भाकृअनुप
ICAR

वार्षिक प्रतिवेदन
ANNUAL REPORT
2017-18

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

करनाल – 132001, भारत

ICAR-Indian Institute of Wheat and Barley Research

Karnal-132001, India

MANDATE

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

THE MISSION

Ensuring food security of India by enhancing the productivity and profatibility of Wheat and Barley on an ecologically and economically sustainable basis and making India the world leader in wheat production.

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भा.कृ.अनु.प.-भारतीय गेहूँ एवं जौ अनुसंधान संस्थान
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डॉ. ज्ञानेन्द्र प्रताप सिंह
निदेशक
Dr. G.P. Singh
DIRECTOR

PREFACE

It gives me immense pleasure to bring out the Annual Report (2017-18) of ICAR- Indian Institute of Wheat and Barley Research, Karnal. The institute undertakes multi-disciplinary research to enhance the production and productivity of wheat and barley crops in India. India is one of the largest producers of wheat and barley in the world. Wheat and barley covers around 31 mha (wheat: 30.05 mha and barley: 0.74 mha) during 2017-18 crop season. Wheat production has substantially increased by 848 per cent post implementation of the AICRP. Wheat output for the current season has reached an all-time record of 98.61 mt which is a big achievement made by all stakeholders involved in raising the yield potential.

During the reported period seven new varieties of wheat (K1317, DBW168, DBW173, UAS375, HI1612, MACS4028 (d) and HI8777) and one variety of barley (DWRB137) were released by the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops (CVRC) for different production conditions and agro-ecological zones in the country. In addition, fourteen genetic stocks of wheat and four of barley were developed by the institute. On seed production front, a total of 35174.91q breeder seed of wheat and 1521.86q breeder seed of barley were produced of different prominent varieties to meet the quality seed demand of the country. The threats of yellow rust in northern India and of wheat blast in Eastern India were successfully averted during 2017-18 crop season through strategic planning and strict vigil as well as through creating awareness among farmers and state government agencies.

14 teams of scientists are engaged in outreach activities as part of Mera Gaon Mera Gaurav Programme. Furthermore, I would also like to congratulate the scientists and staff who have bagged various awards and recognitions at various platforms during the past year.

I feel extremely proud to share that recently ICAR bagged the prestigious BGRI Gene Stewardship Award at Marrakech, Morocco in recognition of outstanding work done by Indian wheat programme. I take this opportunity to thank all the present and past authorities of ICAR, past project directors of the institute and all the cooperating staff and centres for their contribution. I would like to place on record my sincere gratitude to Dr. T. Mohapatra. Secretary DARE and DG-ICAR, Dr. A.K. Singh, DDG (Crop Science), Dr. I.S. Solanki, ADG (FFC) and Dr. H.S. Gupta, Chairman as well as members of the Research Advisory Committee for providing valuable guidance, truthful direction and concrete suggestions towards development and implementation of various research programs.

Finally, I would like to applaud the entire team of scientists and the staff for carrying out their work efficiently and at the same time presenting their results in a most comprehensive manner as reflected in this report. I hope that the salient research and technological developments during 2017-18 along with other noteworthy organizational activities would be an effective resource for planners, researchers and managers.

(GP Singh)

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कार्यकारी सारांश

फसल सुधार

गेहूँ की नई किस्में और जेनेटिक स्टॉक्स

- सी.वी.आर.सी द्वारा गेहूँ की सात नई किस्में रिलीज की गई जिनमें से पाँच किस्में चपाती गेहूँ की (के 1317, डी बी डब्ल्यू 168, यू ए एस 375 एच आई 1612) तथा दो किस्में कठिया गेहूँ की (एम ए सी एस 4028 डी और एच आई 8777) हैं। ये किस्में देश की विभिन्न उत्पादन स्थितियों और कृषि पारिस्थितिक क्षेत्रों के लिए हैं।

- संस्थान द्वारा विकसित की गई गेहूँ की दो किस्मों में से डी बी डब्ल्यू 168 को प्रायद्वीपीय क्षेत्र, सिंचित व समय से बुआई के लिए तथा डी बी डब्ल्यू 173 को उत्तर पश्चिम मैदानी क्षेत्रों में सिंचित, देरी से बुआई की दशा के लिए सी.वी.आर.सी द्वारा जारी किया गया।

- गेहूँ के चौदह जेनेटिक स्टॉकों (जो बीमारियों के प्रति प्रतिरोधक एवं बिस्कुट बनाने के लिए उपयुक्त थे) को एन.बी.पी.जी.आर, नई दिल्ली की पौध जननद्रव्य पंजीकरण समिति द्वारा पंजीकरण के लिए उपयुक्त पाया गया।

अखिल भारतीय समन्वित गेहूँ एवं जौ अनुसंधान परियोजना के तहत गेहूँ की जीनोटाईप्स का बहु–स्थानिक मूल्यांकन

- पच्चीस परीक्षण श्रृंखलाओं में 63 जाँचक किस्मों के साथ प्रजनकों द्वारा विकसित 401 गेहूँ की जीनोटाईपों को उपज, बीमारी, गुणवता और सस्य संबंधी विशेषताओं के लिए बहु–स्थानिक मूल्यांकन पूरे देश में फैले 149 केंद्रों पर किया गया। 415 परीक्षणों में से 279 परीक्षणों के आंकड़े निर्धारित मानदंडों के आधार पर रिपोर्टिंग के लिए उपयुक्त पाये गये।

- 56 वें अखिल भारतीय गेहूँ और जौ अनुसंधान कार्यकर्ताओं की बैठक दिनांक 25–28 अगस्त, 2017 के दौरान बी.एच.यू. वाराणसी में आयोजित हुई। इसमें वैरायटल आइडैन्टिफिकेशन कमेटी (वी.आई.सी) ने गेहूँ की 6 जीनोटाईप (डी बी डब्ल्यू 173, एच.आई 1612, डी बी डब्ल्यू 168, यू ए एस 375, एच आई 8777 डी, एम एसी एस 4028 डी) को किस्म के रूप में जारी करने के लिए चिन्हित किया।

- उपज और मूल्यांकन के लिए महत्वपूर्ण श्रेष्ठता के आधार पर आशाजनक प्रविष्टियों को मूल्यांकन प्रक्रिया के अगले चरण के लिए अनुशंसित किया गया। इस वर्ष 59 ए.वी.टी जीनोटाईप में से केवल 4 जीनोटाईप बेहतर पाए गए और ए.वी.टी–2 में शामिल किए गए। विशिष्ट आवश्यकताओं के लिए 7 विशेष परीक्षणों में मुल्यांकित किए गए 30 जीनोटाईप में से चार जीनोटाईप को अति विलम्ब बुआई के द्वितीय चरण में मुल्यांकन के लिए उपयुक्त पाया गया।

- सात एन.आई.वी.टी में परीक्षण की गई कुल 277 प्रविष्टियों और आई.वी.टी में 38 प्रविष्टियों, में से 68 जीनोटाईप (चपाती गेहूँ के 56 एवं कठिया गेहूँ के 12) को ए.वी.टी–1 में मुल्यांकन के लिए उपयुक्त पाया गया।

बीज उत्पादन

देश में प्रजनक बीज उत्पादन की मांग को पूरा करने के लिए गेहूँ की 157 किस्मों के 22145.69 कुंतल प्रजनक बीज के आवंटन के सापेक्ष कुल 35174.91 कुंतल प्रजनक बीज का उत्पादन किया गया जो आवंटित की गई मात्रा से 13029.22 कुंतल अधिक है। इसके अलावा 163 किस्मों के कुल 1610.97 कुतल के नाभकीय बीज का उत्पादन भी आवंटित मात्रा से 604 कुंतल अधिक किया गया।

जननद्रव्य संरक्षण, मूल्यांकन एवं वितरण

- जननद्रव्य विनिमय में संस्थान ने देश के विभिन्न मांगकर्ताओं को 1495 अभिगम प्रदान किए। गुणन और संरक्षण के लिए एन.बी.पी.जी.आर से सात नए पंजीकृत जेनटिक स्टॉक प्राप्त किए गए।

- गेहूँ के 502 स्वदेशी और विदेशी अभिगम भा.गे.जौ.अनु. सं, करनाल में वर्णित किए गए थे। प्रजनन में उपयोग के लिए विभिन्न उपज घटक लक्षणों और गुणवता के लिए दाताओं को चिन्हित किया गया।
- पावर कोर सॉफ्टवेयर का उपयोग करके 7038 अभिगमों के मूल संग्रह से 122 का एक मूल सेट विकसित किया गया।
- मौजूदा श्रेणी के तहत पी.पी.वी एंड एफ.आर.ए 2001 के तहत संरक्षण हेतु गेहूँ की डब्ल्यू बी 2 किस्म का पंजीकरण प्रस्ताव पी.पी.वी एंड एफ.आर.ए, नई दिल्ली को प्रस्तुत किया गया।
- दो डी.यू.एस परीक्षणों में 44 संदर्भ किस्मों के सापेक्ष 13 नई किस्मों का परीक्षण किया गया था।

अनुसंधान परियाजनाओं के मुख्य बिंदु

- पूर्व प्रजनन कार्यक्रम में गेहूँ की 10 जंगली प्रजातियों (3 डिप्लोइड और 7 टेट्राप्लाइड) के 200 अभिगमों का मूल्यांकन, फिनोलॉजी, कार्यिकी, सस्य संबंधी लक्षणों और बीमारियों के लिए किया गया था। उष्ण तनाव सहनशीलता के लिए कठोर परिस्थितियों में तीस सिंथेटिक लाईनों का मूल्यांकन किया गया था। संरक्षित कृषि के अनुकूल पहचान के लिए हिसार फार्म में द्वितीय पीढ़ी के 18 पादप समूहों का मूल्यांकन किया गया।
- उत्तरी भारत परियोजना के उच्च उत्पादक वातावरण के लिए गेहूँ सुधार कार्यक्रम के तहत एन.डब्ल्यू.पी.जेड के सिंचित, देर से बोए गए परिस्थितियों में खेती, अन्तस्थ के ताप प्रति सहिष्णुता के लिए पहचान की गई थी। इस परियोजना में भा.गे.जौ.अनु.सं के स्टेशन परीक्षणों में परीक्षण किए गए 21 में से 12 उदीयमान प्रविष्टियों को एन.आई.वी.टी के लिए अनुशंसित किया गया। डी बी डब्ल्यू 187 को उ.प.मै.क्षे की सिंचित, समय से बीजाई के लिए ए.वी.टी में अनुशंसित किया गया। जबकि डी.बी. डब्ल्यू 223 और डी बी डब्ल्यू 237 को विभिन्न ए.वी.टी में अनुशंसित किया गया।
- पूर्वी क्षेत्र के लिए गेहूँ प्रजनन परियोजना में, तीन जीनोटाईप एल.बी.आआर.आई.एल 1819 (स्पॉट ब्लॉच प्रतिरोधकता) डी.बी.डब्ल्यू 150 (उश्ण सहिष्णुता) और एल.बी.पी.वाई 11–2 (शीघ्र बुआई और मोटे दानों) को जेनटिक स्टॉक के रूप में पंजीकृत किया गया।
- बंग्लादेश में गेहूँ के झोंका रोग (व्हीट ब्लास्ट) की उपस्थिति की रिपोर्टो के मद्धेनजर भा.गे.जौ.अनु.सं, करनाल में प्रजनन कार्यक्रम शुरू किया और बंग्लादेश की सीमाओं के साथ पश्चिम बंगाल और असम में 88 प्रविष्टियों का एक विशेष परीक्षण नर्सरी का गठन किया।
- उश्ण क्षेत्रों के लिए गेहूँ के सुधार पर परियोजना में, वांछनीय गुणों को शामिल करने के लिए 262 नए संकरण बनाए गए। विभिन्न एन.आई.वी.टी में चार प्रविष्टियों का मूल्यांकन किया गया और ए.वी.टी में दो प्रविष्टियों डी.बी.डब्ल्यू 221 और डी.बी.डब्ल्यू 252 का मूल्यांकन किया गया। एन.जी.एस.एन के हिस्से के रूप में 30 सहयोगी केंद्रों के साथ 10 उदीयमान लाईनों को साझा किया गया।
- अनाज गुणवत्ता कार्यक्रम के लिए कठिया गेहूँ के सुधार से, क्यू एल डी 46 (उच्च प्रोटीन मात्रा) और क्यू एल डी 49 (नरम दाना) जेनेटिक स्टॉक के रूप में पंजीकृत किया गया।
- बसंत x शरदकालीन गेहूँ संकरण कार्यक्रम में, नई विविधता लाने के लिए 71 एकल संकरण और 178 त्रिसंकरण बनाए गए। राष्ट्रीय समेकित विविधता परीक्षणों में आठ प्रविष्टियों का योगदान दिया गया। बसंत x शरदकालीन गेहूँ प्रथकीकरण स्टॉक नर्सरी एस डब्ल्यू एस एन जिसमें एफ 2 पीढ़ी में 46 क्रॉस शामिल थे, को छह सहयोगी केंद्रों के साथ साझा किया गया।

जैव प्रोद्योगिकी का योगदान

- 54 एस.एन.पी मार्कर का प्रयोग 306 जीनोटाईप का डी. एन.ए बारकोड विकसित करने के लिए किया गया।
- सूखा तनाव की स्थिति के तहत डीनोवो गेहूँ के जड़ ऊतक ट्रांसक्रिप्टोम डेटा पर एक व्यापक रिपोर्ट तैयार की गई।

- टी.एस.एस.आर.डी.बी व्हीट माइक्रोसैटेलाइट डेटाबेस विकसित किया गया जिसमें 476169 एस.एस.आर मार्कर शमिल थे।

- जीनोम वाइड एसोसिएशन स्टडीज (जी.डब्ल्यू.ए.एस) के तहत 27 एग्रो मॉर्फोलॉजिकल गुणों के साथ महत्वपूर्ण एम.टी.ए का पता लगाने के लिए उच्च धनत्व 35 के एस.एन.पी चिप का उपयोग किया गया था।

- उच्च तापमान और सूखे के तहत वसंत कालीन के गेहूँ राइजास्फीयर के मेटाजेनीमिक अध्ययन शुरू किया गया।

- गर्मी और सूखे की स्थिति के लिए गेहूँ में टी.ए.डब्ल्यू. आर.के.वाई ट्रांसक्रिप्शन कारक परिवार का अभिव्यक्ति अध्ययन किया गया।

- उपज सुधार के लिए जारी किए गए गेहूँ की किस्मों का अध्ययन उनके स्रोत और प्रकाश संश्लेषण के सिंक गुणों की पहचान की गई।

फसल सुरक्षा

- फसल सत्र 2016–17 में उत्तर भारत में गेहूँ के पीले रतुआ और पूर्वी भारत में ब्लास्ट रोगों के खतरे को रणनीति नियोजन, सफल कार्यान्वयन और सख्त सतर्कता के साथ–साथ किसानों और राज्य सरकार एजेंसियों के बीच सामंजस्य व जागरूकता पैदा करके सफलतापूर्वक रोका गया।

- कई बीमारियों और कीटों के प्रतिरोध वाले विभिन्न जीनोटाईपों की पहचान की गई और गेहूँ प्रजनकों के साथ इस तरह के 51 जीनोटाइपों को साझा किया गया।

- पिछले फसल सत्र की तरह 2016–17 की फसल भी देश के केंद्रीय और प्रायद्वीपीय क्षेत्रों में करनाल बंट रोग से मुक्त रही इसलिए इन क्षेत्रों का उपयोग करनाल बंट से मुक्त गेहूँ के उत्पादन के लिए किया जा सकता है।

- गेहूँ की किस्मों और प्रविष्टियों का परीक्षण, सबसे प्रचलित और हालिया विकसित पीला रतुआ रोग प्रवाहों, 110 एस 119, 110 एस 84 और 40 एस 119 के खिलाफ किया गया था और काफ़ी प्रजातियाँ और प्रविष्टियाँ प्रतिरोधी (एसीआई 0–10.0) मिली।

- वर्ष 2016–17 फसल के दौरान 200 गेहूँ की जर्मप्लाज्म लाईनों को अनावृत कंड प्रतिरोधकता के लिये जाँचा गया जिसमें 33 लाईनें संक्रमण से मुक्त थीं और 76 रोग प्रतिरोधी पाई गई। जबकि 93 लाईनें ध्वज कंड संक्रमण से मुक्त और 65 प्रतिरोधी थीं ।

- गेहूँ के ध्वज कंड के रोगजनक यूरोसिस्टिस एग्रोपीरी का पता लगाने के लिए पोलीमरेज श्रृंखला अभिक्रिया (पीसीआर) आधारित एक सरल और तेज़ विधि विकसित की गई।

- गेहूँ की कुल 40 किस्मों में झोंका रोग से प्रतिरोधकता की जाँच बोलीविया और संयुक्त राज्य अमेरिका भेजी गईं। जिसमें पांच किस्मों में ब्लास्ट रोग से प्रतिरोधकता पाई, इसमें सबसे लोकप्रिय गेहूँ की किस्म एचडी 2967 भी एक है।

- पूर्वी भारत के लिय गेहूँ में झोंका रोग की रोकथाम के लिय एक तदर्थ आईपीएम मोड्यूल तैयार किया गया जो डीएसी एंड एफडब्ल्यू के माध्यम से राज्य कृषि विभागों को दिया गया।

- बीसीकेवी, कल्याणी में राज्य कृषि विभागों, सहकारी समितियों और विस्तार एजेंसियों के लिए 3 फरवरी, 2017 को "गेहूँ में रोग निगरानी और स्वस्थ बीज उत्पादन" विषय पर एक प्रशिक्षण कार्यक्रम आयोजित किया गया।

- तीन भारतीय वैज्ञानिकों को बांग्लादेश, बोलीविया, यूएसए और मेक्सिको में गेहूँ के ब्लास्ट रोग पर प्रशिक्षित किया गया।

- वर्ष 2017–2018 में कुल 98 गेहूँ जीन प्रारूपों का मूल्यांकन पत्ती के माँहू प्रतिरोधकता के लिए किया गया, जिसमें ट्रिटिकम एस्टीवम, ट्रिटिकम ड्यूरम, ट्रिटिकम डाइकोकम एवं 20 एजिलॉप्स प्रजातियां शामिल थी ।

- पत्ती के माहू की बैठने की क्षमता एवं उर्वरता का मूल्यांकन तीन तरह के जीन प्रारूपों ट्रिटिकम एस्टीवम, ट्रिटिकम ड्यूरम एवं एजिलॉप्स स्पेल्टॉयडिस प्रजातियाँ पर किया गया ।

- शून्य जुताई खेती के मुकाबले पारंपरिक जुताई प्रणाली में पत्ती के माहू का प्रकोप सबसे ज्यादा था। इसी तरह शून्य जुताई में जड़ के माहू एवं दीमक का प्रकोप कम था लेकिन गुलाबी तना बेधक की समस्या अधिक थी ।

- दीमक का प्रकोप, सामान्य सिंचाई की तुलना में सीमित सिंचाई में ज्यादा था । सीमित सिंचाई में 7.5 प्रतिशत एवं सामान्य सिंचाई 2.9 प्रतिशत दीमक का प्रकोप पाया गया । सामान्य सिंचाई की तुलना में सीमित सिंचाई में गेहूँ की उपज भी कम थी ।

- गेहूँ प्रजातियों का अध्ययन भंडारण कीटों (राइजोपर्था डोमिनिका और सिटोफिलस ओराईजी) के लिए प्रतिरोधता के लिए गया। डोमिनिका प्रजाति के उच्चतम उन्मुखीकरण व्यवहार (9.2 वयस्क) डीबीडब्ल्यू 88 पर और सबसे कम (5.0) एचडी 2967 में दर्ज किया गया।

संसाधन प्रबन्धन

- धान–गेहूँ प्रणाली के अन्तर्गत विभिन्न जुताई विकल्पों के दीर्घकालीन प्रभाव का धान अथवा गेहूँ की उपज पर देखा गया तथा यह पाया गया कि इसका गेहूँ की उत्पादकता पर कोई प्रभाव नहीं पड़ता है।

- जुताई का दीर्धकालीन प्रभाव गेहूँ की खेती पर नहीं देखने को मिला लेकिन धान में जुताई, विशेषकर जीरो अर्थात् बिना जुताई धान की रोपाई विकल्प का धान की उत्पादकता पर प्रतिकूल प्रभाव पाया गया।

- जुताई, अवशेष प्रबंधन एवं इनका आपस में गेहूँ की प्रजातियों/किस्मों के साथ आपसी क्रिया की कोई महत्वपूर्ण प्रतिक्रिया नहीं पाई गई।

- दीर्घकालीन जुताई प्रयोगों के अंतर्गत मक्का–गेहूँ–मूंग फसल–प्रणाली में पाया गया कि जुताई एवं अवशेष प्रबंधन का गेहूँ की उत्पादकता पर कोई महत्वपूर्ण प्रभाव नहीं पड़ा लेकिन मक्का की उत्पादकता संरक्षण कृषि में सामान्य जुताई वाले खेत से ज्यादा पाई गई।

- गेहूँ को धान तथा मक्का के अवशेषों की उपस्थिति में टर्बो हैप्पी सीडर का उपयोग कर सफलतापूर्वक बोया जा सकता है पर गन्ने की रैटून फसल में रोटरी डिस्क ड्रिल द्वारा गेहूँ की बिजाई प्रभावी रूप से की जा सकती है।

- समेकित पोषण प्रबंधन में अनुशंसित उर्वरकों (150:60:40) नाइट्रोजन, फॉस्फोरस एवं पोटाश की मात्रा 15 टन/है. की दर से देशी खाद का उपयोग सबसे अधिक उत्पादकता देने वाला पाया गया।

- जैविक उत्पादन प्रयोग में 10 से 30 टन प्रति है. देशी खाद डालने से गेहूँ की उच्च उत्पादकता किस्मों (डी.पी. डब्ल्यू 621–50, एच डी 2967, पी.बी.डब्ल्यू 550 एवं डब्ल्यू एच 1105) की उत्पादकता जाँचक प्रजातियों की तुलना में सार्थक रूप में बढ़ी लेकिन अनुशंसित उर्वरकों (एन पी के 150:60:40) की तुलना में सार्थक रूप से कम पाई गई।

- वर्मी कम्पोस्ट का 2.5 से 7.5 टन/है. की दर से पहली सिंचाई पर छिड़काव का गेहूँ की उन्नत किस्मों की गेहूँ उत्पादकता पर प्रभाव नहीं पाया गया।

- पोटेशियम ह्यूमेट के 10–50 कि.ग्राम/है. की दर से उपयोग करने से गेहूँ की उत्पादकता एवं गुणवत्ता पर कोई सार्थक प्रभाव नहीं पाया गया।

- धान की पराली को मृदा में मिलाने के उपरान्त उसमें 25 प्रतिशत अधिक नत्रजन देने से गेहूँ की पैदावार में वृद्धि होती है।

- दलहन फसलों को मक्के के साथ अन्तःफसलीकरण करने से गेहूँ में 25 प्रतिशत नत्रजन की बचत होती है।

- बेड प्लांटिंग के अन्तर्गत घिया (लोकी) व तर–ककड़ी को नालियों में लेने से अधिक लाभ मिलता है।

- गेहूँ की फसल में पाए जाने वाले पाँच मुख्य खरपतवार (फैलेरिस माइनर, एवीना ल्यूडोवीसियाना, पोलीपोगोन मोनस्प्लईनिसस, रूमेक्स डेन्टाटस और चिनोपोडियम

एल्बम) में शाकनाशी प्रतिरोधकता विकसित हो गयी है।

- गेहूँ में विभिन्न प्रकार के चौड़ी पत्ती वाले खरपतवारों के नियंत्रण के लिए हलॉक्सिफेन+फ्लोरक्सीपायर 200.6 (6.1+194.5)ग्राम/हैक्टर या हलॉक्सिफेन+ फ्लोरासूलम +कारफेट्रोजोन (10.21+20) ग्राम/हैक्टर या मैटसल्फ्यूरॉन +कारफेट्रोजोन 4+20 ग्राम/है. की दर से डालने पर प्रभावशाली पाए गए।

- गेहूँ की विभिन्न प्रजातियों की जल उपयोग दक्षता के अध्ययन के लिए मृदा नमी के तीन स्तरों पर परीक्षण किये गए। गेहूँ की जल उपयोग दक्षता एवं विभिन्न अजैविक तनावों में सुधार के उपायों का पता लगाने के लिए भी परीक्षण किये गये। यह परीक्षण संरक्षण और परंपरागत (टिलेज) जुताई प्रणाली के अंतर्गत किये गए। विभिन्न प्रयोगों के परिणामों में यह दर्ज किया गया कि जल उपयोग दक्षता के लिए गेहूँ की विभिन्न प्रजातियों के बीच महत्वपूर्ण भिन्नता थी। सीमित पानी की उपलब्धता के तहत 4 टन प्रति हैक्टर की दर से फसल अवशेष रखना लाभदायक साबित हुआ।

- जल उपयोग दक्षता तथा अजैविक तनावों में सुधार के लिए पोटेशियम व सैलिसिलिक अम्ल के पर्णीय छिड़काव तथा सैलिसिलिक अम्ल द्वारा बीज प्राईमिंग की भूमिका का अध्यन करने के लिए भी परीक्षण किये गए। पोटेशियम का पर्णीय छिड़काव विभिन्न प्रकार के तनावों को कम करने तथा जल उपयोग दक्षता में सकारात्मक प्रभावों की पुष्टि करता है।

- गेहूँ की फसल में विनियमित कम सिंचाई के प्रभाव की जांच के लिए अनुसंधान भी किया गया तथा गेहूँ की फसल के लिए सूक्ष्म सिंचाई प्रणाली (टपका एवं फव्वारा) की दक्षता का अध्ययन किया गया। विनियमित कम सिंचाई के प्रभाव पर प्रयोग के लिए दर्ज आंकड़ों से पता चलता है कि सिंचाई के पानी में कम से कम 25 प्रतिशत की बचत संभव है, अगर सिंचाई को, फसल की महत्वपूर्ण विकास चरणों में ठीक से लागू किया जाये। सामान्य सिंचाई जिसमे की प्रति सिंचाई कम से कम 60 एम.एम. पानी लगता है, के समान उपज 45 एम.एम. प्रति सिंचाई पानी से भी प्राप्त की जा सकती है।

- वर्ष 2016–17 के दौरान कुल 12 उपग्रह चित्र (पाथ 147 एवं रो 39,40) प्राप्त किए गए। तत्पश्चात् इनकी मौजेकिंग प्रक्रिया द्वारा करनाल जिले का सबसेट बनाया गया। जिओरेफेंरेन्सिंग एवं डिजिटलीकरण विधि द्वारा करनाल जिले की सीमा का रेखांकन किया गया। एन्वी–4.8 सॉफ्टवेयर की सहायता से करनाल जिले की भूमि उपयोग एवं भूमि आवरण जो कि विभिन्न मदों के अंतर्गत विभाजित है (गेहूँ, अन्य फसल, रिहायसी, नदी, जंगल इत्यादि) को वर्गीकृत किया गया। इस वर्ष के दौरान गेहूँ फसल का क्षेत्रफल करनाल जिले में लगभग 176700 हैक्टर पाया गया जो कि सरकारी दस्तावेजों से लगभग मेल खाता है (173947 हैक्टर)। इससे यह सिद्ध होता है कि रिमोट सेंसिंग की मदद से क्षेत्रफल का अनुमान लगाना सार्थक हो सकता है।

गुणवत्ता व मूलभूत विज्ञान

- ट्रीटीकम ऐस्टिवम में कई प्रभेद चपाती बनाने के लिए योग्य पाई गई हैं (गुणवत्ता अंक 10 में से 8 से ज्यादा)। इन प्रभेदों में शामिल हैं डी.बी.डब्ल्यू 168 डीबीडब्ल्यू 39, एच.डी 2888, सी 306, के 8027, के 1317, एम.ए.सी ,एस 6478, एन आई.ए.डब्ल्यू 1415

- पाव रोटी/ब्रेड गेहूँ की प्रभेदों यू.ए.एस 375) एम.ए.सी. एस 6222) एम.ए.सी.एस 6478) एन.आई 5439) एन. आई.डब्ल्यू 1415 में लोफ आयातन $\geq$575 सी.सी के साथ अच्छी ब्रेड गणवत्ता पाई गई।

- एच.एस 490 प्रसार गुणांक 10.0 के साथ बिस्कुट के लिए अच्छी पाई गई।

- कठिया गेहूँ (ट्रीटीकम ड्यूरम) के प्रभेदों जैसे, एच.आई 8777, एच.आई 8627, यू.ए.एस 446 ने हेडोनिक पैमाने पर 7.0/9.0 अंक के साथ अच्छी पास्ता गुणावत्ता दिखाई।

- चेक सहित सभी ए.वी.टी प्रस्तुतियों में ग्लू–ए1) ग्लू–बी1 एवं ग्लू–डी1 द्वारा कोडिड उच्च आणविक भार ग्लूटन सब यूनिट इकाईयों की पहचान की गई।

- श्रेष्ठ प्रजातियों की पोषण मापदंडों सहित अलग–अलग गुणवत्ताओं विशेषताओं के लिए पहचान की गई।

- देश के 12 स्थानों पर उगाई गई क्यू.सी.एस.एन की 56 प्रविष्टियों के दानों का रंग रूप, परीक्षण भार, प्रोटीन एवं अवसादन मान के लिए आंकलन किया गया।
- तीन नर्सरियों, एन.जी.एस.एन (103 लाईनें, ई.आई.जी.एन (108 लाईनें) और एन.डी.एस.एन (80 लाईनें) के जननद्रव्य को आई.आई.डब्ल्यू.बी.आर रिसर्च फार्म), करनाल पर उगाया गया तथा उनकी जाँच पोशण गुणवत्ता मापदण्ड़ों के लिए की गई श्रेष्ठ लाईनों को प्रजनन के द्वारा गुणवत्ता सुधार के लिये अनुशंसित किया गया।
- भारत में विमोचित गेहूँ की 300 से ज्यादा एवं ई.एम.एस द्वारा विकसित 500 म्यूटेंट लाईनों का फाईटेज एवं फाईटिक अम्ल के लिए मूल्यांकन किया गया। हमारी प्रयोगशाला में विकसित प्रत्यक्ष परख विधि का उपयोग एन्जाईम क्रियाशीलता के अध्ययन में किया गया और इससे पुनरूत्पादनीय परिणाम प्राप्त हुए। इस अध्ययन द्वारा गेहूँ की किस्मों में फाइटेज के स्तर में 6 गुणा विविधता पाई गई।
- पी.बी.डब्ल्यू 502 की पृष्ठभूमि में विकसित 500 लाईनों के एक सेट में से 20 लाईनों को उच्च फाइटेज स्तर (2000 एफ.टी.यू / कि.ग्रा) के लिए चयनित किया गया तथा सूक्ष्म तत्वों की उपलब्धता में सुधार के लिए इन्हें अधिक उपज वाली किस्मों के साथ संकरण के लिए फसल वर्ष 2017–18 में उगाया गया।
- उच्च प्रोटीन तथा अधिक लौह एवं जस्ते से सम्बंधित अणु सूचकों की पहचान के लिए जीपी सी–बी1 जीन वाली गेहूँ की लाईन तथा अधिक उपज वाली किस्म एच.डी 2967 के संकरण से आर.आई.एल विकसित की गई।
- उच्च उत्पादकता वाली प्रजातियों और नापहाल के मध्य अनेक संकरण बनाए तथा इनसे उत्पन्न लाईनों को 2017–18 के दौरान उगाया गया एवं ग्लूटेन की मजबूती और दानों की कठोरता के लिए आंकलन किया। बिस्कुट गुणवत्ता में सुधार के लिए ग्लू–डी 1 डबल नल एवं नरम दानों की पहचान के लिए अणु / सूचकों (एम.ए.एस) का उपयोग किया गया।
- नापहाल में ग्लू–डी1 डबल नल से सम्बंधित सहप्रभावी मार्कर की पहचान की गई। यह मार्कर उच्च उत्पादकता वाली किस्मों की बिस्कुट की गुणवत्ता बढ़ाने के लिए प्रजनन कार्यक्रमों में ग्लू–डी1 डबल नल के स्थानांतरण में उपयोगी है।
- लवणीय तनाव की स्थिति में उपज के साथ पोटाशियम और प्रोलीन का महत्वपूर्ण सकारात्मक सबंध तथा सोडियम का नकारात्मक सबंध पाया गया। सोडियम, पोटेशियम और प्रोलीन स्तर की लवणीय तनाव की स्थिति में उच्च आनुवंशिकता यह दर्शाती है कि ये लक्षण लावणीय तनाव के लिए गेहूँ की किस्मों के चुनाव एवं प्रजनन के लिए इस्तेमाल किए जा सकते हैं।
- लवणीय तनाव सम्बंधित लक्षणों के लिए चित्रित 21 गुणसूत्रों पर 13 महत्वपूर्ण क्यू.टी.एल पाए गए।

सामाजिक विज्ञान

- वर्ष 2016–17 में रबी फसल सत्र के दौरान देश भर में एक–एक हैक्टर के 600 अग्रिम पंक्ति प्रदर्शन 83 समन्वयक केन्द्रों को आवंटित किए गए थे। जिनमें से 543 अग्रिम पंक्ति प्रदर्शनों का आयोजन 79 समन्वयक केन्द्रों द्वारा किया गया। गेहूँ के अग्रिम पंक्ति प्रदर्शन को 19 राज्यों में 1238 किसानों के 547.4 हैक्टर क्षेत्र में आयोजित किया गया।
- गेहूँ पर अधिकतम अग्रिम पंक्ति प्रदर्शन उत्तर प्रदेश (77), इसके बाद मध्य प्रदेश (57) एवं राजस्थान (46), में आयोजित किए गए। अधिकतम उपज लाभ पश्चिम बंगाल (33.82 प्रतिशत) में इसके बाद उत्तराखंड (29.25 प्रतिशत) एवं झारखंड (27.12 प्रतिशत) में दर्ज किया गया। उन्नत किस्मों के कारण अधिकतम उपज लाभ प्रायद्वीपीय क्षेत्र (37.26 प्रतिशत) में इसके बाद उत्तर पूर्वी मैदानी क्षेत्र (33.39 प्रतिशत) उत्तरी पर्वतीय क्षेत्र (30.41 प्रतिशत) उत्तर पश्चिमी मैदानी क्षेत्र (18.75 प्रतिशत) एवं मध्य क्षेत्र (16.31 प्रतिशत) में दर्ज किया गया।
- मध्य क्षेत्र के इन्दौर केन्द्र पर उन्नत कठिया गेहूँ की प्रजातियों के संदर्भ में एच.डी. 8713 ड्यूरम ने औसत उपज 71.50 कुन्तल / हैक्टर, इसके बाद एच.आई.

8737 ड्यूरम ने 70.75 कुन्तल / हैक्टर महत्वपूर्ण उपज दी।

- गेहूँ के अग्रिम पंक्ति प्रदर्शन में संसाधन संरक्षण तकनीकों के अंतर्गत शून्य जुताई तकनीक में उपज प्रभाव पंतनगर को छोड़कर सभी केन्द्रों पर सकारात्मक एवं गैर–महत्वपूर्ण पाया गया। साथ ही रोटावेटर तकनीक के मामले में भी सभी केन्द्रों पर उपज प्रभाव सकारात्मक एवं गैर–महत्वपूर्ण था। भिवानी केन्द्र टपका पर सिंचाई के कारण महत्वपूर्ण उपज लाभ हुआ। वीजापुर केन्द्र पर टपका सिंचाई के कारण उपज लाभ हुआ लेकिन गैर–महत्वपूर्ण था।

- औसत रूप से, अग्रिम पंक्ति प्रदर्शन में गेहूँ की नवीन किस्में अथवा तकनीकों के कारण एक रुपये लागत के ऊपर 2.83 रुपये की आमदनी प्राप्त हुई। जबकि जाँचक प्रजातियों के साथ यह आमदनी 2.48 रुपये थी। विभिन्न राज्यों जैसे पंजाब से लेकर नागालैंड तक यह 6.51 से 1.76 रुपये तक का अन्तर देखा गया। वही दक्षिणी पर्वतीय क्षेत्र से उत्तरी पर्वतीय क्षेत्र में 3.77 से 3. 32 रुपये तक का अन्तर पाया गया। हैप्पी सीडर के प्रयोग से 8.25 रुपये जबकि फव्वारा सिंचाई तकनीक के प्रयोग से 2.10 रुपये देखने को मिला।

- सभी क्षेत्रों की समग्र बाधाओं के विश्लेषण से पता चलता है, कि नई संस्तुत किस्मों के बीज की अनुपलब्धता गेहूँ उत्पादन एवं उत्पादकता को प्रभावित करने वाली मुख्य बाधा थीं।

- रबी फसल सत्र 2016–17 के दौरान जौ के 100 अग्रिम पंक्ति प्रदर्शन देश भर के 6 राज्यों; हिमाचल प्रदेश, उत्तर प्रदेश, पंजाब, हरियाणा, राजस्थान एवं मध्य प्रदेश के 20 समन्वयक केन्द्रों को आवंटित किए गये थे, जिनमें से 85 अग्रिम पंक्ति प्रदर्शन का आयोजन 18 समन्वयक केन्द्रों द्वारा 206 किसानों की 93.7 हैक्टर भूमि पर किया गया।

- अधिकतम उपज लाभ उत्तर प्रदेश (25.33 प्रतिशत) में, इसके बाद हिमाचल प्रदेश (23.51 प्रतिशत) एवं मध्य प्रदेश (19.46 प्रतिशत) में दर्ज किया गया जबकि सबसे कम उपज वृद्धि पंजाब (05.55 प्रतिशत) में देखी गई। उन्नत किस्मों के कारण क्षेत्रीय औसत उपज से अग्रिम पंक्ति प्रदर्शन में अधिकतम उपज लाभ उत्तरी पर्वतीय क्षेत्र (43.21 प्रतिशत) में इसके बाद मध्य क्षेत्र (39.42 प्रतिशत) उत्तर पूर्वी मैदानी क्षेत्र (36.47 प्रतिशत) एवं उत्तर पश्चिमी मैदानी क्षेत्र (15.16 प्रतिशत) में दर्ज किया गया ।

- अग्रिम पंक्ति प्रदर्शन में जौ की नई प्रजातियों से जाँचक प्रजातियों की तुलना में 16 प्रतिशत अधिक आमदनी प्राप्त हुई। देश के विभिन्न राज्यों एवं केन्द्रों पर अग्रिम पंक्ति प्रदर्शन और 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 पंजाब (6.54 रुपये) में, इसके बाद उत्तर प्रदेश (4.30 रुपये) एवं राजस्थान (4.02 रुपये) में अर्जित की गई।

- विभिन्न क्षेत्रों की सभी बाधाओं के विश्लेषण द्वारा स्पष्ट रूप से संकेत मिलता है कि छोटी जोत एक गम्भीर बाधा है इसके बाद आवकों की उच्च कीमत, श्रमिकों की अनुपलब्धता, इत्यादि को देश की जौ उत्पादन एवं उत्पादकता को प्रभावित करने वाली प्रमुख बाधाओं के रुप में पहचान की गई है।

- रबी सीजन 2017–18 के दौरान 20 किसानों के 8 हैक्टर खेतों में हरियाणा के कैथल जिले के रसीना व हजवाना गांवों में गेहूँ की उन्नत किस्में डब्ल्यू.बी. 2 एवं एच.पी.बी.डब्ल्यू. 01 के अग्रिम पंक्ति प्रदर्शन का आयोजन किए गए। ये सभी प्रदर्शन खेती की समग्र सिफारिशों का प्रयोग करते हुए आयोजित किए गए तथा किसानों को इस कार्यक्रम के तहत प्रावधान के अनुसार उन्नत किस्मों के बीज उपलब्ध कराए गए।

- फसल सीजन 2017–18 के दौरान भा.कृ.अनु.प. –भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल, कृषि एवं कल्याण मन्त्रालय एवं संबन्धित केन्द्रों के विशेषज्ञों के दल ने परभनी, निफाड, पुणे, अम्बाला, रोपड़, लुधियाना, पन्तनगर एवं अल्मोड़ा केन्द्रों पर आयोजित अग्रिम पंक्ति प्रदर्शनों का अवलोकन किया।

- मध्य प्रदेश के सर्वेक्षण में आकड़ों के विश्लेषण के निष्कर्षों से संकेत मिलता है कि मध्य प्रदेश के रीवा एवं

छतरपुर जिलों के कुल परिचालन जोत में फसल क्षेत्रफल क्रमशः प्रतिशत 89.30 प्रतिशत एवं 59.10 प्रतिशत था। डाटा इन्वेलपमेंट विश्लेषण (डीईए) से पता चलता है कि गेहूँ उत्पादक 89.30 प्रतिशत की दर से तकनीकी रुप से कुशल है। जबकि जौ उत्पादक 85–30 प्रतिशत की दर से तकनीकी रूप से कुशल है।

- वर्ष 2017–18 के दौरान आदिवासी उप–परियोजना (टी.एस.पी. परियोजना) के तहत लाहौल घाटी (हिमाचल प्रदेश) के 15 गांवों के 43 किसानों के लिए टी.एस.पी. परियोजना के अर्न्तगत "लाहौल घाटी के किसानों की कृषि आय में बढ़ोत्तरी" पर दो दिवसीय प्रशिक्षण कार्यक्रम का आयोजन भा.कृ.अनु.प.–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल में किया गया।
- उपरोक्त गतिविधियों के अतिरिक्त, सरकार के प्रमुख विकास कार्यक्रमों जैसे–मेरा गाँव मेरा गौरव, किसानों की आय दोगुनी करने, सॉइलहेल्थ कार्ड के प्रति जागरूकता पैदा करने से सम्बंधित गतिविधियों का सामाजिक विज्ञान इकाई समन्वय करती है।

जौ सुधार

- खाद्य जौ किस्म डी.डब्ल्यू.आर.बी 137 को उत्तरी मैदानी भाग और मध्य क्षेत्र की सिंचित एवं समय पर बुआई की दशा के लिए जारी किया गया और डी.डब्ल्यू.आर.बी 160 को एवीटी–टीएस–एमबी के प्रथम वर्ष के मूल्यांकन के लिये चुना गया।
- चार जेनेटिक स्टोकों (डी डब्ल्यू आर बी 173, डी डब्ल्यू आर बी 175, डी डब्ल्यू आर बी 176 और डी डब्ल्यू आर बी 180) को अद्वितीय गुणों के लिए आई.सी.ए.आर.–एन.बी.पी.जी.आर, नई दिल्ली में पंजीकृत किया गया।
- जौ समन्वित उपज परीक्षणों में 116 परीक्षण प्रविष्टियों को 33 चेक प्रविष्टियों के विरूद्ध 12 केंद्रों परखा पर गया।
- माल्ट जौ कार्यक्रम में 1178 संतति परिवारों के 492 संकर लाईनों को उगाया गया। फीड जौ कार्यक्रम में, 816 संतति के 200 संकर लाईनों को उगाया गया था स्टेशन उपज परीक्षण में से 10 प्रमुख जीनोटाईप चिन्हित किये गये।
- डी.डब्ल्यू.आर.एन.बी 17 और डी.डब्ल्यू.आर.एन.बी 23 छिलका रहित जीनोटाईप अधिक उपज के लिये चुनी गई। डी.डब्ल्यू.आर.एन.बी 28 बौनी जीनोटाईप (60–65 से.मी) की पहचान की गई।
- जौ के कुल 8179 जनद्रव्य को संरक्षित रखा गया। 2017–18 की रबी के दौरान, 600 जनद्रव्यों को दोबारा संरक्षित भंडारण के लिये उगाया गया।
- तीन अंतर्राष्ट्रीय परीक्षण (आई.बी.वाई.टी–एच, एन.बी. वाई.टी–एच.आई और 4वीं जी.एस.बी.वाई.टी) और अंतर्राष्ट्रीय नर्सरी (आई.बी.एन–एच.आई., इन बोर्न–एच.आई. और 4वीं जी.एस.बी.एस.एन.एन), कुल लाईनों को विभिन्न वातावरणों में मूल्यांकन किया गया। विभिन्न राज्य कृषि विश्वविद्यालय और आई.सी.ए. आर–संस्थानों में काम कर रहे जौ प्रजनकों के लिए 442 चयनित जीनोटाईप के बीज की आपूर्ति की गई।
- प्रविष्टी बी.एल–16–17–17 (बी.सी.यू 5214) को झुलसा रोग के प्रतिरोध के मध्यम स्तर (36) में पाया गया।
- फाइटिक एसिड के लिए 71 किस्मों की जांच की गई 11 किस्मों में <0.8 प्रतिशत 39 किस्मों मे 0.8 से 1.0 प्रतिशत., 18 में 1.0 प्रतिशत से 1.5 प्रतिशत तथा 3 में 1.5 प्रतिशत फाइटिक एसिड पाया गया। जीनोटाईप बी.के 1127, बी.सी.यू 2237 और बी.सी.यू 2241 में प्रोटीन 13.0 (शुष्क भार प्रतिशत) या उससे अधिक और संतोषजनक माल्ट गुणवत्ता पायी गयी।
- फाइटिक एसिड के लिए 71 किस्मों की जांच की गई और जिनमें 11 किस्मों में मात्रा <0.8 प्रतिशत, 39 किस्मों मे 0.8 से 1.0 प्रतिशत., 18 में 1.0 प्रतिशत से 1.5 प्रतिशत तथा 3 में 1.5 प्रतिशत पाई गयी।
- 1521.86 कुं. प्रजनक बीज का उत्पादन किया गया था, जिसमें आर.डी 2786 आर.डी 2794, पी.एल 426, डी. डब्ल्यू.आर 52 एवं एच.यू.बी 113 प्रजाति मुख्य रही।
- पैदावार बढ़ाने में धान के फसल अवशेषों को उपयोग में लाना लाभाविन्त साबित हुआ है। इसके साथ ही बीज

और अनाज की गुणवत्ता में भी सुधार हुआ है। लाभ प्रतिशत लागत अनुपात फसल अवशेषों के साथ जौ पैदा करने में अधिक पाए गये।

- उर्वरक की सिफारिश बायोफर्टिलाइजर मात्रा के साथ पांरपरिक विधि की तुलना (एज़ोटोबैक्टर + पी.एस.बी बैक्टीरिया) के उपयोग के साथ से उत्पादकता में वृद्धि हुई। बायोमिक्स बायोफर्टिलाइजर के मध्य क्षेत्र में बेहतर परिणाम प्राप्त हुये।
- क्लोर मेक्वाट (सी.सी.सी) 1.25 ली/है तथा इथेफोन के प्रयोग से अधिक उपज प्राप्त हुई एवं पौधे की उँचाई भी कम हुई।
- जौ की 11 जीनोटाईप की पहचान चेपा सहनशील के रूप में की गई। जीनोटाईप्स अणुसूचक एच.वी.इ.एस. एफ 16.1013 एंड बी.आर.जेड बीटा ग्लूकान की मात्रा के लिये चिन्हित किये गये।

क्षेत्रीय केंद्र शिमला

- इस वर्ष के दौरान व्यावहारिक रूप से गेहूँ और जौ के रतुआ रोगों का ज्यादा विस्तार नहीं देखा गया। उत्तरी भारत में गेहूँ के पीले रतुआ की कुछ घटनाओं को देखा गया था, जो केवल कुछ ही क्षेत्रों तक सीमित रहा।
- भारत और पड़ोसी देशों में गेहूँ और जौ के रतुआ रोगों की घटनाओं को जानने के लिए, भारत के 12 राज्यों और दो पड़ोसी देशों से 1300 से अधिक रतुआ नमूने एकत्र/प्राप्त किए गए। इनमें से 910 नमूने का विश्लेषण पूरा किया गया। इस दौरान पीले रतुआ की आबादी पीला रतुआ प्रतिरोधी जीन्स.वाई.आर 5, वाई. आर 10, वाई.आर 11, वाई.आर, वाईआर 13, वाईआर 14, वाईआर 15 और वाई.आर.एस.पी के लिए, काले रतुआ की आबादी प्रतिरोधी जीन्स.एस.आर 26, एस.आर 27, एस.आर 31, एस.आर 32, एस.आर 35, एस.आर 39, एस.आर 40, एस.आर 43, एस.आर.टी.टी 3 और एस. आर.टी.ए.एम.पी.के लिए तथा भूरा रतुआ की आबादी प्रतिरोधी जीन्स.एल.आर 24, एल.आर 25, एल.आर 29, एल.आर 32, एल.आर 39, एल.आर 42 और एल.आर 45 के लिए अप्रभावी रही।
- गेहूँ के पीले रतुए के 56 प्रतिशत नमूनों में 46एस119 को देखा गया, जिसमे पिछले वर्ष की तुलना में 6 प्रतिशत की वृद्धि दर्ज की गई, इसके बाद 34 प्रतिशत नमूनों में 110एस119 को देखा गया । गेहँ के काला रतुआ प्रभेद 40ए को सर्वाधिक नमूनों में देखा गया इसके बाद प्रभेद 11 को देखा गया। गेहूँ भूरा रतुआ के प्रभेद 77–9 (46 प्रतिशत) ने प्रभेद 77–5 (25 प्रतिशत) की जगह ले ली है।
- एवीटी प्रथम एवं द्वितीय वर्ष की 151 लाईनों, एनबीडीएसएन, ईबीडीएसएन और ब्रीडर सामग्री की सहित कुल 3600 लाईनों का मूल्यांकन गेहूँ के तीन रतुओं के विभिन्न प्रभेदों के खिलाफ किया गया। एवीटी द्वितीय वर्ष की किसी भी प्रविष्टी में काले, भूरे और पीले रतुआ के सभी प्रभेदों के लिए प्रतिरोधकता नहीं देखी गयी। एवीटी द्वितीय वर्ष की किसी भी प्रविष्टी में पीला रतुआ के सभी प्रभेदों के लिए प्रतिरोधकता नहीं देखी गयी। सात प्रविष्टियां सीओडब्ल्यू (डब्ल्यू) (सी), एचडब्ल्यू 2044 (सी), एचडब्ल्यू 5216 (सी), एमएसीएस 6222 (सी), एमपी 3288 (सी), एनआईएडब्ल्यू 1415 (सी) और यूएएस 446 ने भूरा रतुआ के सभी प्रभेदों को प्रतिरोध प्रदान किया, जबकि पांच प्रविष्टियों वीएल 892 (सी), एचडी 3043 (सी), डीबीडब्ल्यू 110, टीएल 2942 (सी) और टीएल 2969 (सी) ने काले रतुआ के सभी प्रभेदों के लिए प्रतिरोधकता दिखाई।
- पांच वाईआर (वाईआर2, वाईआर9, वाईआर18, वाईआर27 और वाईआर ए), 10 एलआर (एलआर1, एलआर2ए, एलआर3, एलआर10, एलआर13, एलआर1, एलआर23, एलआर24, एलआर26 और एलआर34) और 14 एसआर जीन्स (एसआर2, एसआर5, एसआर7बी, एसआर8ए, एसआर8बी, एसआर9बी, एसआर9इ, एसआर11, एसआर13, एसआर24, एसआर25, एसआर28, एसआर30 और एसआर31) को क्रमशः प्रतिशत 125, 134 और 131 लाईनों में देखा गया।
- गेहूँ के प्रमुख एसएआर रेगुलेटर और चीनी ट्रांसपोर्टर जीन्स को गेहूँ के पत्ती रतुआ प्रतिरोधकता के दौरान उनके प्रतिलेखन के लिए एक अध्ययन किया गया था। संदर्भ जीन अभिव्यक्ति स्थिरता अध्ययन के नतीजे

बताते हैं कि प्रारंभिक पत्ती रतुआ प्रतिरोधकता के दौरान विभिन्न समय अंतराल पर यूबीआई को गेहूँ में सबसे स्थिर संदर्भ जीन था। एसएआर से संबंधित जीन (टीएईडीएस 1, टीएनडीआर 1, टीएपीएडी 4, टीएसजीटी 1, टीएएचएसपी 90, टीएआरएआर1, टीएईडीएस 5, टीएएनपीआर 1 और टीएपीएएल) और चीनी ट्रांसपोर्टर जीन्स (टीएएचटीपी/एलआर 67 और टीएएसटीपी 13 ए) में इनोक्यूलेशन के पश्चात् अलग–अलग समय बिंदुओं जैसे 0, 1, 3, 6, 12, 24और 48 घंटे के अंतराल पर सापेक्ष अभिव्यक्ति प्रोफाइल को संगत और असंगत इंटरेक्शन के दौरान अंतर जीन अभिव्यक्ति पैटर्न को देखा गया।

- चार रतुआ प्रतिरोधी जेनेटिक स्टॉक एफएलडब्लू18, एफएलडब्लू31, एफएलडब्लू32 और एफएलडब्लू33 को एनबीपीजीआर, नई दिल्ली के साथ पंजीकृत किया गया।
- गेहूँ रोग निगरानी नर्सरी और सार्क गेहूँ रोग निगरानी नर्सरी आयोजित की गईं। गेहूँ की ब्लास्ट बीमारी तथा यूजी 99 प्रकार के गेहूँ का काला रतुआ भारत और पड़ोसी देशों में नहीं देखा गया। इस वर्ष के दौरान गेहूँ की बीमारियों विशेष रूप से रतुआ की घटनाएं कम थीं।
- विभिन्न रतुआ रोगजनकों के 144 प्रभेदों को राष्ट्रीय भंडार मे संरक्षित किया गया। भारत में रतुआ रोगों की महामारी बनाने के लिए गेहूँ और जौ रोगजनकों के प्रभेदों के नाभिक और बड़ी खेप की आपूर्ति 57 केन्द्रों/वैज्ञानिकों को की गयी।

क्षेत्रीय केंद्र दलांग मैदान (लाहौल और स्पीति)

- गेहूँ और जौ में अनुवांशिक सुधार के लिए इन फसलों की लगभग 28,000 लाईनों का संतति वृद्धिकरण किया गया ।
- देश के गेहूँ शोधकर्ताओं द्वारा गेहूँ में 500 से अधिक सुधारात्मक संकरण का कार्य किया गया।
- गेहूँ और जौ की लगभग 10000 लाईनों की पीला रतुआ और चूर्णिल आसिता रोगों के लिए जांच की गई
- गेहूँ के 9000 और जौ के 2000 जननद्रव्यों को प्राकृतिक परिस्थितियों में संरक्षित किया जा रहा है।
- गेहूँ की किस्म डीबीडब्ल्यू 168 का 7 कुंतल से अधिक बीज उत्पादन किया गया।
- जनजातीय उप योजना के तहत दिनांक 4–5 दिसंबर, 2017 के दौरान भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल में कृषि आय को बढ़ाने पर किसानों के लिये एक प्रशिक्षण कार्यक्रम का आयोजन किया गया । इस प्रशिक्षण कार्यक्रम में घाटी के 42 किसानों ने भाग लिया।

बीज और अनुसंधान फार्म हिसार

- सिंचाई की समस्या के कारण रबी 2017–18 में, कुल 190 एकड़ कृषि भूमि में फसल उत्पादन कार्यक्रम के लिए केवल 52.14 एकड़ का उपयोग किया जा सका।
- कुल बोई गयी 52.14 एकड़ भूमि में से 38.40 एकड़ भूमि का प्रयोग गेहूँ के बीज उत्पादन के लिए तथा शेष 13. 74 एकड़ भूमि का उपयोग जौ के बीज उत्पादन कार्यक्रम के लिए किया गया ।
- रबी 2017–18 में कुल 461.24 कुंतल प्रजनक बीज का उत्पादन किया गया जिसमें से 371.15 कुंतल प्रजनक बीज गेहूँ का था और बाकी 90.0 9 कुंतल प्रजनक बीज जौ का था ।
- प्रजनक बीज के अलावा 84.75 कुंतल गेहूँ मिश्रण और 3.04 कुंतल जौ मिश्रण प्राप्त किया गया ।

अन्य संस्थागत गतिविधियाँ

- 56 वें अखिल भारतीय गेहूँ और जौ अनुसंधान कार्यकर्ता मीटिंग का आयोजन दिनांक 25–28 अगस्त, 2017 के दौरान बी.एच.यू. वाराणसी में किया गया। उद्घाटन समारोह के मुख्य अतिथि, केंद्रीय कृषि एवं किसान कल्याण मंत्री, भारत सरकार, माननीय श्री राधा मोहन सिंह जी थे।
- 10 अक्टूबर 2017 को भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल में बीज दिवस और रबी कार्यशाला का आयोजन किया गया ।

- संस्थान अनुसंधान परिषद (आईआरसी) की बैठक दिनांक 16–17 अक्टूबर, 2017 के दौरान डॉ जीपी सिंह, निदेशक महोदय, भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल की अध्यक्षता में हुई ।
- संस्थान की शोध सलाहकार समिति की बैठक दिनांक 26–27 अक्टूबर 2017 के दौरान डॉ एच एस गुप्ता (पूर्व महा निदेशक, बीसा और पूर्व निदेशक, पूसा, नई दिल्ली) की अध्यक्षता में हुई ।
- भा.कृ.अनु.प.–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल ने 9 फरवरी 2017 को हर्ष के साथ अपना स्थापना दिवस मनाया। डॉ आर बी सिंह (चांसलर सीएयू इम्फाल एवं पूर्व अध्यक्ष एएसआरबी, नई दिल्ली) समारोह के मुख्य अतिथि थे।
- संस्थान में दिनांक 15 सितंबर–3 अक्टूबर 2017 के दौरान स्वच्छता अभियान पखवाड़ा आयोजित किया गया।
- दिनांक 21 जून, 2017 को संस्थान में अंतर्राष्ट्रीय योग दिवस पूर्ण उत्साह के साथ मनाया गया।
- देश का 71वाँ स्वतंत्रता दिवस दिनांक 15 अगस्त 2017 को पूर्ण उत्साह के साथ मनाया गया ।
- देश का 69वाँ गणतंत्र दिवस दिनांक 26 जनवरी 2018 को धूम–धाम के साथ मनाया गया ।
- श्री राधा मोहन सिंह, माननीय, केंद्रीय कृषि एवं किसान कल्याण मंत्री, भारत सरकार ने 10 मार्च, 2018 को संस्थान का दौरा किया।
- श्री छबिलेन्द्र राउल, विशेष सचिव (डी ए आर ई) और सचिव (आई सी ए आर) ने 23 नवंबर 2017 को भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल का दौरा किया।

EXECUTIVE SUMMARY

Crop Improvement

New improved wheat varieties and genetic stocks

- Seven new wheat varieties comprising five bread wheat varieties namely K 1317, DBW 168, DBW 173, UAS 375, HI 1612 and two durum varieties viz., MACS 4028 (d) and HI 8777 were released by the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops (CVRC) for different production conditions and agro-ecological zones in the country.
- Wheat varieties DBW 168 (Irrigated timely sown conditions of PZ) and DBW 173 (Irrigated, late sown conditions of NWPZ) developed by IIWBR, Karnal were released for commercial cultivation by the CVRC.
- Fourteen wheat genetic stocks having significant levels of resistance against diseases and soft grains suited for biscuit making were found suitable for registration by the Plant Germplasm Registration Committee of NBPGR, New Delhi.

Multi-location evaluation of wheat genotypes under AICRP on Wheat and Barley

- The multi-location evaluation for yield, disease, quality and agronomic characteristics in wheat genotypes developed by breeders comprising 401 entries alongwith 63 check varieties in 25 trial series was conducted at149 centres spread all over the country. Out of 415 trials conducted the data for 279 trials were found qualifying for reporting based on set norms.
- The Varietal Identification Committee (VIC) during the 56th All India Wheat & Barley Research Workers' Meet held at BHU, Varanasi from 25-28 August, 2017 considered 6 wheat genotypes (DBW 173, HI 1612, DBW 168, UAS 375, HI 8777(d), MACS 4028(d)) tested in final year of AVTs for varietal identification.
- The promising entries based on significant superiority for yield and disease resistance were identified for promotion to the next stage of varietal evaluation process. Among the 59 AVT genotypes tested this year only 4 genotypes were found significantly superior and promoted to AVT-II. From among the 30 genotypes tested in 7 special trials conducted for specific requirements, four genotypes in special trial for very late conditionwas found promising for promotion.
- Out of a total of 277 entries tested in NIVTs and 38 entries in IVTs, 68 genotypes (56 of bread wheat and 12 of durum wheat) were found promising for promotion to AVTs.

Seed production

- To meet the demand of breeder seed production in the country, a surplus production of 13029.22q i.e. 35174.91q against an allocation of 22145.69q breeder seed of 157 wheat varieties was produced at allocated centres. Nucleus seed totaling 1610.97q of 163 varieties was also produced showing a surplus production of 604q over the indented quantity.

Germplasm conservation, evaluation and distribution

- As part of germplasm exchange, institute supplied 1495 accessions to various indenters within the country for utilization and seven new registered genetic stocks were received from NBPGR for multiplication and conservation.
- 502 indigenous and exotic accessions of wheat were characterized at IIWBR, Karnal. Promising

donors for various yield component traits and quality were identified for use in breeding.

- A core set consisting 122 accessions was developed from the base collection of 7038 accessions using power core software
- The registration proposal of WB 2 was submitted to the PPV&FRA, New Delhi for seeking protection under PPV&FRA, 2001 under extant category.
- 13 candidate varieties were tested against 44 reference varieties in two DUS trials.

Salient points from research projects

- In the pre-breeding programme, 200 accessions of 10 wild species of wheat (3 diploid and 7 tetraploid), were evaluated for phenological, physiological, agronomical traits and diseases. Thirty synthetic lines were evaluated under harsh conditions for heat stress tolerance. Eighteen F_2 populations were evaluated under conservation agriculture (CA) conditions at Hisar farm for identification progenies suited to CA.
- DBW 173, tolerant to terminal heat under late sown conditions (HSI = 0.98) was identified and released for cultivation under irrigated late sown conditions of NWPZ under wheat improvement programme for high productive environments of Northern India project. In this project 12 promising entries were promoted to NIVTs out of 21 tested in IIWBR station trials. DBW 187 was promoted to AVT-II under irrigated timely sown conditions of NEPZ while DBW 223 and DBW 237 were promoted to different AVTs from this project.
- In the breeding wheat genotypes for eastern region project, three genotypes LBRIL 189 (spot blotch resistance), DBW 150 (heat tolerance) and LBPY 11-2 (earliness and bold grains) were registered as genetic stocks.
- In view of the reports of appearance of wheat blast in Bangladesh, IIWBR initiated an anticipatory breeding programme and constituted a special trial/nursery of 88 entries and planted in West Bengal and Assam along the borders of Bangladesh.
- In the project on wheat improvement for warmer areas, 262 new crosses were attempted to incorporate desirable traits. Four entries were evaluated in different NIVTs and two entries DBW 221 & DBW 252 were evaluated in AVTs.10 promising lines were shared with 30 cooperating centres as part of NGSN.
- From the improvement of durum wheat for grain quality programme, QLD46 (high grain protein content) and QLD49 (soft grain) were registered as genetic stocks.
- In spring x winter wheat hybridization programme,71 single crosses and 178 three-way or composite crosses were made to bring in new variability into spring wheats.Eight entries were contributed to national coordinated varietal trials. Spring x Winter Wheat Segregating Stock Nursery (SWSN) comprising 46crosses in F2 generation was shared with the six cooperating centres.

Biotechnological interventions

- A DNA barcode of the 306 genotypes has been developed using 54 SNP marker for use as signature to distinguish them.
- A comprehensive report on *De novo* wheat root tissue transcriptome data under drought stress condition was generated.
- TaSSRDb: wheat microsatellite database was developed comprising 476169 SSR markers.
- Genome wide association studies (GWAS) was conducted using high density 35K SNP chip to detect significant MTAs with 27 agro-morphological characters.
- Metagenomic studies of spring wheat rhizosphere under high temperature and drought was initiated.

- Expression of TaWRKY transcription factor family was studied in wheat under heat and drought conditions
- Released wheat varieties were studied for their source and sink characters of photosynthesis to find further opportunities for yield improvement.

Crop Protection

- The threats of yellow rust in northern India and of wheat blast in Eastern India were successfully averted through strategy planning and strict vigil as well as creating awareness among farmers and state government agencies.
- A number of genotypes possessing resistance to multiple diseases and insect pests were identified and 51 numbers of such genotypes were shared with wheat breeders.
- The Karnal bunt incidence was nil in Central and Peninsular zones during 2016-17 crop season like in previous years and these zones may be used for production of wheat free from Karnal bunt.
- The wheat varieties and entries of yield trials were tested against most prevailing and recent pathotypes, 110S119, 110S84 and 40S119 and number of varieties and entries were found resistant (ACI 0-10.0).
- 200 wheat germplasm lines were inoculated with loose smut, 33 lines were found free from infection and 76 were resistant (< 10% incidence). A total of 93 were free from flag smut and 65 were resistant.
- A simple and rapid method based on specific polymerase chain reaction (PCR) for the detection of *Urocystis agropyri*, the causal agent of flag smut of wheat was developed.
- A total of 40 varieties were sent for testing against wheat blast caused by *Magnaporthe oryzae* pathotype *Triticum* in Bolivia and under containment facility in USA. Out of these five were found promising including most popular wheat variety HD 2967.
- An adhoc IPM of wheat blast was prepared and given to state agriculture departments through DAC & FW in Eastern India.
- A training programme entitled "Disease surveillance and healthy seed production of wheat" was organized on 3rd February, 2017 for cooperators and extension agencies of state agriculture departments at BCKV, Kalyani.
- Three Indian scientists were trained on wheat blast in Bangladesh, Bolivia, USA and Mexico.
- A total of 98 wheat varieties (*T. aestivum*) and (*T. durum*) were tested to determine the resistance levels against foliar aphid i.e. *Rholosiphum maidis* alongwith 20 wild *Aegilops* spp.
- The settling test and fecundity was measured to assess the antixenotic effects of selected varieties from all 3 ploidy level (*T. aestivum, T. durum* and *Ae. spelltoides*).
- 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.
- In an experiment to determine the effect the irrigation on termite infestation, the highest termite infestation of 7.5 % was recorded under limited irrigation as compared to 2.9 % under normal irrigation.
- Under wheat varietal resistance studies for storage insect pests (*Rhyzopertha dominica* and *Sitophilus oryzae*), highest orientation behaviour (9.2 adults) of *R. dominica* was recorded in variety DBW-88 and lowest (5.0) in variety HD-2967.

Resource Management

- It has been observed that the long term effect of various tillage options in wheat as well as in rice under rice-wheat system had non-significant effect on wheat productivity.

- The long term effect of tillage in wheat was not significant but the tillage in rice, especially zero-tillage transplanting, adversely affected the productivity of rice.
- The tillage and residue management as well as their interaction with wheat genotypes were not significant.
- 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. However better maize yield was recorded in conservation agriculture compared to conventional tillage system.
- Wheat can be successfully sown using Turbo Happy Seeder in the presence of full loose residues of rice and maize. Whereas, in sugarcane ratoon, wheat can be sown by using Rotary Disc Drill.
- Integrated Nutrient Management consisting of application of recommended doses of chemical fertilizers (NPK 150:60:40) with 5 t/ha FYM was found the highest yielder.
- In organic production of HYVs (DPW 621-50, HD 2967, PBW 550 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).
- Top dressing of vermi-compost at 2.5, 5.0 and 7.5 t/ha at first irrigation was not found much beneficial for yield improvement of HYVs.
- The yield and quality of wheat were not significantly influenced by potassium humate application from 10 to 50 kg/ha.
- Result on residue management revealed that rice straw incorporation coupled with 25% more N application enhanced the wheat yield.
- Intercropping of pulses with maize saved 25% nitrogen in subsequent wheat crop.
- Relay cropping of bottle guard (ghia) and tarkakari in furrows recorded higher income than sole wheat crop under bed planting.
- Five weeds (*Phalaris minor, Avena ludoviciana, Polypogon monspliensis, Rumex dentatus and Chenopodium album*) infesting wheat crop have evolved herbicide resistance.
- For control of diverse broadleaf weeds, ready-mix combinations of Halauxifen + fluorxypyr 200.6 (6.1+194.5) g/ha or Halauxifen+Florasulam+ Carfentrazone at 10.21+20 g/ha or metsulfuron + carfentrazone4 + 20 g/ha were found effective in wheat.
- Under the project "Improving water use efficiency and mitigate abiotic stresses in wheat under conservation and conventional tillage practices, experiments were conducted to study the water use efficiency of wheat genotypes under various moisture levels. Residue retention to the tune of 4 ton/ha proved advantageous under limited water availability.
- Investigations were carried out to study the role of foliar application of potassium, salicylic acid and seed priming with salicylic acid in mitigating the abiotic stresses. Foliar application of potassium confirmed its positive impact on various kinds of abiotic stresses.
- The efficiency of micro irrigation system for wheat crop was also studied. Data revealed that, at least 25 per cent saving in irrigation water is possible, if irrigations were applied precisely at critical growth stages of wheat crop to harvest the same yield as it in normal irrigations of 60 mm water flooding per irrigations.
- Satellite images of path 147 and row 39 & 40 for the wheat season 2016-17 covering Karnal district was downloaded from the website https://earthexplorer.usgs.gov. (digitized using QGIS software) and the images were then classified using different region of interest's viz.

wheat, other crops, fallow land etc. The observed and reported wheat acreage for the season 2016-17 was estimated to be 176700 and 173947 ha, respectively. The observed LULC area of Karnal has been compared with the reported area (http://aps.dac.gov.in/).

Quality and Basic Sciences

- In bread wheat (*T. aestivum*), several genotypes were identified having good chapati making quality (score >8.0/10.0) such as DBW 168, DBW 39, HD 2888, C 306, K 8027, K 1317, MACS 6478 and NIAW 1415
- Bread wheat genotypes namely UAS 375, MACS 6222, MACS 6478, NI 5439, NIAW 1415 expressed good bread quality with loaf volume ≥575cc.
- HS 490 was found good for biscuit with >10.0 spread factor.
- *T. durum* wheat genotypes such as HI 8777, HI 8627, UAS 446 showed good pasta making quality scoring 7.0/9.0 on hedonic scale.
- High molecular weight glutenin subunits encoded at Glu A1, Glu B1 and Glu D1 loci were identified in all the AVT entries including checks.
- Promising genotypes were identified for individual quality characteristics including nutritional parameters and variability was ascertained at the country level.
- Quality component Screening Nursery of 56 entries grown at 12 locations was evaluated for grain appearance, protein content, and sedimentation volume and hectolitre weight.
- Germplasm of three nurseries i.e. NGSN (103 lines), EIGN (108 lines) and NDSN (80 lines) was analysed for processing cum nutritional quality parameters.
- More than three hundred released varieties of wheat in India and 500 mutant lines developed by EMS mutagenesis were evaluated for phytase and phytate levels. Direct assay method developed in our laboratory was used in assaying enzyme activity which gave reproducible results. There were 6 fold variations in phytase levels among the varieties studied in this investigation.
- Among a set of 500 mutant lines in the background of PBW502, 20 were identified having high phytase level (>2000 FTU/kg).
- RILs have been developed using wheat line containing Gpc-B1gene and high yielding variety HD 2967 for identification of molecular markers associated with high grain protein content and Fe & Zn concentrations.
- Several crosses were attempted between High yielding varieties of wheat and Nap Hal and the derived populations were evaluated for gluten strength and grain hardness. Molecular marker assisted selection (MAS) was used in identifying Glu-D1 double null and soft grain characteristics for improving biscuit making quality.
- A co-dominant marker associated with Glu-D1 double null in Nap Hal was identified. The marker is very useful in breeding to transfer Glu-D1 double null into high yielding backgrounds for improving biscuit making quality of wheat.
- Significant positive correlations of K+ and proline content and negative correlation of Na+ content with grain yield were identified under salt stress. K+, Na+ and proline content exhibited high heritability under salt stress indicating that the traits can be used for screening and breading of wheat genotype for salinity tolerance.
- Thirteen significant QTLs were detected on 10 Chromosomes of the 21 chromosomes mapped for different salt tolerant traits.

Social Sciences

- During the wheat crop season 2016-17, 600 WFLDs of one hectare each were allotted to 83 cooperating centres, of which 543 were conducted through 79 cooperating centers. These

WFLDs covered 547.4 hectares area of 1238 farmers in 19 states.

- In case of improved durum wheat varieties, HD 8713 (d) gave a significant average yield of 71.50 q/ha followed by HI 8737 (d) (70.75 q/ha) at Indore centre in CZ.
- Among RCTs, the zero tillage technology under wheat FLDs has shown positive but non-significant impact at all the centers except Pantnagar. The performance of rotavator technology under WFLDs has shown positive and non-significant impact at all the centers. A significant yield gain due to sprinkler irrigation was observed at Bhiwani center. Yield gain due to drip irrigation at Vijapur center was noticed but non-significant.
- On an average, wheat varieties or technologies demonstrated in FLDs gave `2.83 per rupee of investment in comparison to the check varieties (`2.48). The returns from FLDs ranged from `6.51 (Punjab) to `1.76 (Nagaland) across states, `3.77 (SHZ) to `2.32 (NHZ) across zones and `8.25 (Happy Seeder) to `2.10 (Sprinkler) across technologies.
- The analysis on production constraints across zones revealed that non-availability of seed of newly released variety was the major constraints.
- During the rabi crop season 2016-17, 100 BFLDs were allotted to 20 different cooperating centers all over India in six states namely, HP, UP, Punjab, Haryana, Rajasthan and MP of which 85 were conducted by 18 centers, covering 93.7 hectares area of 206 farmers.
- The highest increase in barley yield was recorded in UP (25.33 %), followed by HP (23.51 %) and MP (19.46 %). The lowest increase in yield was reported in Punjab (05.55 %). The yield gain due to improved varieties over regional mean yield was highest in NHZ (43.21 %), followed by CZ (39.42 %), NEPZ (36.47 %) and NWPZ (15.16 %).
- The improved barley varieties demonstrated in FLDs gave around 16 per cent better returns in comparison to the check. Punjab registered the highest returns per rupee of investment (`6.54), followed by Uttar Pradesh (`4.30) and Rajasthan (`4.02).
- Overall analysis of constraints in different barley production zones clearly indicated that small land holding, followed by high cost of inputs and non-availability of labour affected barley production and productivity of the country.
- During rabi 2017-18, 20 acres (8 hectares) WFLDs were conducted at 20 farmers' fields in the villages namely Rasina and Hajwana in Kaithal district of Haryana state using varieties WB 2 and HPBW 01.
- The ICAR-IIWBR team accompanied by the experts from the Ministry of Agriculture & Farmers Welfare and the concerned centres, monitored the FLDs conducted by Parbhani, Niphad, Pune, Ambala, Ropar, Ludhiana, Pantnagar and Almora centres during the crop season 2017-18.
- The positive impact of adoption of zero tillage was on cost saving, time saving, management of Phalaris minor, fuel saving, yield and germination. It also gave 2-3 quintal/acre more yield as compared to the conventional tillage. Adoption of DSR technology has positive impact on saving of time and cost of planting. Farmers also reported that technology adoption could save approximately 50% of water at farmers' fields as compared to transplanted rice.
- The Yield Gap-I was found to be negative in Chhatarpur and the Yield Gap-II was highest in Chhatarpur. Analysis of resource use indicated that there exist significant difference in the level of inputs between Rewa and Chhatarpur, and seeds were used more than the recommended doses for both wheat and barley. Data Envelopment Analysis (DEA) showed that wheat growers are technically efficient to the tune of 89.30 per cent and barley growers by 85.30%.

- A two–days training programme on 'Increasing farm income of Lahaul Valley farmers' was organised at ICAR-IIWBR, Karnal for 43 farmers of 15 villages of Lahaul Valley. Development activities like demonstrations, trainings, farmers' fair/field days were conducted at different centres.
- Apart from the above activities, social sciences unit coordinates the Government flagship development programmes like 'Mera Gaon Mera Gaurav' scheme, activities pertaining to doubling farmers income, creating awareness on soilhealth cards etc.

Barley Improvement

- The barley variety DWRB137 was released for irrigated timely sown conditions of NEPZ and CZ and the strain DWRB160 was promoted to AVT -TS-MB first year evaluation.
- Four genetic stocks namely DWRB173, DWRB175, DWRB176 and DWRB180 were registered with ICAR-NBPGR for unique traits.
- 116 test entries contributed by 12 centres, were evaluated against 33 checks in the coordinated yield trials under rainfed (plains and hills), Irrigated (plains) and saline soils conditions under timely/ late sown conditions
- In malt barley programme, 1178 families of 492 crosses were grown for screening and selection for stripe rust, morphological traits and quality characters. In feed and food barley programme, 816families of 200 crosses were grown for screening and 10 prominent genotypes included in station yield trial.
- DWRNB17 and DWRNB23 hulless genotypes were good yielder and resistant to stripe rust. DWRNB 28, a hulless genotyoes is identified for short height(60-65cm).
- A total of 8179 accessions of barley are being conserved and maintained. During *Rabi* 2017-18, 600 germplasm accessions were grown for rejuvenation and storage.
- Three international trials (IBYT-HI, INBYT-HI and 4th GSBYT) and three international nurseries (IBON-HI, INBON-HI and 4th GSBSN), a total of 420 lines were evaluated in different environments. Seeds of the 442-selected genotypes were supplied to the barley breeders working in different SAUs and ICAR-institutes.
- One test entry BL-2016-17 (BCU5214) was found to possess moderate levels (36) of resistance to barley leaf blight.
- The genotypes BK 1127, BCU 2237 and BCU 2241 had crude protein content of 13.0 % (dwb) or more and satisfactorily malt quality.
- A total of 71 varieties were screened for phytic acid content and 11 varieties had < 0.8% value; 39 varieties were having value of > 0.8 to 1.0 %; 18 were having values of > 1.0 % to 1.5 % and 3 were having > 1.5%.
- 1521.86q breeder seed was produced, aganinst the total allocated quantity of 1140.75q. The maximum production was reported for RD2786 (300.00q) followed by RD2794 (160.00q), PL 426 (110.29q), DWRUB 52 (93.60q) HUB 113 (90.00q).
- Rice residue retention is found to be helpful in increasing yield of barley crop. Seed and grain quality of barley also improved with residue retention. Returns over variable cost and B:C ratio were almost equal when barley was sown under residue retention with zero till technique after un-puddled and direct seeded rice.
- Use of biofertilisers *Azotobacter* + *Phosphosolublizing* bacteria along with recommended dose of fertiliser also increased the productivity in NEPZ, NHZ and NWPZ. In CZ, Biomix application was found superior to biofertiliser application.
- Plant growth regulators, chlormequat-chlorid (CCC) @1.25 L ha^{-1} at GS_{30-31} followed by ethephon(Cerone) @1.0 L ha^{-1} at GS_{39-40} recorded significantly higher grain yield in NWPZ and NEPZ.
- Molecular markers, HvCSFI6-1013F and Brz, for

beta-glucan trait content were identified for foreground selection in backcrosses developed for marker assisted backcross breeding for malt quality in barley.

- Barley genotypes (BCU7624, BCU7628, BCU7635, BCU7652, BCU7653, BCU7659, BCU7721, BCU7746, C1-42, C1-66, C1-67, C1-69, C1-72, C1-213, C2-40, C2-85, C2-142 and C2-163) were identified as resistant for corn leaf aphid.

IIWBR, Regional Station, Shimla

- During this year practically there was no incidence of wheat and barley rusts. Sporadic incidence of wheat yellow rust was observed in Northern India but it remained confined to few fields only.
- To map the occurrence of wheat and barley rusts, pathotype situation in India and neighboring countries, more than 1300 samples were collected /received from 12 states of India and two neighboring countries. Analysis of 910 samples was accomplished. Yellow rust population of the region was avirulent to resistance genes Yr5, Yr10, Yr11, Yr12, Yr13, Yr14, Yr15, YrSp , black rust to Sr26, Sr27, Sr31, Sr32, Sr35, Sr39, Sr40, Sr43, SrTt3 & SrTmp; brown rust to Lr24, Lr25, Lr29, Lr32, Lr39, Lr42 and Lr45.
- In wheat yellow rust, pathotype 46S119 was observed in 56% samples followed by 110S119 in 34% samples, registering 6% increase over preceding year. Pathotype 40A of wheat black rust was most frequent followed by pt. 11. In wheat brown rust pt. 77-9 (46%) has replaced pt. 77-5 (25%).
- A total of 3600 lines including 151 lines of AVTI, II, NBDSN, EBDSN and Breeder's material were evaluated against different pathotypes of three wheat rusts. Rust resistance to all the pathotypes of black, brown and yellow rust was not observed in any of the entries of AVT II. There was no entry in the AVT II which showed resistance to all the pathotypes of yellow rust. Seven entries viz. Cow (W)(C), HW2044(C), HW5216(C), MACS6222(C), MP3288(C), NIAW1415(C) and UAS446 conferred resistance to all the pathotypes of brown rust, whereas five entries (VL892(C), HD3043(C), DBW110, TL2942(C) and TL2969(C)) were resistant to all the pathotypes of black rust.
- Five Yr genes (Yr2, Yr 9, Yr18, Yr27 and YrA), 10 Lr genes (Lr1, Lr2a, Lr 3, Lr10, Lr13, Lr19, Lr23, Lr24, Lr26, Lr34) and 14 Sr genes (Sr2, Sr5, Sr7b, Sr8a, Sr8b, Sr9b, Sr9e, Sr11, Sr13, Sr24, Sr25, Sr28, Sr30 and Sr31) were observed in 125, 134 and 131 lines, respectively.
- A study was carried out to mine the candidate key SAR regulators and sugar transporters in wheat and their transcriptional reprogramming during leaf rust infection.
- Four rust resistant genetic stocks FLW18,FLW31, FLW32 and FLW33 were registered with NBPGR, New Delhi.
- Wheat disease monitoring nursery and SAARC wheat disease monitoring nurseries were conducted. Wheat blast and Ug 99 type of wheat black rust were not observed in India and neighboring countries. The incidence of wheat diseases especially rusts was low during this year.
- National repository of 144 pathotypes of different rust pathogens was maintained. To create rust epidemics of wheat and barley, nucleus and bulk inocula of rusts was supplied to 57 centres/ Scientists elsewhere in India.

Regional Station Dalang Maidan (Lahaul & Spiti)

- Approximately 28,000 lines of wheat and barley were advanced for genetic improvement of these crops.
- More than 500 corrective crosses were attempted by wheat researchers of the country.
- Around 10,000 lines of wheat and barley were screened for yellow rust and powdery mildew diseases
- 9000 wheat accessions and 2000 barley accessions are being conserved and maintained here under natural conditions.

- The seed multiplication of the wheat variety DBW168 was carried out and 7 q. seed was produced.
- Under Tribal Sub Plan, a training programme on "Increasing the agricultural income" was organized at IIWBR Karnal during 4-5 Dec, 2017. A group of 42 farmers of the valley participated in this training programme.

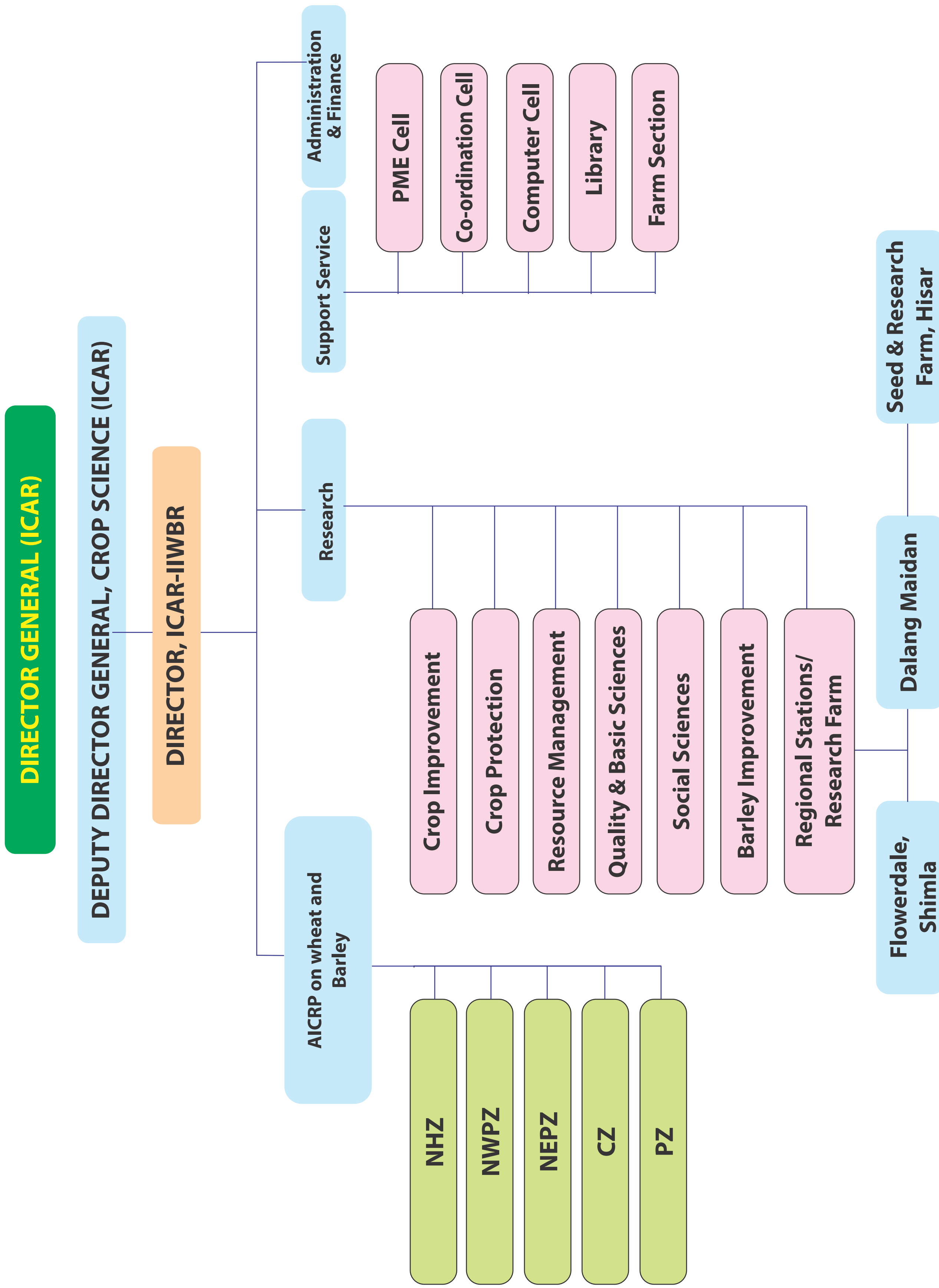
Seed & Research Farm Hisar

- In Rabi 2017-18 due to irrigation problem, only 52.14 acre could be utilized for crop production programme out of total 190 acre cultivable land
- Out of this 52.14 acre land, 38.40 acres was used for wheat seed production and rest 13.74 acres was utilized for barley seed production programme.
- Total breeder seed production at this farm was recorded 461.24q; out of which 371.15q was of wheat and rest 90.09 q was of barley.
- In addition of breeder seed, 84.75q mixtures of wheat and 3.04q mixture of barley were obtained from the experimental materials of these two crops.

Other Institutional Activities

- 56th All India Wheat and Barley Research Workers Meet was organized during 25-28 Aug 2017 at BHU Varanasi. Sh Radha Mohan Singh, (Hon'ble Union Minister of Agriculture & Farmers Welfare, India) was the chief guest of the inaugural function.
- Seed Day and Rabi Workshop was organized on 10th Oct 2017 at ICAR-IIWBR, Karnal.
- Institute Research Council (IRC) meeting was held during 16-17 Oct, 2017 under the chairmanship of Dr GP Singh, Director, ICAR-IIWBR, Karnal.
- Research Advisory Committee meeting of the Institute was held under the chairmanship of Dr HS Gupta (Former DG, BISA and Director, IARI New Delhi) during 26-27th Oct 2017
- ICAR-IIWBR Karnal celebrated its Foundation Day on 9th Feb 2017 with full joy and happiness. Dr RB Singh (Chancellor CAU Imphal and Former Chairman ASRB, New Delhi) was chief guest of the function
- Swachchhata Pakhwara was again organized during 15th Sep-3rd Oct 2017 at ICAR-IIWBR, Karnal.
- 4th International Yoga Day was celebrated with full enthusiasm on 21st June, 2017 at the institute.
- 71st Independence Day was celebrated on 15th Aug 2017, with full enthusiasm and happiness.
- 69th Republic Day of the country was celebrated on 26th Jan 2018, with full enthusiasm and joy.
- Sh Radha Mohan Singh, Hon, ble Union Minister of Agriculture & Farmers Welfare, Govt. of India, visited the institute on 10th March, 2018.
- Shri Chhabilendra Roul, Special Secretary (DARE) & Secretary (ICAR) visited ICAR-IIWBR, Karnal on 23rd November 2017.

ORGANOGRAM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Dalang Maidan
Flowerdale, Shimla
AICRP on wheat and Barley
NHZ
NWPZ
NEPZ
CZ
PZ

01 CROP IMPROVEMENT

In India, wheat covered about 30.72 mha during 2016-17 crop season and accounts for about 36 per cent of the country's total food grains production as per the data estimated by Directorate of Economics and Statistics (DES), Ministry of Agriculture and Farmers Welfare (MoA&FW), India.

During 2016-17, a record wheat production of 98.38mt with an average national productivity of 3172 kg/ha has been achieved. The growth in production is attributed to the increased yield by 4.56 per cent followed by a marginal increase in the crop acreage of 0.98 per cent. The increase in the support price by ₹100 per quintal in comparison to the previous year of ₹1625 per quintal of wheat, has led to an increase in the crop area by 2.97 lakh ha. The average productivity of the country has increased by 138 kg/ha which is a major reason for the increased production.

Release of new wheat varieties for different zones

Central released varieties

During the year 2017-18, the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops (CVRC) recommended the release and notification of following 7 wheat varieties for different cultivation conditions (Table 1.1).

Table 1.1 Wheat varieties released by CVRC during 2017-18

SN	Variety name	Areas of adoption	Developed by	Production condition	Grain yield (q/ha) Average	Grain yield (q/ha) Potential	Special feature(s)
				Bread Wheat Varieties			
1	K 1317	NEPZ	CSA UA&T, KANPUR	Rainfed, Timely Sown	30.1	38.6	Resistant to brown rust and leaf blight. Good chapatti quality (Score: 8.05).
2	DBW 168	PZ	ICAR-IIWBR, Karnal	Irrigated, Timely sown	47.5	70.1	Very good for chapati (8.15/10) as well as for biscuit quality, Soft grains (36), resistant to brown & black rusts
3	DBW 173	NWPZ	ICAR-IIWBR, Karnal	Irrigated, Late sown	47.2	57.0	Tolerant to terminal heat (HSI=0.98), Resistant to yellow and brown rusts
4	UAS 375	PZ	UAS, Dharwad	Rainfed, Timely sown	21.4	29.1	Resistant to brown and black rusts
5	Pusa Wheat 1612(HI 1612)	NEPZ	ICAR-IARI RS, Indore	Restricted irrigation, Timely sown	37.6	50.5	32.4% and 52.4% two irrigations, yield gain at one and respectively as compared to no irrigation. Resistant to yellow & brown rust
				Durum varieties			
6	MACS 4028 (d)	PZ	ARI, Pune	Rainfed, timely sown	19.3	28.7	Resistant against stem and leaf rusts, early maturing (102 days), protein content (14.7%)
7	Pusa Wheat 8777 (HI 8777) (Durum)	PZ	ICAR-IARI RS, Indore	Rainfed, timely sown	18.5	28.8	Resistance to leaf rust, protein (14.3%), zinc (43.6 ppm) and iron (48.7 ppm) content

Table 1.2 Wheat varieties by SVRC during 2017-18

SN	Variety name	Areas of adoption	Developed by	Production condition	Grain yield (q/ha) Average	Potential	Special feature(s)
1	Sabour Nirjal (BRW 3723)	Bihar	BAU, Sabour	Rainfed, Timely Sown	28.7	47.3	Drought tolerant
2	HW 5207 (CoW 3)	Tamilnadu	IARI RS Wellington and TNAU Coimbatore	Restricted irrigation, Timely sown	40.76	59.6	Resistant to leaf and stem rusts, carrying Lr24+Sr24, Sr2, Yr15 rust resistance genes
3	Gujarat Junagadh Wheat 463 (GJW 463)	Gujarat	JAU, Junagarh	Irrigated, early sown conditions of Saurashtra and Irrigated, timely sown conditions of Gujarat	55.7 (ES), 50.9 (TS)	78.3 (ES), 67.46 (TS)	Moderately resistant to brown and black rusts
4	KRL 283	Uttar Pradesh	ICAR-CSSRI, Karnal	Salt affected soils (Irrigated, Timely sown)	20.9	41.0	Resistant to leaf blight, Karnal bunt and hill bunt
5	HUW 669 (Malviya 669)	U.P.	BHU, Varanasi	Rainfed/ Restricted Irrigation	24.1	43.0	Resistant to all the three rusts and leaf blight
6	Chhattisgarh Genhu-3 (CG 1013)	Chhatti -sgarh	IGKVV RS, Bilaspur	Irrigated, Timely sown	33.4	49.3	Resistant to leaf rust
7	UAS 334	Karnataka		Irrigated timely sown conditions	49.1	59.5	Zinc content (43.1 ppm), resistance to black and brown rusts

State released varieties

Seven wheat varieties notified by different SVRC's were recommended for notification by the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops (Table 1.2).

Registration of new genetic stocks

During the year 2017-18, following fourteen genetic stocks of wheat were registered at NBPGR for novel traits. 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).

Significant results from coordinated yield trials

Conduction of coordinated trials

The wheat coordinated varietal evaluation programme entails a huge multilocation testing programme which is undertaken with the cooperation of 33 funded and 116 voluntary centres spread across six wheat growing zones in the country. As many as 8 new voluntary centres from Rajasthan were added during this year to provide wider testing environments for genotypes in the NWPZ (Table 1.4).

During the crop season 2016-17, a total of 25 series of trials comprising AVTs, NIVTs, IVTs and Special trials were laid out in the different zones under four major production conditions *viz*. timely sown irrigated, late sown irrigated, timely sown restricted irrigation and timely sown rainfed conditions. This year altogether 401 test entries were evaluated along with a total of 63 check varieties in different trials.

In all, 429 trial sets were supplied to149 centres out of which 415 trials were conducted (Table 1.5). The non-conduction of the coordinated trials was mainly at voluntary centres. The maximum non-conduction was in the North Eastern Plains Zone followed by Northern Hills Zone, Southern Hills Zone and North West Plains

Table 1.3 Genetic stocks of wheat registered during 2017-18

SN	Genotype	Registration number	National ID number	Developing centre	Trait (s)
1	QBP 12-11	INGR 17033	IC0624127	IARI, New Delhi	Soft grain (Low hardness index)
2	HI 8751	INGR 17032	IC0623451	IARI RS, Indore	Resistant to all the three rusts (leaf, stem, stripe) Karnal bunt and flag smut
3	HI KK10 (NP4+Lr13)	INGR 17034	IC0624491	IARI RS, Indore	Wheat line carrying Lr13 gene in the background of NP 4 to be used as differential for gene cataloguing
4	HI KK11 (NP4+Lr19)	INGR 17035	IC0624492	IARI RS, Indore	Wheat line carrying Lr18 gene in the background of NP 4 to be used as differential for gene cataloguing
5	HI KK12(NP4+Lr19)	INGR 17036	IC0624493	IARI RS, Indore	Wheat line carrying Lr19 gene in the background of NP 4 to be used as differential for gene cataloguing
6	HI KK13(NP4+Lr26)	INGR 17037	IC0624494	IARI RS, Indore	Wheat line carrying Lr26 gene in the background of NP 4 to be used as differential for gene cataloguing
7	HI8765	INGR 17038	IC0624495	IARI RS, Indore	Resistant to all the three rusts (leaf, stem, stripe) Karnal bunt and flag smut
8	HSRBW 2	INGR 17030	IC0623528	ICAR-IIWBR	Tolerant to head scab
9	HSRDW 2	INGR 17031	IC0623529	ICAR-IIWBR	Tolerant to head scab
10	LBPY11-2	INGR 17039	IC0624496	ICAR-IIWBR	Early maturing genotype
11	FLW 31	INGR 17040	IC0624500	ICAR-IIWBR RS Shimla	Resistant to black and brown rusts
12	FLW 32	INGR 17041	IC0624501	ICAR-IIWBR RS Shimla	Resistant to black rust
13	FLW 33	INGR 17042	IC0624502	ICAR-IIWBR RS Shimla	Resistant to black and brown rusts
14	FLW 18	INGR 17070	IC0621835	ICAR-IIWBR RS Shimla	Resistant to brown and black rusts, carrying Lr39 in PBW343 background

Zone. The percent conduction of trials was 100% in Central Zone. It was 98.6% in North Western Plains Zone and Peninsular Zone. In North Eastern Plains Zone trial conduction was 93.8%, while it was 93.3% in Northern Hills Zone and lowest 85.7% in Southern Hills Zone. The overall conduction of trials during the crop season was 96.7 percent (Table 1.6).

During this year, from amongst the 415 trials conducted, the data of 279 trials was found qualifying

Table 1.4 Zone-wise funded and voluntary centres associated in conduction of coordinated trials

Zone	Funded centres	Voluntary centres including ICAR centres
NWPZ	6	35
NEPZ	7	24
CZ	10	15
PZ	4	21
NHZ	6	15
SHZ	-	6
Total	33	116

Table 1.6 Percent success in trial conduction and reporting.

Zone	% conduction proposed trials	% reporting of conducted trials
NHZ	93.3	64.3
NWPZ	98.6	79.4
NEPZ	93.8	64.8
CZ	100	73.8
PZ	98.6	48.5
SHZ	85.7	25.0
Total	96.7	67.2

Table 1.5 Breakup of yield trials

Zone	Proposed	Not Conducted	Conducted	Reported	Not Reported
NHZ	45	3	42	27	LSM (8), RMT (2), LSM&HCV (3), DNR (2)
NWPZ	143	2	141	112	RMT (13), LSM (7), HCV (3), ES (2), LS (2), UY (1), LS&UY (1)
NEPZ	97	6	91	59	LSM (11), RMT (8), TF (1), DNR (3), LS (2), UY (2), HCV (2), LCV (2), LSM & HCV (1)
CZ	61	0	61	45	LSM (9), RMT (1), UY (2), LS (2), HCV (1), M Irr (1)
PZ	69	1	68	33	LSM (21), RMT (7), TF (1), DNR (1), HCV (3), LSM&LS (1), LS (1)
SHZ	14	2	12	3	TF (4), RMT (2), ES (2), LS (1)
Total	429	14	415	279	136 (RMT - 33)

TF: Trial failed; RMT: Rejected by Monitoring Team; LSM: Low site mean; HCV: High coefficient of variation; UY: Unrealistic Yield; ES: Early Sown for reporting based on set norms for disease resistance and yield performance. The norms for the yield limit for acceptance of trial data for reporting in different series of varietal evaluation trials were enhanced during the 55th Wheat and Barley Research Workers' Meet held at Hisar during August 2016. This enhancement caused an increase in the number of trials that did not qualify for reporting, particularly in the PZ. As many as 136 trials were not reported this year due to various reasons.

The overall reporting of conducted trials during this crop season was 67.2%. The reporting of data was highest in NWPZ (79.4%) followed by CZ (73.8%). The reporting of data in other zones was lower *viz.*, NEPZ (64.8%), NHZ (64.3%), PZ (48.5%) and SHZ (25%). Drought conditions were mainly responsible for low yield at centres in PZ, while many new centres added in NWPZ during the current crop season could not generate quality data for consideration. The centres in SHZ were mainly voluntary centres where trial failure was primarily responsible for low reporting. Low site mean yield at voluntary centres in different zones was one of the main reasons for low percentage of reported data.

Varieties in the final year of testing

During the year under report, there were 6 varieties in the final year of yield evaluation in various AVTs in the different zones. The proposal for identification of these varieties would be placed for consideration by the Varietal Identification Committee (Table 1.7).

Table 1.7 Varieties in final year of evaluation in AVTs during 2016-17

Zone	Trial	Final year entries
NWPZ	AVT-IR-LS-TAS	DBW 173
NEPZ	AVT-RI-TS-TAS	HI 1612
PZ	AVT-IR-TS-TAS	DBW 168
	AVT-RF-TS-TAD	UAS 375, HI 8777(d), MACS 4028(d)

Promising varieties in Advanced Varietal Trials

The criteria for promotion of varieties in AVTs was based on significant superiority of genotypes over the best check of the trials and accordingly 59 genotypes were evaluated in different zones during this crop season (Table1.8) Among the varieties evaluated in AVTs, this year only 4 genotypes were identified to be superior based on their yield performance and response to the incidence of rusts. This revealed that only selected varieties possessed the ability to exhibit significant gain in yield over the check varieties. The entries, thus, found promising were one each under irrigated timely sown and late sown condition and two entries were under restricted irrigation condition. Four genotypes were found promising for very late condition (January sown) among the 30 genotypes tested in 5 special trials conducted for specific requirements, only.

Table 1.8 Most promising varieties in AVTs and special trials

Zone	Timely sown, Irrigated	Late sown, Irrigated	Timely sown, Restricted irrigation
NHZ	-	-	-
NWPZ	-	PBW752	HD3237, HI1620
NEPZ	DBW187	-	-
CZ	-	-	-
PZ	-	-	-
Special trials			
SPL-VLS	PBW 757, HI1621, PBW777, HD3271		

Promising varieties in NIVTs and IVTs:

A total of 277 new entries evaluated for their performance in 8 NIVTs, as many as 68 entries were found promising based on high yielding ability and disease resistance (Table 1.9) Out of these 68 promising entries, 56 were of bread wheat and 12 of durum wheat. Thirty-three entries were observed to be promising for timely sown irrigated condition, 3 for late sown irrigated condition and 22 for restricted irrigation condition. In all, 14 entries each were promising in NWPZ & NEPZ, 9 in CZ and 21 in PZ under different cultural conditions at the zonal level.

In IVTs, altogether 38 new entries were tested under rainfed and irrigated conditions in NHZ and restricted irrigation conditions in SHZ.

Breeder and nucleus seed production

Breeder seed production: An indent of 23185.17q breeder seed of 183 wheat varieties was received from Department of Agriculture and Cooperation & Farmers

Table 1.9 Most promising entries in NIVTs and IVTs

Zone	Timely sown,Irrigated	Late sown, Irrigated	Timely sown, Restricted irrigation	Timely sown, Rainfed
NWPZ	DBW222, DBW221, PBW766, PBW763, BRW3792, DBW233, UP2981	PBW773, DBW237, PBW771 -	BRW3806, DBW252, HI1628, NIAW3170	
NEPZ	WH1218, PBW762, DBW221, K1601, HD3249, DBW223, HD3254, PBW769, DBW233	-	DBW252, BRW3806, MP1331, WH1235, HI1628	-
CZ	AKAW4924, GW495, UAS465(d), MPO1343(d), GW1339(d)	- -	MP1331, NIAW3170, UAS446(d), AKDW4896(d)	-
PZ	AKAW4924, GW491, HI1624, GW495, DBW235, GW492, MP1338, PBW770, HI1625, MACS6709, GW493, HI8800(d)	-	NIAW3170, MACS6695, MACS6696, GW1346(d), HI8805(d), MACS4058(d), HI8802(d), MACS4059(d), MPO1336(d)	-
NHZ	-	-	-	HPW441, HS634, HPW442

Welfare (DAC&FW) for its production during *Rabi* 2016-17. The indent included many old varieties like HD 2189, UP 262, WH 147, K 68, C 306, Sharbati Sonara etc. and un-notified varieties like Barbat, DBW 172, DBW 173, DBW 179, HD 2009, HD 2952, HI 2026, MP 9305, PBW 707, PBW 735, PBW 760, PBW 775, PBW 943, UP 2903, UP 2907, WH 1127, WH 1164 and WH 1166 etc.

This year, the highest indent of 3079.94q breeder seed was placed for the variety HD 2967. Other popular varieties in the DAC&FW indent were WH 1105, HD 3086, Lok 1, Raj 4079, GW 366, Raj 4238, GW 322, DPW 621-50 and HI 1544. A list of top ten varieties in breeder seed indent is given in (Table 1.10).

Total allocation of 22145.69q breeder seed of 157 varieties was made for production at 33 centers in the county after excluding one de-notified (HD 2009) and 27 un-notified entries from among the 183 DAC&FW indented varieties. Total production of breeder seed during the year was 35174.91q. Thus, there was a surplus production of 13029.22q over the allocated quantity of breeder seed. The highest quantity of breeder seed was produced in HD 2967 (4319.80q) followed by GW 322 (2313.80q) and GW 366 (2031.6q) varieties.

Nucleus seed production: A total of1006q nucleus seed production of 163 varieties was allocated for its production at 30 breeder seed production canters to facilitate the production of anticipated demand of breeder seed for *rabi* 2016-17. In response, 1610.97q nucleus seed was reported to be produced. IARI, Indore produced maximum quantity of nucleus seed (272q) followed by JNKVV, Jabalpur (198.25q) and ARS Kota (140.80q).

Test stock multiplication: The test stock multiplication of four of bread wheat varieties viz., HS 562 (81q), PBW 1 ZN (63q), HI 1605 (45q) & WB 2 (40q) and durum wheat

Table 1.10 Breeder seed indent & production of top indented varieties during 2016-17

S. No.	Variety	Indent (q)			Production (q)
		2014-15	2015-16	2016-17	2016-17
1.	HD 2967	2886.65	2429.20	3079.94	4319.80
2.	WH 1105	200.00	911.40	1367.00	1654.40
3.	HD 3086	108.00	269.40	1347.20	1621.45
4.	Lok 1	709.20	860.80	916.00	930.00
5.	Raj 4079	666.00	985.00	887.90	1144.30
6.	GW 366	674.40	753.40	765.95	2031.60
7.	Raj 4238	165.00	343.00	756.00	359.50
8.	GW 322	763.60	905.40	745.80	2313.80
9.	DPW 621-50	660.60	628.80	522.80	563.00
10.	HI 1544	529.60	525.40	480.05	972.75

varieties viz., HD 3171 (76q), HD 4728 (63q), HD 8759 (53q) & MACS 3949 (32.0q) identified and four released during 2016-17 was produced at different Central State Farms. Hence, a total production of 453q test stock seed of these varieties was reported by NSC, New Delhi.

Seed Production by the Institute: The institute produced 1184.61q breeder and 164.30q truthful seed of ten wheat cultivars (CBW 38, DBW 17, DBW 39, DBW 71, DBW 88, DBW 90, DPW 621-50, HD 2967, HD 3086, DBW 107 and DBW 110) and seven barley (DWR UB 52, DWRB 64, DWRB 73, DWRB 92, DWRB 101, DWRB 123 and DWRB 137) varieties during 2016-17. The seed was sold to indenting agencies and as well as on 'Seed Day & *Rabi* Workshop' organized on 10th Oct 2017 at IIWBR, Karnal. A total revenue of Rs. 95,02,830/- was generated under the revolving fund scheme on seed during 2016-17.

Germplasm exchange, evaluation, characterization, conservation and documentation

Germplasm exchange

During the period under report, obtained 7 new registered genetic stocks from NBPGR for multiplication and conservation at IIWBR, Karnal and institute supplied 1495 accessions to various indenters within the country

Characterization

Five hundred thirteen indigenous and exotic accessions comprising 380 accessions of *T. aestivum*, 122 accessions of *T. durum*, three of *T. dicoccum*, two accessions each of *T. timopheevi* and *T. turgidum and* one accession each of *T. polonicum*, *T. urartu*, *T. vavilovi* and *T. compactum* were evaluated and characterized as per DUS testing guidelines for 36 characters during 2016-17. A wide range of variation was observed for days to heading (67-137); days to maturity (132-163); plant height (68-157 cm); 1000-grains weight (21.8-64.4g); spike length (6.4-21.4 cm); spikelets/spike (14-30); grains per spike (17-90); grain weight/spike (0.23-4.32 g) and protein (7.34-14.68%). The promising accessions identified for individual and multiple traits are given below:

Days to heading and maturity: Nine accessions of bread wheat flowered in less than or equal to 75 days and matured in less than 140 days. These accessions were HD 1944, HD 2379, HI 1116, HI 2667, HI 916, HP 1628, HP local 2, HS 146 and Kalawada 12-2-5-15.

Plant height (cm): Five accessions showed dwarfness and recorded plant height <80cm. These were 98 (67) SP WHEAT (67.4), HD 1944 (72.6), HI 7965 (77), HD 4601 (77.2) and EC 541864 (79). Six accessions namely HP local 1-B (141.4), IC 78868B (141.4), EC 541182 (142), HY 5-7-6 (144.8), HPW 30 (145.2) and NP 809 (157) recorded plant height more than 140.

Spike length (cm): Eight accessions, Tadia1 (21.4), Tadia2 (18.4), Tadia3 (18.4), Tadia4 (17.5), Tadia5 (16.4), GW 2001-16 (16.2) and H 954 (15.5), GW 2001-19 (15.0) had spike length more than or equal to 15 cm.

Spikelets/spike: Twelve accessions namely HI 7728 (d), HUW 330, GW 2001-5, Tadia2, Tadia3, Tadia5, EC 538200 (*T. timophivi*.), PI 176227, EIGN-I (99-2K)47, EIGN-II (97-98) 26, EIGN-II (97-98) 11, EIGN-II (97-98)15 had spikelet per spike more than or equal to 24.

Grain number/spike: Eleven accessions of bread wheat namely GW 2001-52 (77), HP 803 (75), Tadia5 (74), HI 906 (73), HP 152 (73), CCNRV-4 (72), EIGN-I(99-2k)10 (72), EIGN-I (99-2k)11 (71), EIGN-I (99-2k) 16 (71), HD 2274 (71) and SAWSN(14th) 221 (71) had more than 70 grains per spike. Similarly 10 accessions of durum wheat namely EIGN-II (1997-98)1 (90), EIGN-II (1997-98)42 (90), EIGN-II (1997-98)4 (83), EIGN-II (1997-98)36 (81), EIGN-II (1997-98)41 (80), HI 8185 (78), EIGN-II (2001-02)19 (77), EIGN-II (1997-98)9 (76), EIGN-II 2001-023 (76) and EIGN-II (1997-98)37 (75) recorded more than 75 grains per spike

Grain weight/spike: Six accessions Tadia5 (4.33g), EIGN-II (97-98)11 (3.75g), HY 107 (3.57g), Tadia3 (3.57g), SAWSN (14th) 221 (3.52g) & HP 1327 (3.5g) had more than 3.5g spike weight.

Thousand grains weight: Eight accessions EIGN-II (2001-2)4 (64.4g), Tadia5 (58.2g), Kota local (57.5g), HD 4599 (56.6g), HP 1327 (56.6g), EIGN-II (97-98)31 (56.13g), IC78835-(B) (55.8g) & HUW 329 (55.1g) had

1000 grains weight more than 55g.

Protein: Grain protein was estimated at 10-11% grain moisture content using NMR. Seven accessions SAWSN (14th) 221 (14.7%), HI 8113 (14.2%), GW 2002-19 (14%), HY 130 (14.0%), EC 541182 (13.7%), HY 128 (13.6%) and PI 338451 (13.5%) had more than 13.5% protein content.

Accessions with multiple yield contributing traits: The accessions HD 2274, HP 1327, TADIA 3, TADIA 5, EIGN II (2001-02) 11, EIGN II (97-98) 11, HY 632 were found promising for multiple yield traits.

Unique accession: The accession IC 212176 has only one-two tillers per plant.

Development of core collection of wheat germplasm

For enhancing the utilization of germplasm, a core set consisting 122 accessions was developed from the base collection of 7038 accessions using power core software. The core set was validated using agro-morphological characters. Majority of characters except spikelets/spike recorded same range as during initial evaluation indicating it is a valid core.

DUS testing in wheat

During 2016-17, 13 candidate varieties (DBW 88, DBW 90, HI 1563, Ajeet 349, Eagle 135, BW 321, Eagle 145, Narmada 14, colored wheat (blue), colored wheat (blue-2), colored wheat (blue-3), colored wheat (purple), colored wheat (black) were tested against 44 reference varieties in two DUS trials. Data of all the test centres viz. Karnal, Indore and Dharwad was compiled, analyzed and submitted to PPV&FR Authority for making decision regarding registration. Besides, observation on DUS characters were recorded on 11 farmers varieties (*Mohit Gold, Sonalikaw, Dehati Gehun Lalaka, Gehun (Desi), Gehun Lal, Khilona-br, Shekhar 1, Gehun Desi-2, Lamhrwan Gehun, Quadar Goal Gayhoon, Kathiya Desi Gehun*). In crop season 2017-18, 13 candidate varieties of bread wheat and 64 farmers varieties are being grown for DUS and grow- out test, respectively.

Registration of varieties with the PPPVFRA

The registration proposal of WB 2 was submitted to the PPV&FRA, New Delhi for seeking protection under PPV&FRA, 2001 under extant category.

Pre-breeding for wheat improvement

The genetic variability is an important aspect in the breeding programs. The dual problem of the depletion of genetic resources, combined with the loss of native germplasm due to cultivation of a few improved cultivars over large areas has led to the disappearance of genetic diversity. Thus, pre-breeding approaches are being used with greater precision and efficiency in induction of genetic variability and the conservation of germplasm. There is also a great scope for the transfer of alien genes through wide hybridization.

Wild relatives of domesticated crops contain many useful genes. However, traditional methods for introducing desirable genes typically involve long breeding trajectories to avoid linkage drag, *i.e.* the simultaneous introduction of deleterious traits. Keeping this in view, at IIWBR, the pre-breeding program is under way.

Table 1.11 Number of wild accessions resistant to rusts and leaf blight

Species	Genome	No of accessions	Resistant accessions	
			Number	percent
T. baeoticum	A^uA^u	3	3	100.0
Ae. speltoides	BB	26	18	69.2
Ae. tauschii	DD	84	51	60.7
Ae. polonicum	AABB	9	1	11.1
Ae. carthlicum	A^uA^uBB	5	0	0.0
T. dicoccoides	A^uA^uBB	11	3	27.3
Ae. ovata	MMUU	13	11	84.6
Ae. geniculata	UUMM	4	3	75.0
Ae. kotschyi	UUSS	3	2	66.7
Ae. peregrina	UUSS	35	22	62.9
Total	193	114	59.1	

Evaluation of wild accessions:

More than 200 accessions of 10 wild species of wheat (3 diploid and 7 tetraploid), were evaluated for phenological, physiological, agronomical traits and diseases. About 114 accessions (59.1%) were rust free/ resistant. (Table 1.11)

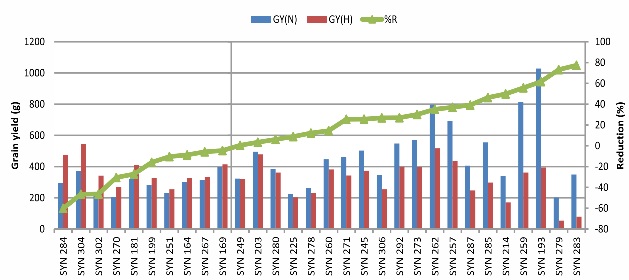

Fig. 1.1 Yield performance of synthetics under normal and harsh soils.

These accessions were also evaluated for different phenological and physiological characteristics. Accessions of *Ae. peregrina, Ae. ovata, Ae. Tauschii* and *T. dicoccoides* had higher chlorophyll content whereas accessions of *T. boeticum, Ae. speltoides, Ae. peregrina* and *Ae. kotschyii* had higher assimilation (photosynthesis) rate. 24 accessions (10 of *Ae. tauschii*, 6 of *Ae. speltoides*, 4 of *Ae. peregrina*, 3 of *Ae. boeticum* and 1 of Ae. *geniculata*) were studied under heat stress in glass house. Accessions of *Ae. speltoides* and *Ae. boeticum* could not survive under stress conditions (Table 1.12).

Evaluation of hexaploid synthetics for heat stress tolerance:

Thirty short-listed synthetic lines were evaluated under harsh conditions. Compared to normal soils (Karnal), 14 lines experienced less than 10% reduction in grain yield under harsh soils (Hisar) (pH 8.1, EC 0.41 dsm^{-1}) (Fig 1.1)

Pre-breeding population evaluated under conservation agriculture System

Eighteen F_2 populations were evaluated under conservation agriculture conditions at Hisar farm. These crosses involved synthetics, long spike material and the promising popular varieties. The selected ones will also be evaluated at Karnal location under normal tillage conditions and the plants showing promise under both conditions will be selected for further testing (Fig 1.13).

Genotypes evaluated under national coordinated trials:

Ten lines out of pre-breeding program were evaluated under IPPSN for resistance to biotic stress. Similarly,

Table 1.12 Mean and range for physiological traits in accessions of wild species

Species & genome	GFR (Unit)	TGW (g)	Tot CHL (mg cm^{-2})	Fv/Fm	Assimilation rate (μmol $m^{-2}s^{-1}$)
T. baeoticum (A^uA^u)	0.72 (0.53-0.89)	18.9 (13.4-25.0)	0.0383 (0.0324-0.0441)	-	34.6 (20.4-45.6)
Ae. speltoides (BB)	0.24 (0.07-0.47)	7.9 (2.7-14.4)	0.0345 (0.0172-0.0420)	0.750 (0.714-0.779)	24.3 (18.0-44.0)
Ae.squarrosa (DD)	0.39 (0.16-0.66)	13.7 (4.9-21.4)	0.0282 (0.0138-0.0470)	0.731 (0.601-0.799)	22.8 (12.3-36.3)
Ae. polonicum (AABB)	0.83 (0.50-1.56)	30.6 (17.9-56.2)	0.0357 (0.0272-0.0435)	0.770 (0.765-0.775)	27.5 (24.5-32.4)
Ae. carthlicum (AuAuBB)	0.65 (0.34-1.01)	25.7 (12.6-35.3)	0.0393 (0.0326-0.0433)	0.754 (0.736-0.769)	26.5 (24.3-33.3)

Table 1.13 Pedigree details of F_2 population for evaluation at Hisar under conservation agriculture

ID	Synthetics lines	S. N	Synthetics lines
BSTCA-1	LSSN-55/ HI 8498	BSTCA-10	Synthetic 99/ *2 DPW 621-50
BSTCA-2	LSSN-80/ *2 DBW 16	BSTCA-11	Synthetic 94/ DPW 621-50
BSTCA-3	DM-6/ HD 2967	BSTCA-12	Synthetic 207/ DBW 17// PBW 550//*2 DBW 16
BSTCA-4	DM-7/ HD 2967	BSTCA-13	New Synthetic 33/ WH 1105
BSTCA-5	DM -7/ *2 DPW 621-50//WH 1105	BSTCA-14	Synthetic 207/*2 PBW502//PBW PBW502//DBW 16//DPW 621-50
BSTCA-6	DM-7/ DBW 17//HD 2967	BSTCA-15	YCSN-22/ DBW 16// DBW 17
BSTCA-7	Synthetic 162/ *2 HD 2967	BSTCA-16	DM-7/ DPW 621-50
BSTCA-8	Synthetic 65/ WH 1105	BSTCA-17	AKDW 2591/C-306
BSTCA-9	NP 846/ HUW 468	BSTCA-18	DM-7/ DH 143// WH 1105

Table 1.14 Performance of genotype along with check in station trial

Genotypes/ Pedigree	Rank at centres					
	Hisar	Durgapura	Cooch Behar	NEPZ	NWPZ	National
DBW 234	3	2	10	10	35	32
K 307 (check)	-	-	5	-	33	46
WH 1105 (check)	23	21	36	11	-	32

one genotype which showed promise in the station trials of IIWBR was promoted to NIVT-1B national coordinated trial for yield testing across country (Table 1.14).

Two genotypes PBS 16-01 and PBS 16-02 developed under pre-breeding program have been included for evaluation in station trials. One genotype DBW 234 as mentioned has been promoted to the national trial NIVT 1B (Table 1.15)

Crosses using wild and other non-conventional sources:

Fresh crosses F_1s / back crosses involving wild accessions were developed. The *aestivum* type F_1s were raised. More than 150 cross combinations were attempted. The differences in ploidy levels in parents caused the anueploidy and thus the sterility in F_1s. To avoid this, technique to rescue the embryo and make it amphidiploid is being standardized at IIWBR. The table 1.16 shows the F_1s developed during the year.

Developing head scab resistance in bread and durum wheat genotypes

Many a times when temperature has been high coupled with humid environment the head scab disease appears and spreads quickly damaging the crop up to 60 percent. Most of the Indian varieties particularly of North West region are susceptible to head scab disease. This year also the head scab was noticed in trials at IARI fields during the monitoring. Therefore, four bread wheat varieties and four durum varieties were improved for resistance utilizing the Sumai# 3 and Frontana (Table 1.17). Out of these crosses, two lines have been submitted for registration at NBPGR, New Delhi. The material generated is in advance stage and it was evaluated under contained artificial conditions in the polyhouse at IIWBR, Karnal.

Out of many lines developed for resistance to head scab two genotypes HSRBW-2 (bread wheat) and HSRDW-2 (durum wheat) have been registered as genetic stocks at NBGR Delhi. These can be utilized in wheat improvement program in the country. The disease score under artificial conditions is given in the table 1.18.

Sharing the diverse material with cooperating centers:

Ten F_2 populations were shared with cooperating centers across country through Segregating Stock Nursery (SSN) during the year. These crosses involved the non-conventional parents in the pedigree. The synthetics having biotic / abiotic resistance were involved in transferring these traits into cultivars (Table 1.19). In addition to it, the fixed lines were also provided to selected centers like Niphad, Powarkheda and Dharwad centers. In this program the non-conventional sources are being used for diversifying the gene pool.

Table 1.15 Performance of synthetic derivative genotypes in station trial.

Genotypes/ Pedigree	Rank at centers				
	Hisar	NWPZ	Faizabad	Cooch Behar	NEPZ
PBS-16-01 (Synth 207/ *PBW 502 //PBW550)	7	13	3 (64.9)	2 (64.3)	1 (64.6)
PBS-16-02 Synth 99/ UP 2425/ FLW 22 //PBW 502	20	20	30	5	19
WH 1105 (check)	09	10	23	36	36
DBW 39 (check)	35	32	8 (58.4)	30 (45.2)	27 (51.8)

Table 1.16 Important crosses available during this season.

No.	Details of cross	No of seed
1	Paragaon / GW322	11
2	Paragaon / HD 2967	11
3	Paragaon / D.DRY	11
4	WH1184 / PARAGAON	55
5	PARAGAON / ISRANA	1
6	HIGHBURY / WH1105	5
7	HD2967 / HIGHBURY	35
8	COMPACTUM / PAVON-76	29
9	Spharococcum / pavon-76	8
10	HD 3086 / pavon-76	61
11	Pavon -76/ HD 2967	2
12	Chinese Spring / HD 3086	92
13	Chinese spring / *T. bessarabicum* / WH 1105	26
14	Chinese spring / *T. turcicum* (P208/P201) / HD 2967	25
15	*T. timopheevi* / PAVON-76	8
16	EC 787011 / *T. spherococcum*	10
17	Pavon-76 / *Ae. speltoides* (214008) / WH1184	9
18	Chinese spring / *Ae. mutica* (28/1/46) /HD2967	8
19	Chinese spring / *Ae. mutica* (28/1/46) /HD3086	21
20	Chinese spring / *T. bessarabicum* / DBW 88	13
21	Chinese spring / *T. bessarabicum* / HD3086	23

Wheat improvement for high productive environments of Northern India

Identification and release of wheat variety DBW 173

DBW 173 was identified and released for cultivation under irrigated late sown conditions of NWPZ. This variety was significantly superior in yield to the popular check varieties HD 3059 (4.8%) and DBW 90 (4.9%). DBW 173 is tolerant to terminal heat under late sown conditions (HSI = 0.98). It has high protein content (12.5%) and protein quality (perfect *Glu* score of 10/10) (Fig (1.2).

Contribution to coordinated trials/nurseries

IIWBR station trial: A total of 21 entries were contributed to different IIWBR Station Trials during 2016-17. From these station trials twelve (12) promising genotypes namely DBW 223 and DBW 226 were promoted to NIVT-1A; DBW 232 was promoted to NIVT-1B; DBW 236 was promoted to NIVT 2; DBW 237, DBW 239 and DBW 240 were promoted to NIVT 3A. Performance of these lines in station trials and IPPSN during 2015-16 is given below (Table 1.20).

Table 1.17 Elite lines showing high degree of tolerance to head scab

Bread wheat		Durum wheat	
HSRBW-1	Sumai#3/ PBW 502	HSRDW-1	Sumai#3/ PDW 274
HSRBW-2	Sumai#3/ HD 2967	HSRDW-2	Sumai#3/ PDW 291
HSRBW-3	Sumai#3/DPW 621-50		
HSRBW-4	Frontana/ Sumai#3	HSRDW-3	Frontana / PDW 233
HSRBW-5	Frontana / PBW 502	HSRDW-4	Frontana / HI 8498

Table 1.18 Genotypes registered as genetic stock for head scab resistance

Genotype	Pedigree	% Average spikelet infection	
		Highest Score	Average score
Donor Parent	Sumai#3	4	3
Recipient Parent	HD 2967	68	66
	PDW 291	80	75
HSRBW-2	Sumai#3/HD 2967	3	3
HSRDW-2	Sumai#3/ PDW 291	3	3

Table 1.19 Pre-breeding material shared through SSN 2017

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

Performance of entries in Advance Varietal Trial :

DBW 187 was promoted to AVT-II under irrigated timely sown conditions of NEPZ (Table 1.21)

Performance of entries in National Initial Varietal Trials

Based on the performance of the entries in different NIVTs, DBW 223 and DBW 237 were promoted to different AVTs. (Table 1.22)

Hybridization and generation advancement

Creation of variability for different traits through hybridizations: 259 new cross combinations were successfully attempted with the aim of enhancing yield, disease resistance and heat tolerance. 13 new crosses and 39 backcrosses were also attempted during summer 2017 in Dalang Maidan.

Evaluation of breeding material at Karnal: Breeding material in different generations from F_1- F_6 was artificially inoculated with different diseases and selections were made on basis of the disease data and other desirable attributes.

Evaluation of breeding material at Dalang: During the summer 2017, breeding material in different generations was evaluated at IIWBR Regional station, Dalang Maidan and selections were made based on disease data and the desirable traits.

Table 1.20 Promising entries promoted to NIVTS

Entry	Promoted to	Yield (q/ha)	IPPSN (2016-17)							
			Stem rust		Leaf rust (South)		Leaf rust (North)		Stripe rust (North)	
			HS	ACI	HS	ACI	HS	ACI	HS	ACI
DBW 256	NIVT 1A	61.7	40S	35.3	40S	10.7	5S	4.3	40S*	14.8
DBW 258	NIVT 1B	60.1	30MS-S	14.4	30S	8.1	20MR	2.7	40S	20.3
DBW 259	NIVT 1B	57.6	10MS	5.4	60S*	12.9	40S	20	5S	1.5
DBW 260	NIVT 1B	55.6	30S	12.7	10MS	1.6	0	0	20S	5.0
DBW 265	NIVT 3A	51.5	40MR-MS	16.7	20S	6.3	0	0	10S	6.0
DBW 266	NIVT 3A	49.1	20S	14	20S	4.4	0	0	10S	8.3
DBW 267	NIVT 3A	47.5	20MS	10	tMR	0.2	20MR	2.7	10S	4.5
DBW 268	NIVT 3A	41.1	10S	6.7	10MR	0.8	20S	6.7	20S	7.5
DBW 269	NIVT 3A	42.1	40MR-MS	16.7	20MR	1.8	0	0	40S	19.5
DBW 273	NIVT 5A	55.1	30MR-MS	12	20S	7.2	0	0	40S	12.2
DBW 274	NIVT 5A	53.4	10MS-S	6	30S	7.8	40S*	13	20S	5.1
DBW 280	NIVT 5B	44.3	10MS	4.1	10S	2	0	0	80S	65

Fig. 1.2 Field view of DBW 173

Table 1.21 Performance on entries in Advance Varietal Trial

Entry	Promoted to	Tested in	Performance in trials during 2016-17			
			Zonal Yield (q/ha)	Rank	Best check (q/ha)	CD
DBW 187	AVT-II (IR-TS-NEPZ)	AVT-I (IR-TS-NEPZ)	48.8	1	K 1006 (46.5)	1.1

Evaluation of advance generation bulks in Preliminary Yield Trial

During the crop year 2016-17, 60 advance generation bulks were tested under timely sown conditions along with four checks namely DBW 90, HD 2967, HD 3086, WH 1105 and also artificially inoculated for stripe rust. Based on yield performance and other desirable traits, 21 bulks were selected for further evaluation in the IIWBR Station Trials in the next crop season of 2017-18. The PYT lines were also evaluated for other end use quality parameters along with physiological and entomological attributes.

Table 1.22 Performance of entries in National Initial Varietal Trials

Entry	Promoted to	Tested in	Performance in trials during 2016-17			
			Zonal Yield (q/ha)	Rank	Best check (q/ha)	CD
DBW 223	AVT-I (IR-TS-NEPZ)	NIVT 1A	49.5	8	HD 2967 (46.3)	2.3
DBW 237	AVT-I (IR-LS-NWPZ)	NIVT 3A	50.1	2	HD 3059 (46.9)	1.8

Contribution to Segregating Stock Nursery

25 F_2 cross combinations were contributed in the 20th segregating stock nursery which was sent to more than 15 centers across the country. The material developed through the programme has the utilization of more than 50.0 %.

Purity testing and seed multiplication:

During the crop season, 26 entries of IIWBR station trials & nurseries, 12 entries of NIVTs and three entries of AVTs were multiplied to produce sufficient amount of seed of these entries in case these entries are further promoted / identified. In addition, the seed of released varieties DBW 14, DBW 16, CBW 38, DBW 90, DPW 621-50 and WB 2 was also multiplied to meet out the demand.

Breeding wheat genotypes for Eastern Region

Registration of Germplasm:

During 2017-18, three genotypes LBRIL 189, DBW 150 and LBPY 11-2 were registered with ICAR-NBPGR, New Delhi for spot blotch resistance, heat tolerance and earliness and bold grains, respectively.

Hybridization and generation advancement:

During the year 2017-18, a total of 126 new cross combinations involving different targeted donors were attempted to diversify base, improve tolerance against biotic/abiotic stresses and quality traits. The F_1 seed of all the crosses was advanced at IIWBR, RS Dalang Maidan during summer 2017 and subsequently F_2 generation of these crosses have been sown at IIWBR, Karnal during 2017-18. Segregating generation *viz*., F_2 (156 crosses), F_3 (41 crosses), F_4 (17 crosses) and F_5 (27 crosses) were sown during main season at Karnal. Apart from this, F_6 bulks (66 crosses), F_7 bulks (15 crosses) and F_8 bulks (64 crosses) were advanced during main season.

Contribution to coordinated Trials:

Based on the performance of genotypes in different IIWBR station trials, genotypes DBW 270 and DBW 277 were promoted to NIVT-3B and NIVT-5B trials, respectively during 2017-18 (Table 1.23). In addition to this, one genotype DBW 250 was also contributed as check in MLHT trials for low Heat sensitivity index.

Table 1.23 Wheat genotypes contributed for testing under different NIVTs during 2017-18

DWR ST-Id	Entry	Pedigree	Trial	Production Condition / Zone
LBP 2016-09	DBW 270	NP 846/ HUW 234	NIVT-3B	IR-LS-CZ/PZ
LBP 2016-05	DBW 277	NI 5439/ MACS 2496	NIVT-5B	RI-TS-CZ/PZ

Contribution to National Nurseries:

Two genotypes LBP 2017-18 and LBP 2017-19 were also contributed to the Salinity/Alkalinity nursery during 2017-18. A set of 36 genotypes were contributed to the national genetic stock nursery for testing and two genotypes RIL S1-38 and RIL S1-46 contributed to short duration screening nursery 2017-18. Besides, segregating populations from 25 crosses were contributed to the segregating stock nursery (SSN) during 2017-18.

Contribution to IIWBR station trials:

Total 15 entries have been contributed to different station trials (timely sown, late sown, restricted irrigated etc.) conducted for different production conditions in all mega zones during 2017-18.

Sharing of ISBL (Institute Shuttle Breeding Lines) to centres in eastern regions of India:

North Eastern Special Trial (NEST) was constituted comprising 51 test entries along with five different checks (DBW 14, WR 544, HD 2967, Raj 3765 and Sonalika were sown at seven different locations viz., Sabour, Coochbehar, Kalyani, Shillongani, Ranchi, Pusa and Faizabad in NEPZ for sowing in two date of sowing (Timely and late sown) conditions for identifying suitable genotypes which are early (in flowering and maturity) and superior in yield.

Evaluation of SSD RIL population for target traits:

A complete set SSD population comprising 248 lines was sown for generation advancement, evaluation for rust and foliar blight and also making further selection of potential lines for large plot testing under preliminary yield trials.

Poly-house screening of potential donors and recipient parents for rust and foliar blight:

A set of 110 genotypes comprising donors and recipient of target traits were sown in two poly-houses on same date of sowing. These lines were artificially inoculated and are being screened for rust and foliar blight.

Evaluation of advanced breeding material for physiological traits:

Data on phenological and physiological traits was recorded on 103 advanced breeding lines (F_7 onwards) along with 24 checks to identify physiologicaly superior cross combination. Cross combinations better than the best check were identified for CTD (1), net photosynthesis (13), cell membrane stability (4), Excised Leaf Water Loss (2) and chlorophyll fluorescence (1) (Fig 1.3, Table 1.24).

Evaluation of material for wheat quality:

Quality data of samples under the project entitled breeding wheat genotypes of eastern region. Total 10 lines were found soft textured with grain hardness less

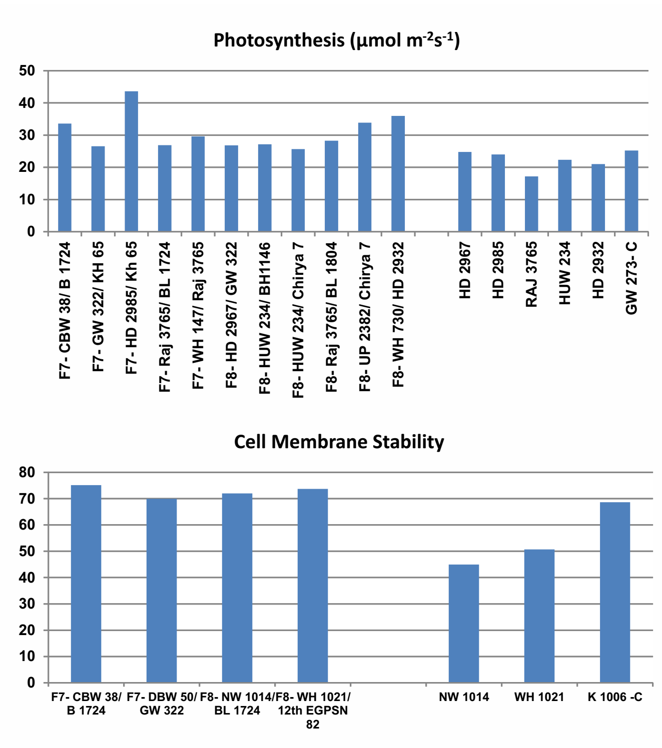

Fig. 1.3 Performance of advanced breeding material for Photosynthesis and Cell Membrane Stability

Table 1.24 Crosses with grain yield more than 600g m-2 and higher physiological trait values

Cross	Physiological Traits
HD 2967/ LBRL1	CTD (4.8), Photosynthesis (assimilation rate) (22.6 µmol m-2s-1), Cell Membrane Stability (50.3), Chlorophyll fluorescence (0.805)
DBW 14/Chirya 7	CTD (5.0), Cell Membrane Stability (50.2), Chlorophyll fluorescence (0.798), chlorophyll (0.045)
WH 147/ RAJ 3765	Photosynthesis (assimilation rate) (29.6 µmol m-2s-1), Chlorophyll fluorescence (0.802)
HW 2045/ LBRL1	Cell Membrane Stability (58.1)
DBW 14/ FLW 3	Chlorophyll fluorescence (0.811)

Table 1.25 Mean and range of breeding material tested for wheat quality parameters during 2017

Parameter	Grain hardness Index	Sedimentation (ml)	Protein % (at 14% moisture)	Hectolitre Weight	Phenol test
Average	70.25	7.68	10.57	79.55	6.55
Range	22.5-101.3	4.5-15.4	8.2-15.5	60.5-83.5	2-9

than 40 suitable for biscuit quality. Three lines showed high sedimentation value suitable for bread quality; two lines showed high grain protein content (>14%). Nine lines showed high hectolitre weight (>83), eight lines exhibited very low phenol colour intensity (Table 1.25). Promising sources identified for wheat quality parameters included; HRWSN-14, HRWSN-94, HRWSN-13, HRWSN-15, HRWSN-22, LBRL-13, BW/SH-6, PI 322087, LSW 110, 23rd HRWSN 44, AC DOMAIN, LB-2016-11, RIL S2-45 (Table 1.26). In addition, advance bulks coming out from target combinations namely; HD 2967/HD 2987, HD 2643/LBRL-1 and DBW 14/CHIRA-7 were also found promising.

DBW218: Promising quality wheat genotype having high sedimentation value

The wheat genotype DBW218 was developed through pedigree breeding method from the cross PRL*PASTOR//PBW343*2/KUKUNA. This genotype was evaluated at total nine locations including five locations (Delhi, Karnal, Hisar, Ludhiana and Gurdaspur) of North Western Plains Zone (NWPZ) and four locations (Faizabad, Kanpur, Pusa and Sabour) of North Eastern Plains Zone (NEPZ) along with the three checks (DBW 71, WR 544, DBW 14) under a very late sown trial during 2016-17 for grain yield, disease resistance and quality traits and this followed as criterion for selecting genotypes for end product purpose. DBW218 showed high sedimentation value of 57ml pooled over both the zones (NWPZ & NEPZ) coupled with desired level of protein content (12.7%) and grain hardness (76) as compared to check varieties.

Besides quality traits, this genotype (DBW 218) showed comparable performance for other agronomic characteristics over checks in both the zones indicating its wider adaptability. Thus, DBW218 is a high yielding genotype having desired level of disease resistance and was found exceptionally good for chapatti making (high sedimentation value, grain protein content and grain hardness) traits.

Anticipatory breeding programme for mitigating wheat blast like disease

In view of the report of wheat blast from Bangladesh, ICAR-Indian Institute of Wheat & Barley Research initiated anticipatory breeding programme and constituted special trial/nursery (consisting of 88 genotypes including released varieties, final year entries, genetic stocks, potential donors and varieties having Milan and 2NS reported to be resistant to wheat blast in the literature) so as to collect preliminary information about the status of blast like disease occurrence. The material was planted in West Bengal and Assam along the borders of Bangladesh.

Improving spot blotch resistance in wheat by Marker-aided backcross breeding:

Spot blotch has been a serious constraint in wheat production in the Eastern Gangetic Plains (EGP) of North Eastern India. Therefore, to enhance spot blotch

Table 1.26 Identification of promising sources for different wheat quality parameters

S.N.	Entry ID	Grain hardness Index	Sedimentation Value (ml)	Protein content	Hectolitre Weight	Phenol test
1.	HRWSN-94	48.6	5.6	12.1	80.5	2
2.	HRWSN-13	82.7	6.8	12.5	83.5	9
3.	HRWSN-14	88	9.9	12.2	81.5	3
4.	HRWSN-15	71.8	5.1	12.8	76	8
5.	HRWSN-22	71.5	5	12.1	78	5
6.	LBRL-13	33.8	9.4	13.1	79	3
7.	BW/SH-6	56.2	6	12.3	78	3
8.	PI 322087	76.5	7.2	12	70	8
9.	LSW 110	81	8.6	14	60.5	7
10.	23rd HRWSN 44	59.7	11.6	12.7	74	3
11.	AC DOMAIN	92.2	11	15.5	71	9
12.	LB-2016-11	100.7	8.5	12.4	78.5	8
13.	RIL S2-45	90.4	6	12.3	81.5	2
14.	F_8 HD 2967/HD 2987	80.2	6	12.8	75.5	7
15.	F_8 HD 2643/LBRL-1	70.1	8.2	12.1	76	6
16.	F_9 DBW 14/CHIRA-7	78.3	6.1	12.1	79.5	7

Table 1.27 Comparative performance of DBW 218 and checks for agronomic and quality traits in NWPZ and NEPZ (2016-17)

Genotype	Quality traits								Agronomic traits					
	Sedimentation value (ml)		Grain hardness		Protein Content (%)		Grain Yield (q/ha)		1000 grain weight (g)		Plant height (cm)		Days to Maturity (days)	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
DBW 218	57.0	52-62	76.0	66-86	12.7	10.8-15.4	32.7	22.2-45.8	33.0	21-42	90	61-106	101	79-114
DBW 71(C)	44.5	42-47	75.0	65-82	12.9	11.3-15.1	32.5	24.4-41.5	33.5	22-40	80	64-94	99	81-115
WR 544(C)	43.0	40-45	70.5	62-77	13.7	11.7-15.5	29.1	25.8-35.2	34.5	24-42	88	58-105	95	75-110
DBW 14(C)	44.0	42-47	65.5	58-65	13.1	11.8-15.5	31.6	23.8-42.9	33.5	25-40	76	58-85	96	77-115

resistant in high yielding cultivar i.e. HD 2967, marker assisted backcrossing programme is initiated at ICAR-IIWBR. BH 1146' (Fronteira/Mentana//Ponta Grossa1) a Brazilian cultivar carrying resistance to spot blotch was used as a donor parent. Transfer of targeted QTLs '*QSb.iiwbr*-7B'and '*QSb.iiwbr*-7D' responsible for conferring resistance to spot blotch was monitored by diagnostic markers (*Xwmc758*-7B and *Xwmc653*-7D) for foreground selection (Table1.28). For background selection against donor segment for rest of the genomic regions of HD 2967, out of 500 SSR markers covering all the 21 chromosomes of wheat, 60 markers were found polymorphic displaying distinguishing banding patterns between parents HD 2967 and BH 1146 (Fig.1.4).

During this season, recipient parent (HD 2967) was crossed with donor parent BH 1146, maximum numbers of crosses were made to obtain sufficient amount of F_1 seeds.

Wheat improvement for warmer areas

Wheat crops in India is exposed to warmer climatic conditions due to higher temperatures during crop period and occasionally coupled with limited water availability. Such conditions affect grain filling and result into improper grain formation leading to reduced yield levels. The rusts and foliar blight are another factor that leads to crop damage in the event of their occurrence. Besides, Karnal bunt has occupied prominence due to its trade related importance. Keeping this in view, efforts were made to develop high yielding, disease resistant wheat genotypes suitable to warmer climatic conditions especially for central and peninsular India. Salient achievements of this programme during 2017-18 are presented as under.

Table 1.28 QTLs, QTL-linked marker, donor and recipient genotype, base line trait values of recipient genotypes and the expected trait values of the improved genotypes.

Markers linked to QTL and donor genotype	Recipient genotype	R2	Base line trait value of recipient genotype	Expected trait value after improvement
QTL: QSb.iiwbr-7B Markers (Chromosome arm): Xwmc758 Singh et al.(2016)	HD2967 BH1146	13%	Spot blotch susceptible and high yielding under optimum conditions	Enhanced spot blotch resistance coupled with yield
QTL: QSb.iiwbr-7D Markers (Chromosome arm): Xwmc653 Singh et al. (2016)	HD2967 BH1146	18%	Spot blotch susceptible and high yielding under optimum	Enhanced spot blotch resistance coupled with yield conditions

New cross combinations and their evaluation

A total of 262 new cross combinations were attempted during the crop season which included diverse genotypes as parents with the objective to incorporate the desirable traits for warmer areas. These crosses involved synthetics, Chinese germplasm, elite material from national and international nurseries/trials as parents for broadening the genetic base of the material. 363 F_1s made in 2015-16 were evaluated for yield and component traits along with 10 check varieties namely HD 3086, HD 2967, WH 1105, DBW 71, DBW 90, DBW 107, K 0307, DBW 110, HD 2932 & DBW 93. Heterosis over best check HD 3086 was estimated for yield and a wide range of -88.5 to 34.2 % was observed. Out of 79 F_1s having positive heterosis, 8 showed more than 25% standard heterosis (Table1.29). These promising combinations for higher yield were identified for more precise evaluation in next generations.

Table 1.29 Heterotic crosses in F_1 generation

S. No.	Cross over	% Heterosis HD 3086
1.	CG1012 /HD3086	34.2
2.	CRS77/WH1105	34.2
3.	15HRWYT-222/UP2425 //WH1105	32.8
4.	CRS75/DBW148	31.7
5.	CG120/CR39	31.2
6.	MUNIA/CHTO/3/PFAU/BOW //WH1105	28.2
7.	CRS37/CRS6	26.7
8.	K1510/DBW71	25.7

Evaluation of breeding material in different generations

A total of 5722 different breeding lines developed from 837 diverse crosses were evaluated during 2016-17. 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, 4381 single spike selections representing 676 cross combinations were made based on plant type, maturity period, disease resistance, grain weight, tillering ability and grain number (Table 1.30). In addition, 128 bulks of advanced lines were made for their advancement to PYTs.

Table 1.30 Evaluation of breeding material in various generations

Generation	Evaluated Selections	Single lines spike
F_2	224	208
F_3	1773 (244)	1342 (187)
F_4	1500 (144)	1171 (110)
F_5	1038 (111)	741 (72)
F_6	1119 (93)	871 (56)
F_7	68 (21)	48 (43)
Total	5722 (837)	4381 (676)

Number of crosses in parenthesis

Evaluation of advanced bulks in PYT

70 advanced bulks were evaluated for various yield traits along with 10 checks, namely, HD 3086, HD 2967, WH 1105, DBW 71, DBW 90, K 0307, DBW 107, DBW 110, HD 2932 & DBW 93 in six rowed plot of 6.0 m length in 02 replications under timely sown irrigated conditions

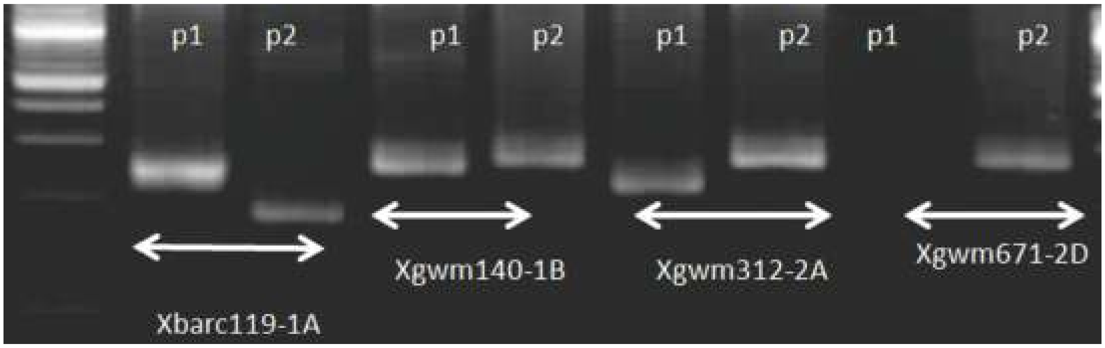

Fig. 1.4 DNA polymorphism survey between two parents HD2967 (P1) and BH1146 (P2) using SSR markers

(IR). Besides, same set was also evaluated under restricted irrigation (RI) conditions in double row plot of 2.5m length spaced 20cm apart. A wide range was observed for various traits under different irrigation conditions (Table 1.31).

Based on the yield and disease reactions, following entries were found promising and were promoted to station trials of the IIWBR (Table 1.32).

Identification of promising bread wheat genotypes for high iron and zinc content

The PYT lines were also evaluated for iron (Fe) and zinc (Zn) content using *X-ray fluorescence analyzer (XRF)* of Oxford Instruments. For the purpose, the entries were harvested and threshed without using any metallic pan. The results indicated higher values of Fe (37.9ppm with range of 31.6 to 44.4ppm) and Zn (32.0ppm with range of 23.2 to 46.6ppm) content under RI condition. Under irrigated conditions, the mean Fe content was 37.7 ppm with range of 31.5 to 45.1ppm whereas mean Zn content was 30.6ppm ranging from 21.2 to 43.9ppm. The Fe & Zn content were found highly correlated (0.58) under both the conditions. Entries 16-62 and 16-21 under irrigated condition and 16-52 and 16-18 under RI condition showed higher Fe and Zn content together. Besides these, 16-37, 16-15, 16-4, 16-17 and 16-60 showed high Fe content under both the production conditions. Few promising genotypes for Fe and Zn content under IR and RI condition have been identified (Table 1.33) for further evaluation in bio-fortification trials which may be potential donors for nutritional improvement of wheat genotypes.

Preliminary analysis of falling number for pre-harvest sprouting tolerance in bread wheat

Germination of wheat within the grain head before har-

Table 1.31 Performance of genotypes for various traits in PYT (2016-17)

Traits	Irrigated		Restricted irrigation	
	Range	Mean	Range	Mean
Days to heading	78-102	91	75-99	86
Days to maturity	104-144	134	103-137	129
Plant height	86-136	105	83-128	99
Tillers/m	60-145	96	80-215	131
Spikelets/spike	19-27	24	16-26	20
Spike length (cm)	7-13	10	7-13	11
Grains/Spike	42-100	64	24-76	50
1000-gr. weight (g)	28-58	42	37-76	47
Grain yield (q/ha)	36.7-69.9	55.6	36.8-52.7	44.4
Biomass yield (t/ha)	14.2-23.1	17.7	8.1-16.4	12.2
Chlorophyll Content	33.8-47.2	41.1	36.7-52.4	44.4
NDVI	0.70-0.83	0.78	0.35-0.77	0.57

Table 1.32 Promising entries in preliminary yield trial during 2016-17

Entry	Yield (q/ha)	Days to heading	Days to maturity	Plant height (cm)	1000 - gr weight (g)	Yellow Rust
Station trial 1						
PYT 2016-65	69.9	91	143	106	41	5S
PYT 2016-34	69.2	93	139	101	46	5S
PYT 2016-31	68.9	95	141	107	39	5S
PYT 2016-66	67.3	93	144	106	41	10S
PYT 2016-79	66.2	93	140	107	49	10S
PYT 2016-71	65.9	100	143	101	35	20S
HD 3086(C)	65.2	94	140	100	45	10S
Station trial 2						
PYT 2016-06	67.7	92	134	106	43	40S
PYT 2016-28	64.2	85	128	113	41	40S
HD 2967(C)	59.6	91	139	108	40	40S
Station trial 3						
PYT 2016-53	62.9	90	130	99	41	5S
PYT 2016-47	62.7	89	140	108	57	10S
PYT 2016-37	60.0	83	128	102	45	10S
PYT 2016-73	59.8	92	134	103	45	20S
PYT 2016-29	58.4	82	128	113	46	5S
DBW 71©	57.9	81	128	101	44	5S
Station trial 4						
PYT 2016-69	71.7	87	131	95	47	
PYT 2016-70	59.2	95	131	92	44	
PYT 2016-33	58.5	86	130	101	52	
PYT 2016-36	54.3	84	130	95	48	
PYT 2016-76	53.9	94	127	97	45	
PYT 2016-63	46.8	84	134	95	49	
DBW 110(C)	43.5	86	105	98	45	

vest is known as 'pre-harvest sprouting' (PHS) which is contributed to periods of prolonged rainfall and high humidity after the grain ripening and before its harvest. The "falling-number test" is internationally accepted, indirect but quite accurate measure of alpha-amylase activity within a grain sample which indicates PHS tolerance. Sound, starchy grains produce thick slurry where plunger takes more time to

Table 1.33 Performance of wheat genotypes for Fe and Zn content during 2016-17

SN	Entry	ID	Pedigree	Fe (ppm)	Zn (ppm)
Timely sown, irrigated condition					
1	16-62	F6-928	HD2967/DBW16	42.80	43.90
2	16-21	F6-241	36IBWSN116/DBW16	40.20	41.50
3	16-59	F6-898	K-307/DBW16	40.40	39.00
4	16-57	F6-819	DBW17/39 IBWSN1081	40.00	37.40
5	16-37	F6-448	LOK62/DBW16	45.10	36.60
	16-32	DBW-71(C)		41.80	36.00
Timely sown, restricted irrigation condition					
1	16-52	F6-752	KRL236/DBW16	44.00	46.60
2	16-18	F6-185	HS277/DBW17	44.40	41.10
3	16-17	F6-182	K-307/HD2967	43.00	37.20
4	16-50	F6-629	KRL236/DBW16	42.90	36.60
5	16-80	SAWSN3210	SAWSN3210	42.70	38.30
6	16-30	F6-362	35IBWSN68/DBW17	41.30	36.00
	16-72	DBW93 (C)		41.40	36.90

Table 1.34 Falling number estimates of wheat genotypes for PHS tolerance

Sr No.	Entry	Pedigree	Falling number (14% moisture)	Grain yield (q/ha)
1	PYT-16-73	28ESWYT107/RAJ4037	608	59.8
2	PYT-16-66	RAJ3765/DBW60	595	67.3
3	PYT-16-67	RAJ3765/DBW60	551	67.1
4	PYT-16-26	PBW396/HD2967	544	55.6
5	PYT-16-7	PHS709/DBW17	543	43.3
6	PYT-16-52	KRL236/DBW16	541	49.5
7	PYT-16-65	RAJ3765/DBW60	536	69.9
8	PYT-16-42	HD2189/DBW16	532	36.7
9	PYT-16-11	PHS709/HD2967	520	63.2
10	PYT-16-19	HS277/HD2967	509	44.5
11	PYT-16-27	PBW396/HD2967	506	55.0
12	PYT-16-58	SGH1/20IBWSN239	502	50.4
13	PYT-16-01	WH 1105 (C)	491	58.6
14		DBW 71 (C)	248	

reach bottom and shows bigger falling number. Sprout-damaged grain results in thinner or less viscous flour and water mixture due to higher alpha-amylase activity to break down the starch where the plunger falls faster to the bottom of the test tube measuring smaller the falling number. In general, falling-number values of 350 seconds or greater indicate good quality flours for milling and baking purposes. The falling number at 14% moisture content was estimated in 80 wheat genotypes as a preliminary investigation to identify PHS tolerant genotypes. The falling number ranged from 127 to 608 with average value of 435. The check varieties from different agro-ecological conditions showed falling number values from 248 (DBW71) to 491 (WH1105). The other released varieties, DBW110 (489), DBW107 (463), HD3086 (460), HD2967 (444), DBW93 (419), DBW90 (416) and HD2932 (387) showed their suitability for milling and baking purposes. The genotypes showing falling number of 500 or more have been identified (Table 1.34) for further detailed analysis to their PHS tolerance.

Evaluation of dwarf genotypes for yield components

Thirty-eight dwarf progenies selected from the segregating material were bulked separately and evaluated to observe their performance for yield and component traits in 2016-17 crop season. The plot size was double-row of 3 m length spaced at 20 cm. Genotypes showed wide range of variability for the traits studied. The average plant height was 71 cm (range of 62-79 cm) and mean yield was 46.3q/ha with range of 25.1 to 71.1q/ha. The average heading and maturity period was 93 days (71-100 days) and 145 days (132-154 days), respectively. On average, these genotypes have longer spikes (mean 11cm), more spikelet number per spike (22) and high grain number (66). The mean harvest index was 32.4% ranging from 21.5 to 45.4%. Despite of the lower plant height, the higher grain yield was attributed to very high tillering ability ranging from 122-187 tillers /meter row length with average value of 166 tillers. Based on grain yield, eleven entries were found promising (Table 1.35) which can be further evaluated for agronomic suitability at variable input conditions. However, these genotypes were also confirmed for the presence of dwarfing genes *(Rht B1b, Rht D1b* and *Rht 8)* through PCR analysis. (Table 1.35)

Contribution from station trials to NIVTs

During 2016-17, fifteen entries were contributed to IIWBR station trial (06 in timely sown, 06 in late sown, 03 in A+D) out of which two entries were promoted to NIVT 2 (DBW 263 & DBW 264) and one entry DBW 271 was promoted to NIVT 3B during 2017-18. In addition,

Table 1.35 Promising dwarf genotypes for yield component traits and Rht genes

Genotype	Gr. Yld (q/ha)	Pl. Ht. (cm)	DH	DM	Tillers /m row	Sp. Lgth (cm)	Spk/sp	TGW (g)	Gr. /sp	HI (%)	YR	Rht genes* B1b	D1b	8
WAPD 1531	71.1	69	95	145	176	11	22	44	72	43.7	5S	+	+	+
WAPD 1521	63.3	69	93	144	163	11	20	43	51	42.4	5S	+	+	+
WAPD 1508	62.8	72	83	138	179	12	23	44	53	42.4	20S	+	+	+
WAPD 1522	58.8	71	95	146	150	10	19	41	48	39.4	5S	+	+	+
WAPD 1528	58.0	73	98	150	175	12	24	41	65	34.1	10S	+	+	+
WAPD 1530	56.5	76	98	150	194	11	21	41	58	31.7	10S	+	+	+
WAPD 1529	56.2	74	99	151	184	11	22	42	47	32.9	10S	+	+	+
WAPD 1519	55.6	67	96	150	183	12	20	41	72	33.9	10S	+	+	+
WAPD 1523	55.3	73	98	148	171	11	22	39	66	32.9	5S	+	+	+
WAPD 1502	53.5	79	95	142	201	14	26	33	84	31.2	5S	+	+	+
WAPD 1505	53.2	72	82	144	207	11	21	39	49	34.1	20S	+	+	+
DBW93 (C)	53.1	86	91	139	153	8	21	40	47	*39.8*	*20S*	-	-	-

**PCR based confirmation at approx. 237bp (RhtB1b), 254bp(RhtD1b) and 192bp(Rht8)*

one entry DBW 276 has been contributed to SPL-VLS-NWPZ/NEPZ.

Promotion from NIVTs to AVTs

During 2016-17, two entries DBW 221 & DBW 252 were evaluated in NIVT 1A & NIVT 5A, respectively. Both these entries were advanced to AVT trials in two zones, i.e., NWPZ & NEPZ. Their performance in coordinated trials is presented in (Table 1.36). In addition, DBW 249 was evaluated in Spl-VLS-NWPZ/NEPZ during 2016-17. It showed significantly superior yield performance (32.4q/ha) in NWPZ under very late sown trial.

New genetic stocks proposed for registration

During the reporting period, three new genetic stocks have been developed which were approved by the IGRC of the IIWBR, Karnal for registration. These are DBW 129 for multiple disease and pest resistance (all 3 rusts, LB, KB, PM, FS, shoot fly & brown wheat mite), PHS 1101 for high iron (49.1ppm) and copper (6.4ppm) content in grains and PHS 1108 for high protein content (14.8%) with bold seeds (55g TGW) and high manganese (44.2ppm) content.

Shuttle breeding under warmer area programme

The segregating material comprising 318 F_2 crosses and 90 F_3 populations was shared with shuttle breeding centres of CZ (Jabalpur, Powarkheda, Vijapur, Junagadh and Bilaspur) and PZ (Dharwad, Niphad, Akola) under warmer area programme for target specific selections that showed 51.8% and 28.1% utilization, respectively. In addition, 82 advanced lines of PYT were sent to these centres for evaluation under irrigated as well as restricted irrigation conditions. A wide range was observed for various traits under different irrigation conditions (Table 1.37) and 42 promising entries were retained by centres for evaluation in respective PYTs.

Table 1.36 Performance of test entries in NIVTs & Special trial during 2015-16

Entry	Yield (q/ha) NWPZ	NEPZ	Rust Reaction Yellow (ACI)	Brown-N(ACI)	Promotion (2016-17)
NIVT 1A					
DBW 221	62.0*	50.6*	40S (11.7)	20S (7.0)	AVT-TS-NWPZ/NEPZ
WH 1105(C)	58.0	-	60S (25.4)	20S (12.0)	
HD 2967 (C)	-	46.3	80S (51.0)	10S (4.0)	
NIVT 5A					
DBW 252	55.1*	38.1*	40S (13.9)	0 (0.0)	AVT-RI-NWPZ/NEPZ
WH 1142 (C)	51.6	-	5S (1.4)	40S (8.1)	
HD 2888 (C)	-	32.8	60S (33.2)	5S (2.0)	

Table 1.37: Mean and range of genotypes for yield traits in different production conditions

Traits	Central zone Irrigated	Restricted irrigation	Peninsular zone Irrigated	Restricted irrigation
Days to heading	64 (55-71)	60 (54-66)	58 (54-69)	58 (54-63)
Days to maturity	107 (84-112)	102 (96-106)	111 (105-116)	115 (108-120)
Plant height (cm)	77 (62-87)	73 (56-85)	83 (62-97)	74 (63-83)
1000-grains weight (g)	42 (38-47)	35 (30-42)	39 (34-47)	36 (31-44)
Grain yield (q/ha)	57.9 (37.4-72.5)	37.4 (24.7-48.9)	51.9 (33.9-69.4)	40.5 (29.8-64.1)

Development of Hybrid Wheat

Diversification of CMS (A) & Restorer (R) lines in Indian background

With a view to diversify cytoplasmic male sterility, CMS lines from CIMMYT and IARI were crossed with Indian varieties as superior agronomic base. Indian varieties were used as male parent and repeated backcrosses were made to recover background of Indian varieties. In all, 73 new diversified CMS lines in 24 different Indian backgrounds were developed that showed complete male sterility. These lines were maintained along-with maintainer lines (Table.1.38) through controlled pollination for further utilization in hybrid development programme. In addition, 276 CMS lines are in different BC generations of diversification in agronomic background of 58 Indian cultivars.

In order to diversify the restorer sources, the fertility restorer lines were crossed with PBW343 and DBW17 that resulted in development of 07 new restorer lines. Besides these, there are 50 new restorer lines in BC6 generation in 27 diverse genetic backgrounds of Indian wheat varieties.

III. Development and evaluation of experimental hybrids

60 new experimental hybrids were made during 2016-17 crop season using 20 CMS (A line) and 3 restorer lines (R line) in 2R:4A:2R planting ratio. The CMS lines used were developed from the diversification programme. Three R-lines namely Res 5, Res 37 and Res 38 were used as male parent in development of experimental hybrids. The CMS lines were planted between the restorer lines and the seeds of experimental hybrids were harvested from the CMS lines.

55 experimental hybrids developed in 2015-16 crop season were evaluated during 2016-17 crop season at half seed rate (50kg/ha). Five checks namely HD 3086, HD 2967, WH 1105, K307 and DBW110 were included at full seed rate (100kg/ha) for comparing the

Table.1.38: New CMS lines developed in Indian wheat background

S No.	A Line					B line		
	Line ID	Parentage	Male sterility (%)	Days to heading	Pl. ht (cm)	Base line	Days to heading	Pl. ht. (cm)
1	DCMS 1	CMS1A/PBW343	100	95	100	PBW343	95	101
2	DCMS 2	CMS10A/PBW343	100	95	101	PBW343	95	102
3	DCMS 3	CMS11A/PBW343	100	85	101	PBW343	95	100
4	DCMS 4	CMS12A/PBW343	100	95	92	PBW343	95	96
5	DCMS 5	CMS13A/PBW343	100	95	97	PBW343	95	98
6	DCMS 6	CMS17A/PBW343	100	95	101	PBW343	95	104
7	DCMS 7	CMS20A/PBW343	100	95	94	PBW343	95	100
8	DCMS 8	CMS3A/DBW17	100	92	92	DBW17	92	91
9	DCMS 9	CMS5A/DBW17	100	93	85	DBW17	93	86
10	DCMS 10	CMS8A/DBW17	100	92	89	DBW17	92	91
11	DCMS 11	CMS10A/DBW17	100	93	77	DBW17	93	80
12	DCMS 12	CMS12A/DBW17	100	96	85	DBW17	94	83

13	DCMS 13	CMS13A/DBW17	100	96	88	DBW17	96	90
14	DCMS 14	CMS14A/DBW17	100	94	85	DBW17	96	93
15	DCMS 15	CMS15A/DBW17	100	93	85	DBW17	93	86
16	DCMS 16	CMS18A/DBW17	100	93	80	DBW17	93	86
17	DCMS 17	CMS21A/DBW17	100	93	84	DBW17	93	90
18	DCMS 18	CMS22A/DBW17	100	93	88	DBW17	93	90
19	DCMS 19	CMS25A/DBW17	100	93	88	DBW17	93	92
20	DCMS 20	CMS26A/DBW17	100	93	90	DBW17	93	87
21	DCMS 21	CMS30A/DBW17	100	93	85	DBW17	93	93
22	DCMS 22	CMS2A/DBW16	100	95	92	DBW16	95	98
23	DCMS 23	CMS8A/DBW16	100	95	96	DBW16	95	104
24	DCMS 24	CMS10A/DBW16	100	95	100	DBW16	95	101
25	DCMS 25	CMS11A/DBW16	100	95	92	DBW16	95	98
26	DCMS 26	CMS12A/DBW16	100	95	88	DBW16	95	90
27	DCMS 27	CMS15A/DBW16	100	95	84	DBW16	95	91
28	DCMS 28	CMS18A/DBW16	100	95	88	DBW16	95	90
29	DCMS 29	CMS19A/DBW16	100	95	101	DBW16	95	96
30	DCMS 30	CMS21A/DBW16	100	95	100	DBW16	95	98
31	DCMS 31	CMS23A/DBW16	100	95	96	DBW16	95	100
32	DCMS 32	CMS1A/PBW502	100	94	105	PBW502	94	101
33	DCMS 33	CMS6A/PBW502	100	94	100	PBW502	94	107
34	DCMS 34	CMS21A/PBW502	100	94	98	PBW502	94	96
35	DCMS 35	CMS5A/DBW55	100	94	94	DBW55	94	96
36	DCMS 36	CMS9A/DBW55	100	94	94	DBW55	94	100
37	DCMS 37	CMS15A/DBW55	100	94	95	DBW55	94	100
38	DCMS 38	CMS24A/DBW55	100	94	97	DBW55	94	94
39	DCMS 39	CMS21A/DBW55	100	94	96	DBW55	94	91
40	DCMS 40	CMS8A/DBW60	100	82	98	DBW60	80	100
41	DCMS 41	CMS20A/DBW60	100	82	97	DBW60	80	101
42	DCMS 58	CMS21A/DBW60	100	82	103	DBW60	80	104
43	DCMS 42	CMS23A/DBW60	100	82	104	DBW60	80	102
44	DCMS 43	CMS26A/DBW60	100	82	105	DBW60	80	103
45	DCMS 44	CMS2A/CBW38	100	94	101	CBW38	94	107
46	DCMS 45	CMS10A/CBW38	100	94	104	CBW38	94	102
47	DCMS 46	CMS15A/CBW38	100	94	103	CBW38	94	105
48	DCMS 47	CMS2A/RAJ3077	100	86	105	RAJ3077	86	110
49	DCMS 48	CMS8A/RAJ3077	100	86	106	RAJ3077	86	107
50	DCMS 49	CMS14A/RAJ3077	100	87	111	RAJ3077	86	110
51	DCMS 50	CMS8A/DBW76	100	84	110	DBW76	84	112
52	DCMS 51	CMS21A/DBW76	100	84	109	DBW76	84	118
53	DCMS 52	CMS2A/UP2338	100	86	100	UP2338	86	102
54	DCMS 53	CMS7A/GW411	100	99	101	GW411	99	105
55	DCMS 54	CMS14A/PBW550	100	84	83	PBW550	80	91
56	DCMS 55	CMS14A/RAJ4037	100	82	102	RAJ4037	99	107
57	DCMS 56	CMS28A/PBW175	100	84	106	PBW175	84	100
58	DCMS 57	CMS28A/DBW39	100	98	108	DBW39	98	114
59	DCMS 59	CMS22A/DBW87	100	94	102	DBW87	94	101
60	DCMS 60	CMS24A/DBW87	100	94	94	DBW87	94	105
61	DCMS 61	CMS5A/HD2687	100	94	107	HD2687	95	105
62	DCMS 62	CMS20A/HD2967	100	86	107	HD2967	85	117
63	DCMS 63	CMS15A/HD1925	100	84	101	HD1925	78	102
64	DCMS 64	CMS20A/HD2925	100	81	103	HD2925	81	96
65	DCMS 65	CMS9A/HI784	100	93	107	HI784	88	100
66	DCMS 66	CMS9A/HI977	100	94	106	HI977	84	108

67	DCMS 67	CMS29A/HI977	100	95	105	HI977	95	107
68	DCMS 68	CMS26A/K9006	100	94	114	K9006	85	112
69	DCMS 69	CMS11A/NW1012	100	94	100	NW1012	94	108
70	DCMS 70	CMS28A/PBW550	100	84	90	PBW550	80	95
71	DCMS 71	CMS29A/PBW550	100	84	90	PBW550	80	92
72	DCMS 72	CMS2A/RAJ1482	100	93	101	RAJ1482	88	96
73	DCMS 73	CMS10A/RAJ1482	100	94	96	RAJ1482	87	97

performance of hybrid combinations. A wide range of heterosis for grain yield (-68.34% to 20.16%) was observed and 11 hybrids out-yielded the best check variety HD 2967 (Table.1.39).

Improvement of wheat for grain quality

Wheat grain quality is very important for many stakeholders in the wheat value chain: farmers (bold and plump grain), millers (high test weight and high flour yield), food manufacturers (processing quality) and consumers (end-use and nutritional quality). Wheat grain can be processed into flour, semolina and other products that form the basic ingredients of many foods globally like bread, cookies, pastries, pasta, noodles, and couscous. Nutritional quality as determined by many factors (high grain protein content, iron, zinc, yellow pigment content) is very important of optimum growth and development for human beings.

Release of variety DBW 168 by CVRC

Central Sub-Committee on Crop standards, notification and release of varieties (CVRC) approved DBW 168 for release and notification for Maharashtra and Karnataka regions of Peninsular Zone under timely sown irrigated condition. This variety has good quality attributes along with grain yield. Besides high yield potential, it has also registered resistance to black rust in the peninsular zone. DBW 168 has shown significant yield superiority over the recently released checks MACS 6222 (4.3%) and MACS 6478 (4.0%). DBW168 has very good chapatti quality with score 8.15 out of 10. Because of comparatively lower grain hardness index (36), DBW168 has additional advantage of higher biscuit spread factor (7.87) in comparison to the prevailing irrigated varieties of the zones (MACS 6478: 6.61 & MACS 6222: 6.19). Since

Fig. 1.5 Field view of wheat variety DBW 168

Table.1.39 : Performance of experimental hybrids

S.N.	Hybrid	Days to heading	Days to maturity	Plant height (cm)	Yield/plot(gm)	Heterosis over best check (%)
1	CMS 15/RES21	98	149	100	1776	20.16
2	CMS 14/RES15	84	142	112	1724	16.64
3	CMS 17/RES15	80	139	113	1676	13.40
4	CMS 9/RES15	81	140	104	1534	3.79
5	CMS 13/RES5	96	146	106	1514	2.44
6	CMS 18/RES21	99	149	80	1510	2.17
7	CMS 19/RES21	82	141	93	1504	1.76
8	CMS 16/RES5	94	148	101	1494	1.08
9	CMS 14/RES21	99	149	97	1490	0.81
10	CMS 12/RES15	83	146	107	1490	0.81
11	CMS 8/RES5	93	140	110	1488	0.68
	HD 2967 ©	94	146	99	1478	0.00

Table 1.40: Performance of entries in NGSN during 2016-17

SN	Genotypes	Agronomic traits									Processing quality			Nutritional quality	
		GY (q/ha)	DH	DM	PH (cm)	TPM	GPS	TKW (g)	SL (cm)	TW (kg/hl)	Protein %	Sed. value (ml)	Hard -ness	Fe (ppm)	Zn (ppm)
1	DBW129	54.2	79	126	98	106	54	42	10	81.0	12.3	65	81	41.1	28.8
2	DBW110	44.7	78	125	92	82	54	43	10	81.3	11.2	60	73	37.0	30.9
3	DBW71	49.0	75	124	89	103	46	41	10	82.6	11.0	42	79	40.4	31.2
4	DBW93	46.3	78	124	82	104	50	39	9	83.4	10.7	45	81	35.5	30.8
5	DBW107	50.4	73	123	89	100	47	42	10	82.5	11.5	43	80	40.6	32.5
6	DBW172	41.5	85	129	89	101	53	38	9	82.7	13.9	64	77	43.4	38.5
7	DBW179	52.6	79	126	100	94	55	42	10	80.3	12.6	61	84	44.1	33.7
8	PHSL5	29.4	71	122	103	49	51	52	13	79.0	12.5	46	76	38.1	31.1
9	PHSL10	34.3	70	122	101	63	54	47	12	79.0	11.7	45	79	38.4	30.0
10	PHSL11	35.1	70	123	94	66	54	45	10	81.2	12.4	57	79	37.0	28.9
	Sonalika©	42.4	73	123	91	95	48	41	10	81.4	12.0	41	84	36.8	31.6
	HD2967©	48.2	81	127	94	98	55	40	10	78.0	11.8	62	81	36.3	30.5
	HI8713(d)©	46.8	82	128	90	89	52	45	9	79.5	11.5	42	96	35.1	30.9

biscuit industry has high demand for softer wheats, DBW 168 can be an asset for providing remunerative price to the growers. Grain protein content in DBW168 (13.4%) is higher than the check varieties MACS 6478 (12.8%) and MACS 6222 (13.1%). Nutritional quality in DBW168 is also supported by high yellow pigments content (3.71ppm) which is better than the checks MACS 6478 (3.19ppm) and MACS 6222 (3.12ppm).

Hybridization program

A total of 388 new cross combinations were made for different quality traits in bread wheat and 158 crosses in durum wheat. Different donor parents were used to improve grain protein content (donors: QLD46, UP2640, 36th IBWSN-138, 12th HRWYT-26), Soft grain for better biscuit making (donors: QLD49, QLD67, QLD73, 39thIBWSN1110, 39thIBWSN1108, HS490), high bread loaf volume (NI5439, MACS6222, HI1605) and high chapatti score (NIAW1415, C306). In durums, the genotypes were selected based on the traits like better quality making (DW1001), high beta-carotene (HI8663, EDUYT54, HI8713), high flour semolina recovery (MACS499, PDW314, GW1255). The breeding material in different generation is presented in Table 1.41.

Table 1.41 Evaluation of breeding material (crosses) of bread and durum wheat in different generations.

Generations	Bread wheat	Durum wheat
F_2	260	75
F_3	928 (222)	50 (150)
F_4	454 (74)	50 (170)
F_5	357 (85)	40 (160)
F_6	486 (159)	35 (140)
F_7	173 (103)	20 (120)

UP2672 (13.72%). This genotype QLD46 would be a potential source in future breeding programs while improving grain protein content of bread wheat varieties. This genotype would also be registered as genetic stock for high protein at NBPGR

Identifying promising soft grain wheat genotypes for biscuit making

Three genotypes (QLD67, QLD73 and QLD49) were developed at ICAR-IIWBR with soft grain texture. These genotypes were evaluated at 11 centers in Quality Component Screening Nursery (QCSN) during 2016-17. QLD67 (GHI: 27), QLD73 (GHI: 22), and QLD49 (GHI: 21) were found to be superior among all the tested genotypes (Table 1.43). These soft grain genotypes

Table 1.42 Grain protein content (%)at 11 locations during 2016-17.

Zone	Location	QLD46	UP2672 (C)	QLD67	QLD73	QLD49
NHZ	Almora	14.20	12.64	27	24	19
NWPZ	Ludhiana	14.76	13.26	27	11	12
	Durgapura	14.24	13.64	27	22	13
	Delhi	14.68	14.24	30	23	21
	Pantnagar	12.73	11.84	30	25	26
	Karnal	14.86	12.85	32	25	23
NEPZ	Pusa	14.37	13.91	18	21	12
CZ	Junagadh	15.68	14.99	23	21	22
	Vijapur	15.43	13.89	32	26	20
PZ	Pune	14.93	15.00	34	25	32
	Dharwad	14.72	14.63	22	22	30
Mean (National)	**14.9**	**13.72**		**27**	**22**	

Table 1.43 Grain hardness index of QLD67, QLD73 and QLD49 at 11 locations during 2016-17.

Zone	Location	QLD67	QLD73	QLD49
NHZ	Almora	27	24	19
NWPZ	Ludhiana	27	11	12
	Durgapura	27	22	13
	Delhi	30	23	21
	Pantnagar	30	25	26
	Karnal	32	25	23
NEPZ	Pusa	18	21	12
CZ	Junagadh	23	21	22
	Vijapur	32	26	20
PZ	Pune	34	25	32
	Dharwad	22	22	30
Mean	**National**	**27**	**22**	**21**

would be a potential source to be utilized in the future breeding programs to develop high yielding wheat varieties suitable for biscuit industry.

Contribution to coordinated trials/nurseries:

Bread Wheat: A total of 10 entries were contributed to different ICAR-IIWBR station trial during 2016-17 (4 for timely sown, 2 for late sown and 2 for A+D) which were conducted at three locations of NWPZ, two locations of NEPZ and three locations of CZ+PZ. Based on ICAR-IIWBR station trial performance one entry (DBW254) was promoted to NIVT-1A and two entries to NIVT-1B (DBW261 & DBW262). DBW254 and DBW262 had high chapatti score of 8.15 and 8.20, respectively. DBW261 recorded high bread loaf volume with 620ml as compared to check varieties of WH1105 with 560ml and DBW39 with 565ml.

Durum Wheat: A total of 8 entries were contributed to different ICAR-IIWBR station trial 2016-17 in A+D trial and evaluated at 2 locations. Based on ICAR-IIWBR station trial data, two entries (DDW48 & DDW49) were promoted to national durum trial NIVT-4.

Utilizing winter wheats for spring wheat improvement

Sharing of segregating materials

The Spring x Winter wheat Segregating Stock Nursery (SWSSN) comprising 46 crosses from F_2 generation was shared with six cooperating centres, namely Malan, Varanasi, Faizabad, Kanpur, Vijapur and Gwalior. The segregating material was subjected to natural biotic and abiotic stresses at different centres located in major wheat zones. There was occurrence of yellow rust and powdery mildew and early season moisture stress at Malan, stem and leaf rust at Vijapur centre, terminal heat and leaf blight at Varanasi centre; leaf blight and sodicity at Faizabad, terminal heat and early and late heat at Gwalior centre.

Table 1.44 Utilization report from cooperating centres

Name of the center	Crosses Selected #	Utilization %	Plants selected#	Characteristics for which utilized
CSKHPKV, Malan	43	93.5	951	Resistance to yellow rust and powdery mildew and yield components
BHU- Varanasi,	5	10.9	39	Yield components and leaf blight resistance
NDUAT-Faizabad	12	26.1	12	Yield components, leaf blight resistance and seed characteristics
CSA Kanpur,	11	23.9	40	Yield components, morphological and seed characteristics
SDAU- Vijapur	14	30.43	17	Rust resistance, yield components, morphological traits and seed c haracteristics
Gwalior	46	100	356	Yield components and morphological traits

The utilization report from cooperating centres showed that the percent utilization of the spring x winter crosses varied from 26% (Faizabad) to 100% (Gwalior) (Table1.44). From supplied 46 crosses, a total of 1478 single plants were selected based on morphological and grain characteristics. None of the cross combination remained unutilized. The maximum number of 951 single plants was selected at Malan followed by Gwalior (356) and Kanpur (40).

The majority selections across the cooperating centres were done in the crosses with pedigree OWL/ SHIROODI/4/OWL/3/ALVAND//ALDAN"S"/IAS 58/PBW 640//VL 941, ZANDER -22//TAM 200/ KAUZ/ DERRIMUT// PBW 621, PYN/ BAU/3/ KAUZ// KAUZ/ STAR/VL 2005//QLD 31, 1-60-1//Emu"S"/TJB 84/3/1-12628/MV 17/VL 907//VL 907, ALBATROS ODESKAJA # 5//SKAUZ/ 2*STAR/PBW 580//QLD 50 and SHARK-1/G.K.PINKA/ BUC/PVN//MILAN/3/TX96V 2427//VW 20168.

Evaluation of breeding material

The derivatives from winter x spring wheat hybridization are naturally endowed with required characteristics for longer vegetative growth period, and hence one of the objectives of the project is to develop breeding material suitable for early planting in NWPZ. The materials selected are similar in heading and maturity, disease resistance with higher yield *per se* to the popular varieties in the zone. During this year, 292 F_2 crosses, and families in filial generations numbering 441 F_3, 155 F_4, 137 F_5, 72 F_6, 27 F_7 and 9 F_8 families were evaluated in the field and plants were selected based on maturity, plant type, rust resistance (yellow and brown) and grain characteristics. Some of the promising cross-combinations in advance generations along with their characteristics are given in Table 1.45.

Table 1.45 Promising cross-combinations in F_6/F_7 generations

SN	Cross Combination	Characteristics
1.	F81.513/Milan-2//HW3067	High tillering, medium late maturity, high thousand grains weight
2.	WR1206/F81.513//Milan-1/3/PBW509	Early maturity, dwarf plant type, bold grains with good grain appearance, and high thousand grains weight
3.	EC429377/DBW16	High tillering, early maturity with good grain appearance resistant to leaf rust and stem rust
4.	UP2556//ID13.1/MLT/3/ESWYT70	High tillering, strong stem and bold grains, immune to all races of stripe rust
5.	EC609395/PBW550	High tillering, early medium maturity and longer spikes

Table 1.46 Performance of entries in coordinated Trials

SN	Entry	Trial	Yield (q/ha)	Best Check Yield (q/ha)
1	DBW196	AVT-TS-NWPZ	57.3	59.5
2	DBW222	NIVT-1A	64.1 (1) (NWPZ);46.0 (28) (NEPZ)	58.0 (NWPZ) 46.3 (NEPZ)
3	DBW224	NIVT-1A	60.4 (8) (NWPZ);46.0 (27) (NEPZ)	58.0 (NWPZ) 46.3 (NEPZ)
4	DBW228	NIVT-1A	50.9 (42) (NWPZ);50.5 (5) (NEPZ)	58.0 (NWPZ) 46.3 (NEPZ)
5	DBW233	NIVT-1B	60.4 (2) (NWPZ) 53.1 (2) (NEPZ)	57.3 (NWPZ) 45.6 (NEPZ)
6	DBW235	NIVT-2	55.9 (9) (CZ) 53.0 (7) (PZ)	55.5 (CZ) 44.4 (PZ)
7	DBW238	NIVT-3A	47.6 (7) (NWPZ) 36.8(23) (NEPZ)	46.9 (NWPZ) 43.1 (NEPZ)
8	DBW243	NIVT-3B	42.4 (19) (CZ);48.5 (8) (PZ)	46.9 (CZ); 51.3 (PZ)
9	DBW244	NIVT-5A	45.9 (27) (NWPZ);30.5(33) (NEPZ)	51.6 (NWPZ); 32.8 (NEPZ)
			36.4 (20) (CZ); 32.1 (21) (PZ)	39.0 (CZ); 34.0 (PZ)

New spring x winter wheat crosses

In 2016-17, 71 single crosses and 178 three-way or composite crosses were made in the programme involving winter and spring parents. The 249 F_1s generated were sown during 2017-18 for making further hybridizations. Also, during 2016-17, 125 winter wheat lines were planted in last week of October under natural photoperiod condition to synchronize their heading time with the spring varieties and genotypes planted in January 2018 to make winter x spring crosses during end March and first week of April.

Contribution of entries to coordinated Trials

In 2016-17 crop season, one entry DBW 196 was tested in AVT-TS-NWPZ and a total of eight entries were contributed to national trial viz., DBW 222, DBW 224 and DBW 228 in NIVT-1A, DBW 233 in NIVT1B, DBW 235 in NIVT2, DBW 238 in NIVT 3A, DBW243 in NIVT 3B and DBW244 in NIVT 5A. The comparative performance of entries with best check is presented in Table 1.44. From the entries tested in different trials during 2016-17, DBW222 has been promoted for evaluation in AVT-IR-TS-NWPZ, DBW233 for AVT-IR-TS for NWPZ and NEPZ and DBW235 for IR-TS-PZ. The entries are being evaluated during the crop season 2017-18.

Biotechnology and physiological interventions

Response of wheat genotypes to terminal heat stress characterized by the activities of starch biosynthetic enzymes and starch composition

The effect of terminal heat stress on the starch characteristics of heat tolerant (K 7903 and WH 730) and heat susceptible (RAJ 4014) wheat genotype were investigated in this study. Results showed that heat stress influenced the activities of key starch biosynthetic enzymes and starch characteristics in developing and mature wheat grains. Activities of ADP-glucose pyrophosphorylase (AGP), soluble starch synthase (SSS), and starch branching enzyme (SBE) in the developing grains were substantially accelerated by heat stress (HS). The effect of HS on starch characteristics seemed to be genotype dependent. At harvest, total starch content in the grains of all the three genotypes under both the sowing conditions was not significantly different. However, starch composition (Amp:Amy) was altered in WH 730 but not in K 7903 and RAJ 4014 under LS condition. Amp:Amy was reduced from 3.0 to 1.9 in WH 730 due to decrease in amylopectin and an increase in amylose content (Fig. 1.6). It was observed that the reduction in Amp:Amy occurred during 30 DPA to the end of grain filling under LS condition.

Signature profiling of wheat genotypes using SNP markers

A set of 54 SNP markers having high minor allele frequency were identified from 35K SNP array, which could distinguish all the selected 368 genotypes comprising landraces, genetic stocks identified for various traits, elite lines, and released varieties. These markers were distributed on all the 21 chromosomes of wheat. The gene diversity across 54 loci had an average of 0.4764 and PIC value 0.3615. These SNP markers were found possessing putative functions responsible for adaptation such as flowering, cold acclimatization, water logging, photosynthesis and carbohydrate metabolism, drought/ salt / aluminum stress tolerance, seed dormancy and disease resistance. Neighbour -Joining tree-based clustering of the 368 genotypes resulted into six different groups *viz*., short duration (early maturing), rainfed, salinity/heat tolerant, biotic stress resistant, modern cultivars including advanced breeding lines and varieties predominantly having 'Veery' lines. Barcode of the genotypes has been developed using these 54 SNP marker profiles of individual genotypes for utilization as their signature. The study enables effective construction of core collection, utilization of gene bank accessions in plant breeding, ensuring the authenticity of germplasm resources with purity of seeds and in development of modern cultivars.

De novo wheat root transcriptome analysis

A comprehensive report on *De novo* wheat root tissue transcriptome data at flag-leaf stage under drought stress condition to decipher molecular mechanisms involve stress signaling and the induction of numerous genes, leading to the activation of tolerance pathways was generated. A total of four samples of two contrasting wheat genotypes were used for comparison under drought and irrigated conditions and 326,091,470 paired end reads were generated. Transcriptome analysis using RNA-sequencing evaluated differentially expressed genes (DEGs) either up- or down-regulated due to drought stress. Gene ontology and enrichment analysis indicated that the DEGs were primarily associated with WRKY, MYB-related, MAPK, NAC, AP2-like ethylene-responsive transcription factor families. qRT - PCR validated the expression profile for 12 DEGs analyzed in response to drought.

In silico mining of putative microsatellite markers in chinese spring wheat and development of TaSSRDb: wheat microsatellite database

An integrated online relational database *Ta*SSRDB with "three-tier architecture" was developed which is accessible at http://webtom.cabgrid.res.in/wheatssr/. The database has the highest number of SSRs (476169) from complex, hexaploid wheat genome (~17 GB) along with previously reported 268 SSR markers associated with 11 traits (Fig. 1.7). Chromosome-wise SSR calling for all the three sub genomes along with a choice of motif types is provided in addition to the primer generation for the desired marker. To obtain homozygous locus, e-PCR was done. Such 30 loci were randomly selected for PCR validation in a panel of 18 wheat AVT lines. These putative markers can be used for linkage mapping, gene/QTL discovery.

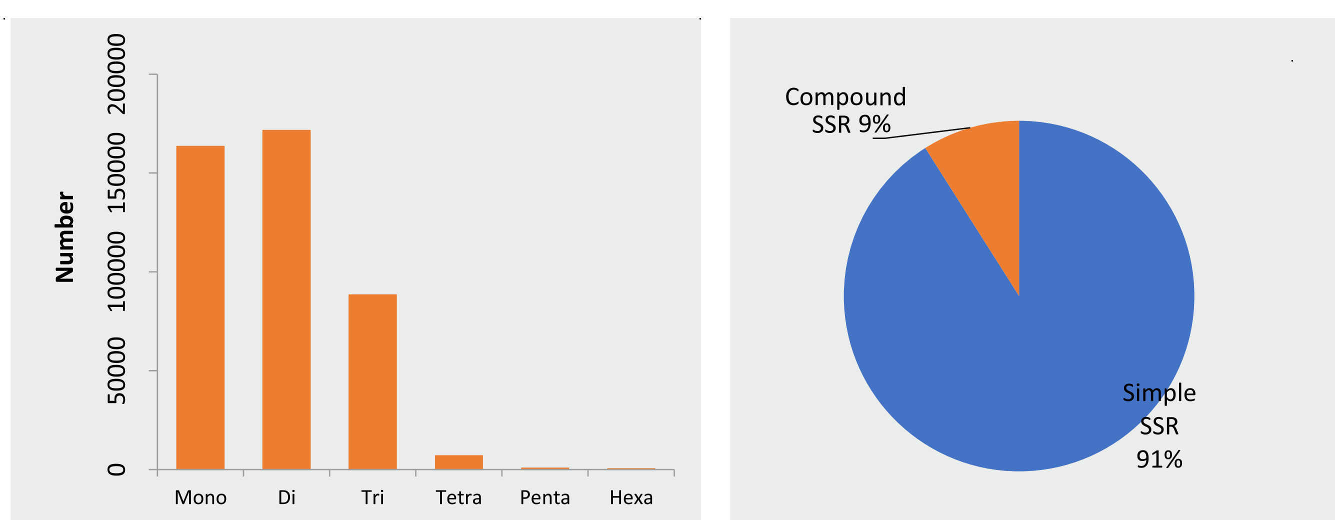

Fig. 1.7 (a) Frequency distribution of motif of microsatellites and (b) graphical view of proportion of simple and compound SSRs in the Chinese spring wheat.

Genome wide association studies for agro-morphological traits in wheat

Genome wide association studies (GWAS) was conducted using high density 35K SNP chip in order to detect significant MTAs with 27 agro-morphological characters to understand the genic region(s) associated with these important traits.Association analysis was done using compressed mixed linear model (CLMM) implemented by GAPIT packages in R studio which took into account a K-PC model where kinship information together with the first three principal components (PC) were included for GWAS; which further improves statistical power. Annotations of the flanking sequence of significantly associated SNPs with the traits further confirmed our results that the protein encoded by these SNPs are the integral component of the various important pathways.

Metagenomics of spring wheat rhizosphere for abiotic stress tolerance

Initiative has been taken for the metagenomic studies of spring wheat rhizosphere for high temperature and drought tolerance. For temperature tolerance studies one temperature tolerant genotype WH 730 and one sensitive genotype HD 2967 were selected. The sampling was done at 20 cm depth at booting and anthesis stages and the samples were processed for total soil DNA extraction immediately. The samples were taken in triplicate. Similarly, for drought tolerance

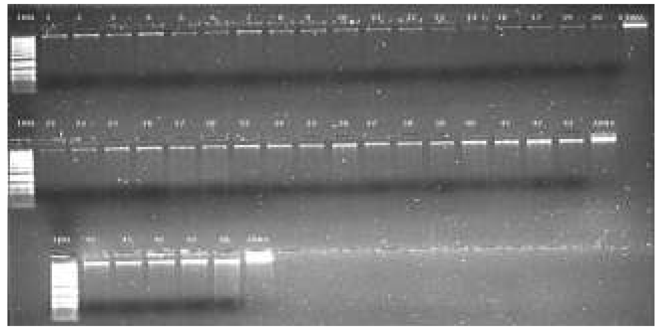

Fig. 1.8 DNA quality check for rhizospheric soil samples of spring wheat sent for metagenomic sequencing

studies one drought tolerant genotype C306 and one sensitive genotype HUW 468 were selected. The sampling was done again at 20 cm depth both at booting and the anthesis stages. Samples were taken in triplicate. The samples were subjected to two portions, one loosely bound to roots and second tightly bound. All the sub-samples were processed for total soil DNA extraction and the extracted DNA for all the samples was checked for quality check by running on 0.8% agarose gel. All the DNA samples were found to confirm the quality (Fig. 1.8) standard needed for metagenomic sequencing.

Genetic studies and molecular mapping for rust resistance in wheat

Indigenous wheat germplasm lines were screened against natural infection of three rusts, at hotspots and under artificial epiphytotic at Karnal. Seedling Resistance Test (SRT) at IIWBR-RS, Shimla against three

Table 1.47: SRT of indigenous germplasm against *P. striformis pathogen*

Acc. No.	46 S 119	78 S 84	K	L	P	A	N	31	20A	T
IC 535368	;-	0;	;	;	;	;	;	;	0;	;
IC 535466	0;	0;	0;		0;	0,	0;	0;	0;	0;
IC 535506	0;	0;	0;	0;	0;	;	;-	;	0;	;
IC 382721	0;	0;	;-	;-	;	0;	;	;-	0;	;
IC 416121	0;	0;1P	0;	0;	0;	0;1P	0;1P	0;	0;	0;
IC 416220	0;	0;1P			0;	0;1P	;	0;		0;
IC 416249	0;1P	0;	0;	0;	0;1P	0;	0;	0;	0;	0;
IC 138635	0;	0;	0;	0;	0;	0;	0;1P	;	0,	0;
IC 145975	0;	0;	0;	0;		;	0;	;	0;	;
IC 252344	0;	0;	0;1P	0;	0;	0;		0;1P	0;	;1P
IC 252395	0;	0;1P		;-	0;	0;1P	0;1P	;-	0;	0;1P

Table 1.48: SRT of indigenous germplasm against leaf rust

Acc. No.	12--2	12--5	77-2	77-5	77A-1	104B	104-2	77-7	77-8	77-10
IC 535282	0;	0;	0;	33+	0;	0;	;1	0;	0;	;
IC 535385	0;	0;	0;	0;	0;	0;	0'	0;	0;	0;
IC 535390	0;	0;	0;	0;	0;	0;	0'	0;	0;	0;
IC 535426	0;	;	0;	0;	0;		0'	0;	0;	;-
IC 535495		;	0;	;1	0;	0;	0'	0;	0;	0;

Table 1.49 Segregation of Stem rust disease infection during seedling resistance test in RIL population CPAN4027 X WL711

CPAN4027		WL711		HR		HS		Segregating lines	
40A	117-6	40A	117-6	40A	117-6	40A	117-6	40A	117-6
;1	0;	3	2-	;1	0;	3	2-	0,;12,3+ ,33+,23,22+,;-	,;12,3+,33 +,23,22+,;-

rusts, i.e. yellow (11 races), brown (10 races) and black (7 races) was done. (Table 1.47, 1.48)

11 stripe and leaf rust resistant lines were used as male parents to cross with PBW 343 as female parent. Two crosses PBW 343/IC 535352 (232) and PBW 343/IC 36900 (254) are being advanced for development of mapping populations. Individual plants from these two crosses at F_4 generation were screened for yellow rust under artificially created epiphytotics during 2016-17.

To locate genomic region conferring stem rust resistant, bulk segregant analysis for RIL Population CPAN 4027 X WL711 was done for chromosomal location of *Sr+* in CPAN 4027. Seedling resistance testing (SRT) was done for stem rust of parental lines and RILs with predominant pathotypes 40A and 117-6 to identify homozygous resistant and susceptible lines (Table 1.49). Total 302 SSR markers across wheat genome were screened using parents and contrasting bulks during bulk segregant analysis. The molecular and SRT information together indicated segregation for stem rust resistance at 2B chromosome for resistant parent CPAN 4027.

Analysis of *TaWRKY* expression in wheat for abiotic stress response

WRKY transcription factor plays a crucial role in the plant development and stress responses. Here, a total of 160 TaWRKY proteins were characterized from the whole wheat genome. Using in silico approach, 38 transcripts were selected having an identity with known WRKY genes and determined their relative expression. Only nine genes; *TaWRKY 3, TaWRKY 5, TaWRKY 12, TaWRKY 13, TaWRKY 19, TaWRKY 20, TaWRKY 21, TaWRKY 4* and *TaWRKY 25* showed their differential expression pattern upon drought, heat and salt stress in wheat. Under heat stress, Raj3765 showed higher expression for TaWRK3 and TaWRK24 at basal thermo tolerance stress as compared to acquired heat. However, the expression level of the all TaWRKY genes was up-regulated with less than two folds in HS240 wheat genotype. Similarly, under salt stress, higher expression of TaWRKY5 and TaWRKY21 was 8-fold up regulated at 12 h of salt stress in Kharchia, in contrary, at 24 h after stress TaWRKY24 was higher (Fig 1.9). In HD 2687, only TaWRKY5 expression was up-regulated at 12h of stress treatment, rest of genes expression was not significantly expressed. Under osmotic stress conditions, expression of TaWRKY genes was not much expressed in C 306, while expression of TaWRKY3 in WL 711 was 3-fold higher as compared to other *TaWRKY* genes.

Variation in photosynthetic source and sink associated traits in released Indian wheat varieties

The selection pressure on yield potential since commencement of green revolution has paid dividends in terms of increase in productivity by as

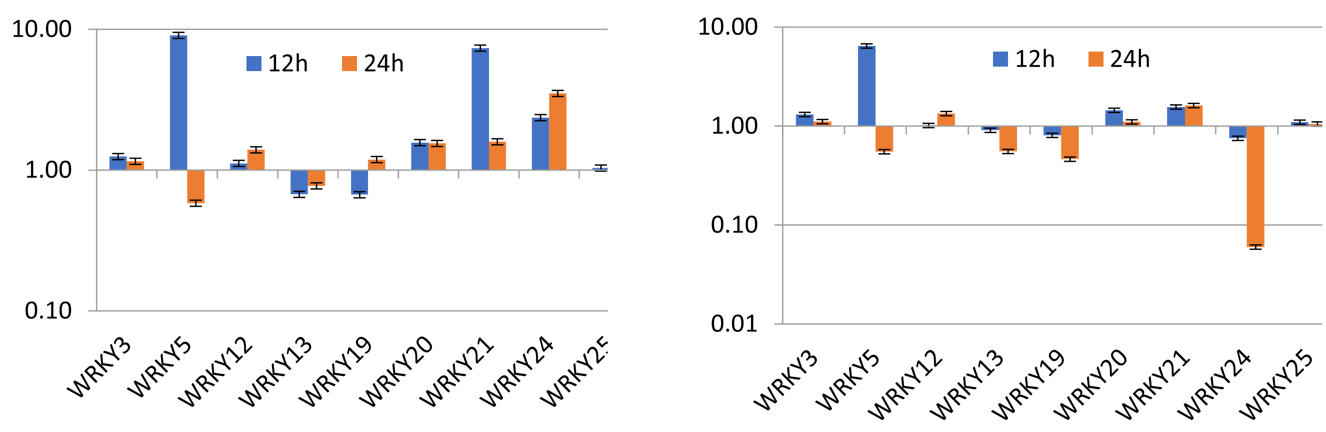

Fig 1.9 Relative expression levels of TaWRKY genes in leaf tissues of salt tolerant Kharchia (A) and susceptible HD2687 (B)

high as six folds. However, the rate of genetic gains realized through traditional breeding approaches in the recent years is not as significant as it was in the beginning of green revolution. This indicates that traits other than grain yield need attention for further improvement. If we consider productivity, the contribution of photosynthesis assumes a significant role. In this context, ten recently released ruling Indian wheat varieties (WH 1105, HD 3086, DBW 88, HD 2967, DBW 17, WB 2, DBW 71, DBW 90, DBW 93, DPW 621-50) were studied w.r.t their source and sink characters of photosynthesis to find further opportunities for yield improvement. The shortlisted genotypes were grown under optimal growth conditions and different photosynthesis associated traits were recorded using IRGA (CIRAS-3) at maximum vegetative growth stage (Zadoks scale 47) in flag leaf. The IRGA readings were recorded by external supply of CO_2 under controlled condition at 390 ppm of CO_2 and at 1600 µmol m^{-2} sec light intensity. The cellular photosynthesis associated traits like internal carbon dioxide concentration (Ci), stomatal conductance (g_s), water use efficiency (WUE), assimilation rate (A) and sink associated traits like the number of tillers, grain filling percentage per spike (GFP), grain number per spike (GNS) and grain weight per spike (GWS) were recorded in three biological replicates for each genotype.

Large variations were observed for these measured traits among the genotypes tested and different genotypes were found as best for different photosynthesis associated traits. WH 1105 was having highest Ci whereas the assimilation (A) was highest in DBW 17 followed by HD 2967. The optimum stomatal conductance with high WUE was observed in WB 2 followed by HD 2967. The GFP was highest in DBW 17 and DBW 90. The highest number of tillers, GNS and GWS was in HD 3086, WH 1105 and in WB 2, respectively. There is very less, or no grain filling was observed in top and bottom spikelets of spikes in most of the studied genotypes. Hence, this study indicates that still there is a large scope for improving one or other photosynthetic associated source/sink traits in these ruling varieties and they can also be used as a potential source for a specific photosynthetic trait in wheat breeding programme. Thus, by complementing these traits, we can increase the grain yield by improving current photosynthesis in flag leaves and assimilate mobilization efficiency from leaf to grain, stem to grain and within spike. So, 5% increase in overall grain weight per spike by improving source and sink traits in wheat can increase the yield per ha by 0.05 x 4.0=200 kg/ha if average yield is 4 ton/ha, as grain yield per ha is function of grain size x grain number x spikes per m^2. The 5% increase in even 50% of the area sown to wheat can enhance overall wheat production of India by 95 x 0.5 x 0.05 = 2.38 million tonnes. Hence, there are great opportunities to explore and use photosynthesis associated traits in wheat breeding programme to achieve significant yield gain.

Dissecting the physiological and anatomical basis for high yield potential of HD 2967

High yield potential is a well desired characteristic of a genotype and is the expressions of several hidden traits, which is needed to be dissected to utilize the material in genetic improvement. Higher adaptability and yield advantages of wheat mega variety HD 2967 make it necessary to find the novel trait combination existing in this genotype. It is a popular wheat variety both in North West Plain Zone and North East Plain Zone due to its better productivity, disease resistance and grain quality parameters. HD 2967 has 98 days of heading, 143 days of maturity, 102 cm plant height, 105 productive tillers per meter along with a 1000-grain weight of 36g. HD 2967 was found superior, for traits like stomatal conductance (430mmolm^{-2}s^{-1}) and water use efficiency (3.45mmol mol^{-1}). The Assimilation rate (27.6µmolm^{-2}s^{-1}) was also significantly higher than other genotypes, which indicates its potential for efficient stomatal regulation and water use.

Traits associated with sink strength, like number of tillers, grain filling percentage per spike (91.7%), grain number per spike (59) and grain weight per spike (2.22g) were also found at par with other high yielding varieties. Microscopic examination of culm transverse section revealed that HD 2967 has well developed sclerenchyma along with multilayered parenchymatous tissue, containing patches of chlorenchyma in-between, which contributes towards enhanced photosynthetic efficiency of the plant. HD 2967 also exhibited higher number of vascular bundles (48-50) which could be a major yield contributing trait as the efficiency of conductive tissue relay on lateral vascular bundles for the continuous supply of food and water. Higher value of the ratio between culm diameter to culm cavity provides better lodging resistance potential to HD 2967. Hence, an optimum combination of these physiological and anatomical traits is contributing for wider adaptability and higher yield in HD 2967.

02 CROP PROTECTION

Crop Protection Programme was given mandate to minimize the losses caused by biotic stresses (Diseases, insect pests and nematodes) so that maximum yield and quality potentials of wheat cultivars may be harnessed. Additionally, programme also worked hand in hand with wheat breeders to evaluate status of resistance to biotic stresses against rusts and leaf blight in pre coordinated yield trial entries (IPPSN) and against major diseases, insect pests and nematodes in coordinated yield trial entries along with check varieties aiming to assist breeders for promotions of their entries in yield trials and proposing a variety for identification as well as release. The crop health of wheat was maintained very good by keeping vigil on new pathotypes of rusts and other diseases, any exotic diseases, survey and surveillance of rusts, Karnal bunt and wheat blast as well as other insect pests and negligible losses could happened due to biotic stresses thus contributed in the record wheat production. The resistant genotypes identified were shared with breeders and resistant varieties were deployed strategically in disease prone areas in different agro ecological zones. Different agencies (DAC & FW, ICAR, State Agriculture Departments, KVKs, Farmers etc.) were sensitized about the potent diseases and insect pests and their management through regular strategy planning meetings, trainings, field days, discussions and distributions of literature and use of mobile phones and IT tools. The Wheat Crop Health Newsletters were distributed regularly and put on web page of ICAR-IIWBR (http://iiwbr.icar.gov.in). Likewise, advise was given to farmers on crop health management on Toll free No. Integrated Pest Management (IPM) was worked out to manage biotic stresses in case of susceptible varieties and to use these under emergency conditions to avoid epidemics of rusts and other biotic stresses. Human resource development was carried out. The achievements of programme are as below:

PLANT PATHOLOGY

HOST RESISTANCE

For providing support to the wheat breeding programme, evaluation of disease screening nurseries was undertaken at various hot spot locations under artificially inoculated conditions. The major nurseries were: Initial Plant Pathological Nursery (IPPSN), PPSN, Elite PPSN, Multiple Disease Screening Nursery (MDSN), Multiple Pest Screening Nursery (MPSN), and disease /pest specific nurseries.

AVT entries were also evaluated at specific locations for race specific Adult Plant Resistance (APR) to three rusts (brown, black and yellow). Slow rusting lines for different rusts were identified by calculating the Area Under Disease Progress Curve (AUDPC).

The IPPSN with 1390 entries and PPSN with 496 entries including checks were the major nurseries which are the base for taking decisions in promotion of entries in yield trials besides yield and quality as well as in identification and release as varieties. 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 number of entries tested in these nurseries are given in Fig. 2.1.

Resistant entries identified:

Rust Resistance materials in AVT IInd and Ist Year (2015-16) with ACI upto 10.0 are given below:

Stem, Leaf and Stripe rusts

AVT IInd Year

WH 1080 (C), WH 1142 (C), HI 1612, MACS 6222(C), UAS 446 (C), DBW 71(C), TL 2942 (C), TL 2969 (C)

AVT Ist Year

HS 630, UP 2993, VL 1011, VL 1012, VL 3013, VL 3014, HD 3226, HS 611, DBW 187, HI 8791 (d), UAS 462 (d), TL

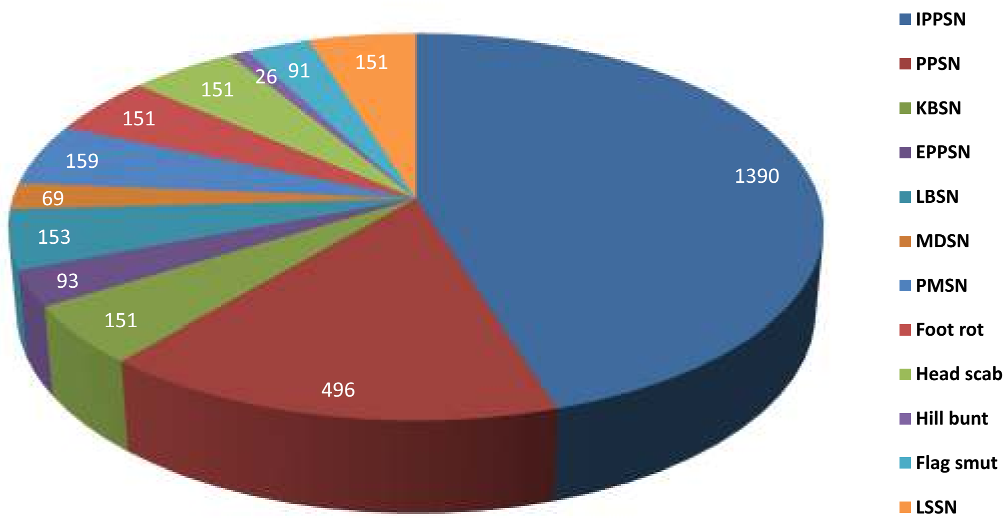

Fig. 2.1. Total entries tested in different nurseries

3011, TL 3012, TL 3013, TL 3014, TL 3015, PBW 777, PBW 778, WH 1232

Stem and Leaf rusts

AVT IInd Year

HPW 251 (C), HS 375 (C), HS 490 (C), HD 2967 (C) DBW 39 (C), HD 2888 (C), K 1317 (I) (C), DBW 110 (C), HI 8627 (d) (C), MP 3288 (C), DBW 168, UAS 375, NIAW 1415 (C), HW 2044 (C), HW 5216 (C), CoW (W) -1 (C), DDK 1029 (C), HW 1098 (C), PBW 550 (C)

AVT Ist Year

HPW 448, HPW 449, HS 644, HS 646, MP 1318, HD 3219, DDK, 1052, DDK 1053, MACS 5047, MACS 5049, HS 375 (C)

Leaf and Stripe rusts

AVT IInd Year

HS 507 (C), HS 542 (C), VL 829 (C), VL 892 (C), HI 8777 (d), AKDW 2997-16 (d)(C), KRL 210 (C)

AVT Ist Year

HS 648, HD 1620, PBW 750, KRL 370, PBW 780, WH 1316, DBW 251, HD 3271, HD 3272, PBW 757, WH 1233

Resistance in Indian wheat and Triticale varieties against prevailing pathotypes of yellow rust

Yellow rust disease of wheat caused by *Puccinia striiformis* westend is a serious disease in major wheat growing region of India. It likes cooler climate and being polycyclic in nature it may create epidemic situation thus causing huge economic losses in wheat. The disease is well managed using resistant varieties. Recently two new pathotypes of stripe rust 110S119 and 110S84 are evolved. As a result it is important to test the status of resistance against these pathotypes under field conditions. A total of 414 released varieties of wheat and Triticale in India were therefore evaluated. Three pathotypes of yellow rust 110S119, 110S84 and 46S119 were inoculated in field at seedling to adult stages by taking disease susceptible varieties like PBW 343, Sonalika, A9-30-1, Agro Local and WH 147. A total of 414 released varieties grown one line each in field were exposed to disease epiphytotic conditions of yellow rust. The rust records were taken on infection response as well as severity.The area under disease progress curve (AUDPC), Average coefficient of infection (ACI) and highest score (HS) were calculated at ICAR-IIWBR

Fig. 2. 2. Yellow rust of wheat

Karnal during 2016-17 crop season.

Based on HS and ACI, 92 varieties were found resistant to yellow rust. Based on AUDPC, 73 varieties were categorized slow ruster to yellow rust. Eight varieties of wheat, CBW 38, RAJ 821, VL 404, WH 1142, AKDW 2997-16, NIDW 15, WH 896 and one of Triticale, TL 2969 were highly resistant to existing pathotypes (110S119, 110S84, and 46S119) and may be used for sowing in disease prone areas. The comparison of rust score was done between 2015-16 and 2016-17 crop seasons, in case of 272 wheat and Triticale varieties. During 2015-16, pathotypes, 46S119 and 78S84 were used. The results revealed change in the yellow rust score of few varieties and break down of resistance due to new pathotypes, 110S119, 110S84 used during 2016-17 crop season as compared to those used in 2015-16 (46S119 and 78S84).

Confirmed sources of multiple rust resistance

Rusts (ACI=0-10.0 only)**, Source: EPPSN, 2016-17**

A. Resistant to all three rusts: HI 8759 (d), PBW 723 (Source: AVT IInd year 2015-16), HI 8774 (d), HPPAU 05, HPW 423, HPW 433, HS 622, HS 623, HS 626, HS 628, PBW 725, PBW 756, PBW 760, RKD 283 (d), TL 3006 (T), TL 3007 (T), TL 3008 (T), TL 3009 (T), VL 3002, VL 3012, WH 1181, WH 1216, WH 1310, HS 627, WH 1184.

B. Resistant to Stem and Leaf rusts: HD 3171, HD 3209, WB 2 (Source: AVT IInd year 2015-16), AKAW 4842, DBW 179, DBW 216, DBW 217, DBW 219, DDK 1051 (dic.), MACS 5044 (dic.), MACS 5046 (dic.), NW 6094, PBW 621, RKD 292 (d), VL 4001, WH 1215, UP 2955, VL 3011

C. Resistant to Leaf and Stripe rusts: DBW 220, PBW 757, HPPAU 10, HPW 424, NW 6046, PDW 344 (d), UAS 459 (d), UP 2954 (Source: AVT Ist year 2015-16)

D. Resistant to Stem and Stripe rusts: HS 580

Confirmed sources of rusts and other diseases

MDSN (2016-17)

A.Resistant to all three rust

PBW 723, HS 580,

+ Loose smut (Highest score 0-5%under artificially inoculated conditions): HI 8737 (d) (Source: AVT IInd year, 2013-14), HD 4730 (d), HI 8750 (d), HI 8751 (d), TL 2995 (T), TL 2996 (T), TL 3000 (T) (Source: AVT Ist Year 2013-14)

+ KB+FS: MACS 3970 (d), MACS 3972 (d), HI8765 (d)

+KB+PM+FS: HS 599, TL 3002(T)

+ PM+FS: TL 3001 (T), TL 3003 (T), TL 3004 (T), TL 3005 (T), K 1314, PBW 709

+LB+FS: HS 596, HS 597

+KB: HI 8765 (d)

+FS: VL 3007, WB5, HPW 422, MACS 4024.

B. Resistant to Stem and leaf rust: DBW 182, HD 3164, HPBW 01, HUW 712, K 1313, VL 3008, HI 1604.

+LB+KB: K 1315

+LB+PM: BW- 1

+PM: PBW 719

+**FS:** HPBW 02, HUW 695, HPBW 08, WH 1309, HS 600,

+KB+FS: DDK 1048 (dic), MACS 5041, MACS 5043, K 1312, GW 463, UP 2383

+KB+PM+FS: DDK 1049 (dic.), GW 1315 (d), MACS 4020 (d), DDW 31

+LB: DBW 150, KRL 350,KRL 351,PBW 716,VL 4001,HPBW 09

C. Resistant to leaf and stripe rust: HD 3165, PBW

721

+KB+FS: UAS 453 (d), UAS 455 (d)

+PM+FS: PBW 718

+FS: DDW 32, DBW 147

D. Resistant to stem and stripe: PBW 707, HD 3159

+KB+FS: UAS 428 (d)

+FS: DBW 184, HPBW 07

+KB: HS 583

(Abbreviations: EPPSN: Elite Plant Pathological Screening Nursery, MDSN: Multiple Disease Screening Nursery, KB: Karnal bunt, LB: Leaf Blight, PM: Powdery Mildew, FS: Flag Smut, LS: Loose Smut, FHB: Fusarium Head Blight, HB: Hill Bunt, FR: Foot Rot, d: *T. durum*. dic. *T. dicoccum*, C: released check variety, T: Triticale)

Utilization of multiple disease resistant genotypes identified in NGSN 2016-17

A total of 41 sources of multiple rusts and other diseases were shared along with all passport data on resistance with breeders at 23 main wheat breeding centres. Forty entries were utilized in the range of 4.2-58.3% at different centres.

Leaf Blight

Moderately resistant (average leaf blight score below 35 and the HS of 57 in 0-9 dd scale)

HI 1612, VL 829 (C), C 306 (C), VL 4001, UP2955, HD 3184, VL 4001

Moderately resistant except that HS at one location was higher than 57

HD 2967 (C), HS 375 (C), HS 507 (C) and HD 3043 (C), HS 645, VL 1013, UP 2942, UP 2993, VL 4002 and HS 630, HS 643, UAS 462 (d), DBW 247, UP 2992, MP 1318, HD 3272, WH 1233, PBW 778, HS 646 and DBW 189

Karnal Bunt

Resistant (Av. KB incidence upto 5% under artificially inoculated conditions):

HI 8777 (d), TL 2969 (C), WR 544 (C), CoW (W) -1 (C), DBW 14 (C), WH 1021 (C), UAS 446 (C), HPW 251 (C), TL 2942 (C), DBW 110 (C), HS 490 (C), K 1006 (C), KRL 210 (C), HI 8627 (d) (C), HD 2733 (C) and AKDW 2997-16 (d) (C)**,** HI 1619, TL 3014, VL 3013, VL 4002, TL 3012, VL 1013, VL 3014, HS 644, HD 3219, HS 647, VL 3015, TL 3011, TL 3015, WH 1202, DBW 187, HPW 448, MP 1318, WH 1316, HPW 439, CG 1023, RL 377, DBW 251, HD 3271, HD 3237, DBW 250, HS 630, HS 643, PBW 780, DDK 1052, HS 645, UP 2942, VL 1011, HS 629, HS 646, PBW 777, HPW 440, HS 648, BRW 3775, UAS 387, DBW 247, WH 1233, UAS 385, PBW 779, VL 4003, HP 1963, PBW 757, WH 1232, HPW 449, KRL 384, HD 3226, HS 611, DBW 196, KRL 370, TL 3013, HI 1620, KRL 386, DBW 249, BRW 3773, PBW 752, MACS 5049, HD 3272, DBW 189, HI 1617, HI 1621, DBW 248, PBW 778, DBW 246, UP 2993, MACS 6677, DDK 1053, HS 375 (C) and HS 490(C)

Powdery Mildew

Resistant (Av. PM score 0-3, highest score upto 5):

DBW 173, TL 2942 (C), TL 2969 (C), DDK 1029 (C), HPW 251 (C), VL 829 (C), HD 3043 (C) and DBW 14 (C)**,** TL 3011, TL 3012, TL 3013, TL 3014, TL 3007, MACS 5047, MACS 5049, TL 3015, DDK 1050, TL 3008, HS 630, DDK 1053, WB 2 , MACS 5044, DBW 179, HPW 448, HPW 449, HS 644, HS 645, HS 646, VL 3013, VL 3014, HI 1619, HS 611, DBW 247, DDK 1052, HD 3272, PBW 737 and KA 1427

Loose Smut

Highly resistant (Free from LS) (No infection at any location):

HI 8759 (D), HD 4728 (D) (I) (C), HI 8498 (D) (C) and UAS 446 (d) (C)

Resistant (Average score: 0.1-5.0 % LS infection):

UAS 428 (d) (C), VL 829 (C), HI 8737 (D) (C), TL 2969 (C), DDK 1029 (C), TL 2942 (C), WH 1124 (C), HW 1098 (C), KRL 210 (C) and HD 3086 (C), TL 3009, TL 3010, UP 2955, TL 3007, VL 3002, DDK 1051, PDW 344 (D), RKD 283 (D), MACS 5046, HPW 433, MACS 4028 (D), HPW 432, VL 3011, UAS 459 (D) and MACS 5044

Flag Smut

Highly resistant (Free from FS infection): HI 8777 (d), UAS 304 (C), HW 2044 (C), CoW (W) -1 (C), DDK 1029 (C), HW 1098 (C), TL 2942 (C), TL 2969 (C) and WR 544 (C), HI 8791 (d), UAS 462 (d), DDK 1052, KRL 384, MACS 5047, TL 3011, TL 3012, TL 3013, TL 3014, TL 3015, DBW 249 and DBW 250

Foot Rot

Highly resistant (upto 5 % disease):

HI 8777 (d), VL 829 (C), HD 3043 (C), WH 1021 (C), DBW 39 (C), K 1006 (C), K 1317 (I) (C), HI 8627 (d) (C), PBW 550 (C), DBW 110 (C), MP 3288 (C) and KRL 210 (C), HPW 449, HS 643, HS 646, UP 2992, UP 2993, VL 1013, VL 4002, BRW 3773, HP 1963, PBW 750, DBW 248, DDK 1052, KRL 370, KRL 377, KRL 384, WH 1316, WH 1233 and HD 3272

Hill Bunt

Resistant (1-10 % HB disease): HS 490 (C), HPW 251 (C) and HS 542 (C) UP 2993, VL 1012, HS 644 and HPW 448

Utilization of resistance sources through NGSN

A total of 41 multiple disease resistant entries were contributed in NGSN for utilization in breeding programme at 23 main breeding centres. Out of these 40 entries were utilized in the range of 4. -58. % of the centres.

Rust resistance genes in AVT material

Survey and Surveillance

Crop health was rigorously monitored during the crop season. Major focus was on the occurrence of yellow rust and surveillance for wheat blast. Status of other diseases, including leaf rust was also monitored during these survey trips. The extensive surveys were also conducted by the wheat crop protection scientists of different cooperating centers including ICAR-IIWBR Karnal. Special teams of scientists were also constituted during the 55th All India Wheat & Barley Workers' Meet held at CCS HAU Hisar during 21-24 August, 2016. Advisory for stripe rust management was issued during December-March regularly. Information on wheat crop health was disseminated through the *"Wheat Crop Health Newsletter"*, Vol. 22 which was issued during the crop season. This was also put on ICAR-IIWBR website (http://dwr.res.in) now known as http://iiwbr.icar.gov.in All the issues of the Newsletter brought out during the crop season, are given as an annexure at the end of this report.

The overall crop health status was excellent in the country. The yellow rust could not make any dent on wheat production and was very well controlled at initiation in adjoining districts in Punjab close to foot hills of Himachal Pradesh. The exotic diseases and pathotypes like Ug99 race of stem rust and wheat blast were not reported from any part of the country.

Strategy planning meetings:

A strategy planning meeting was held at Kolkata on "Occurrence of blast disease on wheat" organised by DAC &FW and Govt. of West Bengal and was attended by ICAR and IIWBR scientists and Director. A meeting on "Evolving strategies for enhancing wheat production with special reference to management of wheat rusts and Karnal bunt" was organized by DAC &FW at Krishi Bhavan, New Delhi. Dr. G. P. Singh, Director, presented a talk entitled "Evolving strategies for enhancing wheat production with special reference to manage wheat rust and Karnal bunt". Dr. D. P. Singh along with DDG (CS) and ADG (PP&B) participated in a meeting called by Hon. Secretary, DAC & FW on the topic occurrence of wheat blast in Bangladesh in Krishi Bhavan New Delhi on 4.3.2017 and given IPM and latest update on wheat blast survey report. Dr. D. P. Singh also participated in the meeting with AS (Ad), DAC & FW, Krishi Bhavan, New Delhi on label claim of fungicides for wheat blast control on 27.3.2017 and given technical inputs. On 1.8.2017, another wheat blast planning meeting was attended by Dr. D. P. Singh at DAC & FW Krishi Bhavan, New Delhi under chairmanship of Hon. Secretary, DAC & FW.

Advisory for stripe rust management:

Advisory for stripe rust management was issued three times i.e. in December, January and February for northern states. Awareness among farmers for stripe rust management was created through mobile, internet, toll free number, newspapers, discussions and delivering lectures in farmers training programmes. The details of survey and surveillance done are presented in wheat crop health newsletter vol. 22 issues 1-5 which have been put on IIWBR web page.

Preparedness for wheat blast disease

Wheat blast present in the primary wheat production areas of Brazil, Bolivia, and Paraguay, and recently identified in a small area in northeast Argentina, Wheat blast is a potential threat to wheat production worldwide. The disease was first reported from Brazil in 1985. Wheat blast pathogen is a distinct population of *M. oryzae* (referred as *M. oryzae tritici* population).

- The first report of wheat blast in South Asia came from Bangladesh in last week of March, 2016, ICAR took note of the disease. Since then ICAR worked hand in hand with DAC&FW and Govt. of West Bengal.
- So far wheat blast is not found in India during 2015-16 and 2016-17 crop seasons.
- Vigorous survey and surveillance programme as per the guidance of ICAR was conducted in West Bengal and found spike blight like symptoms on spikes of two local wheat varieties, Prodip and Satabdi in Murshidabad and Nadia districts close to Bangladesh borders. It was followed by other visit of officials of DAC & FW and Directorate of Plant Quarantine and storage as well as state Agric. department officials of Govt. of West Bengal.
- The samples collected were however negative to wheat blast.
- The affected crop in these districts was sprayed with tebuconazole+ trifloxystrobin @ 0.4g/lit of water. The crop was also sanitized. The farmers were compensated for their damaged crop.
- The surveys conducted from other parts of West Bengal revealed no such symptoms except one field in Malda district. No such symptoms were found from crop grown in other eastern states as well as other agro ecological zones of India.
- The high yielding variety HD 2967 was found resistant to spike blight like symptoms in Murshidabad district of West Bengal during 2016-17 crop season.
- The farmers in Murshidabad and Nadia districts were told not to use seeds of any exotic variety of wheat in near future as well as their own produced wheat seed for at least three years.
- The state government was asked to keep no wheat corridor of up to 5 km from Bangladesh borders, not to allow any wheat seed or grain to enter in state from Bangladesh and diversify cropping system by replacing wheat with oilseeds and pulses during next crop season in Nadia and Malda districts.
- The seed of wheat will be supplied from north in West Bengal during 2017-18 crop season.
- As an immediate step, in collaboration with CIMMYT, Mexico, evaluation of Indian released varieties / advance wheat lines in Latin America (Bolivia) – the hot spot for this disease has been approved by DARE, Ministry of Agriculture and Farmers Welfare on May 19, 2016. For this, a set of 40 Indian popular varieties and advance lines has been sent immediately to CIMMYT for evaluation against blast disease. These were being evaluated under field conditions in Bolivia and under grass house conditions in USA.
- The varieties with 2NS translocation are showing promise against wheat blast in Bolivia and USA.
- During 2017, 100 more varieties of wheat will be sent to CIMMYT for evaluation against wheat blast.
- Adhoc Integrated Pest Management for Wheat Blast Disease (2016-17 Crop Season) was prepared.

Post Harvest Surveys

Karnal Bunt (KB)

A total of 7144 grain samples collected from various mandies in different zones, and were analyzed at cooperating centers. Among different states samples taken from Madhya Pradesh. Maharashtra and Gujarat were found free from Karnal bunt infection. The overall infection was 17.7%. The samples from Haryana showed maximum infection (57.4%) followed by Rajasthan (42.8%) and U.P. (36.5%). The details are given in Table 2.1.

Management of diseases and pests through chemical control: Chemical control has gained attention under the present scenario due to the wide spread occurrence of yellow rust in most of the varieties in the NWPZ. Similarly chemical control is needed for the management of insect pests, since there is no resistance available in wheat against the insect pests. New molecules were also tested for stripe rust, leaf blight and flag smut management. Different brands of propiconazole along with other fungicides were tested for stripe rust.

Table 2.1. Karnal bunt incidence in India during 2016-17 crop season

State	Total samples (Nos)	Infected samples (Nos.)	% Infected samples	Infection range
Jammu	483	83	17.2	0.25-5.00
Uttarakhand	920	62	6.7	0.25-10.00
Punjab	2138	353	16.5	0.01-1.99
Haryana	1516	865	57.4	0.05-3.00
Delhi	130	0	0	-
Rajasthan	509	291	42.8	0.1-5.2
Uttar Pradesh	74	27	36.5	1.0-20.0
Madhya Pradesh	526	0	0	-
Gujarat	673	0	0	-
Maharashtra	175	0	0	-

Integrated management of major disease of wheat under changing climate

- To identify the resistance sources against loose smut of wheat, two hundred germplasm lines were inoculated with loose smut during 2016-17 crop seasons. Out of these lines, 33 lines were found free from infection and 76 were resistant (< 10% incidence). Similarly, set of 200 lines of wheat were screened against flag smut under artificially created disease sick plots. Among these, 93 were found free from flag smut and 65 found resistant (Fig. 2.3).
- For the biological management of foliar blight of wheat, 49 strains of bacterial endophytes were isolated from five different wheat cultivars. Out of these, two bacterial endophytes showed strong antagonistic activity against *Bipolaris sorokiniana* under dual culture assay (Fig. 2.4).
- A total 25 isolates of *U.agropyri* were collected from five different states (Punjab, Rajasthan, Himachal Pradesh, Uttrakhand and Haryana) of India during cropping season 2015-17. For analyzing genetic variation among collected isolates, gene sequence analysis of DNA-dependent RNA polymerase subunit II (RPB2) was performed. The evolutionary history inferred by using the Neighbor-Joining method indicated

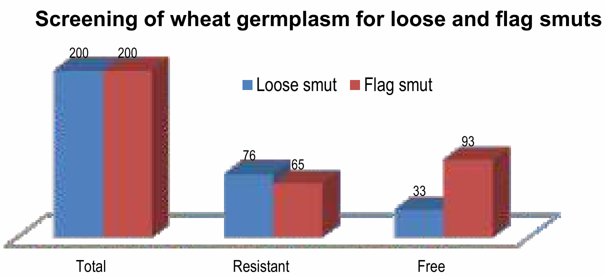

Fig. 2.3. Evaluation of wheat genotypes against smuts in wheat


Fig.2.4. Variability in bacterial endophytes isolated from different wheat varieties

that the collected isolates have large genotypic variation and were clustered in six major clades (Fig. 2.5). The maximum sixteen isolates were grouped in clade-V while isolate UA25 did not fall in any clade.

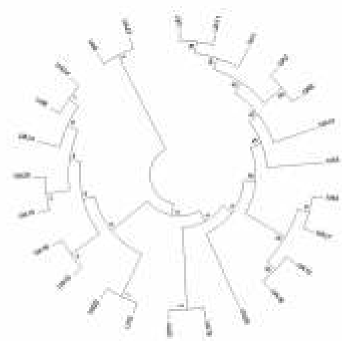

Fig. 2.5. Phylogenetic relationships among 25 isolates of *U. agropyri* on the basis of RPB2 gene sequence analysis

- A simple and rapid method based on specific polymerase chain reaction (PCR) for the detection of *Urocystis agropyri*, the causal agent of flag smut of wheat was developed. To design the specific primers for the detection of *U. agropyri*, partial sequences of 18S ribosomal RNA gene of *U. agropyri*, *Ustilago segetum* var. *hordei*, *Ustilago tritici* and *T. indica* were analyzed and compared. A 548-bp fragment was amplified with the designed primers from the *U. agropyri* genomic DNA (Fig. 2.6). However, no amplicon was obtained from the DNA of other fungal plant pathogens tested in the present work indicating the specificity of the primers for the detection of *U. agropyri*.

Entomology

The evaluation of wheat genotypes done at multilocation hot spot locations during 2016-17 revealed following genotypes possessing resistance to insect pests:

Shoot fly (SF)

TL 3013 (5.7% infestation) as compared to susceptible check HI 1620 (29.7%)

Brown wheat mite (BWM)

K 1006 (9 mites/10cm^2 area), DBW 90, HD 2733 (42 mites/10 cm^2 area) and VL 1011 (10 mites /10 m^2 area) as compared to susceptible check, DBW 204 (60 mites/m^2 area).

Foliar aphid (FA)

HS 375 (c), TL 2969, WR 544, UP 2992, VL 1011, VL 3013, VL 3014,HI 1617,HI 1620,MP 1318,HS 611,DBW 246 and PBW 757 were moderately resistance at Kharibari whereas HS 647 was promising at Karnal.

Root aphid (RA)

HD 2967, K 8027, UAS 375, HS 646, HS 647,VL 3015, CG 1023, DBW 189, HD 3226, HI 1620, PBW 750,TL 3011,TL 3012,TL 3013,TL 3015, and WH 1232 were moderately resistant at Ludhiana.

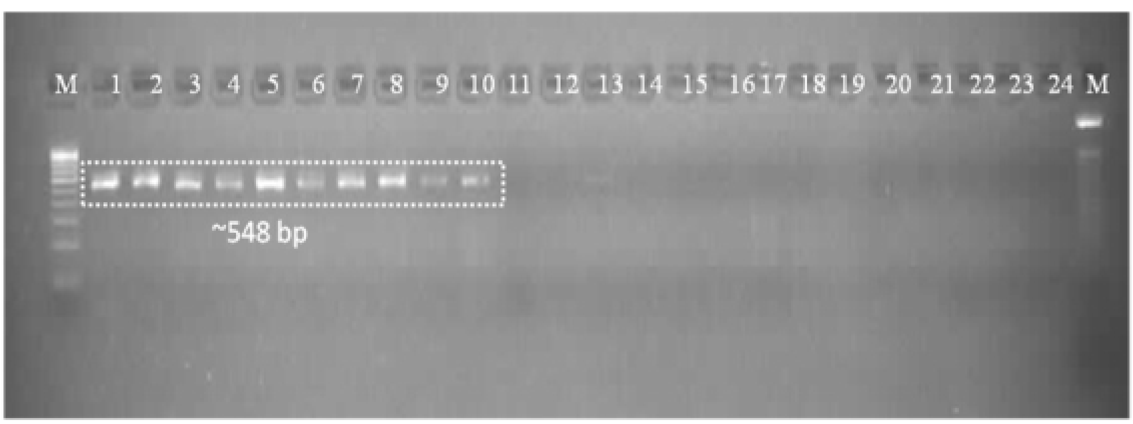

Fig. 2.6. Agarose gel showing specificity (A) and sensitivity (B) using UAF1/R1 primers set. Lane 1- 10: Urocystis agropyri; Lane 11-15: Tilletia indica; Lane 16-18: Ustilago tritici; Lane 19: Alternaria spp., Lane 20: Fusarium oxysporum;Lane 21: Ustilago hordei; Lane 22: Fusarium graminareaum; Lane 23: Bacillus spp.; Lane 24:Trichoderma harzianum

Multiple pest resistance

Shoot fly: IWP 72 (C) with 6.52% infestation.

Brown wheat mite: WB1 (6.00 mites/ 10 cm^2)

Foliar aphid: PBW-723, MACS 4020 (d), MACS 5041 and MACS 5043 were moderately resistant (grade 3) at Karnal

Root aphid: At Ludhiana, the entry WB1 was found to be resistant (grade 2) while sixteen entries were also found to be moderately resistant (grade 3) to root aphid.

Chemical Control

Termites: Three insecticides as seed treatment viz., Imidacloprid 600 FS @ 4 ml /kg, Thiamethoxam 35 FS @ 2.4 ml/kg and Fipronil 5 Sc @ 6 ml/kg were equally effective against termites. In standing crop of wheat, combination of Fipronil 5 SC +Imidacloprid 40 % WG (Lacenta) was found to be the most effective.

Brown wheat mite: For management of brown wheat mite spray of Propargite 57 SC (Omite) @ 1.5 ml/l and Spiromesifen 240 SC (Oberon) @ 1.0 ml/l of water was best.

Foliar aphid: The spray of three insecticides viz., Actara (Thiamethoxam 25 WG) @ 12.5 g.a.i./ha, Fame (Flubendamide 480 SC) @ 20 g.a.i./ha and Confidor (Imidacloprid 17.8 SL) @ 20 g.a.i./ha were found the most effective in curbing aphid population. Amongst tested bio-pesticides, *Metarhizium anisopliae* @ 3g/l and *Azadirachtin* 1500 ppm @ 3ml/l were found to be effective for the management of aphids in wheat.

Survey And Surveillance Of Insect Pests

- In Rajasthan, moderate infestation of termite, mite *H. armigera* and Pink stem borer in wheat fields was found at Jaipur. other pests like *Spodoptera*, Surface gram hopper, shootfly and jassids was occasional and were in negligible form. The cutworm population was also observed in Tank bed condition of Tonk districts.
- Medium to heavy incidence of aphids was recorded in Nasik district of Maharashtra. The Coccinellid predatory grubs, beetles and Chrysoperla feeding on the aphid infested fields were also observed. The incidence of jassids was recorded in medium intensity and stem borer infestation in traces.
- In Punjab, moderate to severe incidence of aphids was observed in some fields at villages viz. Nagar (near Phillour), Lasara (SBS nagar) Langroya and Hayatpur (near Gharshankar) in the month of March, 2017. Sporadic incidences of aphids were also observed in the month of February, 2017 at villages Dburji (Deenanagar), Ladhowal (Ludhiana) and some parts of Gurdaspur.
- In Vijapur, the termite and aphid damage in wheat fields remained moderate throughout the crop season. The population of *H. armigera*, pink stem borer and surface grasshopper were very low.
- Moderate to severe incidence of foliar wheat aphid was observed in Karnal district of Haryana. The minor damage of termite and root aphids was also observed in early period of crop growth in Karnal as its nearby locations Kunjpura, Kaithal, Racina and Hajwana. In some fields, incidence of pink stemborer was observed in early (December month). The grubs and adults of coccinellid beetles were seen frequently in fields infested with aphids.
- In Pantnagar, the insect-pests that were found infesting wheat crop were; Aphids (*Rhopalosiphum maidis*, *R. padi*, *Macrosiphum* sp), armyworm (*Mythimna separata*) *Helicoverpa armigera*, stem borer (*Sesamia inference*), grasshoppers, leaf miner, stink bug (*Nazara* sp), termites (*Microtermis obesi*, *Odontotermis obesus*), thrips (*Thrips hawaiiensis*, *T flavus* and *T. tabaci*), cutworm (*Agrotis* spp), wireworm and mites. Of these, wheat aphid exhibited marked predominance over all other pests. Out of three species of foliar aphids viz., *Rhopalosiphum maidis*, and *Macrosiphum* sp showed higher abundance. The grubs and adults of *Coccinella septempunctata*, *C. transversalis* and maggots of *Episyrphus balteatus* and *Ischiodon scutellaris* were observed

as the predominant predators of wheat aphids. The predatory bug, *Eocanthocona furcellata* (Pentatomidae) was also found to prey upon the larvae of *Helicoverpa armigera*.

Stored Grain Pest Management

Two chemicals *viz*., Emamectin benzoate (Proclaim @40.0 mg/kg) and spinosad (Tracer 4.4 mg/kg) were found to be effective as seed protectants against *Trogoderma granarium* or *Rhizopertha dominica* infestation in wheat.

Host resistance against foliar aphids

A total of 98 wheat varieties including hexaploid (*Triticum aestivum*) and tetraploid (*T. durum*, *T. dicoccom*), and 20 wild *Aegilops* spp were were tested to determine the resistance levels against foliar aphid complex i.e. *Rholosiphum maidis, R. padi* and *Sitobion avenae*. The two-aphid species were recorded, *Rhopalosiphum maidis* and *Sitobion avenae*. The aphid species, *R. maidis* was present in majority and *Sitobion avenae* was observed in few numbers only at heading stage. Amongst 98 durum wheat genotypes, 12 were categorized as moderately resistant, 40 were susceptible while 46 were highly susceptible under net house conditions where aphid infestation was created artificially.

Amongst 20 *Aegilops* spp, 9 were categorized as moderately resistant, 6 were susceptible while 5 were highly susceptible under nethouse conditions. The average grain weight loss in moderately resistant genotypes was 10.3 % as compared to 32.4 % and 42.5 % in case of susceptible and highly susceptible varieties, respectively.

Through AICRP on wheat and barley programme, a total of 60 AVT II year and 91 AVT I year wheat genotypes were screened against major insect-pests of wheat viz., aphids, brown wheat mite, shootfly at various cooperating centres. Three entries viz., HS-375 (c), TL-2969 and WR-544 at location Kharibari showed moderately resistance response to foliar aphid while three entries viz., HD 2967 (C), K 8027 (C) and UAS 375 showed the moderately resistant reaction to root aphid at Ludhiana. The maximum brown wheat mite population was observed in DBW 90 & HD 2733 (42/10 cm^2 area) while K 1006 (9/10cm^2 area) recorded the minimum mite population at Ludhiana. The lowest infestation of shootfly i.e 5.70% was recorded in entry TL 3013, while highest infestation of 29.66% was recorded in entry HI 1620.

Behavioural assay to study settling and fecundity of *Rhopalosiphum maidis*

A study was performed under controlled conditions to study the behavioural response (settling and fecundity) of aphid on genotypes of different ploidy levels Corn leaf aphid, *Rhopalosiphum maidis* and one genotype each from hexaploid *aestivum*, teteraploid *durum* wheat and wild diploid *Aegilops spelltoides* species. It was found that the hexaploid and tetraploid varieties were more preferred by *R. maidis* than the diploid species. The least number of aphids settled on the diploid species (*A. spelltoides*). After 24 hours of testing period, the number of alatae settled on tetraploid genotype was 6.0 and 4.5 on hexaploid genotype as compared to 2.5 alatae aphids on diploid species. In the fecundity test, comparatively fewer nymphs were produced on the diploid varieties while there were no significant differences in nymph production between the hexaploid and the tetraploid varieties. The least number of nymphs were produced on the diploid species (*A. spelltoides*). The nymph production was 5.4 and 4.5 nymphs/day on the tetraploid and hexaploid varieties, respectively in comparison to 3.0 nymphs/day on the diploid species during the test period.

Effect of conservation agricultural practices on insect-pest abundance

A study was conducted during 2016-17 to investigate the impact of three different tillage practices on relative abundance of major insect-pests of wheat i.e. foliar aphid (*Rhopalosiphum* maidis), root aphid (*Rhopalosiphum rufiabdominalis*) and termites (*Microtermes obesi* and *Odontotermes obesus*) under three different tillage systems viz. zero tillage, reduced tillage and conventional tillage. The differences in

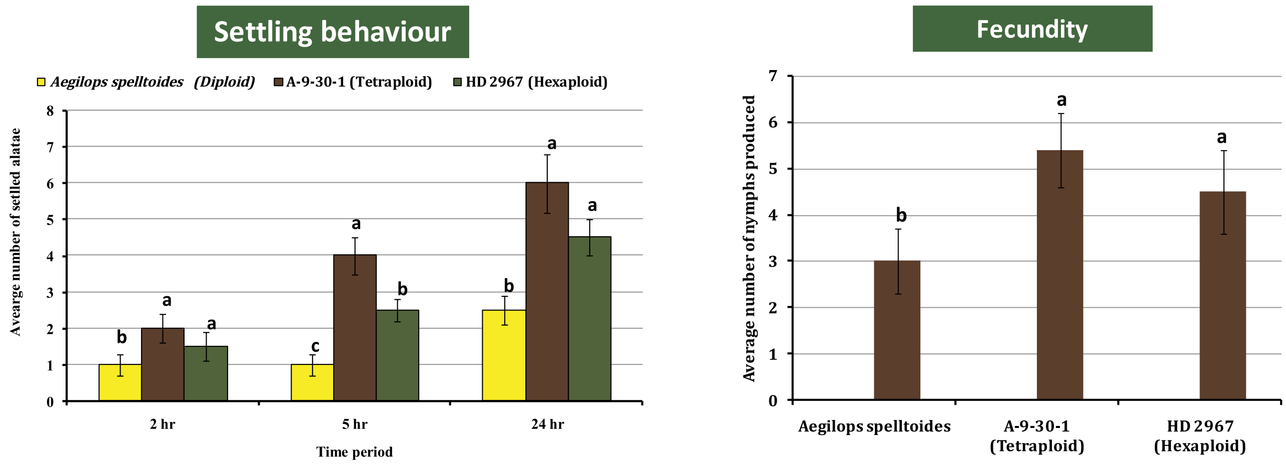

Fig. 2.7. Settling and fecundity of Rhopalosiphum maidis on the genotypes of three ploidy levels during 2016-17

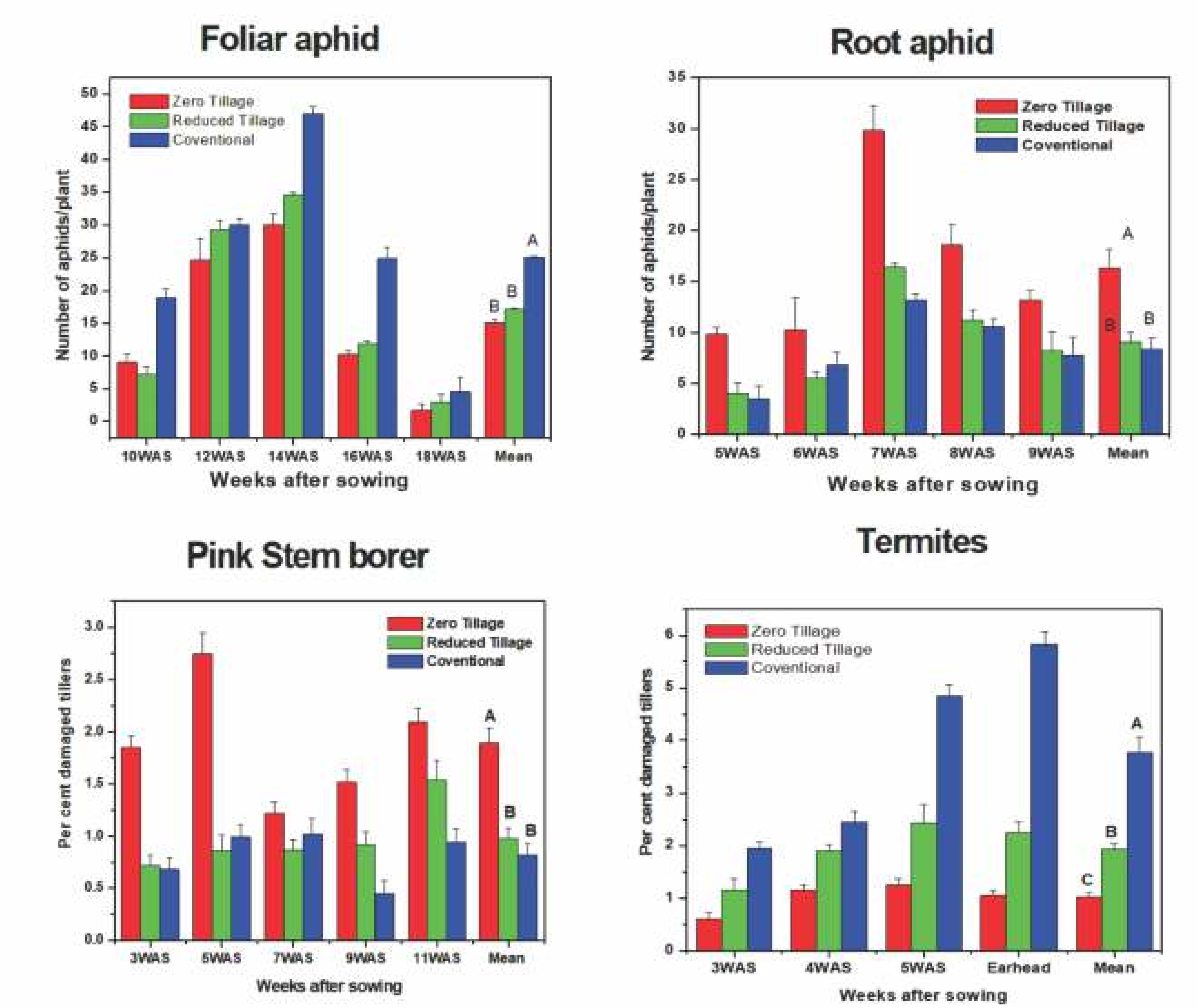

Fig. 2.8. Relative abundance of major insect-pests of wheat under different tillage practices during 2016-17

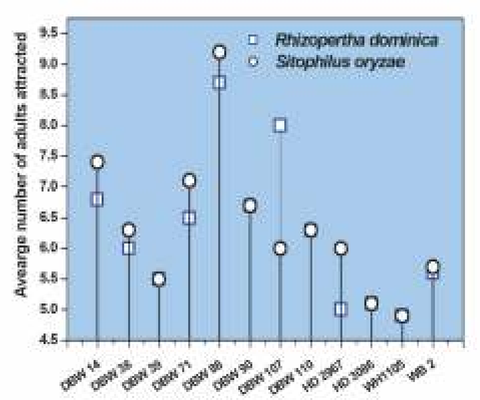

Fig. 2.9. Orientation behaviour of storage insect-pests towards wheat during 2016-17

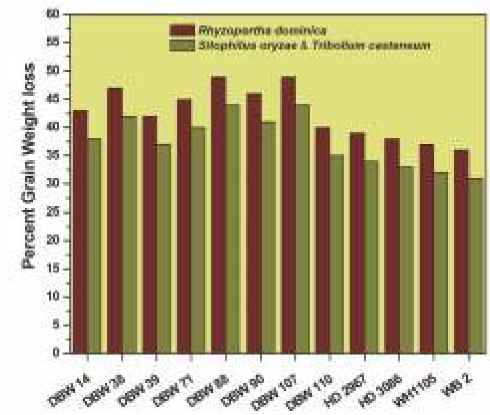

Fig. 2.10. Per cent loss in grain weight caused by storage insect-pests to wheat during 2016-17

insect pest incidence among different tillage conditions were observed. Incidence of foliar aphids was highest in conventional tillage while root aphid incidence was highest in zero tillage. Incidence of termites was highest in conventional tillage while pink stem borer infestation was highest in zero tillage.

Chemical control of insect-pests of wheat

Under chemical trials conducted at Karnal and other AICRP centres, it was found that three insecticides as seed treatment viz., Imidacloprid 600 FS @ 4 ml /kg, Thiamethoxam 35 FS @ 2.4 ml/kg and Fipronil 5 Sc @ 6 ml/kg were equally effective against termites. In standing crop of wheat, combination of Fipronil 5 SC +Imidacloprid 40 % WG (Lacenta) was found to be the most effective treatment in reducing termite population. For management of brown wheat mite spray of Propargite 57 SC (Omite) @ 1.5 ml/l and Spiromesifen 240 SC (Oberon) @1.0 ml/l of water was found effective. The spray of three insecticides viz., Actara (Thiamethoxam 25 WG) @ 12.5 g.a.i./ha, Fame (Flubendamide 480 SC) @ 20 g.a.i./ha and Confidor (Imidacloprid 17.8 SL) @ 20 g.a.i./ha were found the most effective in curbing aphid population. Amongst tested bio-pesticides, *Metarhizium anisopliae* @ 3g/l and *Azadirachtin* 1500 ppm @ 3ml/l were found to be effective for the management of aphids in wheat.

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

Twelve wheat genotypes were evaluated for infestation by three major storage insect-pests; rice weevil, lesser grain borer and red-rust flour beetle. Highest orientation behaviour (9.2 adults) of *R. dominica* was recorded in variety DBW88 and lowest (5.0) in variety WH 1105 (Fig. 2.9). The highest percent loss (42.18) in grain weight was recorded on variety DBW 88 by *S.oryzae* and *T. casteneum* infestation. The lowest damage of 11.45% was caused by *R. dominica* on variety HD 2967 (Fig. 2.10).

Efficacy of chemicals as seed protectants against storage insect-pest infestation in wheat

A study was conducted under room temperature conditions to determine efficacy of seven insecticidal treatments on seed viability during storage. One month after insecticidal application, spinosad (1.69 % damage) was the most effective treatment and it was at par all treatments except deltamethrin and untreated control. Similar trend was observed two months after treatment. After four month, spinosad and emamectin benzoate (1.97 % damage) were the best treatments followed by indoxacarb (3.13 % damage). All insecticidal treatments were at par with each other except novaluron @ 0.05 ml/kg, deltamethrin @ 0.04 ml of seeds including untreated control (8.76 % damage).

Nematology

Crop health monitoring survey for nematodes

Hisar

Crop health monitoring survey for nematodes was done in Hisar and Fatehabad, districts. Cereal cyst nematode was reported in 32.3 % (21/65) samples. It was reported in samples of Jagaan, Asranwa, Mahalsara, Kohli, Khairampur, Sadalpur, Chuli, Adampur, Siswal & Bhodiya bishnoiyan in Hisar (10/35) ; Mehuwala, Dharnia , Bhattu, Dhabi, Dhingsara, Bhodiya khera, Sulikhera, Kirdhan, Gadli, Kumhariyan in Fatehabad (11/30) . Number of cysts ranged from 2-28 per 200 cc soil. Other plant parasitic nematodes present in 200 cc soil samples were *Pratylenchus* sp. 38.4% (5-40); *Tylenchorhynchus* sp. 53.8% (15-300); *Hoplolaimus* sp. 18.4% (2-35), *Helicotylenchus* sp. 16.9% (2-20) and root knot nematode 3.0 % (5-20). Wheat seed gall nematode (*Anguina tritici*) was not recorded from the state.

Durgapura

Survey was conducted in different cultivator's fields of four districts of Rajasthan for studying the incidence and intensity of Cereal Cyst Nematode (CCN). Diseased fields were randomly selected on the basis of above ground symptoms of the crops. Symptoms of stunting, yellowing, patchy and poor growth were recorded during survey of each field. Roots samples were collected from the rhizospere of wheat and barley crops looking above ground symptoms alongwith composite soil sample. Root & soil sample were processed with standard technique of nematode identification. Presence of cereal cyst nematode was further confirmed by seeing the bushy roots with white cyst on it. Cereal cyst nematode infestation was recorded in all four districts.i.e. Alwar, Dausa, Jaipur and Sikar districts. A large number of infested fields were observed in Amber, Bassi, Chomu, Jamwa Ramgarh, Kotputli, Sahapura and Viratnagar tehsil of Jaipur district.

Ear Cockle nematode (*Anguina tritici*)

Biotypes of *Heterodera avenae* at Durgapura

The biotypes studies of cereal cyst nematode were carried out during the crop season 20016-17 against Jaipur population of cereal cyst nematode, *Heterodera avenae*. Out of 26 International differentials of wheat, barley and oat, twelve showed resistant reaction i.e. AUS-15854, AUS-7869, AUS-15895, Psathia, KVL-191, Harlan, Dalmitsche, Morocco, P-313221, Martin, Siri, La-estanzuella while rest showed susceptible reaction. Jaipur population of CCN is Pathotype Ha 21.

Host resistance to CCN

The resistant variety was KRL 19 (C) with 1-4 cysts/ plant and moderately resistant varieties and genotypes (5-9 cysts/plant) were HS 490 (C), HD 3171 (I) (C), MP 3288 (C), UAS 304 (C) and VL 3013 at Durgapura. Likewise,, at Ludhiana, MR types were HI 1620, PBW 750, DBW 187, HI 8791 (d), UAS 462 (d), DBW 246, PBW 778, VL 4002 and DBW 88 (c).

Evaluation of ecofriendly approaches for the management of cereal cyst nematode, *H. avenae*

Hisar

This experiment was done in screen house in earthen pots. There were seven treatments with three replications each. Castor cake, neem cake, vermi compost and FYM (10 g /kg soil) were mixed in soil at sowing time. Cow urine 25, 50 and 100% was used as seed dip treatment for 4 h. Recommended dose of fertilizers and controlled amount of water were applied in pots. In seed treatment with 50 and 100 % cow urine germination did not take place, so no data was obtained. Castor cake delayed germination and crop growth was poor in the beginning, although at later stage, growth was best in this treatment. None of the organic matter or seed treatment with cow urine was effective in controlling cyst nematode in wheat. On *H. avenae* -resistant wheat variety Raj MR 1, no cyst was formed.

Durgapura

Inoculum level was 11.2 larvae/g soil of cereal cyst nematode. The experiment consisted of seven treatments *viz* Neem cake 10q/ha (soil application), Neem oil 10 ml/kg (seed treatment), NSKP (seed soaking) (10 ml/kg), Neem cake 5 q/ha +half dose of Neem oil, Neem cake 5 q/ha +half dose of NSKP along with treated check (Carbofuran@ 1.5 kg ai/ha) and untreated check (Raj 3765) in a completely randomized block design and replicated thrice. The crop after attaining the age of 75-90 days was examined the development of white cyst/plant in each treatment. The grain yield was taken at the time of harvesting of the crop in each treatment separately. The results revealed that all the treatments gave significantly higher grain yield with reduced number of cysts/plant over control. The maximum grain yield (32.60 q/ha) was recorded in Neem cake 5 q/ha +half dose of Neem oil with 9.22 cyst/ plant) with increase 141.80% in yield followed by Neem cake 5 q/ha +half dose of NSKP (Grain yield – 29.1 q/ha; 10.11 cysts/plant). All the neem based formulations was also found effective in reducing the population of nematodes and increased grain yield over control. Half dose of Neem cake (soil application) with neem oil (seed treatment) showed its overall superiority by keeping larvae entry away from root and better plant growth. Response may be due to the fact that neem oil having nematicidal potential and cake might have increased the tolerance level of plant and potential to resist the nematode attack

03 RESOURCE MANAGEMENT

Tillage in rice-wheat system

The long term experiment on the effect of tillage options in rice-wheat system was conducted with three tillage options in rice (1. Zero tillage transplanted, 2. Dry rotary followed by ponding of water and transplanting and 3. Wet rotary *i.e.* puddling using rotary tiller and transplanting) superimposed on which were three tillage options (Zero tillage; Conventional tillage and Rotary tillage) in wheat. The results indicated that the wheat productivity was not significantly affected by both tillage in rice as well as in wheat (Fig.3.1). Over the years, marginally higher wheat yield was recorded in rotary tillage but the differences were not statistically significant

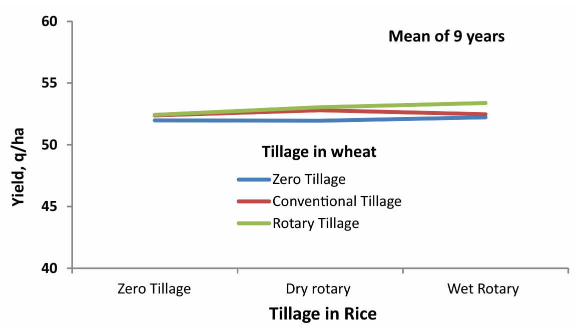

Fig.3.1. Wheat yield under various tillage options in rice-wheat system

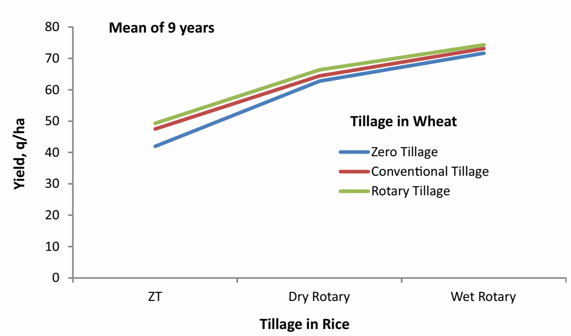

Fig.3.2. Performance of maize-wheat-green gram system in Conservation Agriculture (CA)

In case of rice crop, the tillage in wheat had non-significant effect but the tillage in rice especially zero tillage transplanting had an adverse effect on rice productivity (Fig 3.2). The yield attributes except thousand grain weight were adversely affected leading to lower rice productivity in zero tillage transplanting whereas, similar yield was recorded in dry rotary and wet rotary indicating that puddling (Wet tillage) may not be required and dry field preparation followed by ponding of water and transplanting may be a better option to avoid the destruction of soil structure by wet tillage.

An experiment was conducted to evaluate the long term effect of tillage, residue and nutrient management in maize-wheat-green gram system; in a systems' perspective involving the combination of tillage and residue management in main plots {ZT (Zero tillage); ZT with residue retention (CA); CT (Conventional tillage) and CT+ residue incorporation} and four nutrient management options in sub plots (Control; Recommended N alone; Recommended NPK; and Rec. NPK + FYM 10 t/ha). Sowing was done using Turbo Happy Seeder.

The effect of nutrient management was significant, whereas the effect of tillage and residue management and their interactions were non-significant. Among four nutrient management options, minimum yield was recorded under unfertilized control plots having a mean yield of 15.36 q/ha (Fig. 3.3). The wheat grain yield was maximum (58.28 q/ha) when FYM @ 10 t/ha was

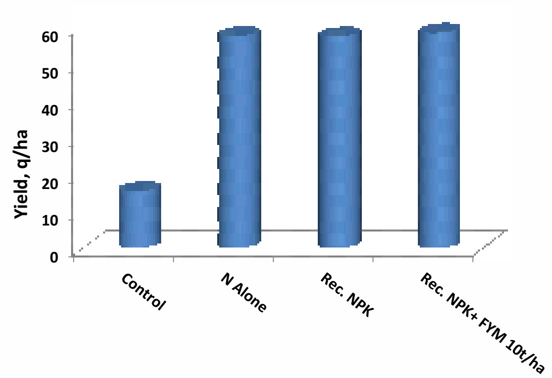

Fig.3.3. Tillage and nutrient management in wheat under Maize-wheat system

applied along with recommended NPK. However, statistically this treatment was at par with N alone and NPK application.

Observations were also taken on soil temperature in the morning and during noon on different dates. The morning temperatures were slightly higher in CA system whereas reverse was observed at noon; where the temperatures were on lower side. The noon temperature in the control plots was higher than treatments with different nutrient management.

Performance of wheat varieties under CT and CA systems

Another experiment was conducted on evaluation of varieties suitable for CA system with two tillage options {CT (Conventional tillage), CA (Conservation tillage)} in main plot and eight wheat genoypes (HD 2967, WH 1105, HD 3086, DBW 88, PBW 550, DPW 621-50, 45thIBWSN1147 and HDCSW 18) in subplots. The residue load under CA treatments was 6.0 t/ha. Sowing was done using Turbo Happy Seeder.

The tillage and residue management as well as their interaction with genotypes were not significant. However, the varietal differences were found significant. The mean wheat yield under CT and CA system were 60.26 and 61.06 q/ha, respectively. The wheat cultivar HD 3086 had significant higher tiller density over other genotypes. The crop biomass was higher in genotypes HDCSW 18 and 45thIBWSN1147. The boldest grains were of HDCSW 18 with an average 1000 grains weight of 47.6 g. Among eight genotypes, the highest yield obtained was recorded in HDCSW 18 which was closely followed by HD 2967 and the lowest yield was observed in WH 1105. Among varieties, the average yield varied from 58.96 to 64.49 q/ha.

Conservation Agriculture demonstrations at farmers' field:

CA demonstrations were conducted in three villages (Bara gaon, Rambha and Taraori). In Village Rambha and Taraori, wheat was sown under rice residue using Turbo Happy Seeder (THS). Wheat cultivar HD 2967 was sown at a seed rate of 125 kg/ha. The row to row spacing was 22.5 cm for Turbo Happy Seeder. The wheat yield was similar and was 60.3 and 59.5 q/ha under CT and CA system, respectively.

Wheat seeded in sugarcane ratoon crop with full trash using Rotary Disc Drill

Under "Mera Gaon Mera Gaurav" scheme in Village Bara Gaon; farmer's (Sh Sarwan Kumar), field of 1.0 Acre was selected for seeding of wheat under sugarcane ratoon. Five wheat varieties (Fig.3.4) were seeded using Rotary Disc Drill. The very late sowing of wheat was done on 24th January, 2017 at a seed rate of 150 kg/ha. The crop was harvested on 2nd May 2017. The average late sown wheat yield ranged between 27.5 to 33.8 q/ha. The maximum yield was recorded with wheat variety DBW 71 followed by Raj 3765 and WR 544. Most of the

Fig.3.4. Late wheat seeded in sugarcane ratoon using Rotary Disc Drill (RDD) at village Bara Gaon under Mera Gaon and Mera Gaurav

farmers of the village were interested to follow this practice if the machine was made available to them. The growing of wheat or other crops like green gram shall act as an additional source of income for the farmers and shall contribute to their profitability as well as enhance wheat production. Moreover, this will promote conservation agriculture with better environmental health as there is reduction in pollution owing to no straw/trash burning.

Nutrient Management

Integrated Nutrient Management in rice- wheat system

An experiment consisting of wheat variety HD 2967 and 10 treatments [Recommended NPK at the rate of 150:60:40 kg/ha N, P_2O_5 and K_2O (T_1), T_1+FYM15t/ha, Rec. N only, Rec. P only, Rec. K only, Rec. NP only, Rec. NK only, Rec. PK only, T_1+ GM (Green Manuring) and absolute control] of major and organic nutrients viz. FYM and green manuring was conducted in Randomized Block Design with three replications. The results revealed that biomass and grain yield were significantly lower where only P, K or PK were applied as compared to all other treatments indicating the significance of nitrogen. The highest grain yield (61.95 q/ha) was recorded in treatment where all the major nutrients with FYM 15 t/ha were applied followed by the treatment in which all the major nutrients as well as green manuring was done (61.02 q/ha). These treatments were significantly higher than all other treatments, however, the lowest yield was recorded where only PK was applied and it was also significantly lower than absolute control.

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

Experiment consisting of four recently released High Yielding Varieties of wheat (HD 2967, DPW 621-50, PBW 550 and WH 1105) and five treatments of organic nutrient supply (control, farm yard manure (FYM) 10 t/ha, FYM 20 t/ha, FYM 30 t/ha and recommended doses of chemical fertilizers at 150:60:40 kg/ha N, P_2O_5 and K_2O, respectively); thus having total 20 treatment combinations, was conducted in Randomized Block Design. The results revealed that application of FYM from 10 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 varieties 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 four varieties, WH 1105 recorded the highest grain yield (61.25 q/ha) followed by PBW 550 (60.82 q/ha) with recommended doses of NPK fertilizers (150:60:40). All the varieties performed similarly at all organics' levels.

Effect of vermicompost with organics on high yielding varieties of wheat

An experiment consisting of four recently released High Yielding Varieties (HYV) of wheat (HD 2967, DPW 621-50, PBW 550 and WH 1105) and five combinations of vermicompost with organic nutrient supply (control, farm yard manure (FYM) 10 t/ha + 2.5 t/ha vermicompost, FYM 20 t/ha + 5.0 t/ha vermicompost, FYM 30 t/ha+ 7.5 t/ha vermicompost and recommended doses of chemical fertilizers at the rate of 150:60:40 kg/ha N, P_2O_5 and K_2O, respectively) with a total of 20 treatment combinations, was conducted in Randomized Block Design. Vermicompost was top dressed just before irrigation at first irrigation to see any beneficial effect of vermicompost application after sowing of the wheat crop. The results revealed that application of FYM from 10 to 30 t/ha with vermicompost top dressing at first irrigation increased the biomass and grain yield of all the wheat varieties significantly, as compared to control (no organic manure or chemical fertilizer) treatment. However, the highest biomass and grain yield of all the varieties of wheat were recorded in the recommended NPK fertilizers treatment which was significantly higher than all other organic treatments including 30t/ha FYM+ vermicompost 7.5 t/ha top dressed at first irrigation. Among the high yielding varieties, PBW 550 recorded the highest grain yield (61.96 q/ha) followed by DPW 621-50 (61.82 q/ha), WH 1105 (61.17 q/ha) and

HD 2967 (60.57 q/ha) with recommended doses of NPK fertilizers (150:60:40). Top dressing of vermicompost at first irrigation did not influence the wheat productivity.

Effect of Potassium Humate application on productivity of wheat

An experiment consisting of wheat variety HD 2967 and 6 combinations [Recommended NPK at 150 kg N, 60kg P_2O_5 and 40 kg K_2O/ha (T_1), T_1+Potassium humate 10kg/ha, T_1+Potassium humate 20 kg/ha, T_1+Potassium humate 30 kg/ha, T_1+Potassium humate 40 kg/ha and T_1+Potassium humate 50kg/ha] of major nutrients and Potassium humate applied as basal, was conducted in Randomized Block Design. The results revealed that growth, biomass and grain yield as well as protein content in grains of wheat were not significantly influenced by potassium humate application. The productivity and quality of wheat crop applied with potassium humate and recommended doses of fertilizers was found at par with control (recommended fertilizers application alone).

Effect of growth regulators on productivity of C 306 cultivar of wheat

An experiment consisting of wheat variety C 306 and 12 treatment combinations [four fertility levels viz. 0, 40, 80 and 120 kg N/ha and three growth regulators treatments *viz*., no growth regulator spray, 0.2% Chlormequat (*Lihocin*) spray at 50 and 80 days after sowing and 0.2% Chlormequat (Lihocin) + 0.1% tebuconazole (*Folicur*) spray at 50 and 80 DAS] of fertility levels and growth regulators sprays, was conducted in Randomized Block Design. The results revealed that plant height and lodging score recorded at harvest, was significantly reduced with application of Chlormequat alone or in combination with tebuconazole. The reduction in plant height and lodging score was more when tank mix application of Chlormequat with tebuconazole was done. The productivity of wheat cultivar C 306 was recorded significantly higher at 80 kg N/ha (49.66 q/ha) and at 120 kg N/ha (56.13 q/ha) wherein N was applied with growth regulators as compared to respective nitrogen doses applied alone (36.27 and 41.53 q/ha with 80 and 120 kg N/ha, respectively), thus indicating the beneficial effect of growth regulators in reducing plant height and lodging.

Rice straw incorporation

A trial was conducted with rice straw removal, incorporation and green manuring in rice-wheat cropping system. Results revealed that rice productivity was similar whether straw was incorporated or removed. When green gram was incorporated, 25 to 50% nitrogen was saved with similar rice yields (Fig.3.5). In wheat season, when rice straw was incorporated and 25 % higher nitrogen was applied, it produced at par wheat yields as compared to recommended practices (Fig.3.6). This showed that rice straw incorporation increases the immobilsation of available soil nitrogen present in the field thereby increasing N requirement for wheat crop.

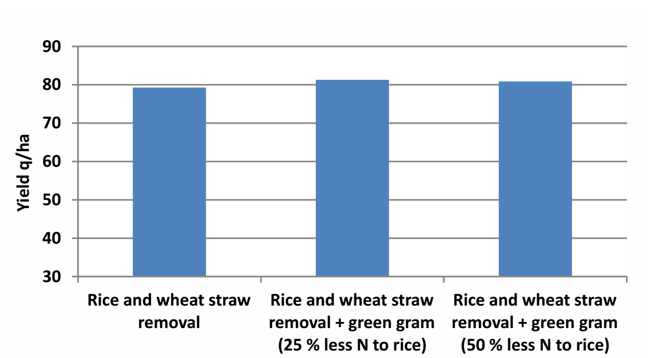

Fig.3.5. Effect of green manuring on rice productivity (q/ha)

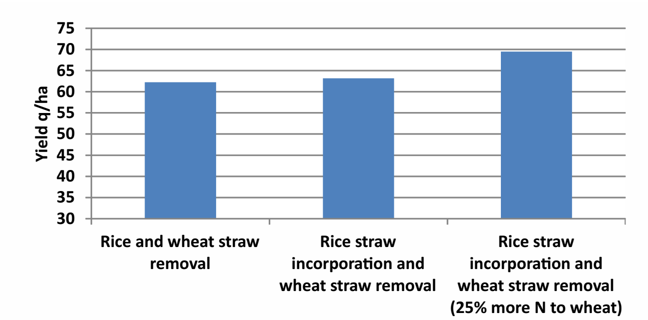

Fig.3.6. Effect of rice straw incorporation and Non wheat productivity (q/ha)

Intercropping of pulses with Maize

An experiment with intercropping of pulses like green gram, urdbean, cowpea and guar was conducted with maize crop followed by wheat (Fig.3.7). In kharif season, only cowpea crop was successful with maize intercropping and rest didn't grow due to probable shade effect. Inter cropping of pulses with maize saved 25% nitrogen in wheat crop with similar yield. Maize yield was to the tune of 8-10 t/ha.

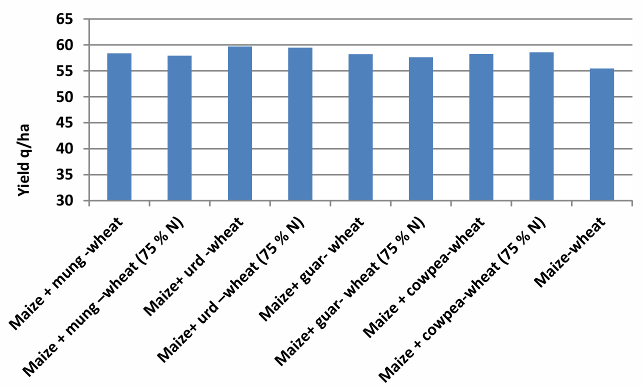

Fig.3.7. Effect of intercropping and N on wheat productivity (q/ha)

Relay cropping

The number of small and marginal farmers are increasing rapidly and more than 85 % farmers belong to these categories in India. The situation is much more severe in NEPZ. Keeping in mind the slogan of prime minister regarding the doubling of farmers' income by 2022, land productivity per unit area per unit time requires immediate attention.The small and marginal farmer especially in NEPZ who practice wheat seeding manually; either line sowing or broadcasting, may achieve higher spatial and temporal productivity by adopting bed planting (FIRB) and realy cropping of cucurbits with wheat. Adoption of bed planting in wheat provides an opportunity to utilize the furrow as intercropping or relay cropping of suitable crops for higher profitability. Presently, aim of researcher should be to maximise the profitability of small and marginal farmers without much increase in cost of cultivation. Even small increase in profit of poor farmers will have an impact on their livelihoods. To utilise furrows; relay crop of cucurbits in wheat under bed planting is one of the options to explore for profit maximisation strategy for poor farmers. Keeping this objective in mind, a series of cucurbits were seeded during first week of March in furrows under bed planted wheat. At this stage, wheat crop was in milk stage and lower leaves had started shedding thereby facilitating more light penetration in furrows. The cucurbits planted were musk melon (kharbuja), water melon (tarbuj), bottle guard (ghia), ridge guard (tori), bitter guard (karela), cucumber (kheera) and tarkakari. These cucrbits were planted on 1.0 m plant to plant apart and 1.4 m row to row spacing. Before transplanting, seedlings of all these crops were raised separately. All the plants of these crops survived and started spreading but after wheat harvest, it spreaded at an increased rate. Obviously, there was no advese effect on wheat yield and additional produce of all cucurbits were obtained. Most profitable (Fig.3.8) relay crop was bottle guard (ghia) followed by tarkakari, ridge guard (tori), bitter guard (karela), water melon (tarbuj), musk melon (kharbuja) and cucumber (kheera). Thus, small farmers can utilize these produce for their own home consumption and excess produce can be sold in the local market for earning more money. In this way, small and marginal farmers can also engage their family labours in summer season and earn more money for their household during lean periods.

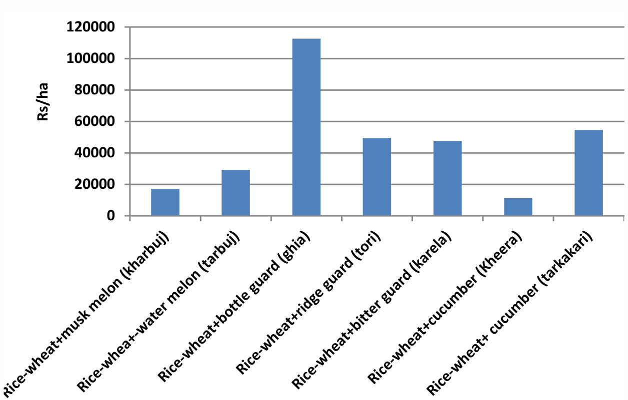

Fig.3.8. Additional returns (Rs./ha) from relay cropping of cucurbits with wheat under bed planting

Weed management in wheat

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

Evaluation of new herbicides

- For control of diverse broadleaf weeds, ready-mix combinations of Halauxifen+fluorxypyr 200.6 (6.1+194.5) g/ha was found effective in wheat.
- For control of grassy weeds, new herbicides found effective were flumioxazine 125 g/ha, flufenacet 250-300 g/ha, and pyroxasulfone 125-150 g/ha. The tank mixtures of pyroxasulfone+isoproturon and pyroxasulfone+metsulfuron, were better compared to the application of pyroxasulfone alone. Pyroxasulfone alone was less effective against broadleaved weeds whereas, Flumioxazine was less effective on wild oat.
- Herbicides and herbicide combinations were evaluated for effective weed management in DSR (Direct Seeded Rice). Application of bispyribac + Metsulforan+Chlorimuron 25+2+2g a.i/ha followed by Rice Star (fenoxaprop with safener) 90 g a.i./ha or penoxsulam + pendimethalin 25 + 1000 g/ha as pre emergence followed by Rice Star + ethoxysulfuron 90 + 18 g a.i/ha can efficiently manage the diverse weed flora in DSR.

Management of herbicide resistant weeds in wheat

Globally herbicide resistance in weeds is a major problem. Experiments were conducted to identify and quantify the herbicide resistance in different weeds *(P. minor, Avena ludoviciana, Polypogon monspliensis, Rumex dentatus* and *Chenopodium album*). Littleseed canarygrass (*Phalaris minor* Retz.) the most troublesome wheat weed has evolved multiple herbicide resistance (Resistance to photosystem II (PS II), ACCase–inhibiting herbicidal chemistries and ALS inhibitor), whereas *Avena ludoviciana* has shown resistance against sulfosulfuron and clodinafop/pinoxaden. *Polypogon monspliensis* has evolved resistance against sulfosulfuron and mesosulfuron. Both the grasses herbicide *Avena* and *Polypogon* were sensitive to isoproturon and pyroxasulfone. Two more broadleaved weeds; Chenopodium album and *Rumex dentatus* have also evolved resistance to metsulfuron but were sensitive to 2,4-D and pendimethalin.

The evolution of herbicide resistance in multiple weeds is an emerging threat to wheat in northern plains. Some of the farmers having infestation of herbicide resistant weed populations are facing significant yield reductions due to lack of knowledge as well as unavailability of effective alternative post-emergence herbicides. If the problem of resistance is not tackled, it may lead to serious consequence of decrease in wheat production.

Experiments were also conducted for weed management with integration of no-till system in combination of various pre seeding herbicides. Results revealed effective weed management with integration of no-till seeding along with residue retention and application of pre-seeding herbicides (Pendimethalin + metribuzin or metribuzin or oxyflourfen or pyroxasulfone + metsulfuron).

Evaluation of herbicides against broadleaved weeds in Wheat

The major weeds infested the experimental plots (Table 6) were *Rumex dentatus, Medicago denticulata*, *Coronopus didymus and Lathyrus aphaca*.. Among these, the most dominant weed species was *Rumex dentatus* followed by *Medicago denticulata*. The tank mix combination of ready mixture halauxifen + florasulam with carfentrazone was the most effective treatment in controlling the diverse weed flora in wheat. The dry matter accumulated by weeds in untreated control was 260.7 g/m^2, (Table 3.1). Compared to weedy check, all the herbicide treatments caused significant reduction in total density and dry weight of weeds. Carfentrazone was not effective against *Lathyrus aphaca (17.6* g/m^2). The most effective treatment in reducing the broad-leaved weed dry weight was ready mix combination of

Table 3.1 : Effect of broad leaved herbicides on weed dry weight and wheat grain yield

Herbicide treatments	Dose g.a.i./ha	Weed Dry Weight, g/sq. m. at 90 days after spray *Rumex Sp.*	*Coronopus didymus*	*Medicago denticulata*	*Lathyrus aphaca*	Other weeds	Total weeds	Grain yield q/ha
Halauxifen + Florasulam + S	12.76	1.77(3.3)*	1.00(0.0)	1.00(0.0)	1.00(0.0)	1.03(0.1)	1.78(3.4)	60.1
Metsulfuron + S	4	1.94(4.5)	1.14(0.3)	1.58(1.7)	1.03(0.1)	1.01(0.0)	2.51(6.6)	58.6
Carfentrazone	20	2.85(7.3)	1.24(0.7)	2.47(5.5)	4.21(17.6)	1.28(0.8)	5.71(31.9)	61.5
2,4-D Na	500	3.49(11.9)	1.14(0.3)	1.24(0.7)	1.11(0.3)	1.03(0.1)	3.97(14.9)	59.8
2,4-D E	500	2.85(7.3)	1.24(0.7)	1.55(1.7)	1.09(0.2)	1.21(0.5)	3.10(8.7)	61.1
Metsulfuron + Carfentrazone + S	4+20	1.00(0.0)	1.00(0.0)	1.06(0.1)	1.00(0.0)	1.00(0.0)	1.17(0.4)	62.7
2,4-D Na + Carfentrazone	400+20	1.66(2.0)	1.00(0.0)	1.14(0.3)	1.03(0.1)	1.00(0.0)	1.93(3.0)	62.3
2,4-D E + Carfentrazone	400+20	1.70(2.7)	1.00(0.0)	1.14(0.3)	1.25(0.7)	1.00(0.0)	1.83(3.5)	61.4
Halauxifen +Florasulam + Carfentrazone+S	10.21+20	1.00(0.0)	1.00(0.0)	1.24(0.7)	1.05(0.1)	1.00(0.0)	1.06(0.1)	62.6
Weedy check		12.3(150.7)	2.07(3.3)	9.16(83.1)	4.36(19.3)	2.03(4.3)	16.16(260.7)	43.3
Weed free		1.00(0.0)	1.00(0.0)	1.00(0.0)	1.00(0.0)	1.00(0.0)	1.00(0.0)	61.0
LSD at 0.05		1.51	0.32	0.75	1.00	NS	1.46	5.00

*Original values in parenthesis and square root transformed (√X+1.0) value used for statistical analysis

Halauxifen+Florasulam+ Carfentrazone at 10.21+20 g/ha followed by metsulfuron + carfentrazone 4 + 20 g/ha. The new herbicide combination halauxifen + florasulam at 12.76 g a.i./ha was found highly safe to wheat crop and superior to metsulfuron and carfentrazone in controlling *Malva parviflora*, and *Lathyrus aphaca*, respectively. In comparison to weedy check (43.3 q/ha) all the herbicide treatments caused significant yield improvement. Although, all the herbicide treatments were having statistically similar wheat grain yield yet numerically, metsulfuron+ carfentrazone 4+20 g/ha and Halauxifen+Florasulam+ Carfentrazone at 10.21+20 g/ha yielded more grain.

The weed competition throughout the season resulted in lowest grain yield (43.3 q/ha) as compared to all other weed control treatments. The presence of broadleaved weeds throughout the crop season reduced the grain yield by 30.9%. Among weed control treatments, all the herbicide treatments had similar yields as observed against weed free conditions.

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

Experiments were conducted to study the water use efficiency of wheat genotypes under various moisture

Table 3.2 : Analysis of variance (P>F) of wheat yield component traits as affected by year, Water applied and genotypes screened

Effect	df	WUE	GY
Year (Y)	1	< .001	< .001
Water applied (WA)	1	< .001	< .001
Genotypes (G)	3	< .001	< .001
Y x G	3	< .001	< .001

Values with bold are statistically significant at < .001 probability level

Table 3.3: Ranking of genotypes for WUE, yield using Tulckey test of significance

Variety/Genotype	WUE (kgm^{-3})	Gr Yield (qha^{-1})
SAGSYT18	2.05[a]	45.4[a]
SAWSN3189	1.90[b]	40.9[b]
HD2967	1.88[b]	40.9[b]
LBP2015-3	1.83[b]	40.6[b]

levels and explore the measures for improving water use efficiency to mitigate the abiotic stresses under conservation and conventional tillage practices. Investigations were carried on to examine the role of foliar application of potassium, salicylic acid and seed priming with salicylic acid in mitigating the abiotic stresses. Research was also undertaken to examine the effect of regulated deficit irrigation in wheat crop, its impact on grain and straw productivity and study the efficiency of micro irrigation system in wheat crop. It was recorded that there was significant variation among genotypes for water use efficiency and residue retention to the tune of 4 ton/ha, which proved advantageous under limited water availability. Foliar application of potassium had positive impact on various kinds of abiotic stresses. Data recorded for the experiment on effect of regulated deficit irrigation revealed that at least 25 per cent saving in irrigation water is possible, if irrigations were applied precisely at critical growth stages of wheat crop to harvest the same yield as is under normal irrigation of 60 mm water flooding per irrigation. The findings of the study are as mentioned below:

- 35 genotypes of wheat were evaluated at various levels of soil moisture *i.e.* 80, 60 and 40% of CPE. The exact amount of irrigation water in mm was calculated with the help of CROPWAT software. 10 genotypes (DBW 243, DBW 110, HD 2967, DBW 222, DBW 90, DWAP 1510, DBW 228, 118WSN938, DBW 233 and WH 1105) were found having water use efficiency of >1.9 kg/m^3 with desirable level of yield under 80% of CPE moisture level.
- Under the project "Evaluation of Irrigation System and Improvement Strategies for higher water productivity in Canal Commands" a field experiment on screening spring wheat genotypes for water use efficiency was conducted at research farm of ICAR-Indian Institute of Wheat and Barley Research, Karnal for two years. The experiment was laid out in split plot design with three replications. Irrigation by drip system was given to compensate the 60% of evapo-transpiration losses of water. The amount of irrigation water was calculated using CROPWAT 8.0 model. The amount of applied water was measured by the inbuilt water meter in pipe line of the drip system. A filter was installed in the main line to prevent sediment from blocking the emitters. The treatment's plot had dimensions of 8×2 m^2. Plots in each replication were separated by a buffer zone of 1 M wide strip. As shown in the table, significant genotypic differences were observed for Grain Yield and WUE when ANOVA was carried out. Ranking of genotypes using

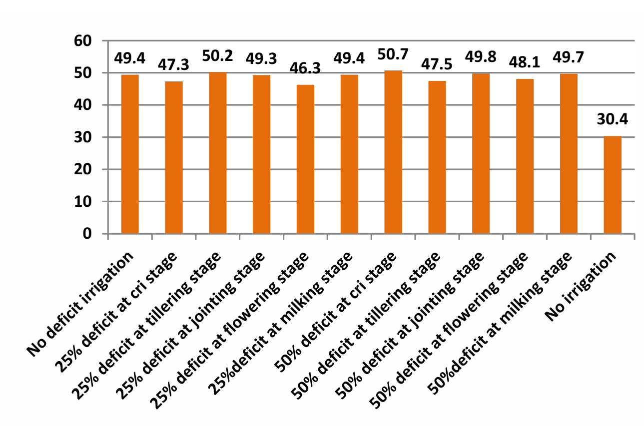

Fig.3.9. Effect of irrigation scheduling on wheat productivity (q/ha)

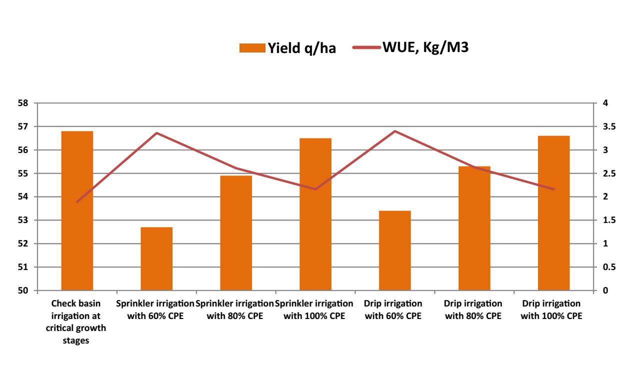

Fig. 3.10. Effect of micro irrigation methods on wheat productivity (q/ha) and WUE

Tuckey's test of significance when means were compared across year under supply of limited water at 60% of CPE (Table), SAGSYT118 was found to be significantly superior with 2.05 kgm^{-3} WUE. It also differed significantly for grain yield than other tested genoty pes.

- Residue retention to the tune of 4t/ha proved advantageous over no residue retention. Residue retention with two irrigations produced grain yield of 49.8 q/ha which was significantly higher over no residue retention (43.4 q/ha).
- Significant higher grain yield (50.3 q/ha) was recorded by foliar application of Nitrogen @ 0.5% and Potassium @ 2.0 % over control (43.4 q/ha). Total three sprays were done at fortnightly interval, starting from 30 DAS.
- Precise and regulated deficit irrigations *i.e.* 25% deficit (45 mm water per irrigation) and 50% deficit (30 mm water per irrigation) were applied at critical growth stages (Fig. 3.9). The data revealed that, at least 25 per cent saving in the amount of irrigation water is possible to harvest the same yield as it is under normal (non-deficit) irrigations of 60 mm water flooding per irrigation.
- Micro irrigation system was evaluated for efficient water management in wheat with an objective to improve water use efficiency and wheat productivity. Maximum wheat yield with higher water use efficiency was obtained under 100% CPE irrigation with drip as well as sprinkler system (Fig. 3.10).

Production estimation of wheat using remote sensing and modelling in Haryana

Conventional methods of acreage assessment are cumbersome, labor-intensive; require more resources and faces problems; like lack of timely dissemination of information. With the evolution of geospatial technologies, crop acreage assessment has become easier due to limited ground truth/surveys required. The accelerated, repetitive and spatial-temporal synoptic view in different windows of the electromagnetic spectrum; offers unique opportunity of gathering information of larger area on real time basis and at economical rates. The geospatial tools transform data information into a geographical information map so that it may be of use to policy makers and planners. In this perspective, an attempt has been made to estimate crop acreage at district level using advanced geospatial tools involving GPS, GIS and remote sensing.

In the present approach, visual image interpretation techniques in combination with ground truth surveys aided by GPS and period pertaining to peak vegetation cover have been adopted in mapping the heterogeneity of land cover classes and estimating wheat acreage accurately at district level. The technique broadly consists of identifying representative sites/grids of equal size and regularly spaced data in the form of pixels of various crops on the image based on the ground truth collection and classifying them using different classifiers. Satellite images of path 147 and row 39 & 40 for the wheat season 2016-17 covering Karnal district were downloaded from the website https://earthexplorer.usgs.gov. The LANDSAT-OLI image of the study region was used to demonstrate the capability of remote sensing to identify various spatial features based on supervised classification scheme. The multi date satellite images enable accurate discrimination of the wheat crop from other entities having similar spectral

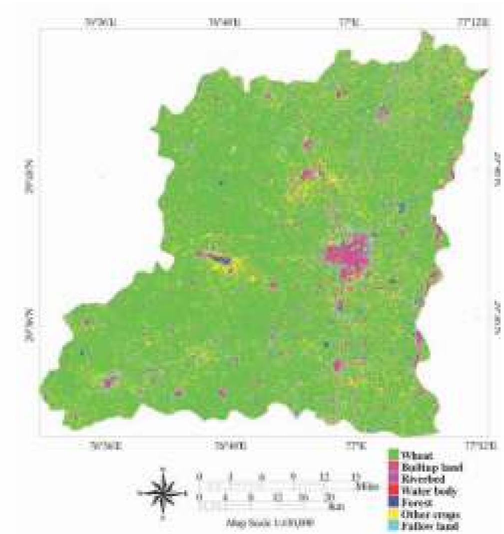

Fig.3.11. Land Use/Land Cover Map of Karnal (2016-17)

LULC	Observed Area (ha)	Reported Area (ha)	R^2	RMSE (%)
Wheat	1,76,700	1,73,947	0.98	14.95
Not Available for cultivation	24,767	30,871		
Forest	4,146	4,600		
Other Crops	38,397	24,382		
Other uncultivated & Fallow land	14,007	20,939		

Table 3.4 : Comparative analyses of Land use/ land cover area of Karnal

signature. Georeferencing was done employing image to map technique and the district boundary of the study area (Karnal) was digitized using QGIS software. Atmospheric Correction was done using QuAC (Quick Atmospheric Correction Technique) to remove the "noise" from image; which otherwise may be present due to atmospheric disturbances. QuAC normalizes the values of RGB (Red, Green and Blue) bands and also helps to generate the exact spectral reflectivity of any object/entity in the image. Presently, the values were normalized from 19596 to 4578 in red band; 6949-202 in green band and from 8026 to 320 in blue band. The image was then classified by taking different region of interest's viz. wheat, other crops, fallow land, built-up land, river bed, water body and forest using Maximum Likelihood Classifier (MXL) embedded under supervised classification in EnVI-4.8 software (Fig. 3.11). The acreage under different entities was calculated using post classification tool in the same software. Maximum likelihood classification of Landsat satellite data gives good results for area estimation under different crops and other land classes. The area under different entities has been summarized in Table 3.4; the observed and reported wheat acreage for the season 2016-17 was estimated to be 176700 and 173947 ha, respectively. Out of the total agricultural area of Karnal, wheat crop occupies the maximum percentage (68.48%), followed by other crops (14.88%) for the year 2016-17. The observed LULC area of Karnal has been compared with the reported area (http://aps.dac.gov.in/). The results were found to be very close to the reported area as provided by government records (R^2=0.98).

04 QUALITY AND BASIC SCIENCES

Analysis of AICRP Trials

Eight thousand nine hundred forty six (8946) wheat grain samples; belonging to different AVTs, NIVTs, IVTs, QCSN and special trials were analyzed during 2016-17. This also included evaluation of all the AVT-II entries including checks for identification of promising genotypes for chapati, bread, biscuit and pasta.

In addition, promising genotypes were identified both for *T.aestivum* and *T.durum* for individual quality parameters like grain appearance, test weight, protein, grain hardness index, sedimentation value, presence of moisture (%), phenol test, extraction rate, wet gluten, dry gluten, gluten index, high molecular weight gluteinin subunits (HMWGS), g-gliadin, yellow pigment, iron and zinc. Different quality parameters have shown wide variability. If we can make segregated procurement possible in the country, better quality wheat products can be made available.

Table.4.1: - Promising genotypes identified for wheat products

Products	Genotypes
Chapati (>8.0/10.0)	DBW168, DBW 39, HD 2888, C 306, K 8027, K 1317, MACS 6478, NIAW 1415
Bread (>575ml loaf volume)	UAS 375, MACS 6222, MACS 6478, NI 5439, NIAW 1415
Biscuit (>10 spread factor)	HS 490
Pasta (>7.0/9.0)	HI 8777, HI 8627, UAS 446

Sixty one (61) 2nd and 1st year AVT entries including checks were evaluated for High Molecular Weight Glutenin Subunits (HMWGS). Subunits 5+10 and 2+12 were present in 73.8% and 26.2% of the total entries, whereas entries having 1, 2* and N subunits were 23.0%, 68.9% and 8.1%, respectively. Likewise, percent entries having subunits 7, 7+8, 7+9, 17+18, 20 and 13+16 were 34.4%, 13.1%, 9.8%, 36.1%, 3.3% and 3.3%, respectively.

Table.4.2: Promising genotypes identified for processing and nutritional quality parameters

Parameter	Value	*T. aestivum*
Protein Content	>12.50%	HD 3226, DBW 168, UAS 375, NI 5439, NIAW 1415, UAS 387
Sedimentation value	≥ 60 ml	DBW 196, DBW 173, PBW 752, HI 1620, MACS 6677, HD 2967, DBW 187, HI 1612, HI 3171, BRW 3775, NI 5439
Grain Hardness Index	~85	DBW 90, HD 3043, K 0307, HD 2888, C 306, UAS 385, UAS 375, NIAW 1415, WH 2044, Cow (W) 1, UAS 387
	<45	HS 611, DBW 168
Yellow Pigment	>3.5 ppm	HD 3043, HD 2888, C 306, HD 3171, K 1371, DBW 168, UAS 304, NI 5439, HW 2044, Cow (W) 1, UAS 387
Iron Content	>45.0 ppm	HD 2888, C 306, NI 5439, NIAW 1415, HW 2044, Cow (W) 1, HW 5216, UAS 387
Zinc Content	> 40.0 ppm	UP 2942, HD 3043, HD 3237, CG 1023, HD 2888, UAS 385, Cow (W) 1, HW 5216
		(T. durum)
Protein Content	>14.5%	HI 9777, MACS 4028, UAS 446
Sedimentation value	~ 40 ml	UAS 462, UAS 446
Grain Hardness Index	~ 90	UAS 462, UAS 446, AKDW 2997-16
Yellow Pigment	> 6.00 ppm	HI 8627
Iron Content	> 45.0 ppm	HI 8777, MACS 4028
Zinc Content	~ 45.0 ppm	UAS 462, HI 8791, HI 9777

Table.4.3: Variability in quality and nutritional parameters

Parameter	*T. aestivum*		*T. durum*	
	Mean	Variability	Mean	Variability
Test Weight (kg/hl)	79.6	72.0-83.5	81.2	77.0-83.2
Protein content (%)	11.71	8.3-15.1	13.51	10.01-15.10
Grain Hardness index	77	33-96	87	72-97
Sedimentation (ml)	53	36-66	36	26-46
Yellow Pigment (ppm)	2.93	1.83-4.19	5.01	3.59-6.44
Iron content (ppm)	40.3	30.8-58.9	43.3	36.7-50.5
Zinc content (ppm)	36.4	17.5-50.3	41.4	27.0-54.8

Quality analysis of National nurseries

During the year (2016-17), 103, 108 and 80 lines including checks belonging to NGSN, EIGN and NDSN were grown at IIWBR Research Farm, Karnal. All the lines of these three nurseries were analysed for processing quality parameters viz. test weight, protein content, grain hardness index, moisture content, sedimentation value and also for nutritional quality parameters like iron and zinc. Different processing and nutritional quality parameters showed wide variability. Attempts were made to identify promising genotypes for various processing and nutritional quality parameters from all the 3 nurseries viz. NGSN, EIGN-I and NDSN.

Industrial quality

Development of co-dominant markers associated with Glu-D1 double null in Nap Hal

The molecular marker available for Glu-D1 double null is recessive which limits the utility of this marker in breeding. Therefore, the work was initiated to identify co-dominant marker for efficient use in breeding to identify Glu-D1 double null in segregating populations. Microsatellite markers representing long arm of 1D chromosome were used in amplification of RILs developed of a cross between Nap Hal and UP 2425.

Table.4.4: Variability in processing and nutritional quality parameters

Parameter	NGSN	EIGN	NDSN
Test Weight (Kg/hl)	80.0 (73.2-83.7)	81.2 (77.5-83.7)	81.8 (74.4-83.7)
Protein Content(%)	11.70 (8.91-14.03)	11.54 (9.51-13.41)	11.24 (8.46-13.38)
Sedimentation Value (ml)	49 (36-65)	54 (35-66)	38 (31-46)
Grain Hardness Index	83 (22-99)	72 (22-98)	95 (76-108)
Iron (ppm)	39.3 (33.7-45.8)	37.7 (32.9-44.7)	36.3 (32.0-44.2)
Zinc (ppm)	32.1 (25.7-39.6)	29.6 (22.3-34.7)	30.6 (25.2-40.0)

Table 4.5: Promising genotypes for processing and nutritional quality parameters (NGSN)

Parameters	Value	Genotypes
Test Weight (kg/hl)	>83.0	K 1204, HD 4730 (d), HI 8750 (d), UAS 446 (d), HI 8755 (d),DBW 93, HD 4758 (d), HI 1605, HI 8708 (d)
Protein Content (%)	>13.0	VL 3004, VL 977, K 0607, DBW 172, AKAW 4924, AKDW 5012 (d), AKDW 5013 (d), LBPY 2013-3
Sedimentation Value (ml)	~65	DBW 129, HPW 373, PBW 677, VL 1004, HD 2967, HI 1605, DBW 172, HI 1604, HI 1615
Grain Hardness Index	>95	TL 2995 (T), HI 9713 (d), HI 8737 (d), HPW 360, HI 8759 (d), MACS 3949 (d), AKDW 5013 (d), KBRL 78-2, KBRL 81-1
	<45	HS 547, NIAW 2064
Iron (ppm)	>45.0	PBW 677, PBW 723, PBW 681, VL 967, HD 4758 (d), AKDW 5012 (d), KB 2013-05
Zinc (ppm)	~40.0	TI 2995 (T), MP 3336, DBW 172, AKAW 4924, KB 2013-05

Table 4.6: Promising genotypes for processing and nutritional quality parameters (EIGN)

Parameters	Value	Genotypes
Test Weight (kg/hl)	>83.0	36th ESWYT 126, 23rd HRWYT 242, 248, 33th SAWSN 3151, 14th HTWYT 25, 26, 39, 26th HRWSN 2003, 2017, DBW 88, 10th STERMRRSN 6039
Protein Content (%)	>12.50	36th ESWYT 130,23rd SAWYT 318, 33th SAWSN 3186, 3080, 3201, 3205, 3284, DBW 88, 48th IBWSN 1004, 1157, 1299
Sedimentation value (ml)	~63	36th ESWYT 126, 23rd HRWYT 240, 17th KBSN 30, 23rd, SAWYT (310, 346), 33th SAWSN 3186, 14th HTWYT 39, 26thHRWSN 2006
Grain Hardness Index	>85	23rd SAWYT (310, 314) HI 1544, 7th HLBSN 11, 19, K 1006, DBW 88, 26 HRWSN 2056
	<45	36th ESWYT 149, 17th KBSN 49, 50, 23rd SAWYT (321, 322) 33th SAWSN 3268, 48th IBWSN (1297, 1299)14th HTWYT 21,1st SATYT 35, 90
Iron (ppm)	>40.0	HI 1544, 23rd SAWYT 321, 346, 33th SAWSN 3152, 3015, DBW 88, 48th IBWSN (1157, 1191, 1283) K 1006, 14th HTWYT 21, 39, 26th HRWSN (2006, 2042)
Zinc (ppm)	~35.0	17th KBSN 14, 7th HLBSN 18, 40, 49, 26th HRWSN 2006, 2017,1st SATYT 39, K 1006

Table 4.7 Promising genotypes for processing and nutritional quality parameters (NDSN)

Parameters	Value	Genotypes
Test Weight (kg/hl)	>83.5	47th IDSN (7033, 7036, 7070, 7079, 7081, 7085, 7090, 7142, 7144), HI 8498, PDW 291, 47th IDYN (725, 729, 736), HI 8737,HI 8796, 8799, HI 8800
Protein Content (%)	>12.50	PDW 291, 47th IDSN 7142, 7144, 47th IDYN 708
Sedimentation value (ml)	>41	47th IDSN (7036, 7085, 7138) 47th IDYN (742, 745), HI 8797, HI 8799
Grain Hardness Index	>100	47th IDSN (7104, 7129, 7136, 7138, 7142), PDW 291, 47th IDYN (712, 715, 717, 729, 739), HI 8498
Iron (ppm)	>40.0	PDW 291, HI 8737, HI 8498, 47th IDSN 403, 708, HI 8801
Zinc (ppm)	>35.0	47th IDSN (7082, 7138), PDW 291, 47th IDYN (708, 730, 746), HI 8498

Nap Hal has Glu-D1 double null while UP 2425 has 2 subunits of HMW glutenin encoded by Glu-D1 locus. Several polymorphic markers differentiating Nap Hal and UP 2425 were identified and used in analysing RILs. Two of the markers namely cfd19 and GWM 642 showed co-segregation with Glu-D1 double null identified by SDS –Page analysis of RILs. The position of both the markers was identified in the consensus microsatellite map developed using ITMI population and Roder's microsatellite map. Cfd19 and GWM 642 exhibited 13.6 cm and 0.9 cm distance from Glu-D1 locus, respectively. GWM 642 co-segregated with Glu-D1 double null in all the RILs having Glu-D1 double null (Fig. 4.1) and thus has great utility in breeding for improving biscuit making quality.

Cross combination	Generation
UP 2425/*3/ Nap Hal	BC_3F_8
PBW 373/*3/ Nap Hal	BC_3F_{10}
PBW 502/*2/ Nap Hal	BC_1F_8, BC_2F_6
PBW 373/*3/ Nap Hal (BC3F4)//HD 2967	BC_1F_3; BC_1F_3; F_5
UP 2425/*3/ Nap Hal (BC3F4)//HD 2967	BC_1F_5, BC_2F_5
UP 2425/*3/ Nap Hal (BC3F4)//PBW621-50	BC_1F_4; BC_1F_2
PBW 373/*3/ Nap Hal (BC3F4)//PBW621-50	BC_1F_4; F_5

Table 4.8. Advanced generations of crosses made using Nap Hal as the donor of Glu-D1 double null and high yielding wheat varieties grown in 2017-18.

Transfer of Glu-D1 double null into high yielding backgrounds using marker assisted selection

Co-dominant marker developed during the investigation for Glu-D1 double null and for wild allele of puroindoline A were used for selecting desirable alleles of both the genes in breeding programme for improving biscuit making quality of high yielding varieties of wheat. Several crosses were attempted between high yielding varieties of wheat and Nap Hal. The derived populations were grown during 2016-17 and evaluated for gluten strength and grain hardness.

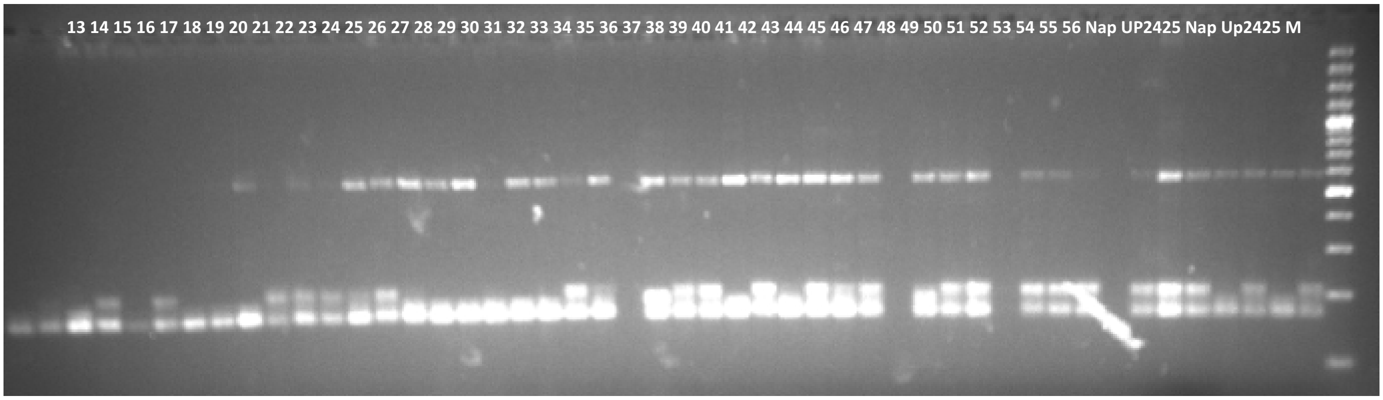

Fig.4.1. Segregation of SSR marker (GWM 642) in RILs of a cross between Nap Hal and UP 2425

The details of crosses and the generations developed are shown in Table 4.8. The advanced lines derived showed strong relationship with low sedimentation value (P<0.001) and better biscuit making quality. Advanced backcross lines of a cross between Nap Hal/PBW 373 and Nap Hal/UH 2425 were also used in making crosses with released varieties such as DPW 621-50 and HD 2967. Many of the lines developed showed higher yield potential and higher biscuit spread factor under large size plot experiments. The lines with high spread factor and higher yield potential will be further tested under national trials for their identification and release. This will lead to significant improvement of biscuit making quality of Indian wheat cultivars.

Nutritional quality

Assessing variability in phytase and phytic acid levels in wheat varieties: For enhancing bioavailability of micronutrients in human beings

Three hundred wheat varieties released in India were used in the present investigation to assess the variability in phytase and phytate levels. Direct assay method developed in our laboratory was used in assaying enzyme activity, which gave reproducible results. The extraction and assay of the enzyme was faster and cost effective as compared to other methods. There were 6 fold variations in phytase levels among the varieties studied whereas phytic content varied from 0.90 to 1.98% among the varieties. Though there was significant effect of both genotype and environment on phytate and phytase levels, it was more genetic with the heritability of 0.96 and 0.92 for phytase and phytate, respectively. Higher variability in phytase levels and more genotypic effect on the enzyme activity demonstrated the potential of improving phytase levels through breeding.

Development and identification of mutant for high phytase and low phytic acid level

More than four hundred lines of mutants developed in the background of PBW 502 using EMS mutagenesis were evaluated for phytic acid and phytase levels using microlevel tests. Many of the lines showed very high phytase levels up to 2400 FTU/kg while, PBW 502 exhibited 720 FTU/kg (Fig. 4.3). All the lines were evaluated for hectolitre weight for identification of lines with sound grains for further use in crossing with high yielding varieties. The lines with sound grains and high phytase levels and low phytic acid content were identified and will be grown during 2017-18 crop

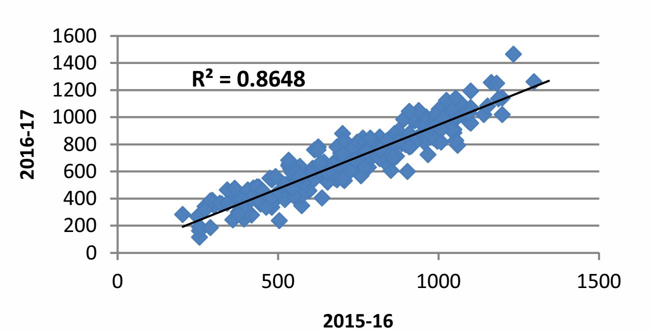

Fig. 2. Variations in phytase levels (FTU/kg) in released varieties

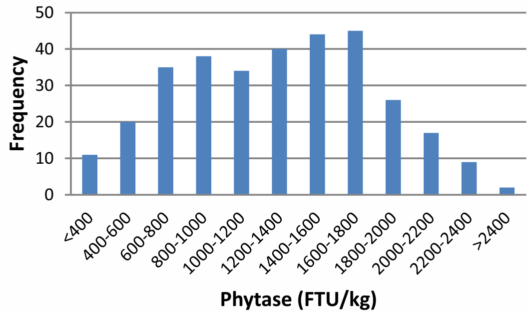

Fig. 4.3. Frequency distribution of Phytase in mutant population of PBW502

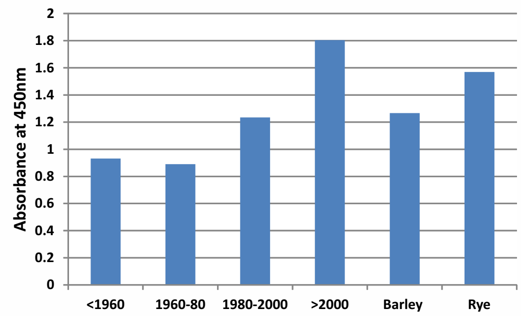

Fig. 4.4. Quantification of CD toxic epitopes in wheat, barley and rye

season for further analysis and also utilized in crossing programme for improving bioavailability of micronutrients to human beings.

Variability in the celiac disease epitope concentration in wheat & barley genotypes:

To evaluate the presence of celiac disease (CD) epitopes in wheat and barley varieties, gliadins were extracted from 80 wheat, 25 barley and one rye varieties. Indirect ELISA protocol was standardized using Gliadin peptide antibody Fig. 4.4. The results indicated that the modern wheat varieties have high number of CD epitopes as compared to the old varieties. Barley varieties have considerably low number of epitopes as compared to the modern wheat varieties. Wheat and barley genotypes with less content of CD toxic epitopes have been identified and can serve as an important source for reducing CD toxicity load in human beings. In addition; the identified genotypes could be used in breeding for reducing CD toxic epitopes of high yielding varieties. This will bring less CD toxic wheat products in food chain resulting in reduced celiac disease.

Salt tolerance

Identification of physiological and biochemical traits associated with tolerance to salinity stress in wheat

Salinity is a problem in agricultural lands across the world affecting production and productivity of major crops including wheat. Therefore, developing tolerant cultivars of wheat for salinity stress has become imperative to minimize yield losses under stress. However, breeding for salt tolerance by conventional means is difficult because of lack of selection criteria and complexity of the trait. Therefore, understanding physiological and biochemical basis of salt tolerance can help breeding process improve wheat varieties for salt stress. For this purpose, a population (120 lines) of recombinant inbred lines (RILs) was developed using a cross between tolerant wheat cultivar Kharchia 65 and sensitive HD 2009 and grown over 2 years (2015-16 and 2016-17) under control (pH~8.1) and salt stressed (pH~9.2) conditions along with parents. Physiological and biochemical traits included sodium, potassium and proline content and yield determining traits such as thousand grain weight (TGW) and grain yield per se were estimated. There was lesser yield reduction in Kh 65 as compared to HD 2009 under saline conditions. Strong negative correlation was observed between Na^+ content and grain yield (r=-0.36) under stress conditions. Na^+ content also exhibited negative correlation with K^+/Na^+ (r = -0.82) and proline (r = -0.38) in stress conditions. K^+ showed positive correlation with K^+/Na^+ (r = 0.72), proline (r = 0.554) and TGW (r = 0.47) under stress conditions. Proline content showed a positive correlation with pH (r = 0.52) and GY(r = 0.49). There were high heritability estimates for Na^+, K^+ and proline content (h^2=0.87, 0.4 and 0.66 respectively) under stress. Similarly, there was high heritability for TGW (0.64) and GY (0.56) under salinity stress. Significant positive correlations of K^+ an grown over two years (2015-16 and 2016-17) under control (pH=8.1) and salt stress (pH+9.2) conditions along with parents and proline content and negative correlation of Na^+ content with grain yield and also high heritability demonstrates that the traits can be used for screening and breeding of wheat genotype for salinity tolerance.

QTL mapping of salt tolerant traits in Wheat (*Triticumaestivum L.)* using SSR markers

The population developed from the cross Kharchia 65/ HD 2009 consisting of 120 lines was used for mapping QTLs. A molecular genetic map covering 3763.37 cM, was constructed using Microsatellite or Simple Sequence Repeats (SSR) markers. In total, 101 loci along the 21 wheat chromosomes were mapped. Genomic regions controlling traits related to salt tolerance were identified by using interval and composite interval mapping (using ICI Mapping) with a threshold of LOD 2.5. Thirteen significant QTLs were detected on 10 Chromosomes of the 21 chromosomes mapped for different salt tolerant traits. QTLs related to Na^+ content was located on chromosome 5D, 6A and 7D; for proline content on 2A and 5A chromosome; for relative water content (RWC), plant height and thousand grain weight on 2D chromosome. QTL for K^+ content and grain yield were identified on chromosome 2D; QTL for tiller number and number of ear heads were identified on 4D chromosome. The information from this study will be useful in improving salt tolerance of wheat by using marker-assisted selection.

Molecular markers for yellow pigment in durum

Two molecular markers (YP7A & YP7B-1) were validated for yellow pigment content in 76 durum wheat genotypes (Fig. 4.5 & 4.6). With YP7A marker, a 194-bp fragment for *Psy-A1a* allele was detected in 36 genotypes (47.36%) and a 231-bp fragment for *Psy-A1b* was detected in 30 genotypes (39.47%), while ten genotypes did not amplify with the marker. *Psy-A1a* allele had significantly higher YP content than that with allele *Psy- A1b*, confirming the association of PCR band pattern with YP phenotype. With marker YP7B-1, 45 accessions showed *Psy-B1a* allele (151 bp) (59.21%) and 20 accessions had *Psy-B1b* allele (156 bp) (26.31%) while no amplification was detected in eleven genotypes. Statistical analysis demonstrated that genotypes having *Psy-B1a* allele had higher mean value of YP content than those with genotypes having *Psy-B1b,* showing significant association of allelic

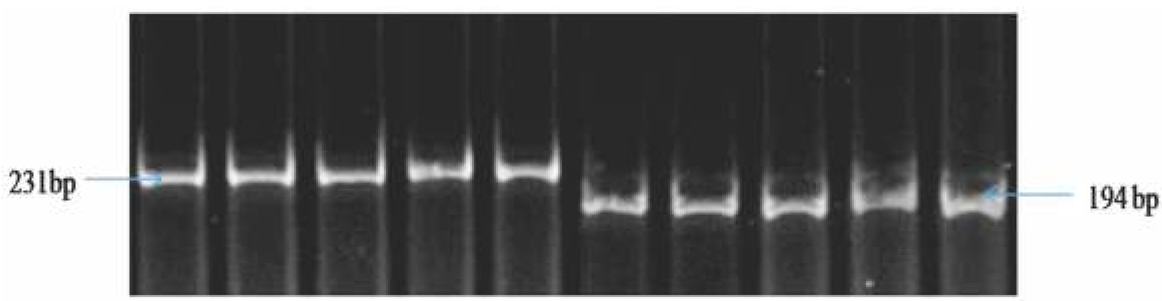

Fig.4.5 : Test of polymorphism for PCR fragments amplified with YP7A in genotypes with low and high YP content 1) HD 4502, 2)JU 12, 3)DWL 502, 4) BIJAGARED, 5)DWR 185, 6)NI 5749, 7)PBW 34, 8)MACS 9, 9)NIDW 295, 10)JNK-4W-184.

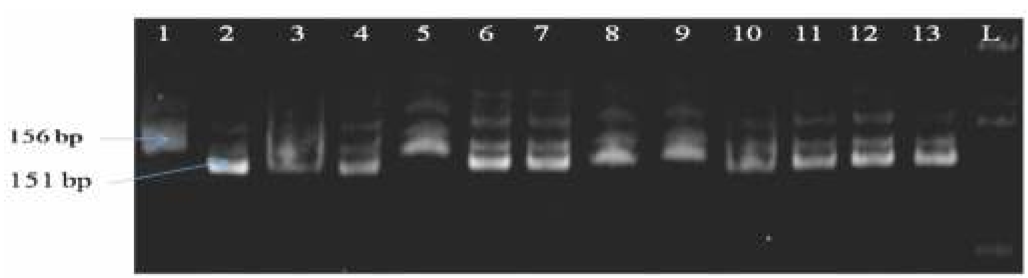

Fig.4.6. Test of polymorphism for PCR fragments amplified with YP7B1 in genotypes with high and low YP content 1)PDW 274, 2) NI 5749, 3)BAXI 288-18, 4)MACS 9, 5)VIJAY, 6)PDW 233, 7)PDW 291, 8) RAJ 911, 9)MPO 215, 10)A-28, 11)NIDW 295, 12)HI 8381, 13)GW 1139, L- ladder on 8% SDS-PAGE.

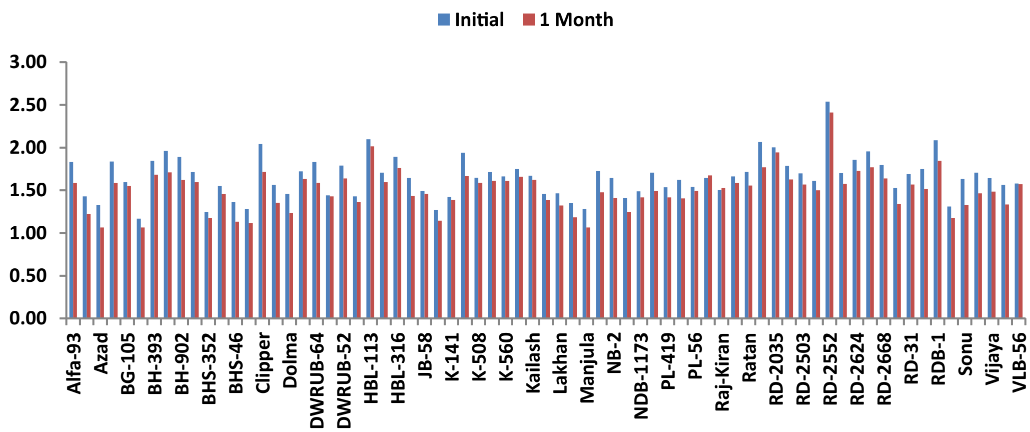

Fig. 4.7. Effect of one month storage at 4^{0}C on yellow pigment content in barley.

variants of *Psy-B1* with YP content.

Yellow pigment studies in barley

Carotenoids represent a large group of phytochemicals in cereals. These have many biological activities and can provide additional health benefits to humans. Information on the content of yellow pigment (YP) in Indian barley varieties is scarce. This study was initiated to generate information on the level of YP in barley genotypes. Yellow pigment estimation by micro method using 0.2g flour was standardized and estimated in 72 barley released varieties during 2016-17 (Fig. 4.7). The YP content varied from 1.2 – 2.62 µg β-carotene Eq/g. The effect of storage was studied on YP content in barley. After one month of storage of flour in refrigerator, the YP content reduced by 0.5–20%. To study the effect of location on YP content, four barley genotypes grown at four different locations in north-western and analysed for YP. No significant differences were observed in the YP content among the four locations.

Proanthocyanidins in Barley

Proanthocyanidins (PAC) are very important during beer storage. High PAC content cause haze in the beer during storage by cross-linking with the proteins and precipitating them. PAC are also responsible for the dark colour of barley dough. Therefore, there is strong need to identify malt barley varieties with low/no PAC. The protocols for extraction and analysis of proanthocyanidins in barley were standardized. In 76 barley varieties, the PAC content varied from 0.6 – 2.4 mg catechin Eq./g (Fig. 4.8). On the other hand, PAC also exhibited high antioxidant activity and can provide health benefits. Further studies are required to identify the malt barley genotypes with low PAC content and food barley genotypes with high PAC levels.

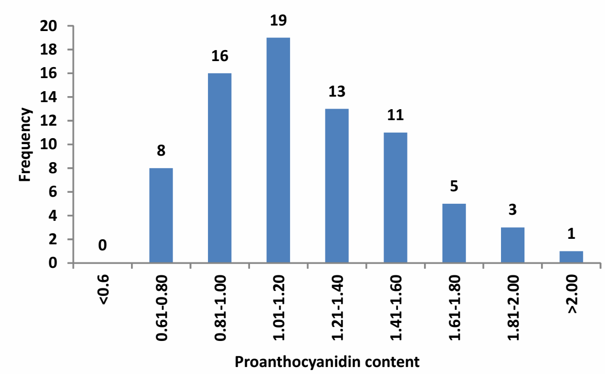

Fig.4.8. Proanthocyanidins content in barley released varieties

05 SOCIAL SCIENCES

Globally, in the realm of food commodities, wheat and barley occupies respectively the first and fourth position in terms of acreage. In India, these *Rabi* cereals altogether cultivated in around 31 million hectares accounting for about 36 per cent of the total foodgrains produced during 2017-18. Wheat has been under cultivation in around 31 million hectares and barley covered approximately 0.7 million hectares during 2017-18 (Source: Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, India). The past year production has reached an all-time record of 98.51 million tonnes and in the current season, the production growth is expected to be maintained. Front Line Demonstrations (FLDs) conducted across regions also witnessed a similar kind of trend.

The improved varieties and technologies demonstrated at farmers field through the FLD programme showed that yield registered in FLDs is significantly higher than check plots. However, there existed yield gaps across regions which should be bridged through need-based interventions by identifying the locations specific constraints. The ICAR-IIWBR makes continuous efforts to popularize the regions specific superior varieites as well as micro level strategies to enhance the wheat and barley productivity. Despite this outreach programme, there exists the need for increasing the productivity of wheat and barley through different scientist-farmer interface programmes with more emphasis on seed replacement, integrated nutrient management (INM), efficient water management, integrated crop management (ICM), integrated pest management

Table 5.1: State wise performance of improved wheat varieties under WFLDs during 2016-17

State	Mean yield (q/ha)		% Gain
	Improved	Check	
Assam	25.22	20.01	26.04***
Bihar	41.42	33.84	22.40***
Chhattisgarh	27.61	23.84	15.81**
Delhi	47.29	43.90	07.72**
Gujarat	47.87	44.58	07.38NS
Haryana	54.12	51.50	05.09***
HP	30.84	26.50	16.38***
J&K	33.45	28.64	16.79***
Jharkhand	34.92	27.47	27.12***
Karnataka	35.04	30.04	16.64**
Maharashtra	40.69	33.35	22.01***
MP	47.79	39.81	20.05***
Nagaland	10.40	8.95	16.20*
Punjab	54.84	52.51	04.44***
Rajasthan	50.19	43.90	14.33***
Tamil Nadu	23.86	-	-
UP	50.98	44.81	13.77***
Uttarakhand	32.70	25.30	29.25***
West Bengal	38.86	29.04	33.82***

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

Table 5.2: Zone wise productivity under wheat FLDs over regional mean during 2016-17

Zone	Mean yield (q/ha)		% Gain
	WFLDs	Regional	
NHZ	30.62	23.48	30.41***
NEPZ	39.15	29.35	33.39***
NWPZ	50.99	42.94	18.75***
CZ	45.49	39.11	16.31***
PZ	38.46	28.02	37.26***
SHZ	23.86	-	-

**** Significant at 1 percent level*

(IPM), weed management, incorporation/ retention of crop residues and soil health management. The farm advisory services/weather forecast through IIWBR portal (www.iiwbr.org) WhatsApp group, MANAGE portal and rigorous training of field level extension functionaries or subject matter specialists by the institute has also played a key role in taking contingent management measures, particularly against blast and yellow rust. 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 replacement and disease 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. 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 front line demonstrations (WFLDs)

During the wheat crop season 2016-17, 600 WFLDs of one hectare each were allotted to 83 cooperating centres across the country, of which 543 were conducted through 79 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, bio-fertilizer and drip/sprinkler irrigation were demonstrated in the selected farmers' fields. These WFLDs covered 547.4 hectares area of 1238 farmers in 19 states. The maximum number of WFLDs were conducted in UP (77), followed by MP (57), Rajasthan (46), Assam (38), Bihar (35), Haryana (35), Maharashtra (35), HP (30), Punjab (28), Karnataka (25), Jharkhand (23), West Bengal (18), Chhattisgarh (17), Uttarakhand (15), Tamilnadu (15), Delhi (14), J&K (14), Gujarat (11), and Nagaland (10).

From Table 5.1, the maximum yield gain was observed in West Bengal (33.82 %), followed by Uttarakhand (29.25 %), Jharkhand (27.12 %), Assam (26.04 %), Bihar (22.40 %), Maharashtra (22.01 %), MP (20.05 %), J&K (16.79 %), Karnataka (16.64 %), HP (16.38 %), Nagaland (16.20 %), Chhattisgarh (15.81 %), UP (13.77 %), Delhi (07.72 %), Gujarat (07.38 %), Haryana (05.09 %) and Punjab (04.44 %).

The yield gain due to improved varieties over regional mean yield (Table 5.2) was highest in PZ (37.26 %), followed by NEPZ (33.39 %), NHZ (30.41 %), NWPZ (18.75 %) and CZ (16.31 %). Yield gap in the NEPZ and CZ need to be bridged if India has to meet its ever-increasing food requirements. The concerted efforts made by the developmental agencies in NEPZ will help in bridging the yield gap and increasing wheat productivity to meet the ever-increasing requirement.

In case of improved durum wheat varieties, HD 8713 (d) gave a significant average yield of 71.50 q/ha, followed by HI 8737 (d) (70.75 q/ha) at Indore centre in CZ. In PZ, the variety HW 1098 (*dic.*) gave an average yield of 50.60 q/ha at Pune center, though it was not significant.

Table 5.3: Performance of zero tillage/happy seeder under FLDs

Zone & Centre	Improved varieties	Zero tillage mean yield (q/ha)	Conventional tillage mean yield (q/ha)	% Gain
NEPZ				
Faizabad	HD 2967	45.50	44.00	03.41NS
Pundibari, Coochbehar	HD 2967	36.23	34.32	05.57 NS
Shillongani	HD 2967	24.65	21.70	13.59 NS
NWPZ				
Ludhiana	WH 1105	57.50	56.00	02.68 NS
Agra	HD 3086	56.25	55.00	02.27 NS
Pantnagar	HD 3086	51.25	53.13	-03.54 NS
Kaithal (Happy Seeder)	HD 3086	58.00	56.00	03.57 NS

NS: Non-significant

In NHZ, at Tutikandi Shimla center, improved rainfed variety HS 507 yielded 37.73 q/ha which was significantly higher than the check varieties, followed by HPW 349 (28.67 q/ha) at Malan Kangra, SKW 355 (27.50 q/ha) at Khudwani Anantnag and HPW 360 (24.37 q/ha) at Hamirpur center. In CZ, DBW 110 gave significantly higher yield of 65.40 q/ha at Neemuch center which was significantly higher than the check variety followed by the same variety DBW 110 (55.50 q/ha) at Kota center. In SHZ, HW 5207 yielded 26.81q/ha at Wellington center.

Among RCTs, the zero-tillage technology under wheat FLDs has shown positive but non-significant impact at all the centers except Pantnagar (Table 5.3). The performance of rotavator technology under WFLDs has shown positive and non-significant impact at all the centers. For effective and efficient use of water, demonstration on sprinkler/drip irrigation was organized at Bhiwani and Vijapur centers. There was significant yield gain due to sprinkler irrigation at Bhiwani center. Yield gain due to drip irrigation at Vijapur center was noticed but non-significant. It is visible that we can produce similar yield with less use of water. Therefore, such technologies have great future in view of the declining water table across the country. The aim of 'Per drop more crop' can be realised by demonstrating the micro irrigation technologies at farmers' fields. The main limitation with this technology is that many centers does not possess the required infrastructure to demonstrate the micro irrigation technologies.

Analysis of constraints in different wheat producing zones of India

India witnessed a continuous increase in wheat production in the recent years. 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 northern hills zone, non-availability of seed of newly released wheat variety, rodents, high cost of inputs, non-availability of farm machinery and small land holding were perceived as top five major constraints.

North eastern plains zone (NEPZ): Realizing the potential of north eastern plains zone, all categories of constraints need to be addressed immediately for achieving the targets of second green revolution. Among major constraints of this zone, non-availability of seeds of newly released variety, followed by small holding size, high cost of inputs, lack of knowledge among the farmers about recent technologies, and non-availability of labour took the top slot. Farmers need to be educated and trained on recent wheat production

Table 5.4: Overall constraints impeding wheat production in the country during 2016-17 (n=1080)

Constraints	Score	Rank
Non-availability of seed of newely released variety	1353	I
High cost of inputs	1276	II
Small land holding	1205	III
Non-availability of labour	1160	IV
Low price of wheat	1141	V
Lack of knowledge among farmers about recent technologies	1029	VI
Lack of irrigation facilities	1014	VII
Declining water table	968	VIII
Chenopodium album (Bathua)	953	IX
Untimely rain	933	X

technologies to harvest potential yield in their fields.

North western plains zone (NWPZ): *Phalaris minor* followed by low price of wheat, high cost of inputs, small land holding and declining water table were perceived as major constraints in this mega zone.

Central zone (CZ): In central zone, declining water table, imbalanced use of fertilizers, low organic matter, high cost of inputs, and non-availability of seed of newely released wheat variety were identified as the major constraints as perceived by the farmers.

Peninsular zone (PZ): In peninsular zone, low price of wheat, erratic power supply, non-availability of seeds of newly released variety, non-availability of labour, and non-availability of electricity were perceived as the major constraints faced by the wheat growers.

Overall constraints (All zones): The overall analysis across zones revealed that non-availability of seed of newly released variety, high cost of inputs, small land holding, non-availability of labour, low price of wheat, lack of knowledge among farmers about recent technologies, lack of irrigation facilities, declining water table, *Chenopodium album* (Bathua), and untimely rain were perceived as major constraints hampering wheat production (Table 5.4). Farmers need to be educated and trained on recent wheat production technologies, complete package of practices and soil health management. There is a need for government intervention to ensure quality seeds as well as quality inputs. Farmers need to be updated on impact of climate change on wheat cultivation and what are the coping strategies they can adopt to mitigate it. The concept of conservation agriculture and adoption of resource conservation technologies at farmers' field can be propagated at a larger scale. To ensure better price, farmers have to go for quality wheat production. All the constraints need immediate attention in order to increase wheat production in all major wheat producing zones of the country.

Barley front line demonstrations (BFLDs)

During the *rabi* crop season 2016-17, 100 BFLDs were allotted to 20 different cooperating centers all over India in six states namely HP, UP, Punjab, Haryana, Rajasthan and MP of which 85 were conducted by 18 centers, covering 93.7 hectares area of 206 farmers. Improved barley varieties with complete package of practices (irrigation management, fertilizer dose and method of application, weed control, seed treatment etc.) were demonstrated.

The highest increase in barley yield (Table 5.5) was recorded in UP (25.33 %), followed by HP (23.51 %), MP (19.46 %), Rajasthan (18.18 %) and Haryana (08.92%). The lowest increase in yield was reported in Punjab (05.55 %).

The yield gain due to improved varieties over regional mean yield was highest in northern hills zone (43.21 %), followed by central zone (39.42 %), north eastern plains zone (36.47 %) and north western plains zone (15.16 %).

In NHZ, BHS 400 was the highest average yielding

Table 5.5: State wise yield gain under BFLDs during 2017-18

State	BFLDs yield (q/ha)	Check yield (q/ha)	% increase
Haryana	46.02	42.25	08.92***
HP	24.06	19.48	23.51***
MP	46.34	38.79	19.46***
Punjab	46.44	44.00	05.55*
Rajasthan	48.75	41.25	18.18***
UP	43.25	34.51	25.33***

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

(25.40 q/ha) variety at Bajaura centre. In NEPZ, RD 2794 at Kanpur (45.00 q/ha), BH 946 at Chomu Jaipur (63.02 q/ha) in NWPZ and BH 959 at Morena (52.50 q/ha) in central zone were the highest average yielding varieties.

At particular farmers' field as well as on average basis, BHS 400 (26.40 q/ha), RD 2794 (48.00 q/ha), BH 946 (65.10 q/ha) and BH 959 (55.00 q/ha) performed better than other varieties at Bajaura, Kanpur, Chomu-Jaipur and Bhind centres in the NHZ, NEPZ, NWPZ and CZ, respectively.

Analysis of constraints in different barley producing zones of India

Northern hills zone (NHZ): In northern hills zone, yellow rust, small land holding, high cost of inputs, non-availability of seed of newly release variety, late sowing, low organic matterimbalanced use of fertilizers, lack of facility of canal irrigation water, lack of knowledge among farmers about recent technologies and powdery mildew were some of the constraints which need immediate intervention.

North eastern plains zone (NEPZ): In north eastern plains zone of barley production, small land holding followed by higher custom hiring rate for land leveling, field preparation, sowing & harvesting, high temperature at maturity, untimely rain and non-availability of labour were identified as the major constraints.

North western plains zone (NWPZ): NWPZ being the most productive and potential zone for barley cultivation, the constraints which were most serious in nature need to be addressed. Among major constraints, small land holding size followed by non-availability of labour, low price of barley, *Chenopodium album* (bathua) and declining water table were perceived as serious by a majority of the FLD farmers of NWPZ.

Central zone (CZ): In central zone, high cost of inputs was perceived as the most serious constraint followed by declining water table, small land holding, temperature fluctuation during crop growth and low organic matter.

Overall constraints (All zones): Overall analysis of constraints in different zones clearly indicated that small land holding, followed by high cost of inputs, non-availability of labour, declining water table, low organic matter, higher custome hiring rate of land leveling, field preparation, sowing & harvesting, high temperature at maturity, temperature fluctuation during crop growth, lack of knowledge among farmers about recent technologies, untimely rain were identified as major constraints affecting barley production and productivity of the country.

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

Wheat: On an average, wheat varieties or technologies demonstrated in FLDs gave ₹2.83 per rupee of investment in comparison to the check varieties (₹2.48). The returns from FLDs ranged from ₹6.51 (Punjab) to ₹1.76 (Nagaland) across states, ₹3.77 (SHZ) to ₹2.32 (NHZ) across zones and ₹8.25 (Happy Seeder) to ₹2.10 (Sprinkler) across technologies. Punjab registered the highest returns per rupee of investment owing to the low operational costs, followed by Tamil Nadu (₹3.74) and Uttar Pradesh (₹3.41). The profit per hectare in FLDs was highest in Punjab (₹99779), followed by Uttar Pradesh (₹74309) and Gujarat (₹72024). The difference in profit between FLD and check plot ranged from ₹21329 in Maharashtra to ₹2243 in Haryana. Interestingly, operational costs in Karnataka and Punjab were lower in FLDs than the check plots. The probable reason for Punjab might be demonstration of resource efficient zero tillage and rotavator techniques which reduces the operational costs. Among the wheat production technologies demonstrated at farmers field, happy seeder gave the highest profit per hectare (₹89850) and the least profit was observed for the dicoccum varieties (₹37865). However, the results were not consistent across sites owing to testing of particular technology in different locations of diverse soil properties. Overall, on an average, an Indian farmer by adopting a new wheat variety or production technology will earn ₹55197 per hectare at his/her farm. Further, ₹777 have to be spent to produce a quintal of wheat through adoption of a new wheat variety or production technology against ₹917 (check varieties).

Barley: On an average, improved barley varieties demonstrated in FLDs gave around 16 per cent better returns in comparison to the check. A significant difference in returns per rupee of investment was noticed between the FLD and check plots across states and zones. Punjab registered the highest returns per rupee of investment (₹6.54) through demonstrations, followed by Uttar Pradesh (₹4.30) and Rajasthan (₹4.02). However, the difference in the returns per rupee of investment between FLDs and checks was highest in Uttar Pradesh. The profit per hectare in FLDs was highest in Punjab (₹76089), followed by Rajasthan (₹67809) and Uttar Pradesh (₹64040). The difference in profit between FLDs and check ranged from ₹18537 in Uttar Pradesh to ₹5472 in Punjab. Interestingly, operational costs in Madhya Pradesh, Punjab and 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 NWPZ (₹4.01), followed by NEPZ (₹3.82) and CZ (₹3.22). Estimates of cost of production indicated that the cost incurred in producing a unit quantity of output was least (₹297) in Punjab (NWPZ) owing to less operational costs and relatively higher yield.

Conducting wheat FLDs at ICAR-IIWBR, Karnal centre

During *Rabi* 2017-18, 20 acres (8 hectares) WFLDs were conducted at 20 farmers' fields in the villages namely Rasina and Hajwana in Kaithal district of Haryana state using varieties WB 2 and HPBW 01. The demonstrations were conducted with complete package of practices and farmers were provided with the improved varieties seeds as per provision under the programme.

Monitoring of FLDs

The ICAR-IIWBR team accompanied by the experts from the Ministry of Agriculture & Farmers Welfare and the concerned centres monitored the following FLDs centers during the crop season 2017-18 (Table 5.6).

Research Project Highlights

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

Sub-Project 1: Diagnosis of Zero Tillage based Rice-Wheat System in Haryana

During 2016-17, analysis of survey data (100 respondents) from the Yamunanagar district of

Table 5.6: FLDs Centers mentioned during 2017-18

Monitoring team leader	Centers monitored	Dates of monitoring
Dr. Satyavir Singh	Parbhani, Niphad and Pune	4-6 March, 2018
Dr. Anuj Kumar	Ambala, Ropar, Ludhiana	26-27 March, 2018
Dr. Rinki	Pantnagar and Almora	22-23 February, 2018

Haryana state indicated that 100% of the sampled farmers adopted zero tillage, 60% adopted Direct Seeded Rice (DSR) and 48% adopted zero tillage+DSR. The rate of custom hiring/acre of turbo happy seeder ranged from `800 to 1000. Farmers mostly used wheat varieties HD 2967 and HD 3086 under zero tillage. The positive impact of adoption of zero tillage was on cost saving, time saving, management of *Phalaris minor*, fuel saving, yield and germination. It was also recorded that continuous use of zero tillage increased organic carbon in soil, improved water retention capacity, improved fertility status of soil, reduces lodging, avoided terminal heat and it also gave 2-3 quintal/acre more yield as compared to the conventional tillage. There was reduction in weed population in zero tillage fields. Out of 100 sampled farmers, 60 adopted DSR technology for rice cultivation. They used all types of rice varieties under DSR such as Pusa 1121, Hybrids, Pusa 1509, HKR 147 and CSR 30. Adoption of DSR technology has positive impact on saving of time and cost of planting. Farmers also reported that technology adoption could save approximately 50% of water at farmers' fields as compared to transplanted rice. Most of the farmers suggested that these technologies should be promoted in the state by increasing/continuing the subsidy on machines and attach SMS (Stubble Management System) with combine harvester to facilitate sowing with turbo happy seeder. With the adoption of DSR method of paddy sowing followed by zero tillage method of wheat sowing, farmers can earn an additional income of ₹4000 to 5000 per acre. There is a need to make the farmers aware about the benefits of DSR and zero tillage through campaigns and training programmes. Subsidy on both the machines must continue and incentive must be given to adopters of these technologies. There is a need to develop champion farmers and para extension workers to promote DSR. To stop straw burning, the farmers of the state should be motivated to adopt zero tillage technology in the coming years.

Sub-Project 2: Identifying Yield Gaps, Resource Use and Adaptation Strategies in Vulnerable Regions of Wheat and Barley Production against Climate Change

A survey has been carried out in Madhya Pradesh (200 wheat producers and 100 barley producers) during the year 2017, a state categorised under high vulnerable zone with respect to wheat and barley production *in lieu* of climate change. Findings from data analysis on wheat production indicated that the share of crop acreage in total operational holdings was 89.30 per cent and 59.10 per cent respectively in Rewa and Chhatarpur districts of Madhya Pradesh. The Yield Gap-I was found to be negative in Chhatarpur and the Yield Gap-II was highest in Chhatarpur. It is against the conventional wisdom and theory that Yield Gap-I i.e., experimental yield – farmer's potential yield was negative. *Inter alia*, yield gaps arise due to difference in management & adaptation strategies. Analysis of resource use pattern indicated that there exist significant difference in the use of resources between Rewa and Chhatarpur. Seeds were used more than the recommended doses. Data Envelopment Analysis (DEA) showed that wheat growers are technically efficient to the tune of 89.30 per cent. The analysis pointed that around 11% of inputs level can be reduced to produce the same level of output. Further, it was found that a majority of the respondents fall under 91 to 100 per cent efficiency (132 farmers). Around 40 wheat growers were technically inefficient by 32 per cent indicating the scope for rational use of resources. In the case of barley, the crop acreage share has been estimated at 18.81 per cent and 18.17 per cent respectively in Rewa and Chhatarpur districts of Madhya Pradesh. The Yield Gap-I was found to be negative in barley and it was highest in Chhatarpur. Similar pattern was noticed for Yield Gap-II as well. Analysis of resource use pattern indicated that there exists significant difference in the use of resources between Rewa and Chhatarpur. Seeds were used more than the recommended doses. DEA showed that barley producers are technically efficient by 85.30 per cent indicating around 15% of inputs level can be reduced to produce the same level of output. Further, it was found that most of the respondents fall under 91-100 per cent efficiency (52 farmers). Around 23 farmers were technically inefficient by 38 per cent indicating the scope for rational use of resources. Perception of farmers 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 in Madhya Pradesh. Sensitive stages in wheat and barley were identified calling for suitable adaptation strategies and climate smart farming practices at crop production, farm and regional levels.

Tribal-Sub-Plan (TSP) project on 'Improving the Socio-economic condition and livelihood of tribes in India through extension education and development programmes'

Under the TSP project, the following seven centers were included for the year 2017-18, namely, Khudwani (J&K), Lahaul & Spiti (HP), Jabalpur (MP), Bilaspur (Chhattisgarh), Udaipur (Rajasthan), Dharwad (Karnataka) and Ranchi (Jharkhand). Baseline survey was conducted at Khudwani center. During 2017-18, different TSP activities were carried out. Under TSP project, a two–days training programme on 'Increasing farm income of Lahaul Valley farmers was organised at ICAR-IIWBR, Karnal for 43 farmers of 15 villages of Lahaul Valley.

The demonstrations of wheat crop were conducted with the complete package of practices at 5, 6, 26, 25 and 25 farmers' fields at Khudwani, Bilaspur, Ranchi, Udaipur and Jabalpur centers, respectively. Three training programmes on wheat production technology were conducted one each at Khudwani, Bilaspur and Jabalpur centers. Four Farmers Fair/Field Days were conducted one each at Khudwani, Udaipur, Bilaspur and Jabalpur centers. Four publications, 3 at Khudwani and 1 at Bilaspur were published. Under the 'Capital' head in budget, no funds have been approved or released for the year 2017-18.

06 BARLEY IMPROVEMENT

The ICAR-IIWBR Karnal coordinates the research programme on barley in country under the AICRP on wheat and barley through multi-disciplinary and multi locational experiments conducted across the barley growing zones at funded and voluntary centres in the barley growing states. This facilitates the identification of new cultivars for commercial cultivation with wider adaptability, resistance to various biotic and abiotic stresses prevalent in the area, suitability to specific production conditions and with desired quality. In addition the experiments are also conducted on aspects of improvement and optimization of production technologies including conservation agriculture. The crop protection programme includes the screening of new genotypes under artificial epiphytotic/ hot spot conditions and experiments on chemical control and IPM are also organized at various test centres. The annual review, work planning and zonal monitoring programmes are also organized to achieve these objectives.

The research efforts are also supplemented through research on specific aspects of barley improvement especially on malt barley improvement, application of biotechnological tools in disease resistance and quality improvement, improvement of cultivation package and basic studies on pathogens/pests. Utilization of the new/ exotic genetic resources and creation of new variability are the important aspects in the improvement of barley quality traits as well as resistance to diseases. Focus is also on better yield and quality of Hulless barley, lodging resistance genotypes for feed barley and better malt extract, diastatic power, optimum protein and beta glucan content in malt barley. In addition, ICAR-IIWBR has linkages with international organizations like ICARDA to facilitate the access to new germplasm of diverse origin from various sources for evaluation and utilization in the national programme. To increase the production and area of barley, efforts are needed to provide support price, market availability and also a quality seeds to the endusers.

New varieties released

DWRB 137

A six-row feed barley variety for irrigated timely sown conditions of central zone (CZ) and north eastern plains zone (NEPZ) was released during 79th meeting of CVRC. In central zone, DWRB137 depicted superiority in grain yield over the zonal check BH959 (10.67%) and other checks namely PL751 (9.01%) and RD2786 (5.46%), respectively. DWRB137 also showed superiority in grain yield over in NEPZ to the zonal checks viz.

Fig. 6.1 : A view of DWRB137

Table 6.1: Salient features of barley variety DWRB137

Variety	Parentage	Zone	Condition	Pot. Yield (q/ha)	Avg. Yield (q/ha)	Salient features
DWRB137	DWR28/DWRUB64	CZ	Irrigated, timely sown	67.44	42.49	Six-row high yielding feed barley with resistance to yellow rust, short plant stature and high grain protein content
		NEPZ	Irrigated, timely sown	53.62	37.93	

Table 6.2 : Details of registered genetic stocks of Barley

Name	INGR No.	Year	Trait
DWRB173	17043	2017	Hooded and extra early heading
DWRB175	17044	2017	Extra dwarf plant stature
DWRB176	17045	2017	Long spikes for more number of grains and resistant to stripe rust
DWRB180	17046	2017	Resistant to spot blotch

HUB113 (5.00%), Jyoti (10%) and K508 (10.05%), respectively.

Genetic stocks registered

Four genetic stocks namely DWRB173, DWRB175, DWRB176 and DWRB180 were registered for different traits with ICAR-NBPGR and the details are given in Table 6.2.

Registration of varieties with PPV&FRA

During the year 13 barley varieties applications under extant category were submitted for the protection with PPV&FRA. The applications were submitted for the varieties namely, BHS380, BHS400, DWRB73, DWRUB64, DWRUB52, DWRB92, DWRB91, DWRB101, HBL391, HUB113, VLB56, VLB85 and VLB118. Out of these varieties the protection was granted for the varieties viz., DWRB73, DWRUB64, DWRUB52, DWRB91, DWRB92 and DWRB101.

COORDINATED YIELD EVALUATION TRIALS

- Out of 120 yield evaluation trials proposed, 110 (91.7%) trials were conducted. 97 trials (80.8% of proposed 88.2% of conducted) were reported.

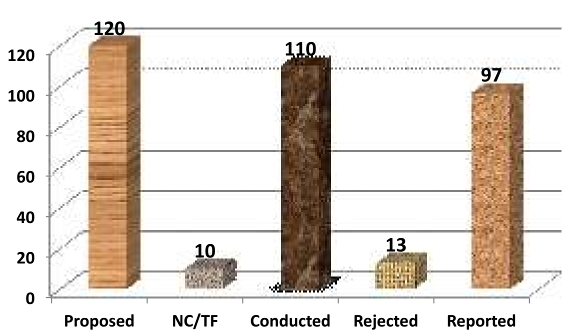

Fig. 6.2 : Barley yield trials (2016-17)

- These trials were conducted at 12 main centres and 35 testing centres (including ICAR, SAUs and State Department of Agriculture) during rabi 2016-17.

In all 116 test entries contributed by 12 centres, were evaluated against 33 checks in the coordinated yield trials under rainfed (plains and hills), Irrigated (plains) and saline soils conditions under timely/ late sown conditions. The new barley entries include malt, feed or dual purposes types and mostly were hulled type with a few hull-less types.

Table 6.3 : Promising entries promoted to coordinated trials

Trial	Entries
AVT-IR-FB-NWPZ	PL 891
AVT-IR-NEPZ	PL892,RD2948, KB1531
AVT-RF-NEPZ	HUB 253
AVT-TS-MB	DWRB160
AVT-IR-CZ	PL892, PL898, KB1531

Nine entries were promoted to different AVT trials under different production conditions.

ZONAL MONITORING

The teams constituted for monitoring of Barley Network Yield Trials & Nurseries in central zone, NWPZ and NEPZ, visited different locations of different zones 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. On the spot decisions were taken about the rejection of trials and purity of test entries through consensus (Table 6.4).

Table 6.4 : Zonal monitoring visits of the barley teams

Zone	Dates	Centres visited
C Z	16-18, February 2018	Vijapur, Udaipur, and Vallabhnagar
NEPZ	21-24, February , 2018	Dalipnagar, Kanpur, Faizabad, Varanasi, and Saini
NWPZ	5-7March, 2018	Kumher, Morena, Gwalior, Durgapura and Bawal
NHZ Team I	12-14 April, 2017	Ranichauri, Majhera and Hawalbagh
NHZ Team II	18-21 April, 2017	Shimla, Berthin, Kangra, Malan, Palampur, Bajaura, Katrain

Malt barley entries promoted to coordinated trials:

During 2016-17 crop season, the entry DWRB160 was promoted to the AVT first year evaluation from IVT-MB-TS. The entry DWRB160 was significantly superior to the all malt barley checks namely DWRUB52, DWRB101, DWRB123 and RD2849 and details are presented in the Table 6.6.

Breeding materials and hybridization (Malt)

During the year 2016-17, a crossing block with 333 entries was grown to maintain potential donors under malt barley breeding programme. To create novelty 95 cross combinations were attempted and out of these, 92 crosses were advanced during *Summer*, 2017 at Dalang Maidan. The available breeding materials were grown and evaluated for yield and yield attributes, stripe rust, spot blotch and aphid resistance. The details of breeding materials selected for 2017-18 is as under.

Table 6.5 : Malt barley breeding material selected and grown during rabi, 2017-18

Generations	Families	Crosses
F_8	14	14
F_7	40	37
F_6	57	42
F_5	33	24
F_4	337	80
F_3	510	108
F_2	92	92
F_1	95	95
Total	1178	492

Table 6.6 : Performance of new entries under Barley Network trials Rabi (2016-17)

No	Name	Parentage	Yield (Q/ha) (Mean & Range)	Rk	Grain protein (%)	HWE (%)
1	DWRB 160	DWRB62/DWRB73	53.3(42.9-67.9)	1	19.9	80.6
2	DWRB101(c)	DWR28/BH581	48.4(36.3-71.0)	5	11.1	81.9
3	DWRB123 (c)	DWRUB54/DWR51	48.5(33.9-60.4)	4	10.3	79.1
4	DWRUB52 (c)	DWR17/K551	47.2(32.9-62.5)	10	10.4	81.6
5	RD2849(c)	DWRUB52/PL705	47.6(29.1-72.5)	7	10.3	81.6

Identification of new genetic resources

Genotype identified for extra early heading and maturity

DWRB174 : The genotype DWRB174 is six-row early heading barley genotype, which was selected (single plant selection) and purified from conserved exotic material (GIJA 121/CI 06248/4/APM/IB65//11012-2/3/API/CM67//DS/APRO/5/ATHS-BCU765) for earliness, plant height, stripe rust tolerance and other morphological characters. DWRB174 is extra early heading (54 days) coupled with desirable plant height.

Table 6.7 : Malt barley breeding material selected and grown during rabi, 2017-18

Location	Year	DWRB174 (six-rowed) check)	BH902 (six-rowed	DWRB173 (two-rowed hooded)
Karnal	2015-16	55	89	55
Karnal	2016-17	54	91	54
Karnal	2017-18	54	89	54
Hisar	2015-16	54	87	53
Hisar	2016-17	54	88	-
	Mean	**54**	**89**	**54**

DWRB174 is six row feed barley genotype with desirable yield attributes, higher grain yield, short plant height (<18-24 cm) than earlier registered genetic stock DWRB173 and can be directly utilized in rainfed breeding programmes with-out grain yield penalty.

Genotypes identified for high grain zinc and iron content

DWRB191 : As new initiatives for bio-fortification, a hulless barley genotype namely DWRB191 was developed from cross BHS352/HBL113, which possesses high grain zinc content than the checks. The grain zinc content was estimated by atomic absorption spectroscopy (AAS) method. The genotype was evaluated at four locations namely Karnal, Hisar, Durgapura and Jobner and the details are as under.

DWRB192 : DWRB192 is hulless barley genotype, which was developed from cross BHS352/HBL113 and possesses higher grain iron content than the checks. The grain iron content was estimated by atomic absorption spectroscopy (AAS) method. The genotype was evaluated at four locations namely Karnal, Hisar, Durgapura and Jobner and the details are given in subsequent section.

Fig. 6.3 : DWRB174 at heading and rest crop is at tillering stage

Fig. 6.4 : DWRB173 (Hooded); DWRB174 (six rowed)

Genotypes identified for higher 1000 grain weight

Four advance breeding strains (19-1, 31-3, 220-1 and 448-1) were identified for very high 1000 grain wt. under malt barley improvement programme (Table 6.10). The 1000 grain wt. of the bold seeded two-row malt barley checks namely, DWRB91 and DWRB92 ranged from 49-56 g. The details of high 1000 grain wt. strain (220-1).

Table 6.8 : Grain zinc content of DWRB191 and checks during 2016-17

Location	DWRB191	BHS352 (c)	Karan16 (c)
Karnal	35.2	33.2	34.0
Hisar	46.7	40.7	38.1
Durgapura	47.8	44.0	37.6
Jobner	49.7	41.5	36.5
Mean	44.9	39.8	36.6

Breeding for food, feed and dual purpose barley

Evaluation of parental lines

Diverse barley genotypes (208) involving Indian released varieties, indigenous and exotic germplasm lines were included in the crossing block. The purpose is to transfer the desirable traits and to create the genetic variability for improvement of the barley for food, feed and dual purpose. The exotic lines included in the crossing block were selected from International nurseries obtained from ICARDA during field day. After

Table 6.9 : Grain iron content of DWRB192 and checks

Location	DWRB192	BHS352 (c)	Karan16 (c)
Karnal	44.9	32.9	32.9
Hisar	43.9	39.9	39.9
Durgapura	51.0	42.9	36.9
Jobner	49.9	43.2	41.3
Mean	47.4	39.7	37.7

Table 6.10 : Details of high 1000 grain wt. barley strain 220-1

Year	220-1	DWRB91	DWRB92
2014-15	69.10	56.23	49.25
2015-16	71.09	53.10	52.77
2016-17	72.27	51.48	54.26
2017-18	71.06	55.81	53.78
Mean	70.88	54.16	52.52

evaluation, 22 exotic lines are being utilized as a parent in the crossing programme for barley improvement.

Hybridization programme

With objective to incorporate the desirable traits *viz*; yield, quality, disease/pest resistance, smooth awn, and earliness into six row barley, crosses were attempted between Indian varieties and exotic germplasm accessions. A total of 57 cross combinations were attempted. Out of them, 33 cross combinations of hulless barley were made for improvement of nutrient enriched food barley such as beta-glucan, protein etc. On the basis of seed availability, 24 crosses of hulled barley were grown at Lahul Spiti for generation advancement. Several sources of resistance (rusts and leaf blights) and yield attributes including indigenous and exotic lines have been utilized in hybridization programme. In addition, two rowed and six rowed parental lines were used in crossing programme for

Table 6.11 : Cross combinations attempted for improvement of the hulless barley during Rabi 2016-17

SNo.	Combination	SNo.	Combination
1	Geetanjali/DWR30	18	Karan16 / BK1127
2	Geetanjali / INBYT-HI-(2013)-11	19	Karan16 / INBYT-HI-(2013)-11
3	Geetanjali / INBYT-HI-(2015)-6	20	BHS352 / BK306
4	Geetanjali / BK1127	21	BHS352 / BK1127
5	Geetanjali / BK306	22	BHS352 / DWR30
6	Geetanjali / Atahualpa	23	BHS352 / INBYT-HI-(2013)-11
7	Geetanjali/Hiproly	24	BHS352 / INBYT-HI-(2015)-6
8	NDB943/DWRNB28	25	BHS352 / Hiprolly
9	NDB943/DWR30	26	BHS352 / BCU554
10	NDB943/ INBYT-HI-(2013)-11	27	Dolma/ BK1127
11	NDB943/Hiprolly	28	Dolma/ DWR30
12	NDB943/BCU554	29	Dolma/ INBYT-HI-(2013)-11
13	Karan16 /Hiprolly	30	Dolma/ INBYT-HI-(2015)-6
14	Karan16 /BCU554	31	Dolma/BK306
15	Karan16 /DWR30	32	Dolma/Hiprolly
16	Karan16 /BK306	33	Dolma /BCU554
17	Karan16 / INBYT-HI-(2015)-6		

Table 6.12 : Details of the hulled barley cross combinations advanced in summer season (2016-17)

SNo.	Combination	SNo.	Combination
1	DL456/SM83	15	BH946/SM94
2	DL456/SM22	16	BH946/ BCU6954
3	DL456/ BCU6954	17	BH946/BCU6857
4	DL456/SM94	18	BH946/SM22
5	DL456/ BCU6857	19	JB1/SM83
6	DWR83/BCU6954	20	JB1/BCU6857
7	DWR83/SM22	21	JB1/BCU6954
8	DWR83/SM94	22	JB1/SM94
9	RD2794/SM94	23	JB1/SM22
10	RD2794/BCU6857	24	DL88/BCU6954
11	RD2794/BCU6954	25	DL88/SM22
12	RD2794/SM83	26	DL88/SM83
13	RD2794/SM22	27	DL88/SM94
14	BH946/SM83	28	DL88/BCU554

generating the variation and incorporation of desirable attributes in the six row barley.

Evaluation and selection in segregating population

F_1 to F_7 generations of feed and food barley were grown at the new farm of IIWBR, Karnal and evaluated under artificial epiphytotic condition for rusts and blights and also natural incidence for aphids. Single plant was selected for early maturity, morphological traits and resistance to rusts and blights, and for generation advancement.

Ten promising genotypes were bulked from F_6 generation for inclusion in barley station trial during 2016-17. However, F_1s were sent for advancement to F_2 at Dalang Maidan. New bulks selected for feed and dual purpose barley and are under evaluation during *Rabi* 2017-18

New genetic resources of huskless barley

DWRNB 17- DWRNB17 is a six rowed huskless barley genotype selected from International nursery procured from ICARDA in 2013. It showed resistance

Table 6.13 : Feed and food barley breeding material grown

Generation	Grown		Field selection	
	Families	Crosses	Families	Crosses
F_7	19	10	9	7
F_6	61	37	39, 10(B)	30
F_5	61	33	94	32
F_4	150	55	127	48
F_3	260	62	294	54
F_2	29	29	253	29
F_1	41	41	-	-
Total	621	267	816	200

Table 6.14 : Particulars of cross combination

S N	Bulk	Cross combination
1	DWRFB30	DWR83 X DWRB73
2	DWRFB31	DWR83 X DWRB73
3	DWRFB32	DL456 X EIBON17
4	DWRFB33	Drummon X HUB19
5	DWRFB34	DWR83X BH902
6	DWRFB35	DWRUB64 X BCU2366
7	DWRFB36	DWRUB64 X W316
8	DWRFB37	BCU6821 X PL721
9	DWRFB38	DWRUB64 X BCU6764
10	DWRFB39	DWRUB64 X BCU6764

to stripe rust as well as leaf blight under artificial epiphytotic in the Initial Barley Disease Screening Nursery (IBDSN) at multi-locations during 2015-16 and 2016-17.

DWRNB 23- DWRNB 23 is a six rowed huskless barley genotype selected from breeding material obtained from ICARDA during 2013. This genotype possesses promising traits like good spike, smooth and easily broken awns and easily threshable spike. The genotype exhibited highly resistant reaction (0) for stripe rust under artificial epiphytotic in the IBDSN at multi locations during 2015-16 and 2061-17.

Disease reaction (artificial inoculation) in DWRNB 17 and DWRNB23 in IBDSN.

DWRNB28- The genotype DWRNB 28 is a two-row huskless barley, which was selected (single plant selection) from International nursery obtained from ICARDA. This genotype consists of dwarf plant stature (Plant height 60-65 cm) and medium maturity. Simultaneously, it exhibited highly resistant (0) to resistant (3) for stripe rust under artificial epiphytotic in the IBDSN at multi locations during 2015-16 and 2061-17.

Table 6.15 : Disease reaction (artificial inoculation) in DWRNB 17 and DWRNB23 in IBDSN.

Entry No.	2015-16				2016-17			
	Yellow rust		Leaf blight		Yellow rust		Leaf blight	
	ACI	HS	Avg.	HS	ACI	HS	Avg.	HS
DWRNB-17	2.00	10S	46	68	3.00	10S	35	36
DWRNB-23	0.00	0	35	69	0.00	0	46	57
Infector	64	100S	68	99	84	100S	79	89

Fig. 6.5 : DWRNB 17 and DWRNB 23

Table 6.16 : Plant height (cm) of DWRNB 28 and check varieties

Location	Year	Plant height (cm)		
		DWRNB 28	Karan 16	NDB 943
Hisar	2013-14	65.0	89.7	100.7
Hisar	2014-15	62.0	84.5	95.9
Hisar	2016-17	62.5	80.9	100.8
Hisar	2017-18	60.0	90.0	98.0
	Mean	62.3	86.3	98.9
	% advantage	-	27.8	37.0

Genetic improvement for feed barley (leaf blight programme)

Yield evaluation trial

A set of 33-elite lines selected from different nurseries of ICARDA have been evaluated in *rabi* 2017-18 in augmented design with three blocks and three check varieties. The superior lines will be identified for their utilization in the hybridization programme.

Hybrdization and generation advancement

Thirty-three crosses were attempted in *rabi* 2016-17 involving eight agronomically superior varieties/genotypes but susceptible to blight and five genotypes known for resistance to blight as pollen parents. A total of 200 fertilized spikes were harvested. Of these cross combinations, 28 crosses were raised at regional station, Dalang Maidan for generation advancement during off-season of summer 2017. F_2 generation of these crosses has been raised at IIWBR during *rabi* 2017-18 for further selections.

Fig. 6.6 : DWRNB 28

Screening of germplasm lines for their reaction to barley leaf blight

A set of 39 genotypes including 34 germplasm lines were evaluated for their reaction to barley leaf blight at hot spot locations Kanpur and Varanasi along with susceptible check varieties Jyoti, Lakhan and HUB113. At Varanasi, most of the test entries (26 out of 39) gave as high as 99 disease score for leaf blight. One test entry BCU5214 (BL-2016-17) was found to possess moderate levels of resistance (Highest score 36) for this disease (Table 6.1). During *rabi* 2017-18 also a set of 24 genotypes has been raised at hot spot locations Faizabad and Varanasi and under artificial epiphytotic conditions at IIWBR-Karnal along with susceptible check Jyoti to screen the material for their reaction to leaf blight. In addition another set of 24-entries is being evaluated under IBDSN for their reaction to blight and rust diseases.

Pre-breeding work initiated in barley

A set of 45 wild accessions of H. vulgare ssp spontaneum imported from ICARDA, Rabat, Morocco; 4 accessions of this species and one accession of H. bulbosum obtained from our GRU have been planted to multiply seed and simultaneously characterize them

Table 6.17 : Details of F1 crosses attempted for blight resistance during rabi 2016-17 and their advancement at IIWBR, RS, Dalang Maidan in summer 2017

S. No.	Combination	S. No.	Combination
1	RD2786 / DWR49*	18	RD2052 /DWR49
2	RD2786 /PL891	19	RD2052 /PL891
3	RD2786 /BCU5527	20	RD2052 /BCU5527*
4	RD2786 /CHWO15488	21	RD2052 /BCU5179
5	RD2786 /BCU5179	22	RD2624 /DWR49
6	DWRNB23 /DWR49	23	RD2624 /PL891
7	DWRNB23 /PL891	24	RD2624 /BCU5527
8	DWRNB23 /BCU5527	25	RD2624 /BCU5179
9	DWRNB23 /BCU5179	26	RD2660 /DWR49
10	DWR101 /DWR49	27	RD2660 /PL891
11	DWR101 /PL891	28	RD2660 /BCU5527
12	DWR101 /BCU5527*	29	RD2660 /BCU5179
13	DWR101 /BCU5179*	30	RD2668 /DWR49
14	RD2035 /DWR49	31	RD2668 /PL891
15	RD2035 /PL891	32	RD2668 /BCU5527
16	RD2035 /BCU5527	33	RD2668 /BCU5179
17	RD2035 /BCU5179		

**Crosses not advanced*

Table 6.18 : Screening of germplasm lines for their reaction to barley leaf blight during rabi 2016-17 at BHU, Varanasi

Entry Code/Checks	BL-2016-17	Check 1	Check 2	Check 3
BCU No.	BCU5214	Jyoti	Lakhan	HUB113
Days to heading	107	-	-	-
Plant height (cm)	108.6	-	-	-
Tillers/meter	42	-	-	-
Spike length (cm)	6.7	-	-	-
Grains/spike	58.8	-	-	-
1000-gran weight (g)	33.6	29.4	31.1	34.1
Leaf Blight score				
85 DAS	0	12	12	12
91 DAS	12	47	24	24
109 DAS	35	89	35	36
113 DAS	36	99	99	99

DAS = days after sowing

Fig. 6.7 : Rejuvenation of barley germplasm

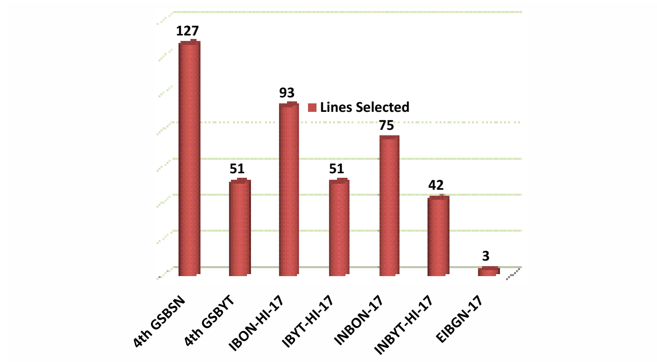

Fig. 6.8 : Germplasm lines selected in different nurseries

morphologically. These accessions will be characterized for their reaction to diseases, agronomic and quality attributes, so that a pre-breeding activity is initiated to augment improvement programme of Indian barley.

Germplasm rejuvenation and DUS characterization

A total of 8179 accessions of barley are being conserved and maintained at ICAR-IIWBR, Karnal. Out of which, during 2016-17, 593 conserved germplasm lines from medium term storage were rejuvenated and during *rabi*, 2017-18, 600 germplasm accessions were sown for rejuvenation and characterization. During *rabi*, 2017-18, 01 farmer variety namely Bhagat Jau-1 is under characterization with 08 reference varieties, whereas, other 16 farmers varieties are under process of purification and grouping characters data recording.

Germplasm exchange and evaluation

A total of 420-germplasm lines (fitting for different production conditions) received from ICARDA were evaluated at different locations of Barley Network (Bajaura, Ludhiana, Karnal, Hisar, Durgapura, Kanpur, Faizabad and Rewa) along with standard checks. In addition an Elite International Barley Germplasm Nursery was constituted with 45-germplasm lines and six released varieties (DWRUB52, BH902, DWRB73, RD2552, RD2035 and DWRB92) as checks and are being evaluated for specific traits.

Germplasm selection and utilization under NARS in rabi 2016-17

Breeders from SAUs and ICAR institutes were given an opportunity to select desirable germplasm from international trials and nurseries during a Field Day organized on 8th March, 2017 at Indian Institute of Wheat and Barley Research, Karnal, and a total of 442 germplasm lines were selected by the barley breeders from Ludhiana, Shimla, Almora, Pantnagar, Kanpur and Karnal. During *rabi* 2016-17 a total of 170 exotic germplasm lines were evaluated in station trials at different locations of Barley Net Work; 33 such lines were under national trials of AICRP; 16 were utilized in hybridization and 35 advanced breeding lines were developed.

Elite international barley germplasm nursery (EIBGN)

This nursery was constituted with 45 germplasm lines selected from different international trials and nurseries based on their performance in *rabi* 2016-17 under respective trials/nurseries and six released varieties (BH946, BH959, BHS400, RD2715, DWRB101 and HUB113) as checks. A set of 75 entries including six checks repeated five times at each location were evaluated in an augmented design at twelve locations in NEPZ (Kanpur, Faizabad, Varanasi, Rewa), NHZ (Shimla, Almora, Bajaura) and NWPZ (Karnal, Hisar, Durgapura, Ludhiana, Pantnagar). In general higher yields were obtained in NWPZ and the least in NEPZ. In NHZ, two test entries 3rd GSYT-(2016)-18 and IBYT-HI-(2016)-4 registered statistically significant higher grain yield over the best check. In the other two zones (NWPZ and NEPZ), no test entry was found to be statistically superior.

National Barley Genetic Stock Nursery (NBGSN)

This nursery comprising of a set of 27 promising entries endowed with trait(s) of breeding value, received from network centres, were evaluated during *rabi* season of

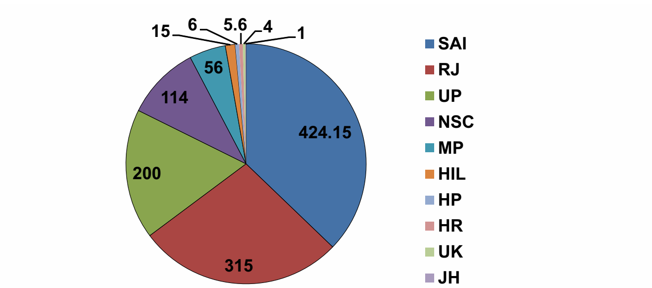

Fig. 6.9 : Breeder seed indent of barley (q.)

2016-17. This nursery was supplied to 11-centres (Rewa, Karnal, Durgapura, Kanpur, Hisar, Faizabad, Varanasi, Bajaura, Ludhiana, Pantnagar and Shimla) of barley network.

Breeder seed production

A consolidated indent of 1140.75 q breeder seed of 38 varieties was received from DAC, Ministry of Agriculture & Farmers Welfare, Govt. of India. The indent included requirement of eight states (Rajasthan, Uttar Pradesh, Uttarakhand, Haryana, Madhya Pradesh, Punjab, Jharkhand and Himachal Pradesh), National Seeds Corporation and National Seed Association of India for the season Rabi 2016-17. The major proportion of the breeder seed indent was placed by NSAI (424.15q) followed by Rajasthan (315.00q), Uttar Pradesh (200.00q), National Seed Corporation (114.00q), Madhya Pradesh (56.00q) etc. From variety point of view, the highest indent was received for variety RD2786 (186.00q) followed by RD2794 (121.00), PL426 (96.15q), DWRUB52 (94.30q), RD2035 (71.40q), HUB113 (63.00q) etc.

A net production of 1521.86q breeder seed was reported, which was surplus (+381.11q) in comparison to the total allocated quantity of 1140.75q. The maximum production was reported for RD2786 (300.00q), followed by RD2794 (160.00q), PL 426 (110.29q), DWRUB 52 (93.60q) and HUB 113 (90.00q). The nucleus seed (77.90q) was produced against the targeted quantity of 56.19q of 33 varieties.

Barley Quality

Malting quality of moderately high protein genotypes: For making food products from barley malt, the quality requirements are bit different as required for brewery purpose barley. Usually the industry requires barley malt with higher protein content from nutritional point of view. In this endeavour 32 genotypes including some of the released varieties were tested for protein content and their malting quality performance. The genotypes BK 1127, BCU 2237 and BCU 2241 had crude protein content of 13.0 % (dwb) or more and satisfactorily malt quality. Malt amylase activity was also estimated in one replication and experiment will be repeated next year. However, based upon the one year result, numerically BK 1127 had highest beta amylase activity, while alpha amylase activity was highest in NP 113. Though the results are very preliminary, BK 1127 seems promising by having good alpha amylase activity. The detailed result are given in following table 6.9 & fig. 6.10:

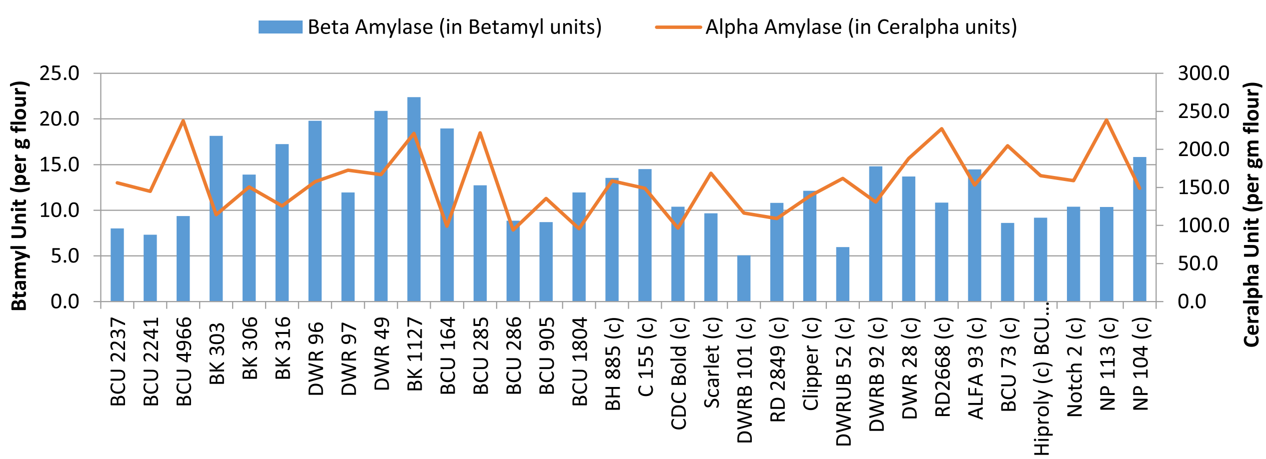

Fig. 6.10 : Amylase activity in barley malt

Table 6.19 : Grain quality parameters of moderately higher protein content genotypes

Genotype	Protein (% dwt)	Test wt (kg/hl)	Bold grain (%)	Thin grain (%)	TCW (g)	Husk (%)	Friab * (%)	FR * (ml/hr)	HWE * (% dwb)	DP* (oL)
BCU 2237	13.5	67.9	96.2	0.6	50.8	9.2	64.1	233.3	81.8	110.0
BCU 2241	13.1	68.1	95.8	0.5	50.5	8.2	63.4	286.7	80.4	95.3
BCU 4966	11.8	70.7	98.0	0.3	60.9	7.3	66.1	257.7	81.1	103.7
BK 303	11.9	67.1	99.4	0.1	66.5	8.2	66.2	193.3	80.4	116.9
BK 306	10.9	68.0	96.9	0.4	48.5	10.1	71.0	173.3	80.2	115.7
BK 316	10.2	67.3	97.2	0.3	48.1	8.1	79.4	203.3	80.6	110.8
DWR 96	10.8	66.9	98.0	0.2	58.1	9.1	77.8	266.7	82.3	118.1
DWR 97	11.2	67.0	97.9	0.2	65.3	8.6	68.8	176.7	82.2	98.9
DWR 49	11.9	68.5	95.0	0.7	57.7	7.7	63.1	190.0	80.8	106.7
BK 1127	13.3	66.2	99.1	0.2	76.7	8.7	65.6	166.7	83.3	102.1
BCU 164	9.0	62.6	88.5	1.8	50.4	9.6	62.3	213.3	81.1	108.1
BCU 285	9.5	64.8	64.3	5.6	43.5	10.0	59.5	216.7	80.6	111.1
BCU 286	9.2	54.7	15.6	13.6	41.3	13.8	71.4	241.7	81.2	100.0
BCU 905	9.4	58.8	41.8	11.9	42.4	11.9	64.1	203.3	81.1	107.1
BCU 1804	8.6	58.7	52.2	8.2	40.4	12.8	68.7	228.3	77.4	106.3
BH 885 (c)	10.4	69.1	96.5	0.2	55.0	9.0	61.0	216.7	81.6	101.1
C 155 (c)	9.2	63.6	83.6	2.7	48.5	12.2	54.5	263.3	80.0	118.1
CDC Bold (c)	8.5	67.1	61.9	9.4	44.8	9.7	94.1	320.0	83.0	113.5
Scarlet (c)	8.8	66.1	87.9	1.3	44.0	10.4	79.8	263.3	83.1	99.2
DWRB 101 (c)	9.4	69.8	93.5	0.5	52.8	10.4	64.2	235.0	81.4	102.1
RD 2849 (c)	8.1	60.5	97.3	0.6	55.0	12.9	56.2	198.3	80.9	107.5
Clipper (c)	10.0	62.1	86.0	2.6	45.0	11.4	66.3	248.3	81.8	114.5
DWRUB 52 (c)	9.5	69.7	94.4	0.4	52.8	9.2	51.5	111.7	81.6	110.0
DWRB 92 (c)	10.3	65.3	99.5	0.2	59.2	10.8	61.2	220.0	79.8	118.1
DWR 28 (c)	9.3	65.3	97.1	0.4	60.7	11.1	54.3	193.3	80.0	113.5
RD2668 (c)	9.2	66.8	90.3	0.6	52.3	10.4	65.6	276.7	81.4	102.4
ALFA 93 (c)	8.6	64.9	90.4	1.2	45.8	11.9	71.3	221.7	81.6	106.4
BCU 73 (c)	8.6	66.9	94.9	0.7	62.3	10.7	74.0	250.0	83.2	102.1
Hiproly (c)	9.1	68.8	91.9	0.8	49.9	8.7	85.5	271.7	84.7	115.4
Notch 2 (c)	7.7	61.4	95.5	0.5	54.4	12.7	82.1	273.3	84.3	108.3
NP 113 (c)	9.0	60.3	91.0	0.9	45.1	11.5	65.3	221.7	82.3	119.1
NP 104 (c)	9.3	64.4	74.2	3.3	42.8	12.2	62.1	255.0	83.4	114.6
LSD (5 %)	0.9	2.2	3.8	1.7	3.7	2.0	14.7	87.5	NS	NS

Phytic acid content in some of Indian Barley Varieties: Phytic acid (myo-inositol 1,2,3,4,5,6-hexakisphosphate or IP6) is an abundant storage form of phosphorus (P) in seeds and said to affect the bioavailability of micronutrients. It has been reported that barley seeds store around 60-75 % of the total seed P as phytic acid. Lower levels of phytic acid or higher phytase activity could be desirable trait for increasing the bioavailability of micronutrients. In this preliminary attempt single replication of different Indian barley genotypes were screened for seed phytic acid content. A total of 71 varieties were screened for phytic acid content and 11 varieties had value of < 0.8%; 39 varieties were having value of > 0.8 to 1.0 %; 18 were having values of > 1.0 % to 1.5 % and 3 were having > 1.5%. The experiment will be repeated to confirm the results.

Grain and malt quality evaluation of exotic genotypes: Thirty one exotic lines from ICARDA were evaluated for grain and malt quality traits and ICARDA 5 and ICARDA 12 (2 rowed) and ICARDA 29 (6 rowed) were found promising and will be tested further. Four lines of IBYT-HI and thirty four lines of IBYON-HI (year 2014-15) were evaluated for grain and malt quality and based upon bold grain percentage and hot water extract IBYON-HI-149; IBYON-HI-127 (both 2-rowed) and IBYON-HI-144; IBYON-HI-30 (both 6-rowed) were found promising, these will be tested alongwith checks for confirmation next year also.

Malting quality evaluation of Indian malt barley genotypes/varieties: A total of nineteen Indian malt barley varieties grown in timely sown condition to see their comparative performance for grain and malt quality traits (Fig 6.11). Test weight (> 68 kg/hl) was obtained in DWRB 101, DWRUB 52 and DWRB 91, thousand grain weight (40-45 g) was obtained in NDB 1173, Clipper, RS 6, Alpha 93 while bold grain percentage (> 98%) was recorded in DWRB 92, DWRB 73 and DWRUB 64. The 100 g sample of bold grains (> 2.5 mm) from each replication was malted in the standard cycle for analysis of malting quality. Friability of ≥70% was obtained in DL 88, Alpha 93, RD 2849, DWRUB 52, BH 902, DWRUB 64 and DWRB 101; while hot water

Table 6.20 : Phytic acid (%) in grains of some of the genotypes (varieties released by CVRC/SVRC)

S.No.	Genotype	Phytic acid (%)	S.No.	Genotype	Phytic acid (%)
1	Amber	0.897	37	PL 419	0.828
2	Clipper	1.075	38	PL 426	0.831
3	Jyoti	0.855	39	K 508	0.839
4	Kailash	0.891	40	Manjula	1.057
5	Ratna	0.923	41	BCU 73	0.698
6	RS 6	0.875	42	DL 88	1.301
7	LSB 2	1.127	43	K 409	0.824
8	Vijaya	1.329	44	K 551	0.897
9	Himani	0.746	45	K 560	0.921
10	Dolma	1.997	46	RD 2503	0.770
11	Ranjit	0.929	47	RD 2508	0.871
12	Azad	0.869	48	HBL 276	1.997
13	BG 105	0.814	49	NB 1	0.843
14	BG 25	0.839	50	NB 2	0.939
15	PL 56	0.905	51	RD 2552	0.704
16	RD 103	0.845	52	K 603	0.899

17	RD 31	1.009	53	BH 393	0.686
18	RD 57	0.949	54	NB 3	0.917
19	Bilara 2	0.925	55	DWR 28	0.873
20	Raj Kiran	0.820	56	BHS 352	1.031
21	Sonu	0.776	57	RD 2592	1.077
22	K 141	0.875	58	JB 58	0.772
23	BH 75	0.720	59	NDB 1173	0.676
24	BHS 46	0.997	60	RD 2624	0.812
25	Jagriti	0.887	61	VLB 56	1.011
26	Lakhan	1.087	62	RD 2660	1.155
27	PL 172	0.867	63	DWRUB 52	1.203
28	VLB 1	0.881	64	PL 751	0.843
29	BHS 169	0.855	65	RD 2668	0.859
30	Karan 16	1.079	66	RD 2715	1.251
31	Gitanjli	1.331	67	BH 902	0.824
32	RD 2052	0.814	68	BHS 380	0.909
33	RD 2035	0.748	69	DWRB 73	1.071
34	Alfa 93	0.784	70	UPB 1008	0.937
35	HBL 113	1.737	71	DWRUB 64	1.249
36	HBL 316	1.165			

extract (≥ 82%) was obtained in RD 2849, RD 2668, RS 6, RD 2552, NDB 1173, BCU 73 and Alpha 93; however differences in values of hot water extract were statistically non-significant showing replication variations

Malting quality evaluation of AICW&BIP material: The Barley Network took up the evaluation of grain samples of Advanced Varietal Trial (AVT) and Initial Varietal Trial (IVT) on malt barley received from various test sites at its central facility for malting quality evaluation. The malt barley varietal trials were

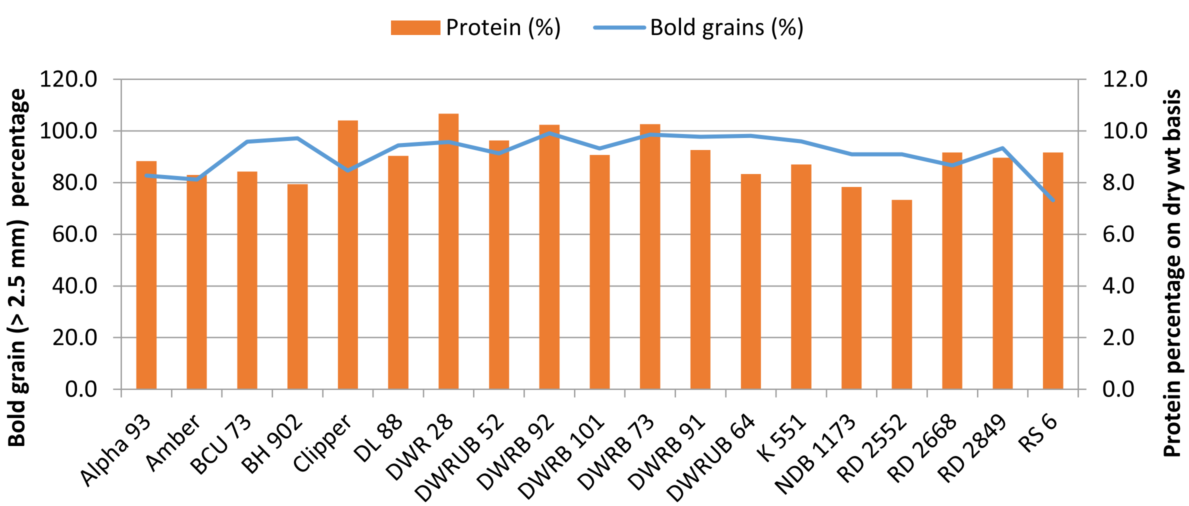

Fig. 6.11 :Protein and bold grain percentage of barley grains in some of the malt barley genotypes

conducted in NWPZ, in two sowing dates as separate sets. The grain samples were received from seven locations (Hisar, Karnal, Bawal, Ludhiana, Bathinda, Durgapura and Pantnagar) in timely sown and from six locations (Hisar, Karnal, Bathinda, Ludhiana, Pantnagar and Durgapura,) in late sown conditions. This year a total of 262 samples were received. There were 16 test entries in IVT (TS) which were analyzed with five checks, while 8 test entries in IVT (LS) were evaluated with three checks. In case of AVT (TS), two entries (DWRB 150 and RD 2917) with five checks were analyzed. There were several entries observed promising for individual traits, after the detailed analysis across locations in the NWP Zone. This was done by the system of scoring giving due weightage to important traits. Thus based on the ten important traits (a maximum possible score of 30), entries PL 895 and DWRB 162 were having better overall malting quality score under timely sown conditions.

Barley Quality Screening Nursery: A total of 19 genotypes alongwith five checks of INBON (2014-15) and six genotypes alongwith checks of INBYT-HI (2014-15) tested last year were again grown for verification of traits at Karnal, Ludhiana, Durgapura and Pantnagar, with respect to some of the grain quality traits. The traits analysed were hectoloitre weight (kg/hl), grain plumpness, thousand grain weight (g) and protein content (% dry weight). In case of INBON the genotype 68, 71 and 43 were found promising taking thousand grain weight and bold grain percentage in consideration (Fig. 6.12). In case of INBYT-HI, two genotypes E 18 and E 8 were found promising taking into consideration the bold grain percentage.

Quality evaluation of feed barley: The feed grain samples from various trials and grown at different locations were analysed for few physical parameters and protein content. A total of 816 samples were received encompassing ten trials and grown in their respective zones. The entries with highest value for each of the parameter analyzed are listed below:

Table 6.21: Promising entries for individual malting quality trait

Traits	Promising entries	
	Timely sown	Late sown
Test Weight	-	DWRB 163
Bold Grains (%)	DWRB 162, DWRB 160, RD 2963, RD 2964, PL 896, DWRB 161, RD 2962, RD 2965	-
Thousand grain weight	DWRB 150, RD 2917, DWRB 160, RD 2964, RD 2965, BH 1017, RD 2963, DWRB 162, DWRB 136, RD 2962	DWRB 160
Husk Content	PL 895, BH 1017, PL 896, DWRB 136, KB 1523, DWRB 162, RD 2962, RD 2965, BH 1018, PL 899	DWRB 163
Beta glucan	UPB 1065, BH 1018, KB 1535	DWRB 161
Malt Friability	PL 895, PL 899, DWRB 161	-
Hot water extract	DWRB 150, DWRB 161, RD 2964	DWRB164, DWRB163, RD2966, DWRB161
Filtration Rate	UPB 1065, KB 1523, RD 2963, BH 1017, PL 899	DWRB 161, RD 2966, DWRB 163, DWRB 170, DWRB 164, RD 2968
Diastatic Power	DWRB 162	-
Kolbach Index	RD 2917, KB 1523, DWRB 161, UPB 1065, DWRB 162, KB 1535	-
Over all MQ	PL 895, DWRB 162	-

**Superior than the best check*

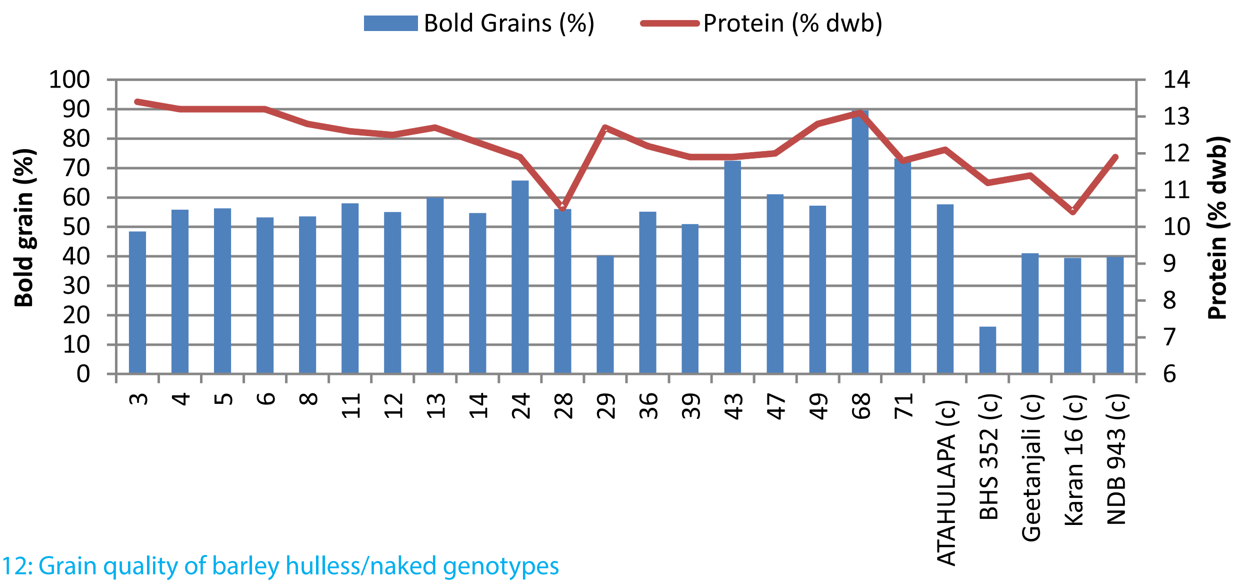

Fig. 6.12: Grain quality of barley hulless/naked genotypes

Resource Management

Higher production, productivity and varietal evaluation under different agro climatic conditions with resource efficient production technologies is of continuous nature under resource management programme. Input management *ie* water, fertilizer and herbicide management under resource scarce conditions, spacing and nutrient requirements of different varieties, role of plant growth regulators, crop management under poor fertility/marginal lands, limited water resource, saline-alkali soils, are the priority researchable areas in barley agronomy. The long term objective is to improve the productivity and quality of barley on sustainable basis.

- New genotypes under different agronomic were evaluated and the results shows that the genotype RD 2917(malt purpose), was at par in grain yield with best check DWRB 101 in NWPZ. In AVT feed barley trial, the test entry DWRB 137 of feed barley recorded significantly higher grain yield (4031 kg ha^{-1}) as compared to all the checks in NEPZ. In Central zone, the test entries DWRB 137 and RD

Table 6.22 : Entries with highest value in each trial

Trial	Test weight (Kg/hl)	Thousand grain weight, (g)	Bold grain (%)	Thin grain (%)
AVT (RF)-NHZ	BHS 352 © (73.0)	UPB1063 (50.2)	UPB1063 (87.0)	UPB1063 (1.3)
AVT (IR)-NEPZ	RD 2921 (56.6)	Jyoti © (40.6)	HUB 113 © (73.1)	RD 2921 (7.5)
AVT (IR)-CZ	DWRB 137 (66.0)	DWRB 137 (45.2)	DWRB 137 (85.7)	DWRB 137 (3.2)
AVT (RF)-NEPZ	K 560 © (56.7)	JB 328 (41.0)	K 603 (c) (60.8)	Lakhan © (12.0)
IVT (IR-FB)-NWPZ/NEPZ/CZ	KARAN 16 (c) (66.2)	BH 902 (c) (44.9)	RD 2948 (82.2)	RD 2948 (5.7)
IVT (RF)-NEPZ	DWRB 166 (58.0)	RD 2961 (45.8)	RD 2961 (87.7)	RD 2961 (2.8)
AVT (SAL/ALK)-NWPZ/NEPZ	DWRB165 (59.6)	BH 1017 (46.7)	RD 2957 (88.0)	RD 2957 (2.2)
IVT (DPB)-NWPZ/NEPZ/CZ	KB 1530 (59.0)	RD 2952 (43.6)	RD 2954 (75.7)	RD 2952 (6.5)
AVT (DPB)-NHZ	HBL 276 (c) (72.1)	BHS 447 (44.5)	BHS 454 (89.2)	BHS 454 (2.0)

2899 were at par with the best check RD 2786. In salinity AVT trial, the new testing genotype RD 2907 was at par with RD 2552. The test entry also responded up to 90 kg N/ ha under salinity.

- In tillage experiment conducted in NWPZ, the yield gain was not noticed but there is saving in the cost of cultivation, time and energy and so increase in net profit. In the same trial conducted in NHZ, the yield was significantly more under conventional tillage.
- The trial on seed rate and varieties conducted in NHZ revealed that variety BHS 400 and VLB 118 recorded significantly higher yield under 100 kg seed ha^{-1}, whereas, HBL 113 and BHS 352 recorded significantly higher yield by using 75 kg seed ha^{-1}.
- The trial conducted on integrated use of nutrients in NWPZ, reported that FYM and mulching has an additive effect on yield and soil fertility. In NEPZ, application of fertilizers coupled with FYM application @ 5 tonne ha^{-1}, mulching @ 6 ton ha^{-1} and foliar spray of ZnSo4@ 0.5% or two foliar sprays of KCl @ 0.5 % resulted in significantly higher grain yield as compared to other treatments. Use of biofertilisers *Azotobacter* + *Phosphosolublizing* bacteria along with recommended dose of fertiliser also increased the productivity in NEPZ, NHZ and NWPZ. In CZ, Biomix application was found superior to biofertiliser application.
- Significantly higher grain yield was recorded when potash was applied through murate of potash as compared to sulphate of potash but there is no definite trend for quality characteristics.
- Plant growth regulators, chlormequat-chlorid (CCC) @1.25 L ha^{-1} at GS_{30-31} followed by ethephon(Cerone) @1.0 L ha^{-1} at GS_{39-40} recorded significantly higher grain yield in NWPZ and NEPZ
- The maximum grain yield (4965 kg ha^{-1}) was obtained when barley crop was sown at a spacing of 22.5 cm in NWPZ, NEPZ and CZ. Row spacing had non- significant effect on grain yield, ear head m^{-2} and grains per ear head.

BARLEY CROP PROTECTION

Barley Crop Health Status

During the crop season 2016-17 surveys were conducted by the scientists from different cooperating centres for recording the presence of barley diseases and insects. There is no report of any rust in farmer's fields during this season. However, foliar blight, loose smut, covered smut and bacterial streak diseases of barley were noticed in traces to 5 per cent at villages of Jaipur district of Rajasthan. Whereas, in Eastern Uttar Pradesh leaf blight was common and in some fields it is upto 67 (on 0-9 scale, double digit system). In few fields, covered and loose smut were also observed but incidence was very low less than 1%. In the hilly areas of Himachal Pradesh very few fields with very low incidence of powdery mildew was observed.

Status of resistance in breeding lines and advanced entries

Adult plant resistance (APR)

A total number of 598 entries were screened during the year 2016-17 under various nurseries (IBDSN, NBDSN and EBDSN) for resistance against various diseases, aphid and CCN at different cooperating centers. There were 400 entries under IBDSN, 149 were for NBDSN and 49 for EBDSN. Out of 400 IBDSN entries tested, 42 entries were found free from yellow rust (ACI = 0) and 183 entries showed resistant reaction having ACI less than 10. In case of leaf blight screening, 32 entries were found resistant (Avg. disease score 13-35 with HS < 57) against leaf blight. A total 149 entries from AVT and IVT yield trials including checks were screened against stripe rust and leaf blight. Among that 19 found free and 66 showed resistance (below 10 ACI) to yellow rust, and 10 were resistant to foliar blight (Avg. disease score 13-35 with HS < 57). Out of 49 entries screened in EBDSN, 7 entries are found free from yellow rust, whereas 33 shown resistant reaction. Twelve entries also showed resistance against leaf blight.

Table 6.23 : Rust resistance in NBDSN lines

Resistant to	Number of lines	Detail of lines
Brown and yellow	11	JB328, PL891, RD2955, RD2956, RD2957, RD2958, RD2959
Black and brown	01	VLB147

Evaluation for seedling rust resistance

Rust resistance in NBDSN lines

None of the NBDSN entry was found to have resistance to all the tested pathotypes of black, brown or yellow rust. Resistance to all the pathotypes of black and brown rust was observed only in VLB147. Eleven entries were resistant to all the pathotypes of brown and yellow rusts.

Rust resistance in EBDSN lines

One EBDSN entry (BCU7746) was resistant to all the tested pathotypes of black, brown and yellow rusts. There were ten entries showing resistance to all the pathotypes of yellow and brown rust. Except these there was no EBDSN entry showing resistance to all the pathotypes of black and brown rust or black and yellow rust.

Screening of barley entries against foliar aphid

A total of 176 NBDSN barley entries were screened against foliar aphid at five locations (Ludhiana, Kanpur, Pantnagar, Karnal and Durgapura). None of the entry was found to be resistant and a majority of the entries were either found moderately resistant (grade 3) or susceptible (grade 4) or highly susceptible (grade 5) to foliar aphid. At location Karnal, six entries *viz.*, BH1019, BHS457, DWRB164, JB328, JB346 and JB347 were found to be moderately resistant (grade 3).

Table 6.24 : Rust resistance in EBDSN lines

Resistant to	Number of lines	Detail of lines
All	01	BCU7746
Brown and yellow	10	DWRB127, HBL113, HBL757, RD2909, RD2913, RD2914, VLB130, RD2917, PL891, RD 2941

Management of foliar aphid

Amongst seven insecticides tested for their efficacy against foliar aphid at four locations; (Ludhiana, Vijapur , Kanpur, and Karnal) three insecticides *viz.*, Clothianidin 50WDS @30 g/ha, Imidacloprid 200Sl @ 100 ml/ha and Acetamiprid 20 SP @ 100 g/ha were found to be equally good.

Varietal resistance of barley to stored grain insect-pest infestation

Thirteen barley genotypes were evaluated for resistance against infestation by three major storage insect-pests; rice weevil, lesser grain borer and red-rust flour beetle. It was recorded that maximum damage by these three insects was caused to varieties DWRB 92 and DWRB 101 and minimum damage was caused to DWRB 73. Also the highest orientation/attraction of insect-pests was recorded towards varieties DWRB 91 and DWRB 92 while minimum attraction was recorded towards to DWRB 73. The longest duration of 47 days to complete life cycle was taken by red rust flour beetle on genotype, Gitanjali and shortest (32 days) by lesser grain borer on variety BH 946.

Effect of tillage on insect-pest infestation in rice-barley cropping systems

Relative abundance of insect-pests in barley-rice cropping system has been recorded and it was observed that the incidence of foliar aphid was highest in reduced till direct seeded rice - zero till barley – green gram (T2) while pink stem borer infestation was more in zero till direct seeded rice - zero till barley – zero till green gram (T3). Termite infestation was highest in puddled transplanted rice - reduced till barley (T9) rotation. In rice crop, it was observed that the incidence of lepidopterous pests; leaf folder and rice stem borer and leaf hoppers was comparatively higher in puddled transplanted rice treatment (T9) as compared to other treatments

Application of molecular approaches in barley improvement

Screening of barley genotypes for corn leaf aphid

A set of 93 genotypes including 15 exotic accessions and 78 fixed & stable (F_8) recombinant inbred lines selected from crosses developed at ICAR-IIWBR were screened against corn leaf aphid (CLA) under epiphytotic conditions during *rabi* season in 2016-17. These 93 genotypes were selected from a set of approximately 550 genotypes screened during two consecutive *rabi* seasons 2014-16 for corn leaf aphid resistance at two locations; under epiphytotic conditions at IIWBR, Karnal and under natural conditions at IIWBR Farm, Hisar. These 93 entries were sown in nethouse in one metre row length replicated twice with one row of Alfa93 (infector & susceptible check) after every 20 rows as a check and screened under heavy artificial infestation of corn leaf aphid. Total 19 entries were found resistant (damage score 01-02) and 37 were found moderately resistant (damage score 03) as compared to resistant check EB921 (damage score 02) and susceptible check Alfa93 (damage score 05) as given in Table 6.25. Among exotic accessions, BCU7624, BCU7628, BCU7635, BCU7652, BCU7653, BCU7659, BCU7721 & BCU7746 were observed resistant with damage score 02 and found equivalently resistant with resistant check lines BCU390 and EB921. Among the fixed & stable (F_8) recombinant inbred lines, 11 were found resistant (C1-42, C1-66, C1-67, C1-69, C1-72 & C1-213 of cross Alfa93/EB921 and C2-40, C2-85, C2-142 & C2-163 of cross Alfa93/BCU390) with damage score 01 and found superior in resistant level against resistant check lines BCU390 and EB92126.

Table 6.25 : Corn leaf aphid resistance scores of barley lines identified resistant under epiphytotic conditions

S.No.	Entry Number	Cross / Pedigree	Damage score (0-5 scale)	Reaction
1.	BCU7624	CLE 233	2	R
2.	BCU7628	MN 610	2	R
3.	BCU7635	MN 599	2	R
4.	BCU7652	ND 14016	2	R
5.	BCU7653	ND 14600	2	R
6.	BCU7659	C9528	2	R
7.	BCU7721	C97006	2	R
8.	BCU7746	ARAMIR/COSSACK	2	R
9.	C1-42	EB921/Alfa93	1	R
10.	C1-66	EB921/Alfa93	1	R
11.	C1-67	EB921/Alfa93	1	R
12.	C1-69	EB921/Alfa93	1	R
13.	C1-72	EB921/Alfa93	1	R
14.	C1-164	EB921/Alfa93	1	R
15.	C1-213	EB921/Alfa93	1	R
16.	C2-40	BCU390/Alfa93	1	R
17.	C2-85	BCU390/Alfa93	1	R
18.	C2-142	BCU390/Alfa93	1	R
19.	C2-163	BCU390/Alfa93	1	R
20.	Alfa93	AURORA/QUEEN//BEKA	5	S
21.	EB921		2	R
22.	BCU390		2	R

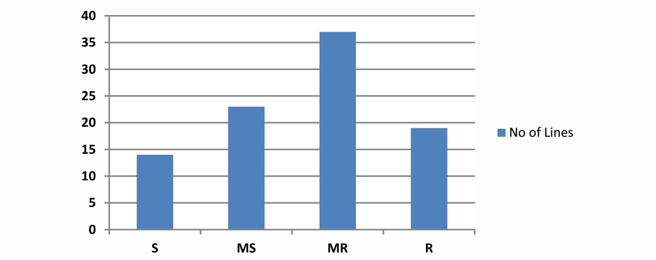

Fig.6.13: Corn leaf aphid resistance screening under epiphytotic conditions

Marker assisted backcross breeding for quality and corn leaf aphid resistance in barley

Remaining 74 entries were showed damage score ranging between 03 to 05 moderately resistant to susceptible infestation of insect pest shown in fig. 6.13. The present studies revealed the availability of resistance sources against corn leaf aphids in barley. These genotypes were also scored for phenotypic descriptors/traits like growth habit, anthocynin pigmentation, foliage colour, average days to heading & maturity, average height and waxiness. 19 lines identified resistant during this study may be used to incorporate CLA resistance in Indian barley.

New crosses attempted in barley

New Crosses were attempted, backcrosses were made and generations advanced in crop season 2016-17 for molecular markers assisted backcross program for quality traits (protein content and beta-glucan) and biotic stress (corn leaf aphid resistance).

Table 6.25 : F_1s developed for different traits

Trait.	Name of the cross
Beta-Glucan	DWRB101/SLOOP VIC 9953
	RD 2849/SLOOP VIC 9953
Protein Content	RD 2849/BK306
	DWRB 101/BCU 7635
Corn leaf aphid resistance	DWRUB 52/EB921
	DWRUB 52/BCU7635
	DWRUB 52/BCU 390

Five parental lines (SLOOP-VIC-9953, SLOOP-SAWL-3167, DWRB101, RD2849 and DWRUB52) used in MABB program were characterized with gene based & closely linked markers reported for various QTLs controlling beta-glucan content in malt barley lines. QTL- HvCSFl6 located on 7H is found as prominent QTL controlling beta glucan content in contrasting parental lines used in this study and gene based marker HvCSFl6-1013F is selected for foreground selection in further study. Another STS marker, Brz, also located on 7H chromosome is selected and found discriminating for this trait. Five parental lines (SLOOP VIC 9953, SLOOP SAWL 3167, DWRB101, RD2849 and DWRUB52) were screened with total 156 SSR/STS markers covering entire genome and markers differentiating recurrent and donor parents were selected for background selection of segregating backcrossed lines for further study.

07 REGIONAL STATION, FLOWERDALE,SHIMLA

Pathotype distribution of wheat and barley rusts

It was practically a rust free year. With the help of cooperators, different wheat growing areas were monitored extensively to keep an eye on the occurrence of wheat rusts in India and neighboring countries. About 1302 wheat and barley rust samples received during the year from 12 states of India and two adjoining countries, 910 were pathotyped. The pathotype situation is presented below:

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

During 2016-17, 401 samples of yellow rust of wheat and barley were analyzed from seven northern states of India. Total 11 pathotypes were identified based on Indian wheat stripe rust differentials. The maximum number of samples was analyzed from Punjab followed by Himachal Pradesh. The frequency of pathotype 46S119 (virulent to *Yr2, Yr3, Yr4, Yr6, Yr7, Yr8, Yr9, Yr17, Yr18, Yr19, Yr21, Yr22, Yr23, Yr25* and *YrA*) was maximum (54.5%) followed by pathotype 110S119 (33.0%). Barring 238S119, which was identified in 6% of the samples, remaining 6 pathotypes were observed in few samples only. It was also true for pt. 78S84 which was predominant up to 2010-11, occurred in one yellow rust sample only. *Puccinia striiformis* f. sp. *tritici*(*Pst*) population was found avirulent on *Yr*5, *Yr*10, *Yr*15, *Yr*Sp and*Yr*Sk. In barley, frequency of pathotype 57 and M was nearly same as was evident from the 13 samples of barley yellow rust analyzed during the year.

Table 7.1 Predominant pathotypes of Puccinia on wheat in India

Wheat Rusts	Predominant pathotypes
Black	62G29(40A), 79G31(11)
Brown	121R60-1 (77-9) followed by 121R63-1(77-5) and 21R55 (104-2)
Yellow	46S119 followed by 110S119

ii. Black rust of wheat (*Puccinia graminis tritici*)

Five pathotypes of black rust of wheat were observed in 73 samples received/collected from five Indian states. Population analyzed during the year had a virulence to *Sr26, 27, 31, 32,35, 39, 40, 43, Tt3* and *Tmp*. Most of the samples were received from Tamil Nadu followed by Gujarat and Maharashtra. Pathotype 40A (62G29) was recorded in more than 50% of the samples. 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, Sr36e, Sr38, SrMcN* was the second most frequent pathotype and was observed in 31 samples received from Gujarat, Maharashtra and Tamil Nadu. Other pathotypes such as 21-1 (24G5), 40-3 (127G29) and 122 (7G11) were observed in few samples only. Diversity in black rust pathotypes was maximum in Tamil Nadu.

iii. Brown rust of wheat (*Pucciniatriticina*)

Analyses of 436 samples of wheat brown rust was accomplished during 2016-17 from 12 states of India and neighboring countries Nepal and Bhutan. Twenty four pathotypes belonging to 4 major groups of pathotypes 12, 77, 104 & 162 were identified. There was shift in virulence pattern in favour of pathotype 77-9 which was identified in about 45.8 % of the samples analyzed. Contrarily pathotype 77-5, predominant in yester years was identified in 24.8 % of the samples. However, pathotype 77-5 was more widely distributed than any other pathotype. Likewise there was reduction in the frequency of pathotype 104-2, 104-3. In addition a new pathotype designated as 162-4 was also observed in 3.9% of the samples. Remaining pathotypes were observed in few samples only. Indian population of wheat brown rust was avirulent to Lr9, Lr19, Lr24, Lr25, Lr29, Lr32, Lr39, Lr45 and Lr47.

Rust resistance in wheat material

To identify rust resistant lines of wheat and characterize resistance genes, 151 lines of AVT I and II were evaluated at seedling stage using an array of pathotypes of black (*Puccinia graminis tritici*), brown (*P. triticina*) and yellow rust (*P. striiformis*) having varying avirulence/virulence structures. These studies were conducted under controlled conditions of temperature and light. None of the lines was resistant to all the rusts. In addition all the lines having *Sr31* were resistant to black rust of wheat, whereas lines possessing *Lr24*, some with *Lr26* were resistant to brown rust and few lines with *Yr9* showed resistance to yellow rust of wheat. Details of the wheat rust resistant lines are given below:

i. Rust resistance in AVT lines

Rust resistance to all the pathotypes of black, brown and yellow rust was not observed in any line of AVT II. There was no line in AVT II which showed resistance to all the pathotypes of yellow rust. Seven entries *viz.*Cow (W)(C), HW2044(C), HW5216(C), MACS6222(C), MP3288(C), NIAW1415(C) and UAS446 conferred resistance to all the pathotypes of brown rust, whereas five lines (VL892(C), HD3043(C), TL2942(C) and TL 2969(C) were resistant to all the pathotypes of black rust.

All the lines carrying *Sr31* were resistant to black rust. Like AVT II entries, rust resistance to all the pathotypes of black, brown and yellow rusts was not observed in any line of AVT I. Entries HS630 and VL3013 were found to be resistant to all the pathotypes of black and brown rusts; whereas resistance to black and yellow rusts was observed on VL1012. Six entries *viz*. DBW246, PBW757, PBW752, PBW777, UP2993 and WH1233 conferred resistance to all the pathotypes of yellow rust, whereas nine entries (HS643, VL4002, HD3226, HD3237, MP1318, HD3219, KRL377, TL3012 and TL3015) were resistant to black rust.

ii. Rust resistance genes in AVT lines

Based on gene matching technique, rust resistance genes were characterized in wheat lines of AVTI and II. These studies were conducted under controlled conditions of temperature and light. Where ever required confirmatory and repeated testing was also undertaken to find out the consistency of the observations. Proper reference checks were maintained to ascertain the purity of pathotypes and behavior of rust resistance genes. Based on the gene matching technique, rust resistance genes in AVT material was generated as given below.

Yr genes

AVT II

Five *Yr* genes/patterns (*Yr2, 9, 18, 27* and *A*) were characterized in 52 lines of AVT II entries either alone or in combinations. *Yr2* was found to confer resistance in maximum number of lines (29). However, this gene is susceptible to many of the virulent pathotypes. *Yr9* which is linked to *Lr26* and *Sr31* was characterized in 10 lines. Other resistance genes like *Yr*A, *Yr18*, *Yr27* were postulated in few lines only.

AVT I

Three patterns of *Yr* genes alone or in different combinations were inferred in 73 lines of AVT I. Among these, *Yr2* was characterized in 42 lines. *Yr9/Lr26/Sr31* was identified in 7 lines. *Yr*Awas characterized in 18 lines and *Yr9+A+* in 6 lines

Table 7.2 : Diversity for rust resistance

Rust	No. of lines	Number of genes inferred: Details of resistance genes
Yellow	125	5: Yr2, Yr9, YrA, Yr18, Yr27
Brown	134	10: Lr1, Lr2a, Lr3, Lr10, Lr13, Lr19, Lr23, Lr24, Lr26, Lr 34
Black	131	14: Sr2, Sr5, Sr7b, Sr8a,Sr8b, Sr9b, Sr9e, Sr11, Sr13, Sr 25, Sr25, Sr28, Sr30, Sr31

Lr genes

AVT II

Lr genes were characterized in 83% of the AVT II lines. Eight *Lr* genes Lr1*, 3, 10,13,23,24, 26* and *34* were identified either alone or in different combinations in 50 lines. Among these,*Lr13* was postulated in 20 lines followed by *Lr26* in 16, *Lr13* and *Lr1* in 13 lines each. Except for *Lr10* which was observed in 11 lines, other *Lr* genes like *Lr34*, *Lr24* and *Lr3* were characterized in 3-5 lines.

AVT I

Eight *Lr* genes (*Lr1, 2a, 3, 10,13,19,23* and *26*) were postulated in 84 of the 91 AVT I lines. It is quite interesting that *Lr26* was postulated in 17.7 % of the AVT I lines, which is the lowest proportion ever. *Lr13* was characterized in maximum number of lines i.e. nearly half of the entries followed by *Lr23* in 33, *Lr10* in 30, *Lr1* in 28 lines. *Lr3* was inferred in 19 lines whereas *Lr2a* which is based on linkage to *Sr30* was postulated in 8 lines only.

Sr genes

AVT II

Twelve *Sr* genes (*Sr2, 5, 7b, 8a, 8b, 9b, 9e, 11, 13, 24, 28* and *31*) were characterized in 56 lines of AVTII. *Sr2*, a known APR gene whose postulation is based on characteristic micro-flecking, was postulated in 37 lines followed by *Sr31* in 17, *Sr11* in 15 and *Sr7b* in 11 lines. *Sr24* and *Sr9b* were identified in 3 lines each, whereas *Sr8b* and *Sr13* were inferred in one line each. *Sr5* and *Sr28* were postulated in five and four lines, respectively.

AVT I

Twelve *Sr* genes (*Sr2, 5, 7b, 8a, 9b, 9e, 11, 13, 25, 28, 30* and *31*) were characterized in 75 lines of AVTI. *Sr2* was most frequent in AVT I material and postulated in 31 lines followed by *Sr*5 and *Sr11*, which were postulated in 22 and 20 lines, respectively. Most of the durum wheat varieties had resistance based on *Sr7b* and *Sr11*. *Sr31*, which confers resistance to all the known pathotypes from India including SAARC countries, was inferred in 14 lines. *Sr25* and *Sr9e* were characterized in two lines each, whereas *Sr8a* and *Sr13* were postulated in three lines each. *Sr30*, *Sr28* and *Sr7b* were postulated in seven, eleven and fifteen lines, respectively.

Disease incidence in WDMN/SAARC wheat disease monitoring nursery

Wheat disease monitoring nursery was planted at more than 40 locations in different wheat growing areas in India both in regular and offseason crops. Disease observations were reported from 35 locations.Wheat blast was not reported from India. Likewise there was no occurrence of black rust on *Sr31* type of resistance (Ug99 type of pathotypes). Yellow rust was noticed at all the locations of NHZ and NWPZ but was absent in southern hills zone. It was also observed at Sabour in NEPZ. All the entries of WDMN in other locations were free from yellow rust. Yellow rust was very severe at many locations in NWPZ and NHZ. High severity of yellow rust was observed on Kharchia mutant at Bajaura. Eleven entries had more than 30S severity of yellow rust at Malan (Kangra). Brown rust was reported from few locations in NHZ and NWPZ *viz*. Shimla in HP, Kathua, Rajauri & Jammu in Jammu & Kashmir, Pantnagar in Uttarakhand, Langroya & Abohar in Punjab. It was reported from all the locations of NEPZ except Ranchi and Kalyani. In central zone brown rust appeared at Vijapur, Indore and Powerkheda only. There was no brown rust on WDMN entries in PZ. At Wellington (SHZ) brown rust appeared on 18 entries of WDMN. Of the 34 locations of WDMNs black rust was observed only at Wellington in SHZ, Vijapur, Indore & Powerkheda in CZ. NHZ, NWPZ, NEPZ and PZ were free from black rust. Leaf blight was reported from WDMNs planted at Almora, Kathua, Rajouri, Jammu (Udhaywalla), Sabour, Pusa, Ranchi, Faizabad, Kanpur, Kalyani, Mahabaleshwar, Pune, Niphad, Dharwad and Wellington. Almora, Kathua, Rajouri, Jammu and Wellington were the only locations of WDMNs where powdery mildew was observed.

Likewise SAARC wheat disease nursery was planted at 17 locations in India and 12 locations in other SAARC countries. Overall disease incidence was less than previous years.

Expression analyses of candidate SAR and sugar transporter genes during wheat-leaf rust interactions

A number of resistance pathways are induced during the plant defense against the attacking pathogens. SAR is important plant defense pathway. Components of SAR resistance could be conserved among plant species, however, their regulations in spatial and temporal manner may vary with pathosystems. Recently, sugars have been shown to play a key role in plant innate immunity due to their role as signal molecules as well as energy source. Defense role of sugars in plant immunity is termed as "Sweet priming". Understanding the molecular components of these defense pathways and their regulation in cereal crops including wheat and rice is limited. A study was carried out to mine the candidate key SAR regulators and sugar transporters in wheat and their transcriptional reprogramming during leaf rust infection was examined.

The key regulators of wheat SAR related genes: *TaNPR1* (gi|672798846), *TaSGT1* (gi|339765023), *TaHSP90* (gi|339765023), *TaRAR1* (gi|723219603), and sugar transporter genes: *TaHTP* (gi|942473027), and *Ta4DHTP* (gi|942473019), and ortholog sequences of Arabidopsis SAR related genes such as *AtNDR1 (AT3G20600)*, *AtEDS1 (AT3G48090)*, *AtPAD4 (AT3G52430)*, *AtPAL (AT2G37040)* and *AtEDS5 (AT4G39030)* were selected and primers suitable for qRT-PCR were designed. Wheat near isogenic lines (NILS) HS240 (susceptible) and HW2020 (resistant) carrying the *Lr24* and the virulent pathotype of brown rust 77–5 were used to study the compatible and incompatible interactions between wheat and leaf rust pathogen, respectively. For RNA isolation, the leaf samples were harvested at 0, 1, 3, 6, 12, 24 and 48 hours post inoculation (hpi) both from inoculated and mock plants. qRT-PCR reactions were performed in Applied Biosystem's 7500 HT Fast Real-time PCR System. Relative quantification of gene expressions was carried out using the comparative Ct (ΔΔCt) method. One-way analysis of variance (ANOVA) followed by Tukey's post hoc test at $p \leq 0.05$ were performed to determine the statistical significance of temporal expressions of selected candidate genes.

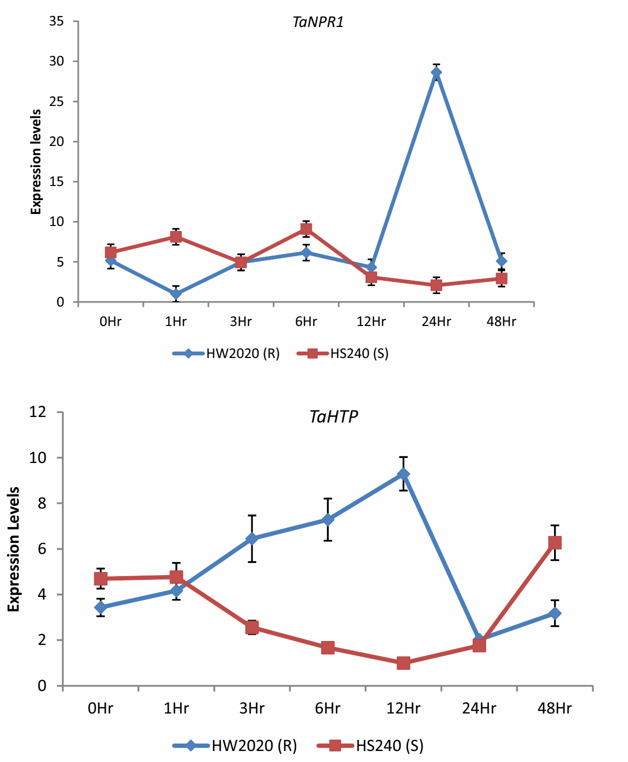

Fig.7.1 Differential expression patterns of TaNPR1 and TaHTP in wheat when inoculated with leaf rust at different time points after inoculation

The results of reference gene expression stability study showed *UBI* was the most stable reference gene in wheat at different time intervals during the early leaf rust infection. Hence, *UBI* was used to normalize the expressions of the candidate genes. The relative expression profiles of SAR related genes (*TaEDS1*, *TaNDR1*, *TaPAD4*, *TaSGT1*, *TaHSP90*, *TaRAR1*, *TaEDS5*, *TaNPR1* and *TaPAL*) and sugar transporter genes (*TaHTP/Lr67* and *TaSTP13A*) at 0, 1, 3, 6, 12, 24 and 48 hrs indicated a differential gene expression patterns during compatible and incompatible interactions at different time points after inoculation (Fig. 7.1)

Activation of SAR signaling pathway by the expression of R genes could form a part of the broad spectrum resistance and hence, manipulation of SA related genes could be a novel and effective means of conferring broad spectrum resistance against phytopathogens. Results of this study provide a Clue of key regulators of the two defense pathways anticipated to be involved in durable and broad spectrum resistance and thereby their potential application in wheat rust resistance breeding.

Table 7.3: Pedigree and other attributes of selected advanced lines

Entry name	Pedigree	Selection for traits
DBWS1	PFAU/MILAN/5/CHEN/AEGILOPS SQUAROSA (TAUS)	Yield, bold grains, Res to brown and black rust.
DBWS2	SHA7//PRL/VEE#6/3/FASAN4/HAAS8446/2*FASAN	Yield, plant type, Res to yellow, brown and black rust.
DBWS3	SHA7//PRL/VEE#6/3/FASAN4/HAAS8446/2*FASAN	Yield, earliness, res to brown and black rust.
DBWS4	MUTUS*2/HARIL#1	Yield, earliness, res to yellow and black rust.
DBWS5	CROC_1/AE. SQUAROSA (205)// BORL95/3/PRL/…	Yield, plant type, res to yellow and black rust.
DBWS6	SHA7//PRL/VEE#6/3/FASAN4/HAAS8446/2*FASAN/…	Yield, grain character, res to yellow and black rust.
DBWS7	C 81-13=TORK-15/VL 892	Yield, earliness, res to yellow, brown and black rust.
DBWS8	VL 912/CTK/VEE//KAUZ//VL 912	Yield, earliness, res to yellow, brown and black rust.
DBWS9	F81513/MILAN/VL 946	Yield, earliness, res to yellow, brown and black rust.
DBWS10	Yr24/KS/DPW621-50	Yield, grain character and res to yellow and black rust.
DBWS11	VL907/FLW21	Yield, grain character and res to yellow, brown and black rust.

Genetics and breeding for rust resistance in wheat

More than 1350 segregating wheat lines were screened using virulent pathotypes of the three rusts. More than 1500 selected progenies from seventy two populations were harvested. Fifteen populations were advanced for genetic analysis of rust resistance in wheat. In the off-season nursery, 740 lines of segregating material were planted for generation advancement at Dalang Maidan. Besides this, studies on resistance pattern were performed and gene postulations based on multipathotype data were done.

Based on the screening at seedling stage resistance and adult plant evaluation, forty five crosses were made during 2016-17 for genetic analysis of rust resistance and gene pyramiding for rust resistance in wheat. These crosses included single cross, back-cross, three-way and double crosses. Three crosses namely Local Red/DDK1009, LWH/HD2922 and LWH/UAS347 were analysed for genetics of brown rust resistance. Further data are being generated to decipher the resistant loci in the three populations.

I. Screening of wheat germplasm for identification of rust resistance

A set of 487 wheat lines including released varieties, elite lines, genetic stocks and exotic donor lines were tested at seedling stage against most virulent and prevalent pathotypes of three rusts under controlled environmental conditions. In addition 189 lines of wild relatives of wheat were analysed for brown and black rust resistance at seedling stage.

ii. Evaluation and selection of elite material from winter-spring hybridization

During crop season, 210 advanced lines from winter-spring segregating nurseries of 2012-13 and 2013-14 were utilized for identification of elite lines resistant to three rusts performing well in northern hill zone. Fifty one lines were selected for further breeding. CIMMYT's 9th SSRN nursery was used to select rust resistant wheat material for advancement and use in the crossing programme. Details of the eleven elite lines are given the below mentioned Table 7.3

iii. Development of rust resistant genetic stocks with diverse resistance genes.

During the year, 4 wheat rust resistant genetic stocks were registered with NBPGR, New Delhi. Characteristic features of these genetic stocks are given below:

Table 7.4: Rust resistant genetic stocks registered

S. no.	Genetic stock	Characteristic features
1.	FLW31 INGR17040	Resistant to black and brown rusts and Ug99 group of pathotypes.
2.	FLW32 INGR17041	Resistant to wheat black rust and Ug99 type of pathotypes.
3.	FLW33 INGR17042	Resistant to wheat black, brown rusts and Ug99 group of pathotypes.
4.	FLW18 INGR17070	Resistant to wheat brown rust.

In addition, 5 diverse wheat rust resistant genetic stocks (FLW34, FLW35, FLW36, FLW37 and FLW38) were screened during 2016-17 for seedling resistance to most prevalent and virulent pathotypes of three rusts.

FLW34: This genotype was developed by cross CMH79A 955//AGA/4*T171/ 3NAC-76/1*HI1077 by pedigree breeding. FLW34 possesses*Lr9*+ *Lr24* and provides complete resistance against all brown rust pathotypes in India. The plants of FLW34 showed moderate waxiness on leaf sheath, peduncle and glumes. Grains are amber colored with 1000 grain-weight of 40.3g.

FLW35: FLW35 is a pedigree selection material from cross between VL907 and FLW21. It carries rust resistance genes *Yr15*, *Lr24/Sr24*. FLW35 is resistant to three wheat rusts in India. The plants of FLW35 show waxy character on leaf-sheath, peduncle and glumes. It has average height of 95cm and matures in about 156 days under Shimla conditions. Grains are amber coloured with semi-hard texture having 1000-grain weight of 41.2g.

FLW36: This is an outcome of cross between HS507/FLW22 through pedigree selections. FLW36 is completely resistant to all the wheat rusts in India. It carries *YrChina-84Lr28* and *Sr31/Lr26/Yr9*. The plants of FLW36 mature in about 160 days and have average plant height of 102cm. It showed waxiness on leaf-sheath, flag-leaf and peduncle. The grains are amber coloured with 1000-grain weight of 40.8g.

FLW37: FLW37 was developed by cross between exotic line HSB-2398 and VL907 through pedigree selection. It is completely resistant to all the pathotypes of yellow rust in India. FLW37 carries *Yr15+24*. It matures in about 152 days and has average plant height of 95cm. It shows slight waxiness on leaf sheath and peduncle. The grains are amber coloured with soft texture and 1000-grain weight is about 39.8g.

FLW38: This genetic stock has been developed by pedigree selection from cross *Yr24*/Kalyansona/ DPW621-50. It carries unutilized *Yr24* gene and shows complete resistance against all the yellow rust pathotypes in India. It matures in about 155 days under Shimla conditions. The plants are medium statured with average height of 92cm and showed medium waxiness on leaf sheath, flag leaf and peduncle. Thegrains of this stock are amber coloured with semi-hard texture and have 1000-grain weight of 40.7g.

National repository of rust pathotypes

More than 144 pathotypes of three rust pathogens of wheat, barley, rusts of oat and linseed were maintained in pure form as live cultures and also cryo-preserved for long term storage. To enable wheat rust research elsewhere in India, nucleus and bulk inocula of urediospores were supplied to 57 Scientists in different parts of India.

08 REGIONAL STATION, DALANG MAIDAN

The offseason facilities play a crucial role in the varietal development of photo and thermo sensitive crop plants. This facility is very useful to shorten the required time for development of improved varieties in any crop plant. Dalang Maidan is one of the strategic sites that help in attaining this goal of many plant breeding programs. The natural environment of the valley provides excellent opportunity to the wheat scientists of the country to use the facility for generation advancement and screening against yellow rust and powdery mildew. The shuttle breeding approach helps in removing the photoperiodic alleles and providing better stability to the genotypes.

The ICAR - IIWBR Regional Station located at Dalang Maidan, Lahaul & Spiti, (HP) act as a national service centre for providing various kind of support to wheat and barley researchers of the country. The progress made under different mandates during the year 2017-18 is presented under following heads.

Generation Advancement of Wheat and Barley:

During the period of May-October, 2017, approximately 28,000 lines of wheat and barley from 22 co-operators of different institutes were advanced at IIWBR regional station Dalang Maidan, for efficient utilisation of the summer nursery facility. The materials from all the major wheat zones were advanced at the station. The maximum material was obtained from North Western Plains Zone followed by Northern Hills Zone, Central Zone and North Eastern Plains Zone. Apart from ICAR-IIWBR, IARI New Delhi, CCSHAU Hisar, NABI Mohali and BHU Varanasi were major co-operators for utilizing the off season facility. This year the material was also received from some of the centres of NEPZ like BHU Varanasi and Sabour. The sowing of all the material was carried out during 13-16 May, 2017. All the research material was harvested in the month of Sept-Oct, 2017 and handed over to the concerned scientists well in time. The disease pressure for both stripe rust and powdery mildew was adequate for screening of the lines and was properly utilized by wheat workers from across the country. Wheat Disease Monitoring Nursery was also planted by IIWBR RS Shimla to monitor the yellow rust.

Corrective hybridization: During this summer season of year 2017, more than 500 corrective crosses were attempted by the researchers across the institutes. Scientific and supporting staff from different institutes such as ICAR – IARI New Delhi, ICAR – VPKAS Almora, SKUAST-J Jammu, CSKHPKVV Palampur and NABI Mohali visited the nursery during months of July and August 2016 for attempting crosses.

Disease Screening: The season was very favourable for the screening of yellow rust and powdery mildew diseases of wheat and barley. Around 10,000 lines of these crops were screened by various centres. The yellow rust incidence was first observed during last week of July and the disease pressure was highest during August, 2017. Powdery mildew disease also appeared during the last week of August.

Fig. 8.1 : A view of summer nursery at Dalang Maidan

Fig. 8.2 : Interaction of farmers of lahaul valley with Director of IIWBR

Natural Repository for Wheat and Barley Germplasm: The Regional Station acts as natural repository for wheat and barley germplasm and at present 9000 wheat accessions and 2000 barley accessions are being conserved and maintained here under natural conditions.

Seed Multiplication of Important Cultures/ Varieties: The seed multiplication of the wheat variety DBW168 (IIWBR Karnal) was carried out and more than 7 q seed was supplied to the indenters.

Training Programme on Increasing Farm Income of the Lahaul Valley Farmers: Under the Tribal Sub Plan (TSP) two days (4-5 Dec, 2017) training programme was organised at the ICAR-IIWBR Karnal for the tribal farmers of Lahaul Valley. 42 farmers of the valley participated in the training programme that was focussed on increasing the farm income through efficient cultivation of exotic vegetables, utilization of polyhouses, fisheries, dairy and other aspects of the agriculture in totality. The farmers visited the center of excellence in vegetable production, Gharaunda, Karnal and learned about the recent developments and its application in the carrying out the exotic vegetable production. The farmers also interacted with the progressive farmers of the Karnal region and visited their farms. The visit to KVK NDRI helped the farmers in understanding the ways to improve the productivity of milch animals of the hills. The farmers also learned about the protection of diversity that is being encouraged through PPVFRA.

09 SEED AND RESEARCH FARM, HISAR

The Seed Production and Research Farm, Hisar covers a total 200 acres of land, out of which approximately 190 acres are utilized for crop production and rest 10 acres are covered under roads, official buildings, ponds, irrigation channel etc. During 2017-18, out of total 190 acres cultivated land, an area of 38.40 acres was used for wheat seed production programme and from this piece of land a total of 371.15 q seed was produced (Table 9.1). In addition of wheat, barley seed production was also carried out in 13.74 acres of land and a total of 90.09 q barley breeder seed was produced. The wheat and barley mixtures obtained from experimental materials were recorded to be 84.75q and 3.04q respectively, which was sold to the staff of CIRB and IIWBR, Hisar. The wheat and barley straw produced from the seed and research farm of IIWBR, Hisar was around 217.65q and it was handed over to the CIRB as per the MOU.

During Kharif season, no commercial crop was grown due to salinity problem. In order to improve the soil health, Dhaincha was sown in all fields in the last week of June and was ploughed at green stage to incorporate in the soil.

Table 9.1: Particulars of area, production and revenue generated from Rabi crops

S N	Name of the crop	Production (quintals)	Remarks
1	Seed crops of wheat	286.40	Transferred to ICAR-IIWBR, Karnal for processing and packaging.
2	Wheat crop mixture	84.75	Sold to ICAR-IIWBR and ICAR-CIRB staff for Rs 110 884/-
3	Barley Seed	87.05	Transferred to ICAR-IIWBR, Karnal for processing and packaging.
4	Barley mixture	3.04	Sold to ICAR-IIWBR and ICAR-CIRB staff Rs 3627/-
5	Wheat and Barley straw produced	217.65	Given to CIRB as per MOU

Fig 9.1: A View of Wheat Crop

10 INSTITUTE ACTIVITIES/ CELEBRATIONS

Research and Educational Activities

Research Advisory Committee meeting of ICAR-IIWBR Karnal was held under the chairmanship of Dr SK Sharma (Former Vice Chancellor of HPKV, Palampur) during 7-8 Apr 2017.

56th All India Wheat and Barley Research Workers Meet was organized during 25-28 Aug 2017 at BHU Varanasi. Sh Radha Mohan Singh, (Hon'ble Union Minister of Agriculture & Farmers Welfare, India) was chief guest of the inaugural function.

24th Meeting of Institute Management Committee was held on 27 Sep 2017 under the chairmanship of Dr GP Singh, Director, ICAR-IIWBR, Karnal.

Seed Day and Rabi Workshop was organized on 10th Oct 2017 at ICAR-IIWBR, Karnal. In this programme thousands of farmers participated from different states and interacted with scientists regarding their queries of wheat and barley crops. On this occasion quality seeds of various wheat and barley varieties were also made available to the farmers at the reasonable prices.

Institute Research Council (IRC) Meeting was held during 16-17 Oct, 2017 under the chairmanship of Dr GP Singh, Director, ICAR-IIWBR, Karnal. Progress report and future action plan of ongoing research projects were presented by concerned scientists before the house.

Research Advisory Committee Meeting of the Institute was held under the chairmanship of Dr HS Gupta (Former Director, IARI New Delhi) during 26-27 Oct 2017. Detailed discussion was made on various scientific strategies to meet out the future challenges for food and nutritional security of the country.

Agricultural Education Day was organized on 3rd Dec 2017 at this institute. More than 200 school going students attended this programme and participated in agriculture quiz. They were acquainted about the golden career opportunities in agriculture and allied sectors.

World Soil Health Day was organized on 5th Dec 2017 at Village- Rasina, District- Kaithal (Haryana). On this occasion hundreds of farmers were acquainted about the importance of soil health for sustainable productivity and profitability of field crops.

ICAR-IIWBR Karnal celebrated its Foundation Day on 9th Feb 2017 with full joy and happiness. Dr RB Singh (Chancellor CAU Imphal and Former Chairman ASRB, New Delhi) was chief guest of the function. On this occasion he delivered VS Mathur memorial lecture on Successful Journey of Wheat Improvement Programme in India.

Wheat and Barley field day was organized at IIWBR, Karnal on 28th Mar 2018. On this occasion a number of wheat and barley scientists visited the institute for selection of elite germplasm for their research programmes.

Social and Cultural Activities

Under Swachchh Bharat Abhiyan, Swachchhata Pakhwara was organized during 16-30, May 2017 at the Institute. During this period, staff members of this institute actively participated in cleanness and plantation programme for the sake of better environment.

Hundreds of shady and ornamental plants were distributed by LG Company to our institute. They were jointly planted in the campus on 22nd May, 2017 by staff of LG and IIWBR.

One-day workshop on liquid and solid waste management was organized on 29th May 2017 at this institute.

Swachchhata Abhiyan Pakhwara was again organized during 15th Sep-3rd Oct 2017 at ICAR-IIWBR, Karnal. During this period all staff members actively participated in the cleanness campaign in different parts of the city.

Vigilance Awareness Week was organized during 30th Oct-4th Nov 2017 at this institute.

Celebrations

The International Yoga Day was celebrated on 21st June, 2017 with full enthusiasm at ICAR-IIWBR, Karnal. A large number of staff members participated in the programme for the benefits in their health.

71st Independence Day of the country was celebrated on 15th Aug 2017, with full enthusiasm and happiness. On this occasion Dr GP Singh, Director urged the staff to contribute maximum for the welfare of farming community through development of innovative technologies.

69th Republic Day of the country was celebrated on 26th Jan 2018, with full enthusiasm and joy. On this occasion Dr GP Singh, Director appealed the staff to deliver their best in the nation development.

11 EXTENSION ACTIVITIES

'Mera Gaon Mera Gaurav' Scheme at ICAR-IIWBR, Karnal

The activities for the government's flagship programme towards doubling of farmers' income, 'Mera Gaon Mera Gaurav' scheme were carried out on a large scale during the current crop season. The teams visited their adopted villages and created awareness among the farmers on advanced practices of crop cultivation and supplied mini kits on DWRB 123 barley variety. Timely reports of monthly and quarterly activities were compiled at IIWBR and submitted to the Zonal Nodal Officer & Director, ICAR- Agricultural Technology Application Research Institute (ATARI), Zone-2, Jodhpur (Rajasthan) regularly. All the fourteen teams have provided detailed information about the various activities in their respective villages. Farmers from different villages were invited on different occasions in the institute premises.

Farm advisory services

The farmers were advised on various aspects of wheat and barley cultivation. More than 1000 farmers/entrepreneurs/ other stakeholders were provided replies to their queries through letters, phone calls, emails, SMS and WhatsApp.

Regular fortnightly advisories were issued on the web page of ICAR-IIWBR for the farmers on weather and cultural practices during the crop season.

Weather Update: IMD based 5 day weather forecast were uploaded on the webpage regularly for the farmers.

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

S.N.	Date	Duration (days)	No. of Trainees	Subject	Organization
1.	May 10, 2017	1	40 farmers	Udhmita Vikas	Rastriya Kisan Sanganthan (RKS) with
2.	November 21, 2017	1	40 Farmers	Improved Wheat Cultivation	ICAR-IIWBR, Karnal, Haryana IFFCO, Rewari Haryana
3.	November 27, 2017	1	22 Farmers	Weed Management	Krishi Vistar Samiti, Karnal, Haryana
4.	December 4-5, 2017	2	43 farmers	Increasing farm income of the Lahaul Valley farmers under TSP Programme	ICAR-IIWBR, Karnal
5.	22-25 January, 2018	4	42 farmers	Banaskantha Gujarat mein vaigyanik kheti dwara gehoonke utpadak kisanon ki aaye mein vridhi	Banaskantha, Gujarat
6.	26 February, 2018	1	35 farmers	Pashchimi Uttar Pradesh mein Gehoon ki Unnat Prodyagiki	DDA, Muzaffarnagar, UP
7.	27 February, 2018	1	52 farmers	Gehoon ki Unnat Kheti.	DDA, Baghpat, UP
8.	7-9 March, 2018	3	55 farmers	Uttarakhand mein Gehoon evam Jau ki unnat kheti dwara kisanon ki Aaye ko doguna karna.	Dehradoon, Uttarakhand
9.	15-18 March, 2018	3	8 farmers	Bihar mein gehoon ki unnat kheti	Piprakothi, Motihari, Bihar
10.	26-28 March, 2018	3	35 farmers	Haridwar Uttarakhand mein Gehoon ki unnat kheti.	Haridwar, Uttarakhand

Table 11.2 : Awareness programmes organised/conducted at / by ICAR – IIWBR, Karnal

S.N.	Date	No. of participants	Subject	Organised by
1.	June 05, 2017	150 participants	World Environment	NABARD and ICAR-IIWBR,
2.	December 03, 2017	100 students from different s chools of Karnal	Day programme at village Raisan, Nilokheri Agricultural Education Day	Karnal ICAR-IIWBR, Karnal
3.	December 05, 2017	290 farmers World Soil. Health day at village Rasina (Kaithal)	ICAR-IIWBR, Karnal	
4.	March,17, 2018	200 farmers Webcast of Honourable Prime Minister address from Krishi Unnati Mela, Pusa was organised	ICAR-IIWBR, Karnal	
5.	30.10.2017	25 participants	Awareness programme to stop stubble bouring	ICAR-IIWBR, Karnal and Dainik Jagran

Table 11.3 : Organization/Participation in Exhibition/Agricultural Awareness Programmes

S.N.	Program	Date	Duration (days)	Organized by
1.	Krishi Kalyan Mela at Motihari, Bihar	April 15-19, 2017	5	ICAR -RCER, Patna
2.	World Environment Day programme at village Raisan, Nilokheri	June 05, 2017	1	NABARD and ICAR-IIWBR, Karnal
3.	Kisan Mela at Rakhra Farm, Patiala	September 16, 2017	1	Young Farmers' Association,
4.	Pt. Deendayal Upadhyay Krishi Mela, Mathura	September 22-24, 2017	3	Rakhra Farm, Patiala ICAR-CIRG, Makhdum, Mathura
5.	Beej Diwas avam Rabi Karyashala : Badalte Jalwayu Parivesh mein Krishi ke Naye Aayaam	October 10, 2017	1	ICAR-IIWBR, Karnal
6.	Exhibition during 'World Food India-2017' at C-Hexagon Park, India Gate, New Delhi.	November 3-5, 2017	3	Ministry of Food Processing
7.	Exhibition during National Dairy Mela-2017 at ICAR-NDRI, Karnal	November 23-25, 2017	3	Industries, GOI, New Delhi. ICAR-NDRI, Karnal
8.	Exhibition during National Seminar at NHRDF, Salaru, Darar, Karnal	November 29-30, 2017	2	NHRDF, Salaru, Karnal.
9.	Agricultural Education Day	December 03, 2017	1	ICAR-IIWBR, Karnal
10.	World Soil Health Day at village Rasina, Kaithal	December 05, 2017	1	ICAR-IIWBR, Karnal.
11.	Foundation Day	February 9, 2018	1	ICAR-IIWBR, Karnal
12.	Ganna Mela at ICAR- SBI, RS, Karnal	February 17, 2018	1	ICAR- SBI, RS, Karnal
13.	North Zone Regional Farmers' Fair	February 23-25, 2018	3	IIVR, Varanasi
14.	Rabi Kisan Mela at ICAR-CSSRI, Karnal.	March 10, 2018	1	CSSRI, Karnal
15.	Exhibition during Krishi Unnati Mela at ICAR-IARI, New Delhi.	March 16-19, 2018	3	IARI, New Delhi
16.	Exhibition during AB InBev's Growers Day at Farukhnagar, Haryana.	March 21, 2018	1	AB InBev, Bar Malt, Gurgaon, Haryana

Table 11.4 : Coordination of visits at ICAR-IIWBR, Karnal during 2017-18

Date	Number of Visitors	Organization
April 06, 2017	25 Students	DAV, School, Gannaur, Sonipat (Haryana)
April 12, 2017	87 Students	SKNAU, Jobner , Jaipur (Rajasthan)
April 27, 2017	106 Students	Khalsa College, Patiala (Punjab)
May 19, 2017	13 Farmers	DDA, Bhind (MP)
June 23, 2017	38 Farmers	Project Director (PD), ATMA Shamli (UP)
June 27, 2017	16 Farmers	Department of Agriculture Saharanpur (UP)
June 28, 2017	44 Farmers	Bijnor (UP)
July 01, 2017	29 Students	B.Sc.(Hons.) Agri. Final year , COA, Bharatpur (Rajasthan)
July 14, 2017	27 Farmers	Churu (Rajasthan)
July 15, 2017	47 Farmers	Kota (Rajasthan)
July 16, 2017	45 Farmers	Alwar (Rajasthan)
July 16, 2017	36 Farmers	Jalore (Rajasthan)
August 22, 2017	13 Farmers	Gyaraspur
August 22, 2017	13 Farmers	Kurwai
September 18, 2017	98 Students	Agri. College & Research Institute, TNAU
September 19, 2017	52 Students	Agri. College & Research Institute, TNAU
September 20, 2017	46 Students	Don Bosco College of Agriculture (DBCA), TNAU Affiliated, Sagayathottam, Vellore (Tamil Nadu)
September 20, 2017	113 Students	Agri. College and Research Institute, Coimbatore ,Tamilnadu,
September 22, 2017	19 Farmers	Gorkha Rifles
September 28, 2017	24 Farmers	GPS, Model Town, Karnal
October 09, 2017	39 Farmers	Female farmers from Rajkot (Gujarat)
October 10, 2017	47 Students	School of Agriculture, ITM University, Gwalior (MP)
October 11, 2017	40 Farmers	Chamba (HP)
October 28, 2017	12 Farmers	Morena (MP)
November 07, 2017	40 Farmers	Jam Nagar (Gujarat)
November 09, 2017	46 Farmers	Sriganganagar (Rajasthan)
November 09, 2017	22 Officers	DDMs from NABARD, Punjab Region
November 14, 2017	47 Officers	Gariyaband (Chhattisgarh)
November 14, 2017	105 Students	Chandigarh University
November 20, 2017	75 Students	Idhipalaraletti Agri. College, Kalavai, Vellore (Tamilnadu)
November 21, 2017	40 Farmers	IFFCO, Gurgaon
November 24, 2017	88 Students	APAC, Kalavai, Vellore (Tamilnadu)
November 25, 2017	18 Farmers	Sri Ganganagar (Rajasthan)
November 25, 2017	24 Farmers	Sonbhadra
November 27, 2017	99 Students	TRIARD, Perambalur, Tamilnadu Agriculture University
November 27, 2017	24 Farmers	Krishi Vistar Samiti, Karnal
December 02, 2017	51 Farmers	Department of Agriculture Valia
December 13, 2017	26 Farmers	Vidisha (MP)
December 26, 2017	106 Students	Tamil Nadu Agriculture University
December 30, 2017	8 Farmers	Kalapipal, Shajoypur (MP)
December 30, 2017	60 Farmers	Jammu & Kashmir
January 02, 2018	28 Officers	Officers of SDA & H, Karnal Zone , Haryana
January 17, 2018	30 Farmers	Jhunjhunu (Rajasthan)
January 24, 2018	50 Farmers	Hisar (Haryana)
January 25, 2018	38 Farmers	Hisar (Haryana)
January 29, 2018	40 Farmers	IWMP, Hisar
January 30, 2018	50 Farmers	मुख्यमंत्री खेती तीर्थ योजनान्तर्गत दतिया (मध्य प्रदेश)
February 03, 2018	52 Farmers	Hansi-I Block, Hisar (Haryana)
February 03, 2018	52 Farmers	Hansi-II Block, Hisar (Haryana)
February 05, 2018	50 Farmers	Water Sector Restructuring, Fatehpur (UP)
February 05, 2018	10 Farmers	मुख्यमंत्री बीज दर्शन योजना भिंड (मध्य प्रदेश)

February 06, 2018	10 Farmers	मुख्यमंत्री खेती तीर्थ योजनान्तर्गत भिंड (मध्य प्रदेश)
February 12, 2018	65 Farmers	Female farmers from Narnaund,Hisar (Haryana)
February 16, 2018	18 Farmers	Datia (MP)
February 17, 2018	34 Farmers	Himmat Nagar (Gujarat)
February 23, 2018	50 Farmers	KVK, Saharanpur (UP)
February 23, 2018	100 Farmers	Block Nissing, Karnal (Haryana)
February 25, 2018	10 Farmers	मुख्यमंत्री खेती तीर्थ योजनान्तर्गत अजय वर्मा
February 26, 2018	10 Farmers	मुख्यमंत्री खेती तीर्थ योजनान्तर्गत अजय वर्मा
February 26, 2018	35 Farmers	किसान प्रशिक्षण जनपद शामली कृषि विज्ञान (उ.प्र.)
February 27, 2018	52 Farmers	Baghpat (UP)
February 27, 2018	37 Farmers	Muzaffarnagar (UP)
March 07, 2018	41 Farmers	Balasore (Odisha)
March 12, 2018	47 Students	College of Horticulture, Mandsour, RVSKVV, Gwalior (MP)
March 13, 2018	50 Agri. Officers	Chhattisgarh
March 17, 2018	31 Farmers	Hamirpur (UP)
March 19, 2018	22 Farmers	Datia (MP)
March 19, 2018	40 Farmers	Jalore (Rajasthan)
March 19, 2018	45 Farmers	Bharatpur (Rajasthan)
March 19, 2018	40 Farmers	Sonbhadra, ओम गोरा सेवा संस्थान अलीगढ़
March 19, 2018	48 Farmers	Bhadohi
March 20, 2018	05 Farmers	Rajkot (Gujarat)
March 20, 2018	45 Officers	Chhattisgarh
March 23, 2018	40 Students	B.Sc. Agri., Guru Nanak Collage, Budhwala, Mansa (Punjab)
March 23, 2018	27 Farmers	Mandi (HP)

Table 11.5 : Lectures delivered

Date	Topic
September 21, 2017	"Bio fortified wheat for ensuring nutritional security" during 21 days training programme on "Extension Strategies for Nutrition Sensitive Agriculture to Address Sustainable Development Goals" during 2-22 Sept., 2017 at Division of Agricultural Extension, IARI, New Delhi.
October 06, 2017	Soft Skill in Policing at Madhuban Police Academy for trainees on traffic
November 7, 2017	(1) Soft Skills for Agril. Students and (2) Positive Motivation During 14 days training programme for B.Sc (Ag) students on personality development at College of Agriculture, CCSHAU, Kaul on.
November 28, 2017	"Hindi Bhasha Ka Prachar Avam Prasar Tatha Karya Sthal Par Hindi Bhasha Ka Upyog" during 3 days training programme organized during 28-30 November, 2018 at ICAR-IIWBR on" Kushal Sahayak Karmachari ki Karyakshamta avam Vyaktitva Vikas.
December 3, 2017	"Agricultural Education: Scope and Career Opportunities" to 100 students from different schools of Karnal on the occasion of Agricultural Education Day.
December 4, 2017	Lecture on 'Introduction of TSP Programme' to 43 farmers of 15 villages of Lahaul Valley (HP) in two days Training Programme under TSP project on 'Increasing farm income of the Lahaul Valley Farmers'.
December 6, 2017	Delivered a lecture on on "Vaigyanik Aur Takniki Anuvaad Ki Vyavaharik Samasyayen Avam Unka Samadhan" during 5 days training programme organized at ICAR-CSSRI, Karnal during 4-8 December, 2017 on" Vishesh takniki Prashikshan Karyakram of Kendriya Anuvaad Bureau.
January 23, 2018	"Krishi Me Udhyamita Vikas" during training programme for farmers on "Banaskantha me Vaigyanik Kheti Dwara Gehoon ke Utpadan tatha Kisano ki aay me Vriddhi during 22-25 January, 2017.
March 08, 2017	"Krishi Me Udyamita Ka Vikas" during training programme for farmers on Uttarakhand me gehoon avam jau ki unnat khet tatha kisano ki aay ko doguna karna" during 7-9 March, 2018
March 14, 2018	"Designing Training Programme" at EEI, Nilokheri during 16-19 March, 2018 on Training Management
March 15, 2018	"Role of Extension Agencies in Characterization and Conservation of Plant Resources in India" in 10 days short course during 12-21 March, 2018 at ICAR-IIWBR, Karnal.
March 28, 2018	"Haridwar me Gehoon avam jau ki Unnat Kheti avam Katai Uprant Prabandhan" Vishay pa vyakhyan diya during training programme for Uttarakhand farmers during 26-28 March, 2018
March 13, 2018	Sendhil R delivered a lecture on "Indigenous Technical Knowledge (ITK) and Geographical Indications (GIs) in Agriculture and Protection Status" in the Short Course organised at ICAR-IIWBR, Karnal.

Table 11.6 : TV programmes on DD National and DD Kisan Channels

Date	Topic
24.10.2017	Shooting for Prashnottari programme on Wheat and Barley Cultivation, Krishi Darshan, DD National on 24.10.2017 and was telecast on 06.11.2017
09.11.2017	1. Shooting for DD Kisan "Vichar-Vimarsh" programme at Delhi 2. Live phone in programme on wheat cultivation in Krishi Darshan, DD National
12.11.2017	Visit of DD National Krishi Darshan Team to ICAR-IIWBR, Karnal to document success stories of progressive farmers of Karnal district
27.02.2018	Shooting for "Vichar-Vimarsh" Programme of DD Kisan was done on 27.02.2018 at Delhi

WhatsApp group: Farm Advisories_IIWBR

The Farm Advisories on wheat and barley crops were shared via WhatsApp group.

Toll Free Phone Number: Through toll free phone number of institute (18001801891), large number of farmers were updated on wheat and barley cultivation and their querries were well addressed.

Advisories Linkage to MANAGE Portal

The advisories issued on different aspects of wheat and barley crop were linked / uploaded on the MANAGE Portal for wide circulation and use.

Production of Video Film

Video film on "Gehoon Ka Peela Ratua" in Hindi was produced and uploaded on website.

12 AWARDS & RECOGNITION

International Awards:

ICAR bagged the most prestigious BGRI Gene Stewardship Award-2018 for its outstanding contribution in the field of Indian Wheat Research Programme. The awarded team consist the scientists from ICAR-IIWBR Karnal, ICAR-IARI New Delhi, PAU Ludhiana and UAS, Dharwad. Dr. T Mahapatra (Secretary DARE & DG ICAR) & Dr GP Singh (Director, ICAR-IIWBR, Karnal) received the award on behalf of the team in BGRI Technical Workshop-2018 held during 14-17 April 2018 at Marrakech, Morocco. The following person of this institute was the part of awarded team.

Dr Gyanendra Pratap Singh, Director, ICAR-IIWBR, Karnal

Dr Ravish Chatrath, Principal Scientist (Plant Breeding), ICAR-IIWBR, Karnal

Dr SC Bhardwaj, Incharge and Principal Scientist (Plant Pathology), ICAR-IIWBR, Shimla

Dr Satish Kumar, Scientist (Plant Breeding), ICAR-IIWBR, Karnal

Dr CN Mishra, Scientist (Plant Breeding), ICAR-IIWBR, Karnal

Dr.Indu Sharma, Retd.- Project Director, IIWBR, Karnal

National Awards:

Dr Dinesh Kumar and his team was awarded with the ICAR most coveted **Hari Om Ashram Trust Award (2014-15)** in Crop & Horticultural Sciences category for their outstanding contribution in Potato Research

Institute Awards

Dr Sendhil R bestowed with the "**Best worker Award 2017 (Scientific category)"** for significant contribution to Agricultural Economics, Technology Transfer and Institution Building during the Foundation Day of ICAR-IIWBR, Karnal.

Dr Subodh Kumar bestowed with the "**Best worker Award 2017 (Technical category)"** for significant contribution to Technical Work during the Foundation Day of ICAR-IIWBR, Karnal

Sh Sunil Kumar bestowed with the "**Best worker Award 2017 (Clerical category)"** for significant contribution to Clerical Work the Foundation Day of ICAR-IIWBR, Karnal

Sh Guman Singh bestowed with the "**Best worker Award 2017 (Supporting category)"** for significant contribution to Clerical Work the Foundation Day of ICAR-IIWBR, Karnal

Dr Anuj Kumar received **Best Article Award** for "Bharat Me Hi Tech Agriculture Ki Sambhavnayen" in Gehoon Evam Jau Swarnima. Published by ICAR-IIWBR Karnal. 2016.

Society Awards

Dr Ravish Chatrath honoured with the **Dr MV Rao Memorial Award 2017** by the *Society for Advancement of Wheat and Barley Research* for his outstanding contribution to the field of Wheat Breeding.

Dr SC Bhardwaj honoured with the **Dr. S. Nagrajan Memorial Award 2017** by the *Society for Advancement of Wheat and Barley Research* for significant contribution to field of Wheat Pathology

Dr Sendhil R honoured with the **Prof. Mahatim Singh Memorial Award 2017** by the *Society for Advancement of Wheat and Barley Research* for significant contribution to Agricultural Economics

Dr DP Singh was awarded "**KC Mehta and Manoranjan Mitra Award"** by *Indian Phytopathological Society* during its annual meeting at AAU Jorhat during 15-17 Feb. 2018.

Dr DP Singh was awarded "**Plant Pathology Leadership Award"** at *Indian Phytopathological Society* (MEZ) Meeting and National symposium at GBPUAT Pantnagar during 21-23 Dec. 2017.

Dr DP Singh was conferred "**Honour of Award"** by *Indian Society of Plant Pathologists* during National Symposium at YSPUH&F Solan (HP) during 27-28 Sep. 2017.

Dr PL Kashyap nominated for **M.K. Patel Memorial Young Scientist Award (2018)** by the Indian Phytopathological Society, New Delhi

Best Paper/ Best Poster /Best Thesis Award

Dr. Sendhil R received the "**Best Presentation Award**" from the Society of Economics and Development for his commendable presentation in the 4th national seminar held at Punjab Agricultural University on April 07, 2017.

Dr. Ankita Jha received **Best Poster Presentation Award** by Pantnagar Agronomy Society, during National Agronomy Congress (20-22 February, 2018) at GBPUA&T, Pantnagar.

Dr. Ankita Jha won **Prof. P.D. Mistry Best PhD Thesis Award -2017** by Association of Agrometeorologists, Anand, Gujarat, India.

Dr. Vanita Pandey won **Best Poster Presentation Award** on the topic 'Molecular approach for selecting good bread-making-quality wheat genotypes utilizing wbm gene' in International Conference on Microbial, Plant and Animal Genome, held during 29-31, Mar 2018 at Mody University, Lakshman garh (Rajasthan).

Rajni Devi, won **Best Poster Presentation Award** on the topic " Identification of physiological and biochemical traits associated with tolerance to salinity stress in wheat" in a National Conference on "Current

trends in plant science and molecular biology for food security and climate resilient agriculture" held at RVSKVV, Gwalior during 15-16 Feb 2018

Extension / Exhibition Award

ICAR-IIWBR bagged Best Exhibition Award in an exhibition organized during 29-30 November, 2017 at NHRDF, Salaru, Darar, Karnal.

ICAR-IIWBR bagged Third Prize for Exhibition Stall in National Dairy Mela-2017 held at ICAR-NDRI, Karnal during 23-25 November, 2017.

Recognition

Dr Dinesh Kumar awarded Fellow of Society for Advancement of Wheat & Barley Research (Quality & Basic Sciences Section)

Dr. D. P. Singh chaired session in IPS (MEZ) symposium at Pantnagar and co-chaired during symposia at Solan (INSOPP) and IPS (AAU Jorhat) as well as during wheat and barley workers' meet at BHU Varanasi.

Dr. Anil Khippal received an appreciation letter from Dr. R.K. Yadav, chairman, Haryana Farmers Commission for his outstanding contribution in conservation agriculture.

13 DISTINGUISHED VISITORS

Dr SS Khanna , Renowned Soil Scientist and Former Vice Chancellor of NDUA&T Faizabad, visited the institute on 17th May 2017 and delivered a lecture on Urban Waste Management and its Utilization in Crop Production

Dr HS Gupta (Former DG, BISA and Ex-Director, IARI New Delhi) visited the institute twice on the occasion of Seed Day & Rabi Workshop (10th October 2017) and on the occasion of RAC meeting of the institute (26-27 October 2017).

Sh. Rajendra Singh, World-fame Environmental Activist (Jal Purush), made a visit of ICAR-IIWBR, Karnal on the occasion of International Yoga Day. In his address to staff of this institute, he emphasized on water saving for better tomorrow. On this occasion he planted a sapling also as the token of his love to green environment.

Shri Chhabilendra Roul, Special Secretary (DARE) & Secretary (ICAR) visited ICAR-IIWBR, Karnal on 23rd November 2017. Shri Roul, in his address emphasized the need to create more impact of ICAR-IIWBR technologies for food and nutritional security of the country.

Prof. R.B. Singh, Chancellor CAU, Imphal and Immediate Past President NAAS, New Delhi visited the Institute on 9th Feb, 2018 as chief guest on the occasion of Foundation Day of ICAR-IIWBR Karnal. On this occasion he delevered Dr VS Mathur memorial lecture on Sucssessful Journey of Wheat Improvement.

Dr DK Yadav (Act ADG Seeds), Dr Kuldeep Singh (Director NBPGR,New Delhi) and Dr PC Sharma (Director CSSRI,Karnal) visited the IIWBR Karnal on 16th Feb, 2018.

Sh RP Singh, Member of Goverening Body of ICAR,New Delhi viseted the institute on 13th Feb 2018. On this occasion he visited the fielda, labs and museum of the institute. He interected with scientists of institute and urged to develop sustainable and ecofriendly technologies for the farmers and country welfare.

Dr AK Joshi (South Asia Regional Director, CIMMYT, New Delhi) and Dr Ravi Singh (distinguished scientist and head of Bread Wheat Improvement, CIMMYT Mexico) visited the institute on 20th Feb, 2018. They visited the experimental plots of wheat and interacted with the wheat breeders of this institute.

Sh Radha Mohan Singh, Cabinet Minister of Agriculture & Farmers Welfare, Govt. of India , visited the institute on 10th March, 2018. On this occasion he interected with scientists and urged to develop more innovative technologies for doubling the farmers income.

Dr. KV Prabhu, Chairman, PPV&FRA, New Delhi visited the institute on 12th March 2018. He was the keynote speaker on the inaugural function of ICAR sponsored short course on Empowering Knowledge on Protection of Plant Varieties, IPRs and other Issues in Cereals

14 TRAININGS & CAPACITY BUILDING

Training: Several training programmes were conducted by this institute for strengthening the efficiency of scientific and technical workforce of agricultural institutes in the country. In addition, a number of staff members were sent to different places in India and outside the country to participate in different training programmes. The details of these training programmes are given below.

(A) Training organized

1. ICAR sponsored 10-days short course on "Harnessing NGS Data for Genetic Improvement in Crops " was organized during 3-12 Oct. 2017 at this institute
2. For skill-upgradation and personality development of skilled supporting staff, a three-days training programme was organized during 28-30 Nov. 2017 at this institute
3. Human Resources Management training programme was organized during 14-16 Dec. 2017
4. For skill-up gradation and personality development of skilled supporting staff, a three-days training programme was organized during 18-20 Dec. 2017
5. Training programme on "Survey and surveillance, creation of epiphytotics and uniform disease recording in wheat and barley" was organized during 18 - 20 Dec. 2017
6. Training programme on "Methodologies for Evaluation of Wheat Quality" was organized during 5-9 Mar , 2018 at this institute
7. ICAR sponsored 10-days short course on "Empowering knowledge on protection of plant varieties, IPR and PGR related issues in cereals" was organized during 12-21 Mar 2018 at this institute
8. Hand on Training on Quality Seed Production was organized during 22-24 Mar 2018 at this institute

(B) Training attended in India

(a) Scientific Staff

1. Dr Rinki Khobra (Scientist, Plant Physiology), attended a training program on " Developing Winning Research Proposal in Agricultural Research" during 1-5 Sept, 2017 at , NAARM Hyderabad
2. Dr Raj Pal Meena (Sr. Scientist, Agronomy) attended a training program on "Advances in nutrient dynamics for improving nutrient and water use efficiency of crops " during 4-14 Sept,2017 at ICAR-IISS, Bhopal
3. Dr Vikas Gupta (Scientist, Plant Breeding), attended a training program on Advanced Statistical Techniques in Biometrics Training held during 10 - 30 Aug, 2017 at IASRI, New Delhi.
4. Dr Prem Lal Kashyap and Dr Poonam Jasrotia attended pre-surveillance training on SAARC tool organised by Satguru at Punjab Agricultural University (PAU), Ludhiana on December 12, 2017.
5. Dr. Vanita Pandey attended training programme on 'Analysis of Experimental Data' at ICAR-NAARM, Hyderabad from 19-24th February, 2018.
6. Dr. OP Gupta and Dr. Sneh Narwal attended two days training programme on "Internal Auditor Training Programme on ISO 9001: 2015 covering full ISO standards" held on 12-13 Dec, 2017 at ICAR-IIWBR, Karnal
7. Dr R S Chhokkar (Pr. Scientist, Agronomy) attended a training program on "Experimental designs and Statistical Data Analysis "during 11-20 Sep 2017 at IASRI, Delhi
8. Dr Mamrutha H.M. (Scientist, Plant Physiology), attended ICAR sponsored short course on Harnessing NGS data for genetic enhancement in

crops from October 3-12, 2017, ICAR-IIWBR, Karnal

9. Dr Suman Lata (Pr. Scientist, Computer application in Agriculture) attended a training programme on Geospatial Analysis for Natural Resources Management using Free and Open Source Software (FOSS)-QGIS, ILWIS & R during November 16-25,2017, at NAARM Hyderabad

10. Dr Dinesh Kumar (Pr. Scientist, Plant Biochemistry) and Dr Anil Khippal (Pr. Scientist, Agronomy) attended a training Programme on Multivariate Data Analysis, during 14-20 December, at NAARM Hyderabad

11. Dr. Ajay Verma (Pr. Scientist, Ag. Statistics) attended a training programme on Policy Workshop on Big Data Analytics in Agriculture, during 8-9 February, 2018 at NAARM Hyderabad

(b) Technical Staff

1. Dr. Subodh Kumar, ACTO at IIWBR-RS, Flowerdale, attended training on "Competence enhancement programme on motivation and positive thinking for Technical Officers of ICAR" at NAARM, Hyderabad from Sept. 13- 22, 2017.

2. Sh. Surendra Singh (ACTO) and Sh. Ramkumar Singh (STO) attended a training programme on "Enhancement of professional competence of ICAR technical and administrative professionals" during 27 -29 June 2017 at NBAGR, Karnal

3. Sh. Om Singh (Tech. Assistant) attended a training programme on "Automobile Maintenance, Road Safety and Behavioural Skills" during July 18-22, 2017 at CIAE, Bhopal

4. Sh. Om Prakash Tuteja (Tech. Officer) and sh. Madan Lal (Tech. Officer) attended a training programme on "Communication and Scientific Writing for Technical Officer" during January 3-9, 2018 at NAARM Hyderabad

5. Smt. Sunita Jaswal (Tech. Officer), Sh. Yogesh Kumar (ACTO), Sh. PHP Verma (ACTO), Sh. Surendra Singh$_1$(ACTO) , Sh. Surendra Singh$_2$ (ACTO) and Dr Mangal Singh (ACTO) attended HRM-Training program on Proficiency Enhancement for Working in Biochemistry & Biotechnology Laboratory" during 14-16 Dec, 2017 at ICAR-IIWBR, Karnal

6. Sh Abhay Nagar (ACTO), attended the "Training Programme on KOHA for library staff of ICAR", during 5-9 Feb., 2018 at NAARM Hyderabad

(c) Administrative Staff

1. Sh Sachin Agnihotri (SAO) and Sh Ashok Kathuria (AFAO) attended a National level training on Procurement and PFMS during 11-15 Sept, 2017 at CPRI, Shimla

2. Sh Ashok Kathuria (AFAO) attended a training programme on OSP for ICAR on GFR during 19-21 July ,2017 at ISTM, New Delhi

3. Sh Krishan Pal (Assistant) Enhancement of professional competence of ICAR technical and administrative professionals" during 27 -29 June , 2017 at NBAGR, Karnal

4. Sh Ashok Kathuria (AFAO) attended a Refresher Course for Section Officers, AAOs, AFAOs, Assistant of ICAR during 18-23 January, 2018 at NAARM Hyderabad

(d) Skilled Supporting Staff

1. Smt Amresh, Sh Harinder Singh and Sh. Bhim Sen attended a ICAR sponsored training programme on "Efficiency Enhancement and Personality Development of Skilled Staff " during 29-31 Aug., 2017 at NBAGR, Karnal

2. Sh Nandan Singh, Sh Biru Ram, Sh Deshraj, Sh Aman Kumar, Sh Yashwant Singh, Sh Paramjit Singh and Smt Suman Thapa attended a ICAR sponsored training programme on "Efficiency Enhancement and Personality Development of Skilled Staff " during 28-30 Nov ,2017 at NBAGR, Karnal

Trainings attended in abroad

1. Dr Gopalareddy K, (Scientist, Plant Breeding) attended Basic Wheat Improvement Course-2017 from 27 Feb to 25 May, 2017 at CIMMYT Mexico

2. Dr SK Singh attended Training on Plant Variety

Protection from 19-30 June, 2017 at Wageningen University, The Netherlands, under Netherland Fellowship Programme.

3. Dr Prem Lal kashyap (Scientist, Plant Pathology) attended a training programme on Wheat Blast and Advanced Wheat Improvement Course (Pathology Module) organized by CIMMYT at USDA-ARS, USA, National Institute of Agricultural and Forestry Innovation, Santa Cruz, Bolivia and CIMMYT, Batan during July 18 – August 16, 2017

4. Dr Sendhil R (Scientist , Ag Economics) participated in the 6 days Training Program on "User-oriented Statistical Downscaling of Climate Information in Agriculture and Water Resources" organized by the APEC Climate Center (APCC) at Busan, South Korea from August 21-26, 2017.

5. Dr CN Mishra (Scientist , Plant Breeding) attended Basic Wheat Improvement Course 2018 from 28 Feb to 21 May, 2018 at CIMMYT, Mexico

Capacity Building: In addition to training programmes, a large number of scientists participated in various programmes such as conference, seminar, symposia, workshop and scientific meetings with in country and outside the country. The details thereof have been given as under.

National programmes:

1. Dr Vanita Pandey participated and made a poster presentation on the topic 'Molecular approach for selecting good bread-making-quality wheat genotypes utilizing wbm gene' in International Conference on Microbial, Plant and Animal Genome, March 29-31, 2018, Mody University, Lakshmangarh, Sikar (Rajasthan).

2. Dr Ankita Jha participated and made a poster presentation on the topic "Land use and land cover mapping of Karnal using geospatial technology" in National Agronomy Congress held during 20-22 February, 2018 at GBPUA&T, Pantnagar.

3. Dr OP Gupta and Dr Vanita Pandey participated in exhibition programme 'World Food India' from 3rd - 5th November, at New Delhi.

4. Dr Sneh Narwal attended one day National Seminar on "Emerging Trends and Challenges in Biosciences" on 10th march, 2018 at GMN College, Ambala, Haryana.

5. Dr Ankita Jha received Best Paper Award (Poster) 2017 by XIII Agricultural Science Congress, UAS, Bengaluru

Foreign Programmes:

1. Dr. G P Singh , Dr. Ravish Chatrath and Dr SC Bhardwaj attended a Project Inception Workshop for ACIAR funded project entitled Mitigating the effect of Stripe Rust on wheat production in South Asia and East Africa held during 27-28 Feb., 2018 at Dubai, UAE

2. Dr. Sindhu Sareen attended 8th International Triticeae Symposium held at Wernigerode, Germany during 12-16 June, 2017

3. Dr. Karnam Venkatesh made a visit of Rothamsted Research, UK for attending the Annual Review Meeting of Indo-UK Centre for Improvement of Nitrogen Use Efficiency in Wheat (INEW) during 5-6 June, 2017, the course on Phenotyping and Phenomics during 7-9 June, 2017 and Wheat Genetics and Marker Development during 12-16 June, 2017

4. Dr. DP Singh visited Dhaka, Bangladesh to participate in Wheat Blast Workshop from 13-14 July 2017.

5. Dr. Sewa Ram visited CIMMYT, Mexico from March 10 – 25, 2018 for attending the International Gluten Workshop along with Latin American Cereals Conference and Global Wheat Programme Visitor's week

6. Dr. Ravish Chatrath, visited CIMMYT, Mexico from 19-23 March, 2018 to make selections in Harvest Plus trials and participate in visitor's Week for familiarization with ongoing research activities at CIMMYT

15 RESEARCH PROJECTS

(A) Institute Projects

S.No.	Project Code	Title of the project/ sub-project	Name of the Project Leader (PL), Principal Investigator (PI) and Co-PI/s	Date of Start	Date of completion
1	**CRSCIIWBRCIL 201500100182**	**Multilocational and Multidisciplinary Research Programme on Wheat and Barley Improvement**	**PL: Dr GP Singh** **Co-PIs:** All the Scientists of ICAR-IIWBR	Continuous nature	Continuous nature
2	**CRSCIIWBRSIL 201500200183**	**Genetic resources and pre-breeding for wheat improvement**	**PL: Dr. BS Tyagi**		
	CRSCIIWBRSIL 201500200183.1*	Wheat improvement utilizing novel germplasm resources through pre-breeding	**PI:** Dr. BS Tyagi **Co-PIs/Collaborators:** Drs. Sindhu Sareen, Vikas Gupta, Arun Gupta, Gyanendra Singh, Raj Kumar, Hanif KhaN	Nov, 2015	Oct, 2020
	CRSCIIWBRSIL 201500200183.2	Management of wheat and barley genetic resources for utilization in crop improvement	**PI:** Dr. Arun Gupta Co-PIs/Collaborators: Charan Singh, Vishnu Kumar		
3	**CRSCIIWBRSIL201 500300184**	**Developing high yielding and climate resilient wheat varieties**	**PL: Dr. Ravish Chatrath**		
	CRSCIIWBRSIL20 1500300184.1	Breeding wheat genotypes for North-Western Plains	**PI:** Dr. Ravish Chatrath **Co-PIs/Collaborators:** Drs. GP Singh, Satish Kumar, Raj Kumar, Sudheer Kumar, Poonam Jasrotia, Mamrutha HM, OP Gangwar, Vanita Pandey, Sh. Om Prakash , Madan Lal	Nov, 2015	Oct, 2020
	CRSCIIWBRSIL 201500300184.2	Breeding wheat genotypes for Eastern regions	**PI:** Dr. Gyanendra Singh **Co-PIs/Collaborators:** Drs. AK Sharma, Charan Singh, Vikas Gupta, Sonia Sheoran, Sindhu Sareen, DP Singh, Sewa Ram		
	CRSCIIWBRSIL20 1500300184.3	Breeding wheat genotypes for warmer areas	**PI:** Dr. SK Singh **Co-PIs/Collaborators:** Drs. Vinod Tiwari, Lokendra Kumar, Rinki , Pradeep Sharma, RK Gupta, PL Kashyap		
	CRSCIIWBRSIL 201500300184.4	Utilizing winter wheats for spring wheat improvement	**PI:** Dr. Vinod Tiwari Co-PIs/Collaborators: Drs. CN Mishra, Rajender Singh, Lakshmi Kant (Almora)		
	CRSCIIWBRSIL 201500300184.5	Improvement of wheat for grain quality	**PI:** Dr. K Venkatesh **Co-PIs/Collaborators:** Drs. BS Tyagi, Gopalareddy K, Vanita Pandey		

4	**CRSCIIWBRSIL 201500400185**	**Basic and genetic studies in wheat**	**PL: Dr. Ratan Tiwari**		
	CRSCIIWBRSIL 201500400185.1	Genomics guided exploration for stress tolerance in wheat	**PI:** Dr. Ratan Tiwari **Co-PIs/Collaborators:** Rajender Singh, Pradeep Sharma, Sonia Sheoran		
	CRSCIIWBRSIL 201500400185.2	Genetic studies and molecular mapping for rust resistance in wheat	**PI:** Dr. Rekha Malik **Co-PIs/Collaborators:** Satish Kumar, CN Mishra, Pramod Kumar		
	CRSCIIWBRSIL 201500400185.3	Exploring physiological, biochemical and anatomical variations in wheat	**PI:** Dr. Mamrutha HM **Co-PIs/Collaborators:** Rinki, Sneh Narwal, Rajender Singh		
5	**CRSCIIWBRSIL 201500500186**	**Management of major diseases and insect pests of wheat in an agro-ecological approach under changing climate**	**PL: Dr. DP Singh**		
	CRSCIIWBRSIL 201500500186.1	Development of eco-friendly technologies for management of rusts, spot blotch, bunts and smuts in wheat	**PI:** Dr. Sudheer Kumar **Co-PIs/Collaborators:** Drs. D.P. Singh, PL Kashyap	Nov, 2015	Oct, 2020
	CRSCIIWBRSIL 201500500186.2	Management of major insect pests of wheat under field and storage conditions	**PI:** Dr. Poonam Jasrotia **Co-PIs/Collaborators:** Dr. Raj Kumar		
6	**CRSCIIWBRSIL 201500600187**	**Physiologic specialization, resistance and molecular studies on wheat and barley rusts**	**PL: Dr. S.C. Bhardwaj**	Nov, 2015	Oct, 2020
	CRSCIIWBRSIL 201500600187.1	Physiologic specialization in brown rust of wheat, barley and genetics of rust resistance	**PI:** Dr. S.C. Bhardwaj **Co-PIs/Collaborators:** Drs. Hanif Khan, Pramod Prasad, Siddanna Savadi, Subodh Kumar		
	CRSCIIWBRSIL 201500600187.2	Monitoring variability in yellow rust of wheat, barley and genetics of rust resistance	**PI:** Dr. O.P. Gangwar **Co-PIs/Collaborators:** Dr. Subodh Kumar		
	CRSCIIWBRSIL 201500600187.3	Physiologic specialization, genetics of resistance in black rust of wheat and barley	**PI:** Dr. Pramod Prasad **Co-PIs/Collaborators:** Dr. Siddanna Savadi		
	CRSCIIWBRSIL 201500600187.4	Genetic and molecular studies on rust resistance and breeding wheat for multiple rust resistances	**PI:** Dr. Hanif Khan **Co-PIs/Collaborators:** Drs. SC Bhardwaj, OP Gangwar, Siddanna Savadi		
7	**CRSCIIWBRSIL 201500700188**	**Improving crop productivity through efficient input management**	**PL: Dr RK Sharma**		
	CRSCIIWBRSIL 201500700188.1	Nutrient management strategies for wheat based cropping systems	**PI:** Dr SC Gill **Co-PIs/Collaborators:** Drs. RK Sharma, RS Chhokar		
	CRSCIIWBRSIL 201500700188.2	Developing effective weed management solutions in wheat	**PI:** Dr RS Chhokar **Co-PIs/Collaborators: Drs.** RK Sharma, SC Gill, Rajender Singh	Nov, 2015	Oct, 2020

	CRSCIIWBRSIL 201500700188.3	Improving water useefficiency and mitigate abiotic stresses stresses in wheat under conservation and conventional tillage practices	**PI:** Dr RP Meena		
	CRSCIIWBRSIL 201500700188.4	Production estimation of wheat using remote sensing and modelling in Haryana	**PI:** Dr Ankita Jha **Co-PIs/Collaborators:** Dr. Rajeev Ranjan, AS Nain		
8	**CRSCIIWBRSIL 201500800189**	**Enhancing productivity and profitability of wheat based cropping system for marginal farmers**	**PL/PI: Dr. S. C. TripathiCo-PIs/ Collaborators:** Dr. S.C. Gill, Raj Pal Meena	Nov, 2015	Oct, 2020
	CRSCIIWBRSIL 201500900190	**Improvement of Industrial and Nutritional Quality of Wheat**	**PL: Dr. Sewa Ram**		
	CRSCIIWBRSIL 201500900190.1	Improvement of processing and nutritional quality of wheat using biochemical/ molecular approach	**PI:** Dr. Sewa Ram **Co-PIs/Collaborators:** Dr. B.S. Tyagi, Sneh Narwal, Vanita Pandey	Nov, 2015	Oct, 2020
	CRSCIIWBRSIL 201500900190.2	Studies on the Bioactive Compounds in Wheat and Barley	**PI:** Dr. Sneh Narwal **Co-PIs/Collaborators:** Dr. Sonia Sheoran, Dinesh Kumar		
10	**CRSCIIWBRSIL 201501000191**	**Development of barley varieties and technologies for yield, biotic & abiotic stresses and quality**	**PL: Dr. AS Kharub**		
	CRSCIIWBRSIL 201501000191.1	Improvement of malt, feed, food and dual purpose barley for better yield, quality and biotic and abiotic stresses	**PI:** Dr. Vishnu Kumar **Co-PIs/Collaborators:** Drs Chuni Lal, Jogendra Singh, Lokendra Kumar, Sudheer Kumar, Dinesh Kumar, Rekha Malik, Poonam Jasrotia, Rinki	Nov, 2015	Oct, 2020
	CRSCIIWBRSIL 201501000191.2	Agronomic interventions for better yield and quality of barley changing climatic conditions	**PI:** Dr. Anil Khippal **Co-PIs/Collaborators:** Drs AS Kharub, Dinesh Kumar, Mamrutha HM, under Subhash Katare, Anuj Kumar, Ashwini Kumar (IARI-RS, Karnal)		
11	**CRSCIIWBRSIL 201501100192**	**Evaluation, Transfer and Impact Assessment of Wheat and Barley Production Technologies**	**PL: Dr. Satyavir Singh**		
	CRSCIIWBRSIL 201501100192.1	Diagnosis of zero tillage based rice- wheat system in Haryana	**PI:** Dr. Anuj Kumar **Co-PIs/Collaborators:** Drs Satyavir Singh, Sendhil R		
	CRSCIIWBRSIL 201501100192.2	Identifying yield gaps, resource use and adaptation strategies in vulnerable regions of wheat and barley production against climate change	PI: Dr. Sendhil R Co-PIs/Collaborators: Drs Satyavir Singh, Anuj Kumar, Ajit Kharub, Ankita Jha	Nov, 2015	Oct, 2020
12	**CRSCIIWBRSIL 201501200193**	**Use of GIS and statistical techniques for wheat & barley**	**PL: Dr. Ravish Chatrath**	Nov, 2015	Oct, 2020

	improvement in climate change scenario			
CRSCIIWBRSIL 201501200193.1	Biplot analysis for GxE interaction in wheat and barley trials	**PI:** Dr. Ajay Verma		
CRSCIIWBRSIL 201501200193.2	Impact of temperature variations on wheat yield and its Agro-climatic suitability assessment at different locations using GIS techniques	**PI:** Dr. Suman Lata **Co-PIs/Collaborators:** Drs Ankita Jha		
CRSCIIWBRSIL 201501200193.3	Design, development and maintainance of mobile application on barley crop information for farmers in Hindi	**PI:** Dr. Suman Lata **Co-PIs/Collaborators:** Dr. AS Kharub	Oct, 2017	Oct, 2019

*Sub-project

(B) Externally Funded projects:

SN	Title of the project	Associated scientists (PI and Co-PI) Date of completion	Collaborating centres (if any)	Funding Agency	Total budget (Rs in lakh)	Date of start	Date of completion
1	Mining alleles for heat tolerance of wheat in Australian and Indian environments	Dr. Ratan Tiwari (PI)	Punjab Agricultural University Ludhiana, ICAR-IIWBR, Karnal , Australian Centre for Plant Functional Genomics, University of Adelaide, Australia	DST, Govt. of India	18.56	Sept., 2015	Sept., 2017 (Completed)
2	Improvement of biscuit making quality of Indian wheats utilizing molecular approach – IInd Phase	Dr. Sewa Ram (PI)	ICAR-IIWBR	DBT, Govt. of India	40.17	March 2015	March.2018
3	Conservation agriculture for enhancing the productivity and profitability of wheat based system	Dr RK Sharma (PI)	CRIDA,IIFSRIISS, IARI,CIAE DWR,RCER CSSRI,CRRI IIWBR,NIASM	ICAR	40.00	Sept 2015	Sept., 2020
4	Induction of high biomass and yellow rust resistance through gamma radiations in wheat varieties HD2967 and WH1105through gamma radiations in wheat varieties HD2967 and WH1105	Dr. Satish Kumar (PI),	-	BRNS	25.05	Aug., 2017	Aug., 2020

5	Combining field phenotyping and next generation genetics to uncover markers, genes and biology underlying drought tolerance in wheat	Dr Pradeep Sharma (PI),	IIWBR Karnal, NIASM Baramati , RAR Station Durgapura (Rajasthan), CERW, SDAU Vijapur, University of Liverpool, Rothamsted Research I nstitute, Lancaster University.	DBT-BBSRC (CGAT)	147.11	Feb., 2015	Feb., 2018
6	Identification and characterization of terminal heat responsive microRNA in wheat	Dr Pradeep Sharma (PI),	IIWBR	LBSYSA challenging scheme by ICAR	30.0	May, 2016	May, 2019
7	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.	Dr. Sonia Sheoran (PI), Dr. Satish Kumar (Co-PI), Dr. Prem Lal Kashyap (Co-PI)	IIWBR IARI CSSRI JNKVV Powarkheda	ICAR (Incentivizing Research in Agriculture)	40.80	May 2015	March, 2020
8	Marker assisted breeding for drought tolerance	Dr. Gyanendra Singh (PI) Co-PI-Dr. BS Tyagi Dr. Sindhu Sareen Dr. Sonia Sheoran Dr. Vikas Gupta	IARI, New Delhi, CCS, University, Meerut	DBT	120.89	March,2018	March,2021
9	Phenotyping and genetic enhancement for tolerance to prioritized abiotic and biotic stresses in wheat	Dr Sindhu Sareen (PI), BS Tyagi (Co-PI)	IIWBR,Karnal JNKVV, Powarkheda MPKV, Akola UAS, Dharwad	ICAR (NICRA – Strategic Research Component)	44.50 for 2018-19	Jan. 2015	Jan.2020
10	Indo-UK Centre for the improvement of Nitrogen use Efficiency in Wheat (INEW)	Dr K Venkatesh (PI)	**Lead Centre:** ICAR-IIWBR, Karnal **Collaborating Centres:** IARI, New Delhi NRCPB, New Delhi NBPGR, New Delhi BISA, Ludhiana PAU, Ludhiana	Department of Biotechnology	850.66	June 2016	June 2019

11	Tribal-Sub-Plan (TSP) project on Improving the Socio-economic Condition and Livelihood of Tribes in India through Extension Education and Development Programmes	Dr.Satyavir Singh (PI) Dr.Anuj Kumar (Co-PI) Dr.Sendhil R (Co-PI)	IIWBR, Karnal. KVK, Leh MPUAT, Udaipur JNKVV, Jabalpur IGKVV, Bilaspur BAU, Ranchi UAS, Dharwad	Ministry of Agriculture and Farmers Welfare	11.50	2015	2020
12	Front Line Demonstrations on Wheat	Dr. Satyavir Singh (PI) Dr. Anuj Kumar (Co-PI) Dr. Sendhil R (Co-PI)	AICRP centres	Ministry of Agriculture and Farmers Welfare	54.00	Ongoing	-
13	Front Line Demonstrations on Barley	Dr. Satyavir Singh (PI) Dr. Anuj Kumar (Co-PI) Dr. Sendhil R (Co-PI)	AICRP centres	Ministry of Agriculture and Farmers Welfare	6.00	Ongoing	
14	DUS testing in wheat	Dr Arun Gupta	-	PPV&FRA , N. Delhi	11.50	Since 2013	Ongoing
15	DUS testing in barley	Dr Vishnu Kumar	-	PPV&FRA, N. Delhi	11.50	Since 2013	Ongoing
16	CRP Agrobiodiversity component wheat	Dr Arun Gupta	PAU Ludhiana, BHU Varanasi, ICAR-VPKAS Almora, GBPUA&T Pantnagar , IARI Regional Station Wellington, UBKVV Cooch Behar	ICAR-NBPGR, New Delhi	44.89	March 2014	March, 2018
17	CRP on Conservation Agriculture	Dr. RS Chhokar, (PI) Dr. RK Sharma (Co PI) Dr. SC Gill (Co-PI)	Lead Institute: ICAR-IISS, Bhopal	ICAR	80.00	July, 2015	June, 2020
18	Agri-CRP on water	Dr. RP Meena (PI) Dr. K.Venkatesh (Co PI) Dr.Rinki (Co-PI)	-	ICAR	38.3	July, 2015	June, 2020
19	Seed Project: Seed production in agricultural crops and fisheries	Dr. Raj Kumar (PI), Dr. Amit Sharma (Co-PI)	IISS. MAU	ICAR	15.39	March,2008	March, 2020

(C) Foreign Funded Projects:

SN	Title of the project	Associated scientists (PI and Co-PI)	Collaborating centres (if any)	Funding Agency	Total budget (Rs)	Date of start	Date of completion
1	Biofortification of wheat	Dr. Ravish Chatrath (PI) and Dr.Vikas Gupta (Co-PI)	IIWBR Karnal, IARI New Delhi	Harvest Plus / IFPRI	127.40	Aug., 2013	Dec., 2018
2	Exploitation of inter-specific biodiversity for wheat improvement	Dr. BS Tyagi (PI), Dr. Sindhu Sareen (Co-PI) Dr. Gyanendra Singh (Co-PI)	IIWBR Karnal, ARI Pune, University of Nottingham UK	DBT-BBSRC-DFID and BMGF joint call under SCRPID	211.00	Feb.2013	Dec. 2017
3	Development of Heat Tolerant Wheat for South Asia	Dr. Sindhu Sareen (PI), Dr. Rinki (Co-PI)	IIWBR Karnal, NBPGR New Delhi CCSHAU Hisar	CIMMYT	222.24	Jan, 2014	Dec. 2017
4	Combining field phenotyping and next generation to genetics to uncover markers, genes and biology underlying drought tolerance in wheat	Dr Pradeep Sharma (PI), Dr. BS Tyagi (Co-PI) Dr. Mamrutha HM (Co-PI)	IIWBR Karnal, NIABM Baramati, RAR Station Durgapura, SDAU-WRS Vijapur	DBT (DBT-BBSRC joint call under CGAT (Crop Genomics (Crop Genomics	144.00	Feb., 2015	Jan., 2018
5	Mitigating the effects of stripe rust on wheat production in South Asia and eastern Africa	Dr. Ravish Chatrath (PI) Dr. SC Bhardwaj (Co-PI)	IIWBR, Karnal & RS Shimla	ACIAR	104.91	July, 2016	June ,2020

(D) Contract Research Projects:

S. N.	Project name	Project Code	Project Leader	Funding Agency	Budget (Rs)	Period
1	Efficacy of F3830 herbicide in rice	DWR/CRP/RM 52	Dr RS Chhokar	FMC India Pvt. Limited	6.80 lakh	2017-18
2	Evaluation of Epivio Energy (product of natural origin) for use in Corn as seed treatment for plant growth and yield enhancement	DWR/CRP/RM-53	Dr SC Gill	Syngenta India Pvt. Ltd.,	1.0 lakh	2017-18

3	Evaluation of Pinoxaden 5.1% EC against grassy weeds in Wheat	IIWBR/CRP/RM-54	Dr RS Chhokar	FMC India Pvt. Ltd.,	1.60 lakh	2017-18
4	Herbicide resistance detection in Phalaris minor using RISQ	IIWBR/CRP/RM-55	Dr RS Chhokar	Syngenta India Ltd.	4.0 lakh	2017-18
5	Efficasy of new herbicides against weeds in wheat	IIWBR/CRP/RM-56	Dr RS Chhokar	FMC India Ltd.	4.72 lakh	2017-18
6	Bio-efficasy of pyroxasulfone 50g/l + pendimethalin 400 g/l ZC (BAS 822 01H) against weeds in wheat	IIWBR/CRP/RM-57	Dr RS Chhokar	BASF India Ltd.	4.72 lakh	2017-18
7	Efficacy of Halauxifen-methyl 1.21% + Fluroxypyr methyl 38.9% w/w EC for broad-leaf weed control in wheat	IIWBR/CRP/RM-58	Dr RS Chhokar	Dow Agro Science India Pvt. Ltd.	4.72 lakh	2017-18
8	Efficacy of Tebuconazole 50% + Triflorystrobin 2S% WG on wheat against wheat blast like disease in West Bengal	DWR/CRP/CP/26	Dr. D. P. Singh	Bayer Crop Science Limited	16.82 lakh	2017-19
9	Evaluation of bioefficacy and phytotoxicity of Mefentrifluconazole 200 f Pyraclostrobin 200 g/l SC against Yellow rust and Powdery mildew diseases of wheat	DWR/CRP/CP/27	Dr. Sudheer Kumar	BASF India Limited,	5.82lakh	2017-19
10	Evaluation of bioefficacy and phytotoxicrty of Fluxapyroxad 167 gfl + Pyraclostrobin 333 g/ l against yellow rust and spot blotch disease of wheat	DWR/CRP/CP/28	Dr. Prem Lal Kashyap	BASF India Limited	5.74 lakh	2017-19

11	Evaluation of bio-efficacy of Thiamethoxam 75%S G against termites (Odontotermeso besus and, Microtermesobesi) in wheat	DWR/CRP/CP/29	Dr. Poonam Jasrotia	Syngenta, Crop Protection (North)	4.41lakh	2017-19
12	Evaluation of bio-efficacy of Thiamethoxam 12.60/0 + Lambda cyhalothrin 9.5% Z C against foliar aphids (Rhaphalosiphummaidis and Sitobion avenae) in wheat	DWR/CRP/CP/30	Dr. Poonam Jasrotia	Syngenta, Crop Protection (North)	4.40 lakh	2017-19
13	Evaluation of Azoxystrobin 7.5% Propiconazole + 12.5% SE against Stripe rust / Yellow rust (Pucciniastriiformisf.sp. tritici) disease in Wheat	DWR/CRP/CP/31	Dr. D. P. Singh	ADAMA- India Private Limited (Formerly known as Makhteshim -Agan India Pvt. Ltd.)	6.22 lakh	2017-19

16 PUBLICATIONS

Research Papers in Journals

Arya, V. K., Kumar, P., Singh, J., Kumar, L., & Sharma, A. K. (2018). Genetic analysis of some yield and quality traits in bread wheat (*Triticum aestivum L.*). Journal of Wheat Research, 10(1), 25–32.

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Gahlaut, V., Jaiswal, V., Tyagi, B. S., Singh, G., Sareen, S., Balyan, H. S., & Gupta, P. K. (2017). QTL mapping for nine drought-responsive agronomic traits in bread wheat under irrigated and rain-fed environments. PLOS ONE, 12(8), e0182857. https://doi.org/10.1371/journal.pone.0182857

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17 हिन्दी कार्यक्रमों पर रिपोर्ट

वर्ष 2017–18 के दौरान भा.कृ.अनु.प.–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल के हिन्दी अनुभाग द्वारा अनेकों कार्यक्रम आयोजित किये गए जिसका संक्षिप्त विवरण नीचे दिया जा रहा है।

1. **राजभाषा कार्यान्वयन समिति की चार तिमाही बैठकें :** इस संस्थान की राजभाषा कार्यान्वयन समिति की चार तिमाही बैठकें (दिनांक 24.05.2017, 18.08.2017, 29.12.2017 तथा 23.03.2018) को 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।

2. **राजभाषा उत्सव एवं हिन्दी पखवाड़ा :** संस्थान में राजभाषा उत्सव एवं हिन्दी पखवाड़े का आयोजन (01–15 सितंबर, 2017) के दौरान किया गया। इस दौरान विभिन्न प्रतियोगिताओं का आयोजन किया गया जिसमें संस्थान के सभी अधिकारियों/कर्मचारियों ने भाग लिया। विजेताओं को ''हिन्दी दिवस'' के अवसर पर दिनांक 14.9.2017 को मुख्य अतिथि के रुप में आए डॉ. विनोद कुमार पंडिता, अध्यक्ष,भा.कृ.अनु.प–भारतीय कृषि अनुसंधान संस्थान करनाल द्वारा सम्मानित किया गया। दिनांक 12.09.2017 को नराकास स्तर पर **''खुला मंच क्या सोशल मीडिया खोखले समाज का निमार्ण कर रहा है?''** प्रतियोगिता का आयोजन किया गया जिसमें सभी केन्द्र सरकार के कार्यालय, राष्ट्रीयकृत बैंक, उपक्रम, निगम, विश्वविद्यालय एवं संस्थान के अधिकारियों/कर्मचारियों ने भाग लिया।

3. गेहूँ एवं जौ स्वर्णिमा के आठवें अंक में प्रकाशित **''भारत में हाईटेक एग्रीकल्चर की संभावनाएं''** (जे. के. पाण्डेय एवं अनुज कुमार,) तथा **''कृषि में आधुनिक तकनीकी प्रयोग से कम लागत में अधिक आय''** (सचिन कुमार, भूदेव सिंह त्यागी, ज्ञानेन्द्र सिंह, आशीष ओझा एवं मधु कुमारी) 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।

4. किसानों के लिए एक छःमाही पत्रिका गेहूँ एवं जौ संदेश का समयबद्ध प्रकाशन किया जा रहा है। साथ ही संस्थान द्वारा हिन्दी में विस्तार बुलेटिन, विस्तार कार्ड व अन्य प्रकाशन समय–समय पर किए जा रहे हैं।

हिन्दी कार्यशालाओं का आयोजन : वर्ष 2017 के दौरान संस्थान में कुल चार कार्यशालाओं का आयोजन किया गया।

(1) **''सड़क सुरक्षा और नागरिक दायित्व''** विषय पर दिनांक 04.01.2017 को एक दिवसीय कार्यशाला का आयोजन किया गया।

(2) **''पैतृकता : प्यार का श्रम''** विषय पर दिनांक 17.03.17 को एक दिवसीय कार्यशाला का आयोजन किया गया जिसमें मुख्य वक्ता श्रीमती मधु सूरी, शिक्षा सलाहकार, श्री राम एजुकेशन ट्रस्ट थी।

(3) **''हिन्दी में काम करना कितना सरल''** विषय पर दिनांक 14.09.2017 को हिन्दी दिवस के अवसर पर एक दिवसीय कार्यशाला आयोजित किया गया।

(4) **''कृषि शिक्षा दिवस''** के अवसर पर दिनांक 03.12.2017 को एक दिवसीय कार्यशाला का आयोजन किया गया जिसमें स्कूल के बच्चों में कृषि के प्रति रूझान बढ़ाने व भविष्य में इस व्यवसाय के रूप में अपनाने के लिए प्रेरित किया गया।

नराकास बैठकों में भागीदारी

- नराकास, करनाल की पहली समीक्षा बैठक 17.06.2017 को राष्ट्रीय डेरी अुनसंधान संस्थान, करनाल आयोजित हुई जिसमें संस्थान का प्रतिनिधित्व डॉ. आर.के. गुप्ता, एवं डॉ. अनुज कुमार ने किया।

राजभाषा उत्सव एवं हिन्दी पखवाड़ा के दौरान आयोजित विभिन्न प्रतियोगताओं के विजेता

विजेताओं के नाम	वर्ग	प्रतियोगिता का नाम	दिनांक
श्रीमती सुमन थापा	कुशल सहायक कर्मचारी वर्ग	श्रुत लेख	प्रथम पुरस्कार
श्री यशवंत सिंह			द्वितीय पुरस्कार
श्री अमन कुमार			तृतीय पुरस्कार
श्री हरिन्द्र कुमार			प्रोत्साहन पुरस्कार
डॉ. ज्ञानेंन्द्र सिंह	वैज्ञानिक वर्ग	आशुभाषण	प्रथम पुरस्कार
डॉ. सोनिया श्योरान			द्वितीय पुरस्कार
डॉ. पी. एल. कश्यप			तृतीय पुरस्कार
डॉ. मामृता एच.एम.			प्रोत्साहन
श्री सुनील कुमार	प्रशासनिक वर्ग	निबंध लेखन	प्रथम पुरस्कार
श्रीमती प्रोमिला वर्मा			द्वितीय पुरस्कार
श्री कृष्ण पाल			तृतीय पुरस्कार
श्री नरेश कुमार			प्रोत्साहन पुरस्कार
श्री ओम प्रकाश	तकनीकी वर्ग	वाद–विवाद	प्रथम पुरस्कार
श्री रामकुमार सिंह			द्वितीय पुरस्कार
श्री सुरेन्द्र सिंह			तृतीय पुरस्कार
श्री राजेन्द्र कुमार			प्रोत्साहन पुरस्कार
श्री जे. के. पाण्डेय	सभी वर्ग	भाषण	प्रथम पुरस्कार
डॉ. विष्णु गोयल			द्वितीय पुरस्कार
श्री ओम प्रकाश			तृतीय पुरस्कार
श्री राम कुमार सिंह			प्रोत्साहन पुरस्कार
डॉ. देवेन्द्र पाल सिंह, डॉ. सुधीर कुमार, एवं डॉ. प्रेम लाल कश्यप	सभी वर्ग	पोस्टर प्रदर्शनी	प्रथम पुरस्कार

श्री सुरेन्द्र पॉल, डॉ.रतन तिवारी, डॉ. आर. बी. सिंह, डॉ. निशु राघव,डॉ. रूचिका शर्मा श्री धीरज राणा, एवं डॉ. सुशमा कुमारी पंवार			द्वितीय पुरस्कार
डॉ. अनुज कुमार, डॉ. सत्यवीर सिंह,डॉ. सेन्धिल आर. एवं श्री जे. के. पाण्डेय			तृतीय पुरस्कार
श्री विकास जून, श्रीमती ममता काजला, डॉ. आर. एस. छोकर, श्री रामकुमार सिंह एवं डॉ आर. के. शर्मा			प्रोत्साहन पुरस्कार
रजनी सिंह, डॉ. रामबरन सिंह, तुषार खंडाले, गीता शर्मा, डॉ. विपिन मलिक, डॉ. वनिता पाण्डेय, डॉ. स्नेह नरवाल एवं डॉ. सेवा राम			प्रोत्साहन पुरस्कार
डॉ. सोनिया श्योरान, एवं डॉ. सुषमा कुमारी पवार			प्रोत्साहन पुरस्कार
डॉ. सत्यवीर सिंह	सभी विभागाध्यक्ष	हिन्दी में पावर प्वाईंट स्लाईड की प्रस्तुति	प्रथम पुरस्कार
डॉ स्नेह नरवाल			द्वितीय पुरस्कार
डॉ विनोद तिवारी			तृतीय पुरस्कार
डॉ डी.पी. सिंह			प्रोत्साहन पुरस्कार
डॉ रतन तिवारी	नराकास स्तर पर	खुला मंच	प्रथम पुरस्कार
श्री जे.के. पाण्डेय			द्वितीय पुरस्कार
डॉ विष्णु गोयल			तृतीय पुरस्कार
डॉ डी.पी. सिंह			प्रोत्साहन पुरस्कार

उत्कृष्ट कर्मचारी पुरस्कार योजना के अन्तर्गत पुरस्कृत कर्मचारी एवं अधिकारी

वर्ग	कर्मचारी का नाम व पदनाम	पुरस्कार
प्रशासनिक वर्ग	श्रीमती सुशीला, प्रवर श्रेणी लिपीक	प्रथम पुरस्कार
	श्री कृष्ण पाल, सहायक	प्रथम पुरस्कार
	श्री सुनील कुमार, सहायक	द्वितीय पुरस्कार
	श्री सुनील, अवर श्रेणी लिपीक	द्वितीय पुरस्कार
तकनीकी वर्ग	श्री जे.के. पाण्डेय, मुख्य तकनीकी अधिकारी	तृतीय पुरस्कार
वैज्ञानिक वर्ग	डॉ. डी.पी. सिंह, प्रधान वैज्ञानिक एवं प्रमुख अन्वेशक, फसल सुरक्षा	तृतीय पुरस्कार

- नगर राजभाषा कार्यान्वयन समिति, करनाल द्वारा आयोजित की गई वर्ष 2016–17 की राजभाषा पुरस्कार प्रतियोगिता में भा.कृ.अनु.प–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल को राजभाषा में उल्लेखनीय कार्य हेतु द्वितीय पुरस्कार से सम्मानित किया गया। यह पुरस्कार संस्थान के कार्यकारी निदेशक डॉ. आर.के गुप्ता व राजभाषा अधिकारी डॉ. अनुज कुमार ने ग्रहण किया।
- नराकास की दूसरी समीक्षा बैठक का आयोजन 19.11.2017 को राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल में हुआ। इस बैठक में संस्थान के निदेशक डॉ. जी.पी सिंह व सहायक राजभाषा अधिकारी श्री जे.के पाण्डेय ने भाग लिया।

18 PERSONNEL

Director Cell

Dr. GP Singh, Director

Smt. Gian Aneja, PS to Director

Crop Improvement

Scientific Staff

Dr Ravish Chatrath, PI & Pr. Scientist

Dr. Gyanendra Singh, Pr. Scientist

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. Rekha Malik, Pr. Scientist

Dr. Rajender Singh, Pr. Scientist

Dr. Sanjay Kumar Singh, Pr. Scientist

Dr. Lokendra Kumar, Pr. Scientist

Dr. Pradeep Sharma, Pr. Scientist

Dr. Amit Kumar Sharma, Sr. Scientist

Dr. Sonia Sheoran, Sr. Scientist

Dr. Hanif Khan, Sr. Scientist

Dr Satish Kumar, Scientist,

Dr. Charan Singh, Scientist

Dr. CN Mishra, Scientist

Dr. Karnam Venkatesh, Scientist

Dr. Mamrutha HM, Scientist

Dr. Vikas Gupta, Scientist

Dr. Rinki, Scientist

Dr. Gopalareddy K, Scientist

Technical Staff

Dr. BK Meena, Assistant Chief Tech. Officer

Sh. Surendra Singh, Assistant Chief Tech. Officer

Sh. Surendra Singh, Assistant Chief Tech. Officer

Sh. Yogesh Kumar, Assistant Chief Tech. Officer

Sh. Om Prakash , Tech. Officer

Sh. Suresh Kumar ,Tech. Officer

Sh. Rahul Singh , Sr. Technical Assistant

Sh. Ronak Ram , Sr. Technical Assistant

Supporting Staff

Sh. Ramesh Pal , Skilled Supporting Staff

Sh. Aman Kumar, Skilled Supporting Staff

Smt. Amresh, Skilled Supporting Staff

Crop Protection

Scientific staff

Dr. DP Singh, Pr. Investigator & Pr. Scientist

Dr. Sudheer Kumar, Pr. Scientist

Dr. Poonam Jasrotia, Senior Scientist

Dr. Prem Lal Kashyap, Scientist

Technical Staff

Sh. Ishwar Singh Barman, Tech. Officer

Smt. Hemlata, Personal Assistant

Resource Management

Scientific staff

Dr. RK Sharma, PI & Pr. Scientist

Dr. SC Tripathi, Pr. Scientist

Dr. SC Gill, Pr. Scientist

Dr. RS Chhokar, Pr. Scientist

Dr. Raj Pal Meena, Sr. Scientist

Dr. Ankita Jha, Scientist

Technical Staff

Sh. Ram Kumar Singh, Assistant Chief Tech. Officer

Sh. PHP Verma , Assistant Chief Tech. Officer

Sh. Rajender Pal Sharma , Sr. Tech. Officer

Sh. Rajesh Kumar , Sr. Tech. Officer

Sh. Ishwar Singh, Sr. Tech. Assistant

Sh. Sukh Ram ,Tech. Assistant

Quality & Basic Sciences

Scientific staff

Dr. Sewa Ram, Pr. Investigator & Pr. Scientist

Dr. Sneh Narwal, Pr. Scientist

Dr. OP Gupta, Scientist

Dr. Vanita Pandey, Scientist

Technical Staff

Smt. Sunita Jaswal, Sr. Tech. Officer

Smt. Jamuna Devi, Sr. Tech. Assistant

Supporting Staff

Sh. Desh Raj, Skilled Supporting Staff

Social Science

Scientific staff

Dr. Satyavir Singh, Pr. Investigator & Pr. Scientist

Dr. Anuj Kumar, Pr. Scientist

Dr. Sendhil R, Scientist

Technical Staff

Sh. JK Pandey , Chief Technical Officer

Dr. Mangal Singh , Assistant Chief Tech. Officer

Sh. Rajender Kumar Sharma, Technical Officer

Supporting Staff

Sh. Paramjeet Singh, Skilled Supporting Staff

Barley Improvement

Scientific staff

Dr. AS Kharub, Pr. Scientist

Dr. Chuni Lal, Pr. Scientist

Dr. Dinesh Kumar, Pr. Scientist

Dr. Anil Khippal, Pr. Scientist

Dr. Vishnu Kumar, Scientist

Technical Staff

Sh. Sant Kumar, Assistant Chief Tech. Officer

Sh. Ravinder Singh, Assistant Chief Tech. Officer

Supporting Staff

Sh. Rampal Saini , Skilled Supporting Staff

Computer Science and Statistics

Scientific staff

Dr. Ajay Verma , Pr. Scientist & In-charge

Dr. Suman Lata, Pr. Scientist

Technical Staff

Sh. P. Chandrababu, Assistant Chief Tech. Officer

Supporting Staff

Sh. Bhim Sain , Skilled Supporting Staff

PME Cell

Dr.Poonam Jasrotia, Sr. Scientist & In-Charge

Sh. Yogesh Sharma, Assistant Chief Tech. Officer

Administration

Sh. Sachin Agnihotri , Sr. Administrative Officer

Sh. Anil Kumar , AAO

Sh. Ramesh Kumar , AAO

Smt. Promila Verma , Assistant

Sh. Sunil Kumar, Assistant

Smt. Sushila , UDC

Sh. Sunil Kumar, LDC

Sh. Naresh Kumar, LDC

Sh. Guman Singh , Skilled Supporting Staff

Smt. Shanti Devi , Skilled Supporting Staff

Accounts & Audit Section

Sh. Jagdish Chander, Finance & Accounts Officer

Sh. Ashok Kumar Kathuria , Assistant Finance & Accounts Officer

Sh. Krishan Pal, Assistant

Sh. Ramesh Chand, UDC

Smt. Suman Thapa , Skilled Supporting Staff

Sh. Harinder Kumar , Skilled Supporting Staff

Sh. Ramu Shah, Skilled Supporting Staff

Library

Dr. RS Chhokar, Pr. Scientist & Incharge

Sh. Abhay Nagar, ACTO

Landscape Section

Sh. Rajender Kumar Sharma, TO & In-Charge

Sh. Hawa Singh, Skilled Supporting Staff

Sh. Biru Ram , Skilled Supporting Staff

Farm Section

Dr. SC Tripathi, Pr. Scientist & In-Charge

Sh. Madan Lal , Farm Manager

Sh. Raj Kumar, Farm Manager (New Farm)

Sh. Raj Kumar, Skilled Supporting Staff

Vehicle Section

Sh. Abhay Nagar, ACTO

Sh. Kehar Singh, Sr. Tech. Assistant

Sh. Ram Jawari, Tech. Assistant

Sh. Om Singh, Tech. Assistant

Sh. Rajbir Singh, Tech. Assistant

Sh. Sunder Lal, Tech. Assistant

Sh. Vinod Kumar, Sr. Technician

Sh. Rajbir Singh, Technician

Regional Station, Flowerdel, Shimla (HP)

Scientific staff

Dr. SC Bhardwaj, Pr. Scientist & In Charge

Dr. OP Gangwar, Scientist

Dr. Pramod Prasad, Scientist

Technical Staff

Dr. OP Dhillon, Assistant Chief Tech. Officer

Dr. Subodh Kumar, Assistant Chief Tech. Officer

Sh. Baldev Singh, Sr. Technical Assistant.

Sh. Sawroop Chand, Sr. Technician

Administrative Staff

Smt. Shanti Devi, Assistant Administrative Officer

Sh. Roop Ram, Personal Assistant

Sh. Anil Kumar, LDC

Supporting Staff

Sh. Sant Ram, Skilled Supporting Staff

Sh. Bhoop Ram, Skilled Supporting Staff

Sh. Khem Chand, Skilled Supporting Staff

Regional Station,Dalang Maidan, Lahaul & Spiti

Dr. CN Mishra, Scientist & In-Charge

Sh. Nand Lal , Sr. Technical Officer

Seed & Research Farm, Hisar

Scientific staff

Dr. Jogendra Singh, Pr. Scientist & In-Charge

Technical Staff

Dr. Rajendra Kumar, Sr. Technical Officer

Sh. Bhal Singh, Sr. Technical Assistant

Administrative Staff

Sh. Mahabir Singh, UDC

19 STAFF POSITION & FINANCE

(Staff Strength as on 31.03.2018)

Scientific Staff

Place	Designation	Sanctioned	Filled	Vacant
ICAR-IIWBR, Karnal	Director	1	1	-
	Principal Scientist	6	3	3
	Senior Scientist	10	6	4
	Scientist	29	33	(-4)
	Sub-total	**46**	**43**	**(3)**
Barley Unit, Karnal	Principal Scientist	1	1	-
	Senior Scientist	1	3	(-2)
	Scientist	7	4	3
	Sub-total	**9**	**8**	**(1)**
IIWBR Regional Station, Shimla	Principal Scientist	1	-	1
	Scientist	4	3	1
	Sub-total	**5**	**3**	**(2)**
IIWBR Regional Centre,	Scientist	2	-	2
Dalang Maidan, Lahaul Spiti	**Sub-total**	**2**	**-**	**2**
	Grand Total	**61+1**	**53+1**	**8**

Administrative Staff

Place	Designation	Sanctioned	Filled	Vacant
ICAR-IIWBR, Karnal	SAO	1	1	-
	AAO	3	2	1
	FAO	1	1	-
	AF&AO	1	1	-
	Assistant	7	3	4
	UDC	3	3	-
	LDC	5	2	3
	PS	1	1	-
	PA	1	1	-
	Steno gr.III	1	-	1
	Sub-total	24	15	7
IIWBR Regional Station, Shimla	PA	1	1	-
	LDC	--	1	-1
	Sub-total	1	2	-1
	Grand Total	**25**	**17**	**8**

Technical Staff

Place	Designation	Sanctioned	Filled	Vacant
ICAR-IIWBR, Karnal	T-3(Cat.II)	19	16	3
	T-1(Cat.I)	23	21	2
	Sub total	**42**	**37**	**5**
IIWBR Regional Station, Shimla	T-3(Cat-II)	2	2	-
	T-1(Cat-I)	3	2	1
	Sub total	**5**	**4**	**1**
IIWBR Regional Centre,	T-1 (Cat-I)	1	1	-
Dalang Maidan, Lahaul Spiti	**Sub total**	**1**	**1**	**-**
	Grand Total	**48**	**42**	**6**

Skilled Supporting Staff

Place	Designation	Sanctioned	Filled	Vacant
ICAR-IIWBR, Karnal	SSS	20	15	5
IIWBR Regional Station, Shimla	SSS	11	3	8
IIWBR Regional Centre, Dalang Maidan, (Lahaul Spiti)	SSS	2	-	2
	Grand Total	**33**	**18**	**15**

Summary

Cadre	Sanctioned posts	Filled posts	Vacant posts
Director	1	1	0
Scientific	61	53	8
Administrative	25	18	7
Technical	48	42	6
Skilled Supporting Staff	33	18	15
Total Staff	**168**	**132**	**36**

Budget Allocation and Expenditure (2017-18)

Name of Scheme	Total RE 2017-18	Total Release Upto 31.03.18	Total Expenditure upto 31.03.18	Exp. In % against RE	Exp. In % against Release
ICAR-IIWBR	2979.00	2979.00	2978.77	99.99	99.99

PLAN (Rs. in Lakhs)

Name of Scheme	HEAD	R.E. 2017-18	EXPENDITURE Other than NEH & TSP	TSP	NEH	TOTAL EXP.	Exp. In % against BE
ICAR-IIWBR, Karnal	Grants in Aid - Capital	323.00	322.99	0	0	322.99	100.00
	Grants in Aid - Salaries	1585.00	1584.88	0	0	1585	99.99
	Grants in Aid - General	1071.00	1065.90	5.00	0	1070.90	99.99
Sub-Total		**2979.00**	**2973.77**	**5.00**	**0.00**	**2978.77**	**99.99**
AICRP on Wheat & Barley, Karnal	Grants in Aid - Capital	0.00	0.00	0	0	0.00	0.00
	Grants in Aid - Salaries	1840.00	1800.00	0	40.00	1840.00	100.00
	Grants in Aid - General	147.00	140.00	2.00	5.00	147.00	100.00
	Sub-Total	**1987.00**	**1940.00**	**2.00**	**45.00**	**1987.00**	**100.00**
	Grand Total	**4966.00**	**4913.77**	**7.00**	**45.00**	**4965.77**	**100.00**

20 JOINING, PROMOTIONS, TRANSFERS AND RETIREMENTS

New Joining:

Sh. Sachin Agnihotri, SAO joined ICAR-IIWBR, Karnal on 05.04.2017 on account of his transfer from ICAR-CICR, Nagpur

Sh. Kehar Singh, STA joined ICAR-IIWBR, Karnal on 07.04.2017 on account of his transfer from ICAR-CPRI, RS Modipuram, Meerut (UP)

Dr. O.P. Ahlawat, Pr. Scientist (Ag. Biotechnology) joined ICAR-IIWBR, Karnal on 20.07.2017 on account of his transfer from ICAR-Directorate of Mushroom Research, Solan (HP).

Sh. Ram Pal Saini, SSS joined ICAR-IIWBR, Karnal on 10.01.2018 on account of his transfer from ICAR-NDRI, Karnal

Transfer:

Sh. Jaspal Singh, got promoted as Administrative Officer to join at CPRI, Shimla. He was relieved off from duties at Regional Station, ICAR-IIWBR, Shimla on 23rd Dec.2017.

Dr. Siddanna Savadi, Scientist, was transferred to ICAR-Directorate of Cashew Research, Puttur, Karnataka. He was relieved from his duties at Regional Station, ICAR-IIWBR, Shimla on 21st July, 2017.

Promotions:

Scientists:

Dr. Charan Singh, Scientist promoted from RGP 6000 to RGP 7000.

Dr.Vikas Gupta, Scientist promoted from RGP 6000 to RGP 7000.

Dr. Om Prakash Gupta, Scientist promoted from RGP 6000 to RGP 7000

Dr.Hanif Khan, Scientist promoted from RGP 7000 to Sr.Scientist RGP 8000

Dr. Sonia Sheoran, Scientist promoted from RGP 7000 to Sr.Scientist RGP 8000

Dr. Raj Pal Meena, Sr. Scientist promoted from RGP 8000 to Sr.Scientist RGP 9000

Technical:

Dr. Subodh Kumar STO promoted as ACTO

Sh. P. Chandrababu STO promoted as ACTO

Administration:

Sh. Ramesh Kumar, Assistant promoted as AAO

Sh. Ramesh Chand, UDC was granted MACP.

Retirements:

1. Sh Abhay Ram (TA) superannuated from service on 30th Apr,2017
2. Sh Uday Singh Thakur (STA) superannuated from service on 30th Apr, 2017
3. Sh Hari Prasad (SSS) superannuated from service on 30th Jun,2017
4. Dr SB Singh (CTO) superannuated on 31st July, 2017
5. Dr Devender Mohan (Pr. Scientist, Plant Breeding) superannuated from service on 31st Jul, 2017
6. Dr RK Gupta (PI, Quality) superannuated from service on retired on 28th Feb, 2018
7. Dr Vinod Tivari (PI, Crop Improvement) superannuated from service on 28th Feb, 2018
8. Sh Nandan Singh (SSS) superannuated from service on 31st March,2018

Obituary:

1. Sh Yashvant Singh, Skilled Supporting Staff, suddenly demised on 13.01.2018.The ICAR-IIWBR Family pays homage and prays almighty for heavenly peace of the departed soul.


"Research Advisory Committee Meeting"
Welcome
Chairman
&
Members
April 7-8, 2017
ICAR-IIWBR, Karnal

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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करनाल – 132001, भारत

ICAR-Indian Institute of Wheat and Barley Research

Karnal-132001, India