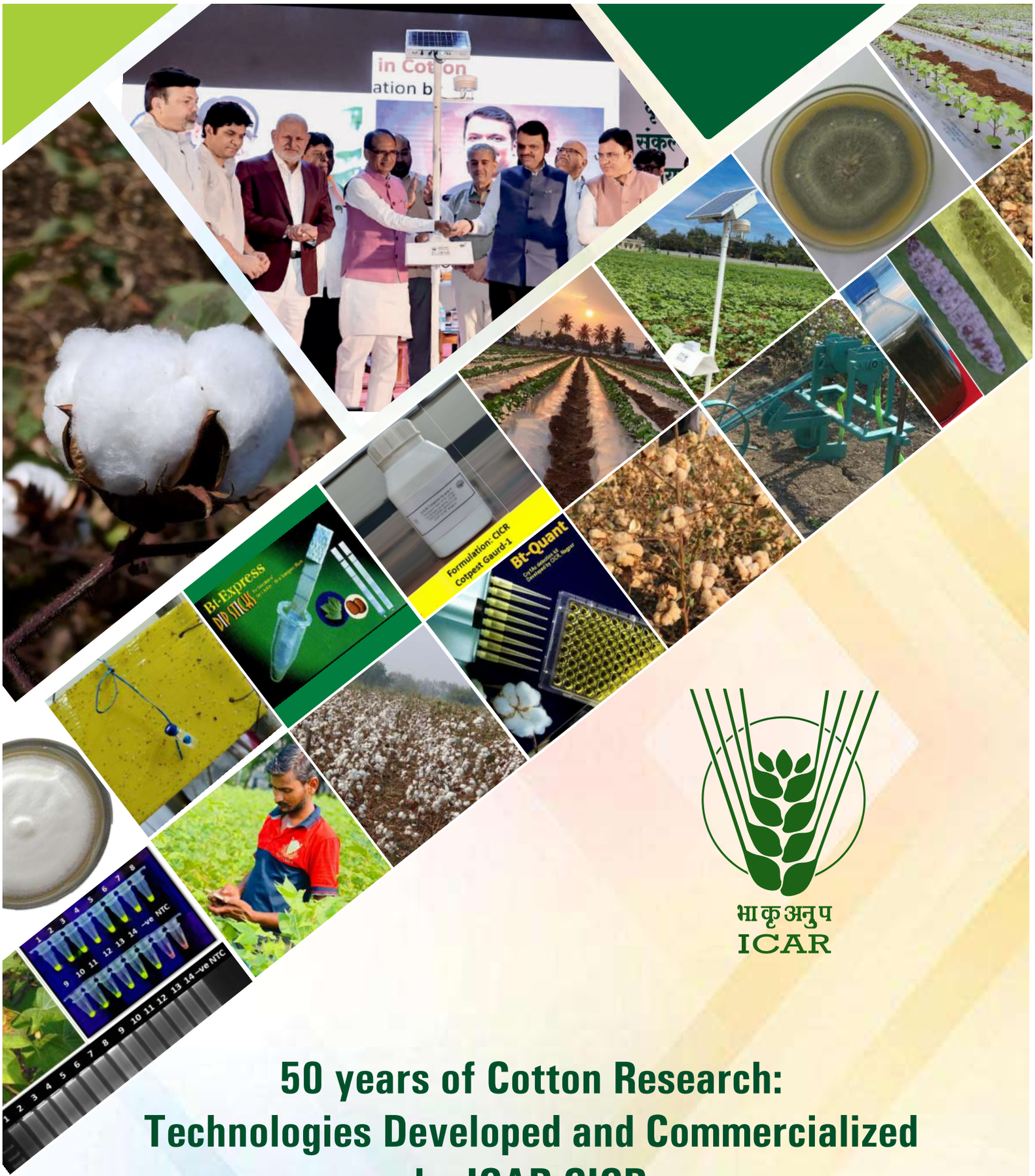

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ICAR

50 years of Cotton Research: Technologies Developed and Commercialized by ICAR-CICR

ICAR-Central Institute for Cotton Research
Nagpur

50 years of Cotton Research: Technologies developed and commercialized by ICAR-Central Institute for Cotton Research (CICR)

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Foreword

Agriculture today stands at a crossroad, where it is imperative to ensure food, feed, fibre, and nutritional security from the ever-shrinking natural resources and increasing climatic uncertainties. With the global population steadily rising, the challenge is not merely to produce more, but to produce sustainably, efficiently, and resiliently. Climate variability, soil degradation, environmental pollution, and growing intensity of biotic and abiotic stresses are placing unprecedented pressure on agricultural systems worldwide.

In this context, cotton assumes a position of immense strategic importance in India's agrarian and industrial landscape. As a primary raw material for the textile sector, cotton sustains millions of farmers, supports rural livelihoods, and contributes significantly to national economic growth. India, despite accounting for a substantial share of about 38% in the global cotton area, continues to face productivity constraints, where nearly 67% of the crop is cultivated under rainfed conditions. The national average productivity, hovering around 450 kg lint/hectare, remains below the leading cotton-producing countries, highlighting the urgent need for transformative interventions.

The way forward lies in harnessing science-led, farmer-centric innovations. Enhancing soil health, improving resource-use efficiency, promoting high-density planting systems, strengthening pest and disease management, and accelerating mechanization are critical drivers for improving productivity and profitability. Equally important is the adoption of climate-resilient, eco-friendly, and precision-based technologies that can sustain cotton production in the face of increasing uncertainties.

Over the past five decades, the ICAR-Central Institute for Cotton Research has been at the forefront of such transformative efforts. Through sustained research efforts, the institute has developed 67 cotton varieties and hybrids, along with a wide range of improved production and protection technologies suited to diverse agro-ecological regions. These contributions have significantly strengthened the scientific foundation of cotton cultivation in the country and has positively impacted farmers' livelihoods.

The present publication, *"50 Years of Cotton Research: Technologies Developed and Commercialized by ICAR-CICR"*, is a testimony to this rich legacy. It embodies the institute's journey of scientific excellence, technological innovation, and field-level impact, providing valuable insights for researchers, students, policymakers, extension functionaries, and stakeholders across the cotton value chain.

As we look ahead, the future of Indian cotton lies in building a resilient, competitive, and sustainable production ecosystem that integrates advanced science, fosters innovation with inclusivity, and aligns productivity gains with environmental stewardship.

I take immense pride in the institute's contributions over the last fifty years. These milestones are not merely a celebration of achievements, but reaffirmation of our commitment to shaping the future of cotton research in India. I am confident that the insights and technologies presented in this publication will inspire continued innovation, stronger partnerships, and accelerated transformation of the cotton sector in the years to come.

V.N. Waghmare

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G. barbadense variety: Suvin

Developer(s): Sh. R. Krishnamurthy, Dr. V. Santhanam, Sh. K.N. Gururajan

Year of Release: 1978
Notification Number: 1004
Pedigree: Sujata × SIV 135

- Successful attempt to develop an extra-long staple *G. barbadense* variety equal in quality to the popular Egyptian Giza varieties.
- Suvin was developed by pedigree method of breeding and has a yield potential of 15-20 q/ha.
- Capable of spinning upto 120s count yarn.
- Still under seed production chain and in cultivation in Salem District of Tamil Nadu.
- At one point of time, Suvin occupied up to 32,000 hectares in South Zone and entirely substituted the Extra long staple cotton imports.

Species	***G. barbadense***
Area for adaption	South zone
Flower Time of flowering	Late
Flower Petal colour	Deep yellow
Flower Petal spot	Present
Flower Pollen colour	Deep Yellow
Boll Shape	Elliptic
Boll Weight (g)	Very small (2.8)
Ginning %	Very low (30.07)
Fibre Length (mm)	Extra-long (40)
Fibre Strength (g/tex)	Very strong (38)
Fibre Fineness	Fine (3.2)

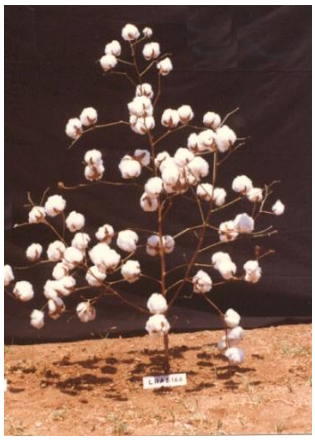
G. hirsutum variety: LRA 5166

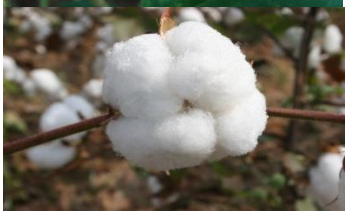
Developer(s): Sh. R. Krishnamurthy, Sh. K.N. Gururajan

Year of Release: 1983
Notification Number: 2 E
Pedigree: Laxmi × (Reba-B50 x AC 122)

- During the early 1980s, with an industry tie up with SIMA, the medium staple variety LRA 5166 was identified for commercial cultivation in 1982.
- LRA 5166 was developed by pedigree method of breeding and has a yield potential of 25-30 q/ha under irrigated and 10-15 q/ha under rainfed conditions.
- This CLCuD resistance variety, because of its drought tolerance and rejuvenation capacity, spread very fast both under irrigated and rainfed conditions in South and Central Zone states and occupied up to 20 % of the total cotton cultivated area in the country. The variety is still under cultivation in certain pockets. The lint of LRA 5166 is ideally suited for producing hosiery yarn.
- It caters to the needs of the Textile Industries' 40s cotton requirement.

Species	***G. hirsutum***
Area for adaption	Central and South Zone
Flower Time of flowering	Late
Flower Petal colour	Cream
Flower Petal spot	Absent
Flower Pollen colour	Cream
Boll Shape	Ovate
Boll Weight (g)	Small (3.8)
Ginning %	High (40.12)
Fibre Length (mm)	Medium Long (26.6)
Fibre Strength (g/tex)	Medium (22.33)
Fibre Fineness	Medium (4.0)





G. hirsutum variety: MCU 5-VT

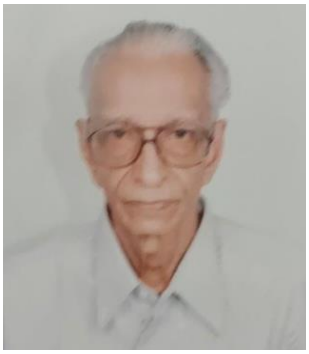
Developer(s): Sh. R. Krishnamurthy, Sh. K.N. Gururajan

Year of Release: 1984
Notification Number: 596E
Pedigree: Reselection from MCU 5

- The long staple cotton variety MCU 5, which was popular in Tamil Nadu was highly susceptible to Verticillium wilt disease. Hence, to develop tolerance to Verticillium wilt, selection was exercised in variety in the hot spot locations of Sandega goundan Palayam in Coimbatore District of Tamil Nadu and thus MCU 5 VT was developed.
- It has yield potential of 25 q/ha
- It is a long staple variety capable of spinning upto 60s count yarn.

Species	***G. hirsutum***
Area for adaption	South Zone
Flower Time of flowering	Medium
Flower Petal colour	Cream
Flower Petal spot	Absent
Flower Pollen colour	Yellow
Boll Shape	Ovate
Boll Weight (g)	Medium (4.6)
Ginning %	High (35.43)
Fibre Length (mm)	Long (32.16)
Fibre Strength (g/tex)	Medium (24)
Fibre Fineness	Medium (3.5)

G. hirsutum variety: Supriya



Developer(s): Sh. R. Krishnamurthy, Sh. K.N. Gururajan

Year of Release: 1985
Notification Number: 295E
Pedigree: MCU 5 × C 1998

- C 1998, a Russian short duration variety, was used to develop short duration variety suitable for summer irrigated situation.
- Supriya was developed by pedigree method of breeding and has an yield potential of 20 q/ha.
- Capable of spinning upto 50s count yarn.
- Tolerant to bacterial blight
- Moderately tolerant to jassids

Species	***G. hirsutum***
Area for adaption	Tamil Nadu
Flower Time of flowering	Late
Flower Petal colour	Cream
Flower Petal spot	Absent
Flower Pollen colour	Yellow
Boll Shape	Ovate
Boll Weight (g)	Large (5.0)
Ginning %	High (38)
Fibre Length (mm)	Medium (28)
Fibre Strength (g/tex)	Medium (21.6)
Fibre Fineness	Medium (4.36)

G. hirsutum hybrid: Savita

Developer(s): Sh. K.N. Gururajan

Year of Release: 1987
Notification Number: E834
Pedigree: T 7 × M 12

- Robust Intra-hirsutum hybrid with yield potential of 25-30 q/ha.
- It is a long staple hybrid capable of spinning upto 60s count yarn.
- It has tolerance to verticillium wilt

Species	***G. hirsutum hybrid***
Area for adaption	South Zone
Flower Time of flowering	Late
Flower Petal colour	Cream
Flower Petal spot	Absent
Flower Pollen colour	Yellow
Boll Shape	Ovate
Boll Weight (g)	Medium (4.6)
Ginning %	High (35.57)
Fibre Length (mm)	Long (31.26)
Fibre Strength (g/tex)	Medium (23.76)
Fibre Fineness	Medium (4.13)

G. hirsutum variety: Anjali (LRK 514)

Developer(s): Sh. K.N. Gururajan

Year of Release: 1992
Notification Number: E814
Pedigree: LRA 5166 (Khandwa -2 × Reba-B-50) BC 2

- It is a medium staple, short duration variety with compact growth habit and earliness capable of spinning upto 40s count yarn.
- Ideally suited for cultivation under multiple cropping conditions in Central Zone.
- It is characterized by short internodes and is suitable for high density planting system.
- Anjali was developed by pedigree method of breeding and has a yield potential of 20 q/ha under normal spacing and 30 q/ha under HDPS.
- Tolerant to jassids, escapes from severe bollworm infestation

Species	***G. hirsutum***
Area for adaption	Central and South Zone
Flower Time of flowering	Late
Flower Petal colour	Yellow
Flower Petal spot	Absent
Flower Pollen colour	Cream
Boll Shape	Ovate
Boll Weight (g)	Medium (4.8)
Ginning %	Medium (38)
Fibre Length (mm)	Medium long (28.8)
Fibre Strength (g/tex)	Medium (21.3)
Fibre Fineness	Fine (3.93)

G. hirsutum hybrid: Surya

Developer(s): Sh. K.N. Gururajan

Year of Release: 1995
Notification Number: E408
Pedigree: T 13 × M 12

- Robust Intra-hirsutum hybrid
- Yield potential is 20 q/ha.
- It is a long staple hybrid capable of spinning upto 60s count yarn.
- It has moderate resistance to bacterial blight
- Tolerant to Jassid and pink bollworm

Species	***G. hirsutum hybrid***
Area for adaption	South Zone
Flower Time of flowering	Late
Flower Petal colour	Cream
Flower Petal spot	Absent
Flower Pollen colour	Yellow
Boll Shape	Ovate
Boll Weight (g)	Large (5.2)
Ginning %	Very high (36.63)
Fibre Length (mm)	Long (32.0)
Fibre Strength (g/tex)	Strong (25.46)
Fibre Fineness	Medium (4.3)
Flower Stigma	Embedded
Flower Anther Filament colouration	Absent

G. hirsutum variety: Surabhi (VRS 7)

Developer(s): Sh. K.N. Gururajan, Sh. A. Kannan

Year of Release: 1997
Notification Number: 360 E
Pedigree: MCU 5VT (MCU 5 × *G. mexicanum*)

- Verticillium wilt resistant variety developed by introgressing immunity to Verticillium wilt from a Leningrad strain.
- Surabhi was developed by pedigree method of breeding and has a yield potential of 16 q/ha.
- Still under seed production chain and under cultivation, especially as a summer crop in Tamil Nadu. It caters to the needs of the Textile Industries' 60s cotton requirement. Resistant to verticillium wilt, bacterial blight, dry root rot and alternaria leaf spot

Species	***G. hirsutum***
Area for adaption	Tamil Nadu
Flower Time of flowering	Late
Flower Petal colour	Cream
Flower Petal spot	Absent
Flower Pollen colour	Yellow
Boll Shape	Ovate
Boll Weight (g)	Small (4.0)
Ginning %	High (35.09)
Fibre Length (mm)	Long (31.6)
Fibre Strength (g/tex)	Medium (24.4)
Fibre Fineness	Medium (3.2)

G hirsutum Hybrid: Om Shankar (CSHH 29) (CICR-HH Cotton 15)

Developer(s): O P Tuteja and S L Ahuja

Year of Development: 1997

Brief description of the technology

Parameter	Details
Hybrid Name	CSHH-29 (Om Shankar)
Year of Release	1997
Breeding Method	Developed through heterosis breeding
Parentage	SH 2379 × K 34007
Adaptation / Recommendation	Ideally suited for the entire North Zone of India under irrigated conditions; released for Haryana, Punjab, and Rajasthan
Average Yield	3400 kg/ha
Boll Weight	3.5 g
Plant Height	140–150 cm
Staple Length	26.7 mm (medium staple)
Ginning Outturn (GOT)	33.6%
Maturity	170–175 days
Release Authority	Identified and released by Central Varietal Release Committee (CVRC)
Notification Details	Gazette of India Notification No. S.O. 647(E), dated 9 September 1997

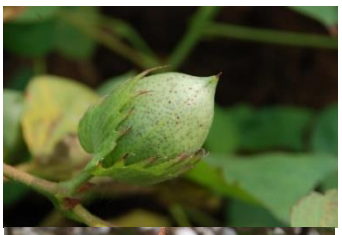
G. hirsutum variety: CWROK 165 (Sumangala)

Developer(s): Sh. K.N. Gururajan, Dr. S. Manickam, Sh. V. Muthuswamy, Sh. C.K. Sankaranarayanan, Sh. N. Venugopal, Sh. K. Krishaswamy

Year of release: 2001

Brief description of the technology:

Parameter	Details
Adaptation / Recommendation	Recommended for South Zone states (Karnataka, Andhra Pradesh, Tamil Nadu) under irrigated conditions
Mean Seed Cotton Yield	2500 kg/ha
Yield Potential	3000 kg/ha
Mean Boll Weight	4.5 g/boll
Fibre Length (UHML)	28.0 mm
Micronaire	4.8
Fibre Strength (Tenacity)	21.4 g/tex
Pest Reaction	Moderately resistant to sucking pests; less damage from bollworms observed
Disease Reaction	Moderately susceptible to Alternaria leaf spot and grey mildew
Special Feature	High yield potential



Intra-*G. arboreum* Hybrid: CICR -2(CISAA 2) (CICR-AA Cotton 18)

Developer(s): R. A. Meena, S. K. Verma, S. L. Ahuja, Dilip Monga, O. P. Tuteja

Year of Development: 2005

Brief description of the technology

Parameter	Details
Hybrid Name	CICR 2 (Desi cotton hybrid)
Year of Release	2005
Cross	DS-5 (GMS) × LD 327 (selection)
Adaptation / Recommendation	Released for the entire North Zone of India
Plant Height	Up to 150 cm in fertile soils
Yield Potential	32.13 q/ha
Mean Lint Yield	797 kg/ha
Ginning Outturn (GOT)	38.4%
Fibre Length	20.5 mm
Fibre Strength	16.3 g/tex
Micronaire	7.06
Boll Opening	Fluffy
Disease Reaction	Moderately resistant to Fusarium wilt
Pest Reaction	Higher resistance to bollworm compared to local check
Notification Details	Gazette of India Notification No. S.O. 122(E), dated 2 February 2005

Current Status: Parents of hybrid are being maintained and supplied to stakeholders; hybrid is being demonstrated at Technology Park ICAR-CICR, RS, Sirsa.

Publication:

Paul, D., Chandra, S., Singh, A., Sain, S. K., Kumar, R. and Prasad Y. G. 2023. Seed production of male sterility-based hybrid CICR-2 in Desi cotton. CICR-Leaflet 2023/4 *(Hindi)*

Intra *G. hirsutum* Hybrid: Shresth (CSHH 198) (CICR-HH Cotton 19)

Developer(s)/ O P Tuteja, Dilip Monga, S. K. Verma, R. A. Meena, P. Jeyakumar, P. Singh, C. D. Mayee, Suresh Kumar, Sunil Kumar, Mahender Singh

Year of Development: 2005

Brief description of the technology

Parameter	Details
Hybrid Name	Shresth (CSHH 198) – intra-G. hirsutum cotton hybrid
Pedigree	CSH 19 × CSH 8
Adaptation / Recommendation	Recommended for North Zone of India under irrigated conditions
Mean Seed Cotton Yield	21.96 q/ha
Yield Potential	26.09 q/ha
Ginning Outturn (GOT)	32.5%
Fibre Length (2.5% span length)	26.5 mm
Micronaire	4.5
Fibre Strength	23.5 g/tex
Maturity	165–170 days
Release Authority	Identified and released by Central Varietal Release Committee (CVRC)
Notification Details	Gazette of India Notification No. S.O. 122(E), dated 2 February 2005

Current Status: Parents of hybrid are being maintained and hybrid is being demonstrated at Technology Park of ICAR-CICR, RS, Sirsa.

Publication:

Monga, D., Meena, R.,Ahuja, S.L., Tuteja, O.P., Verma, S.K.,Kumar, R. and Sain, S. K.2017.Technologies developed by Central Institute for Cotton Research, Regional Station, Sirsa. CICR-Folder, Pp:5 (Hindi)

Intra *G hirsutum* Hybrid: Kalyan (CSHH 238) (CICR-HH Cotton 20)

Developer(s): O P Tuteja, B. M. Khadi, Dilip Monga, S. L. Ahuja, S. K. Verma, R. A. Meena, P. Jeyakumar, P. Singh, Suresh Kumar, Mahender Singh

Year of Development: 2007

Brief description of the technology

Parameter	Details
Hybrid Name	Kalyan (CSHH 238) – intra-G. hirsutum cotton hybrid
Cross	SH 2379 (Y) × PIL 8 (Selection)
Recommended Area	North Zone of India (Haryana, Punjab, Rajasthan) under irrigated conditions
Mean Seed Cotton Yield	21.34 q/ha
Yield Potential	27.59 q/ha
Ginning Outturn (GOT)	33.7%
Comparison (GOT)	Higher than LHH 144 (32.1%) and local checks (33.2%)
2.5% Span Length	27.2 mm
Micronaire	4.4
Uniformity Ratio	47.6%
Fibre Strength	22.6 g/tex
Strength–Length Ratio	0.84
Spinning Capacity	40s count
Maturity Duration	About 160 days
Release Details	Released by CVRC; Gazette Notification No. S.O. 122(E), dated 6 February 2007

Current Status: Parents of hybrid are being maintained and hybrid is being demonstrated at Technology Park of ICAR-CICR, RS, Sirsa.

Publication:

Monga, D., Meena, R., Ahuja, S.L., Tuteja, O.P., Verma, S.K., Kumar, R. and Sain, S. K. 2017. Technologies developed by Central Institute for Cotton Research, Regional Station, Sirsa. CICR-Folder, Pp:6*(Hindi)*

G. hirsutum variety: Suraj (CCH 510-4)

Developer(s): Sh. K.N. Gururajan, Dr. S. Manickam

Year of Release: 2008
Notification Number: 2458 E
Pedigree: LRA 5166 (CCH 526612 × HLS 329)

- Most adaptable, sucking pest tolerant variety combining good yield and desirable fibre quality.
- It was released in 2008.
- Suraj was developed by pedigree method of breeding and has a yield potential of 25 q/ha.
- This variety is also found suitable for organic cultivation and for high density planting system.
- It caters to the needs of the Textile Industries' 50s cotton requirement.

Species	***G. hirsutum***
Area for adaption	South & Central Zone
Flower Time of flowering	Late
Flower Petal colour	Cream
Flower Petal spot	Absent
Flower Pollen colour	Cream
Boll Shape	Ovate
Boll Weight (g)	Large (5.9)
Ginning %	Very high (40.1)
Fibre Length (mm)	Long (30.3)
Fibre Strength (g/tex)	Medium (23.8)
Fibre Fineness	Fine (3.6)

Intra *G hirsutum* Hybrid: CSHH 243 (CICR-HH Cotton 22)

Developer(s): O P Tuteja, B. M. Khadi, Dilip Monga, S. L. Ahuja, S. K. Verma, R. A. Meena, Suresh Kumar and Parab Singh

Year of Development: 2008

Brief description of the technology

Parameter	Details
Adaptation	Ideally suited for entire North Zone under irrigated conditions
Breeding Method	Developed through heterosis breeding
Parentage	CSH-43 (Selection) × CSH-2013 (Selection)
Mean Seed Cotton Yield	21.81 q/ha
Yield Potential	27.50 q/ha
Maturity Duration	Medium duration (165–170 days)
Cropping System Suitability	Suitable for cotton–wheat rotation
Ginning Outturn (GOT)	33.3%
2.5% Span Length	26.7 mm
Micronaire	4.6
Uniformity Ratio	50.7%
Fibre Strength	23.2 g/tex
Disease Resistance	Resistant to Cotton Leaf Curl Virus (CLCuV)
Release Details	Released by CVRC; Gazette Notification No. S.O. 1108(E), dated 8 May 2008

Current Status: Parents of hybrid are being maintained and hybrid is being demonstrated at Technology Park of ICAR-CICR, RS, Sirsa.

Publication:

Monga, D., Meena, R., Ahuja, S.L., Tuteja, O.P., Verma, S.K., Kumar, R. and Sain, S. K. 2017. Technologies developed by Central Institute for Cotton Research, Regional Station, Sirsa. CICR-Folder, Pp:7 *(Hindi)*

Gossypium arboreum variety: CICR 1 (CISA 310) (CICR-A Cotton 23)

Developer(s): S. K. Verma, O. P. Tuteja, R. A. Meena, Dilip Monga and S. L. Ahuja

Year of Development: 2010

Brief description of the technology

Parameter	Details
Parentage	CSA 9-8 × AC 3479
Recommended Area	Irrigated conditions of North Zone
Mean Seed Cotton Yield	2171 kg/ha
Yield Potential	2641 kg/ha
Ginning Outturn (GOT)	36.5%
Fibre Length	20.2 mm
Fibre Strength	15.9 g/tex
Micronaire	7.1
Maturity Duration	140–155 days
Cropping System Suitability	Fits well in cotton–wheat and cotton–mustard systems
Disease Resistance	Moderately resistant to Fusarium wilt
Pest Tolerance	Tolerant to sucking pests and bollworms
Release Details	Notified vide Gazette of India S.O. 211(E), dated 29 January 2010

Current Status: Nucleus and Breeder seeds of CICR-1 are being produced at ICAR-CICR, RS, Sirsa.

Publication:

Chandra, S., Paul, D., Singh, A., Sain, S. K., Kumar, R. and Prasad, Y. G. 2023. Improved varieties of desi cotton and American cotton developed by Central Cotton Research Institute, Regional Station, Sirsa *CICR-Leaflet* 2023/7*(Hindi)*

G. hirsutum variety: CNHO 12 (Saraswati)

Developer (s): SM. Palve, Dinesh Kumar Agarwal, TR. LoknathaN, Nita Kate, RG. Dani, VV. Singh, VN. Waghmare, C. Tuteja

Year of Release: 2010

Brief description of the technology:

Parameter	Details
Species	Gossypium hirsutum
Parentage	(Khandwa 2 × L 147) Khandwa 2
Breeding Methodology	Pedigree
Notification Number	S.O. 733 (E)
Developed at	ICAR – Central Institute for Cotton Research, Nagpur
Area for Adoption	Central Zone (Irrigated)
Special Traits of Importance	This variety has 20s Count which is suitable for denim purpose. It has additional advantage of medium to high seed cotton content of 21.8%.
Fibre Colour	White
Fibre Length	23.2 mm
Fibre Strength	19.9 g/tex
Fineness (Micronaire)	4.4 µg/inch
Uniformity	51%
Maturity	–
Spinnability	20s Count
Ginning Out Turn	35%
Yield Potential	15–17 q/ha

G. arboreum variety: CICR 3 (CISA 614) (CICR-A Cotton 25)

Developer(s) S. K. Verma, O. P. Tuteja, Dilip Monga, K. R. Kranthi, S. L. Ahuja, R. A. Meena, Rishi Kumar

Year of Development: 2010

Brief description of the technology

Parameter	Details
Parentage	CISA 6 (CISA 318 × PA 304)
Breeding Method	Pedigree method
Recommended Area	Irrigated conditions in North Zone
Mean Seed Cotton Yield	2204 kg/ha
Yield Potential	Up to 3428 kg/ha (AICCIP trials)
Maturity Duration	Early (145–150 days)
Cropping System Suitability	Well suited for cotton–wheat rotation
Mean Lint Yield	847 kg/ha
Yield Advantage	25.15% over zonal check
Ginning Outturn (GOT)	36.6%
Staple Length	20.9 mm
Fibre Strength	16.9 g/tex
Micronaire	6.8
Release Details	Notified vide Gazette of India S.O. 733(E), dated 1st April 2010

Current Status: Nucleus and Breeder seeds of CICR-3 are being produced at ICAR-CICR, RS, Sirsa.

Publication:

Chandra, S., Paul, D., Singh, A., Sain, S. K., Kumar, R. and Prasad, Y. G. 2023. Improved varieties of desi cotton and american cotton developed by Central Cotton Research Institute, Regional Station, Sirsa CICR-Leaflet 2023/7*(Hindi)*

Intra *G hirsutum* Hybrid: CSHG 1862 (CICR-HH Cotton 26)

Developer(s): O P Tuteja, Keshav Kranti, Dilip Monga, S. K. Verma, Rishi Kumar, S. L. Ahuja, R. A. Meena, Suresh Kumar and Manju Banga

Year of Development: 2013

Brief description of the technology

Parameter	Details
Type	First-ever GMS (Genetic Male Sterility) based cotton hybrid for North Zone under irrigated conditions
Parentage	GMS-16A × CB-33
Breeding Method	Heterosis breeding
Recommended Area	Haryana, Punjab, and Rajasthan under irrigated conditions
Mean Seed Cotton Yield	21.02 q/ha
Yield Potential	25.57 q/ha
Maturity Duration	Early (165–170 days)
Ginning Outturn (GOT)	34.5%
2.5% Span Length	27.2 mm
Fibre Strength	22.0 g/tex
Micronaire	4.2
Spinning Capacity	Up to 40s count
Disease Resistance	Resistant to Cotton Leaf Curl Virus (CLCuV) under field and screen house conditions
Release Details	Released by CVRC; Gazette Notification No. S.O. 952(E), dated 10th April 2013

Current Status: Parents of hybrid are being maintained and hybrid is being demonstrated at Technology Park of ICAR-CICR, RS, Sirsa.

Publication:

Monga, D., Meena, R., Ahuja, S.L., Tuteja, O.P., Verma, S.K., Kumar, R. and Sain, S. K. 2017. Technologies developed by Central Institute for Cotton Research, Regional Station, Sirsa. CICR-Folder, Pp:8 *(Hindi)*

G. arboreum variety: CNA 1003 (Roja) (CICR-A Cotton 27)

Developer (s): Dr. V.N. Waghmare, Shri. R.V. Salame

Year of Release: 2015

Brief description of the technology:

Parameter	Details
Species	Gossypium arboreum
Parentage	Dhulia 2 × JLA 101
Breeding Methodology	Pedigree Method
Notification Number	S.O. 2680 (E)
Developed at	ICAR – Central Institute for Cotton Research, Nagpur
Area for Adoption	South Zone (Tamil Nadu, Karnataka, Andhra Pradesh and Telangana)
Habit	Medium tall (160 cm), Early maturing (160–165 days) and near synchronous in boll bursting
Special Traits of Importance	Jassids tolerant and recorded less damage by diseases and pests. Immune to Bacterial blight and tolerant to Rust in South Zone. It is lodging resistant. After boll bursting, kapas is retained in the open bolls for 20-30 days or even more, it has high locule retention capacity.
Fibre Length	24.3 mm
Fibre Strength	21.1 g/tex (ICC mode)
Fineness (Micronaire)	5.2 µg/inch
Uniformity	50%
Spinnability	20s Count
Ginning Out Turn	35.7%
Yield Potential	10–27 q/ha

G. hirsutum variety: Central Cotton CCH 2623

Developer(s): Sh. K.N. Gururajan, Dr. S. Manickam

Year of release: 2015

Brief description of the technology:

- The variety Central Cotton CCH 2623 recorded a mean seed cotton yield of 1798 kg/ha in South Zone States of Karnataka, Andhra Pradesh, Telangana and Tamil Nadu.
- The variety recorded a mean Ginning Out turn of 36.9 per cent and recorded higher lint yield.
- The variety recorded a mean fibre length of 25.4 mm, Micronaire of 3.4 and fibre strength of 21.1 g/tex in the spinning test.
- The variety recorded a CSP value of 2276 and was found to spin up to 40s count yarn.
- The variety showed on par incidence vis-à-vis check varieties for majority of diseases.
- The variety showed field tolerance to jassids.
- It recorded lesser boll damage as compared to check varieties.
- It showed on par incidence vis-à-vis check varieties for sucking pests.
- The variety combines high yield potential, better ginning outturn, basic tolerance to pests and diseases and the farmers will be highly benefitted by cultivating this genotype.

G hirsutum Variety: CSH 3129 (CICR-H Cotton 29)

Developer(s): S. L. Ahuja, Dilip Monga, O. P. Tuteja, S. K. Verma, R. A. Meena, Rishi Kumar, Ram Chander, Hamid Hassan

Year of Development: 2017

Brief description of the technology

Parameter	Details
Variety	CSH-3129
Recommended Area	Entire North Zone (Haryana, Punjab, Rajasthan) under irrigated conditions
Parentage	LH-1954 × CISV-24
Breeding Method	Hybridization followed by pedigree selection
Mean Seed Cotton Yield	2293.2 kg/ha
Yield Potential	33.79 q/ha
Yield Advantage	—
Ginning Outturn (GOT)	34.1%
Boll Weight	3.6 g
Staple Length	29.55 mm
Fibre Strength	23.15 g/tex
Micronaire	4.33
Spinning Capacity	Up to 40s count
Pest and Disease Reaction	Tolerant to major biotic stresses
Release Details	Released by CVRC (2017); Gazette Notification No. S.O. 1007(E), dated 30th March 2017

Current Status: Nucleus and Breeder seeds of CSH 3129 are being produced at ICAR-CICR, RS, Sirsa.

Publication:

Chandra, S., Paul, D., Singh, A., Sain, S. K., Kumar, R. and Prasad, Y. G. 2023. Improved varieties of desi cotton and american cotton developed by Central Cotton Research Institute, Regional Station, Sirsa CICR-Leaflet 2023/7 *(Hindi)*

G. hirsutum Variety: CSH 3075 (CICR-H Cotton 30)

Developer(s): S. L. Ahuja, K. R. Kranti, Dilip Monga, R. A. Meena, Rishi Kumar, Sarfraz Ahmad, Ram Chander and Mahender Singh

Year of Development: 2017

Brief description of the technology

Parameter	Details
Variety	CSH-3075
Recommended Area	Entire North Zone (Haryana, Punjab, Rajasthan) under irrigated conditions
Parentage	Biyani-251 × RS-875
Breeding Method	Hybridization followed by pedigree selection
Mean Seed Cotton Yield	2467.33 kg/ha
Yield Potential	38.31 q/ha
Ginning Outturn (GOT)	35.5%
Boll Weight	3.27 g
Oil Content	20.87%
Plant Height	144.57 cm
2.5% Span Length	26.70 mm
Fibre Strength	21.60 g/tex
Micronaire	4.13
Pest and Disease Reaction	Tolerant to major biotic stresses
Release Details	Released by CVRC; Gazette Notification No. S.O. 1007(E), dated 30th March 2017

Current Status: Nucleus and Breeder seeds of CSH 3075 are being produced at ICAR-CICR, RS, Sirsa.

Publication: Chandra, S., Paul, D., Singh, A., Sain, S. K., Kumar, R. and Prasad, Y. G. 2023. Improved varieties of desi cotton and american cotton developed by Central Cotton Research Institute, Regional Station, Sirsa CICR-Leaflet 2023/7*(Hindi)*

G. hirsutum variety: Central Cotton CCH 4474 (Subiksha)

Developer(s): Sh. K.N. Gururajan, Dr. S. Manickam, Sh. J.W. Raja

Year of release: 2018

Brief description of the technology:

- The high strength good quality variety Central Cotton CCH 4474 (Subiksha) has recorded a mean seed cotton yield of 1542 kg/ha under conventional spacing in irrigated conditions in South Zone States of Karnataka, Andhra Pradesh, Telangana and Tamil Nadu.
- The variety was found to be compact and yield better under closer with yield potential of 4201 kg/ha.
- In the large-scale demonstration trial at ICAR-CICR, Regional Station, Coimbatore, the variety recorded higher seed cotton yield of 2800 with good fibre quality as compared to the other long staple varieties viz., Surabhi and Suraj.
- The variety recorded a mean Ginning Out turn of 35.4 per cent. Because of the higher ginning out turn, the variety recorded higher lint yield.
- The variety has a 2.5 % Span length of 32.4 mm, Micronaire of 3.6 in the spinning test in ICC mode and Upper Half Mean Length of 32.7 mm, Micronaire of 3.7 and Tenacity of 33.8 g/tex in the spinning test in HVI mode.
- The variety recorded a CSP value of 2376 in 50s count and 2322 in 60s count and was found to spin up to 60s count yarn.
- The variety showed on par incidence vis-à-vis check varieties for majority of diseases.
- It showed field tolerance to jassids.
- It showed on par incidence vis-à-vis check varieties for sucking pests.
- The variety combines high yield potential under closer spacing, better ginning outturn, basic tolerance to pests and diseases and the farmers will be highly benefitted by cultivating this genotype.

G. hirsutum variety: Central Cotton CCH 12-2 (Suchitra)

Developer(s): Dr. S. Manickam, Sh. J.W. Raja

Year of release: 2018

Brief description of the technology:

- The high yielding good quality variety Central Cotton CCH 12-2 recorded a mean seed cotton yield of 1767 kg/ha under irrigated condition in Central Zone States of Maharashtra, Madhya Pradesh, and Gujarat.
- The variety has a yield potential of 2598 kg/ha.
- The variety recorded an Upper Half Mean length of 28.0 mm, Micronaire of 4.2 and tenacity of 29.0 in HVI mode matching the CIRCOT norm for 30s count yarn.
- The variety recorded a mean boll weight of 3.7 g/boll.
- The variety showed on par incidence vis-à-vis check varieties for majority of pest and diseases.
- The variety was tolerant to grey mildew and moderately tolerant to jassids.
- The variety combines high yield potential, big boll size and basic tolerance to pests and diseases and the farmers will be highly benefitted by cultivating this genotype.

G. hirsutum variety: Central Cotton CCH 14-1 (Sunantha)

Developer(s): Dr. S. Manickam, Sh. J. W. Raja

Year of release: 2020

Brief description of the technology:

- The good quality long staple hirsutum variety Central Cotton CCH 14-1 (Sunantha) recorded a mean seed cotton yield of 1688 kg/ha under irrigated condition in South Zone States of Karnataka, Andhra Pradesh, Telangana and Tamil Nadu.
- The variety has a yield potential of 3675 kg/ha.
- The variety showed yield superiority in closer spacing with 125% RDF.
- The variety registered high ginning outturn of 34.2%.
- The variety combined an excellent fibre quality combination viz., Upper Half Mean length of 32.0 mm, Micronaire of 3.7 and tenacity of 32.7 g/tex in HVI mode and 2.5 % Span length of 32.8 mm, Micronaire of 3.6 and tenacity of 24.1 g/tex in ICC Mode matching the CIRCOT norm for 50s count yarn.
- The variety recorded a mean boll weight of 4.5 g/boll.
- The variety is resistant to Bacterial Leaf Blight, Grey Mildew and Tobacco Streak Virus and Immune to Root Rot.
- The variety is tolerant / resistant to jassids, white fly, thrips, aphids and stem weevil.
- The variety combines moderate yield potential and basic tolerance to pests and diseases and the farmers will be highly benefitted by cultivating this genotype.

G. arboreum variety: CICR CNA 1028 (CICR-A Cotton 34)

Developer (s): Dr. V.N. Waghmare, Shri. R.V. Salame

Year of Release: 2020

Brief description of the technology:

Parameter	Details
Species	Gossypium arboreum
Parentage	Selection from random mating population
Breeding Methodology	Population Improvement
Notification Number	S.O. 3482 (E)
Developed at	ICAR – Central Institute for Cotton Research, Nagpur
Area for Adoption	Central Zone (Maharashtra, Gujarat and Madhya Pradesh)
Bolls Character	Boll weight of 2.5 g
Special Traits of Importance	Jassids tolerant. Recorded less damage by diseases and pests.
Fibre Colour	White
Fibre Length	25.9 mm
Fibre Strength	30.9 g/tex
Fineness (Micronaire)	5.2 µg/inch
Uniformity	81%
Spinnability	30s and 40s Count
Ginning Out Turn	34.23%
Yield Potential	46 q/ha

G. arboreum variety: CICR CNA 1032 (CICR-A Cotton 35)

Developer (s): Dr. V.N. Waghmare, Shri. R.V. Salame

Year of Release: 2020

Brief description of the technology:

Parameter	Details
Species	Gossypium arboreum
Parentage	Selection from random mating population
Breeding Methodology	Population Improvement
Notification Number	S.O. 3482 (E)
Developed at	ICAR – Central Institute for Cotton Research, Nagpur
Area for Adoption	Central Zone (Maharashtra, Gujarat and Madhya Pradesh); Haryana
Habit	Medium tall (150–170 cm), Early maturing (150–160 days) and near synchronous in boll bursting
Bolls Character	Boll weight of 2.5 g
Special Traits of Importance	Identified as Jassids tolerant and recorded less damage by diseases and pests. High Seed Cotton Yield and Long staple arboreums. The variety **CNA 1032** shall be an ideal choice to the farmers of Central Zone on account of its superiority in yield and fibre quality.
Fibre Colour	White
Fibre Length	28.7 mm
Fibre Strength	27.9 g/tex
Fineness (Micronaire)	5.7 µg/inch
Uniformity	81%
Spinnability	30s and 40s Count
Ginning Out Turn	34%
Yield Potential	10–27 q/ha

G. hirsutum variety: CICR-H Cotton 36 (Suraksha)

Developer(s): Dr. S. Manickam, Sh. J.W. Raja

Year of release: 2021

Brief description of the technology:

- CICR-H Cotton 36 (Suraksha), the excellent fibre quality extra long staple hirsutum variety, recorded a mean seed cotton yield of 1598 kg/ha in South Zone and 1372 kg/ha in Central Zone under irrigated condition.
- The variety has an yield potential of 4019 kg/ha in South Zone, and 2235 kg/ha in Central Zone.
- The variety showed yield superiority in closer spacing with 125% RDF in agronomic study.
- The variety combined an excellent fibre quality in all the trials in both South and Central Zone locations. It has been rated as one of the best entry for fibre quality in both south and central zone.
- The average values of Upper Half Mean length of 32.4 mm, Micronaire of 3.7 and tenacity of 34.3 g/tex in HVI mode in South Zone and Upper Half Mean length of 31.9 mm, Micronaire of 4.4 and tenacity of 33.5 g/tex in HVI mode in Central Zone indicates its superiority.
- The highest value of Upper Half Mean length recorded was 34.5 mm and the highest tenacity recorded was 40.9 g/tex.
- The variety had a mean boll weight of 4.2 g/boll in South Zone and 4.0 g/boll in Central Zone.
- The variety is resistant to Bacterial Leaf Blight, Grey Mildew, Root rot, Tobacco Streak Virus, Tolerant to Alternaria Leaf Spot, Rust and Tobacco Streak Virus and Immune to Root Rot.
- CICR-H Cotton 36 (Suraksha) has been confirmed and maintained as Alternaria Leaf Blight resistant line with disease grade of 1.0 at Rahuri.
- The variety is tolerant / resistant to Jassids, White Fly, Thrips, Aphids, and Mirid Bug.
- CICR-H Cotton 36 (Suraksha) has been listed as Leaf hopper tolerant culture in both the zones.
- The variety CICR-H Cotton 36 (Suraksha) combines high yield potential in closer spacing with excellent combination of fibre quality characters and resistance to pests and diseases and the farmers will be highly benefitted by cultivating this variety.

G. barbadense Variety: CICR B Cotton 37 (CCB 51)

Developer(s): Dr. KPM. Dhamayanthi, Dr. K. Rathinavel, A. Dr. Manivannan, K. Subhashree.
ICAR-Central Institute for Cotton Research Regional Station, Coimbatore, Tamil Nadu 641003.

Year of release: 2023

Brief description of the variety:
CICR B Cotton 37 is a new Extra Long Staple (ELS) Cotton (Gossypium *barbadense* L.) variety developed by ICAR-Central Institute for Cotton Research (ICAR-CICR), Regional Station, Coimbatore. CICR B Cotton 37 has been released and notified by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties of Agricultural Crops, Department of Agriculture, Cooperation & Family Welfare, Government of India, New Delhi vide Notification number S. O. 2986 (E) dated July 20, 2021 for cultivation in Telangana State, Andhra Pradesh, Karnataka and Tamil Nadu. CICR B Cotton 37 was developed from a backcross of Suvin × (Suvin × Giza-70) and it was tested in AICRP on cotton in *kharif* seasons during 2016-17 to 2018-19 and recorded an overall superiority to Zonal check variety Suvin. It recorded mean seed cotton yield of 1237 kg/ha as against 1154 kg/ha of the Zonal check variety Suvin under irrigated condition. It has combined fibre quality combination *viz.,* Upper Half Mean Length of 34.7 mm, micronaire of 3.4 and tenacity of 36.6 g/tex in HVI mode. CICR B Cotton 37 which combines moderate yield potential and better-quality parameters with basic tolerance to pests and diseases. The salient features of this variety are high yield, more tolerant to sucking pests with better fibre qualities. Considering its better yield and fibre qualities, this variety gains preference among the cotton farmers in the South Zone of India especially for its Extra Long Staple (ELS) category.

G. barbadense Variety: CICR B Cotton 45 (CCB 143B)

Developer(s): Dr. KPM. Dhamayanthi, Dr. K. Rathinavel, A. Dr. Manivannan. ICAR-Central Institute for Cotton Research Regional Station, Coimbatore, Tamil Nadu 641003.

Year of release: 2021

Brief description of the variety:

Extra-Long Staple (ELS) cotton typically denotes a cotton fibre of extraordinary fibre length of 32.5mm and above. As well as fibre length, ELS cottons are also recognized for their superior strength and better uniformity. It is in great demand world over for the manufacture of high-quality ring spun yarns. The promising end uses of ELS category are sewing thread, loom yarns, blend with polyester firbes and high-quality fabrics. Among the cultivated cotton species, *Gossypium barbadense* L. known for its superior fibre traits and considered as premium ELS cotton. CICR B Cotton 45 is an ELS cotton variety of G. *barbadense* developed by ICAR-Central Institute for Cotton Research (CICR), Regional Station, Coimbatore. It has been rigorously evaluated with the name of CCB 143B in All India Co-ordinated Research Project on Cotton from 2018 to 2020 under irrigated trials of South Zone comprises of Tamil Nadu, Karnataka and Andhra Pradesh. It was developed by the pedigree breeding method from the progeny of Suvin × (Suvin × Giza-70). It recorded the mean seed cotton yield of 1462 kg/ha as against 1197 kg/ha of Zonal check variety Suvin under irrigated conditions. However, it showed the yield potential up to 18 q/ha under ideal conditions. It has the firbe quality traits of Upper Half Mean Length of 37 mm, micronaire of 3.7 and tenacity of 40.8 g/tex in HVI mode. CICR B Cotton 45 has been released and notified vide Gazette notification dated 24th December, 2021; S.O. 8 (E) for the states Andhra Pradesh, Telangana, Karnataka, and Tamil Nadu. The ELS Cotton variety, CICR B Cotton 45 that combines higher yield potential and better-quality parameters. This variety gains preference among the cotton farmers in the South Zone of India especially for its premium Extra Long Staple (ELS) category.

G. arboreum variety: CICR-A Cotton 46 (CNA 1054)

Developer(s): Dr. V.N. Waghmare, Shri. R.V. Salame

Year of Release: 2021

Brief description of the technology:

Parameter	Details
Species	Gossypium arboreum
Parentage	Selection from Random Mating Population
Breeding Methodology	Random mating – Population Improvement
Notification Number	S.O. 8 (E)
Developed at	ICAR – Central Institute for Cotton Research, Nagpur
Area for Adoption	Central Zone under Rainfed conditions
Habit	Tall erect plants
Leaf	Deeply palmate, green flat leaves
Flower	Yellow
Pollen	Yellow
Petal Spot	Prominent petal spot present
Bolls Character	Green, conical to oval pitted bolls
Special Traits of Importance	Shattering tolerance, and tolerant to major diseases of Cotton.
Fibre Colour	White
Fibre Length	26.9 mm
Fibre Strength	28.3 g/tex
Fineness (Micronaire)	5.7 µg/inch
Uniformity	84%
Spinnability	20–30s
Ginning Out Turn	34.87%
Yield Potential	14.32 q/ha

G. hirsutum variety: CICR-H Cotton 47 (CNH 1111)

Developer(s): Dr. V.N. Waghmare, Shri. R.V. Salame

Year of Release: 2021

Brief description of the technology:

Parameter	Details
Species	Gossypium hirsutum
Parentage	Selection from Random Mating Population
Breeding Methodology	Random mating – Population Improvement
Notification Number	S.O. 8 (E)
Developed at	ICAR – Central Institute for Cotton Research, Nagpur
Area for Adoption	Central Zone (Maharashtra, Gujarat, Madhya Pradesh and Odisha) under Rainfed conditions
Habit	Tall, erect type plants
Leaf	Green, flat leaves
Flower	Yellow
Pollen	Yellow
Petal Spot	Absent
Bolls Character	Green, ovate, smooth or finely pitted bolls
Special Traits of Importance	Suitable for timely and late sown conditions. Jassids tolerant variety. High yield potential, responsive to fertigation, suitable for timely and late sown conditions.
Fibre Colour	White
Fibre Length	26.5–28.1 mm
Fibre Strength	28.4–29.1 g/tex
Fineness (Micronaire)	4.3–4.8 µg/inch
Uniformity	84%
Spinnability	20–30s Count
Ginning Out Turn	33.8%
Yield Potential	14.07 q/ha

G. hirsutum variety: CICR-H Cotton 48 (CNH 1128)

Developer(s): Dr. V.N. Waghmare, Shri. R.V. Salame

Year of Release: 2021

Brief description of the technology:

Parameter	Details
Species	Gossypium hirsutum
Parentage	Selection from Random Mating Population
Breeding Methodology	Random mating – Population Improvement
Notification Number	S.O. 8 (E)
Developed at	ICAR – Central Institute for Cotton Research, Nagpur
Area for Adoption	South Zone (Tamil Nadu, Karnataka, Andhra Pradesh and Telangana)
Habit	Tall, erect and compact type
Leaf	Green, flat leaves
Flower	Yellow
Pollen	Yellow
Petal Spot	Absent
Bolls Character	Green, round pitted bolls
Special Traits of Importance	Suitable for timely and late sown conditions. Jassids tolerant variety.
Fibre Colour	White
Fibre Length	28.6 mm
Fibre Strength	27.5 g/tex
Fineness (Micronaire)	4.4 µg/inch
Uniformity	85%
Spinnability	30–40s Count
Ginning Out Turn	34.5 %
Yield Potential	13.99 q/ha

Naturally Colour Cotton Variety: Vaidehi-1 (CICR- H NC Cotton 53)

Year of Development: 2021

Developer(s): Vinita Gotmare[1]*, C Rodge[1], P Akhare[1], A Jaunjal[1], K Gajghate[1], SB Singh[1], [1]SM Palve[1], G Balasubramani[1], HB Santosh[2], M Saravanan[1],N Chandrashekar[1], R Pande[1], N Hiremani[1],VN Waghmare[1], KR Kranthi[3]

[1]ICAR-Central Institute for Cotton Research (CICR), Wardha Road, Nagpur 440040, Maharashtra, India; [2]ICAR - Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, Telangana, INDIA; [3]International Cotton Advisory Committee (ICAC), 1629-K street, NW, Suite 702, Washington DC-20006-1635, USA

Brief description of the technology:

Type: Naturally Coloured Cotton (NCC) – **dark brown lint** Multi-species introgressed reverted tetraploid (*G. hirsutum*, *G. raimondii*, *G. barbadense*, *G. thurberi)*

Parameter	Details
Release	ICAR–AICRP on Cotton for South Zone rainfed conditions (Telangana, Andhra Pradesh, Karnataka, Tamil Nadu)
Gazette Notification	S.O. 8(E), dated 24 Dec 2021 (S. No. 275)
Special Feature	Stable dark brown lint colour derived from wild species
Average Yield	1495 kg/ha (~15 q/ha)
Potential Yield	2723 kg/ha (Nandyal, 2019–20)
Fibre Length	23.8 mm
Fibre Strength	25.1 g/tex
Micronaire	4.1 µg/in
Boll Weight	3.73 g
Ginning Outturn (GOT)	35.0%
Plant Height	130–140 cm
Maturity Duration	160–165 days
Pest & Disease Tolerance	Moderately tolerant to sucking pests, Corynespora leaf spot and rust
Disease Resistance	Resistant to Alternaria leaf spot

G. hirsutum variety: CICR-H Cotton 54 (Nano)

Developer(s): Dr. S. Manickam, Dr. R. Raja, Dr. A.H. Prakash, Dr. J. Gulsar Banu, Sh. J.W. Raja

Year of release: 2022

Brief description of the technology:

- CICR-H Cotton 54 (Nano), the compact cotton hirsutum variety with ideal plant type for High Density Planting System (HDPS), recorded a mean seed cotton yield of 2123 kg/ha in South Zone (irrigated) 1469 kg/ha in South Zone (rainfed) and 1815 kg/ha in Central Zone (irrigated condition).
- The variety has a yield potential of 2859 kg/ha in South Zone (irrigated), 2381 kg/ha in South Zone (Rainfed) and 2963 kg/ha in Central Zone locations (Irrigated).
- The variety showed yield superiority in closer spacing at 90 x 10 cm with the spray of Mepiquat Chloride in agronomic study.
- The variety has combined an excellent fibre quality combination in both South and Central Zone locations.
- The average values of Upper Half Mean length of 30.8 mm, Micronaire of 4.1 and tenacity of 30.8 g/tex in HVI mode in South Zone (Irrigated), Upper Half Mean length of 29.4 mm, Micronaire of 3.9 and tenacity of 30.4 g/tex in HVI mode in South Zone (Rainfed) and Upper Half Mean length of 30.1 mm, Micronaire of 3.7 and tenacity of 30.2 g/tex in HVI mode in Central Zone (Irrigated) indicates its superiority.
- The highest value of Upper Half Mean length recorded was 33.7 mm and the highest tenacity recorded was 35.5 g/tex.
- The variety had a mean boll weight of 4.7 g/boll in South Zone (Irrigated), 4.1 g/boll in South Zone (Rainfed) and 3.4 g/boll in Central Zone locations (Irrigated).
- The variety is resistant to Bacterial Leaf Blight, Alternaria Leaf Spot, Myrothecium Leaf Spot, Rust, Moderately resistant to Grey Mildew, and Immune to Root Rot.
- The variety is tolerant / resistant to Jassids, White Fly, Thrips, Aphids, and Mirid Bug.
- The variety CICR-H Cotton 54 (Nano) combines good yield potential with ideal plant type for HDPS and basic tolerance to pests and diseases and the farmers will be highly benefitted by cultivating this genotype.

G. arboreum variety: CICR-A Cotton 56 (CNA 1031)

Developer and Associates: Dr. V.N. Waghmare; Shri. R.V. Salame

Year of Release: 2020

Brief description of the technology:

Parameter	Details
Species	Gossypium arboreum
Parentage	Selection from random mating population
Breeding Methodology	Population Improvement
Notification Number	S.O. 3482 (E)
Developed at	ICAR – Central Institute for Cotton Research, Nagpur
Area for Adoption	Central Zone (Maharashtra, Gujarat and Madhya Pradesh)
Bolls Character	Boll weight of ---- g
Special Traits of Importance	Jassids tolerant. Recorded less damage by diseases and pests.
Fibre Colour	White
Fibre Length	25.2 mm
Fibre Strength	28.2 g/tex
Fineness (Micronaire)	5.2 µg/inch
Uniformity	84%
Spinnability	30s and 40s Count
Ginning Out Turn	34.23%
Yield	14 q/ha

G. arboreum variety: CICR-A NC Cotton 57 (CNA 1091)

Developer and Associates: Dr. V.N. Waghmare; Shri. R.V. Salame

Year of Release: 2022

Brief description of the technology:

Parameter	Details
Species	Gossypium arboreum
Parentage	Selection from Random Mating Population
Breeding Methodology	Random mating – Population Improvement
Notification Number	S.O. 4065 (E)
Developed at	ICAR – Central Institute for Cotton Research, Nagpur
Area for Adoption	Central Zone under Rainfed conditions
Habit	Tall erect plants
Leaf	Deeply palmate, green flat leaves
Flower	Yellow
Pollen	Yellow
Petal Spot	Prominent petal spot present
Bolls Character	Green, conical to oval pitted bolls
Special Traits of Importance	Shattering tolerance, and tolerant to major diseases of Cotton.
Fibre Colour	White
Fibre Length	24.5 mm
Fibre Strength	23.3 g/tex
Fineness (Micronaire)	5.2 µg/inch
Uniformity	82.2 %
Spinnability	20 s
Ginning Out Turn	32.9 %
Yield Potential	26 q/ha

Bt Cotton Variety: CICR Bt 6 (CICR-H Cotton 38)

Developer(s): O.P.Tuteja, K. R. Kranthi, Dilip Monga, Sandhya Kranthi, Rishi Kumar, R. A. Meena, Suresh Kumar

Year of Development: 2020

Brief description of the technology

Parameter	Details
Developed at	ICAR–CICR, Regional Station, Sirsa
Type	Bt cotton variety (non-hybrid)
Zone	North Zone (Haryana, Punjab, Rajasthan)
Condition	Irrigated, suitable for HDPS
Gazette Notification	S.O. 3482 (E), dated 07 October 2020
Parentage	RS 2013 × BN Bt
Breeding Method	Backcross breeding + pedigree method
Average Yield	2234 kg/ha (AICRP, 2016–17, 2 locations)
Potential Yield	3046 kg/ha (under HDPS)
Ginning Outturn (GOT)	36.2–36.9%
Fibre Length (UHML)	26.1 mm
Fibre Strength	26.6 g/tex
Micronaire	4.7 µg/in
Special Suitability	Areas prone to parawilt
Pest/Disease Reaction	Moderately resistant to Cotton Leaf Curl Disease (CLCuD)
Special Feature	Suitable for HDPS cultivation

Current status: Nucleus and Breeder seeds of CICR *Bt* 6 are being produced at ICAR-CICR, RS, Sirsa.

Publication:

Chandra, S., Paul, D., Singh, A., Sain, S. K., Kumar, R. and Prasad, Y. G. 2023. Improved varieties of desi cotton and american cotton developed by Central Cotton Research Institute, Regional Station, Sirsa CICR-Leaflet 2023/7*(Hindi)*

Bt cotton variety: ICAR-CICR GJHV 374 Bt

Developer(s): Suman Bala Singh[1], K. R. Kranthi[1,2], Sandhya Kranthi[1,2], V. Santhy[1], K. P. Raghavendra[1], B. Fande[1], S. Bhave[1], U. Satija[1], A. H. Prakash[3], S. Manickam[3], Blaise Desouza[1], M. Saravanan[1], H. B. Santosh[1] and M. D. Khanpara[4]
[1]ICAR-Central Institute for Cotton Research (CICR), Wardha Road, Nagpur 440040, Maharashtra, India; [2]International Cotton Advisory Committee (ICAC), Washington DC, USA; [3]ICAR-Central Institute for Cotton Research (CICR), Regional Station, Coimbatore, Tamil Nadu, India; [4]Junagadh Agricultural University (JAU), Jamnagar, Gujarat, India.

Year of release: 2020

Brief description of the technology:

Parameter	Details
Type	Bt cotton variety (non-hybrid)
Recommended Area	Rainfed conditions of Maharashtra
Gazette Notification	S.O. 3482 (E), dated 07 October 2020 (S. No. 164)
Parentage	GJHV 374 × Bikaneri Narma Bt
Average Yield	2578 kg/ha
Potential Yield	2754 kg/ha (Nagpur, 2016–17)
Plant Height	119.5 cm
Boll Weight	4.2 g
Ginning Outturn (GOT)	31.6%
Crop Duration	160–170 days
Fibre Length	28.2 mm
Fibre Strength	26.8 g/tex
Micronaire	4.4 µg/in
Uniformity Index	83.1%
Cry1Ac Expression	Up to 5.63 ppm (in leaves)
Bioassay Result	100% mortality of *Helicoverpa armigera*
Pest Resistance	Excellent protection against American bollworm

Publication: Singh SB, Kranthi KR, Kranthi S, Santhy V, Raghavendra KP, Fande B, Bhave S, Satija U, Prakash AH, Manickam S, D Blaise, Saravanan M, Santosh HB and Khanpara MD (2023) Notification and germplasm registration - Bt cotton variety: ICAR-CICR GJHV 374 Bt, *Indian Journal of Genetics and Plant Breeding,* 83(3): 450.

Bt cotton variety: ICAR-CICR PKV 081 Bt

Developer(s): Suman Bala Singh[1], K. R. Kranthi[1,2], Sandhya Kranthi[1,2], V. N. Waghmare[1], K. P. Raghavendra[1], Punit Mohan[1], B. Fande[1], P. R. Vijayakumari[1], H. B. Santosh[1], T. H. Rathod[3] and V. V. Ujjainkar[3]
[1]ICAR-Central Institute for Cotton Research (CICR), Wardha Road, Nagpur 440040, Maharashtra, India; [2]International Cotton Advisory Committee (ICAC), Washington DC, USA; [3]Dr. PDKV, Akola, Maharashtra India.

Year of release: 2020 & 2024

Brief description of the technology:

Parameter	Details
Type	Bt cotton variety (introgressed from PKV081)
Recommended Area	Rainfed conditions of Maharashtra
Gazette Notification	S.O. 3482 (E), dated 07 October 2020 (S. No. 161)
Parentage	PKV081 × Bikaneri Narma Bt
Average Yield	2744 kg/ha
Potential Yield	2874 kg/ha (Akola, AICRP trial)
Plant Height	121.3 cm
Boll Weight	3.4 g
Ginning Outturn (GOT)	35.1%
Crop Duration	140–150 days
Fibre Length	28.5 mm
Fibre Strength	27.9 g/tex
Micronaire	3.9 µg/in
Uniformity Index	82.8%
Cry1Ac Expression	Up to 6.95 ppm (in leaves)
Bioassay Result	100% mortality of *Helicoverpa armigera*
Pest Resistance	Excellent protection against American bollworm

Publication: Singh SB, Kranthi KR, Kranthi S, Waghmare VN, Raghavendra KP, Mohan P, Fande B, Vijayakumari PR, Santosh HB, Rathod TH and Ujjainkar VV (2023) Notification and germplasm registration - Bt cotton variety: ICAR-CICR PKV 081 Bt, *Indian Journal of Genetics and Plant Breeding,* 83(3): 451.

Bt cotton variety: ICAR-CICR Rajat Bt

Developer(s): Suman Bala Singh[1*], K. R. Kranthi[1,2], Sandhya Kranthi[1,2], B. Fande[1], S. S. Mahajan[1], V. Gotmare[1], G. Balasubramani[1], T. R. Lokanthan[1], S. B. Nandeshwar[1], T. H. Rathod[3] and V. V. Ujjainkar[3]
[1]ICAR-Central Institute for Cotton Research (CICR), Wardha Road, Nagpur 440040, Maharashtra, India; [2]International Cotton Advisory Committee (ICAC), Washington DC, USA; [3]Dr. PDKV, Akola, Maharashtra India.

Year of release: 2020

Brief description of the technology:

Parameter	Details
Type	Bt cotton variety (introgressed from PKV081)
Recommended Area	Rainfed conditions of Maharashtra
Gazette Notification	S.O. 3482 (E), dated 07 October 2020 (S. No. 161)
Parentage	PKV081 × Bikaneri Narma Bt
Breeding Method	Backcross breeding
Average Yield	2744 kg/ha
Potential Yield	2874 kg/ha (Akola, AICRP trial)
Plant Height	121.3 cm
Boll Weight	3.4 g
Ginning Outturn (GOT)	35.1%
Crop Duration	140–150 days
Fibre Length	28.5 mm
Fibre Strength	27.9 g/tex
Micronaire	3.9 µg/in
Uniformity Index	82.8%
Cry1Ac Expression	Up to 6.95 ppm (in leaves)
Bioassay Result	100% mortality of *Helicoverpa armigera*
Pest Resistance	Excellent protection against American bollworm

Publication: Singh SB, Kranthi KR, Kranthi S, Fande B, SS Mahajan, V. Gotmare, G. Balasubramani, T. R. Lokanthan, S.B. Nandeshwar, T. H. Rathod and V. V. Ujjainkar (2023) Notification and germplasm registration - Bt cotton variety: ICAR-CICR Rajat Bt, *Indian Journal of Genetics and Plant Breeding,* 83(3): 451.

Bt cotton variety: ICAR-CICR Suraj Bt

Developer(s): Suman Bala Singh[1], K. R. Kranthi[1,2], Sandhya Kranthi[1,2], V. N. Waghmare[1], K. P. Raghavendra[1], B. Fande[1], A. H. Prakash[3], S. Manickam[3], V. Santhy[1], H. B. Santosh[1], Joy Das[1]and Rakesh Kumar[1]
[1]ICAR-Central Institute for Cotton Research (CICR), Wardha Road, Nagpur 440040, Maharashtra, India; [2]International Cotton Advisory Committee (ICAC), Washington DC, USA; [3]ICAR-Central Institute for Cotton Research (CICR), Regional Station, Coimbatore, Tamil Nadu, India.

Year of release: 2020

Brief description of the technology:

Parameter	Details
Type	Bt cotton variety (introgressed from cv. Suraj)
Species	*Gossypium hirsutum*
Recommended Area	Rainfed conditions of Maharashtra
Gazette Notification	S.O. 3482 (E), dated 07 October 2020 (S. No. 164)
Parentage	Suraj × Bikaneri Narma Bt
Transgene Monitoring	Cry1Ac ELISA at each backcross generation
Average Yield	2528 kg/ha
Crop Duration	160–170 days
Plant Height	130 cm
Boll Weight	3.2 g
Ginning Outturn (GOT)	36.1%
Fibre Length	29.1 mm
Fibre Strength	26.0 g/tex
Micronaire	4.3 µg/in
Uniformity Index	82.9%
Cry Toxin Expression	Up to 6.72 ppm (in leaves)
Bioassay Result	100% mortality of *Helicoverpa armigera*

Publication: Singh SB, Kranthi KR, Kranthi S, Waghmare VN, Raghavendra KP, Fande B, Prakash AH, Manickam S, Santhy V, Santosh HB, Das J, Kumar R (2023) Notification and germplasm registration - Bt cotton variety: ICAR-CICR Suraj Bt, *Indian Journal of Genetics and Plant Breeding*, 83(3): 452.

Bt cotton variety: ICAR-CICR 16 Bt

Developer(s): Suman Bala Singh*, V. N. Waghmare, K. P. Raghavendra, B. Fande, H. B. Santosh, G. Balasubramani, V. Shah, D. Blaise, V. Santhy, J. Amudha and Ramkrushna G. I.
ICAR-Central Institute for Cotton Research (CICR), Wardha Road, Nagpur 440040, Maharashtra, India.

Year of release: 2020

Brief description of the technology:

Parameter	Details
Type	Bt cotton variety (introgressed from cv. Suraj)
Species	*Gossypium hirsutum*
Recommended Area	Rainfed conditions of Maharashtra
Gazette Notification	S.O. 3482 (E), dated 07 October 2020 (S. No. 164)
Parentage	Suraj × Bikaneri Narma Bt
Transgene Monitoring	Cry1Ac ELISA at each backcross generation
Average Yield	2528 kg/ha
Crop Duration	160–170 days
Plant Height	130 cm
Boll Weight	3.2 g
Ginning Outturn (GOT)	36.1%
Fibre Length	29.1 mm
Fibre Strength	26.0 g/tex
Micronaire	4.3 µg/in
Uniformity Index	82.9%
Cry Toxin Expression	Up to 6.72 ppm (in leaves)
Bioassay Result	100% mortality of *Helicoverpa armigera*

Publication: Singh SB, Waghmare VN, Raghavendra KP, Fande B, Santosh HB, Balasubramani G, Shah V, Blaise D, Santhy V, Amudha J, Ramkrushna GI (2023) Notification and germplasm registration - Bt cotton variety: ICAR-CICR 16 Bt, *Indian Journal of Genetics and Plant Breeding,* 83(3): 452

Bt cotton variety: ICAR-CICR 23 Bt

Developer(s): Suman Bala Singh[1], V. N. Waghmare[1], K. P. Raghavendra[1], B Fande[1], H. B. Santosh[1], G. Balasubramani[1], V Shah[1], D Blaise[1], S. Manickam[2] and K. Baghyalakshmi[2]
[1]ICAR-Central Institute for Cotton Research (CICR), Wardha Road, Nagpur 440040, Maharashtra, India; [2]ICAR-Central Institute for Cotton Research (CICR), Regional Station, Coimbatore, Tamil Nadu, India.

Year of release: 2020

Brief description of the technology:

Parameter	Details
Variety Name	ICAR–CICR 23 Bt
Type	Bt cotton variety (non-hybrid)
Developed at	ICAR–CICR
Recommended Area	Rainfed South Zone (Telangana, Andhra Pradesh, Karnataka, Tamil Nadu)
Gazette Notification	S.O. 3482 (E), dated 07 October 2020 (S. No. 159)
Parentage	CNDTS23 × Bikaneri Narma Bt
Average Yield	1459 kg/ha (AICRP trials, 2 years)
Lint Index	4.60 g (2017–18), 4.1 g (2018–19)
Ginning Outturn (GOT)	34.1%
Lint Yield	497.52 kg/ha
Fibre Length	27.6 mm
Fibre Strength	26.8 g/tex
Micronaire	3.7 µg/in
Uniformity Index	83.0%
Cry Protein Expression	~4.7 ppm (leaves at 120 DAS); 4.62–4.46 ppm (boll)
Bioassay Result	100% mortality of *Helicoverpa armigera*

Publication: Singh SB, Waghmare VN, Raghavendra KP, Fande B, Santosh HB, Shah V, Blaise D, Manickam S, Baghyalakshmi K (2023) Notification and germplasm registration - Bt cotton variety: ICAR-CICR 23 Bt, *Indian Journal of Genetics and Plant Breeding,* 83(3): 453.

Bt cotton variety: CICR-H Bt Cottons 49 (ICAR -CICR 9 Bt (SRI 1))

Developer(s): Dr. K. R. Kranthi

Helped in development: Dr. Sandhya Kranthi,Dr. Suman Bala Singh, Dr. S. Manickam, Dr. Rishi Kumar,Dr. Santhy V., Dr. G. Balasubramani, Dr KP Raghavendra, Dr. V.Chinna Babu Naik, Dr. Shailesh P Gawande, Ms. Usha Satija, Ms. Sheeba Ansari, Dr. A. H. Prakash

Year of release: 2021

Brief description of the technology:

Parameter	Details
Variety Name	ICAR -CICR 9 Bt (SRI 1)
Type	Bt cotton variety (non-hybrid)
Recommended Area	Rainfed, Maharashtra state
Gazette Notification	S.O. 8(E), dated 24 December 2021 (S. No. 310)
Parentage	G Cot 16 x BN Bt (MON531 Event)
Average Yield	3109 kg/ha
Potential Yield	3348 kg/ha
Crop Duration	150–170 days
Ginning Outturn (GOT)	36.3%
Seed Index	7.9g
Fibre Length	25.7 mm
Fibre Strength	25.5 g/tex
Micronaire	4.5 µg/in
Uniformity Index	81.2%
Cry Protein Expression	9.0 ppm @ 90 DAS on fresh weight basis
Bioassay Result	100 % mortality of *Helicoverpa armigera*
Special Feature	Responsive to fertilizers, Moderately resistant to lodging and shattering

Bt cotton variety: CICR-H Bt Cotton 50 (ICAR-CICR Bt 14 (CPT 2))

Developer(s): Dr. K. R. Kranthi

Helped in development by: Dr. Sandhya Kranthi, Dr. Suman Bala Singh, Dr. S. Manickam, Dr. B. Dharajothi, Dr. Santhy V. Dr. G. Balasubramani, Dr. Blaise Desouza, Dr K. P. Raghavendra, Dr. V. Chinna Babu Naik, Dr. Neelakanth S Hiremani, Dr. Dipak T. Nagrale, Ms. Suvarna Khadakkar, Dr. A. H. Prakash

Year of release: 2021

Brief description of the technology:

Parameter	Details
Variety Name	ICAR-CICR Bt 14 (CPT 2)
Type	Bt cotton variety (non-hybrid)
Recommended Area	Rainfed, Maharashtra state
Gazette Notification	S.O. 8(E), dated 24 December 2021 (S. No. 311)
Parentage	G 67 x BN Bt (MON531)
Average Yield	3066 kg/ha
Potential Yield	3451 kg/ha
Crop Duration	160–170 days
Ginning Outturn (GOT)	34.4%
Seed Index	6.0 g
Fibre Length	28.1 mm
Fibre Strength	25.4 g/tex
Micronaire	4.8 µg/in
Uniformity Index	82.4%
Cry Protein Expression	4.77 ppm @ 90 DAS on fresh weight basis
Bioassay Result	100 % mortality of *Helicoverpa armigera*
Special Feature	Long Staple Category, Resistance to major pest and disease

Bt cotton variety: ICAR-CICR 21 Bt

Developer(s): Suman Bala Singh[1], H. B. Santosh[1], K. R. Kranthi[2], Y. G. Prasad[1], V. N. Waghmare[1], K. P. Raghavendra[1], G. Balasubramani[1], Vivek Shah[1], B Fande[1], V Gotmare[1], P. R. Vijaykumari[1], G. I. Ramkrushna[1], D. T. Nagrale[1]
[1]ICAR-Central Institute for Cotton Research (CICR), Nagpur, Maharashtra, India; [2]International Cotton Advisory Committee (ICAC), Washington DC, USA.

Year of release: 2021

Brief description of the technology:

Parameter	Details
Variety Name	ICAR–CICR 21 Bt
Type	Bt cotton variety (non-hybrid)
Gazette Notification	S.O. 8(E), dated 24 December 2021 (S. No. 312)
Parentage	CNDTS21 × Bikaneri Narma Bt
Average Yield	997 kg/ha (3-year AICRP trials)
Potential Yield	2715 kg/ha (Nagpur, 2019–20)
Crop Duration	150–160 days
Lint Index	4.2 g
Ginning Outturn (GOT)	34.9%
Fibre Length	27.17 mm
Fibre Strength	27.8 g/tex
Micronaire	4.27 µg/in
Pest/Disease Reaction	Good tolerance to major pests and diseases
Cry Protein Expression	Up to 8.92 ppm (leaf at 60 DAS)
Bioassay Result	99% mortality of *Helicoverpa armigera*
Special Feature	Suitable for HDPS under rainfed conditions
Benefit	Enhances productivity in central zone rainfed cotton

.

Publication: SB Singh, Santosh HB, Kranthi KR, Prasad YG, Waghmare VN, Raghavendra KP, Balasubramani G, Shah V, Fande B, Gotmare V, Vijayakumari PR, Ramkrushna GI, Nagrale DT (2024) Notification and germplasm registration - Bt cotton variety: ICAR-CICR 21 Bt, *Indian Journal of Genetics and Plant Breeding,* 84(1): 139.

Bt cotton variety: ICAR-CICR 25 Bt

Developer(s): Suman Bala Singh[1], H. B. Santosh[1], K. R. Kranthi[2], G. Balasubramani[1], B Fande[1], V Shah[1], G. I. Ramkrushna[1], A. H. Prakash[3], S. Manickam[3], K. Baghyalakshmi[3], V. Santhy[1], K. Gaikwad[1] and S. Gawande[1]

[1]ICAR-Central Institute for Cotton Research (CICR), Wardha Road, Nagpur, Maharashtra, India; [2]International Cotton Advisory Committee (ICAC), Washington DC, USA; [3]ICAR-Central Institute for Cotton Research (CICR), Regional Station, Coimbatore, Tamil Nadu, India.

Year of release: 2021

Brief description of the technology:

Parameter	Details
Variety Name	ICAR–CICR 25 Bt
Type	Bt cotton variety (non-hybrid)
Recommended Area	Rainfed South Zone (Tamil Nadu, Karnataka, Telangana, Andhra Pradesh)
Gazette Notification	S.O. 8(E), dated 24 December 2021 (S. No. 313)
Parentage	CNDTS 25 × Bikaneri Narma Bt
Average Yield	1575.68 kg/ha
Zonal Check Yield	1379 kg/ha (Sahana, non-Bt)
Potential Yield	2325 kg/ha (Mudhole, 2020–21)
Yield Advantage	Higher than non-Bt zonal check
Crop Duration	150–160 days
Ginning Outturn (GOT)	35.4%
Lint Index	4.37 g
Seed Index	8.37 g
Fibre Length	27.0 mm
Fibre Strength	26.4 g/tex
Micronaire	4.0 µg/in
Uniformity Index	82.0%
Cry Protein Expression	4.31 ppm (90 DAS), 4.14 ppm (60 DAS)
Bioassay Result	~95% mortality of *Helicoverpa armigera*
Special Feature	Suitable for HDPS and conventional spacing

Publication: SB Singh, Santosh HB, Kranthi KR, Balasubramani G, Raghavendra KP, Fande B, Shah V, Ramkrushna GI, Prakash AH, Manickam S, Baghyalakshmi K, Santhy V, Gaikwad KG, Gawande SP (2024) Notification and germplasm registration - Bt cotton variety: ICAR-CICR 25 Bt, *Indian Journal of Genetics and Plant Breeding,* 84(1): 139-140.

Bt cotton variety: Yugank Bt (CICR-H Bt Cotton 60)

Developer(s): HB Santosh[1], S Manickam[2], SB Singh[1], VN Waghmare[1], KP Raghavendra[1], Vivek Shah[1], KR Kranthi[3], Kunal Gaikwad[1], SS Patil[4]

[1]ICAR-Central Institute for Cotton Research (CICR), Nagpur, Maharashtra, INDIA; [2]ICAR-Central Institute for Cotton Research (CICR) Regional Station, Coimbatore, Tamil Nadu, INDIA; [3]International Cotton Advisory Committee (ICAC), Washington DC, USA; [4]University of Agricultural Sciences, Dharwad, Karnataka, INDIA.

Year of release: 2022

Brief description of the technology:

Parameter	Details
Variety Name	Yugank Bt
Type	Bt cotton variety (non-hybrid), early maturing & compact
Recommended Area	Rainfed Central Zone (Maharashtra, Madhya Pradesh, Gujarat)
Gazette Notification	S.O. 4065(E), dated 31 August 2022 (S. No. 176)
Parentage	(Bikaneri Narma Bt × RCRSC7) × (RCRSC2 × RCRSC12)
Transgene	cry1Ac gene (MON531 event)
Average Yield	12.65 q/ha (~1265 kg/ha)
Potential Yield	22.1 q/ha (~2210 kg/ha) at Surat (2020–21)
Crop Duration	140–150 days (early maturing)
Plant Type	Compact, suitable for HDPS & mechanized harvesting
Boll Weight	3.4 g
Lint Index	4.8
Seed Index	7.8
Fibre Length	24.8 mm
Fibre Strength	25.7 g/tex
Micronaire	5.43
Uniformity Index	82.87

Publication: Santosh HB, S. Manickam, S.B. Singh, V.N. Waghmare, K.P. Raghavendra, V. Shah, K.R. Kranthi, K. Gaikwad and S.S. Patil (2024) Notification and germplasm registration - Bt cotton variety: Yugank Bt (CICR-H Bt Cotton 60), Indian Journal of Genetics and Plant Breeding, 84(4): 739-740.

Bt cotton variety: Tejas Bt (CICR-H Bt Cotton 61)

Developer(s): HB Santosh[1], S Manickam[2], SB Singh[1], VN Waghmare[1], KP Raghavendra[1], Vivek Shah[1], KR Kranthi[3], Kunal Gaikwad[1], SS Patil[4]

[1]ICAR-Central Institute for Cotton Research (CICR), Nagpur, Maharashtra, INDIA; [2]ICAR-Central Institute for Cotton Research (CICR) Regional Station, Coimbatore, Tamil Nadu, INDIA; [3]International Cotton Advisory Committee (ICAC), Washington DC, USA; [4]University of Agricultural Sciences, Dharwad, Karnataka, INDIA.

Year of release: 2022

Brief description of the technology:

Parameter	Details
Variety Name	Tejas Bt (CICR-H Bt Cotton 61)
Type	Bt cotton variety (non-hybrid), medium staple, early & compact
Recommended Area	Rainfed Central Zone (Maharashtra, Madhya Pradesh, Gujarat)
Gazette Notification	S.O. 4065(E), dated 31 August 2022 (S. No. 177)
Parentage	(Bikaneri Narma Bt × RCRSC7) × (RCRSC2 × RCRSC12)
Average Yield	11.63 q/ha (~1163 kg/ha)
Potential Yield	20.5 q/ha (~2050 kg/ha) at Nagpur (2019–20)
Crop Duration	140–150 days (early maturing)
Plant Height	90–100 cm
Plant Type	Compact, suitable for HDPS & mechanized harvesting
Boll Weight	3.3 g
Ginning Outturn (GOT)	36.37%
Seed Index	8.17 g
Fibre Length	25.47 mm
Fibre Strength	25.73 g/tex
Pest Resistance	Tolerant to Jassids (sucking pests)
Pest/Disease Reaction	Good tolerance to major pests and diseases
Bioassay Result	High mortality of *Helicoverpa armigera*

Publication: Santosh HB, S. Manickam, S.B. Singh, V.N. Waghmare, K.P. Raghavendra, V. Shah, K.R. Kranthi, K. Gaikwad and S.S. Patil (2025) Notification and germplasm registration - Bt cotton variety: Tejas Bt (CICR-H Bt Cotton 61), Indian Journal of Genetics and Plant Breeding, 85(3): 525-526.

Bt cotton variety: Namami Bt (CICR-H Bt Cotton 62)

Developer(s): HB Santosh[1], S Manickam[2], SB Singh[1], VN Waghmare[1], KP Raghavendra[1], Vivek Shah[1], KR Kranthi[3], Kunal Gaikwad[1], SS Patil[4]
[1]ICAR-Central Institute for Cotton Research (CICR), Nagpur, Maharashtra, INDIA; [2]ICAR-Central Institute for Cotton Research (CICR) Regional Station, Coimbatore, Tamil Nadu, INDIA; [3]International Cotton Advisory Committee (ICAC), Washington DC, USA; [4]University of Agricultural Sciences, Dharwad, Karnataka, INDIA.

Year of release: 2022

Brief description of the technology:

Parameter	Details
Variety Name	Namami Bt (CICR-H Bt Cotton 62)
Type	Bt cotton variety (non-hybrid), early & compact
Developed at	ICAR–CICR, Nagpur
Recommended Area	Rainfed Central Zone (Maharashtra, Madhya Pradesh, Gujarat)
Gazette Notification	S.O. 4065(E), dated 31 August 2022 (S. No. 178)
Parentage	(Bikaneri Narma Bt × RCRSC7) × (RCRSC2 × RCRSC12)
Average Yield	11.49 q/ha (~1149 kg/ha)
Potential Yield	20.72 q/ha (~2072 kg/ha) at Surat (2021–22)
Crop Duration	140–150 days
Plant Type	Compact, suitable for HDPS & mechanized harvesting
Ginning Outturn (GOT)	38.17%
Seed Index	8.0 g
Fibre Length	24.67 mm
Fibre Strength	25.4 g/tex
Pest Resistance	Tolerant to jassids (sucking pests)
Bioassay Result	>95% mortality of *Helicoverpa armigera*
Special Feature	Early maturity helps escape pink bollworm
Suitability	Ideal for HDPS and rainfed conditions
Benefit	Enhances productivity in central zone rainfed cotton

Publication: Santosh HB, S. Manickam, S.B. Singh, V.N. Waghmare, K.P. Raghavendra, V. Shah, K.R. Kranthi, K. Gaikwad and S.S. Patil (2025) Notification and germplasm registration - Bt cotton variety: Namami Bt (CICR-H Bt Cotton 62), Indian Journal of Genetics and Plant Breeding, 85(3): 526.

Bt cotton variety: Samrat Bt (CICR-H Bt Cotton 63)

Developer(s): HB Santosh[1]*, S Manickam[2], SB Singh[1], VN Waghmare[1], KP Raghavendra[1], Vivek Shah[1], KR Kranthi[3], Kunal Gaikwad[1], SS Patil[4]
[1]ICAR-Central Institute for Cotton Research (CICR), Nagpur, Maharashtra, INDIA; [2]ICAR-Central Institute for Cotton Research (CICR) Regional Station, Coimbatore, Tamil Nadu, INDIA; [3]International Cotton Advisory Committee (ICAC), Washington DC, USA; [4]University of Agricultural Sciences, Dharwad, Karnataka, INDIA.

Year of release: 2022

Brief description of the technology:

Parameter	Details
Variety Name	Samrat Bt (CICR-H Bt Cotton 63)
Type	Bt cotton variety (non-hybrid), medium staple, early & compact
Developed at	ICAR–CICR, Nagpur
Recommended Area	Rainfed South Zone (Karnataka, Telangana, Andhra Pradesh, Tamil Nadu)
Gazette Notification	S.O. 4065(E), dated 31 August 2022 (S. No. 179)
Parentage	(Bikaneri Narma Bt × RCRSC7) × (RCRSC2 × RCRSC12)
Average Yield	13.73 q/ha (~1373 kg/ha)
Potential Yield	24.14 q/ha (~2414 kg/ha) at Mudhole (2019–20)
Crop Duration	140–150 days
Plant Type	Compact, suitable for HDPS & mechanized harvesting
Boll Weight	3.7 g
Ginning Outturn (GOT)	36.77%
Seed Index	9.07 g
Fibre Length	25.17 mm
Fibre Strength	25.1 g/tex
Pest Resistance	Tolerant to jassids (sucking pests)
Pest/Disease Reaction	Good tolerance to major pests and diseases
Special Feature	Early maturity helps escape pink bollworm & drought

Publication: Santosh HB, S. Manickam, S.B. Singh, V.N. Waghmare, K.P. Raghavendra, V. Shah, K.R. Kranthi, K. Gaikwad and S.S. Patil (2024) Notification and germplasm registration - Bt cotton variety: Samrat Bt (CICR-H Bt Cotton 63), Indian Journal of Genetics and Plant Breeding, 84(4): 740-741.

Bt cotton variety: ICAR-CICR 18 Bt (CICR- H Bt Cotton 65)

Developer(s): Suman Bala Singh[1], Rahul M. Phuke[1], HB Santosh[1,2], VN Waghmare[1], KP Raghavendra[1,3], G. Balasubramani[1], Vivek Shah[1], B Fande[1], YG Prasad[1]
[1]ICAR-Central Institute for Cotton Research (CICR), Nagpur, Maharashtra, INDIA; [2]ICAR - Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, Telangana, INDIA; [3]ICAR – National Institute for Research on Commercial Agriculture (NIRCA), Regional Station, Hunsur, Karnataka, INDIA.

Year of release: 2024

Brief description of the technology:

Parameter	Details
Variety Name	ICAR–CICR 18 Bt (CICR-H Bt Cotton 65)
Type	Bt cotton variety (non-hybrid), medium staple
Developed at	ICAR–CICR, Nagpur
Recommended Area	Rainfed Central Zone (Maharashtra, Madhya Pradesh, Gujarat)
Gazette Notification	S.O. 4388(E), dated 08 October 2024 (S. No. 259)
Parentage	29I × Bikaneri Narma Bt
Average Yield	15.47 q/ha (~1547 kg/ha)
Potential Yield	22.98 q/ha (~2298 kg/ha) at Nagpur (2022–23)
Crop Duration	Not specified (medium duration type)
Boll Weight	3.5 g
Ginning Outturn (GOT)	35.1%
Fibre Length	23.4 mm
Fibre Strength	24.3 g/tex
Pest/Disease Reaction	Good tolerance to major pests and diseases
Cry Protein Expression	Confirmed expression of cry1Ac gene
Bioassay Result	Effective against *Helicoverpa armigera*
Special Feature	Stable performance under rainfed conditions
Suitability	Suitable for rainfed central zone
Benefit	Enhances productivity and farmer returns

Bt cotton variety: ICAR-CICR 20-31 Bt

Developer(s): Santosh H.B.[1,2]*, Rahul M. Phuke[1], S. Manickam[3], Suman Bala Singh[1], V.N. Waghmare[1], K.P. Raghavendra[1,5], Vivek Shah[1], G. Balasubramani[1], Kunal Gaikwad[1], S.S. Patil[4], Y.G. Prasad[1]

[1]ICAR-Central Institute for Cotton Research (CICR), Nagpur, Maharashtra, INDIA; [2]ICAR - Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, Telangana, INDIA; [3]ICAR-Central Institute for Cotton Research (CICR) Regional Station, Coimbatore, Tamil Nadu, INDIA; [4]University of Agricultural Sciences, Dharwad, Karnataka, INDIA; [5]ICAR – National Institute for Research on Commercial Agriculture (NIRCA), Regional Station, Hunsur, Karnataka, INDIA.

Year of release: 2024

Brief description of the technology:

Parameter	Details
Variety Name	ICAR–CICR 20-31 Bt
Type	Bt cotton variety (non-hybrid), early to medium, compact
Developed at	ICAR–CICR, Nagpur
Recommended Area	Rainfed Central Zone (Maharashtra, Madhya Pradesh, Gujarat)
Transgene	cry1Ac (MON531 event, deregulated)
Parentage	(Bikaneri Narma Bt × RCRSC7) × (RCRSC2 × RCRSC12)
Average Yield	14.45 q/ha
Potential Yield	21.02 q/ha
Crop Duration	140–150 days
Plant Height	103–125 cm
Plant Type	Compact, <1.2 monopodia, suitable for HDPS & mechanization
Bolls/m²	~104.9 (high density suitability)
Boll Weight	3.3 g
Ginning Outturn (GOT)	36%
Seed Index	8.5 g
Fibre Length	25.8 mm
Fibre Strength	26.0 g/tex
Micronaire	5.3 µg/in
Uniformity Index	83%
Disease Resistance	Resistant to BLB, Alternaria, TSV, grey mildew, Corynespora, Myrothecium, anthracnose
Pest Tolerance	Tolerant to jassid, thrips, whitefly, aphid
Special Feature	Early maturity helps escape pink bollworm
Suitability	Ideal for HDPS under rainfed conditions
Benefit	Enhances productivity, profitability & sustainability

.

Plant View

Flower

Shalini (CICR-H Cotton 58)

Developer(s): Vinita Gotmare[1], Rachna Pande[1], Neelkanth Hiremani[1], M Saravanan[1], HB Santosh*[2], Harish Kumbhalkar[1], YG Prasad[1]
[1]ICAR-Central Institute for Cotton Research (CICR), Nagpur, Maharashtra, INDIA; [2]ICAR - Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, Telangana, INDIA; [3]ICAR-Indian Institute of Horticultural Research (IIHR), Bengaluru, Karnataka, INDIA.

Year of release: 2022

Brief description of the technology:

Parameter	Details
Variety Name	Shalini (CICR-H Cotton 58)
Type	Naturally Coloured Cotton (NCC), brown lint, non-Bt
Species	*Gossypium hirsutum* (upland cotton)
Recommended Area	Rainfed Central Zone (Maharashtra, Madhya Pradesh, Gujarat)
Gazette Notification	S.O. 4388(E), dated 08 October 2024
Genetic Background	Multispecies introgressed reverted tetraploid (from *G. hirsutum, G. raimondii, G. barbadense, G. thurberi*)
Average Yield	1441 kg/ha
Potential Yield	2367 kg/ha
Crop Duration	160–165 days
Ginning Outturn (GOT)	32.6%
Fibre Length	22.3 mm
Fibre Strength	22.4 g/tex
Micronaire	4.7 µg/in
Uniformity Index	81%
End Use	Suitable for handloom weaving
Pest Tolerance	Tolerant to sucking pests
Disease Resistance	Disease-free for ALS, BLB & CLS

Publication: Gotmare V, R Pande, N Hiremani, M. Saravanan, Santosh HB, N. Chandrasekhar, H Kumbhalkar and Y.G. Prasad (2025) Notification and germplasm registration - Naturally coloured cotton Variety Shalini (CICR-H Cotton 58), Indian Journal of Genetics and Plant Breeding, 85(3): 527-528.

Naturally Colour Cotton variety: CNA17522 (CICR A Cotton 59) [*G.arboreum*]

Year of Release: 2022

Developer(s): Vinita Gotmare

Brief description of the technology:

Parameter	Details
Variety Name	CICR-A Cotton 59 (CNA17522)
Type	Naturally Coloured Cotton (NCC), light brown lint, Desi cotton
Species	*Gossypium arboreum*
Recommended Area	Rainfed Central Zone (Maharashtra, Madhya Pradesh, Gujarat)
Gazette Notification	S.O. 4065(E), dated 31 August 2022 (S. No. 150)
Average Yield	1115 kg/ha
Potential Yield	1592 kg/ha (45 × 17.5 cm spacing, 125% N)
Fibre Length (UHML)	23.3 mm
Fibre Strength	23.1 g/tex
Micronaire	5.3 µg/in
Pest/Disease Reaction	Good tolerance to major pests and diseases
Plant Type	Suitable for closer spacing (HDPS)
Special Feature	Naturally coloured light brown lint
Environmental Benefit	Reduces pollution (no dyeing required)
Compatibility	Can be grown near Bt cotton without contamination risk
Benefit	Enhances productivity in rainfed central zone




G. barbadense variety: CICR B Cotton 55 (CCB 51-2)

Developer(s): Dr. KPM. Dhamayanthi, Dr. A .Manivannan, Dr. K. Rameash, A R Lende.
ICAR-Central Institute for Cotton Research Regional Station, Coimbatore, Tamil Nadu 641003.

Year of release: 2021

Brief description of the variety:
CICR B Cotton 55 is an Extra Long Staple (ELS), high yielding, good quality *Gossypium barbadense* cotton variety developed by pedigree method from a three way cross of Suvin x (ICB125 x Giza 70). CICR B Cotton 55 has been released and notified by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties of Agricultural Crops, Department of Agriculture, Cooperation & Family Welfare, Government of India, New Delhi vide Notification number S. O. 1056 (E) dated March 6, 2023 for cultivation in Telangana State, Andhra Pradesh, Karnataka and Tamil Nadu. CICR B Cotton 55 recorded mean seed cotton yield of 1317 kg/ha as against 1139 kg/ha of the Zonal check variety under irrigated condition. The percentage increase in seed cotton yield was of the order of 16.1 per cent. CICR B Cotton 55 showed yield superiority (1864 kg/ha) in the spacing of 105 x 60 cm with 100% of N as of recommended dose of fertilizers. The variety registered high ginning outturn of 32.9% as compared to 32.1% in zonal checks and is comparable with the qualifying varieties. Tall plant, semi digitate leaves having stem pigmentation. Flowers have deep yellow petals with red petal spot and yellow pollen. The variety is characterized by elliptical boll shape with prominent pointed tips. The variety has combined fibre quality combination *viz.,* Upper Half Mean Length of 37.1 mm, micronaire of 3.7 and tenacity of 38 g/tex in HVI mode. CICR B Cotton 55 combines moderate yield potential and better quality parameters The south zone farmers will be highly benefitted by cultivating this genotype.

CNH18529 (CICR-H NC Cotton 64)

Developer(s): Vinita Gotmare[1], Rachna Pande[1], Neelkanth Hiremani[1], HB Santosh[1,2], M Saravanan[1], N Chandrasekhar[1,3], Harish Kumbhalkar[1], YG Prasad[1]

Year of release: 2024

Brief description of the technology:

Parameter	Details
Variety Name	CNH18529 (CICR-H NC Cotton 64)
Type	Naturally Coloured Cotton (NCC), dark brown lint
Species	*Gossypium hirsutum*
Recommended Area	Central Zone (Maharashtra, Madhya Pradesh, Gujarat) under rainfed & irrigated conditions
Gazette Notification	S.O. 4388(E), dated 08 October 2024
Genetic Background	Multispecies introgressed reverted tetraploid (*G. hirsutum* × *G. raimondii* × *G. barbadense* × *G. thurberi*)
Average Yield (Rainfed)	1011 kg/ha
Average Yield (Irrigated)	1093 kg/ha
Potential Yield (Rainfed)	2582 kg/ha (Nanded, 60×22.5 cm, 125% RDN)
Potential Yield (Irrigated)	2048 kg/ha (Junagadh, 120×45 cm, 160 kg N)
Crop Duration	160–165 days
Flowering	55–65 DAS
Ginning Outturn (GOT)	36.3% (rainfed), 34.9% (irrigated)
Fibre Length	22.5 mm (R), 22.6 mm (I)
Fibre Strength	23.4 g/tex (R), 24.4 g/tex (I)
Micronaire	5.1 µg/in (R), 4.11 µg/in (I)
End Use	Suitable for handloom weaving
Pest Tolerance	Tolerant to aphids, jassids, whitefly, thrips
Disease Reaction	Moderately resistant to ALS, GM, BLB, CLS, Rust

Publication: Gotmare V, R Pande, N Hiremani, Santosh HB, M. Saravanan, N. Chandrasekhar, H Kumbhalkar and Y.G. Prasad (2025) Notification and germplasm registration - Naturally coloured cotton Variety CNH18529 (CICR-H NC Cotton 64), Indian Journal of Genetics and Plant Breeding, 85(3): 527.

G. arboreum variety: CICR-A NC Cotton 67 (CNA 1092)

Developer and Associates: Dr. V.N. Waghmare

Year of Release: 2024

Brief description of the technology:

Parameter	Details
Species	*Gossypium arboreum*
Parentage	Selection from Random Mating Population
Breeding Methodology	Random mating – Population Improvement
Notification Number	S.O. 4388 (E)
Developed at	ICAR – Central Institute for Cotton Research, Nagpur
Area for Adoption	Central Zone under Rainfed conditions
Habit	Tall erect plants
Leaf	Deeply palmate, green flat leaves
Flower	Yellow
Pollen	Yellow
Petal Spot	Prominent petal spot present
Bolls Character	Green, conical to oval pitted bolls
Special Traits of Importance	Shattering tolerance, and tolerant to major diseases of Cotton.
Fibre Colour	White
Fibre Length	24.5 mm
Fibre Strength	25.2 g/tex
Fineness (Micronaire)	5.2 µg/inch
Uniformity	82 %
Spinnability	20s
Ginning Out Turn	33.1 %
Yield Potential	22 q/ha

Intra-*G. Arboreum* Hybrid: CICR – 4 (CISAA 19-4)

Developer(s): S. K. Verma, V. N. Waghmare, O. P. Tuteja, Subhash Chandra, Rishi Kumar, S. K. Sain, Amarpreet Singh, Debashis Paul, R. M. Ramtake, Satbir Singh

Year of Development: 2025

Brief description of the technology

Parameter	Details
Hybrid Name	CICR-4 (CISAA 19-4)
Type	GMS-based intra-arboreum hybrid (non-Bt)
Species	*Gossypium arboreum*
Parentage	GAK 423-1 Sel. × CISA 6-2
Recommended Area	Irrigated North Zone (Haryana, Punjab, Rajasthan)
Average Yield	3092 kg/ha
Potential Yield	4372 kg/ha
Lint Yield	1161 kg/ha
Fibre Length (UHML)	21.6 mm
Ginning Outturn (GOT)	37.5%
Boll Weight	2.6 g
Plant Height	185–200 cm (tall)
Pest/Disease Reaction	Resistant to BLB, fungal leaf spots, sucking pests; tolerant to leaf hopper
Special Feature	High ginning %, better fibre quality
Cropping System	Suitable for cotton–mustard sequence

Current Status: Parents of hybrid are being maintained and hybrid is being demonstrated at Technology Park at ICAR-CICR, RS, Sirsa.

Publication:
ICAR-CICR Newsletter 2025, April-June 2025 Pp 11

Protocol for ascertaining Refugia-In-Bag (RIB) compliance for BG-II cotton

Developer(s): Dr. V. Santhy, Dr. G. Balasubramani, Dr. Ankur Biswas, Dr. HB. Santosh, Dr. Debashish Paul, Dr. V.N. Waghmare, Dr. Y.G. Prasad

Year of Development: 2022-23

Brief description of the variety:

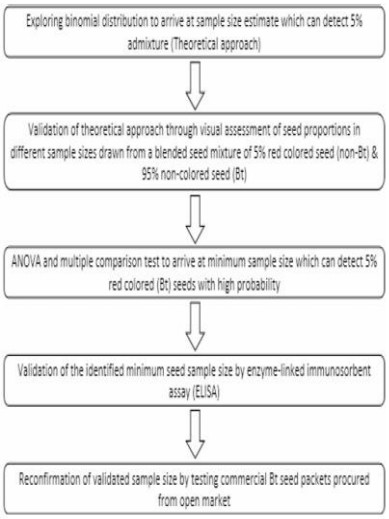
Poor compliance of structured refuge planting recommended earlier by the Govt. Of India played a major role development of resistance by Pink Boll worm to Bt protein. An alternate strategy introduced by the Government i.e. refuge-in-bag (RIB), specifies mandatory blending of 5-10% non-Bt seeds with Bt seeds. As Bt and non-Bt seeds are indistinguishable when mixed, verifying the refuge (non-Bt) proportion is crucial for RIB success. A minimum sample size of 180 seeds was determined statistically as the required seed sample size (table) for non Bt seed detection in the laboratory under RIB. The probability of detection was found to be lowest for sample size of 30 seeds which gradually increased with sample size reaching 100% detection when the sample size is 180 seeds or more (Table). Thus, any sample size beyond 90 seeds would be sufficient as detection probability is more than 99%. A systematic multi-phase study including theoretical estimation followed by physical sampling study and later laboratory validation followed by validation in commercial Bt seed packets (Figure) was undertaken. Another on-field validation was performed by ICAR-CICR, RS, Sirsa in north zone in the fields of Bt cotton hybrids using the derived sample size of plants. This protocol, developed by ICAR-CICR, ensures authentic testing of RIB compliance in Bt cotton seed lots, supporting effective bollworm management through the RIB strategy.

Current Status: This protocol is awaiting to be gazette notified by the Government of India

Publications:

Santhy V, Balasubramani G, Biswas A, Santosh HB, Puttawar M, Raut P, Waghmare VN, Prasad YG (2023) Determination of minimum sample size for testing proportion of non-Bt seeds under Refuge-in-Bag (RIB) for Bt cotton, *Environment, Development and Sustainability.* https://doi.org/10.1007/s10668-023-04188-8

Debashis Paul, Rishi Kumar and Y. G. Prasad (2024) Blending procedure is crucial for BG-II cotton hybrids to adhere to the prescribed 'Refugia in Bag' standards Current Science 127 (1): 101-104.



Flow chart showing the step-by-step methodology

Sample size (n)	Estimated proportion	Average number of detections	Probability of detections
30	0.056	1.675	0.865
45	0.063	2.820	0.985
58	0.075	4.365	0.975
90	0.058	5.175	0.995
180	0.052	9.355	1.000
270	0.061	16.350	1.000
450	0.58	29.085	1.000

Estimated proportion & probability of detection using different sample size

High Density Planting System in cotton to enhance cotton productivity

Developer(s): ICAR- Central Institute for Cotton Research

Brief description of the technology:

The 'High density Planting Systems' (HDPS) is a cotton yield enhancement technology, best suited for shallow/light soils under rainfed production system. The technology was developed around 2010, to accommodate 1.1-1.6 lakh plants/ha of early maturing, semi-compact, non-Bt *G. hirsutum* and *G. arboreum* cotton with tailored agronomic and p[lant protection protocols. For the ultra-compact, *G. arboreum,* Phule dhanwantary, a population 1.5-2.2 lakh plants/ha was found optimum. The HDPS technology was later modified to suit Bt varieties and BGII hybrids planted at a population of 74000 plants/ha.

Key features of the current version of the technology-

- Select a shallow/light, well-drained soil.
- Select sucking pest tolerant, semi-compact, early maturing BG II hybrids or Bt varieties (imidacloprid treated)
- Plant at a spacing of 90 cm between rows and 15 cm between plants to accommodate 74000 plants/ha.
- Wherever available, sow with a pneumatic planter to save time and labour, improve precision, ensure uniform germination and provide early seedling vigour.
- Spray (pre-emergence) Pendimethalin 38.7 % CS @ 1750 ml/ha, within 24-48 hours of sowing and ensure that the soil is moist while spraying.
- Apply the recommended dose of N in 3 equal splits (sowing, squaring and flowering), K in 2 equal splits (sowing, squaring) and P in a single dose at sowing. Ensure that, micronutrients, particularly, Zn and B are not limiting. Supplement this with 2 foliar sprays of water soluble 19:19:19 or 13:00:45 @ 8-10 in 500 l water/ha, post flowering.
- Curtail excess vegetative growth through need-based spray of Mepiquat chloride

Stage	Dose- commercial formulation (Mepiquat chloride 5% AS)
I Spray 45 days (Sqaure initiation)	375 ml/ha (1.0 ml/litre of water)
II Spray 55-60 Days*	500 ml/ha (1.0 ml/litre of water)
III spray (need based) 15- 20 days after II spray*	500 ml/ha (1.0 ml/litre of water)

*II and III spray need-based -when the mean length of top 5 internodes is > 4 cm. Observation to be taken 15 days after 1 and II spray, respectively.

- Do earthing up after the last interculture to conserve rain-water and maintain adequate soil moisture.
- Adopt the recommended plant protection schedule to protect the crop particularly against PBW and boll rot.
- Crop is ready for first picking after 130-135 DAS and 2nd picking after 150-160 DAS.
- To ensure improvement in soil health parameters, shred the cotton stalks after harvest using a tractor operated shredder, decompose them *in-situ* using Trichoderma and incorporate them into the soil.
- HDPS cotton is the forerunner of mechanical cotton harvesting.

Current status: Fully commercialized. The technology has been demonstrated in farmers' field, initially under the Technology Mission on Cotton (MMII), later under NFSM and recently under the Special Project on Cotton in seven cotton growing states with a 20-30% yield advantage. Several farmers have adopted the technology.

Publications:

- Venugopalan MV et al. (2013). High density planting system in cotton- The Brazil experience and Indian initiatives. Cotton Res. J. 5:172–185.
- Venugopalan MV et al. (2016). Development of agro-technology to increase yields of a shy-bearer desi cotton species, *Gossypium arboreum* race *cernuum* in a non-traditional area of cultivation. Current Science. 110. 692. 10.18520/cs/v110/i4/692-695.
- Blaise D et al. (2021). High plant density can improve the productivity of rainfed Asiatic cotton (*Gossypium arboreum* L.). Archives of Agronomy and Soil Science, 67(5), 607–619.
- Prasad YG et al. (2023). High Density Planting System for cotton, CICR Technical Bulletin 2023/2 (English). ICAR-Central Institute for Cotton Research, Nagpur.

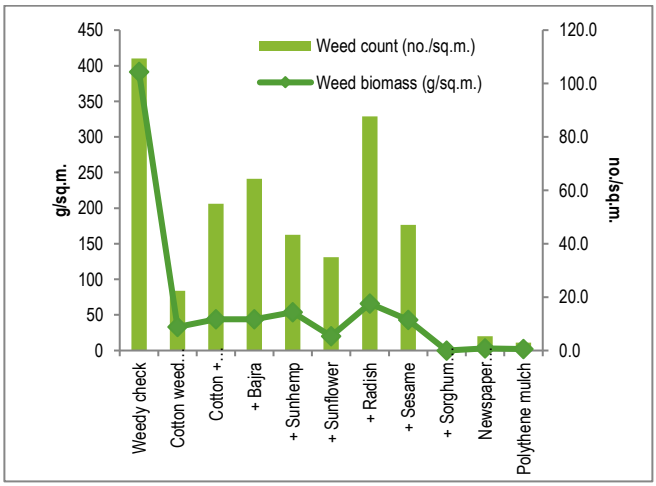
Allelopathy as an alternative weed management strategy for rainfed cotton

Developer(s): D. Blaise, A. Manikandan, P. Nalayini, P. Verma, M. Chakraborty

Brief description of the technology:
Weed management is a major challenge in cotton grown on Vertisols. Cotton is grown at wide-row spacing and has a slow initial growth. Thus, it is susceptible to weeds. To control the weeds, manual weeding is done and labour shortages makes timely weed management a difficult task. Further, the Vertisols due to their inherent nature provides a narrow window for weed management; because the soils become sticky immediately after rains and the soil becomes hard when dry. Use of herbicides is an option, but has a disadvantage of high cost and polluting the environment. Alternative weed management strategies such as growing allelochemical producing crops is a potential solution. We evaluated, 12 different intercrops (bitter cumin, carom seed, coriander, fennel, fenugreek, oat, pearl millet, sorghum, marigold, sesame, natively occurring mixed species of *Desmodium* and sunnhemp). The intercrops were cut at the base after sowing, and left as surface-mulch. Fast-growing intercrops (sorghum, pearl millet, sunnhemp, sesame) were cut earlier than the slow-growing aromatic intercrops. Weed density, weed biomass accumulation and yield were monitored. In general, the control treatment without an intercrop had significantly the highest numbers of both monocot and dicot weeds. Among the intercrops, bitter cumin, carom, fenugreek, mixed species, oat and pearl millet plots had dicot weed density lower than those of the coriander, fennel, sorghum and sesame. On an average, weed emergence with intercrops was reduced by 43–71% and weed biomass by 91.1–96.5% over the control plots. As a result, intercrops increased yield by 1.1 to 14.3% over the farmers' practice. The greatest and significant yield increase was obtained with the sunnhemp because it reduced weed pressure consistently. Also the returns on investment were the highest with sunnhemp and sesame. Seeding inter-row spaces of cotton with sunnhemp or locally available mixed species, marigold, sesame and coriander having potential allelopathic effects should be encouraged.

Current status: The technology has been validated across locations in the AICRP on Cotton.

Publications: Blaise D, Manikandan A, Verma P, Nalayini P, Chakraborty M, Kranthi KR. (2020) Allelopathic intercrops and its mulch as an integrated weed management strategy for rainfed Bt-transgenic cotton hybrids. *Crop Protection* 135: 105214



Intercropping and mulching to reduce erosion and improve soil health

Developer(s): D. Blaise, Dr. A. Manikandan, Dr. B. Bhargavi

Brief description of the technology:

Transgenic *Bt* (*Bacillus thuringiensis*) cotton (*Gossypium* spp.) hybrids are grown at wide-row spacing in India. Farmers practice traditional methods of cultivation that involve excessive inter-row cultivations. These practices exacerbate soil erosion and run-off ultimately leading to land degradation. Growing a cover crop between the cotton rows and retaining its residues *in situ* can reduce erosion and runoff, and improve soil productivity. We compared the effects of growing an intercrop {sorghum (*Sorghum bicolor*), sunnhemp (*Crotolaria juncea*) or sesame (*Sesamum indicum*)} in between the cotton rows and retaining its residues as *in situ* mulch, vis-à-vis plastic, newspaper mulch and the traditional farmers' practice (FP) on the soil physical properties (soil microstructure, porosity, water stable aggregates, infiltration rate, soil erosion and soil loss). Digital image analysis of the micrographs obtained by a scanning electron microscope indicated porosities were highest with intercropping (53–58%) and the least with the FP and plastic mulching (35–36%). Infiltration rate was in the order of intercropping (19.4–22.6 mm h^{-1}) > newspaper mulch (14.5 mm h^{-1}) > FP (13.8 mm h^{-1}) > plastic mulch (12.3 mm h^{-1}); while the reverse occurred with respect to run-off. Although run-off was the greatest (577 mm) in the plastic mulched plots, soil loss was negligible (0.58 Mg ha^{-1}). Intercropping resulted in 35% less soil loss than FP (6.7 Mg ha^{-1}). This study pointed out that growing an intercrop and retaining its residues as *in situ* mulch between the cotton rows can improve soil condition by increasing soil microstructure, water stable aggregation and infiltration rate, and reducing run-off and soil loss.

Current status: The technology has been validated across locations in the AICRP on Cotton for the improvement in soil health and crop productivity.

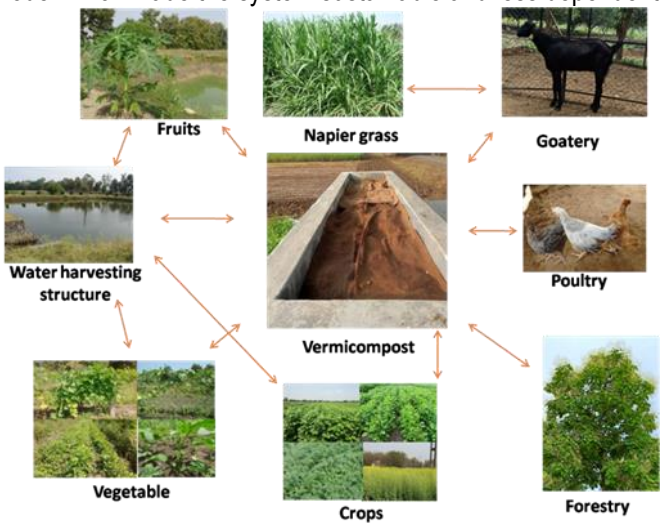
Publications: Blaise, D., Manikandan, A., Desouza, N. D., Bhargavi, B., & Somasundaram, J. (2021). Intercropping and mulching in rain-dependent cotton can improve soil structure and reduce erosion. Environmental Advances, 4, 100068.

Cotton-based integrated farming systems (IFS) model for rainfed dry sub-humid ecosystem

Developer(s): Dr. Ramkrushna G.I., Dr. Rachna Pande, Dr. A. Manikandan, Dr D. Blaise, Dr M.V. Venugopalan, Dr. Y.G. Prasad

Brief description of the technology:

Rainfed mono-cropping systems have low yield and lead to low income. Crop diversification is a choice available to increase productivity as well as farm income. Therefore, an Integrated Farming Systems (IFS) model for one hectare was developed at ICAR-CICR for rainfed cotton-based system of central India. Firstly, a diagnostic survey was done to identify farmers' choice, resource availability, demand in the local market and compatible enterprises. Based on the results of the IFS model (2017-21), pigeon pea intercropped in cotton (6:2 ratio) in 1-acre recorded seed cotton yield of 823 kg and pigeon pea grain yield of 152 kg. In another one-acre area, soybean was cultivated in kharif, followed by chickpea + mustard during the rabi season. Soybean produced 864 kg grain yield, while, in rabi 1060 kg chickpea and 75 kg mustard were harvested. The remaining area (0.5 ac) was allocated to goatery, vegetables, fruits, water harvesting pond and fodder unit. Goatery (Usmanabadi) unit of size 9+1 could earn a net return of Rs. 15,812 with an employment generation of 120 man-days. A poultry (Giriraja) unit with 100 birds in two batches, realized a net profit of Rs. 65,614 over the year. The horticulture component in IFS yielded a net profit of ₹29,134. This component included fruits (custard apple, papaya) and vegetables (French bean, bhindi, tomato, gourd group vegetable). Overall, one-hectare IFS model produced 70.2 q/ha cotton equivalent yield with a B:C ratio of 1.95. In one year, 3020 kg feed, 1590 kg fodder, and 2.50 t manure were produced in the system and were used as input for different enterprises. Water harvested in 20 x 20 m2 pond was used for life-saving irrigation in rabi and vegetable crops. The ICAR-CICR IFS model for 1-ha, could generate 492 man-days during the one-year cropping season. The IFS model integrated all possible and compatible enterprises to improve the income of farmer in rainfed dry sub-humid ecosystem. One-hectare IFS model could meet the majority of energy and nutrient requirement within the model which made the system sustainable and less dependent on external input.



Current status: The IFS model is being demonstrated to farmers at KVK, Nagpur Farm for adoption.

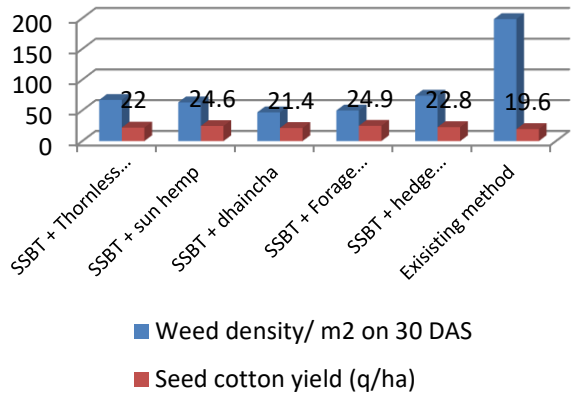
Publications: Venugopalan, M.V., Bhargavi, B. and Ramkrushna, G.I. 2021. Cotton–based integrated farming systems for improving farmers' income–an agro–ecological perspective. Indian Journal of Agronomy 66 (5th IAC Special issue, Volume II): S33-S43.

Stale seed bed and leguminous cover crops as tools for sustainable weed management of Irrigated Cotton

Developer(s): P.Nalayini and D,Blaise

Brief description of the Technology: Integrated weed management approach is preferable to manage weeds effectively and economically. Exploring other options like stale seed bed technique and targeting weeds in advance of cotton sowing to minimize weed pressure during actual cotton growing period and smothering of weeds by compatible leguminous cover crops as inter crops will help in sustainably managing weeds in irrigated cotton. Ridges and furrows are made one month in advance of cotton sowing and one pre sowing irrigation is given, on receipt of moisture, the weeds are tempted to get germinated. After two weeks of pre sowing irrigation, pendimethalin 1.0 kg, glyphosate 1.0 kg ai/ha sprayed to exhaust weed seed bank. The total weed killer, glyphosate kill all the germinated weeds while the germinating weeds for about 3 to 4 weeks are killed by the residual herbicide thus exhausting weed seed bank during off season to reduce weed competition during the actual cotton growing period. Cotton crop and leguminous cover crop sowing can be taken up on the same day. The leguminous cover crops play an important role in smothering the weeds. The weed pressure was reduced significantly with SSBT integrated with leguminous cover crops when compared to currently recommended practice of pendimethalin PE fb hand weeding twice and recommended as an effective, sustainable weed management options in irrigated cotton production system.

Publication: P.Nalayini, D.Blaise and HR Mundafale 2023. Stale seed bed technique and leguminous cover crops as components of integrated weed management in cotton. **Indian Journal of weed science 55(1) 46-49.**




Exhausting Weed Seed bank by SSBT


Weed free cotton under SSBT on 30 Days


Pendimethalin Pre-emergence@ 1Kg a.i/ha


SSBT + Sun hemp

Polyethylene mulching – A new tool for productivity enhancement, water saving and weed control in cotton based system

Developer(s): P.Nalayini and K.Sankaranarayanan

Brief description of the technology: Mulching improves the soil physical condition, conserve soil moisture by increasing infiltration and checking losses by evaporation and run off. It also favorably modifies the soil thermal regime, retards soil erosion and improves soil health by promoting the growth of beneficial microbes. No need for separate weed control. The advantages of using plastic mulches has not been explored for cotton based cropping though used widely for high value vegetable crops in USA. We have standardized the cultivation technique for cotton based system. We have standardized raised bed method with poly mulching to grow cotton (C_3) followed by zero tilled rotation maize (C_4). Dual colour poly film of silver colour top layer for reflective action and black bottom for enhanced mineralization with 30-micron thickness has been standardized for cotton based cropping system. We have recorded 40% water saving with conventional irrigation and up to 85 % water saving when combined with drip irrigation. The yield enhancement of up to 1.9 fold in cotton and 2.1 fold in zero tilled rotation maize under poly ethylene mulching than normal planting was recorded. A new concept of Zero tilled rotation maize was introduced after the harvest of cotton (cutting below cotyledon leaf) without removing the poly mulch sheet. This poly mulch technology is now being practiced for many agronomic crops.

Year of Development: 2003

Publication: P. NALAYINI, R. ANANDHAM, K. SANKARANARAYANAN AND T.P. RAJENDRAN.2009. Polyethylene mulching for enhancing crop productivity and water use efficiency in cotton (*Gossypium hirsutum*) and maize (*Zea mays*) cropping system. Indian Journal of Agronomy 54(4): 409-414 (December 2009)

Poly mulched Cotton with Green

After Cotton harvest

Zero tilled rotation maize

Herbigation in cotton for managing late emerging weeds

Developer(s): P.Nalayini , K.Sankaranarayanan and K.Velmourougane

Brief description of the technology: Herbigation, an application of herbicides through irrigation water can be efficiently done through drip irrigation. The pre-emergence herbicides can manage weeds only up to 30 DAS and controlling the late emerging weeds is really a challenge in cotton production. Application of post emergence herbicides to supplement pre-emergence treatments may give the desired season long weed control in cotton. farmers perform several hand weeding and inter cultivation operations to control weeds which adds to the cost of production. Providing timely weed control becomes difficult, in case of heavy rains, the soils become sticky and wet and trafficability is poor while in the dry soil, the surface becomes hard making inter-row cultivation difficult and also, non-availability of human labourers for weeding makes timely weed control difficult, tedious and costly affair. Repeated use of same herbicide or herbicides of same chemical class may result in development of herbicide resistance in weeds. Rotating herbicides with different modes of action to delay the development of resistance in weeds is suggested. Application of post emergence herbicides through conventional spraying is difficult near the cotton crop and hence weeds which emerge close to cotton crop escape. we have evaluated an alternative system of herbicide application (herbigation) for control of pre and post emergence weeds in cotton. In India, cotton crop is under drip irrigation in about 40000 ha area and there is further scope to extend this area for the judicious use of water for irrigation. Herbicide rotation of pre-emergence application of pendimethalin 1.0 kg /ha followed by hand weeding and application of metolachlor 1.0 kg/ha as an early post emergence herbicide on 30 DAS through drip resulted in the lowest dry matter production by weeds, lesser nutrient removal by weeds and on par seed cotton yield with hand weeding thrice and recommended as efficient weed management option for drip irrigated cotton. The residual herbicides can be applied through drip as herbigation which can kill the late emerging weeds in cotton.

Year of Development: 2008

Publication: Nalayini, P., K Sankaranarayanan and [K] Velmourougane 2013. Herbigation in cotton *(Gossypium spp)*: Effects on weed control, soil microflora and succeeding green gram (Vigna radiata) Indian Journal of Agricultural sciences 83 (11): 1144–1148

Table.1. Weed DMP, WCE on 60 DAS and Seed Cotton Yield

Treatment	Weed DMP (g/m^2) 30 DAS	Weed DMP (g/m^2) 60 DAS	Total number of women labourers used for weeding/ha	WCE in 60 Days	Seed Cotton yield (ka/ha)
Application Method (M)					
Herbigation	15.15	41.02		88.4	3998
Conventional Spraying	12.77	51.08		86.5	3498
CD (P = 0.05)	NS	4.07			496.4
Weed Control treatments (W)					
Pendimethalin 1.5 kg (pre) + HW (30, 60 DAS)	14.2	35.98	50	84.2	3949
Pendimethalin 1.0 kg + metolachor 1.0 kg (pre) + HW (30, 60 DAS)	13.7	32.73	40	85.7	4294
Pendimethalin 1.0 kg (pre) followed by HW (30 DAS), metolachlor 1.0 kg (30 DAS)	17.5	13.95	20	94.0	4669
Hand Weeding (20, 40 and 60 DAS)	3.2	32.48	90	86.0	4821
Unweeded Control	35.4	231.8			817.3
CD (P = 0.05)	5.95	7.85			460
Interaction	NS	NS			NS

Yield maximization in ELS cotton with Drip fertigation and Polyethylene mulching

Developer(s): P.Nalayini and K.Sankaranarayanan

Brief description of the technology: Fiber length of more than 32.5 mmm is categorized as ELS cotton, as per ICAR-CIRCOT. In India, the demand for the textile products made out of ELS cotton is growing exponentially and the requirement is about 20 lakh bales as against the production of 5 lakhs bales. Hence, huge demand for this category of cotton to meet our domestic needs and to tap the export potential for the value added products of ELS cotton. Now, our government is giving more thrust to enhance the production of ELS cotton. Environmental conditions for ELS cotton are specific and parts of south India is ideal to grow best quality ELS Cotton. We at ICAR-CICR, Coimbatore conducted many agronomic studies using promising agro technologies like poly ethylene mulching, drip irrigation, poly mulch plus drip with balanced fertilizer application to enhance the yield potential of ELS Cotton. Drip + poly mulching recorded 86.5 % higher seed cotton yield than conventional method. The water use efficiency was 47,76.5 and 151.7 (kg of seed cotton/ha cm) respectively for conventional, drip and drip plus poly mulching and thus huge water saving due to drip plus poly mulching. Balanced fertigation with 120: 60:60 kg NPK /ha along with zinc sulphate (50 kg/ha), magnesium sulphate (50 kg/ha) + Boron (0.15% foliar spraying twice during flowering to boll development) recorded the highest (7820 kg/ha) seed cotton yield as against 3290 kg/ha recorded under conventional irrigation with NPK alone.Thus, use of hi-tech agro techniques like poly ethylene mulching, drip fertigation with balanced fertilization is recommended for ELS cotton to enhance the production potential and saving of precious water.

Year of Development: 2006

Publication:

Nalayini,P, Paul raj,S and Sankaranarayanan,K.2012.Drip fertigation of major, secondary and micronutrients for enhancing the productivity of extra-long staple Bt Cotton J.Cotton Res.Dev.26(2) 186-189.

Nalayini,P., S.Paul raj and K.Sankaranarayanan.2012. Water use efficiency, nutrient uptake and production potential of extra-long staple Bt cotton – maize system with moisture conservation techniques and ET based irrigation. J. Cotton Research.Dev.27 (1): 45 – 49

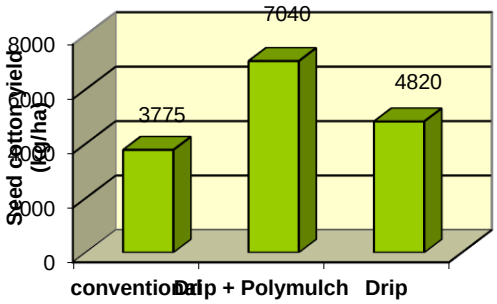


Fig.1 Seed Cotton Yield

Fig. 2 & 3 Drip irrigated Poly mulched ELS

Biodegradable mulching for moisture conservation, weed control and enhanced productivity of winter irrigated cotton maize system

Devloper(s): P.Nalayini ,K.Sankaranarayanan and K.Velmourougane

Brief description of the technology: Use of polyethylene mulching in agriculture is gaining global significance as it is widely used for soil moisture conservation, weed control, coupled with enhancement in productivity of agricultural crops. Drip irrigation used in combination with plastic mulch typically need water to meet the crop water requirement as the other losses of water are kept minimum thereby increasing the water use efficiency. Polyethylene film by nature is non-biodegradable, but it can be made up biodegradable (oxo degradation) by addition of little quantity (4%) of pro degradant additive (d2w), a patented product from UK. The additive was added at the time of manufacturing the poly film. Oxo biodegradable plastics sheets can be programmed at manufacturing stage to degrade soon after the harvest or until the mission is accomplished. The remaining bits in the field after harvest can be collected and buried into the soil to hasten the biodegradability. The small unnoticed left over bits in the field may not pose environmental problem due to its biodegradable nature. the ELS cotton hybrid 'RCHB 708 *Bt* responded significantly to moisture regimes and mulches. Polyethylene mulching along with drip irrigation at 0.4 ETc recorded 5641 kg SCY/ha and was *on par* with biodegradable polyethylene (5241 kg/ha) at the same moisture level. The water requirement for ELS cotton RCHB 708 *Bt* was 46.4, 63.0 and 80.0 ha cm at 0.4 ETc, 0.8 ETc and conventional irrigation respectively. The water use efficiency as measured by the ratio of seed cotton produced to the water consumed by the cotton crop ranged from 58.4 to 91.6 kg/ha cm, the highest (91.6 kg/ha cm) under poly ethylene mulching followed by biodegradable poly mulching (81.8 kg/ha cm) as against the lowest (58.4 kg/ha cm) under no mulching. The zero tilled rotation maize grown after cotton harvest was also benefited under poly mulching and biodegradable poly ethylene mulching.

Year of Development: 2008

Publication: P. NALAYINI, K. SANKARANARAYANAN, K. VELMOUROUGANE AND M. SUVEETHA. 2017. Biodegradable mulching for moisture conservation, weed control and enhanced productivity of winter irrigated cotton maize system. *J. Cotton Res. Dev.* 31 (2) 205-212

Table.1. Seed Cotton yield (kg/ha) of ELS cotton

Mulches	**Moisture regimes**			
	Drip (0.4 ETc)	Drip (0.8 ETc)	Conventional irrigation	Mean
No mulch (control)	3175	4070	3421	3555
Sub soil coir pith (2 kg/ m²)	4314	4067	4092	4158
Maize stover (5 kg/m²)	4254	4215	3979	4149
Sugarcane trash (5 kg/m²)	4208	4077	4002	4096
Surface coir pith (2 kg/ m²)	4111	3809	3442	3787
Gunny sheet mulching	4354	4250	3994	4199
Biodegradable poly mulching	5234	4647	4679	4853
Polyethylene mulching	5641	5418	5357	5472
Mean	**4411**	**4319**	**4121**	**4284**
CD (p = 0.05) for mulches	620.0			
CD (p = 0.05) for moisture regimes	270.1			
CD (p = 0.05) for interaction	928.5			

Fig. 1. Biodegradable Mulching

Alley cropping of *Desmanthus virgatus* (Hedge lucerne) with cotton for Carbon sequestration, yield improvement and sustainability

Developer(s): P.Nalayini., A.Manikandan., D.Blaise and R.Homraj

Brief description of the Technology: Inclusion of legume in the cropping system implies sustainability by improving soil health and saving inorganic nitrogen requirement. Sustainable use of soil is among the global challenges of the twenty first century. Legumes are soil amendment crops with strong benefits on soil health and must be an integral component of the farming system. The important benefits of legumes include soil restoration, increase in the SOC stock, improvement in the N pool by BNF, reduction in energy footprint by reducing the need for N application and restoring the health of ecosystem. Thus, there is tremendous scope of growing legumes in the cropping system to save energy intensive inorganic nitrogen besides improving soil health and microbial biodiversity. The feasibility of growing perennial legume with cotton as alley cropping was attempted at CICR Regional Station, Coimbatore in 2016. In control plot, 30 rows of cotton were grown at 90 cm apart with the plant to plant spacing of 60 cm while in perennial legume plots, every fifth row was allotted for two rows of perennial legume on either side of ridges and thus instead of 30 cotton rows, 24 rows of cotton were grown at the plant to plant spacing of 45 cm so that the cotton plant population was not sacrificed as that of sole cotton. The best performing hedge lucerne was retained and evaluated under three N levels of 75, 100 and 125 % recommended dose of N (RDN) for two consecutive years. *Desmanthus virgatus* has been identified as the most suitable perennial legume to be grown as an alley crop with cotton. This legume crop is fast growing, hardy, withstands drought, has no pest and disease problem, is amenable for multiple pruning, produces huge dry matter and is not competing with cotton crop. Hedge lucerne as alley cropping with cotton and the soil added with pruned twigs of legume at every 45- 60 days. This practice resulted in addition of 75.3 t of fresh biomass (after 42 months of experimentation) which is about 24.1 t/ha on dry weight basis and with the estimated average nitrogen content of 3.15 % works out to 758 kg N addition into the system thus the organic carbon status of the soil improved from 0.53% in sole cotton to 0.86 % due to alley cropping of hedge lucerne besides yield enhancement of about 8 q/ha due to alley cropping.

Year of Development: 2016

Publication: P NALAYINI, A Manikandan, D Blaise and HR Mundafale.2024 Enhancing carbon sequestration, seed cotton yield and sustainability through alley cropping of *Desmanthus virgatus* with cotton. Cotton Research Journal, 15, 38- 44.

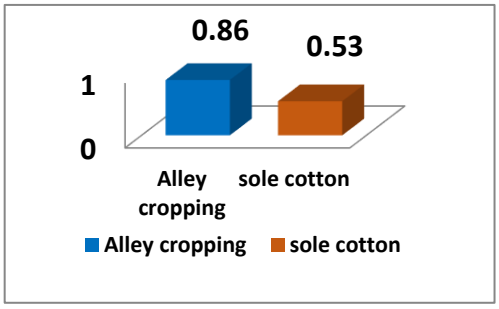


Fig.1 Soil Organic Carbon after 42 Months

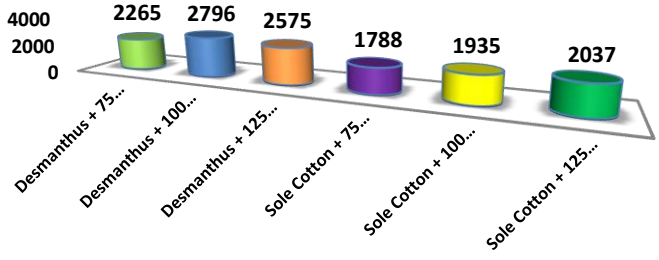


Fig.2 Seed Cotton Yield Kg/ha

Paper tube Nursery technique – Cotton transplanting

Developer(s): Dr. K. Sankaranarayanan, Dr A.H. Prakash

Year of Development: 2016

Brief description of the technology:
Transplanting of cotton has many advantages includes reduces main field duration, maintaining of plant population and fitting of crop into low length of growing period region. Crops like cotton, which are not highly amenable for transplanting. The tap root system of cotton is the bottle neck in transplanting. Many attempts have been made on transplanting but it is successful only at gap filling level. Paper tube with size of 1 cm diameter and height of 20 cm were filled (top 1 cm left unfilled to store moisture) with equal portion of vermi compost, sand and soil and packed gently. Compactness of packing should be ensured in every tube for proper germination. Healthy single seed was dibbled in each tube and water was sprinkled from the top. Tubes were kept in iron tray filled with moist sand (moisture is maintained by sprinkling water) at bottom and covered with wire mesh facilitate to keep paper tubes in upwards. Seedling at the age of 20 days was transplanted in hole made by crow bar and pressed gently to avoid air pockets and irrigated immediately.

Performance: Transplanting registered 15.34 percent higher seed cotton yield as compared to corresponding date of direct sown crop. Under late sown situation, transplanting produced more than 25% higher yield. Paper tube nursery and subsequent transplanting cost is calculated as Rs10620/ha as compared to direct sown (Rs1500/ha). Transplanting realized 4.8% higher net return but transplanting under late sowing realized more than 25% higher net return

Publications:
Sankaranarayanan, K. Prakash, A.H. and Rajendran. K. 2016.Paper tube nursery technique–breakthrough in cotton transplanting. In. Extended Summaries 4th International Agronomy Congress, Nov. 22–26, New Delhi, India by ISA, New Delhi, 2:1286-87

Sankaranarayanan, K, A.H.Prakash 2016Video programme on “Cotton transplanting” , CICR, Coimbatore

Gap Filling Technology for Better Crop Establishment

Developer(s): Dr. Satish K. Sain, Dr. Singh A, Dr. Paul D, Dr. Monga D, Dr. Kumar R, Dr. Verma SK, Dr. Tuteja OP.

Year of Development:

Brief description of the technology /methodology:

In the North Cotton Growing Zone, sowing occurs between 15th April and 15th June, a period characterized by extreme temperatures (35–45°C) and desiccating winds. These harsh conditions often lead to seedling burning, poor germination, seedling mortality, resulting in sparse plant populations and low productivity. Under such circumstance, achieving an optimal plant stand is a primary factor to get yield potential.

Innovative methodology: The Gap filling technology for better crop establishment using inherent soil moisture was developed and validated by ICAR-CICR, RS, Sirsa through field trials and demonstrations from 2017 to 2023. This technology offers a simple yet effective alternative to traditional transplanting or delayed re-sowing. The methodology follows- conducting manual gap-filling within 10 days after sowing, manually removal of the dry surface soil layer at non-germinated spots to reach the inherent field moisture and sowing moist seeds directly into the moist layer using a dibbler or trowel, mirroring the depth and conditions of the initial sowing.

Technical, agronomic advantages: This method outperforms traditional gap-filling practices by aligning with the plant's natural growth cycle. Unlike early irrigation (before 45 DAS), which can stunt root depth, this method utilizes existing moisture, encouraging robust taproot penetration. Plants established via this method showed significantly lower CLCuD severity (13.8%) compared to those gap-filled after irrigation (36%). It eliminates the need for nursery raising, transplanting labor, or supplemental irrigation. The data highlights a stark difference in productivity per plant based on the gap-filling method. Comparative yield performance of the plants raised by following this technique was higher (97.4 g) compared to plants raised through hand irrigation (34.1g) and after first irrigation (19.6g/plant).

Economic Impact, profitability, and scalability: A full yield potential for Bt cotton hybrids (32–35 Q/ha) is attainable even at 80–90% of the target plant population. This technology bridges the gap to reach that threshold efficiently. 1–2 workers can cover 10–20% of a hectare (approx. 2,500–5,000 gaps) in a single day. Filling these gaps add approximately 2.5 to 5.0 Q/ha to the total harvest depending on other crop management practices. The Incremental Cost-Benefit Ratio (ICBR) for net income ranges from 6.3 to 12.6, making it a highly lucrative intervention for small and large-scale farmers. By utilizing inherent soil moisture within 10 days of sowing, farmers can maintain an ideal plant stand, mitigate the risks of extreme heat, and significantly boost their net income with minimal input costs.

Current status: This technology has been developed and being promoted under ICAR-CICR and CSR projects.

Publications: 1: Sain SK, Singh A, Paul D, Monga D, Kumar R, Verma SK, Tuteja OP. 2023. Plant stands and gap-filling methods affect the productivity of Bt cotton hybrid in north-western India. Scientist. 1(3): 1-3.

2. CCI-CICR Pilot project report "Awareness and Extension Services on Best Farm Practices for Cotton Farmers to Improve Quality, Yield and Sustainability" 2023-24

Technology extension folder and on-field demonstration

Technology extension short videoclip

ICAR-NRM-CICR Technology-2024-223

Defoliant formulation for mechanical picking in cotton

Developer (s): Dr. Jayant Meshram, Er.G. Mujamdar, Dr. G.I Ramkrushna, Dr. D. Blaise, Dr. V.N. Waghmare

Year of Development: 2023

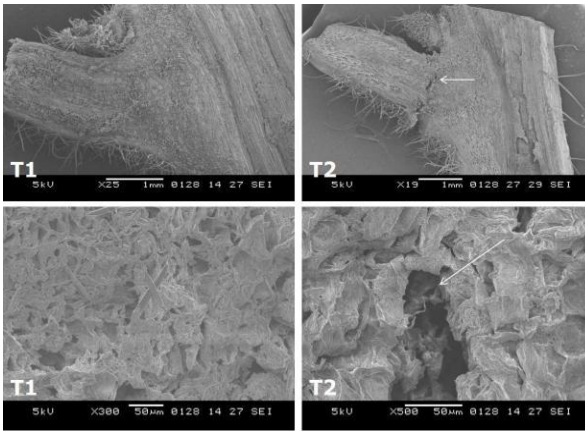
Brief description of the technology/process:
Defoliation is pre-conditioning the plants to prepare cotton bolls for harvest and reduce trash content in harvested produce. The agronomic system in India is developed around the hand harvesting of Bt hybrid cotton. Cotton manual picking by hand is a time -consuming and labor-intensive process. This formulation is liquid based. This defoliant technology was validated under 19 AICRP centres during 2023-24 and 2024-25 in Punjab, Haryana, Gujrat, Maharashtra, Karnatake, Andra Pradesh, Tamil Nadu etc.

Type: Liquid chemical formulation (CICR defoliant)
Tank mixing ability and stability : Easily soluble in water within > 30 minutes
Specific feature : It can act both as defoliant and boll opener for mechanical harvesting in cotton.
Method of Application: One or two foliar spray when cotton plants have more than 60-70 % open bolls. Water required 200 L/ Acre for each spray.
Benefits : Leaf defoliation achieved 90-95 % and boll opening 95 % simultaneously. The defoliant effect was last up 21 days after application on cotton plants. The most ideal environmental condition when night temperature is above 18^{o}C and 5 days rain free condition after application.

Applicability: Liquid formulation can be applied in conventional and HDPS cotton cultivation.

Current Status: This technology has been tested in 19 AICRP centres and Indian patent under process.

Publication:
Meshram JH and M Umap., 2024, Histophysiology of cotton defoliation and molecular screening of potential genes associated with defoliation induced by chemical defoliant in Bt cotton, international conference on Innovative technologies for research and development for sustainable production of cotton, oilseeds and fibre crops, Book of Abstract and Souvenir, Cotton Research and Development Association (CRDA), CCS Haryana Agricultural University, Hisar, ISBN No. 978-81-946148-4-9, PP:15.



Control (T1) (Abscission zone formation T2)

Nutrient Expert® for Hybrid Cotton

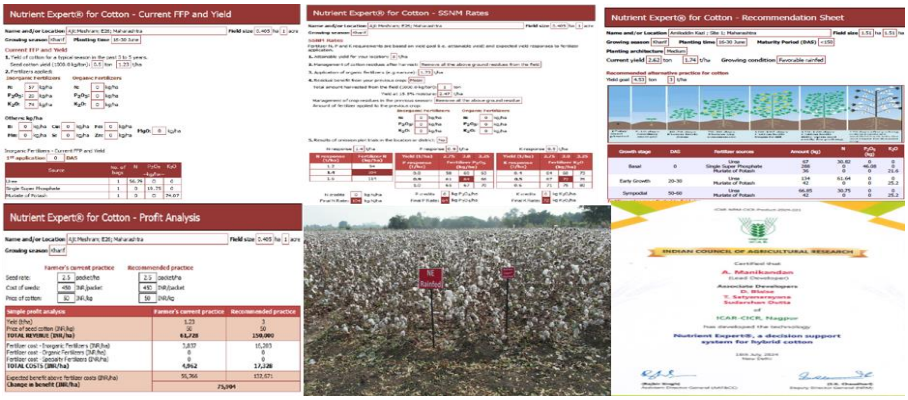
Developer(s) A Manikandan, D Blaise, T Satyanarayana, Sudharshan Datta

Brief description of the technology:

Low cotton productivity in Maharashtra (344 kg lint per hectare) lags significantly behind the national average (524 kg lint per hectare), a shortfall driven largely by erratic soil moisture and poor nutrient management during critical crop growth stages in rain-dependent regions. Cotton fields typically exhibit substantial spatial variability in soil nutrient status and crop growth, influenced by the cultivars used and local conditions. Variable rate application of fertilizers a core component of precision farming offers a pathway to optimize cotton production by enabling precise, site-specific nutrient management. In response to this need, the International Plant Nutrition Institute (IPNI), in collaboration with ICAR-CICR, has developed Nutrient Expert® for Cotton a field-specific, user-friendly decision support system (DSS) designed for researchers, extension specialists, industrial agronomists, and progressive farmers. The tool harnesses the QUEFTS (Quantitative Evaluation of the Fertility of Tropical Soils) model to generate precise fertilizer prescriptions based on the principles of site-specific nutrient management (SSNM). It delivers 4R nutrient stewardship (right source, right rate, right time, and right place) thereby enhancing nutrient use efficiency (NUE) in cotton. By integrating site-specific data such as planting time, crop maturity, canopy characteristics, growing environment, field size, and up to five years of historical data, Nutrient Expert® helps bridge yield gaps and achieve targeted yields. It incorporates current farmer fertilizer practices (FFP), yield modules, and local factors, while accounting for nutrient contributions from crop residues, organic inputs, soil and plant analyses, and various fertilizer sources including inorganic (single or compound), organic manures, and specialty micronutrients. The tool also supports split-dose recommendations and profit analysis modules. Designed for accessibility, Nutrient Expert® operates on systems with Windows XP, MS Office 2003, or MS Access, requires only 17 MB of disk space, and is compatible with JavaScript. As a web-based application, it generates portable document format (PDF) reports that can be easily shared via message or email. Since 2018, Nutrient Expert® has been rigorously evaluated for agronomic performance against existing nutrient management options including recommended fertilizer dose (RDF), soil test crop response (STCR), and farmer fertilizer practice (FP). Through a participatory approach involving ICAR-CICR NFSM-FLD, and ICAR-NePPA the technology has been validated and demonstrated in over 900 on-farm experiments across Maharashtra. However, to ensure sustainable cotton production through balanced nutrition, further evaluation of soil health and quality across these treatment options remains essential.

Current status: This technology has been granted (ICAR-NRM CICR- Product -2024-221) and Nutrient Expert® is available for commercial cotton cultivation.

Publications: Manikandan A, Blaise D, Dutta S, Satyanarayana T & Bussa B (2021) Nutrient Expert for high yield and use efficiency in Rainfed Bt cotton hybrids. Front. Agron. 3:777300. doi: 10.3389/fagro.2021.777300.



Alternate-Row Cotton + Grain Legume Intercropping in High-Density for Rainfed Areas

Developer(s): A Manikandan, D Blaise, P Nalayini, V S Nagrare

Brief description of the technology:

In rainfed areas, to address this productivity stagnation, High-Density Planting Systems (HDPS) with plant populations exceeding 1.11 lakh plants per hectare have been proposed for boosting cotton yields. However, can intercropping succeed within these high-density systems? Through a series of rigorous field studies conducted over five years (2015–2020), ICAR-CICR evaluated compatible legume intercrops for rainfed desi (*Gossypium arboreum L.*) and American (*G. hirsutum L.*) cotton cultivars, with legumes sown 18–20 days after cotton. The results were decisive, HDPS rainfed cotton intercropped with grain legumes achieved significantly higher system productivity than sole cotton, demonstrating that intensification and soil health restoration. Among the legumes evaluated in alternate-row (1:1) HDPS systems, clusterbean, greengram, blackgram, groundnut, and soybean proved highly compatible, while pigeonpea and dolichos were unsuitable at existing cotton row spacings. Clusterbean, followed by greengram and blackgram, delivered the highest Cotton Equivalent Yield (CEY), with medium-duration varieties consistently outperforming others and enhancing benefit-cost ratios by an impressive 22–72% over sole cotton. Beyond these productivity gains, legume intercrops delivered ancillary benefits that address multiple production constraints simultaneously. They effectively trapped pests and diseases, reducing infestations; suppressed weeds through continuous ground cover; and markedly improved soil health through enhanced moisture conservation, carbon buildup (0.1–0.2% increase), and biological nitrogen enrichment (10–15 kg ha^{-1}). Seed Cotton Yield (SCY) analysis revealed that while intercropping typically reduced SCY by 25% compared to sole cotton at 0.90 m spacing primarily due to competition for land, light, and nutrients careful legume selection minimized these requirements. CEY analysis confirmed clusterbean's superiority (79% above intercropped mean, 43% above sole cotton), while pigeonpea yielded the lowest CEY (30% below sole cotton), attributed to severe light competition and shading effects. Duration-wise trends revealed that short-duration legumes (greengram) delivered the highest average CEY, while medium and long-duration legumes showed moderate but consistent improvements over sole cotton. The system offers transformative advantages for rainfed cotton production: doubled plant populations (90 × 10 cm spacing) boost seed cotton yield by 40–50% over conventional spacing; resource use efficiency optimizes soil, water, and energy utilization; biological nitrogen fixation reduces synthetic nitrogen requirements by 25%; legume intercrops yield 600 kg/ha of supplemental grain while reducing pest pressure by 15–20% as trap crops; and soil health improvements including enhanced organic carbon (0.2%) and microbial activity (30% dehydrogenase) ensure that post-harvest biomass incorporation sustains fertility for subsequent crops. This integrated approach thus represents a sustainable, economically viable pathway for revitalizing rainfed cotton production systems.

Current status: This technology has been submitted to ICAR for certification during 2025 and also demonstrated under NFSM-FLD in rainfed areas of Vidarbha region.

Publications: Manikandan A, Blaise D, Nalayini P, Nagrare V S, Prasad YG. Intercropping legumes with high-density cotton to improve the land use efficiencies of rainfed vertisols of India. Agricultural Research (2024). https://doi.org/10.1007/s40003-024-00833-4.

Biochar-Nutrient Composite for Cotton

Developer(s): A Manikandan, KM Manjaiah, D Blaise, Rachana Deshmukh, CR Mundafale and V N Waghmare

Brief description of the technology:

Cotton stalks, with their high lignin content (20–25%), persist in fields for 7–12 months before decomposing, creating a waste management challenge for farmers. Approximately 3–5 metric tonnes of stalks remain per hectare after boll harvest, serving as pest habitat and ultimately disposed of through burning a practice that devastates soil health, contributes to atmospheric pollution, and accelerates climate change. Simultaneously, acute shortages of organic manure in rural areas perpetuate low agricultural productivity, creating an urgent need for sustainable solutions that convert agricultural waste into valuable soil amendments. Biochar, produced through slow pyrolysis of cotton stalks at temperatures exceeding 300°C, offers a transformative approach to recycling this crop residue. This carbon-rich material acts as a powerful soil conditioner, enhancing water and nutrient retention while augmenting overall soil fertility. The porous structure of biochar characterized by extensive meso and micropores provides an ideal matrix for nutrient housing. However, unmodified biochar application alone can temporarily lock up soil nutrients through adsorption, potentially depressing crop productivity. This limitation demands innovation: the pores must be effectively utilized through nutrient loading to prevent nutrient lockup while reducing dependence on organic manure and minimizing nutrient losses from the root zone through enhanced cation exchange capacity.

Although nutrient-enriched biochars have been reported previously, most rely on simple post-pyrolysis mixing or surface coating, resulting in weak nutrient-surface associations and rapid, inefficient release. To address this fundamental limitation, ICAR-CICR has developed an innovative immersion–intercalation–impregnation (III) process specifically designed to achieve nutrient loading within the biochar pore structure rather than solely on the surface. This proprietary III process results in a mechanistically distinct mode of nutrient association—specifically physical entrapment and interlayer intercalation that differs quantitatively from conventional surface adsorption. The mechanistic advantages are threefold: significantly higher nutrient loading capacity, slower and more sustained release kinetics calibrated to cotton's crop-stage requirements. For practical, decentralized adoption, the technology accommodates simple drum or cone-pit pyrolysis methods suitable for localized production, with nutrient loading protocols standardized based on cotton's specific nutritional requirements. Preliminary field responses demonstrate seed cotton yield improvements of 14–21% over conventional fertilizers, alongside substantial reductions in inorganic fertilizer use (20–25%) and enhanced nutrient use efficiency. The biochar nutrient composites prevent leaching losses through improved cation exchange capacity, ensuring sustained nutrient availability throughout the cropping season while building soil health through enhanced organic carbon (0.1–0.2% increase) and microbial activity. Overall, these biochar nutrient composites represent an ecofriendly, cost-effective innovation that reduces chemical fertilizer usage by 20–25% while converting a problematic waste stream into a valuable resource. They can save farmers approximately Rs. 1500–3000 per hectare on fertilizer costs, eliminate the environmental and health hazards of stalk burning, and reduce agricultural runoff pollution.

Current status: BNC technology has been validated across 1200 farmers' fields in Maharashtra, Madhya Pradesh, Telangana, and Gujarat under both conventional and organic cotton systems since 2022.

Publications: Manikandan A. (2021) Development of biochar-nutrient composite for cotton growing in calcareous soils. ICAR-PDF final report. ICAR-Indian Agricultural Research Institute, New Delhi.

Customized fertilizer for cotton

Developer(s): Dr. D.Kanjana, Dr. R.Raja, Dr. S.Usharani

Year of development: 2024

Brief description of the technology:

Nutrient management in cotton is particularly challenging due to the concurrent development of vegetative and reproductive structures during their peak growth stages. Under such circumstances, indiscriminate or imbalanced fertilizer application either excessive or insufficient can significantly limit the crop's yield potential. Therefore, optimization of fertilizer inputs based on soil testing and crop response studies is essential to ensure balanced nutrient supply, meet the crop's nutritional requirements, and achieve maximum yield potential. Such an approach ultimately enhances cotton productivity and farm profitability across varying soil conditions. Achieving balanced crop nutrition, however, is difficult without improving or modifying fertilizer formulations to better match crop demand. Therefore, customized fertilizer pellet was formulated based on soil fertility status assessed through soil and crop response studies in the target region. The method of customized fertilizer preparation for cotton was standardized, and suitable binding materials with their optimal ratios were identified to enhance fertilizer efficacy. Customized fertilizers were developed by combining macro, secondary, and micronutrients along with biofertilizers specifically for cotton. These formulations were evaluated under two major cotton growing soil series of Tamil Nadu *viz.,* Periyanaicken palayam and Irugur soil series. Application of the specially developed customized fertilizer resulted in significant improvements in growth parameters, physiological traits (plant height, total plant dry weight, root length, root volume, LAI, SPAD chlorophyll value, and soluble protein), and yield attributes (number of sympodial branches per plant, total opened bolls per plant, boll weight, and seed cotton yield). Application of customized fertilizer pellets enhanced the seed cotton yield by 24.6 percent over the recommended fertilizer dose.

Basal fertilizer pellets

Top dressing fertilizer pellets

Balanced fertilizer application

Current status: This product was evaluated in farmer's field and will be evaluated in AICRP centres during 2026-27

Publication: Kanjana D**,** Raja R, Usha Rani S, Annie Sheeba J, Amarpreet Singh and Prakash AH. 2025. Customized Fertilizer – A Thought for Sustainable Cotton Production. Cotton Innovations, International cotton Researchers Association, Vol.5 (7) : 10-13.

Ethylene: A key determinant of fiber length in cotton

Developer/Inventor(s): Dr. Pooja Verma, Dr. M V. Venugopalan, Dr. D. Blaise, Dr. V.N Waghmare

Brief description of the technology:

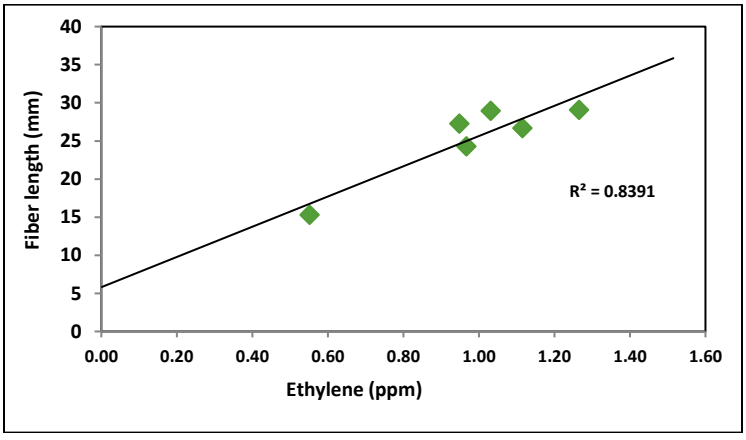
Despite being tolerant to several biotic and abiotic stresses, the *Gossypium arboreum* are not preferred by growers and the industry owing to their small boll size and poor fibre quality. Cotton fiber is a single-celled seed trichome that undergoes extensive morphological and physiological modifications before attaining spinnable maturity. Fiber development is regulated by a complex network of biological pathways, among which phytohormone biosynthesis and signaling play pivotal roles. Here, the role of ethylene during fiber development in cotton was investigated and its correlation with fiber length was examined. Tissue-specific expression analysis of 1-aminocyclopropane-1-carboxylic acid synthase (*ACS*) and 1-aminocyclopropane-1-carboxylic acid oxidase (*ACO*) was conducted in six medium- to long-linted genotypes of Asiatic cotton (*Gossypium arboreum* L.). Both *ACS* and *ACO* exhibited significantly higher expression levels in ovules compared to the subtending leaves of developing bolls. Temporal expression profiling further revealed that these genes are predominantly associated with the early fiber elongation stage rather than the fiber initiation stage. A strong positive correlation (R^2 = 0.84) was observed between endogenous ethylene levels and fiber length across the studied genotypes (medium to long linted arboreum genotypes), suggesting that genotypic variation in ethylene biosynthesis may be a key determinant of final fiber length. Additionally, the functional roles of two candidate genes, BONZAI and PEX1, which are implicated in H_2O_2 and reactive oxygen species (ROS) homeostasis during fiber development, were validated and reconfirmed in *G. arboreum*. Collectively, these findings highlight the critical role of ethylene biosynthesis and ROS regulation in determining fiber elongation and ultimately fiber length in Asiatic cotton.

Current status: This technology validates the role of ethylene during fibre elongation, further linking it with final fiber length of a particular genotype. Hence, may be utilized in breeding programmes as potential targets to attain improvement in fiber properties, particularly fibre length.

Publication:

Verma, P., Venugopalan, M. V., Blaise, D., & Waghmare, V. N. (2020). Ethylene mediated regulation of fiber development in Asiatic cotton (Gossypium arboreum L.). *South African Journal of Botany*, *135*, 349-354.

Role of ethylene during fibre development in cotton. (2020). ICAR Annual Report, 2020, pp 64



Microbially enriched cotton stalk compost as a substitution to farmyard manure in cotton production

Developer(s): Dr. Kulandaivelu Velmourougane, Dr. Manikandan Angamuthu, Dr. P. Nalayini, Dr. D. Blaise, Dr. V. Mageshwaran

Year of Development: 2022

Brief description of the technology:

Although cotton stalks are seasonal wastes, approximately 3–5 Mg stalks are available per hectare. Off late, due to the stringent environmental regulations, the disposal of cotton wastes has become a biggest problem for cotton growers and ginners. Furthermore, there is a short supply of organic manures (especially farmyard manure (FYM)) for cotton farming due to increased adoption of mechanization in agriculture. Largely, farmers have stopped the application of organic manure in their farm lands due to non-availability of organic manure at farm level. Non-application of organic manure along with low organic carbon levels in soils has made the semi-arid regions a less fertile land. Additionally, due to the low soil organic carbon content (<0.5%), the soil health in terms of physical, chemical and biological functions is adversely affected, apart from reducing crop productivity. At present, a small quantum of cotton stalks generated is used for the production of value-added products (particle boards, pulp and paper making, briquetting), and the remaining bulk of the stalks is burned off in the fields after harvest, leading to huge loss of nutrients from soils extracted by the cotton stalks, deteriorating soil health and causing environmental pollution. Though several studies reported the conversion of cotton ginnery wastes into organic manure, few reported on cotton stalk compost. Further, there are no long-term field studies with respect to the use of cotton stalk compost and its effect on cotton yield, fibre properties, and soil biological properties. Thus, recycling of cotton stalks as compost can reduce the dependency on FYM apart from reducing inorganic fertilizer use and soil health enhancement. We conducted field studies over three years on Vertisols to evaluate the impact of integrated use of microbially enriched cotton stalk compost (ECC) as an alternative to FYM along with mineral fertilizers in cotton production. Additionally, we evaluated an option of using native microbial consortia as seed treatment and their synergistic effect along with ECC application on cotton yield, fibre quality, and soil properties. Results indicated that the substitution of FYM with ECC in integrated nutrient management (INM) produced effects similar to that of FYM use in enhancing cotton yield and soil properties. Application of ECC + inorganic fertilizers (modified nutrient management practice) in soil increased boll numbers (8.4%), boll weight (9.9%), seed cotton yield (13%), fibre properties, soil nutrient, and biological activities, which were on par with FYM + inorganic fertilizer application. The use of ECC is estimated to reduce 50% costs on nitrogenous, phosphatic, and potassic fertilizers, and can save approximately US$ 34 ha^{-1} on inorganic and manures in the recommended dose of fertilizers (RDF) and INM practice

Publication:

Velmourougane K, Manikandan A, Blaise D, Mageshwaran V. 2022. Cotton stalk compost as a substitution to farmyard manure along with mineral fertilizers and microbials enhanced Bt cotton productivity and fibre quality in rainfed Vertisols. *Waste and Biomass Valorization*. 13(6): 2847-2860.

Cotton Stalks after harvest

Compost heap preparation

Compost heaps covered

Microbial enrichment

Ready for field application

Cyanobacterium-based bacterial and fungal biofilms as novel biostimulants for Bt-cotton

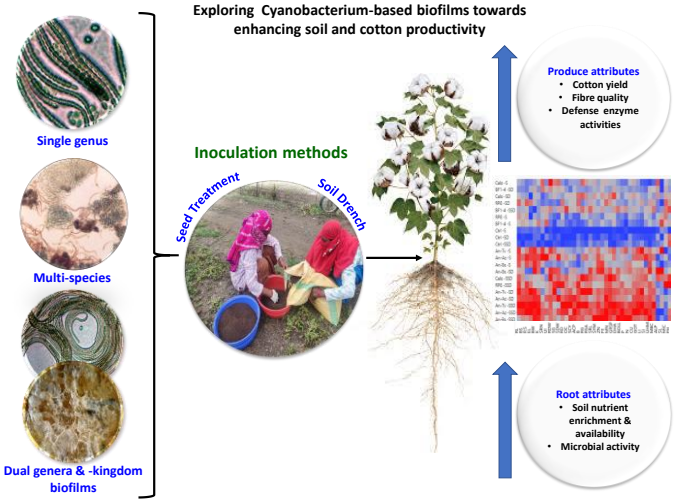
Developer(s): Kulandaivelu Velmourougane, Radha Prasanna, Manikandan Angamuthu, Yenumula Gerard Prasad

Year of Development: 2024

Brief description of the technology:

The multifaceted roles of Cyanobacterium-based bacterial and fungal biofilms in enhancing plant growth, yield, nutrient availability, stress alleviation, biocontrol potential, and soil health on several agricultural crops, as well as the metabolomics of such biofilms has been well established. Further, in recent years, the concept of using Cyanobacterium-based biofilms in agriculture to enhance plant and soil health has gained importance. Although Cyanobacterium-based formulations (CBFs) have been studied extensively for their biocontrol potential against cotton diseases, they have not been evaluated as biofertilizing, plant growth, and soil health enhancers of Bt cotton varieties, grown under rainfed Vertisol. Cyanobacteria and their biofilms as carrier-based formulations were evaluated in a popular Bt-cotton hybrid (Ajeet 155 BG II®), as a prelude to developing a novel and eco-friendly biofertilizing strategy. Comparative performance of single species [*Calothrix elenkinii* (*Calo*), *Anabaena laxa* (RPAN8)], cyanobacterial consortium BF1-4 [*Anabaena torulosa* (BF1), *Nostoc carneum* (BF2), *Nostoc piscinale* (BF3), *Anabaena doliolum* (BF4)] and biofilms [*Anabaena torulosa-Trichoderma viride* (*An-Tv*), *An -Azotobacter chroococcum* (*An-Az*), *An-Bacillus subtilis* (*An-Bs*)] was undertaken. The field experiment using these formulations as seed treatment (S), soil drench (SD), and a combination of both (SSD) revealed significant enhancement in macro/micronutrient availability, soil biological attributes, and plant defense activities, compared with control. Comparison of SSD vs. SD, and single or multi-species, CBFs showed that SSD and biofilms were most stimulatory. Overall, SSD enhanced boll numbers and seed cotton yield by 11 and 8%, respectively, as compared with SD, while dual-species biofilms enhanced yield by 57-71% in seed cotton, compared with the control. SSD method provided an additional income of US$ 462 ha^{-1} compared to SD (US$ 369) and S (US$ 180), excluding other variable production costs. The use of CBFs saved US$ 6.34 ha^{-1} on N fertilizer compared to 100% RDF.

Publication: Velmourougane K, Prasanna R, Manikandan A, Harinkhede LR, Bansod PT, Vaidya JB, Prasad YG. 2025. Cyanobacterium-based bacterial and fungal biofilms as economically viable and climate smart biostimulants for Bt-cotton in rainfed Vertisol. *Journal of Applied Phycology* https://doi.org/10.1007/s10811-025-03671-1



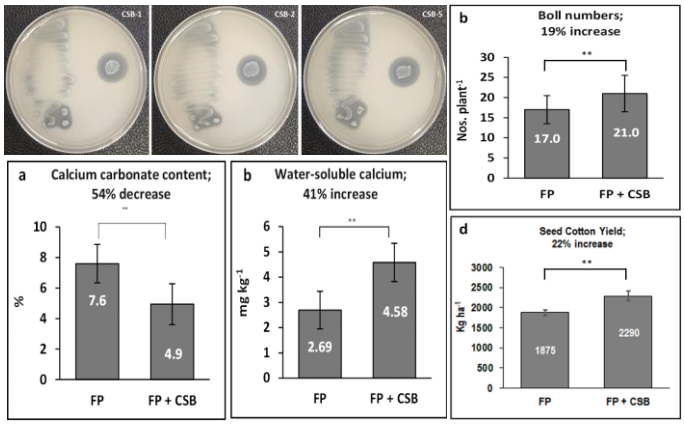
Pedogenic carbonate solubilizing bacterial formulation for alleviating soil calcareousness

Developer(s): Kulandaivelu Velmourougane, Manikandan Angamuthu, Dr. D. Blaise, Dr. V.N. Waghmare

Year of Development: 2025

Brief description of the technology:

The calcareousness of soils is caused by the presence of both pedogenic (soil pH >8.5) and non-pedogenic carbonates (soil pH <8), but the pedogenic formation of $CaCO_3$ induces soil sodicity in dry regions (sub-humid to arid), which impairs the hydraulic properties of soils and reduces crop productivity. Arid and semi-arid climates cover 54% of the total geographical area of India, and the soils of these regions are calcareous. $CaCO_3$ is present not only in soils of arid and semi-arid regions but also in soils of humid and perhumid regions. The estimated area of calcareous soils is 229 million ha, which covers 69.4% of the country's total geographical area. Pedogenic carbonate-induced soil calcareousness disperses clay colloids and causes poor drainage, low infiltration rate, waterlogging, sodicity, nutrient deficiency, low soil organic carbon, low soil and crop productivity, and soil degradation. The carbon required for biological processes becomes unavailable because soil inorganic carbon is trapped as pedogenic carbonate, resulting in reduced soil and crop productivity. Currently, amelioration of calcareous soils has been achieved through the application of chemical amendments, such as gypsum, as a direct source to supply sufficient Ca^{2+} for exchanging Na^{+}. However, recurrent sodicity necessitates sufficient rainfall or irrigation to leach the displaced sodium, and repeated gypsum salt application may affect soil function and the environment. Although several reports on the microbial precipitation, biomineralization, and solubilization of carbonate-bearing minerals, such as calcite, miliolite, and dolomite, for industrial use are available, there has been no information to date on bacterial solubilization or dissolution of pedogenic $CaCO_3$ from agricultural soils. We have developed a novel bacterial formulation (CSB) capable of solubilizing pedogenic calcium carbonate ($CaCO_3$) comprising the bacterial strains CICR-CSB1, CICR-CSB2, and CICR5, for reclaiming calcareous soils to enhance soil health and cotton productivity. The inoculation of pedogenic $CaCO_3$-solubilizing bacterial formulation (CSB) as seed or soil application decreased pedogenic $CaCO_3$ and carbonate-bound calcium content by 54% and 14%, respectively, and enhanced water-soluble and exchangeable calcium content by 41% and 11%, respectively, thereby enhancing soil macro, secondary, and micronutrient nutrient availability, cotton root attributes, plant physiological parameters, soil biological activities, and crop health, contributing to enhanced plant growth, boll numbers, boll weight, seed cotton yield (22% increase), seed, and lint index. The developed formulation is eco-friendly, cost-effective, does not cause any harmful effects on cotton plants and soil biology, and can reduce environmental pollution and associated soil degradation, thus having a wider commercial application prospect in agriculture. **Patent filed**.



Bacterial-based synthetic volatile attractant for whitefly

Developer(s)/inventor(s): Dr. Velmourougane K, Dr. Pooja Verma, Dr. Manikandan A, Dr. Prasad YG, Dr. Rishi Kumar, Dr. Blaise D.

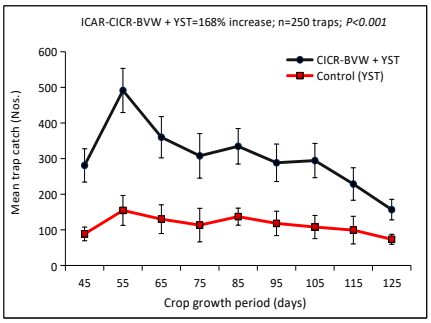
Year of technology development: 2024

Brief description of the technology:

Whiteflies are a deadly pest that spread throughout the growing season and cause significant loss of cotton yield. Whiteflies are not susceptible to *Cry* toxins, and they have resurgence in many parts of the world due to the reduction in insecticide sprays. Apart from direct damage through sap sucking and a related decline in plant photosynthetic activity, whiteflies also act as vectors for many other plant diseases, such as cotton leaf curl disease. Cotton farmers largely depended on conventional insecticides to manage whiteflies, which cost approximately Rs. 3500-11000 per hectare depending on the pest incidence. Furthermore, the continuous and indiscriminate use of insecticides has resulted in whitefly resistance to insecticides, environmental pollution in terms of the accumulation of pesticide residues in soils, adverse effects on natural enemies (predators and parasitoids), and the resurgence of minor pests. In this context, farmers are looking for alternative sustainable, ecofriendly, and cost-effective whitefly management options for cotton. Although plant-based volatiles can manage sucking pest infestation, they are not widely accepted by farmers due to their low field efficacy and high costs. Likewise, although yellow sticky traps (YST) have been popularly used as mechanical control options for sucking pests, the expected field attraction of sucking pests has not yet been achieved. To manage whitefly, the ICAR-Central Institute for Cotton Research (CICR) has developed an ecofriendly, cost-effective, sustainable bacterial-based synthetic volatile attractant formulation **(**ICAR-CICR-BVW), which, on three-year large-scale field studies at ICAR-CICR and 2-year multi-location evaluations in 15 AICRP (Cotton) centres, proved to effectively manage whiteflies through their attraction to the yellow sticky traps (YST). The whitefly attractant integrated with YST achieved an attraction efficiency of 168% over the control (only YST). In addition to managing whitefly infestation, the developed attractant formulation has biostimulatory effects on cotton plant growth and enhanced plant defense and antioxidant enzyme activities, which induce biotic and abiotic stress tolerance in crop plants. Similarly, the attractant formulation had a positive effect on soil chemical and nutrient availability, indicating no harmful effects on soil ecology. Overall, the attractant formulations were eco-friendly and cost-effective (save up to Rs. 1500-7000 per hectare on insecticide usage) and can reduce chemical usage and pest resurgence in cotton. Furthermore, there is great scope and potential for extending the use of the ICAR-CICR whitefly attractant for managing pest infestation in other agricultural crops, and thus, it has wider commercial application and business potential prospects in agriculture.

Current status: This technology has been granted a patent (**Grant No.: 541777; Date: 13.06.2024**). The whitefly attractant formulation has been submitted to Agrinnovate India Ltd for further commercialization and licensing.

Publications: Velmourougane K, Prasad Y.G. 2025. Microbial volatile attractants for monitoring and managing sucking pests in cotton. *Cotton Statistics & News*, 43: 1-5.



Control (Only YST)

ICAR-CICR-BVW + YST)

Whitefly- 541777; 13.06.2024

Bacterial-based synthetic volatile attractant for jassid

Developer(s)/inventor(s): Velmourougane K, Pooja Verma, Manikandan A, Prasad YG.

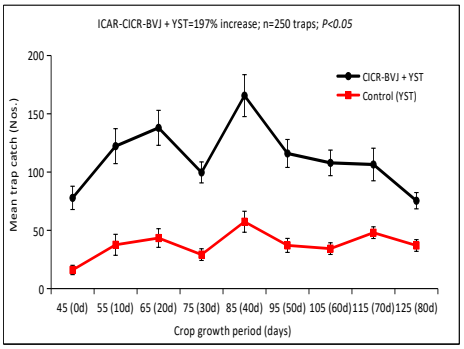
Year of technology development: 2024

Brief description of the technology:

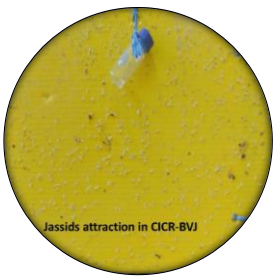
Jassids are a deadly pest that spread throughout the growing season and cause significant loss of cotton yield. Jassids are not susceptible to *Cry* toxins, and they have resurgence in many parts of the world due to the reduction in insecticide sprays. Apart from direct damage through sap sucking and a related decline in plant photosynthetic activity, jassids also act as vectors for many other plant diseases. Cotton farmers largely depended on conventional insecticides to manage jassids, which cost approximately Rs. 3500-11000 per hectare depending on the pest incidence. Furthermore, the continuous and indiscriminate use of insecticides has resulted in jassid resistance to insecticides, environmental pollution in terms of the accumulation of pesticide residues in soils, adverse effects on natural enemies (predators and parasitoids), and the resurgence of minor pests. In this context, farmers are looking for alternative sustainable, ecofriendly, and cost-effective jassid management options for cotton. Although plant-based volatiles can manage sucking pest infestation, they are not widely accepted by farmers due to their low field efficacy and high costs. Likewise, although yellow sticky traps (YST) have been popularly used as mechanical control options for sucking pests, the expected field attraction of sucking pests has not yet been achieved. To manage jassid, the ICAR-Central Institute for Cotton Research (CICR) has developed an ecofriendly, cost-effective, sustainable bacterial-based synthetic volatile attractant formulation **(**ICAR-CICR-BVJ), which, on three-year large-scale field studies at ICAR-CICR and 2-year multi-location evaluations in 15 AICRP (Cotton) centres, proved to effectively manage jassids through their attraction to the yellow sticky traps (YST). The jassid attractant integrated with YST achieved an attraction efficiency of 197% over the control (only YST). In addition to managing jassid infestation, the developed attractant formulation has biostimulatory effects on cotton plant growth and enhanced plant defense and antioxidant enzyme activities, which induce biotic and abiotic stress tolerance in crop plants. Similarly, the attractant formulation had a positive effect on soil chemical and nutrient availability, indicating no harmful effects on soil ecology. Overall, the attractant formulations were eco-friendly and cost-effective (save up to Rs. 1500-7000 per hectare on insecticide usage) and can reduce chemical usage and pest resurgence in cotton. Furthermore, there is great scope and potential for extending the use of the ICAR-CICR jassid attractant for managing pest infestation in other agricultural crops, and thus, it has wider commercial application and business potential prospects in agriculture.

Current status: This technology has been granted a patent (**Grant No.: 568707; Date: 15.07.2025**). The jassid attractant formulation has been submitted to Agrinnovate India Ltd for further commercialization and licensing.

Publications: Velmourougane K, Prasad Y.G. 2025. Microbial volatile attractants for monitoring and managing sucking pests in cotton. *Cotton Statistics & News*, 43: 1-5.



Control (Only YST)



ICAR-CICR-BVJ + YST

Jassid- 568707; 15.07.2025

Bacterial-based synthetic volatile attractant for aphid

Developer(s)/inventor(s): Dr. Velmourougane K

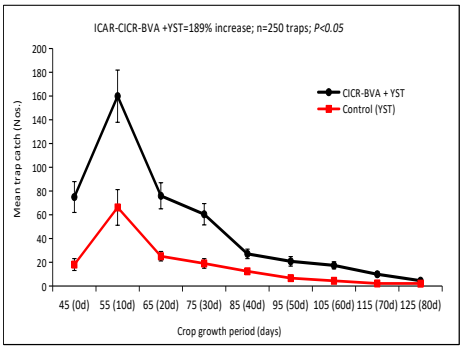
Year of technology development: 2024

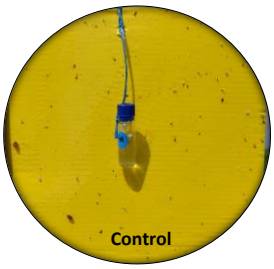
Brief description of the technology:

Aphids are a deadly pest that spread throughout the growing season and cause significant loss of cotton yield. Aphids are not susceptible to *Cry* toxins, and they have resurgence in many parts of the world due to the reduction in insecticide sprays. Apart from direct damage through sap sucking, aphids also act as vectors for many other plant diseases. Cotton farmers largely depended on conventional insecticides to manage aphids, which cost approximately Rs. 3500-11000 per hectare depending on the pest incidence. Furthermore, the continuous and indiscriminate use of insecticides has resulted in aphid resistance to insecticides, environmental pollution in terms of the accumulation of pesticide residues in soils, adverse effects on natural enemies (predators and parasitoids), and the resurgence of minor pests. In this context, farmers are looking for alternative sustainable, ecofriendly, and cost-effective aphid management options for cotton. Although plant-based volatiles can manage sucking pest infestation, they are not widely accepted by farmers due to their low field efficacy and high costs. Likewise, although yellow sticky traps (YST) have been popularly used as mechanical control options for sucking pests, the expected field attraction of sucking pests has not yet been achieved. To manage aphid, the ICAR-Central Institute for Cotton Research (CICR) has developed an ecofriendly, cost-effective, sustainable bacterial-based synthetic volatile attractant formulation **(**ICAR-CICR-BVA), which, on three-year large-scale field studies at ICAR-CICR and 2-year multi-location evaluations in 15 AICRP (Cotton) centres, proved to effectively manage aphids through their attraction to the yellow sticky traps (YST). The aphid attractant integrated with YST achieved an attraction efficiency of 189% over the control (only YST). In addition to managing aphid infestation, the developed attractant formulation has biostimulatory effects on cotton plant growth and enhanced plant defense and antioxidant enzyme activities, which induce biotic and abiotic stress tolerance in crop plants. Similarly, the attractant formulation had a positive effect on soil chemical and nutrient availability, indicating no harmful effects on soil ecology. Overall, the attractant formulations were eco-friendly and cost-effective (save up to Rs. 1500-7000 per hectare on insecticide usage) and can reduce chemical usage and pest resurgence in cotton. Furthermore, there is great scope and potential for extending the use of the ICAR-CICR aphid attractant for managing pest infestation in other agricultural crops, and thus, it has wider commercial application and business potential prospects in agriculture.

Current status: This technology has been granted a patent (**Grant No.: 553413; Date: 29.10.2024**). The aphid attractant formulation has been submitted to Agrinnovate India Ltd for further commercialization and licensing.

Publications: Velmourougane K, Prasad Y.G. 2025. Microbial volatile attractants for monitoring and managing sucking pests in cotton. *Cotton Statistics & News*, 43: 1-5.





Control (Only YST)

ICAR-CICR-BVA + YST

Aphid- 553413; 29.10.2024

Bacterial-based synthetic volatile attractant for thrip

Developer(s)/inventor(s): Dr. Velmourougane K

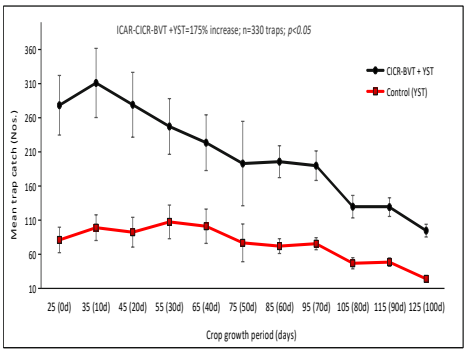
Year of technology development: 2024

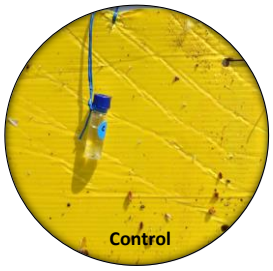
Brief description of the technology:

Thrips are a deadly pest that spread throughout the growing season and cause significant loss of cotton yield. Thrips are not susceptible to *Cry* toxins, and they have resurgence in many parts of the world due to the reduction in insecticide sprays. Apart from direct damage through sap sucking, thrips also act as vectors for many other plant diseases. Cotton farmers largely depended on conventional insecticides to manage thrips, which cost approximately Rs. 3500-11000 per hectare depending on the pest incidence. Furthermore, the continuous and indiscriminate use of insecticides has resulted in thrip resistance to insecticides, environmental pollution in terms of the accumulation of pesticide residues in soils, adverse effects on natural enemies (predators and parasitoids), and the resurgence of minor pests. In this context, farmers are looking for alternative sustainable, ecofriendly, and cost-effective thrip management options for cotton. Although plant-based volatiles can manage sucking pest infestation, they are not widely accepted by farmers due to their low field efficacy and high costs. Likewise, although yellow sticky traps (YST) have been popularly used as mechanical control options for sucking pests, the expected field attraction of sucking pests has not yet been achieved. To manage aphid, the ICAR-Central Institute for Cotton Research (CICR) has developed an ecofriendly, cost-effective, sustainable bacterial-based synthetic volatile attractant formulation **(**ICAR-CICR-BVT), which, on three-year large-scale field studies at ICAR-CICR and 2-year multi-location evaluations in 15 AICRP (Cotton) centres, proved to effectively manage thrips through their attraction to the yellow sticky traps (YST). The thrip attractant integrated with YST achieved an attraction efficiency of 175% over the control (only YST). In addition to managing thrip infestation, the developed attractant formulation has biostimulatory effects on cotton plant growth and enhanced plant defense and antioxidant enzyme activities, which induce biotic and abiotic stress tolerance in crop plants. Similarly, the attractant formulation had a positive effect on soil chemical and nutrient availability, indicating no harmful effects on soil ecology. Overall, the attractant formulations were eco-friendly and cost-effective (save up to Rs. 1500-7000 per hectare on insecticide usage) and can reduce chemical usage and pest resurgence in cotton. Furthermore, there is great scope and potential for extending the use of the ICAR-CICR thrip attractant for managing pest infestation in other agricultural crops, and thus, it has wider commercial application and business potential prospects in agriculture.

Current status: This technology has been granted a patent (**Grant No.: 554409; Date: 14.11.2024**). The thrip attractant formulation has been submitted to Agrinnovate India Ltd for further commercialization and licensing.

Publications: Velmourougane K, Prasad Y.G. 2025. Microbial volatile attractants for monitoring and managing sucking pests in cotton. *Cotton Statistics & News*, 43: 1-5.





Control (Only YST)

ICAR-CICR-BVT + YST

Thrip- 554409; 14.11.2024

Bacterial-based synthetic volatile attractant for beneficial insects & natural enemies

Developer(s)/inventor(s): Dr. Velmourougane K, Prasad YG.

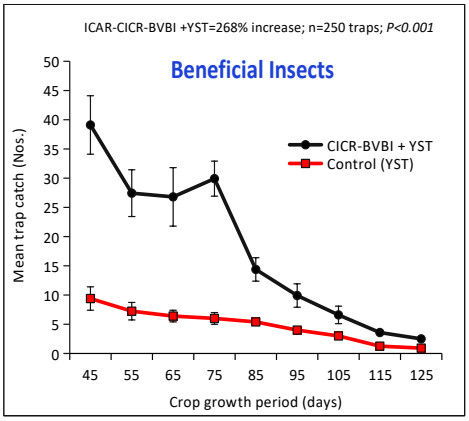
Year of technology development: 2024

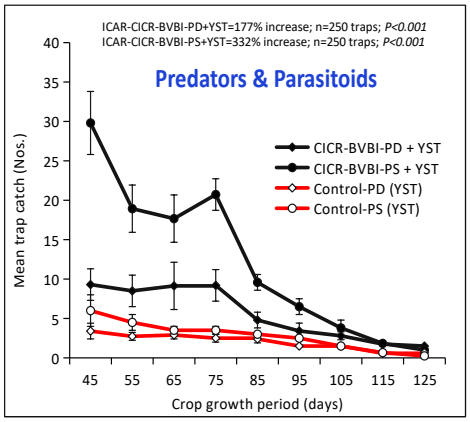
Brief description of the technology:

Several beneficial insects/natural enemies, including predators, parasitoids play an important role in limiting the population of pests. However, no mechanism has been developed to effectively enhance field populations of beneficial insects. ICAR-Central Institute for Cotton Research (CICR) has developed a beneficial insects' attractant formulation consisting of six synthetic analogs of bacterial-based volatile compounds designated as CICR-BVBI to enhance field population of natural enemies in the cotton ecosystem. Large-scale field evaluation (Institute & 15 AICRP centres) of CICR-BVBI has shown a significant attracting efficiency on beneficial insects/natural enemies, including predators, parasitoids (268% over the control). The attractant is eco-friendly and can enhance biological control efficiency, apart from saving cost on insecticide usage and reducing environmental pollution. In addition to enhancing population of beneficial insects/natural enemies in the cotton fields, the developed attractant formulation has biostimulatory effects on cotton plant growth and enhanced plant defense and antioxidant enzyme activities, which induce biotic and abiotic stress tolerance in crop plants. Similarly, the attractant formulation had a positive effect on soil chemical and nutrient availability, indicating no harmful effects on soil ecology. Furthermore, there is great scope and potential for extending the use of the ICAR-CICR beneficial insects' attractant for enhancing their field population and managing pest infestation through biological control (enhanced predators and parasitoids activity) in other agricultural crops, and thus, it has wider commercial application and business potential prospects in agriculture.

Current status: This technology has been granted a patent (**Grant No.: 546146; Date: 26.07.2024**). The beneficial insect's attractant formulation has been submitted to Agrinnovate India Ltd for further commercialization and licensing.

Publications: Velmourougane K, Prasad Y.G. 2025. Microbial volatile attractants for monitoring and managing sucking pests in cotton. *Cotton Statistics & News*, 43: 1-5.





Beneficial insects - 546146; 26.07.2024

Vertical Rotor Precision Planter

Developer(s): Er. G. Majumdar

Brief description of the technology:
Bullock drawn vertical rotor type planter has been developed for planting of delinted cotton and other bold seeds at specified row and plant spacing and at desired depth in vertisols. Farmers use traditional manual methods to plant cotton seed which requires more time and large number of labour. Timely planting with no extra seed requirement and no seed damage can be achieved with this planter in vertisols. The sticky soils of vertisols pose a problem of accurate metering of seeds by planters due to continually varying diameter of ground drive wheel sacrificing the accuracy to plant to plant placement & increased diameter of depth gauge wheels resulting in shallower placement of seeds. The planter incorporates arrangements to clean the sticking soils off the drive and depth guage wheels while in operation. The present invention provides a machine for accurately placing delinted cotton seeds in rows, maintaining plant to plant spacing within rows, and uniform depth of seed placement especially in vertisols.

- Reduced seed damage and uniform seed placement
- Commercialized Cost : Rs. 10,000
- Plant to plant Spacing : 60 ± 5
- Depth of Placement : 6
- Germination (%) : 84
- Field Capacity (h/ha) : 4.5

Benefits over conventional/traditional practices
Accurate placing of delinted cotton seeds in rows, maintaining plant to plant spacing within rows, and uniform depth of seed placement especially in vertisols.

Status of commercialization: Commercialized with Sh. M.G. Bhatt, M/s Precision Tooling Engineers, C-69, Hingna, MIDC, Nagpur,

Small farm equipment for cotton farmers

Developer(s): Er. G. Majumdar

Brief description of the technology:

Ridger:

For making ridges in between the rows of cotton for moisture conservation in soil and to act as a channel for irrigation. It can also be used for creating ridges and furrows before sowing

Adjustable hoe:

Bullock operated hoe for interculture operation in cotton cropping system. Various sizes of blades (9", 12" & 18") can be accommodated in a frame, with quick coupling and decoupling

Iron plough with sowing attachment:

For primary tillage operation of ploughing and sowing of rabi crops like gram

Bund former:

This equipment can be used for making bunds in the fields to facilitate easy surface irrigation

Solar Powered Knapsack Sprayer

Developer(s): Er. G. Majumdar, Dr. D. Blaise

Brief description of the technology:
Solar powered knapsack sprayer has been indigenously developed to spray pesticide, micro-nutrients and growth regulators on agricultural crops. The sprayer can cover an area of 0.25 ha/hr. Elimination of manual operation of the lever in a Lever operated knapsack (LOK) sprayer reduces the drudgery of operation common with LOK spraying. It maintains constant pressure over a longer period of time due to simultaneous charging with the solar power, thus generating uniform spray droplets resulting in effective sprays, reduction in Insecticide resistance and losses due to drift. It ensures conservation of energy by utilizing non-conventional solar energy, and ensuring safety to environment.

Particulars	Solar operated sprayer	LOK sprayer
Dimensions, L x W x H	28 x 24 x 50	37 x 17 x 44
Tank, L x W x H	35 x 19 x 20	37 x 17 x 30
Tank capacity ltrs.	16	16
Field capacity hrs/ha	4	6
Weight, kg	9.0	6
Swath, cm	90	70
System pressure kg/ cm^2	3.0	2.5-3
No. of sprays in one stroke	20	-
Refilling time, min	5	5

Specification		
Power source	:	Battery dry cell 12 volt, 9AH rechargeable
Weight of sprayer, kg	:	9 (without spay liquid)
Tank capacity, ltrs	:	16
Motor	:	12 v DC
PV Solar panel	:	18 watts
Cost of sprayer, Rs.	:	8000
Performance results	:	
Field capacity, ha/hr	:	0.25
Pressure, kg/cm^{-2}	:	3

Benefits over conventional/traditional practices: Reduced drudgery of manual operation of lever in Lever Operated Knapsack sprayer and sustained pressure thereby, ensuring uniform sized droplets over a longer period of time.

Current status: Commercialized.
M/s Padgilwar Corporation, Agriculture Farm Equipment, Machinery & Sprayer Solutions,76, Central Avenue Road, Gandhi Baug, Nagpur 440028, Maharashtra.

Multirow Wick Applicator

Developer(s): Er. G. Majumdar

Brief description of the technology:

Overall dimensions	36x20x60 cm
Tank capacity	15 lit.
Brush width	25 cm
Length of handle	40 cm
No. of orifices	12
Application rate	110-500 l/ha
Field capacity	11 h/ha
Cost of implements, Rs	1500/-

Used paper mulch for weed control

Developer(s): Er. G. Majumdar, Dr. D. Blaise

Brief description of the technology:

Weeding is the second most labor-intensive operation in cotton cultivation after cotton harvesting. Mulching with plastic films has been found to be very effective in controlling weeds and improving cotton productivity, however, the environmental cost associated with plastics is foreboding. Therefore, used News Paper has been tried for mulching in place of plastic with encouraging results. Labour requirement for weeding in cotton is 30-40 man-days/ha at approximate cost of Rs11000-12000/ha. However, inter-culture in cotton is mostly done using Bullock operated blade harrows and costs about 4000-5000/ha. Therefore, total cost of weeding and inter-culture in cotton is Rs 15000-17000/ha.

Mulching technology with waste Newspaper has been shown to be effective and economically viable, at the same time being environment friendly. Therefore, used newspaper has a potential for mulching between rows of cotton.

Technology: Manual laying: Used newspaper pages are laid back-to-back, stuck and rolled on a roller. The roller is then mounted on a frame, having press wheels and shovels on both sides of the newspaper for covering and pinning the paper down on the soil. The frame is dragged by one or two persons along the row.

Mechanical laying: Under the All India Coordinated Research Project on Utilization of Animal Energy with Enhanced System Efficiency, ICAR-CIAE, a low-cost animal drawn mulch applicator has been developed. It is operated by an operating working the bullocks and two labour walking behind the applicator holding the covering devices. Field capacity is 0.113 ha/hr. Cost of laying the newspaper mulch with the applicator will be Rs. 2000/ha and cost of Newspaper would be Rs. 5250/ha and one additional hand weeding with paper mulch technology will cost an additional Rs 4000/-. Therefore, total cost of operation with paper mulch laying technology comes to Rs 11.250/- per hectare.

Current status: Machine available with ICAR-CIAE, Bhopal

Publications: Majumdar, G. Blaise, D. (2020) Used paper mulch applicator. In: Creating wealth from agricultural waste. ICAR, New Delhi, p. 125.

Price Forecasting Models in Cotton

Developer(s): Dr. Isabella Agarwal

Objectives: To generate an appropriate price forecasting model in cotton to forecast its price in the cotton markets of nine States, three in each of North, Central and South Zones of India.

Nature and Source of data:

The study included the major cotton markets viz., Raman, Mukhtsar, Abohar, Mansa of Punjab, Dabwali, Ellanabad, Sirsa, Uchana, Uklana, Fatehabad of Haryana and Sriganganagar, Sangriya, Goluwala, Hanumangarh, Pilli Banga of Rajasthan in North Zone, Gondal, Patan, Palitana, Jamnagar, Bodeli of Gujarat, Gevrai, Parbhani, Hinganghat, Shegaon, Vani of Maharashtra and Sendhwa, Burhanpur, Khargone, Khandwa, Khategaon of Madhya Pradesh in Central Zone, Warangal, Adilabad, Adoni, Jammikunta, Bhainsa, Khammam of Andhra Pradesh, Renubennur, Haveri, Raichur, Bailahongal, Kadur of Karnataka and Thiruppur, Villupuram, Moolanur, Annur, Thindivanam, Gingee of Tamil Nadu in South Zone. The State major cotton market share was to the tune of 40 to 90 per cent of the total cotton regulated markets in India. Based on R^2 value, 15 variables viz., Indian cotton production, Mill Use, Exports, Imports, Beginning stock, Ending stock, World cotton production, Mill use, Export, Import, Beginning stock, Import of cotton by China, MSP of cotton, Production of crude oil in India, Production of crude oil at world level were selected and data collected from 2002 to 2016 sourced from National Cotton Council of America, Statistics OECD Factbook, Min. of Agri. GOI and **www.agmark.nic.in**, respectively.

Analytical Techniques:

Price Forecasting was tried using Artificial Neural Network (ANN) with EXCEL (Alyuda Excel Forecaster) and SPSS 16 Software. Based on proprietary self-constructive neural networks, Alyuda forecasting software provides reliable forecasts even when the input data is noisy, full of non-linear dependencies or incomplete. **Alyuda forecasting software** makes it easy to start with neural nets as it automatically designs, trains and tests neural network forecasting models using the latest advances in artificial neural networks. **Alyuda Forecaster XL** is forecasting Excel add-in based on neural networks. STEPS INVOLVED IN FORECASTING COTTON PRICES WITH ANN THROUGH SPSS 21 Neural Network → Multilayer Perception → Input values → get output page → Forecasting create model → Forecast result

Table I Comparative Forecast Accuracy

STATES	FORECAST ACCURACY (%)		
	ARIMA	ANN EXCEL	ANN SPSS
PUN	92.10	94.46	94.83
HAR	92.45	96.77	91.41
RAJ	93.94	96.88	96.28
GUJ	96.24	96.47	94.23
MAH	93.94	95.32	93.62
MP	95.58	97.10	94.58
AP	96.11	97.02	94.21
KAR	96.89	97.13	95.87
TN	96.68	97.52	94.47

As shown in Table I, the forecast accuracy with ANN through Excel was to the tune of 94 to 97 per cent in all the cotton growing States. Alternative model ANN through SPSS was used to forecast the cotton prices with the same set of 15 variables. The forecast accuracy was to the tune of 91 to 96 per cent. All the three models including ARIMA showed forecast accuracy above 90 per cent.

Publications:

Isabella Agarwal, Anuradha Narala, (2020),'Comparing Predictive Accuracy Through Price Forecasting Models in Cotton', Journal of Cotton Research and Development, vol 34(1), p:146-157

Economic impact of HDPS and policy implication

Contributors: Dr. R. Jaya Kumaravaradan, Dr. A.S. Tayade, Dr. Y.G. Prasad

Year: 2025-26

Brief description on the impact of HDPS technology and policy implication

Since 2023-24, ICAR-CICR is implementing a Special Project on Cotton entitled "Targeting technologies to agro-ecological zones - large scale demonstrations of best practices to enhance cotton productivity" jointly sponsored by the Ministry of Agriculture & Farmers Welfare and the Ministry of Textiles under the National Food Security Mission (NFSM). Under this project, HDPS in cotton cultivation with a spacing of 90×15 cm envisaging a plant population of 74,000/ha, is being promoted in the rainfed regions of five major cotton-growing states, *viz*. Maharashtra, Telangana, Andhra Pradesh, Karnataka and Tamil Nadu on the public–private partnership mode involving stakeholders in the cotton value chain.

Based on a survey conducted among the beneficiary farmers of the Project, it was found that the expenditure, yield, income and profit of rainfed cotton cultivation noticeably changed by shifting from conventional planting system to HDPS. While the cost incurred on land preparation, fertilizer application and pesticide application remained unchanged, the cost of seed and sowing increased significantly from ₹ 9,725 to ₹ 18,200 per hectare, due to doubling of seed rate from 7.5 packets to 15 packets. On the other hand, the cost incurred on weeding decreased from ₹20,625 to ₹15,625 as the labour requirement for manual weeding reduced due to early canopy closure and smothering effect of higher plant density on weeds. Since plant growth regulator has to be applied in HDPS to regulate vegetative growth, farmers incurred a new expenditure of ₹ 2,000. Since the wage rate for harvesting cotton is on quantity basis, the expenditure on manual harvesting increased significantly from ₹ 20,000 to ₹ 30,000 due to 50% increase in seed cotton yield from 20 q to 30 q per hectare. Overall, farmers incurred a total cost of ₹ 89,075/ha in HDPS, i.e., ₹15,475 over and above the ₹ 73,600/ha incurred in conventional planting system under rainfed conditions.

Though farmers earn a gross income of ₹ 2,25,630 and a net income of ₹ 1,36,555 under HDPS, 78% more than ₹ 76,820/ha achieved under the conventional planting system, an increased expenditure of ₹15,475/ha will be a deterrent for the resource-constrained rainfed farmers to adopt HDPS without any funding support. Hence, it was felt necessary to establish a permanent Institutional mechanism to incentivize farmers for adopting HDPS. In this regard, NABARD has accepted ICAR-CICR's cost estimates of HDPS cotton cultivation under rainfed conditions and the Public Sector Banks of Maharashtra have announced a scale of finance of ₹92,000/ha for HDPS cotton cultivation during *kharif* 2025, in addition to the existing scale of finance of ₹75,000/ha for rainfed cotton and ₹85,000/ha for irrigated cotton.

Publication

Prasad, Y.G. and Varadan, R.J. 2025. Economics of HDPS cotton cultivation in India. *Cotton Statistics & News*, 51 & 52, March. Cotton Association of India.

Synergistic Extension Model to bridge the yield and knowledge gaps in cotton

Developer(s): Dr. S. Usha Rani, Dr. S. Manickam, Dr. R. Raja, Dr. M. Amutha, Dr. S. M. Wasnik

Brief Description of the Technology:

India has the laurels of holding top places in acreage and production of cotton at world level for many times. But it always has a concern about yield of the crop. The country's cotton research system produces many technologies and cotton extension system devises many mechanisms to disseminate those technologies but there is always a gap between potential yield of the technologies claimed by the technology inventors and the actual yield realized by the farmers in the fields. Studies conducted to find out the reasons behind this gap revealed that knowledge gap was the major reason in addition to the other researchable and non-researchable constraints. In order to bridge up the yield gap in cotton, at first, the knowledge gap has to be bridged up. It was found that integrating the conventional and contemporary extension innovations for diffusing the appropriate tailor-made technological options would bridge the knowledge gap among heterogenous group of technology adopters and thereby transform their cultivation behaviour. As like Integrated Nutrient / Pest / Disease / Water management in Agriculture, integrating extension innovations for addressing a particular problem was the fundamental idea of this model. Bestowing to the problem, need, locality, nature of farmers and agro-ecological conditions, the selection, integration and execution of technologies and extension methods at different stages of the crop is the principal of this model. Pilotage of the model during 2023-24, through 21 centers under ICAR-CICR and CCI extension pilot project proved that managing the extension tools in an integrated way throughout the crop season to disseminate the tailor-made Best Farm Practices would address the issues of knowledge and yield gaps in an effective manner. In the piloted areas, an average increase in Yield to the tune of 2100 kg per hectare than the prevailing farmers' practices and significant increase in the knowledge level of the beneficiaries was observed.

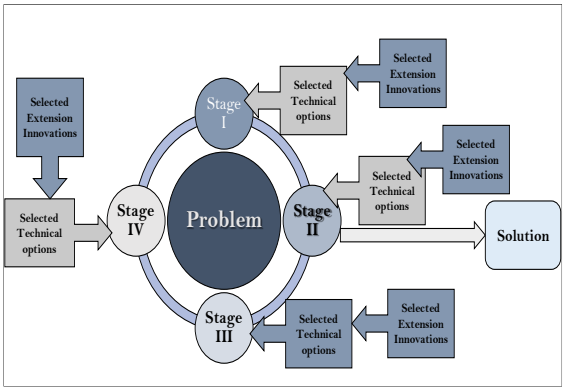
Current Status: Implementing the model across India is aimed for yield realisation and knowledge augmentation.

Publications:

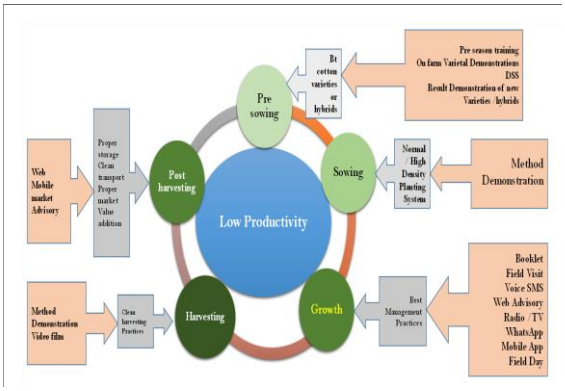
Usha Rani S, A.H. Praksh, R. Raja, M. Amutha, S. Manickam, S.M. Wasnik. 2022. Integrated Extension Management Module for Bridging up the Yield and Knowledge Gaps among Indian Cotton Growers. Book of Papers – World Cotton Research Conference 7 held at Cairo, Egypt, 4-7th October 2022.

Usha Rani, et al., 2024. Assessment of Best Farm Practices and Extension Innovations to Improve Yield In Cotton - A Pilot Study. Book of abstracts of WCRC 8 held at Tashkent, Uzbekistan, 3-7 October 2024

Model - General



Model - Cotton crop



Pluralistic Extension Model for Fostering the Production of ELS cotton in India

Developer(s): Dr. S. Usha Rani, Dr. S. Manickam, Dr. K. Sankaranarayanan, Dr. M. Sabesh, Dr. M. Amutha, Dr. P. Valarmathi

Brief Description of the Technology:

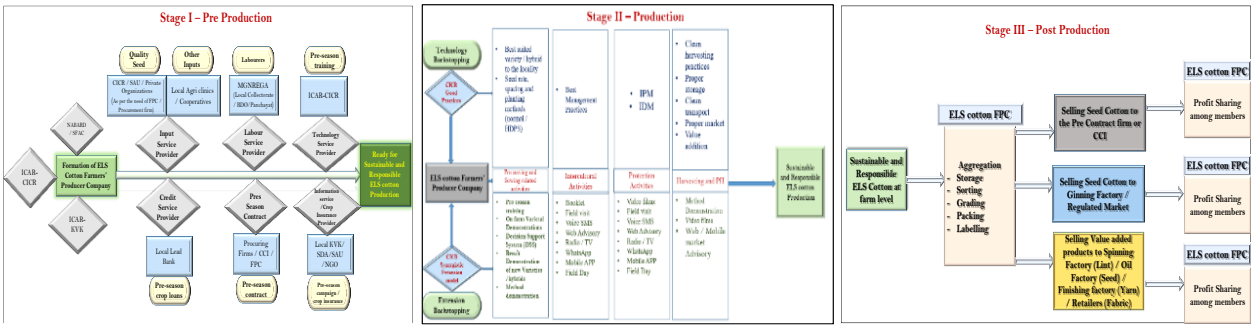
ELS cotton is highly demanded by domestic industries and mostly imported from USA, Egypt and Sudan. As India accounts for 40 per cent of the global share in the fine and super fine cotton yarn trade, it is the country's R & D institutes' responsibility to foster the production of ELS cotton. There are good varieties, interspecific hybrids and other technologies available for improving the production of ELS cotton. For diffusing them to the end users through an appropriate tailor-made diffusion model, the concerns of end users as regards cultivation and marketing of ELS cotton were collected using Problem tree technique of PRA. Primary empirical evident data were collected through structured schedules and Focus Group Discussion. Based on stakeholders' perceptions and analysed empirical data, a Pluralistic extension model was developed for fostering the production of ELS cotton. The Pluralistic model includes ELS cotton grower's aggregation, collective bargaining power, convergence of multiple actors both public and private, diverse funding systems and multiple extension approaches for technology and extension backstopping. Mapping the potential area, conducting base line survey, implementing an action project to foster the production of ELS cotton using this pluralistic model, assessing its impact and replicating the model in other potential areas would pave way for increasing the area and production of ELS cotton in India. Farmers aggregation, collective bargaining power, convergence of multiple actors at policy level, resource level and service delivery level, range of partnership between public and private institutional resources, diverse funding systems and multiple sources of information, multiple extension approaches for extension backstopping, technology backstopping – provision of new technologies and addressing the varying needs of ELS cotton farming community are the advantages of this model. This model can be envisioned as an extension option for fostering the ELS cotton production in India.

Current Status: Pilotage of this model in ELS cotton growing areas is under process.

Publications:

Usha Rani, Prakash A H, Amutha M, Valarmathi P, Sankaranarayanan K, Sabesh M, Manickam S. 2023.Pluralistic Extension Model for Fostering the Production of Extra Long Staple (ELS) Cotton in India. Conference proceedings of 39th AIAEE, held at University of Guelph, Guelph, Canada during 24-29th April 2023. PP 26-28;

Usha Rani, S., Manickam, S., Sankaranarayanan, K., Sabesh, M., Amutha, M., Valarmathi, P and Wasnik, S.M. 2022. Cultivation of Extra Long Staple (ELS) Cotton in South India – Constraint Analysis Using Problem Tree Technique. ICRA Cotton Innovations, Vol. 2 (3) PP 31-36.



Bt detection kits & immunological kits for detection of insecticide resistant bollworms and spurious pesticides

Developer (s)/inventors(s): Dr. K.R. Kranthi

Brief description of the technology:
Following Bt-detection kits were developed to enable farmers, seed testing officers, researchers, seed companies and regulators detect Bt-seed quality and Bt-toxin expression in plants under field conditions.

1. **Bt-Express**: Instantaneous (5-min) farmer useable dip-stick test kit to detect Bt-cotton seeds/plant/tissues. **(PATENTED). Commercialized.** About 20,000 kits have been procured by seed companies, farmers and seed testing laboratories across India, Nepal and Pakistan.
2. **Bt-Quant**: ELISA kit to quantify Cry1Ac in Bt-cotton plants and seeds. **Commercialized.** About 12,000 kits have been procured by seed companies, farmers and seed testing laboratories across India.
3. **Bt-Zygosity:** Multiplex PCR based kit to detect event and zygosity of Bt-cotton plants. **Commercialized.** About 1000 kits have been procured by seed companies, farmers and seed testing laboratories across India.
4. **Bt-Express-II**: Instantaneous (5-min) farmer useable dip-stick test kit to detect the presence of Cry2Ab in Bt-cotton plants and seeds **(PATENTED).**
5. **GUS-test Kit:** The kit detects glucuronidase that is used as a reporter enzyme with Cry2Ab and many other genes. The test takes 30 minutes and has been commercialized. More than 2000 kits were used by various stakeholders.

Current status: Patens Granted on Scientific Inventions**,** Technologies were commercialized, Patents also obtained in South Africa, China, Mexico, Uzbekistan

Rapid detection of Bt-cry toxins based on novel immune-chromatograohic methods. WIPO PCT WO2003/102208/A2/A3

1. **K. R. Kranthi: 2004.** Patent No. ZA200410268. Granted in South Africa
2. **K. R. Kranthi: 2003.** Patent No. ZL 03817641.6 Granted in China
3. **K. R. Kranthi: 2004.** Patent No. MXPA04011769. Granted in Mexico
4. **K. R. Kranthi: 2004.** Patent No. IAP2004-0451. Granted in Uzbekistan.

AI Smart Trap for Real-time Monitoring of Pink bollworm in Cotton

Developer(s)/inventor(s): Dr. K. Rameash

Brief description of technology:
An artificial intelligence (AI) based smart pheromone trap records the pink bollworm moth catches as images; the inbuilt machine learning algorithm counts the number of insects trapped and transmits the data to a remote server along with weather parameters for a real-time pest monitoring. This technology enables timely pest management advisories and decisions, benefiting cotton farmers, government agencies for large-scale monitoring and forewarning

The AI-powered pest monitoring system operates in three key stages: Monitoring Device (Stage I), AI Detection in the Cloud (Stage II), and Information Delivery (Stage III). The trap records the trapped PBW moths at hourly intervals and transmits the image along with corresponding weather data to a remote server where the AI machine learning algorithm (YOLO) process the image with 96.2% detection accuracy, counts the number of insects trapped and transmits the information via mobile/ PC applications to the end user. The AI smart traps are being deployed at 40 villages in 8 major cotton-growing districts spanning three states (Haryana, Punjab Rajasthan) during 2025-2026, with the funding support by the Department of Agriculture & Farmers Welfare, Government of India to monitor the PBW in real-time and to issue timely pest alerts and pest management advisories to cotton growers in the North zone.

Current status: Technology ready for commercialization. A patent application (#202421072205) filed with the Indian Patent Office on September 24, 2024. PCT Application No. PCT/IB2025/059551 filed on September 23, 2025.

Publication: Rameash K, Wagmare V N, Prakash A H, Prasad Y G, Raja R, Rishi Kumar, Singh J P, Sahoo R N., Anil Rai, Bandyopadhyay A. 2026. AI Smart Pheromone Trap for Area-Wide Pink Bollworm Management. Case Study 22Compendium on Real-World Impact of AI in Agriculture. AI Impact Summit 2026, New Delhi, 64p.

Sh. Shivraj Singh Chouhan, Hon'ble Union Minister of Agriculture & Farmers Welfare and Sh. Devendra Fadnavis, Hon'ble Chief Minister of Maharashtra launched the AI Smart Trap in Nagpur on 18.05.2025

Wireless Smart Trap for Automated Pest Monitoring in Cotton

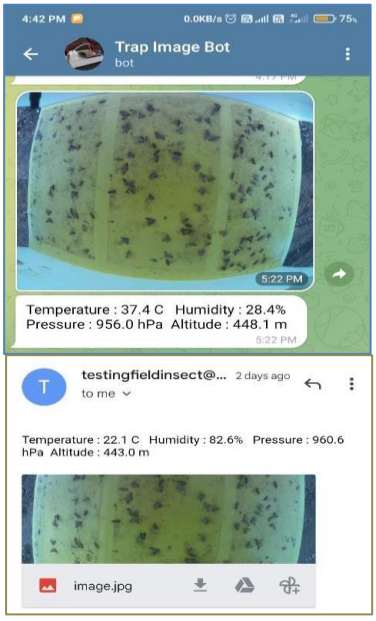
Developer(s)/inventor(s): Dr. K. Rameash, Dr. K. Shankarganesh, Dr. Babasaheb Fand

Brief description of the technology:
The Smart Trap houses four individual pheromone septa in a modified delta trap system for the key lepidopterous pests of cotton viz, *Pectinophora gossypiella*, [7,11-hexadecadienyl acetate]; Spodoptera li*tura* [(Z,E)-9,11-Tetradecadienyl acetate]; *Helicoverpa armigera*, [Z-9-Hexadecenal] and *Earias vittella* [(E, E) - 10, 12-hexadecadienyl]. The smart trap imaging and transmission system is developed by integrating a single board computer; camera module and 4G GSM / wi-fi modules. The standalone system is powered by 10 w solar panel with a 12 V rechargeable battery. The trap control unit will trigger the camera module at specific time intervals (set to one hour intervals and can be modifies according to the need) to record an image of trapped insects. The recorded image is being saved in a memory card kept inside the single board computer. A weather sensor module is integrated with the smart trap that records the information on the temperature, relative humidity, atmospheric pressure and altitude along with the image. The combined data (trap catch + corresponding weather data) is transmitted via 4G GSM and or thorough wi-fi module and delivered to a remote server and via an e-mail client and mobile application. The wireless smart trap provides real time surveillance for multi species lepidopterous pests in cotton for efficient pest monitoring and mass trapping. Multi location trap data can be synchronized to assess the target pest population in a wider area.

Current status: Technology ready for commercialization. ICAR Technology Certification No.: ICAR-AE-CICR-Technology-2023-061; KRISHI Technology Code: 201714061235167

Publication: Rameash, K. 2021. Wireless smart trap for automated monitoring of key lepidopterous pests in cotton. *Cotton Innovate* 2(1): 1-2

Wireless Smart Trap



Trap data delivery via mobile app and email client

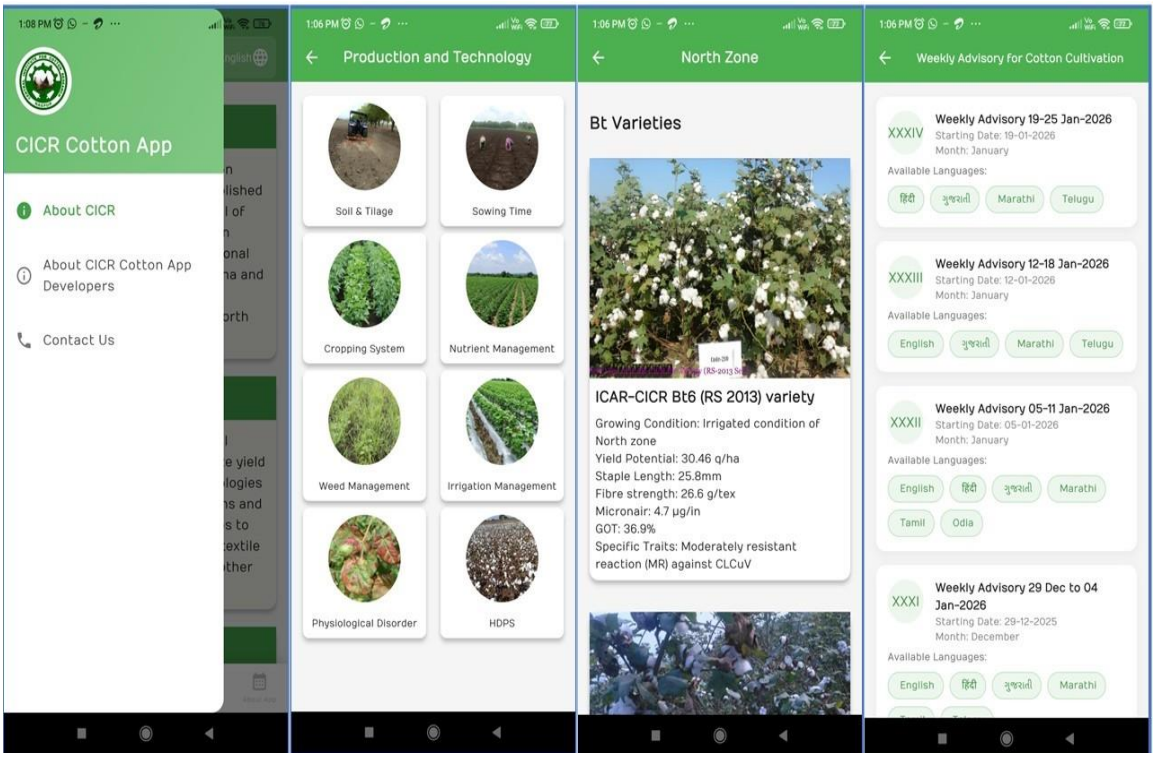
Multi Species pheromone septa and camera unit

CICR Cotton App

Developer(s): Dr V. S. Nagrare, Dr. S. Manickam, Dr Rahul Fuke, Dr Babasaheb B.Fand, Dr Dipak Nagrale, Dr. GI Ramakrushna, Dr. Amarpreet Singh, Dr K. Velmourougane, Dr K Rameash, Dr Rachna Pande, Dr Pooja Verma

Brief description of the technology:
The CICR Cotton App is a mobile application developed by the ICAR-Central Institute for Cotton Research (CICR), Nagpur. It serves as a comprehensive digital resource for the cotton farming community in India, providing end-to-end information from sowing to marketing. The app is designed to be a "one-stop shop" for cotton stakeholders. Its primary features include detailed information on various cotton varieties and hybrids suited for different agro-climatic zones in India, guidelines on best practices for cultivation, including soil health, fertilizer application (nutrient management), and irrigation, tools to help identify common cotton pests and diseases, along with recommended chemical and biological treatment solutions, provides yearly market prices, outreach programs conducted by the ICAR-CICR, Weekly Advisory, etc. While the app is primarily for farmers, it also designed for Agricultural students and researchers, extension workers and personnel from Krishi Vigyan Kendras, policy makers and stakeholders in the textile industry, State Agriculture Department personnel. While initially launched in English, the content is progressively being translated into regional languages including Hindi, Marathi, Gujarati, Telugu, and Tamil to cater to major cotton-growing states. The CICR Cotton App enhances this by providing visual aids, detailed manuals, and real-time updates in a user-friendly interface, helping to reduce the cost of cultivation and improve fiber quality and yield.

Current status: The app Available on the Google Play Store for Android and the Apple App Store for iOS.

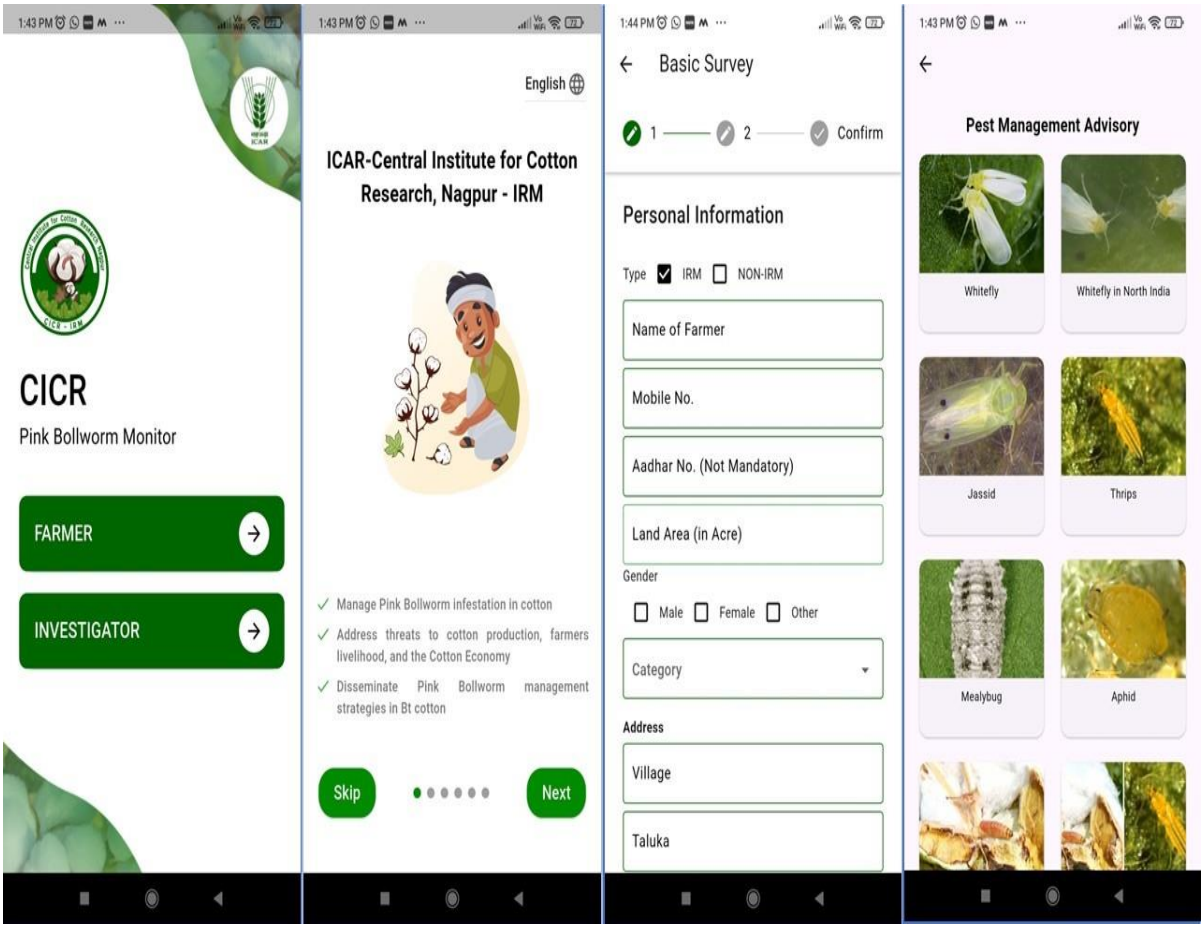


CICR IRM App

Developer(s): Dr V. S. Nagrare, Dr Babasaheb B.Fand, Dr S. P. Gawande, Dr K. Rameash, Dr Dipak Nagrale, Dr Rachna Pande, Dr Rishi Kumar, Dr K. Shankarganesh, Dr S. K. Sain, Dr N. S. Hiremani, Dr Shivaji Thube

Brief description of the technology:
The CICR-IRM App is a specialized digital tool developed by the ICAR-Central Institute for Cotton Research. The app is the digital interface for the Insecticide Resistance Management: Dissemination of pink bollworm management strategies (IRM-PBW) project. It is designed to bridge the gap between field-level pest activity and scientific intervention. It serves as a data collection tool to track the infestations levels of pink bollworm across different zones. It provides a platform to report pest sightings and receive immediate, data-driven advice. Farmers using the app can able to reduce insecticide sprays. The app provides detailed information on major pests and diseases and their management. It educates farmers on identifying the "cryptic" behaviour of the larvae especially of pink bollworm, which usually feed inside the cotton boll where they are hard to see. The app also proved pesticide calculator. Farmers can use the app without registration.

Current status: The app Available on the Google Play Store for Android and the Apple App Store for iOS.



Pink bollworm management strategy

Developer(s): Dr V. S. Nagrare, Dr Babasaheb Fand, Dr Rishi Kumar, Dr V. Chinna Babu Naik, Dr S. P. Gawande, Dr K. Rameash, Dr Dipak Nagrale

Brief description of the technology: The recent emergence of pink bollworm (PBW), *Pectinophora gossypiella* (Saunders) has posed serious ecological and economic implications for cotton production in India since 2017. The management strategy devised was farmer centric to combat this most notorious pest of economic importance during different growth stages of cotton crop. A large scale dissemination and implementation of devised PBW management strategy was taken up but not limited to 1) timely sowing of short to medium duration Bt-cotton hybrids and Bt-cotton varieties, 2) installation of pheromone traps in the field for monitoring moth activity, 3) use of neem based pesticides, 4) crop inspection at squaring and flowering stage of the crop for presence of PBW larvae within the flowers and remove and destroy rosette flowers, 5) release of egg parasitoid *Trichogrammatoidea bactrae* Nagaraja (Hymenoptera: Trichogrammatidae) thrice at 15 days interval, 6) monitoring of pest infestation at boll development stage, green boll sampling by plucking 20 green bolls per acre to assess ETL (at least two bolls i.e. 10% having white or pink larvae/exit holes) (Nagrare et al., 2013), and recommendation for low to moderately hazardous chemical insecticides on crossing ETL level, 7) strictly avoid spraying pyrethroids before 120 days of crop age or any insecticide mixtures at any time to prevent sucking pests' outbreaks, 8) avoiding storage of infested or stained cotton in godowns, 9) averting crop extension beyond time, 10) timely termination of crop to break crop cycle, and 11) clean up fields of residual stalks and partially opened bolls.

Current status: Being used by farmers researchers, students, policy makes, planners

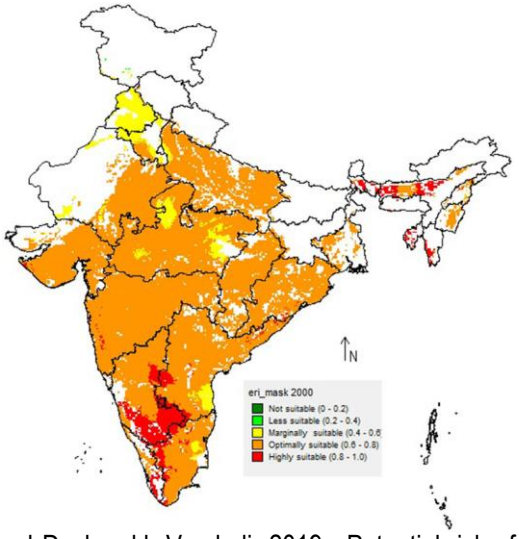
Publications: Nagrare V.S., Fand B. B., Kumar Rishi, et al. 2023. Pink bollworm, *Pectinophora gossypiella* (Saunders) management strategy, dissemination and impact assessment in India. Crop Protection 174,106424, https://doi.org/10.1016/j.cropro.2023.106424

Phenology model for cotton aphid: Potential risk of establishment and survival of cotton aphid *Aphis gossypii* in India based on simulation of temperature-dependent phenology model

Developer(s): V.S. Nagrare, Babasaheb B. Fand, B. V. Naikwadi, Vrushali Deshmukh

Brief description of the technology:

The cotton aphid, Aphis gossypii, is a major sap sucking insect of cultivated cotton, Gossypium sp. We investigated the effects of temperature on the biological parameters of A. gossypii by fitting different non-linear models to the data obtained from constant temperature experiments carried out between 12 and 32 oC. The pest risk in different geographical areas was simulated using GIS tools and represented by two spatial indices viz. establishment risk index (ERI) and generation index (GI). The results revealed that the development rate as a function of temperature increased linearly until approximately 27 oC, after which it became non-linear. Mean longevity of adult female was highest at 12 oC (10.10 ± 0.33 days) and shortest at 32 oC (3.70 ± 0.14 days). The lower and upper development threshold temperatures predicted for immature development of A. gossypii were 6.24 oC and 34 oC, respectively. The temperatures between 22 and 27 oC were found as favourable range for A. gossypii development, survival and reproduction. Majority of the Indian cotton areas were predicted optimally suitable for establishment and survival of A. gossypii (ERI>0.6 and GI>30.0).



Current status: Being used by researchers, students, policy makes, planners

Publications: Nagrare V. S., Fand Babasaheb B., Naikwadi B. V. and Deshmukh Vrushali. 2019. Potential risk of establishment and survival of cotton aphid Aphis gossypii in India based on simulation of temperature-dependent phenology model. International Journal of Pest Management. https://doi.org/10.1080/09670874.2019.1649739

Package of practices for managing mealybug on cotton

Developer(s): V.S. Nagrare, S. Kranthi, V.K. Biradar, N.N. Zade, V. Sangode, G. Kakde, R.M. Shukla, D. Shivare, B.M. Khadi and K.R. Kranthi

Brief description of the technology:
Between 2007 and 2009, a widespread infestation of the cotton mealybug, *Phenacoccus solenopsis*, was observed across all major cotton-growing states in India. Managing this pest requires a strategic shift from blanket chemical spraying to a localized, ecologically sensitive approach. Because mealybugs are protected by a protective waxy coating and often lack native natural enemies in new environments, heavy chemical interventions frequently backfire. The following Package of Practices (PoP) is recommended for effective control. Cultural and Preventive Measures: Removal of alternate hosts like *Parthenium hysterophorus* (Congress grass) and clear weeds from field bunds, water channels, and adjacent wastelands to break the pest's lifecycle, planting 2–3 border rows of barrier crop like pigeonpea, and include a single strip after every 5–6 rows of cotton to block pest migration. Monitoring: regularly scout field edges where infestations typically begin, early detection and the removal of a few infested plants along the borders can prevent a full-scale field outbreak. Biological Control: Release predatory beetles Cryptolaemus montrouzieri beetles on perennial trees and weeds before the cotton season begins, and directly onto infested cotton plants during the season. Conservation of natural enemies: Protect local parasitoids and predators by avoiding the use of broad-spectrum toxins. Chemical Intervention: Chemicals should be used with extreme caution to avoid disrupting the ecosystem: Do not use Extremely Hazardous chemicals like Methyl Parathion, or Highly Hazardous ones such as monocrotophos, dichlorvos, methomyl, triazophos, and metasystox. Use WHO Class III (slightly hazardous) insecticides, such as acephate. Do not spray the entire field. Use stem drenching or spot applications directly on affected plants to minimize environmental impact and preserve natural enemy populations.

Current status: Being used by farmers researchers, students, policy makes, planners.

Publications: Nagrare, V. S., Kranthi, S., Biradar, V. K., Zade, N. N., Sangode, V., Kakde, G., Shukla, R. M., Shivare, D., Khadi, B. M. and Kranthi, K. R. 2009. Widespread infestation of the exotic mealybug species, Phenacoccus solenopsis (Tinsley) (Hemiptera: Pseudococcidae) on cotton in India. Bulletin of Entomological Research 99, 537-541.

Degree day-based model for predicting pink bollworm phenology across geographical locations of subtropics and semi-arid tropics of India

Developers: Babasaheb B. Fand, V.S. Nagrare, S.K. Bal, V. Chinna Babu Naik, B.V. Naikwadi, D.J. Mahule, Nandini Gokte-Narkhedkar, V.N. Waghmare

Year of development: 2017-2020; **ICAR technology certification no:** ICAR-CS-CICR-Method-2023-021

Brief description of the technology:

- Estimation and field calibration of developmental thresholds and thermal constants for pink bollworm
- Establishment of the relationship between phenologies of host crop (cotton) and pink bollworm
- Determination of number of generations by accumulation of degree days (DD) between moth catch peaks
- Validation using geographically and temporally extensive data set of pink bollworm population dynamics
- Multilocation model predictions were > 80% accurate

Uniqueness/ Novelty

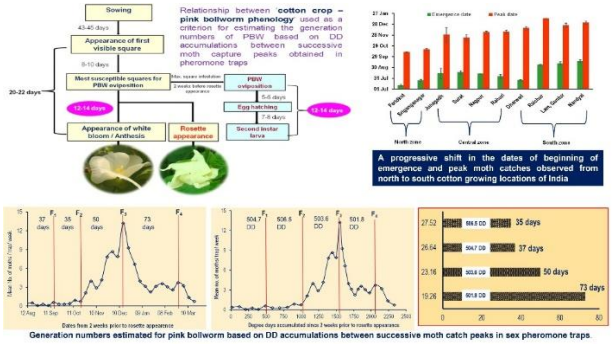
- First comprehensive model that accounts for both host crop (cotton) and pest (pink bollworm) phenologies.
- Extensive data on field phenology of crop and pest generated and correlated in a meaningful manner
- Multi-location data set to validate the model performance adds value to the model significance.
- Provides a more realistic picture of pest activity under field conditions

Advantages

- Comprehending seasonal dynamics of pink bollworm in relation to its peak abundance in field conditions
- Predicting beginning & peaks of moth emergence dates of oviposition & egg hatch, etc.
- Alerting the farmers to undertake timely measures of management
- Helps in minimizing the necessity for frequent insecticide applications
- Helps save time and effort and reduces the cost of control measures and associated labor costs.
- Area wide forewarning of pink bollworm
- Development of Pest Smart Strategies for Climate Smart Agriculture

Users/ client of the technology

- Cotton Scientists, Researchers, Entomologists, Agricultural Extension Workers, Cotton Growers (End user of the technology)



Generation numbers estimated for pink bollworm based on DD accumulations between successive moth catch peaks in sex pheromone traps

Publications:

Peddu H, Fand BB, HR Sawai, NV Lavhe. 2020. Estimation and validation of developmental thresholds and thermal requirements for cotton pink bollworm Pectinophora gossypiella. Crop Protection 127, 104984.

Fand BB, VS Nagrare, SK Bal, VCB Naik, BV Naikwadi, DJ Mahule, Gokte Narkhedkar N, Waghmare VN. 2021. Degree Day-based model predicts pink bollworm phenology across geographical locations of subtropics and semi-arid tropics of India. Scientific reports 11 (1), 1-18.

Rapid, Reliable and Robust methodology for field level yield loss assessment in cotton due to pink bollworm and boll rot

Developers: Babasaheb B. Fand, Vivek Shah, D.T. Nagrale, D.J. Mahule, S.P. Gawande, S.H. Thube, K. Pandian, Indal Ramteke, Rishi Kumar, K.Rameash, T. Prabhulinga, V.S. Nagrare, G.T. Behere, Y.G. Prasad

Year of development: 2023-25; **ICAR technology certification no:** ICAR-CS-CICR-Process-2025-022

Brief description of the technology:

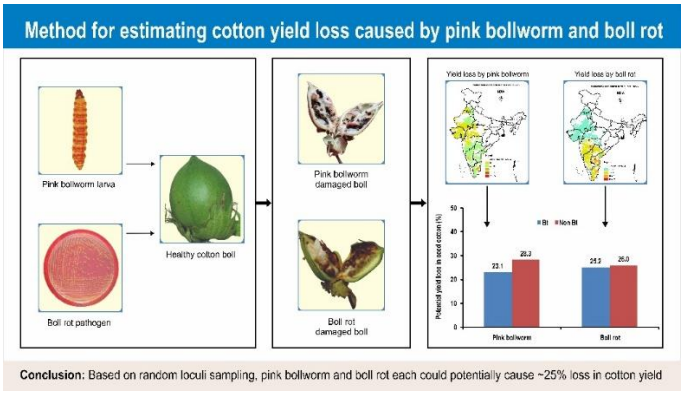
- A robust method to quantify yield losses from pink bollworm and boll rot using incidence levels and proportional weight loss in sampled loculi has been developed
- A temperature-based pest phenology model integrated with GIS was used to simulate population dynamics under climate change scenarios (0.5–2.5 °C warming).
- The model's activity index was regressed with field data from 15 locations to predict future yield losses.
- The PBW and BR could cause ~25% losses without control. Climate change may slightly reduce PBW populations post-2050.

Key features:

- Decision-support tool: Yield Loss Estimation Technology, Predictive Model for forecasting pest associated yield losses
- Rapid in-season yield loss estimation
- No need for full-season trials
- Accuracy/precision - 85–90%
- Cost-effective, 50-60% savings of resources, time, labour, money
- User-friendly and less labour-intensive
- Applicable over large areas – Area wide IPM
- Coupling with pest phenology – enabling climate change impact analyses

Users/ client of the technology

- Cotton Scientists, Researchers, Entomologists, Agricultural Extension Workers, Cotton Growers (End user of the technology)



Publications:

Fand B.B., Vivek Shah, D.T. Nagrale, D.J. Mahule, S.P. Gawande, S.H. Thube, K. Pandiyan, Indal Ramteke, Rishi Kumar, K. Rameash, T. Prabhulinga, V.S. Nagrare, G.T. Behere, Y.G. Prasad. 2025. Field estimates of current and predicted cotton yield loss due to pink bollworm and boll rot in India. Agricultural Systems, 224, 104246. https://doi.org/10.1016/j.agsy.2024.104246.

Innovative on-plant bioassay method for selection of superior cultivar/events against pink bollworm in cotton

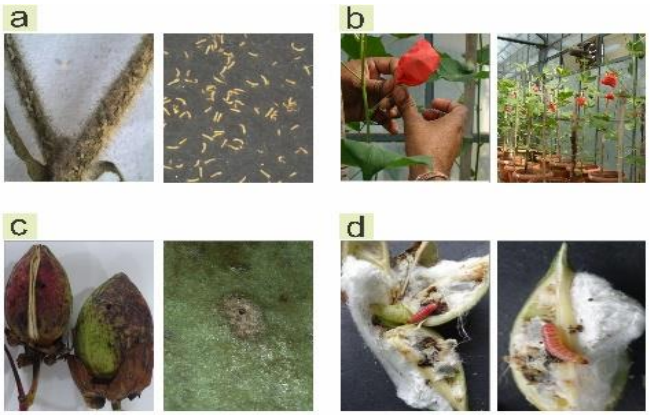
Developer(s): Vivek Shah, Rachna Pande, Babasaheb B. Fand, Nandini Gokte-Narkhedkar and V.N. Waghmare

Brief description of the technology:

Several methods have been advocated for screening of potential transgenic events that use either diet incorporation of toxins or excised plant parts expressing the pure protein (toxin) against insect pests of crops. However, considering the field level variations in transgenic plant expression due to abiotic environmental factors; mainly the temperature and moisture stress, it was a long-felt need for development of a bioassay method that can be readily employed under field conditions. Here, we present a simple, rapid, relatively stable and reliable method of on-plant bioassay for screening of genotypes or transgenic events against pink bollworm, the major insect pest of global significance to cotton. The proposed method involved releasing neonate larvae of pink bollworm on approximately 12–15 days old undetached cotton bolls and covering them with a kite paper bag to prevent larval escape. Tagging a total of 30 bolls each conducted at 100 and 150 days after sowing (DAS) that represented early and late formed bolls, respectively. Five newly hatched pink bollworm larvae were released onto each of the tagged boll and thus, a total of 150 individual larvae were used per treatment. The tagged bolls were kept undisturbed for next 21 days. After completion of this period the observations on larval entry holes, locular damage, exit holes and per cent damaged bolls were recorded in each case. Successful larval establishment and boll damage across the stages observed in non-Bt cotton plants compared to Bt cotton plants indicated the adequacy of proposed on-plant bioassay method. The late formed bolls exhibited relatively higher damage compared to early formed bolls in the plants that carrying Bt genes, indicating temporal decrease in toxin expression due to plant aging.

Current status: The protocol was developed under collaborative research project, validated for two years and ready for commercialization. The protocol was successfully utilized for evaluation of various transgenic cotton events against pink bollworm. ICAR Technology Certification No.: ICAR-CS-CICR-Technology-2023-028.

Publication: Vivek Shah, Rachna Pande, Babasaheb B. Fand, Nandini Gokte-Narkhedkar and V.N. Waghmare. 2021. Innovative on-plant bioassay method for selection of superior genotype/cultivar/event against pink bollworm, *Pectinophora gossypiella* (Saunders) in cotton in protected screen house condition. International Journal of Tropical Insect Science, 41: 3167–3172.



On-plant bioassay protocol for pink bollworm: **a.** Eggs laid on cotton twig (left) and neonate larvae (right); **b.** Bagging of bolls with red kite paper bags, close view (left) and experimental view (right); **c.** Exit hole (left) and entry hole (right) of pink bollworm on cotton boll; **d.** Damaged boll with all four locules damaged (left) and single locule damaged (right) by pink bollworm.

New Protocol for evaluation of transgenic cotton genotypes interogressed with protein against whitefly

Developer(s): Dr. Rishi Kumar, Dr. V.S.Nagrare, Dr. Satnam Singh, Dr. Vivek Shah, Dr. S.K.Verma, Dr Pankaj Rathore, Dr. V.N.Waghmare, Satpal Singh, Dr. Y.G.Prasad

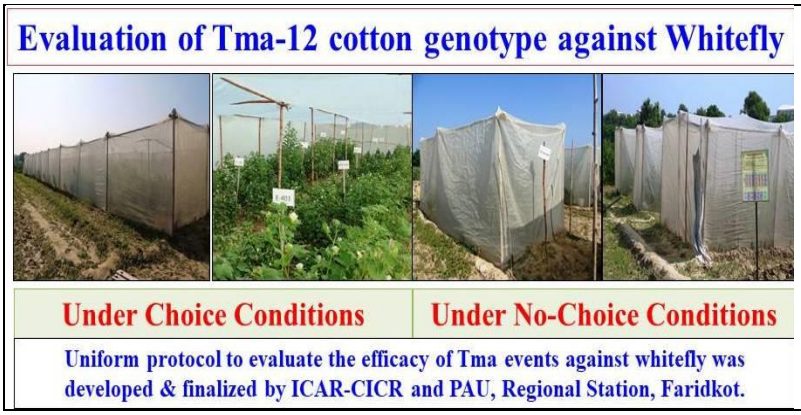
Brief description of the technology:

Whitefly, *Bemisia tabaci* (Gennadius), is a major sucking pest of cotton, especially in India's North zone. To evaluate transgenic cotton with protein-based antibiosis against whitefly, the ICAR-Central Institute for Cotton Research developed a standardized screening protocol for reliable and comparative evaluation of genotypes under open-choice and no-choice conditions. Biology studies were conducted for three consecutive generations across genotypes to evaluate the effects on whitefly life cycle.

The protocol was validated (2021 and 2022) through multi-location trials at Nagpur, Sirsa, and Faridkot. Weekly observations recorded from the 30th SMW indicated variation in adult and nymphal populations across genotypes. Under open choice conditions, the highest whitefly population was recorded on the susceptible check (SC), and lower populations were observed in the Tma events. Overall, adult population reduction ranged between 8.26 to 14.45% in 2021 and 16.95 to 22.81% in 2022 in Tma events as compared to the non-event genotype (Coker-312). Under no-choice conditions, the highest whitefly population was recorded on the N-Event (Coker-312) and comparatively lower populations were observed in the transgenic events, with the lowest adult population on E-402 and nymphal population on E-403. Overall, the average adult population reduction ranged from 11.19 to 20.01% in 2021 and 17.51 to 26.47% in Tma events 2022 over N-Event (Coker-312). Biology studies indicated only minor effects on fecundity and hatching across generations in whiteflies reared on transgenic cotton compared to non-transgenic cotton. The screening methodology developed first time against sucking pests to evaluate the transgenic cotton save times and enhance screening capacity providing complete information on the effects of interogressed proteins on whitefly growth and development.

Current status: The protocol was developed under collaborative research projects and validated through multi-location testing. No IPR is involved. The technology is proposed for use by researchers, extension personnel, and commercial stakeholders.

Publications: Kumar Rishi*, Nagrare V.S., Shah Vivek, et.al. 2025. Evaluation of transgenic cotton lines expressing an insecticidal fern protein against white fly, *Bemisia tabaci* (Gennadius). *Journal of Cotton Research*. 8(11): 15 https://doi.org/10.1186/s42397-025-00210-8



Conceptualization, In-Planta Field Evaluation, Validation and Compliance of Refugia in Bag' to maintain the susceptibility of Bt cotton against bollworm complex

Developer(s): Dr. Rishi Kumar (Lead), Associates: Dr. Debashis Paul, Dr. S.K. Verma, Dr. G. M. V. P. Rao, Dr. H. Desai, Dr. H. Bheemanna, Dr. B. Dharajothi, Dr. Sandhya Kranthi, K. R. Kranthi, Dr. Sandeep Kumar, Dr. Meenakshi Jattan, Dr. Subhash Chandra, Dr. Amarpreet Singh, Satpal Singh, Dr. S.K. Sain and Dr. Y.G. Prasad.

Brief description of the technology:

The ICAR-Central Institute for Cotton Research (CICR), Nagpur developed and validated the "Refugia in Bag" (RIB) technology to sustain the effectiveness of Bt cotton against the bollworm complex. Due to some operational aspects, adoption of the recommended 20% structured non-Bt refuge was inconsistent. RIB was conceptualized as a practical alternative to delay resistance development. The approach involves blending 5–10% non-Bt seeds with Bollgard-II (BG-II) hybrid seeds to create a built-in refuge within the seed bag itself. Initially developed in 2012 across five locations, the technology was further evaluated under AICRP during 2021–22 at 15 locations across North, Central, and South zones, along with in-planta validation studies in 2022 at Sirsa and Hisar. The evaluation was based on six treatments comprising varying proportions and arrangements of Bt and non-Bt cotton, including 5% and 10% seed blends, 20% perimeter refuge, and higher non-Bt proportions. Recommended BG-II hybrids and their isogenic non-Bt versions were used. Observations on bollworm incidence, square and boll damage, and yield were recorded .The main objective was to assess the damage of bollworms in N-Bt plants mixed in various proportions with Bt seed and compared with 20% Non-Bt structured refuge . Having resistance to bollworms, square damage in BG-II plants remained low across treatments, while non-Bt plants showed comparatively higher damage. Pink bollworm incidence was observed on non-Bt plants at all locations, with larval recovery ranging from 0–7.75%. Boll damage in 5% and 10% RIB treatments was comparable to the standard 20% refuge. Seed cotton yield was highest in 100% Bt (22.76 q/ha), followed closely by 5% RIB (22.35 q/ha) and 10% RIB (21.26 q/ha), showing negligible yield reduction. Validation through ELISA testing of thousands of samples confirmed Cry protein expression and RIB standards in BG-II seed packets. However, in-planta verification showed that only a proportion of hybrids found with recommended 5–10% non-Bt standard, need further improvement at parts of stakeholders. Overall, RIB improves refuge compliance to maintain bollworm susceptibility, and enhances long-term sustainability of Bt cotton cultivation.

Current status: Technology is validated and currently adopted by majority of seed suppliers and involves no IPR.

Publications:

Rishi Kumar, S. Kranthi, G. M. V. Prasad Rao, H.Desai, H. Bheemanna, B. Dharajothi , Alka Choudhary & K. R. Kranthi.2020.Assessment of bollworm damage and yield loss in seed blends of Bollgard-II with corresponding Non-Bt hybrid as 'built in refuge' in cotton Phytoparasitica. 49:253-23.https://doi.org/10.1007/s12600-020-00846-z.

Paul, D., Kumar, R. and Prasad, Y.G. 2024. Blending procedure is crucial for BG-II cotton hybrids to adhere to the prescribed 'Refugia in Bag'standards. *Current Science*, 127(1): 101-104.https://doi.org/10.18520/cs/v127/i1/98-101

Use of yellow sticky traps aligned with intercultural operations as an additional tool for monitoring and management of whitefly, *Bemisia tabaci* infesting cotton.

Developer(s): Dr. Rishi Kumar, Dr. Sandhya Kranthi, Dr. D. Monga, Dr. S.K. Sain, Satpal Singh

Brief description of the technology:

Yellow Sticky Traps (YST) are generally installed as stationary unit in the field to monitor whitefly with minimal impact on population reduction. YSTs were not able to significantly suppress the population of adult whiteflies when compared with the chemical control. However, YSTs were helpful in early detection of infestation and minimizing population numerically in comparison to the control plot. In the present case YSTs in addition to installation as stationary units were aligned and moved with intercultural operations by different methods in the field along with various intercultural operations such as movement of **(i)** YSTs attached by rod on either side of the power-weeder so as to move just above the crop canopy, **(ii)** Movement of YSTs behind two people who would move a rope through the plant rows so as to dislodge sucking pests making the adults stick to the YSTs, (iii) YSTs stuck on the pants of the plough operator in the portion just outer to the thigh, and **(iv)** Movement of badminton racket covered with YST on both sides between two rows. In stationary installation of YST, counts were recorded after 24 hours of installation from both sides whereas in case of moving YST trap whitefly counts from single front side after three operations of 40 meters each field length was recorded. Finally, population dynamics of the whitefly in all YST related treatments, plot applied with chemical control and a control plot without any intervention was studied by recording whitefly population/3leaves. In this case, YSTs attached by a rod on either side of the power-weeder trapped maximum whitefly observed immediately after operation but less than stationary YST which was observed after 24 hours of installation. Whitefly disturbed due to intercultural operations in the form of clouds can be trapped easily by moving YST along with intercultural operations without any extra efforts. Though minimal impact on the population dynamics of adult whiteflies was recorded as YSTs were not able to significantly suppress the population of adult whiteflies when compared with the chemical control which further need improvement but their role in monitoring the population is useful.

Current status: Technology is validated and currently adopted by farmers and involves no IPR.

Publications:

Rishi Kumar, Sandhya Kranthi, D Monga, Sandeep Kumar, S K Sain and Alka Chaudhary. 2019. Evaluation of moving yellow sticky traps for monitoring and management of whitefly, *Bemisia tabaci* infesting cotton. *Indian Journal of Agricultural Sciences* 89 (8): 1245–50, August 2019/Article

Stationary YST

YSTs attached by rod on either side of the power-weeder.

Movement of badminton racket covered with YST on both sides between two rows.

YSTs stuck on the pants of the plough operator.

Technology for Management of Whitefly- *Bemisia tabaci* (Gennadius) and Cotton Leaf Curl Disease (CLCuD) in North Cotton Growing Zone of India

Developer(s): Dr. Rishi Kumar, Dr. Dilip Monga, Dr. S.K. Sain, Dr. K.R.Kranthi.

Brief description of the technology:

The technology on Management of Whitefly- *Bemisia tabaci* (Gennadius) and Cotton Leaf Curl Disease (CLCuD) in North Cotton Growing Zone of India was devised based various experiments carried out by ICAR-CICR especially by ICAR CICR Regional Station, Sirsa and NARS under institute and AICRP on cotton programs targeting whitefly & CLCuD management. The strategies devised helped in whitefly & CLCuD management in the entire North zone reducing the insecticide and their mixture load, carryover of pest and subsequently yield enhancement. Studies on effect of date of sowing on occurrence of whitefly and CLCuD (NICRA & Institute project), monitoring of insecticides resistance against whitefly adults and nymphs, effect of use of yellow sticky traps in monitoring of whitefly incidence, identification of weed host for whitefly and CLCuD (Institute projects), screening of varieties/hybrids for CLCuD and whitefly resistance (Under evaluation of GEAC approved BG-II hybrids project) helped in development of whitefly and CLCuD management strategy for North Zone. Based on the studies prominent points identified to develop management strategic plan were: regular monitoring for early detection of whitefly incidence through use of YST in cotton crop, cultivation of recommended hybrids/varieties, timely sowing of cotton crop (before 15th May), clean cultivation, balanced use of recommended fertilizer, use of neem based insecticides and biopesticides formulation during early window to conserve generalist predators, insect growth regulator based insecticides during mid window and broad spectrum insecticides for the later stages.Window based strategy using biorationals during early window to conserve natural enemies and safer insecticides during later part based on ETL discouraging use of insecticides mixtures. Special emphasis for management of whitefly adults and pre-adult stages using stage specific (Adults & Nymphs) interventions were introduced and helped in whitefly management. Surveys conducted at farmer's field locations since 2016 indicated increased awareness towards neem-based insecticides, usage of IGRs instead of traditional insecticides and a smaller number of locations were recorded above ETL

Current status: Technology is validated and adopted by farmers of the zone and involves no IPR.

Publications:

Vijay Kumar, Jagdev Singh Kular, Rishi Kumar et al .2020. Integrated whitefly [*Bemisia tabaci* (Gennadius)] management in Bt-cotton in North India: an agroecosystem-wide community-based approach. Current Science. VOL. 119, NO. 4, 618-24.

Rishi Kumar, Sandhya Kranthi, et al .2019. Insecticidal activity of botanical oils and other neem-based derivatives against whitefly, *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae) on cotton *International Journal of Tropical Insect Science* : https://doi.org/10.1007/s42690-019-00027-4 (NAAS Rating-6.66)

Mealybug Management Strategies in Cotton Crop

Developer(s): Dr. Rishi Kumar, Dr. D. Monga, Dr. K.R. Kranthi

Brief description of the technology:

During the severe mealybug outbreak in cotton, integrated and farmer friendly management strategies were developed and widely disseminated to ensure effective and sustainable control. The approach emphasized early monitoring, ecological balance, and judicious insecticide use. Regular monitoring of fields, particularly the upper 5 cm portion of five plants along field boundaries, as infestations typically began from boarder side. Spot application of recommended insecticides instead of blanket sprays to conserve natural enemies, uprooting and destroying heavily infested plants was recommended, strictly ensuring infested material not thrown into canals or water bodies. Mealybug being a polyphagous pest and weed management was identified as a critical component. Uproot and destroy infested weeds like *Parthenium* and *Abutilon* which served as alternate hosts, rather than spray weedicides on bunds, which could facilitate pest movement. Cultivation of barrier crops (bajra or jowar) around cotton fields was promoted to strengthen pest management. Eco-friendly approaches were prioritized wherein Neem-based products, biopesticides, fish oil rosin soap (FORS), horticultural mineral oil, and entomopathogenic fungi such as *Metarhizium anisopliae* and *Beauveria bassiana* were evaluated and recommended as safer alternatives. The classical biological control agent *Aenasius bambawalei* was reported and introduced in highly infested locations which played an important role in natural suppression of mealybugs. As a last resort, restricted and rotational use of recommended insecticides such as profenophos, chlorpyriphos, quinalphos, carbaryl, and thiodicarb was advocated avoiding highly hazardous insecticides and mixtures.

Extensive awareness campaigns including training programs, farmer meetings, pamphlets, posters, exhibitions, and media outreach ensured widespread adoption of these strategies. Overall, the integrated management approach successfully reduced mealybug incidence while promoting sustainable cotton production and environmental safety.

Current status: Technology validated and adopted by farmers and involves no IPR.

Publications:

Rishi Kumar et al. 2013. Within-plant distribution of an invasive mealybug, *Phenacoccus solenopsis*, and associated losses in cotton. *Phytoparasitica* Volume 42, Issue 3 (2014), Page 311-316.DOI 10.1007/s12600-013-0361-6.

Rishi Kumar et al. 2011. Evaluation of Ecofriendly Control Methods for Management of Mealybug, *Phenacoccus solenopsis* Tinsley in cotton, *Journal of Entomology*, ISSN 1812-5660/DOI:10.3923/je.2011 (First on online).

Rishi Kumar et al. 2009. Natural parasitization of *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) on cotton by *Aenasius bambawalei* Hayat (Hymenoptera: Encyrtidae). *J. Biol. Control*. 23 (4): 457-460.

Rishi Kumar et al. 2009. Studies on *Phenacoccus solenopsis* Tinsley: A newly reported mealybug species on transgenic cotton in North India, *Indian Journal of Entomology,* 71 (2):125-129

Push-Pull strategy for management of pink bollworm in cotton

Developer(s): Vivek Shah, Rachna Pande, Pooja Verma, Prabhulinga T., Shivaji Thube, Babasaheb B. Fand, Madhu T.N., Nandini Gokte-Narkhedkar, Y.G. Prasad and V.N. Waghmare

Brief description of the technology:

Studies on identification of oviposition deterrents or oviposition-deterring pheromones (ODP's) (push component) has been carried out worldwide. ODPs are spacing pheromones emitted by insects that enable female insects to avoid laying eggs on previously exploited hosts, thereby reducing intra specific competition. At the same time plants emit volatile compounds that attract insects towards them (Pull component) for foraging and oviposition. Insects perceive these compounds primarily by olfaction (smell). Considering the importance of chemical repellents and attractants in ecological pest management study was formulated to identify and utilize oviposition deterrents and attractants for management of pink bollworm in cotton.

Oviposition deterrents: Fatty acids namely oleic and linoleic acids were identified as oviposition deterrents in pink bollworm. Vegetable oils containing these fatty acids have shown oviposition deterrent effect under laboratory conditions and reduction in boll damage under field conditions.

Attractants: Volatile compounds were identified from square extracts of all the four cultivated species of cotton which include: α/β pinene, carene, γ terpinene, α copaene, caryophyllene and humulene as major compounds. However, their relative proportion in the blend varies from species to species that impart relative preference to pink bollworm for egg laying. Order of preference of pink bollworm for oviposition is *G. hirsutum*> *G. barbadense*> *G. arboreum*> *G. herbacium*.

Current status: This technology has been scientifically validated and published in a peer-reviewed journal and is currently in the public domain.

Publication: Shah Vivek, Rachna Pande, Pooja Verma et al. 2022. Oviposition preference of pink bollworm, *Pectinophora gossypiella* (Saunders) on cotton. Animal Biology. 72(4), 353-366.
Shah Vivek, Rachna Pande, Pooja Verma et al. 2024. Evaluation of vegetable oil as oviposition deterrents for the management of pink bollworm, *Pectinophora gossypiella* (Saunders) in cotton. Journal of Plant Disease and Protection. 131: 403-412.

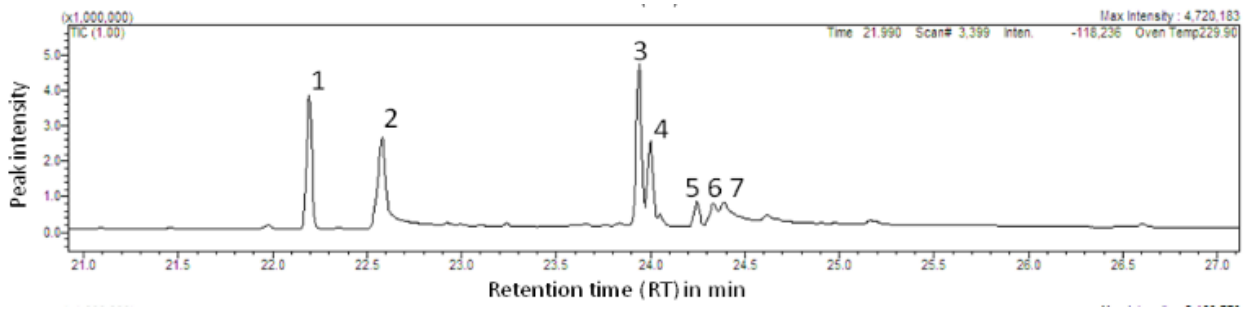


Figure. Compounds identified from feacal pellet extract of pink bollworm, Hexadecanoic acid methyl ester (Peak #1), n- Hexadecanoic acid (Peak #2), 9,12-Octadecadienoic acid methyl ester (Peak #3), 9-Octadecenoic acid methyl ester (Peak #4), Octadecanoic acid methyl ester (Peak #5), 9,12-Octadecadienoic acid (Peak #6), 9-Octadecenoic acid (Peak #7).

Improved bioassay method for evaluation of oviposition deterrents against Old World bollworm, *Helicoverpa armigera*

Developer(s): Dr. Rachna Pande, Dr. Shah Vivek, Dr. Pooja Verma, Dr. VN Waghmare

Brief description of the technology:

Old world bollworm *Helicoverpa armigera* (Hübner) is a polyphagous pest of more than 184 recorded hosts including cotton, and can cause yield losses up to 40% with 20-80% damage intensity. *H. armigera* has developed resistance against conventional insecticides and succeeded in surviving on Bt cotton in some isolated places. Semiochemicals especially oviposition deterrents can serve as an alternative management option by curtailing the infestation at the first line of attack. Hence, the method is developed and standardized for the evaluation of compounds as an oviposition deterrent compound. The five-day duration of the bioassay method was finalized according to the peak activity of adult moths in terms of mating and fecundity. The crucial steps involved in present method were finalization of most acceptable Oviposition substrate, Number of male and female, Release of oviposition deterrent compounds and duration of bioassay. The value of preference index in choice experiment clearly showed that muslin cloth was 78% more preferred substrate over cotton twig. After finalization of oviposition substrate for egg laying number of male and female pairs were standardized for uniform egg laying by making different pairs (5:5, 4:4, 3:3, 2:2 and 1:1) that could be easily counted manually. Using pair of 5 males and 5 females deposited approximately more than 1500±15.31 eggs which were not easy to count for number of treatments and replications hence increasing chances of manual error. Similar limitation also observed in a jar which has four pairs and three pairs as well. Oviposition pattern in a jar which has single pair was not consistent as in more than 50% jars female did not lay eggs. Therefore, it was concluded that 2 males and 2 females pairing was best for conducting bioassay. Further release of oviposition deterrent compounds was finalized. Among different methods of treatment of oviposition deterrent compound (cotton swab treated with compounds, glass vial with cotton wick and treated filter paper with compounds: below muslin cloth and above muslin cloth), egg laying by female moth on treated jar was at par with control except in case of separate treatment of muslin cloth. Among all, separate treatment of muslin (completely dipped in experimental concentration for uniform coverage) cloth (for 20 s) was found the most acceptable method. Finally, bioassay was conducted using identified compounds (with 99.99% purity) palmitic acid in order to evaluate their role as oviposition deterrents (ODs). Two pairs of newly-emerged male and female moths are allowed to mate in enclosed transparent plastic container (13.5 cm height and 11.5 cm diameter) during the scotophase for 48 h period as 70% of *H. armigera* females commence calling to male within three nights of emergence. Transparent jars allowed the easy observation on activeness and mating of adult. Muslin cloth treated (separately) with experimental concentration for identified compound can be used as oviposition substrate keeping diluents as control with desired number of replications. The muslin cloths were completely dipped (for 20 s) for uniform coverage of the treatment on complete surface. The experiments were terminated on 5th day after the treatment because it is the high fecundity period for *H. armigera*. Muslin cloth of each jar was stored in separate container under controlled conditions that will avoid the fact of escape of neonate. In the present study number of eggs laid by the female decreased significantly with increasing concentration of palmitic acid compared with control. Hence, value of Ai and PED were increased with the increasing concentration.

Current status: It is a laboratory method Hence validation was done within the Institute. In present study, the bioassay method is designed to keep all the scientific reasoning as a base so any researcher can replicate the same for any insect. Method was used for the evaluation of all the identified compounds as a deterrent or attractant for 4 year. Many volatiles and natural compounds were evaluated using the same method. Results are published in institute's annual report and presented in various international forum

Publications: Pande, R., Shah, V, Verma, P. Gokte-Narkhedkar N. and Waghmare V.N. 2022 Improved bioassay method for evaluation of oviposition deterrents against Old World bollworm, *Helicoverpa armigera* (Hübner) Indian Journal of Experimental Biology Vol. 60, pp. 851-857 (NAAS rating 2025 6.7)

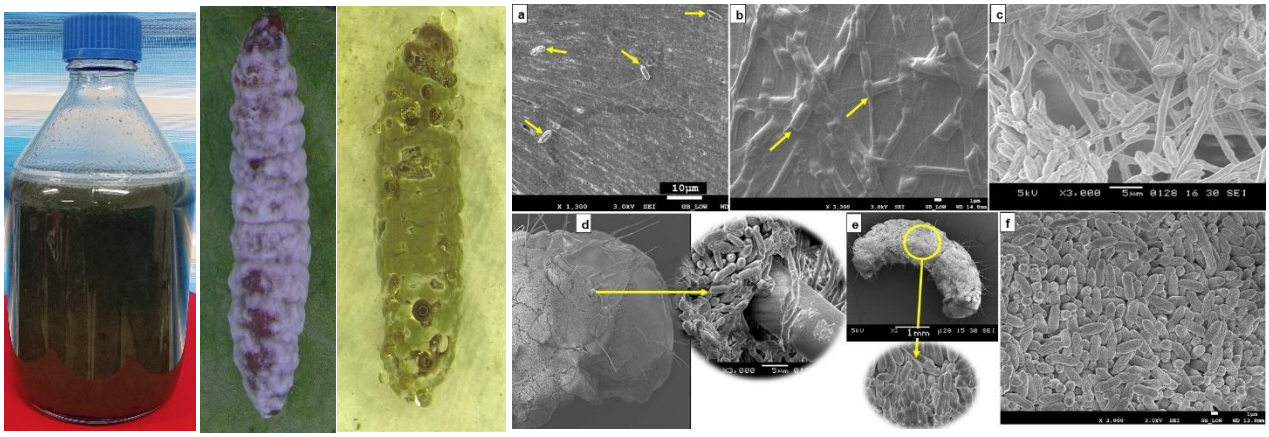
Metarhizium-based oil formulation for cotton insect pest management

Developer(s): Shivaji Thube, G. T. Behere, Babasaheb Fand, Rachna Pande, Vivek Shah, Rishi Kumar, Prabhulinga T., Shailesh Gawande, Vrushali Deshmukh, Y.G. Prasad, V. N. Waghmare

Brief description of the technology:
Insect pests are one of the major constraints in cotton production. Cotton is among the crops that consume the highest amount of chemical insecticides. Excessive use of these chemicals is unsafe for the environment and human health and often results in insecticide resistance and pest resurgence. To address these challenges, a *Metarhizium*-based oil formulation has been developed for the sustainable management of cotton insect pests. The formulation is prepared using oil, surfactants/spreaders, and pure spores of *Metarhizium anisopliae*. Different permutation–combination ratios of these ingredients were tested to develop an effective formulation. Initially, the formulations were evaluated under laboratory conditions against major insect pests of cotton. The most promising combination was subsequently tested under real field conditions. After two years of field evaluation, the product has been sponsored for multilocation testing under the All India Coordinated Research Project on Cotton. The recommended dose of the oil formulation has been standardized at 5 ml per litre of water. Results from two years of evaluation (2023–2025) confirmed a significant reduction in pest incidence, particularly jassids, aphids, and pink bollworm. Additionally, a notable increase in seed cotton yield was observed in the plots treated with the formulation. Overall, this technology offers an eco-friendly and sustainable alternative to chemical insecticides for effective management of cotton insect pests.

Current status: This technology has been sponsored for AICRP on cotton for multilocation evaluation. The Institute Technology Management Unit (ITMU) has approved the trademark filing of this product, and the trademark for the formulation has been successfully filed.

Publications: Thavkar, Snehal, **Shivaji Thube*,** Pramod Panchbhai, Nandkishor Lavhe, Tinni Pillai, Vivek Shah, Vrushali Deshmukh et al. "Evaluation of bio-efficacy of *Metarhizium anisopliae* against the pink bollworm *Pectinophora gossypiella* (Saunders), with insights into its colonization potential and insecticide compatibility." *Journal of Cotton Research* 8, no. 1 (2025): 8. https://doi.org/10.1186/s42397-025-00213-5



EPN-based aqua-formulation for pink bollworm management in cotton

Developer(s): Shivaji Thube, G. T. Behere, Babasaheb Fand, Vivek Shah, Prabhulinga T., Vrushali Deshmukh, Swati Shinde, Dnyaneshwar Ingole, Y.G. Prasad, V. N. Waghmare

Brief description of the technology:
An EPN-based aqua-formulation has been developed for the sustainable management of pink bollworm in cotton. Two indigenous strains of the entomopathogenic nematode Heterorhabditis indica were isolated from the rhizosphere of mango and curry leaf trees and designated as CICR-HI-MN and CICR-HI-CL, respectively. These strains were evaluated for their efficacy and virulence against different larval instars of the fall armyworm, *Spodoptera frugiperda*, and the pink bollworm, *Pectinophora gossypiella*. The results showed that 3rd instar larvae were more susceptible, while higher reproductive potential of the nematodes was observed in later larval stages, indicating their ability to multiply and persist on the host. Among the two strains, CICR-HI-CL exhibited nearly two times higher efficacy compared to CICR-HI-MN. The strains also demonstrated strong virulence against larval instars and pupae of pink bollworm, with maximum reproduction recorded in the 4th instar larvae. Soil-dwelling stages such as hibernating larvae and pupae act as critical targets for the effective application of this aqua-formulation in cotton fields. Field experiments conducted during 2023–2024 recorded an average yield increase of about 2.5 quintals per hectare, corresponding to nearly 20% improvement in productivity over untreated control plots, demonstrating the potential of this technology in eco-friendly pest management in cotton.

Current status: The ITMU fixed the rate of Rs.100000/- per strain for commercialization of strain to Arthro Biotech Pvt. Ltd. Hyderabad. Strain commercialization is under progress.

Publications: **Thube S.H***., Shinde, S., Shah, V., Gokte-Narkhedkar, N., Ingole, D., Nikoshe, A., Tenguri, P., Thavkar, S., Fand, B., Deshmukh, V. and Prasad, Y., 2023. Biocontrol potential of entomopathogenic nematode, *Heterorhabditis indica* against pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae). *Journal of Cotton Research*, *6*(1), p.23.

Metarhizium-based capsule formulation for cotton insect pest management

Developer(s): Shivaji Thube, G. T. Behere, Babasaheb Fand, Rachna Pande, Vivek Shah, Rishi Kumar, Prabhulinga T., Shailesh Gawande, Vrushali Deshmukh, Y.G. Prasad, V. N. Waghmare

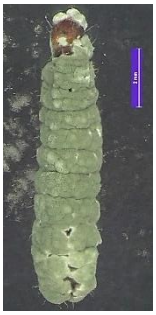
Brief description of the technology:

Insect pests are one of the major constraints in cotton production, and cotton is among the crops that consume the highest amount of chemical insecticides. Excessive use of these chemicals is unsafe for the environment and human health and often leads to insecticide resistance and pest resurgence. To address these challenges, a Metarhizium-based capsule formulation has been developed for the sustainable management of cotton insect pests with the added advantages of longer shelf life, improved storability, and easier transportation. The formulation is developed using vegetative capsules containing pure spores of *Metarhizium anisopliae* along with suitable carriers and stabilizing components. Different permutation–combination approaches were tested to standardize an effective and stable capsule-based formulation. Initially, these formulations were evaluated under laboratory conditions against major insect pests of cotton, and the most promising formulation was further assessed under field conditions. After two years of field evaluation, the product has been sponsored for multilocation testing under the All India Coordinated Research Project on Cotton. The capsule formulation is designed to release viable spores effectively during application, ensuring efficient pest management. Results from evaluations during 2023–2025 confirmed a significant reduction in pest incidence, particularly jassids, aphids, and pink bollworm, along with a noticeable increase in seed cotton yield in treated plots.

Overall, this Metarhizium-based capsule formulation provides an eco-friendly, stable, and user-friendly alternative to chemical insecticides for effective management of cotton insect pests.

Current status: This technology has been sponsored for AICRP on cotton for multilocation evaluation. The Institute Technology Management Unit (ITMU) has approved the trademark filing of this product, and the trademark for the formulation has been successfully filed.

Publications: Thavkar, Snehal, **Shivaji Thube*,** Pramod Panchbhai, Nandkishor Lavhe, Tinni Pillai, Vivek Shah, Vrushali Deshmukh et al. "Evaluation of bio-efficacy of *Metarhizium anisopliae* against the pink bollworm *Pectinophora gossypiella* (Saunders), with insights into its colonization potential and insecticide compatibility." *Journal of Cotton Research* 8, no. 1 (2025): 8. https://doi.org/10.1186/s42397-025-00213-5



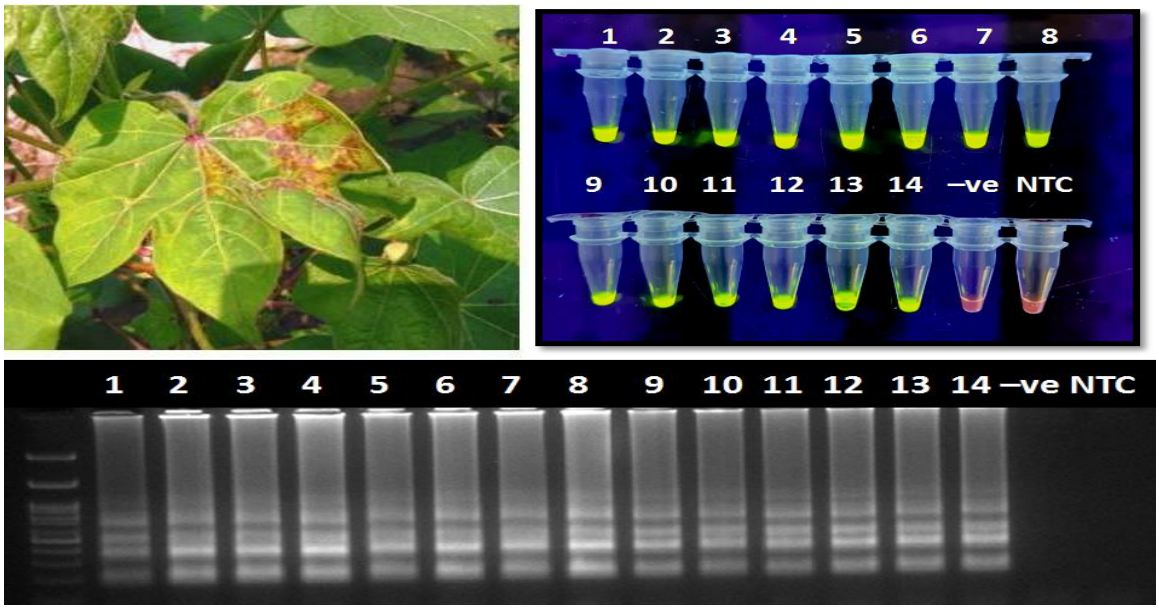
Rapid detection of Tobacco streak virus (TSV) in cotton (*G. hirsutum*) based on Reverse Transcription Loop Mediated Isothermal Amplification (RT-LAMP)

Developer(s): S. P. Gawande, K.P. Raghavendra, D. Monga, D.T. Nagrale , N.S. Hiremani, M. Meshram, Sandhya Kranthi, V. N. Waghmare

Brief description of the technology:

Tobacco Streak Virus (TSV) belongs to the genus Ilarvirus of the family Bromoviridae an emerging pathogen posing threat to the crop species worldwide. Identification of symptoms due to TSV infection by visual observation of plants often results in misdiagnosis as symptoms produced by this virus can match with those reflecting physiological and nutritional disorders affecting cotton. The protocol for rapid diagnosis of TSV infected samples by using Reverse Transcription-Loop Mediated Isothermal Amplification (RTLAMP) was optimized and this is the first report of its use for diagnosis of TSV on cotton and Soybean. The colorimetric detection for diagnostic simplicity of amplified RT-LAMP product by using different dyes lead to enhanced applicability of this technique. The RT-LAMP diagnostic tool can be utilized not only for laboratory research but also for quarantine and field diagnosis of this important emerging pathogen affecting cotton.

Current status: Validated the technique during 2016 to 2019 cropping season by diagnosed TSV infected samples from Central and North India



Colorimetric detection and diagnosis of TSV using LAMP and gel visualization of LAMP product using 1.5% Agarose gel via electrophoresis, where samples1-13= TSV symptomatic samples,14- Positive Control -ve= Asymptomatic cotton sample, NTC= No template control

Publication: Shailesh Pandurang Gawande, Raghavendra K.P., Dilip Monga, Dipak T. Nagrale, Sandhya Kranthi,(2019) Rapid detection of Tobacco streak virus (TSV) in cotton (Gossypium hirsutum) based on Reverse Transcription Loop Mediated Isothermal Amplification (RT-LAMP),Journal of Virological Methods, Volume 270,Pages 21-25,ISSN 0166-0934,https://doi.org/10.1016/j.jviromet.2019.04.018

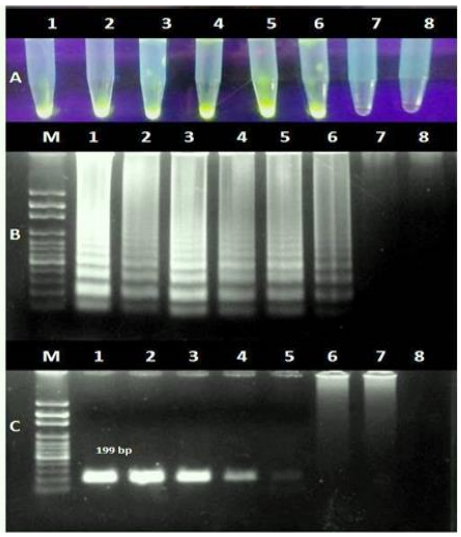
Rapid detection of Cotton leaf curl virus infection by using Single tube Loop Mediated Isothermal Amplification technique (LAMP)

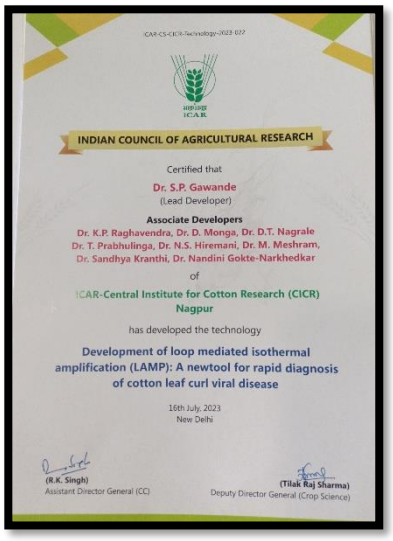
Developer(s) S. P. Gawande, K. P. Raghavendra, D. Monga, D.T. Nagrale,T. Prabhulinga, N.S. Hiremani, M. Meshram, Sandhya Kranthi,,Nandini Gokte-Narkhedkar,V.N. Waghmare

Brief description of the technology:

Viral diseases of cotton in the Indian subcontinent, causing major economic losses to farmers. Early and accurate detection of the causal virus, Cotton leaf curl virus (CLCuV), in both plants and vectors is essential for effective management. In this study, a rapid and highly sensitive diagnostic protocol based on Rolling Circle Amplification–Loop Mediated Isothermal Amplification (RCA-LAMP) was standardized for detecting CLCuV in cotton leaves and whiteflies. The assay enables detection within 60 minutes and shows higher sensitivity than PCR. Colorimetric visualization using SYBR Safe dye further simplifies field diagnosis and supports timely disease surveillance and management strategies.

Current status: Multi-site testing by tested on samples of infected leaf and whiteflies collected from different field locations of Haryana, Punjab and Rajasthan states.





Visual assessment of sensitivity of LAMP assay: A) Colorimetric detection by using SYBR Safe DNA gel stain. B) LAMP assay on the basis of 1.5% agarose gel electrophoresis (C) Result of conventional PCR using F3 and B3 of LAMP primers (199 bp amplicon).

Publication:

S P Gawande, K P Raghavendra, D Monga, D T Nagrale, T Prabhulinga, N Hiremani , M Meshram , Sandhya Kranthi , Nandini Gokte-Narkhedkar , V N Waghmare , (2022) Development of loop mediated isothermal amplification (LAMP): A new tool for rapid diagnosis of cotton leaf curl viral disease Journal of Virological Methods 306, 114541

Oil-based bio-insecticide formulation: CICR GreenGuard-1

Developer(s): Dr. Satish Kumar Sain, Dr. Monga D, Dr. Kumar R.

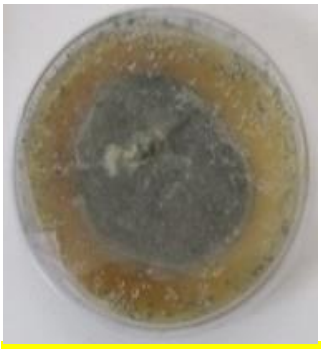
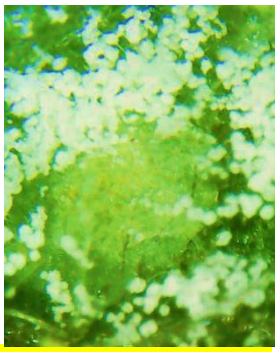
Brief description of the technology /process:
CICR GreenGuard-1 is a novel oil-based water-dispersible liquid bio-insecticide formulation of the most virulent and insecticide-compatible entomopathogenic fungal strain (*Metarhizium anisopliae* CICRRS-Ma1299; NAIMCC-F-04455). Two to three need-based sprays can effectively manage both nymph and adults of whitefly a vector of CLCuD under conventional, IPM/IRM, and organic/natural cotton cultivation systems without negative effects on natural enemies. The technology was validation in Haryana, Punjab, Rajasthan during 2020, 2021 and 2022 under AICRP on cotton.

Microbial constituent: *Metarhizium anisopliae CICR-RS- Ma-1299 (NAIMCC-F-04455).*
Type: Oil-based bioinsecticide formulation; >2 × 10^8 cfu/mL with shelf life of >12 months at 25-35°C.
Target pests and crops: Whitefly (*Bemisia tabaci*) and thrips (*Thrips palmi*) in cotton.
Target agroecological zones/states: Haryana, Punjab, Rajasthan in North cotton growing Zone.
Special features: Compatible with chemical insecticides and botanicals recommended for whitefly management in cotton.
Tank missing ability and stability: >48hours.
Method of application: Two to three need based foliar sprays @ 5 ml/Liter of water at 15 days interval; water required for each spray is 500 Liter/hectare.
Benefits: Causes 21.5-79.4% reduction in whitefly nymphal and adult population. 15-30% reduction in CLCuD and 20-50% increase in seed cotton yield with Incremental Cost-Benefit Ratio (ICBR) of 1.9 to 2.2.
Applicability: Formulation can be applied in conventional, IRM/IPM and organic/natural cultivation systems.

Current status: Technology is ready for licensing. Toxicological data for CIB&RC registration are to be generated.

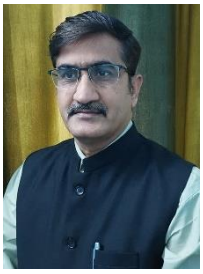
Publications: **1.** Sain SK, Monga D, Hiremani NS, Nagrale DT, Kranthi S, Kumar R, Kranthi KR, Tuteja OP, Waghmare VN. 2021. Evaluation of bioefficacy potential of entomopathogenic fungi against the whitefly *(Bemisia tabaci* Genn.) on cotton under polyhouse and field conditions. Journal of Invertebrate Pathology.183:1076181.
2. Sain SK, Monga D, Kranthi S, Hiremani NS, Nagrale D, Kumar R, Verma SK, Prasad YG. 2022. Evaluation of the bioefficacy and insecticide compatibility of entomopathogens for management of whitefly (Hemiptera: Aleyrodidae) on upland cotton under laboratory and polyhouse conditions. Neotropical Entomology. 51:600-612

CICR Green Gaurd-1- Formulation



Metarhizium anisopliae CICR-RS- Ma-1299, Infected nymph

ICAR-CS-CICR-Technology-2023-027

Oil-based bio-insecticide formulation: CICR CotPest Guard-1



Developer(s): Dr. Satish Kumar Sain, Dr. Monga D, Dr. Kumar R.

Brief description of the technology /process:

CICR CotPestGuard-1 is a novel oil-based water-dispersible liquid bio-insecticide formulation of the most virulent and insecticide-compatible entomopathogenic fungal strain (*Cordyceps javanica* –CICR-RSS-Cj0102; NAIMCC-F-04402/ ITCC-10499.17). Two to three need-based sprays can effectively manage both nymph and adults of whitefly a vector of CLCuD under conventional, IPM/IRM, and organic/natural cotton cultivation systems without negative effects on natural enemies. The technology was validation in Haryana, Punjab, Rajasthan during 2020, 2021 and 2022 under AICRP on cotton.

Microbial constituent: *Cordyceps javanica (CICR RS Cj-0102)* (ITCC-10499)

Type: Oil-based bioinsecticide formulation; >2 × 10^8 cfu/mL with shelf life of >12 months at 25-35°C.

Target pests and crops: Whitefly (*Bemisia tabaci*) in cotton.

Target agroecological zones/states: Haryana, Punjab, Rajasthan in North cotton growing Zone.

Special features: Compatible with chemical insecticides and botanicals recommended for whitefly management in cotton.

Tank missing ability and stability: >48hours.

Method of application: Two to three need based foliar sprays @ 5 ml/Liter of water at 15 days interval. Water required for each spray is 500 Liter/hectare.

Benefits: Causes 21.5-84.7% reduction in whitefly nymphal and adult population. 15-30% reduction in CLCuD, 20-50% increase in seed cotton yield with Incremental Cost-Benefit Ratio (ICBR) of 1.9 to 2.2.

Applicability: Formulation can be applied in conventional, IRM/IPM and organic/natural cultivation systems.

Current status: Technology is ready for licensing. Toxicological data for CIB&RC registration are to be generated.

Publications: 1. Sain SK, Monga D, Hiremani NS, Nagrale DT, Kranthi S, Kumar R, Kranthi KR, Tuteja OP, Waghmare VN. 2021. Evaluation of bioefficacy potential of entomopathogenic fungi against the whitefly *(Bemisia tabaci* Genn.) on cotton under polyhouse and field conditions. Journal of Invertebrate Pathology.183:1076181.

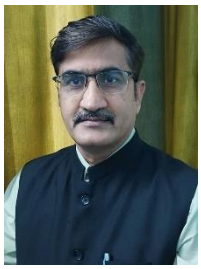
2. Sain SK, Monga D, Kranthi S, Hiremani NS, Nagrale D, Kumar R, Verma SK, Prasad YG. 2022. Evaluation of the bioefficacy and insecticide compatibility of entomopathogens for management of whitefly (Hemiptera: Aleyrodidae) on upland cotton under laboratory and polyhouse conditions. Neotropical Entomology. 51:600-612

CICR CotPest Gaurd-1 Formulation

Cordyceps javanica-CICR-RSS-Cj-0102; infected nymph

ICAR-CS-CICR-Technology-2023-026

Oil-based bio-insecticide formulation: CICR CotPest Guard-2



Developer(s): Dr. Satish Kumar Sain, Dr. Monga D, Dr. Kumar R.

Brief description of the technology /process:

CICR CotPest Guard-2 is a novel oil-based water-dispersible liquid bio-insecticide formulation with >2 x 10^8 cfu/ml of the most virulent and insecticide-compatible entomopathogenic fungal strain (*Beauveria bassiana* CICR RS-Bb-4511; NAIMCC-F-04402). Two to three need-based sprays can effectively manage both nymph and adults of whitefly a vector of CLCuD under conventional, IPM/IRM, and organic/natural cotton cultivation systems without negative effects on natural enemies. The technology was validation in Haryana, Punjab, Rajasthan during 2020, 2021 and 2022 under AICRP on cotton.

Microbial constituent: *Beauveria bassiana CICR RS-Bb-4511* (NAIMCC-F-04402).

Type: Oil-based bioinsecticide formulation; >2 × 10^8 cfu/ml with shelf life of >12 months at 25-35°C.

Target pests and crops: Whitefly (*Bemisia tabaci*) and thrips (*Thrips palmi*) in cotton.

Target agroecological zones/states: Haryana, Punjab, Rajasthan in North cotton growing Zone.

Special features: Compatible with chemical insecticides and botanicals recommended for whitefly management in cotton.

Tank missing ability & Stability : >48hours

Method of application: Two to three need based foliar sprays @ 5 ml/Liter of water at 15 days interval. Water required for each spray is 500 Liter/hectare.

Benefits: Causes 22.3-86.3% reduction in whitefly nymphal and adult population. 15-30% reduction in CLCuD. 20-50% increase in seed cotton yield with Incremental Cost-Benefit Ratio (ICBR) of 1.9 to 2.2.

Applicability: Formulation can be applied in conventional, IRM/IPM and organic/natural cultivation systems.

Current status: Technology is ready for licensing. Toxicological data for CIB&RC registration are to be generated.

Publications: 1. Sain SK, Monga D, Hiremani NS, Nagrale DT, Kranthi S, Kumar R, Kranthi KR, Tuteja OP, Waghmare VN. 2021. Evaluation of bioefficacy potential of entomopathogenic fungi against the whitefly *(Bemisia tabaci* Genn.) on cotton under polyhouse and field conditions. Journal of Invertebrate Pathology.183:1076181.

2. Sain SK, Monga D, Kranthi S, Hiremani NS, Nagrale D, Kumar R, Verma SK, Prasad YG. 2022. Evaluation of the bioefficacy and insecticide compatibility of entomopathogens for management of whitefly (Hemiptera: Aleyrodidae) on upland cotton under laboratory and polyhouse conditions. Neotropical Entomology. 51:600-612

CICR CotPest Gaurd-2 Formulation

Beauveria bassiana CICR RS-Bb-4511, infected nymph

ICAR-CS-CICR-Technology-2023-025

Diaporthe longicolla (isolate CEL-48) as an endophytic, growth promoting, biocontrol agent against major diseases of cotton

Developers: Dr. Neelakanth S. Hiremani; **Associates**: Dr S. P. Gawande, Dr Pooja Verma, Dr S. K. Sain, Dr D. T. Nagrale, Dr Y. G. Prasad

Brief description of the Technology:

Endophytes as biocontrol agents are becoming popular and there is a lot of scope to unravel the potential of endophytes in several crops including cotton. Thus, several fungal endophytes were isolated, identified and evaluated against major pathogens of cotton. Among those endophytes, *Diaporthe longicolla* isolate CEL-48 was found promising with more than 64% and 49% colony inhibition against target leaf spot pathogen *Corynespora cassiicola* and seedling rot causing *Fusarium solani*. The *in vivo* studies against *Macrophomina phaseolina* in pots and root rot incidence in field trials showed promising effects of these isolates when used as seed treatment @ 5g/kg seeds. Seed treatment with CEL-48 significantly reduced wilt incidence in the field which was as low as 0.67% and 2.12% in Phule Dhanwantary and Suraj cotton cultivars, respectively, compared to the control, which showed incidences of 12.61% and 10.29%, respectively. Besides, seed bio-priming with *Diaporthe longicolla* isolate CEL-48 showed remarkable changes in biochemical parameters wherein, an increase in total soluble protein content up to 20% was seen in cotton and as high as 40% in cowpea. An increase in the activity of both catalase and peroxidase enzymes was observed in cotton and non-host crops. Notably, the highest catalase activity was recorded in CEL-48 bio- primed wheat, while the highest peroxidase activity was observed in CEL-48 bio-primed pigeon pea. An approximate increase of 20-30% in the seed cotton yield has been recorded during multilocation trails under AICCIP. Therefore, *Diaporthe longicolla* isolate CEL-48 can be utilized as a promising biocontrol agent for seed treatment, offering the added benefits of growth promotion and enhanced defense mechanisms in plants. The endophytic *D. longicolla* isolate CEL-48 can be used for seed treatment @ 5g/ kg seed or for foliar spray @ 5ml/L of water against cotton diseases. For seed bio-priming, seeds should be soaked in the talc-based formulation or spore suspension (1 x 10^6 CFU) @ 5ml/kg seed for 2 hrs. and shade dried one day prior to sowing.

Current Status: The endophyte *D. longicolla* isolate CEL-48 has been tested for three years in a multilocation trial under AICRP on Cotton. Also, being utilized in the development of a consortium/ formulation in another research project.

Publication: Verma, P., **Hiremani, N. S.***, Gawande, S. P., Sain, S. K., Nagrale, D. T., Narkhedkar, N. G., & Prasad, Y. G. (2022). Modulation of plant growth and antioxidative defense system through endophyte biopriming in cotton (*Gossypium* spp.) and non-host crops. Heliyon, 8(5).

Endophytic and growth promoting *Diaporthe longicolla* isolate CEL-41 as biocontrol agent against cotton diseases

Developers: Dr. Neelakanth S. Hiremani; **Associates**: Dr Pooja Verma, Dr S. P. Gawande, Dr S. K. Sain, Dr D. T. Nagrale, Dr Y. G. Prasad

Brief description of the Technology:

Use of endophytes as biological control agents has been proved beneficial in many of the crop plants. However, there is also a lot of scope to unravel the potential of endophytes in cotton. Several endophytes were identified and evaluated against cotton pathogens. Among those endophytes, we found that *Diaporthe longicolla* isolate CEL-41 was promising with more than 52% colony inhibition against *Corynespora cassiicola*. The *in vivo* studies against *Macrophomina phaseolina* in pots and root rot incidence in field trials showed promising effects of this isolate. Seed bio-priming with CEL-41 in cotton and non-host crops showed remarkable changes in biochemical parameters wherein, an increase of 30% total soluble protein content was seen in cotton, whereas it was as high as 58% in bio-primed cowpea. Moreover, total soluble sugar (7.54 mg/g FW) and reducing sugar (2.488 mg/g FW) were found highest as compared to control (5.46 mg/g FW and 1.736 mg/g FW respectively). An increase in catalase as well as peroxidase enzymes activity was also visible in cotton upon seed bio-priming. Moreover, an approximate increase of 15-20% in the seed cotton yield has been recorded during multilocation trials under AICCIP. The antagonistic endophyte *D. longicolla* isolate CEL-41 can be used for seed treatment @ 5g/ kg seed or for foliar spray @ 5ml/L of water against cotton diseases. For seed bio-priming, seeds should be soaked in the talc-based formulation or spore suspension (1 x 10^6 CFU) @ 5ml/kg seed for 2 hrs. and shade dried one day prior to sowing. The endophyte was found highly efficient in increasing the germination percentage and plant vigor of cotton. Also proved to be efficiently enhancing the antioxidative defense system in the treated plants along with growth promotion.

Current Status: The endophyte *D. longicolla* isolate CEL-41 has been tested for three years in a multilocation trial under AICRP on Cotton. Further, the culture was sent to ICAR-National Bureau of Agriculturally Important Microorganisms, Mau for Microbial Germplasm Registration.

Publication: Verma, P., **Hiremani, N. S.***, Gawande, S. P., Sain, S. K., Nagrale, D. T., Narkhedkar, N. G., & Prasad, Y. G. (2022). Modulation of plant growth and antioxidative defense system through endophyte biopriming in cotton (*Gossypium* spp.) and non-host crops. Heliyon, 8(5).

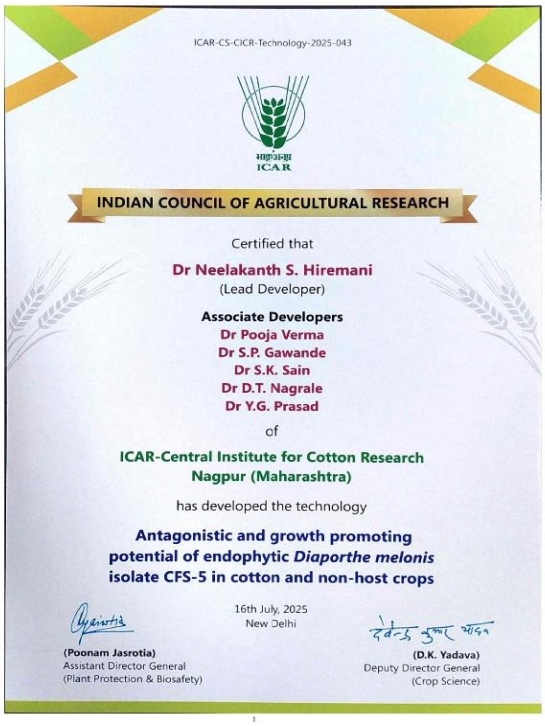
Antagonistic and growth promoting potential of endophytic *Diaporthe melonis* isolate CFS-5 in cotton and non-host crops

(ICAR Certified Technology: ICAR-CS-CICR-Technology-2025-043)

Developers: Dr. Neelakanth S. Hiremani; **Associates**: Dr Pooja Verma; Dr S. P. Gawande, Dr S. K. Sain; Dr D. T. Nagrale; Dr Y. G. Prasad

Brief description of the Technology:

Endophytes are proving to be a new weapon in the arsenal of biological control due to their profound benefits in many of the crops. To unravel the potential of endophytes in cotton, several endophytes were evaluated against major cotton pathogens. Among the shortlisted endophytes, isolates belonging to *Diaporthe* were most promising. *Diaporthe melonis* isolate CFS-5 was also efficient against *Corynespora cassiicola* with more than 54% colony inhibition. The field trials against wilt disease showed promising effects of this isolate. Seed treatment with *Diaporthe melonis* isolate CFS-5 significantly reduced wilt incidence in the field which was as low as 0.53% in cv. Suraj and 1.67% in cv. Phule Dhanwantary, compared to the control, which showed incidences of 10.29% and 12.61%, respectively. Bio-priming of cotton seeds with *Diaporthe melonis* isolate CFS-5 showed remarkable changes in biochemical parameters wherein, an increase in total soluble protein content up to 22.95% in cotton was seen. Interestingly, the increment was strikingly highest in in non-host crops like wheat (69.13%) and cowpea (56.1%). Moreover, total sugar (6.71mg/g FW) and reducing sugar (2.1 mg/g FW) in cotton were found high as compared to control (5.46 mg/g FW and 1.736 mg/g FW respectively). An increase in catalase as well as peroxidase enzymes activity was also visible in cotton, indicating enhanced plant defense responses. These findings highlight *Diaporthe melonis* isolate CFS-5's potential in sustainable crop protection.


ICAR-CS-CICR-Technology-2025-043

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Certified that

Dr Neelakanth S. Hiremani
(Lead Developer)

Associate Developers
Dr Pooja Verma
Dr S.P. Gawande
Dr S.K. Sain
Dr D.T. Nagrale
Dr Y.G. Prasad

of

ICAR-Central Institute for Cotton Research
Nagpur (Maharashtra)

has developed the technology

Antagonistic and growth promoting potential of endophytic *Diaporthe melonis* isolate CFS-5 in cotton and non-host crops

16th July, 2025
New Delhi

(Poonam Jasrotia)
Assistant Director General
(Plant Protection & Biosafety)

(D.K. Yadava)
Deputy Director General
(Crop Science)

Current Status: The endophyte *D. melonis* isolate CFS-5 has been submitted for further commercialization/ licensing. Also, being utilized in the development of a consortium/ formulation in other research project.

Publication: Verma, P., **Hiremani, N. S.***, Gawande, S. P., Sain, S. K., Nagrale, D. T., Narkhedkar, N. G., & Prasad, Y. G. (2022). Modulation of plant growth and antioxidative defense system through endophyte biopriming in cotton (*Gossypium* spp.) and non-host crops. Heliyon, 8(5).

Development and validation of biocontrol potential by cotton endophytic rhizobacteria against root rot disease and foliar diseases in cotton

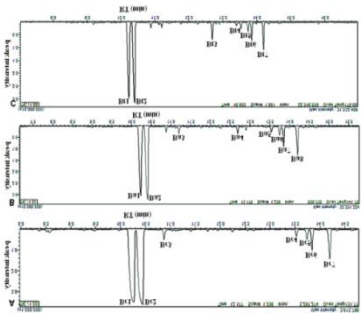
Developer(s): D.T. Nagrale, S.P. Gawande, Vivek Shah, Pooja Verma, N.S. Hiremani, T. Prabhulinga, Nandini Gokte-Narkhedkar, V.N. Waghmare

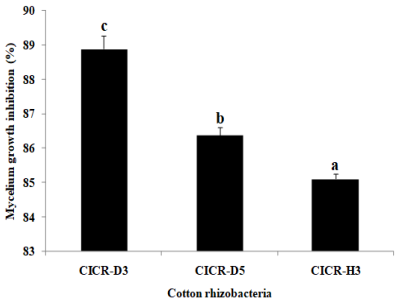
Brief description of the technology:

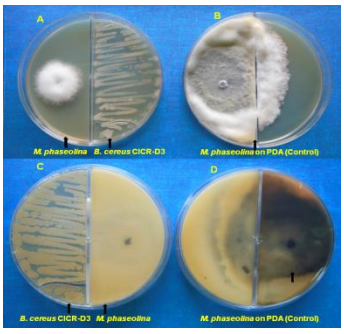
Rhizobacteria produce microbial volatile organic compounds (mVOCs) that can be utilized as biocontrol components against phytopathogenic fungi. Here, we analyzed the mVOCs produced from cotton rhizobacteria and their role in biological control of the fungus *Macrophomina phaseolina*. Three rhizobacterial strains, *Bacillus cereus* CICR-D3, *Bacillus aryabhattai* CICR-D5 and *Bacillus tequilensis* CICR-H3 were screened and evaluated for mVOCs using gas chromatography-mass spectrometry (GC-MS). Major antifungal mVOCs i.e. Benzene, 1, 3-diethyl- and Benzene, 1, 4-diethyl followed by naphthalene, m-ethylacetophenone and ethanone, 1-(4-ethylphenyl) were produced by these strains. The relative abundance of mVOCs released was highest from CICR-D3 followed by CICR-D5 and CICR-H3. Bi-compartmental Petri plate assay against *M. phaseolina* showed that the CICR-D3 strain was the most effective in inhibiting the mycelial growth followed by the CICR-D5 and CICR-H3 strains. Furthermore, in vivo co-inoculation in a polyhouse revealed that severity of root rot caused by *M. phaseolina* was reduced by 72.74% in potted cotton plants inoculated with CICR-D3 strain, followed by strains CICR-D5 (69.04%) and CICR-H3 (66.60%). Similarly, combined application of *Bacillus tequeilencis* CICR-H3 and *Bacillus aryabhattai* CICR-D5 via seed application with 10^8 cfu/g @10 g per kg of seed at the time of sowing and soil application with 2.5 kg/ha (30 & 60 DAS) with FYM/compost was found to be superior in terms of lowest percent disease intensity of *Myrothecium* leaf spot, *Alternaria* leaf blight, *Corynespora* leaf spot, bacterial leaf blight and *Corynespora* leaf spot. The specific volatiles are being reported for the first time from native cotton rhizobacteria, which provides new insight into cotton rhizobacteria and their antifungal mVOCs as an eco-compatible strategy for cotton root rot and foliar diseases management.

Current status: The results have been validated through multilocation trials under ICAR-AICRP on cotton (Annual reports 2019-20, 2020-21, 2021-22) and research publication in reputed international journal.

Publications: Nagrale, D.T., Gawande, S.P., Shah V., Verma P., Hiremani N.S., Prabhulinga T., Gokte-Narkhedkar N., Waghmare V.N. (2022). Biocontrol potential of volatile organic compounds (VOCs) produced by cotton endophytic rhizobacteria against *Macrophomina phaseolina*. Eur J Plant Pathol 163, 467–482. https://doi.org/10.1007/s10658-022-02490-1.







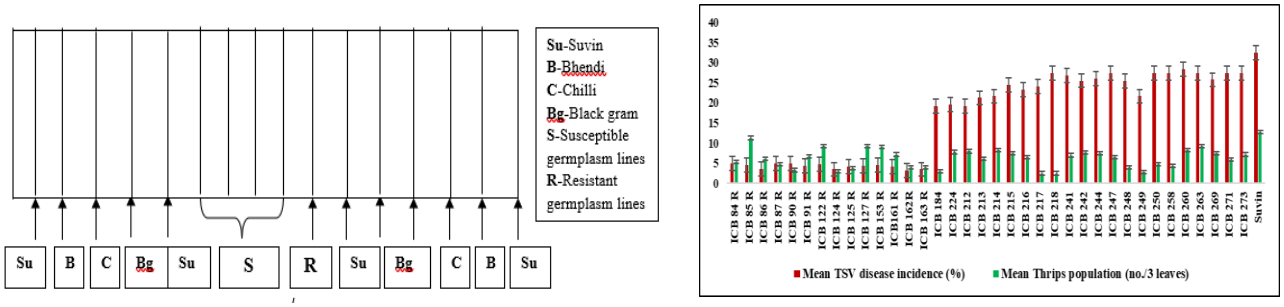
Novel Screening Method for *Tobacco Streak Virus* (TSV)

Developer(s): Dr. Valarmathi, P, Dr. Amutha, M

Year of Development: 2021

Brief description of the technology:
Tobacco Streak Virus (TSV) is an important viral pathogen affecting cotton causing significant yield losses in major cotton-growing regions of Southern India with incidence ranged up to 30 %. TSV belongs to the genus *Ilarvirus* under the family *Bromoviridae* and has a tripartite, positive-sense, single-stranded RNA genome. In cotton, the disease is characterized by symptoms such as necrotic lesions, veinal necrosis, leaf distortion, stunting, and shedding of squares and bolls, which ultimately reduce crop productivity. The virus is primarily transmitted through infected pollen and aided by thrips vectors, especially *Thrips tabaci* and *Frankliniella schultzei*. Weed hosts such as *Parthenium hysterophorus* serve as important reservoirs for the virus, facilitating its survival and spread. The percentage of disease incidence of TSV in *G. barbadense* varied from 5.81% (DB 3, DB 25) to 26.60% (ICB 71). Screening germplasm to identify resistant sources is an essential step towards addressing the challenges posed by this hazardous virus. Since the existing literature suggests the lack of any known resistance sources and screening method for TSV, the present study primarily focuses on developing novel screening method to identify resistance against TSV in *G. barbadense* germplasm under field conditions. In a consecutive two-season screening at ICAR-Central Institute for Cotton Research (CICR), Regional Station, Coimbatore, a total of three hundred *G. barbadense* germplasm lines were screened under natural field conditions for TSV. Among them, fourteen germplasm lines were categorized as Resistant (R), twenty-two as Moderately Resistant (MR), one hundred and sixty-eight as Moderately Susceptible (MS) and ninety-four as Susceptible (S) lines. The identified resistant and susceptible lines were sown in separate rows to screen for TSV resistance. The strong association between resistance and yield-related traits such as boll number and plant vigour suggests that integrating TSV resistance into breeding programs can significantly enhance the development of high-yielding, disease-tolerant cotton cultivars. In addition, traits like plant height and sympodial branching can be effectively used as indirect selection criteria for identifying promising genotypes under TSV pressure. ICB162R's better performance under TSV pressure emphasizes the potential of resistant lines in breeding programs. These sources can be used as parents in crosses to introduce resistance genes into cultivated varieties. The current findings underscore the vital importance of TSV resistance in maintaining cotton yield stability, particularly in regions susceptible to disease outbreaks. **Current status:** This method has been used for screening TSV in *G. hirsutum* varieties and Bt hybrids.

Publications:
Valarmathi, P. and Amutha, M. 2025. Field evaluation of germplasm lines of extra-long staple cotton (*Gossypium barbadense*) for *Tobacco Streak Virus* resistance. *Euphytica*. 221: 140. https://doi.org/10.1007/s10681-025-03586-5



Development of novel screening method to evaluate germplasm lines of G. barbadense against TSV

A novel Biopesticide formulation for the management of Sucking pests in Cotton

Developer(s): Dr. Gulsar Banu J, Dr. Prakash A.H.

Brief description of the technology:
Sucking pests have emerged as major yield-limiting factors, particularly under intensive cultivation and changing climatic conditions. Their heavy infestation at times reduces the crop yield to a great extent. The indiscriminate and repeated use of insecticides to manage these pests has led to several challenges, including development of resistance, resurgence of secondary pests, destruction of natural enemies and environmental contamination. Therefore, the development and promotion of an effective biocontrol strategies against sucking pests have become imperative. Systematic efforts carried out at ICAR-CICR for the past several years yielded a talc based biopesticide formulation of a native entomopathogenic fungus, *Lecanicillium lecanii* which is effective against sucking pests of cotton under field condition. This formulation contains spores, mycelium and active principles of *L.lecanii* which is effective against sucking pests and safer to natural enemies.

Target pests: Mealy bug, Thrips, Jassids, Aphids and Whitefly

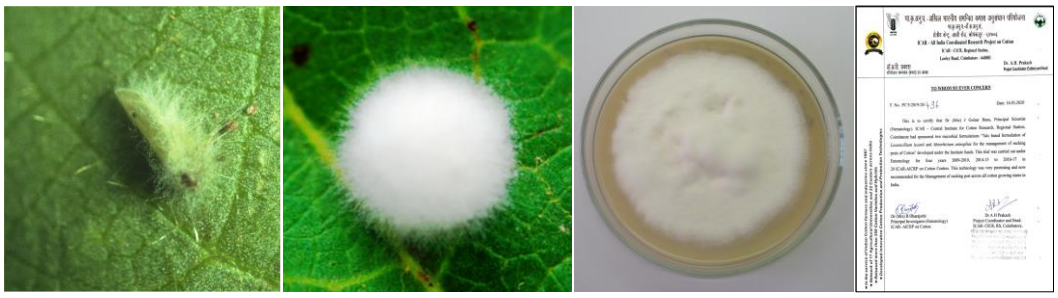
Dosage: 5 Kg / ha. Mix 5 kg of formulation in 500 L of water (i.e.,10 gm per Litre of water). The product should be sprayed on growing plants targeting the insects. The spray volume depends upon the crop canopy. Spraying of biopesticide formulation twice at 15 days interval significantly reduced sucking pests.

Advantages:
- It is selective to target pests without disrupting beneficial component of an agroecosystem thereby helps to maintain ecological diversity. This formulation is safer to natural enemies.
- Compatible with neem and other biopesticide products.
- This technology has been Validated in 20 ICAR-AICRP centres for four years and recommended for the management of sucking pests in all cotton growing states in India.
- *L. lecanii* has wide spectrum of activity against insects and nematodes (Root-knot and reniform nematode).

Current status: Received Technology certificated from The Project Coordinator and Head, ICAR-CICR, RS, Coimbatore. Toxicological data for CIB&RC registration are to be generated.

Publications:
Banu,J.G., Surulivelu,T, Gopalakrishnan,N.2009.On the natural occurrence of an entomopathogenic fungi, *Lecanicillium lecanii* from mealy bug, *Phenococcus solenopsis*. CICR, Newsletter 25 (3): 6.

Banu, J.G, Gopalakrishnan N.2012. Development of formulations of a native entomopathogenic fungus, *Lecanicillium lecanii* and testing virulence against mealybug, *Paracoccus marginatus* infesting cotton. *Indian Journal of Plant Protection* 40(3): 182 – 186.



Talc based biopesticide formulation of *Metarhizium anisopliae* for eco-friendly management of sucking pests in Cotton

Developer(s): Dr. Gulsar Banu J, Dr. Prakash A.H.

Brief description of the technology:
Sucking pests in cotton have become quite serious from seedling stage; their heavy infestation at times reduces the crop yield to a great extent. Insecticides are being recommended for the management of sucking pests. Given the increasing concerns over pesticide resistance, environmental safety, and sustainable cotton production, strengthening research on native natural enemies will be crucial to ensuring long-term productivity and resilience of cotton-based agroecosystems. A native entomopathogenic fungus, *Metarhizium anisopliae* isolated from mealybug was found to be effective against Sucking pests in Cotton. Being native isolate, this fungus can easily have adopted to local conditions and compatible with insecticide recommended for cotton. Talc based formulation of *M.anisopliae* contains spores, mycelium and active principles which are effective against sucking pest.

Dosage: 5 Kg / ha. Mix 5 kg of formulation in 500 Litres of water (i.e., 10 gm per Litre of water). The product should be sprayed on growing plants targeting the insects. The spray volume depends upon the crop canopy.

Advantages:
- Spraying of this biopesticide formulation twice at 15 days interval significantly reduced sucking pests. This formulation is safer to natural enemies.
- This formulation is compatible with insecticides commonly used in cotton ecosystem at field recommended dose.
- Validated in 20 ICAR-AICRP centres for four years.
- Recommended for the management of sucking pests in all cotton growing states in India.

Current status: Received Technology certificated from The Project Coordinator and Head, ICAR-CICR, RS, Coimbatore. Toxicological data for CIB&RC registration are to be generated.

Publications:
Banu,J.G. 2013.Isolation, molecular characterization and virulence of a native entomopathogenic fungus, *Metarhizium anisopliae* (ARSEF-9613) from Mealybug. Proceedings of International Conference Insect Science, February, 14-17, 2013, Bangalore, India. pp 12.

Banu,J.G., Amutha,M. and Rajalakshmi,S. 2014. Compatibility of insecticides with *Metarhizium anisopliae* (ARSEF-9613), a native entomopathogenic fungal isolate from Mealybug. *Journal of Insect Science* 27(1) :144-146.

A bionematicide formulation of *Pochonia chlamydosporia* for eco-friendly management of nematodes in Cotton

Developer(s): Dr. Gulsar Banu J, Dr. Prakash A.H.

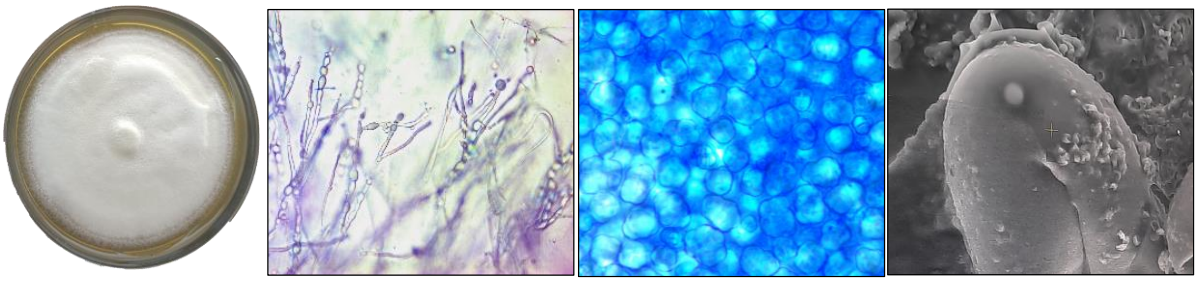
Brief description of the technology:
Plant parasitic nematodes causes a yield loss of up to 10 % annually in Cotton, which is managed mainly through the application of chemical nematicides. The yield loss is increased several fold when they interact with fungus. Owing to increased awareness about the detrimental effect of chemical nematicides on non-target organisms, human beings and the environment besides phytotoxicity, necessitate safer approaches for nematode management in cropping systems. Biological control of plant parasitic nematodes using native nematode antagonistic fungus ia an eco friendly and sustainable strategy that reduces the dependence on chemical nematicides. Native isolate of fungus will have better adaptation to local agro-climatic conditions, enhanced rhizosphere competence, greater efficacy against local nematode populations, minimal risk of disturbing native biodiversity, improved persistence and long-term suppression. A talc based formulation of native nematode antagonistic fungus, *P. chlamydosporia* isolated from the eggmass of Reniform nematode, *Rotylenchulus reniformis* prepared at ICAR-CICR, significantly reduced reniform nematode under pot culture and field condition. Application of talc based formulation at 5 Kg / ha siinificantly reduced root knot and reniform nematode penetration, number of nematodes per gram of root, number of egg mass and eggs per egg mass and also soil nematode population. The ovicidal and nematicidal activity of *P. chlamydosporia* was proved under *in vitro* condition. This fungus also produces several nematicidal metabolites. Soil application of vermicompost enriched with this formulation supported longer persistence of propagules under field condition.

Dosage: Soil application of formulation @ 1 Kg / ac. Mix 1 kg of formulation with vermicompost for longer persistence under field condition.

Advantages:
- This formulation is safer to earth worms and beneficial nematodes.
- This formulation is compatible with fungicides commonly used in cotton ecosystem at field recommended dose.

Current status: Toxicological data for CIB&RC registration are to be generated.

Publications:
Banu J.G. and Prakash A.H. (2021). Isolation, molecular characterization and pathogenicity of a native nematophagous fungus, *Pochonia chlamydosporia* from Reniform nematode, *Rotylenchulus reniformis* in India. Paper presented during International Conference on Global Perspectives in Crop Protection for food security (GPCP -2021) held at TNAU, Coimbatore from 8th to 10th December, 2021.



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