NATIONAL CONVENTION ON

INDIA COTTON : GEARING UP FOR GLOBAL LEADERSHIP

January 6 - 8, 2013

Main Cotton Research Station, NAU, Surat

COMPENDIUM OF ABSTRACTS

in association with

THE GUJARAT ASSOCIATION FOR AGRICULTURAL SCIENCES, NAVSARI

INDIAN SOCIETY FOR COTTON IMPROVEMENT, MUMBAI

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ON

"INDIA COTTON: GEARING UP FOR GLOBAL LEADERSHIP"

January 6 - 8 , 2013

Venue: Main Cotton Research Station, NAU, SURAT

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Vice-Chancellor
Navsari Agricultural University
Navsari - 396 450.

COMPENDIUM OF ABSTRACTS

Compiled by

V. Kumar

N. N. Patel
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in association with

THE GUJARAT ASSOCIATION FOR AGRICULTURAL SCIENCES, NAVSARI

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NATIONAL CONVENTION
"INDIA COTTON: GEARING UP FOR GLOBAL LEADERSHIP"
January 6-8, 2013 **at Main Cotton Research Station, NAU, Surat**

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Research Scientist (Cotton)

NATIONAL CONVENTION

"INDIA COTTON: GEARING UP FOR GLOBAL LEADERSHIP"

January 6-8, 2013

Main Cotton Research Station, NAU, Surat

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21	Research Scientist(Cotton), Surat	Organizing Secretary

Dr. C. D. Mayee
President

Indian Society of Cotton Improvement,
Mumbai.

MESSAGE

I am extremely happy to know that Navsari Agricultural University, Navsari, Gujarat is organising an important conference on cotton at their Cotton Research Station, Surat in collaboration with ISCI and CICR, Nagpur.

With the adoption of Bt technology Cotton production got real boost in the last decade and the average yield of the country has touched the level of around 500 to 550 kg lint per ha. This was envisaged in the vision documents of Ministries of Agriculture and Textile and also the Cotton Associations of India during the formulation of Technology Mission on Cotton in 2001. Today, the country crossed the mark of 500 kg lint per ha after a decade's stagnation of yield at less than 300 kg prior to 2002. Now that we have achieved a respectable yield level, a micro analysis has indicated that again the "stagnation ghost" in cotton yield has come and began haunting the researchers, farmers, planners and also the industry. Therefore there is a real challenge for cotton researchers to look for new technologies not only in crop improvement but also in production, protection and processing to give fillip to Indian Cotton.

I hope the current conference throws light on the future needs of Indian Cotton both in terms of production and utilisation. I wish the conference a grand success.

C. D. Mayee

Nagpur
Date: 23/12/12

Dr. A. R. Pathak
Vice Chancellor

NAVSARI AGRICULTURAL UNIVERSITY
ERU CHAR RASTA,
NAVSARI, GUJARAT

MESSAGE

I am glad to know that our Main Cotton Research Station, NAU, Surat and Central Institute for Cotton Research, Nagpur are organizing a National Convention on "India Cotton: Gearing up for Global Leadership" during January 6-8, 2013 at Surat as a part of Golden Jubilee celebration of Gujarat Association for Agricultural Sciences and bringjng out a souvenir on this occasion.

Gujarat has glorious past and glittering present, ahead of all the states on national map of the cotton production and/or productivity. Cotton Research Station, Surat is well known to the world for distinction of releasing Indo-American variety Deviraj in 1951, world ever first cotton hybrid Hybrid-4 in 1971, first perennial budded cotton G. Cot. 101 in 1977, first desi cotton hybrid G, Cot. DH-7 in 1984 and now the first public bred Bt cotton hybrids G. Cot. Hy.6 and G. Cot. Hy. 8 (both BG II) in 2012. Forty seven high yielding varieties & hybrids and over hundred technological innovations have brought radical improvement in productivity of Gujarat as well as the country.

The current century faces shift in agricultural research and cultivation owing to technological advancements, climate changes and liberalization in trade policy. The changes in climate will adversely affect the country in terms of crop productivity and environment. The convention will deliberate on wider issues related to conventional and biotechnological approach for improvement and modification of cotton for tolerance to biotic and abiotic stresses. Improvement of fiber strength, fineness, boll size, synchronized bearing and bursting and organic farming practices will receive greater attention during the conference. The issues of yield sustainability in rain fed region, resistance management to pesticides and transgene and creation of market demand through innovations and native use may be focused in the convention

I am sure this publication will be beneficial to all those concerned with cotton research and cultivation, pesticide and textile industry and serve as a document for future needs. I compliment Dr. V. Kumar, Organizing Secretary and his team of scientists for their sincere efforts put forth by them in this endeavor.

I wish the convention a grand success.

(A.R.PATHAK)
VICE-CHANCELLOR

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Dr. N. Gopalakrishnan
Assistant Director General (Commercial Crops)
Telefax.011-23384323 ; email: adgcc.icar@nic.in

MESSAGE

I am very pleased to know that Navsari Agricultural University, Surat and Central Institute for Cotton Research, Nagpur are jointly organizing a National Convention in association with Gujarat Association for Agricultural Sciences, Navsari and Indian Society for Cotton Improvement, Mumbai on **"India Cotton: Gearing up for Global Leadership"** during January 6-8, 2013 at Surat. Cotton, the crop of commerce, history, civilization, symbol of economic prosperity to millions of farmers, is grown in the country on variable land holdings, different planting dates, soil and water holding conditions and largely under rainfed situations. Sustainability of production, overcoming biotic and abiotic stresses, meeting requisite quality standards and maintaining economic cost of cultivation are some of the serious challenges for the scientists, development officials, field functionaries and cotton growers. Climate change has also become a major national issue as well as of global concern. Every nation is gearing up to adopt itself to the threat of Climate Change. More than 65 per cent of Indian population relies on agriculture for their livelihood, which is directly dependant on climate.

I am sure that the deliberations during the National Convention will provide needed stimulus and appropriate directions to the cotton research and development programmes in the country for a better future. I convey my best wishes for the success of the Convention at Surat.

N. Gopalakrishnan

(N.GOPALAKRISHNAN)

Dr. Anupam Barik
Additional Commissioner (Crops)

सत्यमेव जयते

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MESSAGE

It gives me great pleasure to learn that Navsari Agricultarat University, Surat and Central Institute for Cotton Research, Nagpur are jointly organizing a National Convention in association with Gujarat Association for Agricultural Sciences, Navsari and Indian Society for Cotton Improvement, Mumbai on "India Cotton: Gearing up for Global Leadership" during January 6-8, 2013 at Surat.

Due to implementation of Technology Mission on Cotton (TMC) significant impacts were noticed in Cotton sector during the last decade. All India compound growth for area, production and yield of cotton during post TMC Period (2000-01 to 2009-10) showed higher growth in Cotton production (13.58%) with 11.22% growth rate in yield despite marginal growth rate in area (2.13%). Cotton productivity has increased from 186 kg lint per hectare in 2001-02 to 476 kg lint per hectare during 2011-12. Though, India is the 2nd largest cotton producer, consumer & exporter in the world, its productivity still remains below the world average (750 kg lint/ha) despite of 90% Bt hybrid adoption with strategic planning on Cotton have to be formulated.

The recent issues of cotton like development of GM cotton varieties suitable for high density planting system, increased yield especially under rainfed conditions, revival of deshi, ELS cotton area & production, attention to promote organic cotton production, disseminate Farmers Field School concept, maintain Bt Resistance Management, continuous flow of on line pest monitoring & advisory services , create custom hiring centers are to be addressed to achieve yield of Indian Cotton to a level of world average.

I am sure that, the convention will be helpful to address the above issues and draw research and developmental strategies for India Cotton. I wish theconvention a grant success and congratulate the organizer for their timely initiative.

(Anupam Barik)
18-12-2012

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Dr. S. K. Chattopadhyay
Director (Acting)

MESSAGE

It is heartening to learn that Navsari Zonal Chapter of Gujarat Association of Agricultural Sciences (GAAS) and Indian Society for Cotton Improvement (ISCI), Mumbai is organizing a National Convention on "India Cotton: Gearing up for Global Leadership", at the Navsari Agricultural University, Surat during 6 - 8 January, 2013.

As estimated, India's USD 52 million textile industry has the potential to grow at the rate of 11% CAGR to reach USD 140 billion by 2020. Cotton, the white gold as the primary raw material of the textile industry is playing a significant role through this growth-trajectory and will continue to do so by providing quality fibres to the industry.

At present, India is the world's second-largest cotton producer, consumer and exporter. It needs considerable deliberation and committed action plan, to gain top slots for the Indian cotton, including its branding in world market in the near future. The hosting of the present convention at this juncture to provide a platform for deliberation among the cotton researchers, processors, policy-makers and end-users thus assumes a great importance to place the Indian cotton and its products at the forefront of the world market, and to acquire global leadership.

I wish the convention a grand success, and congratulate the organizers on this timely initiative.

(S. K. Chattopadhyay)

Director of Research and Dean,
Faculty of PG Studies
Navsari Agricultural University,
Navsari, Gujarat

Dr. A.N.SABALPARA

MESSAGE

Navsari Agricultural University, Surat and Central Institute for Cotton Research, Nagpur are jointly organizing a National Convention on "India Cotton: Gearing up for Global Leadership" at Surat during January 6-8, 2013 in association with Indian Society for Cotton Improvement, Mumbai and Gujarat Association for Agricultural Sciences, Navsari Zonal Chapter to commemorate the "Golden Jubilee" of Gujarat Association for Agricultural Sciences" founded for all round development of agriculture sector in the Gujarat State and beyond.

The state and central support under various plan and non plan schemes, AICCIP, FLD, TMC, RKVY, Sponsored projects provided boost to the cotton research at the Main Cotton Research Station, NAU, Surat which is the oldest historical research station. It has credence of releasing 23 varieties of Desi cotton, 10 varieties of Indo-American cotton, 1 variety of budded cotton and 13 hybrids. The centre has also given more than 60 agro-techniques in the field of cotton production, protection and processing aspects. Popularity of transgenic cotton have laid many controversies to rest, today Gujarat farmers are growing more than 95 % transgenic cotton. Gujarat Government under PPP mode has taken bold initiative to give public *Bt* hybrids (G.Cot. Hy. 6 & 8 BG II) in the state and more in pipe lines. NAU has taken an initiative in strengthening programme in *Bt* cotton research and recently established Gujarat Agricultural Biotechnology Institute at Surat.

The convention may pave the way to find solutions for bridging the gap between irrigated and rain fed as well potential and actual yield, sustenance of cotton cultivation and *Bt* technology, green technology for production, protection, processing and value chain to farmers/processors/consumers. I congratulate Dr. V. Kumar, Research Scientist (Cotton), Dr. K. R. Kranthi Director, CICR, Nagpur and their team to organize the convention for mutual benefit of all stake holders to set goal for commendable position in cotton world. I am taking sincere note of the developmental activities of cotton sector by the Gujarat Association of Agricultural Sciences, Ahmedabad (Navsari Chapter) and Indian Society for Cotton Improvement, Mumbai and congratulate the governing body to co-operate and part of the event.

(A.N.SABALPARA)

PREFACE

The last decade has witnessed unprecedented growth in the national cotton sector. The enhancements in cotton production and productivity recorded during this period have few parallels in the annals of Indian agriculture. India strode ahead to become the second largest cotton producer in world. This is no mean achievement, yet there is no reason to be complacent. The productivity of cotton in India is only around 475 kg/ha below the world average of 734 kg/ha and far below the productivity levels of global leaders like Australia (1522 kg/ha), Brazil (1475 kg/ha), China (1226 kg/ha), USA (910 kg/ha), Egypt (869 kg/ha). There are several reasons assigned for low productivity like socio-economic status of farmers, improper placement of improved technologies, poor credit facilities, timely non availability of inputs and rain dependent cultivation in major cotton tract to name a few. A need was felt to organize a convention to discuss the issues limiting cotton production in the country as also delineate a pathway to attain global leadership in cotton production and productivity. Hence, Navsari Agricultural University, Surat and Central Institute for Cotton Research, Nagpur joined together to organize this National Convention on India Cotton: Gearing Up for Global Leadership during 6th-8th January, 2013 at Main Cotton Research Station, Surat.

We sincerely extend our gratefulness to Dr. A. R. Pathak, H'ble Vice Chancellor, NAU, Navsari, Dr. C. D. Mayee, Chairman, Indian Society for Cotton Improvement, Mumbai, Dr. N. L. Patel, Zonal President GAAS, Navsari who gladly accepted the proposal and extended every possible aid to hold the convention at Surat and to publish 'Compendium of Abstracts' on this occasion. We also extend our heartfelt thanks to National Organizing Committee to direct to hold the convention and screening committee for going through the abstracts and useful suggestions. We are whole heartedly thankful to all contributors who contributed through 160 plenary, lead and oral and poster papers in a short time overwhelming response. The convention would not have been possible without financial support from private sector which is thankfully acknowledged. Our sincere thanks and appreciation to the entire team for organizing this event smoothly.

Dated: 06.01.2013

V. Kumar
Research Scientist (Cotton) NAU, Surat

K. R. Kranthi
Director, CICR, Nagpur

Future R&d Policies for Cotton Improvement

C. D. MAYEE

Former Chairman,

Agricultural Scientists Recruitment Board,

New Delhi, Currently Adjunct Professor, IARI, New Delhi

Cotton is unique crop and economically very important in India. It occupies nearly 12 m ha and ranks first in area in the world. Indian cotton encompasses several unique features in terms of production such as; growing of all cultivated species of *Gossypium*, interspecific and intraspecific hybrid cultivation, intercropping, total rained to total irrigated cropping, hand picking and from North to South variation in sowing from April to December. Although these variabilities are sustainable, the productivity fluctuations are large and range from 300 to 900 kg lint per ha with country average of 500-600 kg lint per ha. Among several reasons of low productivity, the dreaded bollworm complex is considered a major one, as the annual losses due to these pests ranges from 25 to 70 % regularly. The management of these pests relied totally on insecticide uses in several cocktail forms which resulted into several times resistance in bollworms to chemicals.

This is where the GM approach through Bt Cotton technology provided an elegent and effective option. The Bt technology was commercially permitted by Government of India in 2002. In the last decade, Bt cotton hybrid occupied nearly 92% of the total 12 m ha. This phenomenal growth of technology adoption is unparallel in the modern history of Indian Agriculture. The Bt cotton technology is highly successful in controlling bollworms, reducing pesticide uses and increasing the cotton yields. There are obviously certain country advantages of this situation. Reduced uses of chemical brought down pollution and health hazards. Enhanced yields changed the status of country from net importer to assured exporter of cotton, stabilised domestic consumption, made up for shortages of vegetable oil by cotton seed oil and made all the cotton related industries vibrant in the country.

Bt Cotton in India is a classical example of how technology can benefit farmers, consumers and users. The multiple benefits are summarized below;

1. Bt cotton halved the usage of insecticide from 46% of the total uses in 2001-02 to 21% in 2010. Prior to 2004, Bt cotton area was less than 5% and the usage of

insecticide for 10 preceding years was 1.22 kg per ha. The Bt cotton occupied nearly 92% of total area now and insecticide usage average for 2005-2011 was only 0.6 kg per ha.

2. Total production jumped from 14 million bales of 170 kg each prior to 2002 to 35 million bales in 2011, with increase in productivity from 300 kg lint to 550 kg lint per ha.
3. Multiple uses of cotton as food (edible oil), feed (de oiled cake) and fibre has increased. The cotton seed and its by products, oil and meal enhanced from 0.4 million tones in 2002-03 to 1.11 million tones in 2011-21.
4. The Bt technology assisted domestic seed industry to grow and the vibrancy is seen from the fact that the biotech seed industry market jumped two-fold from Rs. 1100 million (US $ 25 m) in 2002-03 to Rs. 24800 million (US $ 551 m) in 2010-11.
5. India's share in world cotton increased from 14% to 21%.
6. Bt cotton created vibrant ginning, spinning industry based on domestic market and export increased from 0.1 m bale to 9 m bales.
7. Bt cotton contributed to farm economy, a whoping US $ 9.4 billion during the last 10 years.
8. Based on 12 studies the profitability of cotton farmers increased to 76-250 US $ per ha.

Inspite of this clear benefits of the technology, those who have never been in practical farming are advocating the ban on GM- technology either through legal or illegal means. They are bent upon stopping the trials of GM crops either by burning them or raising the issues through supreme court or parliamentary committee. However these actions shall certainly not deter the biotechnologists and government to stall the progress of GM technologies as it is sufficiently realised that for ever growing population of this country, the food security can only be achieved by the use of modern tools of molecular biology coupled with the traditional breeding.

It is in back drop the government must develop firm policies for cotton improvement.

1. Necessary permission to RR Flex technology should be immediately accorded as the trials are complete. Policies of food crops need not be attached to cotton where GM technology has already been in use for a decade with success.
2. Cotton being an important cash earner of foreign exchange, sustainable technologies in GE such as use of fibre genes, drought ,salinity ,nutrition efficiency genes nad also the sucking pest transgenic development research should be put on fast track through support mechanism.
3. Creation of an efficient and reliable mechanism for cotton procurement at MSP which should be reviewed periodically in the interest of farmers.
4. Encourage group cultivation with uni-quality of cotton based on zonal concept.
5. Firm up our policy of export-import.

Technologies for high yields in Cotton vis-à-vis Climate Change

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Cotton and cotton based textiles are predominantly used world over. Continued attention and appropriate programmes with emphasis on crop improvement, production techniques, protection technologies and value addition are of paramount importance in ensuring sustainability of cotton production and also livelihood security of the farmers. These aspects gain further importance, especially in the context of global climate change, changing pest and disease scenario, preference for competitive crops etc. It is also important to note that International Cotton Advisory Committee (ICAC) has worked out that the cost of producing a kilogram of cotton continues to rise and world net cost of production in 2009-10 was US$ 1.22 per kg (55 cents/lb) as against the Cotlook A index of 77.5 cents/lb. This necessitates needful reduction in production costs across the globe with strong emphasis in developing nations. The climate change is one of the most complex challenges that humankind has to face and overcome in the coming decades. As the change process seems to be complex, it is significant and urgent to develop sound adaptation processes to the current and future shifts in the climate system so that cotton production technologies are tuned well to result in higher yields with concomitant reduction in cost of cultivation. **Effect of elevated CO_2 on cotton growth and development is more apparent due to significantly greater leaf area, higher leaf and canopy, net photosynthetic rates, lower dark respiration and lower light compensation point than plants grown in ambient CO_2.**

Mitigation of the causal factors and adaptation of the crop to suit changing climate are the two broad strategies to restrain and cope with the changing climate. Whereas mitigation strategy aims at reducing the emission of CO_2 and other greenhouse gases into the atmosphere, adaptation strategy aims at enabling the plant to perform well under the changing climatic conditions by cultural and genetic strategies. It is expected that the insects currently plaguing cotton are expected to possibly pose more problems in new environmental conditions. Pest control would therefore become more critical in achieving

optimal growth and yield. The damage inflicted by cotton boll worms , regardless of the presence or absence of insecticidal genes, predicted to be more serious under elevated CO_2 conditions caused by nitrogen deficiency in the host plants. Global warming could also impact disease control in three ways: through its effect on pathogens; by creating disease-propitiating environments; and by affecting host tissues. Climatic change will likely be more beneficial to weeds due to the fact that genetic variations and selective ecological adaptations are more developed in weeds than in cultural plants. Weed control will then become more critical to achieving optimal cotton plant development and yield. The amount and timing of water availability during the growing season, through precipitation or irrigation, are critical for cotton. If water supply variability increases, it will affect plant growth and cause reduced yields. ICAC estimates that with 69% of the world area in 2011-12 being planted to biotech varieties and 63% of cotton traded internationally being biotech, the impetus to develop further drought tolerant and nitrogen use efficient cottons will be given. Such advanced technology products will hopefully overcome emerging challenges in enhancing productivity, especially in developing countries.

Many of the potential adaptation responses available to the production efficiency include:

- Improving Nitrogen Use efficiency and Water Use Efficiency
- Improving management of climate variability (improving use of short medium and long-term weather and climate forecasts, improving climate risk management including understanding and managing the trends and extremes regionally and globally for production and implications for our markets)
- Plant breeding and farming systems to take advantage of increased temperatures, handle increased water stress, respond to elevated atmospheric CO_2 etc.,
- Auditing energy use in cotton farming systems including developing benchmarks and tools to assess and improve efficiency and being ready to exploit opportunities such as bio-diesel
- Developing Best Management Practices for minimizing the industry's greenhouse carbon footprint

The risk and uncertainty imposed by climate change could be managed by adoption of location specific intercropping and multi-tier cropping system. *In situ* soil moisture conservation techniques include contour bunding, graded, narrow or broad ridges or beds separated by furrows, ridges and furrow, opening of furrow after every rows of cotton, black polythene mulch and spreads of crop residue were found promising. The mitigation strategies should aim to reduce inorganic inputs utilization with more emphasis to nitrogen and include following of Integrated Nutrient Management Practices, use of N fixing *Azotobacter* and *Azospirillum*, legume rotation, application of slow-release nitrogenous fertilizers, adoption of drip-fertigation, incorporation of cotton stalk that could reduce fertilizer nitrogen usage.

It is evident that application of FYM, mulching green gram, glyricidia and sunhemp as green manure recorded 15-30% increase in yield over control and there was considerable build up of soil available nutrients. Cotton crops grown in future environments will be subjected to a climate for which they were not bred. Cotton species of *G. barbadense* exhibit more sensitivity than *G. hirsutum* and intrahirsutum hybrids. *G. arboreum* types are suitable for low and erratic rainfall with prolonged drought situations. In saline environment, *G. herbaceum* showed better adaptability with profitable yields.

The 'changing climate' is a multi-faceted and complex challenge to the cotton industry impacting the sustainability of cotton and ecosystems. Further, an integrated systems-based approach to research and extension is needed to identify management options for minimising economic, social and environmental harm, while maximising newer opportunities and enabling sustainability of cotton-based cropping system and also integrated farming system approaches in the years to come. These measures shall ensure that the climate change issues are adequately addressed for the benefit of all stakeholders in cotton.

Technology Mission on Cotton A success story

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1. TMC was launched in February 2000 by Ministry of Agriculture with its four Mini Missions for overall improvement of cotton sector in the country. Research under MM I has developed several long linted diploid *desi* cotton, high quality *barbadence,* and *hirsutum* hybrids. Technologies like Integrated Nutrient Management including micronutrients. Integrated Water Management, Bt cotton based cropping system, farm mechanization & physiological manipulation of Bt cotton are now available for each zone. Commercialization of bio-pesticides & Bt detection kits were generated for the use of farmers. Similarly insecticide quality test kits also enabled the farmers to buy quality insecticide.

2. Due to implementation of MM II of TMC significant impact were noticed in Cotton sector during the last decade. All India compound growth for area, production and yield of cotton during post TMC Period (2000-01 to 2009-10) showed higher growth in Cotton production (13.58%) with 11.22% growth rate in yield despite marginal growth rate in area (2.13%). Cotton productivity has increased from 186 kg lint per hectare in 2001-02 to 507 kg lint per hectare during 2011-12. Within a short span of time, Bt cotton hybrids proved to be the most accepted technology by the farmers in all the nine cotton growing states. More than 91% of the total cotton area are under Bt hybrids.

3. Introduction of Bt hybrids and IPM technology dissemination reduced insecticide usage from 46% in 2001 to less than 21% during 2011. Bt cotton reduced yield losses from damage of 30 to 60%.The per ha income of Rs.7058/- in 2001 increased to Rs.16125/- in 2010 under rainfed and Rs. 15370/- in 2001 increased to Rs. 25000/- in 2010 under irrigated conditions. The large scale raw cotton import of 22.10 lakh bales in 2001-02 reduced to 5-7 lakh bales in recent years. The export of cotton was nominal (50000 bales) in 2001-02 which increased to 128.81 lakh bales in 2011-12 Thus India becomes 2nd largest producer, consumer & exporter of raw cotton in the world since 2007-08.

4. A total of 246 Market Yards in 10 states were modernized under MM III and the contamination level reduced from 7% to 3% , improvement in cotton procurement system on the basis of quality has been established. A total of 859 G & P Factories were modernized in eleven states under MM IV and India is now capable to produce uniform bales with International quality and are able to reduce trash content (6-7% to 1-2%}, contamination, minimize fibre damage and fibre quality, thereby opened the export opportunities in global market.

5. Despite of significant impact of TMC, Indian cotton productivity still remain below the world average (750 kg lint/ha) with 90% Bt hybrid adoption and 45% irrigation. There is further scope to increase the yield level of cotton for which strategic planning on Cotton Based Cropping System have been formulated. Development of GM cotton varieties suitable for HDPS, fabrication & validation of cotton hand picker, rainfed cotton yield, revival of deshi & ELS cotton, promotion of organic cotton, running of Farmers Field School , Bt resistance Management, continuous flow of on line pest monitoring & advisory services and custom hiring centres of cotton are the recent issues in the cotton sector.

6. During 12th Plan the activities of four Mini Missions are likely to be continued with modified form. The MM II of TMC will be merged with NFSM and Commercial crop based cropping system will be introduced. Respective State Government will draw their cotton developmental programme under RKVY.DOCD Mumbai will implement selected central sector components like Insecticide Resistance Management (IRM), On Line Pest Monitoring and Advisory Services (OPMAS), Front Line Demonstration (INM/IPM , intercropping, Deshi & ELS) and trials on High Density Planting System (HDPS).

7. Additional 70 MY will be covered during 12th plan period in 10 cotton growing states (52 Improvement, 18 new). Thus 66% of the cotton market yard in the country will be upgraded resulting minimum contamination of seed cotton. Mini Mission-IV of TMC has proposed to undertake modernization of 600 ginning and pressing factories during 12th plan.

Pesticides in Cotton-the Road Ahead

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It is estimated that the global demand of cotton from the current level of 25 million metric tons would go up to 48 million metric tons by 2030 driven by growing world population and fast growing economies like China and India. However, considering the issues concerning food security and land pressures, the global area under cotton production is likely to be at the current levels of 34 million hectares. Hence, the increase in demand for cotton fiber by the global textile industry has to be largely met by enhancing the productivity of cotton.

India though has the largest area under cotton about 12 million hectares (1/3rd of the global acreage) but accounts for 1/5th of the global production. The average yield of 500 kg lint / ha is significantly lower than other major cotton growing countries like Brazil (2027 kg lint / ha), China (1311 kg lint/ha), USA (900 kglint/ha) and also global average of 740 kg lint /ha. This offers excellent opportunity to India to further enhance the productivity levels and achieve global leadership in cotton production. India has set a target to double its cotton productivity to 1000 kg lint / ha by 2020. It calls for strong actions on key fronts like technology; crop improvement; production;post-harvest processing and partnership among diverse value chain stake holdersalong with robust policy support from the government.

Cotton is ravaged by various pests (insects / disease causing pathogens / weeds etc.) causing serious economic loss. In the pre-Bt cotton era (before 2002) the boll worm complex led by American boll worm Helicoverpaarmigera almost entirely damaged cotton crop if left unprotected. In the post Bt-cotton era (2002 onwards) sucking insect pests like Aphids, Jassids, Thrips, Whitefly, Mealybugs, Myrid bugs and Mites continue to ravage the cotton crop and pose a serious threat to sustain and enhance cotton productivity. It is reported that among sucking insect pest Jassids alone has potential to reduce cotton yield from 20-60 % if not effectively controlled. Among diseases the bacterial blight caused by

Xanthomonasmalvacearum and boll rot complex are major constraints. Weeds become a serious constraint in cotton in situations of continuous rains or high density planting which limits the intercultural operations.

Pesticides have been the most reliable tool in the hands of cotton farmers to manage various pests and achieve economic yields. However, indiscriminate use of chemical pesticides by Indian cotton farmers have led to situations of development of resistance in pest like Whitefly in 1980's to systemic insecticides like Dimethoate, Monocrotophos, Acephate etc and Helicoverpa armigera in 1990's to synthetic pyrethriods and other Organo Phosphatic insecticides posing serious threat to very survival of cotton cultivation in India. Crop protection industry responded by developing newer solutions to contain these pests like Triazophos/ Profenophos/ Acetameprid / Diafenthiuron /Imidacloprid/Thiomethoxametc for Whitefly and other sucking pest control and newer groups of insecticides like Indoxacarb, Spinosad, Emamectin Benzoate, Flubendiamide, Rynaxypry, Pryidalysl, Novaluron, Lufenuron, etc for Helicoverpa and other bollworms of cotton.

Flonicamid a new insecticide with a new mode of action introduced by UPL in 2012 in India has set a new benchmark for control of sucking pest in Cotton.

To provide chemical solutions which fit Integrated Crop Management / Integrated Pest Management approach, Bayer CropScience is in the process of introducing innovative insecticides / miticides in cotton which belong to new chemical classes Ketoenoles and Diamides. These products (Movento, Oberon and Belt) not only provide new modes of action for insect control, they also protect many beneficial insects occurring in cotton such as earwigs, predatory bugs, larvae of lady bird beetle, hover flies and lacewings.

Biodegradable nanofibres such as starch, cellulose, chitin and lignocellulose as carriers for controlled release of pesticides (insecticides/ fungicides/ herbicides) is being deployed to achieve fullest biological efficacy against target pest and minimize harmful effects to the environment. Cornell University, USA has

produced nanofibres with insecticide Imidacloprid and fungicide Tebuconazole for effective controlled delivery system.

Behaviour modifying chemicals regularly referred as semiochemicals like pheromones and allelochemicals are increasingbeing deployed in monitoring insect pest particularly lepidopteron pest and also for for pest population reduction through mass trapping and mating disruption in Integrated Pest Management strategies in cotton.

The current methods used to discover and develop new pesticide solutions are sophisticated and complex. A new compound has to be not only highly efficacious but also environmentally acceptable.With high throughput screens that can handle thousands of candidate compounds it is now possible to screen 40,000 to 50,000 compounds / year for bio-efficacy against target pests and non-target toxicity.However, as a consequence of increasing safety requirements the numbers of products which have to be tested and evaluated to result in a single successful product have increased significantly. In 1995 one out of 52,500 compounds made it to the market. This number increased to approx. 140.000 in 2000 and is expected to further increase.The cost and time of development and introduction of one successful candidate compound is estimated as 250 million USD and 10 years respectively. Hence, new innovations from the crop protection industry when introduced have to beused rationally to sustain their effectiveness and usefulness in pest management for reasonable time.

Chemical solutions in form of modern target specific, controlled release, relatively ecologically and environmentally friendly pesticides and semiochemicals will continue to play a key role in pest management of cotton in an Integrated Pest Management approach and contribute significantly in the journey of achieving 1000 g lint /ha productivity in cotton by 2020.

Application of Modern Tools of Biotechnology for Pest Management

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Recombinant DNA technology has significantly enhanced our ability for crop improvement, to meet the increased demand for food and fiber. Considerable progress has been made over the past two decades in manipulating genes from diverse sources to develop plants with resistance to insect pests, improve effectiveness of bio-control agents, marker assisted selection for insect resistance, understand the nature of gene action and metabolic pathways, production of genetically modified sterile insects, use of molecular techniques in insect taxonomy, understand the mode of action of insecticides, and identify insecticides with newer mode of action. Despite the diverse and widespread beneficial applications of tools of biotechnology, there is a need to present these benefits to the public in a balanced manner. Testing and release of products generated through biotechnology-based processes should be continuously optimized based on experience. This will require a dynamic and streamlined regulatory structure, which is clearly supportive of the benefit of biotechnology, but highly sensitive to the well-being of humans and environment.

Bridging Gaps Between Cotton Production Research and Spinning Industry

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raw material for the spinning industry. Similarly, Indian spinning Industry is also gigantic in nature with 20% of the world spindlage and 90% of the world rotors, and producing 13% of the world's spun yarn second largest after China. In the last ten years, the production of cotton yarn is increasing at a CAGR of 4.4%.

Therefore, the main thrust of cotton production research has always been for increasing the availability of cotton for the industry, maintaining CIRCOT prescribed fibre quality norms for breeding cotton. Indian spinning industry produces yarns ranging from vary course to super-fine count (1 to 250s Ne) needing production of cottons widely varying in quality, from short to extra long staples. While this has been mostly met by production of cotton domestically and fewer imports mainly in the long and extra-long categories, however, a quality-wise demand assessment of cotton is much needed, particularly in view of modernization of the spinning industry and manufacturing growth of technical textiles in India.

In the present paper, a projection has been made on the quality wise cotton requirement during the 12th Five Year plan period based on the trend in cotton and blended yarn production, textile exports in the past yearsetc. Further use of cotton in new areas, such as technical textiles, meeting the growing demand of absorbent cotton and cotton quality requirements for production of high value textiles have also been discussed.

It may be noted that quality-wise yarn requirement for textiles are prone to changes depending on consumers choice, fashion trend, GDP growth, demand from export markets etc. within a short period, whereas research planning for future cotton development and its cultivation for mass production needed a long-term planning. Thus, projections made in this present paper are to be viewed cautiously and more as a guideline.

DRIP IRRIGATION IN COTTON IN INDIA - AN OVER VIEW

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At the country level one third of the area under cotton crop is irrigated. In the states of Punjab, Haryana and Rajasthan this crop is essentially grown under irrigation only. Nearing 50 per cent of cotton in Gujarat is under irrigation. On the other hand, around 96 per cent of the cotton crop is under rain-fed condition in Maharashtra. Similarly in the southern states of Karnataka and Andhra Pradesh only less than 20 per cent of the crop is irrigated, while in Tamil Nadu nearly 40 per cent is irrigated.

Cotton is one amongst the crops which responses very well to drip irrigation. Though there are reports of use of sprinkler in this crop, in Indian conditions and with indeterminate varieties sprinkler is not a good proposition, though it can be used to give a couple of life saving irrigation before flowering under rainfed condition.

The water requirement of cotton varies widely among the different agro climatic conditions in the country/states. On an average the water requirement of cotton through surface method is around 450 to 550 mm. This can be reduced to around 250-300 mm through adoption of drip. Adopting drip technology there is as potentiality of bringing about 2.3 million hectares of cotton under drip in India. Gujarat, Punjab, Haryana, Andhra Pradesh, Rajhasthan and Madhya Pradesh are the states which together contribute to nearly 80 per cent of the total potentiality while Gujarat alone has a potential of 8.8 lakh hectares out of the 23 lakhs hectares which is the potentiality in the country. There is lot of scope (~60 per cent) in water savings as the farmers tend to over irrigate. The productivity can be increased by About 30 to 40 per cent with better water management through drip and the fertilizer savings can be improved by another 15 to 20 per cent. The cost of the system can be brought down with more scientific designing like adoption of paired row, selection of suitable diameter of lateral etc. There is need to educate the farmers on the operation and maintenance of the system with special reference to irrigation and fertigation scheduling, maintenance of the filter etc.

Resistance management in Bt cotton Present and Future Scenario

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Bollgard® (Bt) cotton in India is being grown since 2002 and currently occupies approximately 90% of the cotton growing area, which includes approved events such as Bollgard II® that was commercialized in 2006. There are a total of six approved events and their products are being marketed by more than 25 companies across India. Bt cotton is being cultivated in an area of more than 11 million ha with a production of 347 lakh bales and India is the second largest producer of cotton in the world. The increased production of cotton in India in the past ten-year period has been primarily attributed to Bt cotton technology and its efficacy on target insect pests besides cotton hybrids with improved characters. The sustainability of Bt technology is dependent on implementation of insect resistance management strategies. Resistance monitoring is being done on annual basis to monitor the susceptibility changes in the pest population(s). In this presentation we will discuss the path forward in Bt cotton resistance management, resistance monitoring and integration of knowledge to sustain insect resistant Bt technologies as part of existing pest management systems.

CHALLENGES FOR PUBLIC SECTOR COTTON BREEDERS

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India is the second largest cotton producing country in the world with lint yields doubling in the past decade. This has been mainly due to the genetic improvement achieved by plant breeders with able support from the plant protection group. Value addition to the cotton plant in the form of Bt gene has mainly been responsible for a revival in cotton yields.

The rise of the private sector is primarily due to its marketing acumen apart from the conducive economic policy regime during the 1990s. That, the private companies initially flourished by selling public sector hybrids is well known. Their scientific personnel also are a public sector contribution. The current effort of the public sector breeders in the overall capacity enhancement of cotton is largely altruistic and it is not impossible to replicate such success in the public sector.

Some studies pointing towards modest achievements using available genetic material are listed. The easiest method of new germplasm creation seems to be double crosses among publicly available hybrids. This was achieved in *Gossypium hirsutum.* Improvement in terms of seed cotton yield and fibre quality has been achieved in one study extending over time in a conventional manner. A notable point is that the germplasm used was freely available in public cotton trials conducted by the All India Coordinated Cotton Improvement Project. Since the hybrids came from different geographical regions of India, the genetic diversity was assured in the generated germplasm. A planned assessment and use of these new lines focusing on trait combinations will lead to better hybrids. Similar results have been achieved in *desi* (*G. arboreum* L.) cotton. The margin of yield improvement is comparatively less as *desi* cotton is quite resilient to breeding exercises. Fibre quality improvement has been achieved in the segregants obtained from single and multiple crosses among public bred lines. Also, introgression of hirsutum/barbadense genes in to *desi* cotton has seen similar results. Immune plants to grey mildew disease, a threatening disease of *desi* cotton, have been isolated through diligent selection among segregants of *desi* hybrids. Elsewhere, the resistance breeding work on CLCuV disease and mealy bug resistance is also progressing. However, with trait rich germplasm abundantly available, introgression breeding should only be resorted to in extreme cases. Even then, use of molecular tools to hasten the process is better advised.

The seemingly academic exercises a public sector breeder involves himself in *viz.*, varietal development, ideotype breeding, apomixis, male-sterility, abiotic stress resistance, non-fibre uses of cotton, among others, should be encouraged by governmental funding which would strengthen a public sector breeder and make him relevant in the coming times. That, these areas have not received enough patronage from the private sector is quite evident. This is a window of opportunity for the public sector. Applied research has been systematically funded in cotton through the TMC and by other scientific bodies. The challenge for the public sector breeders is to show periodic achievements to keep the funds flowing. Some early achievements in these areas have been highlighted.

Plant protection from pests and diseases can help realize the true potential of a genotype. Host plant resistance breeding has been more of a public sector activity. The exemplary Bt gene technology has to be fine tuned by our breeders to make it more remunerative to the Indian farmer. An early maturing compact cotton variety with the Bt gene should be the next target of a public sector breeder. Coupled with mechanization this will be a god send. On the other hand, for such private sector products, a rational pricing in the new IPR regime has to be devised by our government to maintain a social balance.

These days, there has been the use of novel plant breeding techniques. They not only hasten conventional breeding but also ensure food and feed safety since the end product is not a GMO. Such novel techniques like Agroinfiltration, Virus Induced Gene Silencing (VIGS), Reverse Breeding and Accelerated Breeding need to be exploited by the public sector breeders. These techniques are safe and rapid leading to guaranteed results. The ideal cotton plant type and early cultivars can be envisaged through these methods in the immediate future.

There is a notion that progress by public sector breeders is slowing down. It is because of the Bt blitzkrieg by the private sector. However, policy changes by the government in such a scenario can put everyone on an even keel. Substantial research gains are being reported by the public sector. It is time for the public sector breeders to recover lost ground.

Recent Advances in Biocontrol in Cotton Ecosystem

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Cotton, being a cash crop, is of great economic importance for the Indian farming community. A good crop with minimal disease attack leads to prosperity, while a severe pest attack brings misery. But, the cotton crop is highly prone to the attack of both foliar and soil- borne diseases. The major diseases like wilt, root rot, seedling rot, Alternaria leaf blight and grey mildew act as the major determinants in reducing the yield of both Bt and Non Bt Cotton. The management of diseases were attempted through the extensive use of fungicides. Subsequently after one or two years of the usage of fungicide, it is not found to be responding well for the effective control of the diseases. It might be due to the development of resistance among the fungal pathogens. Considering the same issue, several attempts were made to fish out an effective measure for the management of cotton diseases. Attempts made across the country resulted in the genesis of biological control as an alternate tool for the management of diseases under field condition.

Exploration of the microbial biodiversity, in the cotton rhizosphere and the endophytes of cotton revealed that antagonistic *Trichoderma spp.*, *Pseudomonas spp.*, and *Bacillus spp* were found effective in the management of cotton diseases besides plant growth promotion. Studies on the variability of *Bacillus* isolates from the cotton rhizosphere revealed the presence of *Bacillus subtilis* (BSC1, BSC2, BSC3, BSC4,), *Bacillus cereus (BSC5), Bacillus amyloliquefaciens (BSC6), Bacillus lichiniformis (BSC7)*. Analyses on the variability of endophytic *Bacillus* from cotton revealed the presence of *B. subtilis* (EBs3, EBs 4, EBs 5, EBs 6 EBs 9 and EBs14), ***B. mojavensis* (EBs1 and EBs11)**, *B. amyloliquefaciens* (EBs 2) and *Bacillus safensis.*

The molecular detection of antibiotic biosynthetic genes depicted the presence of surfactin, iturin, bacillomycin and fengycin among *Bacillus* isolates. Among the isolates, three isolates *viz.*, ***B. mojavensis*** EBs1, *B. amyloliquefaciens* EBs2 and *B. subtilis* EBs6 showed positive reaction for bacillomycin D. Eight isolates *viz.*, ***B. mojavensis*** EBs1, *B. amyloliquefaciens* EBs2, *B. subtilis* EBs6, *B. safensis* EBs7, *B. subtilis* EBs9, *B. subtilis* EBs10, ***B. mojavensis*** EBs11 and *B. subtilis* EBs12 showed

positive reaction for fengycin D. Seven isolates of *Bacillus viz.*, ***B. mojavensis*** EBs1, *B. subtilis* EBs8, *B. subtilis* EBs9, ***B. mojavensis*** EBs11 *B. subtilis* EBs12, *B. subtilis* EBs13 and *B. subtilis* EBs14 showed positive reaction to iturin and four isolates *viz.*, *B. amyloliquefaciens* EBs2, *B. subtilis* EBs4, *B. subtilis* EBs5 and *B. subtilis* EBs14 showed positive reaction for the presence of surfactin antibiotic gene.

Among *Pseudomonas* isolates, six isolates *viz.*, *P. fluorescens* EPf1, *P. fluorescens* EPf2, *P. fluorescens* EPf5, *P. fluorescens* EPf8, *P. aeruginosa* EPa10 and *P. fluorescens* EPf13 showed positive reaction for the presence of **2,4-DAPG.** Four isolates *viz.*, *P. fluorescens* **EPf4,** *P. fluorescens* **EPf8,** *P. aeruginosa* **EPa10 and** *P. aeruginosa* **EPa11** showed positive reaction for the presence of **pyoluteorin** and six isolates *viz.*, *P. aeruginosa* EPa3, *P. fluorescens* EPf6, *P. fluorescens* EPf7, *P. aeruginosa* EPa9, *P. fluorescens* EPf12 and *P. aeruginosa* EPa14 showed positive reaction for the presence of **pyrrolnitrin gene.**

Bacillus amyloliquefaciens, B. cereus, B.subtilis and *P. fluorescens* were effective against *A. macrospora, Fusarium oxysporum* f.sp. *gossyppii, Rhizoctonia solani* and *Macrophomina phaseolina* under *invitro and invivo.* Besides, *B. amyloliquefaciens* produced higher amount of salicylic acid and HCN responsible for the induction of resistance mechanism in the host against the pathogens. **GC/MS analysis of the secondary metabolites produced by the antagonistic organisms** *B. amyloliquefaciens* isolate EBs2 **revealed the presence of different antimicrobial compounds like** tetratetracontane and hexatriacontane, benzoic acid 4-ethoxy ethyl ester, dodecane, 2,6,10-trimethyl, heneicosane, tricosane, tetracosane, pentacosane, hexacosane, octacosane, nonacosane, hentriacontane, dotriacontane, tetratriacontane. 1,2,3-propanetriol mono acetate, octahydro-2H-pyrido (1,2-a) pyrimidin-2-one, 2,5-piperazinedione 3,6-bis (2-methylpropyl), dihydroergotamine, 1,2-benzenedicarboxylic acid, diisooctyl ester, barrigenol R1 and stearic acid 3-(octadecyloxy) propyl esters were found to be associated with the secondary metabolites from *P. fluorescens* isolate EPf8 **pertaining to aliphatic hydrocarbons, fatty acid, lipopeptide, diterpene and plasticizer nature of compounds with antifungal and antibacterial activity.**

Application of antagonistic bacteria against leaf blight pathogen *A. macrospora* induced systemic resistance by activating the defense related enzymes *viz.*, PO, PPO, PAL, â-1,3 glucanase, SOD and total phenols. Increased expression of PO

and PPO isoforms for these enzymes were observed through native polyacrylamide gel electrophoresis. In addition application of signal molecules like salicylic acid also induced PO, PPO, PAL and total phenols.

The glass house and field experiments revealed that seed treatment and foliar application of either *B. amyloliquefaciens* or *P. fluorescens* or *T. viride* either as individual organism or delivering *B. amyloliquefaciens* isolate EBs2 and *P. fluorescens* isolate EPf8 as the consortia recorded the least disease incidence and higher yield with improved biometric parameters of cotton. Development of IDM module for the management of cotton diseases indicated that Seed treatment with *Bacillus subtilis* (BSC5-TNAU1) (10g/Kg) combined with soil application @ 2.5 Kg/ha along with foliar spray of *B. subtilis* @ 1% on 60, 90 and 120 DAS was effective against Alternaria leaf spot, Grey mildew, Black arm of cotton and root rot compared to the farmers practice. It was on par with seed treatment with *Trichoderma viride* (TV-TNAU1) (10g/Kg) combined with soil application @ 2.5 Kg/ha along with foliar spray @ 1% on 60, 90 and 120 DAS. Hence, selection of biocontrol agents with different mode of action will be effective and would provide a sustainable management for the effective control of both soil borne and foliar diseases of cotton under field conditions.

Cotton Biotechnology -2020

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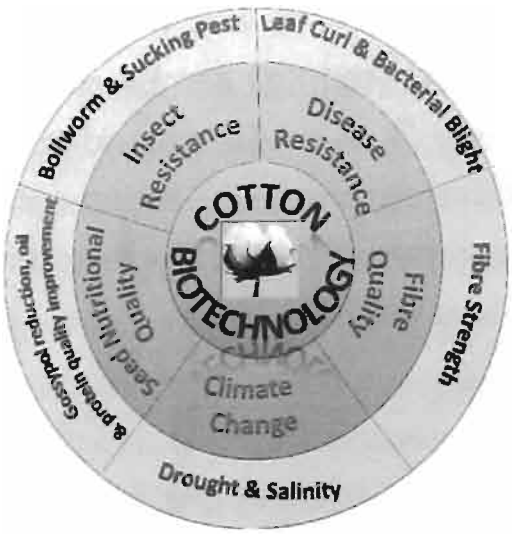
Limitations in genetic variation for desired traits and associated problem with linkage drag in conventional plant breeding has necessitated for an alternative approaches for precise transfer of economically important traits. Recent advances in biotechnological techniques such as genome sequencing, functional genomics, RNA interference, new molecular markers for economically important traits has resulted in sea of changes in cotton improvement.



Insect resistance: ***Bt*** cotton is one of the agricultural technologies where highest adoption rate is observed compared to other recently developed technologies. However, it is important to strengthen the Bt technology with additional genes through gene stacking to ensure long term sustainability. Isolation and identification of novel *cry* genes encoding insecticidal toxins from the bacteria *Bacillus thuringiensis,* proteinase inhibitors and lectins from plants that have a significant effect on several insect species. The possibilities of discovering new genes for pest management have expanded into infinity, with introduction of new concepts such as gene silencing through RNA interference (RNAi). RNAi deploys double stranded RNA (dsRNA) to silence specific endogenous genes in the target organism, which can be specific to the class, genus or even the specific

target species. Gene silencing has been used to develop a new biotech cotton variety that specifically controls bollworms by silencing a gossypol degrading enzyme called *CYP6AE14* which otherwise enables bollworms survive on cotton (Mao et al., 2007, 2011). Thus, crucial species specific genes of insect pest species are being identified and the dsRNA expressed in plants to control them. Gene sequences and the novel structures are being explored for their utility for crop protection through conventional or transgenic approaches for the management of cotton insect pests such as the bollworms, jassids, whiteflies and new pests. (Kranthi 2009).

Fibre yield and quality: Advances in biotechnology research in cotton unrevealed molecular mechanisms involved in fiber development such as, initiation, elongation, secondary cell wall synthesis and maturation. Studies have shown that growth regulators such as auxin and cytokinins are important determinants of fiber initiation and number (**Seagull et al 2004**). The staggered flowering time made it impractical to utilise the growth regulator for increasing fiber yield. However, recently more than 15% increase in lint yield has been reported by targeted expression of the IAA biosynthetic gene iaaM, driven by the promoter of the petunia MADS box gene Floral Binding protein 7 (FBP7) which is known to active between -2 to 10 DPA (Days Post Anthesis) (Zhang et al 2011).The targeted expression of growth regulators such as Auxin and cytokinin needs to be carried out to realise the improvement of fiber yield. **Recent developments in spinning technology demand a stronger fiber.** Synthetic fibers are usually long chain polymer combine with light weight; great strength and wrinkle free fibers offer stiff competition to natural fiber especially cotton. Molecular mechanism for fibre elongation is well understood for cotton; however, there is scarcity of information on genes responsible for fibre strength. ***Exploration of n***ear isogenic lines (NILs) ***for fibre strength using*** high throughput gene expression profiling ***studies revealed putative candidate genes*** (*G. hirsutum* gene cellulose synthase2 (*GhCesA2*), *G. hirsutum* ortholog of the *Arabidopsis* gene irregular xylem3/cellulose synthase7 (Ghirx3), *G. hirsutum* ortholog of the *Arabidopsis* gene COBRA-LIKE4 (*GhCOBL4*) and *G. hirsutum* gene chitinase-like1 (*Ghctl1*)) associated with cellulose synthesis, microtubule rearrangement during secondary wall deposition stage. The targeted expression of above mentioned candidate genes

driven by strong fiber specific promoter will pave way for the development of GM cotton with improved fiber strength (Hinchliffe et al., 2010, 2011).

Disease resistance: Important diseases of cotton such as the cotton leaf curl virus and bacterial blight can be effectively managed by GM technologies including RNAi by pyramiding native resistance available. The target gene sequence of replicase protein, coat protein and movement protein genes have been used to develop leaf curl virus resistant varieties by silencing of the genes through RNAi, for northern India where the cotton leaf curl virus (CLCuV) problem can cause severe economic losses. There is also need to identify effective siRNAs and/or miRNAs and their targets for development of GM cotton resistance to CLCuV. Marker assisted breeding should be the method of choice for the traits where linkage map and linked marker available. Marker assisted selection is the most successful technique in disease resistance breeding. In cotton, studies on bacterial blight resistance resulted in identification of SSR markers such as CIR 246, BNL 3545 and BNL 3644 on chromosome 14 closely linked to B_{12} gene a major gene contributing resistance to almost all the races of *Xam* (Fang *et al.*, 2010). Utilization of available SNP/SSR markers closely linked (3.4 cM) to resistance gene B_{12} can be used for validation of germplasm lines and subsequent utilisation in marker assisted breeding for bacterial blight resistance and also validation and exploitation of marked assisted selection for nematode resistance and GMS of Indian genotypes in also need of the hour.

Climate change: Cotton being C3 crop, genetic manipulation to maintain positive carbon balance either by increasing carboxylation reaction or by decreasing photo respiration will enhance the water use efficiency (WUE) and nutrient use efficiency (NUE), thereby enhancing yields. **Recent successful demonstration of increasing CO_2 (CO_2 Concentration Mechanism) and biomass in *Arabidopsis* by utilizing decarboxylation of glycolate (a pathway that exists in bacteria) acts as an option for improvement of C3 crops such as cotton.** Transgenic approach has **provided proof of concept of their relevance for many genes such as *P5CS*, *Glyoxalase* (Singla-Pareek et al., 2003) *AHK1/ATHK1* (Lam-Son et al., 2007), *DREBs*, *PDH45Helicase*** (Sahoo et al 2012), ***NPK1*(Kovtun et al 2000), *SHINE/WIN1-AP2 ERF Transcription factors* (Asaph et al., 2004), *DREB2* like small protein such as *CAP2*,**

***AtHARDY* (Karaba et al 2007), AVP1** (Pasapula et al 2011) **etc., which mainly addressed cellular level tolerance to drought and salinity in model plant species, need to be utilized in cotton along with the improvement of primary constitutive traits such as root growth.** Recently transgenic cotton with ectopic expression of *AtSAP5* gene under CaMV35S promoter resulted in complete protection of photosystem (PS) II complexes from photo damage and also showed tolerance to moderate heat stress (Hozain et al (2012).

Seed nutritional quality: Cottonseed is the primary by-product of cotton production. Though cottonseed is reported to be a rich source of protein and other nutrients, presence of gossypol within the seed-glands renders it toxic to humans and monogastric animals. Though the protein content and protein efficiency ratio of cottonseed is higher than that of major vegetable proteins, full utilization of cottonseed is hampered by the presence of toxic gossypol. Biosynthesis of gossypol in cottonseed can be lowered through application of biotechnological approach such as detoxification using cytochrome P450 *CYP6AE14* genes from cotton bollworm (Kranthi, 2009) and silencing of ä-cadinene synthase and hydroxylase gene expression in a seed-specific manner (Sunilkumar et al. 2006). During the processing of cottonseed, most of the free gossypol is converted to less toxic form, by binding with the epsilon amino group of lysine. In this process, along with free gossypol reduction, there is drastic reduction of protein is also reported. Hence, enhancing the lysine content in the seed by expression of lys-insensitive dihydrodipicolinate synthase (DHDPS) gene to avoid feedback inhibition is expected to make cottonseed protein rich with less gossypol.

Organic Cotton Value Chain Needs Govt. Support

Kapil shah

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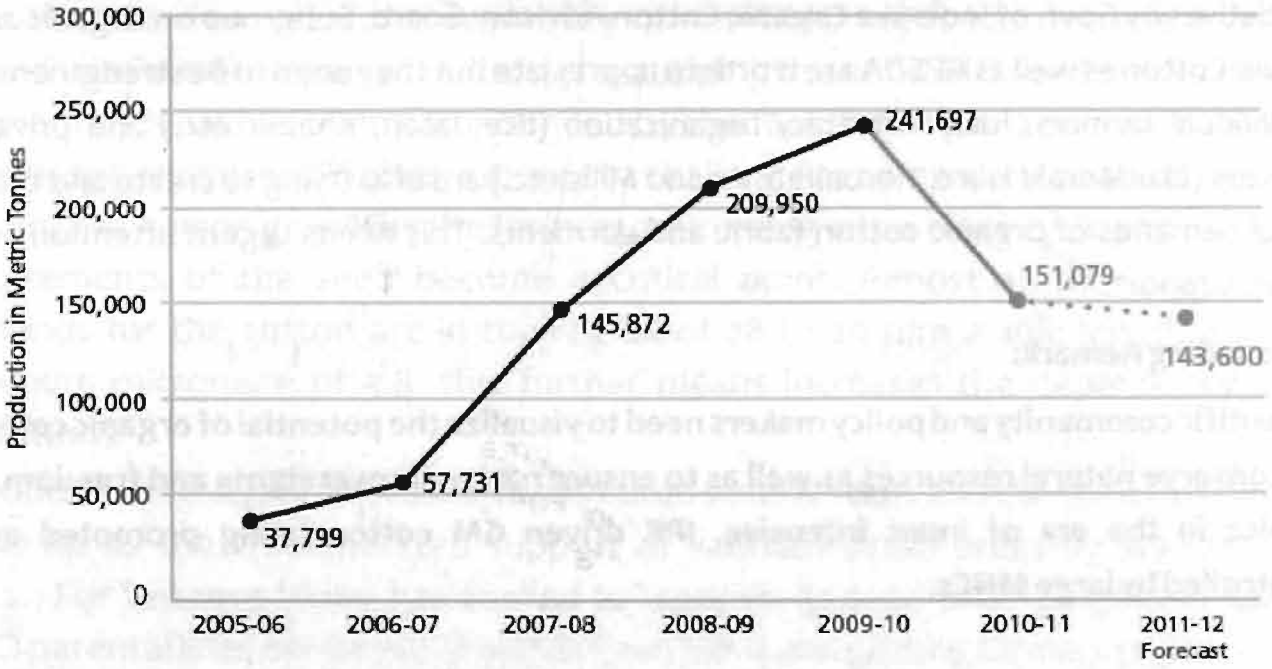
Occupying just 2.5% of agricultural land area, cotton uses 7% of the total amount of pesticides used in farming globally each year and 16% of all insecticides. In developing countries, cotton is thought to account for 50% of total pesticide use. Up to 77 million cotton workers suffer poisoning from pesticides each year. In some parts of the world cotton production is putting unsustainable pressure on our precious and vital water resources. One of the thirstiest crops we farm, cotton uses 11,000 litres of water on average for each kilogram of cotton produced. A researcher in 2010 found that impact of organic cotton on water resources was dramatically less than on non-organic farms. The grey water footprint of non-organic farms was 98% more than the grey water footprint of organic farm. Of the 15kg Co_2e that is emitted in the life of a cotton T-shirt, 14% of these emissions are produced growing cotton. High-input, intensive cotton farming uses a lot of energy by manufacturing and transport of fertilizers and pesticides to boost the crops. 83% of manufactured nitrogen fertilisers spread on crops and up in the environment, releasing huge amounts of N_2O and contributing 42% of cotton's on-farm emissions. By eliminating the use of manufactured fertilisers and pesticides and reducing nitrogen inputs, organic cotton growing produces up to 94% less greenhouse gas emissions. By maintaining soil health, organic practices turn soils into a carbon 'sink' removing CO_2 from the atmosphere. Organic soils soak up and hold more water so they can better cope with floods and drought. GM company Monsanto now controls a staggering 95% of the cotton seed market in India, where 68% of organic cotton is grown. Consequently, research into and availability of non-GM seed varieties is getting less and less. Farmers can't control the quality and type of seeds they use, giving them no choice but to use GM seeds.[1] **The benefits that were assured from Bt cotton cultivation are not coming.[2] On the other hand, research shows that organic agriculture is a good option for food security... and [is] more sustainable in the long term.[3]**

With the increasing awareness about ecology, social justice and sustainability the

world market of organic cotton is projected to exceed 19.8 billion USD by the year 2015.[4] Most of the important textile brands are increasingly buying organic cotton, many of them are present in India. Some of these brands have not only tied up with CSR and NGOs, but have also developed tools (like Nike Material Sustainability Index) to address environmental, social and economic issues to satisfy their customers. Unfortunately, in the year 2010-11 the global production of organic cotton has dropped by 37% compared to previous year and the production estimates for the year 2011-12 shows further down. India is leading the world in organic cotton production, followed by Syria and China.[5]

Organic Cotton Fiber (Lint) Production Trend



Notes:
Data has been rounded to nearest whole number.
Total reported in 2008-09 as 175,113 adjusted in 2009-10 report to 209,950 mt due to review of India figure.

Source: Organic Cotton Market Report (2011), Textile Exchange

Not only to maintain the first position but to take advantage of one of the most promising global markets, India needs to address serious concerns over future of organic cotton cultivation in the country. **Foremost concern is, after introduction of GM cotton most companies and Universities have lost interest in non-GM cotton seed production. Non-GM seeds are mandated for organic production. The crisis of non availability of high quality non-GM cotton seeds in the upcoming years looms large.** This is bound to affect the sustained growth of organic cotton production in the immediate future.[6]

Other concerns include updating agronomic & crop protection practices, **ensuring 'no-contamination' of Genetically Modified Cotton** at all levels of the chain starting from seed production (seed storage-cotton production- cotton storage-processing-transport) to export. Capacity building of farmers through reliable extension service **as well as strong policy and programmatic support from Govt. is inevitable.**

Initiatives by Govt. of India like Organic Cotton Advisory Board, Subgroup on Organic and Suvin Cotton as well as APEDA are worth to appreciate but they need to be strengthened. Individual farmers, local voluntary organization (like Jatan, Khamir etc.) and private players (like Morale Fibre, Herbalfab, Arvind Mills etc.) are also trying to create and cater local demands of organic cotton fabric and garments. This needs urgent attention and Govt. support.

Concluding Remark:

Scientific community and policy makers need to visualize the potential of organic cotton to conserve natural resources as well as to ensure national sovereignty and freedom of choice in the era of input intensive, IPR driven GM cotton being promoted and controlled by large MNCs.

Contemporary Challenges in Organic Cotton

Rajeev Baruah
Managing Director bioRe India Ltd

Introduction

bioRe works with small and marginal cotton growing farmers in the Khargone, Badwani and Dhar Districts of Madhya Pradesh. bioRe has been a pioneer in this field and has been working in the region since the past 20 years. Farmers who grow organic cotton are linked to a unique textile chain, which goes all the way up to retail. called the `bioRe chain'.

There are several challenges that bioRe is facing in the promotion of organic cotton and I would like to state them as follows:

Seed

Over the past few years the availability of non-GMO seeds has become a very limited with seed companies reducing to stopping the non-GMO seed production. Further this issue has been compounded by the fact that most farmers are using hybrids and producing hybrids is more of a challenge as compared to varietal lines. The organic cotton grown by the farmers are coming into a close cycle and quality requirements of the seed become a critical point. Almost all the quality of demands for the cotton are in the region of 28 to 29 mm staple length and a minimum micronaire of 3.8- this further means increases the dependency on `hirsutums'.

The address the above issues bioRe has taken several steps and the solutions have come up by the wholehearted support of various cotton breeding stations in India. For instance bioRe has started to work on its seed chain by getting non-GMO parental lines of released hybrids from Surat and getting farmers to produce them. Also released `varietal lines' are being obtained through the CICR network and given to farmers. We are also working with the University of Dharwad in the identification of `genotypes' meeting our quality requirements and suited for low input and organic conditions.

Training of farmers

Building the knowledge base of the farmers is a key to the success of organic cotton growing. bioRe has its own demo farm where organic cotton is grown each year. The demo farm also is the training center for farmers where large farmers come and take training on various aspects of organic farming and organic cotton growing. Further the development of farmer field schools is imperative where farmers can come and see organic cotton farmers and crop diversity.

Extension Service

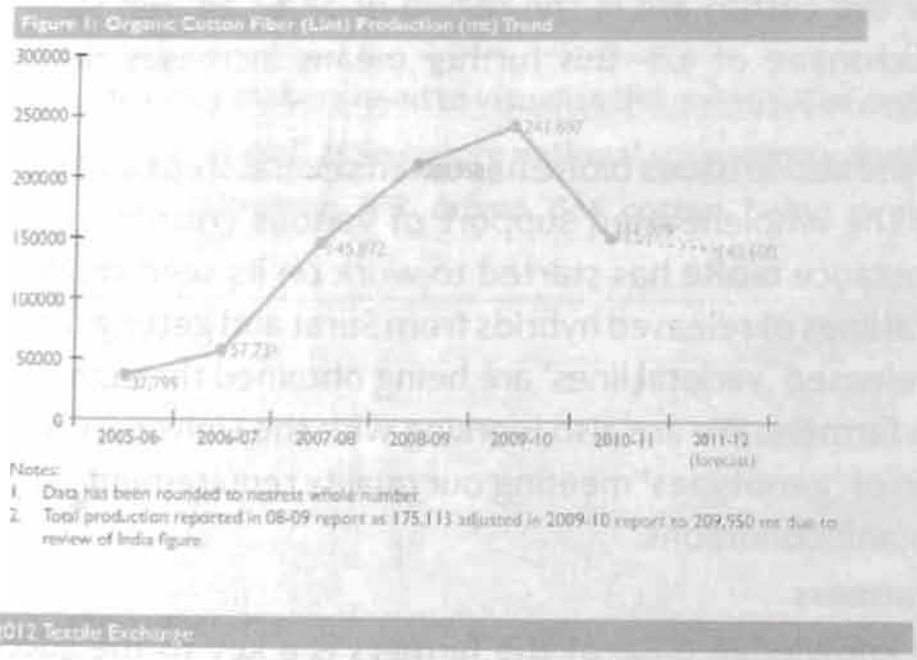
Getting qualified agricultural personnel to work in very rural parts is a challenging task and non availability of such persons implies that often extension personnel are children of farmers or are living in the village where they need to service and work with the farmers. Training of these personnel is a challenging task and I am sure if links are building with Agricultural Universities this issue can be addressed.

Scientific Basis of organic agricultural systems

Systematic comparisons of organic cotton versus conventional cotton both GMO and non-GMO is needed at multi locations under different soil conditions so that scientific data on yields, cultivation costs can be obtained. Such studies have to have a long-term perspective especially to see and understand the improvement of soils. bioRe to address this issue has along the FIBL (Research Institute of organic agriculture) has started a long-term system comparison study (http://www.systems-comparison.fibl.org) comparing organic and conventional systems of agriculture. This study is being done on cotton, soybean and wheat.

Markets

The markets for organic cotton and finally for garments made from cotton grown organically is an important factor in its growth. As you can see from the graph below there is a fall in the production.



Conclusion

The challenges enumerated above are all surmountable with the active support from the cotton scientific community. The organic cotton has to move away from a civil society intervention to an intervention where scientists, farmers, ginners and spinners work together in finding the right solutions.

FIBRE TECHNOLOGY (FT)

Spinning Potential and Quality of Indian Cotton

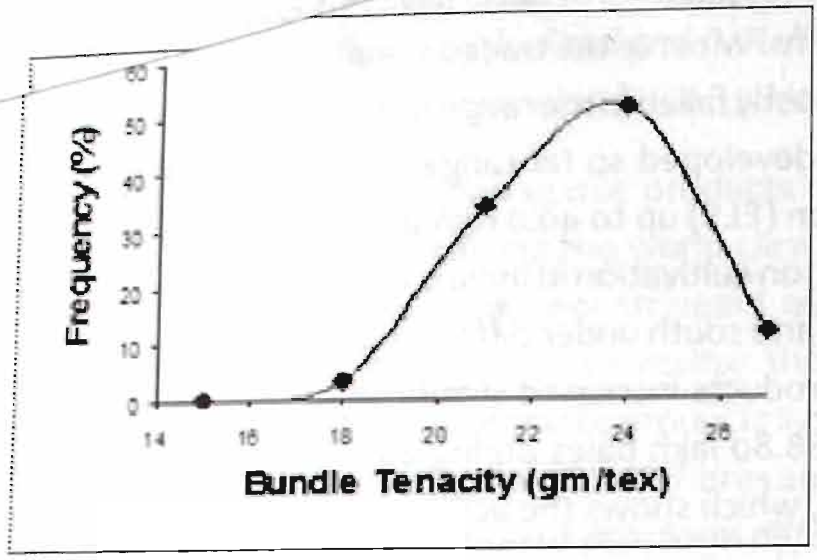
Chitranayak, V. Prasad, R. S. Prabhudesai and D. N. Moon

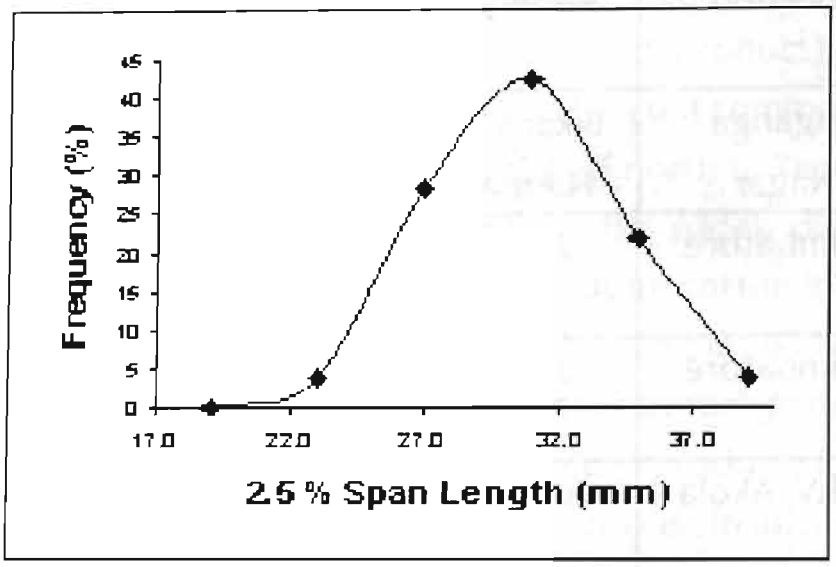
Central Institute for Research on Cotton Technology (ICAR), Matunga, Mumbai

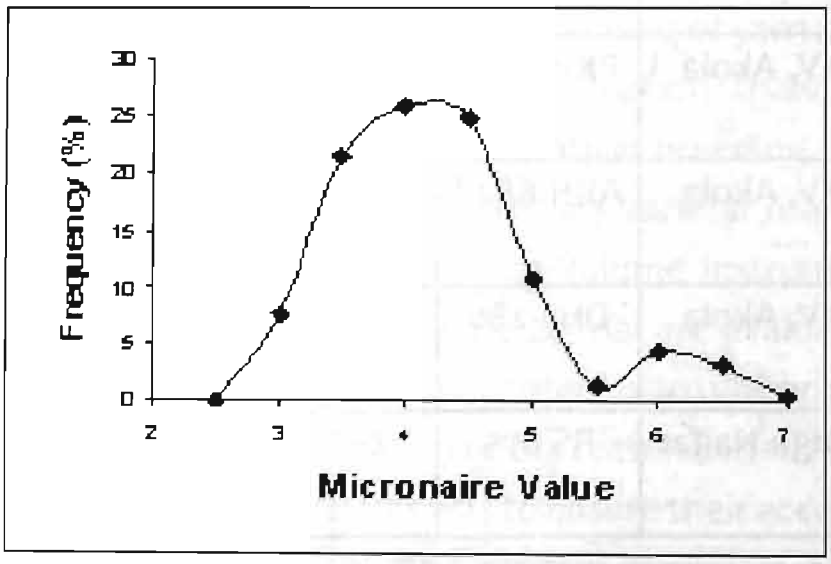
The exports as well as the demand of Indian textile products have been rising successively in the world market, so maintaining the world class quality of these products is of prime importance. The need to meet stringent quality norms, the cotton trade and spinning industry have come to realize the importance of objective testing of raw material. The quality of textile products lies in the quality of its raw materials as cotton, silk, jute, ramie, other natural fibres and the man-made fibres as polyester, nylon, rayon etc. Preparation of yarn form different varieties of Indian cotton developed by the cotton breeder of different cotton zones of country and analysis of spinning potential of Indian standard cotton varieties by evaluations of count, strength and CSP (count strength product). India is the only country where all four genotypes of cotton are cultivated commercially under the vast varying agro-climatic conditions from Punjab of north to Tamil nadu of south and Gujarat of west to Odisha of east, apart from the widely distributed central region of MP and Maharashtra. The share of *G.hirsutum* cotton in the country has largely grown followed by *G.arboreum* cottons. The samples were collected from various locations in the three main cotton growing zones such as north, central and south of the country. With a view to improve cotton productivity and quality of fibre through coordination of research, by various institutes, Agricultural Universities, State Departments of Agriculture and other related agencies were involved in research pertaining to quality evaluation of cotton lint, its mechanical behaviour at various stages of processing up to spinning of yarn and evaluation of its characteristics. Breeding materials, Initial Evaluation Trials and Preliminary Varietal Trials constitutes the initial stages of cotton breeding programme. The samples under Initial Evaluation Trials or Preliminary Varietal Trials are tested only for fibre quality parameters by using the High Volume Instrument (HVI) in ICC mode, whereas samples of Coordinated Varietal Trial are evaluated for spinning performance and seed coat fragments, trash content, yarn uniformity besides fibre parameters. For the commercial cultivation of the cotton varieties and hybrids, it's full spinning potential were checked. This was to ensure their acceptance by Indian and international textile industry. The present Indian cotton varieties and

hybrids cover a wide spectrum of fibre quality and [illegible] ability ranging from 16s count to 120s count. Most of the traded samples of cotton have [illegible] their value had mostly fallen in the range of 2.8 to 5.1 microgram per inch. The [illegible] cotton varieties developed so far range from short staple cotton of 17.5 mm to Extra Long Cotton (ELS) up to 40.0 mm length, which include very coarse to very fine cottons. Cotton cultivation in India is carried out under three prominent zones as north, central and south under different agro-climatic conditions. The export of various textile products increased significantly. The export of Indian raw cotton increased from 68.80 lakh bales during 2010-2011 season to 84 lakh bales during 2011-2012 season, which shows the acceptably and demand of the Indian cotton in world market.

Store No	Location	Variety	2.5 % SL(mm)	MIC	Maturity (%)	Count	CSP
111192	Sriganga Nagar	Bikaneri Narma	24.8	4.7	76	30s 40s	2553 2119
111649	Coimbatore	JK-4	24.6	4.2	82	30s 40s	2202 1960
111651	Coimbatore	JK-5	25.1	4.7	75	30s 40s	2193 1988
111170	PDKV, Akola	AKA-8	25.0	4.4	87	30s 40s	1884 1604
111171	PDKV, Akola	AKA-8401	26.3	4.5	87	16s 20s	2350 2260
111174	PDKV, Akola	PKV-Rajat	25.8	4.6	79	30s 40s	2184 1952
111175	PDKV, Akola	AKH-8828	25.6	3.7	77	30s 40s	2175 1960
111177	PDKV, Akola	DHy-286	26.3	3.8	88	30s 40s	2361 2004
111191	Sriganga Nagar	RS 875	25.6	5.1	80	30s 40s	2049 1888


Frequency (%)
0
10
20
30
40
50
60
14
16
18
20
22
24
26
Bundle Tenacity (gm/tex)


Frequency (%)
0
5
10
15
17.0
22.0
27.0
32.0
37.0
2.5 % Span Length (mm)


Frequency (%)
0
5
10
15
20
25
30
2
3
4
5
6
7
Micronaire Value

Performance of India's Cotton Based Textile Trade - A Constant Market Share (CMS) Analysis

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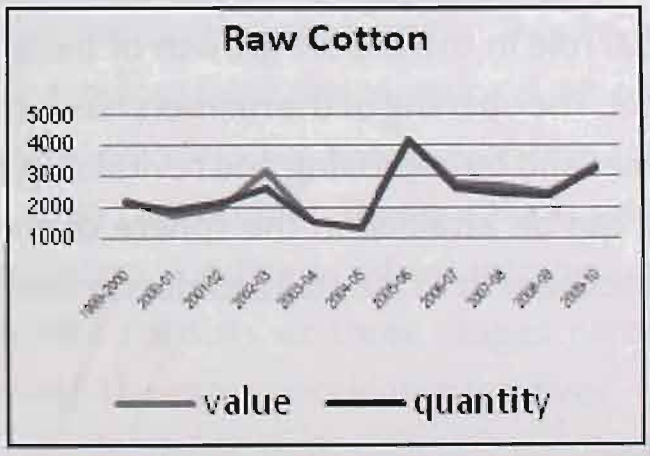
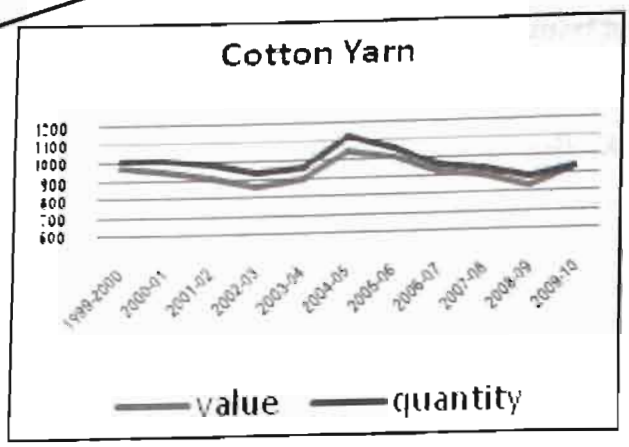
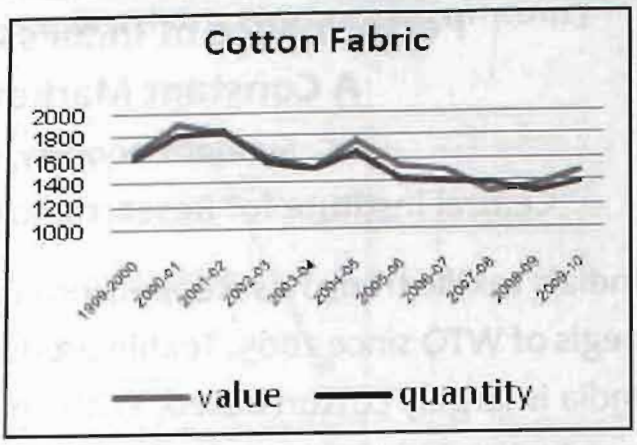
India's textile trade has stepped into the quota free textile trade regime under the aegis of WTO since 2005. Textile production as well as exports of textile item from India is largely cotton based. With improvement in the technological front in the production side and opening of new markets with quota free trade, an immense potential awaits the Indian textile trade in the global market. The present study explores the impact of the opening up of the trade by analysing the diversification of exports and decomposition of the export growth of cotton based textile items into different constituents using constant market share (CMS) analysis.

The degree of concentration of textile exports (fig.1) was measured using the Herfindahl-Hirshmann Index (HHI). The higher the value of the HHI, higher is the degree of concentration of the commodity. Except for raw cotton, other major textiles exports showed a declining HHI, indicating diversification in the exports. The overall textile exports as well as the cotton yarn and fabric exports showed a tendency towards concentration during the period 2005, which reveals that the exports were targeted especially to those destinations (EU and America) which have relaxed the quota during the period. India emerged as one of the major exporters of the raw cotton in the international market and the export trend clearly indicate an increasing concentration towards the Asian markets, especially China, Pakistan and Bangladesh which accounted for more that 85 per cent of total raw cotton exports from India

Figure 1. Degree of Concentration of Textile Exports Herfindahl Hirshmann Index







The Constant Market Share analysis for cotton and cotton based value added exports are presented in Table 1. In case of the over all exports the growth of the market size (growth in volume of imports in global market) had played a significant role in the increase of exports while the growth due to competition effect was around 34 per cent. The increase in market size effect may be attributed to the removal of quota which has increased the scope for free movement of textile goods across all nations especially USA and EU.

Table 1. Destination wise Constant Market Share Analysis for cotton and its value added products

Product Group	Market Size Effect (Import growth effect)	Competition Effect	Composition Effect
Cotton	6.49	93.00	0.51
Cotton yarn	44.38	52.58	3.04
Cotton fabric	142.51	-135.69	93.18
Apparel knitted	46.90	36.61	16.49
Apparel woven	57.72	36.67	5.62
Cotton based exports	67.37	33.71	-1.081

The constant market share analysis indicate that the market size effect play a vital role in the export growth of Indian textiles supplemented by competition effect. The opening of the markets has increased greater access to the world textile market and by improving and revitalizing the capacity of processing sector a great leap can be attained in the sphere of the cotton based textile exports ensuring greater benefit to the stakeholders in the cotton value chain.

Development and Performance Evaluation of Extractor Cleaner for Processing of Machine Picked Cotton

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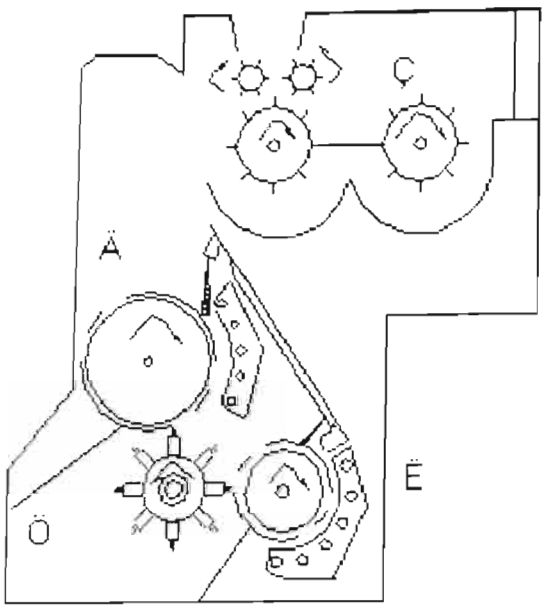
The aim of the present study is to evaluate the performance of an extractor cleaner specially developed at Ginning Training Centre (CIRCOT), Nagpur for pre-cleaning of machine picked cotton. The machine picked cotton contains around 20% total trash content among which the amount of dry leaves is highly significant (i.e. 13.45%) compared to the large foreign matters (such as sticks and burs). A set of pre-cleaning machinery is required for pre-cleaning of machine picked cotton. Double Roller (DR) gins are mostly used in India for ginning of cotton. It is primarily because of the fact that the roller gins utilize gentle shearing action of a polished leather roller rotating at 100 rpm for removing the fibres from cottonseeds thereby inherent cotton fibre properties are preserved while the saw gins remove the cotton fibres by pulling action of sharped saws rotating at around 600 rpm resulting in loss of fibre parameters, specially staple length. The inherent low fibre strength and low micronaire values of Indian cotton lead to wide popularity and acceptance of DR gins for processing of cotton in India. However, the machine picked cotton is ginned using saw type gins in the entire world that have inbuilt pre-cleaners.

Due to increased cost of cotton picking (i.e. around Rs. 10 per kg cotton) and shortage of labour in India, efforts need to be concentrated on mechanization of cotton harvesting in India. In this work, an effort was made to gin the machine picked cotton on a DR gin by pre-cleaning it using a extractor cleaner in combination with a six-cylinder cleaner and a three-stage stick machine. The developed extractor cleaner employs the principle similar to the inbuilt pre-cleaners of saw gins. The extractor cleaner employs both the centrifugal action of spiked cylinders and sling off action of saw cylinders for removal of fine trash content. The major components of the machine are hopper, feeder rollers, spiked cylinders, saw cylinders, doffing brush cylinders, loading brushes, grid bars and deflectors (see Fig). The developed machine consists of three stages namely: cylinder cleaning, saw cleaning and reclaiming. The extractor cleaner removes

both the fine and large foreign matter content from the cotton. Average trash removal efficiency of extractor cleaner is found to be 23.59 % (refer Table). The trash content in the pre-cleaner cotton has been brought down to 3.11% using the developed pre-cleaner in combination with a cylinder and a stick machine. This study demonstrates that the extractor cleaner should be used after pre-cleaning of cotton from a cylinder cleaner and a stick machine.



A - Main Saw Cylinder;
O - Doffing Brush Cylinder;
E - Reclaimer Cylinder;
C - Spiked Cylinders

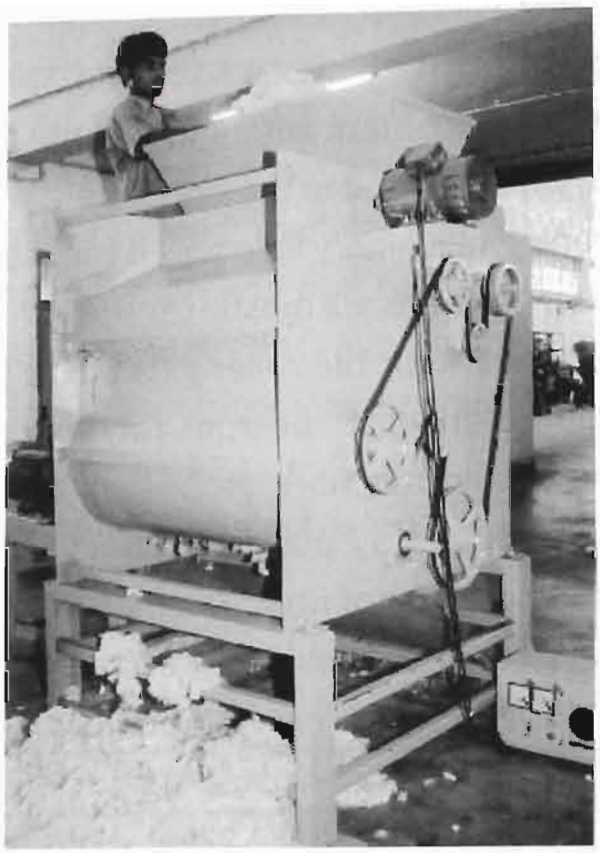


Figure: Interval details and picture of extractor cleaner

Table Effectiveness of extractor cleaner in percentage for removing trash content from machine picked cotton

Treatments*	Bracts/ Burrs	Sticks	Green leaves	Immature seeds/motes	Dry leaves	Total
1	15.38 a	10.17 ab	43.06 f	66.67 i	9.77 gh	20.45 k
2	62.81 b	41.51 cd	51.22 g	100 g	18.41 ik	41.86 l
3	51.11 c	100 ef	13.33 h	0 h	4.87 lm	23.59 m

* For a given measurement followed by the same letter are not significantly different at 95% confidence level.* Treatments: (1) Cylinder cleaner; (2) Stick machine; (3) Extractor cleaner.

GINERP- A Program for Simulation of Cotton Ginning Cost

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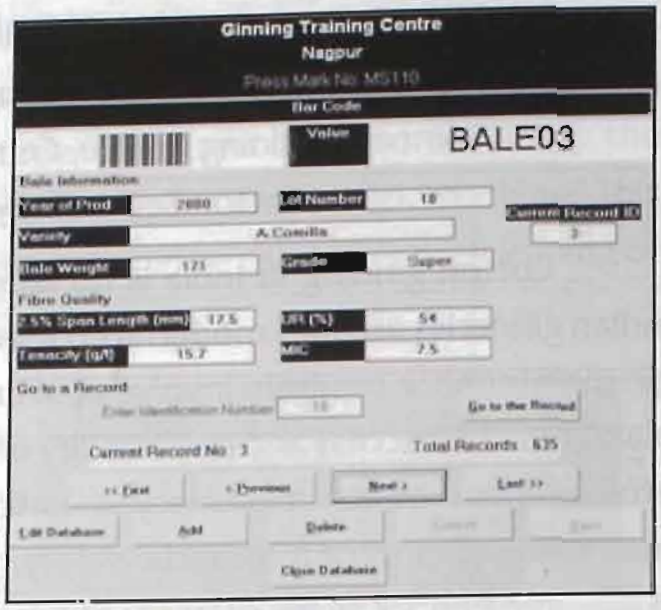
Cotton ginning in India is no longer a farm level exercise. Almost 80% of Indian ginneries are fully modernized thereby multiplying ginning activities. A good gin maintenance program involves continual documentation, communication and planning. The success and profitability of a ginning operation is determined by the effectiveness of its machinery maintenance program. A comprehensive gin maintenance program impacts safety, fibre quality, daily and annual volume, downtime energy costs, material and labour maintenance costs etc. Each employ must communicate the needs, office worker compiling the repair and downtime data, the gin crew performing the preventive maintenance and operating the gin, the gin manager overseeing the entire operation while satisfying the customer's needs of timely, quality ginning - All must become part of the GINNING PROCESS. Computerized record keeping is gaining importance. A database program generated to record all gin operations will assist in day to day transactions with ease of query, search and report generation options. Ginner will be able to schedule his activities and simulate the gin performance and profit. CIRCOT has released GINERP- Enterprise Resource Planning Software for management of ginneries. It supports major financial activities in ginneries like purchase of seed cotton, sale of bales, sale of cotton seed, maintenance & repairs, purchase of spares, ginning and pressing charges, labour charges for material handling, salary of employee, loan repayment, taxes, insurance, development activities & miscellaneous expenses. It integrates different modules related to cotton ginneries like financial and inventory management. Financial data is integrated with Payroll, Inventory Control, Purchase & Logistics, Sales & Distribution and Raw Cotton Processing modules. User can obtain capacity utilization information in an instant and control production losses by scheduling maintenance routines. HVI replaced the hand classification systems and facilitated the marketing of cotton on an identity preserved, quality differentiated basis. HVI data for every bale is a prerequisite. It greatly reduces risks related to unexpected reductions in mill and product performance. GINERP initiates the practice of tagging individual bales with fibre quality data. It integrates barcoded bale labeling and RFID bale tagging to assist ginners in bale management and online bale trading & tracking application.

Fibre quality evaluation



Cotton bale database

PHYSIOLOGY AND BIOTECHNOLOGY (P & B)

Expression of a *Gossypium hirsutum* chitinase gene in cisgenic diploid cotton (*G. arboreum*) delayed pathogenesis of both leaf spot and grey mildew.

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Plant chitinases belong to a group of pathogenesis related (PR) proteins and provide resistance against various fungi, as they can degrade fungal cell walls containing chitin. Using conserved as well as degenerate primers a 1.3 kb novel class I endochitinase gene was amplified and cloned from *Gossypium hirsutum* variety LRA5166 into pGemT. Analysis of the sequence revealed the gene to be unique to upland cotton (GenBank accession # HM125506). Gene-specific primers failed to amplify any similar sequence from *G. arboreum* cultivars PA255, PA402 and RG-8. The chitinase gene was subcloned into binary plant transformation vector pBInAR, under 35S CaMV promoter and NOS terminator. The correct orientation of the cloned gene was determined and the resultant plasmid was conjugated into *Agrobacterium tumefaciens* strain EHA105 by triparental mating. *G. arboreum* cultivars PA255, PA 402 and RG8 were transformed by direct-shoot organogenesis. Transformants were selected on MS medium supplemented with 50 ug/ ml kanamycin and confirmed by PCR. Single copy integration of the chitanse transgene was further confirmed by Southern hybridizations using a gene-specific probe. The cisgenic cotton expressed chitinase activity two times higher than that of the wild type cotton. Bioassays of the resulting cisgenic cotton against *Myrothecium roridum*, a leaf spotting disease of many plant species, and *Ramularia areola, a semi-obligate* areolate mildew pathogen of cotton showed reduced lesion size and delayed symptom development upto 10-14 days.

Development of Cotton Transgenic for Cry 1Ac gene

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Cotton "the silver fibre" has been the principal commercial and industrial crop of India, providing 65-70 per cent of the raw material for the textile industry of the country. Cotton crop is subjected to severe attack of pests and diseases, which cause substantial yield losses. Several studies have shown that American bollworm, Helicoverpa armigera (Hubner) is the most prevalent and damaging pest of cotton. Other lepidopteron pests like pink bollworm, Pectinophora gossypilla (Saunders) and spotted bollworm Erias vitella(F.) also cause extensive damage. H. armigera, being a polyphagous insect is present throughout the year in the field. Bt ä-endotoxins are reported to be toxic to lepidopteron, dipteran and coleopteran insects. In the present study we are aimed at developing transgenics for Bt gene Cry 1Ac (Altosaar source) using three methods of co-cultivation. In our study we have used germinated seeds as explants. Three methods of preparing the explants for co-cutivation of germinated seeds viz., a) without damaging meristem b) slitting the meristem with knife and c) needle prick to the meristem. This was followed by co-cultivation with agrobacterium carrying the Cry 1Ac gene. By slitting of the meristem with knife and co cultivation, it was possible to get positive transgenics successfully.

This method necessitates the use of large number of explants co cultivation. A total of 3000 explants were used for co-cultivation and among them only 80 To plants established and were transferred to green house. Seven positive plants with Cry 1Ac gene were identified in To generation and advanced to T1 generation. The T1 plants were selfed and advanced to T2 generation. The progeny plants in T2 were checked for segregation for Cry 1Ac gene and the lines which were not showing segregation for Cry 1Ac gene were advanced to T3 and T4 generation. Five T4 positive events from four independent To plants (Event Number-6, 10, 25, 32 and 50) were used been used for conducting ELISA, Bioassay, RT PCR and Southern blot analysis. Though all the five events showed positive results for all these tests, among the five only two were having single copy of gene, so these two (Event 6 & 32) will be used for conducting BRL trial and even Event 32 has been submitted for sequencing and event characterization.

Physiological Analysis of *Bt* Cotton in Vertisols

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A field experiment was conducted to assess the physiological variations in cotton and its impact on productivity in different versions of *Bt* cotton hybrids during the *kharif* 2011-12 in vertisols under rainfed conditions at Regional Agricultural Research Station Lam, Guntur, in randomized block design with factorial concept. The cotton hybrids Bunny, Mallika, Tulasi and Rasi as non *Bt*, BG1, and BGII versions were studied in three replications. The crop was raised according to standard package of practices and need based plant protection measures were taken up. The data on plant height, number of sympodia per plant, number of bolls per plant per cent boll set and dry matter production at different intervals, seed cotton yield, harvest index, lint index, seed index, GOT and quality parameters were recorded.

Table 1: Physiological analysis of different events of Bt cotton at Harvest

Tre atments	DM at boll development stage	No. of bolls per plant	Boll weight (g)	Harvest index	Seed cotton yield (Kg/ha)
Main Treatments					
Bunny.	246	42	4.16	31.44	1220
Mallika	315	38	4.68	33.66	1208
Tulsi	439	49	4.55	32.44	1227
RCH2	235	41	3.43	38.5	921
SEm ±	0.9	1.04	0.09	3.02	39
CD (P= 0.05)	2.61	3.04	0.28	NS	113.9
Sub Treatments					
Non Bt	448	38	3.87	23.92	1041
BGI	257	43	4.31	45.42	1206
BGII	322	47	4.43	32.75	1185
SEm ±	0.8	0.90	0.08	2.61	34
CD (P= 0.05)	2.26	2.64	0.24	7.66	98.7

Interaction					
SEm +	1.5	1.80	0.16	5.23	67
CD (P= 0.05)	5.32	6.21	0.58	NS	234
CV%	8.86	7.31	6.94	26.6	10.19

The experimental results indicated that there was no significant variation in days to squaring and flowering in different versions of hybrids tested, but the period required for boll bursting and days to final harvest was reduced in BGI and BGII compared to non Bt. Number of squares and flowers produced per plant were significantly high in BGI and BGII versions of all the cotton hybrids compared to non Bt. The total dry matter production was significantly high in non Bt version of all the hybrids compared to BGI and BGII whereas, significantly superior harvest index was recorded in BGI and BGII compared to non Bt. Among the intra hirsutum cotton hybrids tested Bunny, Mallika and Tulasi recorded similar seed cotton yield and were significantly superior to Rasi. Of the different versions tested, BGI recorded significantly superior yield followed by BGII. The higher seed cotton yield in BG versions was associated with dry matter production from boll formation to boll development period, harvest index, number of bolls per plant and boll weight.

Manipulations of Morphoframe Through Nipping at Grand Growth Stages and Mimic the Effect Using Action Specific Chemical - Maleic Hydrazide in Cotton.

Pinal A. Chaudhari, H. S. Thakare and V. Kumar

Main Cotton Research Station, Navsari Agricultural University, Surat, Gujarat

Many cotton varieties show profuse vegetative growth which not only makes it difficult to manage the crop and do cultural interventions but lot of energy is utilized in vegetative growth. If the morphoframe is modified by arresting vertical and lateral growth, the energy could be diverted to fruiting bodies resulting in higher yield. Nipping is an important agronomic practice, which helps to reduce the apical dominance by removing the apical bud, increases the number of branches, pod set percent and better source-sink relationship, thereby enhancing the yield of a plant. Similar growth retarding action of Maleic Hydrazide has been reported in suppression of apical dominance in different crops. The experiment was

conducted using three varieties and four treatments. Amongst the parameters studied, plant height showed significant reduction due to detopping at 95 DAS followed by nipping of the sympodial meristem at 105 DAS and similar effect was mimicked by foliar application of MH@ 500 ppm at 85 DAS wherein the number of sympodia, number of bolls and boll weight significantly increased. The combined effect of number of bolls and boll weight was clearly depicted on yield/plant. Detopping at 95 DAS or mimicking detopping by MH brought about significant increase in yield per plant over control in individual years as well as in pooled. Usual varietal differences were observed in the yield wherein Bunny Bt was significantly superior to the non Bts. The highest gain was observed in detopping at 95 DAS, which was significant over all other treatments followed by foliar application of MH@ 500 ppm at 85 DAS. However, in terms of BCR, application of MH was found superior.

Biochemical Parameters of Cotton for Tolerance to Water Stress

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Worldwide, sustainability and advancement of cotton yield are the major challenges for meeting impending threats of increasing world population in the face of diminution of arable land, depletion of water resources and environmental stresses. However, drought is one of the major yield-limiting stresses. To breed good yielding varieties for water stress situations and to introgress the trait for tolerance in otherwise high yielding varieties has been a motive of cotton scientists for decades. Hence, twenty genotypes (G.hirsutum) were grown under rainfed as well as irrigated conditions. Besides the yield and its components, the leaf samples were analyzed for biochemical parameters such as protein, proline, free amino acid and reducing sugar content at 110 DAS. Free amino acid and proline content were higher in the leaf under rainfed condition as compared to irrigated condition except few genotypes, while reducing sugars and protein were lower under rainfed condition. The higher amount of free amino acids and proline might have helped in building up the osmoticum for tolerance. Genotypes G. Cot 16, GSHV 152, H1353/10, AKH 0205, indicated their low susceptibility to stress and minimal reduction in

yield. Correlation between different biochemical parameters showed that proline, amino acids and protein exhibited a negative trend with yield while reducing sugars showed a positive trend under rainfed condition but the relationship was not significant.

Evaluating the Effect of Climate Change on Cotton Production

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Cotton is sensitive to climate induced effects like temperature, rainfall, radiation, CO_2 concentration, changes in soil, pests and diseases problem. Work carried out at CICR has indicated the adaptability of select conventional cotton varieties hybrids that are well adapted to elevated CO_2 levels due to better morphophysiological and biochemical attributes. Elevated levels of CO_2 significantly increased plant height, node number, sympodia number, leaf number, leaf area, dry matter production, reduced shedding of bud, bolls and delayed senescence of leaves. Fibre quality improved significantly under elevated CO_2 atmosphere. The photosynthetic rate increased by 34-45% while stomatal resistance decreased significantly. Orissa is facing many problems due to changes in weather patterns in the recent past. The annual mean temperature in the state increased by 100C in the 40 years from 1950 to 1990 and continued to rise by 0.100C during the past 14 years (Orissa University of Agriculture and Technology). Increase in erratic and unreliable rainfall in the area has substantial impact on crop yields. On one hand, yields are declining because the crops are damaged due to untimely and heavy rains. On the other hand, farmers are unable to predict the onset of the monsoon as they used to 20 years ago. Seasonal shifts are confusing farmers to make the important decision on planting time. Wrong decision on this crucial issue has considerable impacts on yields and can even lead to complete crop failure. Changes in temperature and rainfall patterns during the last couple of years had susceptibly affected cotton production. Yields were very low in the last couple of years and farmers reported to look for alternative crops, which support the variable weather better. Changes in rainfall have resulted in changes in the growing seasons as well as in crops grown. "In the past we used to plant our crops after the first rains, but since we started

experiencing frequent droughts we are planting our crops much earlier, to allow the crops to meet the first rains. Instead of planting a local variety of cotton, we have opted for "BT-cotton"17 as it takes a shorter period to mature." Clearly, farmers are uncertain when to plant as rainfall patterns have hindered the growing of long-season local indigenous varieties.

Management of Leaf Reddening in Bt Cotton

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Regional Research and Technology Transfer Station, Bhawanipatna, Odisha

Leaf reddening has become a malady in majority of the cotton growing areas where Bt cotton is grown. A two years trial was conducted in the Research Farm of All India Coordinated Cotton Improvement Project at Regional Research and Technology Transfer Station, Bhawanipatna on management of leaf reddening in Bt cotton in Bunny Bt-2 during kharif 2010 and 2011. The experiment was laid out in randomized block design with 3 replications and 10 treatments consisting of different doses of major and micro nutrients. The soil of the experimental site was black cotton soil with pH of 7.3, organic carbon of 0.55%, and available N of 116, P2O5 of 39.52, and K2O of 448 kg/ ha. There was significant difference among the treatments in seed cotton yield and yield attributing characters like number of bolls/plant and boll weight during both the years and in pooled data. Pooled seed cotton yield (2859 kg/ha) and the number of bolls/plant (40.0) were significantly highest in the treatment with recommended dose of fertilizer (RDF) based on soil test values with 5 t FYM/ha along with foliar application of 2% urea followed by another spray of 1% urea+ 1% MgSO4 during flowering and boll development stages, respectively. Similarly this treatment recorded the maximum boll weight (4.6 g) in pooled data of both the years. The experiment indicated that leaf reddening can be significantly reduced and seed cotton yield with net return can be increased by application of RDF based on soil test values along with 1 spray of 2% urea and 1 spray of 1% urea+ 1% MgSO4 during flowering to boll development stages.

Effect of Different Treatments of Ultra CO_2 Organic Product on Physio-Morphological Traits and Seed Cotton Yield of G. hirsutum Cotton Variety Phule-688

A. S. Mokate, R. W. Bharud and A. R. Aher

All India Co-Ordinated Cotton Improvement Project, MPKV, Rahuri, Maharashtra

A field experiment was carried out to study the effect of different treatments of Ultra CO2 organic product on physio-morphological traits and seed cotton yield of G. hirsutum cotton variety Phule-688 at Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (MS). The experiment was laid out in randomized block design (RBD) with three replications. Seven treatments of foliar application of Ultra C02 were applied alongwith recommended dose of N, P and K Control (T1). Significant variations were observed among genotypes for chlorophyll content, leaf area, rate of photosynthesis at 60 and 90 DAP, rate of transpiration at 60 DAP and photosynthetically active radiation (PAR) at 90 DAP. The results revealed that foliar application of Ultra C02 at 60 and 90 DAP @ 4ml/lit alongwith recommended dose of fertilizers (T6) proved to be the best for higher seed cotton yield (2260.80 kg/ha), plant height (151.7cm), sympodia per plant (16/plant) and number of bolls (35/plant). The ginning percentage, seed index and lint index was also higher in the same treatment (T6). The result of the experiment suggested that alongwith RDF, foliar application of Ultra C02 at 60 and 90 DAP @ 4ml/lit substantially enhanced seed cotton yield and economic value traits.

Effect of Defoliant on Gossypium hirsutum (L) Cotton

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Cotton Research Unit, Dr. PDKV, Akola, Maharashtra

An experiment was conducted to know the effect of defoliant on leaf defoliation, seed cotton yield and fibre properties of G. hirsustum (L) cotton at experimental filed of cotton Research Unit, Dr. PDKV, Akola (M.S.) during kharif season of 2011-12 in split plot design with three different cotton hybrids and three doses of Dirum spray (Thiodiouron + Diuron) i.e. defoliant at two different intervals (days) i.e. at 140-145 and 150-155 days after sowing in three replication. The result revealed that, leaf defoliation percentage at 10th days after spray (i.e. 150-155 days

after sowing) was significantly higher in Diuron-250 ml/ha (87.22%) as compared to control. However it had no significant impact on seed cotton yield/ha. The seed cotton yield (1047 kg/ha), total number of bolls per plant (14.58 Nos), number of opened bolls/plant (10.94 Nos) was greater in PKV Hyb-2.

The effect of sprays at150-155 days was found significantly superior over 140-145 days sprays along with earliness index. The defoliant (Thiodiouron + Diuron, 225 and 250 ml/ha) did not affect the fiber quality significantly. Time of application at 150-155 DAS has significantly adverse effect on 2.5 % span length compared to 140-145 DAS but rest of quality traits showed no significant differences.

Cotton in Era of Climate Change

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Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. It may be a change in average weather conditions, or in the distribution of weather around the average conditions i.e., more or fewer extreme weather events.

By the turn of 21st century, climate change will be a menace resulting in anticipated greater instability in food, feed and fibre production influenced due to substantial losses in agricultural production. Agriculture is extremely vulnerable to climate change viz., increased temperature, erratic rainfall, pest and disease load etc., resulting depletion in quality yield levels. The kind of extreme climatic events manifests the likelihood of short-run crop failures followed by long-term decline in production.

Cotton needs conditions suitable with respect to temperature, photoperiod and soil moisture followed by marked dry spell essentially for good boll opening. A cotton plant more sensibly response to climate changes in respect of growth changes viz., condition at sowing, early vegetative growth phase, flowering, boll formation and condition towards the end of the season i.e. harvesting. Compensatory growth is biological phenomenon commonly observed in cotton, which lead to response to preliminary shedding of vegetative and reproductive plant parts as it resilient to sub-optimal growing conditions in relation

to high temperatures and drought due to its vertical tap root.

Cotton crops grown in future environments will be subjected to a climate for which they are not bred. Cotton production is both a contributor to climate change and subject to its impacts. Agricultural production, processing, trade and consumption contribute up to 40% of the world's emissions when forest clearance is included in the calculation. Cotton production contributes to between 0.3% and 1% of total global GHG emissions.

Cotton species viz., G. barbadense showed more sensitive than G. hirsutum. The G. arboreum is suitable for low and erratic rainfall with drought situations. In saline environment G. herbaceum showed better adaptability. The available drought tolerance hirsutum genotypes may show better adaptation. The risk and uncertainty imposed by climate change could be managed by adoption of location-specific intercropping and multi-tier cropping system. In situ soil moisture conservation techniques include contour bunding, narrow or broad ridges or beds separated by furrows, ridges and furrow, opening of furrow after every rows of cotton, black polythene mulch (25 microns), and spreads of crop residue were found to be adapted along with The practices viz. breeding for abiotic stress resistant varieties, restriction of unnecessary loss of nutrients, proper cropland design, adaptation of sowing dates to offset moisture stress, minimize soil tillage in view to prevent loss of soil organic matter etc.

Abiotic Stress Management in Cotton

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Cotton is the most important fiber cash crop and is the basic input to the textile industry. Significant achievements have been made in increasing yield and production through development of high yielding varieties, appropriate transfer of technology, better farm management practices, increased area under cultivation of Bt cotton hybrids etc. Cotton is grown in about 121.9 lakh ha during the 2011-12 in India of which more than 70 per cent area is rainfed. It is obvious that growth and development of cotton has to face one or other stress entities under rainfed situation. Cotton physiology is unique indeterminate growth habits with longer

crop duration which make cotton vulnerable to abiotic stress influences from emergence to senescence. The adverse effects on the ongoing physiological processes may affect on cotton yield and may become the focal point of attention. The various abiotic stress factors affecting cotton growth, development and yield mostly weather that are low light, high temperature, humidity and soil constraints are drought, water logging and salinity. Their occurrence may be erratic or specific and the intensity may be varying in their adversity. Consequently, stress imprints are marked in the altered plant traits. Adaptive and tolerant morpho physiological, biochemical and anatomical traits in cotton is deep root system, higher root-shoot ratio, decrease in leaf area expansion, epicuticular waxiness, leaf rolling, maintenance of leaf turgidity at lower water potential, osmo-regulation, less no. of stomata per unit leaf area, increase in proline content and non- protein amino acids, decrease in cell size and intercellular space.

Physiological management approaches to mitigate abiotic stress are drought tolerance genotypes, use of antitranspirants, growth regulators, growth retardants, adjusting planting dates, moisture conservation practices, avoiding high plant density, adequate irrigation at critical stage, nutrients management, reclamation and adoption of appropriate management practices for salinity, salinity tolerance variety, anoxia tolerant genotype, in right selection and combination of genotypes. In this context, plant physiological approaches in crop production assume importance to unravel the abiotic stress mechanisms and to identify explicit tolerance traits for countering the detrimental abiotic stress effects.

Physiological Basis for Differences in Seed Cotton Yield Amongst the *G. hirsutum* Cotton Hybrids

R. W. Bharud, A. S. Mokate and A. R. Aher
All India Co-Ordinated Cotton Improvement Project, MPKV, Rahuri

A field experiment was carried out at Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (MS) to study the different physiological parameters influencing seed cotton yield of G. hirsutum hybrids. The experiment was laid out in randomized block design (RBD) with three replications and ten hybrids. The basis for differences in seed cotton yield amongst the high and low yielding hybrids was mainly due to the variation in magnitude of the morphological and physiological characters along with yield contributing characters. The results of the present investigation indicated that the cotton hybrids NHH-44, Phule-492, RHH-516, and Ankur-651 were observed to be photosynthetically more efficient thereby resulting in higher seed cotton yield. These hybrids were also found to be superior in respect of stomatal conductance, chlorophyll content, dry matter production and its partitioning. The higher magnitude of mean values of plant height, leaf area, dry matter production and its partitioning, photosynthetic rate and yield contributing characters are important physiological traits in ideotype for achieving higher productivity in cotton.

Dose and Time of Application Alters Efficacy of Defoliants Among Popular *G. hirsutum* Cultivars in Northern India

Kulvir Singh, Harmandeep Singh, R K Gumber, Pankaj Rathore and Kuldeep Singh
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Defoliation is going to be an important management practice associated with high yields and high quality in modernizing cotton cultivation. The decision as to how and when to remove the leaves and open the bolls appears to be one of the most difficult tasks confronting a cotton grower. If defoliated too soon, yields, quality and profits suffer. On the other hand, depending on the location and the field condition, delaying defoliation may increase likelihood of additional insect problems, or delayed harvest into bad weather which may affect yield and profits. That is why defoliation decisions must be based on the crop environment. Plant

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CROP IMPROVEMENT (CI)

Genotype-Environment Interaction for Yield and other Fibre Quality Traits in Upland Cotton (*Gossypium hirsutum* L.)

A. D. Patel, U. G. Patel and V. Kumar

Main Cotton Research Station, Navsari Agricultural University, Surat, Gujarat

In 8 x 8 half diallel, 8 parents, 28 F1's with two checks viz., G. Cot. Hy-8 and G. Cot. Hy-10 of G. hirsutum (L.), were studied at three locations for Genotype-Environment effect for fibre quality.

Genotype-Environment (linear) and deviation linearity were significant for traits under study. The magnitude of G x E (linear) was larger than non linear. The fibre quality trait 2.5 per cent span length indicated the lack of possibility to predict the performance of genotype across the environments. Fibre uniformity ratio and fibre elongation responded consistantly over environment due to their non-significant G x E interaction. Stability parameters for parental lines GSHV-97/13 and GISV-197 were studied under favourable and unfavourable environment, respectively. Notably, among the crosses, SD-3 x GISV-197 and GSHV-97/13 x GISV-197 were found to be superior in all the environments, hence, should be recommended over several environments for wider adaptability after sufficient testing.

Combining Ability Study for Yield and its Component Traits Through Line X Tester Mating Design in Local and Exotic Upland Cotton (*Gossypium hirsutum* L.)

N. N. Patel, V. D. Pathak, B. S. Pandey and V. Kumar

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Combining ability is mostly used by breeders to select approximate cultivars to produce the larger progeny of new combination through their hybridization. Present study aims to estimate General Combining Ability of the parents and Specific Combining Ability of hybrids for yield and component traits. Line x Tester analysis involving four lines, five exotic testers, resulting twenty hybrids and a check G.Cot.Hy Hy-12, were raised during kharif 2010-2011 at Main Cotton Research Station, NAU, Surat. The significance of GCA and SCA variance was evident from mean square of all the characters, indicating additive and non-additive genes

controlled the traits. Amongst the parents, G.Cot-10, G.Cot-20, SA-1723 and EC - 132021 were the best general combiners for yield and its component traits. The best specific combinations were G.Cot-16 x SA-1756, G.Cot-10 x GISV-264 and Deviraj x SA-1723 for seed yield, lint yield and number of bolls per plant. The hybrids G.Cot-10 x GISV-264, G.Cot-20 x EC-132021, G.Cot-16 x SA-1723 and Deviraj x GISV-264 possessed significant SCA effects on boll weight. None of the crosses possessed significant SCA effects for ginning percentage in desired direction.

Genotype x Environment Interaction for Yield and Quality Traits in GMS Based Hybrids of Upland Cotton (*G. hirsutum L.*)

A. R. Patel, N. D. Modi, J. C. Patel, B. G. Solanki and V. Kumar

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An investigation was carried out to study stability parameters of thirty two GMS based hybrids involving 4 GMS lines and 8 testers at three locations i.e. Achhalia, Surat and Hansot. Yield attributing characters along with ancillary characters were studied. Variance due to genotypes, environments and G X E interaction were significant for all the characters.

Stability analysis revealed that mean square due to genotypes, environment linear and G X E linear was significant for all the characters when tested against pooled error. The G x E interaction components for all the characters were relatively low as compared to genetic components, indicating the necessity to testing the breeding materials in a number of environmental conditions. The parental lines [G(B)-20 and LRA-5166(SB)] and the crosses [G.Cot-10 x 76-IH-20 and DS-70-480 x G(T)-84] with better stability should be recommended for seed cotton yield after sufficient testing over a number of environments/locations.

Variability and Relationship Studies in Cotton (*G. arboreum* L.) Genotypes

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The experiment was conducted during 2011 in rainfed condition to study the variability, correlation and path analysis among the yield and its attributing characters in 150 G. Arboreum genotypes. The genotypes exhibits considerable amount of genetic variation for the traits, and it indicated the good scope for selection for further improvement. The estimates of PCV values were of higher magnitude than GCV for all the traits under study. The estimates of GCV and PCV were high for number of sympodial branches/plant (27.77, 24.26), number of bolls/plant (21.77, 24.26) and seed cotton yield (24.24, 26.74). High heritability and high GAM was obtained for plant height (66.94, 26.42), number of bolls/plant (80.52, 40.25) and seed cotton yield (82.24, 45.30). The genotypic correlation coefficient values for the plant height (0.300), number of monopodial branches/plant (0.328), number of bolls/plant (0.909) and boll weight (0.412) showed positive significant association with seed cotton yield at 1% level of significance. The phenotypic correlation coefficient estimates were exhibited strong positive significance for number of bolls/plant and boll weight with total seed cotton yield. Path analysis revealed that, number of bolls/plant (0.921) and boll weight (0.398) had highest direct effect, whereas other traits studied showed negative non-significant effect on seed cotton yield. It clearly indicated that due weightage given by number of bolls/plant and boll weight would help in increasing the seed cotton yield in cotton through selection.

Influence of Weather Parameters on Quantitative and Qualitative Traits of Diploid Cotton

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Correlation study between weather parameters and different quantitative and qualitative traits of the variety GN.Cot.-25 (G. herbaceum) was carried out at Regional Cotton Research Station Bharuch (Gujarat) during 1999-2000 To 2008-09. The study revealed that the maximum temperature had non-significant and negative association with all the characters except seed cotton yield, lint yield, LUR and elongation percentage while the minimum temperature had positive correlation with all the characters except GP, 2.5% span length and fibre strength showed that lower maximum temperature and higher minimum temperature were desirable for most of the characters.

Significant and positive correlation was found between rainfall and seed cotton yield (0.743), lint yield (0.757), GP (0.707), boll wt. (0.696) and no. of bolls / plant (0.792) indicating that higher rainfall increases the seed cotton yield and its attributing traits. Rainfall was observed to be negatively associated with 2.5 span length, fibre strength and elongation. Rainy days also had positive relationship with all characters except fibre strength and elongation. Rainy days had significantly positive association with fibre fineness (0.644) and significantly negative association with elongation (-0.636) indicating more rainy days favoured more value of fibre fineness and less value of elongation.

Relative humidity was observed to be positively associated with all the characters except fibre strength and elongation. It had significantly positive relationship with seed cotton yield (0.745), lint yield (0.752), GP (0.652), LUR (0.630) and no. of bolls/plant (0.734) meaning that higher relative humidity increases the value of these characters. Vapour pressure was found to have significantly positive relationship with seed cotton yield, lint yield and GP while it was significantly negatively associated with elongation. Wind velocity had showed negative relationship with most of the characters but it had showed positive and highly significant correlation with elongation. Sunshine period had negatively significant association with seed cotton yield and lint yield indicating that shorter days were beneficial in increasing the seed cotton yield. Pan evaporation had negative correlation with most of the characters revealed that lower pan evaporation would be beneficial for these characters.

G x E Interaction in Asiatic Cotton

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Twelve promising entries of G. herbaceum cotton were evaluated alongwith two checks at Surat, Bharuch and Achhalia during 2010-11 with three replications for determining G x E interaction and stability analysis using Eberhart and Russel model. Analysis of variance revealed significant variance for environments which indicated the environmental variability across the locations. ANOVA for stability parameters showed that G x E component was substantial for seed cotton yield studied. Both linear and non linear components were important for seed cotton yield. Pre-ponderence of linear component indicated ability of predicting the performance of genotypes across the environments. Among different entries evaluated, GBhv 289 recorded highest seed cotton yield (1259 kg/ha) with near to unit regression co-efficient (Bi=0.90) and non significant deviation from regression (S2di). Thus it fulfills the criteria of stable variety. It was followed by GBhv 290 with seed cotton yield of 1113 kg/ha with unit value of Bi=0.80 and least deviation from regression.

Stability Analysis in Herbaceum Cotton

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Eight promising entries including a local check of herbaceum cotton were evaluated at Surat, Bharuch and Achhalia during kharif 2010-11 with four replications to study the G x E interaction using Eberhart and Russel model. ANOVA revealed significant differences for environments which indicated the presence of variations in environments across the locations. In this study, both linear and non linear components were important for seed cotton yield. The results indicated that entry GShv 368/05 fulfill all the criteria for stable variety i.e. higher seed cotton yield of 915 kg/ha and near to unit regression value (bi=1.14) and least deviation from regression (S2di). The same trend was observed for GBhv 284 with 932 kg/ha yield, near to bi unit value of 1.21 and least deviation from regression. The entry GBhv 288 recorded highest seed cotton yield (1012 kg/ha) with bi value 0.75 but having significant S2di value hence its performance was considered as unpredictable.

Heterosis in GMS Based Hybrids of Upland Cotton (*Gossypium hirsutum*) and its Possibilities for Commercial Utilization

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Exploiting heterosis is one of the best methods to increase cotton yields that have stagnated in recent years. Forty-four cotton (Gossypium hirsutum L.) hybrids were produced from a line x tester crossing programme with 15 parents (four lines and eleven testers) at Central Institute for Cotton Research, Regional Station, Sirsa. The primary objective of this study was to determine the useful heterosis in Gossypium hirsutum for seed cotton yield, its component traits and fibre quality parameters in 44 GMS (genetic male sterility) based cross combinations. The analysis of variance indicated that the mean squares of genotypes were significant for seed cotton yield (kg/ha), no. of monopodia, no. of sympodia, no. of bolls/plant, boll weight (g), GOT (%), Micronaire value and strength (g/tex) except 2.5% span length (mm) indicated the presence of variability among hybrids and their parents. Studies revealed that none of the cross combinations exhibited significant heterosis over the check hybrid CSHH 198 for seed cotton yield, number of bolls per plant, boll weight and number of sympods/plant and micronaire value. Significant heterosis for number of monopods/plant, seed index, ginning percentage, 2.5% span length and fibre strength were detected over the conventional check hybrid CSHH 198. For number of monopods in GMS-17 x CISV-1 (81.1%), seed index in GMS 20 x Bikaneri Narma (15.9%), ginning percentage in GMS-17x 007 DA (10.4%) showed the highest and significant positive heterosis over the conventional check hybrid CSHH 198. For quality traits, 2.5 per cent span length in GMS 26 x 006 DA (7.4%) and for fibre strength GMS 21 x 006 DA (13.4%) showed the highest and significant positive heterosis over the conventional check hybrid CSHH 198. The cross combination involving female parent GMS-21 and male parent 006 DA, Bikaneri Narma can be used further for development of GMS based hybrids in cotton at commercial level.

Heterotic Studies for Yield and its Component Traits in Desi Cotton (*Gossypium arboreum* L.)

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The investigation was undertaken to estimate standard heterosis with an objective of exploring possibilities of its commercial utilization. The experimental material comprised of twenty-eight crosses along with eight parents and one standard check (JLA794) and, grown at Agricultural research station, MPKV, Jalgaon in randomized block design with three replications. Observations were recorded for characters namely seed cotton yield (kg/ha), bolls per plant, average boll weight (g) and ginning percentage.The standard heterosis was calculated over check variety JLA-794. Marked economic heterosis was observed for most of the characters studied. Among all the cross combinations studied maximum heterosis for seed cotton yield in JLA-0613 X ARBa-08-34(17.31%), for number of bolls per plant in JLA-0613 x GBav-109(29.1 l%),for average boll weight(g) in Turab x GBav-109 (43.30%) and for ginning percentage in Turab x JLA-605(3.38%) was observed. Cross combinations involving JLA-0613 and JLA-605 as a female parent recorded significant positive heterosis for most of the yield contributing characters.

Evaluation of Different *G. arboreum* and *G. hirsutum* Genotypes under Rainfed Condition

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In recent years, the cultivation of G. arboreum is being ignored resulting into reduction in its area. This is due to low yield levels of G. arboretum. In view of this it is necessary to develop high yielding diploid genotypes with superior fiber properties. Present study was under taken to identify G. arboreum genotypes in comparison with G. hirsutum variety under rain fed situation. Fourteen G. arboreum genotypes with two G. arboreum checks and one G. hirsutum variety were evaluated at Oilseeds Research Station, MPKV, Jalgaon. The results indicated that among 14 G. arboreum genotypes, 12 genotypes and two G. arboreum checks recorded high seed cotton yield as compared to G. hirsutum check Phule-688

and the yield levels increased from 7.04 to 40.59%. The G. arboreum genotypes were found superior for ginning percentage, most of the G. arboreum genotypes also found superior or at Par for 2.5 S.L, strength and elongation. The G. hirsutum variety Phule-688 was superior only for micronaire value as compared to G. arboreum genotypes. This study suggests that under rain fed condition G. arboreum genotypes performed better than G. hirsutum for seed cotton yield and quality.

Performance of Improved Genotypes of *G. arboreum* Cotton for Qualitative and Quantitative Characters

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Indigenous diploid Gossypium arboreum cotton possesses inherent ability to resist major insects pests and diseases but have inferior fibre quality. Attempts to improve fibre properties of arboreum cotton without deterioration of productivity were made. This has resulted in to the development of arboreum cotton genotypes with superior fibre properties Present experiment was conducted to evaluate productive long staple advance stage arboreum cotton genotypes at three locations, viz, Parbhani, Nanded and Badnapur during kharif 2011-12.The experiment involved thirteen genotypes with four checks and laid out in randomized block design. Based on the mean performance for seed cotton yield over all the three locations, the genotype PA 528 recorded highest seed cotton yield (1670 kg/ha) followed by PA 720 (1649 kg/ha) and PAIG 326 (1640 kg/ha) .The mean ginning out turn ranged from 34.85 (PA 770) to 38.47 per cent (PAIG 346) amongst the strains under testing. The strain PAIG 346 recorded highest ginning outturn (38.47%) followed by PA 710 (37.97%) and PA 528 (37.64%). 2.5 % span length ranged between 25.4 mm to 29.1 mm. the genotype PAIG 326 recorded highest 2.5% span length (29.1mm) followed by PA 743 , PA 760, PA 770 (28.9mm) . Uniformity ratio ranged between 49 to 53. Fibre Fineness ranged between 3.9 to 5.8 .The genotype PA 760 recorded lowest micronaire of 3.9 . Fibre strength ranged between 19.4 g/tex to 22.5 g/tex . The genotype PA 743 recorded highest fibre strength (22.5g/tex) followed by PA 770 (21.9g/tex). On an average of three locations, performance of genotype PA 528, PA 720 and PAIG 326 was most promising for seed cotton yield (above 16 qtl/ha) coupled with better combination of ginning outturn (around 37.00%) and staple length (above 27.00mm)

Stability Analysis of Promising Genotypes of *G. hirsutum* Cotton for Yield and its Components

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Stability analysis of eight promising G.hirsutum L. cotton genotypes was made along with check LRA-5166 over four environments viz., Surat, Targhadia, Talod and Viramgam during kharif 2008-09. Observations were recorded on five characters related to yield and its components. Variance due to genotypes, environments and environment (linear) revealed significant difference for seed cotton yield, ginning out turn and lint yield suggesting the presence of genetic variability in the genotypes, differences in environments under investigation and their predominant effect on yield. The genotype x environment interaction was significant suggesting that the genotypes interacted considerably with the environment in the expression of yield. The linear component of G x E was not significant indicating that the genotypes respond non linearly to the change in environment. In present study, GSHV-152 and GSHV-97/612 were most stable for seed cotton yield and numbers of bolls/plant. Genotype GSHV-152 also showed stability for ginning out turn while GSHV-97/612 for lint yield and numbers of bolls/plant.

Assessment of Cotton Germplasm (*Gossypium hirsutum*) for Resistance/Tolerance to Insect Pests

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In India, all the four domesticated species of Gossypium are grown successfully but G. hirsutum represents the major share with respect to area and production (in the form of transgenic cotton). Currently, transgenic cotton cultivation faces major constraints in the form of sucking insect pests and CLCV. Screening of germplasm for resistance/tolerance against economically important insect pests can strengthen resistance breeding programmes. Besides, non transgenic elite lines can provide alternative to bt cotton which can be exploited with decrease in bollworm load in cotton ecosystem. This present investigation highlights the results of the ongoing screening of the cotton germplasm for resistance to

insect pests. Total of 352 entries of American cotton were screened from 2008-09 onwards till 2011-12. The trials were sown in a randomized block design with row to row and plant to plant spacing of 67.5 cm x 60 (varieties) / 75 cm (hybrid trials), respectively. The population of jassid (leafhopper), whitefly were recorded per three fully formed leaves (upper, middle and lower canopy) from three plants at random in each replication. Jassid injury grade (JIG) was also recorded. The per cent infestation of bollworms both on boll and locule basis was calculated. The yield per plant was also recorded. The data was analyzed using suitable transformations. In the year 2008-09, the least number of whitefly/ 3 leaves was recorded on RS 2525, RS 2455, LH 2111. The open boll damage was the least in H 1360 (5.25 %) while the H1300 gave the maximum yield of 125.00g per plant. Among the hybrids, SVHH139 and SHH 460 recorded the lowest jassid count of 1.84 per 3 leaves and LMSH263 recorded the lowest of 1.67 whitefly/3 leaves. Per cent boll and loculi damage were minimum on HHH455 (9.15 and 2.26 % respectively). In the successive year 2009-10, only one entry KH 901 recorded JIG 0 (with maximum yield of 116.67 g/plant). The least whitefly of 1.50/3 leaves was recorded on NDLH 1939 and SCS 701. The per cent open boll and locule damage among the entries was the least in BS 27(2.03& 0.99% resp.). Among the hybrids, RAJHH 743, RAHH 951, DHH-1054 and FHH 158(maximum yield 166.67 g per plant) recorded JIG of 0. Population of whitefly was the lowest on RAHH 951 (1.50) and FHH 141(2.20 per 3 leaves). Jassid population, in 2010-11, was the minimum in HS 283 and LH 2108 (1.00) and CSH 10 (1.17 per 3 leaves) whereas whitefly was the least on MR 68 (3.17). Boll and locule damage was the lowest in Bihani 251 and at par with LH 2108, the entry with maximum yield of 133.34 g/plant. The incidence of jassid and whitefly was the lowest on hybrids viz. HHH 483, GSHH 2729 and RAJHH 743. The minimum boll damage of 2.57 % was obtained on ARBH 1051. In 2011-12, amongst the hirsutum varieties, MR 786 and LH 2170 recorded lowest whitefly infestation and per cent boll and locule damage, respectively. Four hybrids viz. LHH 1431, RHH 813, RHH 0711 and RAJHH 843 gave JIG of I. Population of whitefly was the lowest on RAJHH 844 (5.83 per 3 leaves). Per cent boll and locule damage recorded was minimum on SHH 1003. FHH 200 and Ankur 3228 gave the highest yields of 140.0 and 149.50 g per plant. On-going hirsutum germplasm evaluation resulted in selection of some promising material with tolerance to sucking insect pests and other biotic stresses besides having good yields. These entries could be taken up for advanced screening to assist in varietal improvement at later stages.

Stability Analysis of Seed Cotton Yield and Important Quality Characters in *Gossypium barbadense* L. Cotton

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Stability analysis of the material consisting of eight genotypes grown at Surat locations consecutively for 2009-10, 2010-11 and 2011-12 thereby creating three environments E1 to E3 was carried out. The observations were recorded on five characters related to seed cotton yield and fiber quality characters. Variance due to genotypes, environment and genotypes x environment interaction was significant for all the characters studied. Studies to estimate relative stability of Gossypium barbadense cotton genotypes revealed that except fiber strength, major component of genotypes x environment interaction was a liner function of the environment. Simultaneously, consideration of all the parameters of stability revealed that only three genotypes, GSB-21, GSB-24 and GSB-39 were found to be stable for seed yield and fiber quality characters.

Half Diallel Analysis for Combining Ability Studies for Yield and Yield Contributing Characters in Cotton (*Gossypium hirsutum* L.)

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The present investigation was undertaken by adopting half diallel analysis involving 6 diverse parents for combining ability analysis in kharif 2011 at Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri. The analysis of variance for combining ability revealed that variances due to sca were larger than gca for all the characters indicating predominance of non-additive gene action. This was also supported by less than unity ratio of ägca: äsca for all the characters under study. The parents RHCr-0606, RHBB-9718 and HAP-22-4 were good general combiners for seed cotton yield. The hybrids RHC-577/3-3 x RHCr-0606 and RHRIH-13-1 x RHC-577/3-3 had significant sca effect for seed cotton yield and important yield components.

Genetic Analysis of Yield and Yield Components in Intra-Specific Diploid Cotton

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A field experiment was carried out to study the genetic analysis of yield and yield components in intra-specific diploid cotton at Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (MS). Six generations viz., P1, P2, F1, F2, BC1 and BC2 derived from AKA-7 x Dh-2 were sown in randomized block design (RBD) with three replications. Observations on twelve yield contributing characters and four fibre traits were recorded on 15 random plants in each parent and F1 plants, 30 plants in BC1 and BC2 and 60 plants in F2 generation. The scaling test indicated either scale A, B, C or all the three scales deviated from zero for most of all the characters indicating presence of epistasis due to inter allelic interactions. Joint scaling test also resulted into significant chi-square value indicating inadequacy of the three parameter model for these characters. The dominant component (h) found significant for boll weight, ginning percentage and higher in monopodia/plant, whereas, additive component (d) found significant for fibre strength and micronaire value and higher in uniformity ratio.

Evaluation of Upland Cotton (*Gossypium hirsutum*) Genotypes for their Suitability to Machine Picking

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Cotton is an important commercial crop in India and plays a key role in our economy. The area under cotton showed a steady increase after the introduction of Bt cotton hybrids in India in 2002. During 2011-12 total cotton production was about 353 lakh bales from an area of about 121.8 lakh ha and the national average was 493 Kg lint/ha.

Labour requirement for various operations, especially for picking of cotton is very high. The rising labour cost of picking and non availability of skilled labour are becoming serious constraints in cotton cultivation. About 30% of cotton is picked

mechanically world wide. In Australia, Israel and USA 100% cotton is machine picked. Likewise substantial amount of cotton is picked by machines in Bulgaria (85%), Greece (92%), Spain (95%) and Argentina (75%). Machine picking is also used in countries like Uzbekistan (30-40%), Colombia (35%), South Africa (15-20%), Brazil (5-10%), Zimbabwe (5%), Paraguay (5%), Bolivia (4%) and Ecuador (3%). However, it is 100% manually picked in India. The crop is harvested in at least 3 to 4 pickings due to non synchronous maturity.

Machine picking is therefore very important to reduce cost of cultivation and increase efficiency. Development of varieties and hybrids having compact plant type with early and synchronous maturity, wide boll opening, flared kapas attachment to the locule, shedding of leaves at the time of harvesting, etc are some of the traits which are important for machine picking. In view of above research was initiated at Indian Agricultural Research Institute, N. Delhi during 2007-08 to identify varieties / genotypes of G. hirsutum that may be suitable for machine picking.Thirty released / pre-released varieties and promising genotypes of Gossypium hirsutum were evaluated for varying period during 3 year period 2007-2009. Seed cotton yields recorded were 2990 Kg/ha in H1300 (2 year mean), 2956 Kg/ha in PSS 2 (3 year mean) and 2624 kg/ha in local check P 8-6 (3 year mean). The Bt check RCH 134 Bt showed mean yield of 3403 Kg/ha over 3 year period. In comparison compact variety RS 875 showed 1852 Kg/ha over 2 years and okra leaf genotypes, i.e. F 2036 and F 2383 showed mean seed cotton yield of 2624 kg/ha (one year) and 2663 kg/ha (2 year), respectively. The percentage of seed cotton picked 150 days after planting was 95.4% in variety 'RS 875' and 93.4% in 'PSS 2'. It was 85.5% in 'RCH 134 Bt', 92.2% in F 2086', 91.3% in 'F 2383' and 88.7% in local check 'Pusa 8-6'.Amongst the 30 genotypes evaluated in this study, variety 'RS 875' was the most compact and early in maturity. However it gave significantly lower seed cotton yield as compared to high yielding genotypes like 'PSS 2' and 'H 1300', which also showed flared kapas attachment and wide locule opening for easy picking.

In view of the increasing popularity of Bt hybrids an attempt was also made to evaluate their performance for machine picking during 2010 and 2011. A total of 14 Bt hybrids were evaluated for important traits. Amongst the 10 Bt hybrids studied during 2010, MRC 6304 Bt showed highest yield (2076 kg/ha) in 150 days. It showed plant height of 126 cm. In comparison non Bt okra leaf compact

variety 'F 2383' showed 865 kh/ha seed cotton yield with plant height of 76.7 cm. It also showed lower boll weight (3.1g) as compared to 5.0g in MRC 6304 Bt. The kapas attachment in F 2383 was bad and locule opening was acute as compared to medium to clean kapas attachment and wide boll opening in the 10 Bt hybrids. Three Bt hybrids namely VBCH 1534 Bt, MRC 6304 Bt and MRC 7031 Bt and one non Bt genotype F 2383 were evaluated during 2011. The seed cotton yield recorded in Bt hybrids was 2860 kg/ha in MRC 7031 Bt, 2848 kg/ha in VBCH 1534 Bt and 2762 kg/ha in MRC 6304 Bt as compared to 2406 kg/ha in F 2383. Statistically all the 3 hybrids were at par with regard to seed cotton yield whereas yield in F 2383 was significantly lower. F 2383 also showed lower boll weight, bad kapas attachment and acute locule opening as compared to Bt hybrids which showed superior boll size, clean kapas attachment and wide locule opening. Over all Bt hybrids like MRC 6304 Bt, VBCH 1534 Bt and MRC 7031 were found suitable for machine picking. Amongst non Bt genotypes F 2383 and RS 875 were compact and early in maturity and were suitable for machine picking. These non Bt genotypes, however showed significantly lower yields.

AKH-9916: A New Promising American Cotton Genotype for Vidarbha Region

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Cotton is the most important cash crop of Vidarbha. The total area under cotton in Vidarbha region is around 15.5 lakh hectares. The cotton cultivation in Vidarbha is exclusively under rainfed cultivation. For this reason Cotton Research Unit, Dr. PDKV, Akola has evolved four varieties, however, the medium duration varieties are susceptible to sucking pests. The medium duration variety AKH-9916 is resistant to sucking pests due to its hairiness and hence, pre-released for Vidarbha region for rainfed cultivation during 2011-12. The variety AKH-9916 has given high seed cotton yield than PKV Rajat, AKH-8828, LRA-5166, NH-545 and NH-615 in different trials conducted at different locations during last eight years. The overall per-cent increase of seed cotton yield in multi-location trials was 15.8, 15.9, 19.02, 4.59

and 1.95 per cent over PKV Rajat, AKH-8828, LRA-5166, NH-545 and NH-615 respectively. This variety has given high lint yield than PKV Rajat, AKH-8828, LRA-5166, NH-545 and NH-615 in different trials conducted at different locations during last eight years. The overall per-cent increase of lint yield in multi-location trials was 15.5, 14.5, 27.3, 2.3 and 2.0 per cent over PKV Rajat, AKH-8828, LRA-5166, NH-545 and NH-615, respectively. AKH-9916 is having comparable ginning percentage (37-38 %) with existing varieties PKV Rajat, AKH-8828, LRA-5166, NH-545 and NH-615. This variety is having good fibre qualities, superior for strength and comparable for staple length and fineness with other check varieties.. This variety is having 7.2 %, 5.0 %, 6.6 % and 9.4 % more fibre strength than PKV Rajat, AKH-8828, NH-545 and NH-615, respectively. The variety is resistant to jassids and moderately resistant to Bacterial leaf blight, Alternaria leaf spot and Grey Mildew. It is medium maturity duration variety (170-180 days) having average boll weight of 3.03.5g.

Comparative Study of BG I and BG II Cotton Hybrids under Rainfed Condition

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A comparative study of performance of popular Bt cotton hybrids (both BG I and BG II) in relation to seed cotton yield and other characters was studied at Cotton Research Unit, Dr. PDKV, Akola. The experiment was carried out on nine popular Bt cotton hybrids FRBD with three replications during 2011-12. The differences in seed cotton yield per hector were significant. Hybrid PRCH 31 (1468 kg/ ha) recorded significantly highest seed cotton yield PRCH-504 Bt remained second (1277 kg/ ha) and Jay, Akka, Mallika and Bunny Bt were at par to it. The lowest seed cotton yield was noted by Mist Bt (693 kg/ ha). PRCH-31 Bt (6067.5 kg/ ha) also recorded significantly highest biological yield whereas Mist Bt (3065.5 kg/ ha) recorded least biological yield. Similar results were also found in respect of N, P and K uptake.

Stability Analysis of Some Newly Developed Genotypes of American Cotton (*Gossypium hirsutum* L.)

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Eleven newly developed American cotton genotypes with one check were tested at three different locations to determine their stability for seed cotton yield and component characters. The mean sum of squares differences due to genotypes and environments were highly significant for all the characters, indicating variability among the genotypes and the environments for the characters studied. Significant E + (G x E) interactions for all these characters showed differential response of genotypes under different environments. The G x E (linear) component was found highly significant for the characters number of bolls per plant and boll weight, suggesting that prediction of performance of these characters in different environments is possible. Highly significant pooled deviation was observed for number of bolls per plant and seed cotton yield indicating that genotypes differed considerably with respect to the stability for these characters. Three genotypes AKH-9916, AKH-2006-8 and AKH-017, recorded seed cotton yield per plant above population mean with non significant deviation from regression (S2di) values and bi less than unity, exhibiting above average stability and need to be tested over the locations and years to get clear cut idea about their performance.

Evaluation of Sustainable Promising Cotton (*Gossypium hirsutum*) Genotypes for Yield under Rainfed Conditions

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Fourteen promising genotypes of cotton (Gossypium hirsutum L.) were evaluated in coordinated varietal trial during kharif 2010-12 in randomised block design on different centres of central zone under rainfed conditions. Twelve entries were common in both the years while AKH 0205 and BS 79 genotypes were assesed in single year's experimentation during kharif 2010 and 2011 respectively.

Significant differences among the genotypes were observed with respect to seed cotton yield, lint yield and number of bolls per plants etc on each centre of the central region. The highest seed cotton yield (1856 kg ha-1) was given by entry GBHV 164 at Bharuch in Br 03 b testing during10-11 and 1608 kg ha-1 in Br 04 b testing at Banswara during 11-12. The lowest seed cotton yield (428 and 326 kg ha-1) was given by GBHV 164 at Indore during 10-11 and by local check at Nanded during11-12 respectively. The highest mean seed cotton yield (1135 kg ha-1) over years was given by the entry NH 635, while other genotypes viz. BS 30, H 1452 and GBHV 164 were at par among themselves and gave approximately 1060 to 1088 kg ha -1 seed cotton yield as compared to LC (914 kg ha-1). Performance of varieties under different growing environment can be explained by differential values of phenophase indices and finally yield and its attributes reflected the exact effects.

Data pertaining to lint yield was also significantly variable in both the years of testing on all the centres and it was highest in GBHV 164 (613 kg ha-1) and NH 635 (563 kg ha-1) respectively at Banswara during the year 10-11 and 11-12. The highest mean lint yield (416 kg ha-1) over years was noted in genotype NH 635 with the highest GOT (36.5%) and followed by PH 1060 (384 kg ha-1 with 35.9% GOT) and H 1353 (369 kg ha-1 with 36.1% GOT). Genotype H 1455 also expressed better GOT (35.6%).

Sustainable yield index (SYI) is a statistical tool to evaluate yield levels likely to be achieved in long term experimentations in relation to changes in status of soil organic carbon. SYI with respect to seed cotton yield and lint yield was estimated in each year revealed that genotype NH 635 had higher sustainable productivity, (1135 and 416 kg ha seed cotton and lint yield respectively), may be due to higher rain water use efficiency (1.25%), GOT (36.5%) and bolls per plant (18.9). Other genotypes namely BS 30 and H 1452 were at par with NH 635 for sustainable productivity. Regarding oil content genotypes BS 30 and BS 79 were better (19%).

Over all results indicated that NH 635 had sustainable productivity under rainfed conditions and followed by the entries BS 30 and H 1452.

Measuring Association of Quantitative Characters in Cotton at the Level of Breeding Value

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In sexually reproducing crop only breeding value out of entire phenotypic value is passed on to progeny and hence genetic correlation a measure of association between traits at the level of breeding value (rA) becomes important. Correlated response of characters depends upon the genetic correlation existing between them. It is necessary to establish relations and estimate genetic co variances that are required in determining genetic correlation. A procedure is described here to utilize the data generated on half sibs and full sibs generated through NC designs for determining genetic correlations.

Seed cotton yield exhibited highest positive genetic correlation with number of bolls per plant (0.75) followed by monopodia per plant (0.65), boll weight (0.54) and a negative genetic correlation with lint index (-0.39), ginning outturn (-0.24), seed index (-0.23).

There was a clear differences in magnitude and direction of association among quantitative characters when measured at the level of breeding value (rA) as compared to genotypic and phenotypic correlation suggesting that the inferences on relationships among characters and predicted correlated response can be wrong if phenotypic and genotypic correlations are used.

Breeding Cotton Genotypes for the Needs of Organic Cultivation

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Cultivation of Bt cotton hybrids in India has increased productivity but has lead to decline in genetic diversity of cotton. Non GM organic cotton provides a vital source of refugea and contributes to sustainability of bollworm resistance. The study was aimed at understanding the need to develop genotypes exclusively for different situations of organic cotton in India.

Evaluation of variability in segregating populations, early generation lines and stabilized lines and comparison of hybrids and varietal options was done in conventional and organic situation. Farmer's participatory evaluation of breeding material was taken up in association with prominent organic groups at locations of Madhya Pradesh (Bio Re foundation) and Orissa (Chetna organics).

Performance of genotypes differed in organic situation as compared to conventional situation. Varieties developed for conventional farming situation were not the best options in organic farming. Compact varieties with synchronous maturity revealed high productivity in receding moisture situation of rainfed areas and they also revealed high productivity under high density planting. Breeding potential varieties ensure self sufficiency for seed needs of farmers which is presently a major threat to promotion of organic cotton. Some potential hybrids can become an option provided approaches like training for back yard seed production and community seed production are followed.

Evaluation of Popular Bt Cotton Hybrids for Fiber Quality under Rainfed Conditions

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Ninety seven Bt Cotton hybrids were evaluated along with two Bt and two non Bt check hybrids under rainfed conditions at AICCIP, Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) during Kharif 2008-2009. Results on different fibre qualities revealed that the range for 2.5 % span length was 23.2 mm to 35.7 mm, for fibre strength range 15.4 g/tex to 27.0 g/tex and for micronaire it ranged between (2.2 g/inch) to (4.5 g/inch). The uniformity ratio for all the hybrids was in the range of 43 to 53 per cent. The highest ginning outturn was obtained from the hybrid UPLHH-2Bt (36.5%). Desirable hybrids in respect of fiber quality were, MRC-7918 BG II, MARGO Bt and SANDIP Bt under present investigation. However it needs further confirmation on multilocation basis.

Morphological Characterization of Cotton Hybrids and Parental Lines

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The varieties and hybrids attain acceptance when the farmer gets genetically pure seeds of high standards. For this purpose, each cultivar should be properly defined with suitable descriptors, so as to maintain its identity during seed production through field inspection and certification. Apart from this, characterization of cultivars is also required for their protection under PPV & FR Act 2001. Present study was undertaken to characterize four hybrids and five parental lines during kharif 2011-12 season to study the varietal characterization by using morphological characters. The seed material for the present investigation comprised four hybrids (H1098-i x GCA 136, H1098-i x GCA 289, H1098-i x GCA 278 and H 1157 x GCA 289) and their five parents of cotton (H 1098-i, GCA 136, GCA 289, GCA 278 and H 1157). On the basis of morphological characters like leaf shape, leaf colour, stem pigmentation, stem hairiness, leaf appearance, leaf petiole pigmentation, leaf lobe number, boll bearing habit, boll size, boll colour, boll tip prominent, boll opening, boll shape, bract type, sepal pigmentation, petal colour etc. Anther colour of all parents

and hybrids was cream except yellow anther in parent GCA 289 and hybrids (H1098-i x GCA 289) and (H 1157 x GCA 289). One parent GCA 278 was grouped in digitate type of leaves whereas hybrids (H1098-i x GCA 278) and (H 1157 x GCA 278) were grouped in semi-digitate type and all other were in palmate type of leaves. Parent GCA 289 and two hybrids (H1098-i x GCA 289) and (H 1157 x GCA 289) were grouped into red type of leaves, rest were grouped into green leaves. Pigmented stem was observed in parent GCA 289 and two hybrids (H 1098-i x GCA 289) and (H 1157 x GCA 289). Strong stem hairiness was observed in parent H1098-i otherwise it was medium in all cases. Flat leaves were observed in parent GCA 278 only, rest were cup shaped. Leaf nectars were present in all parents and hybrids. Parent GCA 136 was having frego- bracts otherwise normal bracts in all parents and hybrids except hybrid (H1098-i x GCA 136) where intermediate bracts were observed. Cream petal colour was observed in parent H1098-i, red colour in GCA 289, bicolour in (H1098-i x GCA 289) and (H 1157 x GCA 289) and rest were grouped in yellow colour petals. Petal spot and filament colouration was absent in all parents and hybrids as well as stigma was embedded. Five leaf lobs were observed in the parents as well as hybrids except hybrid H 1157 x GCA 289. Solitary boll bearing habit, ovate boll type, smooth boll surface and fluffy boll opening was observed in all parents and hybrids. Boll size was medium in all except H1098 i.

Development of Improved Fibre Quality *G. arboreum* Genotypes for North Zone Conditions

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North zone of India has been cultivating coarse G. arboreum genotypes like RG-8, LD-327, HD-123 and GMS based hybrids CICR-2 and AAH-1 with fibre length around 18 mm and micronaire value around 7.0. Long linted , high strength and low micronaire good fibre quality G. arboreum genotypes from central zone are usually poor yielder and late maturing under North Zone conditions. Under genetic enhancement programme to develop high yielding long linted good fibre quality early maturing G.arboreum genotypes for North zone conditions long linted, high strength and low micronaire good fibre quality G. arboreum genotypes from central zone genotypes were crossed with coarse genotypes of North zone. Genotypes CISA-108, CISA-104, CISA-112,CISA-105 and CISA 101 were developed

under the programme and sponsored in AICCIP trial Br 22a/b. Initial Evaluation Trial of G.arboreum during 2007, 2008,2009,2010,2011 respectively. CISA-108,CISA-104,CISA-112,CISA-105 and CISA 101 had zonal mean 2.5 span fibre length of 23.1, 25.1, 24.3, 25.7 and 25.7 whereas zonal check had corresponding mean fibre length of 17.3,18.8,19.0,18.7,and179 mm during these years. These genotypes had zonal mean microronaire of 4.7, 4.9, 5.9, 6.2 and 5.9 during 2007, 2008,2009,2010,2011 AICCIP trials in comparison to zonal check micronaire ranging form 6.9 to 7.0. Fibre strength of these genotypes was also slightly better than the zonal check and GOT % was at par. This indicated that there was improvement in fibre quality of the genotypes developed under genetic enhancement programme. The yield potential of these genotypes was better than good fibre quality central zone cultures under north zone conditions but lower than coarse fibre zonal varieties of North zone. Zonal boll weight mean of these improved fibre quality genotypes ranged from 2.1 to 2.2g which was lower than zonal check ranging from 2.3 to 2.6 and that seems to be apart from lower boll number/plant the reason for their lower yield in comparison to zonal checks. Thus information indicates that to bring high quality genotypes at par in yield with zonal checks emphasis be laid on their increase on boll weight and boll number and sustaining their fibre quality.

Heterosis for Seed Cotton Yield, Lint Yield and Ginning Outturn in Interspecific Crosses of Cotton.

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The present investigation was carried out at Main Cotton Research Station, Navsari Agricultural University, Surat during kharif 2011 to estimate the extent of heterosis in interspecific crosses of cotton. The trial composed of 39 crosses and one check (G.Cot-20) and evaluated in randomized block design with three replications. Observation were recorded for seed cotton yield (kg/ha), lint yield (kg/ha) and ginning percentage. Maximum heterosis for seed cotton yield was observed in the crosses BC-68-2 x Suvin (237.2%) and G.Cot-20 x Suvin (237.2%). The maximum heterosis for lint yield was observed in GSB -41 x G.Cot-20 i.e., 291.8%. The several crosses showed maximum heterosis for ginning outturn (33.6 %). The crosses showing desirable heterosis can be advanced for isolation of improved lines for seed cotton yield, lint cotton yield and ginning outturn.

Marker Assisted Backcrossing in Cotton

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Marker Assisted Back Crossing (MABC) provides a great opportunity for precise transfer of desirable donor segment by minimizing the linkage drag into a recurrent parent and also in shorter time as compared to conventional backcrossing to convert the recurrent parent with the new trait. In the present study, MABC was used for incorporating insect resistance genes Cry1Ac and Cry2Ab into the genetic background of cotton parental line G.Cot.16 from Coker cotton line. PCR based molecular markers viz., RAPD and ISSR were used to detect genetic similarity among G.Cot.16 parental line and two backcrossed progenies i.e progeny-1 and progeny-2 in BC2F2 generation having insect resistance genes Cry1Ac and Cry2Ab in homozygous condition vis-à-vis morphological similarity to that of the parental line. Plant RAPD primers comprised of 25 primers from GeNeiTM detected total 353 bands of which 336 were found to be non-polymorphic, whereas, 19 ISSR primers detected total 221 bands of which 212 were found to be monomorphic among G.Cot.16 parental line and two backcrossed progenies viz., progeny-1 and progeny-2. Statistical analysis from the pooled data generated by RAPD and ISSR was carried out using NT sys software. The similarity based on Jaccard's coefficient showed 88% similarity between G.cot 16 and transformed progeny-1 and 92% similarity between parental line G.cot 16 and transformed progeny-2. Thus, the present investigation demonstrated that MABC can be employed for identification of parental types plants with donor traits in early backcross generation and assisted in speeding up the backcross programme for transfer of desirable trait.

Effects of Salinity Stress in Cotton using cDNA-RAPD Approach

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Cotton is a long duration crop and influenced by various biotic and abiotic stresses. High salinity is a common abiotic stress condition that adversely affects plant growth. Altered ion and water homeostasis changes due to NaCl stress, lead to molecular damage, growth arrest and even death. Because of salt stress effects, secondary stresses such as oxidative damage of lipids, proteins and nucleic acids causing lipid peroxidation, protein denaturing and DNA mutation may occur. In recent years, several selective and sensitive assays have been developed to evaluate the effects of salinity stress. cDNA-RAPD approach is one of them and developed for DNA analysis. In this study, seeds of two cotton variety viz., G.Cot 23 (G. herbaceum) and G.Cot 10 (G. hirsutum) were grown in the M.S media supplemented with 0.8% agar under salinity stress in the range of 0-200 mM NaCl. Morphological parameters like percentage germination, root and shoot length (at 7days and 14 days) were noted. It was found that with increase in NaCl concentration the percentage germination, root length and shoot length decreases. The effects of salinity were more pronounced in G.Cot 10 as compared to G.Cot 23. Effects of salinity stress were also determined by comparing cDNA-RAPD profiles of normal seedlings and seedlings grown under various salinity levels i.e 50, 100, 200 mM, which include variations in band intensities as well as gains or losses of band numbers. The DNA polymorphisms detected by cDNA-RAPD analysis could be used for development of SCAR markers and this will be our investigative tool and useful biomarker for selection of plants resistant to salinity stress.

Identification of Markers Linked with Male Sterility Genes in Cotton

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India leads the world in both, commercial production and cultivation of hybrid cotton. Seed production is carried out by expensive hand emasculation and pollination techniques, which results in higher seed costs. Genetic male sterility system helps in overcoming these problems and offers clear advantages. GMS system is preferred in cotton, which has no known consequent yield reduction, as is experienced with the CMS systems. However, in GMS based seed production system, rouging of 50% fertile plants is very laborious task and one has to wait till flowering. Marker assisted selection will help in early identification of fertile plants and thus, they can be removed from the field at early seedling stage. In the present investigation, individual sterile and fertile plants of stable genetic male sterile lines SRT GMS-1 were first identified and tagged based on flower phenotype and the DNA of these samples was isolated for molecular characterization. 25 RAPD, 30 SSR and 20 ISSR primers were used to identify suitable molecular markers linked to genetic male sterility. Among these primers; the SSR primers viz. JESPR-231, 234 and 296 showed presence of unique bands of size (180bp, 98bp and 220bp respectively) in the fertile plants. In the sterile plant, these bands were absent. Therefore, these microsatellite markers can be considered as putative markers for linkage studies and for identification of male sterile and fertile plants in the GMS based Hybrid seed production plots at the early stages of the crop growth.

Evaluation of genotypes under different moisture conditions

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Cotton, the "white gold", is India's principal commercial crop. It constitutes about 85 per cent of the raw material of textile industry in India. Cotton crop is essentially an irrigated crop in the Haryana state. The major source of irrigation is canals. The soil temperature and wind velocity at planting time is very high resulting in rapid loss of soil moisture and burning of cotton seedling in the fields. The world is facing multiple challenges including water scarcity due to

global warming andclimate change. So there is an urgent need to develop and evaluate genotypes which perform better under irrigated as well as under rainfed condition.

Keeping in view the above objective in mind, an experiment was conducted at CCS Haryana Agricultural University Research Farm consisting of 17 genotypes during kharif 2012 under irrigated as well as under rainfed conditions to study the effect of water as well water scarcity on different genotypes. The size of the plot was 6.0 x 2.70 m under both the conditions. There were four rows of each genotype of 6.0 m length and the rows were spaced at 67.5 cm apart and plant to plant spacing was kept 30 cm in both the experiments. The sowing of both experiments was done on 23-4-2012 and similar cultural practices were adopted except no irrigation in rainfed experiment. In Haryana normal monsoon season is end of June but this year arrival of monsoon was late, first shower appeared in Mid August before it there were very light drizzling. Data was recorded on yield as well as for other characters. There were no significant differences observed for boll weight as

well as number of bolls per plant under both the conditions. Genotypes differ significantly for seed cotton yield in both conditions. Under irrigated condition seed cotton yield ranged from 1948 kg/h to 3163 kg/h, whereas under rainfed condition it ranged from 1162 kg/h to 2199 kg/h. Some genotypes performed almost at par under both conditions, so there is need of further exploitation of these genotypes in breeding programme.

Evaluation of performance of Bt cotton hybrids under different moisture conditions

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Cotton is most important commercial crop of Haryana and presently more than 90% area is under Bt cotton hybrids. The number of Bt cotton hybrids recommended for cultivation is very high. Even the farmers with less water resources started growing Bt. Cotton. To advise the farmers regarding the Bt. Hybrid with low water requirement it was decided to conduct an experiment for the evaluation of the hybrids under rain fed conditions or under restricted irrigation conditions.

The hybrids were selected on the basis of the information provided by the respective companies. Keeping this objective in mind, ten most popular Bt cotton hybrids of Haryana state were evaluated under irrigated and rain fed conditions. These hybrids were evaluated at Research Area of CCS Haryana Agricultural University, Hisar during kharif 2012. In irrigated experiment three irrigations were applied i.e. one for sowing and two at vegetative stage, whereas in rain fed experiment only one irrigation was applied for sowing purpose. Two insecticidal sprays were applied to control the sucking pests in both the experiments. There was no incidence of boll worms during entire crop season. Data was recorded for seed cotton yield and other yield component traits. The significant differences were observed in both the experiments for seed cotton yield. Under irrigated conditions seed cotton yield ranged from 196 kg/ha to 4124 kg/ha, whereas in rain fed condition experiment it ranged from 2106 kg/ha to 3446 kg/ha. On the basis of mean performance of both the experiments two Bt cotton hybrids produced as high as 3731 kg/ha and 3582 kg/ha seed cotton yield. Three hybrids performed better under rain fed conditions, whereas rest were found superior under irrigated condition. From this experiment it can be concluded that some Bt cotton hybrids can bear stress particularly at vegetative stage without significant loss in seed cotton yield.

CROP PRODUCTION (CP)

Evaluation of Efficient Weed Management Strategies in Bt. Cotton (*Gossypium hirsutum* L.) under Irrigated Condition

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A field experiment was conducted during kharif season of the year 2009 at DWSR-Anand Centre Farm, Anand Agricultural University, Anand for evaluation of efficient weed management strategies in Bt. Cotton (Gossypium hirsutum L) under irrigated condition. The experiment was laid out in Randomized Block Design with four replications. The soils of the experimental field was loamy sand in texture, low in available nitrogen, medium in available phosphorus and high in available potassium with slightly alkaline in reaction. Significantly lower total weed dry weight was recorded at harvest under treatment of hand weeding carried out at 20, 40, 60 and 80 DAS which was remained at par with pre-emergence application of pendimethalin @ 1000 g/ha fb HW at 30 DAS, quizqlofop ethyl @ 75 g/ha POE fb HW at 30 DAS and butachlor @ 1000 g/ha PE fb HW at 30 DAS. Among the cultural weed control treatments, significantly lower total weed dry weight was observed at harvest under hand weeding carried out at 20, 40, 60 and 80 DAS and IC fb HW at 30 and 60 DAS as compared to other treatments. The highest weed control efficacy was observed in hand weeding carried out at 20, 40, 60 and 80 DAS followed by pre-emergence application of pendimethalin @ 1000 g/ha fb HW at 30 DAS, quizqlofop ethyl @ 75 g/ha POE fb HW at 30 DAS and butachlor @ 1000 g/ha PE fb HW at 30 DAS respectively recorded at 25 and 50 DAS and at harvest. Higher seed cotton yield was recorded under the pre-emergence application of pendimethalin @ 1000 g/ha fb HW at 30 DAS, which was remained at par with IC fb HW at 30 and 60 DAS, quizqlofop ethyl @ 75 g/ha POE fb HW at 30 DAS, while the lowest seed cotton yield was recorded in weedy check. The highest oil content in cotton seed was noticed under pre-emergence application of pendimethalin @ 1000 g/ha fb HW at 30 DAS followed by hand weeding carried out at 20, 40, 60 and 80 DAS, paraquat @ 500 g/ha POE as protected spray fb HW at 30 DAS, fenoxaprop-p-ethyl @ 75 g/ha POE fb HW at 30 DAS and butachlor @ 1000 g/ha PE fb HW at 30 DAS.

Among various weed management practices Pre-emergence application of herbicides with hand weeding (pendimethalin @ 1000 g/ha fbhw at 30 DAS and butachlor @ 1000 g/ha fb HW at 30 DAS) and post-emergence application of

herbicides with hand weeding (quizalofop ethyl @ 75 g/ha fb HW at 30 DAS and fenoxaprop ethyl 75 g/ha fb HW at 30 DAS) provides satisfactory weed suppression with fairly low weed density and control against monocot and dicot weeds.

Crop Weed Competition and Post Emergence Weedicides Studies in Bt Cotton

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A field investigation was conducted at Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the 2011-2012 with a view to study the efficacy of post emergence weedicides on growth and yield of seed cotton and weed control efficiency. The experiment was laid out in RBD replicated thrice with eight treatments. Cotton seed variety MRC-7326 was sown at a spacing 90 x 60 cm with RDF 60:30:30 NPK Kg ha-1. In the field Commelina benghalensis, Cynodon dactylon, Cyperus rotundus, Digera arvensis, Parthenium hysterophorus and Celosia argentena were found dominant weeds.

The highest weed control efficiency (79.2%) was found in farmers practice followed by in-situ recycling of sunhemp at 30 DAS (68.2), quizalofop-ethyl 0.050 kg a. i. ha-1 PoE + Hoeing (66.2%) and pendimethalin 1.25 kg a. i.ha-1 PE + Hoeing (60.6) .Among weedicides Quizalofop-ethyl 0.050 kg a. i. ha-1 PoE + Hoeing recorded highest weed control efficiency at 30 DAS and at harvest. The highest weed index was recorded in unweeded control (33.37 %) and lowest in in-situ recycling of sunhemp at 30 DAS (4.41 %), Maximum plant height was recorded with farmers practice followed by in-situ recycling of sunhemp at 30 DAS, quizalofop-ethyl 0.050 kg a. i. ha-1 PoE + hoeing Significantly highest seed cotton yield (1308 kgha-1) was found in farmers practice followed by in-situ recycling of sunhemp at 30 DAS(1251kgha-1) , quizalofop-ethyl 0.050 kg a. i. ha-1 PoE + hoeing(1214 kgha-1).

Mitigation of Yield Losses in Cotton through Nitrogen Levels and Mulch under Salt Affected Area

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Gujarat has largest area of salt affected soils in India because of its geographical positions. Cotton is most important crop of the state and to understand the physiological basis of yield under salinity an experiment was conducted with G.Cot Hy. 8. The experiment comprised of nine treatment combinations of three levels of nitrogen (50, 100 and 150 kg/ha) and three mulches (black plastic, grass trash @5t/ha and no mulch) laid out in factorial randomized block design with four replications. Periodically dry weight, LAI, CGR, NAR and LAR was recorded and correlations with cotton yield were established.

Increasing values of these physiological parameters showed beneficial effect on total dry weight accumulation of the plant. The correlation matrix also indicates that leaf area and LAI was significantly correlated with Hybrid 8 yield under salinity. The highest leaf area and LAI was observed with 150 kg/ha nitrogen and black plastic mulch amongst all other nitrogen and mulch combinations. However, other physiological parameters viz. RGR, CGR, NAR and LAR were not significantly influenced by various treatments at different growth stages. The experimental results indicated that reduction in leaf area development due to salinity can be compensated by adjusting nitrogen levels and application of mulches which helped in higher cotton yield under salt affected soils.

Response of Different Plant Spacing and Fertilizer Levels on Seed Cotton Yield and Economics of Bt Cotton under Protective Irrigation

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A field experiment was conducted on Bt cotton hybrid NHH44 during kharif seasons of 2009, 2010 and 2011 at Cotton Research Scheme, Marathwada Krishi Vidhyapeeth (M.S.) Parbhani to find out the suitable plant spacing and fertilizer levels under protective irrigation. The pooled result revealed that, the spacing of 120 x 30 cm and 150X30 cm was found at par in producing highest seed cotton

yield over rest of the spacing. In case of fertilizer levels , 175:87.5:87.5 kg NPK ha-1 produced highest seed cotton yield which was at par with fertilizer level of 150:75:75 kg NPK ha-1 and 125:62.5:62.5 kg NPK ha-1 but significantly superior over fertilizer level of 100:50:50 kg NPK ha-1. The highest gross monetary returns, net monetary returns were recorded with the spacing 120 x 30 cm which was on par with 150X30 cm and fertilizer dose of 175:87.5:87.5 kg NPK ha-1 which was on par with fertilizer dose of 150:75:75 kg NPK ha-1 and 125:62.5:62.5 kg NPK ha-1 in pooled analysis.

Optimization of Nutrient Requirement and Plant Geometries for Some Bt. Cotton Hybrids

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Experiments were conducted for two years to assess optimum levels of fertilizers for sustainable cotton production with different plant densities. The Bt. cotton genotypes taken were Bunny, MRC-6301, GK -205 with two spacing and three nutrient levels in split plot design. The major available nutrient status of the experimental fields was 181 kg/ha of nitrogen, 13.1 kg/ha of phosphorus and 576 kg/ha of potassium. The two years mean data suggests no significant difference in yield in the hybrids. Closer spacing 60 cm x 60 cm gave significant higher mean yield of 1541 kg/ ha over 75 cm x 75 cm spacing (1475 kg/ha).

Increasing level of fertilizers from 100% RDF to 150% RDF showed significant increase in seed cotton yield. Comparing the economics and the B:C ratio suggested almost similar net returns from Bt. hybrids. However 60 cm x 60 cm spacing was more remunerative than 75 cm x 75 cm spacing. Regarding fertilizer levels 150% RDF was more economical (Rs. 40304/ha) compared to others where the returns were Rs. 34435/ha (100% RDF) and Rs. 37414/ha (125% RDF).

Preparatory Tillage and Sowing Pattern for Enhancing Productivity of Bt Cotton Under South Saurashtra Agro-Climatic Conditions

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A field experiment was conducted during 2010 and 2011 at Junagadh to study the response of Bt cotton (NHH-44) to three tillage practices (conventional tillage i.e. cross cultivation + blade harrowing + planking, ploughing + blade harrowing + planking, and tillage through rotavator) and four sowing patterns (flat bed sowing, furrow sowing, ridge sowing, and paired row sowing). The results revealed that ploughing + blade harrowing + planking significantly improved growth and yield attributes viz., plant height, number of bolls/plant, single boll weight and seed cotton weight/plant and thereby increased seed cotton yield (2363 kg/ha), stalk yield (6115 kg/ha), lint yield (783 kg/ha) and ginning (33.0%) over conventional tillage. Similarly, ridge sowing enhanced growth and yield parameters viz. plant height, number of bolls/plant, single boll weight and seed cotton weight/plant and ultimately increased seed cotton yield (2370 kg/ha), stalk yield (6102 kg/ha), lint yield (781 kg/ha) and ginning (32.9%) over flat bed sowing.

Effects of Potassium Application on Growth of Rain Fed Cotton Grown in Potassium Rich Black Cotton Soils of Guntur District

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Cotton is one of the important commercial crops grown under rain fed conditions in black cotton soils (Vertisols) of Guntur district. Average yields obtained were high in these areas as the crop survives well on residual soil moisture in these highly fertile soils. They are heavy in texture and generally high in available nutrients, especially potassium content. But the crop responds well to application of potassium due to different conditions existing in the soil. With a view to study the response of cotton to K application in soils of different available K levels, an experiment was conducted at RARS, Lam for two seasons during 2008-09 and 2010-2011

During 2008-09, surface soil samples (125no's) were collected from cotton

growing farmers fields (black cotton soils) covering the villages of Veniganda, Mothadaka,Amaravathi,Muttaya palem, Didugu, Malladi,Jupudi, Gundlapalem, Madduru, Jangamguntlapalen, Korrapadu, Perecherla, Kantepudi, Sattenapalli, Dhulipalla, Reddygudem, Dachepalli, Rujupalem, Boppudi, Chilakaluripeta, Degarlamudi, Martur, Ramachandrapuram, Edlapadu, Vankayalapadu, Boyapalem, Utukuru, Vipparla, Turagavaripalem, etc. The available potassium status was analyzed in these samples and based on that,25 bulk samples were collected having different K levels. They were grouped in to 5 categories namely G1.< 345kg/ha, G2. 346-500kg/ha G3.501-700kg/ha, G4.701-900kg/ha and G5. >900kg /ha. Pot culture experiment was taken up taking cotton as test crop with three levels of applied K i.e, 0,30,60 kg/ha.

The different forms of K were estimated in the initial soils. The mean water soluble K2O content increased from 33 to 175 kg/ha, the mean Exchangeable K2O increased from 228 to 903 kg/ha the mean available K2O content increased from 261 to 1078 kg/ha while the non exchangeable K2O increased the from 370 to 1146 kg/ha from group 1 to group 5. It indicated that all the forms were positively related and a linear relationship existed between them.

At seedling stage the dry matter production, nutrient composition and up take were also studied. The dry matter production increased from 3.56g/plant in G 1.(<345plan) to 8.628/plant inG5.With increase in available K2O,there was increase in dry matter production also. The content in plant also increased from 2.5% in group 1to 3.38% in group 5 indicating the same trend. In case of percent N & P contents, there was an increase up to Group3.(501-700 kg/ha) and later a decrease is noticed. The nutrient uptake (N,P&K) was also studied in seedlings which increased with increase in available K2O content in soil from group (1) to group(5).

Similar studies were done at flowering stage also. A continuous increase in dry matter from 8.18 to 13.2 g/plant and N content in plant from (1.92 to 2.30%) with in available K2O content from group (1) to group(5)is noticed .Similarly there was an increase in the uptake of N,P&K in whole plants with increase in available K2O content. Data on yield components like no. of bolls/plant, boll wt/plant, dry matter production at harvest, etc indicated the same trend.

To verify the above trend, during 2010-11, bulk soil samples were collected from twelve locations in the villages of Jaminivari palem, Iderpeta, Emmajigudem, Manne sultan palem , Bellamkonda and Lam. Initial K2O status in these soils was determined and were arranged in the order of increasing available K. Different K-fractions in the initial soils were also analyzed .Pot culture experiment was initiated with these soils with bunny bt. Application of K2O at two levels of 0 K and 60kg / ha was done. Plant samples at flowering were analysed for % P and K contents Which indicated a higher mean % P (0.525) and K (1.964) in K applied treatments than zero K treatment(0.458 and 1.86 respectively. Dry matter production and kappa's yield per plant at harvesting indicated increase with increase in initial available K2O and also with application of K. These results indicated that even though the soils are having high potassium content, application of potassium increased the growth, yield and K-uptake in cotton may be due to various soil factors like moisture, pH, exch.Na content etc, existing at that time.

Effect of Micronutrients on Seed Cotton Yield and Fibre Quality of American Cotton

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A field experiment was conducted at Cotton Research Station, CCS HAU, Sirsa for the three consecutive years i.e. kharif 2007, 2008 and 2009 to find out the response of foliar application of micronutrients viz., Zinc and Boron on seed cotton yield and fibre quality of American cotton (G. hirsutum L.). The experimental soil was sandy loam in texture having pH 8.1 and EC 0.27 dSM-1. The available N was low (74.0 kg/ha) and available P was in medium range (15.5 kg/ha) while available K was high (475 kg/ha). The organic carbon was also low (0.25%). The experiment consisted of three main treatments with four combinations of micronutrients (Zn & B) at various concentrations laid out in randomised block design with three replications. The seed cotton yield of Bt cotton (3148 kg/ha) was significantly higher than non-Bt. genotypes (2341 kg/ha & 25429 kg/ha). The seed cotton yield significantly increased with the spray of micronutrients as compared to water spray (control). The highest increase in seed cotton yield (9.6%) was recorded by a combination of both

micronutrients ($ZnSO_4$ spray @0.50% + B spray @0.24%). The no. of bolls/plant and boll weight (g) both increased significantly with the foliar application of both the micronutrients (Zn and B). The foliar spray of micronutrients (Zn and B) improved fibre quality like 2.5% span length and tenacity of all the genotypes; however the Uniformity Ratio (UR) and Micronaire Value (MV) were not affected by the micronutrients spray. Spray of Zn alone showed better improvement both in 2.5% span length and tenacity as compared to Boron alone or in combination of both.

Productivity and Economics of Cotton (*Gossypium hirsutum* L.) Based Intercropping System as Influenced by Fertilizer Management under Dry Farming Conditions of North Saurashtra Agro-Climatic Zone

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A field experiment was conducted at Main Dry Farming Research Station, Targhadia during kharif season of 2005-06 to 2010-11 to find out the optimum dose of fertilizer for cotton + sesame (1:1) intercropping system with additive series under dry farming conditions of North Saurashtra Agro-climatic Zone. The experiment laid out in factorial randomized block design with three replications comprised of 9 treatments, having three levels of fertilizer to cotton (50, 75 and 100 % of the recommended dose of 80- 00- 00 kg NPK/ha) and three levels of fertilizer application to sesame (0, 50 and 100 % of the recommended dose of 25- 12.5 -00 kg NPK/ha as per area basis). The results revealed that application of 100% recommended dose of fertilizer separately to both the component crops in cotton + sesame (1:1) intercropping system significantly increased the yields of both the crops over their lower dose of fertilizers and unfertilized control. Significantly higher seed cotton equivalent yield (1401 and 1474 kg/ha), maximum gross returns (Rs. 43018 and 45018/ha), net returns (Rs. 21384 and 21400/ha) and benefit cost ratio (2.01 and 2.11) were recorded with 100% recommended dose of fertilizer applied separately to cotton and sesame, respectively over their lower dose of fertilizers and unfertilized control.

Precision Application of Irrigation and Fertilizers to Bt Cotton (*G. hirsutum*) and Effect on Productivity and Input Use Efficiency in Vertisols of South Gujarat

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A field experiment was conducted during kharif 2008-09 to 2011-12 at Main Cotton Research Station, Surat under irrigated condition to develop suitable irrigation schedule and fertilizer requirement for Bt cotton in vertisols of South Gujarat. The experiment consisting of sixteen treatments comprised of four levels of irrigation scheduling based on evapotranspiration at 0.6, 0.8, 1.0 ETC through drip and control treatment (furrow irrigation at 0.8 IW/CPE with 60 mm depth) and sub plot with four levels of nitrogen 75, 100 and 125% RDN in 6 splits at 15 days interval through drip and soil application of RDN (240 kg N/ha) in 3 splits at an interval of 25-30 days. The experiment was laid out in split plot design with four replications.

Irrigation significantly affected number of bolls/plant, yield/plant and seed cotton yield/ha. Irrigation scheduling at 0.8 ETC recorded maximum number of bolls/plant (41.7) and seed cotton/plant (164.6 g), was at par with furrow irrigation treatment. Significantly highest seed cotton yield was recorded with or ETC treatment. As regarding WUE and WP, irrigation scheduling at 0.8 ETC was best followed by irrigation given by furrow method.

Levels of nitrogen had no significant effect on yield and yield attributes, however, 125% RDN through drip in six equal splits yielded maximum seed cotton (3312 kg/ha) compared to normal furrow irrigation and soil application of fertilizers.

Irrigation scheduling at 0.8 ETC recorded maximum net return of Rs. 151126/ha with BCR of 7.44. In case of fertilizer levels, 125% RDN recorded highest net return of Rs. 132818/ha but the highest BCR (6.33) was recorded with 75% RDN applied in six equal splits through drip system. Therefore, Irrigation scheduling at 0.8 ETC through drip system along with 75% RDN applied in six splits at 15 days interval recorded highest seed cotton yield (3644 kg/ha) and net return (Rs. 151260/ha) with BCR value of 7.40 and recommended for Bt cotton growing in vertisols of South Gujarat.

Effect of Depth of Tillage on Water Requirement of Bt Cotton Hybrid

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A field experiment was conducted during kharif 2008-09 to 2011-12 at Main Cotton Research Station, Surat under irrigated condition to study the effect of depths of tillage and levels of irrigation on yield and quality of cotton. The experiment consisted of nine treatments in which, main plot had three depths of tillage (normal tillage 7.5cm, tillage up to 15 cm and tillage up to 22.5 cm) and sub plot had three levels of irrigation (25 & 50 days after cessation (DAC) of rainfall (80 mm), 25 & 75 DAC of rainfall (60 mm) and 25, 50 and 75 DAC of rainfall (60mm)) and were evaluated in three replications. Cotton variety "RCH-2" was sown at 120-60 x 45 cm as paired row during all the years. The maximum seed cotton yield (3986 kg ha-1) was recorded under deep tillage i.e. tillage up to 22.5 cm depth during individual years as well as on pooled basis. In case of irrigation treatments, irrigation at 25, 50 and 75 days after cessation of rainfall recorded the highest seed cotton yield of 3504 kg ha-1. It can be concluded that in irrigated cotton tillage should be done up to the depth of 22.5 cm in summer with three irrigations each of 60 mm depth after cessation of rainfall at 25 days interval for obtaining higher seed cotton yield and net profit.

Performance of Bt Cotton Hybrid under Optimum Plant Geometry and Nutrient Requirement in South Gujarat Conditions

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Bt cotton hybrids have became popular among farmers and is presently cover about more than 90 per cent of the cotton acreage in the state. Apart from improvement in yield, Bt hybrids have also lowered the pest incidence and reduced environmental pollution, due to limited use of insecticides. The productivity of cotton can be improved by identifying high yielding genotypes coupled with suitable agronomic practices. Optimum plant stand and appropriate fertilization play crucial role in increasing the productivity of cotton. Therefore, with the

objective of to evaluate Bt and non Bt cotton hybrids under various plant geometry in different levels of nutrients, this experiment was planned. The experiment was conducted during kharif 2008-09 to 2010-11 at Main cotton Research Station, Surat and treatments comprised two varieties of cotton (Bt hybrid and non Bt hybrid), two levels of plant geometry (120 x 45 and 120 x 60 cm) and three levels of nitrogen (100, 125 and 150 % RDN). It was laid out in split plot design with three replications. Plant height, number of sympodial branches per plant and seed cotton weight as well as seed cotton yield were significantly higher under Bt hybrid as compared to non Bt hybrid variety. Significantly higher seed cotton was harvested in recommended plant geometry (120 x 45 cm). In case of nitrogen levels, number of bolls per plant and seed cotton yield was significantly more under higher level of nitrogen (150% RDN i.e. 360 kg/ha) during individual years as well as on pooled basis. Higher level of nitrogen increased seed cotton yield to the tune of 9% over recommended dose of nitrogen in cotton. There were no significant influence on fibre quality of cotton due to various treatments. The cultivation of Bt hybrid under south Gujarat condition, gave higher net return (Rs.136730/ha). Similarly, plant geometry of 120 x 45 cm gave higher net income (Rs.110095/ha), 150% RDN recorded the maximum net monetary returns of Rs.111381/ha.

Response of Bt Cotton to Integrated Nutrient Management in Relation to Climate Change

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Bt cotton is being extensively cultivated on large area in India. In Karnataka lot of area (5.5 lakh ha) is under Bt cotton cultivation and farmers are harnessing the benefits of its yield advantage with less investment. Bt cotton retaining high squares and bolls during its growth leads to imbalance in the source-sink relationship, which inturn require high nutrients during peak growth and flowering stage. Cold weather situation prevailing during winters, led to sudden fall in the temperature and imbalance in the uptake of nutrients which may led to lower productivity and profitability. In this context, present study on response of Bt cotton to integrated nutrient management in relation to climate change was undertaken in irrigated ecosystem at Agricultural Research Station, Siruguppa.

Development of GIS and GPS Based Spatial Cotton Fibre Quality Maps for Nagpur District of Maharashtra

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A comprehensive knowledge of the spatial cotton quality parameters is of fundamental importance to cotton traders and industry for efficient planning of their business. Cotton is being traded in the market based on its variety and grade. Spatial information related to cotton grown and its quality parameters is not easily available. Even if available, it is represented in tabular forms and it is difficult to interpret and visualize the variations and assess the availability of particular quality of cotton in the given district, region or state. Technologies like Geographic Information System (GIS) and GPS (Geographical Positioning System) are widely used as spatial analysis tools for generating spatial information. GIS is an effective and efficient means of data acquisition, data storage and retrieval, manipulation and analysis and output generation. It provides continuous surfaces from point data. Spatial distribution, classification and characterization of the region are possible with GIS. It helps to analyze trends over time, and spatially evaluate impacts caused by development.

Development of Spatial Fibre Quality Mapsin GIS: To circumvent this problem, an attempt was made to develop GIS and GPS based spatial fibrequality maps for cotton grown in Nagpur district and in the Vidharbha region of Maharashtra. Nagpur district has 14 Talukas but cotton is grown predominantly in only 8 Talukas. Seed cotton samples were collected from spatial locations by using GPS.Spatial database and spatial fibre quality maps were prepared for parameters such as 2.5% span length,uniformity ratio, fineness, strength, elongation, ginning percentage, short fibre index (SFI), degree of reflectance (Rd) and degree of yellowness (+b) were prepared in ARCGIS software. Spatial distribution, classification and characterization of the Nagpur district based on the fibre quality were carried out. Significant variation in fibre quality parameters among the different Talukas were observed in Nagpur district.

The features of the cotton grown in Nagpur district that was observed by looking at the maps were, staple of the cotton was found to be long and extra long, uniformity ratio was observed to be from average to excellent, fineness between very fine to average and the strength good to very good.

Table 1: Fibre quality of cotton as visualized form spatial maps

Fibre Quality Parameter	Classification	Range
2.5% span length (mm)	Extra-long	> 32.5
	Long	27.5-32.5
Uniformity Ratio (%)	Excellent	> 47
	Good	45-46
	Average	44-45
Fineness (mic)	Very Fine	< 3.0
	Fine	3.0-3.9
	Average	4.0-4.9
Strength (g/tex)	Very Good	> 26.1
	Good	23.1-26.0

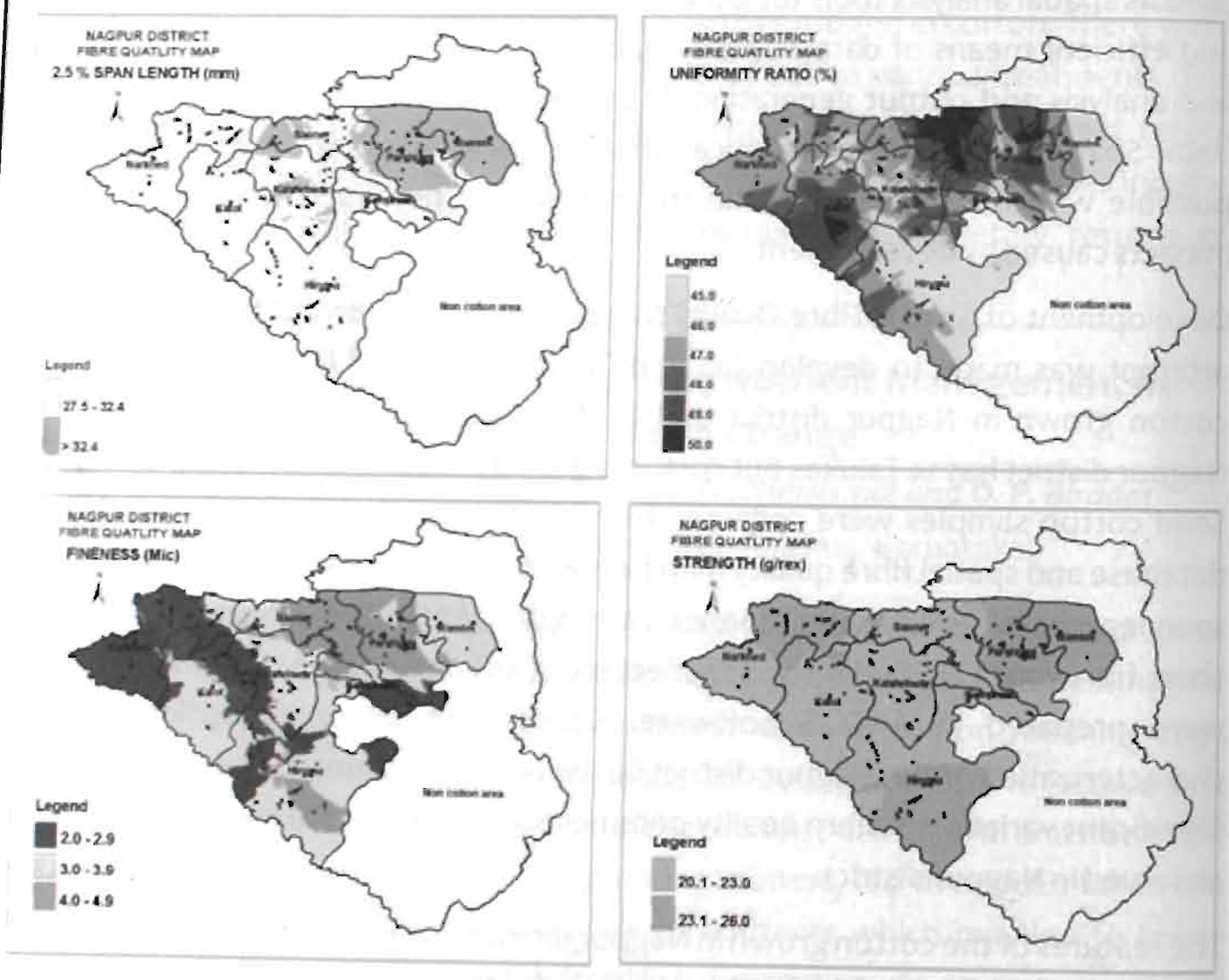

Fig. 1. Spatial map for fibre quality parameters

Correlation of Spatial Fibre Quality Maps with Soil Maps: The soil depth, soil texture and elevation maps of the Nagpur district were prepared in the GIS environment.Spatial fibre quality maps were correlated with the soil maps.Cottons produced in plains were found to have comparatively better staple and better fineness, and higher strength than those produced at higher elevations.

Table 2: Cotton fibre quality with respect to soil type

Soil type	Fibre Quality
Moderately deep to deep clayey	Extralong staple, average fineness, good strength and lower short fibre content.
Very shallow to shallow loamy	Long staple, fineness of fine category, with average strength and comparatively higher short fibre content.

Benefits of Spatial Fibre Quality Maps: It provides site specific information henceavailability of required quality cotton could be known by simply locating area of interest on the map. Visual interpretation of fibre quality information in the form of maps allows finding variations quickly.Highly useful to traders, ginners, researchers and industry for efficient planning and faster decision making process. It is a rapid and effective method of dissemination of location specific information related to fibre quality to the end users.

Bt Cotton Based Crop Diversification for Higher Productivity in the Changing Climatic Scenario of the Rainfed Vertisols

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Cotton crop, the King of fibers and said to be the white gold is mostly grown in Krishna zone of Andhra Pradesh under rainfed conditions in vertisols under rainfed condition where the annual rainfall is around 900mm. The cotton crop is generally raised from second fortnight of July to second fortnight of August after receiving 75mm to 100 mm rainfall in 7-10 days interval. Pulses are sown with the onset of south west monsoon i.e; from second fortnight of May to first fortnight of June. Hence, a period of 50-60 days is available before sowing of cotton which can be effectively utilized. There is a scope to promote Bt. cotton based crop diversification by identifying an innovative and remunerative double cropping system. Keeping this in view, a field experiment was conducted at Regional

agricultural Research Station, Lam, Guntur during kharif 2010-11 to provide a strategic plan to the farmers for changing climatic scenario with increased land use efficiency for sustained productivity, with some agronomic manipulation like raising Bt. cotton seedlings quite in advance for transplanting, introduction of cotton seeds in the standing pulse crop etc. with four treatments viz;T1- greengram + cotton (greengram was sown immediately with the onset of monsoon and sowing of cotton in the standing crop of greengram) T2- greengram - cotton (transplanting of one month old cotton seedlings after harvest of greengram) T3- greengram cotton (sowing of cotton after harvest of greengram) T4 sole cotton (check) were tested in randomized block design in six replications. The cotton variety Tulasi BGII and greengram variety LGG 460 were used for the study. The results revealed that significantly maximum yield of greengram (785 kg ha-1) was recorded in T3- greengram cotton system. The highest seed cotton yield was recorded in T4 sole cotton (1460 kg ha-1) and was on par with T1- greengram cotton system (1352 kg ha-1). However, the highest cotton equivalent yield (1809 kg ha-1), Benefit Cost Ratio (1.51) and production use efficiency (11.31 kg/ha/day and Rs.169/ha/day) were recorded in T1 greengram + cotton . Hence, this system of sowing greengram with the onset of monsoon and dibbling the cotton seed in the standing greengram crop is one of the profitable Bt cotton based cropping system in the rainfed vertisols.

Optimization of Nutrient Requirement and Plant Geometry for Bt Cotton

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A field experiment was conducted at Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri during the 2008-09, 2009-10 and 2010-11 to study the optimization of nutrient requirement and plant geometry for Bt cotton. The experiment was designed in split-split plot with three replication and twelve treatment combinations. The treatments consist of two main plot (H1-Bt hybrid, H2-NBt hybrid), two spacing as sub plot (S1-90x90 sq.cm., S2-90x115 sq.cm) and three fertilizer levels as sub sub plot treatment (F1-100:50:50 kg ha-1 NPK, F2-125:62.5:62.5 kg ha-1 NPK, F3-150:75:75 kg ha-1 NPK). The results revealed that Bt cotton

hybridRCH-2 recorded more seed cotton yield (34.34 q/ha), net monetary returns of Rs.59,983/- per ha. and B:C ratio 2.33. The spacing 90x90 cm recorded more seed cotton yield (31.81q/ha), net monetary returns of Rs.55,333/- per ha. and B:C ratio 2.23 and fertilizer dose of 125% and 150% RDF recorded more or less similar seed cotton yield (31.10 q/ha and 32.25 q/ha, respectively) and B:C ratio 2.23.

Response of Promising/ Newly Released Cotton Hybrids to Nitrogen and Phosphorus Levels

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A field experiment was conducted for three years (2008-09 to 2010-2011) during Kharif season at Agricultural Research Station, Sardarkrushinagar Dantiwada Agricultural University, Talod with treatment combinations of two cotton hybrids viz., GTHH-138 and G.Cot.Hy-12 as main plot treatments and combination of three levels of nitrogen viz., 120,160 and 200 kg. N/ha and two levels of phosphorus viz., 0 and 40 kg. P205/ha as sub-plot treatments in split plot fashion with three replications.

The production potential of GTHH - 138 was significantly higher than the newly released hybrid G. Cot. Hy. ~ 12 during 2009-10 and 2010-2011, where as such difference were found non-significant in 2008-09 as well as in pooled. Application of 200 kg. N/ha and 160 kg. N/ha gave significantly higher seed cotton yield than 120 kg. N/ha during 2008-09, 2009-10 as well as in pooled analysis. Application of 40kg.P205/ha failed to increase the seed cotton yield over no application of phosphorus during individual years as well as in pooled. Economics of this experiment indicated that maximum additional income of Rs. 12105/ha with net ICBR of 1:12.51 was obtained by application of 200 kg. N/ha.

Study the Response of Cotton G.Cot.Hy.10 to Different Levels of Phosphorus in Relation to Content and Uptake

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Experiment was conducted with four soil: sand ratios (1:0, 1:2, 1:4 and 1:6) and four levels of phosphorus (0.0 ppm, 2.5 ppm, 5.0 ppm and 10.0 ppm) at MCRS, Surat. Different soil: sand ratios and levels of phosphorus did not show any significant effect on phosphorus uptake by different cotton plant parts, except lint. Soil: sand ratios did not show any significant differences in phosphorus content in leaves at all growth stages and in petiole at flowering stage. Levels of phosphorus depicted significant differences in phosphorus content in leaves at various growth stages. Different soil: sand ratios and levels of phosphorus showed significant effect on seed cotton yield. The data revealed that levels of phosphorus caused significant variation in soil available P2O5 at harvest. Maximum available P2O5 was found with the application of 10 ppm P2O5

Biotic and Abiotic Stress Managements in Cotton under Rainfed Condition

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Cotton is one of the most important fiber crop and is the basic input to the textile industry. In India, it is grown in an area of 10 million ha. of which about 60 per cent area is rainfed. Crop production encounters various biotic and abiotic stresses particularly in the arid and semiarid regions. The micro and macro crop environments pave way for the natural formation of different situations and the quantum of deleterious and adverse stress factors become realistic in limiting yield realization in crops. The stress factors are likely to develop independently or in selective combination depending upon the magnitude and severity of the problem. For instance, in Central India, cotton has to respond to low light stress during early growth phase. Biotic stresses such as grey mildew, leaf spots, rusts, etc. in extended Bt cotton hybrids were also noted. Under such situations, they reduce net leaf area expressing cry toxin and may further inhibit the level of toxin

expression too, which makes the plant more vulnerable to attack by bollworms. Drought stress mostly commences during reproductive phase, whereas high temperature stress may co-develop under conditions of prolonged dry spell. In this context, plant physiological approaches in crop production assume importance to unravel the abiotic stress mechanisms and to identify explicit tolerance traits for countering the detrimental stress onslaught during ontogeny. Management of biotic and abiotic stresses Some adaptive measures- Development of short duration, compact plant types with high harvest index, resistant/tolerant to biotic and abiotic stress. Adoption of soil and water conservation measures, micro-level water shed based planning and development would increase crop production and the water table. Micro irrigation systems like drip and sprinkler to improve the water use efficiency of collected rainwater to be popularised. Emphasis should be on the development of cultivars tolerant to drought and biotic stresses. Popularisation of alternate pest management strategies and establishment of mass production centres of bioagents should be undertaken.

Salt Tolerant Cotton Accessions Suitable for Saline Vertisols

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The problems of environmental degradation in Gujarat state are as diverse and complex as the ecological fabric of the state. Soil salinity is one of the major environmental constraints in agricultural crop production. Salt affected soils occur to a tune of 6.73 M ha in India of which Gujarat, a Western Province accounts for 2.22 M ha i.e., 32 per cent of the country's total and thus needs a holistic approach for generating economically viable agro-management strategies. Vertisols due to their typical inherent physical and chemical properties like poor hydraulic conductivity, low infiltration rates, high clay content and narrow workable moisture range are the difficult ones to manage. Cotton, the most important fiber crop of India plays a dominant role in its agrarian and industrial economy. Cotton cultivated area in India is the highest in the world i.e., 20 % of the world area and employs seven million people for their living. In order to identify cotton lines which are salt tolerant and

high yielding, field experiments were conducted on Vertisols with subs-surface salinity with a total of 34 accessions comprising nine each of herbaceums, hirsutums and arboreums, seven Bt. Hybrids and two checks G.Cot Hy 8 and G.Cot Hy 12. Each plot has two rows of 3 m (with 12 dibbles/row) with four replications. Three saline water (differing EC) irrigations were applied. The soil samples at the final picking were analysed for root zone salinity. With increase in number of saline water irrigations, salinity in the root zone at the final harvesting stage increased from 4.2 to 11.8 dS/m. Soil salinity, plant tissue ion content and other morphological traits along with seed cotton yield were recorded. The data indicate three hirsutum accessions viz., GSHV 97/612, GJHV 358 and GJHV 374 yielded seed cotton in the range of 1.25 to 1.56 t/ha at 4.2 dS/m, 1.26 to 1.37 t/ha at 8.0 dS/m and 0.82 to 1.02 t/ha at 11.8 dS/m, in the same order. Among herbaceums, three accessions, GShv 297/07, GShv 378/05, GShv 451/08 and GBhv 290 gave seed cotton yields of 1.60, 1.21, 1.25 and 1.08 t/ha respectively at 4.2 dS/m. These lines, however, also yielded 1.12 to 1.4 t/ha at 11.8 dS/m indicating their superiority over hirsutums. Among Aroboreums, GBav 120, GBav 124 and AKKA BG I gave seed cotton yield ranging from 1.22 to 1.70 t/ha at 4.2 dS/m and 1.1 to 1.30 t/ha at 8 dS/m. However, at 11.8 dS/m salinity, the yields were declined by 50 percent. Among Bt hybrids, GK 205, PRCH 31 and VBCH 5050 (Cash) gave seed cotton yield of 0.78 to 0.83 t/ha respectively at 4.2 dS/m salinity. However, the seed cotton yield declined substantially at 11.8 dS/m (0.56 to 0.61 t/ha). While PRCH showed a steep decline in seed cotton yield at higher salinity, GK 205 showed a steady performance at higher salinity levels also. The study also indicted the accessions mentioned above gave higher seed yield than the checks at all salinity levels. While leaf sodium increased with increase in salinity, potassium content declined. Potassium content per se was found to be more in herbaceums and the remained less in other lines. Increased ion content in herbaceums enabled the lines in osmoregulation, better water uptake and thus growth and cotton yield. The studies thus indicated herabceums lines are better adapted to saline Vertisol conditions than hirsutums or Bt lines.

Line X Tester Analysis for Seed Cotton Yield and Fibre Quality Traits in *Gossypium hirsutum* L.

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The nature and magnitude of gene action were studies in L x T analysis comprising 3 lines and 10 testers for seed cotton yield and its quality traits. The magnitude of gca and sca variances revealed that pre-dominance of additive as well as non- additive gene action was important for inheritance of seed cotton yield and its quality parameters. The parents BC 68-2, Surat dwarf, GSHV- 112 and 76 IH-20 were found good general combiners for seed cotton yield and its quality traits. The hybrids, G. Cot. 20 x 76 IH-20, GSHV 155 x LRA 5166, GSHV 155 x GSHV 112 and GSHV 01/1338 x GISV 218 had significant sca effects for seed cotton yield and its quality trait. It is advocated that the good combiner genotypes could be used in crossing programme and the crosses having significant sca effects should be tested over the location and years before commercially exploitation.

હાર્દિક શુભેચ્છા સહ...

શ્રી યોગેશ્વરો વિજયતેતરામ

જીજ્ઞેશ પટેલ

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શ્રી

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-: ડીસ્ટ્રીબ્યુટર :-

ઘરડા કેમીકલ્સ, કેમીનોવા ઈન્ડિયા લી.,

બાયોસ્ટેડ (વોકહાર્ટ), વિમેક્ષ ક્રોપ., મેઘમણી, ઈન્ડેફીલ

બિયારણ, જંતુનાશક દવા તથા

નિંદામણ નાશક દવાના વિક્રેતા તથા માણસ તથા

મશીન સ્પ્રે દ્વારા દવા છાંટી આપવામાં આવશે.

૨૬, ગોલ્ડન પ્લાઝા કોમ્પલેક્ષ, કામરેજ પોલીસ

ચોકીની પાછળ,કામરેજ ચાર રસ્તા, જિ. સુરત.

PLANT PROTECTION (PP)

Espousal and Constraints in of IPM Technologies in Cotton Ecosystem of Tapi District

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IPM is such technology that lessens the cost of plant protection and augment the yield. It also helps in reducing the pesticide utilize and thus, prevents or delays expansion of pesticide resistance, reduces residues in soil, water, food and definite role in the prevention of environment imbalance. The study was conducted in Tapi district of South Gujarat. Majority of the respondents gained medium level of the overall knowledge and adopted cultural, mechanical and biological practices for pest control. Due to adoption of IPM in cotton, the data concerning comparison of economics between conventional and IPM technology indicates that the 63 % reduction in cost of plant protection in IPM as compared with conventional methods of pest control. Increase in yield was 51 per cent. Supplementary income from trap crops was Rs. 2150 per hectare. 56 per cent increase in income and 65 per cent in net profit with IPM technology was the final gain. Different constraint faced by cotton growers in adoption of Bio-control measures in cotton was also studied. The study acknowledges the knowledge level of the cotton growers towards IPM technology. This study can be guideline for other extension workers to implement this way of extension technology for their clients on IPM .On this foundation the extension personnel may locate clients for training and also those who can be used as counselors to other farmers. The study is also useful for effective propagation of the IPM technology in other regions for eco friendly and sustainable agricultural development.

Population Dynamics of Sucking Pest Complex on Bt and Non Bt Cotton Cultivars and their Relative Performance in Yield

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Field experiment was conducted during kharif 2005 at the experimental farm, Department of Genetics and Plant Breeding, Marathwada Agricultural University, Parbhani (Maharashtra) on well drained typical black cotton soil.

During kharif 2005 studies on effect of Bt cotton on incidence of sucking complex was carried under unprotected condition. Experiment was conducted with twenty three Bt and five non Bt, F1 and F2 cotton cultivars in Randomized block design with two replications and twenty eight treatments. The population of aphid, jassid, and whitefly was recorded per three leaves, on randomly selected five plants per plot at weekly interval. Among F1 population of aphid ranged from 8.37 to 20.00 and 8.07 to 18.46 on Bt and non Bt cotton cultivators respectively and among F2 it ranged from 7.46 to 18.00 and 11.80 to 18.96 on Bt and non Bt cultivars respectively. Population of whitefly ranged from 0.22 to 4.07 and 0.52 to 0.68 on Bt and non Bt F1 cotton cultivars. Among F2 population of whitefly ranged from 0.29 to 3.96 and 0.68 to 2.73 on Bt and non Bt cotton cultivars. Whereas, population of jassids on F1 cotton cultivars was in range of 1.40 to 1.76 and 1.31 to 1.60 on Bt and non Bt cotton cultivars respectively. Among F2 population of jassids ranged from 1.40 to 1.76 and 1.31 to 1.60 on Bt and non Bt cotton cultivars respectively. As there was no detrimental effect of Bt toxin on any of sucking pest, lower population of whiteflies on non Bt cotton may be due to hairy leaves. Among F1 seed cotton yield of Bt cotton cultivars ranged from 5.56 to 15.51 and that of non Bt cotton cultivars ranged from 5.31 to 12.00 q/ha. Among F2 seed cotton yield of Bt cotton cultivars ranged from 6.00 to 15.44 and that in non Bt cotton cultivars ranged from 5.30 to 12.00 q/ha.

Evaluation of Different Formulations against Sucking Pests of Cotton

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Field studies were conducted to evaluate the efficacy of bio-pesticides against insect-pests of cotton. The experiment was carried out at All India Coordinated Cotton Improvement Project, B.M. College of Agriculture, and Khandwa during Kharif season 2010-11 and 2011-12. The experiment was laid out in randomized block design (RBD) with three replications and twelve treatments and on varieties Bunny Bt. Row to row and plant to plant spacing was 90 X 60 cm. The results were revealed that there was no significant difference in pretreatment population of all the three sucking pests like whitefly jassid and aphid in both years. The minimum whiteflies after 1st, 2nd and 3rd spray was observed in Pest Guard J 50 EC 600 g/ha. Overall mean population of whitefly was 2.48 per three leaves in 2010-11 and 2.72 in 2011-12 .The minimum Jassids was observed after 1st, 2nd and 3rd spray during both the season in treatment Pest Guard J 50 EC 600 g/ha. Mean jassid population after three sprays during 2010-11 and 2011-12 was 2.54 per three leaves and 2.66 respectively. Similarly, minimum aphid population during 2010-11 and 2011-12 were observed in Pest Guard J 50 EC 600 g/ha. The overall mean population of aphids was 7.02 in 2010-11 and 7.14 per three leaves in 2011-12. Rest of the treatments were found more superior than untreated control plot.

Screening of Bt Cotton Hybrids against Major Insect Pests of Cotton

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Field studies were conducted to evaluate the Bt cotton hybrids against major insect pests of cotton. The experiment was laid out in the randomized block design with the nine entries comprising of Bt. and non-Bt. cotton varieties as the treatments and three replications. Significantly higher larval counts of spotted boll worm, Pink boll worm, American boll worm were recorded in Ajeet 11 (Non Bt) but there was no significant difference found in larval counts of spotted boll worm, Pink boll worm, American boll worm among the all Bt entries. Significantly greater open boll damage percentage was observed in Ajeet11(Non Bt) and among the Bt entries

least open boll damage was recorded in the entry Cash Bt which was at par with seven other Bt entries. Greater locule damage percentage was observed in Ajeet11(Non Bt) and least open boll damage was recorded in the entry Solar-60 Bt which was at par with seven other Bt. cotton varieties Ankur, Uttam Bt, Mallika Bt, Solar-60, Neena Bt., and Cash Bt. were found promising with least Jassid attack grades, where as the entries Dr.Brant and Ajeet -11 Bt recorded maximum Jassid population at various crop growth stages. Significantly lower population of Aphid was observed in Ajeet-11 non Bt Ankur ,Uttam Bt, Cash Bt, Mallika Bt. and Neena Bt whereas higher mean population was observed in the entry Dr.Brant and followed by Ajeet-11 Bt and Cash Bt. Significantly lower population of White fly was observed in Ajeet-11 non Bt entries Uttam Bt. Solar-60, Mallika Bt., Cash and Neena Bt were at par to it. Maximum mean population of White fly was observed in Ankur, followed by Dr.Brant. It was concluded that Non Bt. cotton varieties (Ajeet-11 (Non Bt)) had significantly less sucking pests infestation than Bt. cotton varieties (Dr.Brant and Ajeet -11 Bt).The highest seed cotton yield was realized in Mallika whereas Uttam, Neena, Cash, Ajeet-11, and Ankur. Were at par to it Minimum seed cotton yield was recorded in Ajeet-11(Non Bt.). Thus it was concluded that the Bt cotton hybrids performed well in terms of yield due to less pest infestation, particularly the boll worm. The nutrient uptake by the Bt cotton was higher than the non Bt cotton .Interestingly the attack of sucking pests was more in Bt cotton than non-Bt cotton.

Evaluation of Different Formulation against Bollworms of Cotton

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Field studies were conducted to evaluate the efficacy of bio-pesticides against insect-pests of cotton. The experiment was carried out at All India Coordinated Cotton Improvement Project, B.M. College of Agriculture, and Khandwa during Kharif season 2010-11 and 2011-12. The experiment was laid out in randomized block design (RBD) with three replications and twelve treatments with Bunny Bt. Minimum open boll damage was observed in Pest guard J 50 EC and it was at par with Pest guard L 50 EC and Fish Oil Rosin soap. It was followed by Vertcilliumlecanii, Pest guard O 50 EC, Bobstrate NBA II (Ll5), Ll, Fusarium pallidium Ma4 (NBA II), Neem oil 1%. and Mealyquit, Minimum locule damage was observed

in Pest guard J 50 EC and it was at par with Pest guard L 50 EC Fish Oil Rosin soap, Fusarium pallidium, LI and Ma 4 (NBA-II). Maximum seed cotton yield was recorded in Pest guard J 50 EC which was at par with seven other treatments. All the treatments were found superior than control. Similarly during 2011-12 The Minimum open boll damage was observed in Pest guard J 50 EC and it was at par with Pest guard L 50 EC, Pest guard O 50 EC, Fish Oil Rosin soap, Vertcillium lecanii, Mealyquit, Bobstrate NBA II (LI5),LI and Fusarium pallidium. Minimum locule damage was observed in Pest guard J 50 EC. Maximum seed cotton yield was recorded in Pest guard J 50 EC which was at par with Pest guard L 50 EC, Pest guard O 50 EC, Fish Oil Rosin soap, Bobstrate NBA II (LI5), Mealyqui. All the treatments were superior than the control.

Evaluation of Seed Treatment against Early Season Sucking Pests of Cotton

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Field studies were conducted to evaluate the efficacy of bio-pesticides against insect-pests of cotton. The experiment was carried out at All India Coordinated Cotton Improvement Project, B.M. College of Agriculture, and Khandwa during Kharif season 2010-11. The experiment was laid out in randomized block design (RBD) with three replications and nine seed dressing treatments on three varieties RCH-2 Bt, RCH-20 Bt. and DCH-32. The results revealed that minimum numbers of jassids/3 leaves was observed in RCH-2 Bt treated with Thiomethaxam and it was at par with five other treatments. Maximum number of jassids / 3 leaves was found in untreated DCH-32 non Bt. Minimum numbers of aphids/3 leaves was observed in Thiomethaxam treated RCH-2 Bt and it was at par with three other treatments. Maximum number of aphid / 3 leaves was found in untreated DCH-32. The minimum numbers of white fly /3 leaves was observed in Thiomethaxam treated RCH-2 Bt and it was at par with five other treatments. Maximum number of white fly/ 3 leaves was found in untreated DCH-32. Minimum numbers of thrips/3 leaves was observed in Thiomethaxam treated RCH-2 Bt and it was at par with five other treatments. Maximum number of thrips / 3 leaves was found in untreated DCH-32. Maximum number of natural enemies was observed in untreated DCH-32 and it was at par with three other treatments. Maximum seed cotton yield was recorded in Thiomethaxam treated RCH-2 Bt which was at par with four other treatments.

Bioefficacy of Organic Insecticides against Aphids *A. gossypii* on *Bt* Cotton

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Field experiments for evaluating bioefficacy of organic insecticides against aphids was conducted in two separate sets during late summer season on irrigated Bt cotton of 2007-08 and 2008-09 at the All India Coordinated Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri. The field bioefficacy of organic insecticides viz., spinosad, vertimec, Metarhizium anisopliae (Metchnikoff), Verticillium lecanii (Zimmermen), Beauveria bassiana (Balsamo), dashparni extract and neem oil were evaluated against A. gossypii on Bt cotton.

The means computed from 1-10 DAS against aphid indicated that the supremacy of spinosad (8.65) and vertimec (10.35) followed by neem oil (13.76) continued over rest of the treatments viz., M. anisopliae (16.94), V. lecanii (17.66), dashparni extract (17.98) and B. bassiana (18.89), which were stastiscally in similar range.

Population Dynamics of Sucking Pests, Bollworms and Predators in Cotton Variety G. Cot.-23 under Rainfed Condition at Bharuch

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Field experiments were carried out on G. herbaceum cotton variety G. Cot.-23 under rainfed condition during 2008-11. Observations on the population of sucking pests, bollworms and predators were recorded at weekly interval starting from one week after germination till end of crop season. The experiment plot was kept completely free from insecticidal spray.

Four major sucking pests, i.e. Aphis gossypii, Amrasca biguttula biguttula, Bemisia tabaci and Thrips tabaci were below threshold level (ETL) throughout period of occurrence. The pest reached to its peak i.e. 4.88 aphids, 2.02 jassids, 3.71

whiteflies and 1.49 thrips per 3 leaves during 1st week of December (49th SMW), 1st week of October (40th SMW), 1st week of December (49th SMW) and 4th week of September (39th SMW), respectively. Mealybug, Phenacoccus solenopsis was the only sucking pest that crossed threshold level (ETL), its incidence started from end of August (35th SMW) and continued throughout the crop season with its peak (3.33 average grade) during 2nd week of October (41st SMW) and November (45th SMW). The incidence of american bollworm, Helicoverpa armigera was below ETL throughout the season with its peak (0.21 larvae / plant) during 3rd week of October (42nd SMW). The tobacco caterpillar, Spodoptera litura was negligible throughout the crop season. The spotted bollworm, Earias spp. appeared from 1st week of September (36th SMW), crossed threshold level during mid of November (46th SMW) to mid of December (50th SMW) with its peak (2.03 larvae / plant) during early December (49th SMW). The populations of predators (Chrysoperla and Lady Bird Beetle) were started from mid of September (37th SMW) till end of crop season, however, its intensity was low.

Influence of Abiotic Factors on Population Dynamics of Pests in Transgenic Cotton Pests

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Studies was carried out to investigate population dynamics and the impact of abiotic factors on population dynamics of sucking pests, bollworms and predators of transgenic cotton cv. RCH-138 Bt under unprotected condition. The results of the field study revealed that the sucking pest population recorded throughout the year except in July and first fortnight of August month. The peak population of aphid, jassid, whitefly, thrips per three leaves and mealybug were 4.38, 4.39, 3.98, 1.53 and 4.00 average grade of mealy bug infestation in the 50th, 37th, 46th, 40th and 41st 42nd SMW (Standard Meteorological Week), respectively. Correlation analysis with weather parameters viz., temperature, RH, wind velocity, sunshine hours and rainfall revealed that maximum temperature showed significant positive effect on all the sucking pests. The minimum temperature showed negative effect on aphid population and not significant effect on whitefly and thrips population. The relative humidity had not significant effect, whereas precipitation had negative effect on all the sucking pests.

Field Survival of Pink Boll Worm on Bt and Non Bt Cotton

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Continued toxin exposure of any pest leads to loss of susceptibility over a period of time. In Gujarat, >90 per cent area is under Bt cotton cultivation and majority of the farmers are small holders and do not plant refugia crop Therefore monitoring of target pests is ideal to alert build up of resistance, if any. The incidence and damage of pink bollworm was recorded on two non Bt hybrids viz., DCH-32 (Bollworm susceptible) & popular non Bt hybrid, G. Cot. Hy. 10 and two Bt hybrids viz., Akka BG I and RCH-2 BG II in Kharif 2011-12 at Main Cotton Research Station, Surat. Pheromone trap installed at 90 DAS revealed that PBW moth activity initiated from 90 DAS and continued throughout the crop period being higher in the later season i.e., 48th to 3rd STW. Rosette flowers due to PBW were observed at 115 DAS in G. Cot. Hy.10, 130 DAS in DCH 32, 160 DAS in Akka BG I and 175 DAS in RCH 2 BG II. On non Bt, more or less similar number of rosette flowers by PBW was found along with the recovery of milky white larvae in initial periods and both milky white and pink larvae in later periods of observations. While in Bt, negligible rosette flowers (2 out of 150 totals) were found at 160 and 175 DAS with presence of small milky white larva in Akka BG I type and practically no rosette flower in RCH 2 BG II except at 175 DAS without any PBW larval recovery. Green boll, open boll and locule damage was more in both non Bt than BG I and BG II. Amongst Bt, 21 green bolls found damaged in BG I (145 to 175 DAS) as against 4 in BG II (175 DAS). Boll samples of each variety were collected / sent twice (145-150 DAS & 175-190 DAS) for resistance monitoring bioassay to cry toxins at CICR, Nagpur. Open boll and locule damage were more in Non Bt than Bt. Further; there was no larval recovery in any of the varieties. Field survival of pink bollworm on BG I revealed the possibility of resistance build up and farmers must have to resort appropriate resistance management strategies to sustain the BG I technology especially in the hot spot areas.

Insecticidal Selectivity towards Sucking Pests and Natural Enemies in Bt Cotton

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Standard insecticides registered and used in cotton ecosystem were tested for their selectivity against sucking pests and natural enemies in Bt cotton in Kharif 2011-12 at Main Cotton Research station, NAU, Surat. Nine treatments viz., Neem extracts (NSKE 5%), IGR (Buprofezin), neonicotinoides, conventional insecticides and untreated check were tested by applying at 7-10 days interval initiating from moderate pest infestations. Buprofezin 25 SC @ 312.5 g a.i. /ha, Acephate 75 SP @ 750 g a.i. /ha and NSKE 5 per cent were found effective in controlling Leaf Hopper. Acephate 75 SP @ 750 g a.i. /ha, Chlorpyriphos 20 EC @ 1000 g a.i. /ha, Phosalone 35 EC @ 700 g a.i./ha and Quinalphos 25 EC @ 500 g a.i. /ha were found effective against Aphid. The first two treatments viz., Acephate 75 SP and Chlorpyriphos 20 EC were also found effective against Thrips. Profenophos 50 EC, Chlorpyriphos 20 EC and Buprofezin 25 SC were found effective to Mealybug. NSKE 5 %, IGR-Buprofezin 25 SC @ 312.5 g a.i./ha and Acephate 75 SP @ 750 g a.i./ha found safer to LBB. In addition to the above, Phosalone 35 EC was found safer to Mealybug parasitoid, Aenasius bambawalei Hayat. These treatments recorded 5.29 to 6.35 per cent parasitism as against 11.26 mean per cent parasitism in untreated control and practically no parasitism in other chemical insecticides.

Impact of Bt Cotton on the Growth and Development of Larvae of Helicoverpa armigera (Hubner)

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Growth and development of Helicoverpa armigera (Hubner) was studied in transgenic cotton hybrid MECH-184 Bt and its conventional counterpart non-Bt MECH-184 in laboratory, using food material from field grown plants. Bt cotton leaves and squares when fed to the Helicoverpa larvae revealed profound effect leading to 90% mortality in second and fourth instar and 100% mortality in first and third instar. Bt cotton fed survived larva showed prolonged larval period, reduction in larval length, larval weight and pupal weight, but negligible effect on pupal period over larva fed on non-Bt cotton. Debilitating effect was more when larvae fed on Bt squares compared to Bt leaves.

Integrated Pest Management in Cotton A Boon to Tribal Farmers

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Cotton is one of the most important cotton crops of Narmada district. It is being cultivated in 40600 ha. (22700 ha as irrigated and 17900 ha rain-fed) which contribute to 37 % cultivated area of the district. The productivity of cotton is very low (510 kg in irrigated and 463 kg in un-irrigated conditions). The reason behind this is problem of insect pests especially sucking pasts mainly, jassids and mealy bugs. To over-come situation, application of Integrated Pest Management module is only the way. To disseminate the IPM technology, Front Line Demonstration is an effective tool through which farmers can learn their own by "Learning by doing seeing is believing". Krishi Vigyan Kendra, Dediapada, District: Narmada has demonstrated IPM module in cotton to 125 tribal farmers of seven operational villages of KVK in Dediapada block of Narmada district in 125 acres. The IPM module recommended by Main Cotton Research Station, NAU, Athwa Farm, Surat consisted of seed treatment, conservation of natural enemies through growing maize/sorghum, application of neem based pesticides at ETL, erecting bird perches, monitoring through pheromone traps etc. as major component was demonstrated. Before implementation of FLDs, knowledge level of farmers was worked out and to improve their knowledge level on identification of insect pests of cotton and their integrated management, trainings were given to farmers. Scientists of KVK made regular visits to demonstration plots and guidance was provided to farmers. As a result of demonstrations, farmers were able to effectively manage the insect pests with 42.86 per cent less sprays with 22.4 per cent higher yield. The average BC ratio of Integrated Pest Management Module was 2.7.

Decadal Analyses of Bt Cotton Hybrid on Yield and Fiber Quality in India

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Many farm level studies in past claim that cotton productivity has increased 30 to 40% and reduction in pesticide application and enhancement in the net farm income in India. Questions are raised about the overall contribution of Bt cotton to the enhanced productivity observed with the introduction of Bt Cotton. Detailed data analyses was done to quantify whether Bt cotton has really enhanced cotton productivity in India; was there any improvement in the cotton fiber quality parameter in Bt cotton compared to Non-Bt Cotton in last decade. Data for this study chiefly taken from the Bt Cotton evaluation trial conducted by All India Coordinated Cotton Improvement Project (AICCIP) which conducts multi-location trial across India since the year 2000 from private company seeds for GEAC for permission for commercial release of Bt cotton in India. A total of 1128 Bt cotton hybrids were given permission for commercial release from six events from the year 2002 to 2011 by GEAC.

Analysis of decadal data shows that there was seed cotton yield enhancement in the initial period of introduction of Bt cotton. But after the year 2005 the yield gap between Bt and Non-Bt was narrow downed. In North Zone there was not much yield gap between Bt and Non-Bt. Bt cotton was expected to protect cotton crop from bollworm damage. It was expected to reduce insecticide usage and enhance yields due to effective protection. The technology was highly successful in controlling bollworms and reducing pesticide usage. Yields doubled all over the country including all the eight districts of Vidarbha. But, the most significant contribution of Bt cotton is the reduction in insecticide usage. CICR conducted all-India surveys, including Vidarbha to study the impact. Results clearly showed that insecticide usage has come down and can further be reduced by streamlining the approval of hybrids based on their resistance to sap-sucking insects. Insecticide usage reduced by at least 50%. Prior to the year 2004, the area under Bt cotton was less than 5.0% and the average usage of insecticide for 10 preceding years was 1.22 Kg per hectare. The average insecticide usage during the last six years, 2005 to 2011 was only 0.6 Kg per hectare.

The analysis also highlights maize and wheat (Non-Bt crops) which are primarily the main rotation crops in most of the cotton growing states also performed well in Bt cotton era. Thus, it is possible that a few non-Bt technologies which influenced the growth rate in other crops may also have influenced the productivity enhancement in cotton, to support the Bt-technology. The remarkable increase of cotton production during Bt era was due to enhancement in area under cotton and due to higher price for the produce coupled with relatively conducive condition to grow cotton and not due to enhancement of cotton productivity. Regarding fiber quality aspect, average span length for Non-Bt cotton was higher compared to Bt Cotton in south zone both in irrigated as well as in rainfed trials. There was not much variation in span length in north Zone as well as in Central zone. There was inconsistency in staple length in central zone irrigated Bt trial and inconsistency in Non-Bt under rainfed trial. The strength of the fiber has not shown any appreciable fiber quality advantage for the past 10 years in both Bt as well as Non-Bt as required by many textile industries in all zones. The average micronaire value for Bt cotton was 4.62 compared to Non-Bt with the value of 4.50 in North Zone Irrigated trials. Micronaire value much higher in North Zone compared to South Zone as well as Central Zone irrigated and rainfed trial of both Bt and Non-Bt. The uniformity ratio of fibers among Bt as well as Non-Bt was not much variations irrespective of zones as well as agro-climatic conditions and the average uniformity ratio of many of the trials does not crossed more than 50%. After analyzing the fiber quality data of both Bt and Non-Bt, both rainfed and irrigated trial of Non-Bt cotton in South Zone trials has shown appreciable fiber quality properties compare to Bt cotton with respect to staple length, fiber strength and micronaire value.

Effectiveness of various Synthetic Insecticides against Sucking Insect Pests Infesting *Bt* Cotton

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An experiment was conducted under field condition at B. A. College of Agriculture, AAU, Anand during 2009-2010 to determine the bio-efficacy of different conventional synthetic insecticides against sucking insect pests infesting Bt cotton (RCH- 2 BG-II). The crop was sprayed thrice with respective insecticides at an interval of 20 days after initiation of sucking insect pest's population. The results revealed that dimethoate 0.03%, imidacloprid 0.08% and difenthiuron 0.05% were significantly superior than rest of the treatments and recorded lower number of aphids, Aphis gossypii (Glover). Thiamethoxam 0.0125%, carbosulfan 0.025% and fipronil 0.005% proved to be less effective insecticides against this pest. In case of leaf hopper population; thiamethoxam 0.0125%, imidacloprid 0.08 % and difenthiuron 0.05% recorded significantly lower population of leaf hopper, Amrasca biguttula biguttula (Ishida). Among different insecticidal treatments, fipronil 0.005% and carbosulfan 0.025% recorded significantly higher population and proved to be less effective in managing the leaf hopper population infesting Bt cotton. Imidacloprid 0.08%, acetamiprid 0.01% and difenthiuron 0.05% found significantly superior than rest of the insecticidal treatments and recorded lower population of whitefly, Bemisia tabaci (Gennadius). Carbosulfan and fipronil fail to provide the protection against this pest (white fly) and proved to be less effective chemicals. Considering the effectiveness of insecticides against thrips difenthiuron 0.05%, imidacloprid 0.08% and clothianidin 0.025% recorded significantly lower population (1.24 to 1.60/leaf) and found effective than rest of the insecticides against thrips, Thrips tabaci (Lindeman). Fipronil 0.005% and carbosulfan 0.025% treated plots recorded significantly higher population of thrips and proved to be less effective chemicals.

Screening of *Bt* Cotton Varieties for their Susceptibility to Whitefly and Mechanism of Resistance

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Bt cotton have been success in suppressing the infestation of bollworms. However, sucking pests viz; aphid, leaf hopper, whitefly and thrips continue to be controlled as earlier . Among these, whitefly, reported to be a major and cause severe damage in Bt cotton. Cultural practices such as use of resistant /tolerant varieties is a prime factor to minimize the damage due to insect pests and yield losses. The component can be used for devising the IPM strategies. The study was under taken to screen some BG II and their non-Bt (NBt) verities in comparison to G. Cot. Hy. 10 at Anand during 2008-09.There was significant difference among different Bt and NBt cotton varieties under the test. Vikram-5 Bt and G. Cot. Hy-10 recorded less than 1.48 whiteflies per leaf and found to be highly resistant (HR) whereas; Akka non Bt and Brahma non Bt categorized as resistant (R) and registered 1.48 to 2.33 whiteflies per leaf. Varieties Brahma BG-II and Akka BG-II proved to be susceptible (S) as it scored 2.33 to 3.18 whiteflies per leaf. RCH-2 BG-II and RCH-2 non Bt scored 3.18 to 4.03 whiteflies per leaf and found to be highly susceptible (HS) varieties. Significantly higher (2939.82 kg/ha) seed cotton yield was recorded from Vikram 5 Bt and was at par with Akka BG II (2662.04 kg/ha). Vikram 5 Bt and G.Cot. Hy. 10 found highly resistant (HR) to white fly. RCH 2 BG II and its NBt version proved to be highly susceptible (HS). Akka and Brahma NBt proved to be resistant (R) whereas Brahma, BG II and Akka BG II found susceptible (S) against white fly. Among various morphological characters, leaf length (r = 0.8992**), leaf lamina thickness (r = 0.7981**) and hair density (r = 0.9248**) showed highly significant negative while; plant height (r = 0.6764*) and leaf width (r = 0.6836*) showed significant negative correlation with the incidence of whitefly and played an important role in imparting the resistance.

Impact of various Synthetic Insecticides on Population of Natural Enemies in *Bt* Cotton

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American bollworm *(Helicoverpa armigera)*, a notorious pest of cotton could be managed with the adoption of Bt cotton. However, repeated applications of synthetic insecticides are required for the management of sucking insect pests viz, aphid, jassid, whitefly and thrips. As a result, population of natural enemies is adversely affected in Bt cotton ecosystem. In Bt cotton, spiders, coccinellids, Chrysoperla etc. were reported as potential predators feeding on sucking pests. In order to conserve natural enemies in cotton ecosystem, use of safe insecticides in pest management should be emphasized. Various synthetic insecticides applied on target pests also influence the non-target insects such as parasitoid and predators prevailing in natural ecosystem. Therefore, a study was carried out during 2009-2010 to see the impact of various synthetic insecticides on population of natural enemies in Bt cotton RCH 2 (BG II). Difenthiuron 0.05%, clothianidin 0.025 % and carbosulfan 0.025 % recorded significantly higher (2.19 to 1.52/plant) population and proved to be safer to spiders. As far as adverse impact of insecticidal treatments is concerned, thiamethoxam 0.0125%, imidacloprid 0.08%, fipronil 0.005% and thiacloprid 0.024% recorded lower spider population and proved to be less safe insecticides. In case of larval population of coccinellids, difenthiuron 0.05% and clothianidin 0.025% recorded significantly higher larval population of coccinellids than rest of the insecticides and proved to be safer group of insecticides. The plot treated with fipronil recorded significantly the lowest (1.09/plant) population and proved to be least safe insecticides to coccinellids. While, in case of adult population of coccinellids the plots treated with difenthiuron 0.05%, clothianidin 0.025%, dimethoate 0.03% and imidacloprid 0.08% proved to be safe insecticides. Fipronil 0.005%, thiamethoxam 0.0125%, thiacloprid 0.024% and carbosulfan 0.025% registered the lower adult population of coccinellids. Looking to the larval population of Chrysoperla carnea, the plots treated with difenthiuron 0.05 % and clothianidin 0.025 % proved to be safe insecticides while fipronil 0.005 %, thiamethoxam 0.0125 %, carbosulfan 0.025 % and imidacloprid 0.08% registered the lower (0.99 to 0.75/plant) larval population.

Evaluation of IPM Module for the Management of Sucking Insect Pests and its Impact on Major Natural Enemies in *Bt* Cotton

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Introduction of Bt cotton largely minimized the incidence of Helicoverpa armigera (Hubner) and other bollworms upto certain levels. However, the incidence and infestation of sucking insect pests still continued as it observed in non Bt and conventional hybrids. Farmers generally depend on the use of synthetic insecticides which create problems such as resurgence of pests, development of resistance in pests to insecticides, adverse effects on the natural enemies, and disturbed ecosystem etc. With a view to develop IPM module for the management of sucking insect pests, module consisting of one need based (5 aphid, leafhopper and whitefly /leaf), application of Beauveria bassiana (2 x 108 cfu/g) @ 4 g /litre of water followed by need base application of thiamethoxam 25 WG @ 0.01% (0.4 g / litre of water) and Need based (5 thrips /leaf) application of acephate 75 SP @ 0.075% (1 g/ litre of water) in comparison to non-IPM module (control) was studied consequtively for three years at AAU, Anand.

Cotton (RCH-2) crop (Bollgard II) was raised following recommended agronomical practices under Large Plot Sampling CRD desing. The IPM and Non-IPM (control) blocks were divided into 12 equal sectors. In each block, three plants were selected randomly for recording the observations. Weekly observations on population of sucking insect pests viz., aphid, jassid, whitefly and thrips were made on three leaves, each selected randomly from top, middle and bottom canopy of the plant., Chrysoperla carnea (grubs), coccinellids (grubs) and spiders population per plant etc was also recorded. In all one spray application of Beauveria bassiana followed by two need based spray applications of thiamethoxam 25 WG @ 0.01% and one need based (5 thrips/ leaf) application of acephate 75 SP @ 0.075% was required to keep the population of sucking insect pests below ETL during crop period.

Based on pooled data over three years, module IPM was found effective for the management of aphid, jassid, whitefly and thrips in Bt cotton (BG II) cultivated in middle Gujarat. No adverse effect of IPM module on natural enemies (spiders, Chrysoperla carnea and coccinellids) and also found cost effective (ICBR 1:19).

Bio-Efficacy of Buprofezin 70% DF against Sucking Insect Pests on Bt Cotton

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Buprofezin a novel insecticide is characterized by unique insect growth regulator properties and outstanding activity on all major homopteran sucking insect pests in cotton. It has novel mode of action that is probable chitin synthesis which especially important in moulting). The molecule buprofezin was evaluated against sucking pests infesting Bt cotton variety RCH-2 (BG-2) during 2010-11 and 2011-12. For the purpose, three plants were selected randomly and tagged in each replication. The population of sucking insect pest's viz., nymph and adult of leaf hopper (Amrasca biguttula biguttula Ishida) and adult of whitefly (Bemisia tabaci Gennadius) on three leaves each selected randomly from top, middle and bottom canopy of the selected plants was recorded. The observations were made at 7 and 15 days interval after each spray application. Bio-efficacy of buprofezin against mealy bug (Phenacoccus solenopsis Tinsley) was tested under the laboratory condition during 2011-12. For recording the observation, 25 cm twig of cotton infested with mealy bug brought in laboratory. Total numbers of mealy bugs were counted on twig before application of spray and 1, 3 and 5 days after spray.

The result revealed that efficacy of buprofezin against leaf hopper and whitefly was dose dependent. Buprofezin at higher dose (300 g a.i./ ha) was most effective and significantly superior to its two lower doses i.e. 250 and 200 g a.i./ha, imidacloprid @ 20 g a.i./ha and acephate @ 750 g a.i./ha. In case of mealy bug (P. solenopsis) buprofezin at higher doses (300 and 250 g a.i./ha) was significantly more effective than rest of treatments. Buprofezin @ 200 g a.i./ha was at par with imidacloprid and acephate.

Toxicity of Buprofezin 70% DF against Natural Enemies on Bt Cotton

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Investigations on evaluation of buprofezin, a novel insecticide for its impact against natural enemies in Bt cotton variety RCH-2 (BG-II) was carried out at Anand Agricultural University, Anand during 2010-11 and 2011-12. For the purpose, the observations on population of natural enemies were made on three plants selected randomly in each replication. The population counts on eggs of Chrysoperla carnea)Stephens(and nymphs + adults of coccinellids as well as spiders were made on whole plant before initiation of spray as well as 7 and 15 days after each spray.

The toxicity of different doses of buprofezin (200, 250 and 300 g a.i./ha) to natural enemies viz., Chrysoperla (larvae), coccinellids (adults) and spiders (adults) were dose dependent. However, there was no significant adverse impact of buprofezin at all the three doses i.e. 200, 250 and 300 g a.i./ha on the activity of natural enemies when compared with the population of natural enemies in control. Buprofezin 70% DF at all the doses found less toxic to the major natural enemies i.e. Chrysoperla, coccinellid beetles and spiders.

Bio-Efficacy of Newer Molecule Cyantraniliprole 10 OD against Bollworms in Cotton

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To check the efficacy of a new molecule cyantraniliprole against bollworms infesting of cotton (Hybrid-12), an experiment was conducted in two consequent Kharif seasons (2010-12) in Randomized Block Design with four replications. The bio-efficacy of cyantraniliprole was evaluated based on population of larvae on five randomly selected plants. The observations on number of healthy and damaged buds as well as bolls were also recorded from the selected plants at 7 and 14 days after each spray.

Pooled over periods, sprays and years results indicated that cyantraniliprole @ 105 and 90 g a.i./ha was found significantly superior than rest of the treatments in checking the larval population of H. armigera and S. litura on cotton. The data on bud and boll damage revealed that cyantraniliprole @ 105 and 90 g a.i./ha registered significantly lower bud damage. Cyantraniliprole @ 75 g a.i./ha, indoxacarb and endosulfan were equally effective in checking the bud as well as boll damage in cotton.

Impact of Cyantraniliprole 10 OD on Natural Enemies in Cotton Ecosystem

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Cotton is an important cash crop widely grown in Gujarat. Cyantraniliprole, class anthranilic diamide, has selectivity on ryanodine To see the impact of this new product on natural enemies of cotton (Hybrid-12), an experiment was conducted in two consequent Kharif season (2010-11 and 2011-12) at B. A. College of Agriculture, AAU, Anand in Randomized Block Design with four replications. To ascertain the impact of cyantraniliprole on natural enemies in the field condition, the observations on natural enemies were made on 5 plants selected randomly in each treatment. The population counts on larvae of Chrysoperla carnea (Stephens) were made on three terminal shoots selected randomly from all the sides of selected plants; while the population counts on adults of coccinellids and spiders were made on whole selected plants. The observations were made at 3, 7 and 15 days interval after each spray. The pooled data over periods, sprays and years revealed that the population of natural enemies (coccinellids, Chrysoperla and spiders) was higher in the plots treated with cyantraniliprole @ 45 g a.i./ha, the lower dose and found less toxic and was at par with rest of the doses of cyantraniliprole i.e. 60, 75 and 90 g a.i./ha. The plots treated with indoxacarb 75 g a.i./ha and endosulfan 0.07% recorded comparatively lower population of these natural enemies and proved comparatively higher toxic.

Cyantraniliprole 10 OD - A Newer Insecticide against Sucking Insect Pests of Cotton

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Cotton is an important cash crop widely grown in Gujarat. In world, total cotton production was recorded 345 lakh bales from the 121.91 lakh hectares of total cultivated area and 481 kg/ha productivity in 2011-12 (Anon., 2011). Recently Cyantraniliprole, the second active ingredient in the anthranilic diamide class and the first to control a cross-spectrum of sucking and chewing insect pests was tested for its efficacy against sucking insect pest complex of cotton (Hybrid-12), during 2010-12 at B. A. College of Agriculture, AAU, Anand in Randomized Block Design with four replications. The observations on population of sucking pests i.e. Aphid, Leaf hopper, Whitefly and Thrips were made on five randomly selected plants. Three leaves were selected randomly from top, middle and bottom canopy of the selected plants and population counts were made before first spray as well as 3, 7 and 15 days after each spray.

The pooled data over periods, sprays and years revealed that all the insecticidal treatments was found significantly superior to control. At higher doses, sucking insect pests (aphid, jassid, thrips and whitefly) population effectively managed in the plots treated with cyantraniliprole @ 105 g a.i./ha and it was at par with cyantraniliprole @ 90 g a.i./ha. Both these treatments were significantly superior to rest of the insecticides and also recorded higher yield. Cyantraniliprole @ 75, 60 g a.i./ha and endosulfan 0.07% treated plots found equally effective against sucking insect pests infesting cotton. Indoxacarb treated plots registered higher population of all sucking insect pests and was at par with cyantraniliprole @ 45 g a.i./ha.

Effect of Different Plant Spacing and Nitrogenous Fertilizer on Incidence of Aphid, Aphis gossypii Glover in Bt Cotton

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With wide adaptation of Bt cotton in Gujarat as well in the world, the number of sprays has gone down due to controll of bollworms. The Bt cotton hybrids do not control any of the sucking pests of cotton. The manipulation of spacing and use of nitrogenous fertilizers affects population of sucking pests. For the purpose, an experiment was carried out in a split plot design with three replications during Kharif 2011. Variety RCH-2 (BG II) was grown using recommended agronomical practices without application of insecticides. Population of aphid was made from the three randomly selected plants from each plot at weekly interval starting from one week after sowing. The highest (14.40 /leaf) population of aphid was recorded on Bt cotton raised at the narrow spacing i.e. 120 cm x 45 cm while lowest (5.20) in wider spaced crop. Closer spacing resulted in busy growth of crop that affects the penetration of light. In case of nitrogenous affects, the highest (15.32 /leaf) population of aphid was recorded on the Bt cotton fertilized with the highest dose i.e. 360 N kg /ha. On other hand, significantly the lowest (5.60) population of aphid was recorded in the crop grown with the lowest dose i.e. 180 kg/ha. Amongst different combinations, widest spacing 150 cm x 60 cm with 180 kg N/ha registered significantly the lowest (2.65/leaf) population. In nut shell, incidence of aphid can be minimized in Bt cotton (RCH 2 BG II), when seeded at the widest spacing 150 cm x 60 cm and fertilized with lower dose of nitrogen (180 kg /ha in split) followed by the same spacing with 240 N kg /ha and 150 cm x 45 cm spacing with 180 N kg /ha as well as 150 x 60 cm spacing fertilized with 300 N kg /ha.

Impact of Plant Spacing and Nitrogenous Fertilizers on the Incidence of Leaf Hopper, Amrasca biguttula biguttula Ishida in Bt Cotton

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Cotton plays a vital role in Indian economy by contributing 29.8 % of agricultural gross domestic production. Leaf hopper, Amrasca biguttula biguttula Ishida is major sucking insect pest and has the potential to reduce yield in the range of 15-80 per cent. The manipulation of sowing periods, spacing and use of nitrogenous fertilizers beyond the recommendations definitely affect population of the pests especially sucking pests. For evaluating such practices, the experiment was carried out in a split plot design with three replications on RCH-2 (BG II). Plot was kept free from any insecticidal spray. Four spacing's viz., 120 x 45; 120 x 60; 150 x 45; and 150 x 60 cm in combination with different fertilizer doses viz., 180, 240, 300 and 360 Kg N/ha were evaluated. Standard methodology was used to record observations on pests.

Effect of Plant Spacing and Nitrogenous Fertilizers on the Incidence of Thrips, *Thrips tabaci* Lindeman in Bt Cotton

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Among the different sucking insects attacking in cotton, Thrips tabaci Lindeman have potential to reduce cotton production due to the heavy levels of feeding injury which disrupt the hormonal balance of the plant. There is a significant role in the abundance of insect pests due to the various cultural practices. To see the impact of spacing and nitrogenous fertilizers on the incidence of thrips, an experiment was carried out on RCH-2 (BG II) in a split plot design with three replications during Kharif, 2011. Standard methodology was used to record observations on Thrips. Results revealed that Bt cotton raised at the wider spacing i.e. 150 x 60 cm2 recorded lowest (1.37 /leaf) incidence, while lowest spacing i.e. 120 x 45 cm2, highest (1.96 /leaf) population of thrips. In case of nitrogen effect, significantly highest (1.94/leaf) population of Thrips was recorded with highest dose i.e. 360 N kg/ha. and lowest (1.45 /leaf) population with lowest dose i.e. 180 N kg/ha. Amongst different combinations, widest spacing 150 cm x 60 cm with 180 kg N/ha registered significantly the lowest (1.22 /leaf) population of the pest.

Impact of Plant Spacing and Nitrogenous Fertilizers on the Incidence of Whitefly, Bemisia tabaci (Gennadius) in Bt Cotton

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Whitefly nymphs and adult are found in large numbers on the under surface of leaves and drain out the cell-sap, results in premature defoliation, development of sooty mould due to the excretion of honey dews. To see the impact of different spacing and doses of nitrogenous fertilizers, an experiment was carried out on RCH-2 (BG II) in split plot design with three replications during kharif, 2011. The observations on population of pest were made from the three randomly selected plants from each plot at weekly interval starting from one week after sowing. Results revealed that the highest population of whitefly was recorded in Bt cotton raised at narrow spacing 120 cm x 45 cm, while lowest (1.53) population at wider spacing i.e. 150 cm x 60 cm. As the dose of nitrogen increased, the population of pest also increased significantly highest (2.54 /leaf) population of whitefly was recorded with highest dose i.e. 360 N kg/ha. While lowest (1.24 /leaf) with lowest dose i.e. 180 N kg/ha. Amongst different combinations, spacing 150 cm x 60 cm with 180 kg N/ha registered significantly lowest (1.24 /leaf) population of whilefly.

Susceptibility of Different Varieties of Bt Cotton to Leaf Hopper, Amrasca biguttula biguttula Ishida

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Cotton, popularly known as "white gold" of India is most important commercial cash crop being grown world-wide. Among the different sucking insect pests, leaf hopper, Amrasca biguttula biguttula Ishida is a serious pest and sucks the cell sap from the lower surface of the leaves. Use of resistant / tolerant varieties is an important tool in the pest management. With a view to keep in mind, ten Bt cotton varieties were screened for their relative susceptibility under pesticide free field conditions during Kharif 2010-11. The observations on number of leaf hopper were recorded at weekly interval starting from 45 days after germination. The order of varieties for their susceptibility to leaf hopper based on number per leaf was;

SSCH 333 (2.85) < SRCH 99 (3.15) < PRCH 746 (3.30) < MRC 7017 (4.08) < PCH 404 (4.47) < KCH 172 (4.93) < DPC 7048 (5.16) < NCS 863 (6.63) < RCH 2 (6.84) < PCH 2270 (9.36). SRCH 333 recorded less than 3.05 leaf hopper per leaf and proved to be highly resistant (HS). While, SRCH 99, PRCH 746, MRC 7017, PCH 404 and KCH 172 were found resistant (R). Varieties DPC 7048, NCS 863 and RCH 2 proved to be susceptible (S). Variety PCH 2270 scored more than 9.36 leaf hoppers per leaf and registered as highly susceptible (HS). Among the morphological characters, plant height (r = 0.985**), leaf area (r = 0.782**), leaf length (r = 0.964**), leaf lamina thickness (r = 0.907**) and hair density (r = 0.911**) showed highly significant negative association with infestation of leaf hopper in Bt cotton.

Susceptibility of Bt Cotton Varieties to Whitefly, Bemisia tabaci (Gennadius)

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Host plant resistance is a key tool for the management of insect pests under Integrated Pest Management (IPM) programme. Ten different Bt (all BG II) cotton varieties were screened for their relative susceptibility to whitefly under field conditions during Kharif 2010-11. The experiment was grown after following standard agronomical practices in Randomized Block Design with three replications. The observations on number of whitefly (adult) were recorded at weekly interval starting from 45 days after germination. Various morphological characters were also recorded to see any relationship with the incidence of the pest. Variety SRCH 99 recorded the lowest (1.84 per leaf) population and proved significantly superior to rest of the varieties The chronological order revealed the mean population of the pest (given in bracket) which was; SRCH 99 (2.89) < SSCH 333 (4.21) < PRCH 746 (4.43) < MRC 7017 (4.74) < KCH 172 (5.55) < DPC 7048 (5.95) < NCS 863 (6.16) < PCH 404 (7.45) <RCH 2 (7.79) < PCH 2270 (9.30). The Bt cotton varieties having lower plant height, leaf area and leaf length might be harbouring higher population of whitefly. Thick leaf lamina might be impervious to nymph and adult whitefly to suck cell sap. In case of hair density on leaf, variety having higher density might be interrupting in the activity of this pest. Of the ten Bt cotton

varieties screened for their susceptibility against whitefly; SRCH 99 was found highly resistant (HR); While, SSCH 333, PRCH 746, MRC 7017 and KCH 172 found resistance wherein, number of leaves contributed a major role in mechanisms of resistance. Plant height (r= -0.874**), leaf length (r= V), leaf lamina thickness (r= -0.826**), leaf area (r= -0.698*) and hair density (r= -0.912**) were emerged out as important morphometric characters for imparting resistance to whitefly in Bt cotton.

Life Table Studies of Helicoverpa armigera (Hübner) Hardwick on Bt and Non-Bt Cotton

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Life fecundity tables of Helicoverpa armigera (Hübner) Hardwick constructed on squares/ bolls of Bt (Brahma BG, Brahma BG II, VICH-5 BG and VICH-5 BG II) and its non-Bt counterparts. Results revealed that in non-Bt cotton, the net reproductive rate (Ro) was 432.89, the finite rate of increase (X) was 1.164 females per female per day, the mean generation time (T) was 43.82 days and intrinsic rate of natural increase (rm) was 0.1384. In Bt cotton, the net reproductive rate did not work out due to malformed adults emerged out from pupae. Life table studies showed that only 8 out of 100 larvae could manage to survive up to last instar and the adult emergence was restricted to nearly 5% in Bt cotton.

Implementation of Insecticide Resistance Management (IRM) Programme on Bt Cotton under Bharuch District of South Gujarat

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IRM strategies for Bt cotton were developed / refined and successfully validated in Bharuch district during 2009-10 to 2011-12and still continue. More emphasis was given for IRM strategies of Bt cotton highlighting the importance of refugia, biodiversity maintenance through ecofeast crops and using non harmful biopesticides (neem oil, plant and microbial products), avoiding application of highly toxic pesticides and preventing repeated sprays and spraying at ETL. Conventional products (Quinalphos, Endosulfan, Chlorpyriphos and Cypermethrin) are still effective against bollworms and development of resistance is checked /delayed by implementing IRM strategies in population sampled from project villages.

The project had been implemented in 36 villages covering 3157 ha area and 1626 beneficiaries till from 2009-10 to 2011-12. Amongst sucking pests, Jassids emerged as limiting factor and farmers had to resort 2-3 additional sprays against Jassids. Medium to high infestation of newly emerged pest Mealy bug was noticed in 2009-10 and strategies to combat the menance have been formulated and disseminated. Population of natural enemies especially Coccinelids, Chrysoperla and Spiders was higher in IRM plots (both in Bt and non-Bt) than non IRM plots. Mealy bug menace was also checked to a greater extent by natural parasitism by Aenasius bambawalei Hayat in majority of IRM project villages. Overall bollworms damage percentage in the district was negligible in IRM plots (3.22 and 6.99 per cent in Bt and non-Bt, respectively) than non IRM plots (14.43 per cent). On an average, 6.45 sprays were applied in IRM plots as against 8.45 sprays in non IRM plots. Mean yield obtained by project farmers across years was 21.62 q / ha in the IRM participating villages compared to 19.52 q / ha in the non-participating villages. This was 9.71 per cent higher than non IRM. The net profit obtained by participating farmers due to increase in yield in the project villages was Rs. 10868 / ha. The reduction in insecticide usage is estimated to have benefited farmers to extent of savings of Rs. 1800 / ha. The benefit of programme implementation is estimated to have contributed about Rs 3.99 crores (due to yield increase and saving in insecticide cost in 3157 ha area) in the three years.

Population Build Up of Major Sucking Pests on Rainfed Cotton

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Population buildup of major sap sucking pests i.e. aphids, jassids, thrips and whiteflies, on rainfed cotton var. LRA 5166 was studied at Cotton Research Unit, Dr. P.D.K.V.,Akola during 2005-06 to 2009-10. It was observed that the incidence of aphids started from last week of July every year and two peaks were noticed during the crop season, first in the month of August and 2nd at the end of season during December-January. The incidence of jassids and thrips started from 1st fortnight of August (31 MW and 32 MW) and jassids reached at its peaks during 32 to 41 MW (6 August to 14 October) while thrips at 34 to 38 MW (20 August to 23 September). The white fly population was noticed at low level throughout the crop season during all the five years. From these peak periods of aphids, jassids and thrips, it could be advised to the farmers that they should be watchful for the management of aphids from 1st to 3rd week of August and at the end of season during December- January. For jassids and thrips they should be watchful from 2nd fortnight of August to 1st fortnight of October.

Field Evaluation of Cotton Genotypes against Sucking Pests under Irrigated and Rainfed Conditions

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Cotton is an important renewable natural fibre crop cultivated in tropical and subtropical regions of the world. Damage due to various pests is one of the important reasons for low yield. Cotton crop suffers heavy yield losses due to attack from sucking pests. A field experiment was conducted at Cotton Research Area CCS Haryana Agricultural University, Hisar during kharif 2012-2013 to evaluate the performance of seventeen promising genotypes against sucking pests under irrigated and rainfed conditions. The observations were recorded on population of sucking pests like whitefly (Bemisia tabaci, Gennadius), thrips (Thrip tabaci Lindeman) and leafhopper (Amrasca biguttula biguttula Ishida). The results revealed that the population of whitefly was found maximum on all the

genotypes grown under irrigated condition except in genotype H 1454 and H 1098-i. The incidence of thrips was higher on all the genotypes grown under rainfed conditions compared to those genotypes grown under irrigated condition. Leafhopper population was found comparatively higher on all the genotypes grown under irrigated condition except the genotype H 1467 and genotype H 1435. The leafhopper population was found almost at par on the genotypes H 1469, H 1468 and H 1098-i under both the conditions.

These results revealed that the incidence of whitefly and leafhopper was found higher on the genotypes grown under irrigated condition while the incidence of thrips was found higher under rainfed condition on all the cotton genotypes.

Efficacy of Triazoles in Management of Grey Mildew Disease in Cotton

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Grey mildew is one of the major foliar disease causing 5-20% yield loss in cotton. A field experiment was conducted during kharif 2011 at Agricultural Research Station, Dharwad Farm under rainfed conditions to know the efficacy of fungicides and bioagents in control of the of grey mildew (Ramularia areola) of cotton. The lower grey mildew (15.56 PDI) and maximum yield of 1880.02 kg/ha was recorded in Difenoconazole treatment followed by Hexaconazole (16.86 PDI and yield of 1809.58 kg/ha) and Carbendazim (17.40 PDI and yield of 1758.11 kg/ha). Results showed that Difenoconazole, Hexaconazole and Carbendazim showed better control of grey mildew over the Tridemifon, Propineb. Based on B:C ratio, finally showed that of Hexaconazole (0.1%) controlled the grey mildew disease effectively with maximum returns and better cost benefits.

Major Foliar Fungal Diseases of Bt Cotton and their Management-A Review

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Cotton is an important crop for the sustainable economy of India and livelihood of the Indian farming community. Cotton, "The White Gold" enjoys a pre-eminent status among all cash crops in the country. It is cultivated over an area of about 10.0 million hectares representing approximately one quarter of the global area of 35 million hectares under this crop. After China, India is the largest producer and consumer of cotton, the country. Much of this success owes itself to the introduction of Bt cotton in 2002, prior to which cotton production suffered huge losses due to its susceptibility to insect pests (CICR, 2009). However, the production potential of the crop has not been fully exploited due to several biotic and abiotic factors. Bt cotton is usually cultivated with intensive agronomic practices in Gujarat. Continuous rain and moist condition, injudicious use of nitrogen fertilizer and irrigation create most favorable condition for fungal foliar diseases viz., Alternaria leaf spots, Myrothecium leaf spots, Ramularia grey mildew, Helminthosporium leaf spots and Cercospora leaf spots. Loss due to alternaria leaf spot (26.6%), grey mildew(29.2%) and Myrothecium leaf spot (29.1%) have been reported. Among the fungal diseases grey mildew and alternaria spot are the predominant ones causing economic loss to the cotton crop in the country. These fungal diseases are effectively control by timely spraying of recommended fungicides. Alternaria, Helminthosporium, Cercospora leaf spots and Ramularia grey mildew are effectively control, five sprays of propiconazole (0.1%) at 35, 50, 65, 80, and 95 DAS. The fungicide captan + hexaconazole (Taqat @500g/ha) or Tetraconazole 11.6 % w/w 900 ml/ha or Kresoxim methyl (Ergon 44.3%at 500ml/ha) were effective control of fungal foliar leaf spots and grey mildew disease.

Effect of Different Fungicides and their Concentrations on Mean Radial Growth, Dry Weight of Mycelial Mat and Conidial Spore Germination of Myrothecium roridum Tode Ex. Fr.

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In vitro screening of various fungicides against Myrothecium roridum Tode. was studied (Poisoned food technique, Mycelial mat technique and Spore germination) The test fungicide i.e. Insignia, Propaconazol, Mancozeb, Thiophenate methyl and Carbendazim were incorporated aseptically in sterilized potato dextrose agar medium in a quantity to arrive at a final concentrations of 1000, 500, 250, 100 and 50 ppm. On basis of radial growth, dry wet of mycelium and per cent spore germination clearly indicate that all the five fungicides are potential indicates to be used for the control of M. roridum.. Minimum mean radial growth (8.00mm) was recorded in Thiophonate methyl followed by Carbendazim (13.07 mm), Propocinazole (13.53mm), Insignia (15.73mm) and Mancozeb (22.13mm) respectively. The mean dry weight of mycelial mat in different chemicals varied from 1.31 mg to 1.63 mg against 2.41 mg in control. The minimum mean dry weight of mycelial mat (1.31 mg) was recorded in Thiophonate methyl followed by Carbendazim (1.54mg), Propocinazole (1.65mg),) Mancozeb (1.63mg) and Insignia (1.74mg) respectively.The mean conidial germination in different fungicides varied from 4.40 to 26.93 % as against 86.67 % in control. The minimum conidial germination was recorded in Thiphonate methyl (4.40 %) followed by Carbendazim (6.87%), Propiconazole (7.60%), Mancozeb (20.27 %) and Insignia (26.93 %). The mean conidial germination (4.40 % to 20.93 %) was significantly low as compared to control.

in vitro Efficacy of Cow Urine Distillate against Myrothecium roridum Tode Ex. Fr. Causal Agent of Myrothecium Leaf Spot of Cotton

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Indian farmers are using cow urine and its products in their field for a long period as a traditional method. The use of non chemical methods for disease and pest management cow urine is one of the main component and play important roles in organic cotton production. Myrothecium leaf spot of cotton caused by Myrothecium roridum Tode ex. Fr. has been appearing in significant proportions in all the pockets almost every year during the last decade. It is a key factor for instability and low yields mainly in Malwa and Nimar region of Madhya Pradesh. Keeping in view organic cotton production for the management of this disease, a study on effect of cow urine distillate a substitute of fungicides against Myrothecium roridum is required. In-vitro bioassay study was conducted to screening of different concentration of cow urine distillates against Myrothecium roridum Tode ex Fr. by Poisoned food technique. Five concentration of cow urine distillate viz., 1%, 2%, 5%, 10% and 20 % were evaluated. The minimum mean radial growth (9.50 mm) was recorded in cow urine distillate @ 20% followed by cow urine distillate @ 10% (24.26 mm), cow urine distillate @ 5% (43.53mm), and the maximum radial growth was recorded in check (73.63 mm). Among five concentration tested cow urine distillate @ 20% was found most effective followed by cow urine distillate @ 10% and cow urine distillate @ 5% in inhibit of radial growth and sporodochia formation of Myrothecium roridum.

Management of Foliar Diseases in Cotton through Biological Control Agent

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Cotton is an important commercial cash crop of India. Seed cotton yield are affected by number of biotic and a biotic factors. Effort has been made to control the foliar disease of cotton, increase yield without adverse side effects on the people and the environment. A field experiment was carried out to know the effect of frequent sprays of biological agent Pseudomonas fluorescens against foliar disease alternaria leaf spot, bacterial leaf blight and grey mildew of cotton at Regional Cotton Research Station Junagadh during 2006-07, 2007-08 and 2008-09. Result reveled that, all the bio agents tested frequent sprays treatment significantly reduced foliar disease of cotton as compared to untreated control under field condition. The mean minimum of 8.28 % alternaria leaf spot, 5.86 % bacterial leaf blight and 2.06 % grey mildew disease with maximum seed cotton yield of 1379 kg/ha was recorded in seed treatment with Pseudomonas fluorecens Pf-1 @ 10 g/kg seed + foliar spray @ 0.2 % on 30, 50, 70 and 90 Days after sowing (DAS), followed by seed treatment with Pseudomonas fluorecens Pf-1 @ 10 g/kg seed + foliar spray @ 0.2 % on 30, 40, 50, 60, 70, 80 and 90 DAS and seed treatment with Pseudomonas fluorecens Pf-1 @ 10 g/Kg Seed + foliar spray @ 0.2 % on 30, 60 and 90 DAS with 1357 and 1294 kg/ha seed cotton yield, respectively. Highest B:C ratio of 6.71 also was obtained in same treatment i.e. seed treatment with Pseudomonas fluorecens Pf-1 @ 10 g/Kg Seed + foliar spray @ 0.2 % on 30, 50, 70 and 90 DAS.

Management of Alternaria Leaf Spot of Cotton through Different Fungicides

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Cotton is an important commercial cash crop of Gujarat. Among different foliar diseases of cotton alternaria leaf spot cause by Alternaria macrospora Zimm is the most serious diseases. A field experiment was carried out to know the effect of different fungicide against alternaria leaf spot disease on seed cotton yield at cotton research station, Junagadh agricultural university, Junagadh during 2010-11 and 2011-12. Results revealed that two sprays of tetraconazole 0.037 % at 15 days interval, starting after appearance of disease are significantaly minimizing (13.84%) alternaria leaf spot disease and gave maximum (1557 kg/ha) seed cotton yield; followed by treatment tetraconazole 0.015, tetraconazole 0.021, tetraconazole 0.0185 and carbendazim 0.05 per cent. While the highest cost benefit ratio (16.19) with net return rs. 15950 was recorded in treatment carbendazim 50 % 250 g/ha.

Bioefficacy of Kresoxim Methyl against Alternaria Leaf Spot Disease on Seed Cotton Yield

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Cotton is an important commercial cash crop of India. It plays a key role in national economy in terms of activities, employment and foreign exchange earnings. Among the different foliar diseases Alternaria macrospora Zimm, is the most serious diseases which occurs more or less in all the cotton growing countries of the world and affects yield and fiber quality. A field experiment was carried out to know the bioeficacy of kresoxim methyl against alternaria leaf spot disease on seed cotton yield at Cotton Research Station, Junagadh Agricultural University, Junagadh during 2010-11 and 2011-12. Results reveled that kresoxim methyl 2000 ml/ha recorded significantly minimum of 10.67 per cent alternaria leaf spot disease. The significantly highest seed cotton yield of 1546 was recorded in higher level i.e. Kresoxim methyl 2000 ml/ha followed by Kresoxim methyl at 1000, 500 and 400 ml /ha.

Evaluation of Fungicides against Alternaria Leaf Blight of Cotton

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Cotton is an important commercial crop affected by a number of foliar diseases throughout the season. Fungal leaf spots are caused by Alternaria, Helminthosporium, Cercospora, Myrothecium species in cotton. Alternaria leaf spot/blight is a major disease causing losses upto the tune of 26.6% (Monga et al 2012). In view of the importance of the disease, a field experiment was conducted at Regional Agricultural Research Station, Lam, Guntur during three consecutive kharif seasons to evaluate different fungicides against Alternaria blight of cotton using susceptible variety, L 604. Fourteen treatments viz., Cyperconzole 0.025%; Hexaconzole 0.05%; Propiconazole 0.05%; Tridemorph 0.1%; Chlorothalonil 0.2%; Copper oxy chloride 0.3%; Wettable Sulphur 0.3%; Tebuconazole 0.1%; Tebuconazole 0.15%; Kitazin 0.1%; Carbendazim 0.1%; Mancozeb 0.25%; Captan 0.2% and Control, replicated thrice, were imposed in Randomized Block Design. Three foliar sprays, at 15days interval, were given starting from the first appearance of the disease. Data on disease intensity of Alternaria leaf blight and seed cotton yield was recorded.

Results revealed that Tebuconazole 0.15% resulted in maximum disease reduction of 30.96% followed by Tebuconazole 0.1% (25.75%) (Fig.1). Maximum increase in yield of 33.49% resulted with Tebuconazole 0.15% followed by 24.86% (Copper oxy chloride 0.3%). Efficacy of Propineb 0.28%, Copper oxychloride (0.125%) and Mancozeb (0.15%) against Alternaria leaf spot was recorded while combination of Captan + Hexconazole (Taqat 0.1%) and Propiconazole 0.1% significantly increased the yield to the tune of 22.6% during independent experiments at RARS, Lam. Similar results were obtained using triazoles against Alternaria leaf spot. Based on the present investigation it is concluded that tebuconazole 0.15% is effective against Alternaria leaf blight and can be included in the need based chemical component of integrated disease management of cotton.

Evaluation of Fungicides on Different Concentrations against Rhizoctonia bataticola Causing Root Rot of Cotton in vitro

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Rhizoctonia bataticola (Taub) Butler was isolated from cotton seed (LRA-5166) by agar plate method. Two fungicides and one combination on different concentrations were evaluated in vitro against Rhizoctonia bataticola. The fungicides Thiram (@ 0.2%, 0.3% and 0.4%), Carboxin + Thiram (@ 0.25%, 0.35% and 0.45%) and Carbendazim (@ 0.1%, 0.2% and 0.3%) were evaluated against Rhizoctonia bataticola. All these concentrations of different fungicides showed significantly inhibition (100%) over its control.

Bt Cotton Managing Resistance Development to Sustain Technology

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Bt cotton technology has proved, in every country of its cultivation, to be a landmark example in managing cotton bollworms. But this technology comes with tremendous stewardship responsibility.

Like all other technologies, Bt cotton technology too has to be sustained so that it continues to deliver benefits year after year. Similar to pesticides, this technology also faces risk of resistance development in bollworms, in the absence of non bt cotton refugia planting. Today, almost 93% of the cotton acreage is cultivated under Bt cotton and the farmers are not planting the recommended structured refuge of non-Bt cotton. This places Bt technology is at risk of hastened development of resistance to Bt cotton in bollworms because of high selection pressure, especially those bollworms for which cotton is the major/only host crop. We have seen glimpse of resistance development in pink bollworm in central India to the single-gene Bollgard cotton during the year 2009.

Some of the key measures for managing resistance to Bt cotton are: pre-commercialization study on baseline-sensitivity of bollworms to Bt proteins; post-commercialization resistance monitoring through enablement of public

institutions to participate in collaborative and independent IRM studies; implementation of structured refuge, education and extension; assessment of size of natural refuge consisting of other host crops; Bt cotton product quality Stewardship including pre-approval quality control on Bt trait & product efficacy and post-approval trait quality audits. The authors trace the gradual evolution of resistance management measures thus demonstrating the depth of commitment on the part of both industry and academic sectors to support resistance management programs for Bt cotton in India. Specifically, this document focuses on the steps instituted to manage resistance and those in development and more importantly the need to innovate newer methods especially on refuge compliance.

The authors also discuss that a 'built-in-refuge' (BIR) also known as 'Seed-mix' or 'Refuge-in-bag' approach is a viable alternative to the current recommendation of structured refuge. The key advantage of BIR stems from the assurance that non-Bt refuge seed will be planted which will go to sustain Bt cotton technology through lowering the risk of resistance development in bollworms through availability of adequate numbers of susceptible moths from the mosaic of refuge plants. BIR is not recommended for single-toxin Bt products due to the large size of refuge needed and subsequent issues of pest movement and damage to Bt plants. This shortcoming is greatly reduced with stacked Bt gene products like Bollgard II.

BIR mode of delivery of refuge has been approved in USA & Canada for stacked Bt maize hybrids which express two or more Bt proteins for target insect control.

Considering the benefits delivered by Bt-cotton to over ~ 7.0 million farmers and to the Indian textile economy, we recommend a built-in-refuge approach with Bt cotton so that this valuable technology is preserved as long as possible.

Evaluation of impact of Ecolock mixing with different pesticides to control sucking pests of cotton.

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Ecolock a bioactive nutrient stabilizer represents a combination of cutting edge and conventional technologies that prevent foliage wash off and soil leaching. It has the ability to hold the chemicals in the soil and the foliage, even under torrential rainfall or irrigation allowing the chemicals to work successfully.

The impact of Ecolock mixing with different pesticides (seed treatment or foliar spray) to control sucking pests of cotton were studied during kharif 2011 at MCRS, NAU, Surat. Different pesticides i.e % imidacloprid, acetamiprid, profenophos and thiamethoxam were used alone and also mixed with Ecolock besides recommended pesticides schedule with and without Ecolock and seed treatment. Different pests were studied to measure the effect of Ecolock on enhancing activity of the pesticides, yield and yield contributing characters.

The number of sprays of insecticides mixed with Ecolock treatments i.e. imidacloprid, acetamiprid and thiamethoxam reduced as against their respective counterpart treatments (without Ecolock).

The overall results indicated that different insecticide when mixed with Ecolock and applied consecutively at ETL recorded lower population of leaf hopper, aphid, thrips and mealy bug as compared to insecticide alone. But, the differences were not statistically significant for individual insecticide applied consecutively at ETL. However, recommended pesticides applied (alternate sprays of different insecticides) along with Ecolock recorded significantly lower leaf hopper population as compared to recommended sprays alone. Most dramatic effect of Ecolock mixed with recommended pesticides was observed on seed cotton yield (2461 kg/ha) which showed significant increase over recommended pesticides alone (2105 kg/ha). The biological yield also registered significant increase due to Ecolock which was 7.22 t/ha and 6.20 t/ha, respectively in the above two

treatments. A small trial was conducted in operable lysimeters to study plant growth and root development. At the end of 150 days after sowing distinct increase was in plant height, number of bolls, boll weight, biomass and yield due to Ecolock with pesticides over pesticide alone. Striking increase was observed in root length and volume due to Ecolock. The penetration of root was much deeper with Ecolock.

Based on these findings, it is inferred that Ecolock, when mixed with different pesticides for insect control enhances the efficiency of systemic pesticides with lesser number of sprays, reducing the number of leaf hoppers, thrips, white fly and mealy bugs. It also enhances plant and root growth, increase in yield and biomass with no adverse effect on quality of the product. The Ecolock also increased the organic carbon, available potash and nitrogen of the soil.

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GENERAL AND OTHERS (GO)

Productivity Trends of Cotton Cultivation in North Zone and Future Research Priorities

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Cotton is cultivated in northern zone on sandy loam alluvial soils comprising the states of Haryana, Punjab, Rajasthan and a part of western Uttar Pradesh under assured irrigation conditions. Irrigation needs are met through tube wells and canal network in the region and flood irrigation is the only mode followed at present by the farmers. Northern cotton zone used to fetch 33.4% of country's cotton production from 22.6% of area under cotton in the country about two decades back in 1992-93. However, the trend changed later and during the past five years the cotton production ranging from 12.4 to 15.0% is obtained from 12.2 to 15.5% area. This is mainly attributed to changed scenario in central and south zones. If we look at the productivity trends in north zone before Bt era, the highest cotton productivity of 458 Kg lint /ha was recorded as early as in 1992-93 but with high yield fluctuations(236 kg lint/ha to 458kg lint/ha) mainly due to biotic stresses. Whereas after the introduction of Bt cotton hybrids in north zone in 2005-06, we have achieved up to a maximum of 571 kg lint/ha during 2010-11. There has been an improvement of around 100kg lint with the introduction of Bt cotton hybrids which now covers around 90% of area. The remaining area is under non Bt varieties (G hirsutum-7.8% & G arboreum-3.5%). The major benefits of Bt cotton has been effective control of boll worms and significant reduction of insecticides for bollworm control. In addition to that the fluctuations in productivity trends during pre Bt cotton era have been reduced and an element of sustainability has been added. However, it has also been noted that, the yield have almost reached a plateau in north zone during the past three years. The major thrust areas based on constraints in north zone include diversification and up gradation of cotton germplasm with emphasis on heat tolerance, precision agriculture based production technology with special reference to drip irrigation with fertigation, sucking pest management and cotton leaf curl virus disease. As cotton leaf curl remains a serious concern in the zone, RNAi based silencing of virus, marker assisted selection for development of resistant sources and epidemiology will be the thrusts for the management of this disease

Economic Implications of Trade Openness on Indian Cotton Economy

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The end of the Multi Fibre Agreement (MFA) and increased use of genetically modified (GM) cotton have profoundly altered world cotton markets in recent years. Globally, more than 70 countries produce and export cotton. India has an abundant supply of locally grown long staple cotton, which provides India with a competitive edge for manufacture of wider width fabrics. Traditional producers with large land bases suitable for cotton production continue to benefit from post-MFA trade patterns, including the United States, Sub-Saharan Africa, India, and Brazil. With the above cotton trade scenario and projections, the present study is intended to bring about the prospects of Indian cotton in the domestic as well as world market, future price trends, demand supply fluctuations and modalities for becoming the leading exporter of cotton in the international market. For which the following objectives have been formulated for the present study :- To analyse the growth of production of cotton in India, to study the export and import structure of cotton in pre and post WTO periods, to assess the structure, direction and competitiveness of Indian cotton under changing trade scenario and to assess the nature and extent of market integration of cotton during pre and post WTO era.

The total period of the study was divided into three sub- periods : Pre -WTO period (1970-71to1994-95); Post -WTO period (1995-96 to 2009 -10) - Pre Bt era (1995-96 to 2001-02) and Post Bt era (2002-03 to 2009-10). Growth rate model, first order Markov model and price linkage equations were used to analyse the data.

The compound growth rates of area, production and yield of cotton are reported in Table as given below.

CGR of Area, Production, and Productivity of cotton during pre and post WTO periods (%)

Period	Area	Production	Yield
Pre WTO period	-0.23	3.83***	4.07***
1980-81 to 1994-95	0.85*	7.35**	6.45**
Post WTO period			
1995-96 to 2010-11	Pre Bt era 1995-96 to 2001-02		
Post WTO period	-0.86*	3.44	4.37*
	Post Bt era 2002-03 to 2010-11		
Overall period	4.37***	9.72***	5.12***
1980-81 to 2010-11	0.97	5.42**	4.41**

During the pre WTO period, the area of cotton was almost stagnant with a negative growth rate of 0.23 per cent.. Unlike pre Bt era, the post Bt era showed an enormous increase in area, production and yield to the tune of 4.37, 9.72 and 5.12 per cent respectively. Overall, the performance of cotton area, production and yield with lot of fluctuations in between has shown a positive trend to the tune of 0.97, 5.42 and 4.41 per cent respectively.

The structural changes in the share of exports of cotton was analyzed through a first order Markov model. It is evident that China has been the only stable importer of Indian cotton. The 'other countries' group importing Indian cotton with relatively high retention probability (21 %) is likely to gain from China (20 %) and Japan (20 %). NPC roughly estimated to 0.83 during pre WTO period and 1.34 during post WTO period. DRC and SCB estimated around 0.78 and 0.62 respectively showing the comparative advantage of domestic price with the international prices during post WTO period. It is observed that the domestic markets of cotton were strongly integrated with central market in the post-WTO compared to pre- WTO period. Residual trend linear regressions estimated for international prices revealed a positive and significant trend for cotton in the post-liberalisation period.

Impact of Bt Cotton in India

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Cotton the most important commercial crop of India, often referred as the White Gold, consumes more than 45% of the total pesticides used. The most important insect pests that affect cotton production are jassids, white fly, aphids and thrips among the sap sucking pests and boll worms and Spodoptera among the leaf eating caterpillars. Of these, the American boll worms alone cause yield reduction upto 40 70 % under severe incidence. The genetic resistance, one of the important pest management strategies, is available in cotton gene pool against the sap sucking pests, whereas such resistance is not available against the bollworms. Bt cotton is a cotton variety that has been genetically engineered with the insecticidal gene from the soil bacterium Bacillus thurengiensis. The transgene produces a protein that paralyzes the larvae of pest insects, including the cotton bollworm. Bt cotton was initially introduced in 1996, and in the first decade of its commercialization it was cultivated in an area of over 20 million acres in the world. It is highly specific to the target organisms, numerous scientific studies have indicated that Bt has no adverse effects on human health and the environment, making it an ideal biological pest control tool in integrated pest management practices. The most prominent benefits are lower expenses on insecticide, higher yields and a safer environment. Minimum use of insecticides has multifarious advantages in the form of less human poisoning, lower yield risks and confidence to invest in other inputs. Use of this technology is also helpful in improving wild life population, reduced run-off of insecticides, reduced air pollution and improved safety to farm workers and neighbourhood. The study also suggests that those benefiting most from the technology were the smaller and more intensive cotton growers.

The ICAR (2002) data set from large scale field trials in 2001 reported that the economic advantages for three Bt cotton hybrids (MECH-12, MECH-162 and MECH-184) tested under the All India Coordinated Cotton Improvement Project (AICCIP) from 1998/99 to 2000/01 was relatively high due to severe pest infestations confirming efficacy of Bt technology for targeted insect pests. The overall economic advantages of the three Bt hybrids ranged from 29% to 86% as compared to conventional cotton.

Has Bt Technology been Inclusive? Exploring Evidences from Gujarat

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Introduction of Bt cotton since 2002 has changed the cotton cultivation scenario in India. With more than 80 per cent of the cotton land under Bt in most cotton growing regions, the Bt technology has been inclusive thus far, as both the lower and upper end of the land holding spectrum have adopted the technology with equal fervor. Particularly in Gujarat, farmers have been quick in adopting the Bt technology as ever. While it is known that adoption of any new seed technology nearly replaces the old seed technology that had been in use, there are wide differences in the choice of seeds within a state/district which is based on farmers own rationale. Particularly in Bt, while the GM technology comes from one company, the technology has been licensed to many companies. As the Bt technology has been introduced in variety of hybrid seeds of different companies, appropriate seed choice could help the farmer in terms of : (a) reaping maximum yield; and (b) shortening the harvest cycle of the crop facilitating cultivation of another crop. This besides improving the economics for the farmer would help the land to rejuvenate. Similarly by adopting the GM technology with suitable IPM measures, the farmers can rationalize their insecticide sprays on the crop and also prolong the life span of the technology.

While the voluminous literature on Bt cotton adoption in India has looked at the performance of the technology in terms of yield and reduction in the use of pesticides, few articles have focused on the cotton seed market dynamics and the varietal choice made by the farmers. Drawing from two primary surveys done in Surendranagar and Rajkot districts of Gujarat in 2007 and 2011, this paper examines whether the benefits of the technology has reached all sizes classes of farmers with heterogenous resource endowment status and agro ecological settings. Specifically, this paper tries to understand whether the benefits arising for the technology has been inclusive by analyzing the differences in the (a) choice of varieties used by the farmers; (b) production and yield; and (c) input use pattern followed by the farmers across size classes. The paper hypothesizes that (a) the yield benefits have been consistent across time and space; (b) the crop cycle has been facilitating use of land for second crops in the same season; and (c) area under other crops have increased. Based on the emerging trends in adoption as well as the inclusive outcomes, the paper also brings out the case for conditioning the technology in terms of incorporating the inherent farm level constraints to generate more inclusive and sustainable outcomes of the technology in the Indian context.

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સિધ્ધ કૃષિ ક્લીનીક

અધિકૃત વિક્રેતા :-

કેડીલા

ટીસ્યુકલ્ચર છોડ :-
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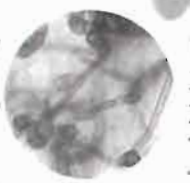

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સ્થાપના : તા. ૧૭-૦૯-૧૯૩૬ *હાર્દિક શુભેચ્છા સહ...* રજી. નંબર : ૭૫૯૨

ધી ઓલપાડ ગૃપ કો-ઓ. કોટન સેલ સોસાયટી લી.

મુ.પો.તા. ઓલપાડ, ઠે. ઓલપાડજીન, સાયણ રોડ, જી. સુરત (ગુજરાત) ફોન : ૦૨૬૨૧-૨૨૧૨૨૨

ઓડિટ વર્ગ : અ

મંડળીનું આર્થિક પાસુ

મંજુર થયેલ શેરની રકમ	રૂા.	૧૦,૦૦,૦૦૦=૦૦
ભરાયેલ શેરની રકમ	રૂા.	૩,૪૭,૪૮૦=૦૦
રીઝર્વ ફંડની રકમ	રૂા.	૫,૨૮,૦૧૦=૨૧
બીજા ફંડો	રૂા.	૬૧,૫૬,૧૭૦=૪૯
સભાસદ બચત થાપણ	રૂા.	૮૪,૨૮,૨૮૮=૮૮
સભાસદ સંખ્યા : વ્યકિત	:	૨૦૫૬
મંડળી	:	૨
		૨૦૫૮

મંડળીનું કામકાજ

૧. સભાસદોના ડાંગર-કપાસ એકત્ર કરી પુર્લીગના ધોરણે ઓછામાં ઓછુ કમીશન લઈ સરાસરી ભાવ વહેંચી આપવાનું.

૨. સભાસદોની ખેતીનાં વિકાસ માટે શુધ્ધ બિયારણ મેળવી પુરા પાડવા તથા રસા. ખાતરો, જંતુનાશક દવાઓ પાકમાંથી વસુલ લેવાની શરતે ટુંકી મુદ્દતનું ધિરાણ આપવામાં આવે છે.

૩. અલ્ટ્રાટેક સિમેન્ટ, એવરેસ્ટ સિમેન્ટ પતરા, જૈન પી.વી.સી. પાઈપ તથા ISI માર્કવાળું સ્ટીલ તથા અલુણા વ્રત નિમીત્તે સુકા મેવાનું વ્યાજબી ભાવે વેચાણ કરવામાં આવે છે.

શ્રી જયંતિભાઈ નારણભાઈ પટેલ, પ્રમુખશ્રી (કોબા)
શ્રી જયેશભાઈ બાલુભાઈ પટેલ, મેનેજરશ્રી (કોબા)
શ્રી કાંતિલાલ મગનભાઈ પટેલ, ઉપપ્રમુખશ્રી (મંદરોઈ)

વ્ય. સમિતિના સભ્યોશ્રીઓ

૧.	શ્રી કિરીટભાઈ ગોમાનભાઈ પટેલ	કસાદ
૨.	શ્રી જગજીવનભાઈ પરસોત્તમભાઈ પટેલ	અસ્નાબાદ
૩.	શ્રી મનહરભાઈ પરભુભાઈ પટેલ	ભાદોલ
૪.	શ્રી ભુપેન્દ્રભાઈ ગોમાનભાઈ પટેલ	કમરોલી
૫.	શ્રી ડાહ્યાભાઈ લક્ષ્મણભાઈ પટેલ	ઠેઠબ
૬.	શ્રી જમુભાઈ ગણપતભાઈ હાં. પટેલ	પારડી-કોબા
૭.	શ્રી હિમંતભાઈ કીકાભાઈ પટેલ	સરસ
૮.	શ્રી રમેશભાઈ રામજીભાઈ પટેલ	મીરજાપોર
૯.	શ્રી કરસનભાઈ ઈશ્વરભાઈ પટેલ	ઓલપાડ
૧૦.	શ્રી રણજીતભાઈ હીરાભાઈ પટેલ	સરસાણા
૧૧.	શ્રી મગનભાઈ વનમાળીભાઈ પટેલ	નઘોઈ
૧૨.	શ્રી મનહરભાઈ ગોપાળભાઈ પટેલ	કાસલાબુજરંગ
૧૩.	શ્રી ચંપકભાઈ ગોમાનભાઈ પટેલ	કુવાદ
૧૪.	શ્રી કિશોરભાઈ મગનભાઈ પટેલ	સોંદલાખારા
૧૫.	શ્રી રણછોડભાઈ મગનભાઈ પટેલ	હાથીસા
૧૬.	શ્રી મગનભાઈ જીવણભાઈ પટેલ	અસનાડ
૧૭.	શ્રી રમેશભાઈ લલ્લુભાઈ પટેલ	જીણોદ
૧૮.	શ્રી મનહરભાઈ ખુશાલભાઈ પટેલ	કદરામા
૧૯.	શ્રી જગદીશભાઈ હરિભાઈ પટેલ	માંઢી

Genetic Improvement for yield and fibre quality in *G.arboreum* for rainfed situation

T.R.Loknathan , Punit Mohan , P.B.Bagde, Prafulla Raut and B.R.Rode
Central Institute for Cotton Research , ICAR , Nagpur
Present address : Maharashtra Hybrid Seeds Corporation, Nagpur

The yield levels of *arboreums* were confined to 1000 to 1100 kg/ha and most of them were short staple ones measuring upto 23 mm staple. The micronnaire was > 5.0. They are known for their endurance to abiotic and biotic stresses. The earlier varieties viz., AKH-4, AKA081, SUJAY , K-6, K-9 followed by newly evolved CINA-306,CINA-310, CINA-323 indicated promise for improvement in *arboreums* in terms of yield, GOT(%), 2.5% span length (mm) , fibre strength g/tex) and micronnaire (mic value) . We selected 3 GMS lines viz., GAK 4234 , GAK 09 (Ml) and GAK-8615 (A) as female parents and crossed with the above mentioned genotypes to develop trait specific improved genotypes. I here has been an improvement upto 23 I g/tex foi fibre strength in case of Maljari and also single plant yield of 100 g/plant. Improvement for fibre strength in K-6(23 g/tex) was visualized with the incorporation of GAK-4234 GMS line as partial conversion. Also AKA-8401 was improved for high strength (23 g/tex) and high GOT (%) (41 %). An improved parental line CINA-329 was crossed with GMS line GAK-4234 resulting in a long staple line of 2.5 % span length (28.6 mm). Thus new CNA-2000 series have been developed. Further improvements in CINA series were made by crossing them with DELA series (material developed by UAS, Darwad) and presently they are at F4 stage with long staple upto 29 mm and high strength upto 23.8 g/tex with and a micronnaire of < 4.7 mm. This explains the diversity of cultures evolved under different genetic background for yield , major yield contributing and fibre quality traits. Thus the arboreums hold quite a promise for yield and fibre quality. But special efforts are needed to promote these *arboreums* considering their gradual decline in area.

CLIMATE CHANGE AND PREPARDNESS COTTON SCENIERO

Prakash[1], A.H., Venugopalan[2], M.V., Khader[1], S.E.S.A, and Gopalakrishnan[3], N

Earth is getting warmer by virtually every measure we know, and the temperature has been well above normal for more than 25 years. Although increases of 1.0-1.6°F (0.6-0.9°C) over the last century or so may not sound very threatening, remember that's a global average. The warming is stronger over land than over oceans and in the higher latitudes than in the tropics. The intergovernmental Panel on climate change has projected an increase in mean global temperature reaching from 1.4 to 5.8°C by 2100, depending on different greenhouse gas emission scenarios. Agriculture is a sector that is particularly vulnerable to changes in climate.

Cotton has a certain resilience to high temperatures and drought due to its vertical tap root. It develops at a pace determined by the temperatures that the plant encounters. If temperatures are between 25-32°C, a cotton plant develops at a very predictable rate. Studies have shown that limited increases in atmospheric CO_2 also favour the cotton plant's development. The impact of climate change has also been worked out on cotton productivity. **Effect of elevated CO_2 on Cotton growth and development is more apparent due to significantly greater leaf area, higher leaf and canopy, net photosynthetic rates, lower dark respiration and lower light compensation point than plants grown in ambient CO_2.** Insects are expected to adapt to climate change through their capacity to adapt their body temperature to the temperature of the environment.

Integration of simulation Crop model and GIS will identify the factors effecting the crop due to climate change and also throw light on mitigating the harmful effects. Information is vital to tackle climate change effects: for this reason, a shift is needed in the agriculture sector to disseminate appropriate knowledge at the right time to the ones who are at the frontline in the battle- the farmers, in both developed and developing countries. It should be underlined that a gap still exists between global and local applications: promoting the development of an integrated framework for information sciences, agro-environmental sciences and communication at different levels is essential in order to fill it. In many of these cases the systems are the result of single Research & Development efforts, rather than collaborative programmes: one of the side effects is a lack of interoperability among different applications. Using an Open Source approach could open the road to the creation of a collaborative community-led environment, as it happened within spatial technology thanks to the Open Source Geospatial Foundation.

Climate change is a global problem with local impacts, thus information technology, jointly with communication sciences, can play a big role in blending different perspectives. the majorit[illegible] on climate change issues within the agricultural sector [illegible] pment, impact assessment and adaptation planning.

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