan Singh, Venkatesh K
		3.3: Improving wheat genotypes for input use efficiency	Venkatesh K	Bhumesh Kumar, RP Meena, Rinki
		3.4 Strategic research for improving biotic stress in Wheat	Satish Kumar	CN Mishra, Venkatesh, Sneha Adhikari, AK Sharma, PL Kashyap
	4.0 New insights & basic studies for integrating molecular, physiological and bioinformatic tools for augmenting wheat improvement CRSCIIWBRCL202000400197	4.1 Biotechnological, bioinformatics and microbiological interventions for wheat improvement	Ratan Tiwari	OP Ahlawat, Rajender Singh, Pradeep Sharma, Sonia Sheoran, Suman Lata, Charu Lata Dinesh Kumar (IASRI-New Delhi) Nominated scientist (NBAIM-Mau)

		4.2:Physiological interventions and application of new tools including CRISPR/cas9 for wheat improvement	Mamrutha HM	Rinki, Rajender Singh
		CROP PROTECTION		
AICRP on Wheat and Barley	1.0- Multilocational and Multidisciplinary Research Programme on Wheat and Barley Improvement CRSCIIWBRCL202000100194		Overall PI- GP Singh Crop Protection PI- Sudheer Kumar	Sudheer Kumar, Poonam Jasrotia, Prem Lal Kashyap Ravindra Kumar
Crop Protection Programme Program Leader/PI: Sudheer Kumar	5.0-Biotic stress management in wheat by integrating innovative approaches CRSCIIWBRCL202000500198	5.1: Management of wheat diseases by integrating molecular and agro-ecological approaches	Sudheer Kumar	Prem Lal Kashyap, Ravindra Kumar, Arun Gupta
		5.2: Management of wheat insect-pests through climate-smart pest management strategies	Poonam Jasrotia	B.S. Tyagi Sindhu Sareen, Rajender Singh, Anil Khippal, Prem Lal Kashyap Dr. S. K. Tyagi (As Collaborator)
		RS, FLOWERDALE SHIMLA		
AICRP on Wheat and Barley	1.0- Multilocational and Multidisciplinary Research Programme on Wheat and Barley Improvement CRSCIIWBRCL202000100194		Overall PI- GP Singh Crop Protection PI- SC Bhardwaj	P. Prasad, O.P. Gangwar
Rust Diseases Program Program Leader/PI- S.C. Bhardwaj	6.0-Physiologic specialization, resistance and molecular studies on wheat and barley rusts CRSCIIWBRSL202000600199	6.1:Characterizing variation in wheat and barley leaf rust pathogens and genetics of resistance	S.C. Bhardwaj	Subodh Kumar, P. Prasad Sneha Adhikari
		6.2:Phenotypic and genotypic characterization of pathotypes of wheat and barley stripe rust pathogens and genetics of resistance in wheat and barley	O.P. Gangwar	P. Prasad, Subodh Kumar, Charu Lata Sharma
		6.3:Exploring population dynamics of Puccinia graministriticiand genetics of stem rust resistance in wheat and barley	Pramod Prasad	S.C. Bhardwaj, O.P. Gangwar
		6.4:Molecular studies on wheat-rusts and identifying novel resistance	Charu Lata Sharma	O.P. Gangwar, Subodh Kumar Sneha Adhikari
		6.5:Genetics of rust resistance and pyramiding multiple resistance in wheat	Sneha Adhikari	P. Prasad, Hanif Khan, Subodh Kumar, Charu Lata Sharma
		RESOURCE MANAGMENT		
AICRP on Wheat and Barley	1.0-Multi-locational and Multi-disciplinary Research Programme on Wheat andBarley Improvement CRSCIIWBRCL202000100194		Overall PI-GP Singh Resource Management PI-SC Tripathi	SC Tripathi, SC Gill, RS Chhokar, Anil Khippal, RP Meena and Neeraj Kumar

Resource Management Programme Program Leader/PI- S.C. Tripathi	7.0- Enhancing productivity and profitability of wheat based cropping systems through efficient resource management practices CRSCIIWBRSL202000700200	7.1: Efficient nutrient management strategies for wheat based cropping systems	SC Gill	SC Tripathi, OP Ahlawat and Sunil Kumar
		7.2:Development of effective weed management practices for wheat based cropping systems	RS Chhokar	SC Tripathi, SC Gill, Anil Khippal, Neeraj Kumar and VK Chaudhary (ICAR-DWR,Jabalpur)
		7.3:Conservation Agriculture for Sustainable Intensification of wheat based systems	Anil Khippal	SC Tripathi, RS Chhokar, SC Gill, Ankita Jha, Neeraj Kumar, OP Ahlawat, Poonam Jasrotia, Mamrutha HM, Ravinder Kumar, R Sendhil and Raghuveer Singh (ICAR-IIFSR,Modipuram)
		7.4:Improving resource use efficiency in wheat under conservation and conventional tillage practices	RP Meena	Ankita Jha and Neeraj Kumar
QUALITY AND BASIC SCIENCES				
AICRP on Wheat and Barley	1.0-Multi-locational and Multi-disciplinary Research Programme on Wheat andBarley Improvement CRSCIIWBRCL202000100194		Overall PI- GP Singh Quality PI-Sewa Ram	Sunil Kumar, OP Gupta, Vanita Pandey
Wheat quality improvement Leader: Program Leader/PI- Sewa Ram	8.0-Improvement of processing and nutritional quality of wheat using biochemical/molecular approach CRSCIIWBRSL202000800201		Sewa Ram	Sunil Kumar, OP Gupta, Vanita Pandey, BS Tyagi, Gopalareddy K
BARLEY IMPROVEMENT				
AICRP on Wheat and Barley	1.0-Multi-locational and Multi-disciplinary Research Programme on Wheat and Barley Improvement CRSCIIWBRCL202000100194		Overall PI-GP Singh, Barley Improvement PI- RPS Verma	AS Kharub, Chuni Lal, Dinesh Kumar, Rekha Malik Jogendra Singh, Lokendra Kumar, SK Bishnoi, Suman Lata, Sudheer Kumar, Poonam Jasrotia
Barley improvement Program Leader/PI- RPS Verma	9.0-Barley improvement and technological interventions for yield, quality, biotic and abiotic stress tolerance for better farmers' livelihood CRSCIIWBRSL202000800202	9.1: Pre-breeding for novel genetic variability in barley using innovative techniques	RPS Verma	Chuni Lal, Dinesh Kumar, Jogendra Singh, SK Bishnoi, Rekha Malik, Poonam Jasrotia
		9.2: Genetic enhancement of malt barley with changing industrial requirements using conventional and molecular approaches	Lokendra Kumar	RPS Verma, Dinesh Kumar, Rekha Malik, SK Bishnoi, Sudheer Kumar, Poonam Jasrotia, Rinki
		9.3: Genetic Amelioration of Grain Quality and Yield in Feed and Food Barley	Chuni Lal	RPS Verma, Jogendra Singh, Dinesh Kumar, Rekha Malik, Sudheer Kumar, Poonam Jasrotia, Rinki

		9.4: Biochemical and molecular approaches to understand nutritional and industrial quality in barley	Dinesh Kumar	RPS Verma, AS Kharub, Rinki, SK Bishnoi, Rekha Malik, Poonam Jasrotia, Sneh Narwal (ICAR-IARI, New Delhi), Vinod Chhokar (GJUS&T, Hisar)
		9.5: Development of resource management technologies for enhancing yield and quality of barley	AS Kharub	Dinesh Kumar, RS Chhokar and RP Meena
SOCIAL SCIENCES				
AICRP on Wheat and Barley	1.0-Multilocational and Multidisciplinary Research Programme on Wheat and Barley Improvement		Overall PI- GP Singh Social Sciences PI- Satyavir Singh	Satyavir Singh, Anuj Kumar, Anil Khippal and Sendhil R
Social Sciences Program Leader/PI- Satyavir Singh	10.0-Evaluation, Dissemination and Impact Assessment of Production Technologies CRSCIIWBRSL202001000203	10.1: Assessment of Farmers' Perspective on Crop Residue Management in Indo-Gangetic Plains of India	Anuj Kumar	Satyavir Singh, Sendhil R
		10.2: Promotion and Impact Evaluation of ICAR-IIWBR Technologies at Farmers' Field	Sendhil R	Satyavir Singh, Anuj Kumar, Anil Khippal, Raj Kumar

B. EXTERNALLY FUNDED PROJECT

Externally funded project (National Agencies)

Name of the project	Team	Funding Agency	Cost (in lakhs)	Duration
Characterization of heat-linked QTLs and Enzymes associated with starch biosynthesis pathway in wheat	Dr. SindhuSareen (PI) Co-PI: Dr. Rajender Singh	ICAR (Extramural Research project	458.79	Nov., 2018 to March, 2021
Exploiting alien genetic resources for developing climate resilient wheatand understanding mechanism of heat tolerance	PI : Dr. Sindhu Sareen CO-PIs: Drs BS Tyagi, Sonia Sheoran,Vikas Gupta	NASF	133.31	Aug,2018 to July, 2021
Marker assisted breeding for drought tolerance	PI-Dr. Gyanendra Singh Co-PI: Drs BS Tyagi, Sindhu Sareen, Sonia Sheoran Vikas Gupta, Charan Singh	DBT, New Delhi	120.89	March,2018 to March, 2021
High resolution QTL mapping for iron (Fe), zinc (Zn), grain protein, and phytate content and their introgression in high yielding wheat cultivars	Drs. Sewa Ram, BS Tyagi, OP Gupta, VanitaPandey and K. Gopalareddy	DBT, New Delhi	72.47	2019-22
Characterization, race profiling and genetic analysis of wheat powdery mildew pathogen (*Blumeria graminis* f.sp. *tritici* (DC) Speer (Syn. *Erysiphe graminis* DC f.sp. *tritici*) in India	PI: Dr. Prem Lal Kashyap Co-PI: Dr. Sudheer Kumar	DBT, New Delhi	14.04	March, 2019- March, 2021
Survey and surveillance for wheat blast caused by *Magnaporthe oryzae* pathotype *Triticum* and strategic research to manage it	Project leader: Dr. GP Singh PI: Dr. Sudheer Kumar Co-PI: Dr. Prem Lal Kashyap, Gyanendra Singh, SK Singh, AK Sharma	DAC&FW, MOA & FW, New Delhi.	127.54	April 2017-March 2020

Identification of salinity stress responsive microRNAs in wheat at reproductive stage	PI: Dr. Garima Singroha Mentor: Dr. Pradeep Sharma	WOS-A scheme		Feb 2020 to Feb 2022
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 Dr. Prem Lal Kashyap	ICAR funded project under incentivizing research in Agriculture	May 2015- March, 2020	May 2015- March, 2020
Development and Implementation of E-pest surveillance system in Haryana for rice-wheat	PI: Dr. Poonam Jasrotia Co-PI: Dr. Prem Lal Kashyap Dr. Sudheer Kumar	RKVY, Haryana	17.00	2018-2020
Functional Genomics and Genetic Modification in Crops (Heat tolerance in wheat)	PI: Dr. Mamrutha HM	ICAR-Network Project	18.00	March, 2017–June 2021
DUS testing in wheat	Nodal officer: Dr. Arun Gupta Co-nodal Officer: Dr. Charan Singh	PPV&FRA, N. Delhi	10.5	Since 2013
DUS testing in barley	Dr. Charan Singh	PPV&FRA, N. Delhi	7.50	Since 2013
Consortia Research Platform (CRP) on Biofortification	Dr. Sewa Ram, Dr.O.P. Gupta, Dr. VanitaPandey		250.00	2017-2021
CRP on Agrobiodiversity	PI: Dr. Arun Gupta Co-PIs: Dr. Sewa Ram and Dr. Sudheer Kumar	NBPGR, N.Delhi	26.00	2018-2021
CRP- Hybrid Technology (Wheat)	PI: Dr SK Singh	IARI, New Delhi	88.0	April 2017 – March 2021
CRP on water	PI: Dr RP Meena - Co PI: Drs K Venkatesh Rinki,	ICAR	38.3	April 2016 – March 2021
Creation of seed infrastructure facilities a component of Sub-mission of Seeds and Planting Material)	Dr Amit Kr Sharma and CN Mishra	DAC F&W, MoA&FW	123	2020-2021
Microbiome studies of bread wheat rhizosphere for improving tolerance against heat and drought stress under changing climate	PI: Dr. OP Ahlawat; Co-PIs: Drs. Ratan Tiwari and Pradeep Sharma	SERB-DST	34.01	Jan. 2020 to Jan. 2023
Germplasm Characterization and Trait Discovery in Wheat using Genomics Approaches and its Integration for Improving Climate Resilience, Productivity and Nutritional quality" Component 3: Evaluation of wheat germplasm for abiotic stresses	PI: Dr SK Singh Co-PI: Dr(s) Sindhu Sareen, Arun Gupta, Charan Singh, Vikas Gupta & Sonia Sheoran	DBT	95.57	Feb. 2020 to Feb. 2025

Germplasm Characterization and Trait Discovery in Wheat using genomics Approaches and its Integration for Improving Climate Resilience, Productivity and Nutritional quality" under mission programme of "Characterisation of Genetic Resources"; Subproject: Quality	Sewa Ram, BS Tyagi, OP Gupta, and K. Gopalareddy	DBT	80.97	Feb. 2020 to Feb. 2025

Externally Funded Projects (Foreign agencies)

Title of the project	Associated scientists(PI and Co-PI)	Funding Agency	Total budget (Lakhs)	Duration
Mitigating the effects of stripe rust on wheat production in South Asia and eastern Africa	PI: Dr SC Bhardwaj Co-PI:Dr Hanif Khan	ACIAR, Australia	64.0	July, 2017 to June 2021
Application of Next-Generation Breeding, Genotyping, and Digitalization Approaches for Improving the Genetic Gain in Indian Staple Crops	PI: Dr. Hanif Khan Co-PI:Dr Satish Kumar Dr CN Mishra Dr Gopalareddy K	ICAR and Bill & Melinda Gates Foundation	60.0	Nov. 2018 to Oct.., 2022

C. CONTRACT RESEARCH PROJECT

Project name	Project Leader	Period	Funding Agency	Project amount (Rs. Lakhs)
Consultancy to AB InBev (Barley Malt Company) for imparting training to the identified barley growing farmers regarding advance barley technologies	PI: Dr. RPS Verma Co-PI: Scientists of Barley Improvement and Social Sciences	Nov. 2020 to April 2021	M/s AB In Bev India Ltd.	16.63
Evaluation of Pinoxaden 5.1 % EC (New Formulation) for grass weeds control in wheat and barley	Dr. RS Chhokar	2020-2022	Syngenta India Ltd.	10.38
Evaluation of Nitritecnia-20 on growth and productivity of wheat	Dr. Raj Pal Meena	2020-2021	Monsoon Crop science LLP Nashik, Maharashtra	1.65
Quantification and Characterization of Herbicide resistance in weeds in rice under Rice-Wheat system.	Dr. RS Chhokar	2020-2022	Syngenta India Ltd.	10.14
Evaluation of efficacy of Biozyme on growth and productivity of wheat	Dr. Raj Pal Meena	2020-2021	BiostadtIndia Limited	3.30
Detection of herbicide resistance in Phalaris minor biotype using RISQ test	Dr. SC Gill	2020-2021	Syngenta India Limited , Pune	5.90
Evaluation of Quantis (product of natural origin) for use in Wheat *(Triticum aestivum)* for supporting plant growth and yield enhancement.	Dr. SC Gill	2020-2021	Syngenta India Limited , Pune	1.88
Evaluation of Morgain, Alivio, Xpert, JU-Potash 150 and Vita Gold in wheat (*Triticum aestivum*)	Dr. SC Gill	2020-2022	JU Agri Sciences Private Limited Unit NOIDA	3.30

Effect of Calcium Borate Suspension concentrate (6% B) coated urea against Disodium OctaborateTetraborate (20%l yield and quality of wheat	Dr. SC Gill	2020-2022	Yara Fertilizers India Private Limited, Gurgaon	4.24
Evaluation of Fipronil 0.6% GR against pink stem borer *(Sesamia inferns)* and army worm *(Mythimna separata)* in wheat.	Dr. Poonam Jasrotia	2020-2022	Gharda Chemicals Limited	33.41
Evaluation of GLol'r 30% wrv EC [propiconazole 13.9 (15% w/v) + Difenoconazole l3.9oh w/w (lSohwlv) EC] against wheat diseases (yellow rust, brown rust, powdery mildew)	PI: Dr. Prem Lal Kashyap Co-PI: Dr. Sudheer Kumar	2020-2022	Syngenta India Ltd., Pune	16.99
Evaluation of bio-efficacy of pydiflumetofen l5.0,l/o + propiconazole w/v SE (275SE) against yerow rust *(Puccinia striiformisf.sp.tritici)* and head scab *(Fusarium graminoreum)* of wheat.	PI: Dr. Prem Lal Kashyap Co-PI: Dr. Sudheer Kumar	2019-2021	Syngenta India Ltd., Pune	8.49
Evaluation of post emergence herbicide 'IlL-1 19' against weeds in wheat	Dr. SC Gill	2019-2021	Product Development Agencies InsecticidesIndia Ltd.	5.90
Evaluation of bio-efficacy of post emergence herbicide 'ALH-816'for control of weeds in	Dr. RS Chhokar	2019-2021	Product Development Agencies AtulIndia Ltd.	5.31
Herbicide resistance detection in *Phalaris minor* using RISQ test.	Dr. RS Chhokar	2019-2020	Syngenta India Ltd, Delhi	5.90
Efficacy of premix of VPP 72.60% WG for control of *Phalaris minor* and broad leaved weeds in wheat	Dr. RS Chhokar	2019-2021	Product Development Agencies FMC India Ltd.	14.75
Identification, quantification and control of herbicide resistance in broad-leaved weeds of wheat in India.	Dr. RS Chhokar	2019-2022	Product Development Agency Syngenta India Pvt Ltd.	16.52

16. PUBLICATIONS

Research papers in journals

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12. Gangwar OP, Kumar S, Bhardwaj SC, Kashyap PL, Prasad P and Khan H. 2019. Characterization of three new *Yr9*-virulences and identification of sources of resistance among recently developed Indian bread wheat germplasm. *Journal of Plant Pathology* 101(4): 955-963
13. Gupta OP, Pandey V, Saini R, Narwal S, Malik VK, Khandale T, Ram S and Singh GP. 2020. Transcriptomic dataset reveals the molecular basis of genotypic variation in hexaploid wheat (*T. aestivum* L.) in response to Fe/Zn deficiency. *Data-In-Brief*, https://doi.org/10.1016/j.jbiotec.2020.03.015
14. Gupta OP, Pandey V, Saini R, Narwal S, Malik VK, Tushar K, Sewa Ram and Singh GP. 2020. Identifying transcripts associated with efficient transport and accumulation of Fe and Zn in hexaploid wheat (*T. aestivum* L.). *Journal of Biotechnology*, https://doi.org/10.1016/j.jbiotec.2020.03.015
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16. Jasrotia P, Jadon KS, Singh SK, Nataraj MV, Haris G, Dutt R and Savaliya SD. 2020. Development and validation of IPM modules against major sucking insect-pests of groundnut. *Legume Research* 43: 592-597

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17 हिन्दी कार्यक्रमों पर रिपोर्ट

भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल में वर्ष 2020 के दौरान कोरोना महामारी (कोविड–19) के कारण हिन्दी अनुभाग द्वारा ऑनलाईन माध्यम से अनेकों कार्यक्रम आयोजित किये गए, जिनका संक्षिप्त विवरण नीचे दिया जा रहा है।

राजभाषा कार्यान्वय समिति की तिमाही बैठकें

इस संस्थान की राजभाषा कार्यान्वयन समिति की चारों तिमाही ई–बैठक के माध्यम से 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 71वीं छमाही समीक्षा बैठक का आयोजन दिनांक 04 अगस्त, 2020 को हुआ, जिसमें संस्थान के निदेशक डा. जी पी सिंह एवं डा. अनुज कुमार प्रधान वैज्ञानिक व राजभाषा प्रभारी अधिकारी ने भाग लिया।

दिनांक 24 नवम्बर, 2020 को 72वीं छमाही समीक्षा बैठक का आयोजन भाकृअनुप–राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल में ई–बैठक के माध्यम से ऑनलाईन किया गया। जिसमें भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल के राजभाषा अधिकारी डा. अनुज कुमार एवं डा. रविन्द्र कुमार ने भाग लिया।

पुरस्कार व सम्मान

नराकास पुरस्कार

दिनांक 24 नवम्बर, 2020 को 72वीं छमाही समीक्षा बैठक का आयोजन भाकृअनुप–राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल में ई–बैठक के माध्यम से ऑनलाईन किया गया। जिसमें विभिन्न श्रेणियों में भाकृअनपु–भारतीय गेहूँ एवं जौ अनसुधान सस्थान, करनाल को पुरस्कार से सम्मानित किया गया है।

नराकास, करनाल उत्कृष्ट हिन्दी प्रकाशन का पुरस्कार

नराकास, करनाल की 72वीं छमाही समीक्षा बैठक एवं वार्शिक नराकास पुरस्कार वितरण समारोह में उत्कृष्ट हिन्दी प्रकाशन पत्रिका के रूप में संस्थान द्वारा प्रकाशित गेहूँ एवं स्वर्णिमा को द्वितीय पुरस्कार से सम्मानित किया गया। राजभाषा अधिकारी डा. अनुज कुमार ने यह पुरस्कार संस्थान के लिए ग्रहण किया।

राजभाषा उत्सव एवं हिन्दी पखवाड़ा

भाकृअनुप–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल में प्रत्येक वर्ष की भांति वर्ष 2020 में भी ''राजभाषा उत्सव एवं हिन्दी पखवाड़ा'' का आयोजन किया गया। इस दौरान विभिन्न वर्ग के अधिकारियों व कर्मचारियों के लिए छह प्रतियोगिताओं का आयोजन किया गया जिसमें संस्थान के सभी अधिकारियों व कर्मचारियों ने बढ़–चढ़कर भाग लिया।

उत्कृष्ट कर्मचारी पुरस्कार 2020

प्रत्येक वर्ष की भांति वर्ष 2020 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 उददेश्य हिन्दी में काम–काज को बढ़ाया देना है।

गेहूँ एवं स्वर्णिमा उत्कृष्ट लेख पुरस्कार

गेहूँ एवं स्वर्णिमा के अंक ग्यारहवें में प्रकाशित ''धान्य फसलों के मुख्य बीज जनित रोग एवं उनकी रोकथाम''रविन्द्र कुमार, सुधीर कुमार, प्रेम लाल कश्यप, पूनम जसरोटिया एवं ज्ञानेन्द्र प्रताप

संस्थान द्वारा प्राप्त नराकास पुरस्कार

श्रेणी	पत्रिका	पुरस्कार
हिन्दी गृह पत्रिका	गेहूँ एवं जौ स्वर्णिमा	द्वितीय
वार्षिक स्मारिका	स्मारिका	प्रथम
हिन्दी बुकलेट / प्रशिक्षण	सूक्ष्म सिंचाईः घटते जल संसाधनों का अधिक पैदावार हेतु उचित उपयोग	द्वितीय
हिन्दी बुकलेट / प्रशिक्षण	बदलते जलवायु परिवेश में जौ की वैज्ञानिक खेती	तृतीय
हिन्दी फोल्डर	सूक्ष्म सिंचाईः पानी बचाने की निपुण तकनीक	प्रोत्साहन
समाचार पत्रक / न्यूज लैटर	गेहूँ एवं जौ संदेश, छमाही पत्रिका, जुलाई–दिसम्बर, 2019	प्रथम
वार्षिक प्रतिवेदन	वार्षिक प्रतिवेदन	प्रथम
लीफलेट / पैम्फलेट	उत्तर पूर्वी मैदानी क्षेत्र के लिए गेहूँ उत्पादन की नवीनतम तकनीकियां	द्वितीय

हिन्दी में अधिक कार्य करने वाले उत्कृष्ट कर्मचारी

कर्मचारी	पदनाम एवं अनुभाग	प्राप्त स्थान
श्री सुनील कमुार	प्रवर श्रेणी लिपिक, प्रशासनिक अनुभाग	प्रथम
श्री कृष्ण पाल	सहायक, वित्त एवं लेखा अनुभाग	द्वितीय
श्री सुनील कमुार	सहायक, प्रशासनिक अनुभाग	तृतीय

सिंह ''गेहूँ फसल रोगों पर आधारित मोबाइल ऐप "गेहूँ डॉक्टर'' सुमन लता, डीपी सिंह, पूनम जसरोटिया, ज्ञानेंद्र प्रताप सिंह 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।

डॉ. रविन्द्र कुमार एवं अन्य को गेहूँ एवं जौ स्वर्णिमा के ग्यारहवें अंक में प्रकाशित उत्कृष्ट लेख पुरस्कार से सम्मानित

18. PERSONNEL

Headquarter, Karnal

Director

Dr. GP Singh

Director cell

Smt. Gian Aneja, PS to Director

Sh. Anil Kumar, AAO

Sh. Sunder Lal, STA

Sh. Aman Kumar, SSS

Crop Improvement

Scientific staff

Dr. Gyanendra Singh, Pr. Scientist & PI

Dr. OP Ahlawat, Pr. Scientist

Dr. Ratan Tiwari, Pr. Scientist

Dr. BS Tyagi, Pr. Scientist

Dr. Arun Gupta, Pr. Scientist

Dr. Sindhu Sareen, Pr. Scientist

Dr. Raj Kumar, Pr. Scientist

Dr. Ajay Verma, Pr. Scientist

Dr. Rekha Malik, Pr. Scientist

Dr. Rajender Singh, Pr. Scientist

Dr. SK Singh, Pr. Scientist

Dr. Suman Lata, Pr. Scientist

Dr. Pradeep Sharma, Pr. Scientist

Dr. Bhumesh Kumar, Pr. Scientist

Dr. AK Sharma, Pr. 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. HM Mamrutha, Scientist

Dr. Vikas Gupta, Scientist

Dr. Umesh R Kamble, Scientist (w.e.f 24.08.2020)

Dr. Rinki, Scientist

Dr. Gopalareddy, Scientist

Technical & Supporting staff

Sh. Yogesh Sharma, CTO

Dr. BK Meena, ACTO

Sh. P Chandrababu, ACTO

Sh. Surendra Singh, ACTO

Sh. Surendra Singh, ACTO

Sh. Yogesh Kumar, ACTO

Sh. Om Prakash, TO

Sh. Suresh Kumar, TO

Sh. Rahul Singh, TO

Sh. Rajesh Kumar, TO

Sh. Ishwar Singh, STA

Sh. Ronak Ram, Sr. TA

Sh. Ramesh Pal, SSS (up to Oct. 2020)

Sh. Bhim Sen, SSS

Smt. Shanti Devi, SSS

Crop Protection

Scientific staff

Dr. Sudheer Kumar, Pr. Scientist & PI

Dr. Poonam Jasrotia, Pr. Scientist

Dr. PL Kashyap, Scientist

Dr. Ravindra Kumar, Scientist

Technical & Supporting staff

Sh. Ishwar Singh, TO

Sh. Bhal Singh, TO

Smt. Amresh, SSS

Resource Management

Scientific staff

Dr. RK Sharma, Pr. Scientist & PI (upto 31.03.2020)

Dr. SC Tripathi, Pr. Scientist & PI (w.e.f 01.04.2020)

Dr. SC Gill, Pr. Scientist

Dr. RS Chhokar, Pr. Scientist

Dr. Anil Khippal, Pr. Scientist

Dr. Raj Pal Meena, Sr. Scientist

Dr. Ankita Jha, Scientist

Dr. Neeraj Kumar, Scientist

Technical & Supporting staff

Sh. Ram Kumar Singh, ACTO

Sh. PHP Verma, ACTO

Sh. Rajinder Pal Sharma, TO

Quality and Basic Sciences

Scientific staff

Dr. Sewa Ram, Pr. Scientist & PI

Dr. Sunil Kumar, Pr. Scientist (w.e.f 19.08.2020)

Dr. OP Gupta, Scientist

Dr. Vanita Pandey, Scientist

Technical & Supporting staff

Smt. Sunita Jaswal, ACTO

Smt. Jamuna Devi, TO

Sh. Vijay Singh, STA

Sh. Desh Raj, SSS

Social Sciences

Scientific staff

Dr. Satyavir Singh, Pr. Scientist & PI

Dr. Anuj Kumar, Pr. Scientist

Dr. Sendhil R, Scientist

Technical & Supporting staff

Dr. Mangal Singh, ACTO

Sh. Harinder Kumar, SSS

Accounts and Audit

Sh. AK Kathuria, AF&AO

Barley Improvement

Scientific staff

Dr. RPS Verma, Pr. Scientist & PI

Dr. AS Kharub, Pr. Scientist

Dr. Chuni Lal, Pr. Scientist

Dr. Dinesh Kumar, Pr. Scientist

Dr. Jogendra Singh, Pr. Scientist

Dr. Lokendra Kumar, Pr. Scientist

Technical & Supporting staff

Sh. Ravinder Singh, ACTO

Sh. Rampal Saini, SSS

PME Cell

Dr. Poonam Jasrotia, Officer- Incharge

Dr. Ramesh Chand, ACTO

Landscape Section

Sh. Rajender Kumar Sharma, TO

Sh. Hawa Singh, SSG (Mali)

Administration

Sh. Sachin Agnihotri, SAO (upto 30.12.2020)

Sh. Gajanand Yadav, SAO (wef 31.12.2020)

Sh. Ramesh Kumar, AAO

Smt. Promila Verma, AAO

Smt. Hem Lata, PA

Sh. Sunil Kumar, Asst.

Sh. Ramesh Chand, Asst.

Sh. Shiva Bhardwaj, Steno-Gr.III

Sh. Sunil Kumar, LDC

Sh. Naresh Kumar, LDC

Smt. Sonam Verma, LDC

Sh. Paramjit Singh,SSS

Sh. Biru Ram, SSS

Sh. Lakhwinder Singh, SSS

Accounts and Audit

Sh. Jagdish Chander, F&AO

Sh. Krishan Pal, Asst.

Smt. Sushila, Asst.

Sh. Suman Thapa, SSS

Sh. Ramu Shah, SSS

Library

Dr. Ajay Verma, Officer-Incharge

Sh. Abhay Nagar, CTO

Farm Section

Dr. SK Singh, Officer- Incharge

Sh. Madan Lal, TO (Farm Manager)

Sh. Raj Kumar, TO (Farm Manager)

Sh. Raj Kumar, SSS

Vehicle Section

Sh. Abhay Nagar, ACTO & Incharge

Sh. Ram Jawari, TO

Sh. Kehar Singh, TO

Sh. Om Singh, STA

Sh. Rajbir Singh, STA

Sh. Sunder Lal, STA

Sh. Vinod Kumar, ST

Sh. Rajbir Singh, ST

Regional Station, Flowerdale, Shimla

Scientific staff

Dr. SC Bhardwaj, Pr. Scientist & Incharge

Dr. OP Gangwar, Scientist

Dr. Pramod Prasad, Scientist

Dr. Charu Lata, Scientist (w.e.f 07.04.2020)

Dr. Sneha Adhikari, Scientist (w.e.f 07.04.2020)

Technical & Supporting staff

Dr. Om Prakash, CTO

Dr. Subhodh Kumar, ACTO

Sh. Swaroop Chand, Tech.

Sh. Bhoop Ram Verma, SSS

Sh. Khem Chand, SSS

Administrative staff

Sh. Roop Ram, PA

Sh. Anil Kumar, LDC

Regional Station, Dalang Maidan, Lahaul & Spiti

Scientific staff

Dr. Hanif Khan, Incharge

Technical staff

Sh. Nand Lal, Sr. Tech.

Seed and Research Farm, Hisar

Scientific staff

Dr. SK Bishnoi, Scientist

Technical & Supporting staff

Dr. Rajendra Kumar, ACTO

Administrative staff

Sh. Mahabir Singh, UDC

19. STAFF POSITION AND FINANCE

Staff position as on 31st December, 2020

Place	Designation	Sanctioned	Filled	Vacant
Scientific cadre strength				
IIWBR, Karnal; and Seed and Research Farm, Hisar	Director	01	01	-
	Principal Scientist	05	03	02
	Senior Scientist	12	10	02
	Scientist	42	39	03
IIWBR Regional Station, Shimla	Principal Scientist	01	-	01
	Scientist	05	05	-
IIWBR Regional Station, Dalang Maidan	Scientist	01	-	01
	Total	**67 (66+1)**	**58 (57+1)**	**09**
Administrative cadre strength				
IIWBR, Karnal	SAO	01	01	-
	AAO	03	03	-
	FAO	01	01	-
	AF&AO	01	01	-
	Assistant	07	04	03
	UDC	03	01	02
	LDC	04	02	02
	PS	01	01	-
	PA	01	01	-
	Steno Gr III	01	01	-
	Total	**23**	**16**	**7**
IIWBR Regional Station, Shimla	PA	01	01	-
	LDC	01	01	-
	Total	**02**	**02**	**-**
	Grand Total	**25**	**18**	**07**
Technical cadre strength				
IIWBR, Karnal	T-3 (Cat.II)	19	14	05
	T-1 (Cat.I)	23	21	02
IIWBR Regional Station, Shimla	T-3 (Cat.II)	02	02	-
	T-1 (Cat.I)	03	01	02
IIWBR Regional Station, Dalang Maidan	T-1 (Cat.I)	01	01	-
	Total	**48**	**39**	**11**
Skilled supporting staff cadre strength				
Station		**Sanctioned**	**Filled**	**Vacant**
IIWBR, Karnal	SSS	16	13	03
IIWBR Regional Station, Shimla	SSS	02	02	-
IIWBR Regional Station, Dalang Maidan	SSS	-	-	-
Total		**18**	**15**	**03**

Summary

Cadre	Sanctioned	Filled	Vacant
Director	01	01	0
Scientific	66	57	09
Technical	48	39	09
Administrative	25	18	07
Skilled supporting staff	18	15	03
Total staff	**158**	**130**	**28**

Finance

Expenditure Statement upto 31-03-2020 (in lakhs)

ICAR-IIWBR, Karnal

HEAD	BE 2019-20	NET RE 2019-20	EXPENDITURE				Total exp.	% of exp. against revised estimate
			Other than NEH & TSP	TSP	NEH	SCSP		
Grants in Aid - Capital	320.00	138.00	118.00	0.0	0.0	20.00	**138.00**	100.00
Grants in Aid - Salaries	1823.79	1870.00	1870.00	0.0	0.0	0.0	**1870.00**	100.00
Grants in Aid - General :-								
(1) Pension	200.00	219.00	218.99	0.0	0.0	0.0	**218.99**	100.00
(2) Others	808.15	696.86	649.99	6.86	0.0	40.00	**696.85**	100.00
TOTAL	**3151.94**	**2923.86**	**2856.98**	**6.86**	**0.00**	**60.00**	**2923.84**	100.00

AICRP (Wheat & Barley)

HEAD	BE 2019-20	NET RE 2019-20	EXPENDITURE				Total exp.	% of exp. against revised estimate
			Other than NEH & TSP	TSP	NEH	SCSP		
Grants in Aid - Capital	0.0	0.0	0.0	0.0	0.0	0.0	**0.00**	
Grants in Aid - Salaries	1864.46	1314.02	1276.10	0.0	37.92	0.0	**1314.02**	100.00
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	205.49	192.99	4.95	7.55	0.0	**205.49**	100.00
TOTAL	**2219.96**	**1519.51**	**1469.09**	**4.95**	**45.47**	**0.00**	**1519.51**	100.00

Expenditure Statement upto 31-12-2020 (in lakhs)

ICAR-IIWBR, Karnal

HEAD	Progressive Receipt of Grant against BE	Progressive Expenditure during 2020-21				Total exp. (upto Dec. 2020)	% of exp. against receipt
		Other than (TSP NEH & SCSP)	TSP	NEH	SCSP		
Grants in Aid - Capital	25.93	5.47	0.0	0.0	0.0	**5.47**	21.10
Grants in Aid - Salaries	1601.13	1590.84	0.0	0.0	0.0	**1590.84**	99.36
Grants in Aid - General :-							
(1) Pension	186.12	141.65	0.0	0.0	0.0	**141.65**	76.11
(2) Others	462.34	409.00	3.56	0.0	2.71	**415.27**	89.82
Grand Total	**2275.52**	**2146.96**	**3.56**	**0.00**	**2.71**	**2153.23**	94.63

AICRP (Wheat & Barley)

HEAD	Progressive Receipt of Grant against BE	Progressive Expenditure during 2020-21				Total exp. (upto Dec. 2020)	% of exp. against receipt
		Other than (TSP NEH & SCSP)	TSP	NEH	SCSP		
Grants in Aid - Capital	0	0	0	0	0	**0**	0
Grants in Aid - Salaries	1099.14	919.08	0.0	64.60	0.0	**983.68**	89.50
Grants in Aid - General :-							
(1) Pension	0	0	0	0	0	**0**	0
(2) Others	176.06	102.80	7.76	1.09	0	**111.65**	63.42
Grand Total	**1275.20**	**1021.88**	**7.76**	**65.69**	**0.00**	**1095.33**	85.89

20. JOINING, PROMOTIONS, TRANSFERS AND RETIREMENTS

New Joining

1. Dr. Sneha Adhikari, Scientist joined ICAR-IIWBR, R.S. Shimla on 07.04.2020.
2. Dr. Charu Lata, Scientist joined ICAR-IIWBR, R.S. Shimla on 07.04.2020.
3. Dr. Sunil Kumar, Pr. Scientist joined ICAR-IIWBR Karnal on 19.08.2020 on account of his transfer from ICAR-CIPHET, Ludhiana.
4. Dr. Umesh R Kamble, Scientist joined ICAR-IIWBR Karnal on 24.08.2020 on account of his transfer from ICAR-IISS, Mau.
5. Sh. Gajanand Yadav, Sr. Admn. Officer joined ICAR-IIWBR Karnal on 31.12.2020 on account of his transfer from ICAR-IISWC, Dehradun.

Promotions

Scientific staff

1. Dr. Amit Sharma, Sr. Scientist promoted to Pr. Scientist from RGP ₹ 9000 to RGP 10000.
2. Dr. Poonam Jasrotia, Sr. Scientist promoted to Pr. Scientist from RGP ₹ 9000 to RGR 10000.
3. Dr. Ankita Jha, Scientist promoted from RGP ₹ 6000 to RGP 7000

Technical Staff

1. Sh. Rajesh Kumar, STA promoted to Technical Officer.
2. Sh. Bhal Singh, STA promoted to Technical Officer.

Administration Staff

1. Smt. Promila Verma, Assistant promoted to Asstt. Administrative Officer
2. Sh. Ramesh Chand, UDC promoted to Assistant
3. Smt. Sushila, UDC promoted to Assistant

SSS Staff

1. Sh. Raj Kumar, SSS was granted MACP from GP 2000 to 2400.

Transfer

1. Sh. Sachin Agnihotri, Sr. Administrative Officer transferred from ICAR-IIWBR, Karnal to ICAR-Research Complex for NEH Region, Umiam on 30.12.2020.

Retirements

1. Dr. RK Sharma, Pr. Scientist on 31.03.2020
2. Smt. Jamuna Devi, STA on 31.12.2020
3. Sh. Raj Kumar, SSS on 31.12.2020

Retirement of Dr. RK Sharma, Principal Scientist

Bid farewell to Sh. Sachin Agnihotri SAO on his transfer

Note

हर कदम, हर डगर
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