International Congress

on

"Cotton and Other Fibre Crops"

at

ICAR Research Complex for NEH Region,
Umiam (Barapani) - 793 103, Meghalaya

20-23 February, 2018

Book of Abstracts

Organised by

Cotton Research and Development Association (CRDA)
CCS Haryana Agricultural University, Hisar - 125 004

ICAR Research Complex for NEH Region,
Umiam (Barapani) - 793 103. Meghalaya

In collaboration with :
Indian Council of Agricultural Research (ICAR), New Delhi
and
Indian Association of Hill Farming (IAHF), Umiam

Complied and Edited by :
Dr. Shiwani Mandhania
Dr. Arun Janu
Dr. Ashish Jain

International Congress
on
"Cotton and Other Fibre Crops"

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International Congress

on

"Cotton and Other Fibre Crops"

February 20-23, 2018

at

ICAR Research Complex for NEH Region, Umiam (Barapani) - 793 103, Meghalaya

BOOK OF ABSTRACTS

Organised by

Cotton Research and Development Association (CRDA)
CCS Haryana Agricultural University, Hisar-125 004

and

ICAR Research Complex for NEH Region,
Umiam (Barapani) - 793 103. Meghalaya

In collaboration with

Indian Council of Agricultural Research (ICAR), New Delhi-110 001
Indian Association of Hill Farming (IAHF), Umiam

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PREFACE

Cotton is one of the most ancient and very important commercial crop of global importance with a significant role in Indian agriculture, industrial development, employment generation and improving the national economy. It is cultivated for domestic consumption and also exported in about 111 countries worldwide and hence called **"King of Fibres"** or **"White Gold"**. Millions of people depend on cotton cultivation, trade, transportation, ginning and processing for their livelihood. India is the only country in the world growing all the four cultivated species of cotton alongwith their hybrid combinations in the vast diverted agro-climatic situations. Cotton is basically cultivated for its fibre which is used as textile raw material. It is cultivated from Punjab in the north to Kanyakumari in the south and Assam in the east to Kutch (Gujarat) in the west.

India, the second largest producer, consumer as well as exporters of cotton next to China with 34 per cent of world area and 21 per cent of world production and continue to maintain the largest area under cotton. Within a span of fifteen years, the cotton production in the country has gone more than double with the increase of the productivity. The productivity of cotton has not made headway because of more than 70 per cent area is under rainfed cultivation and appearance of new diseases and insect pests in transgenic cotton. However, new emerging threats in terms of biotic and abiotic factors are to be understood properly and effective strategies need to be evolved for their proper redressal. The problems and prospects of *Bt* cottons in the country need to be put in a proper perspective. Therefore, there is an urgent need to properly understand the IPR issues in the best interest of farmers and scientists.

In order to maintain pace with the increased demand for the commodity, both in national and international market, it is imperative to give impetus for development of new cotton and fibre crops varieties and hybrids with appropriate cultivation technologies. Introduction of large number of private sector *Bt* cotton hybrids have brought a welcome change in recent times as far as production gains are concerned. However, to meet the ever increasing demand both in the domestic and international markets, an effective strategy needs to be developed.

The Jute, flax, cotton, ramie, Mesta, agave, banana, pineapple etc. are the important fibre crops of north eastern region of India. However, the productivity and area coverage is very low. Technological backstopping and adequate policy support would pave the way for improving fibre crop scenario in the region. The Congress would give the scientists, experts and officials working in the region a platform to share their ideas with experts from other parts of the country and abroad which would be helpful in developing a strategy for the fibre crop development in the region.

The research papers included in the **"Book of Abstracts"** are related to **"Crop Improvement, Biotechnology, Post Harvest Technology, Crop Production, Mechanization, Economic Development, Crop Protection and Biosafety"** which were the theme areas of the congress. Present compilation on **"Cotton and Other Fibre Crops"** is a compendium of holistic advancements and other relevant information related to cotton and other fibre crops covering different disciplines. We hope that the information contained in this **"Book of Abstracts"** will be useful to all the stakeholders *viz.,* researchers, students, developmental officers, planners and farmers. All these manuscripts have been pre reviewed by eminent scientists of the respective disciplines/fields before publishing in this **"Book of Abstracts"**. We are thankful to the authors of individual chapters/papers for their contribution, time and diligence without which this volume would not have been possible.

We deem it a rare privilege to place on record our sincere gratitude to Dr. D. P. Biradar, Vice Chancellor, UAS, Dharwad and President, CRDA for his valuable guidance and directions in the general functioning of CRDA. We take this opportunity to thank all concerned and hope this **"Book of Abstracts"** will serves the purpose of cotton research workers for furthering the cause of cotton and fibre crops farmers.

Place: ICAR Research Complex for NEH Region,
Umiam (Barapani) - 793 103. Meghalaya

Dated: 20-02-2018

Editors
Dr. Shiwani Mandhania
Dr. Arun Janu
Dr. Ashish Jain

COTTON RESEARCH & DEVELOPMENT ASSOCIATION
1986

ACKNOWLEDGEMENT

The Executive Council of the Cotton Research and Development Association, CCS Haryana Agricultural University, Hisar is gratefully acknowledged the Indian Council of Agricultural Research (ICAR), Govt. of India, New Delhi, North Eastern Council (NEC), Govt. of India, Meghalaya and Department of Biotechnolgoy (DBT), Govt. of India, New Delhi, Council of Scientific and Industrial Research (CSIR), Govt. of India, New Delhi for the financial assistance provided for printing of "Compendium of Lead and Invited Papers", "Books of Oral Presentations" and "Book of Abstracts" for the **International Congress** on **"Cotton and Other Fibre Crops"** held at ICAR Research Complex for NEH Region, Umiam (Barapani) - 793 103. Meghalaya from February 20-23, 2018.

COTTON RESEARCH & DEVELOPMENT ASSOCIATION
1986

CONTENTS

CROP PRODUCTION AND MECHANIZATION

CROP PROTECTION AND BIOSAFETY

SOCIO ECONOMIC DEVELOPMENT

CROP IMPROVEMENT, BIOTECHNOLOGY AND POST HARVEST TECHNOLOGY

CROP PRODUCTION AND MECHANIZATION

CROP PROTECTION AND BIOSAFETY

SH. M. VENKAIAH NAIDU
VICE PRESIDENT
INDIA

Message

The Hon'ble Vice President of India is happy to learn that the Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are jointly organizing an International Congress on `Cotton and Other Fibre Crops' from February 20 - 23, 2018.

The Vice President extends his greetings and congratulation to the organizers and the participants and wishes the event all success.

Sd/-
M. Venkaiah Naidu

सत्यमेव जयते

PROF. KAPTAN SINGH SOLANKI
GOVERNOR
HARYANA

Message

I am glad to know that Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are jointly organizing the International Congress on "Cotton and Other Fibre Crops" in Collaboration with Indian Council of Agricultural Research (ICAR), New Delhi and Indian Association of Hill Farming (IAHF), Umiam from February 20-23, 2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya).

Cotton is grown in the country on different holdings, varied planting dates, varied soil and water conditions and pest problems. Sustainability of production, requisite quality standards and rising costs of cultivation are some of the serious challenges for the scientists, development staff, field functionaries and the cotton growers. Release of BT cotton in 2002 on commercial scale marks the beginning of transgenic era in the country. However, new emerging threats in term of biotic and abiotic factors are to be understood properly and effective strategies need to be evolved for their proper redressal.

It is timely action taken by CRDA to organize such a International Congress on cotton. I hope the deliberations will be made on all the aspects and solutions will be suggested to solve the problems and augment future research. I congratulate the Organisers and Scientists for the Nobel effort and wish the International Congress a grand success.

Kaptan Singh Solanki

सत्यमेव जयते

SH. GANGA PRASAD
GOVERNOR
MEGHALAYA

Message

It gives me great pleasure to learn that Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are jointly organizing the International Congress on "Cotton and Other Fibre Crops" in collaboration with Indian Council of Agricultural Research (ICAR), New Delhi and Indian Association of Hill Farming (IAHF), Umiam from February 20-23, 2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya).

I hope the deliberations in the International Congress will prove fruitful and suggest ways for improvement in various sectors of fibre industry. I wish the International Congress a grand success and convey my good wishes to all the participants.

Ganga Prasad

सत्यमेव जयते

DR. MUKUL SANGMA
CHIEF MINISTER
MEGHALAYA

Message

I am glad to know that Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are jointly organizing the International Congress on "Cotton and Other Fibre Crops" in collaboration with Indian Council of Agricultural Research (ICAR), New Delhi and Indian Association of Hill Farming (IAHF), Umiam from February 20-23, 2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya).

Cotton is grown in the country on different holdings, varied planting dates, varied soil and water conditions and pest problems. Sustainability of production, requisite quality standards and rising costs of cultivation are some of the serious challenges for the scientlsts, development staff. field functionaries and the cotton growers. Release of *Bt* cotton in 2002 on commercial scale marks the beginning of transgenic era in the country. However, new emerging threats in term of biotic and abiotic factors are to be understood properly and effective strategies need to be evolved for their proper redressal. However; for North Eastern region of India, other fibre crops like jute, ramie, rnesta etc. also has very good potential for which appropriate strategies and packages arc required.

It is timely action taken by CRDA to organize such an International Congress on cotton and other fibre crops. I hope the deliberations will be made on all aspects and solutions wlll be suggested to solve the problems and augment future research in fibre crops.

I congratulate the organizers and the researchers for the noble effort and wish the International Congress a grand success.

Mukul Sangma

सत्यमेव जयते

SH. RADHA MOHAN SINGH

MINISTER OF AGRICULTURE AND FARMERS WLEFARE
GOVERNMENT OF INDIA

Message

I am glad to know that Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are jointly organizing the International Congress on "Cotton and Other Fibre Crops" in collaboration with Indian Council of Agricultural Research (ICAR), New Delhi and Indian Association of Hill Farming (IAHF), Umiam from February 20-23, 2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya).

Cotton and cotton textile products are a natural and preferred fibre worldwide. The Government of India is providing all necessary help through various schemes and programmes to promote cotton production, improvement in quality and also better utilization of its byproducts. In order to maintain pace with the increasing demand for cotton in both national and international markets, it is essential to impart thrust for development of appropriate cotton production and protection technologies that are farmer friendly and to sustain the productivity of quality cotton to the various stakeholders in the years to come.

I wish the deliberations would prove fruitful and suggest ways for improvement in various sub sectors of cotton industry. I wish the International Congress a grand success and offer my good wishes to all the participants.

Radha Mohan Singh

सत्यमेव जयते

SH. PARSHOTTAM RUPALA

MINISTER OF STATE FOR AGRICULTURE AND
FARMERS WELFARE AND PANCHAYATI RAJ
GOVERNMENT OF INDIA

Message

I am glad to know that Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are jointly organizing the International Congress on "Cotton and Other Fibre Crops" in collaboration with Indian Council of Agricultural Research (ICAR), New Delhi and Indian Association of Hill Farming (IAHF), Umiam from February 20-23, 2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya).

I know the travails of the cotton farmers because of pest attack, improper seed and spurious pesticides. The problems have become much more serious with the emergence of global competition phenomena in recent years. Therefore, as a person hailing from a farming family, I urge the Scientists engaged in R&D, to take their legitimate duty and pride to find a solution to the cotton growing problems and to help the cotton farmers to increase the effective net income from cotton cultivation and at the same time ensure quality cotton availability to the textile sector. More than 65 per cent of Indian population reply on agriculture for their livelihood, which is directly dependent on climate.

It is a timely action by the Cotton Research and Development Association (CRDA) to organise such a International Congress on cotton.

I congratulate the Organizers and Scientists for the nobe efforts and wish the International Congress a grand success.

Parshottam Rupala

सत्यमेव जयते

DR. TRILOCHAN MOHAPATRA
SECRETARY AND DIRECTOR GENERAL
ICAR, NEW DELHI

Message

I am happy to know that Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are organizing the International Congress on `Cotton and Other Fibre Crops' in collaboration with Indian Council of Agricultural Research (ICAR), New Delhi and Indian Association of Hill Farming (IAHF), Umiam from 20-23 February, 2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya).

India is the only country in the world growing all the four cultivated species of cotton along with their hybrid combinations. It is the major cash crop playing a crucial role in Indian agriculture and sustainable rural livelihood. The release of *Bt* cotton for commercial cultivation in India has been a historical event in reducing the losses due to bollworms, which in turn, has increased productivity. There is no parallel to *Bt* cotton technology in the recent history of agriculture. It is believed that the era of transgenic cotton and open global fibre market are likely to reorient priorities of cotton research in India as well as in the world.

I am sure, the International Congress would provide a platform to discuss the emerging issues in cotton research and development.

I wish the Congress a grand success.

Trilochan Mohapatra

सत्यमेव जयते

SH. CHHABILENDRA ROUL
ADDITIONAL SECRETARY, DARE AND SECRETARY, ICAR
GOVERNMENT OF INDIA

Message

I am glad to know that Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are jointly organizing the International Congress on "Cotton and Other Fibre Crops" in collaboration with Indian Council of Agricultural Research (ICAR), New Delhi and Indian Association of Hill Farming (IAHF), Umiam from February 20-23, 2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya).

Globally, cotton is facing challenges that affect not only sustainability of production but also competitiveness with artificial fibres in the textile industry. Cotton is one of the most ancient and very important commercial fibre crops of global importance with a significant role in Indian agriculture, industrial development, employment generation and improving the national economy.

I am sure that the outcome will have a practical value for development of R&D programmes in the country. I convey my best wishes for the success of the International Congress.

(Chhabilendra Roul)

PROF. (DR.) A. K. SRIVASTAVA
CHAIRMAN
ASRB, NEW DELHI

Message

I am glad to know that Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are jointly organizing the International Congress on "Cotton and Other Fibre Crops" in collaboration with Indian Council of Agricultural Research (ICAR) and Indian Association of Hill Farming (IAHF), Umiam from February 20-23, 2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya).

Climate change has become a major national issue as well of a global concern. New projections show that climate change and its consequences will affect every aspect of life. Government of India has constituted the National Council for Climate Change to prepare the road map for sustainable development and to coordinate national plans for impact assessment, adaptation and mitigation to climate change.

This year, there was significant increase in area under cotton production. But the productivity of about 500 kg per ha for the past 6-7 years needs to be revisited with perspective plan. The newer or non-traditional areas for cotton production are to be identified, which may boost the cotton productivity in country. Public-Private Partnership based research agenda need to be encouraged. All innovative cotton production technologies, which are farmers friendly, and practically possible need to be identified and disseminated with comprehensive extension activities.

I hope that the deliberations of this International Congress will be useful to all stakeholders of cotton production.

A.K. Srivastava

DR. ASHOK KUMAR SINGH

DEPUTY DIRECTOR GENERAL (AG. EXTENSION) AND

DIRECTOR, ICAR-IARI (ADDITIONAL CHARGE)

Message

I am glad to know that Cotton Research and Development association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are jointly organizing the International Congress on "Cotton and Other Fibre Crops" in collaboration with Indian Council of Agricultural Research (ICAR) and Indian Association of Hill Farming (IAHF), Umiam from February 20-23, 2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya).

Globally, cotton is facing challenges that affect not only sustainability of production but also competitiveness with artificial fibres in the textile industry. There is a need to enhance productivity of cotton under rainfed ecosystem, which constitutes 70 per cent of cotton area in the country. *Bt* cotton cultivation in 2002 on commercial scale marked the beginning of transgenic era in the country and lead India to become largest cotton producing and second largest cotton exporting country with 5.97 million tons of production and 0.85 million tons of exports as compared to China with a production of 3.69 million tons and 2.77 million tons of export during 2016-2017.

However, the problems and prospects of transgenic cotton with respect to not only insect resistance (*Bt*) but also herbicide tolerance (HT), need to be put in proper perspective. I wish that the deliberations would prove fruitful and suggest ways for improvement in various sub-sectors of cotton industry. I with the International Congress a grand success.

A. K. Singh

DR. DESH BANDHU AHUJA
DIRECTOR (ACTING)
ICAR - NCIPM, NEW DELHI

Message

I am glad to know that Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are jointly organising the International Congress on "Cotton and other Fibre Crops" in collaboration with Indian council of Agricultural Research (ICAR) , New Delhi and Indian Association of Hill Farming (IAHF), Umiam from February 20-23,2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya).

Cotton and cotton textile products, being a natural and preferred fibre worldwide, have a bring future. The Government of India is providing all necessary help through various schemes and programmes to promote cotton production, improvement in quality and also better utilization of the byproducts.

Climate change has become a major issue of concern. Every nation is gearing up to adopt itself to the threat of climate change. Government of India has constituted the National Council of Climate Change to prepare a roadmap for energy efficiency and sustainable development and to coordinate national plans for impact assessment, adaptation and mitigation to climate change.

I wish the International Congress a grand success.

D. B. Ahuja

सत्यमेव जयते

DR. RAM MUIVAH, IAS

SECRETARY, NORTH EASTERN COUNCIL

MINISTRY OF DEVELOPMENT OF NORTH EASTERN REGION

GOVT. OF INDIA

Message

I am delighted to know that Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are jointly organizing the international Congress on "Cotton and Other Fibre Crops" in collaboration with Indian Council of Agricultural Research (ICAR), New Delhi and Indian Association of Hill Farming (IAHF), Umiam from February 20-23, 2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya).

Cotton and cotton textile products being a natural and preferred fibre worldwide have a bright future. The Government of India is providing all necessary help through various schemes and programmes to promote cotton production, improvement in quality and also better utilization of the byproducts. Modernization efforts on the farming and processing area needs special attention to empower the cotton farmers and textile industry to boldly face the global competition in the new trading environment.

I am sure the deliberations would prove fruitful and suggest ways for improvement in various sub-sectors of cotton industry and other fibre crops like jute, ramie, mesta, banana, pineapple etc. I wish the International Congress a grand success and convey my best wishes to all the participants.

Ram Muivah

PROF. K. P. Singh
VICE CHANCELLOR
CCS Haryana Agricultural University, Hisar

Message

I am glad to know that Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are jointly organizing the International Congress on "Cotton and Other Fibre Crops" in collaboration with Indian Council of Agricultural Research (ICAR), New Delhi and Indian Association of Hill Farming (IAHF), Umiam from February 20-23, 2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya).

India is the only country in the world growing all the four cultivated species of cotton along with their hybrid combinations. Cotton and cotton textile products being a natural and preferred fibre worldwide have a bright future.

Climate change has become a major national issue as well as of global concern. Every national is grearing up to adopt itself to the threat of climate change. The impact of climate change will be multifacted raning from fundamental threat to the region's food and energy, security to socio economic issues including large scale migration of rural folk.

I hope that the deliberations in this International congress would prove fruitful and suggest ways and means for improvement in various sub-sectors of cotton industry.

I wish the International Congress a grand success and offer my best wishes to all the delegates.

K. P. Singh

PROF. M. PREMJIT SINGH
VICE CHANCELLOR
CAU, IMPHAL, MANIPUR

Message

I am glad to know that Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are jointly organizing the International Congress on "Cotton and Other Fibre Crops" in collaboration with Indian Council of Agricultural Research (ICAR), New Delhi and Indian Association of Hill Farming (IAHF), Umiam from February 20-23, 2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya).

Globally cotton is facing challenges that affect not only sustainability of production but also competitiveness with artificial fibres in the textile industry. Cotton is one of the most ancient and very important commercial fibre crops of global importance with a significant role in Indian agriculture, industrial development, employment generation and improving the national economy. In the context of Northeastern region of India, other fibre crops such as jute, ramie, mesta, banana, pineapple fibre hold promise and adequate strategy for their development should be formulated.

I am sure that the outcome will have a practical value for development of R&D programmes for fibre crops in the country. I convey my best wishes for the success of the International Congress.

M. Premjit Singh

DR. K. M. BUJARBARUAH
VICE CHANCELLOR
ASSAM AGRICULTURAL UNIVERSITY, JORHAT

Message

I am glad to know that Cotton R esearch and Development Association (CRDA), Hisar and ICAR Research Complex for NEH R egion, Umiam (Meghalaya) are jointly organizing the International Congress on "Cotton and Other Fibre Crops" in collaboration with Indian Council of Agricultural Research (ICAR), New Delhi and Indian Association of Hill Farming (IAHF), Umiam from February 20-23, 2018 at ICAR Research Complex for NEH Region Umiam (Meghalaya).

Climate change has become a major national issue as well of global concern. New projections show that climate change and its consequences will affect every aspect of life. Government of India has constituted the National Council for Climate Change to prepare a road map for energy efficiency and sustainable development and to coordinate national plans for impact assessment, adaption and mitigation to climate change.

No doubt that significant enhancement of area under cotton this year, but the productivity hovering around 500 kg/ha for the past six to seven years which need to be enhanced with perspective plan like discontinuation cotton cultivation wherein the productivity is very low identification of newer or non-traditional areas which boost the cotton productivity level in the country. Public Private Partnership based research agenda need to be revamped. India is not dearth of innovative cotton production technologies; however farmer's friendly, farmer's acceptable and practically possible technologies to be identified which are to be disseminated with comprehensive extension activities. Similarly sincere efforts are required for revival of other fibre crops like jute, ramie, mesta, pineapple etc.

I hope that the deliberation of the International Congress will be useful to all stake holders of cotton and other fibre crop production and their use and policy perspectives.

K. M. Bujarbaruah

DR. B. R. CHIPPA
VICE CHANCELLOR
SKRAU, BIKANER

Message

It is a matter of immense pleasure for me to note that Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam are jointly organizing an International Congress on "Cotton and Other Fibre Crops" during February 20-23, 2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya). I hope that this International Conference shall provide a forum for researchers to discuss the global issues related to sustainable crop production, quality parameters as per industrial requirement and strategy to mitigate the emerging threats for cotton and other fibre crops.

I congratulate the organizers and wish the Congress a great success.

B. R. Chippa

PROF. U. S. SHARMA
VICE CHANCELLOR
MPUAT, UDAIPUR

Message

It is a matter of great pleasure that Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are jointly organizing the International Congress on "Cotton and Other Fibre Crops" in collaboration with Indian Council of Agricultural Research (ICAR), New Delhi and Indian Association of Hill Farming (IAHF), Umiam from February 20-23, 2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya).

Climate change has become a major national issue as well of global concern. New projections show that climate change and its consequences will affect every aspect of life. Government of India has constituted the National Council for Climate Change to prepare a road map for energy efficiency and sustainable development and to coordinate national plans for impact assessment, adaptation and mitigation to climate change.

No doubt, there is a significant enhancement of area under cotton this year, but the productivity hovering around 500 kg per ha for the past six to seven years. The productivity need to be enhanced with perspective plan like discontinuation cotton cultivation wherein the productivity is very low and identification of newer or non-traditional areas which boost the cotton productivity level in the country. Public-Private Partnership based research agenda need to be revamped. India is not dearth of innovative cotton production technologies; however farmers friendly, farmers' acceptable and practically possible technologies are to be identified and disseminated with comprehensive extension activities.

I hope that the deliberations of the International Congress will be useful to all stakeholders of cotton production its use and policy perspectives. I convey my best wishes to the organizers for the grand success of the Congress.

U. S. Sharma

DR. N. C. PATEL
VICE CHANCELLOR
ANAND AGRICULTURAL UNIVERSITY, ANAND

Message

I am glad to know that Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are jointly organizing the International Congress on "Cotton and Other Fibre Crops" in collaboration with Indian Council of Agricultural Research (ICAR), New Delhi and Indian Association of Hill Farming (IAHF), Umiam from February 20-23, 2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya).

India is the only country in the world growing all the four cultivated species of cotton alongwith their hybrid combinations. It is the major cash crop playing a crucial role in Indian agriculture and sustainable rural livelihood. The release of *Bt* cotton for commercial cultivation in India has been a historical event in reducing the losses due to bollworms and in turn increasing the productivity. There is no parallel to *Bt* cotton technology in the recent history of agriculture. It is believed that the era of transgenic cotton and open global fibre market are likely to reorient priorities of cotton research in India as well as in the world.

Hence the International Congress has been well organized to provide platform to discuss the emerging issue in cotton research. I hope that the deliberations are going to give new dimensions and directions to the cotton research and development programmes.

I extend my best wishes to the organizers for the success of the International Congress.

N. C. Patel

DR. P. M. SALIMATH
VICE CHANCELLOR
UNIVERSITY OF AGRICULTURAL SCIENCES, RAICHUR

Message

I am glad to know that Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are jointly organizing the International Congress on "Cotton and Other Fibre Crops" in collaboration with Indian Council of Agricultural Research (ICAR), New Delhi and Indian Association of Hill Farming (IAHF), Umiam from February 20-23, 2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya) .

Globally cotton is facing challanges that affect not only sustainability of production but also competitiveness with artificial fibres in the textile industry. Cotton and cotton textile products being a natural and preferred fibre worldwide have a bright future. Cotton is basically cultivated for its fibre which is used as textile raw material and is the backbone of the flourshing textile industry in India. Cotton is one of the most ancient and very important commercial fibre crop of global importance with a significnt role in Indian agriculture, industrial development, employment generation and improving the national economy and India having a large domestic textile industry, the mill consumption of cotton in the country especially textile mills and small scale spinning units had been continuously in the rise.

I am sure that the outcome is going to be of practical value for national progress and I convey my best wishes for the success of the International Congress.

P. M. Salimath

MR. RAJJU SHROFF
CHAIRMAN
CROP CARE FEDERATION OF INDIA

Message

I am glad to know that Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are jointly organizing the International Congress on "Cotton and other Fiber Crops" in collaboration with Indian Council of Agricultural Research (ICAR), New Delhi and Indian Association of Hill Farmrng (IAHF), Umiam from February 20 - 23, 2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya).

India is the largest producer of Cotton in the world with 118 lakh ha millions of cultivation area. About 338 lakh bales of cotton is produced but productivity is low as 568 kg/ha against the world average productivity (770 kg/ha).

One of the major reason for low productivity is high damage due to insect pests. In recent years whiteflies and pink bollworms have created havoc in all cotton growing areas.

I am sure, the deliberations during the conference would certainly come out with ideas to find the solution, amongst other things, to this ever-growing menace and help improving the cotton productivity.

I wish International Congress a grand success !

Rajju Shroff

PMFAI

MR. PRADEEP DAVE
PRESIDENT
PMFAI, INDIA

Message

It gives me immense pleasure to know that Cotton Research and Development Association (CRDA), Hisar and ICAR Research Complex for NEH Region, Umiam (Meghalaya) are jointly organising an International Congress on "Cotton and other Fibre Crops" in collaboration with Indian Council of Agricultural Research (ICAR), New Delhi and Indian Association of Hill Farming (IAHF), Umiam from February 20-23, 2018 at ICAR Research Complex for NEH Region, Umiam (Meghalaya).

Cotton is one of the important crops cultivated in India. India is one of the largest producers of cotton in the world with 26% of world cotton production, and having largest area under cotton cultivation in the world.

Globally cotton is facing challenges that affect not only sustainability of production but also competitiveness with artificial fibres in the textile industry. Cotton and cotton textile products being a natural and preferred fibre worldwide have a bright future. Cotton is basically cultivated for its fibre which is used as textile raw material and is the backbone of the flourishing textile industry in India.

Cotton being one of the important commercial crop of global importance with significant role in Indian Agriculture, industrial development, employment generation and improving national economy, there is a need to increase our yield per hectare with adoption of technologies.

I am sure, the outcome from the event going to be practical value for national progress and I convey my best wishes for grand success of the International Congress.

Pradip Dave

COTTON RESEARCH AND DEVELOPMENT ASSOCIATION

Life Time Achievement Award 2018

Citation

DR. PHUNDAN SINGH

FORMER DIRECTOR CICR, NAGPUR

Dr. Phundan Singh was born on 5th January, 1946 in village Sakauti of Distt. Meerut in the family of Late Ch. Mangat Singh and Late Smt. Asharphi Singh. He hails from a reputed agricultural family of Western Uttar Pradesh. He got his early education from local school and did his High School and Intermediate from U.P. Education Board, Allahabad during 1961 and 1963, respectively. He did his B.Sc. (Agri.) from Agra University, Agra in 1965 and M.Sc. and Ph.D from Kanpur University, Kanpur in 1967 and 1976, respectively. Dr. Singh was a scholarship holder during his education days.

After completing the education he joined as Senior Research Assistant at C.S. Azad University of Agriculture and Technology, Kanpur and remained from February 5, 1968 to September 14, 1976. He remained at Central Institute for Cotton Research (CICR), Nagpur from September, 18, 1976 to January 31, 2008 at different positions like Head, Division of Crop Improvement and also as Acting Director. During his total research experience of more than 40 years, the major achievements were; developed 2 hybrids (CISAA2 and CSHH198) and three varieties (CNH 120MB, PA402 and DSL17). He also developed seven unique PGR lines (i.e. 30805, G135-49, 30838, CINA 316, CNO131, LRA GMS 5166 and CNH 123) and registered with National Bureau of Plant Genetic Resources, New Delhi. A total of more than 300 publications to his credit like 113 research paper published in journal of National and International repute. Participated and presented 67 research papers in various National and International Conferences and Symposia. He also published 52 popular articles for the benefit of farmers in various magazines. Authored 15 technical bulletins on various aspects of cotton. He also prepared a catalogue of Cotton Genetic Resources for the benefit of cotton researchers and contributed 14 book chapters in different books. He has published 54 books and out of these 6 were on cotton crop. Dr. Singh was the life member of many professional societies. Dr. Singh visited USSR, Tashken and Canada on official as well as on personal visits. During the resume of Dr. Singh as Acting Director of CICR, the Institute received many recognizations like recognized *Bt* Referral Laboratory, received best Annual Report Award and about one dozon scientists got Gold Medal in paper presentation in various Conference, Symposia, Seminar and workshops.

In addition to his regular duties as Scientist, he has to perform other academic work like refree of many scientific journals, expert members in selection, M.Sc./Ph.D external examiner, paper setter, evaluation of projects and M.Sc./Ph.D thesis, supervisor for ARS examination, organized 8 National Seminars/Symposia on different aspects of Cotton, participation in Lab to Land programme, Front Line Demonstrations, delivering Radio/T.V. talks and attended Kapas Mela, Chairman of different Committees like Purchase Committee, Farm Advisory Committee, Farm Security Committee, Farmers Fair Committee and Supervisor ARS examination.

Dr. Singh have 2 sons and one daughter. Dr. Singh and Mrs. Singh have been settled in Nagur and spent time with their grand children.

The Executive Council and Members of Cotton Research and Development Association wish you and your family a prosperous, peaceful, healthy and happy life.

Place : ICAR-RCNEH Region, Umiam
Date : 20th February, 2018

Exectuive Council and members
Cotton research and development association
ccs haryana agricultural university, hisar

COTTON RESEARCH AND DEVELOPMENT ASSOCIATION

Life Time Achievement Award 2018

Citation

SHRI SALIL SINGHAL

CHAIRMAN AND MANAGING DIRECTOR - PESTICIDE INDIA INDUSTRIES, GURUGRAM

Shri Salil Singhal was born on 21st August, 1946 at Kanpur, Uttar Pradesh in the family of late Shri P. P. Singhal ji and Smt. Saraswati Singhal ji. He got his early education at Kanpur and was graduated from St. Xaviers College having Political Science as specialized subject in B.A. (Hons.) in 1965. Since 1965, Sh. Singhal Ji has been associated with industry and his business interest was on agrochemicals. The PI industry was introduced in 1947, having headquarter at Udaipur and the main business was on agrochemicals. Pesticide India produces and sells agrochemicals and specially micronutrients through its 35,000 strong distribution network. The group employs 5000 people and does business in 50 countries'. PI is one of the first few companies to have its R&D facilities and recognized by DST, GOI since 1976 for pesticides chemicals and has developed some of the best brands in the industry that are leaders in their category. Some of the key strengths of the Company is its strong technical capabilities in the area of research and development, manufacturing services, brand building, strong distribution presence in India and customer connect initiatives.

PI has served the Indian farmers for the past 60 years, and its products and farmer support services through a knowledgeable and experienced work force and enjoys tremendous trust and confidence of the Indian farming community.

Sh. Singhal Ji formed group of companies i.e. “Secure Meters Ltd.” in 1987 and is now internationally recognized for its innovations with subsidiaries in UK, Sweden and Australia and is operating through 7 global locations, “Wolkem India” is the world's largest provider of the mineral wollastonite having production facilities in Rajasthan, Orissa, Andhra Pradesh, Tamil Nadu and Vietnam. The company has received many awards and recognitions for environmental management and nest practices. The Group has factories in many parts of India. Sh. Singhal brings a strong marketing and business development focus to the businesses, making them not only international in outlook but also strong in research and development. Each company in the Group is known to be in the forefront of technology. The Group enjoys an excellent reputation for its high standards of business ethics, and for fair and transparent business practices. Sh. Singhal has addressed many conferences and seminars. He is also associated with various social, cultural and educational organizations. Sh, Singhal Ji visited Europe, USA, UK, UAE, South Africa, Iran, Australia, Singapore, Monolia, Japan, China, Kenya, Korea, Thailand, Malaysia, Zambia very frequently.

Sh. Singhal was the Chairman of the “Pesticides Association of India”, now “Crop Care Federation of India”, for 20 years. Members subsequently elected him as “Chairman Emeritus” for life. He was a member of the Executive Committee of the Federation of Indian Chamber of Commerce and Industry (FICCI) and the Chairman of “FICCI's Environment Committee” for 5 years. He was also the Chairman of the “Confederation of Indian Industry (CII)” northern region, from 2008-09 and headed CII's National Council for MSMEs for one year. He is an Independent Director on the Boards of Steel, Construction and Hospitality Companies and presently, he is Co-Chairman of CII, National Council on Agriculture. He was the active member of CII's National Council since 2013 and was also an active member of CII's “National Innovation Council”, and the “Task Force on Corporate Governance”.

Sh. Singhal is a recipient of the Entrepreneur of the Year, Life Sciences and Agrochemicals for 2014, India Today Group Award for “Business Leadership in Agriculture and Chemicals Industry Segments” 2014 & 2015, “Global Corporate Leader of the Year” in was honoured Dec 2011 at London and Agriculture Leadership Award 2014 for Life Time Achievements at 7th International Agriculture Summit 2014 in New Delhi.

Sh. Singhal is having one son Mr. Mayank Singhal and two daughters Mrs. Shefali Khushalani and Ms. Puja Singhal at present he along with his family is residing in Gurugram and enjoy life with his grand children.

The Executive Council and Members of Cotton Research and Development Association wish you and your family a prosperous, peaceful, healthy and happy life.

Wishing you the best of everything.

Place : ICAR-RCNEH Region, Umiam
Date : 20th February, 2018

Exectuive Council and members
Cotton research and development association
ccs haryana agricultural university, hisar

COTTON RESEARCH AND DEVELOPMENT ASSOCIATION

Life Time Achievement Award 2018

Citation

DR. M. RAMAKRISHNA RAO

FORMER HEAD DIVISION OF CROP PRODUCTION, CICR, NAGPUR

Dr. M. Ramakrishna Rao was born on 8th October, 1946 at Nellore, Potti Sriramulu Neellore district of Andhra Pradesh in the family of late Dr. M.V. Chalapathi Rao, a veterinary graduate and late Smt. Vasantha, a housewife Dr. Rao had his early education at Municipal High School, Bapatla. Dr. Rao did his B.Sc. (Agri.) M.Sc. and Ph.D. from Sri Venkawara University, Tirupati in 1965, 1967 and 1974, respectively. He was a Senior Research Fellow from December 15, 1972 to September 15, 1974 at S.V. Agricultural College, Tirupati.

After completing his studies, he started his carrier as Senior Research Assistant at Indian Institute of Horticulture Research, Lucknow from August, 31, 1974 to October 10, 1976. He was selected as Scientist S-1 at CICR, Regional Station, Coimbatore and remained from October 11, 1976 to February 4, 1982. He was again selected as Scientist-2 at CICR, Nagpur from February 5, 1982 to December, 17, 1999 and remained at CICR, Nagpur in different capacities as Principal Scientist from December, 18, 1999 to October 31, 2008 and also as Head of Crop Production Division 2000 till 2006 and retired as Principal Scientist in October 2008. During the job he was given the additional responsibilities like i.e. Incharge of the seed production technology programme from 1983-85; Incharge of the Plant Physiology and Biochemistry Section from 1992-2000; Head of the Technical Cell/Research Coordination and Management Section of the Institute from 1984 to 2008; Member Editorial Board, Member Executive Council of Indian Society Cotton Improvement and Head, RCM Unit from 1985-2002, Member Research Advisory Committee of the Institute and also of Central Research Institute for Jute and allied fibres etc.

Dr. Rao worked on the following lines and developed these technologies : Low Cost hybrid seed production technology enabling three seed crops from once sown material; Use of hormone and nutrients for the management of boll and bool shedding in cotton; Amelioration of leaf reddening problem in cotton through nutrient enrichment; Development and validation of crop simulation model for cotton, based on INFOCROP (Inter-institutional collaboration); Integrated methodology for regional level prediction of cotton production, utilizing satellite data, geographic information system and crop simulation model was developed (Inter-institutional collaboration). INFOCROP-COTTON; Seed quality improvement through crop and fruiting activity management.

As Principal Investigator, he handled 3 externally funded projects. In addition to cotton crop he also worked on other crops like mango, citrus and groundnut. Dr. Rao was the member of many professional societies. During his service he has published 50 research papers, 65 symposia papers, one book and 8 research bulletins. He was the member of many professional societies.

Dr. Rao was the receipient of Prof. R. H. Dastur Memorial Gold Medal and Merit certificate for his outstanding contributions in field of cotton crop physiology.

Dr. Rao have two children, son is Electrical Engineer and settled in USA, daughter is B.D.S and his wife was a Lecturer in Nagpur University. Dr. Rao is settled in Hyderabad and enjoying retired life with grand children.

The Executive Council and Members of Cotton Research and Development Association wish you and your family a prosperous, peaceful, healthy and happy life.

Wishing you the best of everything.

Place : ICAR-RCNEH Region, Umiam
Date : 20th February, 2018

Exectuive Council and members
Cotton research and development association
ccs haryana agricultural university, hisar

COTTON RESEARCH AND DEVELOPMENT ASSOCIATION

Life Time Achievement Award 2018

Citation

DR. NACHHATAR SINGH BUTTER

FORMER HEAD, DEPARTMENT OF ENTOMOLOGY,
PUNJAB AGRICULTURAL UNIVERSITY, LUDHIANA - 141 004

Dr. Nachhattar Singh Butter was born on 13th October, 1948 in village Hakim Singh Wala of District Bathinda in Punjab. He got his early education from village school. He did his high school and higher secondary from Govt. Higher Secondary School, Faridkot. He got his B.Sc., M. Sc. and Ph.D. during 1971, 1973, 1976 from Punjab Agricultural University, Ludhiana, respectively. He was a Post Doctorate Fellow (CSIR) from 24-11-1976 to 22-2-1977. Dr. Butter was award merit scholarish during B. Sc. and M.Sc. programme and was Senior Fellowship holder of ICAR during Ph.D. He was Asstt. Entomologist from 23-2-1977 to 30-6-1987; Entomologist (cotton) from 1-7-1987 to 31-3-1994; Professor Plant Protection from 31-3-1994 to 20-6-2006 and Head of the department from 20-6-2006 to 31-10-2008. Dr. Butter's aspect of cotton identification of morphological, biochemical and physiological basis of resistance to whitefly and *Helicoverpa armigera*; standradized the sampling and screening techniques, economic threshold, forecast procedures and management of whitefly. He also evaluated the microbial pesticides and *neem* based products, spray schedule for LH 900 recommondation of synthetic pyrethroids for the first time in Punjab for the control of grown up larvae of American bollworm of cotton. Triazophos was recommended for whitefly and use of tractor mounted sprayer on cotton was advocated against cotton insect pests of cotton by Dr. Butter. During his stay in the department, he taught under and post graduate couries and guided nine M.Sc and Ph.D. students. He was also on the expert pannel for examinership and for selection of faculty to most of the SAU's. During this period he has published 267 papers including research papers, review articles, popular articles, conference papers, book chapters, bulletins etc. He was the fellow of Entomological Society of India and Society for Advancement of Insect Science. During his span of service he organized biennial workshops on cotton, zonal workshops and conferences/symposia. As master traineer during TV programmes delivered TV/Radio talks, lectures in training programmes and in short term courses. In addition to Dr. Butter provided "Package of Practices" of insect pest of cotton, also as Head he organized winter school on honey bees, Summer school on key insect pests and Second Congres of All India Coordinated Scheme of Pesticided Residues and also strengthened research laboraties. In addition to that the work of plant protection by Dr. butter was appreciated by PAU Board of Management member Sh. S. P. Oswal in 1985 and work of cotton team was also appreciated lead by Dr. T. H. Singh. Dr. Butter also visited USSR as two men delegation to study the Integrated Pest and Disease Management of cotton for 20 days under Indo-USSR project.

Dr. Butter is also a recipient of Punjab Sarkar Parman Patra in 2002 and Hexaman Award in 1993. Dr. Butter's wife (Retired Vice Princial of Govt. Women College) son is a doctor and settled in USA and daughter is Physical Therapist and settled in Canada. At present Dr. Butter is residing in Ludhiana and is busy in writting a book on "Whitefly".

The Executive Council and Members of Cotton Research and Development Association wish you and your family a prosperous, peaceful, healthy and happy life.

Wishing you the best of everything.

Place : ICAR-RCNEH Region, Umiam
Date : 20th February, 2018

Exectuive Council and members
Cotton research and development association
ccs haryana agricultural university, hisar

COTTON RESEARCH AND DEVELOPMENT ASSOCIATION

Life Time Achievement Award 2018

Citation

MR. R. G. AGARWAL

CHAIRMAN, DHANUKA AGRITECH LIMITED

Sh. R. G. Aggarwal was born on 30th July, 1949 in Delhi in the family of Late Sh. Chiranji Lal Dhanuka and Smt. Triveni Devi. He got his entire education from Delhi and B.Com (Hons) from Shri Ram College of Commerce, Delhi University. He was sincer and focused since childhood. He imbibed the family values very early in life. Recognizing unusual talent in him, his father sent him for the best of education in those days which proved to be a turning point in the life of Sh. Agarwal Ji.

After graduating, his vision was that of a technocrat to take over the sick manufacturing unit and transform into a profitable venture and it can be seen in the acquisition of a sick unit “Northern Minerals Pvt. Limited" in 1980. In 1985 "Dhanuka Pesticides" was a separate entity and in 2007 it was renamed as “Dhanuka Agritech Ltd. and Northern Mineral was also merged in it.

Sh. R.G. Agarwal wanted to do something of his own. He ventured into the trading of fertilizers and agrochemicals but due to immense challenges in term of lack of experience and paucity of funds, he could not do justice to that trading. Despite all odds, Sh. Agarwal Ji did not gave up and continued to work for his longer dreams to set up his own manufacturing unit, a rarity in those days. His deep commitment and inspiring leadership in those initial turbulent days, is an example worth inculcating. Sh. Agarwal, in 1975 expanded trading for U.P., Punjab, Haryana, Rajasthan and Andhra Pradesh and the business focus was on pesticides, an essential agricultural input.

Sh. Agarwal is a self made man and under his dynamic leadership Dhanuka Group has attained a distinguished place in Agro Chemical Industry and over the years, "Dhanuka Agritech Ltd." has been bestowed with numerious prestigious awards. His passion to contribute to Indian Agriculture is commendable. During four long decades, he never lost his vision. He has dedicated himself to bring changes in Agrochemicals industry and the farming community. His contribution for adopting newer farming techniques at the grass root level, judicious use of agrochemicals and imparting knowledge through his nationwide network of distributors and Dhanuka scientists in field, has resulted in the overall prosperity of farmers. Today, Dhanuka group is present all over the country with 4 world class manufacturing facilities and one R & D Centre.

Sh. Agarwal was the finalist in "EY Entrepreneur of the year 2016 award" for his outstanding contribution to inspire and support entrepreneur in the agriculture sector and also awarded for “Distinguished Contribution to Indian Agro Chemicals Industry” during India Chem 2016, International Conference organized by FICCI. Sh. Agarwal has been the past chairman of CCFI (Crop Care Federation of India), the apex chamber of all Indian agrochemicals majors. He is presently on the Board of Directors. His philanthropic activities are much more diversified and had always come forward to support any genuine case and several institutions are run for social service. He is also Trustee of Maharaja Agarsen Hospital, Punjabi Bagh New Delhi. He is fully active and working for Honourable Prime Minister's Vision "Double Farmer's Income by 2022"

Sh. Agarwal is having one son and two daughters. At present he alongwith his family is residing in Delhi and enjoys life with his grand children.

The Executive Council and Members of Cotton Research and Development Association wish you and your family a prosperous, peaceful, healthy and happy life.

Wishing you the best of everything.

Place : ICAR-RCNEH Region, Umiam
Date : 20th February, 2018

Exectuive Council and members
Cotton research and development association
ccs haryana agricultural university, hisar

COTTON RESEARCH AND DEVELOPMENT ASSOCIATION

Life Time Achievement Award 2018

Citation

DR. HARSHVARDHAN SINGH CHAUHAN

PRESIDENT - NPCC INDOFIL INDUSTRIES LTD.

Dr. Harshvardhan Singh Chauhan was born on 4th June, 1950 in Isagarh (Shivpuri) in Madhya Pradesh in the family of Sh. Bhanu Prakash Singh Chauhan and Smt. Suryamukhi Chauhan. His father was a Block Development Officer in M.P. and mother was a homely lady. Dr. Chauhan did his schooling from B.R. School, Agra. He did his B.Sc. (Agri.) from P.A.U., Hisar campus in 1969; M.Sc. and Ph.D. (Agronomy) from HAU, Hisar during 1971 and 1975, respectively. Dr. Chauhan was a meritorious student throughout his studies and stood first in M.Sc. and Ph.D. in the department and also a Merit Scholarship holder during P.G. studies. During his university days, Dr. Chauhan not only excelled in studies, but also earned distinction in the field of sports. Apart from being an excellent athlete, he also captained the University Cricket Team in Inter University Cricket Tournaments. He was the University Colour Holder in Athletics and Cricket. He is a passionate cricket lover and is very compulsive reader.

After completion of studies he started his career in the Industry in 1975 by joining Indofil Chemicals Co. as Sales Representative. At Indofil , Dr Chauhan worked in various capacities in Sales, Marketing and R&D. In 1991, He joined the then Ciba Geigy (now Syngenta) as Head of Product Research and Development. During his tenure in Ciba Geigy many new products were developed and registered. These new patented molecules were then commercialized in India, which created a market of few hundred crores for the Industry and helped millions of farmers in productivity improvement. During this tenure he developed good understanding of the International Agri-Chem market and international regulatory systems.

With this rich experience behind him, he was invited in 1995 to take over as Head of Agro Business Division of Indofil Chemicals Company. Agro Business Division at that time had a turnover of less than 100 Crores. He was instrumental in developing International Business at Indofil and now Indofil has now its presence in more than 100 countries in the world. He created a team that helped Indofil as one of the fastest growing Agrochemical Company in the Country with today's turnover of ?1500 crores. He is leading a team of Product Managers, R & D Scientists & Regulatory experts which is working towards creating Innovative Technologies, Formulations, Mixtures, Patents etc., that is driving company's growth prospects.

He has extensively travelled in many countries and many states in Europe (Italy, France, Switzerland, Belgium, Germany, Netherlands,etc) U.A.S, U.K, Japan, Korea, China, Brazil, Russia, Asian countries (Thailand, Phillipines, Indonesia, Malaysia, Singapore, B'Desh), Australia, Maxico, Turkey, etc. His expertise includes creation of alliances especially in Japan, South Korea and China, which have become key accounts now with addition of products at regular intervals. He was Vice Chairman on the Board of Crop Life India till 2013 and is currently on Board of two major national agrochemical associations, Crop life of India and Crop Care Federation of India,. He actively participates for the cause of Indian agriculture and the Industry. These two associations play an important role in formulation of national policies on Agriculture.

He has two daughters; elder one did Ph. D. in Immunology from Kansas State University and is settled in US. Younger daughter chose to be a home maker after doing MBA. Dr. Chauhan lives in Mumbai with his wife and likes to enjoy holidays with his three grand children.

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Wishing you the best of everything.

Place : ICAR-RCNEH Region, Umiam
Date : 20th February, 2018

Exectuive Council and members
Cotton research and development association
ccs haryana agricultural university, hisar

COTTON RESEARCH AND DEVELOPMENT ASSOCIATION

Professional Excellence Award

Citation

DR. RAJINDER KUMAR MALHOTRA

Group Chief Executive Officer - Modi Enterprises

President Indofil Industries Ltd., Mumbai

Mr. Rajinder Kumar Malhotra was born on July 15, 1947, as the second of the 4 children of Ex - army man late Shri Raghubirnath and late Smt. Kailash Kumari Malhotra and was brought up in Delhi. He got his early education in Delhi. Mr. Malhotra graduated (B.Sc. Ag.) from University of Udaipur and degreed M.Sc. in Plant Pathology from the prestigious G.B. Pant Nagar University in 1971. Mr. Malhotra proved himself a vibrant all rounder while at the University. He not only excelled in academics but also was a winner of awards and Certificates of Honour in various extra cocurricular activities.

He started his career at IARI, New Delhi and worked for two years, before joining Indofil in 1973. Over the years, he has gathered rich experience across the functions and successfully handled various responsibilities in product management, sales management and general management before taking over reins of Indofil as Chief Executive in 1994. Mr. Malhotra is the principal architect of Rs.1023 Crs. Indofil Industries Limited and its multifaceted growth story in the Global market.

Mr. Malhotra, is the Group Chief Executive Officer of Modi Enterprises. With a turnover of over 1.5 billion dollars, Modi Enterprises comprises of : Godfrey Philips India Limited (Tobacco and Tea), Indofil industries Limited (Chemicals), Modi Care (Direct Marketing), Color Bar (Cosmetics and retail), Twenty Four Seven (Retail), MAII (Education) and Ego - the Food chain restaurants (Food experience) etc . He has more than 42 years of experience in leading teams & growing businesses, through marketing alliances, joint ventures, manufacturing & acquisitions.

His passion is to serve Indian farmers and develop Indian agriculture. Despite his busy schedule, he never misses an opportunity to travel in the interiors of India with his field staff to understand the problems of farmers and find solutions. Mr. Malhotra is warm and benevolent, with a listening ear and a hearty laugh. An avid reader, nature lover, writes poetry, enjoys a good joke and good music. Which he has kept alive, in spite of this hectic schedule. In a nutshell, he is a great team leader, who is an inspiration, a go-getter, dynamic motivator and a great moral support to his colleagues. Mr. Malhotra believes in collaborative style of management. He is of the opinion that if you want to become the best you can, you need to adopt a mind set of lifelong learning. Learning adds depth to your life. He also undertake coaching from world renowned business advisor, author and speaker Prof. Ram Charan.

In key responsible positions on various associations : On the Board of IPM India Wholesale Trading Pvt. Ltd.; Member of the IM India's CEO Forum. Since 2014, he is a regular member of the G100 group.

He is blessed to have a wonderful family, with a loving wife Madhu, daughter - Loveena and son- Yuvraj. The family has grown to include an equally loving son-in-law and a doting granddaughter. Daughter Ms. Loveena Saigal is working and well settled in USA and Son Yuvraj, is an entrepreneur.

The Executive Council and Members of Cotton Research and Development Association wish you and your family a prosperous, peaceful, healthy and happy life.

Wishing you the best of everything.

Place : ICAR-RCNEH Region, Umiam
Date : 20th February, 2018

Exectuive Council and members
Cotton research and development association
ccs haryana agricultural university, hisar

COTTON RESEARCH AND DEVELOPMENT ASSOCIATION

Professional Excellence Award

Citation

DR. B. V. PATIL

Former Vice-Chancellor
University of Agricultural Sciences, Raichur - 584 102

Dr. Basavaraj Veeranagouda Patil was born on 1st March 1955 in "Hireyerdihal" village, Lingsugur taluk, Raichur district the family of Late Sh. Veeranagouda Patil and Late. Smt. Saraswathemma Patil. He got his early education from Ramakrisna Vidyashala, Mysore. Completed B.Sc. (1975), M.Sc. (1977) and Ph.D. (1981) degrees from University of Agricultural Sciences, Bangalore with Gold medals and Fellowships from ICAR and UNDP. Post Doctoral Degree from University of South Hampton, England with prestigious Commonwealth fellowship.

He worked for more than 36 years 6 Months in Research, Teaching, Extension and Administrations. He started his carrier as Research Assistant in 1980 at Regional Agril. Research Station, Raichur; as Assistant Entomologist from 1982 to 1984 at ARS, Bijapur; Cotton Entomologist from 1984 to 1987 at ARS, Dharwad and as Professor from 1987 at College of Agriculture, Raichur till 2000. Served as Associate Director of Research from 2001 to 2004 and Director of Instruction (Agri.), College of Agriculture, Raichur from May 2004 to August 2008. Served as Director of Research, UAS, Bangalore from August 2008 to January 2009. Nominated as Special Officer, UAS, Raichur from February, 2009 to April 2010.

Appointed as First Vice-Chancellor of UAS, Raichur with effect from 03-05-2010 to 2-5-2014. Worked as Director of Education from May 2014 to Feb 2017. Completed more than 25 externally funded research projects from NFSM, ICAR, DBT, DST, CCI, Monsanto, Aspee, Hexamar and also from Pesticide firms.

Guided 38 M.Sc. (Agri.) and 10 Ph.D. students as Major Advisor. Developed IPM technology for cotton in irrigated conditions, demonstrated bio-control programmes for cotton pests, collaborated for release of cotton varieties resistant to boll worms and sucking pests, developed IPM schedule for *Bt* cotton and worked on insecticide resistance aspects. At present working on Monitoring of Resistance of *Helicoverpa* and Pink Bollworm on *Bt* cotton. Published more than 350 research papers in National and International peer reviewed journals. Visited England, France, Germany, Australia, Netherlands, Israel, Italy, Switzerland, USA, Greece, Iran, Thailand, Russia, Canada, South Africa, Vietnam, Japan, Austria and Malaysia for research paper presentation in International conferences. Worked as expert FAO consultant on cotton IPM in Thailand and Vietnam. Worked as consultant on whitefly management in Iran. Life membership of many Scientific Associations/Societies.

Dr. Patil was acted as Examiner, selection committee member, Governing council member Academic Council member, member board of management and many more.

The prominent Awards/Recognition by Dr. Patil were "University Gold Medal" for Ph.D. degree "Hexamar National Award", "Best Teacher Award" from UAS, Dharwad (1998); "Distinguished Achievement for Pest Management" from C.S. AUAST, Kanpur (1998); "Silver Jubilee Award" from CICR (1999); "Outstanding National Teacher Award" from ICAR (1999).

"Sir C. V. Raman Young Scientist Award" (2000); "Dr. M. Puttarudraiah Endowment National Award" (2002); "Incentive Award" (2006,2009 and 2015) for obtaining Financial Assistance from various Adhoc projects worth more than 10 crores by individual efforts. Fellow "Indian Society for Advancement of Insect Science" and Royal Entomological Society", England. Entomological Society of India", "Life Time Achievement Award (2012)"

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Place : ICAR-RCNEH Region, Umiam
Date : 20th February, 2018

Exectuive Council and members
Cotton research and development association
ccs haryana agricultural university, hisar

COTTON RESEARCH AND DEVELOPMENT ASSOCIATION

Professional Excellence Award

Citation

DR. BASAVARAJ M. KHADI

Former Director of Education
University of Agricultural Sciences, Dharwad - 580 007

Dr. Basavaraj M. Khadi was born on 1st June, 1954 in the family of Late Sh. M. N. Khadi and Smt. Saraswati Khadi at Kalakeri Distt. Vijayapur, Karnataka. He got his early education from Kalakeri. He did B.Sc. (Agri), UAS, Bengaluru (1975). M. Sc. (Agri) G B Pant University of Agriculture & Technology, Pantnagar,)1977). Ph.D. UAS,Bengaluru (1980). Post Doc in Cotton Biotechnology and Genetics,Tashkent Agricultural Institute and Institute of Experimental Biology, Tashkent, USSR (1989).

He remained at different positions at University of Agricultural, Dharwad and Director CICR, Nagpur which is as Professor (Principal Scientist Cotton) and Head, ARS, Dharwad and Cotton Crop Coordinator (1995-2005,), Zonal Coordinator (SZ) AICCIP (ICAR) (1996 -2004), Principal Investigator (Cotton Breeding) AICCIP (2004 -2005),University Head, Department of Genetics and Plant Breeding, UAS, Dharwad (2005), Director, CICR, Nagpur (2005-2008), Dean PG Studies (2008-2012), Director of Research (2012-2015), Director of Education (2015-2016).

During his stay on different positions the salient achievements were involved in the development of 20 cotton varieties/hybrids two in chilli, one each variety and hybrid in sorghum, greengram and two sugarcane varieties. Registered 21 novel cotton germplasm lines with National Bureau of Plant Genetic Resources, New Delhi. Developed naturally coloured cotton DDCC-1 variety, DHH-11 intra *hirsutum* hybrid, DLSa-17 a long staple *arboreum*, DDhC-11 sucking pest tolerant *herbaceum* variety, Sahana – a bollworm tolerant *hirsutum* variety, DDH-2 inter specific *desi* cotton hybrid and developed temperature sensitive genetic male sterility system (TGMS) in diploid cotton.

He has published 226 research papers, 210 conference papers, 165 research abstracts, 53 edited books, 19 extension bulletins, 15 extensions folders and 29 T. V./Radio talks.

Dr. Khadi guided 13 Ph.D. and 29 M.Sc. students, two of his students awarded with a prestigious Jawahar Lal Nehru Award. Dr. Khadi is a fellow of many Academic Societies. During his service he was the receipent of many National and International Awards / recognitions. Namely : Best FAO visiting Scientist to IR of Iran (2000); ICAR Team Research Award (2000 and 2006); Best Poster/Paper Presentation Award (2004 and 2006); Sir C.V. Raman Young Scientist Award (2002); ISCI Hutchinson Memorial Award (1999); Rao Bahaddur Ramdhan Singh Award for best cotton research (2005); Dr. A. B. Joshi Gold Medal and Cash Award (2002), Dr. R. B. Ekbote Award (2013) for contribution in Genetics & Plant Breeding; UAS Dharwad Cash Incentive Award (1996; 2001; 2003) for having brought Adhoc Schemes; UAS Team Award for best maintenance of ARS, Dharwad (1999 & 2000).

Dr. Khadi was a principal investigator, 39 research projects and organized international symposium in 2004, International workshop in 2005, Third Asian Regional Cotton Network Meeting 2015, Rashtirya Kapas Mela in 2005 and 2007 at CICR, Nagpur and member of Governing Body of many socieities, Board of Management, research advisory council and consultant of IR of from.

He visited Tashkent, Leningrad (USSR); Gottingen (Germany); Cambridge (United Kingdom); Varamin, Gorgan (Iran); Nazilli (Turkey); Athens (Greece); Cape Town (South Africa); Faizalabad, Lahore (Pakistan); Damascus (Syria); Lubbac, Texas (USA), Daqing (China), Goiania(Brazil).

Dr. Khadi's wife is Professor (HAG), UAS, Dharwad. and his Son is Civil Engineer at Dharwad and daughter in law: Asst. Prof at B. V. B. Engineering College, Hubli. At present Dr. Khadi is a consultant in a Private industry.

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Cotton research and development association
ccs haryana agricultural university, hisar

COTTON RESEARCH AND DEVELOPMENT ASSOCIATION

Professional Excellence Award

Citation

DR. N. GOPALAKRISHNAN

Former Assistant Director General (Commercial Crops)
Indian Council of Agricultural Research, New Delhi - 110 001

Dr. N. Gopalakrishnan was born on 29th May, 1955 at Madurai; Tamil Nadu in the family of Shri G. Nagarajan and Smt. Visalakshi Ammal. He got his early education at Tirunelveli. He did B.Sc. from Madurai Kamaraj University, Tamil Nadu in 1975 and M.Sc. in 1977 from University of Mysore and Ph.D. from Indian Agricultural Research Institute, New Delhi. Dr. Gopalakrishnan was merit scholarship holder during graduation to post graduation. He started his carrier as Research fellow at Christian Medical College, Vellore on 5th December, 1977. He was selected as Scientist (S1) and joined Central Institute for Cotton Research (CICR), Nagpur on 15th November 1978 and remained at CICR Nagpur upto 20th March 1989 on different positions and from CICR, Nagpur, he was transferred to CICR, Regional Station, Coimbatore on 21st March, 1989 and remained there as Senior Scientist, Principal Scientist and Project Co-ordinator and Head upto January, 2011. In January, 2011 he was selected as Assistant Director General (CC) in ICAR, New Delhi and remained there upto June 2015. He was again shifted to CICR, Regional Station, Coimbatore as Principal Scientist in June 2015 and remained there till his retirement in May,2017. During his stay as Scientist, the major scientific contributions were i.*e.* use of ethel for crop canopy management and uniform boll bursting, low cost polytube drip irrigation system was an effective substitute from conventional drip irrigation system in cotton, developed a multitier cotton based cropping system with beetroot, coriander, cowpea and clusterbean, integrated crop nutrition management, options for cultivation of ELS at cotton hybrids; populazied the polymulch technology for the effective control of weeds and efficient utilization of water and nutrients with resultant higher yields and profitability to irrigated cotton farmers. He also gave scientific help in development and release of several hybrids namely, CNH012, CISA 614 and as ADG (CC). He was responsible for research monitoring in different SAU's centres. Dr. Gopalakrishnan published 50 research papers, 60 conferece papers, 25 manuals, 15 popular articles, 6 book chapters and 25 technical reports. He also provided technical guidance to many M.Sc. and Ph.D. students. He was also responsible for bringing institutional and personal recognitions like Chaudhary Devi Lal outstanding AICRP Award in 2007; Outstanding contribution and achievements in Cotton Research and Development by Indian Society for Cotton Improvement, Mumbai and NAU, Navsari in 2010 at Surat. Four Best Research Poster Awards by Cotton Research and Development Association, CCS HAU Hisar; best research paper award during International Symposium Cotton at UAS, Dharwad. He visited Burkino Faso during November 17 to 21, 2008. He was life member of many professional socieities and was also the Vice-President of Cotton Research and Development Association.

Dr. Gopalakrishnan's wife is working in State Bank of India at Coimbatore and son has completed M.Sc. (IT) from Australia. At present Dr. Gopalakrishnan is enjoying his retired life at Coimbatore.

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ccs haryana agricultural university, hisar

COTTON RESEARCH AND DEVELOPMENT ASSOCIATION

Professional Excellence Award

Citation

DR. P. P. SHASTRY

Dean, B. M. College of Agriculture, Khandwa - 450 001

Dr. P. P. Shastry was born on 4th June, 1955 in the family of Sh. Prabhakar Vishnu Shastry and Smt. Prabhawati Shastry in village Burman of District Narsingh Pur of Madhya Pradesh. Dr. Shastry did his schooling at Jabalpur and obtained an Honours degree in Microbiology from the University of Bombay in 1975. He did his Post Graduation in Plant Pathology from J.N. Agricultural University, Jabalpur in 1979. He started his career in the Department of Plant Pathology, JNKVV, Jabalpur in June 1980 as a Senior Research Assistant. He initially worked on betelvine focusing his attention on identification of strains and pathogenesis of *Xanthomonas campestris* pv. *betlicola*. He joined the College of Agriculture at Khandwa in 1989 and as a part of his doctoral work began on the New Wilt of cotton and completed his Ph.D. Plant Pathology in 1993 from JNKVV, Jabalpur. His pioneer work on understanding the intricacies of New Wilt has been widely appreciated across the country and is considered to be an authority on this disease. He has extensively worked on another emerging problem of cotton *i.e.* Myrothecium leaf blight. It was under his leadership that the Cotton Research Project, Khandwa was one of the recipients of Choudhary Devilal Award ICAR, New Delhi and was adjudged as the best research project with a token award of Rs.10,000/- and citation.

Although Dr.Shastry is basically a Plant Pathologist, he has shown immense interest and has worked in close association of plant breeders. Apart from assisting in developing several varieties of cotton, he has to his got credit for the development of an *arboreum* variety JK 5 with excellent fibre properties. Dr. Shastry was closely associated with the introduction of *Bt* cotton in Madhya Pradesh and has been sensitizing all the stakeholders in Madhya Pradesh on various biosafety issues. He has visited the United States to study biosafety issues in genetically engineered crops.

He was honoured with the prestigious HEXAMAR Award in 1993. His research paper on New Wilt was adjudged as the best research paper of the year published in Indian Journal of Plant Protection in 1995 and was honoured with the Smt. Sarada Memorial Award and under his leadership the Cotton Group at Khandwa was honoured by the District Administration in 2006 for their exceptional contribution in boosting the cotton production and productivity.

He has more than 60 research papers to his credit published in journals of national and international repute and has authored several technical bulletins and a book “Cotton in Madhya Pradesh” and is a member of many Executive Councils.

He is Fellow of Indian Phytopathological Society, Plant Protection Association of India and Councillor of Plant Protection Association of India and Cotton Research & Development Association, Hisar.

Dr. Shastry's wife is a housewife and he is having two sons and one daughter, elder son is Software Engineer and settled in Australia and the younger is as Senior Finance Manager at Mumbai and daughter is married and settled in Indore. Dr. Shastry is Dean, B. M. College of Agriculture, Khandwa since 2008 and also the Head, Main Cotton Research Station, Khandwa.

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ccs haryana agricultural university, hisar

COTTON RESEARCH AND DEVELOPMENT ASSOCIATION

Professional Excellence Award

Citation

DR. RAMESH KUMAR GUMBER

Former Director of Research
Punjab Agricultural University, Ludhiana - 141 004

Dr. R. K. Gumber was born on 12th November, 1956 in the family of Late Sh. Kotu Ram and Late Smt. Vidya Devi in Fazilka (Punjab). He got his early education in Fazilka. He did his graduation from M. R. College, Fazilka (Punjab University, Chandigarh) with first division.

Dr R. K. Gumber obtained his M.Sc. (1980) and Ph.D. degrees (1984) in Plant Breeding from Punjab Agricultural University, Ludhiana. He was awarded Senior Research Fellowship of Indian Council Agricultural Research for his Ph.D program. He was also awarded in service Research Fellowship at International Crop Research Institute for Semi Arid Tropics, Patancheru in Chickpea Breeding from November 1990 to May 1991. He joined Punjab Agricultural University as Asstt. Pulse Breeder in March 1986; selected as Sugarcane Breeder in 1997; Cotton Breeder from 2001 to 2005 and Senior Cotton Breeder from 2005 to 2010 and Director, Punjab Agricultural University, Regional Station, Faridkot from June 18, 2010 to March 31, 2013 and then Head, Department of Plant Breeding and Genetics from April, 2013 to November 2013. After wards as Additional Director of Research (Crop Improvement) in November, 2013; (Director, School of Agricultural Biotechnology (from January 2015 to June 2016) and also having the charge of Director of Research, PAU from June 1, 2016 till retirement on November 30, 2016. He was responsible for planning, monitoring and evaluation of research activities of Plant Breeding and Genetics, Biotechnology and Directorate of Seeds,

Dr. Gumber was a visiting scientist at the University of Hohenheim, Germany from May, 1996 to December, 1996, and from June, 1997 to December, 1997. He has a total professional (research, extension and teaching) experience of about 32 years and the salient research achievements were development and release of 22 varieties of different crops: PAU 626H, LH2076, F2164, LH2108, FHH141, F2228, FDK124, LD949, FMDH9 and FMDH 8 (SZ), FDK124 and FMDH 9 of desi cotton, F2164, LH2108 and F2228 of American cotton have been identified at national level for north zone. He was also associated in the development and release of first PAU variety of *Bt* cotton (PAU *Bt* 1) identified at national level for north zone. He has completed three ad-hoc research projects funded by ICAR, IFFCO and Ministry of Agriculture, New Delhi. He was the Nodal Officer of four ad-hoc projects under Technology Mission on Cotton funded by ICAR, New Delhi; participated in five trainings and and also one on Plant Variety Protection at Wageningen UR Centre for Development Innovation, Wageningen, The Netherlands from June 18-29, 2012; 38 national and international symposia/workshops. He was honored with Punjab Sarkar Parman Patra by Hon'ble Chief Minister of Punjab in 2012 and Appreciation Certificate by the Vice Chancellor, PAU Ludhiana in 2013. He was Member DBT standing committee for Event Based Approval of Bt cotton hybrids in 2013-2014 and 2014-2015.

Dr. Gumber is as a member of many scientific societies, examiner, paper setter and many more works other than routine assignments.

Dr. Gumber wife is working as a teacher in a Govt. School, Sriganganagar, Rajasthan and daughter is B.D.S. married and settled in Australia and son in Bosch Co. and presently doing MS (Electrial Engineering) from University of Texas, Dallas, USA and now settled in Srigangnagar (Rajasthan)

Dr. Gumber retired on November 30, 2016 as Director of Research from Punjab Agricultural University, Ludhiana. Presently, he is working as an Advisor in Ankur Seeds Pvt. Ltd., Nagpur.

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Cotton research and development association
ccs haryana agricultural university, hisar

COTTON RESEARCH AND DEVELOPMENT ASSOCIATION

Professional Excellence Award

Citation

DR. SURENDER SINGH SIWACH

Former Director of Research
CCS Haryana Agricultural University, Hisar - 125 004

Dr. Surinder Singh Siwach was born on 13th March,1958 in Village Dhakla, Distt. Jhajjar in the family of Sh. Munshi Ram and Smt. Natho Devi. He did his early schooling from Govt. Schools in Delhi. After Higher Secondary (1976), he studied at CCS HAU Hisar and did B.Sc. (Hons) Agri. (1980); M.Sc. (Agri.) (1982) and PhD in Plant breeding in 1995 as an in-service candidate. He joined CCS HAU as Asstt. Scientist at KVK, Gurugram and then was transferred to Cotton section on 6.1.1984 at main campus.

He became scientist on 30.12.1995 and Senior scientist on 30.12.2003. He was appointed as Director of Research on 13th March,2013 and remained there till 13th March, 2017. During this period he was also having the additional charge of Director of Extension Education for about one year and also the additional charge of Dean College of Agriculture. During his service, he was involved in the development of sixteen varieties and hybrids of cotton including the first GMS line as well as first GMS based hybrid AAH 1. He was the member of the ICAR Team Research Award of oustanding work in cotton. He was felicitated by Confederation of Indian Industry for contribution to the Agriculture sector in the region during vision 2020. He worked as PI/CCPI for eleven projects. He also worked as leader/member of monitoring team of ICAR, DOCD and RCGM. Also nominated as expert member by UGC for final selection of fresh application received online as well as for mid-term evaluation of ongoing research projects for the subject of Agriculture/Sericulture/Horticulture as per XII Plan. He was patron of HAU Basketball clubs, sports coordinator, College of Agriculture, Advisor, Mountaineering Club and SPICMACAY, CCS HAU, Hisar. He was captain CCS HAU squash racket team during student time in 1981-1982 besides this he represented College of Agriculture in Inter College Cricket Tournaments of CCS HAU Hisar as a student and as well as staff.

He is fellow of Indian Society of Genetics and Plant Breeding; Life Member, Indian Society for Cotton Improvement and Cotton Research and Development Association. He is also Vice-President, Cotton Research and Development Association; Member, Advisory Board, Fasal Kranti Magazine and International Journal of Applied Agriculture and Horticultural Sciences

He has more than 100 publications/popular articles/seminars papers etc. He guided three Ph.D and three M.Sc. students. At present one M.Sc. and one Ph.D. student is working with him.

Dr. Siwach wife Smt. Indira Siwach is working as Teacher in Private School at Hisar and son Mr. Chimnay has completed M.Tech in Science and Engineering.

At present Dr. Siwach is a Principal Scientist, Cotton in the Department of Genetics and Plant Breeding (Cotton Section), CCS Haryana Agricultural University, Hisar.

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ccs haryana agricultural university, hisar

COTTON RESEARCH AND DEVELOPMENT ASSOCIATION

Professional Excellence Award

Citation

DR. P. L. NEHRA

Director of Research
S. K. Rajasthan Agricultural University, Bikaner - 384 006

Dr. P.L. Nehra was born on 7th July, 1958 at Sriganganagar district of Rajasthan in the family of Shri Shiv Kumar Nehra and Smt. Nanu Devi. He got his early education from Govt. Higher Secondary School, Sriganganagar. He did his B.Sc. (Agri.) in 1978 from University of Rajasthan, M.Sc.(Agri.) in 1981 from Unversity of Udaipur and Ph.D. in 1989 from Rajasthan Agricultural University, Bikaner. He joined as lecturer on 10th March, 1981 at ARSS, Sumerpur (Pali) and then transferred to ARS, Sriganganagar in May, 1981 and remained on different positions upto March, 2016. In March he was selected as Director Extension Education and remained upto June 2017 and in July, 2017, he was slected as Director of Research at S.K. Rajasthan Agricultural University, Bikaner. He was also the Principal Investigator of Agronomy from 2004 to 2016. During his service Dr. Nehra developed number of technologies for the welfare of cotton farmers. Dr. Nehra spent more than 25 years in cotton and published 40 papers in journals of national repute. He made success story on cotton wheat production system in South Asia, was published as Dr. Nehra co-author in Asia Pacific Association of Agricultural Research Institute (APARI) through FAO Regional Office for Asia and the Pacific, Bangkok, Thailand. Dr. Nehra visited Capetown, South Africa to present the research paper in World Cotton Research Conference III. He also acted as Master Trainer of Agronomy and Nodal Officer of Research and Extension Service of Zone IBF, Rajasthan. He also nominated as member, Board of Management of S.K. Rajasthan Agriultural University, Bikaner. The Vice-Chancellor of S.K. Rajasthan Agricultural University, Bikaner honoured Dr. Nehra on account of excellent work done as Director Extension Education. He guided one Ph.D. student,

Dr. Nehra's wife is a house wife, two daughters both are married. At present Dr. Nehra is working as Director of Research, S.K. Rajasthan Agricultural University, Bikaner.

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ccs haryana agricultural university, hisar

COTTON RESEARCH AND DEVELOPMENT ASSOCIATION

Professional Excellence Award

Citation

DR. GURMEET SINGH BUTTAR

Additional Director of Extension Education,
Punjab Agricultural University, Ludhiana - 141 004

Dr. Gurmeet Singh Butter was born on 10th November, 1963 at village Assa Buttar, District Sri Muktsar Sahib in Punjab in the family of Sh. Harchand Singh Butter and Smt. Sukhdev Kaur. Dr. Buttar obtained B.Sc. Agriculture (Hons) (1985), M.Sc. Agronomy (1987) and Ph.D. Agronomy (1995) from Punjab Agricultural University, Ludhiana. He was meritorious student throughout his career. Dr. Buttar started his carrier as District Extension Specialist (1988-89), Assistant Extension Specialist (1989-92), Assistant Professor of Agronomy (1992-1996), Agronomist (1996-2005), Senior Agronomist (2005-2007), Director, Regional Station, Bathinda (2007-2010), Head, Department of Agronomy (2010 -2015) and joined as Additional Director of Extension Education, Punjab Agricultural University, Ludhiana in January, 2016. Dr. Buttar has made outstanding research contributions in the field of water management, weed control and nutrient management and developed 48 new recommendations which were included in the "Package of Practices of Punjab". He has published 118 research papers in highly rated Journals, 17 review articles and book chapters, 100 popular articles and 58 papers presented in symposium/seminars. He was conferred with ICAR-Chaudhary Devi Lal Award (2008), Punjab Government Parman Patra (2010), FAI-Dhiru Morarji Memorial Award (2013), Distinguished Scientist Award (2013), ICAR-CSSRI Excellence Award in Soil Salinity and Water Management (2013) and Gold Medal by Indian Society of Agronomy (2014). Nominated as Fellow of four Professional Societies *i.e.* National Academy of Agricultural Sciences (2014); Indian Society of Agronomy (2009); Indian Water Resources Society (2008) and Cotton Research and Development Association (2007). As a teacher guided one Ph.D. student and 3 M.Sc. students and associated in all the teaching activities at university level. As Extension scientist addressed 210 state/district level farmer training camps, 48 technical lectures, delivered 29 TV and 58 radio talks and organised 67 trainings programmes on water management.

Dr. Butter's wife is a Lecturer of Punjabi in Govt. College, Ludhiana and his son is persuing Ph. D. in Soil Science at PAU, Ludhiana and the daughter is final year student of MBBS. Dr. Butter is presently working as Additional Director of Extension Education, Punjab Agricultural University, Ludhiana.

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JOURNAL OF COTTON RESEARCH AND DEVELOPMENT

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CRDA JOURNAL NAAS RATINGS : 4.69

CROP IMPROVEMENT, BIOTECHNOLOGY AND POST HARVEST TECHNOLOGY

1.1
Combining ability studies for yield and yield contributing traits in *desi* cotton (*Gossypium arboreum* L.)

D. B. DEOSARKAR *, V. N. CHINCHANE AND K. S. THOMBRE

Department of Agricultural Botany, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani - 431 402

**E-mail : dbdeosarkar@gmail.com*

Cotton crop is mainly cultivated for its fibre and hence yield and quality of lint are equally important in cotton. Combining ability analysis is a powerful tool to discriminate between good and poor general combiners and for choosing appropriate parental lines to produce hybrids having high yield potential coupled with desirable fibre quality traits as well as to reckon the gene action involved in the inheritance of characters. In present investigation four lines were crossed with six testers to obtain 24 hybrids in Line x Tester design. The crosses and parents with three checks, were evaluated in a randomized block design with three replications during *Kharif* 2015 at Cotton Research Station, Parbhani.

Analysis of variance for means revealed significant differences for all the eighteen characters studied. Among female parents, PA 741 was found to be the best general combiner for 3 characters *viz.,* days to 50 per cent flowering, days to 50 per cent boll bursting and days to maturity had significant GCA effects. The female PAIG 77 was the best general combiner for three characters *viz.,* bolls/plant, seeds/plant and boll weight. The female PA 809 was the best general combiner for 2.5 per cent span length, fibre fineness/ micronaire, fibre strength, uniformity ratio and short fibre index.

Among male parents, AKA 2004-29 found to be best general combiner for days to 50 per cent flowering, days to 50 per cent boll bursting, days to maturity and ginning outturn. Male parent ARBAS 1301 was also found to be best general combiner for sympodia/plant, bolls/plant, seeds/boll, seed cotton yield/ plant, lint index, seed index, plant height, 2.5 per cent span length, fibre fineness, short fibre index and fibre strength. Male parent GAM 162 found to be best general combiner for ginning outturn, 2.5 per cent span length and short fibre index whereas, CNA 1016 for boll weight. The combinations PAIG 77 x ARBAS 1301, PA 734 x ARBAS 1301, PA734 x CNA 1016, PA 809 x ARBAS 1301 and PA 741 x JLA 0614 showed significant and desirable SCA effects for most of the yield and fibre quality traits studied, indicating potential for exploiting hybrid vigour in breeding programme.

1.2
Combining ability studies in CMS based and conventional hybrids of cotton (*G. hirsutum*)

G. R. GOPAL*, D. B. DEOSARKAR AND V. N. CHINCHANE

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Cotton is one of the most important fiber and cash crop of India and plays a dominant role in the industrial and agricultural economy of the country. Sixty crosses with thirteen parents and three checks *viz.,* PKV-Hy-4, NHH-206 and NHH- 44 were grown in randomized block design with two replications. The results showed that the tester AKH-07R possessed the highest GCA effect for the seed cotton yield/ha and also exhibited high GCA (in desirable direction) for the traits, sympodia, bolls/plant, harvest index and cotton seed yield/plant. The line CAK 23 B reported the high GCA effect to the traits, earliness index, bolls/plant, boll weight, seed cotton yield/plant, seed cotton yield/ha, ginning percentage and fiber strength. The CMS cross, CAK 53A x AKH-07 R possessed the highest SCA for the traits sympodia/plant, bolls/plant, boll weight, seed cotton yield/plant also it showed highest *per se* performance for the seed cotton yield/plant. From the conventional system the highest SCA effect for the trait seed cotton yield/plant observed for crosses CAK 23B x DHY-286-1R with high mean performance. For the fiber traits in CMS, highest SCA for strength showed by SRT-1A x R-2000-23 also high SCA for the traits upper half mean length. In the conventional hybrids, CAK 53B x R-2000-23 exhibited the highest SCA effect for the fiber strength also the high *per se* performance to the seed cotton yield.

1.3
Characterization for morphological traits in diallel crosses of upland cotton (*Gossypium hirsutum* L.)

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Characterization of any variety or hybrid is must to know its novelty for the registration and notification. In the present investigation, experiment consisting of 36 F_1 hybrids and their parents (9) along with the check hybrid HHH 223 was carried out during *kharif* 2017 at Cotton Research Area, Department of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar. Observations were recorded for qualitative traits of cotton on the basis of guidelines provided by PPV and FRA for DUS testing. Twenty morphological characters were studied out of which only five characters *i.e.*leaf hairiness, stem hairiness, flower petal colour, pollen colour and flower stigma showed significant variation and no variation is recorded for remaining 15 characters. Among forty six lines 22 showed sparse leaf hairiness, 17 had medium and 7 were strong. Stem hairiness was sparse in 2 lines, medium in 42 and strong 2, respectively. Flower petal colour and pollen colour was cream in 24 lines and yellow in 22 lines. Little variation was recorded in flower stigma position, only 4 lines had embedded position and 42 lines were having exerted type stigma position. The variability in these characters can be used in hybridization program for selection of desirable parents.

1.4
Evaluation of cotton germplasm accessions for yield and fibre quality traits

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Germplasm evaluation refers to the agronomic description of the material in a genebank, for traits that are generally important to breeders in crop improvement. Main aim of evaluation is to reveal

potentially useful variability for further use in genetic enhancement of crops. A total of 372 (Accession No. 501-1012) *Gossypium hirsutum* and 140 *Gossypium barbadense* germplasm accessions were raised for maintenance during *kharif* 2015. In this common trial of germplasm accessions, thirty eight selected *G. barbadense* and twenty eight *G. hirsutum* accessions were evaluated for yield and fibre quality parameters at Department of Cotton, TNAU, Coimbatore. Among the *G. barbadense* lines evaluated, Barbados recorded the highest seed cotton yield of 1659 kg/ha followed by 6002-1 which was 1623 kg/ha. Regarding the fibre quality parameters, five germplasm lines *viz.,* Barbados, Giza 1467, SBS (YF), TNB 1 and SIA 9 recorded more than 33mm of span length and for bundle strength, five germplasm lines *viz.,* Barbados, EC 101786, TNB 1, Suvin and TCB 209 recorded more than 25g/tex bundle strength. This leaves a scope of utilizing *G. barbadense* accessions Barbados and TNB 1 in breeding programe for improving fibre length and strength simultaneously. Among the twenty eight *G. hirsutum* lines evaluated, Abadhitha recorded the highest seed cotton yield of 1810 kg/ha followed by AR 23 (1799 kg/ha) and RAM P59-92 (1745 kg/ha). The highest 2.5 % span length was recorded in B 61-1862 (30.9 mm) followed by AS 139-59 (29.8 mm) and 48/85/C-1919 (29.3 mm). Bundle strength was found to be higher in ELS 527 (23.4 g/tex) with good fibre length (29.2mm). The following *G. barbadense* accessions *viz.,* Barbados (33.4 mm and 25.5 g/tex), Giza 1467(33.3 mm & 22.9 g/tex), SBS (YF) (34.9mm and 24.2 g/tex), TNB 1(34.0 mm and 26.1g/tex) and SIA 9 (33.3 mm & 23.6 g/tex) and ELS 527 (29.2 mm and 23.4 g/tex) of *G. hirsutum* are found to be superior for both fibre length and bundle strength. Utilizing these lines can result in the developing extra long staple hybrids and varieties in addition to higher yield.

1.5

Correlation and path analysis between yield and yield contributing traits in *desi* cotton (*Gossypium arboretum* L.)

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This recent study was carried out to determine the correlation between seed cotton yield and its contributing traits (plant height, days to first flower, number of bolls, boll weight and number of seeds per boll) in desi cotton under the irrigated condition. The present investigation was carried out with a total of 30 advance lines of desi cotton during *kharif* 2016 at the cotton breeding fields of CCSHAU, Hisar. The experiment was laid down in randomized complete block design (RCBD) in three replicates. Day to first flower (0.516), plant height (0.230), mean boll weight (0.711) and seeds/boll (0.259) were

significantly positive genotypic correlated to seed cotton yield per plant. The phenotypic correlation values also revealed that seed cotton yield/plant had highly significant and positive phenotypic correlation with bolls/plant (0.624), significantly and positively phenotypic correlation found between seed cotton yield/plant and mean boll weight (0.327). Furthermore, the path analysis indicated high positive direct seeds/boll (0.577) and mean boll weight (0.207) on seed cotton yield.

1.6

Studies on path analysis, association and genetic parameters for seed cotton yield and its contributing characters in *desi* cotton (*Gossypium arboreum* L.)

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The research work comprising of genetic variability, heritability and genetic advance as well as correlation and path analysis study for 12 quantitative traits in three genotypes of cotton (*Gossypium arboreum* L.) was carried out during 2015 and 2016 at Research Farm of Cotton Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar, India. The genotypic differences were significant for all the traits except monopods/plant and seeds/boll. The variability studies indicated that high PCV and GCV were observed for seed cotton yield/plant, lint yield/plant and bolls/plant. Seed cotton yield per plant, lint yield/plant, bolls/plant and days to first flower shows high heritability with high genetic advance over mean. The correlation study revealed that seed cotton yield was found to be positively and significantly correlated with traits *viz.* lint yield per plant, bolls/plant, boll weight, seed index, seeds/boll, monopods/plant, plant height, days to boll bursting and days to first flower. Path analysis revealed that lint yield per plant exhibited maximum positive direct effect on seed cotton yield followed by bolls/plant, seed index, boll weight and plant height. Hence selection for these traits would be quite effective to improve the seed cotton yield.

1.7
Genetic enhancement for cotton improvement

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Cotton is the one of the most important source of natural fibres that plays a dominant role in country's agrarian and industrial economy. The genus *Gossypium* contains about 50 species, including diploids and tetraploids. The wide geographical distribution of the diploid cottons has provided opportunity for the development of extensive diversity. Tetraploid cottons have been by far the major source of new genes that breeders use, but future improvements in environmental resistance, agronomic fitness and quality of cotton depend on diversity within the genetic resources from which new traits can be selected. Genetic enhancement plays an important role in utilizing unadapted and unutilized germplasm collections and creating vast genetic variability for development of productive cultivars / hybrids in terms of improving the level of resistance to biotic and abiotic stress, improving quality characters and in broadening the genetic base of cultivars. Diploid AD hybrids, upon fertility restoration by doubling their chromosome complement can be crossed with upland cotton to improve and increase the genetic diversity of cotton. The incorporation of G. *barbadense* into G. *hirsutum* and the interspecific diploid into tetraploid cottons have resulted in enhancing the level of gene expression. In cotton, the genetic enhancement is required for yield, fibre quality traits, resistance to biotic stresses, etc. Interspecific hybridization to utilize genes from wild species and races have achieved more than 20 types of high generation hybrids between wild resources and upland cotton. Among them, a lot of upland cotton lines with good quality and stable traits including high quality fiber, disease resistance, pest resistance, high lint percentage, etc. have been selected.

1.8

Genetic diversity analysis through RAPD molecular markers in *desi* cotton (*Gossypium arboreum* L.)

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The genomic DNA from 10 *arboreum* genotypes were evaluated to study the genetic diversity by using Random Amplified Polymorphic DNA (RAPD) analysis. Polymerase chain reaction (PCR) was carried out by using 10 random decamer primers. Six selected polymorphic RAPD primers produced a total of 140 bands. Out of these bands 100 were found polymorphic and 40 were monomorphic. Appreciable amount of polymorphism (*i.e.,* 44.08 to 100 %) had generated by these primers confirmed the genetic diversity present among the individual sample. Highly polymorphic primers like OPA-05, OPA-10, OPX-14, and OPA-19 had proved their significance for genetic diversity analysis in cotton. Using RAPD polymorphism a dendrogram was constructed using unweighted pair group method of arithmetic means (UPGMA). The value of similarity coefficient of dendrogram calculated by RAPD markers ranged from 0.42-2.07. The dendrogram assorted the genotypes into major three clusters which correspond well with their centers or sub centers or genetic relationship. The divers genotypes can be used as parents in heterosis breeding.

1.9

Studies on interspecific hybridization between cultivated tetraploid and diploid species of cotton

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The interspecific crosses between cultivated diploid and tetraploid species were made during the year 2016-2017 in Research Area of Cotton Section, Department of Genetics and Plant Breeding,

CCS HAU, Hisar. These crosses includes the direct and reciprocal crosses of tetraploid (*G. hirsutum*) and diploid (*G. arboreum*) and thus total 12 tetraploid x diploid and 16 diploid x tetraploid crosses were attempted. The emasculation of above crosses was done in evening and these stigmas were pollinated in next day. Normally such embryos fail to develop in hybridizations between *G. arboreum* and *G. hirsutum.* This obstacle was overcome by the application of plant hormone gibberellic acid (GA_3) 250 ppm solution with the help of cotton swab to the bases of pedicles for 24 hours after pollination for 3 consecutive days to reduce embryo and boll shedding. The number of crossed boll set was counted, and these bolls were picked at harvest time. The result revealed that in tetraploid x diploid crosses; the cross H1465 x HD 418 had maximum boll setting per cent (23.08%) and number of seed were 572 followed by the cross H1465 x H432 having boll setting per cent was 21.72 per cent and seeds obtained were 364. From diploid x tetraploid crosses maximum boll setting percent 48.08 was recorded in the cross HD 432 x F 2228 and 410 seeds were obtained followed by HD 324 x F 2228 (366 seeds) whereas, maximum retention was observed for (48.08%) followed by HD 432 x H 1465 where boll setting percent was 40.32.These results showed that average of boll setting per cent in diploid x tetraploid was 23.4 whereas, it was 8.7 per cent tetraploid x diploid. This showed that success rate of boll setting in diploid x tetraploid crosses is much higher than tetraploid x diploid. Genotypic differences also exist in boll setting per cent. The cross H 1465 x HD 432 has very good setting per cent whether it was tetraploid x diploid or its reciprocal.

1.10
Characterization and classification of cotton (*Gossypium hirsutum* L) accessions on basis of qualitative traits

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In the present study, total of 40 accessions were selected out for characterization of *Gossypium hirsutum* L. 21 quality traits as mentioned in DUS characterization of cotton were recorded. Among these, no variation was observed for eleven characters *viz.,* leaf gossypol glands, Leaf nectarines, Leaf shape, leaf petiole pigmentation, stem pigmentation, bract type, flower petal spot, anther filament colour, boll bearing, boll colour and boll surface. Remaining eleven characters have shown significant variation. Light green, green and dark green leaf colour was recorded in 4, 17 and 19 accessions, respectively. Leaf hairiness and stem hairiness had same and equal number of accessions, dense hairiness on leaf and stem was recorded in 10 accessions, while medium and sparse hairiness was recorded on 14 and 16 accessions, respectively. Leaf appearance recorded of two types i.e. cup

shaped (18 accessions) and flat (22 accessions). Flower petal colour and pollen colour had various combinations among all accessions. 19 accessions had yellow petal colour while other 21 had cream petal colour. On the other side, only 10 accessions had yellow pollen and remaining 30 had cream coloured pollen. Twenty one accessions had recorded with exerted type of stigma while 19 had embedded type of stigma. 28 and 12 accessions had pointed and blunt prominence of boll tip, respectively. 29 accessions had oval shaped bolls while 11 accessions had round shape of boll. Two type of boll opening was recorded *i.e.* semi open (6 accessions) and open (34 accessions).

1.11
Effect of Different Pickings on Seed Quality of *Gossypium arboreum* L. Varieties

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The present study was carried out in the Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar, India. The study was designed to to evaluate the effect of various pickings on seed quality of desi cotton varieties (HD 123, HD 324 and HD 432) and to identify the best and most suitable cotton picking stage which constitutes of higher vigor. Crop was sown in two seasons 2012-2013 and 2013-2014 and three pickings were collected from each variety with fifteen days interval starting with 50 per cent boll opening. It was studied that seed quality was significantly affected with difference in picking stage in all *desi* cotton varieties. Seeds collected during second picking showed higher seed quality characteristics in terms of seed weight, seed density, seed germination per cent, seedling length, dry weight, vigor index I, vigor index II where as minimum electrical conductivity was observed during second picking. Seeds collected from first and third picking was found low in quality. Less seed quality characteristics was observed in seeds collected during third picking.

1.12

Combining ability for seed cotton yield and attributing traits in American cotton (*Gossypium hirsutum* L.)

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The present Line x Tester analysis was attempted to obtain information on the magnitude of gca and sca variances and gca and sca effects for individual parents and crosses in respect of eight traits through combining ability analysis. Material for this investigation comprised of forty American cotton hybrids developed on four female parents (testers) using ten male parents (lines) in line x testers mating design. The experimental material was grown at CCS Haryana Agricultural University, Cotton Research Station Sirsa, during *kharif* 2014-2015 in a randomized block design with three replications. Observations were recorded for eight characters namely, plant height, monopods, bolls, boll weight, ginning outturn, seed index, lint index and seed cotton yield/plant. The combining ability analysis revealed that additive variance was more than non-additive variance in the expression of all the traits. For seed cotton yield high sca effects shown crosses H1098 × RED 5-7, H1300 × RED 5-7, H1300 × PUSA-180, H1226 × FM 531B LINE-7 and H1300 × HS-60 were cross combinations of poor combining parents. The study of gca effects revealed that male parents HS-180 and PUSA-1803 were best general combiner for seed cotton yield, bolls, ginning outturn, seed index, lint index and monopods. The respective best combiners for various traits could be used for improvement in that trait. However, considering the economic important of various characters HS 180, GS 10, PUSA 1803 and RED 5-7 among the male and H1117 among female may be used for future breeding programme.

1.13

Assessment of newly developed *Gossypium hirsutum* genotypes for yield and yield contributing characters under irrigated conditions

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An experiment for assessment of forteen genotypes of *Gosspium hirsutum* along with two checks for

yield and yield contributing characters was taken at Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri during 2016-2017. The experiment was laid out in randomized block design with three replications. Two rows of 7.2 m length of each genotype with a spacing of 90 x 60 cm were sown. Results were statistically significant for seed cotton yield and ranges from 1159 kg/ ha to 3120 kg/ha. Out of forteen genotypes two genotypes *viz.,* RHC-1507 (2935 kg/ha) and RHC 1514 (3121 kg/ha) recorded significantly superior yield over the best check Phule Yamuna (2516 kg/ha). The highest lint yield was recorded by RHC 1514 (1145 kg/ha), followed by RHC 1507(1140 kg/ha). Ginning outturn was ranged from 26.5 to 39.6 percent, the highest ginning percentage was recorded by the genotype RHC 1511 (39.6 %) followed by RHC 1507 (38.9%), RHC 1510 (38.9%) and RHC 1512 (38.4%). Regarding earliness three genotypes *viz.,* RHC 1505, RHC 1508 and RHC 1509 showed earliness in fifty percent flowering and fifty per cent bursting. In conclusion, it is clearly visible that among the genotypes studied, the RHC 1514 had performed well in yield and yield contributing characters.

1.14
Study of gene effects for seed cotton yield and its attributing traits in upland cotton (*Gossypium hirsutum* L.)

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The present investigation comprising of six generations (P_1, P_2, F_1, F_2, BC_1 and BC_2) of four crosses *viz*. GCH 3 x HS 6, GCH 3 x RST 9, H 1353 x HS 6 and H 1353 x RST 9 was conducted to estimate the gene effects for the seed cotton yield and its attributing traits during *kharif* 2013-2016. The experimental material was grown in a randomized block design with three replications during *kharif*, 2015 in Cotton Research Area of CCS Haryana Agricultural University, Hisar. The "t" statistical test was applied to test the differences between parental genotypes for the characters studied before considering the biometrical analysis. The gene effects were estimated by employing generation mean analysis which revealed significant differences for all the characters in all the four crosses. Traits namely days to flowering, plant height, number of bolls / plant, boll weight, seed index and seed cotton yield indicated the presence of non-allelic interactions. Dominance component was significant for the characters *viz.,* days to flowering, plant height, seed index and seed cotton yield. Either all or any of the three types of epistatic interactions (i, j and l) were significant for the cases where simple additive-dominance model was found inadequate. Duplicate type of interaction was apparent for days to flower (cross IV) and plant height (cross I, II and IV).

1.15

Breeding potential of hybrids developed from interspecific crossing between upland cotton (*G. hirsutum* L.) and Egyptian cotton (*G. barbadense* L.) in rainfed situation

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The present investigation comprised of 51 interspecific hybrids obtained by mating 17 lines of *G. hirsutum* and three testers of *G. barbadense* in line x tester fashion and were evaluated to study heterosis for seed cotton yield and its component traits. Heterosis over mid-parent, better parent and standard checks (DCH 32, DHB 1071 and DHB 915) revealed that hybrids exhibited heterotic effect in desirable direction for almost all the characters studied. Among the 51 interspecific hybrids, crosses FQT 37 x SB-YF 425 followed by 543403A03N106 x BCS 23, CSHH 243M x BCS 23 and HBS 1 x Suvin recorded high mean performance with significant heterosis over mid-parent, better parent and over all three standard checks. Most of these crosses showed significant values for other yield related characters also. Most of the crosses recorded higher values for all fibre quality traits under study except fibre strength where one cross HBS 137 x Suvin was *on par* with commercial check DCH-32. The highest value for fibre length was 36.80 mm (FQT 26 X BCS 23) and micronaire value was 3.60 ìg/inch (543403A03N106 X BCS-23) which were more than the commercial check value of DCH 32. For fibre strength, overall mean was 23.59 g/tex which was slightly less than commercial check DCH 32. But in comparison with recently released standard check DHB 1071, 24 crosses showed higher fibre strength values. In future, the best interspecific crosses need to be confirmed for superiority over locations and in large scale plots.

1.16
Exploring RNAi efficiency through dsRNA mediated knockdown of various genes in sap sucking insect pests of cotton

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Sap sucking insects such as cotton leafhopper (*Amrasca biguttulla biguttulla*), whitefly (*Bemisia tabaci*), thrips (*Thrips tabaci*) and mealybug (*Phenacoccus solenopsis*) are serious pests of cotton. Not much is known on these insects at molecular level due to lack of reference genomic and transcriptomic data except *B. tabaci*. Double stranded RNA (dsRNA)-mediated gene silencing, also known as RNA interference (RNAi), has been a breakthrough technology for functional genomic studies and represents a potential future tool for the management of insect pests. To explore vital and potential genes in these insects, which can be used in future from pest management perspective, the transcriptome sequencing was done with the help of illumina RNA sequencing methods. The transcripts were annotated using Blast2GO software. The potential genes were selected on the basis of RNAi experiments in other insects in literature and their CDS sequences were used to design and synthesize primers for amplifying ~250-400 bp sequence specific template for dsRNA synthesis. The dsRNA was synthesized *in vitro* using Ambion (Invitogen) T7 transcription system. Methods were developed for feeding dsRNA incorporated in diet. To generate preliminary information on RNAi efficiency in these insects, genes like *Aquaporin* (*AQP*) and *Calcitonin* (*CAL*), inhibitor of *apoptosis* (*IAP*), heat shock proteins (*HSP20*), *vATPase* and *SNF* (targeting transcription and expression) were targeted. In case of cotton leafhopper, feeding 500 ng/ul of dsRNA targeting *SNF7*, *IAP*, *AQP1* and *vATPase* genes caused 56.17 -77.12 per cent knockdown of targeted genes compared to control and 16 to 48 per cent mortality of treated insects. In case of whitefly, feeding of 400 ng/ul of dsRNA targeting *AQP*, *CAL*, *hsp20* genes caused 1.25, 3.32, 1.09 fold downregulation of targeted genes compared to control, respectively and up to 60 per cent of mortality in treated insects. In thrips, downregulation of *SNF* caused 1.24 fold downregulation by feeding of 500 ng/ul of dsRNA compared to control. In case of mealybug, feeding experiments did not resulted in knockdown of targeted genes, so 20 µg of dsRNA targeting *CAL* gene was injected in 3rd instar reared on cotton plant under laboratory conditions. The injection of dsRNA resulted in 1.14 fold downregulation of the targeted gene compared to dsGFP treated insects. The results presented here shed light on the potential of RNAi in hemipteran insects which could be shaped into efficient strategies to affect physiological and molecular pathways in targeted insect pests.

1.17
Character association and path analysis for yield and its related characters in upland cotton (*Gossypium hirsutum* L.)

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Forty two cotton genotypes along with two checks were evaluated in a randomized complete block design with three replications with objective to assess the correlation and causation among different characters related to seed cotton yield. Analysis of variance revealed significant differences among all forty-two genotypes with a wide range of mean values for different characters indicating the presences of variability for different characters. Highest genotypic and phenotypic coefficients of variation were observed for lint yield (67.07, 67.77) followed by seed cotton yield (65.46, 66.01), boll number (30.29, 31.66), monopods/plant (28.32, 32.99) and sympods/plant (20.38, 23.95). High heritability coupled with high genetic advance was observed for seed cotton yield (98.32, 133.70), lint yield (97.95, 136.74) and boll/plant (91.58, 59.72). Direct selection for these characters would be effective as heritability and genetic advance might be due to additive gene interaction. The genotypic correlation coefficients between different characters were generally similar in sign and nature to the corresponding phenotypic correlation coefficients. However, genotypic correlations were higher in magnitude than the corresponding phenotypic values. Significant positive association of seed cotton yield was observed with lint yield, sympods/plant, boll number, plant height, biological yield and ginning out turn. Partitioning of correlation coefficients of various component characters with seed cotton yield into direct and indirect contributions revealed that lint yield (0.9999, 0.9909) had maximum direct effects at both phenotypic as well as genotypic level. Seed index (0.0401) and boll number (0.0279) also exhibited considerable positive direct effect on seed cotton yield/plant at phenotypic level. It is concluded that seed cotton yield may be improved by selection of plants having more lint yield with high boll number and seed index.

1.18
Genetic parameters for seed cotton yield and its contributing traits in upland cotton (*Gossypium hirsutum* L.)

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Thirty upland cotton genotypes were studied to observe mean, range and genetic variability for seed cotton yield and its contributing characters. The present study was undertaken at Cotton Research Area, CCS HAU, Hisar during *kharif* 2015-16. The considerable genetic differences among genotypes for various traits were evident in view of highly significant varietal differences in the analysis of variance in the three environments. Coefficient of variation was low for almost all traits in all the environments, which indicated precision of the experiments conducted. The value of phenotypic coefficient of variation (PCV) is greater than genotypic coefficient of variation (GCV); it means that the apparent variation is not only due to genotypes but also due to influence of environment. GCV was the highest for number of monopods per plant whereas the lowest for number of sympods per plant and also for ginning out turn. Among the characters studied the highest estimate of heritability was recorded for lint yield per plant (92.30%) but sympods per plant showed lowest heritability with 5.39%. High heritability estimates coupled with high genetic advance were recorded for seed cotton yield per plant.

1.19
Significance of biochemical components in *desi* cotton (*Gossypium arboreum* L.)

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Gossypium arboreum is a native plant of India. It is important commercial and natural fibre crop of

global importance and commonly called **'White Gold'**. Gossypol is an important part of defending against plant insects and diseases in cotton crop. Number of gossypol glands varies with the genotypes but is very low in some genotype. Gossypol is a polyphenolic compound which is an integral part of the cotton plants. Gossypol also have antitumor activity, medicinal effects and contraceptive properties. Gossypol compound can be toxic to animals that's why we don't able to use it as animal feed in excess. It also has a detrimental effect on humans as well as other monogastric animals. The seed contains 23 per cent high quality protein but it is not commonly used because of gossypol toxicity. There are many ways to reduce seed gossypol which including mechanical processes to remove gossypol from cottonseed products but these treatments add cost to the products and reduce nutritional value. Cotton seed oil is also used for human consumption. Cotton seed oil is extracted from kernel of cottonseed. Cottonseed oil have high level of antioxidants – tocopherols, linoleic acid and cholesterol free. Conclusively, biochemical components of cotton crop play crucial role for use as food and feed.

1.20
Heterosis studies for yield, yield contributing and fibre quality traits in *desi* cotton (*Gossypium arboreum* L.)

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Cotton crop is mainly cultivated for its fibre and hence yield and quality of lint are equally important in cotton. Cotton crop is highly amenable to both heterosis and recombination breeding as it is often cross pollinated. In present investigation four lines were crossed with six testers to obtain 24 hybrids in Line x Tester design. Data were recorded on 18 yield, yield contributing and fibre quality traits. Estimation of heterosis was done over mid parent, better parent and three standard checks viz., PKVDH 1, PKV Suvarna and NACH 12.

Analysis of variance for means revealed significant differences for all the characters studied. The magnitude of heterosis and heterobeltosis for all the characters in the present study was highly appreciable. Among all the characters, the magnitude of mid parent heterosis was highest for seed cotton yield per plant to the extent of 42.85 per cent in cross PA 734 x ARBAS 1301.Better parent heterosis was highest for number of sympodia per plant to the extent of 39.47 per cent in the cross PA 809 × JLA 0614. Whereas , standard heterosis was highest for number of sympodia per plant to

the extent of 55.56, 47.37 and 43.94 per cent respectively in cross PA 734 × CNA 1016 over standard check PKVDH 1, PKV Suvarna and NACH 12. It was followed by seed cotton yield per plant (48.77 %, 47.44 % and 33.49 %) in the cross PA 734 x ARBAS 1301 over standard check PKVDH 1, PKV Suvarna and NACH 12 respectively. For number of bolls per plant,the range of heterosis over the standard checks PKVDH 1, PKV Suvarna and NACH 12 were from -1.85 to 25.93, -10.71 to 21.43 and 0.00 to 36.00 per cent, respectively. Three, three and nine crosses each were positive significantly superior over check PKVDH 1, PKV Suvarna and NACH 12, respectively. For harvest index, all crosses showed significant positive heterosis over check PKV Suvarna and NACH 12. The cross PA 734 x ARBAS 1301 showed the highest positive significant heterosis over all the checks.

Among all the fibre quality characters, the magnitude of standard heterosis for 2.5 % span length over PKV Suvarna was high in the cross combinations PA 809 X ARBAS 1301 (23.75) and PA 809 X JLA 0614 (21.07). In case of micronaire the magnitude of standard heterosis over PKV Suvarna was found significant in the cross combinations was PA 809 X ARBAS 1301 (-21.82) and PA 809 X JLA 0614 (-16.36). The high magnitude of standard heterosis for fibre strength over NACH 12 was recorded in the cross combinations PA 809 X ARBAS 1301 (21.54) and PA 809 X AKA 2004-29 (16.67). The cross combinations PA 734 X AKA 2004-29 (9.56) and PAIG 77 X AKA 2004-29 (8.80) displayed highly significant standard heterosis over PKVDH 1 for ginning out turn respectively.

The hybrids PAIG 77 x ARBAS 1301, PA 741 x ARBAS 1301, PA 809 x ARBAS 1301, PA 734 x ARBAS 1301 and PA 809 x CNA 1016 were found most heterotic for seed cotton yield per plant and yield contributing characters. The hybrids PA 809 x ARBAS 1301, PA 734 x AKA 2004-29 and PA 809x AKA 2004-29 were found most heterotic for fibre quality traits. On the basis of this study it is concluded that the crosses having highly significant standard heterosis can be exploited for heterosis and heterosis breeding would be rewarding with further testing of these crosses for many seasons at multilocations.

1.21
Screening of American cotton (*Gossypium hirsutum* L.) germplasm lines for pre-breeding

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Cotton is one of the major cash crop of India and generally known as *"White Gold"*. It is a major agricultural commodity and contributes significantly in the Indian economy as well as of farmers.

The role of germplasm in the improvement of cultivated plants has been well recognised by the breeders. Plant genetic resources are reservoirs of genes and genotypes provide the raw material for present and future crop breeding programmes. Natural genetic variability has been exploited from the beginning of agriculture within crop species to meet subsistence food requirement of the country. Until a collection has been properly evaluated and its attributes become known to breeders, it has little practical use. Germplasm evaluation, in the broad sense and in the context of genetic resources, is the description of the material in a collection. 'Pre breeding" also known as developmental breeding or germplasm enhancement is the early phase of any breeding programme utilising germplasm. Keeping in the view of importance of the germplasm, screening of germplasm is very important aspect in any breeding programme. Fifty one germplasm lines were received from CICR, Nagpur. These lines were grown during current year 2017 and screened for some quantitative characters, white fly population and cotton leaf curl disease. The range of the plant height ranged from 67.5 to 182.5 cm. Tallest germplasm line was GCA-N 11 whereas smallest was GCA-N 28. Range for number of bolls per plant was recorded from 6.5 (GCA-N 47) to 57.5 (GCA-N 4). Maximum boll weight was observed in germplasm line GCA-N 44 (3.2 g) followed by and GCA-N 6 and GCA-N 13 (3.1 g each). Maximum plant yield per plant was recorded in germplasm line GCA-N 40 (112 g per plant) followed by GCA-N 13 (102 g per plant).

The all germplasm lines were evaluated against the whitefly by using leaf turn method and cotton leaf curl disease (CLCuD) by counting healthy and virus effected plant/plot. Germplasm lines GCA-N 1, GCA-N 2, GCA-N 3, GCA-N 4, GCA-N 13, GCA-N 23 and GCA-N 50 were found below ET (economic thresh hold level) at first observation and in second observation all the germplasm lines were above ET level. Germplasm lines GCA-N-1 (8.6 adults/leaf) and GCA-N-2 (8.9 adults/leaf) had minimum whitefly population. CLCuD occurred in all the cotton genotypes and the moderately resistant disease reaction was observed in GCA-N 45 line while other showed moderately susceptible and susceptible disease reaction. These screened germplasm lines with desirable characters can be utilized in pre breeding programme for genetic improvement of cotton.

1.22
Characterization of germplasm for cotton improvement

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Cotton generally known as "white gold" is a major cash crop of India. There are four cultivated species of *Gossypium* Linn., grown for their fibre, seed and its by-products. Assessment of the genetic

diversity of cotton cultivars is essential for breeding strategies, such as the characterization of individuals, accessions, and for the choice of parental genotypes in breeding programme. Allelic diversity naturally present in the germplasm pool and characterization of the allelic diversity determines the genetic diversity present in the germplasm pool. This forms the basis for continuous evolution. Genetic diversity and the knowledge on relationship between genotypes are of great importance for crop breeding. From a practical crop breeding perspective, understanding the genetic variability will serve as a guide to choosing the parents from a larger pool of germplasm. Crossing individuals that are genetically distant can result in developing superior hybrids with higher heterotic potential resulting in higher yields. For any meaningful plant-breeding programme, accurate determination of genetic diversity is an essential step for an effective utilization of germplasm resources. An accurate estimation of genetic diversity can be invaluable in the selection of diverse parental combinations to generate progenies with maximum genetic variability and heterosis. So, the characterization of cultivars becomes essential to maintain identity of released and notified varieties and the parental lines of hybrids. The present study was undertaken for phenotypic characterization of 30 cultivars of cotton. The experimental material for the present investigation was sown in the research area of the Cotton Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. Morphological characters namely flower petal colour, pollen colour, boll shape, leaf hairiness, plant growth habit, tip of the boll and position of stigma proved to be useful and stable as diagnostic traits to classify the genotypes based on the phenotypic traits. Variation was observed among for all the characters among genotypes and their hybrids except for the leaf nectaries, gossypol glands, growth habit, filament colouration, petal spot, boll bearing habit and boll surface.

1.23
Study of heterosis for seed cotton yield, yield contributing and fibre quality traits in *desi* cotton (*Gossypium arboreum* L.)

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ABSTRACT : Cotton crop is mainly cultivated for its fibre and hence yield and quality of lint are equally important in cotton. Cotton crop is highly amenable to both heterosis and recombination breeding as it is often cross pollinated. In present investigation four lines were crossed with six testers to obtain 24 hybrids in line x tester design. The crosses and parents with three checks, were evaluated in a randomized block design with three replications during *kharif* 2015 at Cotton

Research Station, Mahboob Baugh Farm, Vasantrao Naik Marathwada Krishi Vidyapeth, Parbhani. Data were recorded on yield,yield contributing and fibre quality traits. Analysis of variance for means revealed significant differences for all the characters studied. The magnitude of standard/economic heterosis for all the characters in the present study were highly appreciable. Among all the characters, the magnitude of heterosis was highest for number of sympodia per plant measuring to the extent of 55.56, 47.37 and 43.59 per cent over standard check PKVDH 1, PKV Suvarna and NACH 12 in the cross PA 734 x CNA 1016. It was followed by seed cotton yield/plant (48.77 , 47.44 and 33.49 %) in the cross PA 734 x ARBAS 1301 over standard check PKVDH 1, PKV Suvarna and NACH 12, respectively.

Among all the fibre quality characters, the magnitude of standard heterosis for 2.5 per cent span length over PKV Suvarna was high in the cross combinations PA 809 x ARBAS 1301 (23.75) and PA 809 x JLA 0614 (21.07). In case of micronaire the magnitude of standard heterosis over PKV Suvarna was found significant in the cross combinations was PA 809 x ARBAS 1301 (-21.82) and PA 809 x JLA 0614 (-16.36). The high magnitude of standard heterosis for fibre strength over NACH 12 was recorded in the cross combinations PA 809 X ARBAS 1301 (21.54) and PA 809 x AKA 2004-29 (16.67).

1.24
Combining ability studies in cotton (*Gossypium barbadense* L.)

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Twenty eight hybrids and eight genotypes along with commercial check, Suvin were sown during *kharif* 2014 at Main Agricultural Research Station, Raichur in a randomized block design with two replications. The detailed objectives included identification of superior parental combinations with high GCA and to understand the nature of gene action governing seed cotton yield, yield attributing and fibre quality traits, association and path co efficient analysis. The study revealed that traits like ginning outturn, seed index, lint index, plant height, sympodia/plant, monopodia/plant, sympodial length at 50 per cent plant height, micronaire and fibre strength are governed by additive gene action and other traits like seed cotton yield, lint yield, boll weight and uniformity ratio are governed by non additive gene action. GSB 40 and TCB 37 were found to be good general combiners the former for seed cotton yield, lint yield, plant height, ginning outturn, sympodia/plant, monopodia/plant and sympodial length at 50 per cent plant height and latter for fibre strength, micronaire and uniformity ratio.

Association analysis across the hybrids revealed highly significant positive correlation for seed

cotton yield with boll weight, ginning outturn, sympodia/plant, monopodia/plant, lint yield and uniformity ratio. The trait showed negative correlation with 2.5 per cent span length at both phenotypic and genotypic levels. Path analysis revealed high positive direct effect on seed cotton yield/ha through lint yield, boll weight, sympodial length at 50 per cent plant height, uniformity ratio and micronaire whereas, other traits showed low direct effects. Highly negative direct effect on seed cotton yield was observed for seed index, lint index, plant height and fiber strength and other traits showed negligible negative effect at both phenotypic and genotypic levels.

1.25

Variability studies for yield and other attributing traits in cotton (*Gossypium hirsutum*.L)

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Sixty eight genotypes including both compact and robust plant types were evaluated for nineteen characters during *kharif, 2015* at Raichur. High variability, heritability and GAM was observed for monopodia/plant, sympodia/plant, bolls/plant, seed cotton yield/ha and the same for plant yield. Among the nineteen characters studied, all the characters except upper half mean length, lint index, micronaire value and fibre strength exhibited highly significant mean sum of squares for genotype suggesting a high degree of genetic variability among the genotypes. Seed cotton yield/ha registered a wide range of 1855 - 4968 kg/ha with a mean value of 2799 kg/ha. The genotype Rahc 1022 recorded the highest mean value for seed cotton yield followed by Rahc 1028 and Rahc 1063 (4390 kg/ha). The heritability estimates indicated high heritability of seed cotton yield under the given environment. The GAM was also found to be on the higher side. GAM together with heritability estimates gives a relatively better picture of the amount of advance to be expected through selection. Among the fiber quality traits micronaire value showed least variability whereas, upper half mean length, uniformity index and fibre strength registered considerable variability. Moreover GCV, PCV, heritability and GAM values were on the lower side for all the four fibre quality traits.

1.26
Performance of *Bt* cotton hybrids under northern transition zone of Karnataka

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Forty two *Bt* cotton hybrids were evaluated for their performance under northern transition zone of Karnataka. Based on the crop duration, hybrids were grouped as early, medium and late duration *Bt* hybrids. Differential yield was recorded among the *Bt* hybrids. Malini (34.54 q/ha) recorded significantly higher seed cotton yield which was on par with Jadoo (33.54 q/ha), RCH- 668 (33.19 q/ha), Deltapine 9121 (32.63 q/ha), Ajeet- 177 (32.15 q/ha) and Ajeet -199 (29.17 q/ha). Lowest yield was recorded with Trinetra (19.35 q/ha). Significantly higher monopodial branches plant^{-1} (4.5) was recorded with Malini *Bt* cotton hybrid. However, it was *on par* with Deltapine, Airavat, Shalimar, Money, Ajeeth 155, Ajeeth 177, ATM, First class and RCH 668. The Nawab *Bt* cotton hybrid recorded significantly lower (2.00) monopodial branches/plant. Deltapine, Malini and Mahalaxmi recorded higher number of sympodial branches at 120 DAS. However, it was on par with RCH 668 (43.50) First class (43.5), ATM, Ajeeth 177 and Money (43), respectively and all were *on par* with each other. The Magic *Bt* cotton hybrid recorded significantly lower number of sympodial branches/plant (26.5). NDVI and SPAD reading recorded at peak growth stage indicated significantly higher correlation with the high yielding *Bt* cotton hybrids.

1.27
Evaluation of genetic diversity and interrelationships of agro morphological characters in flax genotypes

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In Meghalaya the agriculture is mainly focussed on cultivation of rice and maize as the major crops during kharif season and leaving the land fallow during the Rabi season. To increase the

cropping intensity in these fallow lands, crop such as flax, which is suited well under rain-fed condition will be quite useful. Keeping this in view, the present study was conducted to assess the genetic variability in flax and select the suitable genotypes for the conditions of Meghalaya. Twenty-one Flax genotypes were evaluated for agro-morphological traits and genetic parameters. Correlation and path coefficients were estimated for all these traits. Analysis of variance and mean performance for yield and its components revealed significant differences among all the genotypes for all the characters. The correlation studies indicated the significant association of yield with its component traits. A path analysis indicated that numbers of seed per capsule had the highest effect on yield. A Cluster diagram based on agro-morphological traits proposed two major clusters. In the present experiment, the data revealed that first three principal components having greater than one eigenvalue contributed 82.6 % of the total variation among forty genotypes of soybean. The traits, which contributed most positively to PC1 were seed yield (0.522), number of seeds per capsule (0.508) and number of capsules per plant (0.464) and filled pod per plant (0.411). Days to 50% flowering (0.687) and days to maturity (0.660) contributed most positively to PC2. Bud fly infestation was also recorded and in twelve genotypes infestation was found to be very low. In regression analysis, 51% of the variability of the dependent variable Seed yield (kg/ha) is explained by the Bud fly infestation. Entry number 160101 and 160103 were found to be promising for mid altitudes of Meghalaya and may be used as dual purpose i.e. for fibre and oil. Being short duration and high yielding linseed genotype 160121 will be promising as a catch crop in fallow areas.

1.28

Gossypium armourianum: A potential source of resistance to cotton leaf curl disease

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Cotton (*Gossypium* spp.), the king of fibre, is one of the most important commercial crop having profound influence on economics and social status of the country. Cotton leaf curl disease (CLCuD) caused by Gemini virus and transmitted through whitefly (*Bemisia tabaci*) is one of the major limiting factors responsible for low production and productivity of American cotton (*G. hirsutum*) during the last one and a half decade. The disease has assumed serious proportions in the most potential irrigated cotton belt of north India especially in Punjab. The management of CLCuD has been a

challenging task, therefore, to ensure its future production in a sustainable manner, efforts need to be taken to develop resistant varieties/hybrids, which is the only reliable and cheaper method of CLCuD management. As there is no resistance source available against this virus within *Gossypium hirsutum* species. Majority of Bt-hybrids being cultivated in northern India are susceptible to CLCuD. Recently, a new source of CLCuD resistance i.e. *Gossypium armourianum* has been identified. *G. armourianum* ($2n=2x=26$, DD) is related non-progenitor diploid wild cotton species, having desirable genes which conferring resistance toward CLCuD. An attempt has been made to explore the possibility of successfully transferring the CLCuD resistant feature of *G. armourianum* into the cultivated *G. hirsutum* genotypes through backcrossing. The investigation revealed that a few viable seeds of the crosses between *G. hirsutum* and wild diploid species *G. armourianum* were obtained using *G. hirsutum* as female. F_1 progenies between *G. hirsutum* x *G. armourianum* did not show any symptoms and behave as resistant toward CLCuD. Backcross progenies of *G. hirsutum* x *G. armourianum* cross have been developed and resistance to CLCuD is being transferred. Hence, *G. armourianum* species with D genome can be used successfully as potential source of resistance to CLCuD for develop of resistant varieties and hybrids.

1.29
Biochemical changes in different pick American cotton varieties during storage

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Seeds are highly susceptible to damage and mechanical injury during post-harvest handling. Seed quality depends upon initial seed quality, temperature, moisture content and mycoflora. Seed quality and viability during storage depends upon the initial quality of seed and the manner in which it is stored. Seed deterioration is associated with various cellular, metabolic and chemical alterations including lipid peroxidation, membrane disruption, DNA damage, impairment of RNA and protein synthesis and causes several detrimental effects on seed. The present study was carried out to find out the mechanism of seed deterioration in three American cotton (*Gossypium hirsutum* L.) varieties (H-1098 (I), H- 1117 and H-1236). Cotton bolls were picked at three different intervals starting from 50 per cent boll opening after delinting seeds were stored at 19^0 C with 6 per cent moisture content. Seed quality and antioxidant enzyme were studied after storage of 5, 10 and 15 months in all collected seed samples. In all varieties germination found decreasing during storage, whereas membrane deterioration, as assayed by electrical conductivity of the seed leachates, increased progressively with artificial ageing. There was decrease in antioxidant enzymes peroxidase, catalase, superoxide dismutase and dehydrogenase as ageing increased in seeds. The study suggests that cotton seed deteriorates during storage and it is closely related to a decrease in activities of various scavenging enzymes but maximum decrease found in antioxidant enzyme activity was found in seed sample collected at third picking .

CROP PRODUCTION AND MECHANIZATION

2.1
Effects of 2,3,5-Triiodobenzoic Acid (TIBA) on growth and seed cotton (*G. hirsutum* L.) yield of *Bt* cotton hybrid

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A field experiment was conducted at the Cotton Research Station, Junagadh Agricultural University, Junagadh during *Kharif* 2014-2015. G.Cot. Hy-6 BG-II was sown on medium black soil with a spacing of 120 X 45 cm in a RBD with three replications. The experiment consisted of total eleven (11) treatments. Five plants from each treatment were selected randomly and tagged for recording various observations on morphological, growth, physiological parameters and yield components at periodically and at harvest. Foliar application TIBA were found significantly decreased plant height in all the treatments than control and significantly increased in the sympodial length, number of sympodia, bolls/plant and chlorophyll content in the treatments $T_{2,}$ $T_{4,}$ $T_{6,}$ and T_8 than control *i.e.* T_{10}. Crop maturity and 50% bolls opening were found one week early significant in treatments $T_{2,}$ $T_{4,}$ $T_{6,}$ and T_8 over to control. SLW was significantly decreased at 150 DAS in the treatment$T_{2,}$ $T_{4,}$ $T_{6,}$ and T_8 due to transport of photosynthate towards the boll development. Total no of boll (59) and seed cotton yield (3645 kg/ha) were recorded significantly highest at harvest in T_2 (Foliar spray of TIBA @ 5g/ha(10 ppm) at 50, 60, 70, 80 and 90 DAS) as compared to control (3034 kg/ha) *i.e.* T_{10} and it was *at par* with treatments T_4(3642 kg/ha), T_6(3637 kg/ha), and T_8(3643 kg/ha) . The yield increment due TIBA application was 10 to 20 per cent as compared to control.

2.2
Importance of drip irrigation and feritigation in cotton production

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Cotton is an important cash crop of our country as well as Haryana state. Economy of country as well as financial health of farmers depends on crop productivity. In Haryana 84 % of cultivated area is irrigated out of which 62 % area of the state is underlain with poor quality of water. Water is a precious natural resource, so there is need for irrigation and site specific nutrient management.

Irrigation via drip is one of the best methods where WUE is maximum as compare to other irrigation methods. The net utilizations of irrigation water in drip system are 90 % and through the sprinkler system it is 82 %. Micro-irrigation system has many advantages like low water application rate, uniformity of water application around the plant, precision placement of water, efficient fertilizer and chemical application, better control of root zone emergence, significant yield enhancement, low weed infestation and many more. In Haryana, very less area is under drip irrigation in cotton as their is no scheduling and quantification of irrigation and fertigation. Therefore, the efforts are being carried out to quantify the fertigation doses in PFDC. Experiment includes two genotypes viz Desi cotton and Bt cotton having four treatments (100% RDF,75% RDF, 50% RDF and conventional method with RDF in RBD with four replications. 10% of fertilizers will be applied at the time of sowing through basal application and remaining will be applied in equal splits through fertigation between 30 to 120 days at six days intervals. The vegetative and yield parameters are recorded and analysis is in progress.

2.3

Relationship between pest infection and antioxidative metabolites in cotton (*Gossypium hirsutum* L.) genotypes resistant and susceptible to sucking pest attack

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Cotton which belongs to the genus *Gossypium* and family Malvaceae, is commonly known as “White Gold”. It is the principal commercial and cash crop of India since time immemorial. Biotic constraints are of the major factors responsible for low yield of cotton. The ravages caused by insect pest assume greater importance. The non enzymatic antioxidants like ascorbate and glutathione (GSH), tocopherols, flavoniods, alkaloids and carotenoids form the main components of cellular redox buffers. In the present study ascorbate and â-carotene content were estimated in the leaves (2^{nd} and 6^{th}) of cotton genotypes infected by sucking pests at 50, 60 and 68 days after sowing (DAS) stage. The ascorbate and â carotene content before infection was maximum in 2^{nd} and 6^{th} leaves of *G. arboreum* genotypes followed by *G. hirsutum* resistant genotypes and minimum in *G. hirsutum* susceptible genotypes. After infection the ascorbate and â carotene content increased in all the genotypes in both the leaves.

2.4

Developing suitable agronomic methods for *Bt* hybrids under rainfed conditions of scarce rainfall zone of Andhra Pradesh

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An experiment was conducted at Regional Agricultural Research Station, Nandyal during *kharif* season of 2016-17 to develop suitable agronomic methods for Bt hybrids under rainfed conditions to get higher yields. The field experiment was laid out in a randomized block design with four replications with Bhakti BG-II hybrid. The experiment consisted of 6 treatments they are T_1: *Bt* hybrid with 90 x 60 cm spacing, $T_{2:}$ T_1 + closer spacing (25% less than recommended *i.e.* 90 x 45 cm), T_3: T_2+ (125%) recommended nutrients (150-75-75 NPK kg/ha), T_4: T_3+ recommended foliar spray (Urea@ 2% at flowering and boll development stages), T_5: T_4+ micro nutrients ($Znso_4$ @ 20kg/acre), T_6: T_5+ location specific measures for control of reddening ($Mgso_4$ @ 1% twice at 45,75 DAS) . An amount of 809.6 mm rainfall was received in 39 rainy days during the crop period. The results revealed that T_6 *i.e.* Bhakti BG II hybrid sown at spacing of 90 x 45 cm with application of (125 %) recommended nutrients with soil application of micro nutrient and recommended foliar sprays and location specific measures for control of reddening treatment recorded higher plant height (126.3 cm), number of sympodia(23.2), bolls/m^2 (84.5), boll weight (5.25g) and seed cotton yield (3595 kg/ha) compared to other treatments. Lowest plant height(97.8 cm), number of sympodia(14.0), bolls/m^2(40.3), boll weight (4.10g) and Seed cotton yield (1982 kg/ha) were recorded with T_1 *i.e. Bt* hybrid with 90 x 60 cm treatment.

2.5

Leaf trichome density analysis through scanning electron microscope underlines resistance to herbivorus insects in cotton

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Leaf trichome density is considered as a mechanism of defense in plants to prevent or diminish

damage by herbivores. This study assessed the role of trichome density as a component of resistance to herbivores in six species of cotton. In all the six species of *Gossypium*, the trichome density *vis-à-vis* the pest population was compared. Among the species, differences in leaf trichome density, relative resistance and fitness were observed. Leaf trichome density is found to be positively correlated with resistance to herbivores across the species. Trichome density hinders the settlement of insect herbivores. However, it may also affect the abundance and effectiveness of predators and parasitoids feeding on herbivorus insects. This study revealed the adaptive role of leaf trichome density as a component of defense to herbivores and it also varied among different species. *Gossypium triphyllum* species was found to have more number of trichomes (120 Nos./400µm) while the least was observed in *G. hirusutum* (var.CO14; (6 Nos./400µm)).

2.6
Organic cotton production under winter irrigated situation

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Cotton, being a long-duration crop, with more vegetation and high boll load is quite vulnerable to many biotic stresses. Cotton becomes a major consumer of 20-23 per cent of nutrient and hormone chemicals and 55 per cent of the pesticide chemicals produced in our country. Out of the total agro-chemicals that are applied in cotton crop, 75 per cent is used at peak boll development stage. The highly skewed pattern of pesticide use in relation to the crop area has caused many problems to the agro-ecosystem, *viz.,* development of resistance to pesticides, resurgence of newer pests, and elimination of natural enemies, environmental pollution and health hazards to the villagers. Organic farming reduced the chemical inputs and increased the use of organic manure, leading to optimization of resources to develop a sustainable farming. A field experiment was conducted to study the effect of combinations of seed treatment, neem cake application and intercropping on growth and yield of cotton. The treatment combinations included were *viz.***,** bio fertilisers (azospirillum and phosphobacteia - seed treatment @ 600 g / ha each and soil application @ 2 kg/ha each), *neem* cake application @ 250 kg/ha, raising of *sunnhemp* between rows and incorporated before flowering and foliar application of PPFM. Experimental results suggested that application of biofertilisers (*Azospirillum* and phosphobacteia - seed treatment @ 600 g / ha each and soil application @ 2 kg/ha each), *neem* cake application @ 250 kg/ha, raising of *sunnhemp* between rows and incorporated before flowering and foliar application of PPFM recorded a seed cotton yield of 798 kg/ha. Recommended dose of inorganic fertilizer recorded a seed cotton yield of 1314 kg/ha. There had been a reduction of 39 %

per cent yield in organic farming compared to the application of is organic inputs but on long run, cotton farming through organic mode can yield equivalently to that of inorganic practices.

2.7
Evaluation of agronomic requirements of newly released cotton hybrids in south western region of Punjab

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As the cotton hybrids vary with their growth habit, there was a need to work out agronomic requirement of newly released cotton hybrids. Thus, a field experiment was conducted during *kharif* 2015 at Punjab Agricultural University, Regional Research Station, Bathinda to evaluate the performance of three American cotton hybrids (FHH 209, HSHH 31 and LHH 144 (local check)) in main plot; two spacing levels (67.5 × 75 cm and 67.5 × 90 cm) in sub plot and three nitrogen levels (75%, 100% and 125 % of recommended dose of nitrogen (RDN)) in the sub sub plots. Hybrid FHH 209 produced significantly higher sympods/plant and bolls/unit area which contributed to significantly highest seed cotton yield as compared to hybrid HSHH 31 and local check hybrid LHH 144. Significantly higher net returns and B:C ratio were also recorded from FHH 209. Among the different spacing levels, higher plant stand as well as higher bolls/unit area under recommended spacing of 67.5 × 75 cm, resulted in significantly higher seed cotton yield, net returns and B:C ratio as compared to 67.5 × 90 cm. Application of 125 per cent RDN resulted in highest growth and yield attributes, seed cotton yield, net returns and B:C ratio; which were *at par* with under 100 per cent RDN. While, statistically least growth and yield attributes, seed cotton yield, net returns and B:C ratio was recorded under 75 per cent RDN. Thus it was concluded that cotton hybrid FHH 209 perform significantly better for seed cotton yield and give higher monitory returns over hybrid HSHH31 and check LHH144 under recommended planting geometry (67.5 × 75 cm) and recommended level of nitrogen (100% RDN: 150 kg N/ha).

2.8

Cotton production in Meghalaya: Growth performance and decomposition analysis

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The present study assess the contribution of area, yield and their interaction effect to growth in production of cotton and compound annual growth rate in area production and yield of cotton in Meghalaya. The Time series data on area, production and yield of cotton for the period were collected from Secondary sources like Directorate of Agriculture, Shillong and Directorate of Agriculture, Shillong Meghalaya. Decomposition model proposed by Sharma (1977) was used to examine the contribution of area, average yield and their interaction effect on cotton production. The compound annual growth rate of area, production and yield were worked out using the formula recommended by Dandekar (1980). The study found that over the year from 2003 to 2016, yield effect has the highest contribution (94.48 %) to change in the production of cotton followed by area effect (4.11%) in Meghalaya. In the Meghalaya both production and yield of cotton was increased at the compound annual growth rate of nearly 0.52 and 1.97 per cent/annum respectively, while the growth rate in case of cotton area was 0.08 per cent/annum during the 2003 to 2016 in the Meghalaya.

2.9

Role of callose against cotton leaf curl virus disease in upland cotton (*Gossypium hirsutum* L.)

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Plants are easily targeted for biotic stress being sensible organisms. They have evolved different route to deal the biotic stress. The route of defense may be constitutive or induced in response to

stress. However, both of these routes play an important role against the disease to be occurring. In present study, we have investigated the role of callose and â-1, 3 glucanase in transmission/spreading of cotton leaf curl virus (CLCuV) in moderately tolerant and susceptible genotypes. The leaves were harvested at 0, 15 and 30 days after inoculation. The callose, H_2O_2 and â-1, 3 glucanase activity, polyphenol oxidase estimated by their standard methods. The total phenolic compound, H_2O_2, callose are more in tolerant genotypes whereas, â-1, 3 glucanase was more in susceptible genotype whereas â-1, 3 glucanase was more in susceptible genotype. The lower activities of â-1, 3 glucanase in moderately tolerant genotype speculate the deposition of callose in leaf tissue and accumulation of phenolic compound with a class of PR proteins may provide the better defence system against the CLCuD.

2.10
Evaluation of mesta biomass for bioethanol production potential

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Increase in world's energy demand and the progressive depletion of oil reserves motivate the search for alternative energy resources, especially using those derived from renewable materials such as lignocellulosic biomass. Many studies have been undertaken throughout the world to explore rice straw, sugarcane bagasse, or corn cob as raw material for ethanol production, but fibre crops are yet to be explored. Mesta crop is grown in the drier tracts of India, which can adapt to a wide range of climatic conditions. The compositional analysis of two species of mesta namely, Hibiscus sabdariffa and H. cannabinus were carried out which revealed that mesta contains higher percentage of cellulose (57.0 ± 3.0%) as compared to other types of biomass. Pretreatment process was optimized for lignin removal using various physical and physio-chemical methods. Among them, 2% alkali (cold) treatment showed maximum increase in cellulose content (82.60 ± 0.45%). Optimization of saccharification process for the 2 per cent alkali (cold) pretreated mesta biomass was carried out using Box Behnken design. Based on the observations, optimized conditions were set with 4.02 per cent substrate loading, 15.02 FPU/ml of cellulase from psychrotolerant *Aspergillus niger* SH3 and 5.01 IU/gds of â-glucosidase from *Pseudomonas lutea* BG8, which led to a sugar release of 21.33 g/L at 40°C within 24 h of saccharification. Simultaneous saccharification and fermentation (SSF) was carried out using efficient thermotolerant yeast strain *Saccharomyces cerevisiae* LN. After 48 h of fermentation, the ethanol yield obtained was 4.1 g/L with a fermentation efficiency of 53.45 per cent. It can be concluded that mesta crop can be a good biomass source for bioethanol production; ethanol yield can be further

improved by use of accessory enzymes. Since, SSF was carried out at 40ºC, which is 10ºC lesser as compared to that used for commercial enzymes; the optimized process from the present investigation, may result in tremendous energy savings, using a novel substrate such as mesta.

2.11
Constraints in cotton production in the cotton growing states of India

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Cotton is the most important cash crop of the country. In India cotton is known as white gold. Most of the cotton area in country covered by bt cotton. It is growing in India since ancient time. In India all the cotton species are under cultivation such American cotton (*Gossypium hirsutum* and *S. barbadense*) and *desi* cotton (*G. arborium* and *G. herbacium*) species. The production of Cotton is very wise across the country. The introduction of new production technology will help in increase in the production as well as in the productivity of the cotton. The cotton is growing in all the parts of country in different seasons due to wider climatic adaptability and suitability. Since independence the country has transformed from being a net importer of raw cotton into self sufficiency and even a marginal exporter of raw cotton. Besides, cotton yarn, fabric and garment exports add immensely to the nation's foreign exchange. Now a days, production of cotton in different parts becoming somewhat difficult due to climate change, degradation of natural resources and productivity factors are also declining. The major constraints in the production of cotton can be bio physical or socio-economic and at field (micro) level and community (macro) level. The production potential and constraints are unique to the regions and systems of cultivation.

2.12

Effect of different levels of nitrogen fertilizer and weather parameters on the incidence of thrips (*Thrips tabaci* Lind.) in *Bt*, non *Bt* and *desi* cotton cultivars

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The effect of different nitrogen fertilizer levels on the incidence of thrips (*Thrips tabaci* Lind.) in six *Bt* cotton cultivars, namely Ankur 3028, NCS 855, RCH 776, RCH 650, RCH 773, Bioseed 6588 and one each of American cotton LH2108 and *desi* cotton cultivar FDK 124 were conducted in Entomological Research Farm, Department of Entomology, PAU, Ludhiana during 2014 and 2015. The incidences of thrips were higher during 2015 than 2014. During both years, significantly higher incidence of thrips was recorded at higher dose of nitrogen (130 Kg/acre) as compared to lower doses (65 and 100 Kg/acre). Among different cultivars, thrips was significantly higher on *Bt* cotton cultivars as compared to non-*Bt* and *desi* cotton cultivar. Thrips population was significantly higher on *Bt* cotton cultivar, Bioseed 6588 (7.47 /3 leaves) during 2014 and Bioseed 6588 (2.47 /3 leaves) during 2015. However, lower population of thrips was recorded on the *desi* cotton cultivar, FDK 124 (0.83 /3leaves) during 2014 and FDK 124 (0.01/ 3 leaves) during 2015. The correlation co-efficient studies with weather parameter revealed that population of thrips showed significant positive correlation with maximum and minimum temperature indicating abundance of insect. However, sunshine hours showed significant negative correlation with thrips. It may be concluded that incidence of thrips increases at higher dose of nitrogeneous fertilizer. *Desi* cotton cultivar FDK 124 has significantly lowest population of thrips over *Bt* and non-*Bt* cotton cultivar.

2.13
Available sources of mechanization for cotton in India- A Review

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India is the third largest producer of cotton in the world. About one third of total crop is irrigated and rest is rainfed. The yield of crop is 307 kg/ha as compared to 783 kg/ha in USA, 659 kg/ha in China and 988 kg/ha in Egypt. Cotton farmers still use traditional farm implements that have low field capacity and demand lot of energy. Several operations like planting, weeding and picking are labour intensive and during these operations shortage of labour frequently occurs. The delay in completion of operations in time leads to loss of yield. Farm mechanization is essentially a judicious mix of resources, implements, machines, and power sources. It involves injecting extra capital into the farming system with a view to increasing labour capacity to do work, defined in terms of quality and quality of output per worker. Mechanization is substituted for hired farm labour, cost savings may be apparent to the employer. The overall objective of this paper is to make aware the farmers with available sources of mechanization in cotton production which improves the competitiveness of Indian cotton producers among the world.

2.14
Effect of phosphorous on yield and it's uptake by cotton

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A field experiment was conducted to study the long term effect of phosphorous on yield attributes and uptake of phosphorous by cotton (G.Cot Hy 12) at main cotton research station, Navsari Agricultural University, Surat. The experiment was conducted with six treatment was conducted with six treatment viz., T1 –No P_2O_5 with FYM @10 t/ha, T2 – 60 kg P_2O_5/ha every year with FYM @10 t/ha, T3 – 60 kg P2O5/ha every alternate year with FYM @10 t/ha, T4 – 60 kg P_2O_5/ha every year without FYM, T5 – 60 kg P_2O_5/ha every alternate year with FYM @10 t/ha, T6 – NO P_2O_5 and No FYM with four

replication in RBD design. The seven year pooled result revealed that phosphorous content in leaf at 60 DAS and 90 DAs was showed non significant uptake of phosphorous due to treatment.
At harvest, phosphorous content in leaf and carpel showed significant deviation. In leaf, T 2 and T 4 showed significantly higher phosphorous content while in carpel, phosphorous content was significant was significantly higher in due to T 2 and T 5. However, phosphorous content in root, stem, lint and seed showed non significant effect due to treatment in pooled.
Phosphorous uptake in root, lint and seed showed non significant effect due to treatment in pooled analysis. However, phosphorous uptake in stem, leaf and carpel showed significant effect due to treatment in pooled analysis. Phosphorous uptake was significantly higher due to T 5 followed by T 1 in stem while it was significantly higher due to T 4 in leaf. In carpel, phosphorous uptake was significantly higher in T 3 followed by T 5. The effect of phosphorous on yield was significant in pooled. The seed cotton yield (gm/plant) was significantly higher due to T 2 which was followed by T 1 and T 5. The available phosphorous (Kg/ha) at harvest was significantly lower in T 6 which was at par with T 3.

2.15
Agronomic evaluation of compact cultures under HDPS with different nutrient levels in cotton

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Cotton continues to be one of the major agricultural commodities in India. Demand for cotton is expected to increase in India and in future there is a clear need to improve the productivity to meet this increasing demand. Increasing productivity is the way to sustain cotton farming in India. Now high density planting system was identified as a driving force for increasing productivity. However to bring high density planting coupled with specific compact cultures, transformation in agronomic practises is prerequisite. In this line field experiment was conducted at Department of cotton, TNAU, Coimbatore during *kharif* season of 2015 to study the effect of plant geometry related high density planting and nutrient levels on the growth parameters and yield of compact cotton cultures under irrigated summer situation. The soil of the experimental field was sandy clay loam with pH 7.6, available N (132 kg/ha), available phosphorus (11 kg/ha) and available potassium (399 kg/ha). The experiment was laid out in split - split plot design with two compact cultures *viz.,* LH 2298 and TCH 1705, three geometry related high density planting *viz.,* 60 x 10 cm, 75 x 10 cm and 90 x 10 cm and

three nutrient levels *viz.,* 80:40:40 kg/ha,100:50:50 kg/ha and 120:60:60 kg/ha. The results revealed that, cultivar -TCH 1705 recorded significantly higher seed cotton yield than LH2298. With respect to variety and spacing, both cultivars TCH 1705 (3226 kg/ha) and LH 2298 (2443 kg/ha), recorded higher seed cotton with 60 x 10 cm spacing and in case of LH 2298 it was comparable with 75 x 10 cm spacing. With respect to variety and fertilizer, TCH 1705 and LH 2298 recorded higher seed cotton yield with 120:60:60 NPK kg/ha. Thus for high density planting in the cultivars TCH 1705 and LH 2298 a spacing of 60 x 10 cm and a nutrient level of 120:60:60 NPK kg/ha are desirable.

2.16

Effect of saferocks minerals in combination with different levels of nutrients on *Bt* cotton hybrid under irrigated condition of south western Punjab

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To evaluate the agronomic superiority of the use of saferock mineral along with normal farming practices, a study was conducted at PAU, Regional Research Station, Bathinda during *Kharif* 2016-2017. There were 9 treatments in randomonized block design (RBD) with 3 replications each evaluated on *Bt* cotton hybrid RCH 650 BG II. The initial soil status and growth as well as yield attributes were recorded. The studied showed that initial soil status was saline *viz.,* pH 8.2 EC=0.21 mmhos, OC % = 0.5, P (kg/ha 13.75 and K (kg/ha) = 286.25. The data of yield characters and auxiliary characters viz. plant height, monopods, sympods, boll weight showed that there is no significant difference in any of the treatment. Similar observations were reported in plant stand and seed cotton yield. The possible reason behind these finding is that this product is especially used for enhance the phosphorus availability to plant, where as in our conditions use of DAP in previous wheat crop fulfill the requirement in cotton season. So from this study it is concluded that 100 per cent NPK dose is sufficient to fulfill the requirement of P to cotton plant and there is no need of any mineral supplement for cotton.

2.17
Effect of plant growth regulators on growth and yield of *Bt* cotton

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Field experiment to study effect of different growth regulators on growth, yield and economics of *Bt* cotton was conducted at Cotton Research Station, Nanded during monsoon 2016-2017 season under rainfed condition. Plant growth retardants (Mepiquat chloride, Cycocel, Ethrel and Maliec hydrazide) and growth promoter (Nitrobenzene) in various number of sprays and at different stages were compared with detopping and water spray. Eleven treatments were tested and analyzed in randomized block design with three replications.

Application of Mepiquat chloride - three sprays (at square formation, flowering & boll formation @ 16.7 g *a.i.*/ha), Mepiquat chloride - two sprays (at square formation & flowering @ 25 g *a.i.*/ha), four sprays of Nitrobenzene @ 2 ml/lit (at 35, 60, 80, 100 DAS) and detopping resulted to increase seed cotton yield over control (water spray). Increase in seed cotton yield by these treatments was to the tune of 14.21, 12.14, 12.10 and 11.12 per cent, respectively. Higher yield plant^{-1} and boll weight were recorded from Mepiquat chloride sprays whereas number of bolls were found to increase in Nitrobenzene application.

Plant height in treatments receiving Mepiquat chloride sprays at square formation and flowering stages was found to be reduced significantly over control. Mepiquat chloride sprays at square formation and flowering stages reduced internodes length, stalk yield and recorded to increase harvest index. Ginning outturn remained statistically unaffected.

Two sprays of Mepiquat chloride (at Square and Flowering), Mepiquat chloride three sprays (at Square, boll and flowering), Nitrobenzene (4 sprays) and detopping were profitable in terms of gross and net monetary returns over control. Highest B:C ratio was received in treatment detopping (2.66) followed by Mepiquat chloride 2 sprays (2.64).

2.18
Status of bio-inoculants on crop growth and yield of cotton

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Mycorrhiza is a shared association between fungi and higher plants. Diverse types of mycorrhizae occur which vary in extent and physiology. Various researchers have reported better soil structure, enhanced uptake of soil nutrients, improved drought tolerance and various other environmental stresses effecting different plant species. The seed cotton yield of cotton plant is largely affected by various biotic and abiotic stresses and there is a vast scope to increase yield of cotton by managing these factors through some growth regulators etc. Nalayini *et al.,* 2010 conducted a field experiment at Coimbatore to study the usefulness of bio inoculants in reducing the inorganic nitrogen and phosphatic fertilizers for cotton. Four bio inoculants viz., *Azospirillum* were combined with phosphorus solubilizing bacteria (PSB)+Pink pigmented facultative methylotrophs (PPFM) along with uninoculated control. In their study they recommended judicious combination of bio-inoculants along with moderate use of chemical fertilizers. Similarly a study on *Bt* cotton was carried on effect of mycorrhizae based bio yield enhancement product at Punjab Agricultural University, Regional Station Bathinda. Eleven treatments comprising seed treatment @5g, 10 g/kg seed and soil drenching treatment @ 250 g/ha/treatment with various NPK combinations were laid in random block design with three replications. Contrasting results were found in the study on *Bt* cotton than other crops. Only the plant height was significantly higher in bio inoculated treatments than control and only 100 % NPK. Seed cotton yield and other yield attributing characters showed non significant results among all the treatments. Owen *et al.*, 2015 also reviewed the use of commercial bio-inoculants to increase plant uptake of phosphorus. They concluded that beneficial attributes of commercial bio-inoculants were unclear however, it could contribute to sustainable food production systems. Therefore, further work on this facet has to be instigated to study the importance of bio-inoculants in growth and yield of cotton.

2.19
Differences in american cotton genotypes for tolerance ability against weeds

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Weeds have been major issue in cotton during early stages of crop growth, cotton being wide row crop. Moreover, if left uncontrolled, weeds can reduce the cotton productivity by more than 35 per cent. In American cotton, yield reduction due to weeds is even more than the yield losses due to insects. A field study was conducted at Punjab Agricultural University Regional Research Station, Abohar, during *kharif* 2016, to evaluate two different American cotton genotypes (F 2228 – a non *Bt* variety and NCS855 BGII a *Bt* hybrid) for their tolerance ability against weeds. These genotypes were sown under weedy and weed free conditions at three plant population levels (1x, 1.5x and 2x normal population). Normal population recommended for optimum cotton productivity is 20,000 plants/ ha. Plant height of cotton was not influenced under weedy situation, although F 2228 had higher plant height than NCS855 BGII. Among yield characteristics, no significant differences were observed for boll weight in all the treatments. Boll number per plant, an important yield attribute, was found to be highest in *Bt* hybrid under weed free conditions. However, under weedy condition, significant reduction of 28.3 per cent was observed in bolls, for this hybrid. While, variety F2228 although produced significantly lesser bolls/plant than *Bt* hybrid, it did not show any significant differences in two different weed scenarios. Irrespective of cotton genotypes, the number of bolls per plant were found to decrease with increase in plant population; this decrease was more prominent in weed free conditions. This showed higher plant population in cotton can provide sustainable yields in weedy conditions. For seed cotton yield, data trends were similar as that of number of bolls produced by two genotypes under different weed scenarios. Highest seed cotton yield was obtained from *Bt* hybrid NCS855BGII, under weed free conditions, which was significantly higher than non- *Bt* variety F2228, however, the differences for yield between two genotypes was not noticed under weedy conditions. This suggested higher tolerance ability of variety F 2228 against weeds in comparison to *Bt* hybrid NCS855 BGII, in terms of sustaining yield levels. Moreover, this study also showed that increasing plant population in cotton can also help in increasing the yield levels under situations where weeds cannot be controlled effectively, although the yield benefit was not observed at dense plant population under weed free conditions.

2.20
Evaluation of *hirsutum* cotton genotypes under different fertilizer levels in high density planting system

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The manipulation of plant density and crop geometry is one of the basic strategies of Agronomy to increase the productivity of crop. Keeping in view a field experiment (*kharif* 2015 and 2016) was conducted to evaluate the *hirsutum* cotton genotypes under different fertilizer levels in high density planting system in semi arid region of north west India. Two promising pre release *hirsutum* genotypes of cotton suitable for HDPS (CS 3075 and H 1465) were taken in main plots. Three plant spacing (67.5 x 15, 67.5 x 20 and 67.5 x 30 cm) were taken in subplots and three fertilizer treatments were designed including 100, 125 and 150 per cent of recommended rates with N (90), P_2O_5 (30) and K_2O (0) kg/ha were taken in sub-sub plots with three replications. The seed cotton yield of CS 3075 was 23.7 and 36.9 per cent higher than H 1465 in both the seasons respectively. Narrow plant spacing (67.5 x 15 and 67.5 x 20 cm) yielded significantly higher seed cotton yield than the third plant spacing (67.5 x 30 cm) during both the crop seasons. Application of 150% RDF yielded significantly higher seed cotton yield during *kharif* 2015 as compared to other two levels of fertilizer whereas during *kharif* 2016 levels of fertilizer did not affect seed cotton yield significantly. Under semi-arid conditions, to achieve higher productivity cotton genotype CS 3075 (*Gossypium hirsutum*) performs better under high density planting system with recommended dose of fertilizer.

2.21
Response of cotton cultivars due to structured water irrigation

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Water flowing from mountains into river is known to be the purest water and is conditioned by the vortexes formed along its path. Structured water devise is said to create similar effect to water. It

breaks up large low energy water molecule clusters into smaller high energy clusters. This gives water a lower surface tension and better hydrating properties. The structured water devise marketed by crystal blue India based at Mysore was used in this study and the bore well water passed through this device is termed as structured water. Field experiment was conducted at Central Institute for Cotton Research, Regional Station, Coimbatore during winter (August – February) season of 2016-2017 cropping season to study the response of cotton cultivars to structured water irrigation. The design used was split plot with four replications. The main plot treatments constituted two irrigation treatments such as structured water irrigation and bore well water irrigation while seven cotton cultivars *viz.,* Suvin, Suraj, Mallika *Bt,* Bunny *Bt*, Surabhi, MCU 5 VT and Anjali were allocated to the sub plot. The soil of the experimental plot was low in available nitrogen, medium in available phosphorus and high in potash. The results of the experiment revealed that the cotton cultivars responded to structured water irrigation as evidenced from 3.87 q/ha of additional seed cotton yield across cultivars due to structured water irrigation which resulted in higher dry matter, nutrient uptake, root cation exchange capacity and boll numbers as compared to bore well irrigated cotton. The available moisture holding capacity on fourth day of irrigation was 27.1 per cent with structured water as compared to 25.6 per cent with bore well water irrigation indicating better hydration due to structured water**.** Hence, it is concluded that the **t**he structured water irrigation is beneficial to cotton cultivars.

2.22
Economics of bed planted transgenic cotton (*Gossypium hirsutum* L.) as influenced by different fertilizer levels

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Cotton 'The King of Apparel Fibers' plays a vital role in the Indian economy as the country's textile industry is predominantly cotton based. A study was conducted during *kharif* 2012 and 2013 at Agronomy Research Area of CCS Haryana Agricultural University, Hisar, Haryana (India) situated at 29°10' N latitude and 75° 46' E longitude at an elevation of 215.2 m above mean sea level to study the response of different fertilizer levels on economics of furrow irrigated raised bed (FIRB) planted transgenic cotton in semi-arid region of north-west India. *Bt* and non *Bt* cotton of same genotypes under two planting methods, *viz.,* FIRB and conventional in main plots and four fertilizer levels, *viz.,* 75, 100, 125 and 150 per cent of recommended dose (RDF) in sub plots were evaluated on the same

field during both the crop seasons. Soil of the experimental field was low in OC (0.54%) and N, medium in available P and high in K, and was slightly alkaline (pH 7.40) in reaction. Based on the research investigation it was found that planting cotton under FIRB achieved significantly higher net benefit and B:C as compared to conventionally grown cotton crop during both the year. Over all bed planting was profitable with reduced cost of cultivation. Non *Bt* hybrid cotton resulted in higher net benefit and B: C than the *Bt* cotton. Among the various fertility levels, application of RDF in transgenic cotton resulted in better economics returns.

2.23

Respose of soluble fertilizer on productivity and profitability of *Bt* cotton based cropping system in semi arid environment

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Cotton-wheat cropping is the second most important cotton based cropping system in the south Asia (4.5 M ha) and India (2.6 M ha) and contributes significantly to the food security in the region. Being a cash and grain cropping system, it is highly remunerative with assured returns. Production of Bt cotton has suffered severely due late planting of cotton in cotton-wheat rotation, severe incidence of sucking pest, occurrence of wilt, flower drop, not/late opening of bolls and abrupt weather conditions resulted yield loss. Thus, there is need to increase its yields through adoption suitable crop production technique like foliar sprays of fertilizers along with other agronomic practices. Cotton plants require a specific amount of certain nutrients in specific format applied at an appropriate time for their growth and development. Now a days, soil application of nutrients (*i.e.* N, P, K and Zn) is found to be very expensive. In addition, the availability of these nutrients will be affected by several environmental factors, that is, antagonism, element deposition, leaching etc. In contrast, foliar feeding technique as a particular way to supply these nutrients could avoid these factors and results in a rapid absorption, which is more effective and less costly. Therefore, for achieving above purpose the FLDs on on foliar spray of potassium nitrate (Three foliar sprays of potassium nitrate @ 1 % starting from flowering at 10 days interval) were conducted on *Bt* cotton hybrids during *kharif* 2013-2015 at 40 locations covering an area of one acre at each location selected from the cluster villages under Krishi Vigyan Kendra, Fatehabad, Haryana. The data on yield and economics of preceding *Bt* cotton crop as well as succeeding wheat crop were analysed during three consecutive years using simple tabular analysis. Results of the trial reveals that pooled average seed cotton yield and wheat

yield was to the tune of 24.58 and 50.65 qtl/ha in demonstration as compare to 22.73 and 45.92 q/ha in local check, which was 8.14 and 10.3 per cent higher that of local check of both the crops, respectively. Return over variable cost was to the tune of 4.6 and 10.9 per cent higher under demonstration over local check during both the years, respectively. Benefit: Cost ratio figured 1.51:1 and 1.17:1 under demonstrations as compared to 1.37:1 and 1.05:1 in local check in both consecutive crops, respectively.

2.24
Manipulation of source sink relation through growth regulators for enhancing productivity of cotton in North-Western India

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Cotton is the immensely crop for the sustainable economy of India and livelihood of the Indian farming community. It is grown 33.0 M hectares across the world and in about 11.0 M hectares in the country. India accounts for about 32% of the global cotton area and contributes to 21% of the global cotton produce. Cotton in India grown in varied soils, climates, and agricultural practices under irrigated and rainfed situation. Approximately 65% of the Indian cotton is produced under rainfed conditions and 35% on irrigated lands. It is cultivated in three distinct agro-ecological zones (North, Central and South) of the country. The Northern zone is almost totally irrigated, while the percentage of irrigation area is much lower in Central (23%) and Southern zone (40%). Cotton in North India is grown in about 1.5 M hectares in three states Punjab, Haryana and Rajasthan. Cotton is the major *Kharif* crop in irrigated North-West plain zone of Rajasthan.

The field experiments were conducted during Kharif 2013, 2014 and 2015 at Agricultural Research Station, Sriganganagar (Rajasthan) to manipulate 'Source-sink' relationships in *Bt*-cotton and non *Bt* cotton, clearly indicate that the combined spray application of Ethereal 45 ppm and Malice hydrezid 750 ppm (T_7) 95 days after sowing recorded significantly higher seed cotton yield (1508.00 kg ha^{-1}) in *Bt* cotton and in non *Bt* cotton seed cotton yield was 1474.71 kg ha^{-1}, over control and rest of the treatments. In both *Bt* cotton and non *Bt* cottonT_7 performed better and total seed cotton yield increased significantly. Similar observations were recorded for bolls number and boll weight per plant. It was concluded that the combined spray application of ethereal 45 ppm and Malice hydrezid 750 ppm after 95 days after sowing was found effective to increase the seed cotton yield in *Bt* and non-cotton.

2.25
Prospects of micro irrigation in production of high quality cotton fibre : A Review

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In our country cotton is one of the most important cash, commercial and fibre crop which also plays a vital role in the textile industry. It finds importance as feed and in oil industries with its seed, rich in both oil (18-24%) and protein (20-40%). Cotton is a kharif crop grown both under rainfed and irrigated conditions. In India it occupies an area of about 8.5 M ha with an average yield of about 405 kg lint ha^{-1}. As an irrigated crop it is extensively grown with conventional irrigation methods. However, with such methods considerable amount of water is lost and hence irrigation efficiency in the country is rather low with low yields. One of the biggest challenges presently confronting irrigated agriculture is striking a balance between limited water supplies and obtaining optimum yield. Under such circumstances advanced irrigation methods and water management practices with minimum water applications are needed for high yields. This could be made possible through advance cultivation of rainfed cotton with micro- irrigation as the total water availability is also decreasing over the years all most in all the cotton growing states in the country. High yield using micro-irrigation is due to maintenance of uniform soil moisture regime in the crop root zone by way of frequent irrigations at shorter intervals. Under such a system, more than 90% irrigation efficiency is recorded with improved yield and quality of the produce. With it we could expand the cotton area substantially with the same quantity of water. Thus, there are immense prospects of adopting micro-irrigation in cotton.

2.26
Standardization of planting geometry for pre-released promising cotton genotypes under high density planting system

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An experiment was conducted to standardize the planting geometry for pre-released promising cotton genotypes developed from the AICRP on Cotton, Bhawanipatna centre under high density planting system (HDPS) in the Research Farm of AICRP on Cotton, Bhawanipatna during 2016-17. The experiment was conducted in split plot design with four spacing (S_1- 45 cm X 10 cm, S_2- 60 cm X 10 cm, S_3- 75 cm X 10 cm and S_4- 90 cm X 10 cm) in main plots and four cotton genotypes (V_1- BS 279, V_2- BS 30, V_3- BS 79 and V_4- BS 1) in sub plots. The soil of the experimental site was black cotton type having pH- 6.11 , O.C.- 0.72 %, E.C- 0.004 (dS/m), available N -175.9 kg/ha, available P-36.7 kg/ha, available K- 243.6 kg/ha, available S - 66 ppm, Available B - 0.8 ppm, and available Zn- 2.0 ppm.

Results indicated that planting geometry or spacing has significant effect on all the characters like seed cotton yield, number of bolls per plant and per m^2, boll weight, number of sympodial branches, plant height, number of leaves per plant and leaf area index. Seed cotton yield (2799 kg/ha), number of bolls per plant (11.67) and per m^2 (144.53) were significantly the highest in spacing 60 cm x 10 cm (S_1). Lowest number of bolls per m^2 (83.96) was recorded in spacing 75 cm x 10 cm (S_3). Highest significant boll weight was observed in S_4 (3.30 g). Boll weight recorded in S_2 and S_3 was statistically at par. Plant height recorded with S_4 was remarkably the highest (75.75 cm) whereas it was the lowest in S_1 (71.20). S_2 (74.43 cm) and S_3 (74.53 cm) were statistically at par with respect to plant height. Significantly highest numbers of sympodial branches per plant was observed in S_4 (9.10). Leaf area index was significantly the highest in spacing S_4 (2.96) which were at par with S_2 (2.66). Varieties have significant effect on all the characters except plant height, number of sympodial branches and leaf number per plant. Seed cotton yield (2742 kg/ha), boll number per plant (11.87) and per m^2 (120.9) and boll weight (3.29 g) were significantly highest in variety BS 279 (V_1) followed by BS 30 (V_2). Leaf area index was significantly the highest in variety BS 30 followed by BS 1. The interaction effect between spacing and variety was found to be non-significant with respect to seed cotton yield.

2.27
Integrated weed management and herbicide residues in cotton

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A field trial was conducted to study the bio-efficacy and phyto-toxic effects due to combination of various herbicides like pendimethalin, quizalofop, propaquizafop, pyrithiobac-Na along-with protected spray of glyphosate and paraquat against complex weed flora and their effect on growth and yield of cotton. Persistence of their residues in cotton lint, seed and soil under cotton crop were also evaluated. It was observed that application of pendimethalin at 1 kg/ha was supplemented with two hoeings at 30 and 60 days after application (DAA), one hoeing and post emergence application of quizalofop at 60 g/ha or propaquizafop at 62.5 g/ha at 60 DAA caused significant reduction in density and dry wt. of weeds as compared to weedy check up to harvest. Protected spray of glyphosate (0.5%) integrated with pendimethalin and paraquat (0.3%) with pyrithobac-Na *fb* quizalofop being at par with three mechanical weeding helped to reduce the population and dry weight of weeds at 90 DAA significantly. Among herbicidal treatments, pre-emergence application of pendimethalin *fb* hoeing *fb* quizalofop gave seed cotton yield of 2303 kg/ha which was significantly higher than that obtained with pendimethalin at 1 kg/ha supplemented with protected spray of glyphosate (0.5 %) or paraquat although with higher weed controlling efficiency. Herbicides residues were quantified in cotton lint, seed and soil under cotton crop following validated experimental procedures using GC-MS tandem mass spectrometry and high pressure liquid chromatography (HPLC). Pendimethalin was found persistent in soil at both the doses and thus may be effective for weed control almost throughout the crop season. Quizalofop, propaquizafop, pyrithiobac-Na, glyphosate and paraquat reached below detection limit (BDL) 0.05 ìg/g within 10 days after application and dissipation followed first order kinetics in soil. Residues were not detected in cotton lint and seed.

2.28
Studies on transplanting of cotton under drip and surface irrigation

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Cotton is the major *kharif* crop in irrigated north west plain zone of Rajasthan. The border strip method of irrigation is mainly practiced for raising cotton crop. For annual maintenance of canal, canal closure in this region is practiced during the month of April. Due to canal closure the sowing of cotton is delayed resulting in yield reduction due to more infestation of diseases and pests in delayed sown cotton. Sowing of cotton at optimum time in plastic bags and then its transplanting in the field may enhance yield as well as water saving. An experiment was conducted to find out suitability date of transplanting in cotton, work out water use and WUE for transplanted cotton and to work out the economics of transplanted cotton with three date of sowing/transplanting (30th May, 10th June and 20th June) , three methods of of planting *i.e.* direct sowing, trans planting with drip irrigation and Trans planting with surface irrigation and Control (Direct sowing on 15th May with surface irrigation) during Kharif 2013 to 2016 at Agricultural Research Station, Sriganganagar. The crop of cotton (direct sown/ transplanted with drip) was raised without pre sowing irrigation as per treatment. Post sowing irrigations were applied through drip to germinate or establish the crop. After establishment of the crop irrigations were applied through drip at 1.0 ETc as per package of practices. The post-sowing irrigations in surface irrigation treatment were applied at IW/CPE 1.0. The results revealed that in case of canal closer or some other reason sowing is not possible in time, then Bt cotton crop may be raised in plastic bags and transplanted in field up to 30th May with drip irrigation without yield losses. The water use in 15th May direct sown crop was recorded 755.70 mm with WEE of 3.69 kg/ha mm as against water use of 744.62 mm and WEE of 3.65 kg/ha mm in 30th May transplanted crop. Transplanted cotton crop with drip irrigation on 30th May, 10th June and 20th June gave 15.42, 24.18 and 47.00 percent higher seed cotton yield over direct sown on these dates with drip irrigated crop, respectively. The water expense efficiency also decreased with delay in sowing as well as in transplanting. The respective net seasonal income was Rs 86,589, Rs 66,289 and Rs 43437/ha with B:C ratio of 1.95, 1.73 and 1.48 for transplanted cotton on drip on respective dates as against seasonal income of Rs 1,00,591/ha and B:C ratio of 2.24 for direct sown cotton on 15th May with drip irrigation.

2.29
Effect of foliar application of micro nutrients on morpho physiological parameters for enhancing the productivity in *Bt* cotton

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A field experiment was conducted during *kharif* 2013-2014 to know the effect of foliar application of micro nutrients on morpho-physiological parameters for enhancing the productivity in *Bt* cotton at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka. The experiment consisted of nine treatments *viz.*, $FeSO_4$, $ZnSO_4$, $MgSO_4$, $MnSO_4$, Boron and combination of $MnSO_4$ + $ZnSO_4$, $MgSO_4$ + $ZnSO_4$ and $FeSO_4$ + $ZnSO_4$ foliar spray of all these at 70 and 90 DAS. The experiment was laid out in randomized block design with three replications. Among all the treatments, foliar application on micronutrients with $MgSO_4$ (1 %) + $ZnSO_4$ (0.5 %) at 70 and 90 DAS recorded significantly highest plant height, monopodial, sympodial, total dry matter production, number of bolls/plant and seed cotton yield as compared to other treatments. It was *on par* with the treatment $FeSO_4$ (0.5 %) + $ZnSO_4$ (0.5 %) and treatment $MgSO_4$ (1 %) and the minimum yield and yield components were recorded under control. Significantly highest seed cotton yield (2393 kg/ha) was recorded in foliar spray with $MgSO_4$ (1 %) + $ZnSO_4$ (0.5 %) compared to control (1788 kg/ha). It is concluded that, application of foliar spray with $MgSO_4$ (1 %) + $ZnSO_4$ (0.5 %) at 70 and 90 DAS more effective in increasing the yield in *Bt* cotton as compared to other treatments.

2.30
Episodal rainfall and whitefly population and CLCuD of cotton

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Field observation were taken on jassid and whitefly pest. over the cotton crop during *kharif* seasons at CCS HAU Research Farm. Data on whitefly of cotton from 2005 to 2016 were correlated with the weather parameters for SMWs with no rainy day (SMWs with <2.50 mm rainfall) and SMWs weeks

with different rainfall amounts (>=2.5, >=10, >=15, >=20 and >=25 mm/SMWs). During the Episodal maximum and minimum temperature, morning relative humidity, evening relative humidity, wind speed, and bright sunshine hours showed +ve correlation with white fly population, whereas pan evaporation, rainfall and cumulative rainfall (CUR) showed –ve correlation. Episodal rainfall and PDI (% disease incidence) of cotton leaf curl virus disease (CLCuD) of cotton. PDI on cotton from 2005 to 2016 were and correlated with the non rain fall weeks (<2.50 mm rainfall SMWs considered), rainfall weeks (from >=2.5, >=10, >=15, >=20 and >=25 mm per SMWs was considered) along with different weather parameters. Maximum temperature, minimum temperature, pan evaporation, rainfall and cumulative rainfall showed –ve correlation with PDI, whereas morning relative humidity and evening relative humidity (<2.50 mm weekly rainfall show the negative correlation), wind speed and bright sunshine hours (at <2.5 to >25.0 mm weekly rainfall) and accumulated rainfall showed +ve correlation.

2.31
Use of drip irrigation in cotton for higher productivity and saving of irrigation water

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The present study was carried out at farmers' field in Hisar district during 2013-2014. The trial was conducted at fields of five farmers on sandy loam soils low in available nitrogen, medium in available phosphorus rich in available potassium and slightly alkaline in reaction (pH 7.8). The *Bt* cotton hybrid RCH 134 was sown in lines 67.5 cm apart by dibbling method with 30 cm distance from plant to plant using seed rate of 2.0 kg/ha. Sowing was done in the month of May at all the locations after pre sowing irrigation. The two treatments *i.e.* drip irrigation method and conventional flood method were tested on half acre plot at each site. The drip system was laid after the sowing. In both the treatments, the irrigation was started after 40 days of sowing. The recommended dose of fertilizers i.e. 175, 60, 60 kg/ha of nitrogen, phosphorus and potash, respectively, were given. The other recommended package of practices were followed during crop season.

The results indicated that the use of drip irrigation gave higher seed cotton yield (26.9 q/ha) as compared to the conventional flood irrigation method (23.4 q/ha). Drip irrigation enhanced the seed cotton yield by 14.9 per cent over the flood method. Similarly, the higher net returns of Rs.78,425/ ha were realized with drip irrigation than the conventional method of irrigation (Rs. 61,000/ha.)

which resulted in higher B:C ratio (2.39) as compared to flood irrigation method with the corresponding value of B:C ratio 2.08. Apart from the higher yield and net returns, the drip method also saved the irrigation water to the tune of about 40 per cent in comparison to conventional flood irrigation method which clearly indicates the scope of drip irrigation in cotton in forthcoming years. Spectral characteristics of Bt cotton in response to precision nutrient management

2.32
Spectral characteristics of *Bt* cotton in response to precision nutrient management

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Characterization of the leaf characteristics is a tool for effective management of the crop monitoring and improvement. Differential reflectance and emittance is a measure of the pigmentation, nutritional status, leaf water content and pest incidence. Experiment was conducted during 2015-2016 to study spectral characteristics of *Bt* cotton in response to precision nutrient management through SSNM approach. Precise application of fertilizer N through target yield approach increased the SPAD chlorophyll meter readings and NDVI values. Higher NDVI values (0.90) was observed in LHH 40 q/ha over target yield of 25, 30, 35 q/ha, RDF and absolute control. Significantly lower NDVI values (0.76) were recorded in absolute control. Similarly, higher SPAD value **(**44.98) was observed with LHH 40 q ha^{-1}over target yield of 25, 30, 35 q ha^{-1}, RDF and absolute control. Lower SPAD value (28.38) was recorded in absolute control. NDVI and SPAD values observed were at peak during 120-150 DAS. Leaf reddening is having a greater effect on SPAD and NDVI value. Higher red leaf index (RLI) (1.98) was observed in RDF and absolute control over target yields of 25, 30, 35 and 40 q/ha of the cotton. Strong correlation was observed with NDVI and SPAD values with cotton yield.

2.33
Jute: A potential fibre crop of eastern India

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Jute (*Corchorus* spp) is an important natural fiber crop in India next only to cotton. Jute is a fiber plant which grows into a straight, cylindrical stalk with branches only near the top of the plant. Jute cultivation is mainly concentrated in the eastern and north eastern India. Raw jute was earlier considered as a source of raw material for packaging industries only. But it has now emerged as a versatile raw material for diverse applications, such as, textile industries, paper industries, building and automotive industries, use as soil saver, use as decorative and furnishing materials, etc. Its fiber is used chiefly for bags and covers and generally does not command a high price due to large yields and very good adaptability to modern methods of manufacture. The jute plants are cut close to the ground with sickles. Cut plants are tied into bundles upto 23 cm in diameter. Jute is retted in any type of clean water that is available in the vicinity of the fields. In low land areas it is retted in slow running water, and the fibre of very good quality is obtained. If water is stagnant it is usual to steep the bundles twice or thrice with short intervals between successive steeping. The fibre obtained is somewhat dark in colour. For steeping, the bundles are generally arranged in two or three layers. Each individual float is called Jak. The surface of the Jak is covered with weeds or other refuse and it is submerged by weighting it down with logs, banana stems or mud. Complete submersion is essential for uniform retting, but care should be taken that the Jak does not sink to the bottom. Retting results in the separation of fibre strands from the central woody portion due to the disintegration of soft tissues in which fibres are embedded. When retting is completed the bundles are removed for stripping the fibres. The retted stems are broken into two or three parts by a mallet, and the fibre is separated from the sticks by jerking and washing in water. The stripped fibres are washed and dried in the sun for two to three days. Dried fibres are made up in hanks or lots of about 4 kg each, tied at the top ends. In some parts, lots are given a slight twist and folded into small compact bundles, varying in weight from 40-50 kg each. The extracted fibre is weaved through machines and subsequently the products prepared for marketing. Other uses of jute are pith is used in paper industry and in preparation of alcohol; leaf and young shoots are used as vegetable. stalks after removal of fibre is used as firewood, stalks are also used for farm fencing, fruits are used as medicine in the treatment of headache; an infusion of leaves is a demulcent, stomachiac, laxative, carminative, stimulant and used to improve appetite. It is also given in dysentry, fever,

dyspepsia and disorders of the liver; decoction of roots and unripe fruits is used in diarrhea and the leaves contain glucoside capsularin which is related to corchorin and chorchoritin, extracted from seeds and used in cardiac diseases. With the development of pre mature flowering resistant tossa jute varieties like JRO 7835, JRO 878, and JRO 524 etc, enabled the tossa jute to be sown early and be fitted before kharif rice in the rice based cropping sequence of eastern India. As a result, 80 per cent of the jute area came under tossa jute owing to its higher fibre yield. Jute rice potato, jute rice mustard and jute rice-pea/lentil are becoming popular in eastern and north eastern region of India. However there is an urgent need to support the jute cultivation to revive the dying jute industries in the region through adequate policy and technological supports.

2.34

Dynamics of soil microbes as influence by various cover crops under hybrid cotton cultivation in Vidharbha region

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A field experiment was conducted over two consecutive years, during 2013-14 and 2014-15 at Agronomy Research Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola to identify the effect of cover crops on soil health improvement and productivity of cotton. Cover crops viz., soybean, green gram, kawachbeej, guar, finger millet and cowpea were evaluated for their cover cropping benefit and influence on biological activity of a soil. Incorporation of cover crops favourably help in augmentation of beneficial microbial population and their activities. Highest dry biomass was observed in kawachbeej that extended up to 5331.12 and 462 g m-2 followed by cowpea and guar and lowest in finger millet. Statistically highest colonies of soil microbes recorded at flowering stage as compared to boll bursting stage of cotton during both the consecutive year during 2013-14 and 2014-15, respectively. Among the all cover cropping system, Bacterial, fungal and actinomycets population at both the grand growth (50% flowering and 50% boll bursting) stages was recorded significantly highest in cotton + kawachbeej cover cropping followed by cotton + cowpea at 50% flowering, while cotton + guar at 50% boll bursting and lowest in sole cotton (no cover crops) during 2013-14 and 2014-15, respectively.

2.35

Impact of cover crops on growth, yield and economics of cotton

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A field experiment was conducted over two consecutive years, during 2013-2014 and 2014-2015 at Agronomy Research Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola to identify the effect of cover crops on soil health improvement and productivity of cotton. Cover crops *viz.,* soybean, green gram, kawachbeej, guar, finger millet and cowpea were evaluated for their cover cropping benefit. Sole cotton (no cover crop) recorded highest plant height, number of monopodia, sympodia/ plant and dry matter accumulation/plant and which was comparable with cotton + green gram (1:2) cover cropping system during both the years of investigation. However, highest number of leaves and leaf area/plant at harvest was recorded cotton + green gram and which was *at par* with cotton + soybean cover cropping, during 2013-2014 and 2014-2015, respectively. Significant reductions in boll/plant, boll weight (g), seed cotton yield/plant as well as seed cotton yield/ha, cotton stalk yield/ ha, biological yield/ha and harvest index were recorded due to all cover crop treatments over sole cotton. As a consequence of better growth and yield attributes, sole cotton had recorded higher seed yield (1597 and 993 kg/ha) and stalk yield (2698 and 1911 kg/ha) during 2013-2014 and 2014-2015, respectively. Cotton + guar cover cropping recorded highest seed cotton equivalent yield (2543 and 2000 kg/ha) during two respective years. Highest net monetary return was received from cotton + guar cover crop (Rs. 88217 and Rs. 67726/ha) during both consecutive years. Cotton + guar was most remunerative cover cropping systems in terms of B:C ratio (3.71 and 3.36) during 2013-2014 and 2014-2015, respectively.

2.36

Effect of climate change on growth and yield in *Bt* and non *Bt* cotton hybrids

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Cotton crop is highly sensitive to water availability particularly at the time of flowering and boll formation. Prolonged dry spell during critical crop growth stages adversely affects seed cotton yield. Cotton plants need adequate water to grow and maintain their temperature within optimal range and may suffer for heat stress without water for cooling. Moisture stress at the time of critical growth period may causes reduction in seed cotton yield and biomass production to the tune of 42 and 36 per cent, respectively in addition to shortening of crop growth period. To assess the impact of climate change on cotton, an experiment was conducted at Cotton Research Station, Nanded during 2012-2013, 2013-2014 and 2014-2015 comprising of seven *Bt* and non *Bt* cotton hybrids with two sowing dates. On an average of three years data, normal sowing (1030 kg/ha) of cotton genotypes were found superior over late sowing (630 kg/ha) in terms of yield and yield contributing characters. However, the *Bt* cotton hybrids viz., NCS 145 and Ankur -3028 recorded significantly highest seed cotton yield 1289 kg/ha and 1290 kg/ha respectively in normal sowing. Whereas, in late sowing condition, the non *Bt* hybrid recorded significantly highest seed cotton yield ranges 844-608 kg/ha against *Bt* cotton hybrids ranges 493-438 kg/ha. There is more reduction in yield of *Bt* cotton hybrids as compared to non *Bt* cotton hybrid in terms of number of bolls/plant. Duration of 50% boll opening is more in normal sowing D1(145 days) as compared to late sowing D2 (135 days). Duration of 50 per cent boll development is also more in normal sowing D1 (119 days) as compared to late sowing D2 (110 days) indicating more duration of boll development in normal sowing than late sowing. The growing degree days (GDD) occurred as affected by environments are 28300C-d in normal sowing and 26580 C-d in late sowing. It is clearly indicated that the GDD is higher than 18000 C-d, which is above normal cotton crop production occurs due to climate change.

Overall, the non *Bt* cotton hybrids recorded the highest seed cotton yield and other yield contributing traits in late sowing condition as compared to *Bt* cotton hybrids.

2.37
Treated domestic sewage water as an alternate irrigation source in cotton

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Reuse of treated sewage water in agriculture is becoming a necessity due to scarcity of water resources for irrigation purposes. In India, waste water production is approx. 22900 million litres/ day out of which 5900 Mld (26%) is treated in sewage treatment plants (STP). Domestic treated sewage water has a great irrigation and nutritive potential. In Punjab, STP's with more efficient technology has been set up in major cities. Cottonwheat is the major crop rotation in south western region of Punjab. An experiment was started in *kharif* 2016 at PAU Regional Research Station, Bathinda on loamy sandy soil to explore the possibility of using treated domestic sewage water in combination with canal water in cotton wheat cropping system. The experiment comprised of six treatments of irrigation combinations viz. canal water (CW; T_1); treated domestic sewage water (TSW; T_2); TSW_{psi} – subsequent irrigations with CW (T_3), CW_{psi} – subsequent irrigations with TSW (T_4), two irrigation with TSW – two irrigation with CW alternately (T_5) and two irrigation with CW – two irrigation with TSW alternately (T_6) with four replications in randomized block design. Initial pH, electrical conductivity and organic carbon status of surface layer (0-15 cm) of soil was 8.28, 0.173 dS/m and 0.28 per cent, respectively. In the first year of study, the seed cotton yield was highest in the treatment where all irrigations were given with treated domestic sewage water (TSW). In other words, all irrigations with treated domestic sewage water (T_2) gave significantly higher seed cotton yield than canal water alone (T_1) and T_3. The bolls and sympods were significantly higher in T_2 than T_1 and T_3. However, among treated domestic sewage water treatments, seed cotton yield, bolls and sympods recorded were statistically *at par* in T_2, T_4, T_5 and T_6 treatment combinations. Likewise, the water expense efficiency was found to be highest in T_2 (TSW) and least in T_1 (CW).

2.38

Nitric oxide (no) as a potential drought stress mittigating agent in cotton (*Gossypium Spp.*)

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The present study was conducted to inv investigate different physiological and biochemical attributes under PEG-induced water deficit stress and the mitigative effect of nitric oxide (NO) over the water deficit stress in a cotton hybrid namely BG 6488 II (*Bt* cotton) under controlled screen house conditions. Water stress was induced after 60 days of sowing at the reproductive stage by application of PEG 20% solution. NO was applied in the form of sodium nitroprusside (SNP-250iM) after induction of drought stress. Observations were recorded on the 3rd day after all the treatments were given. A significant decrease in physiological parameters like total chlorophyll content, relative water content andthe photosynthetic rate was clearly observed with 20% PEG-induced water stress. Exogenous application of SNP through foliar spray was very much effective and increased the values of these parameters significantly. Due to the water stress, the lipid peroxidation level increased significantly from the control plants. SNP application was effective and decreased the lipid peroxidation values significantly. The antioxidant enzymes like catalase and peroxidase were increased during this stress condition and SNP was able to further increase these values which were helpful in mitigating the drought stress.

CROP PROTECTION AND BIOSAFETY

3.1
Cotton leaf curl disease: A potential threat for *Bt* cotton production and productivity

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Cotton is the most important fibre crop of global importance including India and has high commercial value. Approximately 95 per cent area is covered under Bt. cotton in north western India. Several insect-pests and diseases are responsible for decreased production and productivity of cotton in India, among them cotton leaf curl disease is in key responsible threat. An experiment was conducted to find out the impact of cotton leaf curl disease on seed cotton yield and yield attributing characters using BGII Bt cotton cultivars viz. Bio 6488, RCH650, MRC7017, Kribhco Varsha during *kharif* 2015 and 2016 at CCS HAU Cotton Research Station, Sirsa. A significant reduction was recorded in seed cotton yield and other yield attributing characters due to cotton leaf curl disease. Percent decrease in seed cotton yield varied from 19.6 to 47.9 and 24.0 to 44.9 during *kharif,* 2015 and 2016 respectively. Whereas, per cent decrease in open bolls ranged from 22.8 to 46.8 during *kharif*, 2015 and 21.3 to 37.9 during the year 2016 in different cultivars. Minimum per cent decrease in seed cotton yield and number of bolls was reported in RCH 650 in both the years of experiment. Overall per cent reduction in seed cotton yield/plant, open bolls/plant of all the *Bt* cultivars under experiment was recorded 37.8 and 36.4 respectively during *kharif*, 2015 while during 2016 per cent reduction in seed cotton yield was reported 37.3 and per cent reduction in open bolls was 32.8. So it is evident that cotton leaf curl disease has a severe impact on *Bt* cotton crop leading to decreased production and productivity.

3.2
Population dynamics of whitefly *vis a vis* bio control agents in *Bt* cotton under field condition

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Cotton is one of the major commercial crops and backbone of textile industry in India which provides

employment to vast majority of population directly or indirectly. It provides livelihood of 60 million people depending on cotton cultivation, processing trade and textiles. Textile industry contributes 4 per cent of GDP, 14 per cent of total industrial product, 20 per cent of total work force, 17 per cent of country's exports earning and employment to 30 million people. Cotton has the most fragile ecosystem amongst the field crops where approximately 162 insect-pests damage the crop in India. Among the vast array of insect pests, whitefly; *Bemisia tabaci* (Gennadius) is one of major pest which cause high economic losses in cotton. The present investigations on the incidence of whitefly and it's natural bio control agent on cotton variety RCH 650 were undertaken during 2016-2017 at CCSHAU, Cotton Research Station, Sirsa. Observation on sucking pests especially on cotton whitefly started from 19th upto 42nd Standard Meteorological Week (SMW). Infestation of whitefly ranged from 1.1 in 19th SMW to 9.7 in 35th SMW nymph/adults whitefly/plant. Whitefly infestation (9.1) peaked in 26th SMW; again it speared up 9.7 and 8.4 nymph/adults whitefly/plant in 35th and 38th SMW. After 38th SMW, population of whitefly exhibited decline trends in number. Observation on parasitization of whitefly started in 31st SMW having 16.7 per cent parasitization of nymphal whitefly. Highest level of parasitization of whitefly nymph (31.8 %) was recorded in 33rd SMW. In 35th SMW parasitization per cent dipped to 8.9, however it again mounted to 26.5 per cent in 36th SMW. Thereafter, there was a continuous decrease in per cent parasitization. Thus, use of *Bt* cotton in lieu of conventional could positively impact non-target and beneficial organisms by preserving their host populations

3.3
Efficacy of cobalt chloride against parawilt of *Bt* cotton

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The genetically modified cotton completely revolutionized the cotton protection technology. These alterations have brought in many new abiotic problems like parawilt. The parawilt is well established problem in *Bt* cotton growing areas of India. The roving survey revealed that parawilt is also well established in Haryana and prevalent from flowering to boll development stages. This physiological disorder is characterized by sudden drooping of all leaves, partial epinasty, and premature defoliation with or without reddening. Hence, on farm trials were undertaken at different locations at farmer's fields in Sirsa district of Haryana during *kharif,* 2015 and 2016. The foliar spray of cobalt chloride (2 g / 200 l water/ac) was done at different time intervals after parawilt symptom appearance. It was noticed that if the foliar application of cobalt chloride was done within 48 h of symptoms appearance

of parawilt then whole plant revived and good recovery was observed. The minimum disease incidence of parawilt *i.e.* 3.6 per cent was observed, when cobalt chloride was sprayed just after the onset of the symptoms which was significantly lower than that of spray done after 24 h of symptoms appearance (15.80 %). Maximum seed cotton yield (2086 kg / ha) was recorded in field where cobalt chloride was sprayed at the outset of symptoms.

3.4
Standardization and validation of multiresidue method in cotton by Gas Chromatography - Tandem Mass Spectrometry (GC-MS/MS)

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For supervising the residues in environmental components and food commodities, monitoring of pesticide residues is the most specific step which requisite for an efficient, cost effective and comprehensive method of residue-analysis. Therefore, it has been endeavored to optimize and validate a multi residue method using highly precise GC-MS/MS for commonly used pesticides *viz.*, dimethoate, thiamethoxam, acephate, fipronil, spiromesifen in cottonseed and lint. Seed oil was extracted on Soxhlet extraction set with hexane: acetone while samples of cotton lint were extracted with acetonitrile; diluted with brine solution, partitioned into dichloromethane following liquid-liquid partitioning, dried over anhydrous sodium sulfate and cleaned up by treating with activated charcoal powder. Final clear extracts were concentrated on rotatory vacuum evaporator and residues were estimated by GC-MS/MS. The average recoveries obtained at different spiking levels ranging from 0.01 to 0.05 mg kg^{-1} was typically in the 82-98% range. The limit of quantification (LOQ) of the method was worked out to be 0.01 mg/kg. The analytical method was validated in terms of parameters including selectivity, linearity, precision, accuracy, reproducibility, *etc.* The standardized method offered satisfactory accuracy with repeatability and reproducibility typically <15%. Based on these results, the methodology has been proven highly efficient and robust.

3.5
Effect of new fungicidal molecules against Alternaria leaf blight of cotton

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Cotton is one of the most important commercial crops of the World, belonging to the botanical family Malvaceae. Cotton is referred to as **"King of Fibres"** and also known as **"White Gold"**. In India, 70 per cent of the crop is being cultivated by small and marginal farmers with almost 60 per cent under rainfed condition. Cotton is cultivated in Tamil Nadu in 1.50 lakh hectares and the production is 2.8 lakh bales with a productivity of 659 kg/hectare. The crop suffers from many fungal diseases, of which foliar diseases take a heavy toll and among the diseases, Alternaria leaf blight causes yield losses up to 30-40 per cent. An experimental trial in RBD with six treatments and five replications was conducted during Winter 2016 for the management of Alternaria leaf blight (ALB) complex using new fungicidal molecules in cotton. The susceptible variety SVPR 4 and hybrid RCH II BG II were sown at 90x45cm distance in 6.0mx6.0m plots. Three sprays of fungicides were made at 20 days interval from initiation of disease. The effect of new fungicides ingredients on the management of *Alternaria* leaf blight was tested using Probineb 70 WP (0.25%), Tebuconazole 250 EC (25.9% w/w) (0.15%), Trifloxystrobin (25%w/w- 0.1%), Hexaconazole 4% (WP) (0.25%) and Mancozeb (75WP) (0.25%). The results revealed that all the treatments reduced the incidence of Alternaria leaf blight in cotton when compared to control. There was a significant difference in yield between the treatments and control. Analysis of treatments revealed that the spray of Tebuconazole 250 EC (25.9% w/w) @ 0.15% was found to reduce the ALB more significantly and prominently compared to all other chemicals. The Per cent Disease Index (PDI) was in the range of 2.5 for SVPR4 and 3.8 for the hybrid RCH II BG II. The yield was found to be 1276 kg/ha in SVPR4 and 1433 kg/ha in RCH II BG II which is more than yield of cotton in other treatments.

3.6
Screening for resistance of root knot nematode, *Meloidogyne incognita* race 3 on *Bt* cotton

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Cotton producers worldwide suffer with the losses caused by a number of insect pests and diseases including phytoparasitic nematodes. The annual cotton yield loss due to damage by plant parasitic nematodes on global basis, is estimated to be 10.7 per cent. Among phytoparasitic nematodes, root-knot nematode (*Meloidogyne incognita*) constitutes one of the important nematode pests of cotton under Haryana conditions. The avoidable losses in cotton yield due to *M. incognita* under field conditions in Haryana ranged from 16.8 to 20 per cent. Cry proteins of *Bacillus thuringiensis* have been successfully used as bio-pesticides and transgenic crops throughout the world. However, resources against the most serious agricultural pathogens, root-knot nematodes, are limited. The aim of the present study was to investigate the inheritance of resistance to *M. incognita* race 3 in *Bt* cotton. Therefore, The screening of ten *Bt* cotton hybrids against root knot nematode *Meloidogyne incognita* race 3 using 1-5 root knot index in the screen house condition, Dept of Nematology, CCS HAU, Hisar. The nematode inoculum of 700 J_2 per plant was inoculated to the fifteen days after sowing and each hybrid was replicated thrice. Based on 1-5 root knot index, seven Bt cotton hybrids showed susceptible reaction and three were moderately resistant.

3.7
Impact of neonicotinoids on diversity of pollinators in *Bt* cotton

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The study on impact of neonicotinoids on the diversity of pollinators in *Bt* cotton was carried out at Bathinda during 2015 and 2016. The experiment comprised of 13 treatments namely imidacloprid 70WS (Gaucho) @ 5 g/kg seed, thiamethoxam 30FS (Cruiser) @ 7g/kg seed, imidacloprid 17.8SL (Confidor) @ 100 ml/ha, imidacloprid 17.8SL (Confidor) @ 200 ml/ha, thiamethoxam 25WG (Actara)

@ 100 g/ha, thiamethoxam 25WG (Actara) @ 200 g/ha, acetamiprid 20SP (Pride) @ 50 g/ha, acetamiprid 20SP (Pride) @ 100 g/ha, clothiandin 50WDG @ 30 g/ha, clothiandin 50WDG @ 60 g/ha, dinotefuran 20SG @ 125 g/ha, dinotefuran 20SG @ 250 g/ha and untreated control. A total of seven pollinator species were identified viz. Giant/rock bee, *Apis dorsata* (Fabricius), Little honey bee, *Apis florea* (Fabricius), Italian honey bee, *Apis mellifera* (Linnaeus), *Xylocopa* spp., Carpenter bee, *Pithitis smaragdula* (Fabricius), *Megachile* spp., *Sphecodes* spp. These species constituted 8.98 per cent of the total arthropods complex in *Bt* cotton agro-ecosystem. Diversity of pollinators was higher in imidacloprid 70WS and thiamethoxam 30FS and in lower doses of all neonicotinoids while it was lower in double doses of neonicotinoids after the first, second and third spray of different neonicotinoid treatments. At the higher doses of neonicotinoids, the species richness reduced and the evenness index was lower while in the seed treatments and lower doses of neonicotinoids, the eveness index was comparatively higher. Thus, it is concluded that imidacloprid 70WS (Gaucho) @ 5 g/kg seed, thiamethoxam 30FS (Cruiser) @ 7g/kg seed, imidacloprid 17.8SL (Confidor) @ 100 ml/ha, thiamethoxam 25WG (Actara) @ 100 g/ha, acetamiprid 20SP (Pride) @ 50 g/ha, clothiandin 50WDG @ 30 g/ha and dinotefuran 20SG @ 125 g/ha are comparatively safer to the pollinators while at the higher doses of neonicotinoids, diversity of pollinators reduces as richness of species becomes minimum.

3.8
Screening of cotton genotypes for resistance to sucking pests

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Field studies were carried out to investigate the relative resistance of 24 cotton genotypes against sucking pests i.e. whitefly (*Bemisia tabaci*), leafhopper (*Amrasca biguttula biguttula*) and thrips (*Thrips tabaci*) during *kharif* 2015-2016 at Research Farm, Cotton Section, Department of Genetics and Plant Breeding, Hisar. The whitefly, leafhopper and thrips population/leaf was recorded on each genotype. The results revealed that lowest whitefly population of 40.9 and 42.2 adults/leaf was found on PC-P 061 and NC 1154 genotype, respectively. Whereas, PC-P 251 *Bt2* (83.6 adults/leaf) and PC-P 951 *Bt2* (82.1 adults/leaf) genotype had highest whitefly population. The leafhopper population was highest at 7.9 and 7.8 nymphs/leaf on NC 160/3 BG II and PC-P 6507/1 BG II genotype, respectively. Whereas, the lowest leafhopper population was observed on NC 1154 *Bt2* (1.9 nymphs/leaf) and NC 160/4 BG II (3.6 nymphs/leaf). The lowest thrips population was recorded on 18.0 and 19.5 population/

leaf on NC-160 and PC-P 061 genotype, respectively. Whereas, the highest thrips population was occurred on PC-P 251 *Bt2* (25.1 population/leaf) and NC 1154 *Bt* (24.2 population/leaf).

3.9
Status of different diseases in Haryana

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The survey was undertaken to record the occurrence of different diseases in major cotton growing districts (Hisar, Bhiwani, Fatehabad, Sirsa and Jind) as well as in the non traditional areas of Haryana (Mahendergarh, Rewari and Rohtak) from July to September, 2016. Ten to fifteen villages from each district were surveyed and five sites from each village were observed. Cotton leaf curl disease (CLCuD), Bacterial Blight (BB), Fungal Foliar leaf spots (FFLS) and root rot were the diseases observed in different districts of Haryana.

At HAU Farm cotton leaf curl virus disease ranged from 22.7 to 49.9 per cent. Whereas at farmer's field the Per cent Disease index(PDI) was low as compared to the HAU Farm. The highest per cent disease index (PDI) of 13.0 (RCH 602 in Barwala distt. Hisar), 12.0 (RCH602 in Bhattu kalan district Fatehabad) and 9.4 (Pur village in Bhiwani). Among the fungal diseases Myrothecium leaf spot (MLS) PDI varied from 0.0 to 5.3 per cent. Other diseases *viz.* Alternaria leaf spot (ALS) and Bacterial leaf blight did not appear at farmer's field, Root rot (RR) was upto 2.0 per cent on all locations surveyed in Haryana

3.10
Management of Alternaria leaf spot of cotton with newer fungicides

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An experiment was conducted during *kharif,* 2016-2017 at Experimental Field, Department of Plant Pathology, Dr.PDKV, Akola to evaluate newer fungicides against Alternaria leaf spot diseases of cotton. The experiment was conducted in RBD with four replication and seven treatments including

check. The Alternaria leaf spot was observed during 34th meteorological week with very low intensity. The disease increased after inoculum spray. At 4th day after inoculum spray the disease intensity was recorded. The percent disease intensity was in the range of 7.05 to 7.92 per cent. The disease intensity reduced significantly in all the treatments as compared to control. The minimum disease intensity was recorded in treatment T3 (Flint Pro (Trifloxystrobin 3.5% + Propineb 61.3% WG) *i.e.*1.62 per cent at 5DAS. Where as at 10DAS treatment T2 (0.22%) and T3 (0.25) were found better in managing the disease over all the treatments. Flint Pro (Trifloxystrobin 3.5%+Propineb 61.3% WG *a.i.*133+2329.4 with 3800 Formulation) showed phytotoxic effect on plants at 7th and 10th DAS with rating 1. Regarding yield maximum seed cotton yield was achieved in treatment T2 and T3 *i.e.* 17.0 and 17.2 q/ha respectively. Where untreated control showed 7.2q/ha seed cotton yield.

3.11
Bio efficacy of biopesticides and insecticides against pink bollworm in *Bt* cotton (Bollgard II)

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Out of ten treatment tested on *Bt* cotton bollgaurd II against pink bollworm lowest per cent rosette flower was recorded in treatment of spinosad 45 SC 0.014 per cent (3.92% damage per plant), which was statistically at par with chlorantraniliprole 18.5 SC 0.006 per cent (4.00% damage per plant) and *Beauveria bassiana* 1.15 WP 0.009 per cent (4.32% damage/plant) at 9 days after spraying. The lowest per cent green boll damage per plant was recorded in treatment of *Beauveria bassiana* 1.15 WP 0.009 per cent (7.44% boll damage/plant) which was statistically at par with chlorantraniliprole 18.5 SC 0.006 per cent (7.57% boll damage/plant) and spinosad 45 SC 0.014 per cent (9.61% boll damage/ plant).

3.12
Bio efficacy of different biopesticides and its combination against sucking pests of *Bt* cotton (Bollgard-II)

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More or less similar trend in effect of different treatments was also observed in 2nd, 3rd and 4th spray in population of all sucking pests' *viz.*, aphid, whitefly and jassid. The highest yield was recorded from treatment dinotefuran 20 SG 0.01 per cent (2412.6 kg/ha) followed by diafenthiuron 50 WP 0.05 per cent (2353.4 kg/ha), flonicamide 50 WG 0.15 per cent (2238.2 kg/ha).

3.13
Bio-efficacy of insecticides against natural enemies in *Bt* cotton

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Effect of various chemical insecticides on natural enemies of cotton crop was evaluated as a state trial at cotton research station, Junagadh Agricultural University, Junagadh, Gujarat during *Kharif* 2015 and 2016- 17. The chemical insecticides used to spray on cotton crop are Flonicamid (50%) WG, Difenthiuron (50%) WP, Buprofenzin (IGR) (25%) SC, Thiamethoxam (25%) WG, Fipronil (5%) SC, Neemazal F (5%) WSC, Carbosulfan (48%) EC, Spiromesifen 22.9% SC, Clothianidin (50%) WG, Acetamiprid (20%) SP and Dinotefuran (20%) SG. The difference in population of all predators (Coccinellids, *Chrysoperla* and spider) was significantly lower in all the insecticidal treatments than control. There was non-significant difference among all the insecticidal treatments at 7 days after first, second and third spray.

3.14
Identification of Fusarium wilt resistant cotton genotypes using "Pune Technique"

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Fusarium wilt of cotton caused by *Fusarium oxysporum* f.sp. *vasinfectum* is not that much devastating disease in India, however, mutation, recombination in fungal genes and climate change may enhance the disease epidemics in cotton growing areas and will become most challenging disease. The indiscriminate and continuous use of fungicides for the control of various disease poses environment related problems therefore use of resistant varieties being economically feasible and ecofriendly would be the best way to manage this disease. To identify genetic sources of resistance against wilt disease under artificial epiphytotic condition, forty six cotton genotypes obtained from various centres and susceptible check were rigorously evaluated by "PUNE TECHNIQUE" under Seedling Resistance Test (SRT) and Adult Plant Resistant Test (APRT) in glasshouse and field conditions respectively. Wilt sick soil with CFU count of 2 x 10^3 /g was used in pot culture experiment in glasshouse (SRT). The genotypes which were found resistant to Fusarium wilt in SRT were transplanted in wilt sick field to screen in APRT. Percent wilting and disease observations were recorded at seedling and adult stages. A considerable variation among the genotypes observed at both the stages. Disease incidence ranged from 0 to 71.42 per cent manifested as vascular discoloration at adult stage and it varied from 0 to 100 per cent at seedling stage as per cent wilting. At seedling stage in SRT, the only genotype DWDa1601 was found resistant, 11 genotypes (PBD20/2016 , CNA1031, DWDa1602 ,ANGH 1602 ,GShv 385/12, GShv 367/12, GBhv 307/12, GShv 362/12 ,GBhv 304,JLA1102 and JLA 1227) were moderately resistance, and remaining 34 were found susceptible to Fusarium wilt. On the contrary, at adult/reproductive stage, out of these 12 genotypes, 9 (PBD20/2016 , CNA1031, DWDa1602 ,ANGH 1602 ,GShv 385/12, GShv 367/12, GBhv 307/12 and GBhv 304) exhibited less than 50 per cent vascular discoloration and found resistant to Fusarium wilt in APRT under field conditions. DWDa1601 was the only genotype found resistant in both SRT and APRT. Nine genotypes were which identified for resistance against Fusarium wilt could be tested under wide range of environments and further utilized as resistant sources.

3.15

Effect of host plants on parasitization of cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) by *Aenasius arizonensis* (Girault) (Hymenoptera: Encyrtidae)

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A study on the effect of host plants on parasitization of cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) by *Aenasius arizonensis* (Girault) (Hymenoptera: Encyrtidae) was carried out under controlled conditions in screen house of Entomological Research Farm, CCS HAU, Hisar during 2016-2017. The experiment was carried out under two conditions *viz.*, free choice and no-choice condition. In free choice condition, six host plants *viz.*, *Abutilon indicum* (Linn.), *Parthenium hysterophorus* (Linn.), *Hibiscus rosa-sinensis* (Linn.), *Abelmoschus esculantus* (Linn.), *Solanum melongena* (Linn.), and *Gossypium hirsutum* (Linn.) were raised in pot separately and caged together in muslin cloth net. Fifty third instar laboratory reared mealybugs were placed on each host plant in the cage. The cage was then introduced with six mated parasitoid females. In no-choice condition, each host plant was raised separately and were kept in separate muslin cloth cages. Fifty third instar laboratory reared mealybugs were placed on potted host plant in every cage. Each cage was introduced with one mated female parasitoid. Both the experiments were replicated thrice. After 48 hrs the mealybugs were collected and kept separately in pertri dishes and were observed until parasitoid emergence. Per cent parasitism and sex ratio was recorded in both the conditions. Data obtained were transformed suitably and analyzed using *ANOVA*.

In free choice condition, per cent parasitism ranged between 42.7 and 62.7 per cent. Significantly maximum per cent parasitism was recorded on *A. indicum* (62.7 %). It was followed by *G. hirsutum* (55.3%) which was significantly higher than *H. rosa-sinensis* (52.0%). Significantly minimum parasitization was recorded on *S. melongena* (42.7%). In no-choice condition, parasitization ranged between 48.0 and 65.3 per cent. Significantly maximum per cent parasitism was recorded on *A. indicum* (65.3%) and it was on par with *H. rosa-sinensis* (60.0%). It was then followed by *G. hirsutum* (55.3%) and *P. hysterophorus* (54.7%). Significantly minimum per cent parasitism was recorded on *S. melongena* (48.0%). Sex ratio was found female biased and non significant in both the conditions.

3.16
Efficacy of some biopesticides and insect growth regulators against *Bemisia tabaci* (Gennadius) in *Bt* Cotton

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India is the leading country in terms of area under cotton cultivation and raw cotton production in the world. As per CAB estimate, cotton production in India during 2016-2017 is expected to produce 351 lakh bales of 170 kg from 105 lakh hectare with a productivity of 568 lint/ha. However, as with many cotton growing areas of the world, a major limiting factor in its production is damage due to insect pests. Currently, whitefly management in Punjab relies heavily on synthetic insecticides, however, indiscriminate use of insecticides led to development of resistance and reduced efficacy worldwide as well as concern of environmental impacts. Extracts from plant species may be excellent alternatives to synthetic insecticides as they reduce negative impacts on human health and the environment, possess insecticidal properties (toxicity and insect growth regulation) do not persist in soil, and are non toxic to humans and environment. The present study was undertaken to investigate the bioactivity of different plant extracts and insect growth regulators against adults and nymphs of *B. tabaci* and their consequent effect on development and adult emergence. Whitefly population were collected from the fields of cotton belt and reared on potted cotton plants in screen cage house separately at Entomological Research Farm, PAU, Ludhiana during 2017. Commercial formulation of pyriproxyfen10EC @ 5 ml/l, buprofezin 25EC@ 5 ml/l, spiromesifen 22.9SC @ 2 ml/l, achook 1500 ppm @ 3.33 ml/l, castor oil @ 10 ml/l *neem* oil 300 ppm @ 3 per cent and sesame oil @ 3 ml/l were tested. To carryout development studies, cotton leaves infested with 0-1 day old eggs were dipped in insecticide or in water as a control. Cumulative crawler, 2^{nd} instar, pupation and adult emergence was observed after 10, 15, 25 and 35 days after application of the biopesticide and insect growth regulator. For toxicity parameters test concentration of these was prepared from the commercial formulations with required quantity of distilled water. The leaf disc dip method of bioassay was used to determine LC_{50} values. Concentrations of the biopesticides and insect growth regulators were prepared by serial dilutions of the respective test biopesticide and insect growth regulator with distilled water. The control treatment consisted of distilled water. A bioassay was developed for testing susceptibility in adults. Leaves were cut from *Bt* cotton plants leaving a stem length of 3 cm and these were dipped in test solutions for 20 seconds with gentle agitation and dried. Then, the stem was introduced into a plastic vial with hole on the base and maintained in a rack over a tray containing deionised water. Bioassay was held in these vials at 25^0C. A total of 20 whitefly adults were released

(unknown age) from the population into the vial containing the cotton leaf. Each treatment was replicated thrice including control. Mortality was assessed after 24, 48 and 72 h of exposure to biopesticides and insect growth regulators. Adults that failed to show movement after a gentle touch with a brush were considered as dead. The log concentration mortality regression was estimated by Probit analysis using Polo-PC. After 10 days, highest reduction of the hatchability was caused by sesame oil (2.85% 2nd instar) followed by spiromesifen 22.9SC (19.42% 2nd instar), castor oil (29.75% 2nd instar), buprofezin 25EC (32.52% 2nd instar), achook 1500 ppm (55.05% 2nd instar).The lowest reduction of the hatchability was 55.05 per cent attributed to achook 1500 ppm as compared to control (72.58%). However, no hatchability was observed in pyriproxyfen 10EC and neem oil 300 ppm. After 15 days, highest reduction in hatchability was recorded in *neem* oil (3.05% 2nd instar) followed by sesame oil (12.12% 2nd instar), buprofezin (13.27% 2nd instar) and castor oil (28.52% 2nd instar). The lowest reduction in hatchability was 91.74 per cent (2nd instar) observed in achook 1500 ppm in comparison control (42.20% pupae) and (40.85% adults). However, no hatchability was observed in pyriproxyfen 10EC. After 25 days, highest reduction in hatchability was caused by buprofezin (14.08% 2nd instar) followed by spiromesifen (44.35% 2nd instar). Minimum adult emergence was observed in neem oil (2.17%) followed by achook (26.58%) and castor oil (27.29%). Similarly, after 35 days highest reduction of the hatchability was caused by buprofezin (6.09% 2nd instar) followed by spiromesifen (31.41% 2nd instar). Based on LC_{50} values obtained, the order of toxicity against whitefly population was pyriproxyfen> buprofezin> spiromesifen>sesame oil> castor oil> achook and *neem* oil. Insect growth regulators and plant extracts proved to be effective in reducing the hatchability of the eggs of *B. tabaci*. They showed promising results similar to some synthetic chemical insecticides and therefore, can be used as an alternative to these chemicals in the beginning of crops season being environmentally friendly.

3.17

Surveillance of cotton crop in south western region of Punjab for different diseases

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Cotton crop is the prominent crop in the Malwa belt of the South Western region of Punjab and popularly known as the **"White Gold"**. The survey was carried out for the disease incidence and severity of the cotton crop in the South Western region of Punjab especially in Bathinda, Mansa and Mukstar district in 286 locations in *kharif* 2017. Incidence of mainly viral or fungal disease and the

physiological disorder was noticed in the cotton crop at the farmer's field which leads to yield loss. The major diseases *i.e.* Leaf curl (viral disease), Root rot, leaf spots and sooty mold (fungal disease) and Para wilt (Physiological disorder) were noticed.

Among the 35 recommended *Bt* cotton hybrids for the *kharif* 2017 in Punjab State, 13 *Bt* cotton hybrids were found to be at the 95.4 per cent area of the farmer's field (popular *Bt* Cotton hybrid - RCH 773 BG II at 156 locations) and rest of the un-recommended *Bt* cotton hybrids(JKCH Pass Pass BG II, Gujarat Eshwar BG II, Gujarat Power BG II, Gujarat 715 BG II, Gujarat 161 BG II and Gujarat Josh BG II) constituted the 4.6 per cent area.

The incidence of the cotton leaf curl virus disease noticed for the first time in *kharif* 2017 in the second fortnight of June in Bathinda district at the cotton field having guara crop as intercrop. The disease severity (grades) usually 0 – III grade noticed in the recommended *Bt* cotton hybrids and in the un-recommended *Bt* cotton hybrids 0 – IV and in some isolated pockets V-VI grade were noticed. The root rot noticed in the few pockets at the time of first irrigation (30 DAS).Incidence of the leaf spots noticed at the time of heavy rains about 100-120 DAS in all the *Bt* cotton hybrids/*desi* cotton but its severity were less. Incidence of the sooty mold noticed in the farmer's field having high population count of whitefly or in the farmer's field in which the tank mixing of insecticides or un-recommended sprays done or the field which the farmer's have left.

The para wilt (Physiological disorder) usually found in the cotton field at the time of first irrigation but its incidence noticed in the later stage at after 100-120 DAS when the heavy rains occurred after drought like condition.

3.18

Screening of cotton genotypes for Fusarium wilt resistance through root feeding of pathotoxin

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Screening of genotypes in wilt sick plot is somewhat laborious and time consuming. Moreover, maintenance of soil sickness is always a difficult job. A technique for rapid screening of cotton genotypes against *Fusarium* wilt based on the response of the genotypes to fusaric acid is reported here. The seeds of the cotton genotypes were germinated by towel paper method. Ten days old seedlings were then placed in test tubes containing 0,15, 25 and 35 PPM fusaric acid . Simultaneously, genotypes were also tested under sick soil for their wilt reaction. It was observed that fusaric acid at concentration of 25 and 35 ppm caused complete death of cotton seedlings in both resistant and

susceptible genotypes within seven days. However at 15 ppm concentration, wilting and death of seedlings in susceptible genotype DH 2 occurred within four days, whereas the resistant genotype AKA 7 was able to survive upto 15 days. In control (0 ppm) seedlings of all the cotton genotypes were able to survive upto 15 days when the experiment was terminated. Thus, fusaric acid at 15 ppm differentiated resistant and susceptible cotton genotypes by causing early death of seedlings in susceptible genotype. From the results it is concluded that fusaric acid at 15 ppm concentration differentiates resistant and susceptible genotypes and such test can be used for screening of cotton genotypes for fusarium wilt resistance.

3.19

Screening of some cotton cultivars against whitefly *(Bemisia tabaci)* (Gennadius) (Hemiptera: Aleyrodidae) under agroclimatic conditions of south western Punjab

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A study was conducted to assess the performance of ten cotton cultivars (PBD 18, PBD 19, PBD21, PBD11, PBD1, PBD22, FDK273, FDK275, FDK274, FDK281, LD949 and FDK124) in response to population dynamics of whitefly (*Bemisia tabaci*) in the agroclimatic conditions of South-western Punjab by using RCBD. The experiment was replicated thrice. Observations were recorded on number of whitefly adults per three leaves on weekly basis (15 weeks) from 15-06-2016 to 23-9-2016. The results of the present study indicated that average whitefly population among different cotton cultivars was varied from 6.08 to 8.48 adult / 3 leaves. Highest mean population of whitefly (8.48 adults/3 leaves) was recorded on FDK-124 followed by 8.18, 7.58, 7.25, 7.22, 7.18 whitefly adults/ 3 leaves on PBD 21, PBD 22, PBD 11, FDK 275 and LD 949, respectively. However, PBD 18 was found least susceptible cotton cultivar with average of 6.08 whitefly adults/ 3 leaves. Moreover, results revealed that during the observation period whitefly ranged from 1.3 - 24.0 adults/ 3 leaves. It was clear from the results that July and August months are more important for the management of whitefly in South-western region of Punjab, because maximum population of whitefly was observed during July, followed by August.

3.20
Impact of transfer of technology for the management of cotton whitefly (*Bemisia Tabaci*) in south western region of Punjab

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Punjab faced worst-ever crisis in *kharif* 2015, as nearly 60 per cent of cotton crop was damaged due to severe whitefly (*Bemisia tabaci*) incidence and the lint yield dropped to 2.62 q/ha in 2015 from 6.53 q/ha in 2014. The different factors responsible for failure in whitefly management was unrecommended cotton varieties, delayed sowing, local weather factors, unawareness of the farmers towards whitefly and PAU recommendations, spurious pesticides available in the market, use of insecticidal mixtures of recommended/ un recommended chemicals and faulty spray technology adopted by the farmers. Resultantly, the area under cotton had reduced from 4.5 lakh hectares in 2015 to 2.46 lakh ha in 2016 in Punjab. Alone in district Fazilka, 2.24 folds decrease in cotton area from 2015 to 2016 was recorded. Therefore, in district Fazilka, we took whitefly management as a challenge and initiated extensive campaigns from 2015 itself. Several teams were constituted with a wide agenda including whitefly surveillance around the year, farmer trainings, pesticide dealers trainings, agriculture supervisor/ scouts trainings, weed eradication programme, spray technology demonstrations, and Front Line Demonstrations. Print and electronic media was also involved to create mass awareness regarding whitefly and its management strategies. As a result of these efforts, the average cotton yield in Fazilka increased (7.16 q/ ha) in 2016 which was 3 times higher than that of 2015. Number of insecticidal sprays was reduced to 5-6 in 2016 from 12-16 during 2015. Thus cost of production is reduced and farmer expenditure on the pesticides reduced as unnecessary and unwanted chemical sprays were avoided. Confidence level of cotton farmers has increased to take up cotton as a major crop in the coming season. Increased cotton yield in 2016 in district Fazilka lead to increased cotton area from 35,000 ha to 74,655 ha in 2017.

3.21

Perception of pesticide use and associated risks among farm workers in agricultural farms of south western Punjab

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Farmers and farm workers from six villages of south western Indian Punjab took part in a study that evaluated their knowledge, attitude and practice of pesticide use on crops particularly cotton and paddy. Punjab is the third leading state in pesticide consumption. Most of it is skewed in favor of *kharif* crops due to maximum share of pesticide consumption in paddy followed by cotton. Demographic features of the sprayers/farm workers showed that the majority of them had primary-level education. The duration of work (spraying) by workers on the farms ranged from 2 to 4 months in a year, with majority of them having carried out spraying for less than five years. Their knowledge about hazards from pesticides was indicated by the responses given to the standard questionnaire before and after the awareness programme. Careful working was considered to be very important by all the farm workers. Instead, only 21per cent of them knew about the toxicity labels on the packing, while only 5 per cent suggested the use of personal protective clothing and other equipments. Only 9.5 per cent farmers knew about the signs of inhalation of pesticides, antidotes, regular medical checkup and emergency medical help. To minimize risk from pesticide application, 25.6 per cent were aware about avoiding applications during windy and sunny weather. It was concluded that the innumerable interactions through trainings/campaign, street plays, distribution of literature, school quizzes etc. were helpful in sensitization of the farm workers *w.r.t.* precautions to be observed while mixing, spraying, storage, disposal of pesticides etc. Nearly 20 per cent increase was noted in the number of workers using protection clothing while spraying. An unexpected raise of 27.5 per cent was observed *w.r.t* understanding about ETL, toxicity labels etc. 12 per cent workers were more aware about proper disposal and storage of pesticides. The study indicated that lot more work needs to be undertaken *w.r.t* attitudinal change regarding pesticide use safety, importance of the hygiene and sanitation practices. It is recommended that pesticide safety education be necessarily given to the farm workers/ laborers and their families and pesticide dealers. In addition, low cost protection clothes and information about antidotes should be made readily available.

3.22
Evaluatuion of different management schedule against whitefly, *Bemisia tabaci* in cotton

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The cotton whitefly, *Bemisia tabaci* (Gennadius) has emerged as a major pest of cotton, vegetables and other crops in tropical and sub-tropical regions of Asia. A field experiment was conducted at Cotton Research Area CCS Haryana Agricultural University, Hisar during *kharif,* 2014 and 2015 to find out the effective schedule for whitefly management. There were twelve treatments including control replicated thrice in a randomized block design. The spray of insecticides and botanical were applied at 5 days and 10 days interval. Observations were recorded before and after 5 days of spray on 10 plants /plot. The results revealed that different schedule were statistically superior to reduce the population of whitefly adult in comperision to control (without spray). During 2014 minimum whitefly population (12.99 adults /leaf) was observed in Schedule 2 incorporated with six spray of nimbecidine 300 ppm @ 5 ml/l at 5 days interval + yellow sticky trap followed by Schedule 1 incorporated with six spray of nimbecidine 300 ppm @ 5 ml/l at 5 days interval (13.57 adult/leaf) which were at par with each other. In 2015 minimum whitefly population (18.73 adults /leaf) was observed in schedule 1 incorporated with six spray of nimbecidine 300 ppm @ 5 ml/l at 5 days interval followed by schedule 2 incorporated with six spray of nimbecidine 300 ppm @ 5 ml/l at 5 days interval + yellow sticky trap and Schedule 3 incorporated with spray of nimbecidine 300 ppm @ 5 ml/l altered with triazophos 40EC @ 3 ml/l at 5 days interval + yellow sticky trap. Maximum seed cotton yield 20.73 q/ha was also obtained from treatment 2 and minimum 14.13 q/ha from treatment 9 incorporated with spray of dimethoate followed by imidacloprid, thiamethoxam and dimethoate (at 10 days interval). Hence utilization of botanicals or neem derivatives showed more reduction of the test insect population.

3.23

Elimination of secondary endosymboints through tetracycline treatment leads to significant decrease in virus titre in whitefly, *Bemisia tabaci*

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The whitefly *Bemisia tabaci* is a cosmopolitan pest capable of feeding on hundreds of plant species and transmits several major plant viruses. Cotton whitefly, *Bemisia tabaci* is responsible for 50-70% yield losses by direct feeding and indirectly by producing honeydew and vectoring 115 different pathogenic plant viruses. Multiple symbionts including primary and secondary endosymboints coexist in *Bemisia tabaci.Porteira* is the only primary endosymboints in whitefly while secondary endosymboints includes *Wolbachia, Hemiltonella, Cardinium, Rickettsia, Arsenophonus* and *Fritschea.*These endosymboints have been reported to be responsible for conferring important abilities to their host *B. tabaci* which include insecticide resistance, increased female ratio, thermal tolerance and virus transmission. Several lines of evidence indicates the direct involvement of a 63-kDa GroEL protein, produced by endosymbionts of insect vector exhibit high binding affinity to virus and plays a major role in whitefly mediated virus transmission. The selective elimination of a specific symbiont may be helpful in elucidating their specific roles in their host. Oral delivery with five different antibiotics *i.e.* Ampicillin, Chloramphenicol, Rifampicin, Kanamycin and Tetracycline allow the successive elimination of endosymboints in whitefly. Diagnostic PCR using bacterial specific 16s primers were used to ascertain absence of endosymboints from single whitefly. The primary endosymbiont *Porteira* could not be eliminated with any of the antibiotic. Among all the antibiotics that were studied tetracycline was found to be most effective antibiotic in eliminating secondary endosymboints. Verification of Virus titre in antibiotic treated whitefly has been done through qPCR analysis using the CLCuV specific primers to amplify the coat protein gene fragment . Significant reduction of Virus titre has been observed in tetracycline treated whitefly samples.

3.24
Induced tolerance in *Bt* cotton against sucking insect pests

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All the living beings have their innate capacity to thrive hard and sustain but due to stress they lose their tolerance capacity. The ways and means by which the tolerance in capacity of the plant system can be improved by two means, one is by adding the fertilizers and secondly by use of growth promoters. Plant hormones act readily as elicitors of induced resistance. In this context the present study conducted at Main Agricultural Research Station, UAS, Raichur during *kharif* 2014-2015 was aimed at utilization of most widely used phyto hormones *viz.,* jasmonic acid (JA) and salicylic acid (SA) along with nutrients spray to induce tolerance in *Bt* cotton so as to know how far the crop can tolerate the pest infestation which may help in reducing the insecticide application. The study indicated that when observations were taken at 60 days after spraying, maximum plant height (73.00 cm), highest sympodial branches (9.33/plant), more fruiting bodies (31.67/plant) and highest yield (150 g/plant) was recorded in plants treated with jasmonic acid which was *on par* with salicylic acid followed by nutrient KNO_3. Increased growth and yield parameters in jasmonic acid treatment was due to less population of leaf hopper, aphids and thrips recorded at 30 days after application. This defence mechanism was further confirmed by the presence of higher levels of total sugars (5.76, 4.95 mg), phenols (5.96, 5.35 mg) and tannins (2.99, 2.75 mg) in plants treated with JA and SA respectively under glass house condition. Correlation studies indicated negative correlation of these biochemical parameters with sucking pest population.

3.25
Efficacy of some new molecules against whitefly *(Bemisia tabaci)* in cotton

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Fifteen insecticides *viz.* Bifenthrin 10 EC @800g/ha, Clothianidin 50WDG@ 40g/ha, Diafenthiuron 50WP@ 500g/ha, Fipronil 5SC@1500ml/ha, Imidacloprid 17.8SL@100ml/ha, Phorate 10CG@10kg/

ha, Pyriproxyfen 10EC@1250ml/ha, Spiromesifen 22.9SC@ 500ml/ha, Triazophos 40EC@1500ml/ha, *Verticilium lecanii* 1.15 WP@2.5kg/ha, Nimbicidine@2.5lt/ha, Achook@2.5lt/ha, Acetaphate 50%+Imidacloprid 1.8 % SP@1000ml/ha, Clorpyriphos (50%)+Cypermethrin (5%) EC@1000ml/ha, Deltamethrin 1%+Triazophos 35%EC@1250ml/ha and a untreated control were tested against whitefly in cotton during kharif seasons 2016 and 2017. In both the seasons pyriproxyfen and imidacloprid were found to be most effective in controlling the whitefly population. During 2016, 70.62% and 69.64% reduction in whitefly population 14DAS was recorded in imidacloprid and pyriproxyfen respectively. During 2017, 69.89 and 69.29 per cent reduction in whitefly population 14DAS was recorded in imidacloprid and pyriproxyfen respectively. Fipronil was found to be least effective. Resurgence of whitefly population and phytotoxic effects were also observed in case of fipronil treatment.

3.26
Bio efficacy of some newer insecticide against major insect pests of cotton

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Cotton is the most important cash crop of India, which have worldwide significance. Sucking pests *viz.,* leafhoppers (*Amrasca biguttula biguttula*), thrips (*Thrips tabaci*) and whitefly (*Bemisia tabaci*) are major sucking pests of cotton and cause considerable losses during seedling stage, their heavy infestation reduces the crop yield to a great extent. Insecticides are heavily used in India to control sucking pests. Due to continuous and indiscriminate use of these synthetic insecticides several problems like resurgence, outbreak and resistance have been reported. To overcome with such type of problems discovery of novel insecticide with different mode of action are needed. Novel insecticides are very effective at low doses and have less impact on the environment. An experiment was conducted at Agricultural Research Station, Sriganganagar, (SKRAU, Bikaner) to evaluate the efficacy of new molecules for the management of major sucking pests of cotton *viz.*, jassid, whitefly and thrips during the *kharif,* 2014 and 2015. The insecticides *viz.*, spirotetramat 150 OD @ 500, 600 and 700 ml/ha, imidacloprid (17.8%) SL 125 ml/ha and spiromesifen 240 SC @ 600 ml/ha were applied two times at ETL during both the seasons. Among the treatments, the most effective insecticide in controlling the jassid, whitefly and thrips population was spirotetramat 150 OD @ 700 ml/ha and the least effective was imidacloprid (17.8%) SL @ 125 ml/ha. The order of bioefficacy on the basis of per cent reduction of jassid, whitefly and thrips over control was: spirotetramat >

spiromesifen > imidacloprid. The highest seed cotton yield of 22.42 and 19.32 q ha^{-1} was harvested with higher dosage of spirotetramat 150 OD @ 700 ml/ha during *kharif,* 2014 and 2015, respectively.

3.27
Development of monitoring and management tools for emerging key pests mirid bugs and flowerbud maggots in *Bt* transgenic cotton hybrids

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In India, adoption of *Bt* cotton to contain bollworm menace has seen dramatic increase from 0.038 to >114 m.ha just in fifteen years. Being largest grower of *Bt* cottons hybrids expressing *CryIAc* + *CryIIAb* toxins striking benefits of bollworm suppression (>95%), insecticide usage reduction (60-100%) against bollworms and yield advantages have been harnessed. The reduction synthetic pyrethroids and organophosphate insecticides after introduction of BG-II has led enhanced infestation of non-target species in India and elsewhere. The emerging pests *viz.*, miridbug *Poppiocapsidea (=creontiades) biserratense* Distant (Miridae : Hemiptera) and flowerbud maggots *Dasinuera gossypii Fletcher* (Cecidomiidae : Diptera) which were reported for the first time in 2005 in Southern states of India slowly reached key pest status Karnataka by 2010. The loss encountered by these pests is always huge (40-90%) as they damage fruiting structure directly. The response of these sap feeders to systemic insecticides is very poor to and good to contact molecules. It has been great challenge for farmers to notice the incidence and manage suitably due to lack of information. In order to develop reliable tools for monitoring and management of these two pests various experiments have been conducted during 2014-15 and 2015-16. In a statewide survey Haveri district appeared to be endemic for mirids (25.90 bugs /25 squares) and 22.6% flowerbud maggot infestation followed by Davanagere. This was the area where in outbreak was experienced in 2013. Among 24 popular *Bt* hybrids screened Chaitanya, Jaadoo, Presidentgold were having relatively lesser incidence of these pests in unprotected conditions rendering higher yield. Among different insecticides Profenophos 50EC @ 2.0 mL+ DDVP 100 EC 0.5 mL per liter of water sprayed twice recorded least incidence of mirid bugs (1.17/25 squares) and adult midges (1.39/10bolls) at 7 DAS which was on par with Malathion 50 EC +DDVP or Fipronil 5 SC +DDVP . Thus there was a yield advantage of 5-6 q/ha through plant protection with best possible options. Evaluation of sticky color traps for monitoring was undertaken in research farm as well as farmers fields in endemic area. Yellow colored trap found to be best option by trapping 26 to 32 bugs and 17 to 19 adult midges per 10^2 cm of the trap on weekly bases. This was followed by blue colored traps. Among different sprayers petrol operated power sprayer was convenient and most effective in suppressing these two pests compared to battery as well as manually operated knapsack sprayers. These tools have to be integrated and demonstrated in large-scale for containing deadly new pests.

3.28
Biochemical basis for cotton leaf curl disease (CLCuD) tolerance mechanism in cotton genotypes

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CLCuD which is characterized by upward curling of leaves, vein thickening is the most destructive disease of cotton plant caused by Cotton leaf curl virus (CLCuV). CLCuV belongs to genus *Begomo virus* and family Geminiviridae and has monopartitie genome associated with alpha and beta satellites. It is observed that this virus is dominant in the fields of northwestern India. Cotton plants respond to the disease by active and passive defenses. Hence, the study was accomplished on two contrasting cotton genotypes *i.e.* one highly tolerant (GCH 3) and one highly susceptible (HS 6) to scrutinize the biochemical basis for CLCuV tolerance mechanism. The amount of total soluble protein, total sugar, total phenolic content, gossypol, hydrogen peroxide (H_2O_2), malondialdehyde (MDA) and the activites of phenylalanine ammonia lyase (PAL), catalase (CAT), peroxidase (POX), polyphenol oxidase (PPO) was estimated in virus inoculated and non inoculated leaves of both cotton genotype at 0, 30 and 45 days of inoculation. The results showed that amount of total soluble protein, total sugar, total phenolic content, gossypol, MDA and activity of PPO and POX were higher in inoculated plant of tolerant genotype and lower in inoculated plants of susceptible genotype as compared to their non inoculated plants respectively. H_2O_2 content was higher in leaves inoculated plants of susceptible genotype and lower in leaves of tolerant genotype as compared to their non inoculated plants. CAT activity was found to increase in inoculated plants of both genotypes as compared to their non-inoculated plants but increase was more in leaves of tolerant genotype while the activity of PAL changed non-significantly in inoculated plants of both genotypes as compared to their non-inoculated plants. Thus, the increase in the content of total phenolics, total sugar, gossypol with increase in the activity of POX, PPO, CAT can be correlated with the potency of the plant to strive stress.

3.29
Evaluation of new fungicides against Foot and stem rot incited by *Phytophthora parasitica* var. *sabdariffa* in Mesta

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Field trials were conducted at Agricultural Research Station, Amadalavalasa for four consecutive years during *Kharif* 2013-14, 2014-15, 2015-16 and 2016-17. New fungicides were evaluated against Foot and stem rot incited by *Phytophthora parasitica* var. *Sabdariffa* in Mesta. Among the five different fungicides tested as seed dressing and foliar spray against *Phytophthora parasitica* var. *sabdariffae* in Mesta, the seeds treated with Metalaxyl MZ and further spraying at 30 DAS and 45 DAS resulted in less disease incidence (10.56%) at the time of harvest. It proved superior in all the parameters *viz*, plant height, basal diameter and fibre yield compared to untreated check. The next best treatments were Trifloxystrobin (12.19%), Azoxystrobin (15.01%), Cymoxanil (18.55%) and Copper oxychloride (19.20%). Highest disease incidence was recorded in control plot (33.06%) with lowest fibre yield. The disease incidence was highest at 120 days age of crop stage and before harvest of the crop. All the fungicidal treatments have shown moderately susceptible (MS) reaction compared to control plot (high susceptible reaction).

3.30
Efficacy of combination insecticides against sucking pests of cotton

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A field experiment was conducted during *kharif* 2016-17 in the research farm of the AICRP on Cotton under the Regional Research and Technology Transfer Station (OUAT), Bhawanipatna situated in the Western Undulating Agro-climatic Zone of Odisha to study the efficacy of combination insecticides against sucking pests of cotton. The trial was laid out in randomized block design with three replications at spacing of 90 cm x 60 cm taking Suraj as the test variety. Combination

insecticides treatments *viz.*T_1:Spinetoram 10% + Sulfoxaflor 40% WG @ 120 g a.i/ha, T_2:Spinetoram 10% + Sulfoxaflor 40% WG@ 140 g a.i/ha, T_3:Spinetoram 12% SC @ 30 g a.i/ha, T_4:Sulfoxaflor 24% SC @ 90 g a.i/ha, T_5:Spinetoram 12% SC @ 35 g a.i/ha, T_6:Sulfoxaflor 24% SC @ 105 g a.i/ha, T_7:Pyriproxyfen 5% EC + Fenpropathrin 15% EC @ 37.5 + 112.5 g a.i/ha, T_8:Pyriproxyfen 5% EC @ 37.5 g a.i/ha, T_9:Fenpropathrin 15% EC @ 112.5 g a.i/ha and T_{10}:Control (unsprayed) were evaluated against sucking pests of cotton. Two sprays were given for better efficiency of the insecticides. Observations were recorded from five randomly selected plants for aphids, jassids and thrips population before spraying, at 7th and 14th days after each spray.

All treatments performed well over the control. The lowest population of jassids (0.79 / 3 leaves), aphids (2.75 / 3 leaves) and thrips (0.46 / 3 leaves) were recorded in T_2 (Spinetoram 10% + Sulfoxaflor 40% WG@ 140 g a.i/ha) which was at par with T_1 (Spinetoram 10% + Sulfoxaflor 40% WG@ 120 g a.i/ha) with jassids (1.00 / 3 leaves), aphids (3.71 / 3 leaves) and thrips (0.71 / 3 leaves). Highest seed cotton yield of 21.91 q/ha was recorded in T_2 (Spinetoram 10% + Sulfoxaflor 40% WG@ 140 g a.i/ha) which was statistically at par with T_1 (Spinetoram 10% + Sulfoxaflor 40% WG@ 120 g a.i/ha) with 21.71 q/ha, T_5 (Spinetoram 12% SC @ 35 g a.i/ha) with 20.16 q/ha and T_6 (Sulfoxaflor 24% SC @ 105 g a.i/ha) with 20.06 q/ha.

3.31
Record the bollworms damage on bolls in cotton on different *Bt* gene events

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Cotton, *Gossypium hirsutum* L., is one of the commercially important fibre crops in the world. Being cash crop, it provide livelihood to millions of people associated with its cultivation, textile and apparel industries. Cotton bollworms American bollworm; *Helicoverpa armigera* (Hubner), spotted bollworm; *Earias insulana* (Boisduval) and pink bollworm; *Pectinophora gossypiella* (Saunders) are the most important pests of cotton crop. Cotton yield is highly reduced due to attack of these bollworms. Their damage differs in *Bt* and non-*Bt* cotton genotypes. Therefore, the present experiment was carried out on seven varieties of cotton (five were *Bt* with different gene construct; BIOSEED-6588, NECH-6, JK-1947, SP-7007 and RCH-134; two non *Bt* namely HHH-223 and H-1236) under unsprayed condition. Experiment was carried out at research farm of cotton section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. Bollworms infestation was recorded at 90, 120 and 140 days after sowing. Ninety days after sowing significantly higher boll damage (10.85%)

was observed on non-*Bt* variety H-1236. This was followed by RCH-134 (3.02%) and it was statistically on par with HHH-223 (2.59%). Lowest damage 0.17 per cent was recorded in BIOSEED-6588 and it was superior over all other genotypes. At, 120 days after sowing, 22.67 per cent boll damage was observed on H-1236 which was significantly higher than the rest of the treatments. It was followed by non-*Bt* hybrid HHH-223 (4.82%) and RCH-134 (4.10%) both were statistically at par. Lowest boll damage by bollworms was recorded in BIOSEED-6588 (0.68%). At, 140 days after sowing, significantly higher boll damage by bollworms was recorded on non-*Bt* variety H-1236 (27.66%). This was followed by HHH-223 (8.53%) and RCH-134 (6.38%) and these were statistically on par with each other. Minimum boll damage was recorded in *Bt* genotype BIOSEED-6588 (1.02%) and it was significantly superior over all other genotypes. All the *Bt* genotypes of cotton showed superiority over HHH-223 and H-1236 in managing bollworms.

3.32
Studies on the bio efficacy of carbosulfan in cotton

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Studies were undertaken to find cut bio efficacy of Carbosulfan (25%) EC, its phytotoxicity and effect on natural enemies in cotton at Regional Agricultural Research Station, Khandwa during *kharif* 2014 and 2015. Field trials were conducted with seven treatments in randomized block design with three replications. Seeds of cotton cv. Bunny *Bt* BG II was sown on 25-06-2014 and 20-06-2015 respectively during 2014 and 2015. First sprays of the treatment were given when population of the target pests was above ETL. Second application was taken 15 days after first application. Aphids and thrips (target pests) population was recorded in three top, middle and bottom leaves in five randomly tagged plants in each plot before application and 3,5 and 10 days after application. Similarly, the observations on natural enemies like *Coccinellid* and *Chrysoperla* were recorded. Phytotoxicity assessments in cotton was undertaken by testing Carbosulfan (25%) EC @1250 ml/ha and at double dose of Carbosulfan (25%) EC@2500 ml/ha.

The field experiments during *kharif* 2014 and 2015 concluded Carbosulfan (25%) EC at 1500 and 1250 ml/ha was found to be the best for the control of aphids and thrips on cotton. Carbosulfan (25%) EC treatment with higher dosages did not result in any phytotoxicity symptom on cotton. The application of Carbosulfan (25%) EC @ 1500 and 1250 ml/ha reduces the insect pest population effectively and have resulted in higher cotton yield when compared to other treatments. Carbosulfan (25%) EC is safe to the natural enemies in cotton and there is no adverse effect observed in any of the treatments. Therefore, Carbosulfan (25%) EC can be recommended against the insect pests of cotton i.e. aphids and thrips.

3.33
Pyriproxyfen: A novel IGR for the management of whitefly, an emerging problem subsequent to the introduction of *Bt* cotton

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Cotton, also known as the white gold, is one of the important fiber crops grown in India. The Shift from Desi cotton to Bt incorporated GM cotton also lead to a shift in the pest scenario, It so happened that, the once dreaded bollworm complex was left behind by the sucking pest complex. The current scenario is such that the cotton crops suffered a lot due to severe infestation of sucking pest such as whitefly, thrips and jassids. This change has instigated the scientific community all over and they are now trying to decipher the solution to this emerging pest problem. Going on the same track Pyriproxifen 10% EC (Daita) is one such molecule that has the potential to solve this hyped problem and offer effective solution to the cotton growers. Pyriproxifen, IGR targets the eggs, nymph as well as the adult of Whiteflies and renders them impotent thereby protecting the crop against damage. A study was conducted at Hisar, where Pyriproxifen 10% EC (Daita) was tested in the field at different doses along with other prevalent molecule like Acetamiprid 20SP, Imidacloprid 17.8SL, Diafenthiuron 50WP against whitefly (*Bemisia tabaci*). A comparative study of Pyriproxifen 10% EC (Daita) along with standard check revealed that Pyriproxifen 10% EC (Daita) performed well at the dose of 1000 and 1250 ml/Ha. At 7 days after first application 61.02 and 67.15 per cent control over whitefly adult population was observed at 1000 and 1250 ml/ha respectively, as compared to 47.12 per cent reduction in Diafenthiuron 50WP (Standard check). In case of nymphs significant results have been observed at 7DAA where 62.68 and 66.38 per cent reduction was recorded at 1000 and 1250 ml/Ha of Pyriproxifen 10% EC (Daita) after first application. After second application percent control over nymph and adults was 83.29, 89.50 and 83.55, 89.81 percent respectively @ 1000 and 1250 ml/ha of Pyriproxifen 10% EC (Daita). However in all standard checks, reduction in nymphal population was quite low. Pyriproxyfen (Daita)@1000 ml/ha and 1250 ml/ha found to be most effective for the suppressing nymphal and adult population of white fly. However it does not give a knockdown control of the pest and being an IGR takes a minimum of 3-5 days to express results, but it provides a long term control over the pest. Also it is safer to the environment and the beneficial insects.

3.34
Dissipation and leaching potential of cotton insecticide flubendiamide

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Persistence of flubendiamide was studied in soil collected from cotton growing areas from South India; at two concentrations, 1.0 and 10 ìg g^{-1} and under three different moisture regimes *viz.* air-dry, field capacity and submerged. Trend in dissipation was submerged ($T_{1/2}$ 150.5-158.4 days)>field capacity ($T_{1/2}$ 177.0-181.1 days)> dry ($T_{1/2}$ 206.6-215.0 days). Slightly faster dissipation was observed at 1.0 ìg g^{-1} level as compared to 10 ìg g^{-1} level. Flubendiamide residues persisted in water beyond 250 days with a half-life ranging from 250.8-301 days. Dissipation from water was faster at pH 4.0 ($T_{1/2}$ 250.8 days), followed by pH 9.2 ($T_{1/2}$ 273.6 days) and 7.0 ($T_{1/2}$ 301.0 days). Application of 2.5% compost to soil enhanced degradation of flubendiamide under both field capacity ($T_{1/2}$ 155.1 days) and submerged condition ($T_{1/2}$ 130.8 days). Residues dissipated faster under UV-light ($T_{1/2}$ 7.0-9.1 days), in comparison to sunlight ($T_{1/2}$ 12.0-19.1 days) and dark light ($T_{1/2}$ 33.4-44.2 days). Leaching experiments were carried out in packed soil columns. Effect of analytical grade and its formulation on leaching behavior of flubendiamide was studied. Reduced leaching was observed in case of formulation treatments as compared to analytical grade material. Effect of water available for leaching was studied by passing varying amount of water, simulating 51.92, 103.85, 207.71 and 415.42 mm rainfall, to the columns. Metabolite desiodo flubendiamide was found to be more mobile than flubendiamide. In case of analytical grade flubendiamide even after leaching with water equivalent to 415.4 mm rainfall, more than 68.08% residues remained in top 5-10 cm soil layer.

3.35

Biorational management of Bihar hairy caterpillar, *Spilosoma Obliqua* Walk. (Arctiidae: Lepidoptera) in jute (*Corchorus Olitorius* L.) under Terai agro climatic region of West Bengal

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Field experiments were conducted at instructional farm, Cooch Behar Krishi Vigyan Kendra, Pundibari, Cooch Behar, West Bengal during the pre *kharif* seasons of 2015 and 2016 to evaluate some biorational insecticides against Bihar hairy caterpillar (*Spilosoma obliqua* Walk.) infesting tossa jute (*Corchorus olitorius* L.). Eight treatments *viz.,* chlorantraniliprole 18.5SC (0.3ml/l), flubendiamide 480SC (0.3ml/l), emamectin benzoate 5 SG (0.4ml/l), indoxacarb 14.5SC (1ml/l), *Beauveria bassiana* (5g/l), *Bacillus thuringiensis* (*Bt*) (2g/l), azadirachtin 1EC (2ml/l) and quinalphos 25EC (2ml/l) were applied along with control (untreated check). The experiments were laid out in randomized block design (RBD) with three replications. The treatments were applied twice at ten days interval. The results revealed that the most effective treatment in controlling the bihar hairy caterpillar was flubendiamide 480 SC followed by chlorantraniliprole 18.5SC with lowest mean larval population as well as higher yield. Per cent reduction of hairy caterpillar over untreated control was highest in flubendiamide 480 SC (83.24%) followed by chlorantraniliprole and indoxacarb.

3.36

Management of whitefly in cotton with novel insecticide and biopesticide combinations

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The cotton production has greatly reduced in the year 2015 in Haryana and Punjab due to heavy attack of whitefly. The excessive and indiscriminate use of insecticides for the control of sucking pests has resulted in development of insecticide resistance to cypermethrin, acephate, chlorpyriphos,

dimethoate, monocrotophos, oxydemeton methyl and quinalphos. The management of *Bemisia tabaci* is challenging task as well as having ill-effects to human health and environment in the present day scenario upon using the insecticides for the control of the pest. So, a field experiment was conducted during *kharif* 2016 at Entomology Research Area of CCS Haryana Agricultural University, Hisar. Among nine treatments T_8 (Neem Baan 1500 ppm @ 1.0 l/acre + thiamethoxam 25 WG @ 40 g /acre + Neem Baan 1500 ppm @ 1.0 l/acre) was better, where the minimum population of adults and nymphs were found during 3rd DAS (1.89 adults/leaf), 5th DAS (1.78 adults/leaf), 7th DAS (2.11 adults/leaf) and 7th DAS (8 nymphs/leaf) but T_1 was found safest to the natural enemies with 1.89 per plant natural enemies population and had highest BC ratio (1.17). Use of newer insecticide chemicals in combination with biopesticides have been proved safer to natural enemies population and also had higher BC ratio than the use of newer insecticides alone. The insecticide combinations have successfully managed the whitefly populations.

SOCIO ECONOMIC DEVELOPMENT

4.1
Impact of FLD intervention on yield, adoption and horizontal spread of cotton crop in Pali district of Rajasthan, India

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The present study was undertaken in the villages of Pali district of Rajasthan where on cotton var. MRCH 6025 was conducted by KVK, Pali during *kharif* season from 2011-2012 to 2015-2016 (five consecutive years) in the farmers' field in fifteen adopted villages. During these five years of study an area of 105 ha was covered with plot size of 0.40 ha under front line demonstration with active participation of 250 farmers. Before conducted FLDs, a list of farmers was prepared from group meeting and specific skill training was imparted to the selected farmers regarding different aspects of cultivation etc. Out of the total participating farmers, 180 respondents were selected by random sampling method. The front line demonstrations enhanced the yield of crops vertically and ensured rapid spread of technologies horizontally. The FLDs made positive and significant impact on yield enhancement of cotton by 56.20 per cent. Impact of FLDs on adoption of technologies showed increased trend in adoption of cotton production technologies by 82.55 per cent, respectively. FLDs made positive impact adoption of improved varieties, enhancing up and drum rolling operation of cotton and adoption of recommended varieties of cotton. Further, local variety of cotton was replaced by MRCH 6025 on large scale in demonstration cluster. FLDs organized by KVK Pali made significant impact on horizontal spread of technologies. It was found FLD is proven extension intervention to demonstrate the production potential of different crops on farmer's field. Therefore, it is recommended that stockholders who are engaged in transfer and application of agriculture technologies on farmers' field should give priority to organize FLD extensively in cluster approach for enhancing productivity potential of main crops and to make rapid spread of flagship technologies. Most of the low yielding local varieties are replaced due to FLDs. Therefore it is suggested that policy maker may provide adequate financial support to frontline extension system for organize FLDs under close supervision of agricultural scientists and extension personnel. This may help to raise the agricultural productivity at district, state and national level.

4.2
Microbial resistant cotton fabric

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Hygienic textiles and congenial micro environment are prime requirements for human beings to live healthy. It is necessary to impart different physical and chemical treatments to fabrics. An innovative approach is to apply the plant extract containing active substances to make the cloth microbial resistant. Extracts from plant sources with active substances are eco friendly, non toxic and non allergic. Guava, *(Psidium guajava L.)* an important member of *myrtle* family (*Myrtaceae*) is a tropical plant found in hot climatic areas all over the world. There are bioactive components in the Guava leaf that can fight against pathogens, regulate blood glucose levels, and can even aid in weight loss. Guava leaves are also effective in eliminating acne and black spots from the skin. They contain an antiseptic that can kill acne causing bacteria. The phenolic compounds found in Guava leaves possess antioxidant and antimicrobial properties. Aqueous extracts of guava leaves are described to be effective against a number of microbial strains like *Aeromonashydrophila*, *Shigella* spp. and *Vibrio* spp., *Staphylococusaureus, Escherichia coli*, *Pseudomonas aeruginosa* and *Bacillus subtilis.* Microbial action is a dominant factor limiting the service life and performance of all textile. Cotton covers almost all the possible fields of human living from formal and informal clothing, home furnishing items to textile materials used in several medical applications etc. Cotton fibres have cellulose which provide basic requirements such as moisture, oxygen, nutrients and temperature for bacterial growth and their multiplication. Unfortunate odors in shoes and clothing come from micro-organisms that feed on moisture, heat and humidity to survive. With antimicrobial textile product protection, clothing and other textile materials can stay fresher for longer. From odor-resistant clothes and footwear to mould and mildew-inhibited window coverings, antimicrobial treatment can be helpful for healthy living.

4.3

A study on scientific cultivation of *Bt* cotton in Hisar district of Haryana state

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A study on scientific cultivation of *Bt* cotton was carried out in Hisar district of Haryana state during 2015-2016.The data were collected with the help of personal interview schedule from 100 *Bt* cotton growers .The major findings of the study were that only 48 per cent of *Bt* cotton growers were having medium knowledge level about recommended practices of *Bt* cotton cultivation. A very high percentage of the *Bt* cotton growers had correct knowledge about the sowing and harvesting time (89%). Majority of the *Bt* cotton growers were between the age of 35-45 years. Fourty per cent of the *Bt* cotton growers were having the education up to middle school. Sixty per cent of the *Bt* cotton growers were having farming experience more than 10 years and almost none of the farmers was using Reffugia while sowing of *Bt* cotton. It was found that there was positive and significant relationship between knowledge level and education. It was also found that there was significant relationship between knowledge level and agricultural experience. The problems faced by majority (90%) of the respondents expressed that they do not know fertilizer calculation, 86 per cent of the respondents expressed heavy occurrence of sucking pests particularly whitefly followed by delay in sowing due to unfavorable climatic conditions(66%) and the inadequate storage facilities(80%) as the main constraints in adoption of scientific *Bt* cotton cultivation practices. To reduce technological gap in *Bt* cotton cultivation that majority of respondents (98%) suggested to generate awareness among the farmers regarding use of IPM practices for the control of insect pest and diseases particularly whitefly, importance of soil testing and fertilizer dose on the basis of soil test, easily availability of original seed and fertilizer.60 per cent of the respondents suggested that university should test and recommend the high yielding seed

4.4
Handloom weaving: A capacity building programme for self-help group women

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The handloom sector is the second largest employer in India providing employment in tune of 65 lakh persons. The sector represents the continuity of the old age Indian heritage of hand weaving and reflects the socio- cultural tradition of the weaving communities. There are number of government schemes that provide assistance for this sector in new five year plan. Self help groups (SHG) of women in India have been recognized as an effective strategy for capacity building of rural as well as urban women. Training is a major catalytic force for augmenting human productivity in all spheres of development. Proper training in handloom weaving and value addition is needed to take up as an entrepreneurial activity for SHG's. Present study was conducted in *Dhangar and Bhighar* villages in Fatehabad district of Haryana state. Intervention on handloom weaving was given to twenty five SHG women of each village for 45 days by weaver service centre, Panipat. Five products namely *durrie, khes*, towel, bed sheet and tool mat were prepared by SHG during training period. All the respondents (100%) had low knowledge regarding towel weaving followed by bed sheet weaving (92%) and *durrie* weaving 40 per cent. For reinforcement and practice *addas* and raw materials were provided at each centre. Technical know how was also provided through literature. After completion of intervention, majority of them (52.0%), and 44 per cent succeeded in gaining high level knowledge in *durrie, khes* and toot mat weaving. Skill acquisition was found in high category regarding *durrie* weaving (84.0%) and foot mat weaving (72.0%). Training impact in terms of knowledge gain, attitudinal change and skill acquisition was found 49.77 per cent regarding handloom weaving. Adoption feasibility index was found 82.28 per cent on five attributes. Major constraints in adoption of handloom weaving as an entrepreneurial venture perceived by SHGs during training were 'non co-operation' of SHG members (88.0%) in using resources 'less time allotment' for work on *addas* (80%) and 'within group conflicts' reported by 72 per cent. Self help group effectiveness index was found 50.45 per cent on different traits of SHGs, which speaks of a moderate level functioning.

4.5
Eco friendly antimicrobial cotton fabric

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Natural fibers such as linen, cotton, rayon and silk are comfortable, absorbent and cooler. One of them, cotton can easily absorb the sweat one experiences in tropical climates as it is wonderfully lightweight, breathable, soft to the skin and easy to maintain. Due to the high humidity present in tropical climates, micro-organisms create problems in textile, including discolouration, stains and fibre damage, unpleasant odour and a slick, slimy feel which may cause skin rashes and irritation. Cotton fabric is more susceptible to bacterial attack because they retain oxygen, water and nutrients. These are not only the carriers of micro-organisms such as pathogenic bacteria, odour generating bacteria and fungi, but also good media for the growth of the micro-organisms. The consumers are now increasingly aware of the hygiene and potentially harmful effect of microbes. An increasing interest in the textile has been noticed in the functionalization based on environment friendly and biodegradable reagents which possess the necessary bioactive properties as substitute for toxic chemicals. Therefore, there is a great demand for textiles with antimicrobial or self cleaning properties. Among these, the antimicrobial property of fabric is being considered to be an important and inevitable parameter. There are many natural products, which show anti bacterial properties like extracts from roots, stem, leaves, flowers, fruits and seeds of diverse species of plants. Now, there is a good deal of demand for the fabrics having functional or speciality finishes. An application of Peach leaves which are available in abundance especially in autumn is an effective treatment for bacterial resistance on cotton fabrics. Peach plants and their parts are well known for medicinal and healing properties from centuries. Though a number of commercial antimicrobial agents have been introduced in the market. Recent developments on Peach leaves extract have opened up new avenues in this area of research.

4.6
Jute cultivation and jute industry in Meghalaya: Current scenario and future prospects

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Jute is one of the major fibre crop of India next to cotton. The cultivation of jute in India is mainly confined to the eastern region of the country and it is grown in seven states of the country viz. West Bengal, Assam, Orissa, Bihar, Uttar Pradesh, Tripura and Meghalaya. In Meghalaya Jute is grown exclusively in the Garo Hills District due to the favourable weather and soil conditions. Jute area has increased from 3.9 ('000 ha) in 2010 to 6.6 ('000 ha) in 2015 and it accounts 0.5 per cent of total jute area. An increase is noticed in its production from 34.4 ('000 Bales of 180 Kg. each) in 2010 to 66.3 ('000 Bales of 180 kg each) in 2015. Similarly there has been an increase in the yield of jute from 1586 kg/ha in the year 2010 to 1810 kg/ha in 2015. During the five years period (2010-2015). In Meghalaya Jute is the second most cultivated fibre crop next to cotton. Jute is a very important cash crop of the state, and it also grows well in certain parts of the State. Presently there are few small scale industries and individual household production units which are involved in manufacturing various jute products like jute bags, jute mats and several other jute handicraft. Therefore government support, proper planning, effective marketing network along with popularization campaign on various advanced technologies, will create employment opportunities for unemployed youth as well as help in improving the standard of living of resource-poor jute farmers which will uplift the state's economic condition as a whole.

4.7
Study on efficacy of natural dye on cotton fabric

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Natural dyes are dyes or colorants obtained from plants, animals, insects and minerals. Most of the natural dyes are obtained from parts of plants, leaves, flowers, stem, bark and root etc. Natural dyes

are abundantly available in North Eastern part of India throughout the year. Processing of natural dye is easy as well as safe from the point of view of environmental pollution. They are mild, eco-friendly, non-toxic in nature, good for health and skin. Nowadays people are becoming health conscious. They are going after organic textile or herbal or natural. They also prefer natural dye instead of synthetic dye which causes serious health hazard like cancer and influence negatively the eco-balance of nature. Dyeing with natural dye is more suited with cotton fabric as cotton is considered to be relatively an easy fibre to dye and print. The ease with cotton takes up dyes and other colouring matter is due to the polarity of its polymers and polymer system. When dying cotton fabric with natural dye, it gives a creative natural finish to the textile material. In this study, attempt has been made to find out the efficacy of curcuma longa on cotton fabric. Curcuma was crushed and boiled for 30 minutes to extract dye juice. Mordants were used to increase colour fastness and also to give different shades of the finished product. In this experiment, 5 treatments were undertaken. In the first experiment, cotton fabric was dyed with dye solution. In the second experiment, it was dyed with tannic acid, alum and dye solution. In the third experiment, it was dyed with tannic acid, ferrous sulphate and dye solution. In the fourth, it was dyed with tannic acid, stannous chloride and dye solution. In the fifth and final experiment, it was dyed with tannic acid, potassium dichromate and dye solution. By using these different mordants, it gives different shades of colour and has even penetration. In this experiment, colour fastness to sunlight, washing and pressing in dry and wet condition was also observed. Hence, natural dye could be utilized on a large scale as a substitute to the synthetic dye and could improve the livelihood of many farmwomen by enhancing their income generation.

4.8

Growth and instability of fibre crops in India: Scope in north east India

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In India, the major fibre crops are cotton, jute and mesta with total area of 13083 thousand ha, 749 thousand ha and 59 thousand ha, respectively during 2014-2015 (GoI, 2016). These fibre crops play an important role in countries economy as it gives employment either directly or indirectly in agriculture and industrial sectors in production, processing, textile and other activities and by way of export to other countries (CAB, 2008). The area under cotton was highest in Maharashtra (4192

thousand ha) followed by Gujarat (3010 thousand ha) and Andhra Pradesh (2540 thousand ha). In case of jute, the area was highest in West Bengal (567 thousand ha) followed by Bihar (95 thousand ha) and Assam (70 thousand ha). Regarding productivity of cotton, Tamil Nadu ranked first with total productivity of 718 kg/ha followed by Punjab (648 kg/ha) and Gujarat (626 kg/ha). While, in case of jute, the highest productivity was observed in West Bengal (2795 kg/ha) followed by Bihar (2413 kg/ha) and Assam (1975 kg/ha). The present study analyses the growth and trend in cotton, jute and mesta in India using compound annual growth rate (CAGR) and also explores the scope of fibre crops in North-East India.

4.9
Banana fibre extraction with different spices and methodology at hill district of Manipur

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The productivity of fruits from banana is less in all the state of the north east. Both wild and cultivated generate huge quantity of biomass all of which goes as waste and the above ground parts like pseudostem and peduncle are the major source of fibre. Fibre quality can be use As raw material for agro- industry for production of range of products like paper, cardboards, tea bags, currency notes and reinforced as polymer composite in high quality dress materials. North east is the hot spot of the banana, where in area under wild banana is more than edible one. Fibre quality varies plant type and extraction procedure. Among the fermented extraction (retting) and fresh extraction (mechanical method) the fibre was tested with two different spices of banana (*Musa acuminate* and *Musa balbisiana*). Retting has smooth surface and better workability. The tenacity was better in retting process but not significant. *M. balbisiana* has are better quality of fibre than cultivated type. The man day requirement for was less in mechanical extraction.

4.10
Women empowerment through banana fibre production in RI-Bhoi district of Meghalaya, India

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Field demonstrations, awareness and training programme were conducted on banana fibre production during 2012-2014 at five different villages for women SHG member of Ri-Bhoi district of Meghalaya to study the feasibility of banana fibre production for women empowerment. The Results revealed that about 250 -300 g of fibre was obtained from 9-10 kg of raw banana pseudo stem. Wild banana fibres were found to be rougher, thicker and stronger as compared to jahajee and champa cultivar. Colours of the fibres vary with the variety of the banana. The fibre was used as such or blended along with jute fibre and prepared products such as bags, hats, coasters, door mats etc. The total fibre production per year was 2200 kg with the net return of Rs.91600/year with B : C ratio of 2.09. However, the total value added products (coasters/doormats) of 480 nos with net return of Rs. 57600/ year with benefit cost ratio of 3.0. Hence, the banana fibre extraction with machine was found to be beneficial for fibre and value added product preparation for the empowerment of rural women with additional income.

4.11
Cotton simulation models and on farm decision approach – A Review

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Crop simulation models are valuable tools the scientists can use in testing hypotheses. Models are used to recognize the areas where knowledge is missing, signifying the need for future research activities. Within this, models are being used as decision support systems at the farm level to optimize resource management. The cotton simulation models *viz.*,GOSSYM,Cotton Production Model (CPM), Cotton2K and SUCROS-Cotton etc. simulates cotton growth, development and yield.These models has been used for over 20 years as an on-farm decision support tool by cotton growers and

consultants resulting in increased profits to cotton producers. By optimizing the inputs such as chemical fertilizers, insecticides, plant growth regulators and harvested chemicals, the model not only contributes to increased yields but also helps to decrease environmental contamination. The use and application of the model in research management, yield forecasting, and farm management is reviewed. Also, the application of cotton simulation models on the impacts of projected climate change on cotton production is reviewed.

4.12
Technological interventions for management of whitefly in *Bt* cotton

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Cotton is the world's most important fibre crop. Cotton is grown in India in three distinct zones: Central zone (65 % of total area; Gujarat Madhya Pradesh, Maharashtra), the South (20 %; Karnataka, Andhra Pradesh and Tamil Nadu) and the North (14%; Punjab, Haryana and Rajasthan). The growth, development and yield of the cotton crop are considerably affected by abiotic factors i.e. air temperature, cloud cover, relative humidity, rainfall and radiation. Climate change is most likely to impact cotton yield through weather condition variations that leads to changes in temperature, rainfall, soil moisture and humidity, and the levels of pest and diseases. Cotton crop has been devasted by approximately 162 insect-pest species and economically important insect pest are leafhoppers, whitefly, aphids, mealy bugs and boll worm (American boll worm, pink boll worm and spotted boll worm). A hot and humid climate, as is being witnessed in cotton producing areas of Sirsa, Hisar, Fatehabad, Jind, Bhiwani and Mahendragarh districts of Haryana, is considered conducive for the whitefly attack. Farmers shifted to other crops after incurring huge losses due to whitefly pest attack during the season *kharif* 2015. Instead, farmers have shifted to pulses, paddy and other crops as a result of which, cotton area coverage in Haryana fell 14% to 5 lakhs hectares during 2016 as against 5.8 lakhs hectares in 2015. To manage this problem as per direction of CCS HAU, Hisar an integrated crop management practices with some technological interventions viz. weed management, selection of suitable hybrids, discrase cocktail of insecticides and more sprays below ETL level, use of bio-pesticides and foliar spray of fertilizers were undertaken by CCS HAU,Krishi Vigyan Kendra, Fatehabad through farmers trainings, group meetings, farmer field schools, farmer scientist interactions and campaigns in adopted villages. Regular survey was done and data on yield were collected from 45 farmers and economics was worked out. The data reveals that average

yield 21.8 q/ha was recorded after KVKs intervention during 2016 as compared to 16.4 q/ha during 2015, which was 32.93 per cent higher over previous year. The B:C ratio worked out during 2016 was 1.03 , while it was 1.42 during 2016.

4.13
Gender friendliness of transfer of technology programs in cotton

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In India, various Transfer of Technology (TOT) programs in cotton have been implemented underlining the importance of problem solving, creating effective scientists and farmers linkage and transferring the latest cotton production technologies. Front Line Demonstrations, Farmers Field Schools, Contract Farming Approach are some of the TOT programs which created remarkable impact on cotton production. Analysis on the laurels and let downs of those initiatives revealed that they have high farmers’ acceptability due to its focus on problem solving and the practical application of knowledge. But the acceptability of these TOT programs by the women farmers was remained as a less attempted researchable problem. The acceptability of any TOT programs by the farmwomen generally depends upon the women friendliness of the programs. Women are the major source of knowledge for cotton farming and they have accumulated a variety of indigenous technical knowledge. Women perform many tasks in cotton farming. They constitute almost half of the work force engaged in cotton farms. They participate in a broad range of activities in cotton farms such as production, processing, preservation and marketing. They play key roles in the entire cropping system, starting from the selection of seeds through sowing, manuring, weeding, harvesting, cleaning, drying, stacking and storing to marketing. They play a major role in the decision making process at the farm household level regarding the choice of varieties / hybrids as well as the performing the crop protection measures. A study was conducted to analyze the gender friendliness of popular cotton extension programs viz., Front Line Demonstration and e-Kapas network among 120 regular women e-Kapas beneficiaries and 50 FLD women beneficiaries in South India. The data collected through personal interview using a semi structured interview schedule with an exclusive scale to analyze the women friendliness of cotton TOT programs found that the cotton extension programs both FLD and e-Kapas network were having medium level of women friendliness. Lack of awareness, lack of inclusiveness, not owning the gadgets and lack of time were the major constraints experienced by the majority of the women farmers in involving cotton TOT programs. Creating awareness about cotton extension programs among women, fixing reservation for women in cotton extension programs including training programs, finding solutions for labour scarcity,

hands on training to handle the gadgets for understanding the new ICT based TOT and considering the opinions of women farmers while formulating the TOT programs were the suggestions expressed by the women beneficiaries to improve the women friendliness of future cotton extension programs.

4.14
Cotton production in Meghalaya: Growth performance and decomposition analysis

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The present study assess the contribution of area, yield and their interaction effect to growth in production of cotton and compound annual growth rate in area production and yield of cotton in Meghalaya. The Time series data on area, production and yield of cotton for the period were collected from Secondary sources like Directorate of Agriculture, Shillong and Directorate of Agriculture, Shillong Meghalaya. Decomposition model proposed by Sharma (1977) was used to examine the contribution of area, average yield and their interaction effect on cotton production. The compound annual growth rate of area, production and yield were worked out using the formula recommended by Dandekar (1980). The study found that over the year from 2003 to 2016, yield effect has the highest contribution (94.48 %) to change in the production of cotton followed by area effect (4.11%) in Meghalaya. In the Meghalaya both production and yield of cotton was increased at the compound annual growth rate of nearly 0.52 and 1.97 percent per annum respectively, while the growth rate in case of cotton area was 0.08 percent per annum during the 2003 to 2016 in the Meghalaya.

4.15

Diversification in cotton crop and constraints perceived by rural women in Hisar district

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The choice of a cropping system is dependent primarily on physical variables and secondary on size of operational land holding, marketing and transportation facilities, capital price policy of government and techno organizational factors. In Haryana state, Hisar and Sirsa are the two major cotton producing districts accounting for 80 percent of the acreage and 86 percent of the cotton production in the state. It covers only 1.4 percent of total geographical Area of India. The problem of diversification has been studied by many geographers and the main advantage of the study of crop diversification is that it provides a relationship between the relative a real strength of crops grown in the region. The study for patterns of crop diversification in a state like Haryana becomes more relevant where more than 82% of the total population is engaged primarily in agriculture directly or indirectly. Therefore, the study is undertaken to see the pattern of diversification in the existing cropping pattern. With the Passage of time Haryana made rapid progress in the field of agriculture since its creation and it has achieved a prestigious position among .There are two main cropping season in Haryana Kharib and Rabi, Kharif Crops are sown in the month of may and June and harvested in the month of october- November like Rice, Cotton, Jawar, Bajra, Maize etc Rabi crops are sown in October and November and harvested in the month of March and April like wheat, gram, mustard, barley are the main crops of this season. Cropping pattern of Haryana mainly dominant by coarse cereals like Jowar, Bajra, gram. With the introduction of HYV technology, expansion of irrigation facilities, increase in the use of chemical fertilizer, cropping pattern has changed. Crop diversity specifically is important factors in improving livelihoods. Crop diversity also helps the farmer reduce risk - if one crop fails or market prices drop, other crops can compensate for the loss. Keeping all this in mind, in the present paper, an attempt has been made to analyze the scenario of diversification in cotton crop and the constraints perceived by rural women in Haryana. Total 20 rural women from village Gawar, who were picking cotton in the field, were selected for data collection . Regarding diversification women told that they produce ***til*** with cotton and when cotton crop is scattered; Okra is sowed along with cotton. 53.0 percent women told that they could pick 40-50 kg of cotton per day, if they start the work at 6.00 am and finish it at 6.00 pm i.e. in 12 hours and earn upto Rs.300-Rs.500/-/day. Cent per cent women used their *duppatta* as cotton pick bag and could collect up to 5-7 kg of cotton/hour. As far as constraints are concerned, 35.0 percent complained about pain and swelling in feet, thighs and lower calf. Cent percent women complained of tanning, 10.0 per cent women told that cotton picking is a good exercise for shoulders and fingers.

4.16
Adoption of recommended silkworm rearing technology in the district of erode in Tamil Nadu

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A study was undertaken on level of adoption of recommended silkworm rearing technologies in five blocks of Erode district of Tamil Nadu based on farmers personal as well of their socio economic status. Adoption of improved technologies in the above aspect aid those to get attain with maximum potential level of production and thereby they able to enhance their income... The level of adoption by them was categorized as high, medium and low, respectively in the part of the study in order to find out the area, in which the weakness in adoption level exists and thereby it is possible to make remedy by means of addressing and intervening by respective Block Departmental functionaries and in turn by policy makers as well to maximize production level in quantity as well in quality wise. Many numbers of farmers are used to adopt the practices of rearing houses under hygienic condition by following adequate disinfection procedures and are maintaining it throughout the period of silkworm to become attaining of level of formation of cocoon by ranging from 91.6 to 98.3 per cent without any lapse. Moreover, many of the farmers had separate rearing houses of their own (92.5%), and they tend to preserve their collected shoots be kept under upright position (87.5%). The medium level of adoption was observed in the practices of maintaining rearing houses under optimum temperature condition and the frequency of feeding and use of appliances by 65.0 and 67.5%, respectively. It was found out that the performance of task as a weakness part in silkworm rearing for maximizing the production level is lack of early brushing in summer season. Those farmers, who had good educational background, those possessing of good working experiences and those likelihood of getting more information sources and use of available utilization of resources are able to receive higher level of income from the sericulture rearing houses besides their farm income.

4.17
Packaging and emerging technologies on cotton and other fiber crops production for Indian/ International agro based industries for improvement

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The objective of this study is evaluating the innovative packaging on the Cotton **("King of Fibers"** and **"White Gold")** is one of the most ancient and very important commercial crops of global importance with a significant role in Indian agriculture, industrial development, employment generation and improving the national economy. It is cultivated for domestic consumption and also exported worldwide. In this study, I introduced the large number of private sectors; *Bt* cotton hybrids have brought a welcome change in recent times as far as production gains are concerned. Keeping in view the present day threats in cotton and other fiber crops cultivation and sustainability and to tap new opportunities or improvements, is being organized with the packing and safety of products will be beneficial to all those associated with fibers crop research, development, cultivation, pesticide, seed and textile industry and generate new ideas and plan new strategies for cotton and other related manufactures of agro based industries in relation to changing climate or environment so as to track a pathway for 21st century Efficient utilization of natural resources with new state of the art options such as remote sensing, , GIS, informatics, modeling and automation in harvesting and better communication to the farming community. Emerging technologies research is a comprehensive analysis of the most promising and disruptive technology poised to impact our nation as well world in the next few years. This is a flagship research of the crop, the global emerging technology, innovation and convergence focused practice of farmers and public industrial manufactures. Today's agricultural university is one of the verges of turning into a high tech industry from family farms too smart for factories. The fourth agriculture revolution is already on its way. Due to the effect of the disruption drivers, agriculture faces challenges that offer significant, untapped growth for opportunities.

4.18
Ultrasound assisted extraction of cottonseed oil

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Abstract: The objective of present study was to decide optimum conditions for ultrasound assisted extraction (UAE) of cottonseed oil. The statistical optimization was carried out by using central composite design (4 factors, 5 levels) of Response Surface Methodology. The effect of processing variables: amplitude (A, %), extraction temperature (Te, °C), solvent/seed ratio (LS) and pulse duration/pulse interval ratio (PD/PI) on oil recovery was studied by fitting second order polynomial model to the experimental data. The results revealed that cottonseed oil recovery of 36.03 ± 0.904 per cent (92 % of total oil content) could be achieved at optimum conditions of UAE as 50 per cent A, 52°C Te, 16:1 LS and 0.5 PD/PI. Significant linear effect ($p<0.01$) of A, LS and PD/PI was observed on oil recovery. The interaction of PD/PI with temperature as well as with LS significantly ($P<0.05$) affected cottonseed oil recovery. Qudratic effect of A, Te and PD/PI also showed highly significant effect ($p<0.01$) on cottonseed oil recovery. The iodine value (102 ± 0.37 g iodine/100 g), saponification value (191 ± 0.42 mg KOH/g), free fatty acids content (1.28 ± 0.05 % oleic acid) and acid value (2.61 ± 0.02 mg KOH/g) of cottonseed oil obtained through UAE were found within acceptable limits specified for raw cottonseed oil.

4.19
Studies for development of organic farming package of practices of cotton crop in north west Rajasthan

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ABSTRACT : To develop the organic farming package of practices of cotton crop, an experiment was conducted at ARS, Sriganganagar in RBD design with 3 replications during *kharif* 2014 to 2016. Three production systems *viz.,* Organic approach, INM and organic intensive were taken with three, three and one nutrient management treatments, respectively. In organic approach, (100%) N through FYM was applied @ 200 q/ha whereas, in 50% N through crop residue treatment, mustard straw @

35 q/ha was applied at the time of last prepatary tillage before sowing gypsum, micronutrient (Zinc Sulphate) and neem cake were applied @ 150 kg, 40 kg and 6 q/ha, respectively. In organic approach, three sprays of neem oil @ 5 ml/l of water were given for the control of insect pest, however in INM and organic intensive chemical sprays were used.

Among the three approaches, highest mean seed cotton yield (19.07 q/ha) was recorded with (50%) RDF + (50%) N through FYM + bio fertilizers + zinc sulphate application @ 24 kg/ha but it was at par with 100% N through FYM + bio fertilizers (18.48 q/ha) and organic intensive treatment 75% N through FYM + (12.5%) N through crop residue and (37.5%) N through neem cake. In organic approach treatments, (50%) N through FYM recorded highest mean seed cotton yield (18.48 q/ha) followed by (50%) N through FYM + (50%) N through crop residue + gypsum @ 150 kg/ha.

Soil analysis data after harvesting of cotton crop indicated significant improvement in organic carbon (0.30%) as compare to alone application of 100% RDF (0.27%). The net returns and B:C ratio of different treatments were also calculated. (100%) N through FYM recorded highest mean net return (Rs. 87,110) and B:C ratio (2.85) as compare to (50%) RDF + (50%) N through FYM due to 25% higher selling rate of organic cotton (Rs. 7250/q) as compare to general cotton (Rs. 5800/q). Above mentioned results indicate that organic cotton can be successfully grown in north west Rajasthan with higher net return as compare with inorganic cotton cultivation traditional doing in this zone.

4.20
Effect of mercerization on thermo physiological comfort properties of cotton fabric

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Thermo physiological comfort is related to the fabric's transmission behaviours; namely thermal resistance, water vapour permeability, air permeability and wickability. The study was aimed to evaluate the effect of different mercerization techniques on thermo physiological comfort properties of woven cotton fabric. Desized, scoured and bleached cotton fabrics were subjected to four different mercerization treatments at two levels of temperature (20°C and 65°C) under two different conditions (tension and slack). Non-mercerized fabric was served as control. Mercerization caused significant changes in physical properties, surface morphology and crystallinity of cotton fibres, facilitating changes in thermo physiological comfort of fabric. Results showed that slack mercerized fabrics (in hot and cold conditions both) presented high thermal insulation values (0.499 and 0.529 clo) over

control fabric (0.471 clo). The reverse was the trend for tension mercerization. Air resistance of slack mercerized fabrics was found to be high; indicating their low air permeability. The fabrics which undergone tension mercerization had high air permeability than other fabrics; thus reflecting superior cover and improved fabric warmth. Water vapour permeability values of mercerized fabrics showed similar trend as that of air permeability. Vertical wicking of fabrics in warp direction was measured in terms of time required to wick specified fabric height. Fabric mercerized under hot and tension conditions was characterized by lowest wicking time (11.6 seconds), thus highest wickability. On the basis of the thermo physiological comfort results, it could be stated that slack mercerized cotton fabrics with high thermal resistance, low air permeability and low water vapour permeability can provide the desired protection to the human body against climatic fluctuations. Low thermal resistance of tension mercerized fabrics together with high air and water vapour permeability and high wicking ability made them suitable for summer clothing.

4.21
Potentials and prospects of banana fibre in north east India

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Indeed, banana is famous for its fruit across the country but apart from that, the availability of huge quantity of biomass is usually ignored by the growers. This biomass which is normally considered as the waste can be utilized through various ways. In case of north east India, banana has a very important place in the field of farmers and simultaneously can be found across the length and breadth of the region. During the year 2014-2015 a total of 99 thousands hectare covered by banana plant with a production of approximately 1461 thousand tons of banana fruit obtained, which is 12.04 per cent and 5.0 per cent of total area and production of India, respectively. The harvesting of banana fruit is left by enormous amount of biomass residue as waste such as pseudo stem, leaves, sucker, etc. in the tune of 60-80 t/ha. Accordingly, biomass residue production ranged from 5.94 to 7.92 million tons in north eastern states. Presently, the leftover biomass of banana is absolute waste for the farmers and if not properly disposed off can cause environmental problems. Their disposal require a routine way *viz*. dumping in and around the field and burning, disposing in *nalla* or drains, etc. Among the waste components, there exists a vast potential of extracting fibres from pseudo stem, rachis, leaf sheath and dried petioles. Cellulose is the major component of the fibre.

The extracted banana fibre can be used as raw material for industry for production of a range of products like papers, tea bags, paper for currency notes, ropes, threads, toys, in handicrafts and natural textiles, etc. Fibres obtained from pseudo stem have higher specific strength modules and lower strain at break than that obtained from leaf sheath and rachis. Eco-friendly nature of banana fibre and its ability to be easily blended with cotton or other synthetic fibres to produce blended fabric and textiles offers excellent potential as compared to other natural and man-made fibres. About 0.45 million tons to 0.60 million tons of banana fibre can be produced from the biomass residue available in north eastern states. If leftover biomass is properly utilized for fibre production, then it can partially replace the consumption of cotton and jute fibre. The real cost involved in the production of banana fibre comes from waste stem collection and fibre extraction which is negligible in comparison with other natural fibres like cotton, jute, hemp, etc., this cost competitiveness and preference of eco-friendly fabric over synthetic fabric in hot and humid climates will fuel growth of this product. This will add value to banana plantation besides helping in solving environmental problems.

4.22
Effect of textile softener on tactile comfort properties of BTCA treated cotton fabric

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Abstract : Polycarboxylic acids represent safe, environment friendly alternative to conventional formaldehyde based anti wrinkle agent to produce easy care fabric. However, it imparts many unwanted effects to fabrics such as reduced breaking and abrasion resistance, loss in tensile strength, yellowing and stiff harsh, uncomfortable feel. Taxtile softeners are known to modify the hand or feel of a fabric by lubricating the fiber. The aim of this work was to study the effect of fabric softeners on tactile comfort properties of anti-crease finished cotton fabric. Desized and bleached cotton fabrics were treated with polycarboxylic acid based anti crease agent [1,2,3,4-butane tetracarboxylic acid (BTCA)] and softener by conventional pad dry cure method. Tactile comfort properties in terms of low stress mechanical properties such as tensile, shear, bending, compression, roughness and friction, were measured on a Kawabata fabric evaluation system (KESF). The crease recovery angle increased from 154 to 257 after treatment with BTCA. The bending and shear rigidity

increased for BTCA treated sample, but decreased when BTCA and cationic softener were used together, implying better handle property. The surface roughness was found to be directly related to the crease recovery angle. Softener treatment resulted in higher total hand value of fabrics as compared to BTCA treatment.

4.23

Traditional processing and weaving using Himalayan Nestle plant by Mishmi tribe

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Himalayan Giant Nestle (*Girardinia diversifolia* (Link) Friis) is an eco-friendly plant from wild forest which the tribal population of Anjaw namely Digaru and Mizu Mishmi have been using as a fibre (Khujalli patta/ Chuaam/Tatsa) for different weaving items. This study was conducted in Hayuliang, Metengliang and Goiliang Circle of Anjaw district, Arunachal Pradesh. The data was collected from 40 male and female respondents by using a self-structured questionnaire of age group (20-50 years). Information were collected regarding aboriginal knowledge of the processing and uses of fibre. The investigation reveals that whole processes are eco friendly and have been in practiced from time immemorial providing multiple benefits to rural households. These plants is widely available in local vicinity and used for food, feed, fibre as well as source of income. The product from Khujalli patta /Chuaam/Tatsa processed fibre is still in demand at the local market and can be further exploited at the larger scale in terms of its fibre and products to popularise and increase market base for obtaining higher income level.Dissipation and leaching potential of cotton insecticide flubendiamide

4.24
Innovative value added product from animal fibre with special reference to pig bristle

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Animal fibre has been of great importance to man and it is a basic need after food in their usefulness. Different types of animal fibres from the hair are available in our country *viz.*, wool from sheep, mohair from goat and bristle from pig. Pig hair fibre is a key by product of humane slaughtered pigs with considerable economic value. An in-house methodology for bristle processing has been developed to remove dirt (epithelial scales and wax), destroying microbes and parasitic eggs clinging to pig hair, bleaching for softening and colour removal before dyeing. Different products can be made for different purposes according to the property of the bristle i.e. hard carpet cleaning brush with long handle, coat and jacket cleaning brush, cloth washing brush, shoe brush, soft carpet cleaning brush, hair comb for pet dogs, coat cleaning brush and furniture /equipment dusting brush . The main advantages are natural, durable and flexible, better removal of dirt and dust even in deep or zigzag corners which synthetic bristles may not achieve, better choice in washing brushes, as the pig bristles are stable and remarkably resistant to hard soaps. The production cost of pig bristle is each product varies depending on the size of the products (small comb/brush: 20-30g, medium brush: 50-70g and large size brush: 100-120g). Cost of production also varies depending on the size (small size brush: INR 80, medium brush: INR 100 and large size brush: INR150). A trained person can make 4-5 medium size brushes/day manually. The production cost can be reduced drastically with engineered automatic method. The Product demand is to enhance revenue through export of processed bristle that has high demand in the international markets. The Availability of Raw Material of A total of 15.35 lakh pigs are slaughtered per year in the organized sector in the region, besides the number of unorganised pig slaughter at block as well as level that is not yet known. An average of 300-400g of bristle/ pig is obtained, so 10-12 thousand quintal of pig bristle can be produced/year from slaughter houses in the region from the organized sector alone. The effective and efficient use of animal fibres like wool, hair and bristle enhance income and livelihood of farmers. Besides this it also generates employment and entrepreneur among farmers.

4.25

Production possibility of sunnhemp (*Crotalaria juncea* L.) under organic management in mid hills of Sikkim

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Sunnhemp (*Crotalaria juncea* L.) is an annual shrub cultivated as multipurpose legume for its fine fibre in India. The quality of the fibre is very soft and slightly lignified. The fibre contains high cellulose, low lignin and traces in ash content. The potential of the crop is also for legume or as a fodder. Species of this genus are widespread throughout the tropical, sub-tropical and to a lesser extent temperate countries. The sunnhemp crop is native to India. Being a leguminous crop it can fix 60-80 kg N/ha the atmospheric nitrogen into the soil. Thereby it enhances the soil health by improving the physical, chemical and biological properties of soil. It has high photosynthetic rate enabling it to trap atmospheric carbon dioxide thereby reducing green house gas (GHG) effect. Sikkim is the first Organic state in the country. Hence, it is desirable to introduce new leguminous crops which have not been introduced earlier in the state. Keeping the production potential performance of sunnhemp, one varietal evaluation was undertaken at Research Farm, ICAR-National Organic Farming Research Institute, Tadong, Gangtok (formerly ICAR Sikkim Centre) in 2015. Two variety *viz.*, Ankur and Prankur were tested in randomized block design. The crop was sown in the month of June. The plant height of Ankur was significantly higher (183.1 cm) as compared to Prankur (169.4 cm). The green biomass yield was also significantly higher with Ankur (12.6 t/ha) compared to Prankur (9.96 t/ha). Flowering was also observed in both the varieties but the seed setting was not noticed in either of the varieties at mid hills of Sikkim under organic management conditions. It may be recommended as a green manure crop in the state.

4.26

Potential and prospect of fibre crops in Arunachal Pradesh - A new horizon for livelihood improvement of agrarian community of the state

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Abstract

With over eighty percent of population directly or indirectly depending on agriculture, agricultural development is vital for overall economic development of Arunachal Pradesh. This demands exploration of all potential crops having commercial significance. One such unexplored crops of commercial importance in the state are fibre crops. The current paper aims to evaluate the potential and prospect of fibre crops in different agro-climatic locations of Arunachal Pradesh. It also tried to survey the minor fibre crops used by the indigenous tribal community of the state. Arunachal Pradesh having wide agro-climatic and topographical variations, there is immense potential of diversified fibre crops of class textile fibres, brush fibres, rough weaving fibres, natural fibres and paper making fibres like banana, bamboo, ramie, linseed, knef (*Hibiscus cannabinus L.*), okra, sunhemp, broom and several wild indigenously used crops. The fibre crops may be a very promising sector of secondary agriculture in the state. The sector will have wide social acceptance as handloom and craft has great cultural significance in the tribal communities of Arunachal Pradesh. If grown commercially, the fibre crops will be a new horizon towards economic development and livelihood improvement of tribal agrarian community of the state.

4.27
Linseed to Linen: Prospective commercial transformation for North East India

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Linen is a natural fabric more ancient than cotton or wool. Originating in ancient Egypt, it has now reached all parts of the world and is considered to be organic and thus safe to be worn in all weather conditions, especially hot conditions, to provide comforts to body. Linseed or Flax (Linum usitatissimum) is a plant from which linen fabric is obtained though a lot of processing goes into making the fibers and later fabric. As far as its cultivation is concern, it is grown extensively in the eastern part and northern part of the country with few pockets in the southern India. Assam and Nagaland, from north eastern India are the major linseed cultivating state. The yield of Linseed in North East is higher than the country. As per the data of Ministry of Agriculture, in 2009-10 the yield of linseed was 621.4 kg/ha in north east India whereas the county average yield was only 449 kg/ha. It shows the potential of linseed cultivation in this part of the country. Considering its prospect in the region, the AICRP on linseed as well as Cluster Front Line Demonstration on Linseed under NMOOP project of Ministry of Agriculture & Farmers Welfare, Govt. of India is also undertaken through ICAR institutes and KVKs respectively. The initial results of the above projects signify that the climate of the region more specifically, Assam, Nagaland, Meghalaya and Mizoram are suitable for its cultivation. The major concern raised by the grower is related with its processing particularly the fibre from its stem and marketing of it. The extraction of fibre from the stem of flax is the cumbersome process and requires proper skill as well as machinery. In this regard, the KVKs and the ICAR institutes of the respective states can play a pro-active role by creating an incubation centre at their level and develop the infrastructure for linseed processing. This infrastructure can be utilized by the linseed grower for processing on group basis by paying a nominal fee. These institutions can also linked the producer groups to prospective buyers and make the system sustainable.

4.28

Temporal changes in growth and instability in area, production and productivity in major cotton producing states of India

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Cotton is the most promising crop of Indian agriculture in terms of its contribution to the country's agricultural GDP as well as in creating employment and export earnings. But despite technological and policy interventions having ensured phenomenal growth in cotton sector over the decades, the country's yield is still 30 per cent less than the world average. At the same time, since the introduction of *Bt* technology there has been significant increases in growth dimensions of cotton. Such dynamic changes call for the study of growth and instability in cotton production. Accordingly, the present study has analyzed the growth dynamics in cotton during 1971-72 to 2015-16 using compound growth rate and coefficient of variation. The findings showed that the growth rates after *Bt* introduction (2001-2015) in terms of area (3.70 %), production (9.89 %) and productivity (5.98 %) were more than that of the overall study period. At the same time, instability was less in earlier pre-*Bt* periods (viz. 1971 to 1985 and 1986 to 2000) when compared to the *Bt* phase and the overall phase. In connection to zone-wise details, the Central zone exhibited higher growth rates and lower instability when compared with Northern and Southern counterparts. Besides, the observations from Gujarat revealed that the local cotton cultivators of the state were equally as effective as that of *Bt* cotton in productivity. The study suggests that cotton productivity can further be accelerated by strengthening the research system with singular focus on developing multiple resistances to pests and diseases.

1.29

Genetic and genomic resources in *G. barbadense* cotton for improving fibre traits and seed cotton yield in cotton

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Cotton (*Gossypium* spp.) is the world's most important natural textile fibre crop and fibre quality is becoming an increasingly important aspect in modern textile industry (Ali *et al.,* 2008 and Kranthi 2014), because modern textile technologies, rotors, friction and air jet require high fibre strength and uniformity (Rowe 1992; Chen, 1999; Saha *et al.,* 2008). Most of the commercial cultivars (*G. hirsutum*) although high yielding, lack some of the desirable fibre quality traits. *G. hirsutum* produces medium to long staple fibre which is suitable for 30 to 50's count yarn production, used in production of superior quality garments. *G. barbadense* is known for its extra long, strong and finest fibre used to spin 120's count yarn to manufacture most superior garments. Because of low yielding ability, higher susceptibility to sucking pests and sensitiveness to moisture stress, *G. barbadense* has not been cultivated in large scale except Egypt. But, it continued to be good genetic resource for improving fibre quality of *G. hirsutum* cotton. India has enjoyed the advantages of interspecific (*G. hirsutum* and *G. barbadense*) extra long staple cotton hybrids such as Varalaxmi, first inter-specific hybrid (Katarki, 1971) followed by DCH-32, NHB-12, HB-224 and TCHB-213 developed at various institutes. Forever *G. barbadense* has also going to be the number one genetic resource for improving fibre qualities (Choudki *et al.,* 2012; Ramesh, 2015). In order to combine superior fibre quality traits from *G. barbadense* through conventional breeding methods involve repeated back crossing, selfing and testing which is time consuming and less precise process as compared to direct selection of plants based on molecular markers (Preetha and Raveendren, 2008). Further conventional selection depends upon availability of lines with clear-cut phenotypic characters and accurate screening methods. Marker assisted selection (MAS) hasten the transfer of desirable fibre quality QTLs from *G. barbadese* to background of *G. hirsutum* genotypes, hence there is urgent need to identify QTLs responsible for fibre quality traits in *G. barbadese*. Therefore present investigation was carried out on "Genetic linkage mapping and QTL analysis for fibre quality and yield contributing traits in *G. barbadense* cotton".

1.30
AKH-09-5: A promising American cotton genotype for rainfed cultivation of Maharashtra

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Cotton the important cash crop of Maharashtra mostly grown under rain-fed situation. The total area under cotton in Maharashtra is around 40 lakh hectares. The main reason for low productivity of cotton in Maharashtra is its dependence on the monsoon rain and growing cotton on marginal and sub marginal soils. Intermittent dry spells during June to August followed by cessation of monsoon activity in middle of September results in low productivity. There is a need to have high yielding genotypes which can withstand biotic and abiotic stresses. Cotton Research Unit, Dr. PDKV, Akola has evolved few varieties i.e. DHY-286 a late maturing variety (200-210 days), AKH-081 an early maturing variety (150 days), PKV Rajat (170 days), AKH-8828 (170 days) and AKH-9916 (170-180 days) medium duration varieties. The American cotton new genotype AKH-09-5 is medium duration variety (160-180 days) having average boll weight of 3.5–4.0 g. It has recorded higher seed cotton yield and lint yield over the checks viz., PKV Rajat (31.5 & 24.7 %), AKH-8828 (31.7 & 24.7%) and AKH-9916 (29.7% & 17.9), respectively in university multi location varietal trials conducted during 2012-2016. It has shown higher seed cotton yield and lint yield over state checks viz., PKV Rajat (25.2 & 20.0 %), AKH-8828 (33.9 & 24.5 %), NH-615 (20.8 & 23.7 %), NH-545 (16.3 & 11.7 %) and Phule 688 (21.8 & 22.6%) in State Multi location Trials conducted during 2012-2016. In AICCIP trials, the genotype AKH-09-5 had shown an increase in seed cotton yield and lint yield over the zonal check NH-615 by 19.8 and 13.3 per cent, respectively. This genotype is having 35-37 per cent ginning out turn. It is having good fibre qualities, superior for Upper Half Mean Length (28-30 mm), Fibre Strength (27-29 g/tex), micronaire value (3.5-4.5 ìg/inch) and Uniformity Index (82-84) over the other check varieties. The genotype AKH-09-5 is resistant to jassids, *Myrothecium* leaf spot and grey mildew and moderately resistant to Bacterial Leaf Blight diseases. On the basis of these features the genotype AKH-09-5 may become good option for farmer for rainfed cultivation in Maharashtra.

1.31
Production of high quality fibre in cotton through pre-breeding efforts

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The variability available in cultivated germplasm is limited and has been exhaustively utilized in breeding programmes hence it has become a necessity to develop basic germplasm materials enriched with rare useful genes from wild species through introgression. Pre-breeding involves all the activities associated with identification of desirable traits and/or genes from un-adapted germplasm (donor) that cannot be used directly in breeding populations (exotic/wild species), and to transfer these traits into well-adapted genetic backgrounds (recipients) resulting in the development of an intermediate set of material which can be used readily by the plant breeders in specific breeding programmes to develop new varieties with a broad genetic base. Pre-breeding offers a unique tool to enhance the use of genetic variability present both in cultivated and wild type germplasm. Linkage drag associated with utilizing wild relatives makes the pre-breeding activities much more cumbersome. Genomic-assisted pre-breeding will help to overcome the linkage drag and will facilitate focused transfer of useful genes/segments from wild relatives for genetic enhancement.

As an effort to utilize the available cultivated and wild species of cotton at ICAR-CICR to develop introgressed lines with high strength; four parents namely *G. hirsutum, G. barbadense, G. thurberi* and *G. raimondii*. Advance breeding lines of the population from two way cross involving these parents have been developed which possess traits like fibre length & strength ranging from 29.0 – 30.54 mm and 34 – 37.54 g/tex (HVI) , resistance to sucking pests and waterlogging tolerance. Further we have initiated work to increase Ginning Out Turn (GOT), introgress genes for biotic stress and delayed morphogenesis of gossypol gland through pre-breeding methods into the cultivated cotton using wild species like *G. longicalyx, G. capitis virides* and *G. bickii*. Thus, efforts are being made to develop basic interspecific material with enhanced genetic base which can be used readily by the cotton breeders.

1.32
Genetic Variability and Heritability Studies in Cotton (G.*arboreum*)

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An experiment was conducted with ten G.*arboreum* varieties of cotton during summer at cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist : Ahmednagar (M.S), India.The anlysis of variance indicated that there were significant differences among the genotypes for all the ten characters. Which indicated the presence of sufficient amount of variability among the genotypes.The characters seed cotton yield (kg/ha) and lint yield (kg/ha) showed wide range of variabilty 1397 to 2130 and 495 to 744, respectively and can be exploited through selection.

From the variabilty parameters,number of monopodial branches/plant showed high GCV 18.27 % followed by number bolls per plant(14.40 %), lint yield 11.94% and seed cotton yield 11.92 % .Among ten characters,the character ginning outturn, number monopodial branches per plant and number of bolls per plant recorded high broad sense heritabilty 99.52, 75.25 and 69.63 respectively. The highest GA percent of mean was observed in number monopodial branches per plant (32.64).The characters *viz*: number bolls per plant, number monopodial branches per plant , seed cotton yield, lint yield had medium to high heritabilty coupled with medium genetic advance as percent of mean which indicate that these characters are less influenced by enviornment as compared to rest of the characters.This clearly indicates that these four characters are controlled by additive gene action and selection will be effective for improvent the same.

1.33
Impact of morphological traits on seed cotton yield at different stages in *G. hirsutum* L. under HDPS

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An experiment was designed to determine correlation between the eleven yield contributing traits (days to 50 percent flowering, days to 50 percent boll bursting, number of monopdia, number of sympodia, plant height, seed index, lint index, number of bolls per square meter, boll weight, lint yield and ginning outturn) and seed cotton yield at three stages of harvesting (at 130 DAS, 130-

160DAS and 160DAS) using nineteen genotypes of *G. hirsutum* L under High Density Planting System (HDPS) ensuring 1.48 Lac plants per hectare.

The analysis of variance exhibited the substantial level of variability in experimental materials. The correlation analysis among the seed cotton yield and eleven morphological traits revealed that number of bolls per square meter (0.592**, 0.613** and 0.967**) and lint yield (0.533*, 0.685** and 0.985**) found positively and statistically significant correlation with seed cotton yield in all three stages under compact ecosystem. All traits shown positive correlation with seed cotton yield (at 130DAS), whereas all traits except boll weight, days to 50 per cent flowering, number of sympodia, seed index and lint index were found negatively correlated with SCY at 130-160 DAS stage. In last stage i.e. at 160 DAS all traits have shown positive correlation except that of number of sympodia, seed index and lint index. The suitability of cultivar under Compact planting system may be determined based on the number of bolls per unit area which is the key factor for yield potential ensuring improvement for productivity and profitability.

2.39

Influence of mulching and irrigation regimes under drip irrigation on productivity and profitability of *Bt* cotton and resources use efficiency

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Cotton is a major cash crop in India which mainly cultivated in rain-fed area, where water scarcity is occurred at pick boll development stage therefore, crop productivity is reduced due to lesser boll development and falling of immature bolls. Keeping the view, an experiment was conducted at Agriculture Research Station, Banswara during kharif season of 2014 and 2015 to assess the moisture conservation techniques like Drip at 0.4 $ET_{C,}$ 0.4 ET_C + polymulch, 0.6 $ET_{C,}$ 0.6 ET_C + poly mulch 0.8 $ET_{C,}$ 0.8 ET_C + poly mulch with poly much and convention irrigation. These eight treatments were randomized in randomized block design with three replications. The results revealed that irrespective of the irrigation schedule, poly mulching significantly improved the growth, yield attributes and yield of Jai Bt than drip and conventional method. Plant height, bolls and yield were 15.8%, 31.3% and 52.4% increased in poly mulching compared to conventional irrigation. Plant height, yield attributes, yield and water use efficiency were recorded higher with poly mulch in all irrigation regimes. The maximum seed cotton yield (5402kg/ha) recorded in drip + poly mulching at 0.8 ET_C irrigation regime which was significantly 11, 05, 14, 29 and 97% higher over drip at 0.8 $ET_{C,}$ drip+poly mulching at 0.6 $ET_{C,}$ drip+poly mulch at 0.4 $ET_{C,}$ Poly mulching and conventional

irrigation, respectively. Water use efficiency was recorded highest (89.33 kg seed cotton/ha-cm of water) under drip+poly mulch at $0.8ET_C$ as against the lowest (43.56kg seed cotton/ha-cm of water) under conventional irrigation. Drip without mulch outperformed than furrow irrigation with poly mulching. The drip irrigation technique coupled with plastic mulch improved the crop productivity and water productivity. Highest benefit: cost ratio was 5.16 recorded in drip irrigation at 0.8 ET_C and minimum recorded at conventional irrigation.

2.40
Screening of upland cotton (*G. hirsutum* L.) germplasm for root traits under waterlogged field condition

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Cotton crop is sensitive to waterlogged conditions. In recent years with an increase in climatic variability and poor drainage in Vertisols in cotton growing areas of India creates waterlogging in extreme rainfall events and affects the crop severely. In this regard field level screening for waterlogging tolerance in selected cotton germplasm accessions were taken up during 2017-18 at ICAR-CICR, Nagpur for studying root traits. Of 4000 germplasm accessions screened for waterlogging conditions during 2014, 2015, and 2016, eighty waterlogged tolerant accessions were identified. These selected germplasm were evaluated in two replications in the stagnated waterlogged condition in the field. Waterloggging condition was imposed by maintaining water level of 10 cm in standing crop for continuous 20 days after 45 days of sowing. Deficiency of oxygen (hypoxia) level sensed by roots in the rhizosphere and reflected symptoms on leaves initially during waterlogging. An imposition of stagnated water around vertical tap root affected total root growth, root distribution and overall development of the plants. The root growth was slowed; inhibited root elongation and roots proliferation near the soil surface where oxygen was present. Consequent upon termination of waterlogging condition after 20 days root growth showed a significant recovery in tolerant germplasm accessions. Individual effects of waterlogging on cotton growth and yield under saturated soil condition amplify WL damage that leads to yellowing of leaves, shedding of squares and bolls. Besides, yield and final boll produced, impaired leaf nitrogen acquisition from roots and consequent effect on development of new fruiting nodes were recorded. Amongst screened eighty lines, one line, G2-1-17-904 of East Africa origin exhibited encouraging results in terms of height to node ratio, effective root distribution, root-shoot ratio, root dry weight and yield as compared to susceptible lines.

2.41

Status of traditional cultivars of *desi* cotton (*G. arboreum*) cultivation, characterization and conservation from North Eastern Hill (NEH) Region of India in the context of climate change

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Endowed with diverse and rich flora and fauna, the North Eastern Himalayan Region of India is one of the twelve mega-biodiversity hotspot areas in the world. It is believed that the *Desi* cotton (*Gossypium arboretum* L.) has been originated from this region. *Desi* cotton landraces particularly '*cernuum*' and '*burmanicum*' are found in the region. Over the generations, the farmers are maintaining the indigenous cotton cultivars in their house backyards and Jhum cultivation areas on the hill slopes. Mostly cotton is grown as a mixed crop along with other crops such as brinjal, tomato, pigeon pea, taro, yam, banana, chilli etc. Owing to the climate change and gradual introduction of improved rice cultivars along with commercial crops such as rubber and other vegetable and fruit crops, it leads to the severe erosion of genetic diversity of *desi*-cotton cultivation in their original habitats. Since 2010, exploration surveys have been conducted to collect, characterize, evaluate, document, and conserve the *desi*-cotton germplasm from NEH Region and their further use in the breeding programme. Eighty-one morphological variants of *Gossypium arboreum* have been collected from the states of Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland and Tripura. The *desi*- cotton germplasm accessions are being maintained in the field gene bank, experimental plots and cold storage facility at ICAR-CICR, Nagpur. Morphological characterization including DUS has been carried out for the collected *desi* cotton germplasm accessions. The races showed unique and novel traits particularly for race '*cernuum*' exhibiting high locule retentivity, high ginning outturn per cent, high boll weight (8.5 grams) and tolerant to high wind velocity and hailstorms. The fibre quality traits of the collected germplasm accessions in HVI mode ranges as follows: the staple length of different accessions from 20.7 to 25.3 mm; the fibre strength of these genotypes from 23.7 to 28.5 g/tex and micronaire values of genotypes from 3.5 to 7. In view of this, the germplasm accessions are valuable sources of economically important genetic traits that could be used in breeding programmes for cotton improvement.

2.42

Moisture conservation techniques for enhancing cotton productivity under drip irrigation

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Cotton is the most important commercial crop of Vidarbha region. The cotton crop is very sensitive to moisture stress. Excess moisture in initial growth stages and uncontrolled water stress at later stages may adversely affect the cotton yield. The practice of mulching is well proved for complete control of evaporation and saving the precious water in agriculture. Drip irrigation has been shown to increase crop water productivity of cotton by increasing yields and decreasing the amount of water used. The experiment was conducted at Cotton Research Unit, Dr. PDKV, Akola in RBD design with 4 replication having 5 treatments during the year 2016-17. The treatments are T_1 : Control (No mulch on flat bed with drip) T_2: Poly mulch on BBF with drip T_3: Poly mulch on ridges and furrow with drip T_4 : Crop residue mulch (5t ha^{-1}) on BBF with drip and T_5: Dust mulch by hoeing (Dust mulch on flat bed with drip). It reveals that plant height, Sympodia, boll numbers, boll weight, Seed cotton yield and lint yield were significantly influenced due to different mulching techniques with drip irrigated to Bt hybrid. Significantly highest SCY (3715 Kg ha^{-1}) and lint yield (1173 kg ha^{-1}) was recorded with bio mulching (Crop residue 5 ton over BBF and which is at par with poly mulching on BBF with drip irrigation. The SCY was increased by 42 % in crop residue mulching over control. The WUE was maximum (5.51 kg ha-mm^{-1}) with crop residue mulching on BBF followed by poly mulching on BBF. The lowest with control, where Bt hybrid grown on flat bed with drip. Significantly highest GMR (154185 Rs ha^{-1}) was recorded with bio mulching (Crop residue 5 ton over BBF and which is at par with poly mulching on BBF with drip irrigation. However, NMR and B:C ratio were recorded more with bio mulching (Crop residue 5 ton ha^{-1}) on BBF with drip.

2.43
Performance of *Bt* cotton (*Gossypium hirsutum* L.) as influenced by different agronomic practices

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Field experiments were conducted to study the influence of different agronomic practices on growth, yield attributes, yield and economics of *Bt* cotton at the Main Agricultural Research Station, Raichur during *Kharif* 2015 and *Kharif* 2016. The experiments were laid out in a Randomized Complete Block Design (RCBD) comprising of seven treatments replicated thrice. The pooled results revealed that closer spaced Bt hybrid + 125% RDF + 3 sprays of 1% each of $MgSO_4$ and 19: 19: 19 (T6) recorded significantly higher sympodia/plant (26.0), bolls/plant (45.1) and seed cotton yield (3096 kg/ha) over other agronomic practices. It was followed by closer spaced *Bt* hybrid + 125% RDF + Micronutrients (Soil application) @ 25 kg $MgSO_4$/ha, 10 kg $FeSO_4$ & 10 kg $ZnSO_4$ /ha (T5), closer spaced *Bt* hybrid + 125% RDF + Recommended foliar spray (1% spray $MgSO_4$ at 90 & 110 days after sowing-2 times or 1% spray of KNO_3 during flowering & Boll initiation stage) (T4) and closer spaced *Bt* hybrid + 125% RDF (T3) which found on par with T6. Significantly higher gross returns (Rs.162346/-), net returns (Rs.100308/-) and B: C (2.63) ratio were recorded with T6 (closer spaced *Bt* hybrid + 125% RDF + 3 sprays of 1% each of $MgSO_4$ and 19: 19: 19) followed by T5, T4 and T3.

3.37
Bio-efficacy of some newer insecticide against major insect pests of cotton

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Cotton is the most important cash crop of India, which have worldwide significance. Sucking pests *viz.,* leafhoppers (*Amrasca biguttula biguttula*), thrips (*Thrips tabaci*) and whitefly (*Bemisia tabaci*) are major sucking pests of cotton and cause considerable losses during seedling stage, their heavy infestation reduces the crop yield to a great extent. Insecticides are heavily used in India to control sucking pests. Due to continuous and indiscriminate use of these synthetic insecticides several

problems like resurgence, outbreak and resistance have been reported. To overcome with such type of problems discovery of novel insecticide with different mode of action are needed. Novel insecticides are very effective at low doses and have less impact on the environment. An experiment was conducted at Agricultural Research Station, Sriganganagar, (SKRAU, Bikaner) to evaluate the efficacy of new molecules for the management of major sucking pests of cotton *viz.*, jassid, whitefly and thrips during the *Kharif,* 2014 and 2015. The insecticides *viz.*, spirotetramat 150 OD @ 500, 600 & 700 ml ha^{-1}, imidacloprid 17.8 % SL 125 ml ha^{-1} and spiromesifen 240 SC @ 600 ml ha^{-1} were applied two times at ETL during both the seasons. Among the treatments, the most effective insecticide in controlling the jassid, whitefly and thrips population was spirotetramat 150 OD @ 700 ml ha^{-1} and the least effective was imidacloprid 17.8 % SL @ 125 ml ha^{-1}. The order of bioefficacy on the basis of per cent reduction of jassid, whitefly and thrips over control was: spirotetramat > spiromesifen > imidacloprid. The highest seed cotton yield of 22.42 and 19.32 q ha^{-1} was harvested with higher dosage of spirotetramat 150 OD @ 700 ml ha^{-1} during *Kharif,* 2014 and 2015, respectively.

3.38
Studies on foliar diseases of cotton in relation to weather parameters

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The occurrence of foliar diseases of cotton were studied in relation to weather parameters during 2016-17.Bacterial blight was initiated during first week of August (31 MW), when the maximum and minimum temperature was 29.8 ^{0}C and 23.6 ^{0}C along with relative humidity between the range of 91 and 72 percent. Later gradually increased and maximum per cent disease intensity i.e. 9.0% was observed during (35th MW). Maximum and minimum temperature was 31.0 ^{0}C and 24.5 ^{0}C with relative humidity range of 85 - 62 percent. The *Myrothecium* leaf spot diseases was initiated during second week of August 2016 (32 MW), maximum disease intensity i.e. 2.08% was observed during (34 MW). Maximum and minimum temperature was 31.0 and 23.4^{0}C along with relative humidity between the range of 85 and 58 per cent in LAR 5166 and Bunny Bt respectively. Similarly,Grew mildew initiated in the last week of October i.e. 43 MW with 1.66% disease intensity on AKA-8. The maximum disease intensity 6.86 was recorded at 47th MW, when maximum temperature was 30.7 and morning relative humidity 85.3 and evening 32.0 per cent. The LRA 5166 and RCH-2 were free from grey mildew.

3.39
Thrips diversity in cotton ecosystem

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India is very rich in terms of biological diversity due to diversified climatic conditions. It's recognized as one of the major centres of biodiversity in the world. A comprehensive account of cotton thrips insect diversity of Tamil Nadu was assessed which is mainly based on the collection and the random surveys undertaken by the Department of Cotton. Totally, three species belonging to three genera in two families of Thysanoptera order were recorded from Coimbatore cotton ecosystem.Though species level identification is important for managing the pests through the biological control,it is difficult because of its small size and not clearly visible morphological differences. Phylogenetic analysis and diversity indices done to identify the species and their variation revealed the maximum prevalence of *Scirtothrips dorsalis* (3.25) followed by *Thrips tabaci* (1.34) and *Thrips palmi* (0.24). This study demonstrated the high diversity of thrips species in cotton production system and the importance of its management.

3.40
Bio-efficacy and phyto-toxicity study of clethodim 25 % w/w EC on cotton

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Field experiment was conducted to access the "bio-efficacy and phyto-toxicity of clethodim 25 % EC on cotton" at College of Agriculture, Navsari Agricultural University, Bharuch during *kharif* season of 2014-15 and 2015-16 under rainfed condition. Total nine treatments including six treatments consisted level of Clethodim *viz.*, 60, 90, 120, 150, 240 and 300 g/ha along with 0.5 % Amigo (Surfactant) and three treatments *viz.*, Quizalofop ethyl 5% - 50 g/ha, Weed Free Check and Weedy check were evaluated with three replication in a randomized block design. Major weed flora *viz.*, *Cloris infata, Brachiara spp., Dinebra retroflexa, Eragrostis major* among monocot; *Digera arvensis, Portulaca oleracea, Euphorbia hirta* among dicots and *Cyperus rotundus* only sedges were recorded

during investigation. Total weed populations and dry weight of weeds significantly reduced under weed free condition and herbicidal treated plot, however, Clethodim 300 g/ha + 0.5 % Amigo found more effective among the herbicides. Moreover, application of Clethodim 60 to 300 g/ha or Quizalofop ethyl 50 g/ha was not found effective on dicot and sedges weeds. Further, highest weed control efficiency and lowest weed index was observed in weed free check, closely followed by Clethodim 240 or 300 g/ha + 0.5 % Amigo. Plant height, no. of monopodial and sympodial branches/plant, no. of ball/plant, seed cotton yield were recorded significantly higher under weed free situation and found at par with Clethodim either applied 240 or 300 g/ha + 0.5 % Amigo. Application of Clethodim 240 g/ha + 0.5 % Amigo (surfactant) is found promising by producing higher seed cotton yield as well effectively control monocot weeds.

3.41
Efficacy of different traps and lures against cotton pink bollworm

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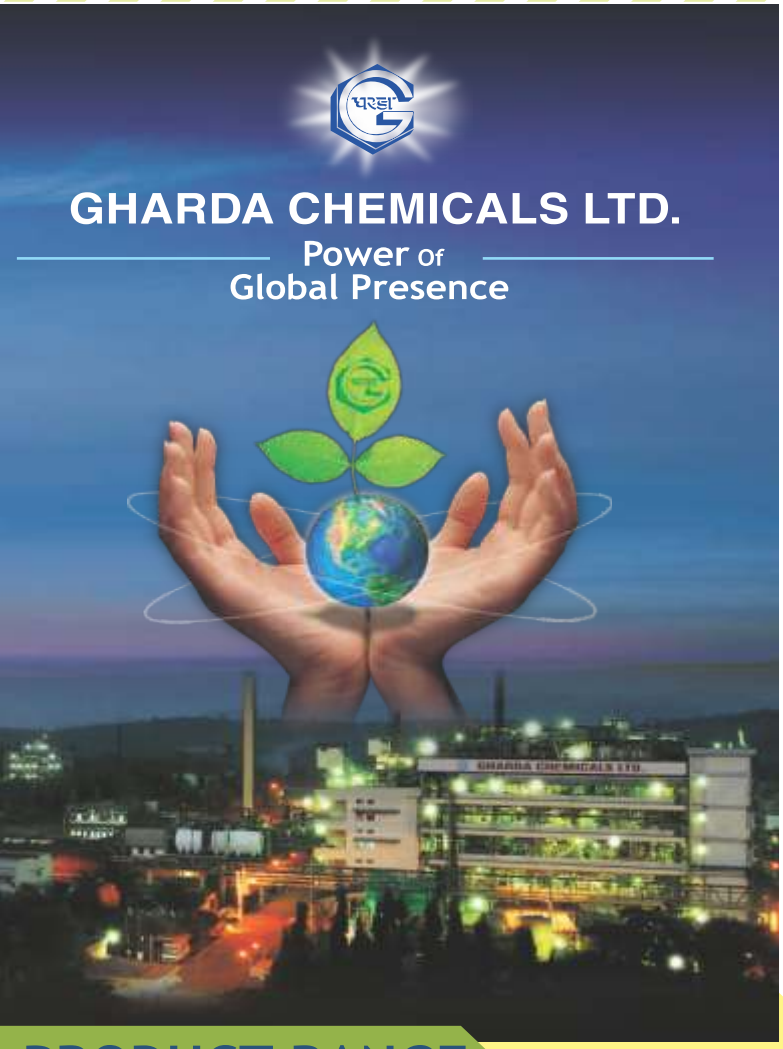
Among the several insect pests that attack cotton, the pink bollworm, *Pectinophora gossypiella* (Saunders) is considered one of the most destructive pests of kapas in the later stage. In the recent past, this insect is found progressively increasing its activity in Gujarat, Andhra Pradesh and Maharashtra. The larval stage is destructive usually damage within the cotton fruiting bodies without exhibiting easily distinct external damage symptoms and not accessible. The monitoring of the adult population with the help of traps baited with pheromones or other semiochemicals, is a potential device to predict subsequent larval infestation in cotton crop and ensure timely chemical intervention.

The experiment was conducted at Agricultural Research Station- Borwat Farm, Banswara during *kharif*-2016 to evaluate the efficacy of different traps and lures against pink bollworm. The trial was laid out in randomized block design (RBD) with four replications and six treatments. The cotton variety Jai Bt BG II was sown in row to row and plant to plant distance of 90 × 45 cm in one acre area. The traps were installed 10 m distance within row and traps. Trap height increases with canopy height. Observations on pink bollworm moth catches/ trap/week were recorded in all treatments.

The present data study revealed that the maximum mean moth (8.71 moth catches/trap/week) was recorded in Phero – Sensor TM– BP – sleeve trap with PBW lure and it was at statistically at par with Phero– Sensor TM– SP –sleeve trap with PBW lure. The PCI- Delta Trap and PCI –Funnel trap with PCI Pectino lure (Season Long) were found next best trap and lure. Whereas, PCI –Delta Trap and PCI –Funnel trap with PCI Pectino lure was found very less effective.

AUTHOR INDEX



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Insecticides

Product Name	Purity
Alpha Cypermethrin Technical	97% +
Cypermethrin Technical	93% +
Deltamethrin Technical	98% +
Permethrin Technical	92%, 94% and 95% +
Chlorpyriphos Technical	98% +
Indoxacarb Technical	67% + and 95% +
Fipronil Technical	97% +
Diflubenzuron Technical	95% +
Quinalphos Technical	70% +
Profenophos Technical	94% +
Triazophos Technical	60% +
Temephos Technical	92.5% +

Herbicides

Product Name	Purity
Anilofos Technical	93% +
Isoproturon Technical	97% + and 98% +
Dicamba Technical	97% +
Triclopyr Butoxy Ethyl Ester	97% +
Bispyribac Sodium Technical	98% +

Plant Growth Regulator

Mepiquat Chloride	44/50% Aqueous Solution

Vet Products

Product Name
Oxyclozanide
Deltamethrin Technical
Cypermethrin Technical
Permethrin Technical
Fipronil Technical

Public Health Products (WHO approved)

Product Name
Alpha Cyper Technical
Deltamethrin Technical 98.5%
Temephos Technical
Chlorpyriphos Technical

Intermediates

Product Name	Purity
Cypermethric Acid (98:2)	99% +
Cypermethric Acid Chloride (40:60)	99% +
High Trans CMA (2:98)	99% +
High Trans CMAC (2:98)	99% +
Meta Phenoxy Benzaldehyde	99% +
Meta Phenoxy Benzyl Alcohol	98% +
Bromo Benzene	99% +

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