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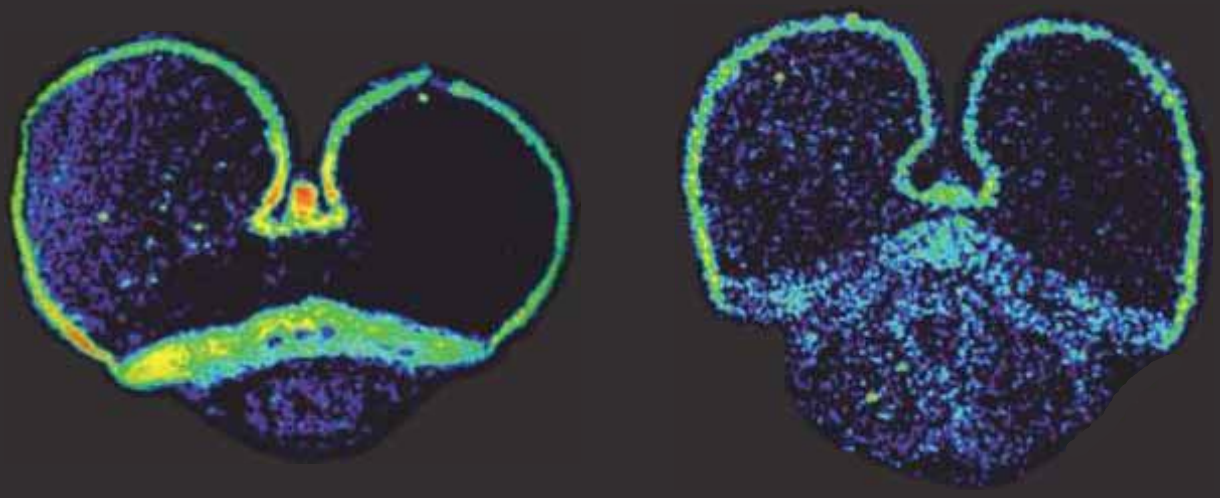
FOUNDATION YEAR 2010-2011



राष्ट्रीय कृषि-खाद्य जैव प्रोद्योगिकी संस्थान

National Agri-Food Biotechnology Institute

(An Autonomous Institute of Department of Biotechnology, Government of India)

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Publication Committee:
Dr. Ajay K. Pandey
Sh. Shrikant Mantri
Dr. Kanthi K. Kiran

Cover Page Layout:
Dr. Sudhir P. Singh
Dr. Kanthi K. Kiran

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Figure on Cover:
The cover page portrays localization of iron in transverse section of *Aegilops kotschyi* (Left) and *Triticum aestivum* (Right) wheat grain by micro-PIXE (micro-Proton Induced X-ray Emission). The picture shows most of the iron localized in aleurone (details of this study is given on page 13 to 15).

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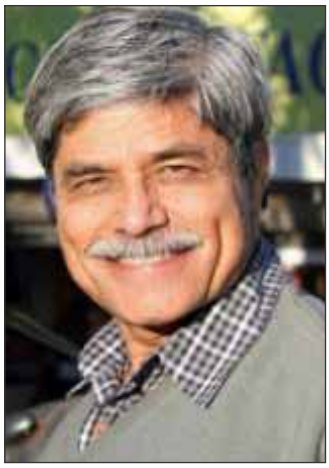
C-127, Industrial Area, Phase 8, S.A.S. Nagar, Mohali, Punjab, India - 160071
EPABX: +91-172-2290100, Fax: 0172-4604888
Website : www.nabi.res.in

CONTENTS

कार्यपालक निदेशक की कलम से

पंजाब राज्य में कृषि-खाद्य क्षेत्र में नए राष्ट्रीय संस्थान की स्थापना से देश को खाद्य क्षेत्र में असीमित अवसर प्राप्त होंगे। राष्ट्रीय महत्त्व के इस क्षेत्र की अनेक अपेक्षाओं का पूरा करना संस्थान के संस्थापक निदेशक, संकाय सदस्यों एवं स्टाफ कर्मियों के लिए एक बड़ा कार्य है। राष्ट्रीय कृषि-खाद्य जैवप्रौद्योगिकी संस्थान (नाबी) से बहुत बड़ी अपेक्षाएं हैं। यह देश में विकसित किया जा रहा पहला पादप विज्ञान संस्थान है, जिसका अधिदेश तीन प्रमुख क्षेत्रों यथा कृषि, खाद्य एवं पौष्टिक आहारों में है। साथ ही यह विकसित किया जा रहा एक ऐसा मॉडल है, जहां नवाचार से लेकर उद्यमिता विकास के लिए कृषि-खाद्य क्षेत्र की संपूर्ण श्रृंखला में सहयोग स्थापित करने के लिए संस्थानों का एक समूह विकसित किया जाएगा।

केन्द्रीय मंत्रीमंडल ने नाबी के साथ-साथ जैव प्रौद्योगिकी विभाग (डीबीटी) के एक अन्य स्वायत्तशासी संस्थान जैवप्रक्रमण यूनिट (बीपीयू) की स्थापना को अनुमोदन प्रदान किया। यह दोनों ही संस्थान मोहाली में 50 एकड़ भूमि में सह-स्थित हैं। संस्थानों का सामूहिक परिसर का कृषि-खाद्य पार्क के साथ योग्यतम उपयोग किया जाएगा, जिससे कि एक ही स्थान पर सृजक एवं ज्ञान के उपयोगकर्ता आपस में मिलकर कार्य कर सकें। डीबीटी द्वारा दिए गए सक्रिय सहयोग के फलस्वरूप अन्य दो घटकों से पहले ही नाबी की स्थापना हो गई और यह अंतरिम सुविधाओं के साथ 18 फरवरी, 2010 से कार्य कर रहा है। नाबी की स्थापना एवं कार्यों का विवरण इस स्थापना दिवस रिपोर्ट में दिया गया है और यह संस्थान के इतिहास में दर्ज होगा। नाबी को कृषि जैवप्रौद्योगिकी; खाद्य प्रक्रमण एवं पौष्टिक आहारों के क्षेत्र में प्रतियोगी अनुसंधान एवं नवाचार के लिए विश्व स्तरीय संस्थाना बनना है। प्रांरभ में बीपीयू एक अनुकरणीय अनुसंधान संस्थान होगा। यह उद्योगों को जैव प्रक्रमण समाधान उपलब्ध करवाने के लिए 'बिना लाभ वाली' एक कंपनी के रूप में कार्य करेगा। कृषि-खाद्य पार्क कॉरपोरेट रूप में कार्य करते हुए उद्यमिता को उत्प्रेरित एवं सुदृढ़ बनाने के लिए प्रौद्योगिकी एवं पारिस्थितिकी उपलब्ध करवाएंगे।



आसपास स्थापित अन्य संस्थानों में इंडियन इंस्टिट्यूट ऑफ साइंस एड्यूकेशन एंड रिसर्च; इंडियन स्कूल ऑफ बिजनेस ; इंस्ट्टियूट ऑफ नैनो साइंस एंड टैक्नोलॉजी तथा पंजाब बायोटैक्नोलॉजी इन्क्यूबेटर होंगे। यह समूह को अधिक संपूर्ण एवं पोषणक्षम मॉडल बनाएगा तथा इससे कृषि-खाद्य क्षेत्र का मूल्य संवर्धन होगा। नाबी का अधिदेश समुचित एवं स्वस्थ खाद्य पदार्थों के लिए बीजों की खोज एवं प्रक्रमण-आधारित समाधान उपलब्ध करवाना है। इस पहुंच को समुचित बनाने के लक्ष्य की प्राप्ति खाद्य फसलों की पैदावार को बढ़ाकर, न्यूनतम भूमि में अधिकतम पैदावार वाली फसलों की परिकल्पना एवं कृषि उत्पादों के जल्दी खराब होने की प्रकृति के कारण होने वाली कृषि पश्च क्षतियों को कम करके ही की जा सकती है। इन तीनों में से अंतिम समस्या का निदान नाबी के वैज्ञानिकों द्वारा सुझाया जाएगा। इसके लिए जैविक प्रक्रियाओं की जैनेटिक मॉड्युलेशन करना आवश्यक होगा, जिससे कि कृषि उत्पाद की गुणवत्ता एवं स्थिरता में संवर्धन होगा। नाबी में प्रारंभ किया एक कार्य फसल के पकने की प्रक्रिया, कीट-पतंगों से क्षति - कृषि उत्पाद को हानि पहुंचाने वाले कुछ घटकों के साथ सहयोजित परिवर्तनों की जैविक क्रियाओं को समझना है। एक अन्य कार्य सुरक्षित सतह लेपन, एंजाइम, बैक्टीरियो-फेज़िस, प्रक्रमण एवं पैकेजिंग प्रौद्योगिकियों से कृषि पश्च उपचार कर क्षतियों को कम करना है। जबकि देश के अन्य संस्थान पर्याप्त उपज के लिए अनुसंधान कार्य कर रहे हैं, नाबी खाद्य क्षतियों को कम

करने तथा पोषण, स्वास्थ्य, स्थिरता एवं सैसरी अपील के माध्यम से क्षमता स्थापित करने के कार्यक्रम करेगा।

भारत को न्यूनपोषण एवं अत्यधिक सेवन, जो स्वास्थ्य पर प्रतिकूल प्रभाव डालते है, दोनों ही स्थितियों का अनुभव है। विश्व स्थास्थ्य संगठन (डब्ल्युएचओ) का अनुमान है कि वर्ष 2020 तक विश्व में होने वाले दो-तिहाई रोग मोटापे के कारण होने वाले रोगों से जुड़े होंगे। मोटापे में खाद्य संघटकों, प्रीबायोटिक्स एवं प्रोबायोटिक्स के प्रभाव तथा इनके कार्य करने की पद्धति को समझने की नितांत आवश्यकता है, जिससे कि स्वस्थ खाद्य पदार्थ परिकल्पित की जा सकें। नाबी में खाद्य संघटकों के संबंध में जिनोमिक, एपिजिनोमिक एवं बायो-मार्कर परिवर्तनों के विश्लेषण के लिए कोशिका संवर्धन एवं जीव अध्ययन प्रारंभ किए जाएंगे। निम्न ग्लाइसीमिक इन्डैक्स के स्टार्च के साथ एवं प्रक्रमण गुणवत्ता पर अधिक प्रभाव के बिना फलसों की विविध किस्में तैयार करना केवल स्टार्च ग्रेन्यूल पाथवे इंजीनियरिंग एवं बायोकैमिकल इंजीनियरिंग के माध्यम से संभव हो पाएगा। नाबी में खाद्य फसलों में लिपिड जैवसंश्लेषण एवं कार्बोहायड्रेट की पाथवेइंजीनियरिंग दो महत्त्वपूर्ण कार्य होंगे, जिससे कि जीवनशैली के कारण होने वाले रोगों से बचने के लिए अन्न, दलहन एवं तिलहन फसलों के डिज़ाइन तैयार किए जा सकेंगे।

भारत में सूक्ष्मपोषक कुपोषण, विशेषत: लोहा, जिंक, आयोडीन और विटामिन 'ए' एवं 'डी' की कमी, व्यापक स्तर पर फैला हुआ है। देश में प्रबल खाद्य प्रक्रमण क्षेत्र की अनुपस्थिति एवं लागतसामर्थ्य न होने के कारण भारत को सूक्ष्मपोषक की कमी की समस्या का समाधान प्रथमत: फसल इंजीनियरिंग द्वारा करना होगा न कि खाद्यों के रासायनिक आलेपन से। आयरन ग्रहण करने, इसके स्थानीयीकरण तथा फसल व खाद्य पदार्थो में इसके रासायनिक रूप से जैवआलेपन एवं जैवउपलब्धता के लिए उपज की आनुवांशिक इंजीनियरिंग के द्वारा मार्ग मिल सकता है। नाबी में गेहूं, जिसमें विशेषकर आयरन की कमी होती है, में खनिज पदार्थो के संवर्धन पर एक महत्त्वपूर्ण परियोजना पर कार्य चल रहा है। विश्व स्तर पर चयनित प्रस्ताव में नाबी के एक वैज्ञानिक को इस संबंध में कुछ महत्त्वपूर्ण उपलब्धि प्राप्त हुई है।

भारत और विशेषत: पंजाब राज्य में गेहूं के महत्त्व को ध्यान में रखते हुए पोषक एवं प्रक्रमण गुणवत्ता पर एक प्रमुख अनुसंधान कार्यक्रम प्रारंभ किया गया है। विकसित किए जा रहे बीजो में विस्तृत ट्रांसस्क्रिप्टोमिक्स से अनेक अलग-अलग रूप में प्रस्तुत अनेक जीनों की पहचान की गई, जिनकी बीज की कठोरता, प्रोटीन गुणवत्ता एवं स्टार्च जैवसंश्लेषण में भूमिका है। गेहूं की गुणवत्ता को निर्धारित करने वाले विविध परिमापकों के अध्ययन के लिए बड़ी संख्या में विविध प्रकार के गेहूं की एसएनपी मैपिंग की जाएगी। जीन के कार्य की पहचान के लिए गेहूं की जीन डालने की प्रणाली विकसित करना महत्त्वपूर्ण है। नाबी में पहली बार भारतीय गेहूं में एक जैमिनी वासरस की पहचान की गई। इसका प्रयोग जीन आपूर्ति एवं प्रतिबंधन प्रणाली विकसित करने के लिए किया जा रहा है। यह देश में गेहूं जिनोमिक्स के संवर्धन के लिए महत्त्वपूर्ण सिद्ध होगा। जिनोमिक्स, जीन मार्करस एवं जीन आपूर्ति प्रणाली में इसी प्रकार के प्रयास फल उपजों, विशेषत: आम व लीची पर भी किए जाएंगे। फल उपज में आम एक अत्यधिक महत्त्वपूर्ण फल है, जिस पर भारत में जिनोमिक्स संबंधी कार्य किए जाने चाहिए।

नाबी सूक्ष्मपोषकों, वसा एवं लिपिड पाथवे इंजीनियरिंग के माध्यम से स्वस्थ खाद्य फसलों पर कार्य करेगा। यह खाद्य गुणवत्ता एवं सुरक्षा के लिए राष्ट्रीय संदर्भ केन्द्र के रूप में भी कार्य करेगा। संस्थान भारतीय खाद्य मानक एवं सुरक्षा प्राधिकरण एवं भारतीय जैवप्रौद्योगिकी नियामक प्राधिकारण के परामर्श में खाद्य मानक, मार्गदर्शी सिद्धांत एवं प्रक्रिया कोड से जुड़े अनुसंधान करेगा। संस्थान देश के सामने आ रही खाद्य सुरक्षा संबंधी चिंताओं के समाधान के लिए गुणवत्ता आश्वासन प्रयोगशालाओं का नैटवर्क स्थापित करने में सहायता प्रदान करेगा। यह मानक, बायोमार्कर, किट्स एवं प्रोटोकाल के विकास पर कार्य करेगा तथा वैश्विक खाद्य सुरक्षा विनियमों एवं प्रक्रियाओं के अनुरूप मानक एवं प्रोटोकॉल निर्धारित करने पर अनुसंधान करेगा। ताज़े एवं प्रक्रमित खाद्य पदार्थो की गुणवत्ता में अंतर की पहचान के लिए विश्लेषणात्मक पद्धतियों एवं संकेतक आधारित उपस्करों के विकास में प्रौद्यागिकीय प्रगति की आवश्यकता है। ''उपभोग करने की तिथि' के प्रचलन,

जिससे कि प्रक्रमित खाद्य का भी अपव्यय होता है, के विस्थापन हेतु खाद्य गुणवत्ता की वास्तविक निगरानी के लिए सस्ते विकल्प विकसित किए जाने अपेक्षित हैं। नाबी अत्यंत संवेदनशील एवं सस्ते गुणवत्ता सूचक विकसित करने के लिए रासायनिक विश्लेषण, एंजाइमोलॉजी एवं नैनोविज्ञान के विविध मार्गों का संयोजन करेगा।

नाबी खाद्य उत्पादों में जीएमओ की पहचान के लिए अनुसंधान एवं अभिदेश्य सुविधा स्थापित करेगा। यह जीएम फसलों की पर्यावरणीय सुरक्षा, जैव समता और जैव सुरक्षा के संबंध में उठ रहे प्रश्नों का समाधान देगा। संस्थान आरएनएआइ की सुरक्षा, घोषित एवं अघोषित जीनों एवं संवर्धकों की पहचान तथा जीएम खाद्य फसलों के जोखिम मूल्यांकन के संबंध में आने वाली समस्याओं का समधान सुझाएगा। नाबी फसलों के सुधार के लिए रुचि के जीनों एवं जीएम फसलों के विकास के लिए सुविधा स्थापित करने के राष्ट्रीय भंडार के रूप में कार्य करेगा। यह आशाजनक जीन एवं जी एम फसलों और उनकी सुरक्षा स्थापित करने के लिए भारतीय अनुसंधानकर्ताओं के नैटवर्क में कार्य करेगा। इस प्रकार नाबी भारत में जीएम फसलों का सुरक्षा मूल्यांकन कार्य करेगा एवं जिम्मेवार रूप में इन्हें जारी करवाने पर अनुसंधान करेगा। यह भारतीय अनुसंधानकर्ताओं द्वारा विकसित कृषि की दृष्टि से उत्कृष्ट जीएम फसल पर नियामक निर्णयों, जो विश्वसनीय सुरक्षा आंकड़ों की कमी ; उपयुक्त प्रोटोकॉल की अनुपस्थिति अथवा जन विश्वास में कमी के कारण उपेक्षित थे, को आगे बढ़ाएगा।

नाबी कृषि विज्ञान के कुछ अत्यंत चुनौतिपूर्ण क्षेत्रों में भी अनुसंधान कार्य प्रारंभ करेगा, इनमें शामिल हैं : (1) स्थान निदेशित म्यूटाजैनिसिस से फसल का आनुवांशिक आशोधन, (2) मार्कर मुक्त ट्रांसजीनिक पौद्यों का विकास, (3) ट्रांसजीन्स के उच्च स्तरीय अभिव्यक्ति के लिए सुदृढ़ता से नियंत्रित संवर्धकों का विकास, (4) खाद्य पदार्थों के प्रति मानव की प्रतिक्रिया तथा पादपों में जीन की अभिव्यक्ति की नियंत्रण के एपिजिनॉमिक्स आधार को समझना, (5) बारहमासी फल फसलों में कलम के कार्यनिष्पादन में सुधार के लिए जड़ों के चयन की नवीन पद्धतियां एवं परिकल्पना, (6) पौधों में सिगनल इन्ड्यूस्ड संकेतों पर अनुसंधान और उसके द्वारा बीज, फूल और पौधों की वृद्धि के लिए पद्धतियों का विकास, (7) स्वास्थ्यवर्धक एवं लज़ीज़ खाद्य पदार्थों की परिकल्पना के लिए रिसैप्टर आधारित पद्धतियां, (8) बेहतर एवं लक्षित जैवउपलब्धता वाले खाद्य पदार्थों की परिकल्पना के लिए ट्रांसपोर्ट चैनल आधारित पद्धतियां।

चूंकि संस्थान स्वास्थ्यवर्धक खाद्य पदार्थ तैयार करने के लिए नवाचार कार्य कर रहा है, इसलिए संस्थान परिसर में उद्योग की सांझेदारी में खाद्य पदार्थों पर व्यक्ति के मूड, मस्तिष्क एवं रुचि के आधार पर मानव प्रतिक्रिया को समझने पर अनुसंधान होगा। स्वास्थ्य एवं तैयार किए गए खाद्य पदार्थों के प्रति संवेदी एवं व्यावहारात्मक प्रतिक्रियाओं के आधार पर अध्ययन किया जाएगा। यह खाद्य कंपनियों को व्यावहार आधारित खाद्य पदार्थ तैयार करने में सहायता के लिए एक नवीन प्रयोग होगा और इससे खाद्य पदार्थों और स्वास्थ्य के प्रति आम जनता को जागरूक किया जा सकेगा।

संस्थान, बीपीयू, एग्री-फूड पार्क एवं ऑफ-कैम्पस भागीदारों के नैटवर्क तथा आसपास के संस्थानों के सहयोग से मोहाली तथा देश में नवाचार आधारित पोषणक्षम कृषि व्यापार पारिस्थितिकी का विकास चाहता है। यह फीडबैक एवं विभिन्न सांझेदारों की प्रतिभागिता के नैटवर्क के माध्यम से कृषि-खाद्य आविष्कार में आगे बढ़ना चाहता है। संस्थान अपने अनुसंधान एवं विकास कार्यक्रमों के लिए रोडमैप तैयार करने हेतु उद्योगों के भागीदारों को संस्थान परिसर तथा अपने सलाहकार निकायों में लाना चाहता है। यह जिनोमिक्स, प्रजनन मार्करस, प्रोटियोमिक्स, बायोइन्फॉरमेटिक्स, मैटाबॉलोमिक्स, ट्रांसजैनिक्स, प्रयोगात्मक जीव एंव क्लीनिकल परीक्षण आदि के लिए श्रेष्ठतम सुविधाएं स्थापित करना चाहता है। संस्थान इनमें से कुछ क्षेत्रों को धीरे-धीरे प्रौद्योगिकी प्लेटफॉर्म में परिवर्तित करना चाहेगा है, जिससे कि वह सांझेदारी में उद्योग द्वारा प्रदान की जाने वाली राष्ट्रीय सुविधाओं का एक हिस्सा बन सके। आशा है कि इस प्रकार नाबी एक अन्वेषक, आविष्कारक के रूप में कार्य करने के साथ-साथ एक श्रेष्ठ पारिस्थितिकी को बढ़ावा देकर नवाचार के रूपांतरण का उत्प्रेरक बने, जहां

शोधकर्ता, प्रबंधक, उद्यमी, विद्यार्थी, प्रौद्योगिकीविद, बीज एवं खाद्य कंपनियां एवं समाज विज्ञानी नियमित रूप से मिलें और सांझेदारी में कार्य करते हुए नवाचार को बाजार तक पहुंचा सकें। संस्थान खाद्य सामर्थ्यता, पोषणक्षमता, गुणवत्ता एवं पौष्टिक आहार से संबंधित मामलों पर सक्रियता से कार्य करते हुए अंतर्राष्ट्रीय स्तर पर सम्मानित नेतृत्व ग्रहण करने का विचार रखता है। संस्थान खेत से थाली तक की खाद्य श्रृंखला के विभिन्न चरणों पर क्षमता और आय में संवर्धन करने के लिए कृषि-खाद्य क्षेत्र का रूपांतरण जैव प्रोद्योगिकी द्वारा करने की आशा रखता है।

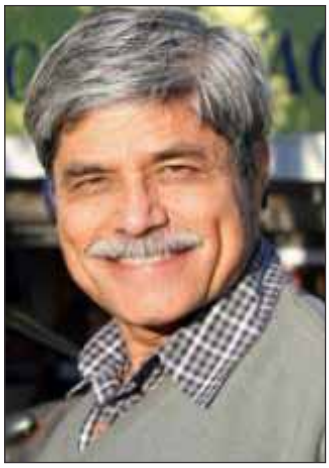
नाबी परिवार नाबी सोसायटी एवं गवर्निंग बोर्ड के समस्त माननीय सदस्यों का संस्थान को दिशा प्रदान करने एवं कार्यात्मक अवसंरचना स्थापित करने में मार्गदर्शन, प्रेरणा, सलाह एवं सतत् सहयोग के लिए हार्दिक आभार प्रकट करता है। संस्थान के लिए स्थापना का यह वर्ष निर्णय लेने एवं उन्हें कार्यान्वित करने की दृष्टि से अत्यंत चुनौतिपूर्ण एवं अपेक्षाओं से भरा रहा। डॉ. एम. के. भान, सचिव, जैव-प्रौद्योगिकी संस्थान (डीबीटी) संस्थान के शासी निकाय के अध्यक्ष के रूप में निर्णय लेने में सहायता प्रदान करने के लिए सदैव उपलब्ध रहे, हम उनका हृदय से धन्यवाद करते हैं। मैं व्यक्तिगत तौर पर भवन समिति के समस्त सदस्यों एवं उन अनेक विशेषज्ञों का आभार प्रकट करता हूँ जिन्होंने संस्थान में सुविधाएं आदि स्थापित करने में अपना अमूल्य समय दिया। डॉ. समीर के. ब्रह्मचारी, महानिदेशक, सीएसआइआर और प्रो. एन. सत्यमूर्ति, निदेशक, आइआइएसईआर (मोहाली) का नाबी को प्रदान किए गए हर प्रकार के सहयोग के लिए मैं आभार प्रकट करता हूँ। जब मैं 18 फरवरी, 2010 को सम्मान समारोह में आया तब मेरे पास केवल एक नाबी बैंक खाता और एक निदेशक का अधिकार था। आइआइएसईआर, मोहाली के प्रशासनिक दल और राष्ट्रीय वनस्पति अनुसंधान संस्थान (एनबीआरआइ), लखनऊ के मेरे पूर्व सहकर्मियों ने राष्ट्र को एक विश्वस्तरीय संस्थान प्रदान करने के स्वप्न को लेकर मेरे साथ नाबी में कार्य किया। जैसा कि इस रिपोर्ट में उल्लेख किया गया है नाबी में विश्व के प्रतिष्ठित संस्थानों से प्रशिक्षण ग्रहण कर चुके कुछ श्रेष्ठ युवा वैज्ञानिकों ने संस्थापक संकाय सदस्यों के रूप में कार्यभार संभाला है। कर्मठ प्रशासनिक स्टाफ से सहयोग प्राप्त 'टीम नाबी' अथक कार्य कर रही है और इसके लिए वे प्रशंसा के पात्र हैं। मेरे सहकर्मियों की सामर्थ्य एवं शक्ति के बल पर एक महत्त्वपूर्ण संस्थान आज अस्तित्व में है।

राकेश तुली
कार्यपालक निदेशक
राष्ट्रीय कृषि-खाद्य जैव प्रोद्योगिकी संस्थान

FROM THE DESK OF EXECUTIVE DIRECTOR

Establishment of a new national institute in agri-food sector in the state of Punjab will open limitless opportunities for agri-food sector in the country. For the founding Director, faculty and staff, it poses a formidable challenge to meet numerous expectations of this nationally important sector. National Agri-Food Biotechnology Institute (NABI) signifies much more. This is the first plant science institute, being developed in India, with mandate in three major disciplines – agriculture, food and nutrition. Also, this is the first model being developed, where a cluster of institutes will be developed to achieve synergy of the complete chain in agri-food sector - from innovations to entrepreneurship development.

The Union Cabinet gave approval for the establishment of NABI along with a second autonomous institute of the DBT, named (generically) Bioprocessing Unit (BPU). The two are co-located within 50 acres of land at Mohali. Their common campus wall will be shared most substantially with Agri-Food Park to facilitate hand holding between the creators and users of knowledge, through close physical proximity. Thanks to the very active support extended by the DBT, NABI has been established before the other two components, and has been functioning from an Interim Facility since 18th February, 2010. Timelines in the formation of NABI are given in this Foundation year report and will go in the history of the Institute. NABI is to be a world class institute for competitive research & innovations in the area of agricultural biotechnology, food processing and nutritional sciences. BPU will primarily be an institute for translational research. This will function as a 'Not For Profit' company to provide bioprocessing solutions to industry. It will have facilities for bench level optimisation, mini plants and pilot plants of interest to agri-food sector. The Agri-Food Park will be operated in corporate manner and provide technology and ecology for catalysing and strengthening entrepreneur-ships. Other institutes in neighbourhood will be the Indian Institute of



Science Education and Research, Indian School of Business, Institute of Nano Science & Technology and Punjab Biotechnology Incubator. This would make the cluster a more complete and sustainable model for value addition to agri-food sector.

NABI has a mandate to find crop and processing-based solutions for access to adequate and healthy foods. Adequacy can be achieved through enhancing the yield of food crops, designing crops for high yields from marginal soils and reducing the post-harvest losses suffered due to perishable nature of the farm produce. The last of the three will be addressed by the scientists at NABI. This will require genetic modulation of the biological processes that can enhance the quality and stability of farm produce. One approach initiated at NABI is to understand the biology of changes associated with the ripening process, insect and pest damage – some of the major factors that cause losses to farm produce. The second approach is to reduce losses through post-harvest treatment with safe surface coatings, enzymes, bacteriophages, phytochemicals, processing and packaging technologies. While other institutes in the country lay higher emphasis on research for producing enough, NABI shall carry out programmes on securing efficiency through reducing food losses and enhancing food quality for nutrition, health, stability and sensory appeal.

India experiences the problem of both undernourishment and over-intake - both lead to

adverse effects on health. WHO estimates that by 2020, two thirds of the global disease burden will be attributable to chronic diseases associated with obesity. Effects of food constituents, prebiotics and probiotics on adipogenesis, and the mechanism of their function need to be understood to design foods for health. Cell culture and whole animal studies will be taken up at NABI to analyze the genomic, epigenomic, miRNA and biomarker changes in response to dietary constituents. Designing crop varieties with starch of low glycaemic index, without significant effect on processing quality could be achievable through starch granule pathway engineering and biochemical processing. Pathway engineering of carbohydrate and lipid biosynthesis in food crops will be important strategies at NABI to design cereal and oilseed crops, healthier against 'lifestyle diseases'.

Micronutrient malnutrition, especially deficiency of iron, zinc, iodine and vitamin A are widely prevalent in India. In the absence of a significant food processing sector and cost affordability, India has to address the issue of micronutrient deficiency primarily by crop engineering, rather than chemical fortification of foods. Understanding molecular details of iron uptake, its localization and chemical form in crops and foods can give clues to genetic engineering of crops for biofortification and bioavailability. A major project has been taken at NABI for enhancing minerals in wheat grain, which is particularly deficient in iron. In a globally selected proposal, a NABI scientist obtained first clues to differential iron translocation efficiency, between different tissues in wheat seed, through the application of synchrotron radiation. Tissue layer specific differential gene expression is now being examined through transcriptomics of sections excised by Laser Capture Microscopy of wheat seed.

Considering the importance of wheat to India, and particularly Punjab, a major research programme on nutritional and processing quality has been initiated. Detailed transcriptomics in developing seeds has identified a number of differentially expressed genes with role in seed hardness, protein quality and starch biosynthesis. SNP mapping of a large number of diverse wheat accessions has been initiated to study associations with a variety of parameters that contribute to processing quality in wheat. In preparation for the need to identify gene function, it is important to develop gene delivery systems for wheat. A Gemini virus has been identified at NABI for the first time in Indian wheat. It is being deployed to develop a gene delivery and suppression system. This will be a critical tool to promoting wheat genomics in India. Similar efforts in development of markers for accelerated breeding, genomics and gene delivery systems will be initiated in fruit crops, specially mango and litchi. Mango is the most important candidate among fruit crops, to take a major initiative in genomics in India.

NABI will contribute to healthier food crops through micronutrient, carbohydrate and lipid pathway engineering. It would also function as a National Reference Centre for Food Quality and Safety. The institute will actively carry out research for developing food standards, guidelines and codes of practices, in consultation with Food Standards and Safety Authority of India and Biotechnology Regulatory Authority of India. It would carry out research on the development of standards, biomarkers, kits and protocols. It will establish the standards and protocols in harmonisation with global food safety regulations and policies. Analyses methods and indicator based tools to distinguish the quality of fresh and processed foods needs a technological breakthrough globally. Affordable alternatives for real time monitoring of food quality are required to substitute the 'Use by' and 'Best Before' practices, that lead to a very significant waste of even processed foods. NABI would combine the finest approaches in chemical analysis, enzymology and nanoscience to develop sensitive and affordable real time quality indicators.

NABI would establish a research and referral facility for the detection of GMOs in food and feed products. It would address the emerging questions related to bioequivalence, biosafety and environmental safety of the GM crops. Issues related to the safety of RNAi, detection of declared and undeclared genes and promoters, and long term risk assessment in case of GM food

crops will be addressed. NABI would function as a National Repository of Genes of interest to crop improvement and establish facilities for developing GM crops. It will network with Indian researchers to take up promising candidate genes and GM crops, and establish their safety. Hence, NABI would facilitate safety assessment and responsible release of GM crops in India. This would expedite regulatory decisions on agronomically superior candidate GM crops that have been developed by Indian researchers, but are held in limbo due to the lack of reliable safety data, the absence of suitable protocols or the lack of public confidence.

NABI would undertake research in some of the highly challenging areas of biology. These will include (i) genetic modification of crops by site directed mutagenesis by designing sequence specific DNA nucleases, ligases, and repair enzymes, (ii) development of marker free transformation strategies for crops, (iii) designing promoters for tightly regulated, high level expression of transgenes, (iv) understanding epigenomics basis of regulation of gene expression in plants and human response to diet (v) development of novel approaches to selecting, and designing root stocks for improving the performance of scion in perennial fruit crops, (vi) development of approaches for signal induced seedlessness, male sterility, early flowering, altered canopy etc. in fruit crops (vii) receptor based approaches to design healthier and tastier foods, (vii) transport channel based approaches to design foods with improved and targeted bioavailability.

As the institute works innovatively to design healthier foods, it may establish a food designing facility on the campus in partnership with industry to study human response to designer foods in terms of mood, mind and likability. The sensory and behaviourial responses of members and visitors to health and designer foods would be studied through the tracking of their eyes, sensory responses and visiting behaviour. This would be a novel set up to help food companies design behaviour-based foods and to enhance awareness in public regarding relationship between food and health.

NABI, together with BPU, the Agri-Food Park and through a network of "off-campus" partners, and the institutes in neighbourhood, hopes to catalyse the development of an innovation driven sustainable agribusiness ecosystem at Mohali and in the country. It hopes to grow in agri-food discovery mode through a network of feedbacks and participation by different stakeholders. It hopes to have industry partners on the campus and on the advisory bodies for carving roadmap for its R&D programmes. It hopes to have top-of-the-line facilities in genomics and gene based marker development, proteomics, bioinformatics, metabolomics, transgenics, experimental animals and hopefully clinical trials. It hopes to gradually convert some of these into technology platforms to become part of National Facilities to be run by industry in partnership mode. It hopes to therefore, function as a discoverer as well as catalyse the translation of innovations by promoting a perfect ecosystem where researchers, managers, entrepreneurs, students, technologists, seed and food companies and social scientists meet regularly and draw synergy through partnerships, and carry innovations to marketplace. The Institute hopes to develop into an internationally respected leader, dealing proactively with the issues facing food sufficiency, sustainability, quality and nutrition. The Institute hopes to transform the agri-food sector for enhancing the efficiency and income at various points in the food chain from farm to fork.

The NABI Family is very grateful to the honourable members of the NABI Society and the Governing Body for their guidance, advice and unstinted support in developing the vision and functional infrastructure at NABI. The founding year was the most challenging and demanding for making judgements and implementing decisions. As Chairman of the Governing Body, Dr. M.K. Bhan, Secretary DBT was always available to accelerate decision making. I am personally thankful to members of the Building Committee and a number of experts who spent long hours in helping NABI in taking technical decisions related to the establishment of facilities and works. I appreciate the immense understanding shown by Dr. Samir Brahmachari, Director General, CSIR and Professor N. Sathyamurthy,

Director IISER (Mohali) for extending help to NABI in several ways. When I arrived at Mohali for the Felicitation Function on 18th February, 2010, all I had was a bank account and the authority of a Director. The administrative team at IISER, Mohali and my former colleagues from National Botanical Research Institute, Lucknow worked at NABI with a dream to help the nation in establishing a world class institute. As the report describes, some of the brightest young scientists, trained in globally reputed institutes have joined as the founder faculty at NABI. Helped by the energetic administrative staff, team NABI has since been working very hard. I express my deep appreciation for their untiring efforts. On the strength of my colleagues, a great institute has now come into being.

(Rakesh Tuli)
Executive Director
National Agri-Food Biotechnology Institute

EVENTS LEADING TO THE ESTABLISHMENT OF NABI

1. **Scientific Ties with Canada to establish Agri-Food Cluster**

   On 5th December, 2006 signing of two MoUs with Canada to strengthen S&T ties and promote the development of Agri-Food Biotech Park in Knowledge City, Mohali through Public-Pvt. Partnership laid basis for the development of research institutes in form of an agri-food cluster at SAS Nagar, Mohali in the state of Punjab. (Annexure 1).

2. **Formation of National Agri-Food Biotechnology Institute**

   On 21st August, 2008, the Union Cabinet of India approved the establishment of the National Agri-Food Biotechnology Institute (NABI) and Bioprocessing Unit (BPU) as two autonomous institutions of the Government of India, under the aegis of the Department of Biotechnology. (Annexure 2).

3. **Establishment of a NABI/BPU Cell at Biotech Consortium India Ltd.**

   DBT, Ministry of Science & Technology, Government of India vide sanction Order No: BT/FNS/NABI & BPU, Facilitation Centre / 2008 dated 23-12-2008 setup a 'Facilitation Centre for NABI & BPU at BCIL, New Delhi for a period of two years. The centre provided support for the establishment of NABI till 31st May, 2010

4. **Registration of National Agri-Food Biotechnology Institute as a Society at SAS Nagar, Punjab vide Certificate No: 2677 of 2009-2010 dt 27/11/09 under the Act XXI of 1860** (Annexure 3).

5. **Establishment of a NABI Cell at National Botanical Research Institute, Lucknow with Dr. Rakesh Tuli as Officer on Special Duty** (Annexure 4).

6. **First Meeting of GB of NABI, held on 24th December, 2009 at DBT**

   The GB approved and adopted Memorandum of Association and Rules and Regulations of NABI. It also approved the joining of Dr Rakesh Tuli, Director, NBRI with the dual charge as OSD of NABI, till he takes full charge as Executive Director, NABI as per approval of Appointments Committee of the Cabinet (ACC). (Annexure 5).

7. **Dr. Rakesh Tuli takes charge as Executive Director of NABI at Department of Biotechnology, New Delhi.** (Annexure 6).

8. NABI takes on lease a state of art building with 35000 sq. ft area to establish the Interim Facility of NABI at, Phase-VIII, Industrial Area, Mohali to set up a functional core team and laboratory, who would then develop the main campus of NABI in Sector-81.

A Snapshot of the Knowledge City and the Agri-Food Cluster at Sector-81, Mohali

Railway line

Power line

Proposed canal

Proposed road

Existing roads

Roads in use (new)

Roads used previously (old)

Institute boundry

Pump

9. Felicitation of NABI at Mohali

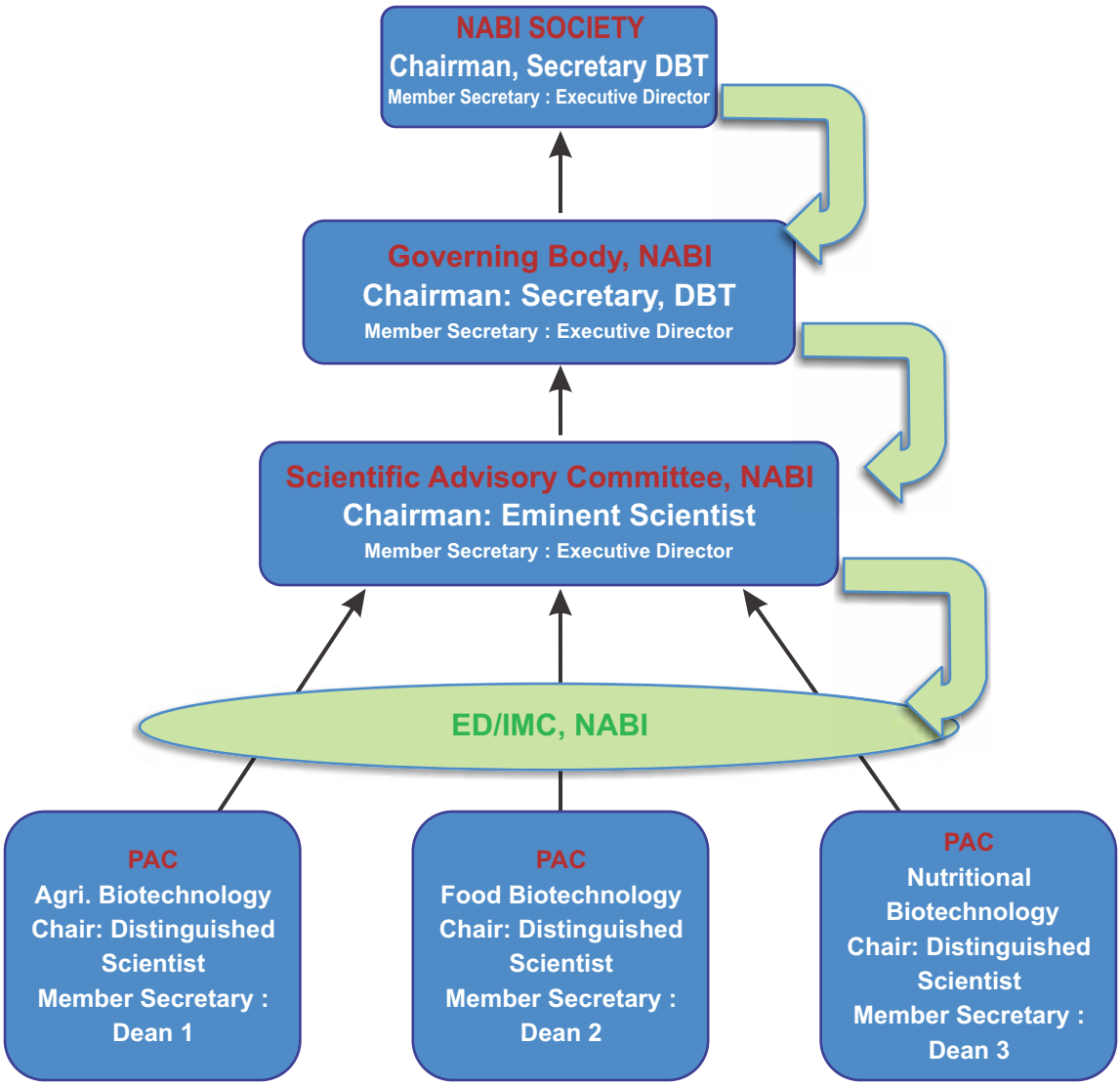
Dr. M. K. Bhan, Secretary DBT inaugurated NABI at the Interim Facility at Mohali on 18th February, 2010.

VISION & MISSION OF NABI

To be a nodal organization for knowledge generation and translational science leading to value added products based on agri-food biotech innovations.

- To transform agri-food sector into globally rewarding and sustainable biotechnology-based enterprise through innovative solutions in primary and secondary agriculture including high-end food processing.
- To develop synergy among knowledge providers and investors in agri-food sector to carry innovations to marketplace.

GOVERNANCE AT NABI



RESEARCH INITIATIVES AT NABI

Nutrition and Processing Quality of Wheat

Co-ordinator:	Dr. Rakesh Tuli	Executive Director
Investigators:	Dr. Joy K Roy	Scientist-D
	Sh. Shrikant Subhash Mantri	Scientist-C
	Dr. Monika Garg	Scientist-C
	Dr. Siddharth Tiwari	Scientist-C
Research Associates and Fellows:	Dr. Sudhir P. Singh	Research Associate
	Jitendra Kumar	Senior Research Fellow
	Anuradha Singh	Junior Research Fellow
	Sukhdev Singh	Junior Research Fellow

Components:

A. Micronutrient and bioavailability enhancement
B. Gene discovery in wheat for improvement of processing quality
C. Development of virus induced gene silencing vector for wheat
D. Genetic transformation of wheat

A. Micronutrient and bioavailability enhancement

Introduction:

Iron deficiency, its consequences, and strategy to alleviate have been globally discussed. This issue is very serious in India where rice and wheat are staple crops and their iron content and variability is very low (~20-40 mg/kg). A number of molecular biology strategies are under study to increase the iron content and improve iron bioavailability in staples like rice, wheat and maize in order to alleviate iron deficiency. These strategies comprise the study of iron uptake mechanisms, transport, localization of iron and the understanding of the promoters, genes, pathways and inhibitors that influence the accumulation and bioavailability of iron. The identification and manipulation of potential bottlenecks in the transport pathway in the cereal grain from phloem unloading until deposition, including barriers from aleurone layer to endosperm need special attention. Then the candidate genes can be transferred into local adapted and high yielding varieties either through marker-assisted selection and/or transgenic approach. Bioavailability of micronutrient such as iron can be enhanced by lowering the expression of phytic acid, which is considered as a chelating agent, widely distributed in aleurone layer of seeds as an insoluble salt.

Research objectives:

- Procurement of germplasms for genetic diversity and allele mining of genes responsible for high accumulation of micronutrients and bioavailability.
- Estimation of micronutrients including iron, folic acid, carotenoids, ascorbic acid and phytic acid in the germplasm.
- Gene discovery for high accumulation of micronutrients, specially iron and low phytic acid through gene discovery and candidate gene approaches.
- Determination of iron localization and their chemical forms in different tissues of grains of contrasting genotypes of wheat.
- Differential transcriptomics of seed tissues (vascular cells, transfer cells, aleurone,

endosperm) by using Laser Micro-dissection (LCM).

- Validation of function of genes through functional genomics approach.
- Micro RNA and mutagenesis approaches to reduce phytic acid in seeds.

Long term objectives:

The studies will lead to designing high yielding wheat varieties and/or advance breeding lines for combination of two or more of nutrition related traits in collaboration with Punjab Agricultural University (PAU), Ludhiana and Directorate of Wheat Research (DWR), Karnal

- Transfer of genes responsible for high accumulation of micronutrients into high yielding Indian wheat varieties through marker-assisted breeding and/or transgenic approach.
- Gene discovery for other important nutrients such as zinc, vitamin A, folic acid and ascorbic acid.

Research in progress:

- For gene discovery, a diverse range of germplasms of bread wheat, landraces, wild relatives and parents of mapping populations has been procured.
- Total RNA is being extracted from whole caryopsis and seed tissues such as aleurone layer, vertical crease (reported to have high accumulation of iron), embryo, and endosperm.
- The transcriptomes will be sequenced to identify putative genes for high accumulation of iron. The putative genes will be validated by screening diverse germplasm.
- Initially four Indian cultivars, two each for good and poor chapatti making, were used for estimation and localization of iron and zinc using LA-ICP-MS (Table 1; Figure 1).
- Seeds of a few backcross derivatives of wild and cultivated wheats showing variability for micronutrient contents were multiplied

Table 1: Estimation of iron and zinc in four Indian varieties using LA-ICP-MS

Variety	Iron (mg/kg)	Zn (mg/kg)
C306	41.9±2.1	32.9±1.4
LOK1	36.9±1.2	34.9±0.3
Sonalika	44.6±2.8	33.3±1.3
WH291	29.9±0.9	21.4±1.6

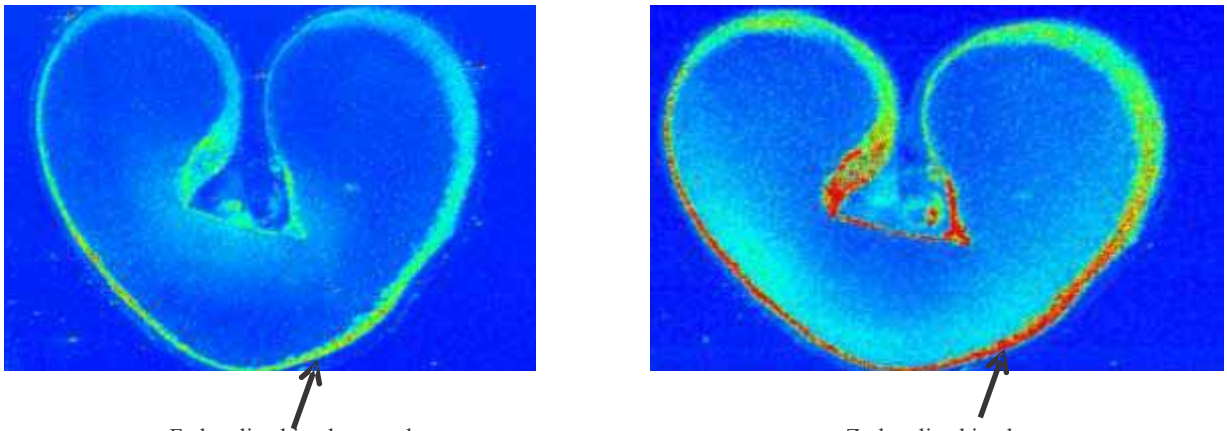


Figure 1: Localization of iron and zinc in wheat using LA-ICP-MS

and will be used for genetical study of high micronutrient content.

- Element localization maps and XANES (X-ray Absorption Near Edge Structure) spectra have been generated in grains of contrasting genotypes of wheat by using synchrotron powered beam line, VESPERS (Very Sensitive Elemental and Structural Probe Employing Radiation) (Figure 2 A, B), at Canadian Light Source, Saskatoon, Canada.

- Micro-PIXE (Microproton induced x-ray emission) and EXAFS (Extended X-ray absorption fine structure) experiments are in progress at Biotechnical Faculty and Jozef Stefan Institute, Ljubljana, Slovenia.

- Two low phytic acid lines (MM169 & MM225) have been identified from a recombinant inbred line (RIL) population of *Triticum monococcum* (Prof. H. S. Dhaliwal, IIT, Roorkee). Transcriptome sequencing will be done at different seed development stages to identify genes responsible for low phytic acid.

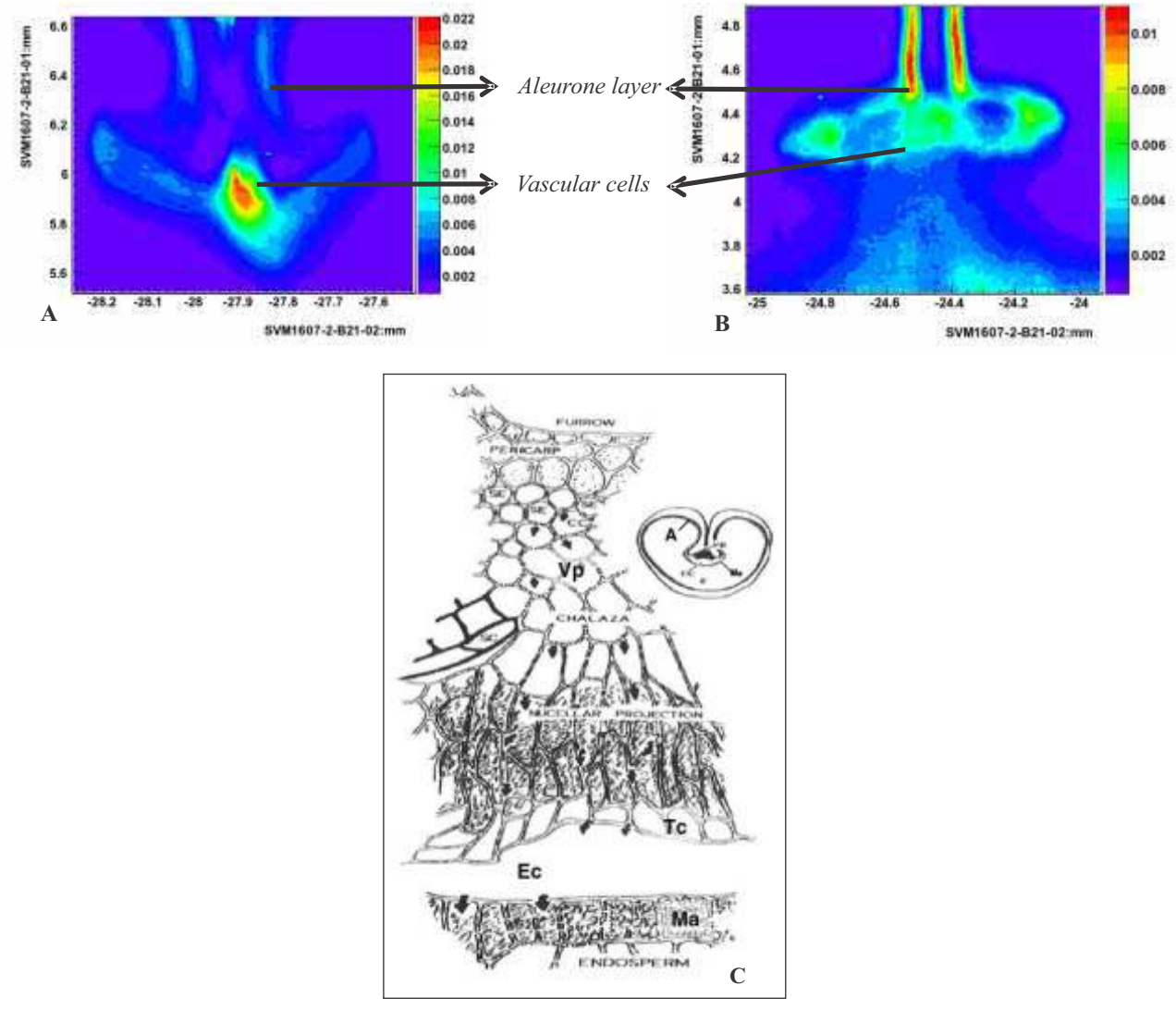


Figure 2: Iron localization in seeds of contrasting genotypes of wheat: **(A)** *Triticum aestivum* IITR-26 (High iron genotype), **(B)** *Triticum aestivum* WL711 (Low iron genotype), **(C)** Transverse section of wheat seed (Borg et al., 2009, Plant Soil, 325, 15-24). A: aleurone layer, SC: seed coat, SE: Sieve element, CC: Companion cell, Vp: Vascular parenchyma. Tc: Transfer cells, Ec: Endosperm cavity, Ma: Modified aleurone. In high iron genotypes, iron is present at higher concentration in the vascular cells than the aleurone, while in contrast, in the low iron genotypes, most of the Fe is mobilized from vascular cells to aleurone cells.

B. Gene discovery in wheat for improvement of processing quality

Introduction:

Genes related to wheat seed storage proteins, starch and non-starch carbohydrates, their interactions and relationship with processing parameters are being studied at NABI. Such genes will then be transferred to high yielding varieties. Improving wheat for good chapatti making quality requires defining processing quality parameters to achieve the structure of dough and its composition required to make self-stable, sensually satisfying, good quality chapatti. Defining the contributing wheat traits and identifying the associated genes are two major challenges for improvement of wheat for chapatti making. Biscuit quality has not received much attention in India. There is a major need and demand for evolving varieties for good quality biscuit. None of the high yielding Indian wheat varieties are suitable for good biscuit making. One of the important traits considered for biscuit making quality is soft grains in wheat.

Research objectives:

- The processing parameters (gluten strength, gelatinisation, viscoelastic properties, etc.) of contrasting wheat varieties are being studied, jointly with Dr. B. Khatkar at Guru Jambheshwar University of Science & Technology (GJUST), Hisar.
- Genes for good chapatti and biscuit making will be identified by screening diverse germplasm and mapping populations, and examining associations.
- Genes involved in starch biosynthesis pathway and their relationship to chapatti and biscuit making quality will be examined.
- Composition and structure of seed storage proteins and seed carbohydrates, and their effect on chapatti and biscuit making quality will be examined.

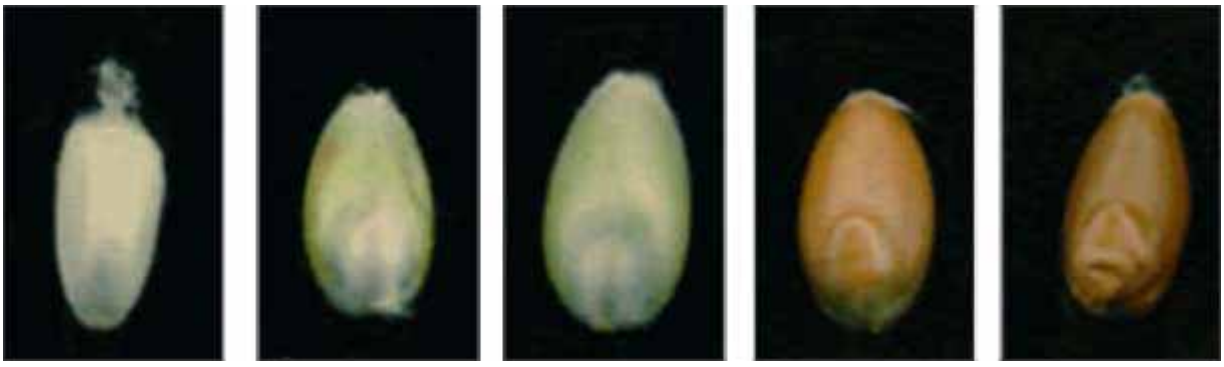
Long term objectives:

The studies will lead to designing high yielding wheat varieties and/or advance breeding lines for combination of two or more of the following traits in collaboration with PAU (Ludhiana), DWR (Karnal) and GJUST (Hisar).

- Good chapatti
- Good biscuit
- High amylose starch
- Low gluten allergen
- High fibre (soluble and non-solube)

Research in progress:

- Candidate genes for processing quality are being identified in contrasting lines through transcriptomic studies using wheat microarray having~22,000 genes and transcriptomic and small RNA sequencing.
- Total RNA extracted from three development stages- 7, 14, and 28 days after anthesis (DAA) (Figure 3) from two good chapatti varieties (C306 and LOK1) and two poor chapatti varieties (Sonalika and WH291) was hybridized to wheat microarray chips for identification of



7DAA **14DAA** **21DAA** **28DAA** **35DAA**

Figure 3: Caryopses at developmental stages-7, 14, 21, 28, and 35 days after anthesis (DAA) http://www.extension.umn.edu/distribution/cropsystems/dc2547.html

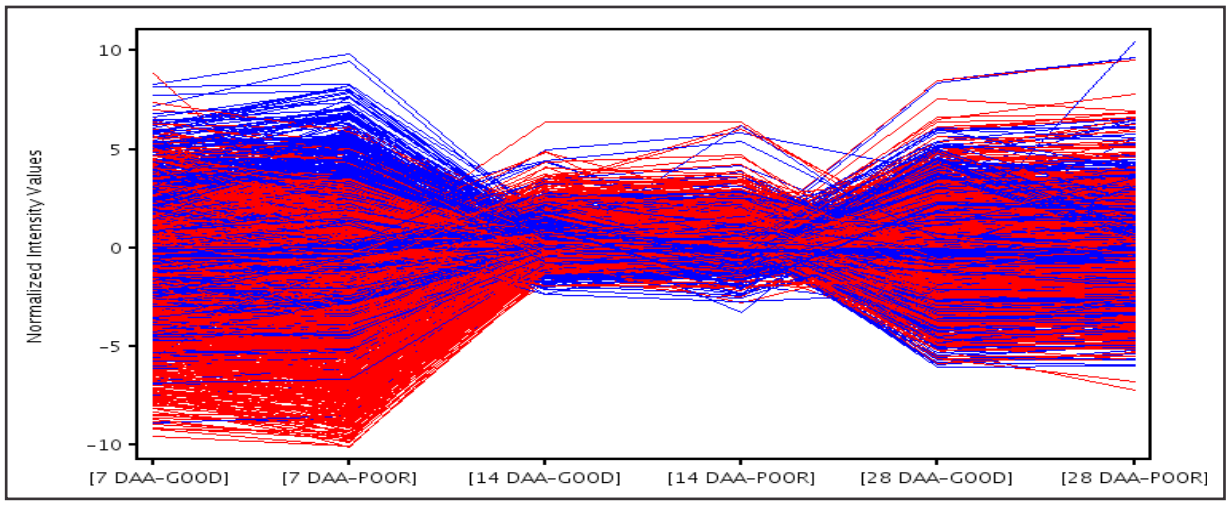


Figure 4: Expression profiling of 17,344 probe sets at three developmental stages- 7, 14, and 28 days after anthesis (DAA) between two good and two poor chapatti making varieties. These probe sets are significant (P<0.05; Benjamini-Hochberg false discovery rate multiple testing correction with >=2.0 fold changes cut-off) showing differences in expression between good and poor varieties at the three stages. Red and blue colors represent up- and down- regulated genes.

differentially expressed genes (Figure 4).

- The microarray studies identified a set of 895 differentially expressed unigenes (≥2 fold) at the three developmental stages among good and poor chapatti varieties.
- Most of the differentially expressed genes are involved in expression of seed storage proteins, grain softness, dough quality (-amylase, alpha amylase inhibitor), starch synthesis pathway, antioxidant system, stress responsive genes, regulatory genes, etc.
- Out of the 895 unigenes, the present study is focusing on a subset of 53 unigenes (≥10 fold differentially expressed; Figure 5A, 5B, Tables 2-4) for confirmation of expression using RT-PCR and identification of their function using functional genomics approaches.

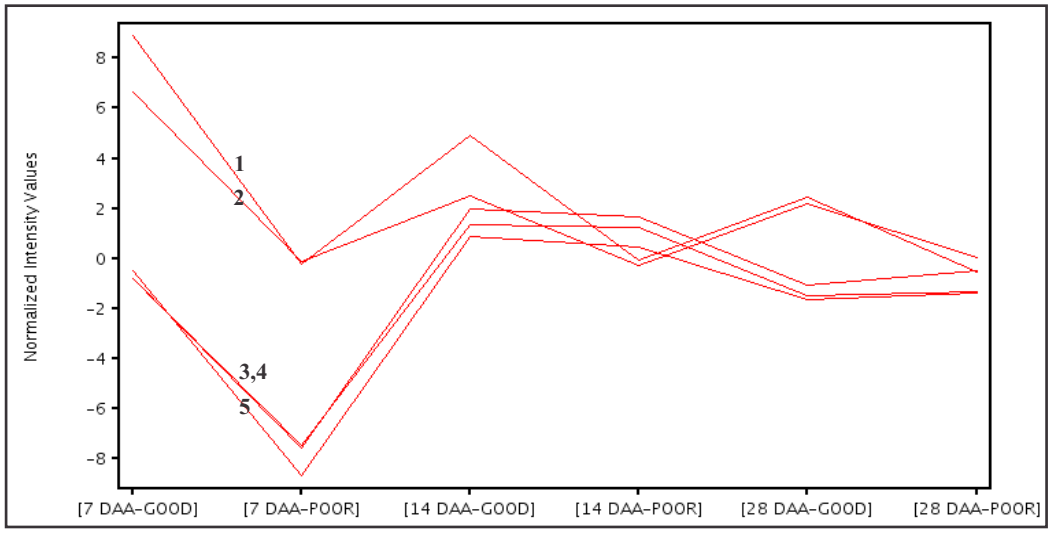


Figure 5A: Expression pattern of top 5 up-regulated genes at 7DAA between good and poor chapatti making varieties of wheat

Table 2 : Probe set ID, annotation and fold change in the expression of the genes of up-regulated (Top 5) at 7DAA between good and poor chapatti making varieties of wheat.

S.No.	Probe Set ID	UniGene ID	Function	Fold changes (Good vs. Poor)		
				7DAA	14DAA	28DAA
1	Ta.24736.1.S1_at	NA	Predicted protein (*Hordeum vulgare*)	550.2	31.2	8.0
2	Ta.27778.4.S1_x_at	Ta.54206	Pre-alpha-/beta-gliadin A-II	284.7	1.3	-1.2
3	Ta.7158.1.S1_at	Ta.7158	Transcribed locus but no significant similarity was found in non-redundant (nr) protein sequences database	108.1	6.8	4.5
4	Ta.7158.1.S1_at	Ta.7158	Transcribed locus but no significant similarity was found in non-redundant (nr) protein sequences database	108.1	6.8	4.5
5	Ta.24114.14.S1_x_at	Ta.65881	*Triticum aestivum* gamma-gliadin gene	102.3	1.1	-1.1

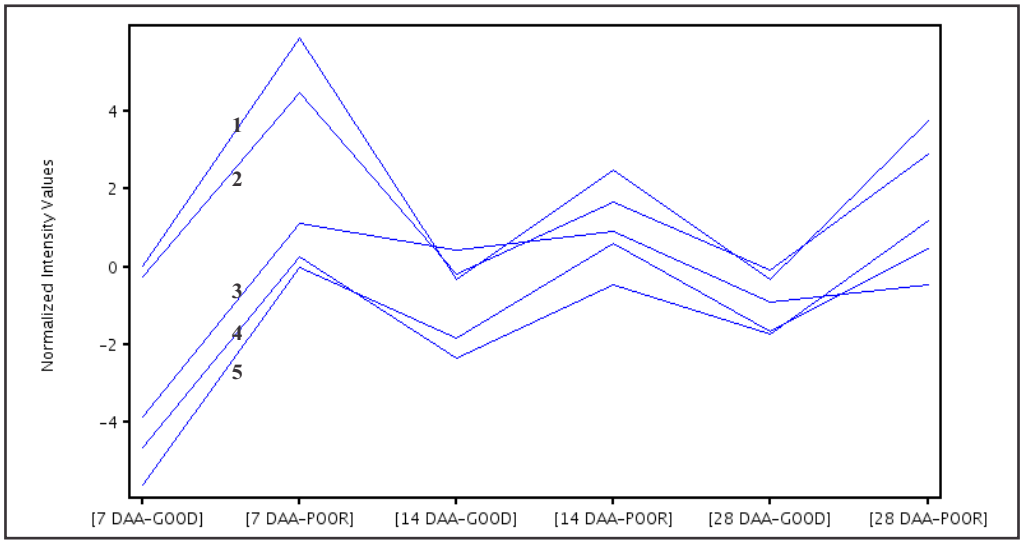


Figure 5B: Expression pattern of top 5 down-regulated genes at 7DAA between good and poor chapatti making varieties of wheat

Table 3 : Probe set ID, annotation and fold change in the expression of the genes of down-regulated (Top 5) at 7DAA between good and poor chapatti making varieties of wheat.

S. No.	Probe Set ID	UniGene ID	Function	Fold changes (Good vs. Poor)		
				7DAA	14DAA	28DAA
1	Ta.6984.1.A1_at	Ta.57100	Predicted protein & also similar with PHD zinc finger protein-like [*Oryza sativa* Japonica Group]	-58.0	-7.0	-16.9
2	Ta.4957.1.S1_at	Ta.4957	Predicted protein & also similar with Acyl-coenzyme A oxidase	-26.6	-3.6	-7.9
3	Ta.23013.3.S1_s_at	NA	B22EL8 [*Hordeum vulgare*]	-31.5	-1.4	-1.4
4	Ta.14507.2.S1_at	Ta.54186	Predicted protein & also similar with nucleotide-binding protein 1 [*Zea mays*]	-29.9	-3.6	-7.6
5	TaAffx.104444.1.S1_at	Ta.35784	No significant similarity	-47.5	-5.4	-4.4

Table 4 : Differentially expressed genes (≥10 fold) in good chapatti making wheat.

7 DDA-↓↑; 28 DAA-↓↑	Possible role
Peroxidase ↑	Cell rigidity
Beta-1,3-endoglucanase ↑	Defense
Granule bound starch synthase ↓	Amylopectin
Gliadin ↑	Seed storage protein, responsible visco-elastic properties of dough
Avenin ↑	Seed storage protein,in oat
Fernesylated protein 3 ↑	Cell cycle progression
Trypsin inhibitor ↑	Less proteolytic degradation
ATP dependant Zn metalloprotease ↓↓	Involved in thylakoid formation
ATPase subunit B and E ↓	Chloroplast gene
PHD zinc finger ↓ ↓	Transcription regulation
Retrotransposon Ty1/copia ↑	Mobile element
Cytochrome C heme protein ↓	Mitochondrial gene
Acyl coenzyme A oxidase ↓	Catalysis of hydrgen peroxide

↑↑ up regulated ↓↓ down regulated

- The two good and two poor chapatti varieties were phenotyped for several processing quality parameters (Table 5). These parameters will be used to phenotype additional wheat varieties showing variability for processing quality for identification of genes underlying the traits.

Table 5: Scores of processing quality parameters in two good and poor chapatti makingvarieties

Parameter	C306	LOK1	WH291	SONALIKA
Chapatti score	Very Good	Good	Poor	Medium Poor
Grain hardness (g)	Hard	Med Soft	Med hard	Soft
Seed size	Med	Med	Small	Large
Color	White	Brown	Brown	Brown
Water absorption	High	Med	Med	Med
Protein content	Med	Med	High	Med
Gluten	Medium	Medium	High	Low
Starch gelatinisation	Medium	High	Medium	High
RVA Breakdown	High	High	Low	Medium
HMW-GS-ABD	20, 2+12	2*+17+18, 2+12	2*+20, 2+12	2*, 7+8, 2+12
Puroindolines (5DS)	PinaD1b, PinbD1a	PinaD1b, PinbD1a	PinaD1b, PinbD1a	PinaD1a, PinbD1b

C. Development of virus induced gene silencing vector for wheat

Introduction:

Virus induced gene silencing (VIGS) is an approach to facilitate the assessment of gene function in plants. A recombinant virus that infects plant tissue and spreads systemically is used to express small RNA and silence the targeted endogenous gene. The target transcript is degraded by post-transcriptional gene silencing (PTGS). VIGS can thus validate the function of a specific gene within a single generation and obviates the need for screening large populations to identify a mutation in a specific gene. Only a single plant is needed to identify a phenotype. Being a transient method, it does not require the generation of stable transgenic plants. This project aims at searching a virus from Indian wheat varieties and modifying its genome to develop a suitable VIGS vector.

Research objectives:

- Detection of viruses infecting wheat in India.
- Analysis of the viral genome sequence.
- Establishment of infectivity in different Indian wheat varieties.
- Development of VIGS vector by modifying the viral genome.
- Validation of VIGS vector using visual markers.

Long term objectives:

- Elucidation of functions of candidate genes involved in processing quality and nutritional traits in wheat by knocking down the expression.

Research in progress:

- **Detection of viruses infecting wheat in India:** Presence of virus and insect vector was investigated in wheat growing fields in India and suspected samples (Figure 6A-C) were tested. About 80% of the samples were tested positive in the samples collected during 2010 and 2011.
- **Analysis of the viral genome sequence:** The whole genome of virus was sequenced and nucleotide sequence of one clone was submitted to the GenBank under accession number JF781306.

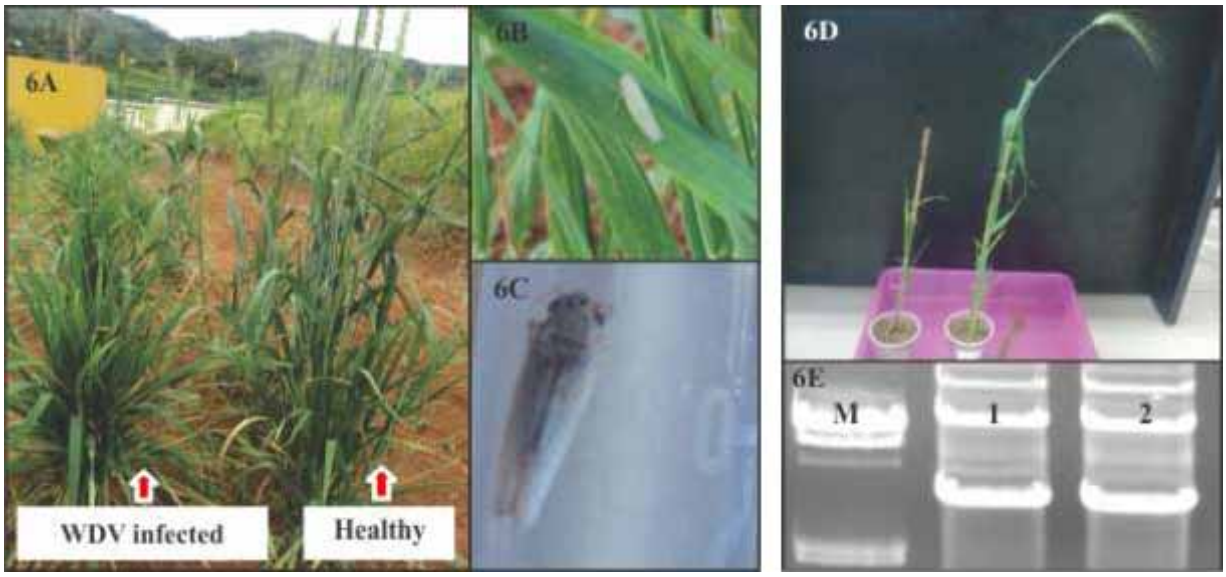


Figure 6: Panel **6A** showing the difference in growth and physical appearance of healthy and WDV infected plants; panel **6B** and **6C** showing the detected insect vector (*Psammotettix alienus*); Panel **6D** showing the result of infectivity test. Left plant inoculated with infectious clone shows dwarfism whereas mock inoculated plant looks like healthy; Panel **6E** showing the infectious clone as dimer and full length as monomer of the virus.

- **Establishment of infectivity in different Indian wheat varieties:** Infectious clone (Figure 6D) was made and infectivity tests were done. Host ranges was determined by infecting different Indian wheat varieties (Figure 6E).
- **Development of VIGS vector by modifying the viral genome:** Three modifications were done in the viral genome by removing a small stretch of nucleotide and inserting multiple cloning sites (MCS) at the same positions (Figure 7). The modified viral genome was cloned in a plasmid vector for further manipulation.
- The detected virus is mastrevirus and is known as monopartite geminivirus. Association of the two sub genomic components (alpha and betasatellites) was noticed for the first time with this virus. This is being verified by co-infectivity. The sub genomic components can be very good candidates for VIGS vectors.
- The virus under study has strong silencing suppressor (betasatellite). Using the suppressor, viral vectors for the transient expression of proteins (eg. Zinc finger nuclease) of interest in wheat are being developed.

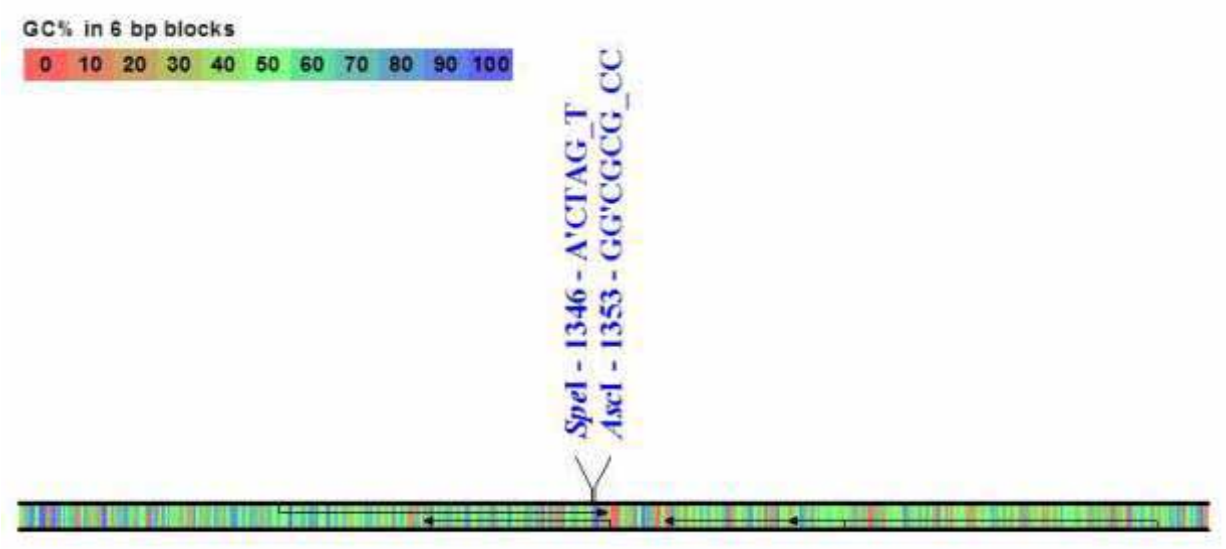


Figure 7: Genome organisation of wheat dwarf virus showing MCS.

D. Genetic transformation of wheat

Introduction:

Efficient regeneration and genetic transformation protocols are pre-requisites for successful crop improvement through genetic engineering. The optimization of callus mediated *in-vitro* regeneration and *Agrobacterium*-mediated stable genetic transformation of wheat are in progress.

Research objectives:

Establishment of efficient *in-vitro* regeneration and genetic transformation protocols of wheat.

Long term objectives:

- Development of nutritionally rich varieties.
- Development of agronomically improved varieties.

Research in progress:

Establishment of *in-vitro* regeneration: In the four cultivated varieties of wheat, the best response for callus induction was observed when mature embryos were cultured on MS medium supplemented with 2, 4-D and Zeatin (Figure 8 A, B, C).

- Multiple shoot induction and elongation from callus was most efficient on MS medium supplemented with Zeatin (Figure 8 D, E).
- Healthy roots were induced on the MS basal medium (Figure 8 F).

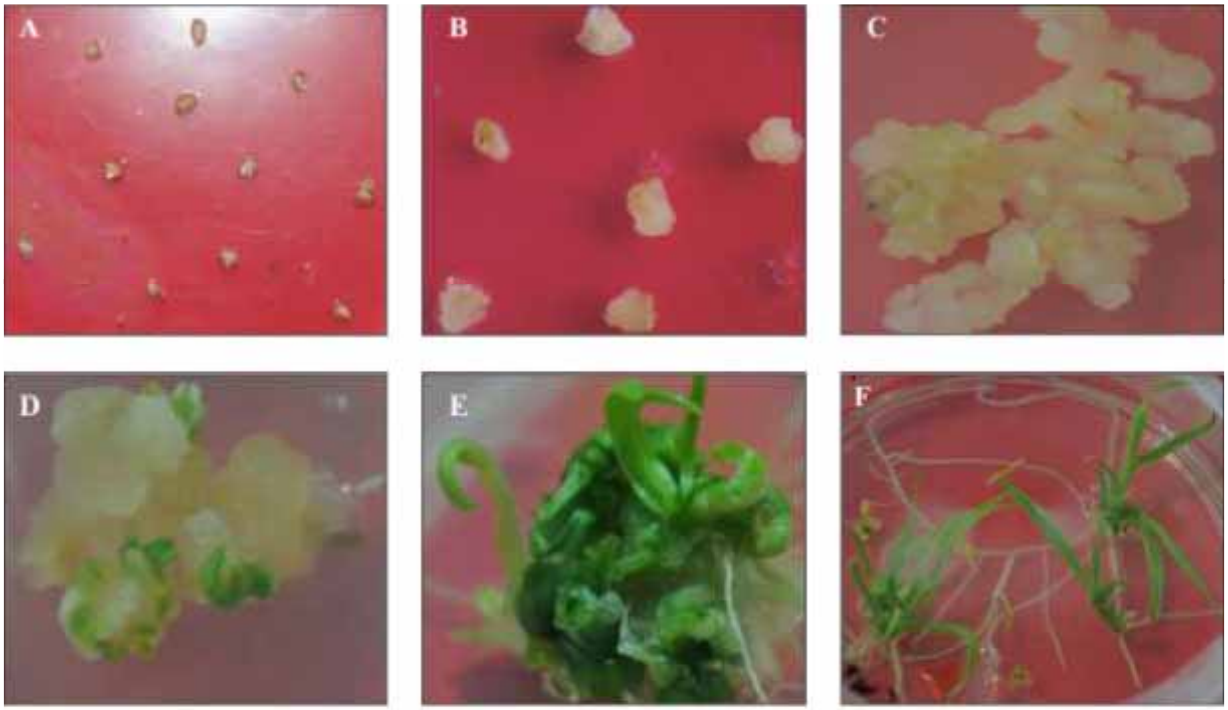


Figure 8: Different stages of *in-vitro* regeneration of wheat plants. **(A)** isolated mature embryos used as explant, **(B)** one month old calli, **(C)** two months old callus, **(D)** and **(E)** shoots induction and elongation, and **(F)** root formation

Establishment of genetic transformation:

Using mature embryos, and GUS reporter gene, successful transformation was noticed as blue spots on the callus (Figure 9A). No expression of GUS was noticed in control callus (Figure 9B).

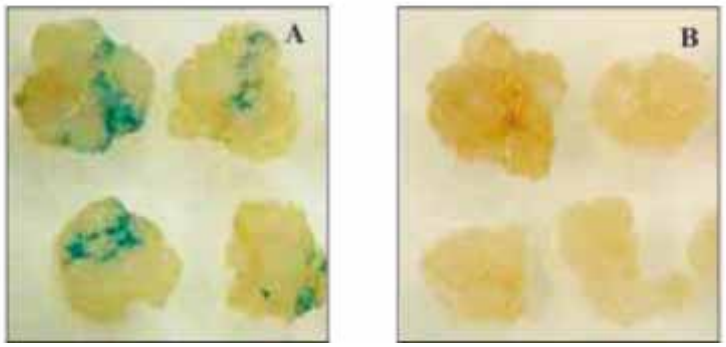


Figure 9: GUS histochemical assay: **(A)** Transgenic callus (blue spots), **(B)** non-transgenic callus

ACCELERATED BREEDING FOR QUALITY IMPROVEMENT

Investigator:	Dr. Monika Garg	Scientist-C
Co-investigator:	Dr. Joy K. Roy	Scientist-D

Introduction:

Processing quality of wheat depends on the constituents in seeds i.e. proteins, starch, non-starch carbohydrates, lipids and other small molecules. The protein content and types determine the end product quality like bread, biscuit, cake, chapatti and noodles etc. Biscuit making requires soft wheat with low protein content and specific combination of different alleles, like (2+12) allele of high molecular weight glutenin subunit gene (HMW-GS)on chromosome 1D (locus *GluD1*); *PinaD1a, PinbD1a* alleles of Puroindoline gene etc. Bread making requires hard wheat with high protein content noticed with specific combination of different alleles (5+10 allele of *GluD1*-HMWGS, *PinaD1b, PinbD1a/b* etc). Chapatti making requires medium strength wheat with medium protein content. The contribution of different alleles to chapatti making is poorly understood.

Research objectives:

Generation of the breeding material with trait specific, improved processing quality is the major objective. Three traits: Bread, biscuit and chapatti making will be studied. For improvement of bread making quality we are utilizing wild species of wheat and their genetic stocks (addition lines, substitution lines and translocation lines). For improvement of biscuit making quality, we are utilizing soft wheat landraces NAP HAL and IITR67. For chapatti making old cultivars C306 and Lok1, well known for their good chapatti quality will be utilized. Factors responsible for good biscuit/chapatti making quality will be characterized. These factors/genes will be transferred to agronomically superior background by accelerated breeding approach.

Long term objectives:

Generated breeding material will be screened for multiple traits and put into multi location national trials with the help of DWR/State University scientists to design the end product (bread, biscuit, Chapatti) specific cultivars.

Research in progress:

- For improvement of chapatti making quality, good chapatti making old cultivars C306 and Lok1 were crossed with high yielding recent cultivars (PBW343, PBW550 and PBW621). Crossed seeds were backcrossed at DWR Regional Station, at Dalang Maidan, Lahaul, Himachal Pradesh in offs season. BC_1 and F_2 seeds have been sown in the field.
- For improvement of biscuit making quality major genes (Puroindoline and HMW Glutenin genes) responsible for grain softness were characterised in the soft wheat land races NAP HAL and IITR 67. PCR multiplexing for selection of grain softness genes in the backcross lines was standardised. The landraces were crossed with high yielding recent cultivars (PBW343, PBW550 and PBW621). Crossed seeds were backcrossed at Dalang Maidan in off season. BC1 and F2 seeds have been sown in field.
- For improvement of bread making quality wild species/genetic stocks of *Ag. elongatum, Ae. searsii* and *Ag. intermedium,* are being utilized. HMW-GS genes related to high grain strength will be transferred from wild species to chromosome 1A of

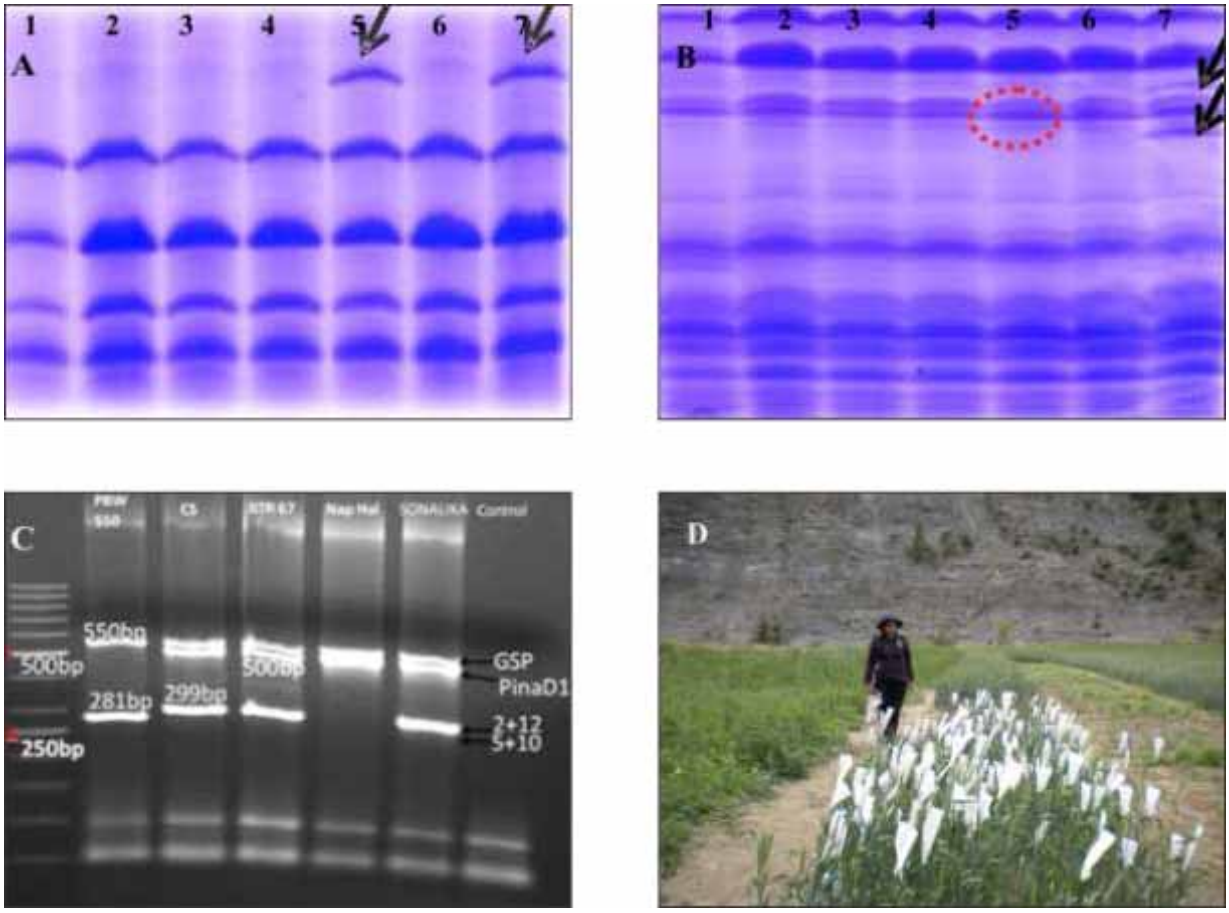


Figure 1. Marker assisted breeding for processing quality. **(A)** SDS-PAGE of HMW-GSs of endosperm half of seeds to find individual plants carrying addition subunit from wild species (indicated by arrow) having positive effect on bread making quality. **(B)** SDS-PAGE of gliadins of endosperm half of seeds to find translocation line (lane 5) having only HMW-GSs and no gliadins from wild species for improvement of bread making quality. **(C)** PCR multiplexing for biscuit making quality to co-amplify Puroindoline gene and high molecular weight glutenin genes. **(D)** Crossing in progress at DWR-regional station, Dalang maidan, July-2011.

wheat (translocation lines) as later has some alleles that contribute negatively to bread making quality. Marker assisted selection and transfer to agronomically superior cultivars is in progress. Genetic material was screened by SDS-PAGE of storage proteins from endosperm half of seeds. Seeds expressing selected wild species' HMW-GSs were sown at the NABI field and crosses/backcrosses of selected material were carried out. Harvested seeds were rechecked by similar procedure and selected seeds were grown at Dalang Maidan. Selfed seeds were reselected and sown at NABI field.

GENETIC TRANSFORMATION OF BANANA FOR QUALITY IMPROVEMENT

Investigator:	Dr. Siddharth Tiwari	Scientist-C
Co- investigator:	Dr. Rakesh Tuli	Executive Director

Introduction:

Banana is a tropical fruit crop, cultivated over 130 countries and contributing 16 % of total world's fruit production. Banana is known as poor man's food in developing counties. Most of the cultivated varieties are triploid (AAA/ AAB/ABB) in nature, hence sterile and provide natural barrier to cross pollination. *In-vitro* plant regeneration of banana has been reported from various explant sources. Immature male flowers are the most responsive starting material for initiating embryogenic cultures. Embryogenic cell suspension culture is used for *Agrobacterium-tumefaciens* mediated genetic transformation in many laboratories. Genetic transformation and regeneration frequencies are highly genotype dependent. Thus, optimization of transformation protocol for any particular type of cultivar becomes a prerequisite for agronomic improvement in that cultivar. The following objectives need to be achieved by NABI for the development of bio-fortified Indian banana varieties.

Research objectives:

The major research objectives would be germplasm screening for nutritional traits, bioavailability study, development of efficient genetic transformation and agronomical analyses of transgenics.

Long term objectives:

- Screening of banana germplasm for the identification of pro-vitamin A & iron synthesis new candidate genes in nutritionally superior lines.
- Model-based evaluation of bioavailability of vitamin A & iron in fortified banana.
- Biochemical analyses of germplasm with contrasting levels of iron & pro-vitamin A in target tissues to understand the regulation of metabolic pathways, limiting steps, kinetic basis of efficient enzymes, nutrient transport and localisation.
- Comparative transcriptomic and genomic analyses in nutritionally contrasting lines for gene discovery, to identify the desired alleles and genes.
- Allele/gene discovery and validation of function.
- Evaluation of candidate promoters and genes & combinations thereof after transformation.
- Development of transgenic lines using constructs for iron & pro-vitamin A biofortification.
- Selected lines for fruit nutritional bioavailability analysis.

Research in progress:

- Germplasm collection and plantation at NABI research field:

  Suckers of banana cultivars (Grand Nain, Robusta, Nendran, Poovan, Rasthali, Red Banana, Ney Poovan, Virupakashi, Karpuravalli, Dwarf Cavendish, Dwarf-Robusta, Udhayam and Nanjanagud-Rasabale) have been collected from Tamil Nadu Agricultural University (TNAU), Coimbatore and Gandhi Krishi Vigyana Kendra (GKVK) Bangalore (Figure 1A). The collected suckers have been grown in NABI research field for establishing germplasm (Figure 1B).

- Establishment of embryogenic suspension culture (ESC) for genetic transformation of banana:

  a) Immature male flower buds of four cultivars (Grand Nain, Robusta, Nendran and Dwarf Cavendish) were collected from TNAU, Coimbatore (Figure 2A, B).

  b) Immature male flower hands of rank 1 to 15 adjacent to the floral apex were isolated and cultured on MS medium containing several combinations and concentrations of different growth regulators for the optimization of protocol (Figure 2C).

  c) Calli were formed on the callus forming medium. However, efficiency and response for callus induction depends upon the cultivars.

  d) Grand Nain and Dwarf Cavendish cultivars show best response for callus formation (Figure 2D).

  e) Optimization of ESC has been initiated for the induction of globular embryos and genetic transformation(Figure 2E).

Figure 1: (A) Banana suckers and **(B)** establishment of banana germplasm at NABI research field

- Establishment of micro propagation:

  a) Suckers of Grand Nain and Dwarf Cavendish cultivars were used for optimization of protocol for micropropagation.

  b) Multiple shoots were induced and multiplied under some of the culture conditions (Figure 3B, C, D).

  c) Tissue culture raised acclimatized plants has been generated and transferred at NABI research field (Figure 3E).

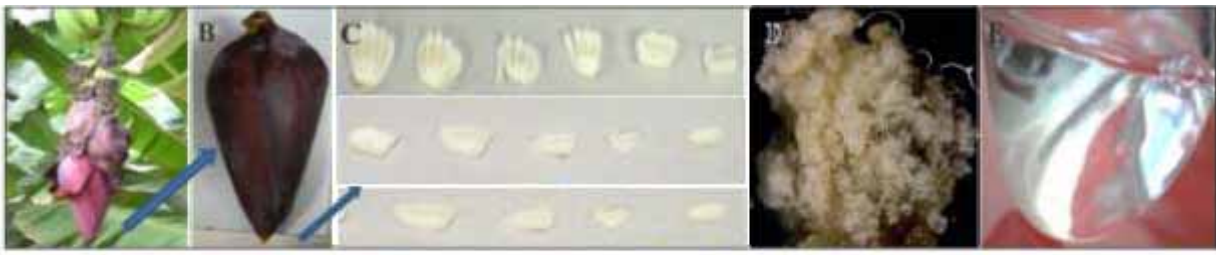


Figure 2 : (A and **B)** Immature male flower bud. **(C)** Immature male flower hands of rank 1 to 15 adjacent to the floral apex. **(D)** embryogenic callus induction. **(E)** Suspension culture

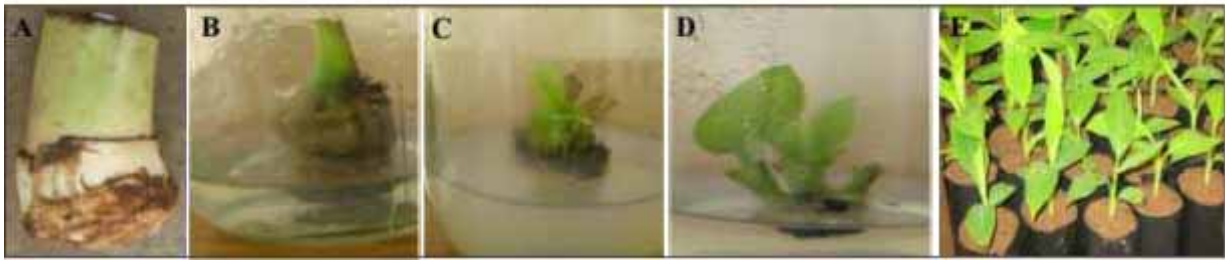


Figure 3: Different stages of *in-vitro* plants development. **(A)** Suckers of Grand Nain cultivar. **(B)** Sucker turned into green bud. **(C)** Green bud turned into shoot bud. **(D)** Shoot elongation and multiplication. **(E)** Tissue culture raised plants

QUALITY AND POSTHARVEST STABILITY OF FARM PRODUCE

Investigator:	Dr. Sukhvinder Pal Singh	Scientist-C
Co-investigator:	Dr. Rakesh Tuli	Executive Director

Introduction:

Quality and postharvest stability of farm produce underscore the success of supply chain constituents such as primary producer, processor, trader, shipper, distributor, retailer and consumer. Superior quality produce and its postharvest stability are fundamental in reducing postharvest losses, ensuring enterprise profitability and meeting consumer expectations. Quality is governed by a number of factors including genotype, environment, farm management and postharvest practices. This research program is focused on understanding biological basis of produce quality and generating basic knowledge to assist genetic and molecular manipulations for better quality traits. The research initiative emphasises the substitution of empirical and subjective approaches of quality evaluation with the objective, biochemical and molecular methods for defining quality in a holistic manner.

Produce stability is influenced by pre-harvest and postharvest factors such as physiological state at harvest, handling and storage conditions, and postharvest treatments. The research program is aimed at developing postharvest procedures that can minimise quality losses and maintain produce integrity in the supply chain. The development of commodity-specific postharvest techniques requires prior information about their physiology, biochemical composition and molecular events that control the processes of ripening, senescence, and decay. The application of physical, chemical and biological agents/treatments or their combination is being followed to enhance produce stability for longer duration.

Research objectives:

- Understanding and explicating the complexity of biochemical and molecular factors contributing to produce quality.
- Development of preharvest and postharvest strategies to improve quality and enhance postharvest stability of farm produce.
- Translation of knowledge and innovation into commercially important products/processes/services for primary producers and industry.

Long-term objectives:

- To develop protocols to address commodity specific quality and postharvest issues.
- To improve and maintain farm produce quality through application of generally recognised as safe (GRAS) compounds, natural metabolites, growth regulators and antagonistic microorganisms.
- Generating primary data on produce quality with special reference to flavour and nutritional quality.

Research in progress:

Mango, citrus, litchi, and guava are the target crops for studies on quality and postharvest stability.

Mango:

Aroma is an integral component of mango flavour that affects quality and consumer perception. Identification of volatile compounds linked to postharvest stage of ripeness, senescence and fruit quality is important for developing intelligent packaging and quality control systems. Research activities have been initiated to characterise the aroma-volatiles profiles of mango fruit and to optimise method for rapid assessment of these compounds for developing biomarkers linked to

fruit quality and postharvest status. Experiments were conducted to optimise the static headspace (SHS) method for extraction of aroma volatiles and its efficacy was compared with the widely used solid-phase micro extraction (SPME) technique. The improved SHS extraction technique was combined with separation on different types of columns (polar and non-polar) and simultaneous detection using flame ionization detector (FID) and mass spectrometer (MS) to achieve better resolution and detection of maximum number of compounds.

The aroma volatiles profile of mango cv. 'Chausa' were deciphered during different stages of ripeness (unripe, partially ripe, fully ripe and over-ripe) using GC and tandem mass spectrometry (Figure 1). The application of two-dimensional GC coupled with time-of-flight (TOF) mass spectrometer to identify untargeted compounds with greater sensitivity and accuracy is in the future plan.

Postharvest treatment of mango with heat (hot water and vapour heat) has been commercially adopted in India to meet phytosanitary requirements of importing countries such as USA, Japan and Australia. In 2011 season, a semi-commercial scale experiment on vapour heat treatment (VHT) of 'Chausa' mango was conducted to study the effect on fruit quality. The results showed that VHT accelerated the rate of fruit ripening and softening and resulted in development of uniform skin colouration. The comprehensive biochemical analysis for targeted and untargeted compounds including aroma volatiles is in progress.

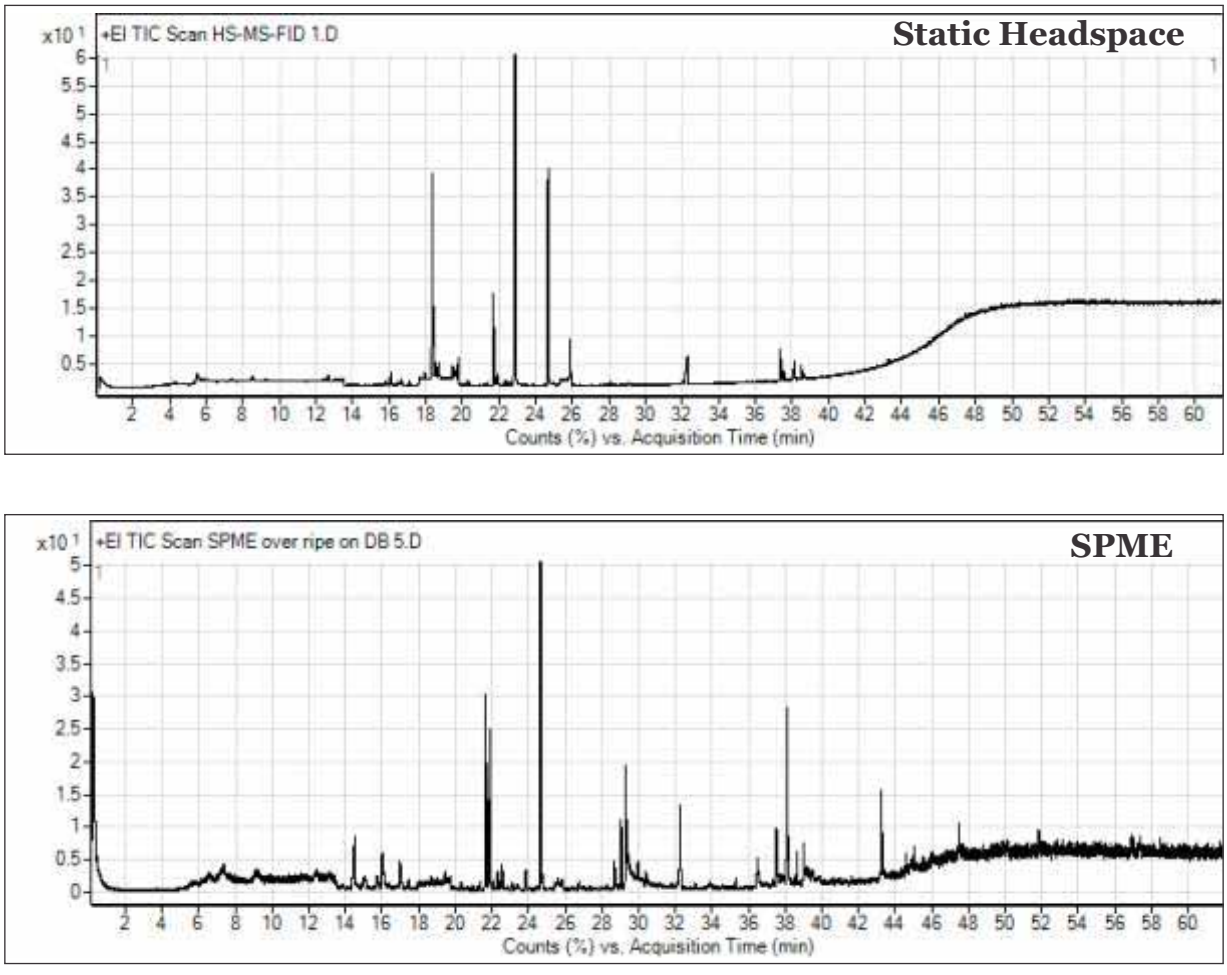


Figure 1: Total ion chromatogram (TIC) obtained by static headspace and SPME of fully ripe 'Chausa' mango fruit.

Litchi

Skin colouration in litchi is due to the presence of anthocyanin pigments whose biosynthesis and postharvest stability can seriously affect fruit quality. To develop better understanding of anthocyanin biosynthesis at molecular level, the samples of litchi fruit (cvs. 'Calcuttia', 'Dehradun' and 'Seedless') at different stages of maturation (green, colour break/pink, and red) have been collected (Figure 2).

Figure 2: Maturation and ripening stages of litchi fruit.

Pericarp browning is a serious postharvest problem impeding the consumer acceptability of fruit. The degradation of anthocyanin pigments, increased activity of phenol oxidases and pericarp desiccation are the primary factors causing pericarp browning. An experiment was conducted to study the effect of modified humidity packaging and treatment with organic acids (citric and ascorbic acids) on postharvest quality and stability of litchi fruit. Preliminary results were promising in stabilising the anthocyanin pigments and thus delaying the degradation process leading to pericarp browning.

RNA from the skin and aril tissues has been extracted for whole transcriptome analysis. It is expected that transcript profiling will give insights into the biosynthetic pathways related to pigments in the skin and sugar-acid metabolism in the aril. Targeted and untargeted metabolite profiling of litchi pericarp tissue at various developmental stages is in progress. Metabolomics and transcriptomics data will be integrated to understand the processes of fruit maturation and ripening in litchi fruit.

DEVELOPMENTAL BIOLOGY FOR CROP IMPROVEMENT

Investigator:	Dr. Rakesh Tuli	Executive Director
Research Associate and Fellows:	Dr. Sudhir P. Singh	Research Associate
	Mr. Yogesh Gupta	Junior Research Fellow

A. Identification of genes responsible for the developmentof seedless fruitlets

Introduction

Seedlessness increases fruit acceptance by consumers due to several benefits: seedless fruits are easier to eat and fruit processing is easier. Also, seeds have bitter taste and in some instances seeds accumulate toxic compounds.

In *Annona* flowers comprise of a cluster of stamens (more than 200) and carpels (more than 100). Each carpel has a single anatropous ovule that may develop into a single seed. The *Annona* fruit develops from the cluster of fertilized carpels, thus the aggregate fruit contains several fruitlets. Out of the multiple fruitlets a few fruitlets develop naturally, without seeds (Figure 1). Objective of this study is to understand the molecular basis of the development of seeded and seedless fruitlets in the same fruit of *Annona* sp.

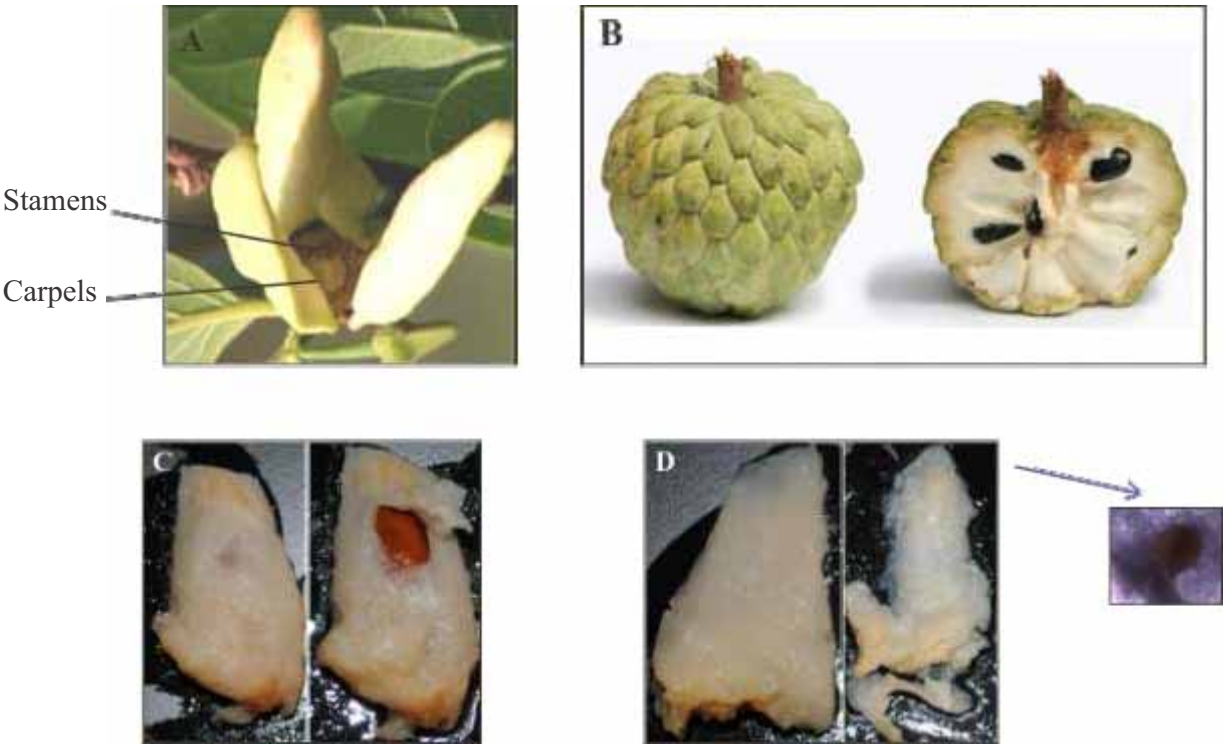


Figure 1. A) Flower of *Annona squamosa* with multiple stamens and pistils. **(B)** Fruit of *Annona squamosa* with aggregation of fruitlets. **(C)** Seeded fruitlet. **(D)** Seedless fruitlet with a minute, aborted seed.

Research objectives:

- Differential transcriptomics of developing fruits of *Annona squamosa, Annona chermola and Annona atemoya* for identifying genes involved in seed development.
- Tissue specific differential transcriptomics in developing fruitlets of *Annona* sp.
- Identification and validation of genes associated with fruit development in Annona.
- Screening of germplasm for diversity in the sequence and expression of known seed development related genes.

Long term objectives:

- To identify genes responsible for the development of fruits and seeds.
- To develop varieties of fruits crops with seedless fruits.

Research in progress:

- Total RNA has been extracted from developing fruits of *Annona squamosa, Annona chermola, Annona atemoya.*
- Identification of anatomical differences between seeded and seedless fruitlets during early stages of development is in progress (Figure 2A).
- Laser micro-dissection of different tissues of ovules and embryo-sac of developing fruitlets of *Annonasquamousa* and RNA extraction from the micro-dissected tissues is in progress (Figure 2B, C).
- Screening of *A. squamosa, A. chermola, A. atemoya* for the identification of SNPs in candidate seed development related genes. Degenerate primers of known seed related genes have been designed. Amplification and sequencing of seed related genes is in progress.

Figure 2 : (A) Ovule of *Annona squamosa* Stage: 16 DAP. The fruitlet with smaller ovule is probable seedless fruitlet. Laser micro-dissection of embryo sac, Stage: 0 DAP; **(B)** before and **(C)** after excision of the ovule.

B. Development of approaches for the modulation of seedlessness, in the scion through rootstock signalling

Introduction:

Trees, shrubs and fruit crops are mostly propagated through asexual reproduction by grafting. In grafting one plant is selected for its roots and is called rootstock. The other plant is selected for its stems, leaves, flowers, or fruits and is called the scion. Scion–rootstock interaction affects the physiology and thus phenotype of the scion plant. For example, to induce dwarfing in apple trees, scions are grafted on to dwarf root stock to give smaller canopy, so that it becomes suitable for planting the trees at high density. In recent years, evidence suggestive of long-distance transport of signals through vascular system appears to be increasing. Such signals can influence various developmental and physiological processes such as flowering, tuberization, nodulation, leaf development, shoot branching and disease resistance.

Recent reports on Graft transmissible long distance signalling can involve proteins, RNAs and small RNAs transported through the vascular system. As of now, the molecular basis of such long distance control of any economically important trait has not been studied. This area can have valuable opportunities in designing plants through transgenic rootstock research. Silencing of reporter transgene (GFP) by siRNA, mobile and transmissible through grafted plant parts will be examined in our studies.

Research objectives:

- To optimise grafting systems in *Arabidopsis thaliana.*
- To develop various constructs, using a reporter gene for studying root-stock scion effect in Arabidopsis.
- To examine the movement of RNAi in Arabidopsis

Long term objective:

Development of improved rootstock for the delivery of long distance signals into the scion.

Figure 3. Stem grafting in *Arabidopsis thaliana*

Research in progress:

- Transgenic lines expressing GUS reporter gene constitutively have been developed.
- Development of transgenic lines expressing GUS reporter gene in ovule is in progress.
- Several constructs have been prepared for the expression of double stranded RNA-hairpin homologue of reporter gene and candidate genes of seed development.
- Stem grafting has been optimised in *Arabidopsis thaliana* (Figure 3).

DEVELOPMENT OF GENOMIC RESOURCES FOR GRAIN CROPS

Coordinator:	Dr. Rakesh Tuli	Executive Director
Investigator:	Sh. Shrikant S. Mantri	Scientist-C
	Dr. Joy K. Roy	Scientist-D
Research Associates and Fellows:	Dr. Sudhir Pratap Singh	Research Associate
	Ms. Anuradha Singh	Junior Research Fellow

Development of genomic resources for wheat

Genomic sequence data holds the promise of dramatically advancing both the understanding of basic plant science, and of catalyzing practical advances in plant breeding. Genome data of wheat, *Triticum aestivum*, is available in public domain from University of Bristol (5X coverage of genome , ~200 million 454 reads). Similarly genome data of wild wheat, *Aegilop tauschii*, is recently available from CSHL (Illumina reads). The studies are undertaken for genome assembly and analysis to generate framework map of wheat and to identify the vast majority of genes in three closely related progenitor genomes of wheat (AA, AABB, and DD genome containing species) and hexaploid wheat (Chinese spring). Data from the above resources along with in-house data generated for transcriptomes of different germplasms at NABI will be used for improving the draft assembly and scaffolding. Algorithmically and computationally it is challenging to assemble wheat genome. Specialised algorithms and computational infrastructure needs to be developed. Re-sequencing experiment data will pose additional challenges in terms of scale and volume of data to be analysed. Development of advanced algorithms and computational infrastructure to handle this large amount data is necessary

50K SNP discovery and genotyping of Indian wheat cultivars:

Recently wheat SNP chips having 50K SNPs is available from Illumina that is not publicly released. NABI will use this chip for genotyping diverse sets of wheat germplasm for association mapping for nutritional and processing quality related traits. However, we have identified 90K putative SNPs by comparing inhouse generated transcriptome and publicly available ESTs till date. We are also identifying SNPs for differentially expressed genes which we have identified by using wheat microarray for processing trait.

Research objectives:

- Transcriptome sequencing, assembly and annotation for contrasting wheat varieties.
- Digital expression profiling and microarray data mining.
- SNP database development.
- Comparative genomics and related data mining.
- Repository of germplasm.

Long term objectives:

- Framework map development for wheat genome (assembly and annotation).
- Identification of genes involved in high accumulation of micronutrients and quality.
- Genome-wide association analysis for correlating quality and processing related traits with the identified SNPs.

Research in progress:

- Collection and establishment of nearly 1000 diverse links of wheat, wild relatives and mapping populations, from different sources and growing at NABI. *Triticum monococcum* and *Aegilops tauschii* transcriptomes are being compared to identify genome related sequence and expression signatures.
- Microarray data analysis and meta-profile analysis of *Triticum aestivum* expression array for understanding the gene expression dynamics in starch and sucrose metabolism pathways in genotypes with contrasting processing related traits.
- Datamining for identification of SNPs in transcription factors and genes involved in starch biosynthesis and metabolism in wheat.
- Haplotype and SNP identification in storage proteins in wheat.
- Several germplasm have been collected such as wheat (>1500 lines), rice (16 lines), pearl millet (4 lines), finger millet (5 lines), mung and urd bean (26 lines), sorghum (41 lines) and chickpea (9 lines).

Comparative study of *Triticum monococcum and Aegilops tauschii* transcriptomes

- Transcriptome sequencing was out-sourced on next generation sequencing pyrosequencing platform of 454. Pre-anthesis spike and leaf tissue was used for *Triticum monococcum* and leaf tissue was used for *Aegilops tauschii* for isolation of total RNA. Nearly 535 Megabases and 457 megabases was generated using GS FLX titanium kit respectively for each transcriptome.
- CLC assembly cell was used for transcriptome assembly. CLC Assembly Cell utilizes SIMD (Single instruction, multiple data) instructions to parallelize and accelerate the assembly algorithms. Assembly statistics as shown in Table 1 and unassembled reads were retrieved using 'assembly_info' and 'un-assembled_reads' scripts respectively.

Table 1: Transcriptome assembly statistics

Sequence feature	*Triticum monococcum* transcriptome	*Aegilops tauschii* transcriptome
Reads	1406164	1243896
Total Bases in Reads	535022417	457425878
Contigs	13075	10413
Total Bases in Contigs	7336349	5882312
Unassembled reads	23773	19348
Assembled reads	1382391	1224548

- All the contigs and unassembled reads were annotated using BLAST against NR, Uniprot and dbEST database. Both the transcriptomes were also compared within themselves (Tables 2 to 4; Figures 1, A, B, C).

Table 2: Unannotated sequences with respect to NR database

Un-annotated Sequences	Singlets	Contigs
Sample12	11860	3349
Sample16	8557	2280

Table 3: Novel genes with respect to dbEST database for A and D genome

Annotation	A	D
ESTs present in dbEST	11190	192
Contigs+singlets matching with EST	7438	1474
Contigs+Singlets	36848	29761
Transcripts new to Database	29410	28287

Table 4: Novel transcripts with respect to *Triticum aestivum* unigenes

Annotation	A	D
Contigs+Singlets	36848	29761
Match with Unigene (TA)	23228	19811
Transcripts new to Unigene	13620	9950

Table 5: Comparison of A transcriptome with D transcriptome

Annotation	A Transcripts	D Transcripts
Similar Contigs+Singlet	19795	18041
Unique Contigs+Singlet	17053	11720

- Functional categorization of all the transcripts was done based on similarity search with *Arabidopsis* orthologs and their subsequent gene ontology terms enrichment.

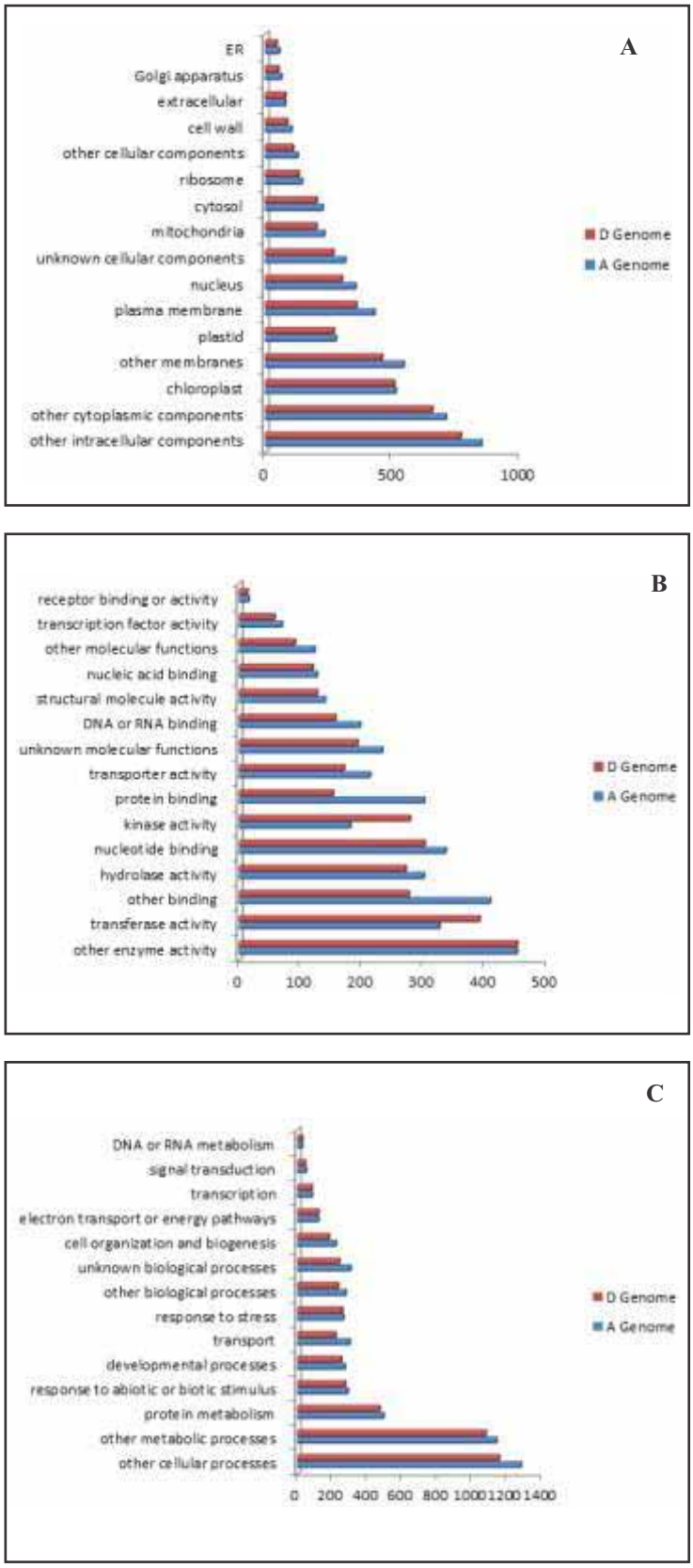


Figure 1: Functional categorization of annotated transcripts. **(A)** cellular components. **(B)** molecular function. **(C)** Biological Process.

Meta-profile analysis of *Triticum aestivum* expression array

- Meta-profile analysis was done for understanding the gene expression dynamics in starch and sucrose metabolism pathway for baking quality.
- Meta-profiles summarize expression levels according to the biological context of the sample. In contrast to normal expression profiles where each signal value denotes the expression level of one gene in one sample, each signal value in a meta-profile corresponds to the average expression level of one gene over a set of samples sharing the same biological context. Meta-profiles of genes involved in starch and sucrose metabolism and their expression in different tissues at different developmental stages were developed.

DEVELOPMENT OF GENOMIC RESOURCES FOR HORTICULTURAL CROPS

Coordinator:	Dr. Rakesh Tuli	Executive Director
Investigator:	Sh. Shrikant S. Mantri	Scientist-C
	Dr. Sukhvinder Pal Singh	Scientist-C
Research Associate:	Dr. Sudhir Pratap Singh	Research Associate

Introduction:

Collection of diverse germplasm of custard apple, litchi, banana, kinnow and mango through networking with crop specific national institutes has been initiated. Developing genomic resources for horticultural crops such as custard apple, litchi, and mango has been taken up through transcriptomics and SNP database. Globally, the effort on tropical horticulture crops is sparse. Development of germplasm and genomic resources would be useful to discover the genes and alleles for desirable characters.

Research objectives:

- Developing linkages with national institutes specialised in fruit crops.
- Establishment of some germplasm collection at NABI for banana, custard apple and litchi.
- Extraction of RNA from different plant organs of custard apple and litchi, followed by transcriptomics.
- Amplification of known seed development related genes in litchi and custard apple followed by SNP detection and determination of their expression pattern at different developmental stages.

Long-term objectives:

- Development of transcriptomics, genomic and SNP database for custard apple, mango and litchi.
- Identification of genes and alleles for fruit quality (seedlessness, flavour and postharvest life) and tree architecture.

Research in progress:

- Some germplasm in case of banana, custard apple and litchi has been established at NABI. Most of this will be utilised in partnership with national horticultural institutes.
- Leaf samples of diverse litchi germplasm have been collected from different places: Litchi Research Centre, Muzaffarpur, Pinjore Garden, Panchkula and Nawanshahr
- DNA from the above collected germplasm has been extracted. RNA extraction from developing seeds and other plant organs is in progress for sequencing.
- Designing of degenerate primers of more than 50 seed related candidate genes is in progress to screen germplasm for diversity in the sequence and expression of such genes.

EMERGING INITIATIVES

Effects of Diet and Its Constituents on Adipogenesis

Introduction:

Obesity is a phenotypic manifestation of excessive fat accumulation that affects the health and increases mortality. It is characterized by increase in BMI i.e. body mass index. A BMI more than 30 is classified as obesity risk and is increasing in Indian population. World Health Organization (WHO) estimates that by 2020, two third of the global disease burden will be attributable to chronic diseases associated with obesity. Phytochemicals may have a potential to inhibit the adipocyte life cycle or adipogenesis and hence reduce obesity. Fat reduction processes may involve inhibition of lipid accumulation by decreasing adipogenic process, increase in lipid breakdown, modifying insulin action and glucose homeostasis and increasing apoptosis of adipocytes.

In the current project selected cereal grains viz., wheat, finger millet, kodo millet, barn yard millet and buck wheat millet will be extracted to get phenolic, water soluble, protein and carbohydrate fractions to study their potential to inhibit the adipocyte life cycle *in vitro* using 3T3-L1 adipocytes and *in vivo* in mouse models. Expression levels of various biomarkers will be assessed. Changes in total bacteria; bifidobacteria, lactobacilli and the Eubacterium rectale/ *Clostridium* coccoides group of the caecal and faecal contents will be monitored using primers targeting the 16S rRNA gene by quantity PCR (QPCR) after feeding the animals with different test diets. Micro array analysis will be carried out on adipocytes and peripheral blood mononuclear cells in animal studies.

Research objectives:

- Selection of cereal grains (wheat, finger millet, kodo millet and buck wheat) and starches with contrasting amylose and amylopectin contents and to fractionate the grains into phenolic, water soluble, protein and carbohydrate fractions.
- Study the effect of extracts on adipogenesis and biochemical markers *in vitro* in 3T3-L1 adipocytes.
- Differences in the level of enzymes and biomarkers for fatty acids and carbohydrate metabolism.
- Genome wide transcriptome expression changes in the adipocytes challenged with soluble extracts of the grains.

Long term objectives:

- To study the interaction of dietary components of whole grains and functional foods (probiotics) at the genetic level using nutrigenomic approach in mouse model.
- To develop a functional food product for preventing non-communicable diseases like obesity, diabetes and other non-communicable diseases.

Targeted mutagenesis for modification of plant genes

Introduction:

Targeted genome modification/mutagenesis in plants is an important tool to investigate basic plant biology or modify plants for the improvement of important agricultural traits. One of the ways for gene targeting is by utilizing homologous recombination (HR) which is of very low efficiency. Recently developed techniques for gene editing by non-transgenic modifications is the use of a non-specific DNA cleavage domain of restriction enzymes together with DNA binding zinc finger protein to design sequence specific zinc finger nucleases (ZFNs). ZFNs are synthetic proteins consisting of an engineered sequence specific zinc finger DNA-binding domain fused to the cleavage domain of the restriction endonuclease (for example: Fok1). ZFNs can be used to induce double-stranded breaks (DSBs) in specific DNA sequences and thereby promote site-specific recombination and targeted manipulation of genomic loci in a variety of different cell types. Targeted mutagenesis/ modification by using ZFNs has now been optimized in several organisms including yeast, mouse, *C. elegans*, zebra-fish, and model plant species like *Arabidopsis*, maize, soybean and tobacco. ZFN based approach will be deployed at NABI to target for gene modification with the objective of targeting novel traits in crop plants.

Since, this technology is of immense potential so it would be applied in one or more of the following areas, depending upon the sequence specificities and efficiency of the ZFN to be designed and the availability of virus or *Agrobacterium* based methods for genetic transformation. Initially, the target crops could be tomato and potato as efficient transformation technologies are available for these crops. Next we would like to include wheat, legumes and banana. Work will be undertaken to design ZFN arrays, improving their targeting efficiencies and eventually to translate the available information from model plant systems to crop species like wheat, tomato and legumes. In summary, a non-transgenic approach will be developed for crop improvement.

Long term objectives:

- Identification and targeting the genes involved in different traits or processing quality of selected crop species.
- Design construction and screening of zinc finger nucleases for site specific targeting.
- Utilizing ZFN's approach for gene targeting to modify genes which contribute to increases in the trait value of the crop plants.

SYNERGY THROUGH COLLABORATIONS & NETWORKING

MoUs signed with other organisations

I. The following MoUs were signed with two universities in neighbourhood to catalyse networking, R&D collaborations, human resource development and the award of degree to students who pursue Ph.D research at NABI.

a) MoU with Punjab University, Chandigarh

b) MoU with Guru Jambeshwar University of Science & Technology, Hissar.

II. The following three MoUs were signed with Canadian institutes, for co-operation in S&T.

a) MoU between National Research Council, Plant Biotechnology Institute, Saskatoon and NABI

b) MoU between University of Saskatchewan, Saskatoon and NABI

c) MoU between Genome Prairie, Saskatoon and NABI

III. Following two MOUs were signed with CDAC for the development of high through put research infrastructure at NABI:-

a) MoU between NABI and CDAC, Mohali for the development of prototype indigenous green house with precision controls.

b) MoU between NABI and CDAC, Pune for the development of HPC Cluster at NABI.

PROGRESS OF INFRASTRUCTURE AT INTERIM FACILITY OF NABI

Continuous efforts are being made to develop laboratory infrastructure at NABI to facilitate high quality research in agri-food sector. Significant progress has been made by procuring general laboratory equipment and other specialised platforms to conduct research into genomics, food quality, proteomics, and bioinformatics. Based on application areas, laboratory equipment has been broadly classified into seven categories: genomics, food quality, chromatography, mass spectrometry, microscopy, controlled environment, and bioinformatics. Some of the major facilities are listed below.

Genomics

MassArray System

(Model: MassARRAY®; Sequenom, Inc., USA)

MassARRAY® system is a flexible, high performance (40 SNPs and 384 individuals at one time) and powerful (mass spectrometry) platform that allows researchers to perform a variety of DNA analysis applications such as i) SNP genotyping for fine mapping, validation of GWAS studies, linkage studies, and genetic testing with SNP panels of interest; ii) highly accurate, sensitive, and quantitative method for DNA methylation analysis; iii) molecular typing; iv) somatic mutation profiling; and v) quantitative analysis of gene expression. The platform includes MassARRAY System, MassARRAY Liquid Handler, and MassARRAY RS1000 Nanodispenser.

MicroArray System

(Model: GeneChip®; Affymetrix, Inc., USA)

The Affymetrix GeneChip® provides a systems biology perspective for both expression profiling and DNA analysis. This integrated system gives the flexibility to view the genome at a global level or focus on a specific subset of genes. The system includes the GeneChip® scanner 3000 7G, fluidics station 450, hybridization oven 645 and a powerful computer workstation with quad-core Xeon processors loaded with Affymetrix GeneChip® Command Console® Software (AGCC).

DNA Sequencer

(Model: 3730xl; Applied Biosystems, USA)

The 96-capillary 3730xl DNA Analyzer is being used for high throughput genetic analysis. It can be used for DNA fragment analysis applications such as microsatellites, AFLP, SNP analysis, mutation detection and traditional DNA sequencing. Higher optical sensitivity and advanced polymers enable the system to deliver higher-quality sequencing data.

Real-Time PCR System

(Model: 7500 Fast; Applied Biosystems, USA)

The Applied Biosystems 7500 Fast Real-Time PCR System offers maximum performance in the minimum time. The system is fully optimized for fast cycling and high-quality results in as little as 30 minutes. It has fast optical plates ensuring excellent precision in 10-30 µL reaction volumes.

DNA Analyser

(Model: 4300; LI-COR Biosciences, USA)

The 4300 DNA analyser system is a third generation instrument based on LI-COR Biosciences highly sensitive infrared fluorescence detection technology. It is very versatile imaging system which can be used for variation analyses such as AFLP, cDNA-AFLP, microsatellites, TILLING, Ecotilling, and DNA sequencing.

Bioanalyzer

(Model: Agilent 2100 Bioanalyzer; Agilent Technologies, USA)

Bioanalyzer is a microfluidics based platform for sizing, quantification and quality control of DNA, RNA, proteins and cells. Results are delivered

within 30-40 minutes in automated, high quality digital data. This instrument is very useful for RNA analysis offering total RNA, mRNA and Small RNA's data including RIN algorithm (RNA Integrity Number).

NanoQuant

(Infinite® 200 Pro; Tecan Group Ltd, Switzerland)

Tecan's NanoQuant is used as a measurement tool for the quantification of small volumes (2 µL) of nucleic acids in absorbance mode. The NanoQuant plate permits the application and parallel measurement of 16 different samples in a single measurement procedure. Tecan's i-control software is used for automatic calculation of nucleic acid content and purity check using the 260/280 ratio.

Particle Delivery System (Gene gun)

(Model: Biolistic PDS-1000/He, Bio-Rad Laboratories, Inc., California, USA)

The biolistic PDS-1000/He system uses helium-accelerated nucleic acid coated micro particles to penetrate target cells, tissues and organelles. High-velocity microparticles penetrate and transform a huge range of cultured plant and animal cells, pollen, algae, fungi, bacteria, intact plant tissues, mitochondria and chloroplasts.

Food Quality

Texture analyser

(Model: TA.HDplus; Stable Micro Systems, UK)

Texture analyser is used for mechanical testing of food, pharmaceuticals, adhesives and other consumer products either in compression or in tension. The TA.HDplus Heavy Duty Texture Analyser assesses textural properties by capturing force, distance and time data at a rate of up to 500 points per second which is then displayed by fully integrated Exponent 32-bit software. NABI has a collection of different load cells (1 to 500 kg), probes and fixtures required for diverse testing applications in foods.

Oxygen-carbon dioxide analyser

(Model: CheckMate 3; PBI Dansensor, Denmark)

The gas analyser is used for measurement of O_2 and CO_2 in the headspace of packages, canned products, and respiration rates of fresh produce. The instrument is fitted with zirconia based sensor for O_2 measurement and dual beam infra-red CO_2 sensor. SmartPen option is unique to assure quality of gas flushed products.

Ethylene analyser

(Model: MACView®; Environmental Monitoring Systems (EMS) BV, Netherlands)

MACView® portable ethylene gas analyser is based on nano-gold electrochemical sensor technology. It is capable of measuring ethylene concentration up to 500 ppm with a resolution of 0.1 ppm. The instrument is very useful for quick estimation of ethylene levels in storage atmospheres, ripening facility, fresh produce, modified atmosphere packs etc.

Colour Spectrophotometer

(Model: ColorFlex EZ; Hunter Associates Laboratory Inc., USA)

HunterLab's ColorFlex EZ offers the advantage of 45/0 design ensuring perfect colour measurement of solid, semi-solid and liquid food samples.

Digital Refractometer

(Model: RX-5000i-Plus; Atago Co. Ltd, Japan)

Atago's benchtop digital refractometer is capable of measurement of degree brix (0-100%) and refractive index (1.32422 to 1.58000) with an accuracy of ±0.010% Brix and ±0.00002 nD. It has provision of automatic temperature compensation in the range of 5-75°C.

Microplate Reader

(Model: SpectraMax M5e; Molecular Devices, Inc., USA)

The micoplate reader can operate in different modes including absorbance, fluorescence intensity, luminescence, time-resolved

fluorescence, and fluorescence polarization. It has full spectral range detection for cuvettes, 96-well, and 384-well microplates.

Chromatography

Gas chromatograph (GC) with Triple Quadrupole Mass Spectrometer (MS/MS)

(Agilent Technologies, USA)

This platform delivers advanced high-speed GC/MS/MS quantitation for ultra-trace analysis of the most complex samples. The triple quadrupole (7000) analyser perfectly complements the front-end separation capabilities of the Agilent 7890A GC. The GC is equipped with flame ionization and thermal conductivity detectors. Automatic liquid (7693A) and headspace samplers (7697A) are also included with the system for high-throughput analysis, greater accuracy and performance.

Liquid Chromatography

(Agilent Technologies, USA and Waters, USA)

Three liquid chromatography systems have been purchased: analytical HPLC, preparative HPLC or automated purification system and ultra-high performance liquid chromatograph. The analytical HPLC (Agilent 1260) and UHPLC (H-class) are equipped with photodiode array (PDA), fluorescence, and evaporative light scattering (ELS) detectors for broad range of analytes. The autopurification HPLC/MS system includes sample manager (2767), binary gradient module (2545), system fluidics organizer (2545), photodiode array detector (2998), mass detector (3100), and MassLynx Software with the FractionLynx application manager.

High performance thin layer chromatography (HPTLC)

(CAMAG, Switzerland)

The HPTLC system procured by NABI is the most advanced and latest in terms of both hardware and software. The system includes sample applicator (Linomat 5), post-chromatography photo-recording system, TLC scanner, TLC visualizer, gradient automatic multiple development chamber, plate heater, TLC MS interface, and winCATS planar chromatography software. The system is a great tool for natural products chemistry.

Mass spectrometry

MALDI-TOF-TOF

(AB SCIEX TOF/TOF 5800)

The 5800 system is the fastest, most sensitive platform for MALDI mass spectrometry imaging of the tissue. It provides high-sensitivity MS and MS/MS data on small molecules as well as peptides and proteins. EasyAcess™ protein identification wizard is a simplified workflow for fast, definitive protein identification. ProteinPilot™ and QuanTIS™ Precursor Ion selector assist the identification of peptides and proteins, and biomarker discovery. The other software tools include LipidView, SW Simglycan and MASCOT. NanoLC-1D plus MALDI spotting system (Eksigent Technologies, USA) is a part of this platform.

TripleTOF™ 5600

The AB SCIEX TripleTOF™ 5600 is a high resolution LC/MS/MS system for qualitative analysis that has speed and high sensitivity to deliver quantitation like a high-performance triple quad. SmartSpeed™ 100 Hz acquisition collects 100 spectra/ second. EasyMass™ accuracy of 1 ppm over 24 hours with external calibration is possible. The system offers a resolution of 25, 000 FWHM at low mass, m/z 100 and up to 40, 000 at m/z 950, at 100 spectra/sec. The system has been offered with softwares such as MultiQuant, PeakView, ProteinPilot, MetabolitePilot and MarkerView.

QTRAP 5500

The AB SCIEX QTRAP 5500 system is next-generation hybrid mass spectrometer with triple quadruple/linear ion trap. The system houses the most sensitive ion trap for unmatched performance in qualitative and quantitative analysis. It includes Turbo V source that accepts

either the Turbo Ion spray probe or atmospheric pressure chemical ionization.

Microscopy

Laser Microdissection and Microscope System

(Model: PALM MicroBeam IV, Microscope: Axio Observer Z1, Apotome2; Zeiss, Germany)

It is an integrated laser micro-dissection and microscope systems for live cells and fixed material. It is capable to isolate single cells and cell groups, as well as biomolecules. It has an apotome attachment which is a plug-in module for the fluorescence beam path with "grid projection" for improved image quality and 3D microscopy.

Microscopes

(Model: Upright Microscope- DM6000B, Inverted microscope- DMI6000 B, Stereo Zoom Microscope- M205 C; Leica, Germany)

Upright and inverted automated microscopes are capable of bright field, phase contrast, DIC and fluorescence applications, with high resolution 12 mega pixels, 42 bit color depth camera and software. The stereo microscope offers 20.5:1 zoom and is capable to resolve structural detail down to 476nm.

Microtome

(Model: RM2265; Leica, Germany)

The microtome is fully motorized and programmable. It also has a microscope carrier with two fiber optic light guides for the optimal illumination of the knife and specimen. It provides semi-thin to thick sectioning. Even the most demanding specimen can be precisely sectioned in a thickness range from 0.25 µm to 100 µm.

Microwave Histostation

(Model: KOS; Milestone, Denmark)

The microwave based system is capable of performing tissue processing decalcification, special stains, gross hardening, and fixation in a fraction of time. It minimizes the time investment in the aforsaid experiments from two to three weeks to a few hours. The histomodule technology preserves the pH of the solution throughout the procedure. Nucleic acid can be extracted from the paraffin infiltrated tissue samples.

Tissue Embedding System

(Model: TES99; Medite, Germany)

Tissue imbedding system is a microprocessor controlled bench top unit with dispensing unit, cooling unit and pre-warming unit. By this system paraffin infiltrated tissue samples are paraffin embedded in blocks with perfection and in faster mode. Small sized samples may also be handled comfortably.

Controlled environment

Plant Growth Chambers

(Model: PGR14, PGC20-Flex, PGW36, BDW120, ATC60, Adaptisis-A 1000-AR; Conviron, Canada)

Seven plant growth chambers procured by NABI are suitable for a range of applications including plant science, bioengineering, and food sciences. The chambers have precise and repeatable control of light output, automatic lumen maintenance, tight temperature control, additive humidity and carbon dioxide control. Two of the chambers have ability to accommodate tree plants.

Tissue culture chambers

(Percival Scientific, Inc.,USA)

This chamber is specifically designed for plant cell and tissue cultures. Its unique design of air diffuser with slow vertical airflow helps to eliminate condensation on Petri dish.

Laminar flow cabinet

(Model: ULPA Filters ISOCIDE™; ESCO Micro Pte Ltd., Singapore)

Esco Airstream Horizontal Laminar Flow Clean Bench offers proven protection for our samples and processes. NABI has procured six laminar flow cabinets fitted with ULPA filters.

Miscellaneous

Laboratories are equipped with high capacity refrigerators, deep freezers (-20°C and -80°C), controlled environment shakers (Kuhner, Switzerland). A range of refrigerated centrifuges has been procured including ultra-high and high speed centrifuges. Media dispenser system (Model: APS 320, AES Laboratoire, France) features a single carousel with a capacity of 320 or 540 petri dishes (90-100 or 55-60 mm) and has a rapid pouring rate of 750 dishes per hour.

Bioinformatics

National Knowledge Network (NKN)

Via NKN, currently NABI is connected to 150 institutions (Universities and Research Institutes) throughout the country at speed of 100Mbps to 500Mpbs. The network consists of an ultra-high speed core, starting with multiple 2.5/10 G and progressively moving towards 40/100 Gigabits per Second (Gbps). Maximum internet bandwidth upto 10 Mbps is currently available. NKN Services that will be useful for NABI research infrastructure include VPN, web hosting, email gateway, virtual class rooms, GARUDA connectivity, cluster computing, and IP telephonic throughout country.

High Performance Computing (HPC) Cluster

State-of-art bioinformatics research facility (High Performance Computing Cluster) at NABI for genome, transcriptome and epigenome analysis of food crops is under development with consultation from CDAC Pune HPC group. Parallel HPC for genome annotation is under development. SMP Server with high RAM capacity for assembly of food crop genomes will be developed. Development of LIMS (Laboratory Information Management System) for the major genomics/transcriptomics projects of NABI will be carried out. GPGPU (General Purpose Graphic Processing Unit) based Computing and other recent technologies will be exploited to cope up with high computing requirements.

Software

Genevestigator is a microarray database and analysis system allowing context-driven queries. The Genevestigator software suite belongs to a new generation of web-based tools that provide categorized quantitative information about elements (genes or annotations) contained in large microarray databases.

CLC Assembly Cell is a high-performance computing solution for read mapping and de novo assembling of Next Generation Sequencing data.The command-line interface of CLC Assembly Cell enables the functionalities to be easily included in scripts and other Next Generation Sequencing work-flows.CLC Assembly Cell is utilizing SIMD instructions to parallelize and accelerate the assembly algorithms.

PROGRESS OF INFRASTRUCTURE AT CAMPUS OF NABI

Undulated areas at the main campus

Building of the campus wall by CPWD in progress.The shifting of high tension cables (220KVA & 66 KVA) passing through the middle of the main campus plot is in limbo.

About 7 acre plot on the campus has been converted into research farm of NABI. Several hundred genotypes of wheat, minor millets, maize, legumes and banana have been planted there, and a variety of experiments have been initiated. Nearly complete campus plot has been placed under cultivation to ensure security of land, train staff and organise infrastructure.

Green belt being developed along the boundary wall

EVENTS AT NABI

1. Inauguration of NABI- 18th February, 2010

   Dr. M. K. Bhan, secretary DBT inaugurated NABI at Interim Facility in Mohali.

2. NABI Interim Facility -formal initiation of research activities- 15th July, 2010

3. First Independence Day celebration: 15th August, 2010

   Dr. Rakesh Tuli, Executive Director hoisted the national flag at NABI Interim Facility.

4. Ground Breaking Ceremony for the inauguration of boundary wall construction at NABI main campus- 20th August, 2010

5. First Republic day celebration- 26th January, 2011

   Dr. Tuli hoisted the national flag at NABI Interim Facility.

6. Foundation Day celebration- 18th February, 2011

   Dr. Bikram S. Gill Professor of Kansas State University, USA as a Chief Guest on the first Foundation Day of NABI.

Meetings

1. Agriculturalists and Industrialists Meet- 27th February, 2010. Theme- Key project discussion for NABI. Eminent guest- Prof. D.P.S. Verma

2. Network Project development meeting- 20th-21st March, 2010. Theme- Wheat network project development

   Institutional participation-National Botanical Research Institute,Punjab Agriculture University, Central Connecticut State University, Indian Institute of Technology, Roorke, Agarkar Reserch Institute, Directorate of Wheat Reserch, Chandra Shekhar Azad Technical University.

3. Indo-Canada strategic meeting at NABI- 22nd-23rd November, 2010

   Theme- Innovations in Agri-Food research at the Agri-Food Cluster

   Chief Guest- Mr. S.C. Agarwal - Chief Secretary, Punjab

   Institutional participation- NRC-PBI Canada, Genome Prairie: Saskatoon, IITs, GNDU, IISER, NBRI and Agri-Food industries

4. DBT-ISTP Workshop at NABI- 24th-25th November, 2010

   Theme- Integrated bio processing & bio products technologies for sustainable food security

   Institutional participation- NRC-PBI Canada, Genome Prairie: Saskatoon, IITs, GNDU, IISER, NBRI and Agri-Food industries

5. Nano-Technology Meeting at NABI on 10th January, 2011.

   Theme- Nanoscience applications in agri-food sector.

   Institutional participation- NIPER, CSIO, IISER, GNDU and IIT.

6. DBT-ISTP Workshop at NRC-PBI, Saskatoon, Canada on 13-15th February, 2011.

International visits of NABI staffs

1. Dr. Joy K. Roy visited Beijing, China to participate in 20th International Triticeae Mapping Initiative meeting and 3rd Conference on Plant Molecular Breeding on 1-5th September, 2010.

2. Dr. Tuli, Dr. Roy, Dr. Sudhir P. Singh and Mr. Shrikant Subhash Mantri visited Canada to participate in DBT-ISTP Workshop on 13-15th February, 2011.

Visits of international visitors to NABI

1. Dr. Bikram S. Gill, Kansas State University, USA gave the First Foundation Day talk on TILLING for wheat functional genomics analysis on 18th February, 2011.

FOUNDING FACULTY AT NABI

Dr. RAKESH TULI

Date of Birth: 21-09-1953

Designation: Executive Director

Area of Research Interest: Genomic & Transgenic Approaches for Improving Plants for Agricultural & Health Applications, Molecular Details of Promoter Expression, Designing Artificial Promoters, Novel Systems for Hybrid Variety Development, Crop Resistance to insects, Biochemistry and Molecular Genetics of Agriculturally and Medicinally Important Plants, Plant–based Protein expression systems, Genomic Diversity in Plants and Precision Breeding, Biological Nitrogen Fixation, Secondary Metabolism and Regulation of Gene Expression.

Past Appointments:

1. Director (2006-2010): National Botanical Research Institute (NBRI), Lucknow, UP, India
2. Director In-Charge (2007-2008): Central Drug Research Institute (CDRI), Lucknow, UP, India
3. Scientist (F & G) (1992-2006): National Botanical Research Institute (NBRI), Lucknow, UP, India
4. Scientific Officer (C, E & SF) (1976-1992): Bhabha Atomic Research Center (BARC), Mumbai, India

Selected Publications:

1. Ranjan A, Ansari SA, Srivastava R, Mantri S, Asif MH, Sawant SV and **Tuli R** (2009). A T9G mutation in the prototype TATA-box TCACTATATATAG determines nucleosome formation and synergy with upstream activator sequences in plant promoters. Plant Physiology. 151: 2174-2186.
2. Chaturvedi CP, Lodhi Niraj, Ansari SA, Tiwari S, Srivastava R, Sawant SV and **Tuli R** (2007). Mutated TATA box / TBP complementation system for regulated transgene expression in tobacco. The Plant Journal, 50: 917-925.
3. Singh PK, Kumar M, Chaturvedi CP, Yadav D and **Tuli R** (2004) Development of a hybrid - endotoxin and its expression in tobacco and cotton for control of a polyphagous pest *Spodoptera litura* Transgenic Research, 13: 397-410.
4. Misra HS and **Tuli R** (2000) Differential expression of photosynthesis and nitrogen fixation genes in the cyanobacterium *Plectonema boryanum*. Plant Physiology, 122: 731-736.
5. **Tuli R**, Iyer RK and Thomas J (1982) Regulation of expression of *nif* and *hut* operons in *Klebsiellapneumoniae* by *glnA* linked genes of *Escherichia coli.* Molec. Gen. Genetics 187: 342-346.

Dr. JOY KUMAR ROY

Date of Birth: 11-03-1970

Designation: Scientist D

Area of Research Interest: Wheat improvement program through genetic and molecular principles, grain quality and nutrition including good flat bread (chapati) and incorporating good quality/high micronutrient content into high yield cultivars using marker-assisted selection.

Past Appointments:

1. Scientist-QHS (2009-2010): Plant Molecular Biology Laboratory, Centre for Plant Molecular Biology and Genetic Engineering Division, National Botanical Research Institute, Rana Pratap Marg, Lucknow-226001, UP
2. Research Associate (2004-2009): Department of Plant Pathology, 495 Borlaug Hall, 1991Upper Buford Circle, University of Minnesota, St. Paul, MN 55108, USA
3. Post-Doctoral Fellow (2002-2004): Department of Biology, Life Science Centre, Dalhousie University, 1355 Oxford St., Halifax, NS B3H 4J1, Canada
4. Research Fellow (1996-2004): Department of Genetics & Plant Breeding, Ch. Charan Singh University, Meerut-250005, UP

Selected Publications:

1. **Roy JK,** Smith KP, Muehlbauer GJ, Chao S, Close TJ, Steffenson BJ (2010) Association mapping of spot blotch resistance in wild barley. Molecular Breeding 26: 243-256.
2. Kumar A, **Roy JK**, Kulwal P, Balyan HS and Gupta PK (2009) QTL analysis for growth related traits in intervarietal mapping populations of common wheat. J. Genetics and Plant Breeding 61:30-38.
3. **Roy JK**, Bandopadhyay R, Balyan HS, Gupta PK (2006) Association analysis of agronomically important traits using SSR, SAMPL and AFLP markers in bread wheat. Current Science 90: 683-689.
4. **Roy JK**, Lakshmikumara M, Balyan HS, Gupta PK (2004) AFLP-based genetic diversity and its comparison with diversity based on SSR, SAMPL, and phenotypic traits in bread wheat. Biochemical Genetics 42: 43-59.

Dr. SUKHVINDER PAL SINGH

Date of Birth: 18-12-1978

Designation: Scientist C

Area of Research Interest: Postharvest Biology and Technology

Past Appointments:

Sessional Academic (2007-2010), Curtin University, Perth, Australia

Endeavour International Awardee (2007-2010) Curtin University, Perth, Australia

PhD (2004-2007), Indian Agricultural Research Institute, New Delhi, India

ICAR-JRF (2001-2003) Indian Institute of Horticultural Research, Bangalore, India

Selected Publications:

1. **Singh SP**, Singh Z and Swinny EE (2009). Postharvest nitric oxide fumigation delays fruit ripening and alleviates chilling injury during cold storage of Japanese plums (*Prunus salicina* Lindell). Postharvest Biology and Technology, 53: 101-108.

2. **Singh SP** and Pal RK (2008). Controlled atmosphere storage of guava (*Psidium guajava* L.) fruit. Postharvest Biology and Technology, 47: 296-306.

3. **Singh SP** and Pal RK (2008). Response of climacteric-type guava (*Psidium guajava* L.) to postharvest treatment with 1-MCP. Postharvest Biology and Technology, 47: 307-314.

4. **Singh SP** and Pal RK (2009). Ionizing radiation treatment to improve postharvest life and maintain quality of fresh guava fruit**.** Radiation Physics and Chemistry, 78: 135-140.

5. **Singh SP** and Singh Z (2008). Major flavor components in some commercial cultivars of Japaneseplum. Journal of the American Pomological Society, 62: 185-190.

Dr. SIDDHARTH TIWARI

Date of Birth: 20-03-1979

Designation: Scientist C

Area of Research Interest: Plant Genetic Engineering, Plant Tissue- Culture and Genetic Transformation.

Past Appointments: Research Scholar (2008-2010): Plant Molecular Biology Laboratory, Centre for Plant Molecular Biology and Genetic Engineering Division, National Botanical Research Institute, Lucknow, UP

Selected Publications:

1. **Tiwari S**, Mishra DK, Chandrasekhar K, Singh P and Tuli R (2011) Expression of -endotoxin Cry1EC from an inducible promoter confers insect protection in peanut (*Arachis hypogaea* L.) plants. Pest Management Science 67:137-145.

2. **Tiwari S**, Mishra D, Roy S, Singh A, Singh P and Tuli R (2009) High level expression of a functionally active cholera toxin B: rabies glycoprotein fusion protein in tobacco seeds. Plant Cell Reports, 28:1827–1836.

3. **Tiwari S**, Verma P, Singh PK and Tuli R (2009) Plants as bioreactors for the production of vaccine antigens. Biotechnology Advances, 27:449-467.

4. **Tiwari S**, Mishra DK, Singh A, Singh PK and Tuli R (2008) Expression of a synthetic *cry1EC* gene for resistance against *Spodoptera litura* in transgenic peanut (*Arachis hypogaea* L.). Plant Cell Reports, 27:1017-1025.

5. Chaturvedi C, Lodhi N, Ansari SA, **Tiwari S**, SrivastavaR, Sawant SV, and Tuli R (2007) Mutated TATA-box/TATA binding protein complementation system for regulated transgene expression in tobacco. The Plant Journal, 50:917-925.

Dr. MONIKA GARG

Date of Birth: 20-09-1973

Designation: Scientist C

Area of Research Interest: Cereal grain quality, Wide introgression, Accelerated breeding, Cytogenetics, Disease resistance, Drought tolerance, Processing quality.Special interest in improvement of wheat flour processing quality, modifying wheat storage proteins for improving the bread, biscuit and chapatti making quality.

Past Appointments:

1. Associate Scientist (2009-2010): ICARDA, Syria

2. JSPS Post Doc Fellow (2008-2009): Tottori University, Japan

3. Sr. Research Fellow (1996-2003): Punjab Agricultural University, India

Selected Publications:

1. **Garg M**, Tanaka H, Ishikawa N, Takata K, Yanaka M and Tsujimoto H. *Agropyron elongatum*(2009) HMW-glutenins have the potential to improve wheat end product quality through targeted chromosome introgression. J. Cereal Sci. 50, 358-363.

2. **Garg M**, Tanaka H, Ishikawa N, Takata K, Yanaka M and Tsujimoto H (2009). A novel pair of HMW glutenin subunits from *Aegilops searsii* improves quality of hexaploid wheat. Cereal Chemistry. 86, 26-32.

3. **Garg M**, Tanaka H, Elamein HMM, and Tsujimoto H (2007). Preferential elimination of chromosome 1D from homoeologous group-1 alien addition lines in hexaploid wheat. Genes and Genetic sys. 82(5), 403-408.

4. **Garg M**, Dhaliwal HS, Chhuneja P, Kumar D, Dou Q-W, Elamein HMM, Tanaka H and Tsujimoto H (2007). Negative effect of chromosome 1A on dough strength shown by modification of 1D addition in durum wheat (*Triticum durum*).Theor. Appl. Genet. 114(7), 1141-1150.

5. **Garg M**, Tanaka H, and Tsujimoto H (2009). Exploration of Triticeae seed storage proteins for improvement of wheat end-product quality.Breeding Science. 59, 519-528.

Mr. SHRIKANT SUBHASH MANTRI

Date of Birth: 24-10-1983

Designation: Scientist C

Area of Research Interest: Bioinformatics, Genome and Epigenome Analysis, Transcriptome analysis, Transcription Regulation, Data Mining, High Performance Computing.

Past Appointments: Scientist-QHS (2007-2010): Bioinformatics Laboratory, Centre for Plant Molecular Biology and Genetic Engineering Division, National Botanical Research Institute, Lucknow, UP

Selected Publications:

1. Yadav HK, Ranjan A, Asif MH, **Mantri S**, Sawant SV, Tuli R (2011) EST derived SSR markers in *Jatropha curcas* L.: Development, characterization, polymorphism and across species / genera transferability. Tree Genetics and Genomes, 7:207-219.

2. Asif MH, **Mantri S**, Sharma A, Srivastava A, Trivedi I, Gupta P, Mohanty CS, Sawant SV, Tuli R (2010) Complete sequence and organization of *Jatropha curcas* chloroplast genome. Tree Genetics and Genomes, 6:941-952.

3. Dubey S, Mishra P, Dviwedi S, Chatterjee S, Bag SK, **Mantri S**, Asif MH, Rai A, Kumar S, Shri M, Tripathy P, Tripathy RD, Trivedi PK, Chakraborty D, Tuli R (2010) Transcriptomic and metabolomics shifts in rice roots in response to Cr(IV) stress. BMC Genomics, 11:648.

4. Ranjan A, Ansari S, Srivastava R, **Mantri S**, Asif M, Sawant S, Tuli R (2009). A T9G Mutation in the Prototype TATA-box TCACTATATATAG Determines Nucleosome Formation and Synergy with Upstream Activator Sequences in Plant Promoters. Plant Physiology, 151: 2174-2186.

FACULTY AWAITED TO JOIN

Dr. KANTHI KIRAN KONDEPUDI

Date of Birth: 01-11-1978

Designation: Scientist C

Area of Research Interest: Nutritional Biochemistry, Probiotics, antimicrobial peptides, Prebiotics and bacterial exopolysaccharides, extremophilic microbes and biotechnological potentials

Past Appointments:

Post-Doctoral Fellow (May 2009-August 2011), Lund University, Lund, Sweden

PhD (2003-2009), Indian Institute of Technology, Madras, Chennai, Tamilnadu

Selected Publications:

1. **Kondepudi KK** and Chandra TS (2011) Identification of osmolytes from a moderately halophilic amylolytic *Bacillus* sp. strain *TSCVKK*. European Journal of Experimental Biology, 1 (1): 113-121

2. **Kondepudi KK** and Chandra TS (2011) Isolation of a moderately halophilic and amylolytic bacterium from saline soil of a salt manufacturing industry. Journal of Pure Applied Microbiology, 5 (2): 545-552

3. **Kondepudi KK** and Chandra TS (2008) Production of surfactant and detergent-stable, halophilic, and alkalitolerant alpha-amylase by a moderately halophilic *Bacillus* sp.Strain *TSCVKK*. Applied Microbiology Biotechnology, **77**, 1023-1031

MANAGEMENT OF THE INSTITUTE

a) Members of NABI Society

Dr. M.K. Bhan
Secretary,
Department of Biotechnology,
Ministry of Science & Technology,
New Delhi
(Chairman)

Sh. K.P. Pandian
JS & FA
Department of Biotechnology,
Ministry of Science & Technology,
New Delhi

Dr. N. Sathyamurthy
Director,
Indian Institute of Science & Education
Research (IISER), Mohali

Dr. Akhilesh Kumar Tyagi
Director,
National Institute of Plant Genome Research
(NIPGR),
New Delhi

Dr. S. Nagarajan
Chairperson,
Protection of Plant Varieties and
Farmer's Rights Authority,
New Delhi

Dr. V. Prakash
Director,
Centre Food Technological
Research Institute (CFTRI),
Mysore

Dr. B. Sesikeran
Director,
National Institute of Nutrition (NII),
Hyderabad

Dr. Rajesh Kapur
Advisor,
Department of Biotechnology,
Ministry of Science & Technology,
New Delhi

Dr. Rakesh Tuli
Executive Director
National Agro-Food Biotechnology Institute
Mohali, Punjab
(Member Secretary)

b) Governing Body of NABI

Dr. M.K. Bhan
Secretary,
Department of Biotechnology,
Ministry of Science & Technology,
New Delhi
(Chairman)

Dr. S. Nagarajan
Chairperson,
Protection of Plant Varieties and Farmers' Rights Authority,
New Delhi

Dr. Manju Sharma
President & Executive Director
Indian Institute of Advanced Research
The Puri Foundation for Education in India,
Gandhinagar, Gujarat

Dr. B. Sesikeran
Director,
National Institute of Nutrition (NII),
Hyderabad

Ms. Vandana Srivastava
Financial Advisor,
CSIR,
New Delhi

Dr. J. S. Pai
Former Director, UICT
Executive Director
Protein Foods & Nutrition Development Association of India (PFNDAI),
Mumbai

Dr. Ashok D.B. Vaidya
Research Director
Kasturba Health Society Medical & Research Centre (MRC),
Mumbai

Dr. Rajesh Kapur
Advisor,
Department of Biotechnology,
Ministry of Science & Technology,
New Delhi

Dr. Girish Sahni
Director
Institute of Microbial Technology
Chandigarh

Dr. Nirmal Kumar Ganguly
(Formerly DG, ICMR), Distinguished Biotechnology Prof.
Translational Health Science & technology Institute,
C/o National Institute of Immunology,
New Delhi

Dr. N. Sathyamurthy
Director,
Indian Institute of Science & Education Research (IISER)
Mohali

Dr. Akhilesh Kumar Tyagi
Director,
National Institute of Plant Genome Research (NIPGR),
New Delhi

Dr. Rakesh Tuli
Executive Director,
National Agri-Food Biotechnology Institute,
Mohali
(Member Secretary)

c) Finance Committee of NABI

Dr. M.K. Bhan
Secretary,
Department of Biotechnology,
Ministry of Science & Technology,
New Delhi
(Chairman)

Dr. Rajesh Kapur
Advisor,
Department of Biotechnology,
Ministry of Science & Technology,
New Delhi

Ms. Vandana Srivastava
Financial Advisor,
Council of SIR,
New Delhi

Dr. Rakesh Tuli
Convenor
Executive Director,
National Agri-Food Biotechnology Institute,
Mohali
(Member Secretary)

d) Building Committee of NABI

Dr. Rakesh Tuli
Executive Director,
National Agri-Food Biotechnology Institute,
Mohali
(Chairman)

Dr. Talwar Gursaran Parshad
Director Research,
Talwar Research Foundation,
New Delhi

Dr. N. Sathyamurthy
Director,
Indian Institute of Science & Education
Research (IISER)
Mohali

Dr. P.K. Seth
Chief Executive Officer
Biotech Park,
Lucknow

Dr. K.K. Kaul
Former Chief Town Planner GMADA,
Chandigarh

Er. S.L. Kaushal
Former Chief Architect Punjab,
Chandigarh

Er. N.S. Bhatti
Former Chief Engg,
Punjab Administration,
Chandigarh

Dr. Jagdeep Singh
Coordinator
Indian Institute of Science Education and
Research (IISER),
Chandigarh

Mr. Sanjay Goel
Director (Finance),
Department of Bio Technology
New Delhi

Ms. Balwinder Saini
Chief Architect Punjab Govt.
Chandigarh

Dr. S.B. Katti
Scientist G,
Central Drug Research Institute,
Lucknow

Er. S.K. Jaitley
Former Chief Engr., UT Sect.
Chandigarh

Er. Kuldeep Singh
Formerly Chief Engg (Chandigarh Admin),
Good in Civil & Legal aspects,
Chandigarh

Dr. U.V. Pathre
Scientist,
National Botanical Research Institute,
Lucknow

Er. A.A. Malik
Supt. Engineer,
National Botanical Research Institute (NBRI),
Lucknow

RESEARCH PUBLICATIONS OF FACULTY AND RESEARCH FELLOWS AT NABI 2010-2011

Since this is the first report, the publications primarily represent the research outcome of faculty from the their earlier institute

1. Rai A, Tripathi P, Dwivedi S, Dubey S, Shri M, Kumar S, Tripathi PK, Dave R, Kumar A, Singh R, Adhikari B, Bag M, Tripathi RD, Trivedi PK, Chakrabarty D, **Tuli R (2011)** Arsenic tolerances in rice (*Oryza sativa*) have a predominant role in transcriptional regulation of a set of genes including sulphur assimilation pathway and antioxidant system. **Chemosphere,** 82:986-995.

2. **Tiwari S**, Mishra DK, Chandrashekar K, Singh PK, **Tuli R (2011)** Expression of -endotoxin Cry1EC from an inducible promoter confers insect protection in peanut (*Arachis hypogaea* L.) plants. **Pest Management Science,** 67:137-145.

3. Upadhyay SK, Chandrashekar K, Thakur N, Verma PC, Borgia JF, Singh PK, **Tuli R (2011)** RNA Interference for the control of whiteflies (*Bemisia tabaci*) by oral route. **Journal of Biosciences,** 36:153-161.

4. Yadav HK, Ranjan A, Asif MH, **Mantri S**, Sawant SV, **Tuli R (2011)** EST derived SSR markers in *Jatropha curcas* L.: Development, characterization, polymorphism and across species/genera transferability. **Tree Genetics and Genomics,** 7:207-219.

5. Dubey S, Mishra P, Dviwedi S, Chatterjee S, Bag SK, **Mantri S**, Asif MH, Rai A, Kumar S, Shri M, Tripathy P, Tripathy RD, Trivedi PK, Chakraborty D, **Tuli R (2010)** Transcriptomic and metabolomics shifts in rice roots in response to Cr(IV) stress. **BMC Genomics**, 11:648.

6. Upadhyay SK, Mishra M, Singh H, Ranjan A, Chandrashekar K, Verma PC, Singh PK, **Tuli R (2010)** Interaction of *Allium sativum* leaf agglutinin with midgut BBMV proteins and its stability in *Helicoverpa armigera*. **Proteomics,** 10:1-10.

7. Misra P, Pandey A, Tiwari M, Chandrasekhar A, Sidhu OP, Asif MH, Chakrabarty D, Singh PK, Trivedi PK, Nath P, **Tuli R (2010)** Modulation of transcriptome and metabolome of tobacco by *Arabidopsis* transcription factor, *AtMYB12*, leads to insect resistance. **Plant Physiology,** 152:2258-2268.

8. Roy S, Tyagi A, Shukla V, Kumar A, Singh UM, Chaudhary LB, Datt B, Bag SK, Singh PK, Nair NK, Husain T, **Tuli R (2010)** Universal Plant DNA barcode Loci May Not Work in Complex Groups: A Case Study with Indian *Berberis* species. **PLoS ONE,** 5(10).e13674.

9. **Kumar J**, Kumar A, Roy JK, **Tuli R**, Khan JA **(2010)** Identification and molecular characterization of begomovirus and Associated satellite DNA molecules infecting *Cyamopsis tetragonoloba*. **Virus genes,** 41:118-125.

10. Upadhyay SK, Saurabh S, Rai P, Singh R, Chandrashekar K, Verma PC, Singh PK, **Tuli R(2010)** SUMO fusion facilitates expression and purification of garlic lectin but modifies some of its properties. **Journal of Biotechnology,** 146:1-8.

11. Sidhu OP, Annarao S, Pathre U, Snehi SK, Raj SK, Roy R, **Tuli R**, Khetrapal CL **(2010)** Metabolic and histopathological alterations of *Jatropha mosaic begomovirus* infected *Jatropha curcas* L. by HR-MAS NMR spectroscopy and Magnetic Resonance Imaging. **Planta,** 232:85-93.

12. Pandey V, Misra P, Chaturvedi P, Mishra MK, Trivedi PK, **Tuli R (2010)**

Agrobacterium tumefaciens-mediated transformation of *Withania somnifera* (L.) Dunal: an important medicinal plant. **Plant Cell Reports,**29: 133-141.

13. Dwivedi S, Tripathi RD, Srivastava S, Singh R, Kumar A, Tripathi P, Dave R, Rai UN, Chakrabarty D, Trivedi PK, **Tuli R**, Adhikari, B, Bag MK **(2010)** Arsenic affects mineral nutrients in grains of various Indian rice (*Oryza sativa L.*) genotypes grown on arsenic-contaminated soils of West Bengal. **Protoplasma**, 245:113-124.

14. Dwivedi S, Tripathi RD, Tripathi P, Kumar A, Dave R, Mishra S, Singh R, Sharma D, Rai U, Chakrabarty D, Trivedi PK, Adhikari B, Bag M, Dhankher OP, **Tuli R (2010)** Arsenate Exposure Affects Amino Acids, Mineral Nutrient Status and Antioxidants in Rice (*Oryza sativa L.*) Genotypes. **Environmental Science & Technology**, 44:9542–9549.

15. Tyagi A, Bag SK, Shukla V, Roy S, **Tuli R (2010)** Oligonucleotide frequencies of barcoding loci can discriminate species across kingdoms. **PLoS ONE**, 5(8):e12330.

16. Asif MH, **Mantri S**, Sharma A, Srivastava A, Trivedi I, Gupta P, Mohanty CS, Sawant SV, **Tuli R (2010)** Complete sequence and organization of *Jatropha curcas* chloroplast genome. **Tree Genetics and Genomics**, 6:941–952.

17. Chatterjee S, Srivastava S, Sidhu OP, Sangwan RS, Roy R, Khetrapal CL, **Tuli R (2010)** Comprehensive metabolic finger printing of *W. somnifera* leaf and root extracts. **Phytochemistry,**71:1085-1094.

18. **Tuli R**, Chakrabarty D, Trivedi PK, Tripathi RD **(2010)** Recent advances in arsenic accumulation and metabolism in rice. **Molecular Breeding,** 26:307-323.

19. Misra P, Gupta N, Toppo DD, Pandey V, Mishra MK, **Tuli R (2010)** Establishment of long-term proliferating shoot cultures of elite *Jatropha curcas* L. by controlling endophytic bacterial contamination. **Plant Cell Tissue and Organ Culture,** 100:189-197.

20. Behera SK, Srivastava P, Pathre UV, **Tuli R (2010)**An indirect method of estimating leaf area index in *Jatropha curcas* L. using LAI-2000 Plant Canopy Analyzer. **Agricultural and Forest Meteorology,** 150:307-311.

21. Roy S, Tyagi A, **Tiwari S**, Singh A, Sawant SV, Singh PK, **Tuli R (2010)**. Rabies glycoprotein fused with B subunit of cholera toxin expressed in tobacco plants folds into biologically active pentameric protein. **Protein Expression and Purification,** 70:184-90.

22. Chaurasiya ND, Sangwan RS, Misra LN, **Tuli R,** Sangwan NS **(2010)** Metabolic clustering of a core collection of Indian ginseng *Withaniasomnifera* Dunal through DNA, isoenzyme, polypeptide and withanolide profile diversity. **Fitoterapia,** 80:496-505.

23. Chakrabarty D, Trivedi PK, Manju S, Misra P, Asif MH, Dubey S, Kumar S, Rai A, Tiwari M, Shukla D, Pandey A, Nigam D, Tripathy RD, **Tuli R (2010)** Differential transcriptional expression following thidiazuron induced shoot primordial developmental shifts in rice. **Plant Biology,** 12:46-59.

24. **Roy JK**, Smith KP, Muehlbauer GJ, Chao S, Close TJ, Steffenson BJ **(2010)** Association mapping of spot blotch resistance in wild barley. **Molecular Breeding,** 26:243-256.

25. Kishii M, Dou Q, **Garg M**, Ito M, Tanaka H, Tsujimoto H **(2010)** Production of wheat-*Psathyrostachys huashanica* chromosome addition lines. **Genes and genetic system,** 85:281-286.

26. Singh K, Chhuneja P, Singh I, Sharma SK, Garg T, **Garg M**, Keller B, Dhaliwal HS **(2010)** Molecular mapping of cereal cyst nematode resistance in *Triticum monococcum* L. and its transfer to the

genetic background of cultivated wheat. **Euphytica,** 76:213-222.

27. **Singh SP,** Pandey T, Srivastava R, Verma PC, Singh PK, **Tuli R**, Sawant SV **(2010)** BECLIN1 from *Arabidopsis thaliana*, under the genetic control of regulated expression system - a strategy for developing male sterile plants. **Plant Biotechnology Journal**, 8:1005-1022.

28. Kumar A, **Kumar J,** Khan ZA, Yadav N, Sinha V, Bhatnagar D, Khan JA **(2010)** Study of betasatellite molecule from leaf curl disease of sunn hemp (*Crotalaria juncea*) in India. **Virus Genes,**41:432-440.

29. Kumar A, **Kumar J**, Khan JA **(2010)** Sequence characterization of cotton leaf curl virus from Rajasthan: phylogenetic relationship with other members of geminiviruses and detection of recombination. **Virus Genes,** 40:282-289.

30. **Kumar J,** Kumar A, Gunapati S, Khan JA **(2010)** Detection and characterization of begomovirus-associated alpha and beta satellites from infected tomato plants with leaf curl symptoms. **Journal of Plant Pathology,** 92:544.

HUMAN RESOURCE DEVELOPMENT

1. **Research Associate** - 1
   Dr. Sudhir P. Singh

2. **Senior Research Fellow** - 1
   Sh. Jitender Kumar

3. **Junior Research Fellows** - 3
   Ms. Anuradha Singh
   Sh. Yogesh Gupta
   Sh. Sukhdev Singh

Trainees from institutes in neighbourhood- 17

Gauri Gupta, Subodh Verma, Rajwinder Kaur, Anshu Alok, Kavita Chahal, Chirra Srinivasa Reddy, Akhil Saini, Jitesh Kumar, Aditi Rajan, Chehak Bharti, Suman, Madhvi Ahuja, Khushboo kumari Singh, Mohit Kakkar, Neha Arora, Ravi, Meenal Kohali

A total of 22 students at different levels from Master's to Post-doctoral stage were trained in the techniques and approaches in plant biotechnology, food science and analytical chemistry of natural products.

FOUNDING YEAR STAFF AT NABI

I.	Scientific & Academic staff		
S. No	**Name**	**Designation**	**Date of Joining**
1	Dr. Rakesh Tuli	Executive Director	08-02-2010
2	Dr. Joy K. Roy	Scientist D	09-08-2010
3	Dr. Basavaprabhu L. Patil	Scientist D	28-10-2010
4	Dr. Siddharth Tiwari	Scientist C	28-07-2010
5	Mr. Shrikant Subhash Mantri	Scientist C	18-08-2010
6	Dr. (Ms.) Monika Garg	Scientist C	30-11-2010
7	Dr. Sukhvinder Pal Singh	Scientist C	06-12-2010
II.	**Technical and Engineering staff**		
S. No	**Name**	**Designation**	**Date of Joining**
1	Er. E. Subramanian	Computer Operator	27-02-2010
2	Sh. A. Hari Krishna	Computer Operator	01-03-2010
3	Er. Jatin Singla	Asst. Engineer	21-01-2011
4	Ms. Aakriti Gupta	Senior Tech Asst.	22-02-2011
5	Sh. Jagdeep Singh	Senior Tech Asst.	01-03-2011
III.	**Administrative staff**		
S. No	**Name**	**Designation**	**Date of Joining**
1	Sh. S. Krishnan	Store & Purchase Officer	10-03-2010
2	Sh. Sabir Ali	Executive Asst (Admin.)	21-01-2011

Sanctioned Manpower to NABI

S.No	Sanctioned Post	No. of posts
1	Executive Director	1
2	Dean	3
3	Associate Director (Admin)*	1
4	Core Scientist -G	7
5	Core Scientist - F	13
6	Core Scientist - E	20
7	Core Scientist - D	26
8	Core Scientist - C	33
9	Manager Business Development	1
10	Manager (IPR/ Legal)	1
11	Manager (Admin.)	1
12	Manager (Finance)	1
13	Institute Engineer	1
14	Admin. / Finance Officer	2
15	Store Purchase Officer	1
15	Library-cum-Informatics Officer	1
16	Senior Technical Officer	3
17	System Analyst	1
18	Sr. Private Secretary	1
19	Technical officer	6
20	Assistant Engineer	2
21	Management Asst.	4
22	Senior Technical Asst.	8
23	Executive Asst. /(Head Clerk)	1
24	Executive Asst. / (Head Clerk)	1
25	Computer Operator	2
26	Library Asst.	2
	Total	**144**

PHOTO GALLERY OF IMPORTANT EVENTS

Entrance of NABI Interim Facility

NABI Interim Facility on the Inauguration Day: 18th February, 2010. Inside view of ground floor lab.

NABI Interim Facility on the Inauguration Day: 18th February, 2010

Dr. M. K. Bhan, Secretary, DBT giving inaugural message at the NABI Interim facility

Dr. Rakesh Tuli, Executive Director, NABI welcoming the guests and audience

NABI Interim Facility on the Inauguration Day: 18th February, 2010

Dr. Rakesh Tuli, Executive Director, NABI showing the lab to the Chief Host, Dr. M. K. Bhan, Secretary, DBT, India

Distinguish experts along with Dr. M. K. Bhan, Secretary, DBT, India

NABI Interim Facility on the Inauguration Day: 18th February, 2010

NABI Main Campus Land at Sector 81, Mohali: 2010-2011

First row: Land condition in a flat, undulated and choe bound area of NABI plot (February, 2010); Green manure in 15 acres land (June 2010), seen on photo from left are: Mr S.S. Shergill, Project Coordinator, NABI; Dr. S.C. Sharma, Emeritus Scientist-CSIR; Dr. Siddharth Tiwari, SRA, NABI and Dr. S.K. Tiwari, Scientist NBRI, Lucknow. **Second row from left:** Green manure incorporation in soil (August 2010); Wheat germplasm (November 2010). **Third row from left:** Banana germplasm (March 2011); Wheat crossing experiment (March 2011).

NABI Main Campus Land at Sector 81, Mohali: 2010-2011

Top : Dr. Madhu Tuli, wife of Dr. Rakesh Tuli, was invited as special guest for inauguration (20th August, 2010) of the work for building campus wall. **Bottom Left :** Dr. Joy K. Roy and Dr. S.P. Singh, Scientists at NABI monitoring the routine progress of work (February 2011). **Bottom Right :** Work in progress (March 2011).

First Formal Research Activity at NABI Interim Facility: 15th July, 2010

Left: Basic laboratory has been organized and Dr. Rakesh Tuli, Executive Director, NABI formally inaugurating the research activities. **Right:** Seen on the photo from left are: Dr. Rakesh Tuli, Executive Director, NABI; Mr. S.K. Sadana, Administrative Officer, NABI; Mr. E. Subramanian, Computer Operator, NABI; Harikrishna A, Computer Operator, NABI; Siddharth Tiwari, SRF, NABI; Mr. Antariksh Tyagi, JRF, NBRI, Lucknow; Mr. Jitendra Kumar, SRF NABI.

NABI First Celebration of
Independence Day: 15th August, 2010

Dr. Rakesh Tuli, Executive Director and NABI staff with their family members celebrating the First Independence Day at NABI.

NABI First Celebration of
Republic Day: 26th January, 2011

Dr. Rakesh Tuli, Executive Director, NABI hoisted the National flag and addressing the NABI staff at NABI Interim Facility

Indo-Canada Strategic Meeting at NABI: 22nd and 23rd November, 2010

First row from left: Dr. Rakesh Tuli, Executive Director, NABI delivering a welcome speech. Sitting on the dais (L to R): Dr. S. Nagarajan, Former Chairperson, PPV & FRA, New Delhi; Mr. Vishvajeet Khanna, Secretary S & T, Punjab; Mr. S.C. Agrawal, Chief Secretory, Punjab; Mr. Jerome Konecsni, Director General, NRC-PBI, Canada; Dr. Reno Pontarollo, Chief Scientific Officer, Genome Prairie, Saskatoon; Dr. Rajesh Kapur, Adviser, DBT. Mr. S.C. Agrawal, Chief Secretory, Punjab, invited as Chief Guest of the meeting, addressing the invited experts and delivering the speech on 'Technology as a Driver of Economy in Punjab'. **Second row from left:** Mr. Vishvajeet Khanna, Secretary S & T, Punjab delivering speech on 'Development of Knowledge City at Mohali'. **Third row from left:** Mr. Jerome Konecsni, Director General, NRC-PBI, Canada addressing the experts on "Opportunities and Challenges in Agri-Business". Distinguish experts from NRC-PBI, Canada; Genome Prairie, Saskatoon; IITs; GNDU; IISER; NBRI and Agri-Food industries participated in the strategic meet on the "Development of Vision & Partnerships for Innovations in Agri-Food Research at the Agri-Food Cluster, Mohali".

DBT-ISTP Workshop at NABI: 24th and 25th November, 2010

First row from left: Dr. Rakesh Tuli, Executive Director, NABI giving the welcome address. Dr. S. Natesh, Senior Advisor, DBT addressing the invited scientists and experts. **Second row from left:** Dr. Venkatesh Meda, University of Saskatchewan, Saskatoon delivering opening remarks. Dr. Reno Pontarollo, Chief Scientific Officer, Genome Prairie, Saskatoon giving lecture on "Partnership Opportunities and needs for Success of Agri-Food Clusters". **Third row from left:** Dr. Suzzanne Abrams, Director of Research, NRC-PBI, Saskatoon, Canada addressing the experts on "Opportunities and Challenges in Plant Biotechnology Research". Distinguished experts from premier research institutes, universities and agri-food industries from India and Canada participated in the Workshop on "Integrated Bioprocessing & Bioproducts Technologies for Sustainable Food Security".

Signing of MoUs between NABI and NRC-PBI Canada; NABI and Genome Prairie, Saskatoon; NABI and University of Saskatchewan, Saskatoon: 25th November, 2010 at the residence of Mr. Scot Slessor, Consulate General of Canada at Chandigarh

First row from left: Dr. Rakesh Tuli, Executive Director, NABI and Mr Jerome Konecsni, Director General, NRC-PBI, Canada signing MoU. Dr. Rakesh Tuli and Mr. Jerome Konecsni exchanging MoU documents. **Second row from left:** Dr. Rakesh Tuli, Executive Director, NABI and Dr. Reno Pontarollo, Chief Scientific Officer, Genome Prairie, Saskatoon signing MoU. Dr .Rakesh Tuli and Dr. Reno Pontarollo exchanging MoU documents.

Third row from left: Dr. Rakesh Tuli, Executive Director, NABI and Dr. Venkatesh Meda, University of Saskatchewan, Saskatoon signing MoU. Dr. Rakesh Tuli and Dr. Venkatesh Meda exchanging MoU documents.


Closing Session of DBT-ISTP Worksop: 25th November, 2010

Left: Participants from Canada along with Dr. Rakesh Tuli, Executive Director, NABI. **Right:** Participants from NRC-PBI Canada, Genome Prairie: Saskatoon, NABI, IITs, GNDU ,IISER, NBRI and Agri-Food industries.

Nano-Technology Meeting at NABI: 10th January, 2011

Experts from NABI, NIPER, CSIO, IISER, GNDU and IIT participating in the conference on "Nanoscience Applications in Agri-Food Sector" at NABI Interim Facility.


Second ISTP Canada-DBT India Workshop at NRC-PBI held at Saskatoon, Canada: 13-15th February, 2011

Left: NRC-PBI, Saskatoon organized a workshop at Saskatoon for bringing together researchers, scientists, students, industry partners and policy makers from both the countries. **Right:** Dr. Rakesh Tuli, Executive Director, NABI addressing the experts at NRC-PBI, Saskatoon on the development of understanding to from a broader and stronger cluster partnership linking several departments and institutions in India and Canada.

Presenting a bouquet to Distinguished Professor Dr. Bikram. S. Gill, Kansas State University, USA invited as a Chief Guest on the First Foundation Day of NABI

Dr. B. S. Gill celebrating the first Foundation Day of NABI at guest house with NABI staff and families

First Foundation Day of NABI: February 18, 2011

BUDGET

Highlights of the Annual Accounts

The annual accounts of the Institute have been compiled on the basis of accrual system of accounting using the standard format of accounts prescribed by the Government of India for all Central Autonomous Bodies (CABs).

Accounts for the Financial Years 2009-10 and 2010-11 have been audited by the Statutory Auditor, M/S Raj Gupta & Co., Chandigarh (Chartered Accountant) appointed as the auditor of the institute in accordance with the provisions of Rule 62 of the Memorandum of Association of NABI

Financials

(Figures in Rupees)

S.NO.	PARTICULARS	As on 31-03-2010	As on 31-03-2011
A.	**SOURCE OF FUNDS**		
1.	Grants from DBT	60000000	222224014
2.	Internal Receipts /Income	50000	2301994
B.	**APPLICATION OF FUNDS**		
1.	Main Campus	6350000	----
2.	Equipment	161078	120876581
3.	Vehicle	662497	---
4.	Furniture and other Fixed Assets	689024	4467606
5.	Manpower	391897	7735259
6.	Chemical & Consumable	2767285	9860464
7.	Administrative Expenses	397364	29761647
C	**Closing Bank Balance (Including FDRs)**	8349773	83952849

ANNEXURES

Annexure 1

Press Information Bureau Government of India
(Tuesday), December 05, 2006; 19:52 IST
Ministry of Science & Technology

India today signed two Memoranda of Understanding (MoUs) with Canada to strengthen Science & Technology relations with each other. The MoUs were signed between the Department of Biotechnology, Govt. of India and Department of Agriculture and Agri-Food of Canada (AAFC) and National Research Council, (NRC) Canada in the presence of Union Minister for Science & Technology and Earth Sciences, Shri. Kapil Sibal. Following are details regarding the two MoUs :

MOU WITH AGRICULTURE AND AGRI-FOOD CANADA

The MoU was signed by Mr. Leonard Edwards, Deputy Minister, Agriculture & Agri-food Canada and Dr M.K. Bhan, Secretary, Department of Biotechnology, Govt. of India on behalf of their respective countries. The major objectives are:

a) To provide researchers and institutions with opportunities to exchange scientific information and to facilitate the exchange of scientists;

b) Foster scientific cooperation and promote cooperative projects mutually beneficial to the two countries including industrial programs.

The identified priorities for cooperation include:

a) Agriculture and food processing and storage;

b) Bio-pesticides and bio-fertilizers;

c) Functional and nutraceutical foods and impact on human nutrition;

d) Agricultural biotechnology;

e) Biomass utilization;

f) Sustainable alternative energy and environmental technologies; and

g) Water quality.

AAFC and DBT will hold joint workshops in identified areas to work out details. This will be followed by joint calls for proposals for funding in a defined time frame.

The respective organisations/executing agencies will bear the costs of its participation in all collaborative activities. Each activity will be conducted in accordance with the laws, statutes, regulations and policies of the Executing agencies' respective countries.

MOU WITH NATIONAL RESEARCH COUNCIL, CANADA

The MoU was signed by Vice President Dr. Roman Szumski, National Research Council, Canada and Dr. S. Natesh, Sr. Adviser, Department of Biotechnology, Govt.of India on behalf of their respective

countries. The major objectives are to promote research collaboration in the field of biotechnology of mutual interest by encouraging and facilitating close and frequent consultation between DBT and NRC.

The identified priorities for initial collaboration between DBT and NRC are:

a) Harnessing plants for improving human and animal health, and

b) Understanding and exploiting genomics of plants of common interest to the benefit of both the countries

Collaborations in additional areas such as, but not limited to, vaccine design, production and delivery systems, and bio devices are being explored.

It has been agreed that, to begin with, a workshop on 'Plants for health' will be organized by NRC Plant Biotechnology Institute, Saskatoon during March 2007. In case there is scope for mutual collaboration in identified sub-areas of this topic, feasibility of funding collaborative projects will be explored.

Each organisation will pay the operating costs of its facilities as well as the salaries, benefits, travel costs etc.

CANADIAN HELP IN SETTING UP OF AGRI-FOOD CLUSTER IN PUNJAB

As part of fulfilling Prime Minister Dr. Manmohan Singh's promise to Punjab, a 'Knowledge City' is being planned at Sector 81, Mohali. Spread over an area of 350 acres, the Knowledge City will comprise the National Institute of Nanotechnology, Indian Institute of Science Education and Research as well as an Agri-food cluster. Department of Biotechnology is involved in planning the agri-food cluster.

The agri-food cluster itself (about 150 acres) will have the *National Agri-food Biotechnology Institute* (NABI) and a *Bioprocessing Unit* (BPU) to provide scale-up facilities. Both, NABI and BPU are planned to come up as autonomous institutions under DBT in an *Agri-food Biotech Park* designed to house start-up companies. The park itself is proposed to be set up through public-private enterprise.

NABI will work on innovative food processes and products keeping in view the current and future markets both within the country and abroad. It will be a centre purely dedicated to translation and in this sense *different*. It will also be involved in training world class human resource in food science and technology as well as nutritional science. The BPU is designed to link the R&D system with a miniature production facility to serve as an incubator for start-ups. It will not only facilitate the scale-up and process optimization of new technologies developed by NABI or acquired through inlicensing from other sources within India and abroad but also services, consultancies and support to the start-up companies.

All the institutions in the agri-food cluster (NABI, BPU and Agri-food Biotech Park) will share a common vision and have a common Technical Board and a common CEO. This will be first such cluster in India.

Canadian experts from the following institutions have been involved right from the beginning in this project:

- National Research Council, Canada
- University of Saskatchewan, Saskatoon
- POS Pilot Plant Corporation, Saskatoon
- Ag-west Bio, Saskatoon

They have not only been providing valuable inputs towards the designing of the cluster proposal based on expertise available in Canada; they are also willing to provide technical support, consultancy, facilitation of industrial interaction and licensing agreements. Several of these experts are likely to be on the Advisory Board of the cluster as well. Canadian institutions are willing to sign a series of MoUs with DBT through which specific bilateral partnerships with NABI, BPU etc. will be possible. In fact, the two MoUs being signed today are reflective of the spirit

Annexure 2

Press Information Bureau Government of India
(Thursday) August 21, 2008; 5:03:23 PM
Ministry of Science & Technology

Government approves NABI and BPU as Autonomous Institutions of Department of Biotechnology. The Union Cabinet today gave its approval for establishment of (a) National Agri-Food Biotechnology Institute (NABI) and (b) Bioprocessing Unit (BPU) in Knowledge City at Mohali, Punjab, as autonomous institutions of the Department of Biotechnology, Ministry of Science & Technology, Government of India with the total estimated cost of Rs. 380 crores for 5 years w.e.f. 2008-2009 to 2012-13. Following are the highlights:

=> **NABI represents 3 institutes in one:** Agri-technology, food technology and nutrition technology. Thus it integrates 3 disciplines under its roof

=> **BPU** is designed to link R&D system with production facility to serve as an incubator for start-up agri-food companies

=> There will be an **Agri-food Park** within the cluster to be operated in the Public Private Partnership, PPP model

=> This kind of **integration** of R&D and production and enterprise is being planned **for the first time** in the country

=> The cluster has been designed with the help of Canadian experts from the Saskatchewan Agri-food Park

=> NABI is designed to be translational in the area of :

>> Agriculture – new gene discovery, genomics, designer crops etc.

>> Food Technology – food processing technologies, bioprocess engineering, food safety etc.

>> Nutrition science and technology – Public health nutrition technologies, functional foods and nutraceuticals, wellness foods etc.

=> The cluster will produce not only PhDs but also agri-food entrepreneurs and spawn new industries for the region

=> The HR component reflects multiple skill sets needed - breeders, food specialists, toxicologists, nutritionists, process engineers, managers, computer experts etc.

PRA/SKK
(Release ID :41640)

Annexure 3

CERTIFICATE OF REGISTRATION OF SOCIETIES
(ACT XXI OF 1860)

No 2677 of—2009—200 .

I hereby certify that National Agri-Food Biotechnology Institute (NABI) C-127, Ind Area Phase - VIII, S.A.S. Nagar Distt. S.A.S. Nagar, Punjab has this day been registered under the Societies Registration act. (XXI of 1860) and amended by Punjab Amendment Act, 1957.

Given under my hand and seal at S.A.S. Nagar this day of 27th. November 2009 - 200 .

Rupees Five Hundred only.

Addl. Registrar of Societies
Distt. Industries Centre,
S.A.S. Nagar (Punjab)

Office of the Addl. Registrar of Societies, Distt. Industries Centre
S.A.S. Nagar (Punjab)

Annexure 4

भारत सरकार
विज्ञान और प्रौद्योगिकी मंत्रालय
बायोटेक्नोलॉजी विभाग
GOVERNMENT OF INDIA
MINISTRY OF SCIENCE & TECHNOLOGY
DEPARTMENT OF BIOTECHNOLOGY

MINISTRY OF SCIENCE & TECHNOLOGY

ब्लाक–2,7 वां तल, सी० जी० ओ० कम्पलेक्स
लोदी रोड, नई दिल्ली–110003
Block-2, 7th Floor C.G.O. Complex
Lodi Road, New Delhi-110003

URGENT
CONFIDENTIAL

No. BT/FNS/NABI-Exec. Director/Appointment/2009

Date: 14.09.2009

To,
Dr. Rakesh Tuli,
Director,
National Botanical Research Institute,
Rana Pratap Marg, Post Box- 436,
Lucknow- 226 001

Sub: Appointment of Dr. Rakesh Tuli to the post of Executive Director, National Agri-Food Biotechnology Institute, Mohali, Punjab.

The undersigned is directed to communicate the approval of the "APPOINTMENTS COMMITTEE OF THE CABINET (ACC)"on the above mentioned subject, which is as follows:

(i) Appointment of Dr. Rakesh Tuli to the post of Executive Director, National Agri-Food Biotechnology Institute (NABI), Mohali, Punjab, for a term of five years or till the date of his superannuation whichever is earlier.

(ii) In the event of Dr. Rakesh Tuli requiring a transition time to wind up and hand over his current charge of Director, National Botanical Research Institute, Lucknow, and join as Executive Director, National Agri-Food Biotechnology Institute, at Mohali, Punjab, Dr. Rakesh Tuli to function as "Officer on Special Duty (OSD)" for NABI from National Botanical Research Institute, Lucknow, as an additional charge, with full executive powers as that of Executive Director, NABI, for a period not exceeding six months.

2. In view of above, kindly communicate your acceptance for either of the above two options and accordingly confirm the date for your assumption of the charge as Executive Director, NABI or in the event you require a transition time, the date of your functioning as OSD for NABI from NBRI, Lucknow mentioning the transition time period, which should not exceed six months from your assumption of the charge as OSD for NABI.

For my personal file & records

25/3/10

(Rajesh Kapur)
Advisor
Tel 24360745

Website: http://www.dbtindia.nic.in http://www.btisnet.gov.in
दूरभाष / Telephone : 24363012, 24362329 फैक्स / Fax : 011-24362884

Annexure 5

Date : 24th December, 2009

Association and set out several & respective hands hereunto and form ourselves into a Society under the Societies Registration Act ,1860 (XXI of 1860), this _ _ ,day of _____Two thousand nine.

SN.	Name & Address	Occupation	Signature
1	Prof. M. K. Bhan Secretary, Department of Biotechnology, Ministry of Science & Technology, GoI, F14, Hauz Khas Enclave, New Delhi 110 016	Scientist/ Administrator	
2	Shri K. P. Pandian JS&FA, Department of Biotechnology, Ministry of Science & Technology, GoI , E-2/92 Asian Games Village Complex, New Delhi-110049	Administrator	
3	Dr. N. Sathyamurthy Director, Indian Institute of Science Education and Research, Mohali, MGSIPA Complex, Sector 26, Chandigarh-160019	Scientist/ Administrator	
4	Dr. Akhilesh Tyagi Director, National Institute of Plant Genome Research, Aruna Asaf Ali Marg, P.O. Box No. 10531, New Delhi-110067	Scientist/ Administrator	
5	Dr. S. Nagarajan Chairperson, Protection of Plant Varieties and Farmers' Rights Authority, NASC Complex, (Opp. Village Todapur), D.P.S. Marg, New Delhi - 110012	Scientist/ Administrator	
6	Dr. V. Prakash Director, Central Food Technological Research Institute, Mysore-570 013	Scientist/ Administrator	
7	Dr. B. SesiKaran Director, National Institute of Nutrition, Indian Council of Medical Research, Jamai Osmania P.O., Hyderabad-500 007 (A.P.)	Scientist/ Administrator	
8	Dr. Rajesh Kapur Advisor/Scientist 'G', Department of Biotechnology, Ministry of Science & Technology, GoI, New Delhi	Science/ Administrator	

7

(M. K. Bhan) (K P Pandian) (Rajesh Kapur)

Annexure 6

Date: (Monday) February 08, 2010

Certificate of transfer of charge

Certified that we have in the forenoon of this day respectively made over and received charge of the Office of Executive Director, National Agri-Food Biotechnology Institute, Mohali, Punjab in pursuance of order No.OSD/1 dated February 7, 2010.

Relieved Officer	Dr. Rakesh Tuli
Signature	8-02-10
Designation	Officer on Special Duty, NABI, Mohali
Relieving Officer	Dr. Rakesh Tuli
Signature	8-2-10
Designation	Executive Director, NABI, Mohali

(M K Bhan)
Secretary, Department of Biotechnology
Chairman Governing Body, NABI

राष्ट्रीय कृषि-खाद्य जैव प्रौद्योगिकी संस्थान
National Agri-Food Biotechnology Institute

C-127, Industrial Area, Phase 8, S.A.S. Nagar, Mohali, Punjab, India - 160071
EPABX: +91-172-2290100, Fax: 0172-4604888
Website : www.nabi.res.in

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