

# Milestones of the bioRe<sup>®</sup> Organic Cotton Seed Research at bioRe<sup>®</sup> in India



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*February 2021*

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## SUMMARY

Human civilization has lived in harmony with nature and so has agriculture but in past few decades, modern intensive agriculture, under the cover of green revolution has resorted to exploiting and exhausting nature for increasing agricultural production endangering the natural balance and capacity of ecosystem to support crop growth. The conscious movement of organic agriculture is aiming at bringing that lost harmony back in the present culture of agriculture. Globally this movement has picked up pace even in cotton crop which attracts very high usage of harmful chemicals for its cultivation. Patrick Hohmann, the founder of bioRe® was among the first to promote organic cotton cultivation from 1991 and by working with cotton farmers of Madhya Pradesh for decades and building their confidence in organic cotton cultivation, the movement has grown in to a large group of organic cotton farmers. Indian scenario of cotton cultivation has witnessed sudden rise in prominence of GM hybrid Cotton cultivation during past two decades. As a result, the seed industry has withdrawn its non-GM hybrids from seed chain leading to a big void in availability of non-GM hybrid seeds in market and further it has increased the threat of GM contamination in organic cotton. This double blow became one of the major causes for low productivity and frequent rejection of such GM contaminated cotton in organic cotton market. Visualizing the seriousness of these problems, bioRe® initiated a unique research program in 2010 in association with University of Agricultural Sciences Dharwad under leadership of cotton breeder, Dr. Shreekant S Patil on developing cotton varieties and hybrids suitable for the diverse situations of organic cotton cultivation in Madhya Pradesh. The basic work of creating genetic variability handling generated material in initial generations are handled at Dharwad and the stabilized lines and the hybrids based on them are brought to bioRe® research farm. The evaluation system at bioRe® is rigorous and separate trials were laid out for heavy and light soils which broadly represented the diversity of situations and the evaluation trials consisting of Hirsutum varieties (H) and hybrids (HH) and arboretum Varieties which are compared with ruling checks in the market and the consistently best genotypes are selected at different stages namely initial evaluation, Advanced evaluation and Multi location trial followed by demonstrations in farmers' fields (spanning over 5-6 years) and even testing in regional universities for authentic confirmation of their potential.

Textile industry consuming organic cotton continuously raises the benchmark of acceptance of fibre quality and the difficult trends of labour availability and preferences of farmers in terms of acceptable boll size, comfortable picking, convenience of plant type for comfortable agricultural operations etc., have also assumed importance. To balance these diverse needs objectives of improving “remunerative value” of cotton was given prominence rather than just productivity. bioRe® has always sought maximum farmer’s participation in cotton breeding to policy decision making. Farmers have instrumental role in selecting potential genotypes at stages of evaluation to promotion of genotypes. Because of concerted efforts the research system and organization of bioRe® was approved by Indian government (DSRD) and as a result it has been possible to release 8 cotton varieties and hybrids for commercialization. While this first batch of cotton hybrids and varieties are being accepted by the farmers, efforts are geared up to become self-reliant for seed needs.

In the history of India, it is the first instance of an organic group planning and executing its research and becoming self-reliant in providing its seeds to the ultimate beneficiaries. In research, there is no room for complacency as the scenario of cotton and the priorities of problems in cotton and thrust areas of Research change at rapid pace. When breeding activities meant to develop new varieties take nothing less than 8-10 years to give new stable lines breeding research requires anticipatory planning for new ideal plant type traits it breeding amounts to aiming at moving target. Because of the special techniques of multiple parent-based genetic improvement and innovative steps of breeding are used to improve productivity along with acceptable fibre quality and the system of breeding is so built that it continuously spins out new blends of genotypes with all these desirable features. These continued efforts have given rise to many potential climate resilient varieties and hybrids in the pipeline and they are aimed at reaching the larger farming community of the region and other states of the country.

In addition, some new areas of focus are defined for bioRe's futuristic research plans which require support from donors. This includes a continued pursuit of Improvement in productivity and fibre quality, exploiting heterotic groups of cotton for developing potential hybrids, Introgression breeding to add stress tolerance, stay green nature to be blended with high harvest index, increasing boll weight higher Ginning out turn (%) and in turn lint yield. The showcase of research products is getting ready with diverse products including futuristic compact cotton varieties for high density planting Compact cottons have a range of benefits of reducing labour requirement due to earliness and synchronous maturity, effective double cropping. These new lines are being developed and stabilized for evaluation. Even in hybrid front, diversity in product range is improved by developing hybrids with reduced diameter to enhance crop density, add synchrony and earliness. Attempt is also made to explore and develop male sterility system in cotton so that instead of producing hybrid seed through manual emasculation and crossing male sterile female parents are developed and used to produce hybrids there by reducing the cost of hybrid seed production. Efficient maintenance of germplasm and its enrichment and utilization along with related cotton species for introgressing desirable traits is being explored. Aiming at zero contamination in commercial organic cotton cultivation is a big challenge and, different efficient ways of GM testing for eliminating contamination under commercial cultivation are being developed and strict GM purification of the new cotton genotypes is taken up at different stages of development. Further to meet this challenge, innovative research work is initiated on determining and developing genetic markers for detecting GM contamination.

bioRe® makes efforts to organize seminars and workshops for bringing all the stake holders on one platform, for collaboration in promotion of organic cotton, resolving problems of farmers etc. bioRe's scientists participate in international and national conferences to present research findings on organic cotton breeding and related areas. Training programs are organized in imparting training to scientists, subject matter specialists, farmers and extension workers alike. So far seed research activities have been well supported by some donors and bioRe® aspires for useful association with some more funding agencies for partnering in this noble cause of supporting organic cotton farmers in an adverse scenario of cotton cultivation.

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## Detailed Report: Growing awareness to protect the soil and environment

In the past, human civilization evolved in harmony with nature and achieved progress in agriculture without sacrificing the principles of harmonizing growing with nature. The developments of green revolution have intensified the excessive use of pesticides and synthetic fertilizers, which has affected the ecosystem, ravaged the cultivable soil and jeopardized the balance of beneficial soil micro fauna, the beneficial insects and other microorganisms which are very helpful in managing the pests and enriching soil fertility and soil structure. There is a growing awareness among cotton farmers to protect the soil and environment from the harmful effects of synthetic chemical fertilizers and pesticides.

India is a leading country in organic cotton production and bioRe® is a reputed organic group which has been torch bearer in the movement of organic cultivation in India. Madhya Pradesh is a unique state of India where the small farmer is realizing the benefits of organic farming in the form of sustaining productivity and balancing it with improvement of soil health and cleansing the ecosystem.

Patrick Hohmann, the founder of bioRe® organized the farmers, convinced them about organic farming and laid foundation to organic cotton cultivation as early as in 1991. Under his leadership bioRe® has led from the front in educating and organizing thousands of farmers in Narmada river belt to cultivate organic cotton. Patrick Hohmann took an initiative of integrated efforts by bioRe® and helped them in resolving the key issues and clearing the hurdles in the path of organic cotton cultivation. The organic farmers group has grown since then and today there are over 3'000 organic cotton farmers associated with bioRe® India Ltd. and it is growing from strength to strength and attracting farmers from neighboring states.

In the era of GM cotton cultivation, the entire seed industry which meets 90% of farmers seed needs is focusing on GM cotton hybrids and there is lack of concerted efforts to develop non-GM cotton varieties and hybrids suitable for organic situation in general and region-specific requirements of organic farmers in particular. Under Patrick Hohmann's leadership bioRe® has led from the front in educating and organizing thousands of farmers in Narmada river belt to cultivate organic cotton and helped them in resolving the key issues and clearing the hurdles in the path of organic cotton cultivation. It has initiated a systematic cotton breeding program exclusively under organic conditions of this Narmada river belt of Madhya Pradesh.

Visualizing the critical seed issue bioRe® in India started working in association with University of Agricultural Sciences Dharwad (UASD) right from 2010, to resolve different seed related problems of organic cotton farmers. Agricultural Research Station Dharwad (in UASD) is a leading Centre for cotton research with its reputation of developing world's first interspecific Hirsutum X Barbadosense cotton hybrids and many other varieties and hybrids in different

species of cotton. Under the leadership of cotton breeder Dr. Shreekant S Patil, research programs were initiated to develop cotton varieties and hybrids suitable for different situations of cotton cultivation existing in the region.



Cotton plants from the systematic cotton breeding program: developing non-GM cotton varieties and hybrids suitable for organic situation



## Organizing brainstorming sessions of stake holders

As early as in June 2011, bioRe® went ahead to create awareness of the problems of seed in the scenario of organic cotton cultivation and associated with University of Agricultural Sciences Dharwad and the Research Institute of Organic Agriculture FiBL Switzerland to organize a National Workshop and suitably entitled it as:

*“Disappearing non-GM cotton – ways forward to maintain diversity, increase availability and ensure quality of non GM cotton seed”*

This led to interaction among stakeholders of organic cotton leading workers and organizations associated with cotton. Such interactions are regularly organized among organic groups and scientists. It raised the issue in many national forums like the World Cotton Research Conferences, Textile Exchange conferences with its Organic Cotton Roundtables and National conferences where our cotton team of scientists regularly participate. bioRe® in India has also initiated joint activities with some other organic groups of the region in cotton research and development. Cotton genotypes have been spared to other organic groups for evaluation in organic farmers’ fields with an intention of benefiting the larger organic farming community.

## Farmers participation

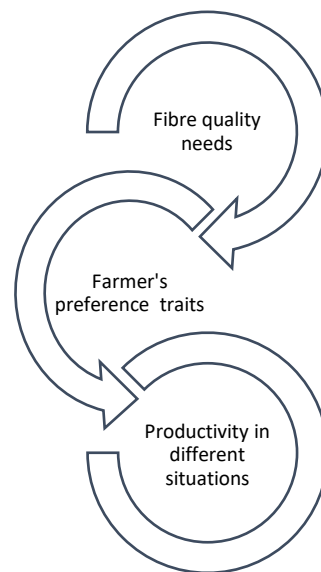
It was realized that apart from being productive, the genotypes identified for cultivation must meet the requirements and preferences of farmers in terms of ease of harvesting, yield, boll size, plant type and its architecture determining convenience of spraying botanicals in the standing crop and inconvenience in agricultural operations, higher Ginning out turn fetching higher lint yield, which is of economic importance as well.

By formulating a farmers' participatory approach, it was decided to give prime importance to farmers' assessment of the genotypes and the term remunerative value of cotton was kept as the target yardstick rather than just productivity.

At the stage of maturity farmers are regularly invited in different workshops and the scientists and extension workers have face to face interaction to discuss the plan of research activities where their ideas and suggestions are synergized and plan of action for the year is finalized. At the time of maturity, the workshops are meant to involve the farmers in the evaluation and identification of superior varieties and hybrid entries evaluated in the research trials. They play a crucial role in scoring and assessment of the genotypes.

## Preferences of fiber quality

The textile industry's consuming the cotton have strict requirement of higher fibre quality making it suitable for ginning with modern machines and making superior quality garments. Hence special breeding programs were planned to bring out improvement in productivity as well as fibre quality to meet the benchmark of quality which are set and revised from time to time to meet the changing needs of textile industry. Blending two objectives and bringing about simultaneous improvement in productivity and fibre quality is a tougher task of breeding. Special techniques of genetic improvement involving use of multiple diverse and complimenting parents and intermating among transgressive segregants was useful in bringing about quick genetic gains.







„Organic seeds truly reflect organic life and provide balance to the biodynamic forces in the field as they embody necessary dimensions for organic situations and go in line with basic principles of organic movement and deliver positive “seed footprint” for an ethical supply chain.“

Vivek Rawal  
Managing Director, bioRe® India Ltd.

## The rigorous task of developing cotton genotypes exclusively for organic situation

Efforts on genetic improvement and breeding cotton exclusively under organic situations was initiated in 2010/11. For effective genetic improvement, multiple crosses (if need be) and handling the initial segregating populations was taken up at University’s research farms at Dharwad. On nearing stabilization these lines were tested for evaluation under organic situation at bioRe® research farms.

### The situations of Cotton cultivation in Narmada river belt

Currently cotton is grown in both irrigated situation and rainfed situation and it is cultivated broadly in heavy soils and light soil types. Initially, evaluation of the varieties and hybrids based on different cultivated species of cotton like Hirsutum, Arboreum, Barbadosense and Herbaceum was done to check suitability of these species and the evaluation trials were laid out in

- a) heavy soils
- b) light soils.

Based on the initial years comparison it was observed that broadly the Hirsutum varieties (H) and Intra Hirsutum Hybrids (HH) along with Arboreum cotton are more suitable to the different situations and climatic specificities of this region.

An attempt of genetic improvement aims at creating variability for large number of component traits addressing biomass related traits, harvest index related traits, fibre quality and other traits mentioned above in these figures. A team of parents complimenting for these traits are involved in multiple parent-based crossing creating large useful variability which needs to be exploited by using some innovative concepts in breeding. After handling initial segregating generations at Dharwad (requiring 4-5 years evaluation) the nearly stabilized lines are brought to bio Re for evaluation. In recent years, some activities of handling segregating generations were also taken up at bio-Research farm. The initial evaluation trials are conducted separately

under light soils and heavy soils under organic situation at bioRe® farms. The table given below gives an overview of the number of genotypes tested in different trials conducted at bio Re over these years. Roughly over 100 varietal lines and hybrids are evaluated annually along with checks. Each year the lint samples of each entry in replicated trial is tested elaborately at ATIRA a fibre quality testing institute. This helps in eliminating all the entries with poor fibre quality.

**Table:** Number genotypes evaluated at different levels of trials

No. of Cultivars Evaluated	Year	Phase-I				Phase-II			Phase-III			Phase-IV
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Trial	Cultivar type											
Advanced replicated trial-CCE	HH	5	50	50	78	32	32	30	18	20	14	24
	HV	-	-	-	-	28	28	44	46	24	12	16
	AV	-	-	-	-	-	-	-	10	10	4	8
	Compact HV	-	-	-	-	-	-	20	9	25	12	14
Multilocation trial-MLT	HH	-	-	-	-	5	5	5	6	6	4	5
(4-6 locations)	HV	-	-	-	-	5	5	5	4	6	5	4
	AV	-	-	-	-	3	3	3	4	2	5	3
	Compact HV	-	-	-	-	-	-	-	-	-	-	2
Farmers Demonstrations	HV, HH, AV	-	-	-	-	-	7	11	10	26		
Early generation populations	HV, AV	-	-	-	-	-	100	205	426	238	85	78
Germplasm evaluation	HV, AV	-	-	-	-	131	135	102	160	-	74	82
Initial Evaluation trial	HH	-	-	-	-	-	-	-	-	-	36	24
	HV	-	-	-	-	-	-	-	-	-	37	32
	AV	-	-	-	-	-	-	-	-	-	5	4
Regional university's trials Official Testing at Khandwa		-	-	-	-	-	6	7	8	-	-	-
	HH	-	-	-	-	-	2	3	3	-	-	-
	HV	-	-	-	-							

Superior entries were identified based on comparison with ruling check varieties and hybrids cultivated by farmers of the region. These superior genotypes were advanced to Advanced trials or Cotton Cultivar Evaluation trial. Superior entries selected based on performance in CCE trials were advanced to multi-location trials MLT from these two years advanced trials. Continuing with the sequence of evaluation indicated in the figure best entries from MLT were given for evaluation under organic situation by farmers in half acre plots. These demonstrations were helpful in giving a feedback of farmers. In many of the demonstrations of Hirsutum varieties and hybrids new entries gave a higher remuneration to farmers than what they obtained from the previous varieties / hybrids grown by them. Two years' demonstrations gave confidence in the potential of the genotypes shortlisted for release to the organic farmers of the region.

In the meanwhile, the research activities of bioRe® were duly recognized (by DSIR – Department of Scientific and Industrial Research of the Indian government) and it was given the state of Research Organization authorized to commercialize its own research varieties and hybrids.



Involving farmers in the evaluation and identification of superior varieties and hybrids throughout the research phases:

- Development at Dharwad
- Initial Evaluation trial
- Advanced trial(CCE)
- Multilocation Trial
- Farmers demonstrations
- University's trials
- Release of Varieties/Hybrids



To fulfill the needs of testing these potential genotypes parallelly in the university's testing system, these potential Hirsutum varieties, hybrids and arboretum varieties were proposed for testing in the regional university's system of testing trials research genotypes under organic conditions. These entries were tested identified in the research trials and Based, Demonstration in rainfed situation and irrigated situation conducted by regional **Agricultural university of Gwalior**. In the evaluation trials conducted during 2016/17 to 2018/19 for a

period of three years, superior entries were certified by the university. The data on performance of the new cotton varieties and hybrids in different station trials, multi-location and testing university's authentic data under organic situation were utilized for proposing these genotypes for release. The permission was granted by state authority for commercializing these genotypes and selling truthfully labeled seeds.

### Genotypes that have been approved for release for commercialization

Sr. No.	Commercial name	Class of genotype	Average Yield kg / Acre	Average Fibre Fineness (Mic)	Upper half mean Length (mm)	Average Fibre Strength (g/tex) 1/8"	Boll wt. (g)
1	Narmada Shakti Platinum	Hirsutum Hybrid	7 to 9	3.9	28.9	30.2	6.0
2	Narmada Shakti Gold	Hirsutum Hybrid	7 to 9	4.5	26.9	25.1	5.5
3	Narmada Shakti Silver	Hirsutum Hybrid	7 to 8	4.0	28.0	26.2	5.0
4	Narmada Bio Power	Hirsutum Hybrid	6 to 7.5	3.7	29.1	28.7	6.0
5	Bio Dhan Varsha 714	Hirsutum Variety	6 to 8	4.3	32.6	32.8	4.5
6	Bio Dhan Varsha 814	Hirsutum Variety	7 to 8	4.2	31.7	35.5	4.5
7	Jaiv Shakti	Arboreum Variety	5 to 6	5.1	29.6	28.3	3.5
8	Jaiv Samruddhi	Arboreum Variety	5 to 6	5.3	30.6	33.1	4.0

The Hirsutum Hybrid, Narmada Shakti Platinum, has been a highly accepted product among the farmers of both rainfed and irrigated situations and special efforts are made to meet the requirements of the farmers by organizing hybrid seed production of this hybrid. Apart from this Narmada Gold and Silver are being commercialized by providing the hybrid seeds to organic farmers. These are the first batch of hybrids commercialized in the organic cotton belt of Madhya Pradesh.

This is the first instance in the history of India that an organic cotton group has planned and executed its own research and come out with its hybrid and started providing its seeds to the ultimate beneficiaries.

Continued research has given rise to many potential varieties in the pipeline and they are being taken through to different stages of testing and release. Some of these genotypes are also

given to other organic groups to benefit larger farming community of the region. bioRe® in India is open to joint activities of research aimed at sharing benefits of its research to even farmers of other states after confirming their adaptability to other regions of the country.



„On the one hand it is very important that the fibre quality meets the requirements of the industry and on the other hand it is very important that the developed genotypes are liked by farmers. To find the best solution for Industry and farmer is a challenging but an interesting task. We are proud that already some genotypes could be developed that meet both requirements.”

Markus Kunz  
Head Supply Chain Management, Remei AG  
Project Manager, bioRe® Foundation

## Renewed priorities of research

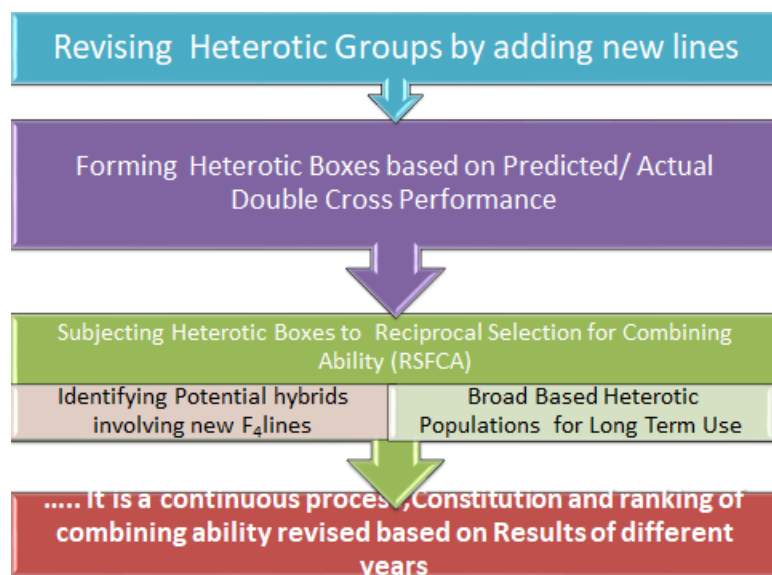
The scenario of cotton and the priorities of problems in cotton change at rapid pace. Breeding activities meant to develop new varieties take nothing less than 7-8 years to give new stable lines. As thrust areas of Research itself keeps changing breeding for new ideal plant type amounts to aiming at moving target. Hence long-term research plans are drawn in a multipronged approach of improving cotton for ever changing needs. The breeding activities aim at developing a showcase of genotypes for a wider range of farmers, textile industry's needs and matching the volatile background scenario of cotton cultivation. It is necessary to have wider options of varieties and hybrids meeting needs of different situations existing and foreseen trends as well as some unforeseen changes in requirements. Research is hence called as a continuous process which defines objectives by visualizing changing scenarios of cotton cultivation, farmers' situations and preferences, changing textile industry's needs, the emphasis is laid on continuous intensive research to develop wide range of genotypes meeting different needs of farmers. Some of the objectives on which greater emphasis is laid are described below.

### A continued pursuit of Improvement in productivity and fibre quality

Some innovative concepts of **target genotype-based breeding**, multiple parent-based development of broad-based populations (from 2013 attempt) was made to derive multiple parent-based populations where productive complimentary lines were used for developing four, and eight parent-based combinations and the parents were advanced to segregating

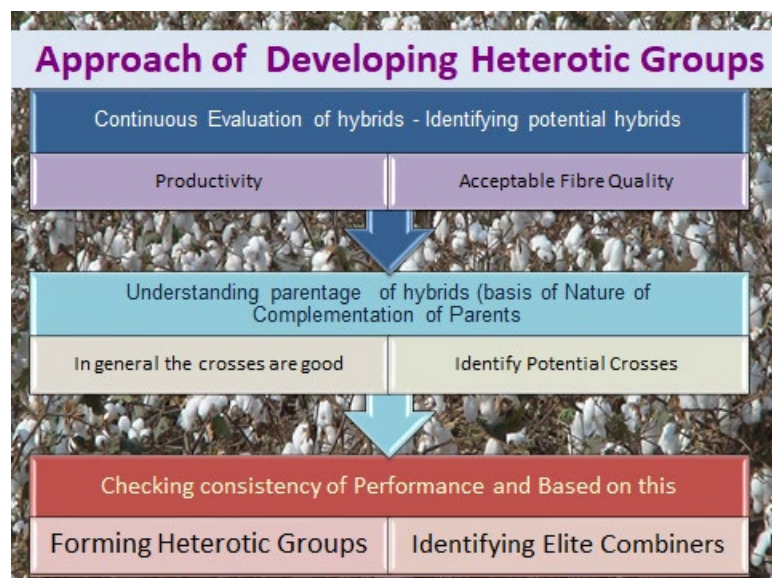
generations and subjected to selection at Dharwad as well as bioRe® research farm. The lines derived through this approach are showing greater potential and improvement in fibre quality. Some of the lines OSB 417, OSB 418, OSB 415, and others derived from these populations and have shown superior yield and fibre quality. Some of these lines are now released as varieties in the name of Bio Dhan Varsha 714 and Bio Dhan Varsha 814.

In the renewed **target of fibre quality standards**, the benchmark of fibre quality is set at fibre length between 28 and 31 mm for medium staple and long staple above 30 mm for different categories of long staple cotton. Micronaire value between 3.7 and 4.2 is treated as desirable for Hirsutum cotton while the Arboreums known for coarseness of fibre Micronaire value of acceptance is set at below 5.0. The short fibre Index between 6 to 7.5 is selected and fibre strength for medium staple and long staple cotton is set between 28 and 32 g/tex (tested by HVI mode). Uniformity ratio is treated as desirable between 80 and 83.

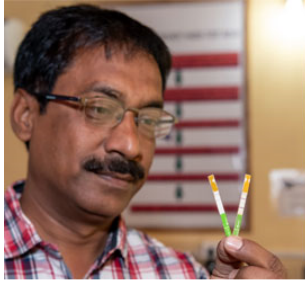


Exploiting heterotic groups of cotton for developing potential hybrids

In pursuit of increasing and improving productivity of cotton hybrids, **heterotic groups of cotton** have been developed and procedures such as reciprocal selection for combining ability are being followed to improve combining ability and increase performance of hybrids. The robust stay group of genotypes are forming one group and the High relative growth rate types form opposite heterotic group and these robust stay green types are also known to combine well with Compact cotton types. Broad bases populations involving four parents within a heterotic group are being developed and subjected to exploitation for improving combining ability. The inter group crosses are found to be in general productive. The process of reciprocal selection for



combining ability is just initiated and this approach is expected to give rise to improvement in heterosis and performance of hybrids.



"bioRe Non GMO cotton seed research under organic conditions with participation of organic farmers is a unique research in India. This research will be very helpful to provide solution of unavailability of good quality cotton seeds for organic sector in India.

I feel proud to be a part of bioRe seed research."

Yogendra Shrivastava  
Project Leader, bioRe® India

The priority research objectives will lead to a constant source of heterotic populations which will continue to spin out very potential hybrid combinations with improved acceptance by farmers. Hirsutum Varieties and hybrids as well as Arboreum genotypes have to meet the basic needs of improved productivity, higher fibre quality, boll weight, higher ginning out turn (GOT%) higher boll weight altering plant type in different situations to enhance productivity. There are other facets of improving performance of hybrids by adding stay green nature blended with high harvest index. Increase in boll weight improves farmers' acceptability for picking, higher Ginning out turn (%) which contributes to improving lint yield which is of commercial value.



Stay Green Nature



Improvement in Boll size

## Development of Compact cottons for different situations

**Compact cottons** are a unique plant types with reduced diameter enabling the plant to grow in narrow space so that we can accommodate higher plant population per hectare. Even though per plant yield of the plant may be less, because of increased density the cotton total yield/ha can be higher than that of a variety or hybrid with larger / bushy canopy. These genotypes reveal synchronous maturity as a result of which entire cotton can be picked in one go and the farmer saves on labour cost and since it's a non-bushy canopy he may find it easy to use plant protection as well as harvest equipment. In northern India double cropping is a regular system in cotton ecosystem where cotton is followed by wheat crop. The organic cotton belt in Madhya Pradesh also has potential for introducing early maturing Hirsutum compact varieties which can be harvested early and the farmer has better options of second crop or better scope for effective soil care and land preparation before sowing a second crop. This is possible in case of those farmers who have irrigation facilities to support wheat cultivation. This enhances the remunerative value of inter-cropping system. It is proposed to evaluate early maturing compact varieties in organic situation and compare them with routine late measuring varieties for their accessibility to introduction of wheat as a second crop and its timely sowing in November.



Compact cotton

The existing compact cotton types have productivity but lack the high fibre quality and the boll size is low. Hence research programs are initiated to develop compact segregants based on multiple compact parents meeting the defined needs of their compact cotton types. Many potential multiple parents based compact crosses are being advanced to early segregating generations. It is proposed to evaluate the early segregating generations of these broad-based compact cotton material and derive new compact lines. These early generation segregants will be evaluated at Dharwad and subsequently introduced under organic situations in Madhya Pradesh to practice selection and stabilizing the lines. It is also proposed to evaluate the early segregating generations and practice selection of superior genotypes through farmers'



participatory activity in early segregating generations. These compact lines will also be tested in hybrid combinations to see if they can give rise to productive but tall compact hybrids suitable for high density and close planting situations.



„The journey of developing cotton for organic situation has been challenging but highly satisfying. If it can bring smile on the faces of organic cotton farmers it will give meaning to my life.“

Shreekant. S. Patil

Professor Dept of Genetics & Plant Breeding UAS, Dharwad

## Development of Desi cotton (Arboreum cotton) Varieties

One of the important components of cost of cultivation is the seed cost. In varietal cultivation the farmer uses his own seed and the source of seed thus becomes reliable as compared to the cultivation of hybrid where the cost of seed is much higher and the farmer is more prone to be deceived because of the likelihood of seed being spurious or contaminated. It is expected that Arboreum varieties perform better in moisture stress situations and marginal soils as compared to Hirsutum varieties. Since Arboreums are diploid cottons there is a genetic reproductive barrier between diploid Arboreum cotton and the tetraploid Hirsutum cotton varieties or hybrids when farmers grow desi cotton, the chance of contamination with Hirsutum pollen is reduced as their pollen of Hirsutum will not set seed on Arboreum cotton. Further the morphological features of the plant and even the seed are so different that any mixture of Hirsutum can be detected at different levels.

Among two species of diploid (desi) cottons, Arboreum varieties were grown in north India with the advent of Bt era the area under desi cotton is dwindling. They have great potential especially under low rainfall situations. The ongoing research has led to improvement in productivity as well as fibre quality. Through the approach of genetic introgression with *Gossypium Hirsutum* species genes for fibre quality and improved ginning out turn are being introduced in to Arboreum varieties. These new varietal Arboreum lines have improved fibre quality and more tolerant to pest than Hirsutum cottons. Some Arboreum hybrids (desi hybrids) are currently grown by farmers in the region but the trials conducted over years have shown that the Arboreum varietal lines have yielded on par close to that of the desi hybrids cultivated by farmers. Hence these Arboreum lines may prove to be better choice especially in low rainfall

situation involving marginal farmers with small holding. This is a special category of organic farming where even small saving accrued in terms of low cost of varietal seed, inherent tolerance to pests and lower cost of protection can be crucial. Ongoing research is focusing on improving productivity blended with higher ginning out turn, high fibre quality, improvement of boll size, better boll opening determining acceptance of the arboretum varieties.



Performance of Arboretum  
varietal lines  
in Farmer's Field

Attempt is also made to explore and develop male sterility system in cotton so that instead of producing hybrid seed through manual emasculation and crossing male sterile female parents are developed and used to produce hybrids there by reducing the cost of hybrid seed production.

#### Maintenance of Germplasm, its enrichment and utilization

Efforts are made to purify, maintain and multiply a large collection of over 1000 germplasm lines. They are being characterized systematically for their desirable species. Attempts are made to procure wild species of cotton for use in introgression breeding to transfer stress tolerance traits, male sterility and initiate long term programs of improving drought, pest tolerance, male sterility for use in cotton breeding.

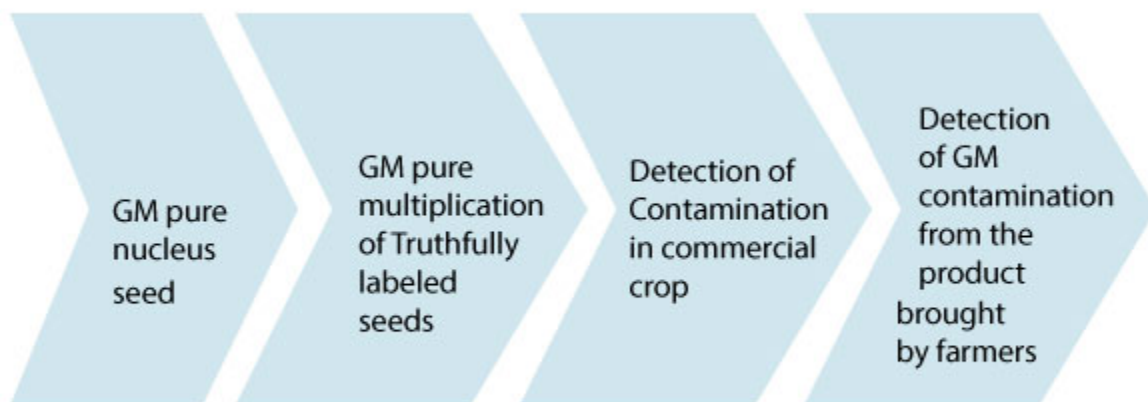


„Different varieties of high quality organic cotton seeds are prerequisite for organic agriculture. Yet we experience massive loss in plant diversity. As bioRe Foundation we support this essential research together with our longterm donors, to provide room for a healthy farm organism with Non-GM seeds which are locally adapted and suitable for organic situation.“

Christa Suter  
CEO, bioRe® Foundation

## Dimensions of producing GM free cottons

Steps of cultivating cotton with zero GM contamination



Steps of obtaining GM pure cotton from organic farmers field

Towards the target of Zero GM contamination

There is a greater stress on producing GM free cotton and bioRe® standard follows zero contamination. Elimination of GM contamination is challenging and it must be carried out at various levels of research and development of genotypes and commercialization. Hence during the course of research work, evaluation of entries in research trials, every entry is tested even the parents of hybrids under evaluation (in trials evaluation of hybrids) testing for presence of different released and commercialized Bt cotton events. During germplasm maintenance, GM Purification of varietal lines and parental lines and hybrid seeds is done at initial level as well as large scale multiplication and production of varietal genotypes and hybrid seed production. For

development of zero contamination a very elaborated procedure of GM purification is carried out where individual plant selections are tested by Elisa kits for presence of GM events. Even at seedling level and seed level tests are carried out. Procured cotton is systematically tested for presence of GM contamination.

### New research on developing Cotton genotypes with marker traits to ensure distinction of the genotypes from GM cotton

When more than 90% cotton grown in India is Bt cotton hybrids the biggest hurdle of organic cotton cultivation in the Indian situation is to get GM free cotton. It is possible that with the help of some marker traits the non-GM genotypes be it varieties or hybrids, can be distinguished from the GM (BGII cotton hybrids) cotton commonly grown in farmers fields. Developing our own genotypes bearing these marker traits will enable us to easily detect contamination from GM cotton. Since this will avoid the cumbersome tests of GM free cotton the use of such markers in cotton will be a boon to cotton growers and utilizers of organic cotton. Contemplating on this idea of developing marker trait in cotton genotypes work is initiated to have marker traits introduced in populations sharing alleles (genetic background) for productivity fibre quality and other yardsticks of acceptance of cotton by textile industry, and the target groups in the cotton chain. Some important research steps are to be executed to bring the required fibre quality along with other benchmark requirements.

### Overall improvement in the remunerative value of cotton-based cropping system

It is observed that cotton is grown in many parts of this region and the crop is alternated with crops like soybean and wheat. In some regions cotton crop is followed in a double cropping system by wheat crop. The overall objective of bioRe® is to improve the remunerative value of the cotton-based cropping system which means that the organization should aim at improving the productivity of these component crops of the cotton-based cropping system. Attempts are made to evaluate genetically improved new wheat varieties and soybean varieties under organic conditions to ensure that the income from the complimentary crops in the cotton-based cropping system and also the alternate crops of cotton ecosystem is also improved.

### Supporting work on Bio pesticides and fertilizers

Use of organic bio pesticides and organic manures are essential components in the crop management of organic cotton and they affect the total income of cotton. Attempts are made to develop combination of plant [protection schedule based on organic, biodynamic principles. New techniques of pest management are researched up on through use of different combinations of bio pesticides, introduce newer effective bio pesticides and bio fertilizers and establishing a bio pesticide production unit at bioRe® so that the farmers are provided with range of bio pesticides and bio fertilizers and are trained in their usage so that there is a continued growth of the productivity of the crop, the health of soil and crop ecosystem.

## Towards the target of self-sufficiency for seed needs

Attaining the goal of self-sufficiency with respect that choice of Farmers will be educated about varietal features to be utilized in purifying and multiplying cotton varieties and the varietal genotypes found to be potential will be multiplied in isolation by involving farmers who will be trained during cropping season for the activities connected with purification and maintenance of varieties. Different DUS traits of each variety / parent are being documented and the individual plant selections will be made in each variety or the parental line of the hybrid. These IPS lines will be evaluated for uniformity, expression of defined traits of the parental line. A perfect program of nucleus seed production is the back bone of multiplication of varietal and parental seeds of the varieties /hybrids.



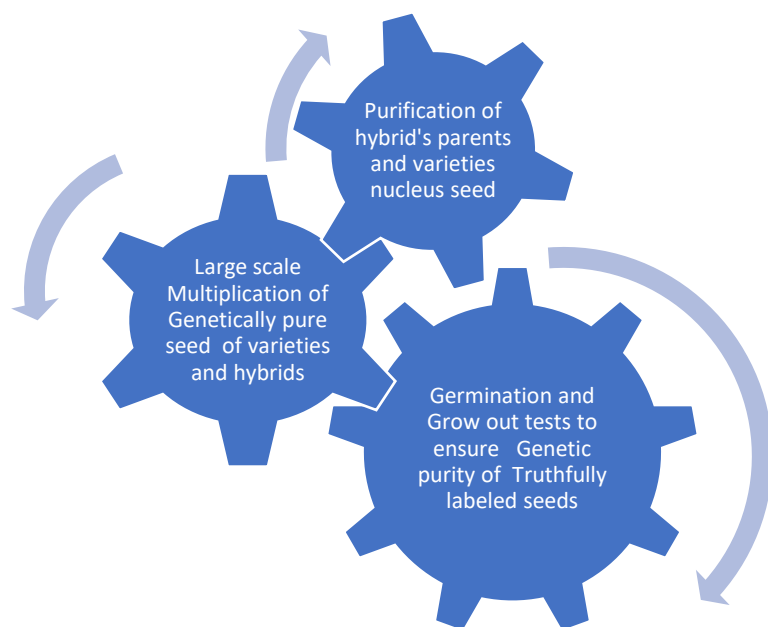
„Non GM cotton seeds bred and produced under organic situations are a true reflection of self dependence of the organic cotton farming community. It provides higher adoption with the organic system by avoiding negative impacts of dominant seed system which otherwise provides organic farmers with seeds which are produced under a chemical intensive conventional system, not suitable for organic conditions.”

Ishwar Patidar  
Research head, bioRe® India

## Large scale commercial hybrid seed production

Technique of production of pure seeds of hybrids is a skillful activity and many hybrid seed producers in professional hybrid seed producing area it is a remunerative livelihood. Looking to the success of the hybrids developed by bioRe® it becomes important to have a highly organized program of hybrid seed production done mainly by bioRe’s farmers. At present we are mostly depending on outsourcing hybrid seed production to different locations in other states of India. It is proposed to build the strength of organic farmers in producing large scale hybrid seed production.

## Process of genetic purification of varieties and hybrids



## Other supporting research programs undertaken

The Research Institute of Organic Agriculture FiBL is a reputed organic institute in Switzerland and bioRe® initiated some research programs in association with University of Agricultural Sciences Dharwad and some activities on genetic improvement were supported through Green Cotton Project for a period of three years. Dr. Monika Messmer participated from FiBL in associating with bioRe's team of Scientists. In addition, a long-term system comparison research program is carried out at bioRe® in India since 2007 to compare organic, biodynamic, and conventional systems of cotton cultivation. These results have given scientific information on the benefits of organic cotton cultivation, on the changes in the soil properties, on the yield and economic benefits of each system as well as pest infestation and resistance of different cultivation systems.



"I am proud of being a member of this team on organic cotton breeding. It has been a great learning experience and has given a sense of satisfaction."

Mahesh Birla  
Asst. Breeder, bioRe® Association India

## Main Partners involved in bioRe cotton seed research program

**bioRe® India Ltd.** is the pioneering organic cotton project in the world started in year 1991 supplying organic cotton to Swiss company Remei AG. Presently, it works with more than 3000 organic farmers in the Indian state of Madhya Pradesh in Khargone and Barwani districts. Since 2018, bioRe® India Ltd. is recognised by the government as Indian research institute under DSIR. bioRe® India Ltd. is led by the CEO Mr. Vivek Rawal.

**bioRe® Association India** is a social organization closely working to support the organic farming community through on-station and on-farm research projects and through social projects on health, education, and livelihood. The bioRe® Research team is led by Mr. Ishwar Patidar who is a post graduate in Agricultural Entomology. The cotton cultivar research is led by Mr. Yogendra Shrivastava who is an expert in organic cotton cultivation. Mr. Mahesh Birlais post graduate in Plant Breeding and he is working as Cotton Breeder at bioRe®.

**bioRe® Foundation Switzerland** is supporting organic and biodynamic agriculture in cotton growing areas and is the promoter and main donor agency supporting social and agricultural endeavours in India and Tanzania. The bioRe® Foundation is led by Mrs. Christa Suter.

**Remei AG** is an important professional partner with regard to the desired fibre qualities, both for the specific industrial requirements of cotton fibres and for the marketability of individual varieties.

**Senior cotton breeder Dr. Shreekant S Patil** is an expert cotton breeder and has three decades of experience in cotton breeding and innovativeness in plant breeding based on his research and teaching experience of population genetics and quantitative genetics at the Indian University of Agricultural Research Dharwad. He is the principal scientist of the bioRe® cotton cultivar research and a consultant breeder to the organization. The research material developed by him have given rise to many new cotton varieties and hybrids which have been released for cultivation for organic farmers of this region. Ms Nikhila a Ph D scholar in genetics and Plant breeding at UAS D is working as Research Associate at UAS Dharwad. This team is supported by field assistants at bioRe® and at Dharwad, Karnataka.

## Organizing seminars, trainings and conferences

National Workshop on “Disappearing non-GM cotton – ways forward to maintain diversity, increase availability and ensure quality of non-GM cotton seed” in association with University of Agricultural Sciences Dharwad (UASD) at Dharwad, Karnataka on 21 June 2011 | Research Institute of Organic Agriculture (FiBL), Frick, Switzerland, bioRe® India (Ltd), District Khargone,

Madhya Pradesh, India and University of Agricultural Sciences Dharwad (UAS Dharwad), Karnataka, India.

### Organizing Training for Improving technical skill of research and extension staff

To increase the scientific knowledge regular trainings are organized on various issues such as Application of Statistical tools in experimentation and evaluation of genotypes, principles of bio control of pests, production of bio pesticides and other aspects. Eminent scientists from Agricultural universities are invited to train the bioRe® Research and Extension workers.

### Organizing Refresher Course

Members of the Research team have high reputation in the field of Plant Breeding. Dr Shreekant S Patil has conducted online four weeks refresher course from 27-7-2020 on application of Population Genetics principles in Plant Breeding organized by University of Agricultural Sciences Bengaluru India and it is meant to train breeders across India and other countries on the genetic basis of Plant breeding and need for innovative approaches of cotton breeding. It is attended by breeders, teachers and post graduate students from different countries.

### Participation in National and international conferences

Dr Shreekant S Patil has participated in the World Cotton Research conferences held at Cape town in South Africa, Texas in USA, Mumbai in India and presented research findings on cotton.

He has also participated in Textile Exchange conferences on Organic cotton held at Barcelona, Spain, Textile and organic round table conference on organic cotton (18-20th September 2011). Sixth meeting of the Asian cotton Research and development network held at Dhaka, Bangladesh during June 18- 20, 2014

FiBL Workshop on Participatory Research hosted by World Food System at ETH, Zürich on 28, August 2014 He has also participated in national conferences held on cotton at Bhuvaneshwar (2019), organized by CRDA International conference on cotton and other fibre crops organized by ICAR and CRDA at Umium, Meghalaya India, during (20-23 February 2018) to present research findings on cotton. He also participated and delivered lead lecture in FiBL Workshop on Participatory Research hosted by World Food System Centre, ETH, Zürich, presented topic “Genetic improvement of cotton for organic cotton” on 28, August 2014 and participated in discussions along with other team members from bioRe®.



Dr. Shreekant S. Patil and CEO of bioRe® India, Mr. Vivek Rawal, together participated in seed task force meeting and textile exchange conference (Nov 1-13. 2013, Istanbul, Turkey) and Asian cotton research conference held at Tashkent, Uzbekistan (held during 18-21 Sep 2019) to present research and development activities of bioRe® and to interact with various stake holders of organic cotton.

## Awards and Recognition for the Research Team

Dr. Shreekant S. Patil the leader of the research team of bioRe® is conferred with Professional Excellence award for his innumerable contributions in the field of Agriculture in general and Cotton improvement in particular. This award was given to him at the national conference on Cotton organized at OUAT, Bhubaneswar Odisha. He has served as member of Research Advisory Committee (RAC) of Central Institute of Cotton Research (CICR) for a tenure of three years and presently he is serving as RAC member for Indian Institute of Millets Research (IIMR) apart from serving as member of editorial board of leading research journals (including Indian Journal of Genetics and Plant Breeding).

### Organizing National Conference

Disappearing non-GM cotton – ways forward to maintain diversity, increase availability and ensure quality of non-GM cotton seed Organic Cotton achievements, challenges and prospects in India at UASD along with FiBL and UASD.

### Research Publications

At University of Agricultural Sciences Dharwad over ten M.Sc (Agri) and five PhD students have worked on the different concepts of exploiting heterotic groups of cotton for improvement of hybrids performance in cotton, Concept of Target genotype in varietal improvement completed their research work at UAS Dharwad by utilizing the support of research project funded by bioRe®.

List of Post graduate students<sup>1</sup> who completed post-graduation under Dr. Shreekant S. Patil's guidance (2010 onwards) at University of Agricultural Sciences, Dharwad, India.

Some of the publications resulting from these studies are shown below under Publications.

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<sup>1</sup> See Appendix 1

## Publications and References

Dr. Patil and team have published over 20 research publications on different aspects in journals and presented on over 20 occasions in international and national conferences<sup>2</sup>.

### Participation in international conference to present research on Organic cotton breeding

- 2011 Textile Exchange conference held at Barcelona, Spain
- 2013 Textile Exchange conference held at Istanbul, Turkey
- 2019 Textile Exchange conference held at Vancouver, Canada
- Seminar at Switzerland
- Asian cotton research Conference at Tashkent, Uzbekistan

### Main donors of the bioRe cotton cultivar evaluation programme

- Coop Fond für Nachhaltigkeit
- Foundation Edith Maryon
- Foundation Dreiklang
- bioRe® Foundation

### Previous donors of phase 1/2

- Mercator Foundation (Green Cotton programme)
- Corymbo Foundation
- C&A Foundation

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<sup>2</sup> See Appendix 2

## Appendix

### Appendix 1

#### a) Students who completed Ph.D.

Sl.No	Name of the candidate	Degree/Year	Major Advisor	Title of the thesis
1	Jayaprakash.M. Nidagundi	Ph.D/2010	Dr.S.S.Patil	Genetic studies on productivity and quality features in cotton ( <i>G.Hirsutum L.</i> )
2	Shobha Immadi	Ph.D/2012	Dr.S.S.Patil	Genetic analysis of the axillary branched mutant (sbABM) in sorghum ( <i>Sorghum bicolor L.moench</i> )
3	Yanal Ahmad Alkuddsi	Ph.D/2013	Dr.S.S.Patil	Development and Exploitation of Heterotic pools of <i>G Hirsutum</i> and <i>G barbadense</i> for developing potential inter specific hybrids, Molecular Manken and Genetic transformation study in cotton
4	Pranesh K.J.	Ph.D/2014	Dr.S.S.Patil	Exploitation of heterotic groups through reciprocal selection for combining ability in cotton ( <i>Gossypium Hirsutum L.</i> )
5	Rajeev. S.	Ph.D.2018	Dr.S.S.Patil	Exploiting concept of <i>Gossypium Hirsutum L.</i> vs <i>Gossypium barbadense L.</i> Heterotic groups through reciprocal selection for combining ability in cotton.

#### b) Students who completed M.Sc (Agri)

Sl.No	Name of the candidate	Degree Year	Major Advisor	Title of the thesis
2	Deepika. M.	M.Sc/(Agri) 2011	Dr.S.S.Patil	Genetic studies in <i>Gossypium barbadense L.</i> cotton for productivity
3	Ranganatha.H.M.	M.Sc/(Agri) 2011	Dr.S.S.Patil	Genetic studies involving inter plant type crosses in cotton ( <i>G.Hirsutum L.</i> )
4	Ashok Kusugal	M.Sc(Agri) /2014	Dr.S.S.Patil	Genetic studies on improving productivity, fibre quality traits and combining ability in barbadese ( <i>Gossypium barbadense L.</i> ) Cotton

5	Girish Tantuway	M.Sc(Agri) /2015	Dr.S.S.Patil	Genetic studies on constancy of combining ability over segregating generations of a heterotic box in cotton ( <i>Gossypium Hirsutum L.</i> )
6	Vinayak Edke	M.Sc(Agri) /2016	Dr.S.S.Patil	Genetic studies on utilizing heterotic groups for varietal improvement in cotton ( <i>Gossypium Hirsutum L.</i> )
7	Aman Tigga	M.Sc(Agri) /2016	Dr.S.S.Patil	Studies on target genotype, based on different selfed and backcross derived generations in cotton ( <i>Gossypium Hirsutum L.</i> )
8	Adarsha	M.Sc/(Agri) 2017	Dr.S.S.Patil	Genetic studies on target genotype and response to selection in cotton ( <i>Gossypium Hirsutum L.</i> )
9	Raghuveer M.	M.Sc(Agri) 2018	Dr.S.S.Patil	Genetic studies on plant types of cotton ( <i>Gossypium Hirsutum L.</i> )
10	Revanasiddayya	M.Sc/(Agri) 2019	Dr.S.S.Patil	Genetic studies on target genotypes of cotton ( <i>Gossypium Hirsutum.L</i> )

## Appendix 2

### Scientific Publications from 2010

#### a) Papers published in Journals

1. Patil, S. S. 2011, Importance of teaching concepts of population genetics in effective understanding of plant breeding. *Indian J.Genet.*, 71(2) special issue: 106-114.
2. Patil, S. S, Ramakrishna V, Maralappanavar,M.S, Swathi.P., Ranganatha H.M, Kencharaddi H.G And. Babu D H. 2011, Deploying reciprocal selection for combining ability for improving performance of hybrids in cotton (*Gossypium Hirsutum L.*), *Indian J.Genet.*, 71(2) : 180-184.
3. Shoba Immadi, Shreekant S Patil, Manjula Maralappanavar and Gowramma Sajjanar., (2014)., Penetrance, expressivity and inheritance of axillary branching in somaclonal mutant of sorghum (*sorghum bicolor L.*) *Euphytica* 196:449-457.
4. Patil, Shreekant S. 2014 Conventional Breeding of Cotton Needs to Change, *The ICAC Recorder*. XXXII No. 3:13-20
5. Pranesh KJ and Patil S S 2014 Identification of transgressive segregants for combining ability in early generation of cotton. *Green Farming* 5(5):734-737
6. Ashok Kusugal., Patil, S. S., Pranesh, K. J., Rajeev, S and H. G. Kencharaddi, 2014, Improving genetic base of *Gossypium barbadense L.* for developing inter specific hybrids, *Electronic journal of plant breeding* 5(3):594-601
7. Ranganatha, H. M., Patil, S. S., Manjula, S. M. and Patil, B. C., 2013, Studies on Heterosis in cotton (*Gossypium Hirsutum L.*) for seed cotton yield and its components. *Asian J. Bio Sci.*, 8(1): 82-85.
8. Ranganatha, H. M., Patil, S. S., Manjula, S. M., Arvindkumar, B. N. and Swathi, P., 2013, Combining ability studies for fibre quality traits in upland cotton (*Gossypium Hirsutum L.*). *Intl. J. Plant Sci.*, 8(2): 312-315.
9. Ranganatha, H. M., Patil, S. S., Rajeev, S. and Swathi, P., 2013, Combining ability studies for seed cotton yields and its component traits in upland cotton (*Gossypium Hirsutum L.*). *Bioinfolet.*, 10(4c): 1549-1553.
10. Ranganatha, H. M., Patil, S. S., Rajeev, S. and Swathi, P., 2013, Heterosis studies for fibre quality traits in upland cotton [*Gossypium Hirsutum L.*]. *Bioinfolet*, 10(4c): 1569-1572.
11. Ranganatha, H. M., Patil, S. S., Swathi, P., Rajeev, S. and Nethra, B., 2013, Character Association and Variability for Yield and its Component Traits in Upland Cotton (*Gossypium Hirsutum L.*). *Plant Archives*, 13(2): 785-788
12. Ranganatha, H. M., Patil, S. S., Swathi, P., Rajeev, S., Srivalli, P. and Kanti, V. M., 2013, Development of heterotic pairs or groups of cotton genotypes based on predicted double cross performance. *Intl. J. Agri. Crop Sci.*, 6 (5): 231-235.
13. Ranganatha, H. M., Patil, S. S., Manjula, S. M. and Arvindkumar, B. N., 2013, Genetic Variability Studies in Segregating Generation of Upland Cotton (*Gossypium Hirsutum L.*). *Molecular Plant Breeding*, 4: 84-88.
14. Alkuddsi, Y. A., Patil, S. S., Manjula, S. M., Patil, B. C., Pranesh, K. J., Rajeev, S., Swathi, P. and Ranganatha, H. M., 2013, Mismatch in Source and Sink as a Reason Determining Realized Potentiality of Bt Cotton Hybrids. *Bt Res.*, 4:

15. Girish Tantuway and Shreekant S. Patil, 2017 Determining the Combining ability of F4 lines of RSG population developed through exploitation of heterotic groups in cotton Bull. Env. Pharmacol. Life Sci., Vol 6 Special issue [3]: 161-168
16. Girish Tantuway, Shreekant S. Patil, Hanamaraddi Kencharaddi, Aman Tigga and Vinayak Edke 2016. Estimation of Heritability for Seed Cotton Yield in Cotton Based on Regression Approach Journal of pure and applied microbiology, 10(4), p. 3249-3252
17. Girish Tantuway and Shreekant S. Patil 2018. Estimation of Combining Ability and Heterosis of F5 lines of RSG Population Developed through Exploitation of Heterotic Groups in Cotton. International Journal of Agriculture, Environment and Biotechnology Citation: IJAEB: pp. 963-975
18. Giiirish Tantuway , Shreekant S.Patil and H.G. Kenchraddi I J. 2019 Consistency of combining ability in segregating generations of a heterotic box subjected to reciprocal selection in cotton. Cotton Res. Dev. 33 (1) 26-35
19. Girish Tantuway and Shreekant S. Patil (2019) Combining Ability of Early Segregating Generation RGR F Lines of Heteroticbox in Cotton Indian Journal of Ecology 46(4): 810-817
20. Rajeev, S., S.S. Patil, S.M. Manjula and P. Srivalli 2018. Studies on Recombinational Variability for Combining Ability or Seed Cotton Yield and Contributing 4040 Traits in F4 Hirsutum Lines Against Barabdense Testers Trends in Biosciences 11(39), Print: ISSN 0974-8431, 4040-4057,
21. Rajeev, S. and Patil, S.S. 2018. Combining Ability Studies in Cotton Interspecific Heterotic Group Hybrids (G. Hirsutum x G. barbadense) for Seed Cotton Yield and its Components. Int.J.Curr.Microbiol.App.Sci. 7(07)
22. Patil, Shreekant S. 2019 Innovative Approaches to Breeding Cotton. ICAC Recorder Volume XXXVII, No. 4:19-30
23. H. G. Kencharaddi., R.R.Hanchinal and S.S.Patil., 2015., Determining path of productivity in derived F1 involving diverse heterotic groups in cotton (G.Hirsutum L) Green Farming , 6 (3) :443-447
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26. H. G. Kencharaddi., S.S.Patil., R.R.Hanchinal., K.J.Pranesh and S. M. Manjula 2015, utilizing heterotic groups of cotton and forming sub groups for further exploitation based on combining ability pattern, symposium on " Future technology :Indian cotton in the next decade" December 17-19, 2015 at Acharya Nagarjuna university Guntur, Andra Pradesh.
27. Seraina Vonzun 1,2, Monika M. Messmer 1, Thomas Boller 2, Yogendra Shrivastava 3, Shreekant S. Patil 4 and Amritbir Riar (2019) Extent of Bollworm and Sucking Pest Damage on Modern and Traditional Cotton Species and Potential for Breeding in Organic Cotton Sustainability 2019, 11(22), 6353;

**b) Presented in International and National Seminar/conference**

1. Patil Shreekant S. 2012 Need for breeding system research in improving cotton. Proceedings on "Global Cotton Production Technologies vis-a-vis Climate Change" Silver Jubilee International Symposium on "Global Cotton Production Technologies vis-a-vis Climate Change" October 10-12, 2012 CCS Haryana Agricultural University, Hisar: 37-46

2. Patil, Shreekant S. Pranesh K.J., Sharanagoud A. Patil, Prakash Salimath and Raosaab R. Hanchinal 2011. Development of compact genotypes for machine picking and double cropping system in India Proc WCRC5, held at Mumbai
3. Alkudsi, Y., M.R.G. Rao and S. S Patil. 2011, Heterosis of new Hybrids of Upland cotton (*Gossypium Hirsutum* L.) for Kapas yield and its attributing characters. WCRC-5 Mumbai: P.108. (Poster Presentation)
- 4 Patil, S. S. 2011, Importance of teaching concepts of population genetics in effective understanding of plant breeding. presented in National seminar on contemporary approaches to crop improvement held at GKVK, Bangalore.
5. Kencharaddi, H.G, R. S. Patil, K.J Yashavanthakumar, S.S. Patil. (Poster Presentation). 2011, A systematic approach to identify superior segregants for yield and ideotype breeding. WCRC-5 Mumbai: P.114.
6. Patil., S. S., V. Ramakrishna., S. M. Manjula., P, Swathi., H. M, Ranganath., H. G. Kencharaddi., and Deepakbabu. 2011, Deploying reciprocal selection for combining ability for improving performance of hybrid s in cotton (*Gossypium Hirsutum* L.). Poster presented in National seminar on contemporary approaches to crop improvement held at GKVK, Bangalore.
7. Alkudsi, Y.A., M.R. Gururaja Rao and S.S. Patil. 2011, Estimating combining ability effects and forming heterotic boxes for exploitation in cotton (*Gossypium Hirsutum* L.). Poster presented in National seminar on contemporary approaches to crop improvement held at GKVK, Bangalore.
- 8 Patil, Shreekant S., M. S. Maralappanavar, I. S Katageri, R.S. Patil and J.P. Nidagundi. 2011, Prospects, status and future breeding strategies for crop improvement of cotton in Karnataka. Souvenier of National seminar on Contemporary approaches to crop improvement.
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11. Baruah. R., Messmer, M., Forster, D., Verma, R., Patil, S.S., (2011). Participatory breeding of cotton for organic and low external input conditions. World Cotton Research Conference – 5, November 5 – 10, Mumbai, India.
12. Messmer, M., Roner, T., Verma, R., Baruah, R., Forster, D., Patil, S.S. (2012) Participatory Cotton Breeding for Organic and Low External Input Conditions. NUE Crops Workshop in: 'Farmer participatory approaches for variety selection/breeding and nutrient/environmental management' – 9th and 10th June, 2012 – Sivas, Crete
13. Roner, T., Messmer, M.M., Finckh, M., Forster, D., Verma, R., Baruah, R., Patil, S.S. (2012): Participatory cotton breeding for organic and low input farming in Central India. In: Tropentag: "Resilience of agricultural systems against crisis", Göttingen, 19. - 21 September 2012, 2012. Tielkes, E. (ed.), pp 247.
14. Monica .M.Messmer, TinaRoner, Maria Finckh, Dionys Forster, Rajeev Varma, Rajeev Baruah, Shreekant. S.Patill, (2011). Participatory cotton breeding for organic and low input farming in India, Organic Plant Breeding: What makes the difference? 10 year's Anniversary Conference, Frankurt,3rd and 3th November 2011.
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16. Monika Maria Messmer, Amritbir Riar, Seraina Vonzun, Yogendra Shrivastava, Lokendra Mandloi, Mahesh Birla, Ishwar Patidar, Ramprasad Sana, Gobinda Mahapatra, Arun Ambatipudi, H.G. Kencharaddi, Shreekant S. Patil (2017) David against Goliath Participatory non-GM cotton breeding in India. 5th ISOFAR Scientific Conference "Innovative Research for Organic 3.0" at the 19th Organic World Congress, New Delhi, India, November 9-11, 2017
17. Alkudsi.Y. and S.S. Patil. 2010 Development of interspecific heterotic groups in cotton Eighth international Symposium on biocontrol and Biotechnology held at Khon Kaen University, Non Khai Campus, Thailand from 4-6. October, 2010
18. Patil, Shreekant S., 2012, Need for breeding system research in improving cotton. Proceedings on "Global Cotton Production Technologies vis-a-vis Climate Change" Silver Jubilee International Symposium on "Global Cotton Production Technologies vis-a-vis Climate Change" October 10-12, CCS Haryana Agric. Univ., Hisar, 12: 37-46.
19. Kencharaddi, H.G., S.S. Patil and R.R. Hanchinal (2016) Exploitation of heterotic box derived from high RGR Vs Stay green – Robust heterotic group through reciprocal selection for combining ability to improve performance of cotton hybrids in First National conference on Genetics and Cytogenetics held at UAS Dharwad on 1-2 February 2016 (won best poster award).
20. Patil, Shreekant S. (2018) Insight into Genetic basis of varietal and hybrid development. Second National conference on Genetics and Cytogenetics held at UAS Dharwad on 1-2 February 2018 (Lead lecture).
21. Aman Tigga, S.S. Patil, Vinayak Edke, Utpal Roy and Ashutosh Kumar, 2018. Studies on target genotype based on different selfed and backcross derived generations in cotton (*Gossypium hirsutum* L.). Second National Conference on Genetics and Cytogenetics, UAS, Dharwad, Karnataka, 1-2, February, 2018.
22. Adarsha, S.S. Patil and Aman Tigga, 2018. Determining target genotype and choice of breeding approach based on comparison of backcross and F2 derived selfed generations (B1F2, F3 and B2F2) in *Gossypium hirsutum* cotton combinations. Second National Conference on Genetics and Cytogenetics, UAS, Dharwad, Karnataka, 1-2, February, 2018.
23. Patil S.S. (2018) Innovative approaches of conventional breeding in cotton International Congress on Cotton and other fibre crops organized at Umiam by ICAR and CRDA (oral presentation).
24. Patil S.S. (2012) Orienting breeding programs for changing needs of cotton cultivation. National seminar on "Paradigm shift in cotton cultivation held at Navsari Agricultural University, Surat from 18-20th December 2012 (Lead lecture).
25. Patil Shreekant S (2019) Innovative Approaches in Cotton Breeding oral presentation in 8th meeting of the ICAC-Asian Cotton Research and Development Network. September 9-11, 2019 in Tashkent, Uzbekistan on 'Best Global Sustainable Practices on Production, Processing & by-products Value Addition'.
26. Vivek Rawal, and S.S. Patil 2019 Organic Cotton achievements, challenges and prospects in India oral presentation in 8th meeting of the ICAC-Asian Cotton Research and Development Network. September 9-11, 2019 in Tashkent, Uzbekistan on 'Best Global Sustainable Practices on Production, Processing & by-products Value Addition'.
27. Shreekant S. Patil (2020) Innovative approaches in Breeding Cotton National Symposium on Cotton production technologies in the next decade: Problems and perspectives organized by CRDA, CSHAU and OUAT at Bhubaneswar Odisha, 22-24 Jan 2020.